Framework for Cooperative Conservation and Climate Adaptation for the Southern Sierra Nevada and Tehachapi Mountains

Volume I

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The Southern Sierra Partnership bears responsibility for factual errors. Recommendations and views expressed are those of the Southern Sierra Partnership and do not necessarily represent those of funders, workshop participants, and others who offered assistance.

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OVERVIEW

In early 2009 Audubon California, the Sequoia Riverlands Trust, the Sierra Business Council, and The Nature Conservancy formed the Southern Sierra Partnership (SSP) and launched a collaborative conservation assessment with representatives from ten agencies and organizations for the southern Sierra Nevada and Tehachapi Mountains. The objectives of this assessment were:

1. Characterize the biodiversity, ecosystem services, ownerships, and land uses in the Southern Sierra and Tehachapis, and assess threats to conservation values.
2. Examine how a changing climate will impact or interact with these threats, and forecast long-term responses in the landscape.
3. Identify conservation opportunities, at project-specific and regional scales, that would allow adaptation to climate change and so ensure maintenance of conservation values.

Based on this assessment, the SSP developed a Regional Conservation Design, or spatial vision that integrates conservation goals, threat projections, and climate change responses to identify areas of the landscape that offer the best opportunities for sustaining biodiversity and ecosystem services. To convert opportunity into action, the SSP recommends strategic approaches for climate adaption across public and private lands in the southern Sierra and Tehachapi Mountains, an area spanning 7 million acres in Fresno, Tulare, and Kern counties.

The landscape-scale spatial and temporal changes that are projected to occur reinforce the sense of urgency and underscore the importance of addressing direct threats now to ensure long-term ecosystem resilience and opportunities for species adaptation. The magnitude and scope of change highlights the need for collaboration across jurisdictional boundaries to achieve meaningful, landscape-level conservation. With this in mind, the SSP articulates a long-term regional vision for working together to protect and restore the southern Sierra's irreplaceable natural heritage within an adaptive management and monitoring framework.

The SSP's Regional Conservation Design identifies a network of core areas and connections that support high biodiversity and valuable ecosystem services. The Design includes landscape features likely to support adaptation and zones projected to be climatically stable within the existing ranges of common trees and shrubs and key systems. Although ambitious, it is an efficient, pragmatic design based on current realities and future projections. It does not presuppose specific strategies nor is it a land acquisition plan. Rather, it highlights the significant contribution of the region's extensive private rangelands to conserving biodiversity and in sustaining key ecosystem services now and in the future. In addition, it offers a regional approach for aligning priorities across watersheds, ecosystems, and jurisdictions. Such a design can help government, organizations, landowners, districts, utilities, and industry coordinate with one another.

This Framework for Cooperative Conservation and Climate-Adaptation provides a regional context for federal, state and local agencies, districts, and organizations focused on individual parks, preserves, watersheds, and project initiatives in the southern Sierra. With climate change, land managers responsible for individual parks or preserves will face challenges of scale, as suitable conditions for some species of concern may fall outside of the parks. Given this, collaborative data development and sharing is critical and we have taken a first step toward that end.

Many of SSP's datasets and analyses are available through Data Basin (www.databasin.org), an open-access web tool that connects users with conservation datasets, tools, and expertise. Through Data Basin, individuals and organizations can explore and download SSP and other conservation datasets, upload their own datasets, connect to external data sources, and produce customized maps that can be easily shared for conservation purposes.

Climate change – its scope and pace, and the uncertainty about how ecosystems will respond to it – fundamentally challenges conservation planning. Traditional assumptions and methods of setting priorities must be recalibrated to create new approaches and methods for incorporating climate change into the conservation planning process. This Framework provides a real-world example of a climate-adapted conservation plan which can help move the conservation field beyond ideas and concepts toward implementation. The SSP presents more details about our planning approach and lessons learned in the Appendix.

1.0 INTRODUCTION

Just over a century ago, the Sierra Nevada's towering giant sequoias, pines, and firs were under assault by uncontrolled logging and mining. Hundreds of thousands of sheep, cattle, and horses trampled and devoured the wildflowers and grasses of once-pristine mountain meadows. Roads were under construction and dams were being proposed for major rivers.

In response, John Muir, Teddy Roosevelt, Bob Marshall, the Visalia newspaper editor George Stewart, Tulare County citizens, and many other determined individuals and organizations fought for, won, and over the decades repeatedly defended what became an unparalleled complex of national parks and national forests extending along the spine of the Sierra.

Today, threats that those pioneering conservationists could not have imagined face the southern portion of the Sierra Nevada: invasive non-native species threaten to replace many native species, altered fire regimes and air pollution stress the forest, spreading rural development is fragmenting and degrading oak woodlands and wetland communities, and climate change could dramatically change the entire landscape and the functioning of its ecosystems. These new threats cross jurisdictional boundaries and sometimes interact with and reinforce each other, magnifying the management challenges.

In recent years, the ecology and condition of the southern Sierra Nevada — and the threats to these landscapes — have been the subjects of numerous studies, assessments, and plans. The landmark Sierra Nevada Ecosystem Project, conducted by a multidisciplinary team of scientists at the request of Congress, assessed ecological, social, and economic conditions across the Sierra Nevada (SNEP 1996). This and many other studies[1] highlight the need to take climate change into account, and many call for fuller collaboration among public agencies, conservationists, private interests, and other stakeholders in order to achieve a more holistic approach to the management of the southern Sierra and its natural resources.

In 2009 Audubon California, the Sequoia Riverlands Trust, the Sierra Business Council, and The Nature Conservancy formed the Southern Sierra Partnership (SSP, or Partnership) and launched

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[1] Examples include national park general plans, national forest management plans, and the joint 2009 Science Framework by the National Park Service, the U.S. Geological Survey, and the USDA Forest Service, *A Strategic Framework for Science in Support of Management in the Southern Sierra Nevada Ecoregion*. Other relevant studies include: *Grinnell Re-survey*, Moritz et. el. 2008; *Birds Track Their Grinnellian Niche Through a Century of Climate Change*, Tingley et. al., 2009; *Recent Projections of 21st-Century Climate Change and Watershed Responses in the Sierra Nevada*, Dettinger et. al, 2002; *Widespread Increase of Tree Mortality Rates in the Western United States*, van Mantgem et. al., 2009; *Sierra Nevada Ecoregional Assessment*, The Nature Conservancy, 1999; *Sierra Nevada Ecosystem Services Demonstration Site,* Natural Capital Project, The Nature Conservancy (in preparation); *Missing Linkage: Restoring Connectivity to the California Landscape*, Penrod, 2000; *Conservation Significance of Tejon Ranch: A Biogeographic Crossroads*, White et al, 2003; *Proceedings of the Sierra Nevada Science Symposium*, Murphy and Stine, 2004; *Southern Sierra Nevada Fisher Assessment,* Spencer et. al 2008; *Sierra Climate Change Toolkit*, Sierra Nevada Alliance. 2007; A *Guide to Wildlands Conservation in the Greater Sierra Nevada Bioregion*, Shilling et. al. 2002. *An Ecosystem Management Strategy for Sierran Mixed-Conifer F*orest (North et al. 2009).

a collaborative conservation assessment process that spans the public and private lands of the southern Sierra. This process seeks to fill the niche identified by previous studies: it takes a rigorous approach to incorporating climate change into conservation planning, and it brings together a diversity of stakeholders. To achieve enduring conservation results in the face of diverse threats, including climate change, the SSP pledges to work with others to explore, develop, and implement innovative conservation solutions.

1.1 ASSESSMENT OBJECTIVES

The objectives of SSP's assessment process were to:

4. Characterize the biodiversity, ecosystem services, ownership patterns, and land uses in the southern Sierra and Tehachapi Mountains.
5. Assess the major threats to biodiversity at regional and project scales.
6. Examine how a changing climate will impact or interact with these threats, and anticipate long-term responses in the landscape.
7. Identify conservation opportunities, at project-specific and regional scales, that would allow adaptation to climate change and ensure maintenance of conservation values.
8. Based on the above, develop a regional conservation vision – this Framework – that
    a. Articulates the long-term conservation design goals for the region.
    b. Acknowledges the spatial and temporal changes that will occur with a changing climate, relative to existing conservation investments, land uses, and ecosystem services.
    c. Based on these anticipated impacts, propose strategic approaches for threat reduction and climate adaptation.

This Framework, prepared by the Partnership, presents an assessment and conservation vision for the southern Sierra and Tehachapis that explicitly considers opportunities for adapting to climate change on a broad regional scale. The adaptation approach recognizes that the climate is already changing and will continue to do so, and that these changes present challenges to both humans and nature. This Framework describes the conditions and approaches that favor adaptation. There is a relationship between adaptation, avoided emissions of greenhouse gases, and carbon sequestration. Therefore, while the focus is on climate adaptation, this vision also supports climate mitigation by advocating for ecosystem health and protection of the carbon sequestration functions of natural forests, woodlands and grasslands.

1.2 PROJECT AREA

The Framework covers 7 million acres, or nearly 11,000 square miles, within Fresno, Tulare, and Kern Counties. The project area encompasses the southern third of the Sierra Nevada Mountain range as well as the entire Tehachapi Range and extends westward from the Sierra crest to the San Joaquin Valley along Highway 99. It is bounded on the south by Interstate 5 along the Coastal Transverse Range and on the north by the San Joaquin River (Figure 1).

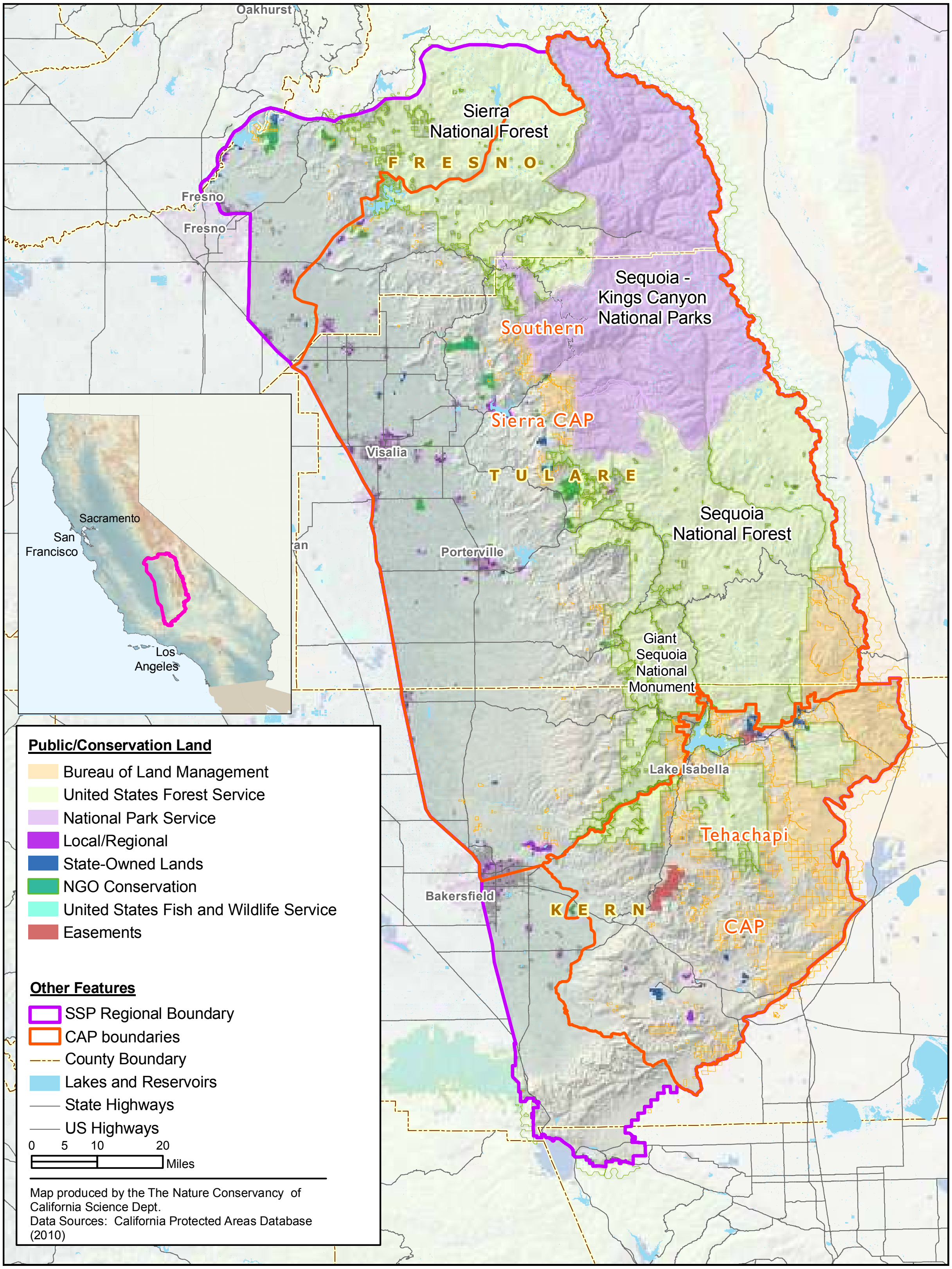

Figure 1. Southern Sierra project area with land ownership. The regional boundary shown in purple encompasses the two Conservation Action Plan (CAP) boundaries shown in red and labeled.

The project area is situated at the crossroads of four ecoregions (Sierra Nevada, Great Central Valley, South Coast, and Mojave Desert) and five geomorphic provinces (Sierra Nevada, Great Central Valley, Coast Ranges, Transverse Ranges, and Mojave Desert).

Size: 7,033,942 acres

Elevation: 200 ft to 14,491 ft (Mount Whitney)

Terrestrial Systems: grasslands, oak woodlands, chaparral, mixed conifer forest, including 60 groves of giant sequoia, alpine and sub-alpine, Mojave Desert and Joshua tree scrub, and sage brush-pinyon juniper.

Aquatic Resources: Alpine lakes, five major rivers, 3,750 miles of perennial streams, riparian wetlands, and vernal pools

Species: >60 endemic species. Iconic species such as giant sequoia, blue oak, condors, Valley oaks, bristlecone pine, and 13 species listed under the federal Endangered Species Act.

Landscape Integrity and Connectivity: High landscape integrity except portions of the lower foothills and the Valley floor where land use is irrigated agriculture, urban centers, and roads.

The southern Sierra's rugged, complex terrain and 14,000-foot elevational gradient from the floor of the San Joaquin Valley to the range's highest peaks combine to produce tremendously diverse habitat niches and support a large number of natural communities in a relatively compact area. (Figure 2) A large portion of the precipitation in the area occurs as snow. The Sierra snowpack is gradually released to rivers, streams, and aquifers throughout the dry season. High in the southern Sierra, glaciers and snow-capped peaks — no fewer than 117 of which rise to 13,000 feet or more — form the headwaters of five major rivers. Their waters feed montane meadows, riparian forests, and wetlands; provide humans with hydropower, drinking water, and irrigation for internationally significant agricultural production; and recharge groundwater tables in the San Joaquin Valley.

The Tehachapi Range is recognized as a biological "hot spot" with a high number of endemic species and unusual assemblages of native species from the various intersecting ecoregions (White 2003). The recent agreement opening the way for the protection of most of the 270,000 acre Tejon Ranch, coupled with The Nature Conservancy's work to safeguard strategically located adjacent ranches, has provided conservationists with momentum and an unprecedented opportunity to secure the critical link that the Tehachapis provide between the Coast Range and the southern Sierra.

While only 7% of the state's land area, the region boasts a diverse set of habitats that harbors a disproportionately high number of wildlife. Based on an analysis of all vertebrate ranges in the state, over 90% of the state's amphibians have part of their range within the study area, and 85% of the reptiles, 80% of the mammals, and 57% of the birds. Over 60 rare and endemic species occur, including threatened and endangered species such as, Kern Canyon slender salamander, western yellow-billed cuckoo, southwestern willow flycatcher, California condor, Swainson's hawk, Kaweah *brodiaea*, Springville *clarkia*, and striped adobe-lily. The steep foothills in the project area feature the most extensive oak woodlands in California while the Kern Valley contains California's largest unbroken stand of cottonwood-willow riparian forest, two species rich communities.

Along the spine and flanks of the Sierra Nevada lie 2.8 million acres of public lands — national forests, national parks, Bureau of Land Management holdings, and others. These lands include *all or portions of* Kings Canyon and Sequoia National Parks, Giant Sequoia National Monument, Sequoia, *Sierra, and Inyos* National Forest, *fifteen* federal wilderness or wilderness study areas, six state ecological reserves, and numerous private conservation properties.

Photo credit: Jennifer Browne

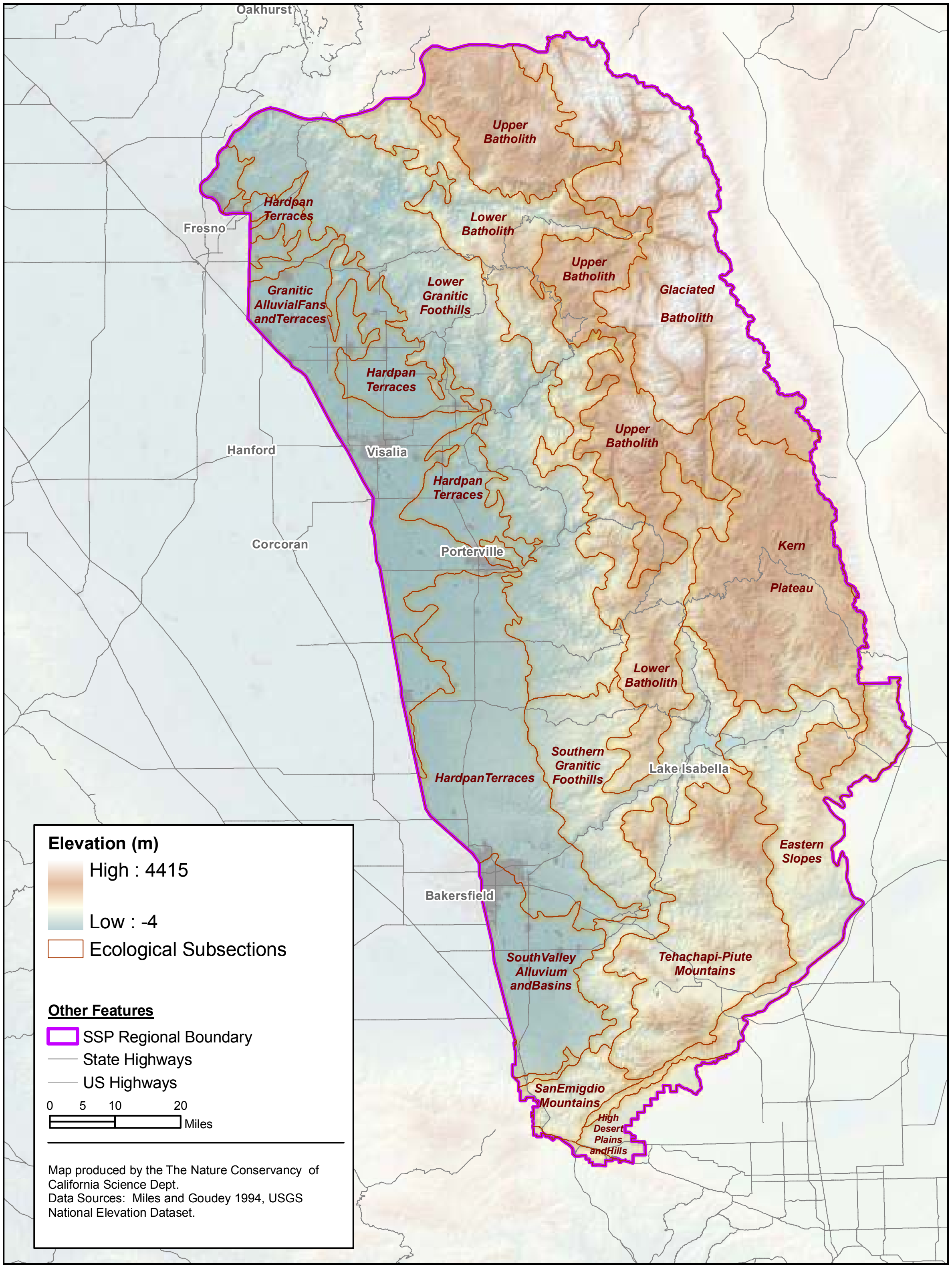

Figure 2. Elevation map with subregions. The vertical relief in the region of over 14,000 feet is the highest in the lower 48. The subregions were used to ensure that the regional design spans the major physiographic gradients in the region.

2.0 ASSESSMENT OVERVIEW

In April 2009 the Southern Sierra Partnership initiated the collaborative assessment. Three teams were established:

- Southern Sierra project area for the northern part of the region (4,298,812 acres)
- Tehachapi project area for the southern part of the region (1,217,892 acres)
- Regional assessment for the entire project area (7,033,942 acres)

2.1 FOCAL CONSERVATION TARGETS

A key decision was the selection of focal conservation "targets" to serve as the basis for planning and priority setting. Nine ecosystem types and two species groups were selected to represent the region's biological diversity. We were interested representing the region's biological diversity and span of geography, rather than assessing individual species.

Focal Conservation Targets

- Grasslands
- Oak woodlands
- Chaparral
- Mixed conifer forest
- Sub-alpine and alpine communities
- Mojave desert scrub and Joshua tree communities
- Semi-arid montane shrublands
- Riparian communities
- Aquatic Communities
- Migratory and wide-ranging wildlife
- Endemic species

Ecosystem services were selected as secondary targets. The secondary targets were mapped and evaluated for representation in priority areas of the Regional Conservation Design, and potential impacts by climate change were assessed.

- Aquifer Recharge
- Water yield
- Forest carbon storage
- Forage production

Subsequent analyses and priority setting were based on both primary and secondary conservation targets. The assessment process, which incorporated numerous analyses (described in Section 2.3), included assessments of current condition and threats to the primary targets, climate conditions and models of climate impacts on dominant trees and shrubs and "habitats", and hypotheses how we think climate change will interact with threats and affect the conservation targets. A regional conservation design, which integrates biodiversity, site suitability, and climate adaptation factors, identifies the areas that are most likely to support the short- and long-term viability of our targeted species and communities and, thus, of the region's biodiversity and also to provide the maximum co-benefits for ecosystem services.

Over the course of one year the methods and findings of the teams were vetted in three workshops and multiple conference calls. The three workshops were attended by members of non-governmental organizations and federal and state agencies, including the Tejon Ranch Conservancy, Sierra Nevada Conservancy, Conservation Biology Institute, National Park Service, U.S. Geological Survey, Natural Resources Conservation Service, University of California-Merced, and California Department of Fish and Game. Our process and this Framework benefitted greatly from the input, research and strategic advice from these partners.

2.2 STARTING ASSUMPTIONS

The SSP started this project with a suite of assumptions which were incorporated into the assessment process.

1. **Riparian communities are very important now and will be even more so with climate change.** Streamside or riparian habitats in this region support high species richness, rare species, and provide movement pathways for fish and wildlife, nutrients, and water. Because they are often the only habitats in the valley floor and foothills with adequate natural cover, they offer shelter and serve the movement needs for wide-ranging terrestrial animals, such as mountain lions. With the climate change, riparian vegetation can aid in slowing and capturing extreme floodwaters, shade river waters, link and buffer upland and wetland habitats, and provide thermal *refugia* for species.
2. **Preserving landscape integrity, or the degree of ecological functionality and intactness of the landscape, increases the likelihood of long-term viability of native species and ecosystems**. The greater ecological intactness the better native species and their natural habitats are able to withstand or recover from human and natural disturbances.

3. **Maintaining connectivity and gradients within and between ecosystems support critical ecological processes and will enable climate adaptation over time**. Unfragmented landscapes aid plant and animal dispersal and range shifts which is expected to be important for long-term viability under a changing climate. Given this,

maintaining connectivity within and across multiple habitats and across latitudinal, elevational, and climatic gradients is considered to be essential.

4. **Sierra Foothills play a pivotal role in the future of the region by virtue of their scale and location**. The grasslands and oak woodlands, wetlands and streams, and ranches of the foothills support high species richness and are major landscape features of the southern Sierra. They are given extra attention in this assessment, because most of the loss of natural habitat in the southern Sierra is likely to occur in the foothills and the member organizations of the SSP have histories of working in the foothills. The SSP believes that well-managed private ranches contribute to the conservation of biodiversity and water, forage, and carbon resources.

5. **The Tehachapi Mountains, located at the convergence of four ecoregions, form an essential landscape-scale linkage between desert, grassland, and forest biomes**. With high levels of endemism and many species at the edge of their range, this ecological nexus is referred to as a "crucible of evolution" (White et al. 2003). The Tehachapis are the only ecological connection for many species between the coast ranges of California to the rest of North America. Thus, protecting the unique ecological communities of, and the ecological permeability through, this linkage is of hemispheric importance.

6. **In terms of methodology, we would use computer-generated models which offer useful, cost-effective decision support tools for conservation planning**. Because models are always based upon simplifying assumptions and outputs are only as good as the data going in, we would cross-reference model insights with independent lines of evidence based upon field observation. In this plan, we would use models to infer spatial and temporal patterns of ecosystem service production, fire return interval departures, climate, species and habitat distributions, as well as our conservation design. Local experts would review model outputs, and results would be adjusted accordingly where appropriate. Despite limitations, these models would be used to generate testable hypotheses about the risks and the opportunities that climate change poses for biodiversity conservation in the southern Sierra.

7. **The analyses and narrative would be a first iteration which would be used as a <u>starting point</u> for consultations and collaboration with others interested in creating a common vision.** There would be follow-up to refine analyses, findings, and priorities. The SSP, which is most familiar with the foothill region, would depend upon the federal agencies for in-depth input related to forests and high elevations for future analyses and iterations.

2.3 ASSESSMENT APPROACH

Figure 3 summarizes the planning framework within which we conducted analyses and developed a long-term regional conservation vision. As noted above, we used both project-level and regional planning extents, linked by the same set of fundamental challenges: characterizing the current and future viability of conservation targets by taking into account their distribution, level of conservation management, degree of impact from current threats, and projected impact from climate change and synergistic threats. The information, process, and methods unique to each scale of planning allowed us to explore these fundamental issues in complementary ways (see box).

Benefits of project-scale assessment and planning:

- Determines site or project-level implementation of work plan and strategies
- Informs the regional evaluation
- Allows for more in-depth analysis of specific factors affecting target viability
- Enables geographically focused data and strategies

Benefits of regional assessment and planning

- Provides context for local priority-setting and selection of priority conservation areas
- Assesses broader distribution of targets and threats
- Characterizes response of targets to climate change at scale of impact
- Represents ecosystem service values and dynamics at relevant scale
- Informs regional-level policies and strategies able to affect a larger area
- Provides a foundation of regional data that serves implementation and project-level planning.

Photo credit: Susan Antenen

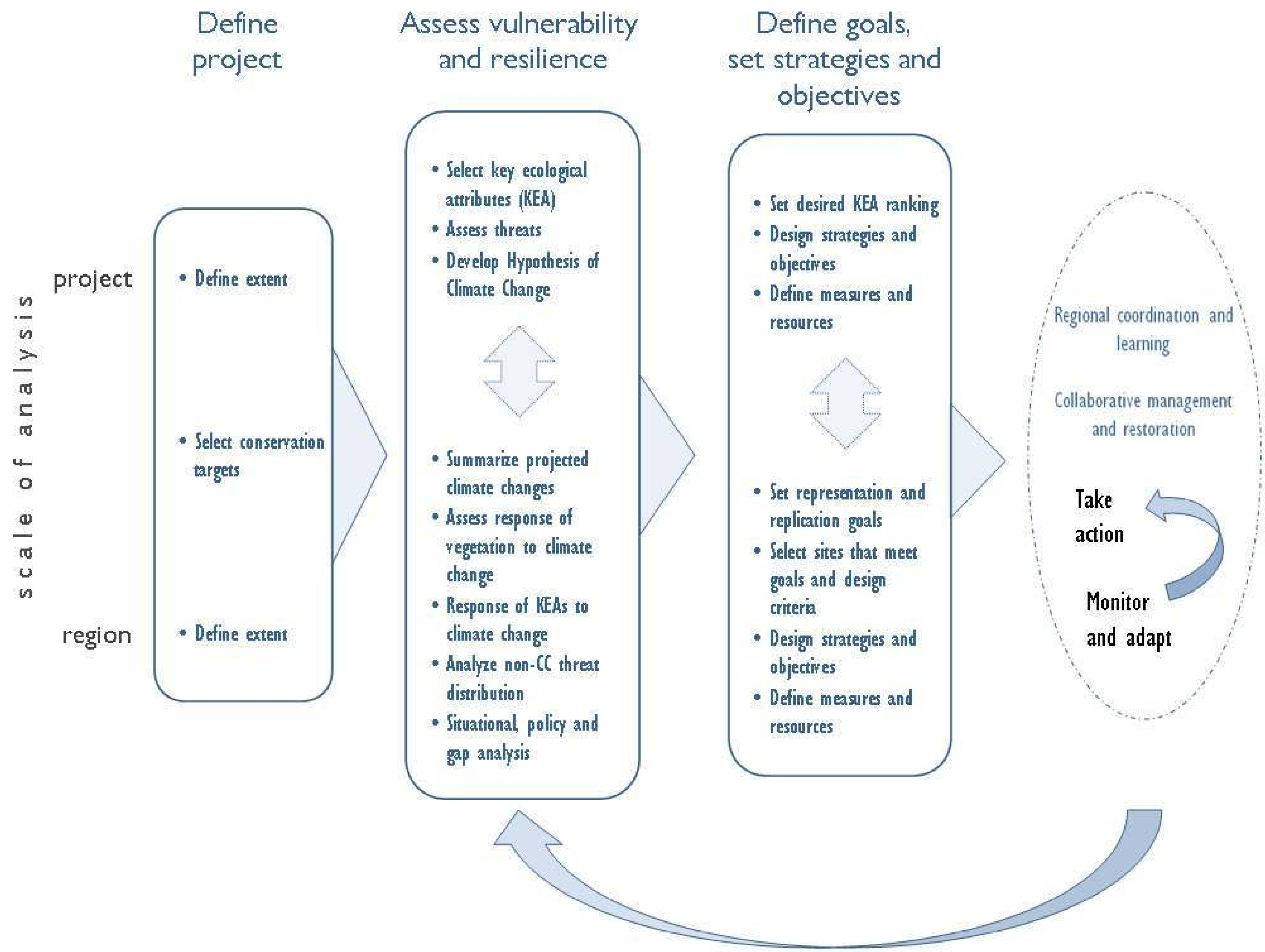

Figure 3. Assessment Framework.

2.4 ASSESSMENT COMPONENTS

2.4.1 Project-level Assessments

The Conservation Action Planning (CAP) methodology developed by The Nature Conservancy (http://conserveonline.org/workspaces/cbdgateway/cap/index_html) is an important component of this assessment and plan. We used the CAP process to identify the key ecological attributes, characterize current conditions, and assess threats for the 11 conservation targets. Identifying the key ecological attributes requires understanding how various physical or ecological conditions and processes affect the vulnerability and resilience of conservation targets. The relationships between the ecological attributes, the conservation targets, and how they are impacted by existing and future threats, including climate change, are used to develop project-level strategies and to inform conservation actions for the ecological system as a whole. Section 4 summarizes the conservation targets and threats, and Appendices A and B includes the full Southern Sierra and Tehachapi CAPS.

2.4.2 Regional Assessments

Regional-scale analyses were conducted to achieve multiple objectives:

- Provide a context and specific data for the CAPs
- Characterize the broader distribution of threats and condition of targets
- Analyze climate change impacts at scale of impact
- Model ecosystem services production
- Provide a set of mapped priority conservation areas as a vision for developing conservation strategies

Many specific analyses supported these objectives, including a gap analysis, endemic species assessment, species and habitat distribution models, and a land use development threat analysis. The regional conservation design integrated these analyses and followed many of the steps of an Ecoregional Assessment (http://conserveonline.org/workspaces/cbdgateway/era/index_html) to develop the set of areas that provide the best opportunity to meet long-term conservation goals. The process is described more fully in Section 5 and Appendix C.

2.4.3 Ecosystem Services

A primary objective of this process was to incorporate information on the ecosystem services or benefits from nature provided by the region as they relate to the implementation of conservation strategies in the region. Ecosystem services are the goods and services that people obtain from naturally functioning systems. The Millennium Ecosystem Assessment (MEA 2005), a global study co-authored by 1,300 scientists, found that human exploitation and degradation of ecosystems was jeopardizing the delivery of these services to humans, often most acutely affecting the poorest communities. The MEA categorizes services into four categories:

- Provisioning: those services producing a recognizable commodity (e.g., food, water supply, wood fiber).
- Regulating: those that regulate key dynamics in the atmosphere, landscapes, or water (e.g., carbon sequestration, crop pollination, water purification).
- Supporting: foundational, background processes that enable other services (e.g., primary production, soil formation).
- Cultural: the values that human communities receive for recreation, aesthetic, or religious purposes (e.g., spiritual inspiration, backpacking).

The diverse scope and breadth of these categories made it essential to focus on a limited set that have significance to the conservation and management of natural resources in our region. Of those, we were limited by what we could represent in spatial models at a resolution similar to our other data on targets, threats, and climate change effects. In this assessment, we focused on mapping the predominant locations of four services: (1) groundwater or aquifer recharge, (2) delivery of clean water (water yield), (3) forage production, and (4) forest carbon storage. These services are linked to the majority of ecological systems in the region. Land use, management and policy affect their production, economic value, and resilience to climate change. This assessment does not focus on the socio-economic value of these services due to their complexity. We also do not focus on cultural services, and other provisioning services that depend on functioning landscapes and water resources, such as recreational opportunities, aesthetic and spiritual services, and crop pollination.

2.4.4 Climate Change

Climate Projections

We based our climate change estimates on eleven General Circulation Models (GCMs) run under the A2 emission scenario by the International Panel on Climate Change (IPCC 2007). To characterize a baseline of contemporary California climates, we relied on PRISM data (http://www.climatesource.com). All future climate projections were downscaled using the change factor approach described in Klausmeyer and Shaw (2009). Our focus on A2 emissions scenarios should represent a conservative approach that even potentially under-estimates climate impacts, given that current emissions already exceed A2 projections. Only GCMs with mid-century projections (2045-2065) were considered, as end-of-century data (2080-2100) significantly inflate uncertainty. (Appendix D)

Species Projections

To assess how ecologically dominant trees and shrubs might respond to projected climate changes, we modeled current and future climate suitability for 25 plant species. Maps derived for individual species portray areas where climate is projected to be suitable both today and in the future (*climate refugia*), in contrast to those areas where suitable climates are projected to be lost (*climate stress zones*) or gained in the future (*climate expansion zones*). All vegetation forecasts developed herein represent potential distributions based solely on climatic factors. Implications for alternative limiting factors such as land conversion, soil type, and biological interactions were discussed ad hoc. Section 4.3 presents examples for tree species in oak woodlands, and Appendix E provides detailed methodology on the species distribution modeling process. Potential climate impacts for species were used to inform hypotheses of climate change. In the future, they can be used to guide species-level monitoring priorities.

Habitat Projections

Our planning efforts focused primarily on ecosystem or “habitat” targets; therefore, we used local expert knowledge to select species representatives for each habitat type, and then developed a rule-based approach for aggregating species projections into habitat projections. To minimize uncertainty, only areas with high model agreement from species data were aggregated into habitat projections. For regional priority setting, we used habitat projections to modify existing habitat distributions, allowing us to prioritize potential *refugia* over areas considered more at risk from climate impacts. See Appendices C and E for methods.

Ensemble Forecasts

Using eleven climate models (Appendix D), we employed an ensemble approach with respect to climate projections, which treated all possible futures as equally likely, and then characterized levels of consensus, based on model agreement. In maps, we used colors to designate projected outcomes (e.g., climate stress, climate *refugia*, expansion zones) and saturation to indicate model agreement (e.g., dark shades = $\geq$ 80% models agree; light shades = 60-80% models agree). In contrast, a scenario planning approach focuses on extreme outcomes. Planning independently for multiple extreme futures was beyond the scale and scope of the project and planning objectives (i.e., independently assessing impacts, setting priorities, developing strategies, etc.). However, the scenario approach may be useful for planning efforts designed to manage ecological processes with potentially catastrophic outcomes, such as wildfires and floods, or to help land managers who are working within jurisdictional boundaries select management strategies that best respond to the full range of possible change.

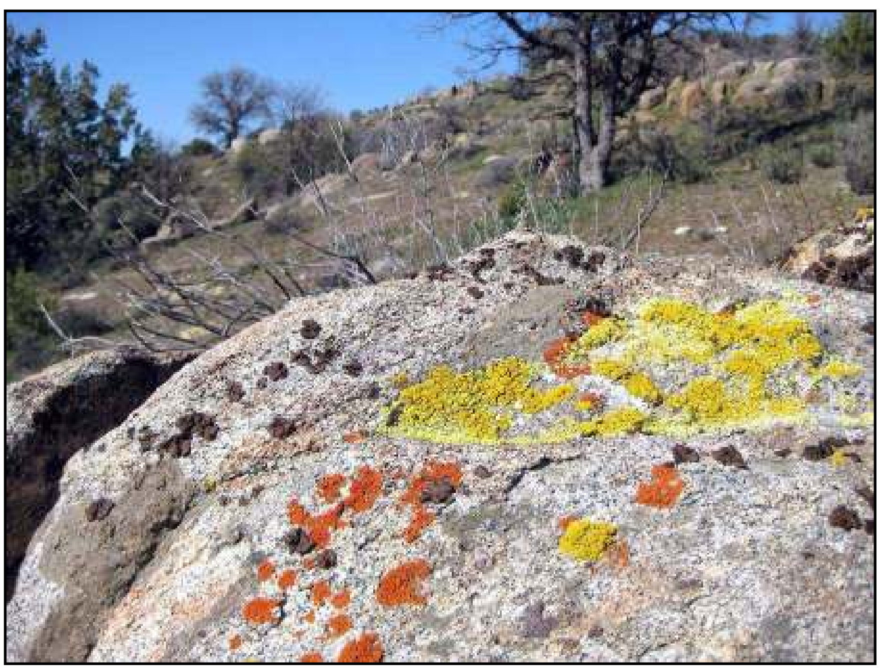

Photo credit: Sophie Parker

Hypotheses of Change

After reviewing the modeled species and habitat projections described above, the SSP team considered how increased temperatures and other manifestations of climate change are expected to affect the conservation targets over the next 50 years. The "Hypotheses of Change" describe the climate factors, identify the targets' climate-sensitive key ecological attributes, their indicators, the hypotheses of change, and likelihood of ecological change. Our intent was to document our assumptions and present them as "testable" hypotheses; on-going refinement will be necessary. The results informed our vision and can be used in the future to inform strategies and research and monitoring.

2.5 ADDRESSING UNCERTAINTY

The Intergovernmental Panel on Climate Change (IPCC) made robust findings about climate change that are directly applicable to this assessment effort (IPCC 2007):

1. Warming of the global climate is unequivocal, and many natural systems are being affected. Warming will continue even if greenhouse gas concentrations stabilize.
2. Some ecosystems are likely to be highly affected by climate change including, among others, mountains and areas affected by snow and ice melt.
3. Predicting extreme weather patterns is more difficult than predicting average weather patterns.
4. Difficulties remain in reliably simulating temperature at smaller than continental scales. Predicting climate impacts at regional scales is limited by uncertainties concerning precipitation projections.
5. Detecting the effect of climate change on some natural systems is difficult due to interactions with diverse threats, including altered fire regimes and invasive species.

We know that in this region on average the temperature is warming and that precipitation patterns may change to more rain than snow and perhaps less precipitation overall. It is not essential to know the exact number of degrees of average temperature increase, or the exact change in precipition patterns, in order to forge adaptation strategies. Similarly, we know that nature in the Sierra Nevada is already responding to climate change and will continue to do so. Basic principles of conservation biology support the importance of conserving interconnected spaces and maintaining healthy natural communities so that we maintain as many indigenous species as possible during this process of change. We developed "Hypotheses of Change" and propose "no-regret" strategic approaches in a framework of adaptive monitoring where conservation actions may shift based on success, failure, and new unforeseen circumstances (e.g. Millar et al. 2007, Lawler et al. 2009).

3.0 CONSERVATION CONTEXT

This section characterizes the existing conditions of the project area, including the land uses and public ownerships that represent existing conservation investments which are managed according to the individual missions of each agency. Land use and ownership patterns are defined largely by elevation. The lands within the mid to high elevation zone are mostly in public ownership (Figure 1). The lands below ~4,000 ft are mostly in private ownership.

3.1 LAND USE

Old growth trees were logged in the 19th and 20th centuries, altering forest composition and structure in ways which influence forest health and management decisions to this day. Now the predominant land use relates to outdoor recreation. The national parks and forests attract millions of visitors annually from around the world for camping, hiking, fishing, and sightseeing. Visitor facilities and communities of private in-holdings within the national forests are the primary developed areas. A network of over 2500 miles of paved and dirt roads provide access to visitor areas and National Forest lands designated for off-road vehicle use. The rocky alpine and sub-alpine zones of the Sierra are undeveloped with a network of hiking trails.

The predominant land use of the foothills is private ranching, with 44 ranches greater than 5,000 acres. Of these, 13 ranches are greater than 10,000 acres, with the largest ranch, Tejon Ranch, totaling 270,000 acres. These rural working landscapes are now experiencing increased pressures of development, often as a result of inter-generational land transfers. With some significant exceptions, the majority of large ranches are enrolled in 20-year Williamson Act contracts, which restricts land use to open space and agriculture, including cattle ranching. Although enrollment is high, this incentive-based, voluntary program can be compromised if a landowner decides to sell parcels for development. In addition, the Williamson Act itself is in jeopardy now that the State of California no longer provides financial support to the counties.

Other economic activities include harvesting wood for lumber and fuel, and recreational activities including hunting, fishing, camping, hiking, skiing, and river rafting. Selective logging on public lands occurs largely in association with fire and forest management operations. Ranchers lease public lands on BLM and Forest Service lands livestock grazing.

Below 500 feet, the southern San Joaquin Valley, once a rich complex of braided river deltas, lakes, wetlands, and grasslands, has been converted to high value, irrigated agriculture interspersed with cities and towns. Intensive agriculture, urbanization, and flood control measures have drastically modified floodplains and in-stream flows. Natural waterways have been converted to an engineered system of water storage and conveyance structures. Small remnants of once vast Valley oak woodlands and willow-dominated marshes remain as narrow ribbons or small patches along these altered waterways. During high flow years, the water from the mountains fills the historic Tulare Lake Basin, once the largest lake in the western U.S.,

which is now dry most years. Most of the southern Sierra waters are utilized in the San Joaquin Valley, via the Friant-Kern Canal.
Until the end of the 20^{th} century, urban development pressures were less intense in this region than in other parts of California due to its rugged geography and remoteness. However urbanization and high population growth rates in Fresno, Tulare, and Kern counties in the last two decades converted agricultural fields and ranch land into suburban and exurban development. Since the financial collapse of September 2008, the halt of new housing construction and declines in other sectors are fueling very high unemployment of 15% to >30%. Job creation is a major concern of local citizens and elected officials.

3.2 OWNERSHIP

Sequoia, the second oldest national park in the United States, was dedicated in 1890 to protect the big trees in the "Giant Forest," including the General Sherman Tree, sometimes referred to as the world's largest living thing. The same year, Grant Grove of giant sequoias was also set aside as General Grant National Park in the same piece of legislation as Yosemite National Park. Sixty years later, General Grant was absorbed into the newly created Kings Canyon National Park.

Now, nearly half of the land in the project area is administered by the National Park Service, Forest Service, Bureau of Land Management (BLM), and California Department of Fish and Game. While all of these lands are considered "conserved," management for natural resources and biodiversity differs across the different ownerships, as defined by their missions (Table 1), resulting in differing levels of actual protection. Moreover, in spite of their proximity and similar resources, there has been generally little collaboration until recently among agencies toward a regional conservation vision across the planning area.

Photo credit: Sophie Parker

There is also a network of private nature preserves managed for their biodiversity values by non-governmental organizations: Audubon California manages the 1,200-acre Kern River Preserve, Sequoia Riverlands Trust manages 6 preserves totaling 4,069 acres, and Sierra Foothills Conservancy manages 3 preserves in the SSP planning area totaling 4,787 acres. Sequoia Riverlands Trust, The Nature Conservancy, and Sierra Foothills Conservancy also hold about 20,000 acres of easements conveyed by private landowners. In addition, there are mitigation lands held by water districts. Immediately adjacent to the southern boundary of the SSP planning area is the 97,000 acre Wind Wolves Preserve managed by the Wildlands Conservancy.

Table 1. Public agencies and their missions.

Agency	Mission	Acres	Conservation Area
National Park Service	*"...to promote and regulate the use of the...national parks...which purpose is to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations."*	863,700	Sequoia National Park Kings Canyon National Park
Forest Service	*"...to achieve quality land management under the sustainable multiple-use management concept to meet the diverse needs of people."*	1,716,500	Sierra, Sequoia and Inyo National Forests Giant Sequoia National Monument
Bureau of Land Management	**"…** *to sustain the health, diversity, and productivity of the public lands for the use and enjoyment of present and future generations."*	441,200	Caliente and San Joaquin River Gorge Resource Management Areas
CA Dept. of Fish & Game	*"... to manage California's diverse fish, wildlife, and plant resources, and the habitats upon which they depend, for their ecological values and for their use and enjoyment by the public."*	13,200	6 Ecological Reserves

4.0 CONSERVATION TARGETS

4.1 CURRENT CONDITIONS

The majority of ecosystems, natural communities, and important species in the Southern Sierra and Tehachapis are contained within the 9 ecological systems that comprise our primary focal targets (Figure 4). These targets are combinations of mapped California Wildlife Habitat Relationship (WHR) types (Mayer and Laudenslayer 1988, Appendix G). We did not select individual species for this analysis; rather, we aim to protect the majority of species by conserving their habitats.

Despite the fact that the region as a whole is largely intact, the current condition of the individual conservation targets vaies. In summary tables 3 and 4, the current condition describes the status of landscape context (ecological processes and regimes that maintain the target and connectivity), condition (composition, structure, and biotic interactions), and size (area). A ranking of “fair” or “poor” indicates the need for restoration.

4.1.1 Vegetation Communities

Grasslands

The once extensive grasslands in the San Joaquin Valley have been largely replaced by crops. Between 500 and 1,000 ft elevation in the foothills, grasslands are largely intact and interspersed with oaks and oak woodlands (>10% canopy cover). Areas of native perennial grasslands persist, along with vernal pools and perennial alkali meadows, but most grasslands are now dominated by Mediterranean annual grasses with a diverse native forb (wildflower) component. In areas with continuous heavy grazing and along roads, there is a moderate invasion by non-native thistles. Both the perennial and annual grasslands support rare and endemic plant species and grassland-obligate bird species which are declining in California as a result of conversion to agriculture.

Oak Woodlands

Oak woodlands in the foothills are dominated by blue oak with interior live oak, California buckeye, and foothill pine as significant components. Oak woodlands increase in density with elevation. Tree cover becomes denser with elevation. This community is relatively intact. Mediterranean grasses are the dominant understory, with a high diversity of native forbs and rare and endemic plant species. In our planning area, there are few invasive plant species in this community, except for moderate invasion by thistle species. With high mortality rates of seedlings and saplings, blue oak recruitment is considered to be poor. Cavity nesting birds and acorn-dependent species are important nested targets throughout the planning area.

Chaparral

At 1,000 – 5,000 ft elevation, highly variable shrublands comprise the chaparral community. Dominant species, which vary by area and elevation, include chamise, redshank, scrub oak, ceanothus, and manzanita. The chaparral of the western flanks of the Sierra differs from chaparral communities in the Kern Valley and Tehachapis. This community is relatively intact throughout its range, with good connectivity to oak woodlands and mixed conifer forest. There appears to be a fairly natural fire regime, with 50% of the community burning at intervals comparable to pre-settlement levels and >15% burning at higher frequencies. (Appendix H) With more frequent burning, there is a shift toward more arid species and more grass in the understory, which increases its vulnerability to fire and eventual habitat conversion.

Mixed Conifer Forest

Conifers and oaks form the primary vegetation community from 4,000 – 8,000 ft elevation. The old growth groves of giant sequoias and other "big trees" form part of this community in the southern Sierra, while fir species dominate these forests in the Tehachapi Mountains. Mixed conifer forests support old-growth indicator species, such as pine martin, Pacific fisher, sooty grouse, and spotted owl, but populations of these species are likely declining. In the Tehachapis, the conifer forests are dominated by white fir with lesser amounts of incense cedar, Jeffrey and Ponderosa pine.

The fire return interval for the majority of mixed conifer forests is significantly longer than the past range of natural variability, which on average was every 12 years in ponderosa pine-mixed conifer and 15 years in white fir-mixed conifer forest (SNEP 1996). Approximately seventy percent of the landscape has not burned since 1910, creating greater fuel loads and fire intensity (Appendix H). Now, when fires do occur in the Sierra Nevada forests, there is a trend toward stand-replacing fires (SNEP 1996). In general, the once diverse mosaic of forest patches is becoming a more homogeneous landscape with fewer snags, large trees, and structural complexity (SNEP 1996). Relative to historic species mixes, the proportion of giant sequoias, black oaks, and pine species has been greatly reduced in this community, and the rate of large tree mortality has doubled in some areas. There appears to be a decreasing fire return interval in the Tehachapis, and there is evidence that the size of fires has increased in the last 30 years, at least on Tejon Ranch (M. White pers. comm.).

Alpine and Sub-alpine Communities

Alpine and sub-alpine communities, at elevations of 6,500-11,500 ft, are dominated at different elevations by red fir, lodgepole pine, foxtail pine, and whitebark pine, among other conifers. The understory includes a mixture of dwarf shrubs and low-growing plant species, naturally fragmented by bare rock. Coverage by vegetation is fairly continuous at lower elevations and on moist or mesic sites, but becomes more disjunct with altitude, exposure, and bare rock. This system appears to be in good condition with localized impacts due to recreational use, but, as presented in section 4.3.4, it is vulnerable to climate change and atmospheric pollutants.

Semi-arid Montane Shrubland

Located on the arid eastern flanks of the Southern Sierra and Tehachapis, this shrubland is comprised of sagebrush interspersed with pinyon-juniper and montane chaparral and lies largely within an intact landscape. While the pinyon-juniper community is considered to be relatively "management-independent," much of the sagebrush community is more sensitive to human-induced degradation and requires more active management. Lack of fire has resulted in domination by old age-class sagebrush, which is less resistant to invasion by cheatgrass and juniper.

Mojave and Joshua Tree Desert Scrub

The desert plant communities on the eastern side of the Sierra Nevada are a patchwork of Joshua tree, creosote bush, blackbrush, and other desert shrubs. Vegetation is typically sparse, and fires tend to be small and infrequent, continuing the historic fire pattern. These communities are fragmented by many roads; thus, intactness is considered only fair. Native plants comprise the majority of the cover.

Riparian Communities

Riparian communities, such as Valley oak woodlands, sycamore alluvial woodlands, willow-cottonwood woodlands, alder thickets, and mountain meadows, are the vegetation and wildlife communities found in moist soils along rivers and streams. Mountain meadows support high plant and animal diversity and provide important ecosystem services of natural water storage and flow regulation. Lower elevation riparian communities provide nest sites, water sources and oasis of cooler temperatures during hot, dry summers, many species are dependent on these communities for some or all of their habitat needs, and they are important wildlife movement corridors. Riparian communities are much diminished by intensive agriculture and urbanization in the Valley and gravel mining at the intersection of the foothills and Valley. Livestock grazing and residential development simplifies and/or fragments wetland communities. In the mountains they are fairly intact except the mountain meadows which are impacted by overgrazing and roads that disrupt hydrology. Altered flooding-deposition regimes, groundwater withdrawals and invasive species like *Arundo* and tamarisk are long-term concerns, especially at lower elevations. The Kern River Valley above Lake Isabella boasts the most extensive riparian woodland in the project area and supports endangered species, such as the willow flycatcher. Nested target species include cavity-nesting birds, such as wood ducks, neotropical migrant birds, and endemic amphibians.

Aquatic Communities

The complex geography of the project area provides for a wide array of aquatic habitats and communities. Natural alpine lakes lie in the glacier-carved cirques of the High Sierra. Snowpack-fed perennial rivers and creeks run down steep canyons, and then braid out across the gentler slopes of inland deltas of the San Joaquin Valley. Flashy intermittent streams with headwaters below the snowpack closely follow rainfall patterns, disappearing altogether during the hot, dry summers. Tule marshes, vernal pools and other seasonal wetlands of the low foothills and Valley also come and go with the annual precipitation cycle. Thousands of man-made reservoirs dot the landscape, from tiny seasonally-filled stock ponds to large lakes impounded by major dams.

The varied native aquatic habitats once supported a huge diversity of amphibians, cold- and warm-water fish assemblages, and aquatic invertebrates. In the low foothills and Valley these habitats have been transformed by intensive, irrigated agriculture and flood control measures. Dams on the region's five major rivers drastically altered downstream flow regimes, groundwater recharge, and cycles of floodplain sediment deposition and scouring. Where the Valley joins the foothills, alluvial gravel mining further disrupts aquatic habitats.

Undammed rivers and stretches of perennial waterways upstream from the major dams are disrupted in the foothills by surface and groundwater withdrawals for ranching and residential uses. Flows in perennial foothill streams have always declined by the end of the summer dry season, but now routinely go completely dry along significant stretches.

Rugged terrain constrains development pressures above about 2,500 feet in elevation, so higher elevation aquatic systems are relatively intact relative to the Valley and foothills. Here the impacts have mainly come from erosion and sedimentation associated with logging, livestock grazing, and roads. Conditions have improved somewhat over the last 25 years with changes in resource management practices. Now, however, elevated levels of airborne pollutants such as nitrogen and pesticides are being detected in alpine lakes, with as yet undetermined consequences (SNEP 1996). Invasive exotic animals (e.g., bullfrogs, stocked non-native trout) and pathogens imperil native species in many aquatic habitats.

Photo credit: Susan Antenen

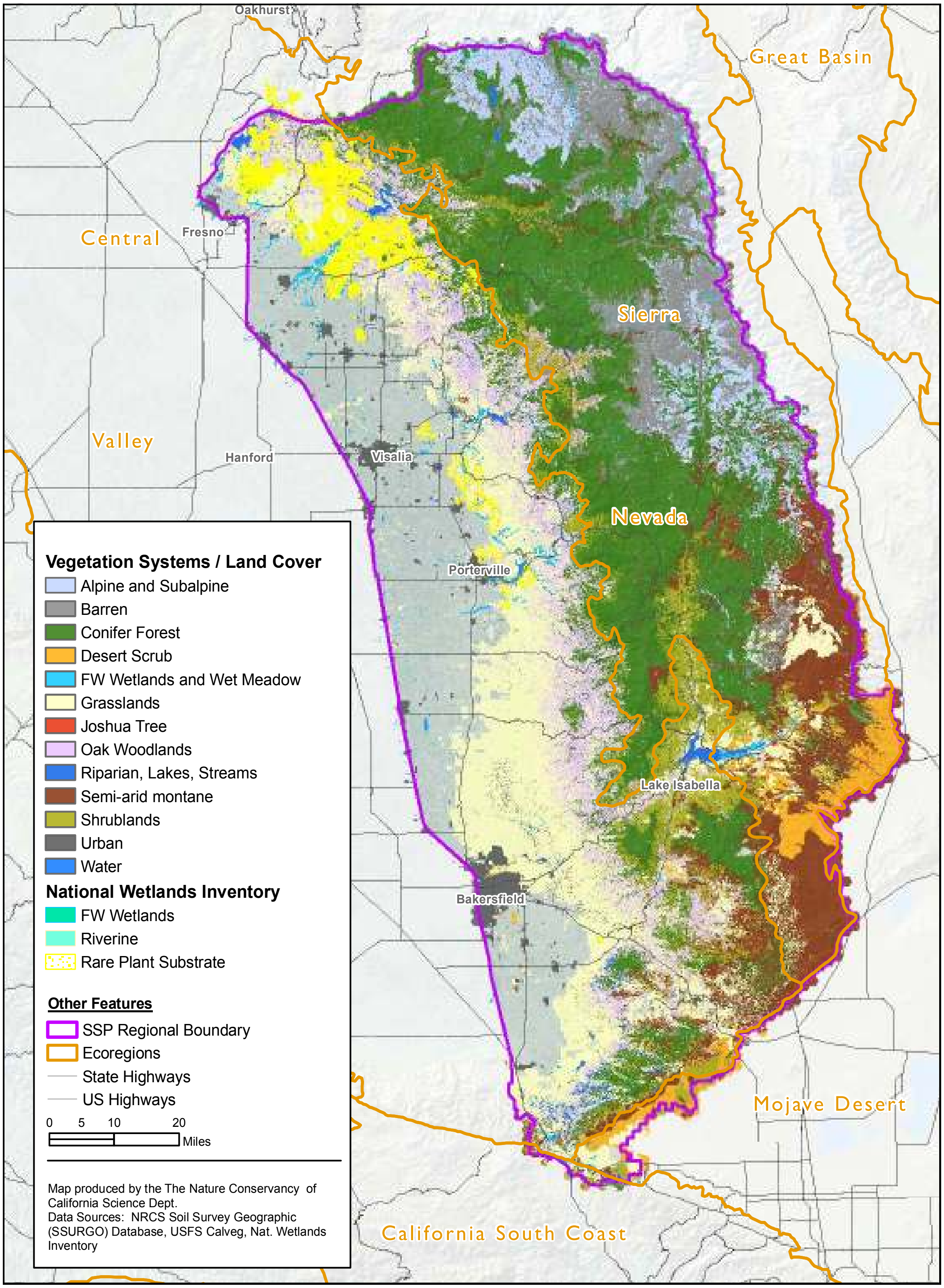

Figure 4. Current vegetation systems. These systems were mapped using the USFS Calveg data primarily and aggregated into broad target categories. The light gray areas to the west of the grasslands are intensive agriculture.

4.1.2 Target Species

Migratory and Wide-ranging Wildlife

Species with large home ranges, or that migrate seasonally across elevational or latitudinal gradients, require large landscapes to roam in search of food, water, cover, and mates. Examples include the California condor, migratory birds and bats, mule deer, mountain lion, Pacific fisher, and black bear. Connectivity among populations of these species is necessary for genetic health and demographic viability.

One of three populations of condors restored to the wild regularly uses the Tehachapis and surrounding grasslands. The largest documented migration of turkey vultures in the United States passes through the Southern Sierra Nevada and toward the areas proposed or being developed for wind energy areas. Between 16,000 to 30,000 vultures and up to several hundred raptors of 18 species were recorded each year from 1994 to 2006 as they passed through the Kelso Creek region in the fall on their southward migration (Southern Sierra Research Station, unpublished data). (Appendix I) North-south running canyons are important northward spring migration routes. Butterbredt Canyon is a very significant route for dozens of neo-tropical migrant bird species. For this reason it was designated a Globally Important Bird Area by the American Bird Conservancy.

The Southern Sierra and Tehachapi Mountain project area, with its expanses of parks, national forests, and other conservation areas, provides relatively intact and connected ecosystems for migratory and wide-ranging wildlife, with few obstacles other than roads in the upper watersheds. However, development, agriculture, and roads have compromised much of the connectivity and natural habitats at the lower ends of the watersheds below 1,500 ft.

Endemic Species

There are over 60 endemic species in the Southern Sierra and Tehachapi Mountains, of which about half are concentrated in mountain meadow, riparian, and wetland communities (Appendix J). The Tehachapi Mountains are recognized as a "hotspot" for genetic variation and speciation (White 2003).

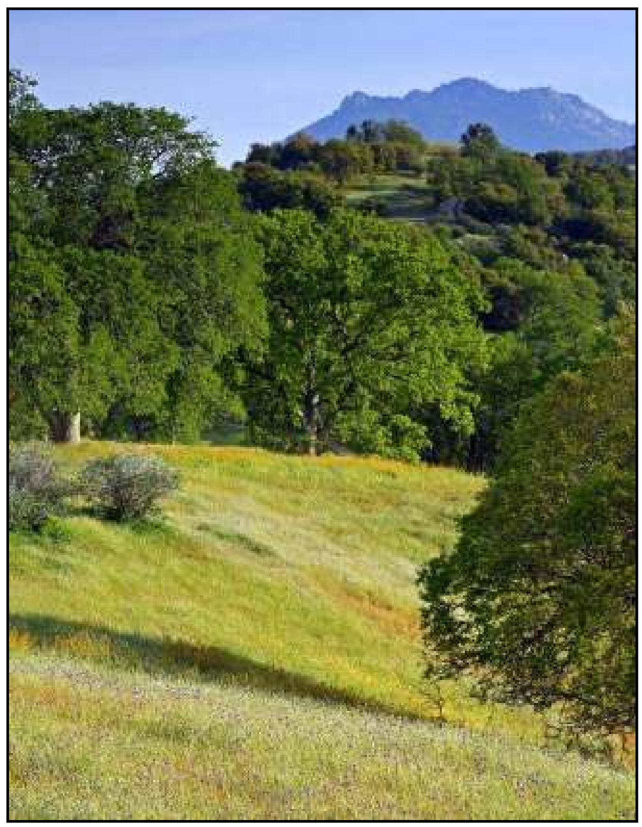

Photo credit: John Greening

Table 2. Summary of Current Condition of Conservation Targets: Southern Sierra Project CAP.

	Conservation Targets	Current Ranking: Landscape Context	Condition	Size	Viability Rank
1	Grasslands	Good	Fair	Good	Fair
2	Oak Woodlands	Very Good	Fair	Very Good	Good
3	Mixed Conifer Forest	Fair	Fair	Very Good	Good
4	Sub-alpine & Alpine Communities	Very Good	Good	Good	Good
5	Chaparral	Good	Good	Good	Good
6	Riparian Communities	Fair	Fair	Poor	Fair
7	Aquatic Communities	Fair	Fair	Poor	Fair
8	Migratory and Wide-ranging Wildlife	Fair	Good	***	Good
Project Biodiversity Health Rank					Good

Table 3. Summary of Current Condition of Conservation Targets: Tehachapi Project CAP.

	Conservation Targets	Current Ranking: Landscape Context	Condition	Size	Viability Rank
1	Oak Woodlands	Good	Poor	Very Good	**Fair**
2	Riparian Communities	Fair	Fair	Fair	**Fair**
3	Mojave Desert Scrub and Joshua Tree Communities	Good	Fair	Very Good	**Good**
4	Grasslands	Fair	Good	Very Good	**Good**
5	Semi-arid Montane	Fair	Fair	Very Good	**Good**
6	Coniferous Forests	Fair	Fair	Good	**Fair**
7	Migratory and Wide-Ranging Wildlife	Very Good	-	-	**Very Good**
Project Biodiversity Health Rank					**Good**

4.1.3 Ecosystem Services

In addition to its significance to biodiversity and intact, functional landscapes, the Southern Sierra provides ecosystem services or benefits from nature critical to the well-being of Californians, including water supply, flood control, hydropower, groundwater recharge, water and air quality, carbon sequestration, agriculture, and recreation. The ecosystem services we analyzed cover the major physiographic regions in the planning area, with forest carbon and water yield having the highest values in the mountains, while forage production is highest in the foothills, and potential aquifer recharge is highest in the San Joaquin Valley (Figure 5). The total ecosystem service production for the four services shown in Figure 5 is surprisingly well-distributed across the subsections with no subsection having more than 25% of the total service production value in the region with the exception of forage in the Lower Granitic Foothills, and carbon in the Upper Batholith (see Figure 2 for subregion map).

Potential Aquifer Recharge

Southern Sierra rivers and streams are the major source of natural groundwater recharge for the Tulare Basin, the main aquifer underlying the southern San Joaquin Valley. Groundwater recharge occurs naturally through percolation from lakes, unlined channels, and rainfall, and through engineering using conveyance facilities, recharge basins, and percolation on open land, unlined canals, and fields.

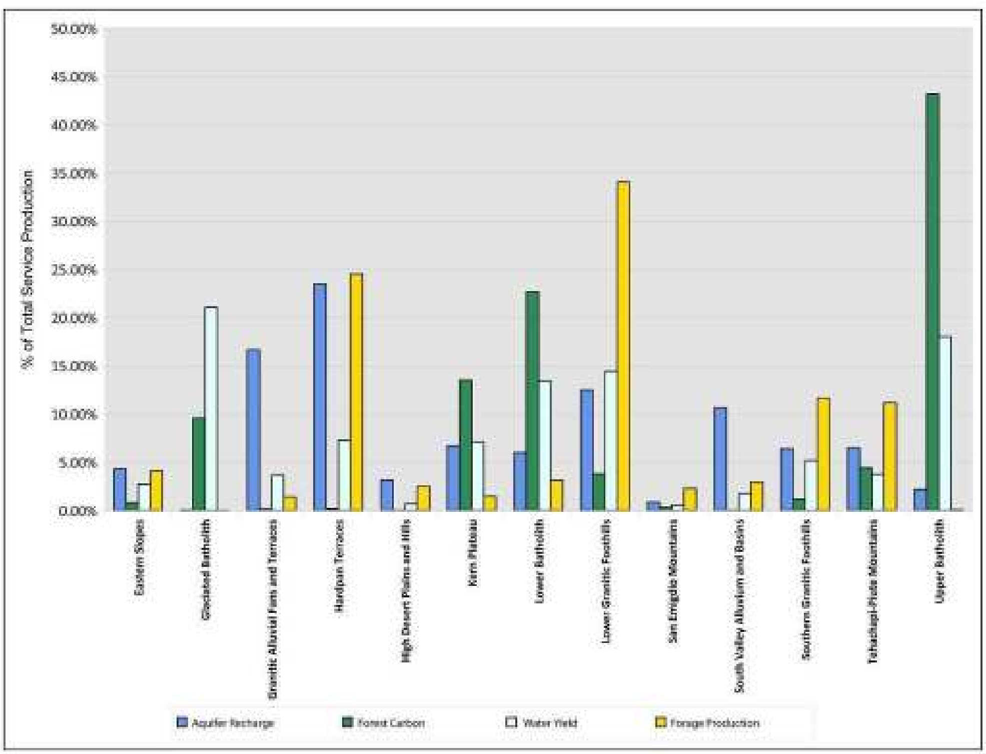

Figure 5. Ecosystem services by subregion. This chart shows the distribution of total ecosystem service production across the subregions (Figure 2). The aquifer recharge model maps values as an

index of potential recharge and should not be interpreted as the total amount of recharge in a given subregion.

Groundwater is important for river recharge, wetland communities, and many species, as well as for human use for drinking and agriculture. As much as 30-40% of California's water for urban and agricultural uses comes from groundwater. A prolonged drought has increased the demand for groundwater, resulting in declining levels (Faunt 2009).

We modeled aquifer recharge potential as a function of slope and soil type. Soils with high permeability on level ground have the highest potential aquifer recharge. Figure 6 shows aquifer recharge values based on an index, ranked from poor to good. Both agricultural and urban areas have a high potential for aquifer recharge based on soils and topography, but are affected by the high amount of impervious surfaces in urban areas limiting actual recharge.

Photo credit: Hilary Dustin

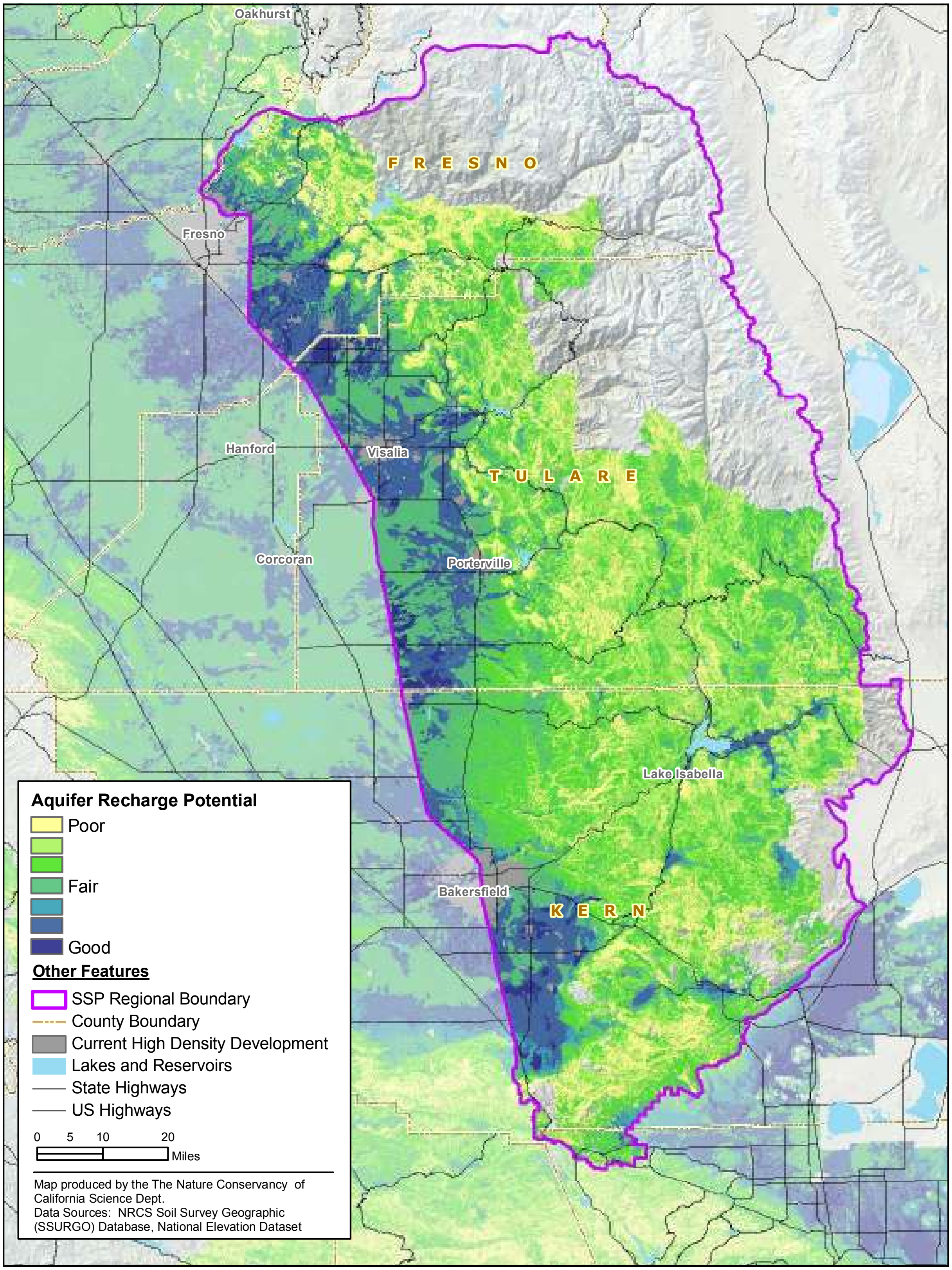

Figure 6. Ecosystem Services: Aquifer Recharge. Based on slope and soil infiltration capacity, areas are classified based on their potential to contribute to aquifer recharge.

Water Yield

The water that comes from the Sierra Nevada provides a vital resource for California's agriculture, industry, and urban users. To represent this critical ecosystem service, we used a simple water balance model, largely a function of precipitation and evapotranspiration, to map water yield across the planning area. As defined in our model, water yield is the volume of water that does not evaporate or evapotranspire from the ecosystem and, therefore, is potentially available for use as either surface or groundwater.

Water yield can contribute to storm runoff, base flow (water entering streams from groundwater sources), or deep groundwater. Water yield in an ecosystem is greatly influenced by soil properties, vegetation, and land cover, which affect evapotranspiration and the amount of water taken up from the soil. Changes in yield caused by vegetation change can affect water flow and sedimentation, which can in turn affect flood events and water quality for communities that live downstream. For example, conversion from hardwood forests to conifer forests can result in reductions in water yield, depending on the size of the area converted, while vegetation removal can increase water yield in some cases (Brooks et al. 2003).

Roughly half of the land that is in public or private conservation management provides 64% of the water yield (Figure 7). Water yield in the planning area is highest in the northeastern part of the area, within National Park and Forest Service land, and decreases in the foothills and valley (Figure 8).

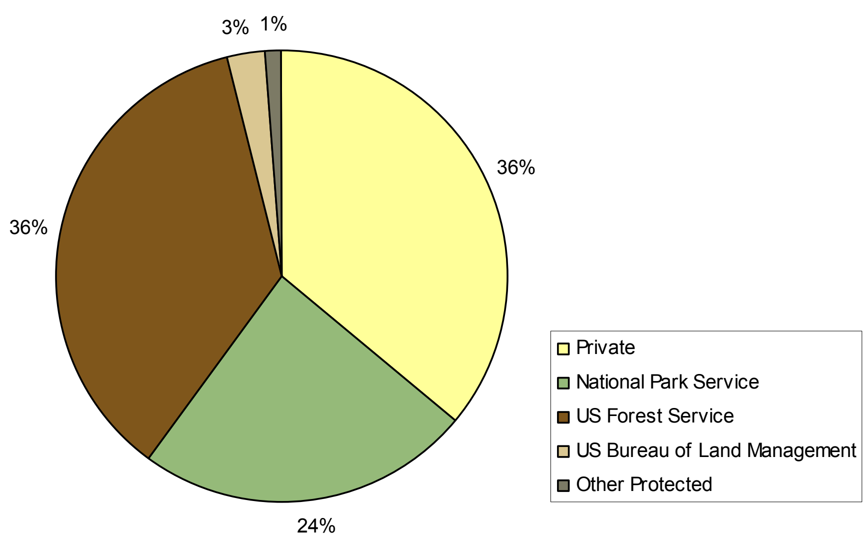

Figure 7. Water yield by owner group.

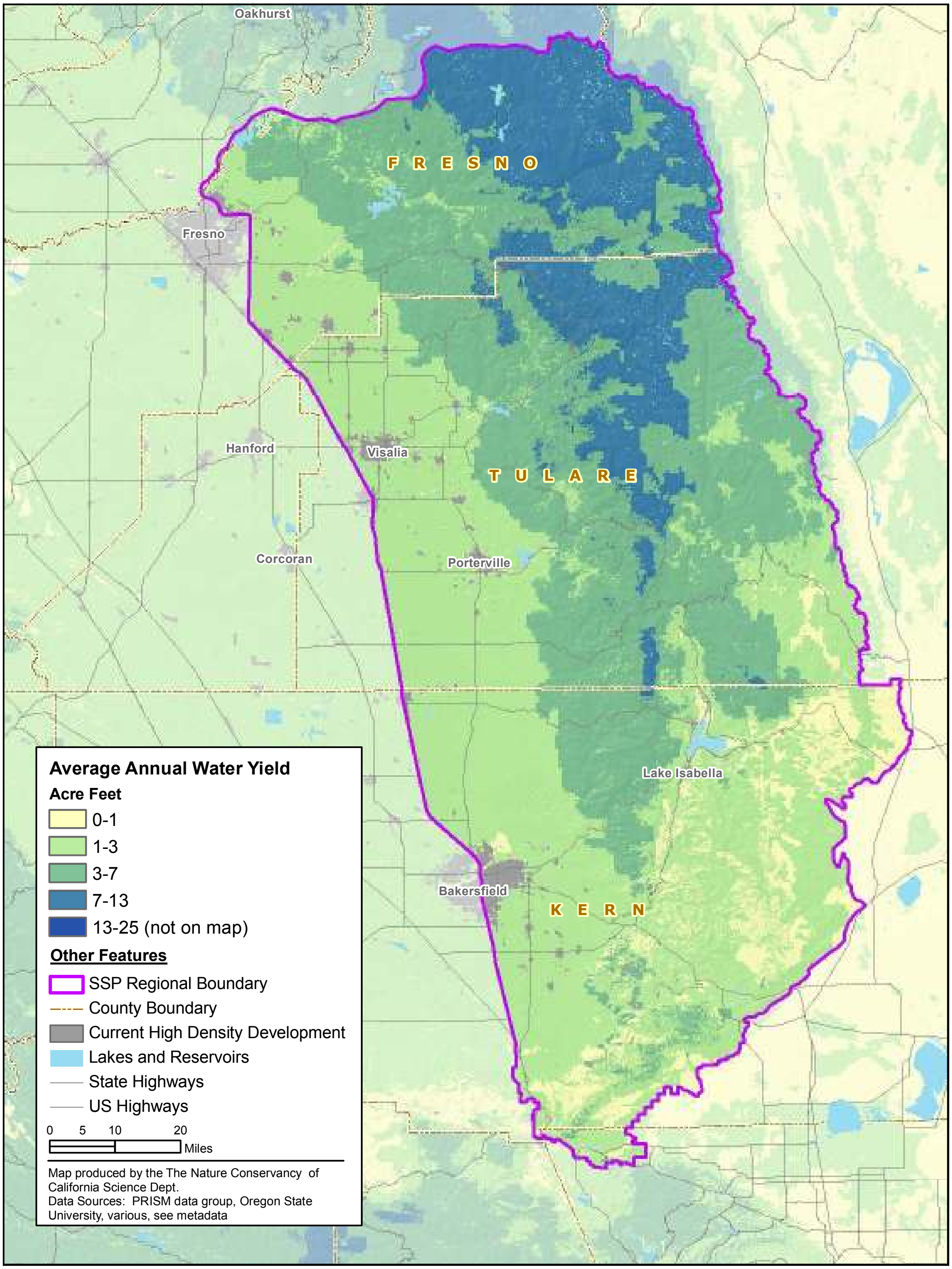

Figure 8. Ecosystem Services: Water Yield. Based on a simple water balance model that accounts for vegetation type, this model shows the amount of water contributing to runoff or recharge in the region.

Forage Production

Forage production is a provisioning service that represents the primary productivity of herbaceous cover in grasslands and woodlands. This production supports both wild herbivores and domestic livestock. The quality and abundance of forage varies annually and is influenced by rainfall, length of growing season, and soil characteristics (George et al. 2001). In the planning area, forage production occurs primarily on private land, and approximately 44% of the forage production occurs on parcels greater than 2,000 acres. With over 100 private owners with parcels >2000 acres, the Tejon Ranch accounts for about 8% of the annual forage production (Figure 9).

Ranching as an economic enterprise is dependent on adequate forage production, and in drought years production can be so low that permanent soil impacts can result from overgrazing if stocking rates are not lowered. It is commonly estimated that the equivalent of 800 lbs of air dry matter is needed to support one animal unit month (AUM) per year (M. George pers.comm.). Ideally, half of the production would be considered available for cattle, and the rest would be maintained for soil conservation and wildlife. So, theoretically an area with 1,600 lbs/acre of production should have a carrying capacity of 1 AUM per acre.

Forest Carbon Storage

Carbon sequestration, a regulating ecosystem service, is defined as the net removal of carbon dioxide from the atmosphere into long-lived stocks of carbon. The stocks can be living, above-ground biomass (such as found in the giant sequoias and blue oak trees), living biomass in the soils (such as roots and micro-organisms), or organic and inorganic carbon in soils, especially rangeland and peat soils.

Figure 10 shows existing carbon stocks based on field surveys, remote sensing, and spatial analysis. Of the over 55 million metric tons of carbon stored in aboveground forests and woodlands of the SSP region (using data from NBCD 2009) over 90% of the forest carbon in the region is on public or private conservation lands, with the vast majority in USFS lands and Sequoia and Kings Canyon National Parks.

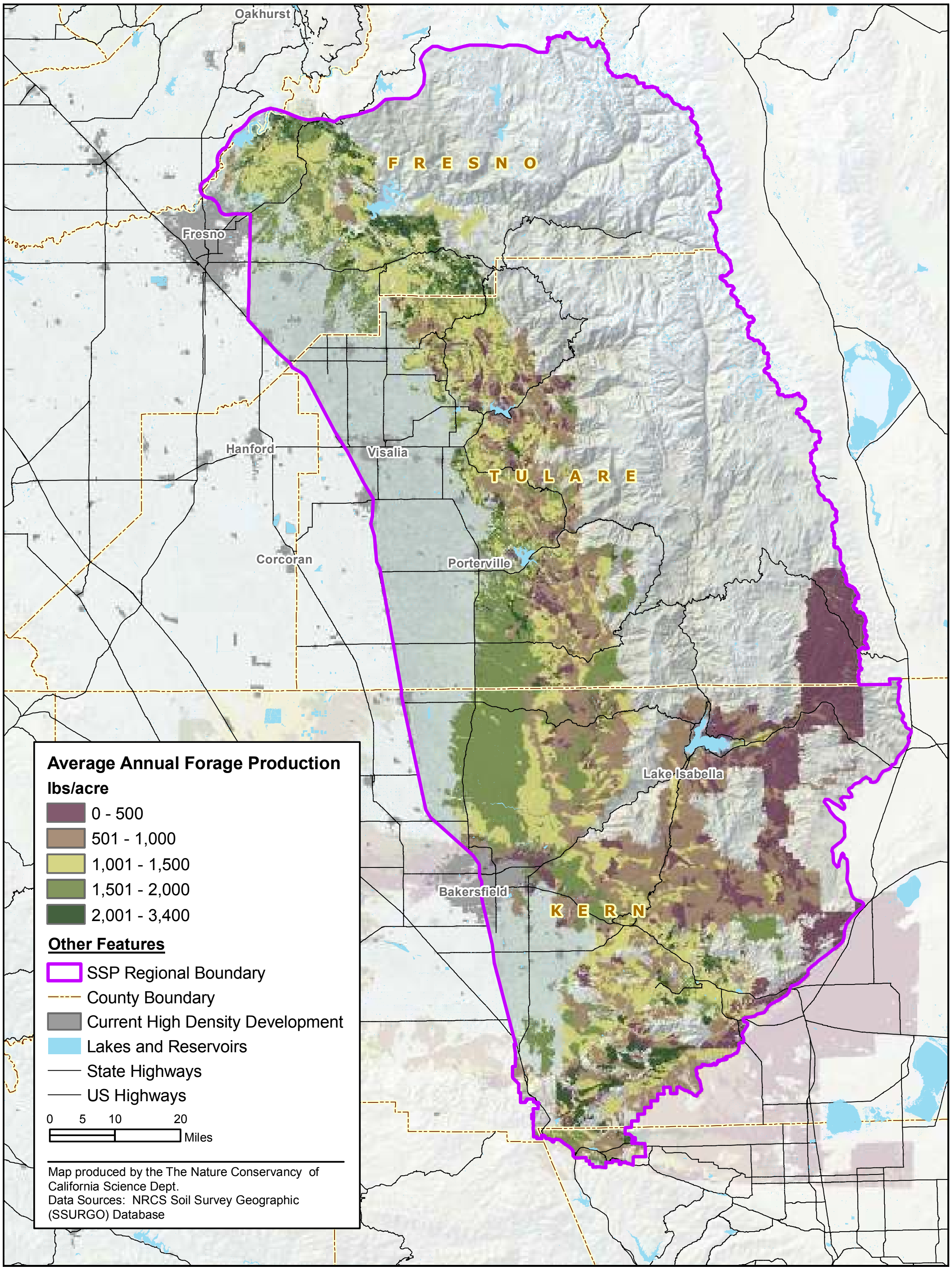

Figure 9. Ecosystem Services: Forage Production. Based on soil survey information, this map shows the potential average annual forage production in a normal rainfall year.

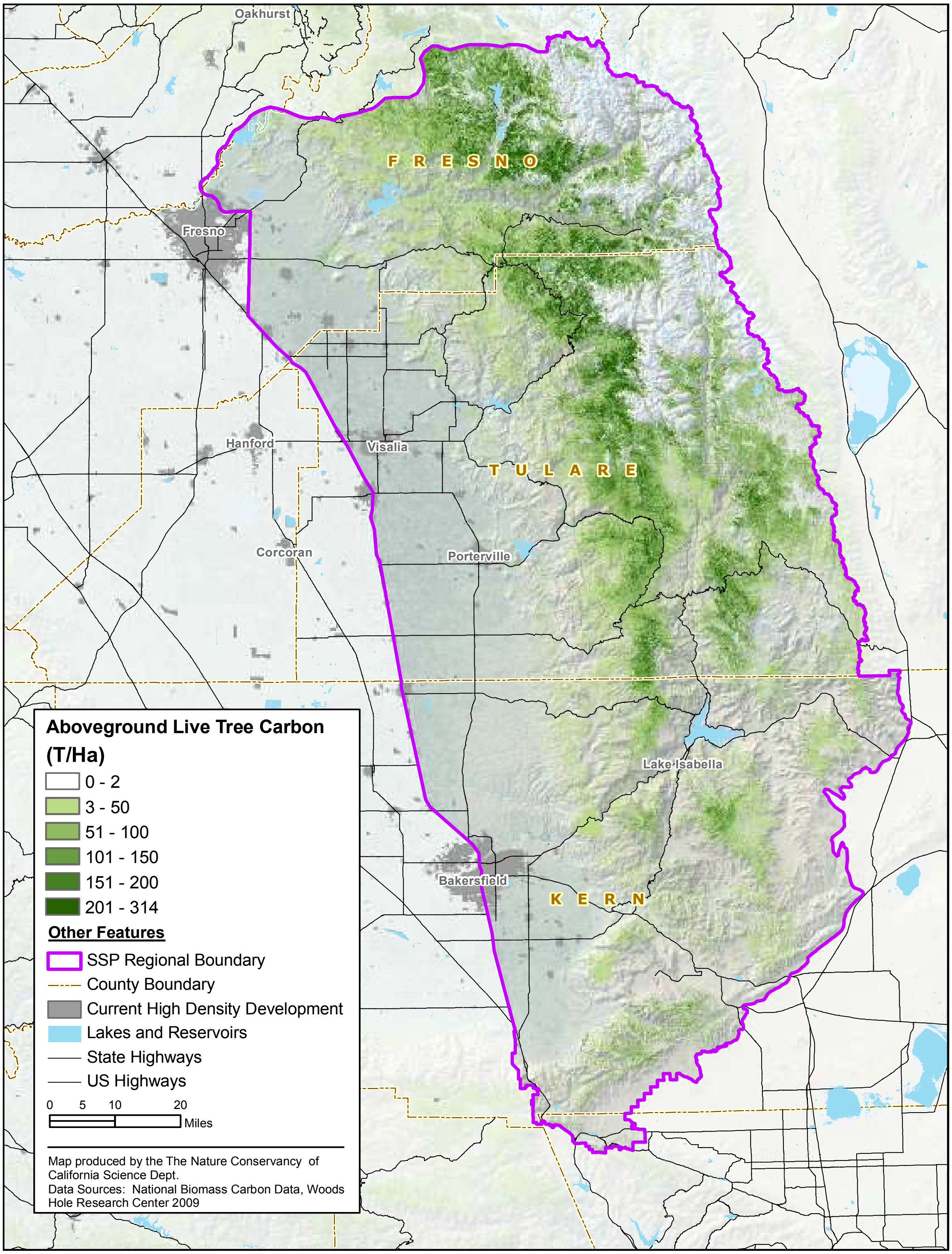

Figure 10. Ecosystem Services: Forest Carbon Storage. Based on a model that integrates stand surveys, remote sensing imagery and environmental data, this map shows the amount of carbon stored in aboveground live tree biomass.

4.2 THREATS

Threats have the potential to destroy or impair the viability or health of the conservation targets. In the Southern Sierra and Tehachapis, the threats relate primarily to activities that destroy, fragment, and degrade terrestrial, riparian, and aquatic habitats and create conditions for spread of competitive non-native species and more severe fires. The top threats described below were derived from the two CAPs (Appendix A and B).

4.2.1 Urban Expansion and Exurban Sprawl

Urban expansion, rural subdivisions, "ranchettes," and associated roads and grading are the most serious, direct threat to grasslands, oak woodlands, and the Mojave Desert. They affect the conservation targets through:

- Direct destruction of habitat, particularly those communities found at low elevations in the Mojave Desert, grasslands, and oak woodlands with slopes of less than 30%.
- Serving as invasion pathways and reservoirs of invasive non-native plants and animals.
- Creating disturbance zones for native wildlife, thereby limiting access to water and seasonal habitats.
- Degrading aquatic and wetland habitats and increasing competition for water resources.

Development projects are usually reviewed on a case-by-case basis which does not account for cumulative impacts. Under current zoning regulations, as much as 400,000 acres of communities, subdivisions, and exurban sprawl would be permitted in the planning area[2]. Figure 11 shows the distribution of these areas, based on analysis of county general plans and parcel data. Kern County has 20-acre zoning, which facilitates subdivision and development of properties. Tulare County has 120-acre zoning and an established Foothill Growth Management Plan, but communities such as Springville and Three Rivers, in the heart of the foothills, are projected to greatly increase in size. New development may even be permitted within the riparian zone of the North Fork of the Tule River and South Fork of the Kaweah River. Exceptions to zoning restrictions may be made to allow establishment of new towns. Neither Tulare nor Kern County has adopted Oak Protection measures. In Fresno County, which is more densely developed than the counties to the south, more urban expansion is expected into the foothills near Squaw Valley and the Dunlap corridor. Fresno County does have an Oak Protection Plan.

[2] Based on an analysis of the undeveloped parcels that are zoned for development and amount of land area that is undergoing specific plans. This number likely overestimates the amount of land that would ultimately be converted, because not all land within specific plans or large parcels would not be developed.

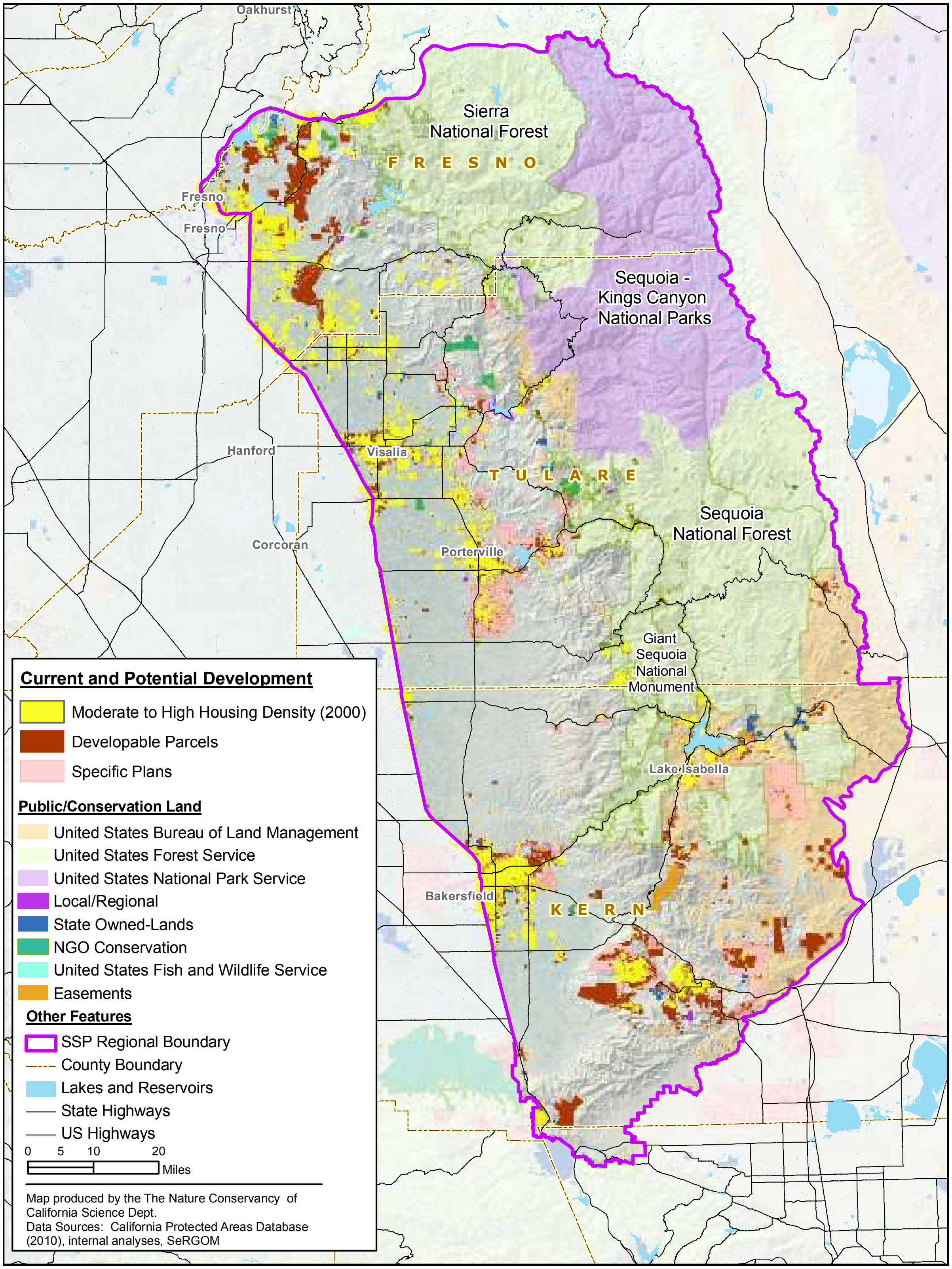

Figure 11. Current and Future Development. Future development is shown as parcels that are currently not developed, but that are zoned to allow development, or as areas where specific plans are expected to result in development proposals for all or part of the areas shown.

4.2.2 Surface and Groundwater Overuse and Management

The aquatic and riparian communities at all elevations and ownerships are the most degraded ecosystems in the planning area. In the foothills and Valley these natural communities suffer from the combination of surface and groundwater withdrawals, water management practices, and physical impacts related to water management structures, particularly dams, irrigation and flood control channels and channel maintenance practices. The timing and amount of flows released by dams and management of flood waters below the dams is significantly different from pre-dam hydrologic regimes. Livestock grazing alters streambed morphology, simplifies the understory of riparian communities and impacts water quality.

Water is 100% adjudicated and, in most years, there is not enough water for all the allocations. Surface water management practices are entrenched in a 150-year history of development of water rights and creation of management and irrigation jurisdictions. Water resources are largely allocated to agriculture, cities, and other human uses, with habitat uses often relegated to the leftovers available in wet years. Agriculture, domestic water supply, and energy developments are increasingly reliant on groundwater. Groundwater management in California is complex: some groundwater basins are managed by local agencies, some by districts, and others are not managed at all. California Water Code determines surface water appropriations, but groundwater appropriations are determined primarily through court decisions (DWR 2000).

4.2.3 Invasive Non-native Species

Invasive, non native plants and animals present a rapidly growing threat to native biodiversity. They affect the conservation targets by:

- Competing for space, food, and water
- Altering fire regimes
- Preying on native species (e.g., bullfrogs and non-native trout as predators of the endangered yellow-legged frog)
- Simplifying community structure and species composition
- Destroying habitats (e.g., feral pigs)
- Amplified tree mortality due from introduced tree pests and pathogens (e.g., white pine blister rust),
- Altered soil hydrology (e.g. salt cedar/tamarisk)

Invasive species in the project area are represented by nearly every major taxonomic group: plants, mollusks, fish, amphibians, mammals, and birds. Soil disturbance related to roadsides, construction, and off-road vehicles favors plant invaders such as thistle, cheatgrass, and other species, many of which are unpalatable by wildlife and livestock. Some stretches of riparian communities, especially in the lower foothills, are dominated by perennial pepperweed, edible fig, purple loosestrife, salt cedar, tree-of-heaven, and giant cane/*Arundo*. Invasive mollusks such as zebra and quagga mussel now threaten low elevation reservoirs and water ways. Invasive fish are widespread in the project area, causing great disruption to aquatic ecosystems. Invasive birds such as the European starling and brown-headed cowbird are disrupting nesting success of many native bird species.

Non-native pests and pathogens threaten forest tree species, especially when the trees are already stressed. One potential pest is the golden spotted oak borer which is nearby in the Southern California's Cleveland National Forest). In addition, feral pigs are expanding in the planning area (J. Versteeg, pers. comm.). Pigs can significantly impact native species and ecosystems, as they use a wide variety of habitats and will eat anything, including grain, acorns, carrion, and plant roots. Their rooting and wallowing behavior is degrading riparian habitats, and they are potential disease carriers.

4.2.4 Incompatible Grazing and Economic Trends of Ranching

Grazing impacts vary by location and local management practices. On grasslands and oak woodlands, grazing can limit invasive grasses and promote greater diversity and abundance of native plants. On riparian corridors and montane meadows, grazing can cause damage to stream corridors and wet meadows. Livestock grazing in the montane meadows of the National Forests reduces their wildflower diversity and ability to absorb and store water (SNEP 1996; Purdy and Moyle 2006). Livestock grazing in montane and alpine riparian corridors tends to cause erosion of stream banks and severe channel alterations such as entrenchment, leading to de-watering of surrounding wet meadows. Livestock grazing was a major factor in the decline of native trout habitat in the Golden Trout Wilderness Area, until action was taken to address this threat. In the rangelands, both overgrazing and under-grazing are problematic. Overgrazing reduces plant diversity and endangers soils by exposing them to erosion, while exclusion of grazing promotes the growth of invasive, non-native plant species and affects fire impacts. Large working ranches help protect large areas of open space and habitats in the foothills. There is trend towards absentee landowners. Absentee landowners may lease their ranches to managers with less incentive for maintaining fencing, water supplies, and a sustainable grazing regime. If the economic viability of ranching declines and incentives to convert rangeland to development increase, significant areas of grassland and woodland habitat could be lost.

4.2.5 Altered Fire Regimes and Incompatible Forest Management

A hundred years of fire suppression and timber harvest practices have changed the character of the mixed conifer forests from those dominated by well-spaced, shade-intolerant conifer tree species, such as sugar pine, ponderosa pine, and giant sequoia, to those with areas of dense small trees dominated by shade-tolerant species, such as incense cedar and white fir (SNEP 1996). Larger, more severe fires are also altering forest composition and structure. The Forest Service faces particularly difficult challenges in addressing the legacy of fire suppression and logging. Fuels management and use of prescribed fire is politically contentious, and the scale of management is beyond current capacity. In addition, the private in-holdings create a difficult wildland-urban interface to manage and ambient air pollution restricts prescribed fire options.

4.2.6 Air Pollution

Southern San Joaquin Valley has a very serious air pollution problem that affects human health and agricultural production, as well as the health of natural resources. Motor vehicles are responsible for more than 50% of the air pollution (Bedsworth 2004). The mountains at the south end of the Valley trap the air pollution from urban centers, agriculture, and vehicles, and the hot, summer temperatures promote the formation of harmful ground-level ozone (also known as smog). In the summer, the ozone wafts uphill and concentrates at the roughly 2,000-6,000 ft elevation, enveloping the mixed conifer forest in a toxic yellow-gray haze during the summer. Ponderosa and Jeffrey pines are particularly susceptible to damage (SNEP 1996). In addition, nutrients and contaminants in air pollution threaten water quality and living resources, even in high elevations.

4.2.7 Energy and Transportation Infrastructure

This region has extraordinary wind resources, leading the State of California to target the Tehachapis as the priority area for wind energy development to meet the Governor's Executive Order S-14-08 which requires that California utilities reach the 33% renewable energy goal by 2020. Wind, solar, and other electricity generation projects and their associated transmission lines and infrastructure, if sited or managed poorly, can lead to degradation and fragmentation of natural landscapes and mortality of birds and bats. In this project area, project permits are currently determined on case by case basis without evaluating cumulative impacts to biodiversity and ecosystem services and none of the responsible agencies are prepared to adequately address the complex issues associated with siting of wind turbines, transmission lines, roads, and additional infrastructure. The proposed high speed rail between San Francisco and Los Angeles has the potential of fragmenting the Tehachapi wildlife linkage between the Los Padres and Sequoia National Forests.

Photo credit: Sophie Parker

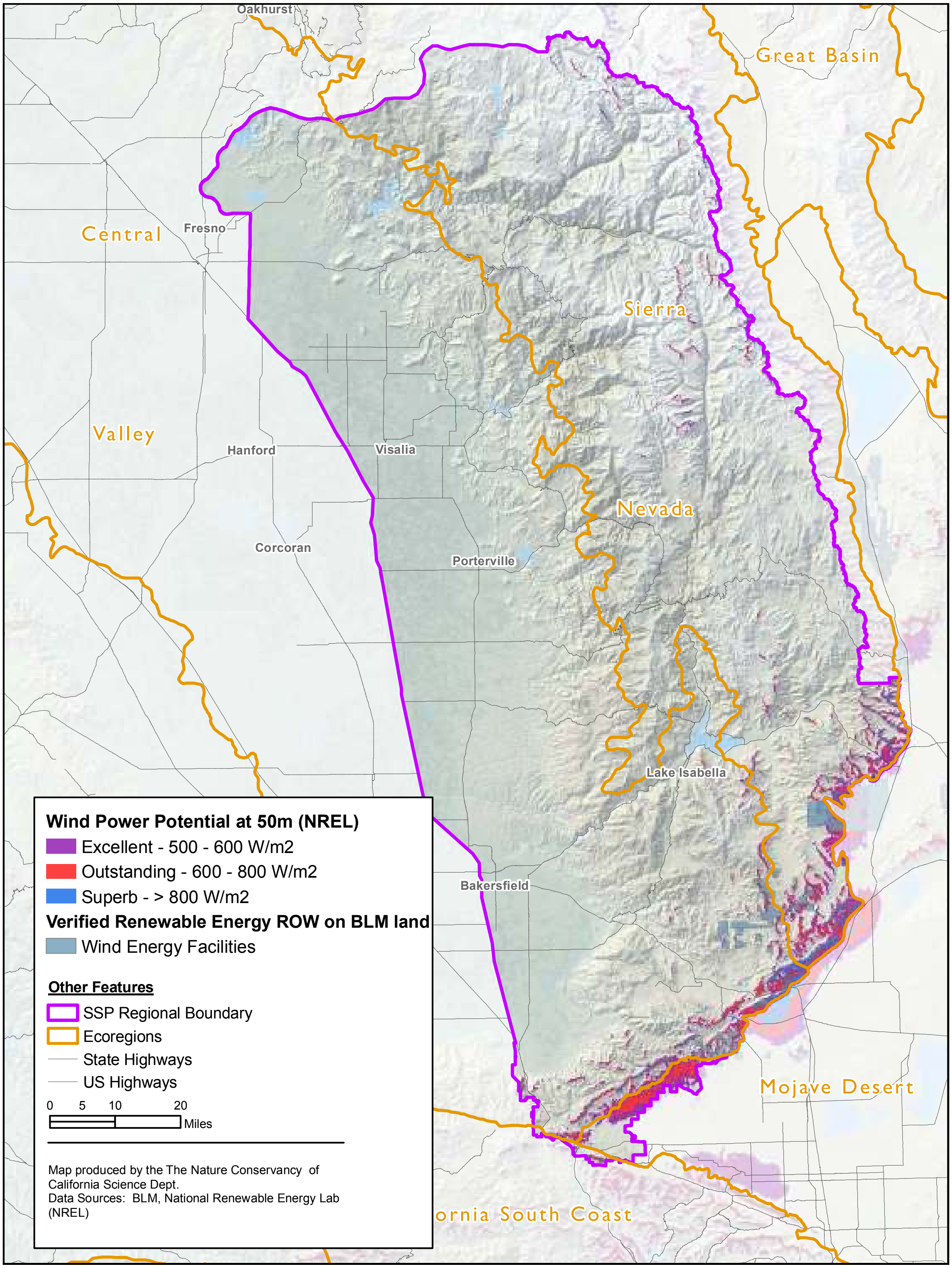

Figure 12. Wind power potential.

Table 4. Summary of the Top Threats to Conservation Targets: Southern Sierra Project CAP. VH = Very High; H = High; M = Medium; L = Low

	CONSERVATION TARGETS								
Project-specific Threats	**Grassland**	**Oak Woodlands**	**Mixed Conifer Forest**	**Sub-alpine & Alpine Communities**	**Chaparral**	**Riparian Communities**	**Aquatic Communities**	**Migratory & Wide-ranging Wildlife**	**Overall Threat Rank**
Surface and groundwater withdrawals	L	L	L		L	VH	VH	M	**VH**
Flood control / water mgmt / channel mtce	L	L				H	VH	H	**H**
Climate Change	M	M	H	VH	M	H	H	M	**H**
Residential Development	H	H	M	L	M	H	H	H	**H**
Roads	M	M	H	M	M	H	M	H	**H**
Changes in fire regime	L	M	VH	M	M	M		M	**H**
Intensive Ag (including marijuana)	H	M	M		M	VH	M	M	**H**
Incompatible livestock grazing practices	M	H			M	VH	L		**H**
Invasive, non-native plant species	H	H	M	L	M	H	M	M	**H**
Non-native animals	L	M	M		L	L	VH	M	**H**
Pests and pathogens		L	H	M		M	VH	M	**H**
Habitat loss outside site planning area		H	M	M		H		H	**H**
Airborne pollutants	M	M	H	M			M		**M**
Incompatible veg management practices		M	H	M	M	M	L	M	**M**
Energy and transmission line devel.	M	M			M	L	L	M	**M**
Aggregate mining	M	L				H	M	M	**M**
Intentional prevention of T&E spp. occurrences	M	M				M	L	M	**M**
OVERALL THREAT RANK BY TARGET	**M**	**H**	**H**	**H**	**M**	**VH**	**VH**	**H**	

Table 5. Summary of the Top Threats to Conservation Targets: Tehachapi Project CAP. VH = Very High; H = High; M = Medium; L = Low

Project-specific threats	**1 Oak Woodlands**	**2 Riparian Communities**	**3 Mojave Desert Scrub and Joshua Tree Communities**	**4 Grasslands**	**5 Semi-arid Montane**	**6 Coniferous Forest**	**7 Migratory and Wide-Ranging Wildlife**	**Overall Threat Rank**
Land grading and housing development	H	H	H	VH	M	M	M	VH
Climate change induced temp. changes	H	H	H	M	L	H	L	H
Surface and groundwater diversions		VH						H
Construction of roads	H		M	H	M	L	M	H
Presence of existing non-native plant species	H	H		M	L			H
Decrease in economic viability of ranching	H			H			M	H
Poorly managed cattle and/or sheep grazing	M	H	M	M	L	M		M
Invasion of new species (plants, fungi, pathogens, etc.)		H	M	M				M
Predation by non-native feral animals (cats and/or pigs)	M	M				H		M
OHV use		M	H		L			M
Large-scale solar energy development			H				M	M
Increase in frequency of extreme conditions in streamflow.		H						M
Wind energy development			M	M	M		M	M
Altered fire frequency and intensity		M	M		M			M
Conversion to agriculture			M	M				M
Utility & Service Lines			M				M	M
Threat Status for Targets and Project	H	VH	H	VH	M	H	M	VH

4.3 CLIMATE IMPACTS

4.3.1 Past and Present Trends

The climate of the Sierra Nevada has been variable over the past 1,100 years suggesting that future anthropogenic climate change may occur against a backdrop of natural climatic variation (Stine 2004). From approximately AD 900 to AD 1300 during the Medieval Warm Period the Western United States experienced greater aridity and epic drought, which exceeded weather extremes of the last one hundred years (Cook et al. 2004). From approximately AD 1300 to AD 1800 the Sierra Nevada experienced cold conditions in which mountain glaciers advanced, a period called the Little Ice Age (Clark and Gillespie 1997, Grove 1988). Fluctuations in pollen and plant macrofossils (Anderson 1990) and treeline elevation (Lloyd and Graumlich 1997) provide supporting evidence of past climatic variation. The modern climate of the Sierra Nevada (past 150 years) is abnormally wet and warm compared to past millennia (Stine 1996, 2004).

The southern Sierra experiences the Mediterranean climate of cool, wet winters and hot, dry summers. There is a considerable temperature range within this mountainous region; climate data from the PRISM dataset averaged from 1960 to 1990 show that average annual maximum temperatures range from 32°F to 80°F (0°C to 26.7°C) and the average annual minimum temperatures range from 16°F to 58°F (-8.9°C to 14.4°C) depending on elevation, aspect, and topography (Daly 2008). In addition, an analysis of the PRISM data over time shows the average annual daily maximum temperature averaged for the whole region has varied between 39° and 44°F (3.9°C to 6.7°C). Moritz et al. report an increase of 3°C in minimum temperatures in the Sierra Nevada in the 20th century (Moritz et al. 2008). However, analysis of the PRISM data suggests that the warming trend was most consistent in the second half of the 20th century, and the average minimum temperature of a 20-year moving average window increased 1.5°F (0.94°C) while the average daily maximum temperature increased by 1°F (0.63°C) in the southern Sierra (unpublished analysis, TNC science department). Since 1900, there is no clear trend in precipitation patterns or amount, which ranges from 4 in. to 63 in. based on annual averages.

Photo credit: Sophie Parker

The increased temperatures are already having an impact in the Sierra Nevada, including less snow and more rain (Knowles et al. 2006), less spring snowpack (Kapnick and Hall 2009), and earlier snow melt run-off (Dettinger et. al. 2004; Peterson et. al. 2005). As a whole, the Sierra Nevada may be receiving less snowpack, but many of the higher elevation watersheds of the Southern Sierra Nevada region has actually been increasing in snowpack for the past 50 to 60 years (Moser et al. 2009). There is some evidence in the region of increased variation in precipitation, including more extreme droughts and floods, over the past century of weather records (Meyer and Safford 2010).

4.3.2 Future Climate Projections

Bakersfield and the southern San Joaquin Valley currently experience daily summer temperatures of 100°F between June and September, with highs above 110°F. Looking ahead 50 years, all models show a dramatic increase summer average daily high temperatures of 2.6°F to 8°F (average 5°F (Figures 13 and 14). Model results for annual precipitation are mixed, but more models project slightly drier conditions rather than wetter conditions (Figure 15).

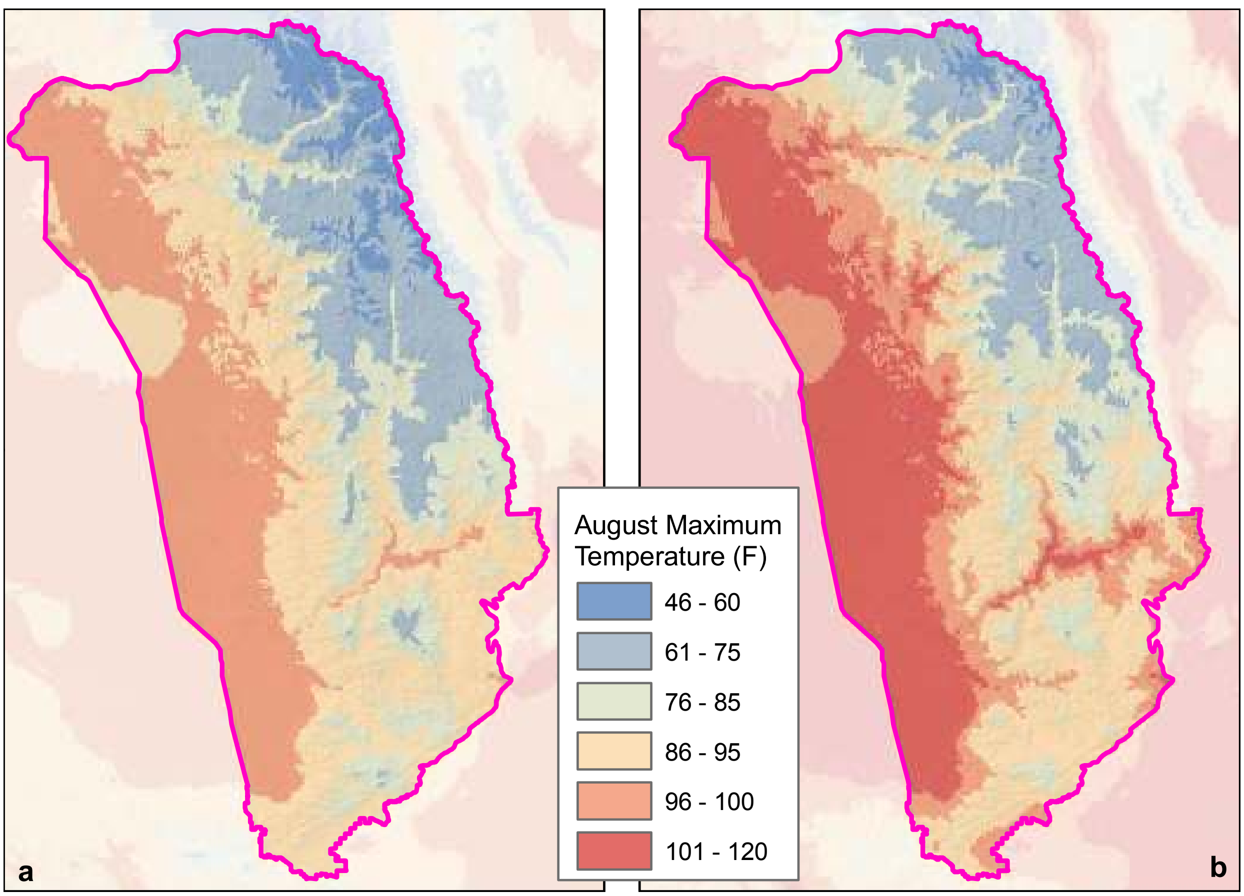

Figure 13. August maximum temperature in the reference period (1961 – 1990)(a) and mid century (2046 – 2065). (b) Projected future temperatures are based on the average of 11 General Circulation models run with the A2 emissions scenario.

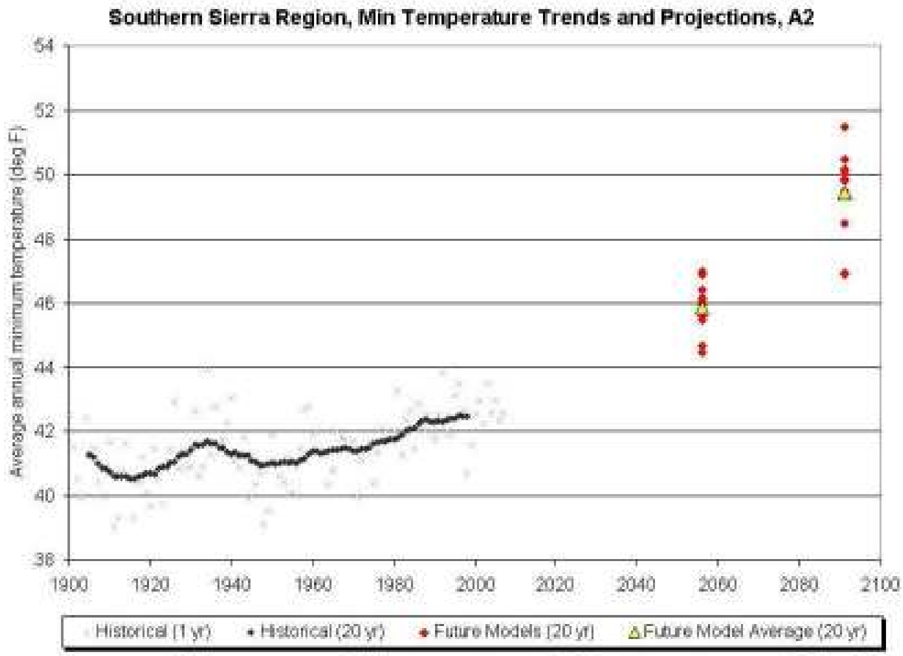

Figure 14. Comparison of observed historical annual minimum temperatures (1 and 20 year averages) and future projections by General Circulation Models (GCM)for the southern Sierra under the “A2” scenario.

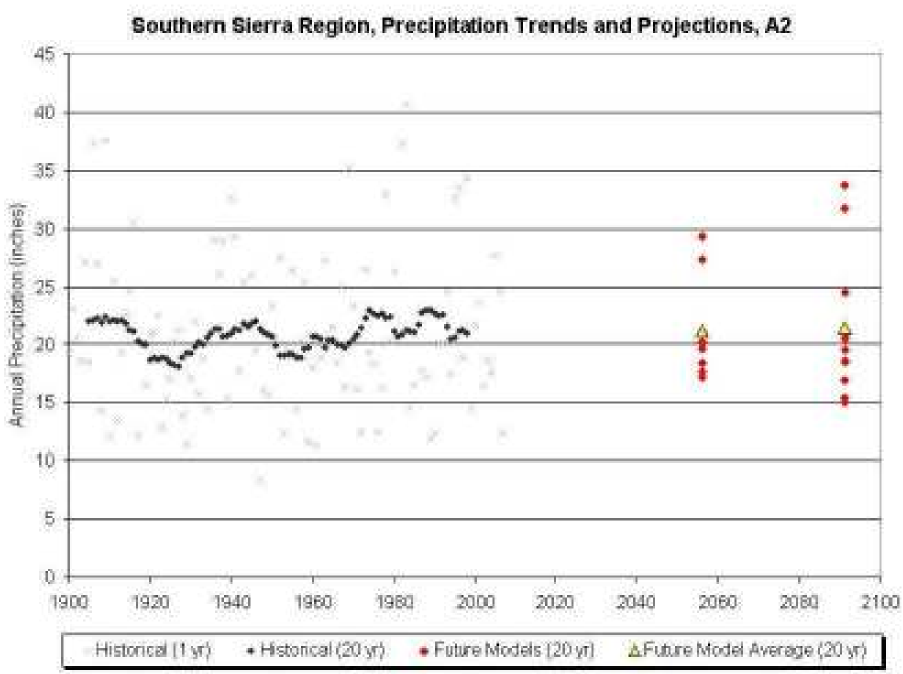

Figure 15. Comparison of observed historical annual precipitation (1 and 20 year averages) and future projections of annual precipitation (20 year averages) by GCM for the southern Sierra.

4.3.3 Species and Habitat Projections

To inform climate-adaptive conservation priorities in the Southern Sierra, we projected responses of the conservation targets to future climate changes.

Species Projections

Species in the Sierra have already responded to recent climate change through shifts in elevational ranges (Moritz et al. 2008, Kelly and Goulden 2008), shifts in phenology (Forister et al. 2009), and increased mortality (Mantgem et al. 2009). We forecast how species may respond to future climate changes by mapping ensemble projections for 25 ecologically dominant tree and shrub species in the Southern Sierra and deriving tables of summary statistics (Appendix E).

In general, species projections in the Southern Sierra often show relatively more stability, and relatively less climate stress, than state-wide (Appendix E), emphasizing the regional significance of the project area for climate-adaption. Plant species forecasts support the expectation of migration uphill along steep elevational gradients to offset warming temperatures. Potential climate stress tends to occur in the lower elevations of species' ranges, with stable zones, then potential expansion areas, replacing one another with increasing altitude. In the Tehachapis, novel climates, complex biogeographic histories, and significant data gaps on species distributions highlight the urgent need for survey data from the Tehachapis to enable model reliability comparable to that in the Sierra.

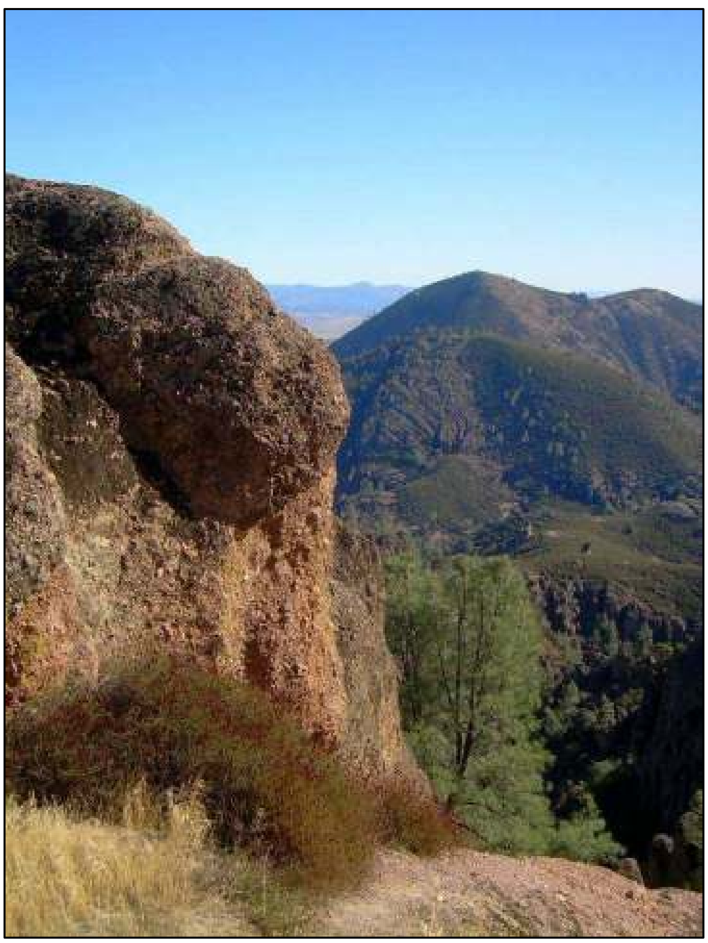

Photo credit: Susan Antenen

Figures 16 – 19 show results of species distribution models for four dominant species of the oak woodlands. We highlight foothill species and oak woodlands in this plan, because oak woodlands comprise more than 830,000 acres of public and private lands within the project area and support very high species diversity, yet are vulnerable to many threats and are actively being converted. The results of all four models indicate that lower elevation occurrences will be increasingly stressed by climate change. The models highlight the importance of the stable zones where the species currently grow and are expected to persist.

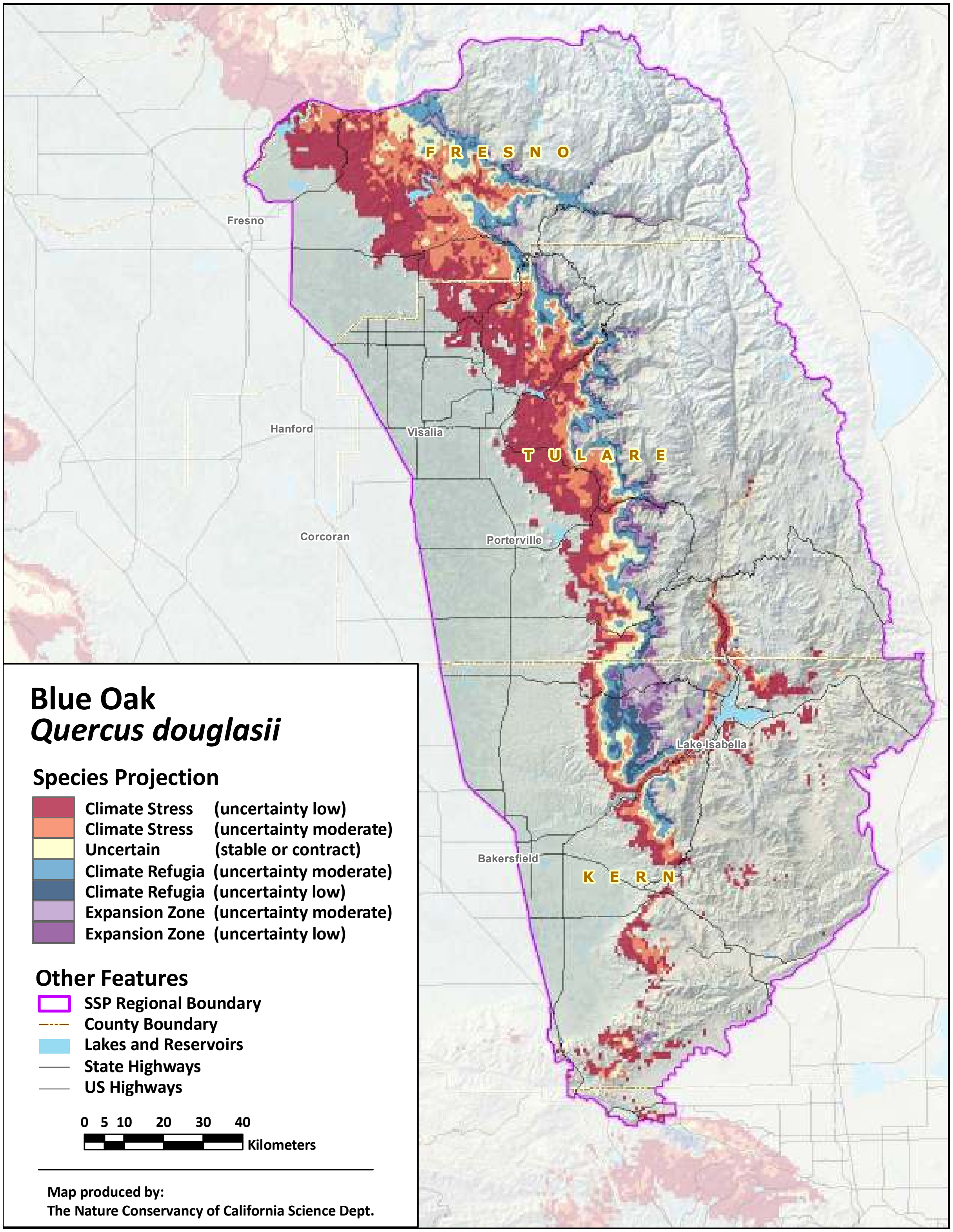

Figure 16. Species projection for blue oak (*Quercus douglasii*). Ensemble forecasts characterize suitability for current and multiple future climates (2045-2065 A2 emission scenarios). Colors denote potential outcomes (i.e. red = climate stress, blue = climate *refugia*, and purple = expansion zones) and shading denotes relative levels of model consensus or uncertainty (i.e. light = moderate, dark = low).

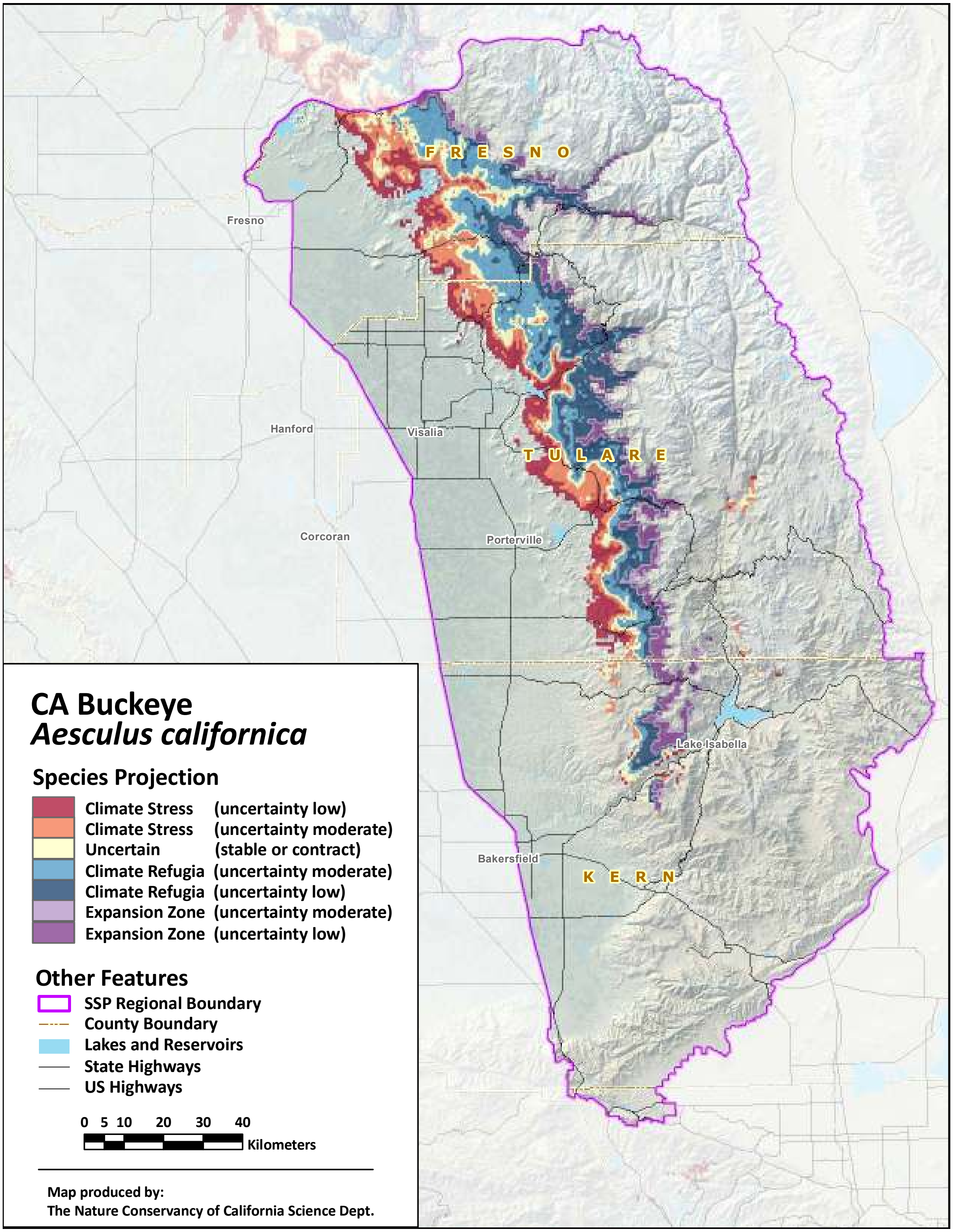

Figure 17. Species projections for California buckeye (*Aesculus californica*). Symbology of layouts is identical to Figure 15.

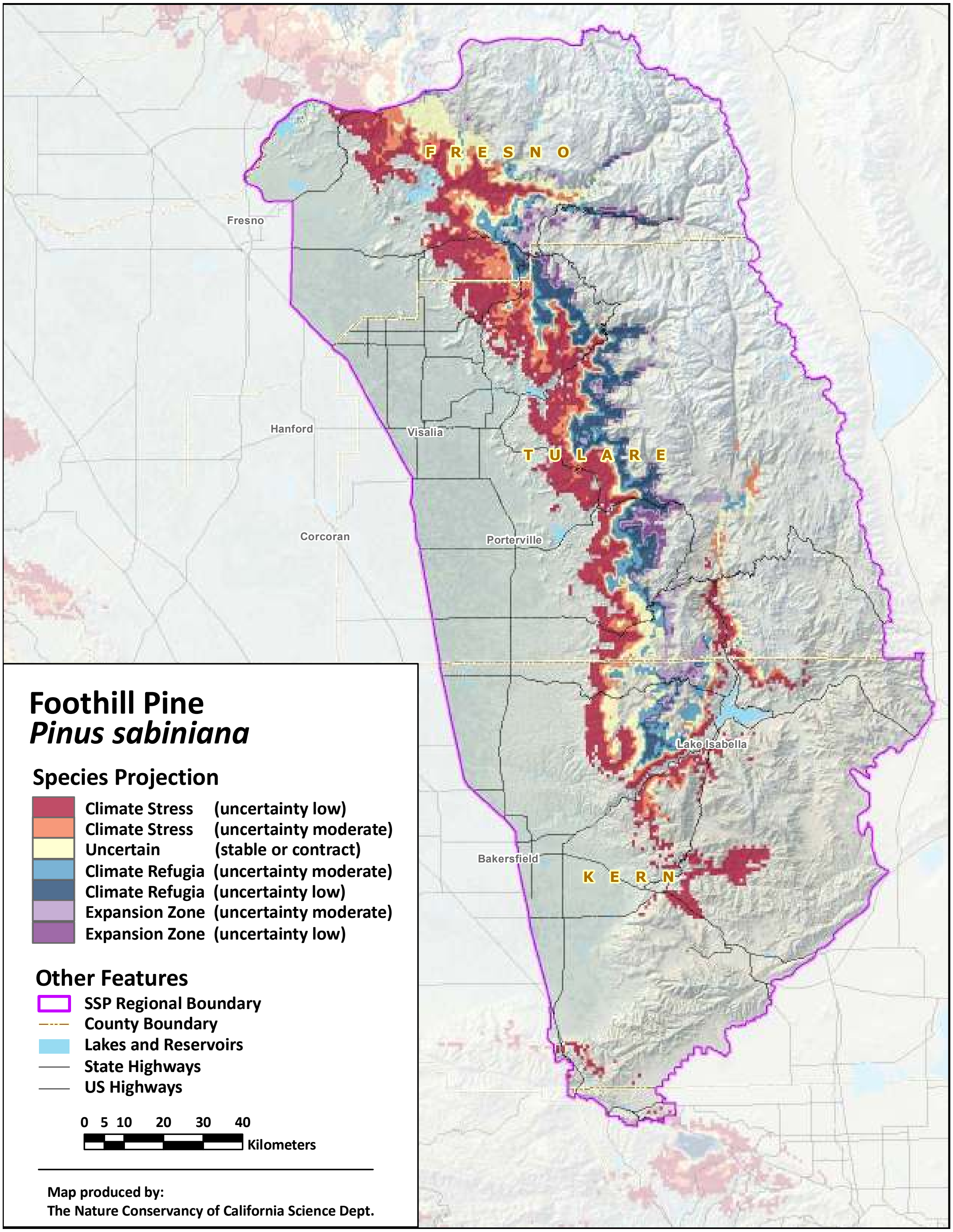

Figure 18. Species projection for foothill pine (*Pinus sabiniana*). Symbology of layouts is identical to Figure 15.

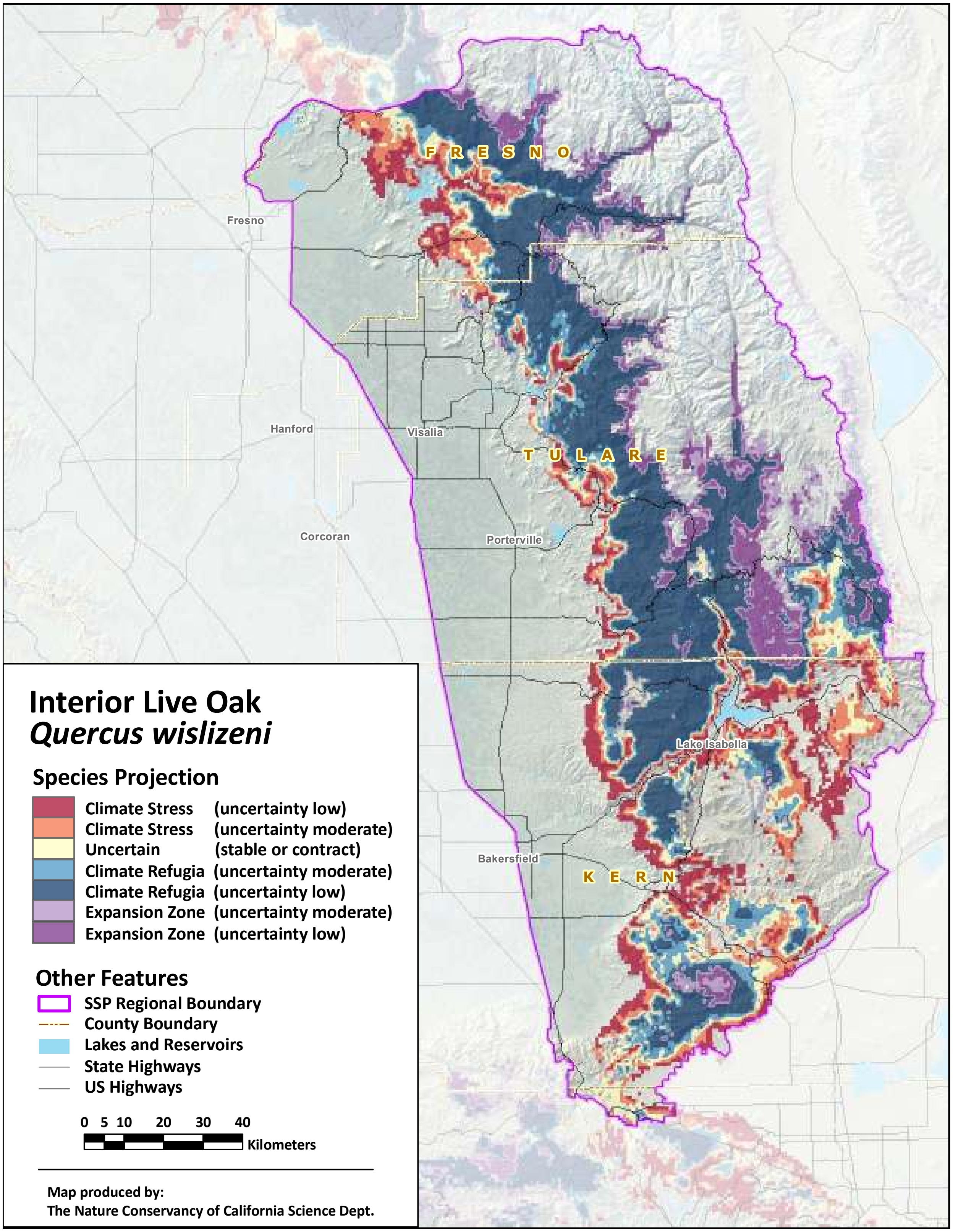

Figure 19. Species projection for interior live oak (*Quercus wislizeni*). Symbology of layouts is identical to Figure 15.

Projections for Target Communities

Photo credit: Susan Antenen

We aggregated species projections to create projections of vegetation community responses to climate change. We used these community projections to modify current vegetation distributions so as to help identify stable *refugia* over climate vulnerable areas in the regional conservation design. Projections for mixed conifer forests, semi-arid montane shrublands, and sub-alpine communities are included in (Appendix E).

Habitat projections for oak woodlands identify where climate impacts converge with multiple threats to increase the vulnerability in low elevations, and opportunities for conservation where potential climate *refugia* occur across large, intact areas which currently support oak woodland species (Figure 20). Projected oak woodland *refugia* span both public and private lands, highlighting an emerging need to coordinate management between regional stakeholders. Collaboration on adaptation planning between the Southern Sierra Partnership and federal agencies could help maximize the adaptation potential of regional oak woodlands (Figure 21). Design of future oak woodland monitoring programs should consider placing transects across a projected narrow transition dividing potential stable and stressed areas for multiple co-distributed tree species. Locations where co-dominant species projections suggest climate-related tipping points may represent strategic areas for applied research on climate vulnerability as associated with recruitment limitation, adult mortality and habitat type conversion (Figure 22).

4.3.4 Hypotheses of Change

To integrate the findings of Conservation Action Plans with the results of the species and habitat projection models, we developed "Hypotheses of Change" which describe how we expect the conservation targets to respond to climate change (Appendix F).

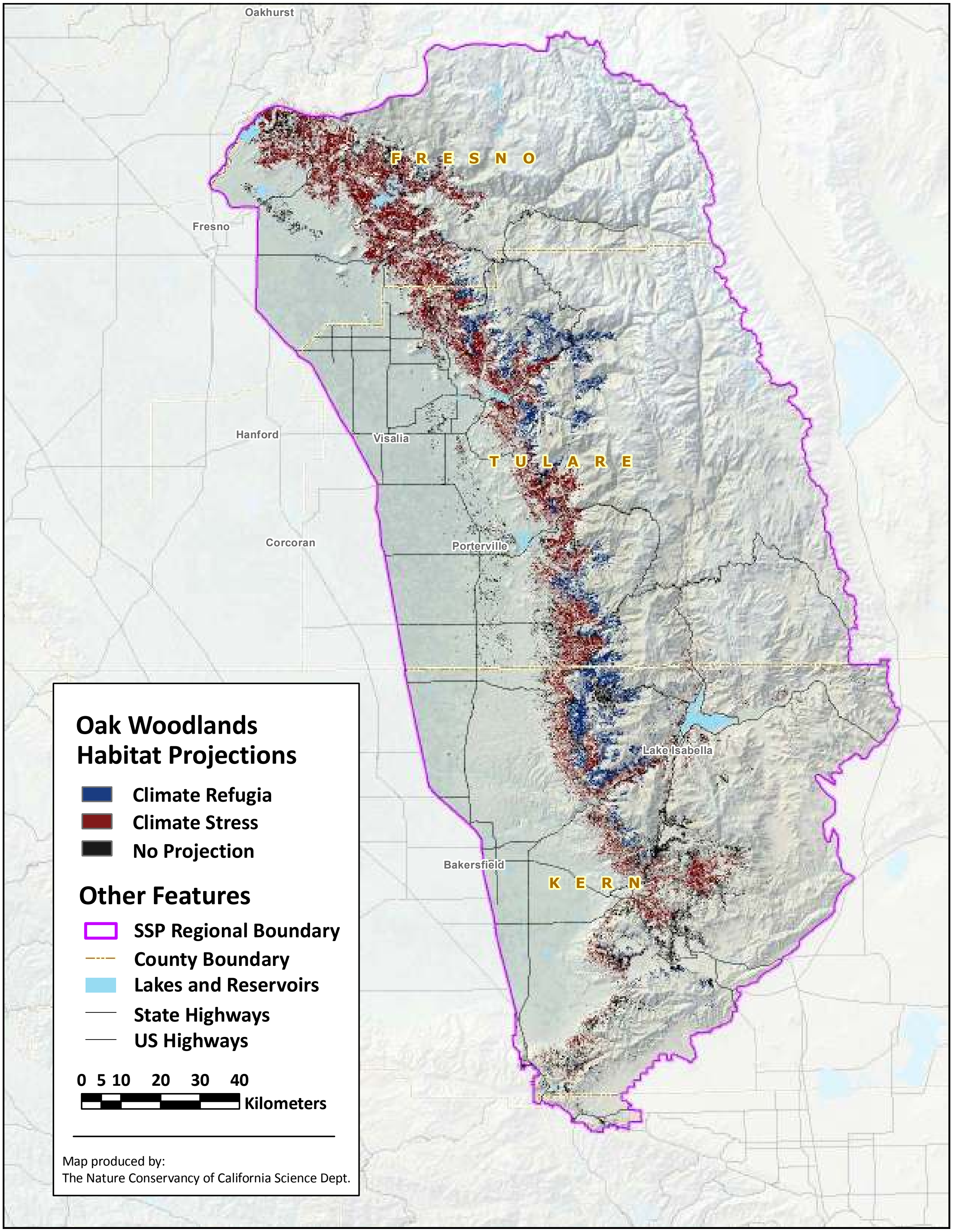

Figure 20. Habitat projection for oak woodlands. Ensemble forecasts suggest where climate impacts could converge with multiple threats to increase their vulnerability (red). Potential *refugia* are identified where suitable climate will persist within the current oak woodland range (blue).

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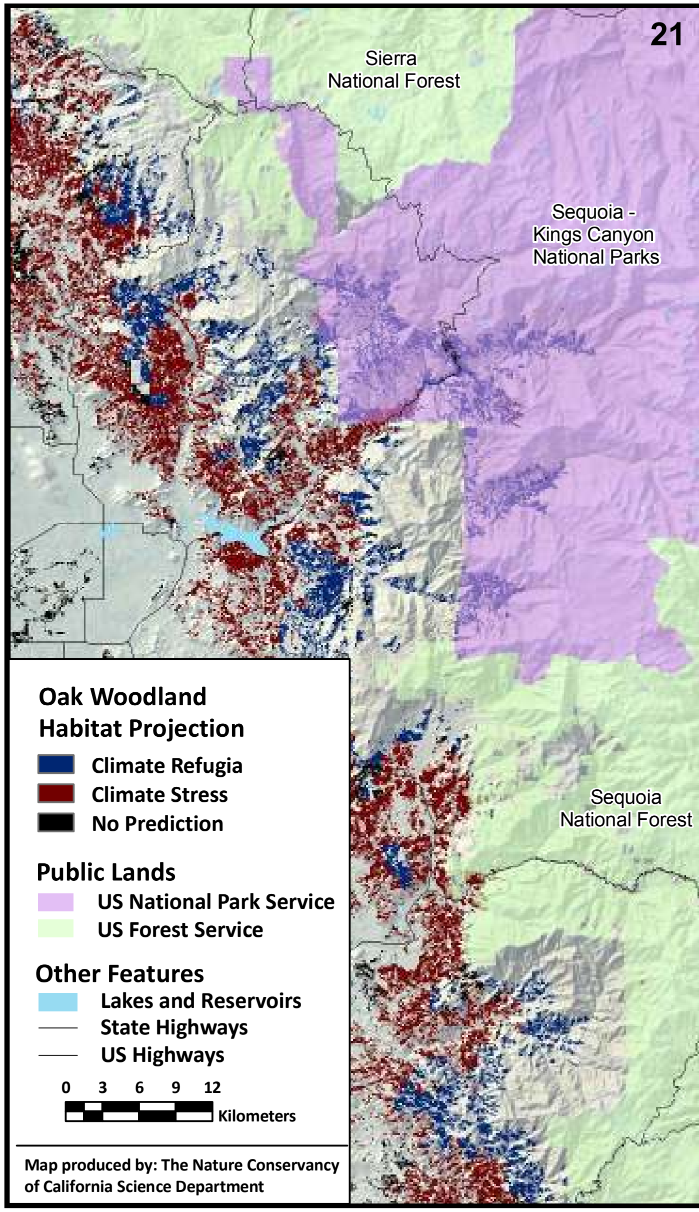

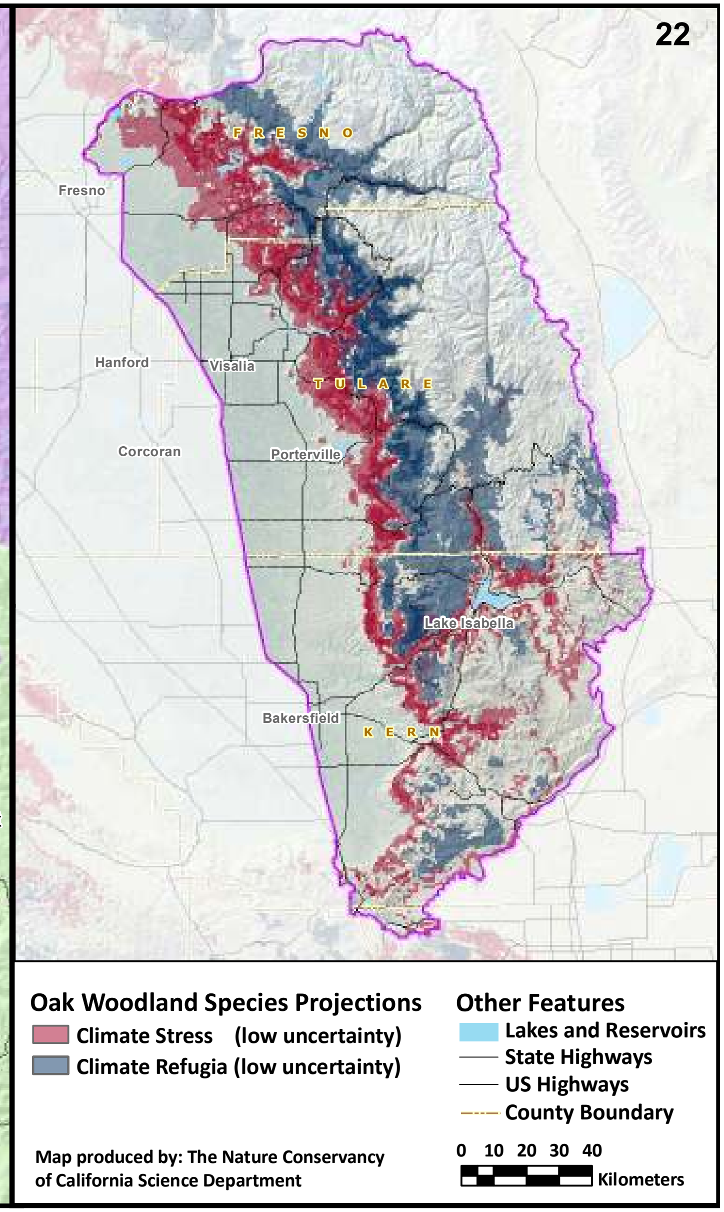

Figure 21. Oak woodland *refugia* span public and private lands. Habitat projections highlight an emerging need for coordinated management.

Figure 22. Future monitoring should explore potential tipping points between stress and stable areas. Transects could be strategically placed across a sharp transition observable in multiple co-distributed tree species projections. Locations where co-dominant species projections indicate climate-related tipping points should be strategic areas to focus applied research on climate vulnerability, with specific emphasis on recruitment limitation, adult mortality and habitat type conversion.

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Table 6. Hypotheses of Change					
	Climate Factor	**Key Ecological Attributes**	**Indicator**	**Hypothesis of Change**	**Likelihood of ecological change**
Grasslands	Temperature rise +5˚F • Increase in ET • Reduced soil moisture • Shorter growing season	Species composition & dominance	% Native species	Higher temperature will lead to: • Earlier flowering for some species which may then impact wildlife dependent on those species	Very likely
				• Loss of diversity on south-facing slopes at lower elevation	Very likely
				• Increased productivity in grasses when rainfall is abundant	Likely
				• North-facing slopes may provide *refugia* for native species	Very likely
				• Smaller and shallower vernal pools become less suitable for sensitive vernal pool-dependent plant and animal species	Very likely
		Vegetation structure	Residual Dry Matter	• Drought tolerant invasive species may increase	Virtually certain
				• Overall extent of grassland habitat may increase as a result of type-conversion from chaparral and semi-arid montane habitats	Very likely
Oak Woodlands	Temperature rise +5˚F • Increase in ET • Reduced soil moisture • Shorter growing season • Longer droughts	Oak recruitment	Survivor-ship of seedlings and saplings	Higher temperature will lead to: • Magnification of the recruitment problem, which already seems to threaten the long-term viability of oak woodlands	Very likely
				Oak woodlands are adapted to variable climate conditions and trees are long-lived, but we expect gradual reduction in area and more patchiness in lower elevations of their range	Likely

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Chaparral	Temperature rise +5˚F			Higher temperature will lead to:	
	• Increase in ET	Species composition	Abundance of grass	• Increased fire frequency	Very likely
				• Invasion of annual grasses	Very likely
		Fire regime		• Conversion of some shrubland areas to grasslands, especially in lower elevations	Likely
				• Loss of species diversity	Uncertain
Mixed conifers	Increase of minimum temperature +5˚F	Fire regime	Fire return interval	Higher temperatures and less snowpack will lead to:	
	• Less snow, more rain	Species composition and dominance	Fire severity and area	• Increased large tree mortality	Very likely
	• Longer droughts			• More outbreaks of wood boring insects and disease	Very likely
		Mosaic of forest structure	Rate of large tree mortality	• Homogenization of forest structure with loss of old growth forest	Likely
				• Expansion of chaparral or non-native grasslands into forest areas if there is forest die-back	Likely
		Pests and pathogens	Extent of forest die-off	• In the Tehachapis, fir forest becomes patchier	Likely
Alpine and Sub-alpine	Increase of minimum temperature +5˚F	Species composition and structure	Status of indicator species	Higher temperatures and less snowpack will lead to:	
	• Less snow, more rain			• Local extinctions or fewer occurrences of cold-adapted species	Virtually certain
				• Colonization of higher elevations by lower elevation plants and animals	Virtually certain

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Mojave-Joshua Tree Desert Scrub	Temperature rise +5˚F • Increase in ET • Reduced soil moisture • Shorter growing season • Increase in minimum temperatures	Species composition and structure Keystone species Fire regime	% Native species Desert tortoise population Fire frequency	Higher temperatures will lead to: • Loss of Joshua trees in their current range • Species composition in lower elevation areas and on south facing slopes will change • Increased fire frequency that causes type conversion • Expansion of desert species into adjacent systems, but not expansion of the diverse desert community due to soil and other disturbances	 Uncertain Likely Likely Likely
Semi-arid Montane Shrublands	Temperature rise +5˚F • Increase in ET • Reduced soil moisture • Shorter growing season	Species composition and structure Fire regime	% native species Fire frequency	Higher temperatures will lead to: • Invasion of annual grasses • Increased fire frequency in lower elevations that conversion of some shrubland areas to grasslands, especially in lower elevations • Loss of species diversity	 Highly likely Likely Uncertain
Riparian Communities	Temperature rise +5˚F • Less snow, more rain • Earlier melting of snowpack leading to earlier peak flows and longer lower flow seasons • Increased ET • More frequent, flashier floods	Hydrologic Regime Access to groundwater Streambed morphology	Flooding Water level fluctuations Species Composition and dominance	Increased temperatures and less snow and more rain will lead to: • More incised streambeds which drain water faster • Contraction of riparian communities • More simplified species composition and vertical structure • Spread of invasive plant species, such as *Arundo*, which can tolerate drier conditions • Less groundwater recharge	 Virtually certain Likely Likely Highly likely Highly likely

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Lakes, Rivers and Streams	Temperature rise +5˚F • Less snow, more rain • Earlier melting of snowpack leading to earlier peak flows and longer lower flow seasons • Increased ET • More frequent, flashier floods • Warmer water	Hydrologic Regime Groundwater recharge Streambed morphology Fish assemblages	Integrity of montane meadows Flow amounts and timing Populations of native cold and warm water fish	Increased temperatures and less snow and more rain will lead to: • More incised streambeds which drain water faster • Less groundwater recharge • Change in fish assemblages.	Likely Highly likely Likely

4.3.5 Ecosystem Services Projections

The effect of climate change on key ecosystem services in the region will be driven by climatic changes directly, as well as associated changes in ecological processes that affect the distribution and condition of different ecosystem types. In a recent study conducted as part of the 2009 Climate Action Team Biennial Report to the California Legislature, Shaw and colleagues looked at the effect of climate change on ecosystem services in the state using two emissions scenarios (A2- high, and B1- low) and three atmospheric-oceanic general circulation models ("general circulation models") - GFDL-CM2.1 (Delworth et al. 2006), NCAR-CCSM3 (Collins et al. 2006, data not shown) and NCAR-PCM1 (Washington et al. 2000). Each general circulation model was selected based upon strong regional performance in California (Cayan, pers. comm.) and were selected to bracket future projected extremes ranging from a warm, wet future (NCAR-PCM1) to hot, dry futures (GFDL-CM2.1, NCAR-CCSM3).

We present the results for the end of the century from that study for two key services for the whole SSP region: forest carbon sequestration and forage production, and the water quantity results for two rivers in or near the study area. More details on methods and analyses can be found in that study (Shaw et al. 2009).

Photo credit: Sophie Parker

Forage Production

Forage production in this model is determined by the amount of rainfall during the growing season, cover type, and soil productivity. Figure 23 shows scenarios of change over time. Figure 24 shows the geographic distribution and net change in forage produced across the whole southern Sierra in comparison to the region without climate change. Under the hot and dry model (GFDL) production drops in each time period with larger decreases in the mid-century and end-of-century, where the A2 scenario decreases more than the B1 scenario. The warm, wet PCM model shows an increase in production under both scenarios until the end-of-century where both scenarios show a decrease, from 10% under the B1 scenario to 25% under the A2. Ranching is already a marginal economic enterprise with increasing challenges to the viability of the industry. Reduced forage production due to climate change could be another significant blow to an industry that provides conservation benefit to California's grasslands and oak woodlands.

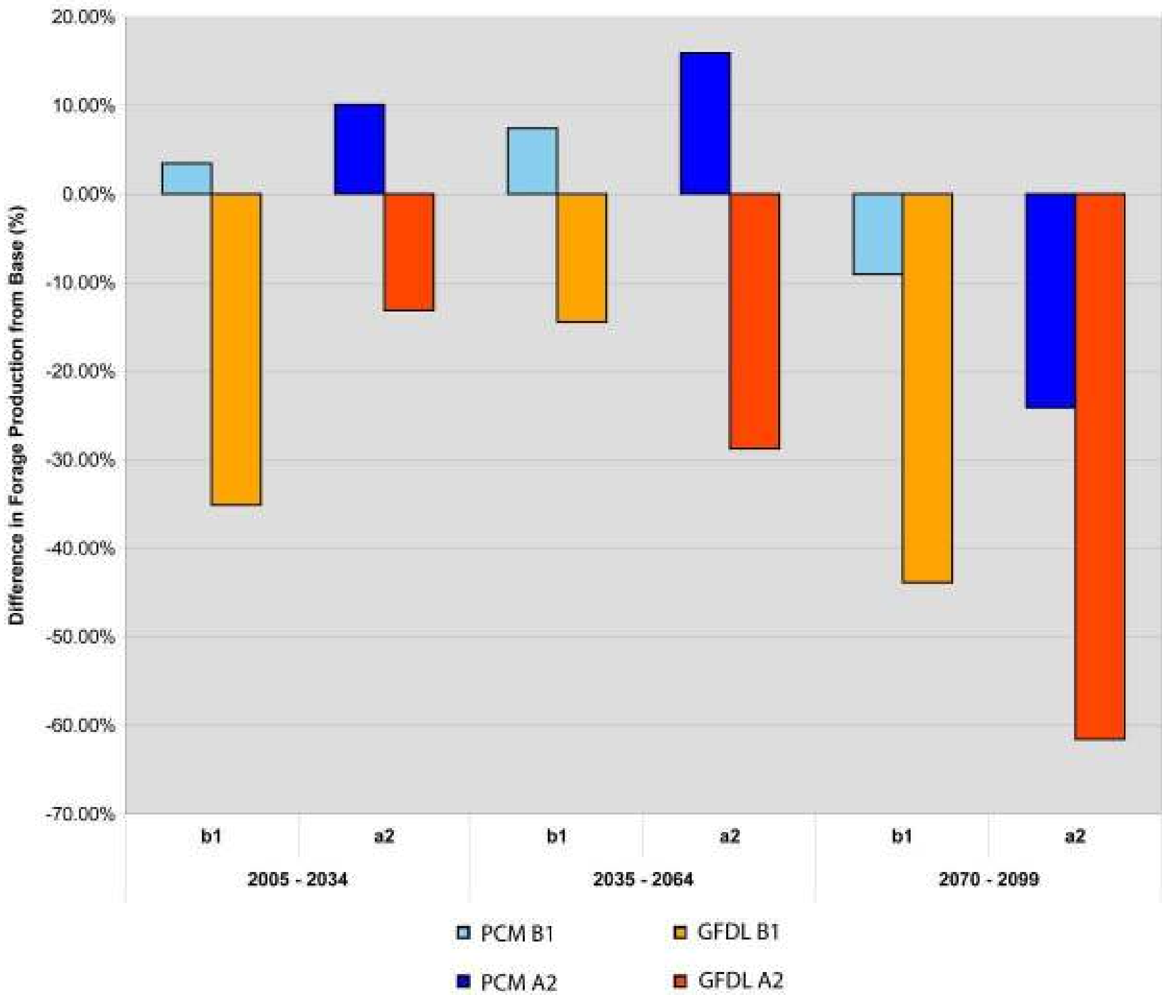

Figure 23. Forage Production Scenarios. Both models (blue is "warm wet," orange is "hot dry") show decreases at the end of the century.

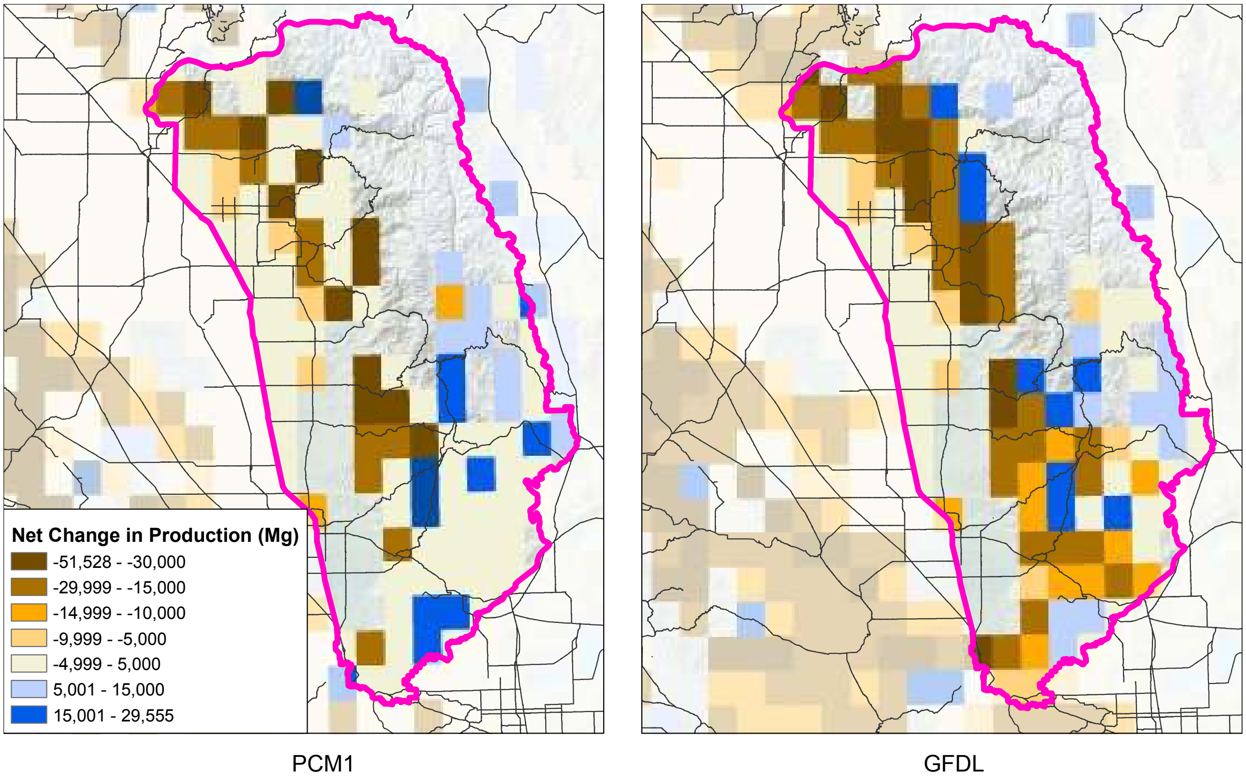

Figure 24. Forage net change. In both models (warm, wet PCM1 and hot, dry GFDL) the decreases occur in the lower rangelands, while areas in higher elevation show an increase in production.

Forest Carbon Storage

Forest carbon projections under climate change show a marginal decrease in the near term, in general, but the differences in models and emissions scenarios start to become more pronounced toward the end of the century. The warm, wet PCM model shows a consistent increase in forest carbon under both emissions scenarios (as high as 20% increase) by the end of the century under the A2 scenario. The hot, dry GFDL model, under the A2 scenario, shows a marked decrease by the end of the century (Figure 25).

The forest carbon stocks in the Southern Sierra and Tehachapis have a more positive direction in terms of increases in sequestration compared to the statewide averages where the CCSM model shows a significant drop in carbon by the end of the century (17% *decrease* under B1 and 30% decrease under A2). If natural carbon sequestration is reduced through drought stress and emissions from increased wildfires, the state will not be able to meet its ambitious emissions reductions goals set under AB32. Active restoration of forests through thinning and prescribed burning has been shown to be an effective strategy to minimize catastrophic wildfire emissions and maintain natural sequestration (Hurteau et al. 2008).

The geographic distribution of modeled changes by the end of the century in forest carbon for the A2 scenario is shown in Figure 26. The northwestern part of the region shows a decrease under the PCM model, while the northern part of the region shows a decrease in both the GFDL and CCSM models.

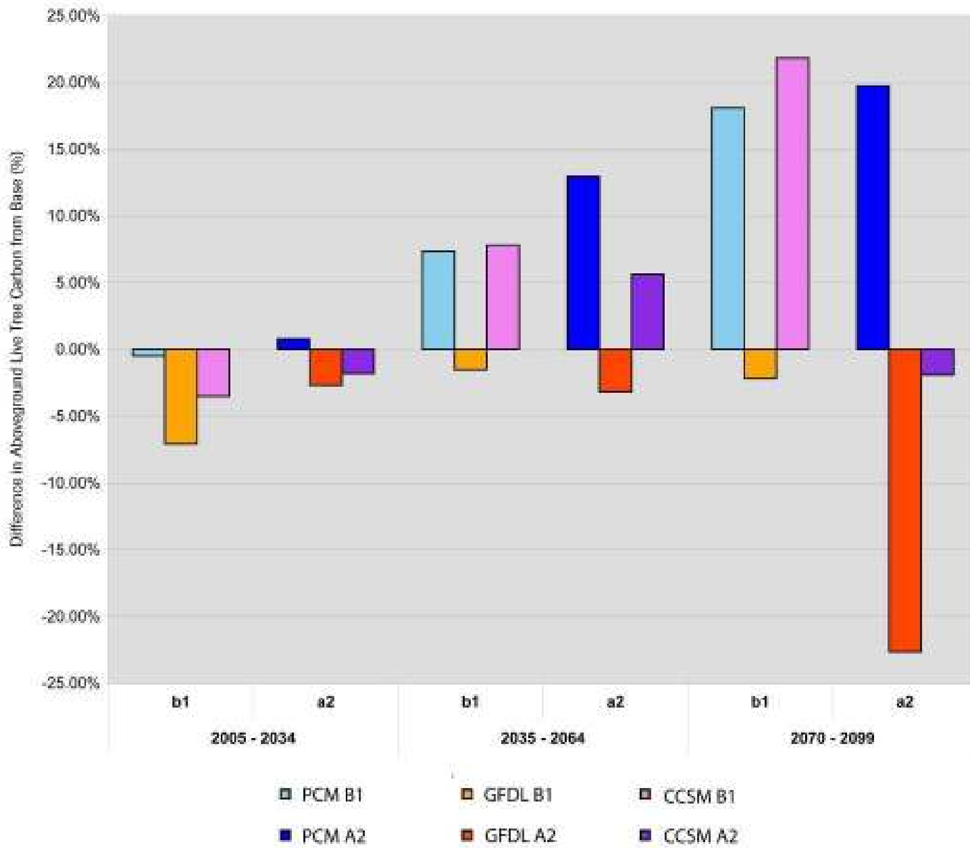

Figure 25. Carbon sequestration scenarios. The warm, wet PCM model shows a consistent increase in forest carbon under both emissions scenarios by the end of the century under both scenarios. The hot, dry GFDL model, under the A2 scenario shows a decrease of 22% by the end of the century, while the hot, dry CCSM model shows a mixed response by the end of the century.

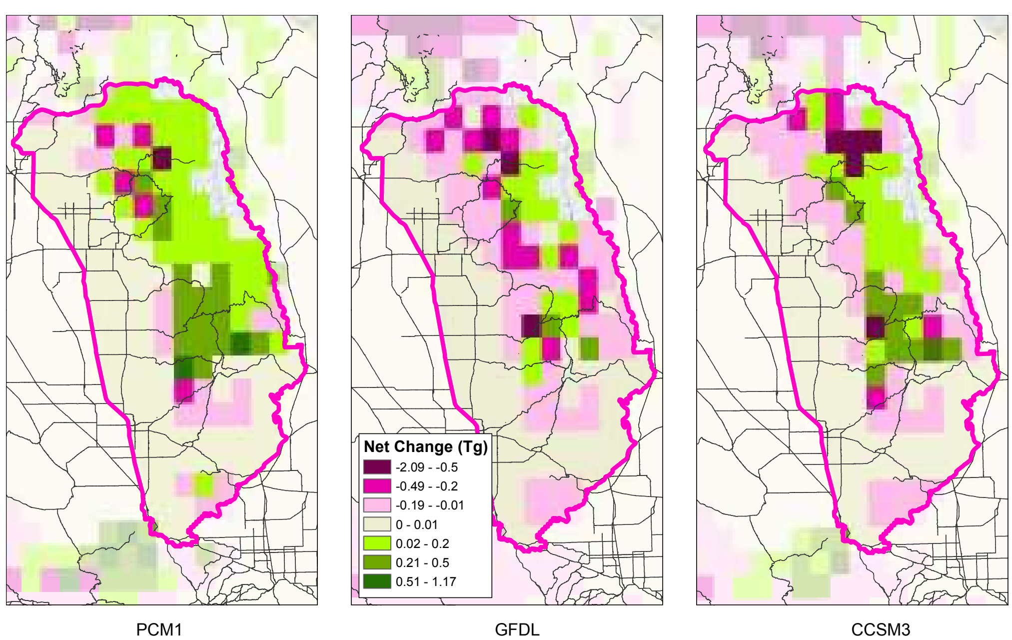

Figure 26. Carbon net change. The hot, dry GFDL model shows a more pervasive decrease in carbon throughout the region with only a few cells showing a net increase.

Changes in Streamflow

Using results from models run for major California rivers to project changes in streamflow, the net changes (compared to 1961-1990) in monthly flow for the Kings River and Upper San Joaquin River are significant with higher streamflow in the later winter in three of four model-scenario combinations and decreases in summer flow in all four combinations (Figure 27). This pattern of difference in the hydrograph is due to increases in the amount of precipitation falling as rain in the winter compared to snow.

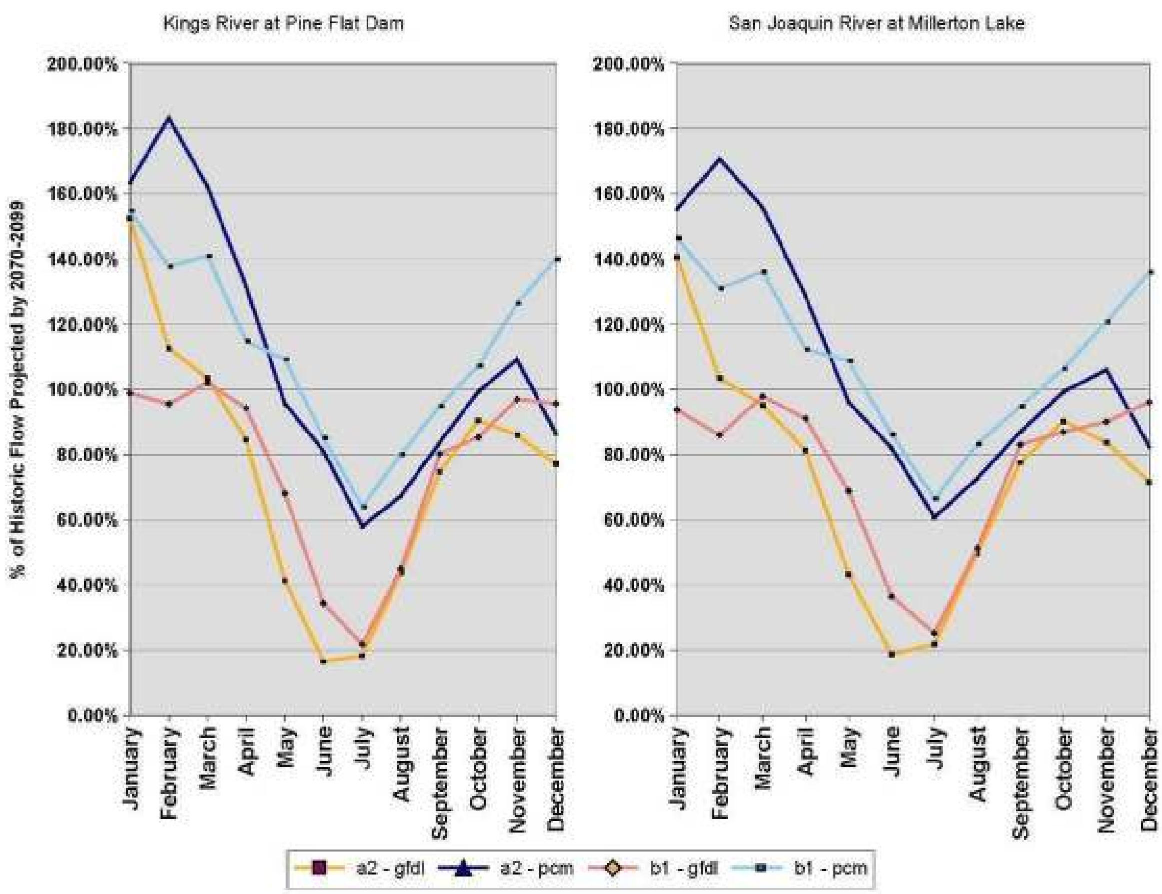

Figure 27. River change over time. Warm wet and hot dry models show similar flow patterns. Higher temperatures and lower snow pack will result in earlier snowmelt and longer summer droughts, reducing water availability when it is most critical.

5.0 DEVELOPING A REGIONAL CONSERVATION DESIGN

The regional design provides a vision for conservation in the region that takes into account the current distribution of targets and threats as well as the projected effects of climate change. By identifying a network of priority conservation areas, anchored by existing conserved lands, the regional design can help align conservation and management efforts on both public and private lands.

Key steps in the regional design included:

1. Map the distribution of conservation targets.
2. Set quantitative representation and replication goals. Characterize the suitability of areas for conservation, based on intactness or anthropogenic disturbance.
3. Factor climate change into the design by (a) incorporating species distribution models for vegetation systems under different climate models and (b) including physical features in the landscape that promote resilience in targets and will likely enable adaptation.
4. Use a site-selection tool to assemble efficient networks that meet goals in areas with the highest suitability for conservation, given current and emerging threats.

We used the site-selection tool Marxan (Ball et al. 2000) to identify areas that will contribute to short- and long-term viability of the chosen targets and provide the maximum co-benefits for ecosystem services. We defined site-selection criteria to guide the initial selection of areas, then used design criteria to integrate these priority areas into the regional conservation design (see box).

We developed a land use change analysis to assess how irreversible threats, such as development, may impact the regional design in coming decades. This assessment used existing zoning information for Fresno, Tulare, and Kern counties to assess what parcels are currently undeveloped, but able to be developed. In addition, we mapped all of the specific plans in the counties as a proxy for areas where steps toward development proposals have been taken. Appendix C includes details on the methodological decisions and conceptual basis for the regional design

Site-selection criteria

- Relatively intact areas with low fragmentation
- Areas within or adjacent to existing protected lands
- Areas buffered from converted or highly degraded land uses
- Features or areas that promote adaptation to climate change

Regional design criteria

- Representative: encompass full range of variability and full complement of biodiversity
- Redundant: include multiple examples of targets stratified across biophysical gradients
- Efficient: build on existing network of conservation lands
- Resilient: large enough to withstand disturbance, environmental change, and provide refugia
- Connected: maintain connectivity at multiple spatial and temporal scales for species, ecological processes.
- Restorative: include opportunities to restore degraded habitats or create new (although this criterion is better addressed at a finer scale, it is included here because it is important over longer time periods.

5.1 INCORPORATING VEGETATION

As described in Section 4, we used the USFS/CDF Calveg vegetation data (http://www.fs.fed.us/r5/rsl/projects/classification/system.shtml) to map the distribution of vegetation communities across the planning area and assess the percentage of the community represented within conserved lands. These data were used to help define future conservation goals for each target and to assess the level of conservation needed for long-term viability.

5.2 SETTING REPRESENTATION GOALS

We divided the planning area into subregions (shown in Figure 2 elevation map) to ensure that the conservation priorities would be distributed across major biophysical gradients, using the ecological subsections mapped by Goudey and Smith (1994). For each vegetation target we set percentage "representation" goals for how much of each target should be prioritized for conservation within each subregion (Appendix C). Conservation goals were based on the rarity, historic degradation, or loss of each target relative to the project area as a whole, the level of existing conservation management for that target within the project area, and the necessary level of representation to maintain viability. More common and widely distributed targets that have not undergone extensive conversion were given relatively lower goals for conservation, and targets that are limited in distribution were assigned higher goals. For example, riparian and wetland habitats were assigned relatively high conservation goals because of historic losses and degradation of these communities. These systems will become even more critical for natural water storage and flood attenuation under changing climate projections. Ecosystem services were given the same goal as the majority of the vegetation communities.

Given the uncertainty associated with both the necessary level of representation to maintain viability and the response of targets to the increasing rate of climate change, we established two sets of goals (low, high) to bracket the range of what is likely sufficient to conserve targets in the face of uncertainties (Table 7).

Table 7. Representation goals.

Target Group	Low Goal	High Goal
Vegetation Systems	30%	50%
Grasslands	40%	60%
Wetland and Riparian	60%	90%
Rare plants substrate	60%	90%
Rare, unique or imperiled species (NDDB)	60%	90%
Ecosystem Service	30%	50%

To have future conservation actions build on past conservation and to improve the viability of existing protected lands, we used selected existing protected lands (public or private, fee or easement) as kernels for larger, future conservation areas by "locking-in" these areas into the final set of selected planning units. We kept the number of locked-in conservation lands to a minimum to allow the model to establish intact conservation areas independent of current land ownership. We did this because much of the foothills has very low levels of formal protection but is still in large private ownerships. We locked-in all conservation easements in the region and those fee lands that were in private, local or state ownership that have conservation as a primary goal of management. The full list of areas is shown in Appendix C.

5.3 DEFINING SUITABILITY

To guide the selection of sites toward more intact landscapes, we defined the suitability, or cost, layer as a function of road density, intensive agriculture, and housing density (Figure 28, Appendix C). This forces Marxan to preferentially select areas that are more intact and thereby more "suitable" for enduring conservation success.

Photo credit: Hilary Dustin

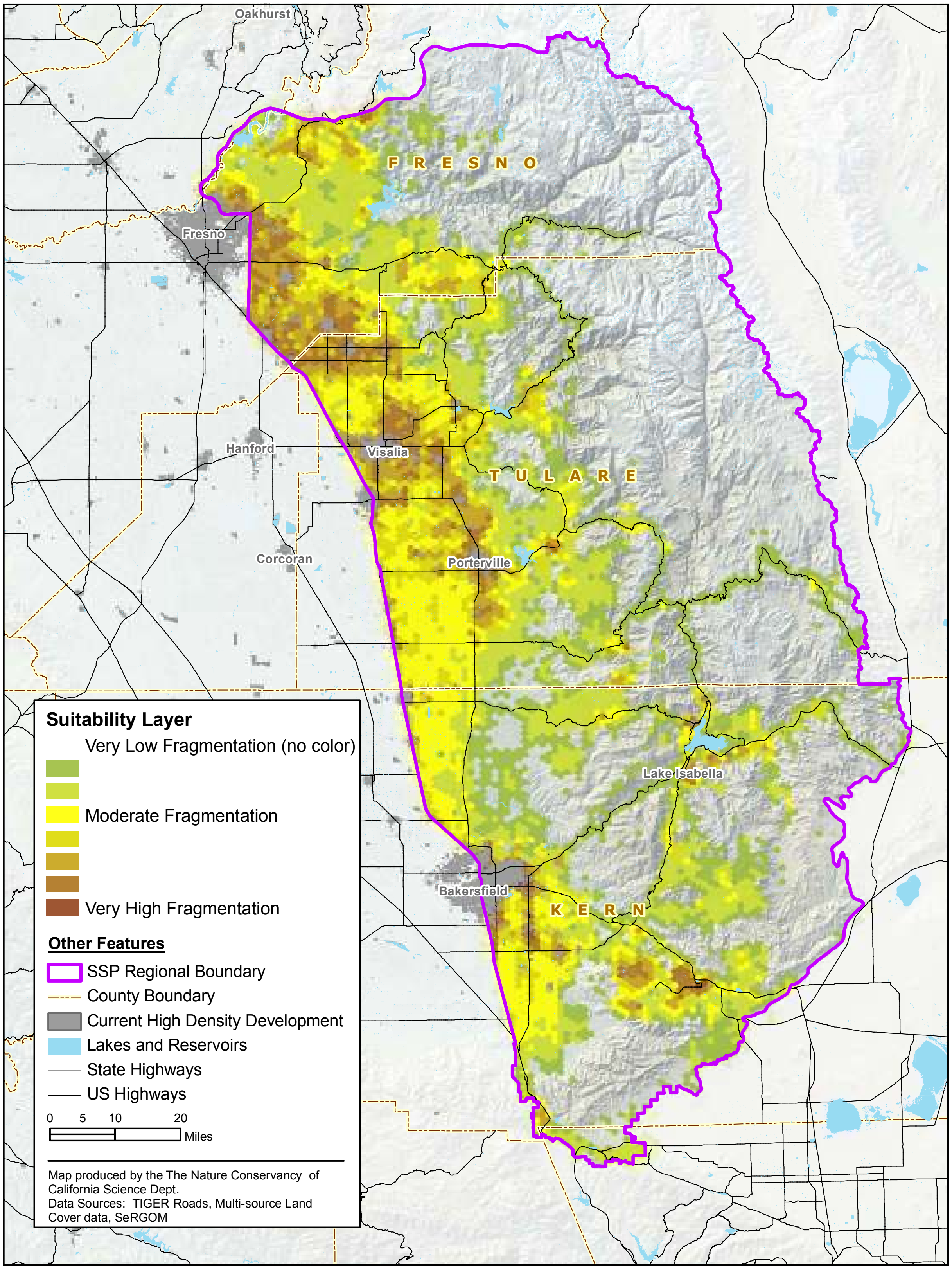

Figure 28. Suitability index used for regional conservation design combines current road density, intensive agriculture, and housing density.

5.4 INTEGRATING CLIMATE CHANGE INTO THE REGIONAL DESIGN

Explicitly factoring in climate change impacts and adaptation into the selection of areas for the regional design was a stated objective in the planning process and an area of innovation that we discussed at length. The overall objective was to ensure that the areas we selected would have the highest resilience and would enable adaptation of targets to a changing climate. We implemented this objective using a multi-scale approach. At the broader scale, we overlaid the current mapped distributions of the vegetation targets with the species distribution model results (discussed in Section 4.3.3) to assess what parts of targets' current distributions are projected to be stressed versus stable. We set higher goals for the stable areas and lower goals in the stressed areas for the climate-adapted scenarios, with the assumption that stressed areas will continue to play an important role in the ecosystem and will be important to connect with potential *refugia* (Table 8). The planning team felt that adjusting representation goals based on projected climate effects was an efficient and balanced way to integrate these data into our selection of regional priorities. It is interesting to note that 55% of the oak woodlands target is projected to be stressed while 29% of the conifer forest is projected to be stressed.

Table 8. The amount of current target distribution by climate change projection from the species distribution models (Section 4.3.3) The goals are those that were used for the climate-adapted site selection scenarios. The parts of the current range of targets where model agreement was lower received the default goals shown in Table 8 for the climate-adapted runs.

SSP Target Group	SDM Status	Total Areas (Ac)	Current Target Area (Ac)	% of Current	Low Goal	High Goal
Oak Woodlands	Low Agreement	111,024	505,229	21.97%	30%	50%
	Stress	279,537		55.33%	25%	45%
	Stable	111,422		22.05%	45%	65%
Semi-arid Montane	Low Agreement	100,821	700,858	14.39%	30%	50%
	Stress	109,295		15.59%	20%	40%
	Stable	486,929		69.48%	40%	60%
Alpine and Subalpine	Low Agreement	67,337	254,372	26.47%	30%	50%
	Stress	17,069		6.71%	20%	40%
	Stable	167,649		65.91%	40%	60%
Desert Scrub	Low Agreement	65,373	154,313	42.36%	30%	50%
	Stress	88,929		57.63%	25%	45%
	Stable	11		0.01%	45%	65%
Conifer Forest	Low Agreement	194,753	1,634,784	11.91%	30%	50%
	Stress	478,350		29.26%	20%	40%
	Stable	957,473		58.57%	40%	60%

At a finer scale of analysis, we expect that certain areas in the landscape will provide *refugia* from increasing stress caused by temperature or drought conditions and increase the resilience of the targets near these areas. These "landscape resilience features" are defined by physical and hydrological properties of the landscape (Table 9). In the climate adapted site-selection scenarios, we modified the suitability layer based on the degree of overlap with the resilience features to select areas that have higher values for resilience features when all other factors are equal. Appendix C describes the data, processing steps, and results.

Table 9. Landscape resilience features used to discount the suitability layer in the adaptation scenarios.

Resilience features	Assumptions
Temperature gradients- average slope of January minimum temperature	Areas with steeper temperature gradients will facilitate access to suitable climate
Topographic moisture potential (amount per planning unit)	Areas that are topographically likely to accumulate or hold water will buffer temperature and drought stress
Distance from perennial water/key riparian corridors	Habitats and species closer to perennial water will have lower drought stress

5.5 ALLOWING FOR CONNECTIVITY

The regional design process helps to identify areas that allow connectivity across habitat types, physiographic regions, and land ownerships, especially for wide-ranging and migratory species. Preserving connectivity in this region is critical to support wildlife population viability, maintain critical ecological processes, and mitigate the negative effects of fragmentation. Wildlife move within and between suitable habitat for many reasons at multiple spatial and temporal scales. In addition, maintaining movement pathways for plant species' seed dispersal and longer-term range shifts is important for long-term viability under a changing climate. Given this, it is important to maintain connectivity within and across multiple habitats and across latitudinal, elevational, and climatic gradients.

It is beyond the scope of this planning process to model the distribution of habitat and movement needs for focal wildlife species, as has been done in the Tehachapi (Penrod et al. 2003). This study was helpful in defining broad areas important for multiple focal species and possible options in maintaining movement between large public land blocks. While the modeling efforts define a statistically efficient linkage between two defined areas based on habitat and permeability factors associated with different land uses, there are often many movement options in an intact landscape. Currently, much of the region is intact, particularly at higher elevations. Yet, much of the intact rangeland and desert scrub habitat in the privately-owned lower elevation areas could undergo fragmentation in the coming decades due to infrastructure development (renewable energy, transportation) and residential development. There are several large privately owned lands between public lands that provide connectivity (i.e., Tejon Ranch), and some known north-south movement barriers in the foothills associated with developed areas and state highways.

There are several ways in which the regional conservation design incorporates habitat connectivity.

1. **Suitability layer and Marxan settings:** The suitability, or cost, layer reasonably represents intactness in this region at a broad scale. Areas that have higher suitability scores were preferentially selected over areas that are more degraded. In addition, the model promotes clumping of selected areas to minimize edge habitat in conservation areas.
2. **Subregions:** By forcing Marxan to select areas across major physiographic zones to meet representation goals, the regional conservation design promotes connectivity across environmental gradients.
3. **Riparian connectors:** Riparian areas in this region provide movement pathways for fish and wildlife, nutrients, and water. Because they are often the only habitats in the valley floor and foothills with adequate natural cover, they serve the movement needs for larger animals. We included perennial and other streams and rivers identified as important in other planning processes to provide east/west and elevational connectivity in the region.
4. **Expert input, other studies**: We added planning units as the top priority (core areas) in the regional design that are known to be important for wildlife movement, based on field observations, feasibility, and other factors.

5.6 SYNTHESIZING AND INTEGRATING GOALS AND SCENARIOS

By running site-selection scenarios at each of the two goal levels, with both current and climate-adapted inputs, we generated four regional designs that were synthesized into one set of priorities. By integrating the different scenarios we were able to focus the priorities to those areas that are important no matter what the goal level or the planning horizon. We assigned planning units into three different levels of conservation priority based on the frequency of selection across all four scenarios according to rules defined in Appendix C.

Given that the site selection runs were based on GIS data and thus could not fully account for conservation values in the region, we reviewed and edited the priority areas using expert input based on knowledge of specific areas. We also edited the set of planning units to simplify the design and consolidate areas for the same priority level, reducing the Marxan artifacts that don't contribute to implementation feasibility. Appendix C includes a map of areas changed through this process and a description of the changes.

5.7 REGIONAL CONSERVATION DESIGN

The regional design is presented as a long-term vision for conservation based on what we know today about the distribution and status of our targets, and how we expect them to respond to increasing rates of climate change (Figure 29). Yet, the regional design is not meant to be a definitive recipe for success or an immutable set of priorities.

As a set of priority areas that were derived from a systematic, transparent and repeatable process, the regional design serves as an initial hypothesis of what it will take to conserve the natural systems of the region in the face of climate change. It is a geographic expression of our assumptions about what is sufficient to maintain the viability of our targets and specific inputs regarding replication (subregions), representation (goals), landscape permeability (suitability).

We addressed these factors in the same way independent of current land management and ownership, yet we need to view the regional design priorities in light of their current level of protection and conservation management. Because our representation goals range from 30 – 60% for major vegetation targets, only a subset of the large federal land units managed by the National Park Service, Forest Service, and Bureau of Land Management were selected. Even though not all public lands are shown as priorities, we strongly emphasize the importance of land management activities in sustaining the biodiversity of the region on all public and privately-conserved lands, not just those in the priority areas of the regional design. We consider the public and privately protected lands that provide the matrix for the regional design just as high a conservation management priority as any of the lands shown in the three tiers of priority in Figure 29.

The priority areas shown on the map represent how different parts of the regional can contribute to a network managed for ecosystem resilience. It is not a plan for public or private land acquisition, nor is it meant to imply that areas in clue should be subject to increasing regulatory constraints. The SSP strongly respects private property rights and would only engage willing landowners in conservation projects.

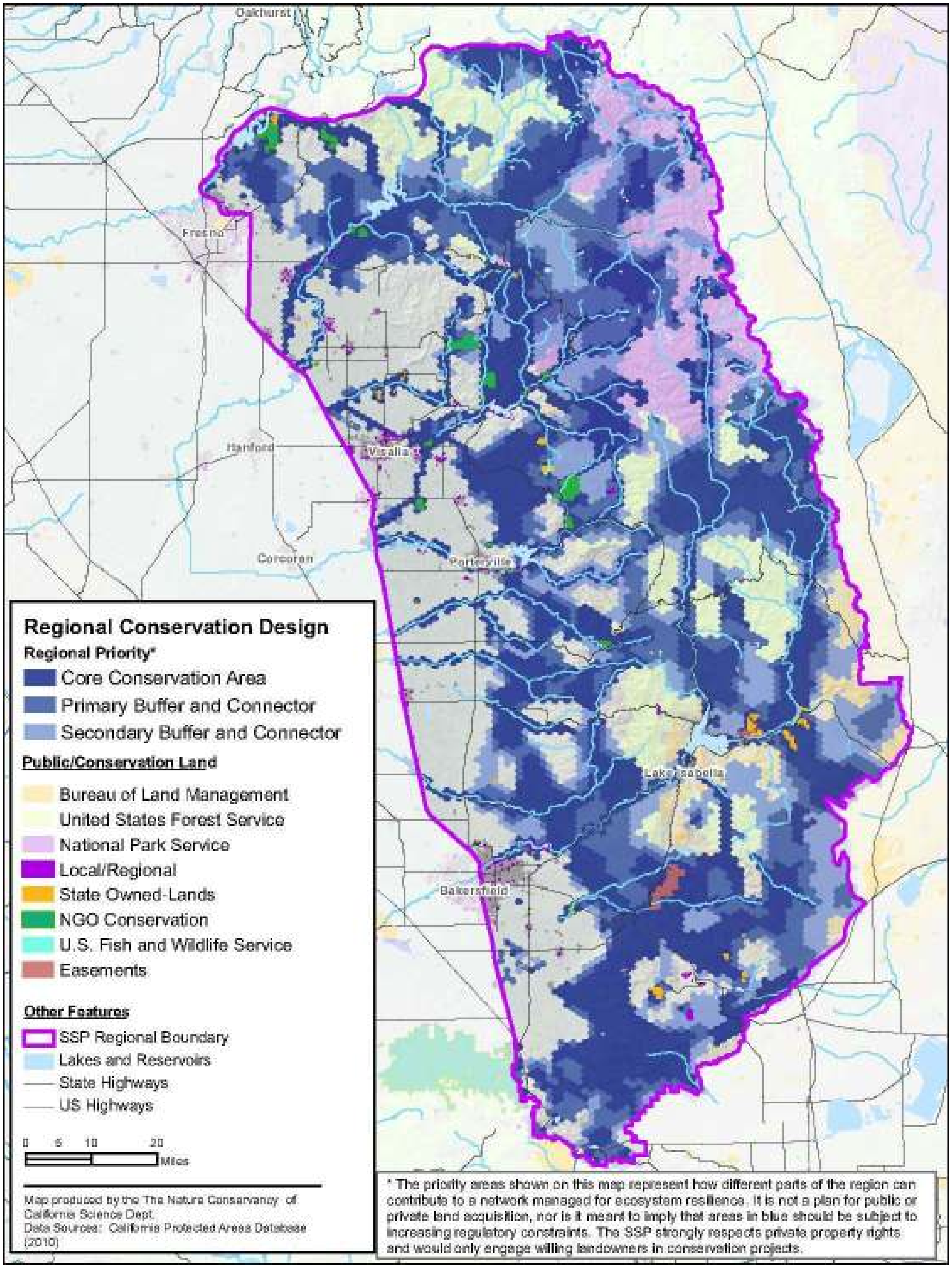

Figure 29. Regional Conservation Design. This regional design serves as a hypothesis of what it will take to conserve the natural systems of the region in the context of a changing climate. The priority areas shown on the map represent how different parts of the regional can contribute to a network managed for ecosystem resilience. It is not a plan for public or private land acquisition, nor is it meant to imply that areas in blue should be subject to increasing regulatory constraints. The SSP strongly respects private property rights and would only engage willing landowners in conservation projects.

The implementation strategies necessary for conservation will vary based on current management. For example, the 46% of core conservation areas in areas already in some sort of conservation management will require a different set of strategies from the 54% on private land (Table 10). A range of strategies on private lands from acquisition of land from willing sellers to support for state and federal policies that fund voluntary private landowner stewardship and restoration projects will help maintain the ecological values of the areas in any shade of blue on the map. On public lands, a similarly broad range of strategies will be needed to conserve target systems and species, tailored to, and aligned with, the management objectives and missions of different agencies and within the context of existing administrative guidelines and laws.

Yet, one of the primary benefits of the regional approach is the alignment of effort and investments across public and private lands and jurisdictions in the region. As such, we hope that this design serves as a focal point in the conversation among the various stakeholders in the region about how to conserve the exceptional ecosystems of the Southern Sierra and Tehachapis in the face of accelerating threats, including climate change.

Table 10. Regional conservation design results by level

Regional Priority	Sum Area (Ac)	Area in Public/Private Conservation (Ac)	% in Public/Private Conservation	% of Total Region
Core Conservation Areas	2,294,630	1,044,981	46%	33%
Primary Buffer and Connector	1,015,787	606,701	60%	14%
Secondary Buffer and Connector	900,315	604,983	67%	13%

5.8 EVALUATING ECOSYSTEM SERVICES IN THE REGIONAL DESIGN

Incorporating ecosystem services into the planning approach is a primary objective of this assessment and the SSP's conservation objectives more generally. As such, it is important to evaluate how well our set of conservation areas represents the areas important for the production of these services. Because different ecosystems produce different services in many cases, we wouldn't expect a high degree of overlap between all services provided by a large region, yet we would expect intact, functional ecosystems to provide multiple services. Also, it is important to note the beneficiaries of the services, or those communities that share in the benefits of the services produced are distributed at very different geographic scales. For example, the uptake of carbon from the atmosphere that is stored in woody biomass is a service that benefits the whole world, while forage production has a more local set of beneficiaries such as the ranchers that operate the ranches or the consumers of the beef. Services such as aquifer recharge benefit a more diffuse region defined by groundwater basin or major river system. While considering the economic value and flow of services to beneficiaries is critical in designing conservation strategies, we focus our analysis on the degree to which the priority areas in the regional design capture the most important areas for service production.

The amount of overlap between service production and the priority areas is quite high with at least 30% representation in all but a few cases. Aquifer recharge is highest in the Valley floor-foothills transition subsection (Hardpan Terraces), but has only 32% of the total value represented in the priority areas. This is due to the predominance of intensive agriculture in this subsection, a detractor in our site selection. Forest carbon is picked up at least 45% of the time in each subsection, with over 70% of the carbon in priority areas in the subsection with the largest amount (Upper Batholith). Similarly, forage production is well-captured in each subsection with at least 37% of the total within priority areas.

Photo credit: Susan Antenen

These results suggest that our regional design overlaps with areas important for services to a large degree. It's important to emphasize that these results are specific to the services that we analyzed and would not be expected for all services (e.g. agricultural production). Also, the degree to which services and our biodiversity targets respond similarly to management actions would be varied and complex. For example, managing only for forest carbon storage and sequestration may limit ecological resilience or habitat values. Also, managing an area to maximize aquifer recharge may lead to degradation of the natural vegetation communities.

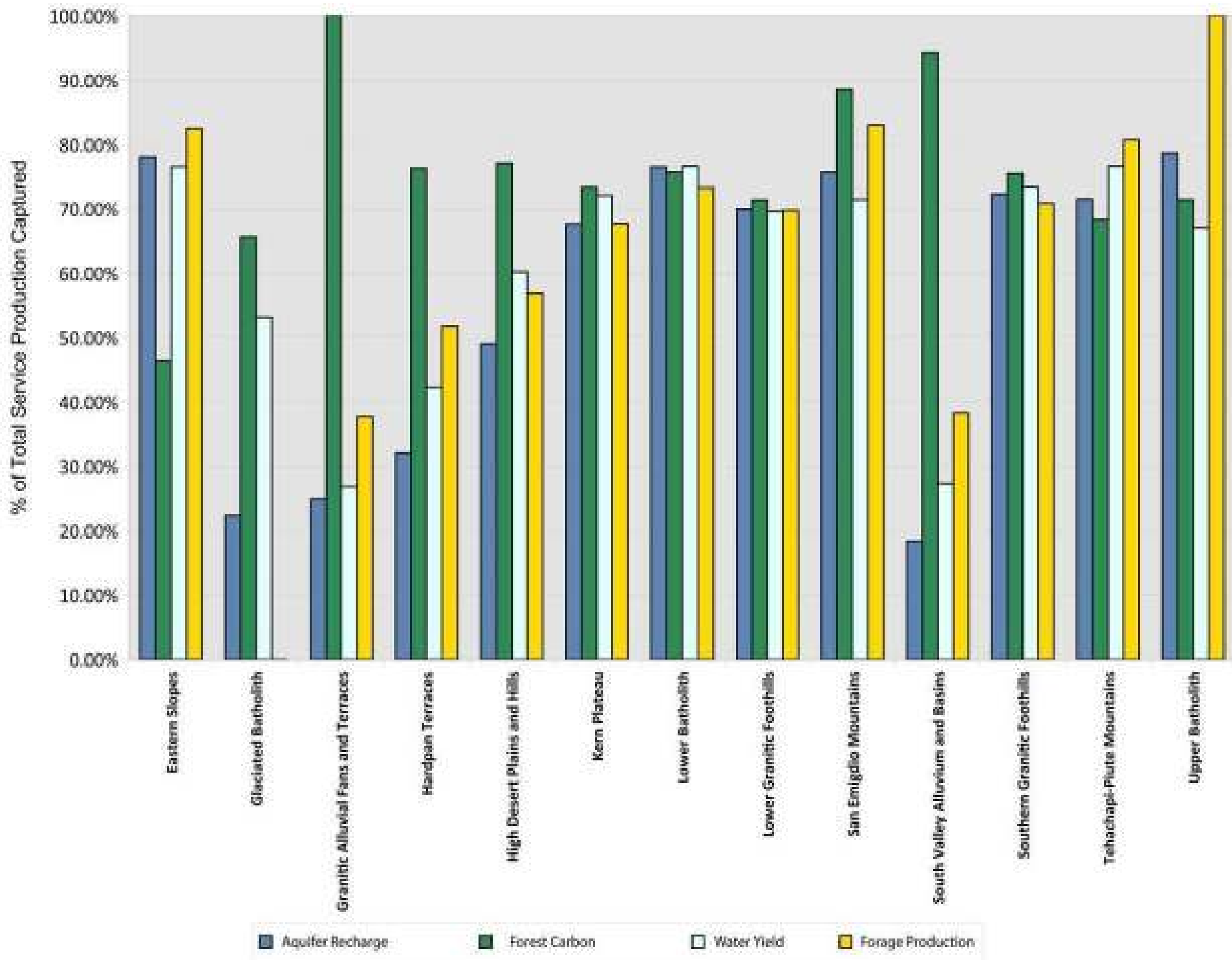

Figure 30. Ecosystem services captured by subregion in the regional conservation design. The overlap between service production and priority areas is high.

5.9 ASSESSING POTENTIAL LAND USE IMPACTS

A more immediate threat to biodiversity than climate change is habitat loss due to residential and commercial development. This is especially the case in the foothills that are now primarily rangelands in private ownership, but with a high potential for conversion to low density rural residential housing or high density housing developments. To anticipate which areas will be most likely to undergo this transition without active intervention, we identified the parcels in each county that are currently undeveloped, but are zoned to allow for residential development. We also mapped areas that have or are undertaking a specific plan as a follow-up to the general plans in the counties, assuming that a specific plan will precede development proposals. Figure 11 shows the areas highlighted as part of this analysis overlaid on the regional design. This clearly demonstrates the importance of land use planning as a key strategy to implement the climate-adapted conservation vision.

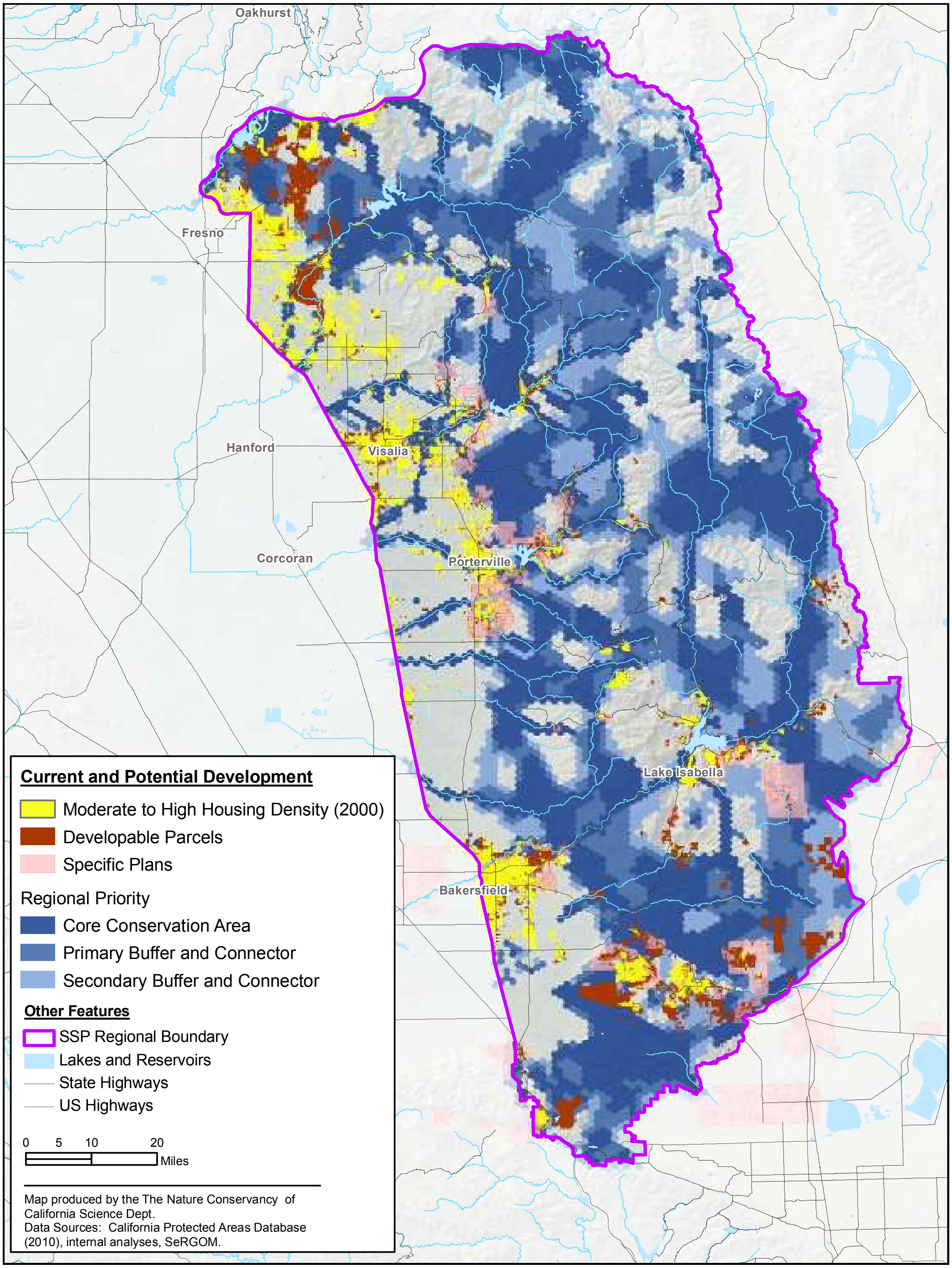

Figure 31. Regional conservation design and land use impacts based on current zoning and proposed projects. Agricultural lands, foothills, aridlands, and riparian corridors are the most affected.

6.0 CONSERVATION VISION

6.1 Regional Conservation Vision

Our vision for the southern Sierra and Tehachapis in the twenty-first century builds on the accomplishments of previous generations of conservationists. In the future we envision the region's natural areas benefit from cooperative, adaptive management across public and private lands. The national parks, national forests, and wilderness areas are able to sustain their rich biodiversity and valuable ecosystem services in the face of climate change and other threats through the protection and restoration of natural processes.

In our vision the 2.8 million acres of public lands are embedded within the larger, functional landscape which encompasses the extensive foothills, Tehachapi Mountains, and fertile Valley. A network of buffered core areas and natural lands across all elevations, as illustrated in the Regional Conservation Design, creates a broad canvas for climate adaptation.

Restored streams and riparian corridors run through the foothills and across rich agricultural lands to the vital wetlands of the San Joaquin Valley. Ecologically and economically sustainable working ranches provide livelihoods and maintain one of the region's traditional ways of life.

Conservation agreements and acquisitions safeguard key properties in the Sierra foothills and Tehachapi Range, protecting on-going evolutionary processes and preserving the only remaining natural linkage between the Pacific Coast and the Sierra Nevada landscape. Public agencies, landowners, local citizens, and non-governmental organizations work together to protect this majestic landscape, which provides benefits to nature and humans alike.

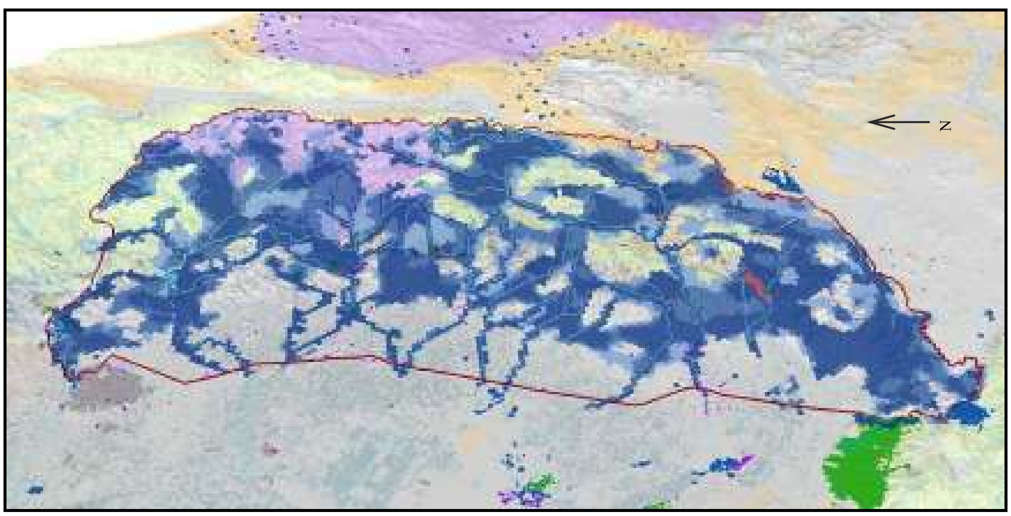

Figure 32. Regional Conservation Design. See figure 29 for map legend. Building on the core of public land in the mountains and conservation land in the foothills, this design presents a vision for preservation, management and restoration activities across ownership. Maintaining connectivity across habitats, elevational and other physical gradients, areas in blue represent an efficient, yet ambitious long-term conservation vision that accounts for the projected effects of climate change. It is not a plan for public or private land acquisition, nor is it meant to imply that areas in blue should be subject to increasing regulatory constraints. (The SSP strongly respects private property rights and would only engage willing landowners in conservation projects.)

6.2 CONSERVATION OPPORTUNITIES

While diverse threats, including climate change, are likely to lead to environmental change of unprecedented pace and scope, our analyses project conditions favorable to supporting climate adaptation in the southern Sierra. Other factors in this region will contribute to long-term persistence of high conservation values.

The southern Sierra's intactness and environmental variability, combined with steep topography and geological diversity, enhance ecological resilience and increase the likelihood of successful climate adaptation by most species. Resilience is the ability of the ecological system to absorb disturbance while retaining the same basic structure and way of functioning (IPCC 2007). While ecological change is inevitable, we expect most systems and species within the region to shift and persist over the next 50 years. Our model projections indicate climatically stable zones for common trees, shrubs, and habitats within their existing ranges. On average, this project's climate projections for many tree and shrub species show more stability and less climate stress in the southern Sierra than that found statewide (Appendix E). The sharp vertical relief of the region makes it possible for species to access significantly different climatic regimes by moving only a short distance. Average annual daily maximum temperatures within the southern Sierra region span a remarkable range from 16° to 58°F. Mount Whitney and the 117 peaks greater than 13,000 feet tall are more likely to retain year-round snow pack in a warmer climate, which should moderate the seasonal extremes in stream flow and saturation of riparian soils.

The scope and diversity of public and private conserved lands (more than 40% of the planning area) offer an exceptional opportunity to experiment with innovative adaptive management practices at a meaningful scale. Privately conserved lands in the Tehachapis, San Joaquin Valley, and Sierra foothills complement large public holdings in the mid to high elevations of the Sierra Nevada.

Large, private ranches dominate ownership in the Sierra foothills and Tehachapis, with more than 44 ranches greater than 5000 acres. These private lands are now and will continue to be extremely important for biodiversity and ecosystem services. They span elevational and latitudinal gradients and contain riparian corridors and other features which support climate adaptation. In addition, they buffer the federal and state public lands and private nature reserves. Their scale and function in preserving landscape intactness highlight the critical role of local ranchers and the need to provide incentives and support for compatible rangeland and riparian management.

The landmark Tejon Ranch Conservation and Land Use Agreement, if implemented, will permanently protect the majority of the western Tehachapis and enable preservation of the ecological linkage between the coastal range and the southern Sierra Nevada. The Tejon Ranch Conservation and Land Use Agreement, signed by five conservation organizations[3] and Tejon Ranch, dedicates up to 178,000 acres of conservation easements in relation to planned developments and allows the purchase of up to an additional 62,000 acres. The acquisitions will

[3] The Sierra Club, Natural Resources Defense Council, Audubon California, the Planning and Conservation League and the Endangered Habitats League

codify the Tejon Ranch Conservancy's role as land steward which opens the way for large-scale adaptive grazing and riparian management studies. Implementation of the Tejon Agreement will leave only a few miles of unprotected lands between Tejon and the Sequoia National Forest. Efforts are underway to close this gap, which will secure the Tehachapi linkage and preserve vital landscape-scale ecological processes.

There is growing momentum towards cooperative science and conservation in the region and an opportunity to mobilize cooperative management, research, and monitoring. New formal and informal conservation partnerships are being formed from interagency initiatives, public-private alliances, and consortiums of non-governmental organizations, such as the Southern Sierra Partnership. Some are explicitly incorporating climate change into their considerations and priorities. Examples include:

- In 2009, three federal agencies[4] crafted a "Strategic Framework for Science in Support of Management in the Southern Sierra Nevada Ecoregion." This joint agreement creates a conceptual guide to priority science information needs to inform their collective response to climate change effects of ecosystems in the southern Sierra. (http://www.fs.fed.us/r5/spotlight/2009/snfframework.php) To address the key issue of fire and climate change, an Interagency Southern Sierra Nevada Fire Science Working Group is now established to examine climate scenarios and assess risk.

- The SSP's assessment process has already catalyzed new public-private discussions. The federal agencies which established the aforementioned Strategic Framework have joined with the Bureau of Land Management, Sierra Nevada Conservancy, and the SSP to establish a Southern Sierra Conservation Cooperative (SSCC) intended to enhance cooperative learning and coordinated action. The mission is to "leverage partners' resources and efforts to conserve regional native biodiversity and key ecosystem functions within the southern Sierra Nevada ecoregion in the face of accelerated local and global agents of change."

- The Southern Sierra Integrated Resource and Water Management Planning Program (SSIRWMP) has assembled diverse stakeholders, officially defined their large project area, and is in phase I of creating a non-regulatory planning document that will identify broadly-supported goals and objectives pertaining to water supply, water quality, habitat and environment, recreation, and land use. This will be a key program for distribution of state water conservation funds.

- In addition, legislative and agency mandates and funding priorities are converging around the themes of climate change and landscape-level collaboration. This creates new opportunities for public-private partnerships as well as enables conditions for conservation in the region.

[4] Memorandum of Understanding between Sequoia/Kings Canyon National Park, US Geological Survey – Western Ecological Research Center, USDA Forest Service--Pacific Southwest Research Station and Sequoia National Forest/Giant Sequoia National Monument

The SSP Framework reinforces the findings of other ecosystem assessments. This is strong base of planning and prioritization supports the transition into cooperative conservation action.

- In 2003, South Coast Wildlands developed a connectivity design for the Tehachapis based on 34 species (South Coast Missing Linkages: A Linkage Design for the Tehachapi Connection; http://www.scwildlands.org/reports/SCML_Tehachapi.pdf).
- The California Rangeland Conservation Coalition conducted a biological prioritization of California's rangelands and produced a map of areas critical for grass and woodland-dependent systems (2007) (http://www.carangeland.org/Files%20to%20Link/Focus%20Area/Rangeland%20Coalition%20Focus%20Area.pdf).
- The Tulare Basin Wildlife Partners Working Group has evaluated riparian and aquatic restoration and protection opportunities and developed vision and comprehensive plan for restoring the Tulare Basin in the southern San Joaquin Valley (2009). (http://tularebasinwildlifepartners.org/documents/TBWPconservationvision072110.pdf)
- Most recently, the California Department of Transportation led the Essential Linkage Analysis to identify and map large habitat blocks and important linkages between them (2010). (http://www.dot.ca.gov/hq/env/bio/program_efforts.htm)

6.3 CONVERTING OPPORTUNITIES INTO ACTION AND ADAPTATION

While the assessment process confirmed that traditional conservation strategies still apply in the face of climate change, i.e. protect interconnected blocks of representative habitats and maintain natural processes; however conservation actions must be accelerated and be implemented within an "adaptive management" and regional framework.

Climate adaptation strategies will evolve as we gain greater understanding about the synergies between climate change and other threats and the ecological response. The SSP proposes five strategic approaches which will help abate threats, support multiple climate scenarios, and maintain flexibility over time. All of them emphasize collaboration and leverage of resources.

1. Prevent landscape fragmentation and enhance ecosystem resilience of the Sierra Foothills and Tehachapis

- Provide incentives, funding, and technical support to help willing ranchers voluntarily adjust their rangeland management practices to changing conditions, including control and prevention of invasive species.
- Acquire easements and/or fee title from willing sellers of 6-8 priority properties to fill in missing linkages and capture key gradients (in addition to Tejon).
- Engage with Tulare County General Plan updates and Upper Kern General Plan update to incorporate provisions that minimize habitat fragmentation and designate core lands and linkages for conservation (including riparian corridors).

- Engage with Bureau of Land Management and the US Fish and Wildlife Service and others to conduct a Tehachapi wind energy constraints and opportunity analysis to avoid, minimize, and mitigate negative ecological impacts.

2. **Reconnect and restore functionality to riparian corridors**
    - Pilot at least two significant collaborative riparian restoration projects in the Valley designed to achieve multiple benefits such as floodwater capture for groundwater recharge, flood control, and enhancement of seasonal wetland habitat, riparian corridor connectivity, carbon sequestration, and scenic values.
    - Link interested farmers and ranchers to available technical and funding support to help them voluntarily restore 1000 acres of riparian habitat. Resolve issues related to endangered species which might move into the restored habitat.
    - Through the Southern Sierra Integrated Resource and Water Management Program (SSIRWMP), collaboratively develop and implement integrated watershed management plans and leverage State funding for their implementation.

3. **Manage for ecosystem resilience on public lands.**
    - Assess and adaptively manage priority species and individual Parks, Forests, and Preserves within a regional context.
    - Address socio-political barriers to vegetation and fire management practices needed to abate the threat of intense, type-converting wildfires in the chaparral and mixed conifer systems.
    - Support public-private partnerships for conducting one significant adaptive forest management project designed to increase forest resilience to catastrophic fire, pests, and climate change
    - Elevate the importance of oak woodlands with stable climate areas on public lands and incorporate into regional monitoring.

4. **Marshall increased financial resources for implementing adaptation strategies.**
    - Engage with federal agencies and Congress to authorize and fund a national program that facilitates federal agency partnerships with non-federal entities to maintain landscape-scale connectivity essential to wildlife movement and adaptation of natural systems to climate change. The program would include federal grants to non-governmental organizations to purchase and manage conservation easements from willing sellers in the vicinity of federal lands. Establish a pilot project in the Southern Sierra under this new authority.
    - Design a policy initiative that creates a new funding stream from outside the Southern Sierra that contributes to protecting rangeland and aquatic resources and related ecosystem services within the region.

- Direct mitigation funding from three major development projects (e.g., high speed rail, major energy development project) to conservation priorities, and ensure that the development projects are sited to avoid and minimize impacts on biodiversity and ecosystem services.
- Align five public funding programs with regional vision and collaborative implementation.
- Secure a Cooperative Forest Landscape Restoration Act (CFLRA) grant for a forest management pilot project in the Southern Sierra.

5. Build community support for effective land and water conservation.

- Link biodiversity and ecosystem service conservation with social, health, and human welfare climate-adaptation challenges.
- Develop and implement outreach strategies and messages that increase public understanding of the issues.
- Increase public access for conservation-compatible recreation in the foothills.

Moving forward, the SSP will continue to broadly communicate a common vision for the future of the southern Sierra and provide a regional perspective in evaluating conservation and mitigation priorities. The SSP will engender collaboration among scientists, agencies, landowners, local government, businesses, water boards and utilities, and others to help align conservation and land use priorities and investment across watersheds and ecosystems.

Climate change – its scope and pace, and the uncertainty about how ecosystems will respond to it – fundamentally challenges conservation planning. Traditional assumptions and methods of setting priorities must be recalibrated to create new approaches and new methods for incorporating climate change into the conservation planning process. The Framework provides a real-world example of a climate-adapted conservation plan which can help move the conservation field beyond ideas and concepts toward implementation. To support on-going learning, the SSP presents more details about our planning approach and lessons learned in Appendix K.

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