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

Volume II - Appendix

Southern Sierra Partnership

Southern Sierra Partnership
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VOLUME II: APPENDIX

APPENDIX A:

SOUTH SIERRA CONSERVATION ACTION PLAN (CAP)

Introduction

In April 2009, the Southern Sierra Partnership initiated the process of conservation planning. Three teams were established to manage components of the assessment:

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

The two project areas used the Conservation Action Planning (CAP) methodology developed by The Nature Conservancy (http://conserveonline.org/workspaces/cbdgateway/cap/index_html). Each project team used the CAP process to identify the key ecological attributes, characterize current conditions, and assess threats for their 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 strategic approaches for the region as a whole.

Southern Sierra CAP Project Area Description

The southern Sierra CAP project area, for purposes of this analysis, encompasses the area south of the Kings River south to the Kern Valley and the Pacific crest west to route 99 in the Central Valley. It is topographically diverse with a 14,000' elevational gradient between the high peaks and the valley floor. Roughly half of the area is public lands in the mid to high elevations. The foothills which form a significant north-south band are predominantly private ranches. The Valley floor is now intensive agriculture and cities. Rivers and riparian corridors cut across the foothills and farmlands.

Southern Sierra CAP Analysis

This document is a rapid assessment CAP which does not include all steps of Conservation Action Planning process. It was used to inform the overall Framework and provide a first iteration of Key Ecological Attributes, threats assessment, and objectives and strategies.

TARGET	DESCRIPTION	Nested Target	Nested Target	Nested Target	Nested Target	Nested Target
Grasslands	Primarily Mediterranean annual species-dominated grasslands with diverse native forbs with <10% tree canopy cover located in the Valley floor up to 1000' elevation. Vernal pools and perennial alkali meadows are embedded in the grasslands.	Rare and endemic plant species, such as striped adobe lily and adobe sunburst	Grassland-obligate bird species, such as burrowing owl, horned lark, W. meadowlark	Kit fox		
Oak Woodlands	Foothill woodlands with more than 10% canopy cover, primarily blue oak with interior live oak, buckeye and foothill pine as significant components	Rare and endemic plant species such as Kaweah brodaiea, Springville clarkia	Acorn-dependent spp such as acorn woodpecker			
Mixed Conifer Forest	Mixed conifer forest from about 5,000 to 6,500 ft elevation; mix of shade tolerant and fire-dependent conifer spp, intermixed with black oak	giant sequoia	black oak	pine spp	Pacific fisher	
Sub-alpine & alpine communities	Red fir, lodgepole, foxtail pine, whitebark pine and other high elevation conifers; alpine shrubs and forbs	pika	gray-crowned rosy finch			
Chaparral	Shrub-dominated community from about 2000 to 8000 ft elevation?					
Riparian Communities	Riparian communities, including Valley oak woodland, sycamore alluvial woodland, mountain meadows	Mountain meadows	Sycamore alluvial woodland	Valley oak woodland	Endemic amphibians	Cavity nesting bird species, such as wood duck
Lakes, rivers and streams	Aquatic communities from Valley floor up to alpine headwaters of western Sierra	native trout	warm water fish assemblage	W pond turtle	water dep. birds - dippers, mergansers	
Migratory and wide-ranging wildlife	Species that have a large home range, migrate seasonally (e.g. elevational or latitudinal migrations), or migrate to breed/exchange genetic material (e.g. deer herds moving among watersheds)	CA condor	deer herds	migratory birds (especially neo-tropical migrants?)		

Target Viability Tables

Target	Key Ecological Attribute (KEA)	Indicator	Current Rank	Current Status	Desired Rank	Desired Status	Notes / Questions
Grasslands	Spatial area	Area of grassland	GOOD	Almost gone in Valley; 50% gone in foothills below 500' elevat, largely intact above 500' elevat.; total of XX acres in site planning area.	GOOD	Have protected remaining grassland in Valley, 80% of remainder in foothills below 500' elevat., 65% in foothills above 500' elevat.	Deleted N deposition KEA -- better handled as a threat (in so far as it affects spp composition and invasives). Verify existing and desired acres with spatial analysis.
Grasslands	Landscape integrity	Area and configuration relative to site potential	GOOD	Small remnants in Valley, moderately fragmented in foothills below 500' elevat; relatively intact above 500' elevat with good connectivity to oak woodlands	GOOD	Protected swaths of un-fragmented grassland that span from Valley floor to upper end of grassland range, and include riparian/wetland communities (streams, vernal pools)	Verify with spatial analysis. Mostly converted to intensive ag and urban uses in Valley; fragmented by subdivisions/ranchettes (many with horse fences) and conversion to orchards and dryland grain farming at lower elevat's of foothills; still mostly in large ranch-holdings at upper end of range .
Grasslands	Fire regime	Proportion of grassland with fire frequency departing from past range of natural variability (approx 17 yr FRI); combined with likelihood of severe fire	FAIR	Fire frequency higher in some areas due to increased human starts, but perhaps less area burned overall due to fire suppression and grazing (low fuels)	GOOD	75% of protected grassland burned on 20-yr cycle.	Rationale for including this KEA is that fire may have important ecological effects other than veg structure/RDM -- e.g. kill seeds of non-natives, release nutrients to soil. Do CalFire and county fire depts map grass fires or at least have acres-burned data? See also John Austin's comments re: perils of using FRID for grasslands.

Grasslands	Species composition & dominance	Relative cover of native vs. non-native plant species	FAIR	Mediterranean annual grasses dominant over vast majority of grasslands; still have good diversity of native forbs except in areas with continuous heavy grazing	GOOD	Representation of native grasses increased, diversity of native forbs maintained	What can we realistically measure or map across our large planning area?
Grasslands	Invasive exotic species (plants & animals)	Extent and density of invasive exotic cover	FAIR	Moderate to heavy invasion by exotic thistle spp, poison hemlock, Bassia at lower elevations with repeated re-introductions in controlled areas; moderate invasion of thistles in upper elevations	GOOD	Invasive exotics limited to current extent/density or reduced	Lower elevation invaders = milk thistle, Russian thistle, star thistle, poison hemlock, Bassia, prickly lettuce. Upper grassland invaders mainly Italian thistle.
Grasslands	Soil stability & organic carbon gain	RDM and spatial extent of erosion features (e.g. gullies, slumps)	FAIR	RDM either very low (e.g. <300 lbs/ac) with erosion features common, or RDM very high (i.e. not grazed or burned) favoring undesirables like ripgut brome	GOOD	RDM averages 800-1200 lbs/ac over most of the area in most years; few erosion features evident	Spatial info available other than our general observations?
FINAL RANK			**FAIR**		**GOOD**		

Target	Key Ecological Attribute (KEA)	Indicator	Current Rank	Current Status	Desired Rank	Desired Status	Notes / Questions
Oak Woodland	Spatial area	Area of oak woodland	GOOD	Total of XX acres in site planning area	GOOD	Total of YY acres of oak woodland in site planning area	Verify with spatial analysis. Deleted N deposition KEA -- better handled as a threat (in so far as it affects spp composition and invasives).
Oak Woodland	Landscape integrity	Area and configuration relative to site potential	GOOD	Relatively intact throughout historic range with good connectivity to grasslands and mixed conifer forest	GOOD	Protected swaths of un-fragmented oak woodland that span from upper grasslands to conifer forest, and include riparian/wetland communities (streams, vernal pools); blocks of oak woodland connected by corridors allowing free movement of terrestrial wildlife	Verify with spatial analysis. Existing fragmentation primarily from residential development and associated fences, non-native landscaping/orchards/golf courses
Oak Woodland	Fire regime	Proportion of oak woodland with fire frequency departing from past range of natural variability (approx 17 yr FRI); combined with likelihood of severe fire	FAIR	Large proportion (76%) of oak woodlands unburned in last 50 years, another 24% beyond 17 yr FRI; however area likely to be affected by severe fires is relatively low (10% per USFS fuels data)	GOOD	75% of protected oak woodland burned on 20-yr cycle.	Rationale for including this KEA is that fire may have important effects other than veg structure/RDM -- e.g. kill seeds of non-natives, release nutrients favorable for germinat, change soil microbiology. Do CalFire and county fire depts map oak woodland fires or at least have acres-burned data?

Oak Woodland	Species composition & dominance	Relative cover of understory natives vs. non-natives? Extent of invasives? Diversity of native forbs?	FAIR	Mediterranean annual grasses dominant over vast majority of grasslands; still have good diversity of native forbs except in areas with continuous heavy grazing	GOOD	Representation of native grasses increased, diversity of native forbs maintained	What can we realistically measure or map across our large planning area?
Oak Woodland	Invasive exotic species (plants & animals)	Extent and density of invasive exotic plant cover	FAIR	Moderate invasion of thistles throughout range	GOOD	Invasive exotics limited to current extent/density or reduced	Invaders = star thistle, tocolote, Italian thistle
Oak Woodland	Oak recruitment	Presence and abundance of seedlings and saplings	POOR	Few young trees anywhere in the oak woodlands	FAIR	Enough seedlings and saplings to maintain stands in most areas of oak woodland	The presence/abundance of young trees is the measure of survivorship (except in very limited areas, we're not going to count the no. of acorns that germinate and survive to be saplings)
Oak Woodland	Oak tree mortality	Rate of mature tree mortality relative to past background rate	FAIR	Unexplained mortality in patches of mature oak woodlands, as well as accelerated mortality in vicinity of development	GOOD	Mortality rate in balance with recruitment rate	Accelerated mortality in vicinity of development is from things like cut & fill slopes, compaction in root zone, altered hydrology (e.g. summer watering of non-native landscaping under oaks)
Oak Woodland	Soil stability & organic carbon gain	RDM and spatial extent of erosion features (e.g. gullies, slumps)	FAIR	RDM either very low (e.g. <300 lbs/ac) with erosion features common, or RDM very high (i.e. not grazed or burned) favoring undesirables like ripgut brome	GOOD	RDM averages 800-1200 lbs/ac over most of the area in most years; few erosion features evident	Spatial info available other than our general observations?
FINAL RANK			**FAIR**		**GOOD**		

Target	Key Ecological Attribute (KEA)	Indicator	Current Rank	Current Status	Desired Rank	Desired Status	Notes / Questions
Mixed conifer forest	Fire regime	Proportion of mixed conifer forest with fire frequency departing from past range of natural variability (approx 16 yr FRI); combined with likelihood of severe fire	POOR	Fire return interval significantly longer than past range of natural variability for majority of mixed conifer forest with 70% unburned since 1910. Approx 28% of area likely to be subject to severe fire.	FAIR	50% of mixed conifer forest burned on 15-30 yr cycle or treated to reduce fuel loading and fuel homogeneity. This 50% is distributed across the range of the mixed conifer forest community (i.e. don't have large areas with high FRID)	Verify current and desired status per existing data and models.
Mixed conifer forest	Forest structure -- within stands	mortality rate of large trees relative to past range of natural variability	POOR	Rate of large tree mortality has doubled in some areas	GOOD	stabilize rate of large tree mortality?	
Mixed conifer forest	Forest structure -- mosaic across the landscape	distribution of stands in different age classes	FAIR	Stands of same age over large areas, creating homogeneous forest structure conducive to large, stand-replacing fires?	GOOD	Stands of various ages distributed over the landscape ("clumpiness"), improving resistance to large, stand-replacing fires?	This combines indicators of "area in early seral stages" and "area in large size classes". Variety across the landscape (i.e. "clumpiness") is what we're after.
Mixed conifer forest	Forest health	extent of forest die-offs	FAIR	(refine description based on available data)	GOOD	(refine description based on available data)	Forest health factors -- air pollution (especially ozone), disease (e.g. white pine blister rust) and pests (e.g. pine bark beetle?)
Mixed conifer forest	Species composition & dominance	Relative representation of giant sequoias, black oak, pine species vs. white fir and incense cedar	FAIR	Proportion of giant sequoias, black oaks and pine species reduced relative to past spp mix	GOOD	Increase proportion of giant sequoias, black oaks and pine species relative to white fir and incense cedar	Representation of giant sequoias, black oaks and pine species has been diminished by preferential harvesting (or control) of those spp, and by fire suppression that favors shade tolerant spp like white fir.

FINAL RANK			FAIR		GOOD		
Target	**Key Ecological Attribute (KEA)**	**Indicator**	**Current Rank**	**Current Status**	**Desired Rank**	**Desired Status**	**Notes / Questions**
Sub-alpine & alpine communiti es	Spatial area	Current area of sub-alpine and alpine veg communities	GOOD	(refine description based on available data)	GOOD	(refine description based on available data)	Any particular species we're concerned about (e.g. foxtail pine)?
Sub-alpine & alpine communiti es	Forest health	extent of forest die-offs	GOOD	(refine description based on available data)	GOOD	(refine description based on available data)	Deleted "air quality" KEA -- I think it's better handled as a threat (air pollution), and my recollection is that the air pollution was so far mainly affecting Mixed Conifer forest (ozone) and alpine lakes (N deposition and pesticides). Other forest health issues?
Sub-alpine & alpine communiti es	Species composition & dominance	status of cold-dependent species (e.g. pika)	FAIR	Pika range has shifted up in elevation; population declining?	FAIR	Pika populations maintained in climate refugia?	Deleted "air quality" KEA -- I think it's better handled as a threat (air pollution), and my recollection is that the air pollution was so far mainly affecting Mixed Conifer forest (ozone) and alpine lakes (N deposition and pesticides)
FINAL RANK			**GOOD**		**GOOD**		

Target	**Key Ecological Attribute (KEA)**	**Indicator**	**Current Rank**	**Current Status**	**Desired Rank**	**Desired Status**	**Notes / Questions**
Chaparral	Fire regime	Proportion of chaparral with fire frequency departing from past range of natural variability (50	GOOD	About 50% of chaparral within SSP is burning at pre-settlement intervals, about 15% is burning more frequently and the remainder has not	GOOD	Reduce percentage with greater than natural fire frequency; maintain natural fire frequency elsewhere?	Verify with Dave Schmidt, John Keeley. See USDA General Technical Report PNW-GTR-779, March 2009, "Ecological Foundations for Fire Management in North American Forest & Shrubland

		yr FRI chamise, 60 yr FRI mixed chaparral), combined with likelihood of severe fire		burned in the last 50 years. Not clear if unburned stands are more vulnerable to conversion by severe fires.			Ecosystems"
Chaparral	Landscape integrity	Area and configuration relative to site potential	GOOD	Relatively intact throughout historic range with good connectivity to oak woodlands and mixed conifer forest?	GOOD	Protected swaths of un-fragmented chaparral connected to oak woodlands and mixed conifer forest?	Verify with spatial analysis.
Chaparral	Species composition and dominance	Relative cover of arid vs. mesic chaparral species, and grasses	GOOD	Shift toward more arid species, and more grass in understory, increasing vulnerability to frequent, intense wildfires?	GOOD	Native chaparral species dominate cover	Verify with spatial analysis.
FINAL RANK			**GOOD?**		**GOOD**		

Target	Key Ecological Attribute (KEA)	Indicator	Current Rank	Current Status	Desired Rank	Desired Status	Notes / Questions
Riparian Communities	River-floodplain connectivity and flooding / deposition regime -- BELOW MAJOR DAMS	Geomorphic profile of river channel relative to floodplain; degree of flood control (e.g. via dams, other control measures)	FAIR	Morphology of most streams modified to varying degrees to serve as conveyance structures, and extent of flooding much reduced by flow regulation structures. Historic patterns of floodplain saturation and sediment scouring / deposition are	GOOD	River-floodplain connectivity restored along 10% (?) of riparian corridor miles; flood waters allowed to spread into those restored floodplain areas during most flood events	Not sure how important river-floodplain connectivity is to the saturation issue (e.g. Dry Crk Preserve monitoring wells show that groundwater levels are closely tied to flow levels in the main creek channel even when surface water doesn't flow into floodplain), but river-floodplain connectivity is important for sediment deposition/scouring (i.e. seedbed prep for spp like

				disrupted.			CA sycamore) and inundation of seasonal wetlands (e.g. for waterbirds). Also important for ecosystem services like natural flood abatement, groundwater recharge.
Riparian Communities	River-floodplain connectivity and flooding / deposition regime -- ABOVE MAJOR DAMS OR ALONG UN-DAMMED STREAMS	Geomorphic profile of river channel relative to floodplain or meadow; degree of flood control (e.g. via dams, other control measures)	GOOD?	River-floodplain connectivity good in most areas, with exception of alluvial gravel mining sites where flows are typically confined to one excised channel, and mountain meadows with excised stream channels.	GOOD	River-floodplain connectivity restored to pre-mining condition at all alluvial gravel mining sites; river-floodplain connectivity maintained elsewhere.	Change current rank to FAIR on account of degraded condition of many mountain meadows?
Riparian Communities	Hydrologic regime	Groundwater levels in vicinity of riparian corridors	FAIR	Groundwater levels lowered dramatically in some parts of Valley, but have actually increased in other areas (e.g. due to water imports via Friant-Kern Canal). Riparian and near-riparian wells in the foothills may be contributing to summer dry-out of some riparian areas.	FAIR	Groundwater levels maintained or restored along riparian corridors	Primarily have spatial data for Valley floor (e.g. KDWCD maps of groundwater level trends over last 50 yrs). Question is whether groundwater drawdowns are drying out the riparian areas and threatening riparian communities. And conversely, where are the best places to invest in riparian restoration because the groundwater situation looks good.
Riparian Communities	Area & continuity of complex vegetation community along riparian corridors - BELOW ABOUT 1,500'	Riparian corridor miles with complex veg community throughout floodplain	POOR	Majority of riparian corridor miles with only intermittent trees or shrubs often confined to edge of stream channel, simplified understory (e.g. grass)	FAIR	20% of riparian corridor miles lined with broad swath (300+ ft?) of complex riparian veg; additional 30% has narrower band of riparian veg (50 ft?) but it is multi-layered	Natural pattern would be broad floodplains with braided stream channels, multi-layered veg throughout floodplain (e.g. Valley oak woodlands with elderberry, willows and perennial grasses/sedges in understory; or CA sycamore with button willow and mulefat in understory). Now heavily modified by ditch mtce

	ELEVAT.						practices, agriculture, livestock grazing and urbanization at these lower elevations.
Riparian Communities	Area & continuity of multilayered riparian vegetation along riparian corridors - ABOVE ABOUT 1,500' ELEVAT.	Riparian corridor miles with complex veg community throughout floodplain (including mountain meadows)	FAIR	Many riparian corridors in forested areas unnaturally dense and homogeneous (prone to severe fire); veg cover of many mountain meadows reduced and simplified	GOOD	Increased heterogeneity of riparian corridor veg; increased cover and diversity of veg in mountain meadows	Natural pattern would be relatively straight channels with narrow floodplain and narrow band of multi-layered riparian vegetation, except where mountain meadows form at broader depressions in topography. Stream buffer requirements (re: timber harvest) and fire suppression leading to dense, homogeneous veg in some forest riparian areas; inappropriate livestock grazing removing or simplifying veg cover in many mountain meadows.
Riparian Communities	Species composition & dominance -- RIPARIAN VEG. in VALLEY & FOOTHILLS	Relative cover of natives vs. invasive exotics	FAIR	Himalayan blackberry and fig widespread in Valley and foothill riparian communities; extent of Arundo & tamarisk moderate overall (varies by watershed); cockleburs ubiquitous in major reservoir basins	GOOD	Invasive exotics are minor component of riparian veg communities	Invasives include tamarisk, Arundo, Himalayan blackberry, edible fig, cockleburs, etc
Riparian Communities	Recruitment of key tree species	Presence of multiple age classes of trees, from seedlings to mature (especially Valley oak, CA sycamore)	FAIR	Valley oak recruitment good where allowed (e.g. Kaweah Oaks Preserve); sycamore recruitment poor overall	GOOD	Good recruitment & multiple age classes	sycamore recruitment poor probably due to summer grazing of stump sprouts and seedlings, and disruption of flooding/deposition regime that creates favorable conditions for establishment of seedlings

Riparian Communities	Species composition & dominance -- BIRDS in VALLEY & FOOTHILLS	Species richness & abundance for native riparian-associates	**FAIR**	In Valley and lower foothills, diversity of native riparian-associates low in most areas, and some important species missing or imperiled (e.g. Swainson's hawk, SW willow flycatcher), non-natives significantly compete for breeding sites.	GOOD	Native riparian-associates are dominant and diverse; missing species are re-occupying parts of former range; abundance of native riparian-associates is increasing	Reduction / simplification of riparian veg community, and competion from non-natives (e.g. starlings) for cavity nest sites are two major factors in decline of riparian birds
FINAL RANK			**FAIR**		**GOOD**		
Target	**Key Ecological Attribute (KEA)**	**Indicator**	**Current Rank**	**Current Status**	**Desired Rank**	**Desired Status**	**Notes / Questions**
Lakes, rivers & streams	Hydrologic regime -- UNDAMMED STREAMS AND STREAMS ABOVE MAJOR DAMS	Late summer base flows in perennial rivers and streams	POOR	Smaller rivers (e.g. Deer Creek) and perennial tributaries of major rivers (e.g. N Fork Tule, S. Fork Kaweah) routinely de-watered by end of summer	GOOD	Base flows maintained in smaller rivers and perennial tributaries of major rivers throughout the year	Main issue seems to be withdrawals by foothill ditch companies and riparian wells (for irrigation, domestic use, stock water)
Lakes, rivers & streams	Hydrologic regime -- BELOW MAJOR DAMS	Departure from (past) natural range of variability for timing, duration and volume of flows	FAIR	Channels often full during summer/early fall (when volume would normally be low), completely dry during most of winter/spring (when flows would normally peak); peak flow (i.e. flood) volumes much reduced by flood	FAIR	Increased capture of flood water in groundwater recharge / floodplain habitat "conjunctive use" areas?	

				control measures			
Lakes, rivers & streams	Hydrologic regime -- MOUNTAIN MEADOWS	Percent of mountain meadows that fall into different condition classes re: erosion, disrupted hydrology	GOOD?	More than 50% of meadows severely degraded -- gullying, disrupted hydrology (drying out) and/or denuded by grazing	GOOD	90% of meadows are in good condition -- little erosion, normal hydrology, diverse and dense veg cover	This KEA is intended to capture the importance of mountain meadows as natural water storage/slow-release system (especially as snowpack declines?).
Lakes, rivers & streams	Water quality -- SUB-ALPINE AND ALPINE LAKES	Algal blooms, fish kills, status of macro-invertebrates	POOR	Seeing degradtion by aerial deposition of N; also measurable pesticide accumulat's (effects unknown)	GOOD	Diverse native macro-invertebrate populations; no algal blooms or fish kills	Need more info on this
Lakes, rivers & streams	Species composition & dominance -- vertebrates	Relative abundance of non-native invasives vs. native aquatic vertebrates	**FAIR**	Several native species imperiled by predation or competition from invasive exotics, disease outbreaks. Number of spp. and populations of invasive exotics increasing.	FAIR	Healthy native fauna maintained in 50% of aquatic habitats in site planning area? Number of spp. and populations of invasive exotics stable or declining overall.	Invasives -- mussels, bullfrogs, etc. Natives -- red & yellow-legged frogs, W pond turtle, native trout, native warm-water fish assemblage. Disease also seriously affecting some species (e.g. yellow-legged frog).
FINAL RANK			**FAIR**		**GOOD**		

Target	Key Ecological Attribute (KEA)	Indicator	Current Rank	Current Status	Desired Rank	Desired Status	Notes / Questions
Migratory and wide-ranging wildlife	Landscape integrity	Availability of large, intact blocks of habitat	GOOD	Large expanses of relatively intact grassland, oak woodland, mixed conifer forest, sub-alpine and alpine communities; riparian and aquatic habitats diminished at lower end of watersheds (under about 1500' elevat)	GOOD	Large, intact blocks of major vegetation communities maintained; riparian and aquatic habitats strategicially restored at lower end of watershed	Verify with spatial analysis. Small amount of riparian / aquatic restoration can have disproportionate impact on wildlife utilization of adjoining veg communities (e.g. SRT's Herbert Preserve, Audubon's Kern River Preserve)
Migratory and wide-ranging wildlife	Landscape integrity	Connectivity among habitat blocks and among different veg communities used by migratory and wide-ranging species	FAIR	Good connectivity within and among veg communities; some indication of disrupted connectivity among ranges of different deer herds (in-breeding)	GOOD	Connectivity within and among veg communities maintained; disrupted connections between ranges of different deer herds restored	Verify with spatial analysis.
Migratory and wide-ranging wildlife	Status of representative species	Reproductive status and population trends of condor, deer herds, migratory birds	**GOOD?**	Status of condors improving but still precarious; some deer herds have declined significantly and there's some evidence of in-breeding (lack of genetic exchange among herds); many neo-tropical migrants declining	GOOD	Continued increase of wild-breeding condor population; improved reproductive vigor and success in deer herds; increased species diversity and abundance of migratory birds	Verify with spatial analysis.

FINAL RANK			**GOOD?**		**GOOD**		

Table 3: Viability Summary

TARGET	VIABILITY RANKING
Grasslands	GOOD
Oak Woodland	FAIR
Mixed Conifer Forest	FAIR
Sub-alpine & Alpine Communities	GOOD
Chaparral	GOOD?
Riparian Communities	FAIR
Lakes, Rivers & Streams	FAIR
Migratory and Wide-ranging Wildlife	GOOD?

Stresses and Sources of Stress for Low Elevation Communities

Grassland

(ALTERED KEA'S)

	Stressor #1	**Stressor #2**	**Stressor #3**	**Stressor #4**	**Stressor #5**	**Stressor #6**	
Threats / Sources of Stress (causes of altered KEA's)	Altered spatial area	Altered landscape integrity	Altered fire regime	Altered species composition & dominance	Altered extent of invasive exotics	Altered soil stability & organic carbon gain	**Overall Threat**
Climate change: Increased temperatures and more erratic precipitation pattern (e.g. more extreme wet / dry periods, more severe events; see H of C for rationale)	LOW	LOW	LOW	HIGH	VERY HIGH	MEDIUM	HIGH
Residential development (and assoc. land grading, fencing, non-native landscaping)	HIGH	HIGH	HIGH	LOW	HIGH	LOW	HIGH
Roads (ranch roads to major highways)	LOW	MEDIUM	LOW	HIGH	VERY HIGH	LOW	MEDIUM
Fire suppression / increased human-caused wildfires			MEDIUM	MEDIUM		LOW	MEDIUM
Airborne pollutants (N deposition, ozone, airborne pesticides)	LOW	LOW	LOW	HIGH	MEDIUM	LOW	MEDIUM
Conversion of native habitat to intensive agriculture, with accompanying fertilizers, pesticides, etc (including illicit marijuana gardens)	MEDIUM	MEDIUM			MEDIUM	MEDIUM	MEDIUM
Incompatible livestock grazing (too much or too little)			HIGH	HIGH	HIGH	MEDIUM	HIGH
Energy resource and transmission line development		HIGH	LOW	LOW	MEDIUM	MEDIUM	MEDIUM

Invasive, non-native plant species			HIGH	HIGH	VERY HIGH	LOW	VERY HIGH
Non-native animals (bullfrogs, feral pigs, trout, mussels, starlings, domestic cats & dogs, etc)				MEDIUM			MEDIUM
Intentional prevention of new T&E species occurrences or T&E species re-occupying historic range				HIGH			MEDIUM
Habitat loss outside site planning area (e.g. for migratory & wide-ranging spp)				HIGH			HIGH

Oak Woodland

	Stressor #1	Stressor #2	Stressor #3	Stressor #4	Stressor #5	Stressor #6	Stressor #7	Stressor #8	
Threats / Sources of Stress (causes of altered KEA's)	Altered spatial area	Altered landscape integrity	Altered fire regime	Altered species composition & dominance	Altered extent of invasive exotics	Altered oak recruitment	Altered oak tree mortality	Altered Soil stability & organic carbon gain	**Overall Threat**
Climate change: Increased temperatures and more erratic precipitation pattern (e.g. more extreme wet / dry periods, more severe events)	MEDIUM (gradual loss of long-lived trees)	HIGH	MEDIUM	HIGH	VERY HIGH	VERY HIGH	MEDIUM	MEDIUM	VERY HIGH
Residential development (and assoc. land grading, fencing, non-native landscaping)	MEDIUM	HIGH	HIGH	MEDIUM	HIGH		MEDIUM	MEDIUM	HIGH
Roads (ranch roads to major highways)	LOW	MEDIUM	LOW		HIGH			MEDIUM	MEDIUM
Fire suppression / increased human-caused wildfires			HIGH	MEDIUM	MEDIUM	HIGH	LOW		HIGH
Airborne pollutants (N deposition, ozone, airborne pesticides)				HIGH	MEDIUM	MEDIUM	LOW		MEDIUM

Conversion of native habitat to intensive agriculture, with accompanying fertilizers, pesticides, etc (including illicit marijuana gardens)					MEDIUM (as source of exotics)					LOW
Incompatible livestock grazing (too much or too little)			HIGH (affects both directions)	MEDIUM	HIGH	VERY HIGH		MEDIUM	HIGH
Incompatible timber management / wood-cutting practices / fuelbreak construction	LOW				MEDIUM		LOW	MEDIUM	MEDIUM
Energy resource and transmission line development	LOW	HIGH	MEDIUM		HIGH		MEDIUM	MEDIUM	HIGH
Invasive, non-native plant species			HIGH	HIGH	VERY HIGH	HIGH		LOW	VERY HIGH
Non-native animals (bullfrogs, feral pigs, trout, mussels, starlings, domestic cats & dogs, etc)				HIGH		MEDIUM		MEDIUM	MEDIUM
Pests and pathogens				LOW		LOW	HIGH		MEDIUM
Acorn predation	MEDIU M					HIGH			MEDIUM
Intentional prevention of new T&E species occurrences or T&E species re-occupying historic range				HIGH					MEDIUM
Habitat loss outside site planning area (e.g. for migratory & wide-ranging spp)				HIGH					HIGH

Chaparral

	Stressor #1	Stressor #2	Stressor #3	
Threats / Sources of Stress (causes of altered KEA's)	Altered fire regime	Altered landscape integrity	Altered species composition & dominance	**Overall Threat**
Climate change: Increased temperatures and more erratic precipitation pattern (e.g. more extreme wet / dry periods, more severe events)	HIGH	MEDIUM	HIGH	HIGH
Residential development (and assoc. land grading, fencing, non-native landscaping)	HIGH	MEDIUM	LOW	MEDIUM
Roads (ranch roads to major highways)	LOW	MEDIUM	LOW	LOW
Fire suppression / increased human-caused wildfires	MEDIUM	MEDIUM	MEDIUM	MEDIUM
Conversion of native habitat to intensive agriculture, with accompanying fertilizers, pesticides, etc (including illicit marijuana gardens)			MEDIUM	MEDIUM
Incompatible timber management / wood-cutting practices / fuelbreak construction	MEDIUM	MEDIUM		MEDIUM
Energy resource and transmission line development	MEDIUM	MEDIUM		MEDIUM
Invasive, non-native plant species	HIGH		HIGH	HIGH

Riparian Communities

	Stressor #1	Stressor #2	Stressor #3	Stressor #4	Stressor #5	Stressor #6	Stressor #7	Stressor #8	
Threats / Sources of Stress (causes of altered KEA's)	Altered river-floodpain connectivity -- below major dams	Altered river-floodpain connectivity -- above major dams; undammed streams	Altered hydrologic regime -- groundwater near riparian areas	Altered area & continuity of riparian veg. -- below 1500 ft elevation	Altered area & continuity of riparian veg. -- above 1500 ft elevation	Altered species comp. & dominance -- riparian veg in Valley & foothills	Altered recruitment -- Valley oak, CA sycamore	Altered species composition & dominance -- riparian birds	**Overall Threat**
Climate change: Increased temperatures and more erratic precipitation pattern			MEDIUM	HIGH	MEDIUM	HIGH	HIGH	HIGH	HIGH
Residential development	HIGH	MEDIUM	HIGH	HIGH	MEDIUM	HIGH	HIGH	HIGH	VERY HIGH
Roads (ranch rds to major hwys)	HIGH	HIGH	MEDIUM	HIGH	MEDIUM	HIGH	HIGH	HIGH	HIGH
Groundwater withdrawals (wells)			HIGH	HIGH	LOW	MEDIUM	HIGH	MEDIUM	HIGH
Surface water withdrawals (ditch cos., hydropower cos., etc)			MEDIUM	HIGH	MEDIUM	HIGH	HIGH	HIGH	HIGH
Flood control / water management systems / channel mtce practices	VERY HIGH	MEDIUM	HIGH	VERY HIGH	MEDIUM	VERY HIGH	HIGH	HIGH	VERY HIGH
Fire suppression / increased human-caused wildfires				MEDIUM	MEDIUM	MEDIUM			MEDIUM
Conversion of native habitat to intensive agriculture	MEDIUM		HIGH	HIGH	LOW	HIGH	HIGH	HIGH	

Incompatible livestock grazing (too much or too little)		MEDIUM		VERY HIGH	HIGH	MEDIUM	VERY HIGH	HIGH	
Incompatible timber mgmt / wood-cutting / fuelbreak construction				MEDIUM	MEDIUM	HIGH	MEDIUM	LOW	MEDIUM
Energy resource and transmission line development		HIGH (new dams, hydro devel?)	LOW	MEDIUM	MEDIUM	LOW		MEDIUM	HIGH
Aggregate mining	HIGH	HIGH	HIGH	HIGH	LOW	MEDIUM	HIGH	HIGH	HIGH
Invasive, non-native plant species			MEDIUM			HIGH	HIGH	MEDIUM	MEDIUM
Non-native animals (bullfrogs, feral pigs, trout, mussels, starlings, domestic cats & dogs, etc)				MEDIUM		MEDIUM	MEDIUM	HIGH	MEDIUM
Pests and pathogens					MEDIUM	MEDIUM	MEDIUM	LOW	HIGH
Acorn predation	LOW	LOW	LOW	MEDIUM	LOW	MEDIUM	MEDIUM	LOW	HIGH
Intentional prevention of new T&E species occurrences or T&E species re-occupying historic range						HIGH (elderberry)		MEDIUM	MEDIUM

Threats Summary

Threats / Sources of Stress (causes of altered KEA's)	Grassland	Oak Woodland	Mixed Conifer Forest	Sub-alpine & Alpine Communities	Chaparral	Riparian Communities	Lakes, Rivers, Streams	Migratory & Wide-ranging Wildlife	Overall Threat Rank
Climate change: Increased temperatures and more erratic precipitation pattern	HIGH	VERY HIGH	HIGH	VERY HIGH	HIGH	HIGH	HIGH	MEDIUM	VERY HIGH
Residential development	HIGH	HIGH	LOW	LOW	MEDIUM	VERY HIGH	HIGH	VERY HIGH	VERY HIGH
Roads	MEDIUM	MEDIUM		LOW	LOW	HIGH	MEDIUM	VERY HIGH	**MEDIUM**
Groundwater withdrawals (wells)						HIGH	MEDIUM		**HIGH**
Surface water withdrawals						HIGH	VERY HIGH	LOW	**HIGH**
Flood control / water mgmt systems / channel mtce						VERY HIGH	VERY HIGH	HIGH	VERY HIGH
Fire suppression / > human starts	MEDIUM	HIGH	VERY HIGH	MEDIUM	MEDIUM	MEDIUM		MEDIUM	**HIGH**
Airborne pollutants	MEDIUM	MEDIUM	MEDIUM	LOW	LOW		MEDIUM	MEDIUM	**MEDIUM**
Conversion to intensive ag (including marijuana)	MEDIUM	LOW			MEDIUM	HIGH	MEDIUM	MEDIUM	**MEDIUM**
Incompatible livestock grazing (too much or too little)	HIGH	HIGH			LOW	HIGH	LOW	MEDIUM	**HIGH**
Incompatible timber management / wood-cutting practices / fuelbreak construction		MEDIUM	HIGH	LOW	MEDIUM	MEDIUM	LOW	LOW	**MEDIUM**

Energy resource and transmission line development	MEDIUM	HIGH			MEDIUM	MEDIUM	MEDIUM	HIGH	**MEDIUM**
Aggregate mining	LOW					HIGH	MEDIUM	MEDIUM	**MEDIUM**
Invasive, non-native plant species	VERY HIGH	VERY HIGH	MEDIUM	LOW	HIGH	HIGH	MEDIUM	MEDIUM	VERY HIGH
Non-native animals	MEDIUM	MEDIUM	LOW		LOW	MEDIUM	VERY HIGH	HIGH	**HIGH**
Pests and pathogens	LOW	MEDIUM	HIGH	MEDIUM	LOW	MEDIUM	VERY HIGH	MEDIUM	**HIGH**
Acorn predation		MEDIUM	LOW			MEDIUM		MEDIUM	**MEDIUM**
Intentional prevention of T&E spp establishment or re-establishment	MEDIUM	MEDIUM	LOW	LOW		HIGH	MEDIUM	HIGH	**MEDIUM**
Habitat loss outside site planning area (e.g. for migratory & wide-ranging spp)	HIGH	HIGH	MEDIUM	MEDIUM	LOW	HIGH		HIGH	**HIGH**
OVERALL THREAT RANK BY TARGET	**MEDIUM**	**HIGH**	**MEDIUM**	**HIGH**	**MEDIUM**	**VERY HIGH**	**VERY HIGH**	**HIGH**	

Objectives and Strategies

Objective	**Achieve RDM standards across 75% of rangeland by 2020.**
Strategic action	Craft easement terms for newly protected lands to address RDM standards.
Strategic action	Work with easement landowners to implement best grazing practices and serve as demonstration projects
Strategic action	Refer conservation-oriented grazing lessees to realtors and conservation easement landowners.

Objective	**Achieve desired forest structure and fire regime across ___ acres of mixed conifer forest by 2020.**
Objective	**Achieve desired forest structure and fire regime across ___ acres of chaparral by 2020.**
Objective	**Restore multi-layered, native riparian vegetation along __ river miles in priority watersheds by 2015.**
Strategic action	Acquire agricultural conservation easements containing riparian communities; craft easement terms to encourage restoration of riparian vegetation.
Strategic action	Work with County Association of Governments to encourage consistent policy and implementation of riparian habitat mitigation by Kern and Tulare Counties.
Objective	**Maintain 75% of foothill rangeland with compatible livestock grazing by 2020.**
Strategic action	Evaluate trends re: livestock grazing on lands owned by rancher vs. leased by rancher, and relate to trends in land use practices and our ability to influence those practices.
Strategic action	Work with ranching community to develop strategies for economic sustainability and public awareness of the importance of ranching and livestock grazing to conservation.
Strategic action	Develop incentives that support protection of ecosystem services by farmers and ranchers.
Objective	**Protect 73,000 acres of grasslands and blue oak woodlands by 2015.**
Strategic action	Secure easements from willing sellers over six large ranches with significant elevational gradients.
Strategic action	Facilitate adoption of oak conservation plans and ordinances in Tulare and Kern Counties.
Strategic action	Assess opportunities for strengthening conservation of grasslands, oaks, riparian and aquatic systems in the Tulare and Kern County General Plans.
Strategic action	Develop a revolving fund for Southern Sierra land protection projects.
Objective	**Protect areas with known blue oak regeneration and encourage landscape-scale research/monitoring of blue oak recruitment**
Strategic action	Facilitate adoption of oak conservation plans and ordinances in Tulare and Kern Counties.

Strategic action	Cooperate with research institutions on landscape-scale research on blue oak recruitment.
Objective	**Protect habitat connectivity within 3 watersheds from high elevation to the Valley by 2015.**
Strategic action	Secure easements over six large ranches with significant elevational gradients.
Strategic action	Work with ranching community to develop strategies for economic sustainability and public awareness of the importance of ranching and livestock grazing to conservation.
Strategic action	Encourage County-level adoption of scenic highway and byway designations in priority watersheds.
Strategic action	Develop a revolving fund for Southern Sierra land protection projects.
Strategic action	Develop incentives that support protection of ecosystem services by farmers and ranchers.
Objective	**Reduce or contain invasive exotics thistles throughout project area.**
Strategic action	Cooperate with other agencies (e.g. in Weed Management Areas) for strategic control of invasive exotics.
Objective	**Reduce riparian invasives to low levels by __ river miles in priority floodplains by 2015.**
Strategic action	Cooperate with other agencies (e.g. in Weed Management Areas) for strategic control of invasive exotics.
Objective	**Restore __ mountain meadows in the headwaters of priority watersheds by 2020.**
Strategic action	Identify meadows needing restoration and the causes of degradation
Strategic action	Collaborate with agencies and others on restoration of __ meadows in the headwaters of priority watersheds.
Objective	**Restore multi-layered, native riparian vegetation along two riparian corridors in the lower foothills and valley by 2020.**
Strategic action	Cooperate with willing landowners and funding entities to fence __ miles of riparian corridor and develop alternative stock watering sources.

Strategic action	Link easement landowners with agency programs for riparian revegetation projects.
Strategic action	Cooperate with agencies and developers to target riparian mitigation projects to priority watersheds.
Strategic action	Give priority to acquisition of agricultural and habitat conservation easements containing riparian communities.
Strategic action	Collaborate on project to manage and improve season wetlands
Objective	**Strategically restore natural hydrologic regime in riparian areas below major dams; enhance balance between groundwater withdrawal and re-charge.**
Strategic action	Identify areas where natural flooding and deposition patterns could be restored without significant damage to crops and property; collaborate to restore channel-floodplain connectivity and natural flooding/deposition patterns in those areas.
Strategic action	Cooperate with gravel mining industry and mine landowners to improve mining and reclamation outcomes for riparian habitat.
Strategic action	Become partner with ACOE, hydropower utilities, and other water management entities on flood control, protection and management of groundwater recharge areas, and ditch maintenance practices.
Strategic action	Secure groundwater protection policies and regulations on State and local levels.
Strategic action	Promote research into groundwater status in the foothills to inform local land use decisions
Strategic action	Insert "proof of water" (adequate water availability) standards into the approval process for development
Strategic action	Prevent new development in the foothills without "proof of water"
Strategic action	Promote water conserving infrastructure design standards for new development.
Objective	**Restore minimum flow in priority perennial rivers and streams above the dams by 2020.**
Strategic action	Identify dewatered perennial streams and causes of de-watering (e.g. riparian wells, ditch cos.)
Strategic action	Craft conservation easement terms for willing sellers who agree to limit withdrawals from foothill perennial streams.

APPENDIX B - TCAP

ABRIDGED TEHACHAPI CONSERVATION ACTION PLAN

April 2010

Audubon CALIFORNIA

The Nature Conservancy
Protecting nature. Preserving life.™

Tejon Ranch CONSERVANCY

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EXECUTIVE SUMMARY

The Tehachapi region has been identified as a critically important conservation landscape based on a multitude of factors. These include the region's high levels of biodiversity and habitat integrity, its location at the convergence of four ecoregions, its intact connection between two major mountain systems, and its biological function as a "crucible of evolution". Many of these factors are interrelated, making the protection of a large system of interconnected lands in the region vital to the continuation of the conditions and processes that support them.

The Tehachapi Planning Team includes staff from Audubon California, The Nature Conservancy, and the Tejon Ranch Conservancy. Together they have protected thousands of acres of important habitat in the region. The team formed to prepare this Conservation Action Plan (CAP) for several reasons. First, there is a need for a coordinated approach to conservation in the region. Currently, there is no single regional conservation plan for the area that identifies targets, threats, and actions to achieve conservation over this large area. Second, recent conservation successes (e.g. Tejon and Parker ranches conservation) combined with other existing conservation investments (e.g. Wind Wolves and Kern River preserves) identify the need to build and link these valuable conservation assets. Third, the region and many of its unique habitat types need to be highlighted for future conservation action. There are many opportunities to achieve important conservation at scale in the planning area. Finally, the Tehachapi team is working in subordination to the Southern Sierra Partnership (SSP). The SSP includes other conservation partners that are concurrently preparing a regional conservation plan extending over a larger area of the southern Sierra Nevada range. The SSP has conducted workshops, interviews and research that greatly assisted this planning effort.

The conservation targets developed by the team include oak woodlands, riparian communities, Mojave Desert scrub and Joshua tree communities, grasslands, semi-arid montane (includes sagebrush, pinyon-juniper, and montane chaparral communities), coniferous forests, and migratory and wide-ranging wildlife. Key ecological attributes with status indicators were developed and rated on a scale of poor, fair, good or very good. The riparian communities target is the most threatened in the Tehachapi region.

Threats in the form of stresses and sources of stress were then determined for each target. Stresses were ranked by scope and severity and sources of stress were ranked by contribution and irreversibility. The highest ranking sources of stress across the project area were determined to be land grading and housing development, climate change-induced temperature increases, surface and groundwater diversions, road construction, and presence of existing non-native plant species.

After defining the indicators and developing situations around future threats, objectives were created that meet the criteria of being specific, measurable, achievable, realistic and time-limited. For each objective, strategic actions were created and ranked by cost, benefit, and feasibility. Based on the ranking criteria, six objectives rose to the top:

1) Protect 50-70% (60,000 new acres) of Oak Woodland by 2015

2) Protect 75% of all Riparian Communities by 2015

3) By 2011, ensure effective conservation of at least one elevational transect in the Tehachapi region, identify two additional purchase opportunities

4) By 2012, protect key conservation lands with protected designation in local land use policy/laws

5) Create a minimum viable linkage (to build upon with future land protection) from Tejon Ranch to Sequoia National Forest by 2013

6) Protect 50-70% of Grasslands by 2015

Conservation Action Planning is designed to recognize the shifting nature of knowledge and the challenges conservationists face by encouraging practitioners to view the conservation planning process not as a once-a-decade exercise but as a regular, iterative process of “successive approximations”. CAP encourages teams of practitioners to capture their best understanding of the conservation situation, build a set of actions based on that understanding, implement the actions, measure the outcomes of their actions, learn from these outcomes and refine actions over time. Thus this plan represents a first iteration of conservation planning for the region that permits us to begin conservation work with confidence.

1.0 INTRODUCTION

The Tehachapi region has been identified as a critically important conservation landscape based on a multitude of factors. These include the region's high levels of biodiversity and habitat integrity, its location at the convergence of four ecoregions, its intact connection between two major mountain systems, and its biological function as a "crucible of evolution". Many of these factors are interrelated, making the protection of a large system of interconnected lands in the region vital to the continuation of the conditions and processes that support them.

Primary ecological processes supporting and controlling the natural systems of the Tehachapi region are climate, groundwater availability, soils, wind, and topography. Parts of the region contain some of the more imperiled ecosystem types in North America, largely due to impacts associated with increasing human development throughout the Southwest. Human population growth has resulted in an increasing interaction of humans, their houses, machines, pets, and introduced exotic species with the native species, both plant and animal – more often than not to the detriment of the native species. Despite these impacts, the habitats of the Tehachapi region are relatively intact compared to most other regions in California.

The Tehachapi region's high level of biodiversity is related to its location and geology. The region 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) (White et al. 2003). This convergence results not only in a large number of communities present in a small geographic area, but also in distinct plant and animal communities formed from the co-occurrence of species from the various regions. Recent geologic activity has created a topographically diverse landscape which has provided the conditions necessary to allow evolutionary divergence and speciation for many taxa. As a result, the Tehachapi region supports a high number of endemic species (White et al. 2003).

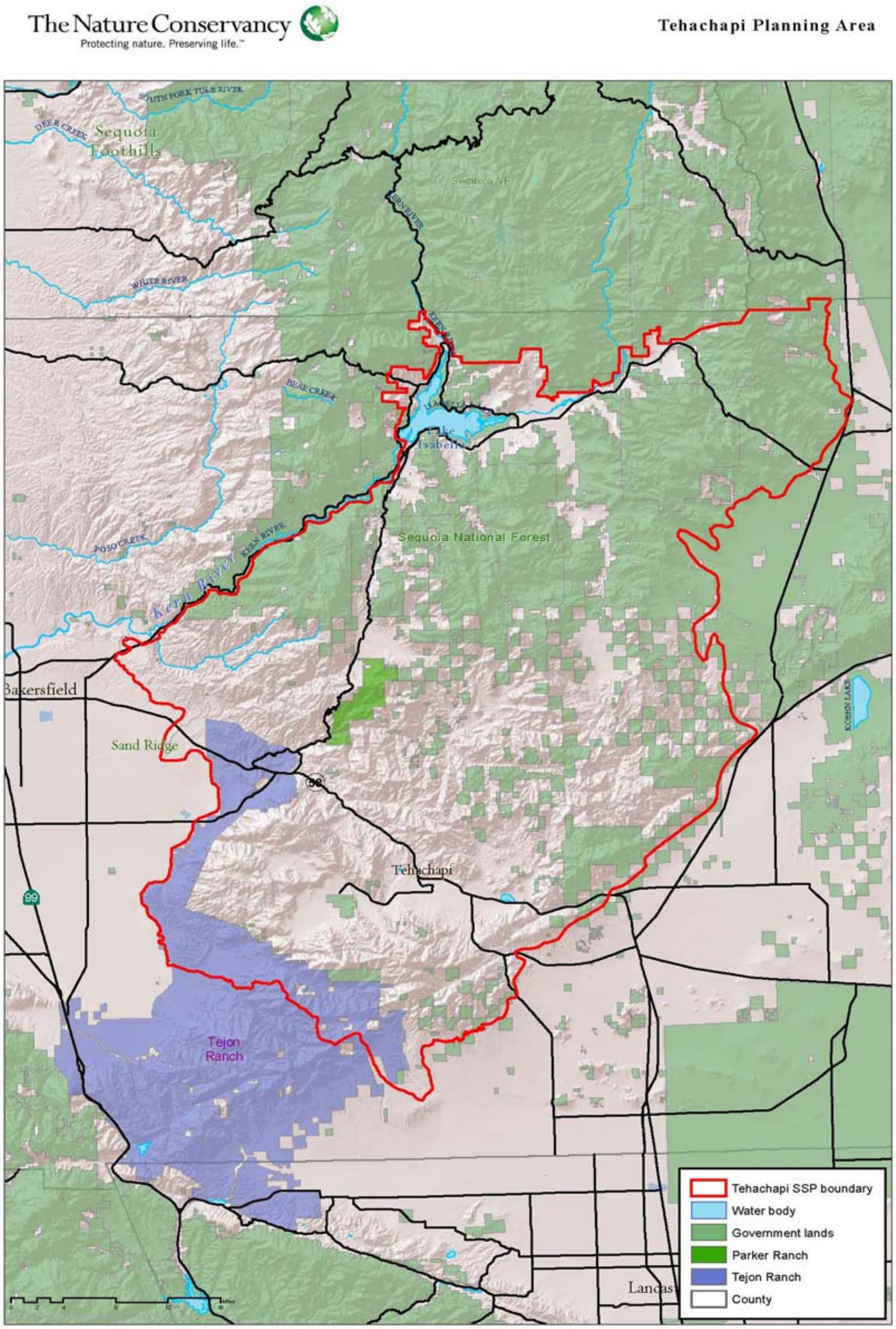
The Tehachapi region not only continues to support high levels of biodiversity, but also supports the conditions necessary to allow species to respond and evolve in response to climate change. The high level of habitat intactness at the landscape scale allows the processes necessary for species to respond and evolve to climate change to remain functional. Fragmentation by roads and development is concentrated in a few small areas in the region allowing for relatively unimpeded species movement. The diverse and often steep topography supports many large elevational gradients over short distances, allowing species to quickly respond to changing temperatures. The diverse topography also supports an abundance of steep canyons which create highly variable microsite conditions at the local scale.

The high level of habitat intactness not only allows local scale responses to climate change, but permits species to move between two major mountain ranges, the Sierra Nevada and Sierra Madre. The importance and influence of what has been coined the "Tehachapi Connection" extends far beyond the connectivity between these ranges as it provides the only remaining connection between the California coast ranges and inland ecosystems. As a result, the Tehachapi Connection has been identified as perhaps the most important wildlife linkage influencing the South Coast Ecoregion (Penrod et al. 2003) and it is likely as important to the Central Coast Ecoregion. To understand the significance of this linkage, one must step back and look at the topography of the west coast of North America. To a large degree, the Central and South Coast ecoregions exist as ecological islands. Many of the plants and animals found in the coast ranges south of San Francisco Bay are essentially isolated from the rest of the continent by the Mojave and Sonoran Deserts to the southwest and intensive human land uses in the Central Valley. The Tehachapi Mountains and the low elevation bands of habitat on its slopes are thus the last intact connection for species unable to cross desert or human land uses (Mas et al. 2006). The system of passes and valleys separating the Tehachapi and Sierra Nevada Mountains (including Tehachapi Creek, Tejon Creek, Cummings Valley and Tehachapi Valley) also provides the greatest connectivity opportunity for species occupying low lying areas of the Central Valley and Mojave Desert.

The Tehachapi region experiences a Mediterranean climate with hot dry summers and cool wet winters. Within the Mediterranean portion of the region, average temperatures range from 54° to 61° F increasing to 64° F on the eastern mountain slopes near the desert floor. Elevations range from roughly 800 feet in the San Joaquin Valley to Piute Peak at 8,417 feet. Variability in annual precipitation, however, is relatively low for such a large region that covers a nearly 7,000 foot elevation gradient. Precipitation is lowest on the eastern mountain slopes near the desert floor ranging from 4 to 5 inches and highest on the western mountain peaks ranging from 15 to 16 inches. A majority of the region is located between 3,000 and 5,000 feet in elevation and receives 9 to 12 inches of precipitation with an average temperature around 57° F. Precipitation is concentrated from early fall to mid spring with about 90% falling between October 1st and April 30th.

Land ownership patterns in the Tehachapi region can best be described by splitting the region into northern and southern sections. The majority of land in the northern half of the planning region is publicly owned and managed. The Bureau of Land Management is responsible for a variety of lands from small isolated parcels scattered throughout the region to the large Jawbone-Butterbredt area in the northeast. The US Forest Service manages the Sequoia National Forest, which covers a majority of lands in the northwest. Lands in the southern portion of the region are primarily under private ownership. The majority of private lands occur as large ranches. However, there is a recent trend, especially in the vicinity of the City of Tehachapi, for large ranches to be divided into small ranchettes. As a result, clusters of ranchettes are starting to dot the landscape and more and more large ranches are being purchased from the ranching families by real estate investors.

Figure 1. Tehachapi Planning Area Map



2.0 METHODS

The Tehachapi planning team consists of staff and partners of The Nature Conservancy (hereafter, “the Conservancy”) who are experienced conservation practitioners and scientists working throughout the Tehachapi region. The team is working in conjunction with the Southern Sierra Partnership to develop this Tehachapi Conservation Action Plan (CAP), which is one of two parallel plans that will together comprise a holistic vision of conservation action within the Southern Sierra Nevada and Tehachapi region. Team meetings of both the entire Southern Sierra Partnership, and of the smaller Tehachapi team took place from June through December of 2009. At these meetings, Conservancy staff and partners collaborated to develop conservation targets, threats, and strategic actions.

The methodology used was the Conservation Action Planning methodology. For more information on Conservation Action Planning visit http://conserveonline.org/workspaces/cbdgateway/cap/resources/index_html. CAP is a collaborative, science-based process used to: (1) identify the conservation targets that warrant action, (2) decide where and how to act, and (3) measure effectiveness to achieve continuous improvement. The complete output of the CAP process was captured in a spreadsheet – the CAP Workbook – which has outputs included in the appendices of this report.

Conservation Action Planning is designed to recognize the shifting nature of knowledge and the challenges conservationists face by encouraging practitioners to view the conservation planning process not as a once-a-decade exercise but as a regular, iterative process of “successive approximations”. CAP encourages teams of practitioners to capture their best understanding of the conservation situation, build a set of actions based on that understanding, implement the actions, measure the outcomes of their actions, learn from these outcomes and refine actions over time.

At its core, CAP is a framework to help practitioners to focus their strategies on clearly-defined elements of focal targets and fully articulated threats to these targets and to measure their success in a manner that will enable them to adapt and learn over time. The CAP process accomplishes this by prompting a team to work through a series of diagnostic steps that culminate in the development of clearly defined objectives and strategic actions. Together these represent a testable hypothesis of success that forms the basis of an “adaptive” approach to conservation management. Please refer to Appendix A for a glossary of CAP terms.

An additional challenge for the team was to incorporate climate change into the CAP process. The output of eleven climate change models were analyzed and summarized to come up with the best estimate for future climatic conditions in the region. The influence of this single climate change scenario was then assessed on each target by developing a Hypothesis of Change (HoC). Development of each HoC focused on the current understanding of how species and communities will respond to conditions under the selected climate change scenario. The HoCs were then used to inform completion of the CAP Workbook sections addressing climate change for each target.

3.0 CONSERVATION TARGETS

This project covers the Tehachapi sub-region of the larger Southern Sierra region. Once the boundaries of the planning area were selected, the next step was to decide upon focal conservation targets. Focal conservation targets are a limited suite of species, ecological communities, and ecological systems that are chosen to represent and encompass the biodiversity found in a specific area. Targets serve as the foundation for all project actions. Accurately defining targets greatly increases the potential to set measurable objectives and realize when success is achieved.

As seen in Figure 1, the oak woodlands, riparian communities, grasslands, semi-arid montane and coniferous forests have been determined to be in "fair" condition while the Mojave Desert scrub and Joshua tree communities were determined to be in good condition. The migratory and wide-ranging wildlife target was the only target to receive the status of "very good". As displayed in the following section, the information and calculations for determining the ratings were captured in an Excel spreadsheet. By combining all ratings for all targets, the entire project gets an overall biodiversity health rating of "fair".

3.1 TARGET DESCRIPTIONS

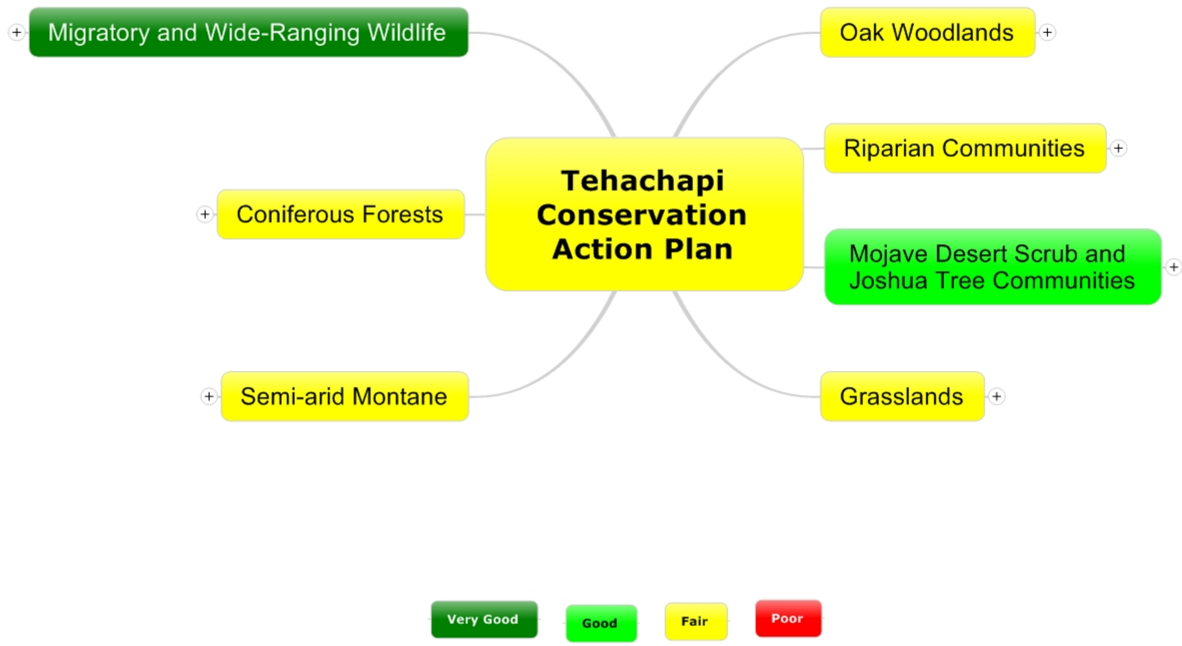
3.1.1 Oak Woodland

This target includes California blue oak (*Quercus douglasii*), interior live oak (*Quercus wislizeni*), and valley oak (*Quercus lobata*) communities found primarily within the foothill region of the southern Sierra Nevada mountains. Oak woodlands (as opposed to scattered oaks or savannas) are defined as having an oak canopy cover of at least 10%. The canopy is dominated by broad-leaved trees, commonly forming open savanna-like stands on dry ridges and gentle slopes. California buckeye (*Aesculus californica*) and gray pine (*Pinus sabineana*) can be significant components of this community as well. While native forbs are thought to have once dominated the understory in these systems, nearly all oak woodlands now support an understory dominated by non-native annual grasses and forbs from Eurasia. Native forbs are often present within the understory, but they rarely dominate. Shrubs are often present but rarely extensive, often occurring on rocky outcrops. Associated shrub species include poison oak (*Toxicodendron diversilobum*), California coffeeberry (*Rhamnus californica*), Manzanita (*Arctostaphylos* spp.), and *Ceanothus* spp.

3.1.2 Riparian Communities

This target includes riparian habitat from the center of the riverbed to the upland edge of the 500 year floodplain. Dominant species in the canopy layer include Fremont cottonwood (*Populus fremontii*), California sycamore (*Platanus racemosa*) and valley oak (*Quercus lobata*). Subcanopy trees include white alder (*Alnus rhombifolia*), boxelder (*Acer negundo*), mulefat (*Baccharis salicifolia*) and Oregon ash (*Fraxinus latifolia*). Typical understory shrub layer plants include California wild grape (*Vitis californica*), wild rose (*Rosa californica*), California blackberry (*Rubus ursinus*), elderberry (*Sambucus* spp.), poison oak (*Toxicodendron diversilobum*), and willows (*Salix* spp.). The herbaceous understory consists of sedges, rushes, grasses, miner's lettuce (*Claytonia perfoliata*), Douglas sagewort (*Artemisia douglasiana*), poison-hemlock (*Conium maculatum*), and hoary nettle (*Urtica* spp.). Montane meadows are also included as part of this target. These areas are influenced by permanent water and are variable in size due to varying sources of permanent presence of surface water throughout the region. The species and structural diversity of riparian communities varies greatly depending on elevation, climate, and soil. These communities are of particular importance to rare nesting and migratory avian species.

Figure 2. Conservation Targets for the Tehachapi Conservation Action Plan



3.1.3 Mojave Desert Scrub and Joshua Tree Communities

These communities subsist in harsh conditions of high temperatures, low moisture and rocky/sandy soils. Desert Scrub habitats typically are open, scattered assemblages of broadleaved evergreen or deciduous microphyll shrubs usually between 0.5 and 2 m in height. Canopy cover is generally less than 50%, with bare ground between plants. This target includes a variety of Mojave Desert shrub species. Creosote bush (*Larrea tridentata*) and blackbrush (*Coleogyne ramosissima*) are often dominants, but many other species can be found in desert scrub communities as well, including catclaw acacia (Acacia greggii), desert agave (*Agave deserti*), coastal bladderpod (*Isomeris arborea*), white brittlebush (*Encelia farinosa*), burrobush (*Ambrosia dumosa*), barrel and hedgehog cactus (Ferocactus and *Echinocereus* spp.), cholla (Cylindropuntia spp.), desert globemallow (Sphaeralcea ambigua), jojoba (*Simmondsia chinensis*), beavertail and pricklypear cactus (*Opuntia* spp.), rabbitbrush (*Chrysothamnus* spp.), desert sand verbena (Abronia villosa), desert senna (*Senna armata*), and Mojave yucca (Yucca schidigera). Forbs and grasses often occur in the shrub understory in desert scrub. These include galleta grass (*Pleuraphis rigida*), and spanish needles (*Bidens bipinnata*). In undisturbed systems, non-native grass species are absent, and native grass species are typically rare. The Joshua tree woodland is a distinct desert scrub community that forms a unique, structurally diverse community type that serves as a definitive and characteristic vegetative symbol of the Mojave Desert. Joshua trees are often found in distinct "woodland" patches which contain a low to dense community of many of the same shrub species found in other types of desert scrub. Joshua trees occur at the same upper elevation limits of the Mojave Desert along with shadscale scrub and blackbrush scrub, although Joshua trees tend to occur on sandier, finer-grained loose soils (TNC 2001). Additionally, structurally they appear to dominate the landscape in relatively dense woodlands within their preferred bands of soil and temperature regimes, they form less than 20% of the vegetative land cover.

3.1.4 Grasslands

California grasslands contain many species that also occur as understory plants in oak woodland and other habitats. Plants grow slowly during the cool winter months, remaining low in stature until spring, when temperatures increase and stimulate more rapid growth. Large amounts of standing dead plant material can be found during summer in years of abundant rainfall and light to moderate grazing pressure. This target is primarily dominated by annual grass species introduced from Eurasia, including ripgut brome (Bromus diandrus), soft chess (Bromus hordeaceus) red brome (*Bromus madritensis* ssp. rubens), wild oats (Avena spp.), wild barley (Hordeum spp.) and foxtails (*Vulpia* spp.), among many others. Grasslands also include a wide variety of native forb species, and non-native forbs such as broadleaf filaree (Erodium botrys) are common. However, intact native perennial bunchgrass stands are rare, and native annual grasses are usually absent in California grasslands. Native perennial grasses, found in moist, lightly grazed, or relic prairie areas, include purple needle grass (Nassella pulchra) and Idaho fescue (Festuca idahoensis). Native perennial grasses are most common in untilled areas and in sites high mean annual rainfall. The California grassland community type serves as important foraging habitat for raptors, and is home to kangaroo rats, kit fox, and many other vertebrate and invertebrate species.

3.1.5 Semi-Arid Montane

Sagebrush, pinyon-juniper woodland, and montane chaparral are all included within the Semi-Arid Montane target. A mosaic of these communities occurs on the slopes of the eastern Sierras. The dominant community depends on rainfall, climate and soil type. Sagebrush stands are typically large, open, discontinuous stands of fairly uniform height. Big sagebrush (*Artemisia tridendata*) is often mixed with other species of shrubs of similar form and growth habit. In better sites, sagebrush stands have an understory of perennial grasses and forbs, including Idaho fescue (*Festuca idahoensis*), bluebunch wheatgrass (*Pseudoroegneria spicata*), several species of needlegrass (*Achnatherum* and *Nassella* spp.), squirreltail (*Elymus elymoides*), and Sandberg bluegrass (*Poa secunda*). At higher elevations, big sagebrush occurs as an understory in conifer stands. Often the habitat is composed of pure stands of big sagebrush, but many stands include other species of sagebrush (*Artemisia* spp.), rabbitbrush (*Chrysothamnus* spp.), horsebrush (*Tetradymia* spp.), gooseberry (*Ribes* spp.), western chokecherry (*Prunus virginiana* var. *demissa*), curl-leaf mountain mahogany (*Cercocarpus ledifolius*), and bitterbrush (*Purshia tridentate*). After disturbance and during years with excess moisture, annual grasses such as cheatgrass (*Bromus tectorum*) and medusahead (*Taeniatherum caput-medusae*) invade sagebrush stands. Pinyon-juniper habitat is open woodland of low, round crowned, bushy trees that range from less than 10 m to 15 m in height. Crowns of individual trees rarely touch and canopy cover generally is less than 50%. Open groves of overstory trees often include a dense to open layer of understory shrubs and low herbaceous plants. Stand structure varies depending on site quality and elevation. Overstory species composition at lower and mid-level elevations ranges from pure stands of pinyon, either singleleaf (*Pinus monophylla*) or Parry (*Pinus quadrifolia*), to stands of pinyon mixed with junipers (*Juniperus* spp.), scrub oaks (*Quercus* spp.), or Mojave yucca (*Yucca schidigera*). At higher elevations, ponderosa (*Pinus ponderosa*) and Jeffrey pine (*Pinus jeffreyi*) may be found in this habitat. Shrub-size plants in the subcanopy include small individuals of the overstory species, as well as big sagebrush, blackbrush (*Coleogyne ramosissima*), common snakeweed (*Gutierrezia sarothrae*), Parry nolina (*Nolina parryi*), curl-leaf mountain mahogany, bitterbrush, and rabbitbrush. Grasses and forbs associated with this habitat include western wheatgrass (*Pascopyrum smithii*), blue grama (*Bouteloua gracilis*), and Indian ricegrass (*Achnatherum hymenoides*). Montane chaparral includes species that can vary from treelike (up to 3 m) to prostrate. When mature, it is often impenetrable to large mammals. Its structure is affected by site quality, history of disturbance (e.g., fire, erosion, logging) and the influence of browsing animals. Following fire in the mixed conifer forest habitat type, whitethorn ceanothus-dominated chaparral may persist as a subclimax community for many years. Montane chaparral is characterized by evergreen species; however, deciduous or partially deciduous species may also be present. Understory vegetation in the mature chaparral is largely absent. Conifer and oak trees may occur in sparse stands or as scattered individuals within the chaparral type. Montane chaparral varies markedly with elevational and geographical range, soil type, and aspect. Common species include: whitethorn ceanothus (*Ceanothus cordulatus*), snowbrush ceanothus (*Ceanothus velutinus*), greenleaf Manzanita (*Arctostaphylos patula*), pinemat Manzanita (*Arctostaphylos nevadensis*), hoary Manzanita (*Arctostaphylos canescens*), bitter cherry (*Prunus emarginata*), huckleberry oak (*Quercus vacciniifolia*), sierra chinquapin (*Chrysolepis sempervirens*), Greene's goldenweed (*Ericameria greenei*), mountain mahogany (*Cercocarpus* spp.), toyon (*Heteromeles arbutifolia*), sumac (*Rhus* spp.) and California buckthorn (*Frangula californica*).

3.1.6 Coniferous Forests

Within the Tehachapi Mountains, the conifer forest is dominated by white fir (*Abies concolor*). ponderosa pine (*Pinus ponderosa*), Jeffery pine (*Pinus jeffreyi*), and incense cedar (*Calocedrus decurrens*) are also present. According to the Sierra Nevada Ecoregional Assessment created by the Conservancy in 2001, montane and subalpine coniferous forests of the Sierra Nevada comprise one of the largest and most economically important vegetation regions in California. This region includes most of the east and west slopes of the Sierra from 2,000 to 5,000 ft on the lower margin to 10,000 to 11,500 ft at its upper limit. The elevation of the vegetation zone is higher in the south because warm, dry conditions extend farther upslope than in the north. In general, every 1,000 ft climb in elevation is equivalent to moving a distance of 300 miles north. Increasing elevation brings with it lower temperatures, greater precipitation, shallower soils, and higher winds. These changes are gradual and so are the changes in vegetation which accompany them. The lower montane zone of Sierran coniferous forests is composed of ponderosa pine forests on more xeric sites and white fir forest on more mesic sites with special areas of giant sequoia groves. Above this zone, forming a transition to the higher subalpine forests, are the upper montane red fir (*Abies magnifica*), Jeffrey pine, and lodgepole pine (*Pinus contorta* spp. *murrayana*) forests. The subalpine zone includes several geographically restricted types dominated by the mountain hemlock (*Tsuga mertensiana*), western white pine (*Pinus monticola*), whitebark pine (*Pinus albicaulis*), foxtail pine (*Pinus balfouriana*), and limber pine (*Pinus flexilis*).

3.1.7 Migratory and Wide Ranging Species

This target includes raptors, migratory passerines, bats, and wide-ranging mammals such as the mountain lion (*Puma concolor*). These species are currently doing well in the region due to the relative intactness of the aforementioned conservation targets. The goal is to keep them in good or very good condition by protecting and enhancing the above habitat types and connectivity and preventing impediments to movement.

3.2 VIABILITY OF CONSERVATION TARGETS

Viability assessment begins by identifying key attributes for each of the conservation targets. At its most basic, a key attribute is an aspect of a target's condition that if present, defines a healthy target, and, if missing or altered, would lead to the outright loss or extreme degradation of that target over time. For example, a key attribute for a freshwater stream target might be some aspect of water chemistry. If the water chemistry becomes sufficiently degraded, then the stream target is no longer viable. Often, key ecological attributes can be placed in three categories to better articulate biodiversity health. The categories of size, condition, and landscape context help teams to further analyze which of target's attributes are the most important.

Although key attributes are specific descriptions of an aspect of a target, they are generally still too broad to measure or assess in a cost-effective manner over time. To this end, it is important to develop indicators that can be used to assess the attribute over time. An indicator is what is measured to keep track of the status of a key attribute. Viability assessment begins by identifying key attributes for each of the conservation targets. The rating system is enhanced by determining a category for each key ecological attribute. Size, condition and landscape context are the general categories that apply to most conservation targets and help project teams create a snapshot of overall biodiversity health.

3.2.1 Viability Rating

Any given key attribute will vary naturally over time. It is "acceptable" when it is in the range as determined by critical thresholds, or the estimate of what constitutes an acceptable range. Once the acceptable range of variation for an attribute is established, the viability rating scale can be specified. This scale involves establishing the following boundaries for an indicator based on the thresholds:

Very Good – Ecologically, economically or socially desirable status; requires little intervention for maintenance.

Good - Indicator within acceptable range of variation; some intervention required for maintenance.

Fair - Outside acceptable range of variation; requires human intervention.

Poor - Restoration increasingly difficult; extirpation of target is likely.

The final step in the viability assessment is to use the rating scale that has been constructed and available evidence and/or expert opinion to determine the current status of the conservation target and the desired status of the target for some point in the future. This desired status becomes a goal for the project. The default philosophy is to improve each target at least one level (e.g. from fair to good).

Table 1. Focal Targets, Key Attributes and Indicators for the Tehachapi Region of Southern California.

#	Conservation Target	Category	Key Attribute	Indicator	Current Rating
1	Oak Woodlands	Landscape Context	Connectivity among communities & ecosystems	Proportion adjacent to unconverted habitat (unconverted= rangeland or housing density < 1 unit per 20 acres)	Good
		Condition	Population structure & recruitment	Proportion of sapling to adult trees (sapling= ~30 year age range, trunk diameter 1-10 cm)	Poor
			Presence/abundance of focal native bird species	Number of native cavity nesting birds	Good
		Size	Size / extent of characteristic communities / ecosystems	Total aerial extent	Very Good
2	Riparian Communities	Landscape Context	Water level fluctuations	Stream flow volume & duration. Ground water levels.	Fair
		Condition	Community architecture appropriate to vegetation community type (as determined by dominant keystone native species)	Heterogeneity of age classes of dominant riparian plant species	Fair
			Intact vs. degraded montane meadows (area-weighted: what proportion of total meadow area shows signs of degradation)	Structural heterogeneity of vegetation characteristic of community	Good
			Presence/abundance of focal native bird species	Presence/abundance of native breeding birds (indicated by presence of birds during the breeding season)	Fair
			Species composition / dominance	Presence of invasive species or other non-natives by patch (fine scale)	Good

#	Conservation Target	Category	Key Attribute	Indicator	Current Rating
		Size	Size / extent of characteristic communities / ecosystems	Total aerial extent	Fair
3	Mojave Desert Scrub and Joshua Tree Communities	Landscape Context	Connectivity among communities & ecosystems	Proportion adjacent to unconverted habitat (unconverted= rangeland or housing density < 1 unit per 20 acres)	Good
			Fire regime - (timing, frequency, intensity, extent)	Proportion of Mojave Desert scrub with natural fire regime	Good
		Condition	Landscape integrity	Habitat intactness at scale	Fair
			Presence of key animal indicator species	Presence of desert tortoise burrows	Fair
			Species composition / dominance	Percent relative native cover	Fair
		Size	Size / extent of characteristic communities / ecosystems	Total aerial extent	Very Good
4	Grasslands	Landscape Context	Connectivity among communities & ecosystems	Proportion adjacent to unconverted habitat (unconverted= rangeland or housing density < 1 unit per 20 acres)	Fair
			Soil / sediment stability & movement	Soil slumping and erosion	Good
		Condition	Species composition / dominance	Percent relative native cover	Good
			Vegetation structure	RDM	Good
		Size	Size / extent of characteristic communities / ecosystems	Total aerial extent	Very Good

#	Conservation Target	Category	Key Attribute	Indicator	Current Rating
5	Semi-arid Montane	Landscape Context	Connectivity among communities & ecosystems	Proportion adjacent to unconverted habitat (unconverted= rangeland or housing density < 1 unit per 20 acres)	Good
			Fire regime - (timing, frequency, intensity, extent)	Proportion of chaparral community with natural fire regime	Fair
		Condition	Heterogeneity of age classes across the landscape	Presence of multiple sagebrush age classes at the watershed scale	Fair
			Lack of invasive plant species	Absence of invasive grass species	Fair
			Landscape integrity	Habitat intactness at scale	Fair
			Presence of native herbaceous cover	Percent relative native perennial grass cover	Fair
		Size	Size / extent of characteristic communities / ecosystems	Total aerial extent	Very Good
6	Coniferous Forests	Landscape Context	Connectivity among communities & ecosystems	Proportion adjacent to unconverted habitat (unconverted= rangeland or housing density < 1 unit per 20 acres)	Good
			Fire regime - (timing, frequency, intensity, extent)	Proportion of conifer community with natural fire regime (FRID)	Fair
		Condition	Population structure & recruitment	Proportion of sapling to adult trees	Fair
			Presence of key animal indicator species	Presence of old growth forest indicator species	Fair
		Size	Size / extent of characteristic communities / ecosystems	Maintain minimum patch size	Good

#	Conservation Target	Category	Key Attribute	Indicator	Current Rating
			Size / extent of characteristic communities / ecosystems	Maintaining area of historic sky islands	Good
			Size / extent of characteristic communities / ecosystems	Total aerial extent	Very Good
7	Migratory and Wide-Ranging Wildlife	Landscape Context	Numbers of migrants successfully traversing region	Bats	Very Good
			Numbers of migrants successfully traversing region	Index of migration - passerines	Very Good
			Numbers of migrants successfully traversing region	Migrating raptors	Very Good
			Numbers of migrants successfully traversing region	Viable mountain lion population	Very Good

4.0 THREATS

Conservation targets are frequently degraded or face threats. In this planning effort, threats consist of stresses and sources of stress as defined below. Threat ranking is a process that identifies and prioritizes direct threats and develops actions to address those threats, beginning with the most critical and reversible threats. Two criteria are established for ranking stresses to ensure objectivity – severity and scope. Severity is defined as the level of damage to the conservation target that reasonably can be expected within 10 years given the continuation of the existing situation. Scope is most commonly defined spatially as the geographic scope of impact on the conservation target at the site that reasonably can be expected within 10 years given the continuation of the existing situation.

In this plan we are also considering the long term impacts of climate change. Since climate change induced threats may take many years to manifest themselves the plan also evaluates potential threats from climate change over a 50 year horizon. See Section 6 for more on the impacts of climate change.

4.1 STRESSES

Every natural system is subject to disturbances. For this plan, only human caused destruction, degradation or impairment of conservation targets are considered. Thus stresses are impaired aspects of targets that result directly or indirectly from human sources (e.g., low population size, reduced extent of forest system). In essence, stresses are degraded key attributes.

4.2 SOURCES OF STRESS

Sources of stress (also known as direct threats) are the proximate activities or processes that have caused, are causing or may cause the stresses (e.g., incompatible management practice or land development). For each stress to a given conservation target there are one or more causes or sources. For the most part, sources of stress are limited to human activities. Thus, tropical storms that blow down large swaths of forest are not threats, but instead part of a natural (and often necessary) disturbance regime. Sources of stress can be currently active, likely to occur in the future (usually defined as within 10 years), or historical. See Appendix B for the detailed ranking of stresses and sources by target.

In addition to ranking the actual direct threat (i.e. stress), the source of that stress is ranked also. The source of stress is ranked based on its (1) level of contribution to the stressed condition and (2) its level of irreversibility. The rankings for the stress and the source of stress are combined to determine the final ranking. A summary of threats, including the final rankings, is presented in Table 2. A detailed summary of threats across the project area can be found in Appendix C.

Table 2. Summary of Threats, with Rank, for the Tehachapi Region of Southern California

Threats Across Targets		Overall Threat Rank
Project-specific threats		
1	Land grading and housing development	Very High
2	Climate change induced temp. changes	High
3	Surface and groundwater diversions	High
4	Construction of roads	High
5	Presence of existing non-native plant species	High
6	Decrease in economic viability of ranching	High
7	Poorly managed cattle and/or sheep grazing	Medium

Threats Across Targets		Overall Threat Rank
Project-specific threats		
8	Invasion of new species (plants, fungi, pathogens, etc.)	Medium
9	Predation by non-native feral animals (cats and/or pigs)	Medium
10	OHV use	Medium
11	Large-scale solar energy development	Medium
12	Increase in frequency of extreme conditions in streamflow.	Medium
13	Wind energy development	Medium
14	Altered fire frequency and intensity	Medium
15	Conversion to agriculture	Medium
16	Utility & Service Lines	Medium
17	Air quality	Low
18	Presence of non-native bird species (i.e. cowbirds and starlings)	Low
19	Mining & Quarrying	Low
20	Oil & Gas Drilling	Low
21	Poorly managed timber harvesting	Low
22	Problematic Native Species	Low
	Threat Status for Targets and Project	Very High

As displayed in Table 2, the top five sources of stress are land grading and housing development, climate change induced temperature changes, surface and groundwater diversions, construction of roads, and presence of existing non-native plant species. The next section goes over in detail the situation analyses dealing with these threats and how they affect the various conservation targets.

5.0 SITUATION ANALYSIS

Once the status of the conservation targets was determined and critical threats were identified, the recurring and most serious threats became apparent across the system. The group then decided to focus on the “situation” at hand or “situation analysis”. It is through this process that we gain a better understanding of what and who is really driving those critical threats, what would motivate these conditions to change, and who might be allies in the efforts to change the trajectory we have defined so far. It was through this process that the team gained a fuller understanding of what and who was really driving those critical threats, what motivations warranted change, and where to focus partnerships.

A complete situation analysis involves assessing the key factors affecting targets including direct threats, indirect threats and opportunities. Each factor can typically be linked to one or more stakeholders. The situation analysis helped the project team understand the project's context - including the biological environment and the social, economic, political, and institutional systems that affect the biodiversity targets in the Tehachapi planning area. It also provides transparency as to precisely what the planning team was considering for causal or compounding factors that contributed to giving the stress a “high” ranking. We selected the highest ranked stresses to and developed a situation analysis for each. These will be the basis for creating work plans and understanding the connection between targets, indicators, and threats (not included in this abridged version).

All targets are affected by climate change induced temperature changes (increases). The situation analyses for targets where this source of stress (direct threat) ranked high are detailed separately in the next section.

For oak woodlands, the stresses (or altered key attributes) of altered connectivity, reduction in size, and low number of cavity nesting species were ranked as a “medium” level stress. In earning such a ranking, the team believes that the problems that are likely to occur in the next 10 years resulting from these stresses will not be widespread or severe. The problems occurring from poor population structure and recruitment, however, will increase in the near future.

Although there are many potential stresses for the Mojave Desert Scrub and Joshua Tree Communities target, only one rises to the top in terms of priority. The decrease in desert tortoise breeding success has earned the highest ranking stress and warrants additional detail.

While there were multiple highly ranked threats, there was much overlap in the situations. Problems arise from transmission lines and roads and should be further developed in the conservation objectives section.

The riparian communities target is the most threatened of the conservation targets in the project. The planning team focused on deciphering the situation analysis further for reduction in recruitment of new riparian woody vegetation and montane meadow degradation.

In examining the situation in a little more detail, surface and groundwater diversions are the driver for native woody vegetation being altered. The montane meadow is threatened on several fronts. The advantage from this particular view is the threats that are only ranked at a "medium" level, which represents a lower priority for action.

The grasslands conservation target has the major stressors of lack of recruitment of native plant species, fragmentation and reduction in size of grassland habitat. Lack of recruitment became the focus of the planning team for additional effort in creating the situation analysis.

The lack of economic viability of ranching exacerbates other threats including invasive species, land grading and housing development. Large expanses of land that are being managed for grazing are more feasible for restoration than land that has been developed. However, the potential for invasive species to proliferate on inappropriately managed ranch lands can also negatively impact the grassland target.

The current health rank for the semi-arid montane target is fair based on viability criteria. However, the future threats are not in a position to dramatically alter the current condition.

Poor population structure and recruitment and lack of key animal indicator species are the stresses that warrant attention for the coniferous forests.

The most pressing stress for the Coniferous forest is the predation by non-native feral animals destroying seeds and seedlings while destabilizing soils and providing a vector for disease.

Currently, the migratory and wide-ranging wildlife conservation target is in very good condition and has no pressing stresses.

6.0 CLIMATE CHANGE

In the context of this CAP, we define climate change as changes in the Earth's climate that are driven by human activity. Warming temperatures, changes in precipitation regimes, shifting weather patterns, and rising seas are all possible outcomes of a changing climate. These changes can lead to accelerated deleterious effects to people and ecosystems including economic losses, increased risk of drought and flood, wildlife at risk, and increased disease and displacement of human populations. While the degree of change likely to occur is somewhat uncertain and difficult to predict, the resolution of climate prediction models is constantly improving.

The Tehachapi planning team examined the particular aspects of climate change and created what we call "Hypotheses of Change" for each of the community-level target within our planning area. For the purposes of our planning exercise, we chose a fifty-year time horizon, and assumed that the following changes would occur over this period of time:

- Unprecedented levels of atmospheric CO_2
- Unprecedented temperatures at all elevations
- Stable or slight decrease of total precipitation, with more falling in the form of rain, and
- More extreme storm events.

These assumptions represent a plausible scenario of climate change over the next half-century, and are supported by agreement among climate models. A situation analysis exercise was conducted for those targets in which climate change induced temperature increases were considered a “highly” ranked source of stress. The results of the exercise are in the table and figures below. A literature search revealed the following information regarding how specific changes in particular climate factors would influence our targets.

Table 3. Hypotheses of Change.

Predicted responses of target communities to hypothesized changes in climate over the next 50 years.

Target	Climate Factor Prediction	Response Variable	Direction of response	Related References
Mixed Conifer Forest	warmer temperatures	forest structure	large tree mortality will increase due to drought stress	Bouldin (1999); Brown et al. 2004; Ferrell (1996); Fried et al. 2004; Lenihan et al. 2008; Littell et al. (2009); Lutz et al. (2009); McKenzie et al (2004); Miller et al. (2008); Panek et al (2008); Safford et al. (2008); van Mantgem et al. (2004); van Mantgem and Stephenson (2007); van Mantgem et al. (2009); Westerling and Bryant (2008); Westerling et al. (2006)
		fire severity	larger and more frequent fires and conversion to chaparral	
Semi-Arid Montane	warmer temperatures	fire frequency	increased drought stress will lead to drier conditions and more frequent fires	Chambers (2007), (2008), and GTR (2004); Bradley (2008); Miller IJWF (2008); Taucsh personal communication (2009)
		native cover	fires will reduce native cover	
		pinyon/juniper health	drought stress will kill trees	
Target	Climate Factor Prediction	Response Variable	Direction of response	Related References
Oak Woodlands	warmer temperatures	oak seedling recruitment	reduction in soil moisture will increase seedling mortality; acorn production may be earlier	Bradford et al. (2007); Davis et al. (1991); Swiecki and Bernhardt (1998)
		size of existing oak woodland stands	rate of mortality of existing oak trees will increase- stands will thin and some will disappear	Mackenzie, Jason (2009)
Grasslands	warmer temperatures	flowering onset	all species earlier	Cleland et al. (2006)
		species	favors some forbs	Zavaleta et al. (2003b)

		composition		
	higher CO_2 concentration in atmosphere	species composition	favors late-season species	Field et al. (1996); Chiariello and Field (1996); Zavaleta et al. (2003b)
		species diversity	fewer forbs	Zavaleta et al. (2003a)
Mojave Desert Scrub and Joshua Tree Communities	warmer temperatures	plant productivity	reduced plant growth (if hotter in summer); more plant growth (if warmer in winter)	speculation
		species composition	shift towards more drought-avoiding species (i.e. invasive annual grasses)	speculation
	higher CO_2 concentration in atmosphere	plant productivity	more plant growth (high CO2 offsets neg. effects of higher temps and drought)	Hamlerlynk et al. (2000)
			range expansion due to increased tolerance for low temps with high CO2	Loik et al. (2000)
		species composition	anthropogenic CO2 increases will drive ecosystem change even in the absence of significant climate change	Dole et al. (2003)
			more shrubs and woody species	Polley et al. (2002)
			elevated CO2 may have its greatest positive effect on Mojave Desert shrub recruitment when accompanied by increased rainfall	Housman et al. (2003)
Riparian Communities	warmer temperatures	flooding/saturation of riparian areas	above 5,000 ft, peak runoff will shift to earlier in season b/c of reduced snowpack, causing more flooding at low elevations	3 years of baseline data from KREW study by USDA Forest Service Pacific Southwest Research Station; Vorster (2005); Sequoia Riverlands Trust (2004), (2008)

The planning team predicts that the warming climate will adversely affect the population structure of the oak woodland target. As with other targets, the population structure and recruitment of the oak community are already affected by the threat of competition for moisture light and space from invasive species. Warmer temperatures exacerbate the effects of all of the other known threats.

For riparian communities, climate change induced temperature changes affect recruitment by changing the timing, extent and duration of how water is cast upon and transferred across the landscape.

The desert tortoise represents one of the keystone species of the Mojave Desert scrub and Joshua tree communities target. A warming climate will adversely affect breeding success as well as other population dynamics of the desert tortoise. Aside from the direct effects of changing the sex ratio of eggs, more energy is predicted to be needed in other life stages including burrowing, foraging, and finding mates.

7.0 CONSERVATION OBJECTIVES

Objectives are specific and measurable statements of planned achievement. For the Tehachapi region, conservation objectives were selected that would enhance target viability or abate critical threats. For each objective, specific strategic actions were defined. To prioritize the objective, the associated strategic actions were evaluated based on benefits, feasibility, and cost. The objectives were then prioritized by group (A, B or C) with the strategic actions prioritized within each objective. These conservation objectives with ranked strategic actions are presented in Table 3. The objective groupings represent the priorities for implementation by the planning team with ranked strategic actions. Group A consists of mostly protection strategies while Group B focuses on restoration activities.

Table 4. Group A Conservation Objectives with Ranked Strategic Actions

#	Objectives and Strategic Actions	Overall Rank
Objective	**Protect 50-70% (60,000 new acres) of Oak Woodland by 2015**	
Strategic action	Acquire fee or easements over strategic range lands.	High
Strategic action	Include transect protection funding in CAPP priorities.	Very High
Strategic action	Include slope orientation and other micro level climate factors in site selection for direct protection.	Very High
Strategic action	Incorporation of key conservation areas in County General Plan & land use regulations.	High
Strategic	Ensure appropriate mitigation funding/conditions are received from	Very

#	Objectives and Strategic Actions	Overall Rank
action	for development/infrastructure impacts and applied within the project area.	High
Strategic action	Conserve lands in "elevational transects" or wildlife linkages where practical.	High
Objective	**Protect 75% of all Riparian Communities by 2015**	
Strategic action	Acquire fee or easements over strategic range lands.	High
Strategic action	Include transect protection funding in CAPP priorities.	Very High
Strategic action	Include slope orientation and other micro level climate factors in site selection for direct protection.	Very High
Strategic action	Protect lands with significant existing riparian resources.	High
Strategic action	Develop strategies to restore flows (e.g. purchase water rights, water management, etc).	High
Strategic action	Incorporation of key conservation areas in County General Plan & land use regulations.	High
Strategic action	Focus conservation in major drainages with highest diversity (e.g. Kern, Caliente, Walker, and Tejon)	High
Strategic action	Focus conservation on areas projected to have long term perennial flows.	High
Strategic action	Ensure appropriate mitigation funding/conditions are received from for development/infrastructure impacts and applied within the project area.	Very High
Strategic action	Explore an "ecosystem services mitigation fee" on water exported from project area.	High
Strategic action	Target areas with large tree canopy (or restoration candidates that can support large canopy).	Low
Strategic action	Maintain/enhance stream passage to higher elevations by protecting key reaches.	High
Objective	**By 2011 ensure effective conservation of at least one**	

#	Objectives and Strategic Actions	Overall Rank
	elevational transect in the Tehachapi Region, begin two others.	
Strategic action	Review current BLM plans and ensure that their disposal of properties aligns with our strategies for acquisition and the creation of landscape linkages. Timeline: finish by 2010.	High
Strategic action	Select transect extending from low to high elevation that includes targets with large projected CC stable and expansion areas.	High
Strategic action	Ensure appropriate mitigation funding/conditions are received from for development/infrastructure impacts and applied within the project area.	Very High
Strategic action	Identify and protect refugia that may facilitate species survival in light of climate change.	High
Strategic action	Include slope orientation and other micro level climate factors in site selection for direct protection.	Very High
Strategic action	Include transect protection funding in CAPP priorities.	Very High
Strategic action	Locate future transects at appropriate latitudes intervals (e.g. separate on north south access to address CC impacts).	High
Strategic action	Promote appropriate management of public lands to help achieve this objective.	High
Objective	**By 2012, protect key conservation lands with protected designation in local land use policy/laws**	
Strategic action	Incorporation of key conservation areas in County General Plan & land use regulations.	High
Strategic action	SSP take action to support SB 375 implementation.	Very High
Objective	**Create a minimum viable linkage (to build upon with future land protection) from Tejon Ranch to Sequoia National Forest by 2013**	
Strategic action	Conserve lands in "elevational transects" or wildlife linkages where practical.	High
Strategic action	Review current BLM plans and ensure that their disposal of properties aligns with our strategies for acquisition and the creation	High

#	Objectives and Strategic Actions	Overall Rank
	of landscape linkages. Timeline: finish by 2010.	
Strategic action	SSP promotes long term partnerships with ranching community to retain Williamson Act.	Very High
Strategic action	Review and comment on Caliente Resource Management Plan. Timeline: finish by end of 2009.	High
Strategic action	Ensure protection of wildlife corridor through Tejon Ranch by 2013.	Very High
Strategic action	Conduct overview and analysis of existing information regarding renewable energy and migration/wildlife movement	Very High
Objective	**Protect 50-70% of Grasslands by 2015**	
Strategic action	Acquire fee or easements over strategic range lands.	High
Strategic action	Include transect protection funding in CAPP priorities.	Very High
Strategic action	Include slope orientation and other micro level climate factors in site selection for direct protection.	Very High
Strategic action	Incorporation of key conservation areas in County General Plan & land use regulations.	High
Strategic action	Ensure appropriate mitigation funding/conditions are received from for development/infrastructure impacts and applied within the project area.	Very High
Strategic action	Conserve lands in "elevational transects" or wildlife linkages where practical.	High

Table 5. Group B Conservation Objectives with Ranked Strategic Actions

#	Objectives and Strategic Actions	Overall Rank
Objective	**By 2012, enhance and maintain north-south migratory flyways for birds and bats to/from Southern Sierra Nevada**	

#	Objectives and Strategic Actions	Overall Rank
Strategic action	Review current BLM plans and ensure that their disposal of properties aligns with our strategies for acquisition and the creation of landscape linkages. Timeline: finish by 2010.	High
Strategic action	Review and comment on Caliente Resource Management Plan. Timeline: finish by end of 2009.	High
Strategic action	Conduct a new study within the Tehachapi CAP area using radar and/or observational data to understand the impacts of turbines on bird migration. Complete by 2012.	High
Strategic action	Develop a science-based set of comments for county, state, and federal agencies regarding permitting of wind energy development by 2012.	Medium
Strategic action	Ensure appropriate mitigation funding/conditions are received from for development/infrastructure impacts and applied within the project area.	Very High
Objective	**Restore stream flows to key perennial streams by 2015.**	
Strategic action	Develop strategies to restore flows (e.g. purchase water rights, water management, etc).	High
Strategic action	Evaluate potential partnerships with fishing, recreation and other conservation groups to meet objective.	Medium
Strategic action	Acquire water rights needed to maintain flows in important drainages.	High
Strategic action	Convert high water usage operations in key drainages to lower water use crops or grazing land.	High
Objective	**By 2013 increase BLM and other agency management of Mojave Desert Scrub and Joshua Tree communities to increase desert tortoise breeding success**	
Strategic action	Create higher designation of protection for "protected" land with managing agencies.	Very High
Strategic action	Make CC data/projections and strategies available to public agencies.	Low
Strategic action	Create renewable energy mitigation funded program for improved land management.	Very High

#	Objectives and Strategic Actions	Overall Rank
Strategic action	Assist/support elimination and reduction of edge and in holdings of incompatible uses.	Medium
Strategic action	Review current BLM plans and ensure that their disposal of properties aligns with our strategies for acquisition and the creation of landscape linkages. Timeline: finish by 2010.	High
Strategic action	Review and comment on Caliente Resource Management Plan. Timeline: finish by end of 2009.	High
Strategic action	Increase capacity within governmental agencies to combat new alien species infestations by developing and funding a rapid response team.	High
Strategic action	By 20XX have major invasive plants (e.g. arundo, tamarisk, lepidium) declared noxious weeds (illegal).	Medium
Strategic action	Improve best management practices by public agencies.	Medium
Objective	**By 2014 protect >75% of 100 year floodplain on key rivers/streams (e.g. Kern, Walker, Caliente, etc)**	
Strategic action	Create alliances with water agencies, ground water mgmt. districts flood control agencies and local water users to develop a floodplain protection program.	High
Strategic action	SSP support and implement a watershed (hydrologic cycle) education program for local community.	Low
Objective	**No new or expansion of existing dams in project area**	
Strategic action	By 2010 determine if key reaches of the Kern River would benefit from designation as Wild and Scenic or other special status preventing export of water.	Medium
Strategic action	Explore an "ecosystem services mitigation fee" on water exported from project area.	High
Strategic action	SSP support water conservation in central and So. CA.	Low
Strategic action	Acquire water rights needed to maintain flows in important drainages.	High

#	Objectives and Strategic Actions	Overall Rank
Objective	**Improve Riparian Communities to at least 3 size classes of vegetation in 50% of lands by 2020**	
Strategic action	Include best management practices in all conservation easements.	Medium
Strategic action	By 20xx identify dewatered perennial streams and the cause thereof.	-
Strategic action	Develop strategies to restore flows (e.g. purchase water rights, water management, etc).	High
Strategic action	Maintain/enhance stream passage to higher elevations by protecting key reaches.	High
Strategic action	Promote fencing and/or appropriate livestock management in Riparian Communities on newly acquired easement land (EQIP and WHIP)	Medium
Strategic action	Promote programs such WHIP and EQUIP to fence X miles of riparian corridor and develop alternative stock watering sources.	Low
Strategic action	Protect lands with significant existing riparian resources.	High

Group C contains objectives that may be considered risky, uncertain or costly. These are the areas that warrant more detailed consideration before implementation is carried out.

Table 6. Group C Conservation Objectives with Ranked Strategic Actions

#	Objectives and Strategic Actions	Overall Rank
Objective	**Promote retention of economically sustainable ranching as a viable land use in appropriate areas.**	
Strategic action	SSP promotes long term partnerships with ranching community to retain Williamson Act.	Very High
Strategic action	Create & implement a BMP certification program for cattle grazing by 20XX.	Low
Strategic action	By 20XX create and fund a program for oak conservation BMP's incentives implemented by NRCS.	Low

#	Objectives and Strategic Actions	Overall Rank
Strategic action	Develop a conservation buyer/young rancher program/data base.	Medium
Strategic action	Develop a conservation/ranching collaborative with equal interests to promote retention of ranching.	Medium
Strategic action	Acquire fee or easements over strategic range lands.	High
Objective	**No additional export of water from project area**	
Strategic action	By 2012 assess potential long term water export threat including additional diversions, ground water extraction and dam/reservoir construction.	Low
Strategic action	By 2010 determine if key reaches of the Kern River would benefit from designation as Wild and Scenic or other special status preventing export of water.	Medium
Strategic action	Evaluate potential partnerships with fishing, recreation and other conservation groups to meet objective.	Medium
Strategic action	Acquire water rights needed to maintain flows in important drainages.	High
Strategic action	Explore an "ecosystem services mitigation fee" on water exported from project area.	High
Objective	**Annually maintain healthy fire regimes throughout the region**	
Strategic action	Collaborate with agencies to determine and implement appropriate non-native roadside fuel reduction measures	Low
Strategic action	Improve best management practices by public agencies.	Medium
Strategic action	Promote appropriate management of public lands to help achieve this objective.	High
Strategic action	Work with agencies to enforce use of spark arresters and educate OHV users about fire. Timeline: finish by 2015.	Low
Strategic action	Collaborate with agencies to make a plan for prescribed burning (controlled burns) in INTACT sagebrush communities	Low

#	Objectives and Strategic Actions	Overall Rank
Objective	**Annually maintain or reduce current levels of invasive species in priority areas in the Tehachapi Region**	
Strategic action	Increase capacity within governmental agencies to combat new alien species infestations by developing and funding a rapid response team.	High
Strategic action	Collect invasive species information from a rapid field assessment of Riparian Communities. Timeline: finish by end of 2010.	Low
Strategic action	Modify CEQA and NEPA to create an exemption for rapid response invasive removal by 20XX.	Very High
Strategic action	By 20XX have major invasive plants (e.g. arundo, tamarisk, lepidium) declared noxious weeds (illegal).	Medium
Strategic action	Evaluate and implement appropriate bio control measures (e.g. UCSB tamarisk).	Low
Strategic action	Assess and manage the threat of wild pigs.	Low
Objective	**Improve oak recruitment so that 50% of Oak Woodlands throughout its range have a ratio of 1 sapling per 2 adult trees by 2050**	
Strategic action	Include best management practices in all conservation easements.	Medium
Strategic action	Assess and manage the threat of wild pigs.	Low
Strategic action	Create & implement a BMP certification program for cattle grazing by 20XX.	Low
Strategic action	Develop best grazing practices for oak woodlands by 20XX.	Medium
Strategic action	By 20XX create and fund a program for oak conservation BMP's incentives implemented by NRCS.	Low
Strategic action	Support a study/survey that will ID issues and solutions for oak recruitment within the project area to be completed by 20XX.	Low
Objective	**Design and implement climate change studies focusing on population recruitment for oak woodlands, riparian, and**	

#	Objectives and Strategic Actions	Overall Rank
	coniferous forests and breeding success in desert tortoises	
Strategic action	At least every 5 years update this CAP to include up-to-date CC science.	Medium
Strategic action	Make CC data/projections and strategies available to public agencies.	Low
Strategic action	SSP partners schedule and host CAP update workshops =< every 5 years.	Low
Strategic action	Revised CAP strategies incorporated in SSP partner conservation plans within 12 months of CAP updates as appropriate.	Medium
Strategic action	Choose "early warning" indicator species for climate change (e.g. change in avian territories) and develop a monitoring program to track changes.	Medium
Strategic action	By Dec. 2010 SSP partners develop/implement a program to improve and collect CC data for area.	Medium
Strategic action	Update CNDDB data and veg data for private lands.	Medium

8.0 MEASURING RESULTS

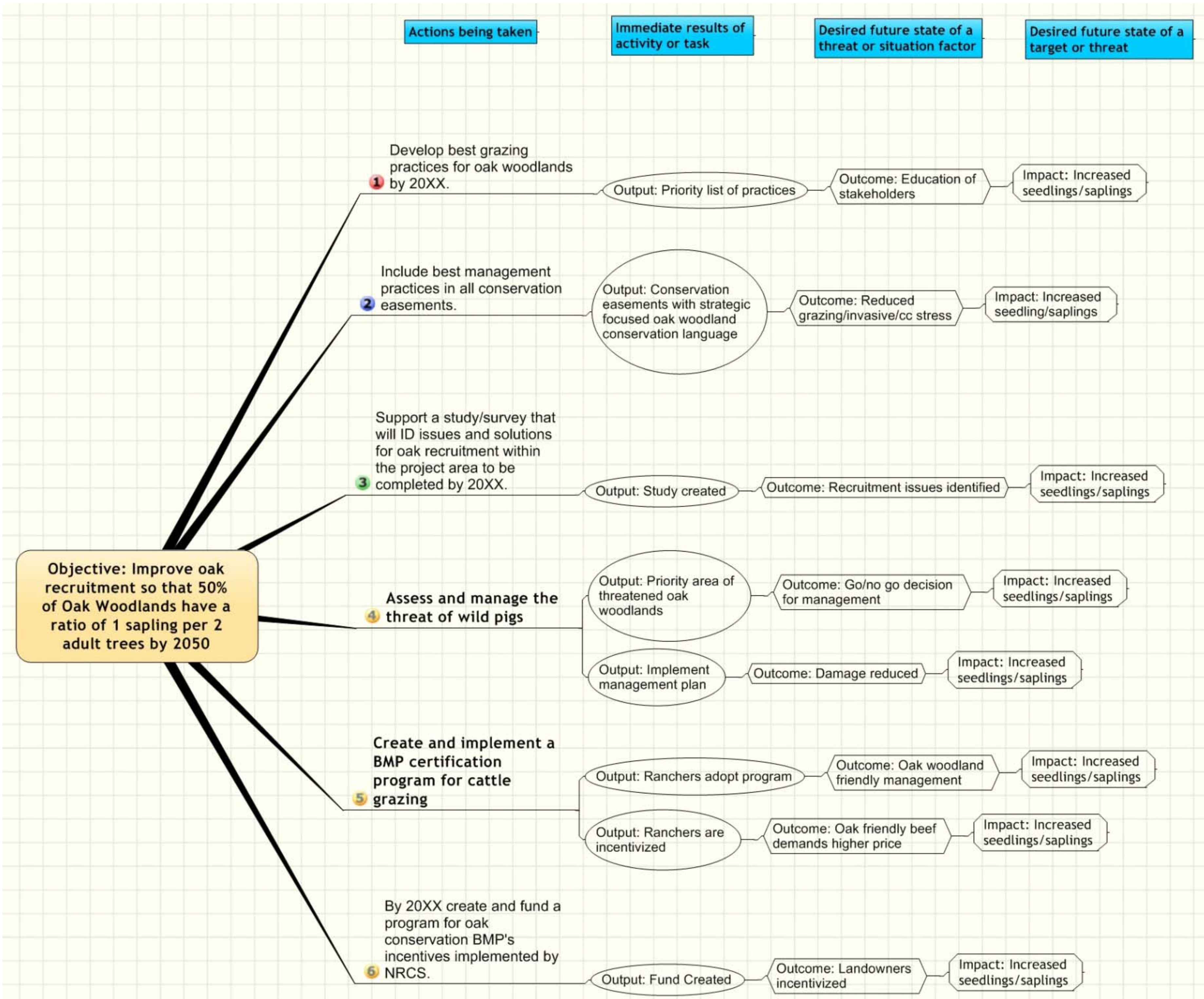
Measuring results is imperative in determining how the biodiversity of interest is doing and in determining whether or not chosen actions are having the desired effects. Status measures are those measures of viability that yield the current condition rating. Clearly defining status indicators facilitates the creation and execution of measurable objectives. Status indicators rated as poor or fair or that are directly related to conservation objectives should be monitored at least annually. Status indicators with a rating of good or very good still warrant monitoring, but at longer intervals.

Strategy effectiveness measures indicate if chosen actions are yielding the intended conservation results. Many times when strategic actions are created, there are assumptions that are taken into account. Without clarifying those assumptions, teams could falsely believe that when they carry out the tasks in their management plan that they will be successful. True success includes not only measuring how effective strategies are, but their impact on the specific indicators of the key ecological attributes that are instrumental in protecting and enhancing biodiversity.

8.1 RESULTS CHAINS

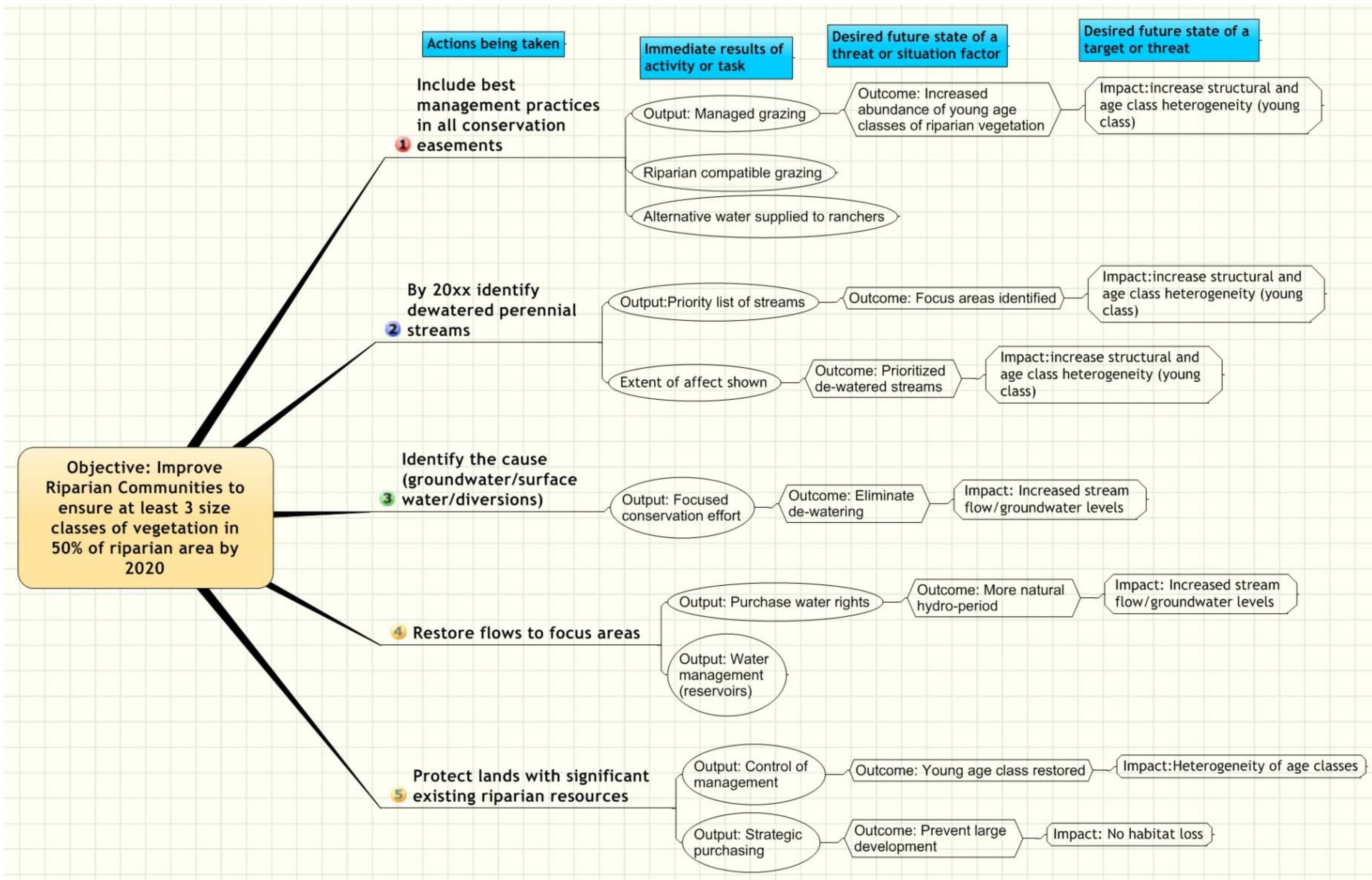
Results chains are a way to connect status and effectiveness measures while keeping transparent the inputs and outputs with expected impacts. These results chains are the product of the planning group where we explored a series of “if…then” statements. The results chain captures the group’s philosophy concerning how a specific activity will contribute to abating a critical threat or enhancing target viability. Different from situation analysis, this method clarifies assumptions and focuses on achieving results. The exercise is represented in the form of a flow diagram starting with strategy and ending with impact.

Figure 3. Oak Woodlands Results Chain for improving recruitment



For the oak woodlands target, the above results chain will greatly aid in deciding whether to act or delay implementation by providing an outline for a detailed work plan.

Figure 4. Riparian Communities results chain exploring increasing structural heterogeneity.



The above objective ranked a little lower due to its action steps being broad and potentially less feasible to implement. As above, the implementation decision can be aided by this "road map" for a detailed work plan.

8.2 MONITORING GUIDELINES AND RECOMMENDATIONS FOR PRIORITY INDICATORS

1) Total area protected of oak woodlands

   The total area of oak woodlands protected will be determined by using Geographic Information System (GIS). Baseline vegetation data used was the USFS-CDF EVEG Vegetation data obtained from USDA Forest Service - Pacific Southwest region - Remote Sensing Lab 2001, 2003. Oak woodlands can be mapped every three years using up-to-date county parcel data to track changes in the amount of area protected. Verification of the presence of oak woodlands can generally be completed using aerial images.

2) Total area of protected riparian communities

   Two GIS methods can be used to track riparian community protection. One is based on the USFS-CDF EVEG Vegetation data. The second is based on the total linear distance of creeks, streams and rivers. Vegetation data can under estimate the presence of riparian vegetation as the resolution of vegetation mapping is often too coarse to capture these many of these linear features. Using the distance of creeks, streams and rivers can over estimate riparian vegetation as not all of the areas along these features will contain riparian vegetation. Unless relatively high resolution data exists for the area, field verification may be necessary to accurately map the extent of these communities. GIS can be used to estimate protected riparian communities every three years and field verification can be completed every six years.

3) Number of key conservation areas protected

   Parcel data obtained from the various counties can be compared, using GIS, to key conservation areas to determine the amount of protected lands occurs within each area. Key conservation areas can be mapped every three years using up-to-date county parcel data to track changes in the amount of protected lands.

4) Number of elevational transects protected

   The location of protected lands can be mapped using GIS to determine their location with respect to elevational transects. This exercise will not only identify transects that have been protected, but can help prioritize future transects based on proportion complete and proximity to other completed or potential transects. Elevational transects can be mapped every three years using up-to-date county parcel data to track changes in the amount of area protected.

5) Total area of grassland protected

   The total area of grasslands protected will be determined by using GIS. Baseline vegetation data used was the USFS-CDF EVEG Vegetation data. Grasslands can be mapped every three years using up-to-date county parcel data to track changes in the amount of area protected. Verification of the presence of grasslands can generally be completed using aerial images.

6) Proportion of sapling to adult trees in oak woodlands

Long-term monitoring sites can be established throughout the region to monitor oak recruitment and regeneration. The simplest design would be to tag and map individual adult trees and count the number of seedlings and sapling present in an area that extends 3 meters beyond the edge of the canopy or to the canopy of the nearest tree, whichever is the shorter. The ratio of saplings to adults can then be calculated. The number of seedlings can be used to help make inferences about the future of saplings. This design allows other factors to be surveyed relatively easily if time or money becomes available including slope, aspect, soil type, litter depth, and acorn production. Survey sites could also be monitored for the presence of invasive species increasing the value of monitoring these sites. As changes in sapling densities change slowly, sites can be monitored every eight years. Optimally a subset of sites would be monitored every two or four years to maximize the number of sites.

7) Structural heterogeneity of age classes and vegetation in riparian communities

Structural heterogeneity of age classes could be determined by establishing long-term belt-transects perpendicular to creeks supporting riparian vegetation. Within the belt transect the species, height and stem diameter of riparian woody species would be recorded. This data would be used to describe the community's age class distribution. Additionally, species relative abundance provides information on the condition of the community as different species may be present in the community based on time since disturbance, incompatible management, and invasive species invasion. All species present along belt-transects should be recorded to assist with invasive species monitoring. Monitoring should be conducted every five years at stable sites and every three years in areas expected to change due to changes in management or protected status.

8) Presence of desert tortoise burrows for Mojave Desert scrub and Joshua tree communities

Systematic surveys for desert tortoise burrows could be conducted in suitable habitat. Surveys should be based on established protocols, but would likely include surveying an area following the lines of a predefined grid. Lines of the grid would be walked and burrows observed would be documented. Optimal line spacing, grid size, timing and frequency may be available from FWS or other agencies or organizations with a mission to protect the desert tortoise.

9) Percent relative native cover for Mojave Desert scrub and Joshua tree communities

Various methods are available to monitor relative cover, each with benefits and costs. Point-intercept data taken along transects provides a relatively fast and accurate method for monitoring shrubland communities that minimized observer variability and bias. This method is best for sites that will be monitored through time to detect changes in cover. The CNPS relevé survey method provides a rapid monitoring method best suited for assessing large areas very quickly. This method is relatively subjective resulting in a lot of observer variability. The relevé method is best suited for monitoring at the scale necessary for this type of assessment, but care should be taken not to over interpret the data, especially if collected by many individuals or at the same site for multiple years. If aerial or satellite images are available from the right time of year, GIS could potentially aid in this monitoring. If herbaceous plants have a different spectral signature than native shrubs strategic ground surveys could inform the relative abundance of native and non-native herbaceous species in give areas and be scaled up using GIS. As a majority of the keystone desert species are large slow-growing perennials, monitoring should occur every four years. Optimally, two sets of sites should be established with one set being sampled every two years.

10) Proportion adjacent to unconverted habitat for grasslands

The proportion of (protected?) grasslands adjacent to unconverted habitat can be determined using GIS. Baseline vegetation data used was the USFS-CDF EVEG Vegetation data. The amount of grasslands adjacent to converted lands and intact habitats can be determined and a proportion calculated. The proportion can be calculated every three years using up-to-date aerial or satellite image (and county parcel data if protected) to track changes.

11) Presence of invasive species across all targets

A road-based survey method may be best to monitor for invasive species across all targets across the region. Driving allows rapid surveys of large areas and roads are often the mechanism for the introduction and spread of invasive species. If specific species have distinct spectral signatures, GIS could be used to map larger occurrences. Optimally, this would be ongoing and a local organization or agency could keep track of occurrences reported by local agencies and residents, confirm them and document any treatment and changes based on treatment.

For all objectives that will be chosen for implementation in an annual plan, strategy effectiveness measures with a timeline should be developed.

8.3 PRIORITY LIST OF OBJECTIVES THAT NEED DETAILED WORK PLANS

Because the objectives have been grouped by priority of ranking, detailed work plans should be developed for all objectives in Groups A and B. With each strategic action, a responsible person should be identified with an implementation schedule and resources needed. Development of work plans is imperative for organizations to accurately budget the necessary time and financial resources to achieve any desired conservation impacts and creates realistic performance measures for management.

APPENDIX C

REGIONAL CONSERVATION DESIGN METHODS AND NOTES

This appendix covers some methods documentation as well as overall conceptual basis for the regional conservation design.

Subregions

Given the large and diverse planning area, and the multiple configurations of areas that could meet our goals, it is important to ensure that our conservation areas are not overly biased to one particular environmental context. One key factor that contributes to many of the regional design objectives is subregional stratification across major physiographic zones. Similar to ecoregions, but at a finer scale, a subregion should have similar vegetation, landforms, and climate and each subregion should be as different as possible from others. In ecoregional planning, subegions are often defined based on latitude and elevation, as these are primary gradients across large areas. In this region, the primary gradients are also latitudinal and elevational and the subregions that we've chosen divide up the region along those gradients.

We used the Ecological Subsections as our subregions published by the U.S. Forest Service (Goudey and Smith 1994). These units are defined as "areas with similar surficial geology, lithology, geomorphic process, soil groups, subregional climate, and potential natural communities" (ECOMAP 1993). The primary purpose of the subregions is to allocate the conservation areas across the major gradients to ensure that the network is capturing the full variability in target distributions, and as such will be more resilient to changes in environmental conditions.

Targets

Our ecological system targets are the same as those used in the Conservation Action Planning process. The GIS data that we used to represent the distribution of these targets was based primarily on the Calveg vegetation data developed by the Regional Remote Sensing Lab of the U.S. Forest Service (Existing Vegetation – CALVEG 2008). These data are relatively high resolution for this large of an area and were aggregated to the general level of the targets in this process. See Appendix for a crosswalk table and processing notes. To supplement the coarse-filter vegetation data we assembled two finer-scale layers for the region which represent important conservation features and components of our targets, soils that harbor rare plants (based on NRCS SSURGO surveys, Table 2) and freshwater wetland data from the National Wetlands Inventory.

Table 1. Crosswalk of WHR types to SSP vegetation targets

SSP Target	WHR Type	WHRCODE
Alpine and Subalpine	Alpine-Dwarf Shrub	ADS
	Subalpine Conifer	SCN
Conifer Forest	Jeffrey Pine	JPN
	Lodgepole Pine	LPN
	Montane Hardwood	MHW
	Montane Hardwood-Conifer	MHC
	Ponderosa Pine	PPN
	Red Fir	RFR
	Sierran Mixed Conifer	SMC
	White Fir	WFR
	Redwood	RDW
Desert Scrub	Alkali Desert Scrub	ASC
	Bitterbrush	BBR
	Desert Scrub	DSC
	Desert Succulent Shrub	DSS
	Desert Wash	DSW
Freshwater Wetlands and Wet Meadow	Freshwater Emergent Wetland	FEW
	Wet Meadow	WTM
Grasslands	Annual Grassland	AGS
Joshua Tree	Joshua Tree	JST
Oak Woodlands	Blue Oak Woodland	BOW
	Blue Oak-Foothill Pine	BOP
	Coastal Oak Woodland	COW
Riparian	Desert Riparian	DRI

	Montane Riparian	MRI
	Valley-Foothill Riparian	VRI
	Valley Oak Woodland	VOW
	Valley Foothill Riparian	VRI
Rivers, Lakes, Streams	Lacustrine	LAC
	Riverine	RIV
Semi-arid montane	Low Sage	LSG
	Juniper	JUN
	Montane Chaparral	MCP
	Pinyon-Juniper	PJN
	Sagebrush	SGB
Shrublands	Chamise-Redshank Chaparral	CRC
	Coastal Scrub	CSC
	Mixed Chaparral	MCH

Table 2. List of SSURGO parent material classes used for rare plant substrate layer

PMGROUPNAME (Parent material group name)
basalt
calcareous, altered serpentinite
colluvium derived from gabbro
colluvium derived from gabbro-diorite
gabbro
gabbro-diorite
hornblende schist
residuum weathered from basalt
residuum weathered from gabbro
weathered granitic rock

Locked-in conservation lands

To meet the design objective of efficiency and to improve the viability of existing protected lands, planners often use 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. The Marxan model seeks to minimize the total edge (boundary length) of conservation areas and will build around lock-ins to meet as much of the goal as possible. As such, lock-ins can strongly influence how the model selects areas to meet goals and as such, is a factor that needs clear justification.

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 have very low levels of formal protection but are 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 planning team decided not to lock-in federal lands in the region (BLM, NPS, USFS) for several reasons: 1. they are so extensive that would overwhelm the regional design to the detriment of intact foothill ecosystems with similar targets, 2. many team members felt that locking-in these lands would make them less of a conservation priority, because it implies that their conservation needs are being met (targets are viable and threats are abated), 3. climate change effects will be owner-blind and may erode the values that these areas were set up to maintain. The list of fee areas locked-in is below.

Table 3: Fee lands locked-in (source CPAD 2009, GreenInfo Network 2009)

Unit Name	Agency
Avocado Lake	California Department of Fish and Game
DWR Mitigation-L.A. Property	California Department of Fish and Game
Lost Lake Fishing Access	California Department of Fish and Game
San Joaquin Fish Hatchery	California Department of Fish and Game
Bakersfield	California Department of Fish and Game
Kings River Nature Preserve	Tulare, County of
Dry Creek Preserve	Sequoia Riverlands Trust
Homer Ranch	Sequoia Riverlands Trust
James K. Herbert Wetland Prairie Preserve	Sequoia Riverlands Trust
Kaweah Oaks Preserve	Sequoia Riverlands Trust
Lewis Hill Preserve	Sequoia Riverlands Trust
Blue Ridge National Wildlife Refuge	United States Fish and Wildlife Service
Blue Ridge Ecological Reserve	California Department of Fish and Game
Kaweah Ecological Reserve	California Department of Fish and Game
Monache Meadows Wildlife Area	California Department of Fish and Game
Springville Ecological Reserve	California Department of Fish and Game
Stone Corral Ecological Reserve	California Department of Fish and Game
Sand Ridge Preserve	Center for Natural Lands Management
Pixley Preserve	Center for Natural Lands Management
McKenzie Preserve at Table Mountain	Sierra Foothill Conservancy
Big Table Mountain Ecological Reserve	California Department of Fish and Game
Miller Preserve at Black Mountain	Sierra Foothill Conservancy
San Joaquin River Ecological Reserve	California Department of Fish and Game
Tivy Mountain Preserve	Sierra Foothill Conservancy

Wind Wolves Preserve	The Wildlands Conservancy
Canebrake Ecological Reserve	California Department of Fish and Game
Yaudanchi Ecological Reserve	California Department of Fish and Game

Suitability factors

One of the primary factors that Marxan uses to select areas to meet goals is the suitability, or cost layer. This layer is usually derived as an index of multiple factors that enable or constrain conservation in a place. It is meant to represent the suitability of a place for conservation action, and can either be specific to the ecological attributes of the target species and communities, or reflect more general land use patterns. Areas with high suitability are more attractive for Marxan (have lower cost to select and include in solution), and are preferentially selected to meet goals.

In this study, we defined suitability as a function of three factors: road density, housing density and agricultural land use. For each planning unit, the mean housing density (in 2000), the weighted road density (weighted by class of roads, with larger roads counting more), and the extent of intensive agriculture land uses (does not include grazing land) is derived from GIS layers representing each factor. Each factor is assigned a relative weighting to account for the degree to which that factor affects suitability. Here, housing is 5X, road density is 2X and agriculture is 1X. As such, when combined these factors basically are surrogates for degradation and fragmentation due to anthropgenic land use and infrastructure.

These land use factors tend to penalize selection of areas on Valley floor and in the foothills, favoring montane and subalpine zones. Threats that lower suitability of high elevation areas including air pollution, fire suppression and invasive species are not included in the suitability layer because in most cases their effects can be mitigated or reversed over time, while it is more difficult to restore areas that have undergone development or land use conversion.

Climate change factors in site selection

Steep temperature gradients:

Using recent temperature data (1961-1990) developed by the PRISM group (Daly et al. 2001), we derived temperature gradients from the slope of January minimum temperature (Tmin) values. We used the planning units to sample the resulting 800m slope surface and recorded a range of statistics for each unit, including the mean, range, minimum and maximum. We used mean slope as the value to discount suitability. The goal of using slope as the measure for temperature gradients is to characterize the relationship to climate space (the rise) over the geographic space (the run). The assumption is that areas with steeper gradients (more climate space per geographic area) will be more likely to provide adaptation options in the face of increasing temperatures. Across the whole region, average slope values were transformed and scaled so that the maximum value in the region was .25. The original suitability values per planning unit were multiplied by this slope value to apply the "discount."

Proximity to perennial streams and rivers and key riparian connections

We assume that under climate change, perennial streams will be more likely to mitigate drought stress under climate change for wildlife and vegetation communities and to provide connectivity through riparian corridors. Using the National Hydrography Dataset (NHD, USGS 2009) we selected all perennial streams in the region and created a new dataset. To those streams, we added key foothill riparian connecting streams and rivers. These streams and rivers provide connectivity from montane areas to the valley floor and are important for connectivity across the large east-west topographic gradient in the region. We generated a dataset showing the distance from both of these features and used the planning units to sample this surface. Taking the mean distance per planning unit, we rescaled and transformed the values to have a maximum value of .25, providing an additional 25% discount.

Topographic Moisture Potential

Areas that have high capacity to accumulate and hold moisture in soil will be better able to mitigate the effects of increased drought on vegetation. These areas have been modeled by USGS to support global mapping of ecosystems types (http://rmgsc.cr.usgs.gov/ecosystems/index.shtml). The moisture potential is calculated for a given spot on the landscape by summing the number of other cells that could potentially drain into this location. The resulting range of values is categorized into four classes (wetlands, mesic uplands, dry uplands, and very dry uplands) using empirically-derived thresholds from actual wetland, upland transitions and calculated slope and aspect. We grouped the mesic uplands and wetlands into one class representing areas with higher soil moisture and gave these pixels a value of 1, and all others a value of 0. The average value per planning unit was rescaled and transformed to have a maximum value of .25, to apply the 25% discount. The areas that have high soil moisture potential values are areas within the drainage channel and flat areas in river valleys. Specific soil properties may reduce the moisture-holding capacity of soils considerably, making the index an overestimate. This is likely the case in the valley floor where there are deep alluvium soils through which water infiltrates to groundwater.

Connectivity

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 will be important for the long-term viability under a changing climate. The key types of movement that this plan hopes to support are inter- and intra-regional movements for dispersal from natal home ranges, seasonal movements for foraging, mating, cover and migration, and disturbance- or climate change-induced shifts in ranges or habitat use (Figure 1). Yet, the specific locations that are important for more frequent movement within a population (e.g. within home range movements) are difficult to generalize for the multitude of species that live in the Southern Sierra and Tehachapis. Given this, it is important to maintain connectivity within and across multiple habitats and across latitudinal, elevational and climatic gradients.

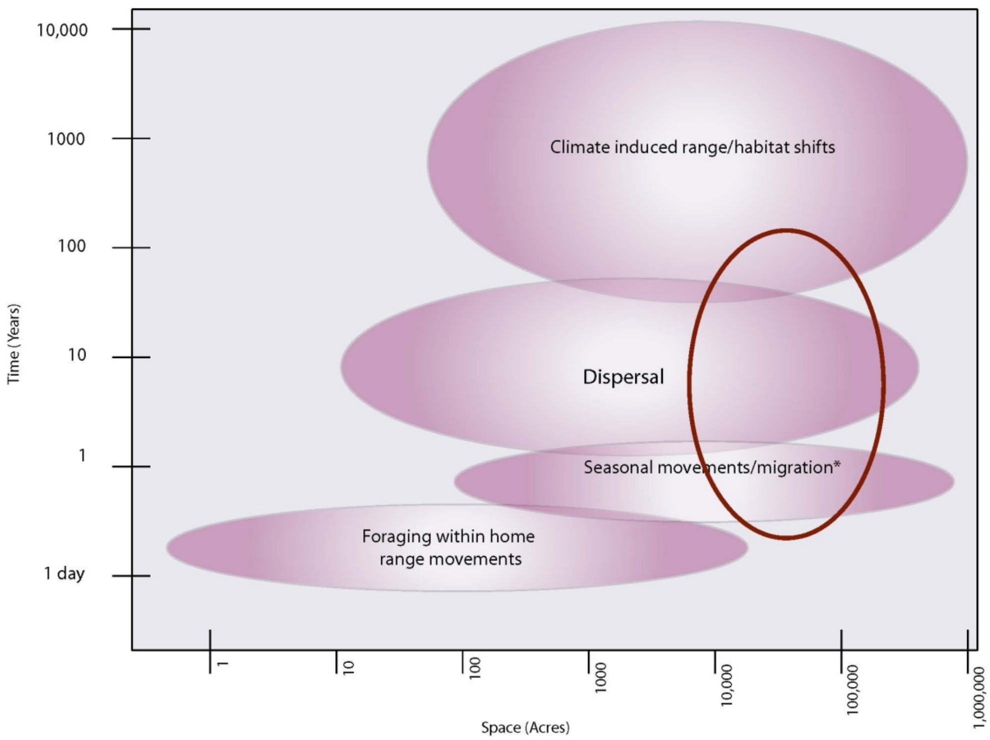


Figure 1. Space- time plot of different types of plant and animal movements. Area in red outline is zone that this regional analysis can help inform.

Below, we define several key concepts that are important to understanding the different elements of connectivity:

Linkage: A linkage is a defined area with known or assumed connectivity value for a defined set of plants and animals. Linkages are bounded in real terms by developed areas that are impermeable to wildlife movement or in statistical terms by a threshold in accumulated cost to movement in a model. A linkage is usually a modeled efficient or optimal path through a landscape, but is not usually the *most* efficient or optimal per the model used to derive it. This is in recognition of the uncertainty associated with the actual movement paths or the variability with which actual movement paths are used. A less commonly used term, *corridor,* implies a more linear pathway and a higher level of locational precision.

Permeability: Permeability is the degree to which a land use or habitat type enables or hinders movement between core areas. This is also commonly referred to as cost, friction or resistance, in a modeling environment. Permeability is a key input into any connectivity modeling and is often parameterized based on habitat suitability values. This is a valid assumption, that preferred habitat for other ecological reasons would be the preferred habitat for movement. Permeability can either be diffuse (heterogeneous over a large area) or precise geographically (e,g, when a large highway is an impermeable barrier).The key issue is that permeability is difficult to generalize across taxa for a variety of reasons as species have different abilities to traverse unfavorable habitat, different behavioral characteristics, and biotic interactions that can make the same habitat very permeable for one species and impermeable for another.

Chokepoint: A chokepoint is a location with a barrier or highly impermeable feature or land use between otherwise intact regions. A chokepoint, or pinchpoint, is usually well-defined and often small compared to the areas that are being connected. There are usually no other options in the landscape to maintain connectivity due to non-permeable land uses.

Functional connectivity: The degree to which species benefit at a population level from connectivity of habitat. A given configuration of land uses or vegetation may provide different levels of functional connectivity for species that use an area, with different population consequences. An important distinction here is with *structural connectivity,* or the degree to which patches of vegetation, or habitats are connected to each other. An area may be connected on a map (has structural connectivity), but does not provide functional connectivity because of the behavior or perception of a species, it is not wide enough, competition or lack of stepping stone habitat or resources.

Intactness: An area or landscape that is intact is characterized by low internal fragmentation. Within an intact area, permeability is generally high, but intactness does not describe how well the area is connected to another area. This is a scale-dependent concept, the degree of intactness depends at what scale you are looking at. For example, at the scale of the western United States, the southern Sierra is an intact region with low internal fragmentation, but some parts of the region are more intact than others. The suitability layer for this plan is used to represent intactness.

Fragmentation: The process by which patches of habitat or vegetation types are reduced in size, become isolated, or simplified in shape due to land use conversion, infrastructure development (powerlines, roads) or any other land disturbance. Patches of habitat or blocks of natural vegetation can be fragmented by either human land use conversion, or naturally by rock outcrops, water bodies, or by natural disturbances such as wind throw and fire. Studies of the effects of fragmentation on wildlife and ecological processes are a cornerstone of conservation biology literature.

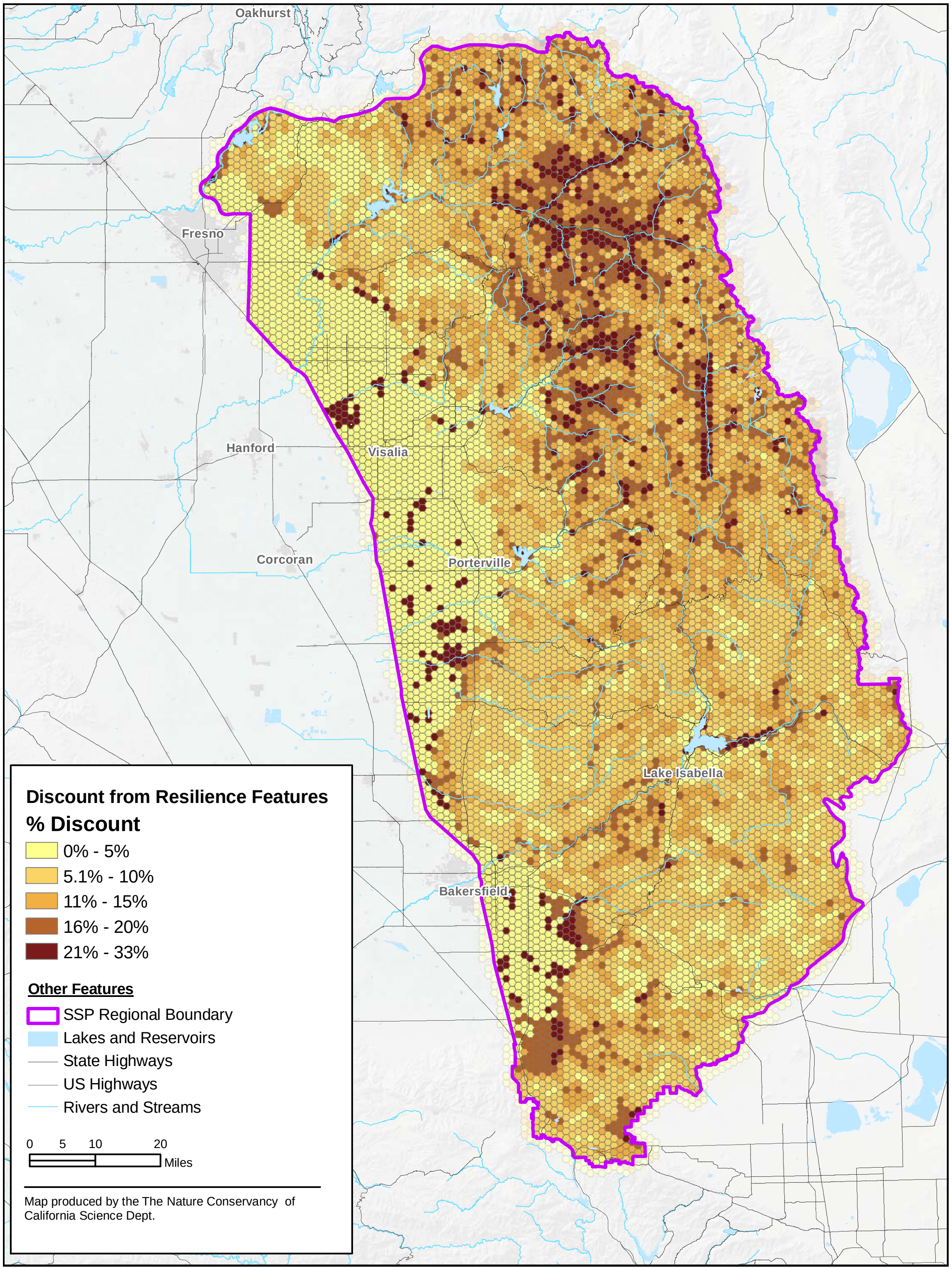


Figure 2. Effect of landscape resilience features on suitability values. Areas in darker brown are discounted more than areas in light yellow. Much of the valley floor received no discount because the land use conversion made the suitability to low to receive the discount.

Integration across current and adaptation site-selection runs

Following the approach defined in the plan of running site-selection scenarios at two different goal levels and based on current and climate-adapted inputs, we generated four primary output designs that were synthesized into the regional conservation design. For each planning unit, we added together the “summed solution” output from Marxan from each of the four primary scenarios. The summed solution records how often a planning unit was selected of the 20 runs in a scenario. The maximum value in this combined layer was 80 (max of 20 for 4 scenarios). Each planning unit was assigned to one of the three priority area classes or excluded from the conservation areas design based on the rules defined in the table below.

Table 4. Class breaks for default priority area assignments through the integration of the four site selection scenarios that formed the basis for the regional conservation design. The values represent the sum of the number of times Marxan selected a planning unit in a given run (max of 20 per run, max of 80 for all integrated runs).

Priority Area Name	Summed Solution Range	Other Factors
Core Conservation Area	Greater than 60	Locked in conservation lands / riparian connectors or expert-nominated sites
Primary buffer and connector	35 – 59	
Secondary buffer and connector	10 – 35	

This formed the basis for the regional conservation design and using expert review and criteria to simplify the set of priority areas, we edited the default assignments that were based on the breaks in Table 4. Figure 3 shows the areas that were added, removed or changed priority level based on expert input and design goals.

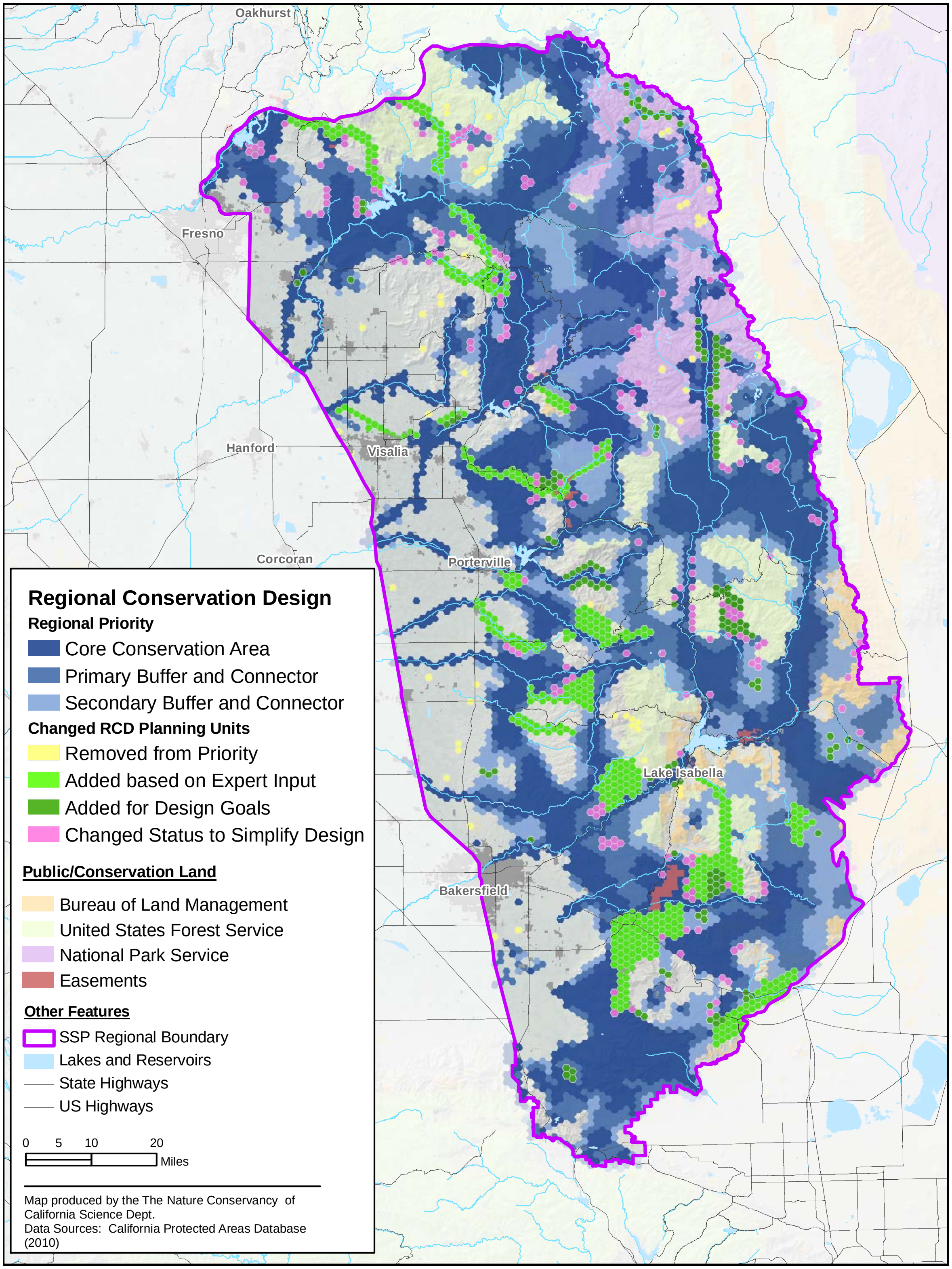


Figure 3. Areas edited after the default priority categories shown in Table 4 were applied.

Understanding how the selection of priority areas would change under Marxan runs with and without climate change was of theoretical interest to the planning team. The results of the comparison are shown in Figure 4 below.

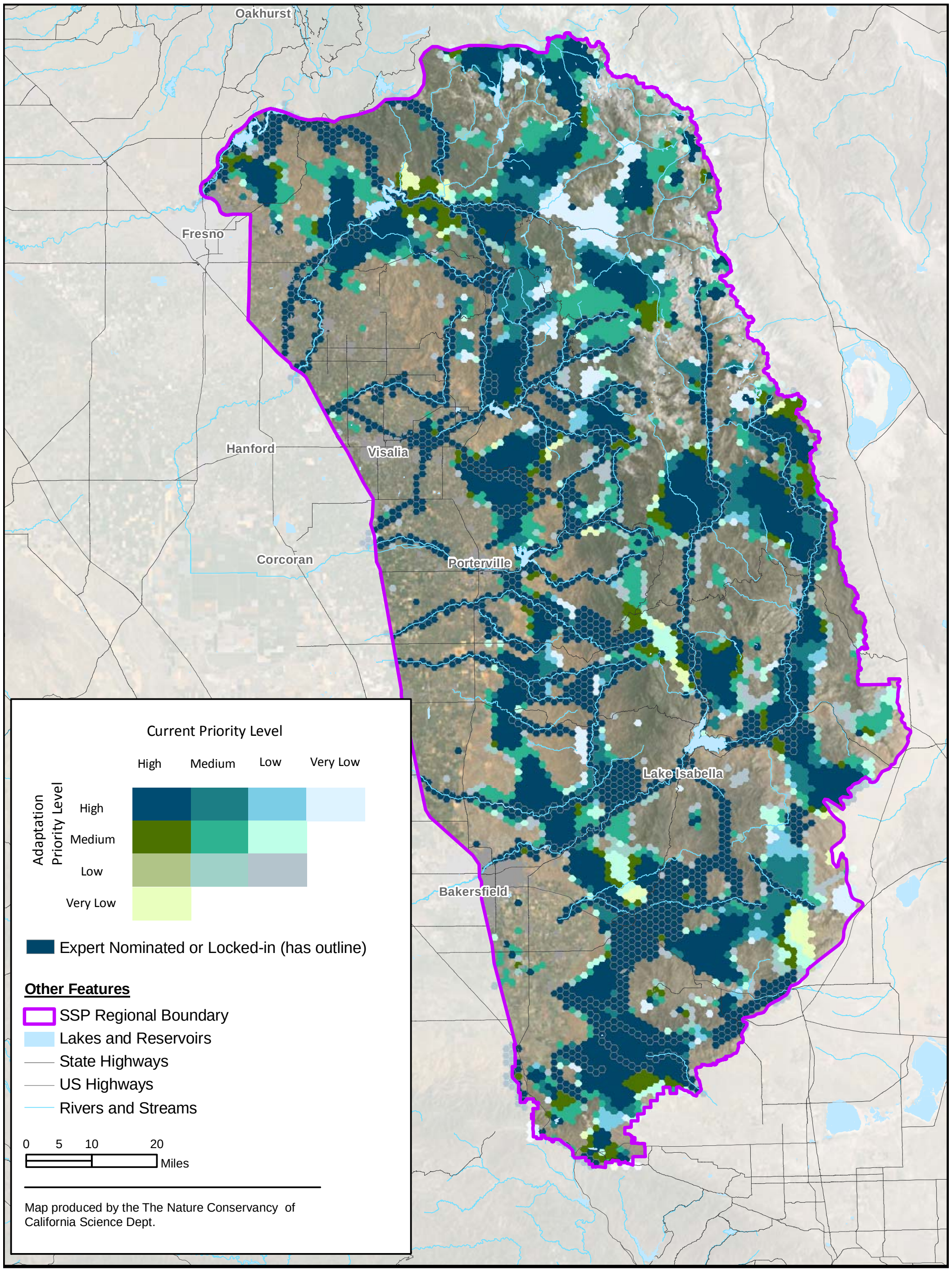


Figure 4. Comparison of areas selected using current site selection factors and climate-adapted site selection factors. See Figure 5 for class breaks for selection frequency in summed solution.

	Current			
Adaptation	40 - 30	29 - 18	17 - 10	<10
40 -30	1	2	3	11
29 - 18	4	5	6	
17 - 10	7	8	9	
<10	10			

Figure 5. Class breaks for current and adaptation prioritized areas. The values represent the sum of the “summed solution” values for the current and “adaptation” runs which included the landscape resilience factors and the species distribution model results.

Assessing Effectiveness of Regional Conservation Design

The following four charts report on the area of the vegetation targets by subregion in the regional conservation design that falls in public or privately protected lands (fee or easement) (Figures 6 and 7) and the percentage of each priority area class by vegetation targets and subregion (Figures 8 and 9).

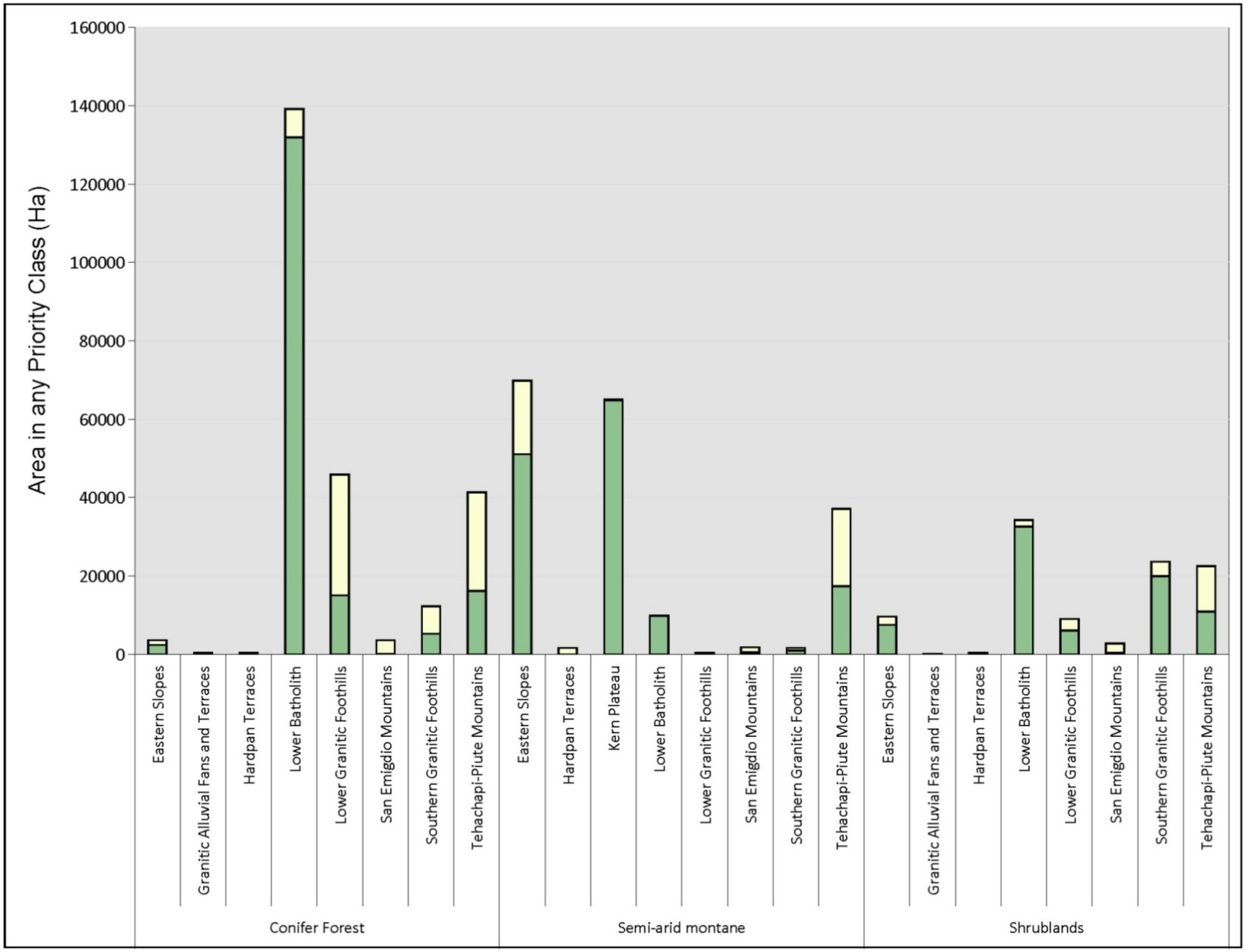


Figure 6. Area in any priority level in regional conservation design on private land (yellow) and public/private

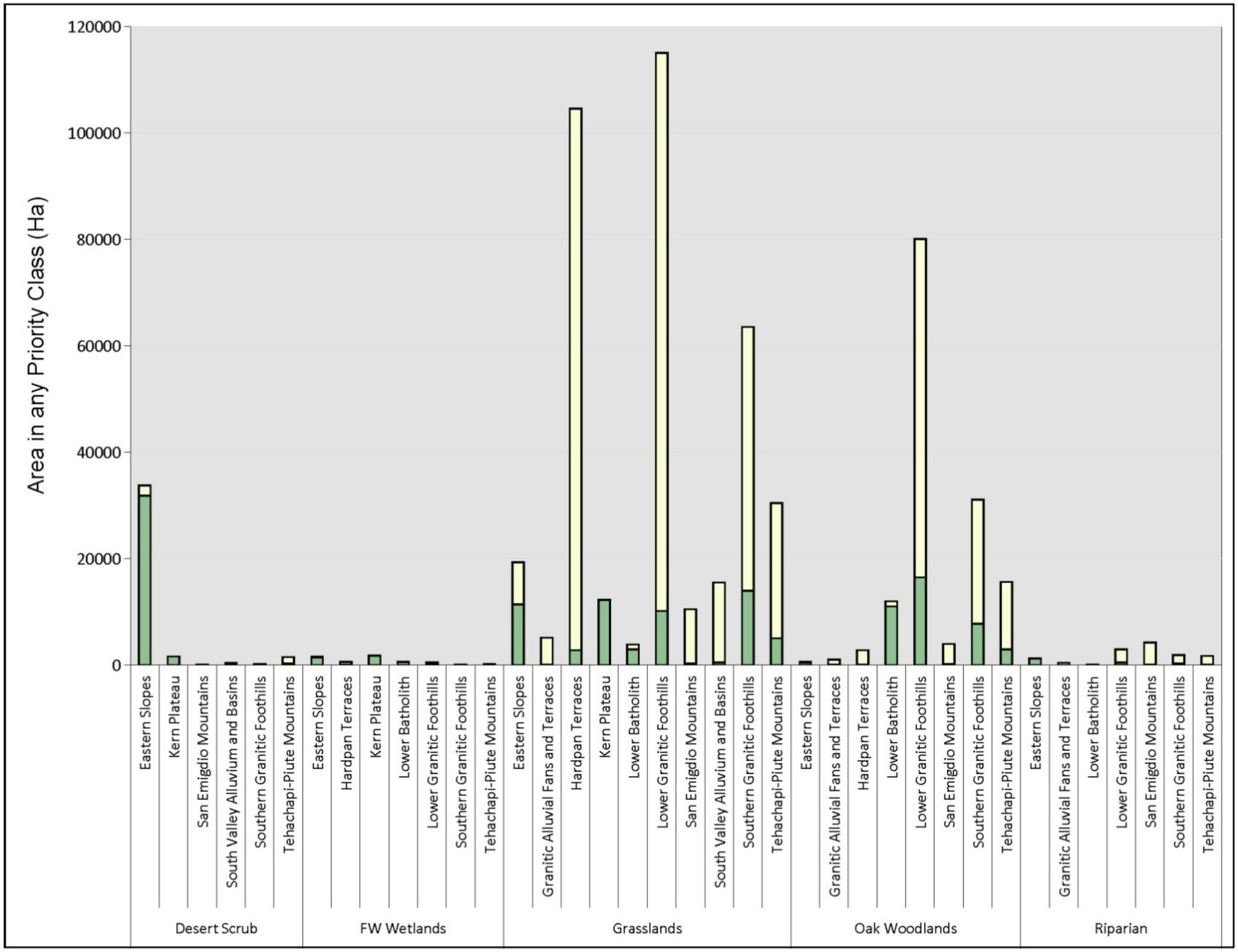


Figure 7. Area in any priority level in regional conservation design on private land (yellow) and public/private

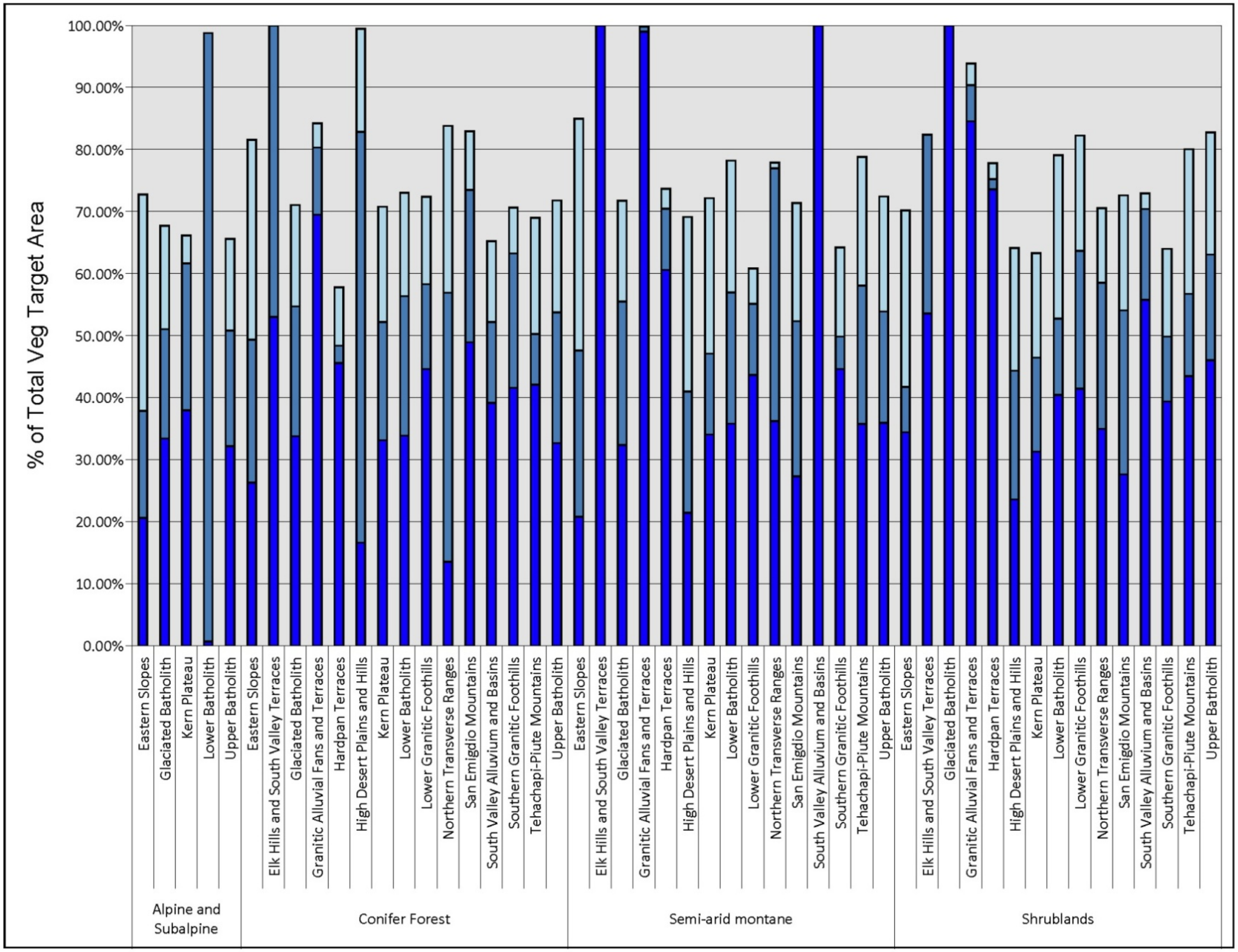


Figure 8. Percent of total target area by subregion in regional conservation design priority areas- dark blue = core conservation area, medium blue = primary buffer and connector, light blue = secondary buffer and connector for upper elevation species.

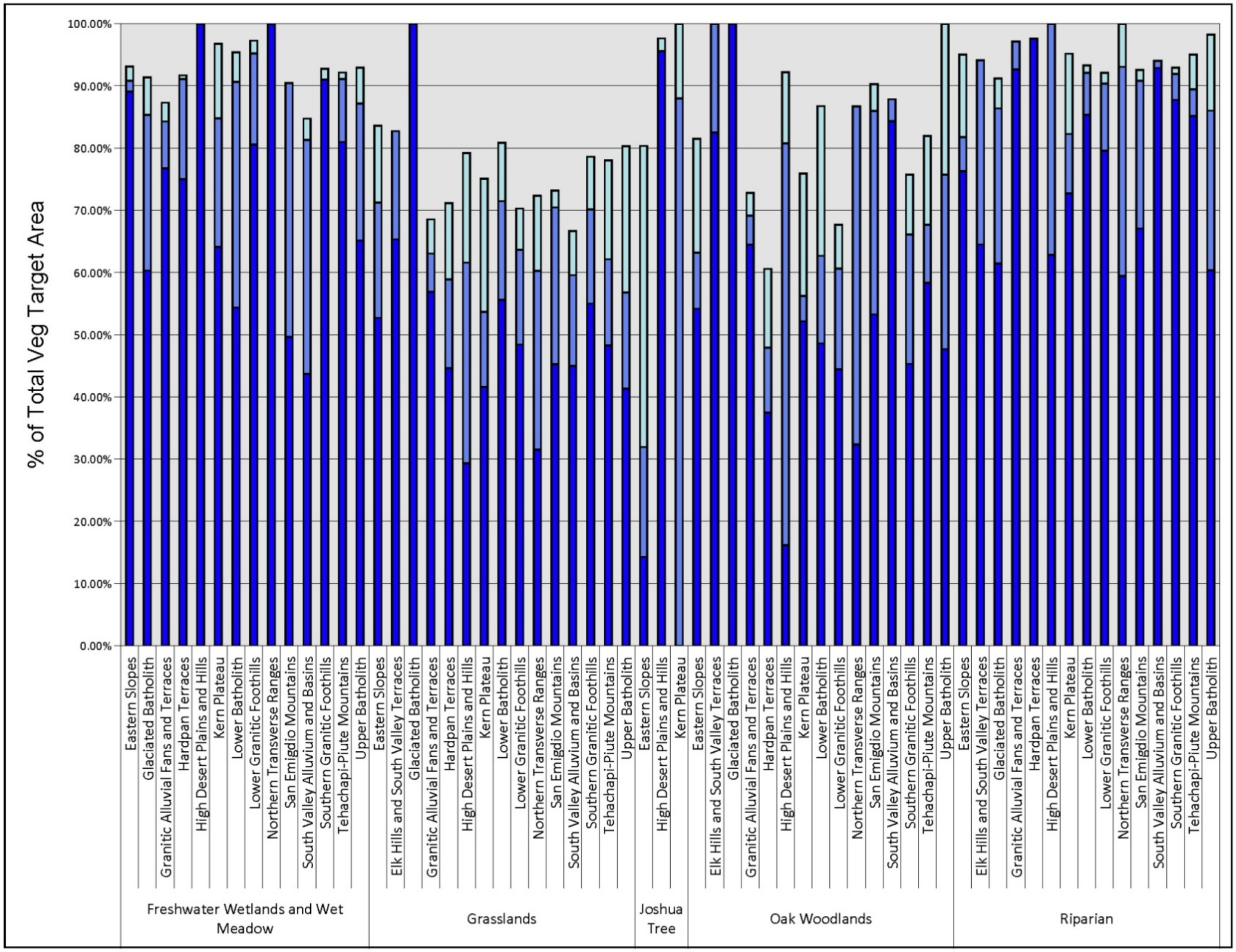


Figure 9. Percent of total target area by subregion in regional conservation design priority areas- dark blue = core conservation area, medium blue = primary buffer and connector, light blue = secondary buffer and connector for lower elevation species.

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APPENDIX D

CLIMATE MODELS

General Circulation Models

Eleven General Circulation Models (GCM) were used by the Southern Sierra Partnership. The models in this analysis are from the World Climate Research Programme's (WCRP's) Coupled Model Intercomparison Project phase 3 (CMIP3) multi-model dataset. If a GCM provided data for multiple realizations, these were averaged.

Model Name	Country	Center Name
CGCM3.1(T47)	Canada	Canadian Centre for Climate Modeling & Analysis
CNRM-CM3	France	Météo-France / Centre National de Recherches Météorologiques
CSIRO-Mk3.5	Australia	CSIRO Atmospheric Research
CSIRO-Mk3.0	Australia	CSIRO Atmospheric Research
GFDL-CM2.0	USA	US Dept. of Commerce / NOAA / Geophysical Fluid Dynamics Laboratory
GFDL-CM2.1	USA	US Dept. of Commerce / NOAA / Geophysical Fluid Dynamics Laboratory
IPSL-CM4	France	Institut Pierre Simon Laplace
ECHO-G	Germany & Korea	Meteorological Institute of the University of Bonn (MIUB), Meteorological Research Institute of KMA (METRI), and Model and Data group (M&D)
ECHAM5/MPI-OM	Germany	Max Planck Institute for Meteorology
MRI-CGCM2.3.2	Japan	Meteorological Research Institute
MIROC3.2(medres)	Japan	Center for Climate System Research (The University of Tokyo), National Institute for Environmental Studies, and Frontier Research Center for Global Change (JAMSTEC)

Full documentation can be found at the following link:

http://www-pcmdi.llnl.gov/ipcc/model_documentation/ipcc_model_documentation.php.

We acknowledge the modeling groups, the Program for Climate Model Diagnosis and Intercomparison (PCMDI) and the WCRP's Working Group on Coupled Modeling (WGCM) for their roles in making available the WCRP CMIP3 multi-model dataset. Support of this dataset is provided by the Office of Science, U.S. Department of Energy.

APPENDIX E

SPECIES DISTRIBUTION AND HABITAT PROJECTION MODELS

Species Distribution Models (SDMs)

Models of climate suitability herein consider modern climate projections (1961-1900) in relation to multiple (n=11) future climate projections (2045-2065) based on the A2 emission scenario (IPCC, 2007). We first model the modern and future suitability of species representing ecologically dominant trees & shrubs, then aggregate species data to assess the climate vulnerability of major habitat types. We limited future projections to mid-century (2045-2065) in order to avoid excessive inflation of uncertainty over time (relative to end-of-century), and to focus the set of implementable actions for the next several decades. We conducted gap analyses to show how climatically suitable areas both now and in the future relate to current land uses and management.

We derived all species distribution models in Maxent (Phillips et al., 2004). We selected dominant species for major habitat types in California (California Department of Fish and Game, 2008), filtering out certain habitat types with minimal associated wildlife (e.g., barren, rock). Herbaceous plants were excluded due to frequent associations with soils and microclimates that we did not include in our models. Observation data for vegetation came from a combination of rapid and relevee surveys, as well as herbarium specimens (Robinson et al., 2008). Only species with 30+ spatially unique observation records were considered. Desert flora is likely under-represented due to gaps in available field observation data. Modern climate data (1961-1990) was purchased from the PRISM group (Daly et al. 2008).

Future A2 emission scenarios were derived from publicly available IPCC general circulation models (GCMs) (http://www.ipcc-data.org) and then downscaled to the spatial resolution of PRISM data (800m) using a standard change factor approach (Klausmeyer & Shaw, 2009). Minimum and maximum monthly temperature change factors were calculated from daily projections for all IPCC GCMs. Bioclimatic predictor variables were derived from monthly precipitation, minimum monthly temperature and maximum monthly temperature using an Arc Macro Language script kindly provided by Robert Hijmans (http://www.worldclim.org/bioclim) with additional processing of raster data performed in R (R Development Core Team, 2009) using the raster package (Hijmans & Etten, 2010). Maxent was run using default parameters settings, in addition to removing all duplicate records, and partitioning observation data into training data (70%) and testing data (30%) for model validation. To compare projections across futures and between species, continuous logistic model projections were converted into binary grids (0=unsuitable, 1=suitable) using species-specific thresholds, derived as the minimum suitability value required to accurately score 95% of presence data as suitable (sensitivity = 0.95) (Liu et al., 2005). For each species, thresholds were derived from modern projections, then applied uniformly to all modern and future suitability models. We developed categories of climate vulnerability by the overlap in modern and future suitability models as follows: suitable in modern, but not future climates (e.g. 'climate stress'), suitable for both modern and future climates (e.g. 'stable refugia') or suitable for only future climates (eg 'expansion zones'). We characterize levels of uncertainty by the degree of agreement between multiple future projections, where 'low uncertainty' implies $\geq$ 80% model agreement, and 'moderate uncertainty' implies $\geq$ 60% model agreement.

Species Aggregation to Habitats

Systematic conservation planning often focuses upon habitat types, with the assumption conservation of habitats will also benefit associated, or nested, species (Noss, 1987). Here we aggregate species projections into habitats using crosswalks based upon local expert knowledge.

The species used to inform projections of each habitat type are as follows:

1. Oak woodlands = blue oak, interior live oak, California buckeye and foothill pine (Figure 19 of SSP Plan).
2. Mixed conifer = white fir, red fir, incense cedar, lodgepole pine, Jeffrey pine, ponderosa pine, sugar pine, aspen, douglas fir and mountain hemlock (Figure 1).
3. Semi-arid montane = chamise, big sagebrush, California mountain mahogany, chaparral whitethorn, rubber rabbitbrush, California buckwheat, California juniper, singleleaf pinyon, California scrub oak, horsebrush (Figure 2).
4. 4) Subalpine & alpine = mountain heather (Figure 3).

An example for the aggregation for oak woodlands in the Southern Sierra is shown in Figure 19 of the SSP plan. Our aggregations are conservative in 2 ways: 1) only areas of low uncertainty from species projections are considered (eg areas of $\geq$ 80% agreement across all modeled futures); 2) projections of stable refugia trump all other potential outcomes (eg climate stress or expansion zones) regardless of the species involved. Focus on high model agreement avoids unnecessary uncertainty for decision makers. We justify symbolizing areas as 'stable refugia' when some species projections are stable and others are stressed, based upon the assumption that all species considered within habitat types are of equal concern to conservation. Finally, we ran a gap analysis to explore how the climate vulnerability of terrestrial flora and fauna fits within constraints of existing land use patterns. For both species and habitats, we calculate the area in each climate vulnerability category (eg. % climate stress, % stable refugia, % expansion zones) that are also either converted or protected (Table 1).

Connectivity

To identify adaptation linkage priorities for habitat-based conservation targets, we model connectivity between multiple projected habitat refugia using land use to direct movements in Circuitscape v3.4 (McRae et al., 2006; McRae & Shah, 2008). For run settings, we use the 'all to one' mode with '4 neighbor connections' assigning 'focal points' to each unique, contiguous polygon representing potential habitat refugia (n=2200). To avoid accumulating resistance for movement within suitable areas, we include habitat refugia as a 'short circuit' grid. For assigning weights to land use categories in the resistance layer, we use the following relative values: agriculture = '1', roads = '5', urban areas = '10'.

Results

Table 1: Comparison of Southern Sierra Partnership study area species distribution model results with State-wide averages.

Common name	SSP only stressed	SSP only uncertain	SSP only stable	SSP only expand	State-wide stressed	State-wide uncertain	State-wide stable	State-wide expand
Aspen	31.79	22.95	40.61	4.65	58.42	14.73	24.16	2.70
Big Sagebrush	43.50	20.25	33.70	2.56	63.83	14.56	20.30	1.31
Blue Oak	62.52	10.57	16.32	10.59	71.12	13.20	9.58	6.10
CA Black Oak	28.70	11.63	46.96	12.70	25.20	8.05	48.39	18.36
CA Buckeye	30.00	11.67	40.80	17.53	36.20	16.10	35.21	12.49
CA Buckwheat	22.40	7.05	18.58	51.97	21.63	9.07	28.64	40.66
CA Juniper	27.08	3.81	40.77	28.34	26.90	6.66	20.75	45.69
CA mtn mahogany	29.97	22.20	36.33	11.49	46.68	16.30	28.73	8.28
CA scrub oak	20.45	9.69	45.46	24.40	21.75	10.37	32.34	35.54
CA Sycamore	13.28	33.48	38.54	14.71	29.53	16.26	37.49	16.72
chamise	56.22	16.23	13.55	14.00	62.40	10.60	20.45	6.55
chaparral whitethorn	28.08	23.03	30.55	18.33	43.01	13.35	33.23	10.41
Douglas Fir	18.34	9.11	57.18	15.37	17.12	6.60	63.52	12.75
Foothill Pine	54.79	14.76	20.82	9.63	50.55	12.15	26.79	10.51
Horsebrush	7.38	9.23	62.66	20.73	20.18	21.01	48.55	10.26
Incense Cedar	26.79	17.05	42.39	13.77	25.02	8.21	51.25	15.53
Interior Live Oak	23.72	9.95	50.28	16.05	19.59	11.96	54.76	13.69
Jeffrey Pine	31.09	8.90	49.39	10.62	40.24	8.67	45.99	5.10

Joshua Tree	63.65	27.46	8.70	0.18	56.27	25.10	10.57	8.06
Lodgepole Pine	26.22	10.26	59.64	3.89	57.69	6.75	33.94	1.62
Mountain Heather	46.51	11.81	29.85	11.83	60.57	10.08	19.83	9.52
Mountain Hemlock	16.87	9.72	34.62	38.80	40.08	12.14	38.32	9.45
Oregon White Oak	36.14	9.97	23.78	30.11	33.38	6.03	33.58	27.01
Ponderosa Pine	28.29	16.63	40.32	14.76	28.66	10.02	44.21	17.11
Red Fir	27.82	6.41	48.50	17.27	56.43	7.10	26.85	9.63
Rubber Rabbitbrush	20.54	4.64	74.33	0.49	28.14	9.42	61.51	0.93
Singeleaf pinyon	42.24	8.72	31.70	17.34	39.22	9.14	43.24	8.40
Sugar Pine	22.45	9.93	51.66	15.96	23.75	5.91	54.93	15.42
Valley Oak	72.23	7.85	12.25	7.66	74.68	7.15	12.70	5.46
White Fir	25.91	7.62	51.46	15.01	33.70	7.56	52.30	6.44

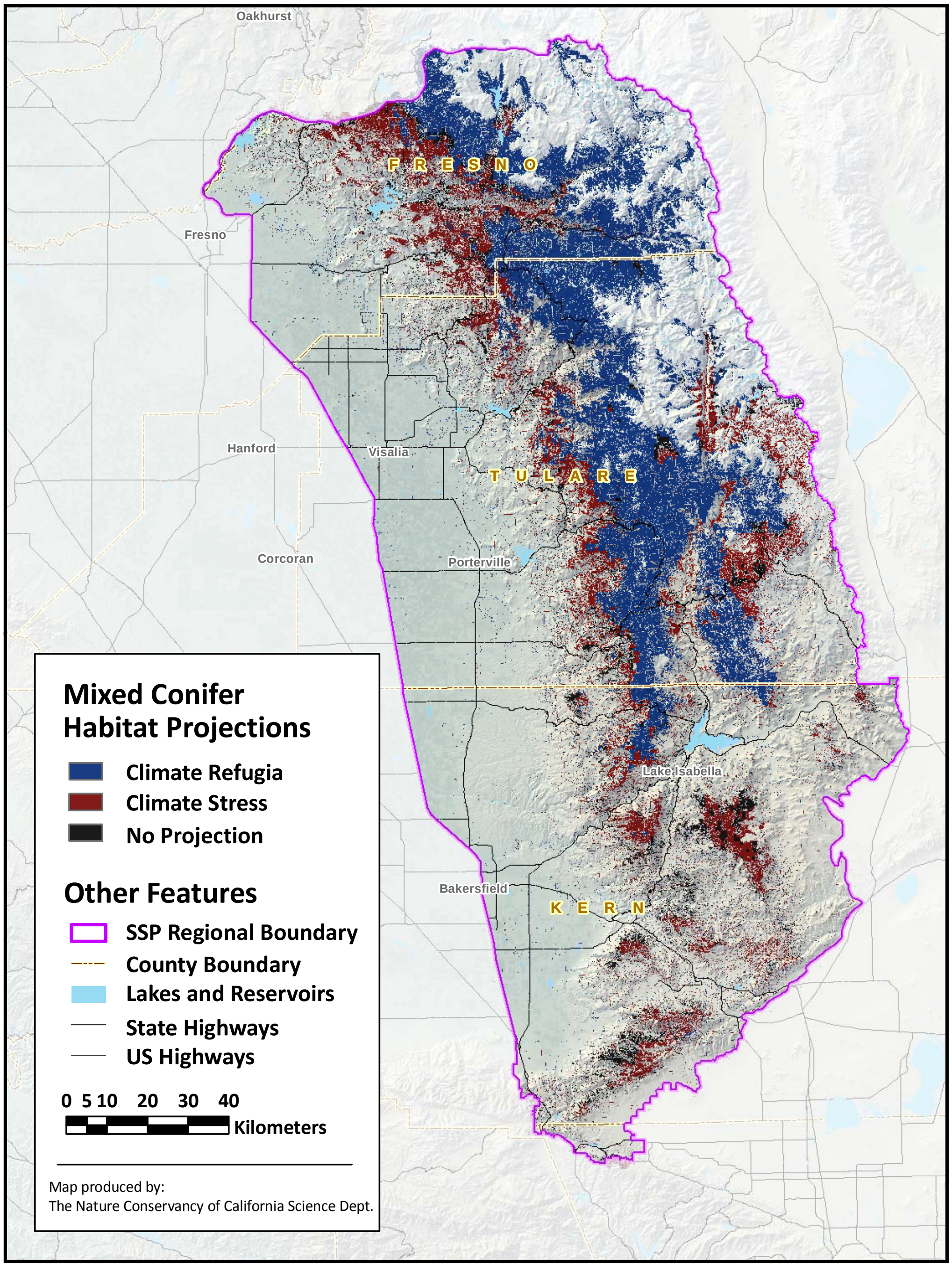

Figure 1: Mixed Conifer Habitat Projections

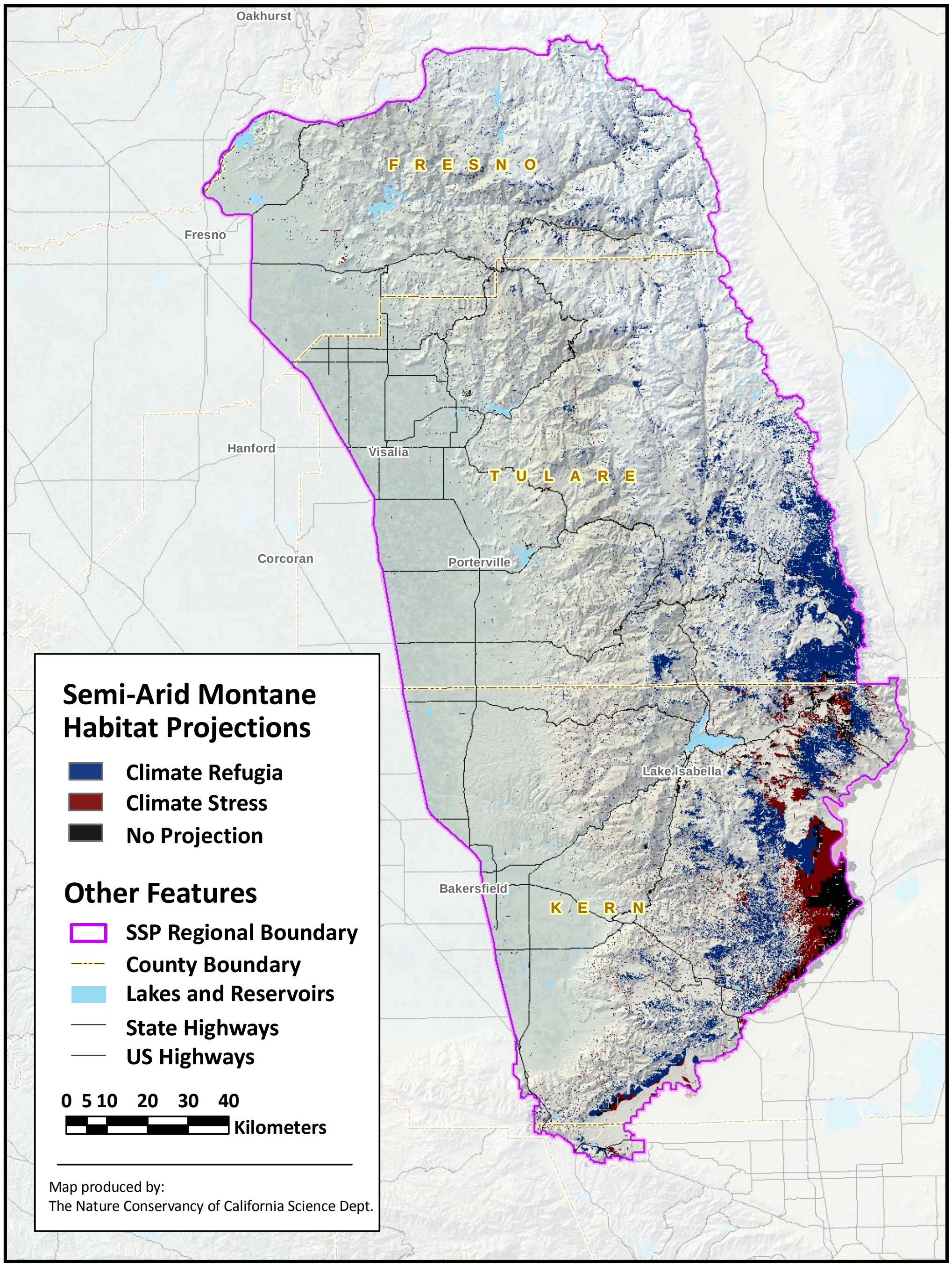

Figure 2: Semi-Arid Montane Habitat Projections

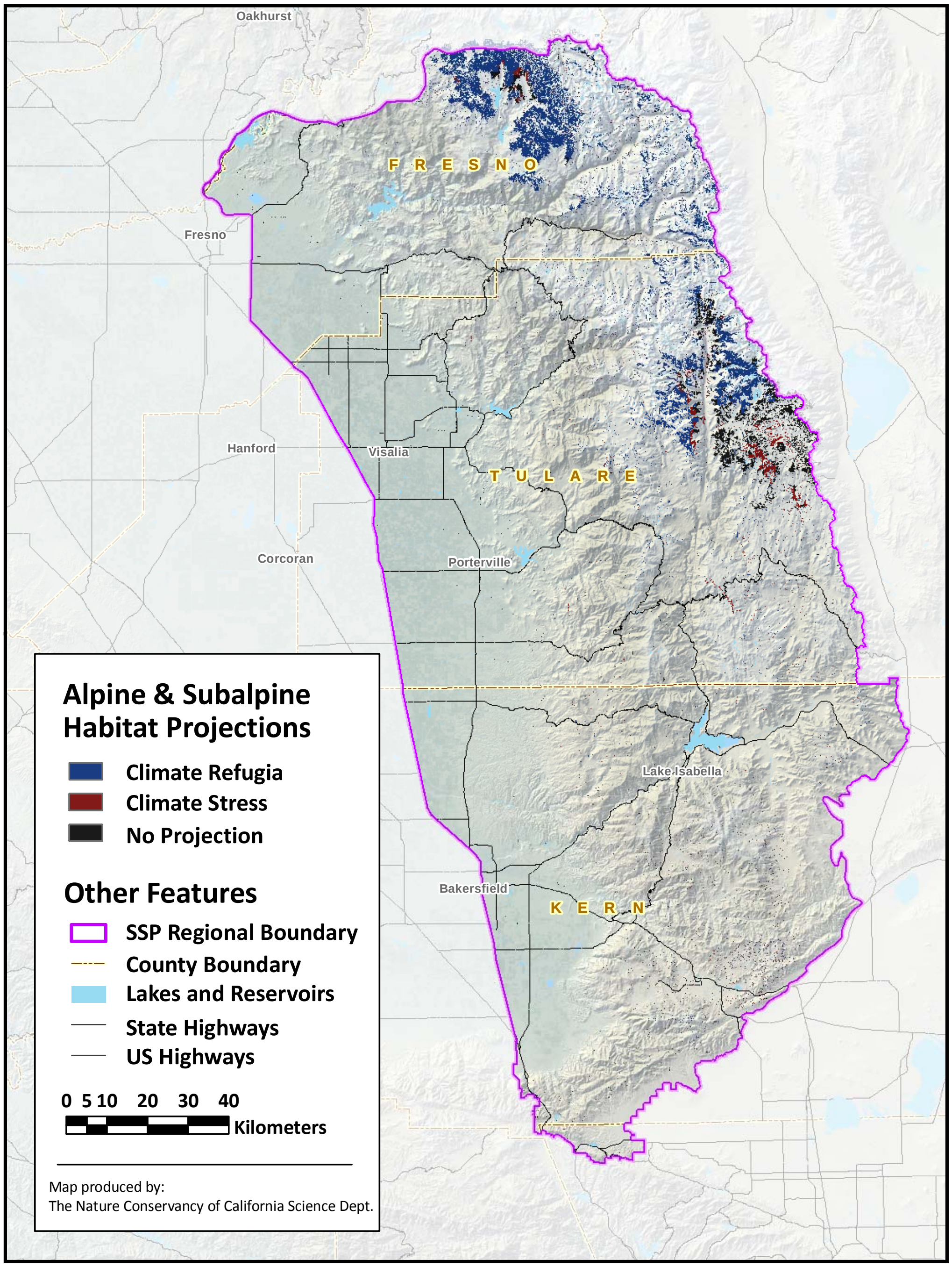

Figure 3: Alpine and Subalpine Habitat Projections

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APPENDIX F

HYPOTHESES OF CHANGE

Target: GRASSLANDS

Discussion:

Higher temperatures are expected in grasslands throughout the SSP planning area. Winter temperature is a significant driver of grass productivity, and warmer winters could result in increased grass growth at times when rainfall is abundant enough to keep soils moist. However, a rise in temperature will also lead to increased evapotranspiration and reduced soil moisture. This may be offset in some areas by increased precipitation, but drought stress may occur in grasslands, especially within the southern portion of the SSP planning area. Drought stress could compress the growing season and cause earlier flowering for certain plant species. This could impact animals dependent on these plant species.

Low productivity or drought-stressed grasslands often contain a higher proportion of herbaceous plant species (forbs). However, the response of forbs to climate change is uncertain, as there is evidence for both increased forb cover with warmer temperatures, and reduced forb cover with higher CO_2 concentrations. Late season forbs, such as tarweeds, might become more successful as the climate warms and soil moisture is reduced. Non-native forbs could also benefit from higher temperatures and reduced soil moisture, so climate change will not necessarily benefit native plant diversity in grasslands.

The response of grasslands may differ throughout the SSP planning area depending on local climate, slope, and aspect. Grasslands at lower elevations and on south facing slopes may be subject a change in species composition as drought-adapted species may gain a greater competitive advantage over species that are less drought-tolerant. North facing slopes where solar radiation is lower and higher elevations where temperatures are cooler may provide some species with refugia from drought stress. Differences are also likely between grasslands in the northern part of the planning region and those further to the south. Drought-tolerant desert scrub species may become established in some grassland communities, but this is only likely to happen in areas with minimal disturbance and long fire return intervals. Grasslands may also expand uphill.

Hypotheses of Change: Mediterranean grasslands of California are adapted to wide swings in temperatures and drought cycles so it is likely that the grasslands of the Southern Sierra are fairly resilience to climate change. At this time, climate change is not the biggest threat to grasslands within the SSP planning area or their associated species assemblage. Conversion of grasslands to other human land uses is a greater immediate threat than climate change. In addition, invasive species will likely continue to be problematic in California grasslands as the climate changes.

Ecosystem Services Affected: Grassland composition and biomass determines forage quality, which in turn affects management practices and the viability of ranching. Higher grass productivity would be a positive change for ranchers. However, a shorter growing season caused by high temperatures and greater evapotranspiration may lead to an increased need to move animals across the range, supplement their feed, or reduce numbers of livestock for year-round operation. Warmer temperatures can affect forage quality directly by altering the proteins available in grasses. Early flowering or the invasion of non-native forbs such as thistles can also decrease forage quality, which would have a negative impact on ranching.

Water availability is predicted to become a larger problem for ranchers as the climate warms (see groundwater recharge and water retention and yield discussions). Some springs are already drying up in drought years, leaving cattle without natural sources of water.

Strategy Implications:

- Prevent conversion of grasslands to other land use types.
- Track invasive non-native species.

Monitoring Recommendations:

- Monitor the diversity and distribution of native forbs and grasses.
- Monitor the distribution and spread of invasive species.
- Monitor for changes in grassland productivity.
- Monitor for changes in forage quality.

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Target: OAK WOODLANDS

Discussion:

Oak woodlands are found in the uplands of the SSP planning area, with the forest canopy dominated by blue oak, interior live oak or black oak, depending on aspect and elevation. Riparian species such as Valley oak and canyon live oak are addressed with the Riparian target. Species such as buckeyes and foothill pine may also be present. Canopy cover varies from open savannah to fairly dense woodlands. There is often a pronounced north-south slope effect, with denser woodlands on the cooler north slopes, particularly in the lower elevation blue oak woodlands. The understory is typically composed of a mix of introduced Mediterranean annual grasses, much like the grassland community described above.

The dominant trees have a variety of lifecycle adaptations to the area's distinct wet and dry seasons and year-to-year fluctuations in the precipitation and temperatures. Blue oaks and black oaks are deciduous and dormant in winter; buckeyes are deciduous and dormant in summer; interior live oak and foothill pine are evergreen.

As in the grasslands, the understory of oak woodlands provides a significant share of the forage supporting cattle production in the region, with much the same issues affecting forage quantity, quality, and ranchers' ability to utilize the resource. Long-lived trees and undisturbed soils sequester carbon. The oak tree is also a unique iconic image drawn from the California landscape.

Lack of oak regeneration is a concern over much of the oak woodland range. Acorn and seedling production seem to be occurring, but few seedlings make it to the sapling stage. As a result, trees in the oak woodlands are in excess of 75 years old in most areas. It is not clear whether this is a function of oaks reproducing en masse during rare convergences of multiple favorable conditions, or whether we are seeing the cumulative effects of such factors as livestock grazing, competition with introduced annual grasses, fire suppression, and a warming climate.

The harsher conditions may also lead to increased mortality of mature oaks stressed by factors such as disease or air pollution. The Species Distribution models for blue oaks and associated foothill pine, California buckeye, and interior and canyon live oak indicate contraction of suitable climate conditions in the lowest elevations and the southern part of the region, but some expansion of the suitable climate envelope at higher elevations. North facing slopes and higher elevations may provide refugia from the effects of a warming climate. Field research by Davis *et al.* (1991) found that seedling mortality was six times higher in an open savanna site compared to a north-slope forest. They attributed this to heavy competition between oak seedlings and annual grasses, but it's possible that this was related to drought stress and may be a preview of climate response. Grasslands may extend their range into the lower elevation oak woodlands as conditions there become untenable for the existing tree species.

However, oaks are long-lived species, adapted to wide fluctuations in temperature and precipitation and capable of going dormant during extended drought. These traits may confer some resilience to the effects of climate change, or at least mean that changes to existing oak woodlands will be fairly subtle over the next 50 years.

Climate change are likely to be synergistic with the other main threats to oak woodlands, including fragmentation by residential development, apparent lack of oak regeneration, and incompatible livestock grazing practices. For example, we expect the warming climate to further compromise oak regeneration, making it harder for oak woodlands to spread to new areas of climate suitability.

Hypotheses of Change: While the mortality of mature oaks may not accelerate greatly, regeneration may be further compromised by longer, more severe dry seasons and periodic droughts. Climate models suggest expansion of the suitable "climate envelope" at higher elevations, but this can only occur if soils are suitable and regeneration is occurring. Therefore, oak woodlands may contract to the climatically stable portions of their current range over the long term. Elevational and latitudinal connectivity will be important during the transition to allow species to move and enable genetic transmission by trees that are especially well-adapted to warming conditions. With climate change we expect higher temperatures to result in increased evapo-transpiration, causing soils to dry out earlier in the spring, effectively extending the annual dry season and making it more extreme. This will be especially the case on south and west-facing slopes and in the southern part of the oak woodland range. Increased evapo-transpiration may make it even harder for oak seedlings to survive their first dry season, aggravating existing challenges to regeneration. Warmer temperatures during the wet season may also favor fast-growing, early-season annuals that compete heavily with oak seedlings for light, nutrients and moisture.

Ecosystem Services Affected: See narrative for Grasslands target for discussion of livestock forage. Carbon sequestration by oak woodlands will decline if their range contracts with a warming climate. In addition, iconic oak woodlands may disappear in some areas, such as the lower elevation foothills or southern end of range.

Strategy Implications:

- Protect significant swaths of oak woodland along elevational gradients, particularly emphasizing topographically heterogeneous areas.
- Maintain strategic connectivity among the conserved swaths of oak woodlands, and between the oak woodlands and adjoining chaparral and mixed conifer systems.

- Initiate or continue long-term studies of oak regeneration under various land management regimes (e.g. grazing seasons and intensity, fire).
- Work with ranchers, NRCS and other agencies to maintain existing stock watering facilities and develop a well-distributed water supply on SSP-owned land and easements.
- Promote livestock management practices (e.g. rotational grazing, well distributed water supply, moderate stocking levels) that periodically allow native species (including oaks) to reproduce, and that maintain sufficient residual dry matter to prevent erosion and serve as protective mulch for new seedlings the following wet season.
- Track invasive non-native species and respond quickly to new occurrences. Seed or plant native grassland species in areas where invasive plants have been removed, as feasible.

Monitoring Recommendations:

- Track extent of oak woodland conversion and fragmentation vs. protection.
- Track status of connectivity among oak woodland patches, and between oak woodlands and adjoining chaparral and mixed conifer communities.
- Track long-term shifts in distribution of oak woodlands.
- Map where oak regeneration is currently occurring and explore correlations with soil type, upslope margins of existing range; slope aspect, livestock grazing regimes, proximity to riparian areas, groundwater levels, etc.
- Monitor shifts in diversity and cover of native forbs relative to non-native forbs.
- Monitor occurrence and extent of invasive plants, and efforts to control them.
- Residual dry matter – broad patterns across the grassland landscape; more detailed assessments on SSP-owned land and easements.

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Zavaleta ES, Shaw MR, Chiariello NR, Thomas BD, Cleland EE, Field CB, Mooney HA. 2003b. Grassland responses to three years of elevated temperature, CO_2, precipitation, and N deposition. Ecological Monographs 73: 585–604.

Target: CHAPARRAL

Discussion: This shrub-dominated system is expected to decrease in areal extent as foothill savanna expands. At the same time, chaparral may spread into currently forest covered north-facing slopes (Fields *et al.* 1999). Lenihan *et al.* (2003) state that high fire frequency, plus drier conditions, could lead to shrublands expanding into areas currently dominated by conifers. However, in a follow-up study Lenihan *et al*. (2008) found that shrublands decreased in area for all scenarios. Increasing fire frequency, often anthropogenic, tends to promote invasion by non-native grasses which further favors higher fire frequency. Observations in southern California indicate that increased fire frequency can lead to type conversion of chaparral to grasslands dominated by non-native species, leading to loss of the high plant and animal species diversity associated with shrublands.

Hypotheses of Change: Increase in fire frequency, driven by human-caused ignitions and interplay of fire and invasive annual grasses, could lead to loss of the chaparral community, especially in the lower elevations. This could happen with or without climate change, therefore, climate change is predicted to play a minor role compared to human-caused degradation and conversion.

Ecosystem Services Affected: Carbon sequestration, watershed ground cover, and soil stabilization.

Strategy Implications:

Discourage expansion of the WUI.

Control human development and land use in the chaparral zones.

Protect from too-frequent of fires by supporting enhanced fire suppression and fire prevention capacity where appropriate.

Discourage destructive fuel treatments in chaparral when possible.

Monitoring Recommendations:

Monitor amount and distribution of annual grasses.

Influence community response to fire and fuels treatments.

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Target: MIXED CONIFER FORESTS

Discussion: Historically there has been great diversity of stand structure and composition throughout the mixed conifer forests of the SSP planning region. Landscape position and access to surface and groundwater shape this mosaic. In the last century, fire exclusion and other factors have reduced the area dominated by well-spaced "big trees" compared to dense small trees and diminished the proportion of shade-intolerant conifer tree species such as sugar pine, ponderosa pine, white fir, and giant sequoia compared to shade-tolerant species, such as incense cedar and white fir.

In Yosemite the current rate of large tree mortality is increasing. Large tree mortality may be related to increased competition from dense growth of younger trees (which also exacerbates drought stress), greater area and impact of wood boring insects (Ferrell 1996), and increased intensity and severity of fires. Some of the observed rate of large tree mortality is a legacy of ongoing fire suppression practices (van Mantgem *et al.* 2004). Warmer winter temperatures is making it possible for wood boring beetles to survive winters and have larger outbreaks.

Increased fire intensity has been observed in the Sierra Nevada leading to increased fire-caused tree mortality with loss of forest cover. Deforested areas are likely to be colonized by chaparral.

Large trees, with their deeper roots, may be more resilient to drought, especially if the trees were established during dry periods. The last 150 years since the end of the Little Ice Age have been generally warmer and wetter when compared with past 1000-4000 years.

Climate suitability models for characteristic mixed conifer species indicate that their optimal habitat ranges may shift upslope, northward, and onto cooler, north-facing slopes.

Hypotheses of Change: While the region's topographic heterogeneity creates refugia and favors resilience to climate change, across the landscape the interplay of higher temperatures with denser small trees, die-off due to insect herbivory, and greater fire intensity will decrease resilience of the forest. The current rate of large tree mortality will likely continue or become worse due to temperature and drought stress combined with the competition from dense growth of younger trees, outbreaks of wood boring insects, and increased intensity and severity of fires. The forest may become more homogenous as it is dominated by large patches of early and mid-seral stages and fewer large trees. Smoke emissions and suppression difficulty are expected to increase.

Ecosystem Services Affected: Carbon sequestration; water retention and yield, groundwater recharge, recreation, aesthetics, clear air, timber, wildlife habitat

Strategy Implications:

Promote forest management practices that encourage large-diameter tree retention; thin unnaturally dense small-diameter trees (especially fire-intolerant species).

Promote sound WUI development policies to decrease fire suppression hazards and costs.

Fuels thinning and prescribed fire may eventually reduce fire hazard enough to allow expansion of currently limited wildland fire use policies. This can be politically contentious but wildland fire use is one of the best options for federal agencies faced with the high costs of fuel treatment and fire suppression.

Monitoring Recommendations:

Monitor the large tree mortality rate, distribution, and causes of tree death.

Determine climate's role in forest dynamics and change.

See if habitat ranges shift upslope, northward, and onto cooler, north-facing slopes.

Monitor the impacts of fire over time.

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Target: ALPINE and SUBALPINE

Discussion:

The alpine and subalpine zones are expected to receive less precipitation as snow, and the snowpack is predicted to melt earlier in the spring. This will increase the length of the snow-free season. Summers may be longer, warmer, and drier in a future with climate change. The carbon dioxide concentration in the atmosphere will be higher. This may be a benefit to plant growth.

The net impact of climate change and atmospheric CO_2 increase on plant species distribution and abundance is very difficult to predict with any certainty. In general, for plants and animals, we can expect upward range shifts and local extinction of species adapted to the coldest climatic conditions.

Climate change is predicted to be the greatest threat to alpine areas worldwide compared to land use change, nitrogen deposition, invasive species, and atmospheric CO_2 concentrations

(Sala *et al.* 2000). A long-term study in the Sierra Nevada identified an upward shift in the elevational distribution of butterflies, consistent with the impact of climate change (Forster *et al.* 2010).

High elevation small mammal species are more threatened by climate change than low elevation species (Moritz *et al.* 2008). Fourteen of 28 small mammal species show upward shifts in elevational distribution in the Sierra Nevada; low elevation species tended to expand their ranges whereas high elevation species experienced range contraction (Moritz *et al.* 2008). Species such as the pika who are adapted to the highest and coldest alpine settings may not be able to migrate to suitable habitat during climate change and may thus go locally extinct (Holtcamp 2010).

Hypotheses of Change: The SSP planning region contains the tallest portion of the Sierra mountain range. Peaks in the northern sierra reach 9,000 feet yet peaks in the southern sierra exceed 14,000 feet. So, we can expect the southern sierra alpine areas to retain alpine species longer than some other areas of the Sierra Nevada through the climate change process. Many species will be able to move upslope. Total species richness may remain the same in the alpine and subalpine zones, but we can expect local extinctions of cold-adapted species while lower elevation species colonize higher elevations.

Ecosystem Services Affected:

The plants and animals of the alpine and subalpine zone provide ecosystem services in the form of recreation, and in the provision of clean water as a headwater region for many watersheds in California and Nevada.

Livestock grazing and horse/mule packing is currently a threat to recreation by harming the physical beauty of wet meadows and riparian areas, and by causing irritation to recreationists in the form of manure, trail dust, and flies. Livestock grazing and horse/mule packing is also a threat to the provision of clean water in the Sierra Nevada because these land uses promote coliform bacteria in downstream lakes and streams (Derlet *et al.* 2008).

If climate change increases the snow free period or causes drier conditions, then cows, horses, and mules may have an increasing negative impact to natural systems such as wet meadows and riparian areas. Cows, horses, and mules can cause soil compaction; erosion; down-cutting of stream channels; erosion of stream banks; introduction of invasive plant species; and pollution in the form of coliform bacteria in lakes and streams.

We are not familiar with studies that compare the financial benefits of livestock grazing to the financial costs of livestock grazing (in terms of loss of recreation values, damage to riparian areas, damage to wet meadows, and water pollution). We are also not familiar with such cost/benefit analyses of horses and mules in recreation.

There are very few invasive plants in the alpine and subalpine zone, so there is no benefit to livestock consuming invasive plants and thereby releasing native plants from competition.

A change in plant or animal species composition may not have a measurable effect on recreation patterns or on water delivery.

Fish stocking is a threat to freshwater systems in the alpine and subalpine zone, but this threat will not be addressed here.

A change in snowpack depth or the timing of snowmelt will affect water delivery to humans, but that is separate from biotic changes to the alpine zone.

Strategy Implications:

Millar *et al*. (2007) categorize climate adaption strategies as "resistance options (forestall impacts and protect highly valued resources), resilience options (improve the capacity of ecosystems to return to desired conditions after disturbance), and response options (facilitate transition of ecosystems from current to new conditions)."

The alpine and subalpine zones of the Sierra Nevada are under very little active management due to rough topography and difficult access. Resistance and response options are unlikely to be practical or effective due to the difficulty and expense of management actions.

Resilience options may offer the only realistic area of activity in the alpine and subalpine zones of the Sierra Nevada. Such options would be related to fish stocking, livestock grazing, and fire suppression. Resilience options may also apply to changes in recreation activity in the alpine and subalpine zone includes hiking, backpacking, and horse/mule packing.

The optimal strategies to promote the resilience of the alpine and subalpine zone in the face of climate change will include: stopping fire suppression, stopping livestock grazing, stopping fish stocking in historically fishless lakes, and stopping horse/mule packing.

Monitoring Recommendations:

Monitor changes in the distribution of plants and animals to understand the impacts of climate change.

Monitoring the changing impacts of cows, horses, and mules on alpine and subalpine systems as climate warms would be very helpful.

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Target: SEMI-ARID MONTANE SHRUBLAND

Discussion:

Located on the arid eastern edge of the SSP planning region, semi-arid montane shrubland is comprised of sagebrush interspersed with pinyon-juniper. A key ecological attribute of the semi-arid montane shrubland system is the heterogeneity of age classes across the landscape, and the health of the system can be determined by knowing if there are multiple sagebrush age classes at the watershed scale. Lack of fire due to naturally low fuel levels, fire suppression, and unmanaged livestock grazing have resulted in the landscape being dominated by old age class sagebrush (Provencher 2009).

Hypotheses of Change: In the absence of changes to human activities, climate change will likely have little influence on age structure (Provencher 2009), unless the systems become unsuitable for grazing. In this case, following very wet years, fuel build up should result in an increase in fires. Fire in intact sagebrush will lead to greater age class heterogeneity resulting in a system more resistant to cheatgrass. However, if fire burns in degraded sagebrush, cheatgrass will invade. Fragmented and degraded areas further stressed by climate change will be more likely to be type converted to cheatgrass dominated systems after fire. This invasion will initiate the grass-fire cycle and shift the paradigm to too much fire resulting in the loss of native plant species (Chambers *et al.* 2007; Chambers *et al*. 2008; Provencher 2009; Taucsh 2009). Under this scenario, many areas would likely become marginal for grazing, but fire suppression activities could continue to minimize fire on the landscape.

With climate change, increased temperatures and increasing variability of precipitation will bring longer drought periods, and make vegetation more likely to catch fire. Increased ignitions resulting from greater human populations (Keeley *et al*. 2004), a longer fire season due to increased temperatures (Lenihan *et al*. 2008), and increased plant growth resulting from CO_2 enrichment and N fertilization (Ainsworth and Long 2004, Roberts *et al*. 1998) will result in more fires within the semi-arid montane community at lower elevations. Higher temperatures may lead to the expansion of semi-arid montane vegetation at mid elevations at the expense of coniferous forests due to very limited conifer recruitment. This conversion will be facilitated by high intensity crown fires that kill existing trees. Type conversion to grasslands at low elevations is likely at the intermediate scale (Halsey 2009). Increase in semi-arid montane species at mid elevations is less certain as the extent of forest decline is unknown. Additionally, forest could type convert to non-native grassland or oak woodland.

Ecosystem Services Affected: Carbon sequestration, watershed ground cover, and soil stabilization.

Strategy Implications:

Control human development and land use in the semi-arid montane zone.

Track invasive non-native species of grass.

Protect from too-frequent of fires by supporting enhanced fire suppression and fire prevention capacity where the semi-arid montane ecosystem has been fragmented, degraded, and invaded by non-native invasive grasses.

Discourage destructive fuel treatments when possible.

Encourage a natural fire regime that allows for varied age-classes of sagebrush vegetation.

Monitoring Recommendations:

Monitor amount and distribution of annual grasses.

Influence community response to fire and fuels treatments.

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Target: MOJAVE DESERT SCRUB AND JOSHUA TREE COMMUNITIES

Discussion:

Higher temperatures will lead to increased evapotranspiration and reduced soil moisture in desert systems where water scarcity already limits plant growth and the survival of animals. This may be offset in some areas by increased precipitation, but many desert species are likely to encounter greater drought stress than they have in the recent past. Warmer temperatures and drought stress may lead to a shorter growing season and earlier flowering for some plant species, which could impact some animals dependent on these plant species.

Mojave scrub communities at lower elevations and on south facing slopes may be subject to a loss in diversity and a change in species composition if temperatures inch above the thermal maxima for some species, or the required minimum temperatures necessary for seed germination or flowering are no longer met. Joshua trees may no longer be able to survive in their current range. North facing slopes where solar radiation is lower and higher elevations where temperatures are cooler may provide some species with refugia from drought and heat stress.

Research has shown that increased CO_2 concentrations in the atmosphere mitigate the negative impacts of higher temperatures and drought stress on some plants. Plants can reduce water loss through their stomata when taking up CO_2 for photosynthesis if atmospheric CO_2 concentrations are higher. This could lead to increased productivity and range expansion for some Mojave shrub species, particularly if the climate becomes wetter. With greater productivity and a more closed shrub canopy, fire may become more common in the Mojave.

Plant species dominant in Mojave Desert Scrub may become more common in other plant communities due to climate change, but the establishment of many desert species requires an absence of disturbance (either natural or human-caused) over long periods of time. In addition, if the monsoon rains common in the Sonoran desert shift north and become more common in the Mojave, it is likely that some species that are found in the Sonoran Desert may move north into the Mojave.

Hypotheses of Change: At this time, climate change is not the biggest direct threat to Mojave Desert Scrub and Joshua tree communities. Conversion and the invasion of non-native grasses following disturbance are greater immediate threats than climate change.

Ecosystem Services Affected: Reduced water availability due to increases in temperature is a potential problem for all human activities in the desert, where water is already scarce. If a rise in air temperature leads to a reduction in soil moisture, it is also possible that the carbon sequestration capability of desert soils will be reduced. This is because sequestration of CO_2 in desert soils is highly dependent on the activity of soil organisms, which is in turn controlled by soil moisture. Finally, Joshua trees are a unique iconic symbol of the Mojave Desert. Loss of the trees from their native range due to climate change would diminish the cultural and recreation values of the Mojave Desert, which are important ecosystem services for this community target.

Strategy Implications:

Prevent conversion of Mojave Desert Scrub and Joshua tree communities.

Track invasive non-native species.

Monitoring Recommendations:

Monitor diversity and distribution of native plants, including Joshua trees.

Monitor changes in native plant productivity.

Monitor distribution and spread of invasive species.

Monitor changes in fire frequency.

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Target: RIPARIAN COMMUNITIES

Discussion:

The type and condition of riparian communities varies widely in the planning area, depending on elevation, slope, whether the drainage they are in is fed primarily by rainfall or snowpack, and land use history. Since streams at higher elevations tend to be quite steep and fast-flowing, their floodplains and associated riparian communities are narrow. Mountain meadows form in shallow depressions in this otherwise rugged topography. The steep terrain has slowed residential development, but the higher elevation riparian communities are subject to livestock grazing and impacts of road construction.

As streams and rivers flow down through the foothills, they take on gentler gradients and a more braided, meandering character. As a result, foothill riparian communities tend to be broader than their higher elevation counterparts. Where livestock have access to riparian areas, they trample stream banks and browse understory vegetation, changing floodplain morphology somewhat and creating a two-story riparian community (grasses and forbs below, tree canopy above). Foothill residents and ranchers withdraw surface water and groundwater for domestic and ranch uses, reducing summer flows and saturation of riparian areas.

Where streams and rivers exit the foothills the velocity of stream flows declines further still, and gravels eroded from the mountains are deposited in floodplain alluvial terraces. These alluvial deposits are mined for gravel, with attendant impacts on riparian vegetation, and the morphology and hydrology of floodplain habitat.

Floodplain morphology and stream flows in the San Joaquin Valley have been drastically modified by intensive agriculture, urbanization and flood control measures. 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. Groundwater over-drafting and unnatural timing of stream flows may adversely affect the remaining valley riparian communities.

Because riparian areas provide a mesic oasis during the area’s hot, dry summers they may provide important refugia in a warming climate. Rivers and streams flowing from the highest mountain peaks to the Central Valley cut across numerous climatic zones and vegetation communities, from alpine, to montane, to grassland, to desert. Riparian communities along these waterways form important biological connections among these climatic zones, especially since so many species are at least partially dependent on riparian communities for their livelihood.

Riparian communities provide a number of ecosystem services, including:

Natural water storage, flood amelioration, groundwater recharge – e.g. spongy mountain meadows, floodplains, seasonal wetlands where water pools during high flows

Sand and gravel

Oasis for humans – shady, moist, cool, pretty

Carbon sequestration by riparian woodlands

Native American cultural uses – acorns, elderberry, sedges, willows and other plants used for food, fiber, and medicines

Riparian communities are adapted to dynamic weather conditions, especially in lower third of most watersheds where there are tremendous fluctuations in the area inundated from one storm to the next, from wet season to dry season (especially at lower elevations), and from year to year. For example, annual flows in Tulare County's Dry Creek have ranged from 135 to 93,750 acre-feet, and peak flows have ranged from 9 cfs to 14,500 cfs. Groundwater levels in the floodplain of streams like Dry Creek are closely to volume of stream flow, with spikes during flood events and an annual cycle of saturation and drawdown.

The primary climate change concerns for riparian communities are long term trends in the amount and frequency of floodplain inundation, floodplain morphology (e.g., connectivity to stream channels, patterns of sediment deposition or scouring), and average groundwater levels. These, in turn are tied to the things that are likely to be affected by climate change, such as average amount of precipitation, pattern of precipitation events (as they affect flood frequency and magnitude, and groundwater recharge), whether precipitation falls primarily as rain or snow (and therefore how it is released to the watershed throughout the year), how early the snowpack melts (as it affects summer flow volumes in streams adjoining riparian areas, and therefore how wet the riparian soils stay), amount of evapotranspiration (as it affects depletion of soil moisture and groundwater), and length of dry season (as it affects depletion of groundwater).

With climate change, we expect:

The bulk of precipitation to occur earlier in the winter, with less falling as snow, more as rain.

Earlier melting of snowpack, resulting in earlier peak flows in rivers and streams with high elevation headwaters that are fed by snowpack. This in turn means earlier peak flows, and longer periods of low or no surface flows in rivers and streams during the dry season.

Increased evapotranspiration due to warming temperatures.

Combination of longer periods of reduced flows and increased evapotranspiration with floodplain soils drying out sooner in the summer, near-stream groundwater levels declining over the long term, and a shrinking area suitable for heterogeneous, vertically complex riparian vegetation.

Some models suggest that precipitation events will become more extreme, leading to more frequent major floods which inundate larger areas of the floodplain. However, because these events are flashy, floodwaters may not have as much chance to percolate and recharge the groundwater table, at least not more than is already happening. There may also be a net loss of alluvium through scouring, gradually lowering the water table. Reduced snowpack (natural water storage) and increased incidence of extreme events may result in intense political pressure for engineered water storage and flood control measures, further modifying floodplain morphology and riparian communities. It will be essential to champion the advantages of cooperating with natural processes (e.g., restoring natural patterns of flooding and deposition, especially in areas suitable for groundwater recharge; or restoring and maintaining the integrity of mountain meadows).

Effects of climate change are complicated by human modifications of floodplain morphology (e.g. by gravel mining, or conversion of meandering or braided stream channels to engineered water storage and conveyance structures for flood control and irrigation), by removal or simplification of riparian vegetation (e.g. by livestock grazing or clearing of vegetation along water conveyance channels), and by withdrawal of both surface flows and near-stream groundwater. Invasive exotic plants like tamarisk, Arundo, Himalayan blackberry, and edible fig also displace native species and may form homogeneous stands of reduced habitat value to wildlife. These factors will all conspire to reduce the area, continuity and heterogeneity of riparian vegetation communities, especially in the lower reaches of each watershed.

Hypotheses of Change: Riparian communities will become even more critical as refugia during the increasingly hot, dry summers, and riparian corridors will provide important pathways for species distribution shifts driven by climate change. Riparian communities will gradually contract, become more simplified (e.g. less trees and vertical structure), and become more fragmented over the long term, especially at lower elevations and in watersheds without significant snowpack. The pace of change may be slower relative to other plant communities due to more mesic conditions along waterways. There will be a shift in plant species composition to more drought-tolerant species, starting at the lower elevations and in watersheds without significant snowpack.

Ecosystem Services Affected:

Riparian areas will become even more critical for natural water storage and flood amelioration.

People will increasingly seek out riparian communities as refugia from hotter, drier summers, putting more development pressure on these areas.

Strategy Implications:

Protect lands along major riparian corridors, especially in areas with topography and soils suitable for groundwater recharge.

Reduce impacts of livestock grazing in riparian areas (e.g. cooperative projects to fence riparian areas and provide livestock with alternative water sources).

Restore wetlands, floodplains and riparian vegetation disrupted by gravel mining, inappropriate grazing, road construction or other human disturbances (e.g. remove barriers to natural patterns of flooding and deposition, plant native riparian vegetation, restore degraded mountain meadows).

Work with water districts and ditch companies on maintenance practices that allow multi-story native riparian vegetation along water conveyance structures.

Control invasives like arundo, tamarisk, and Himalayan blackberry, especially to prevent establishment where they don't already have a strong foothold. Plant native riparian species in their place.

Encourage and assist flood control districts to utilize natural flood control measures (e.g. stormwater storage on agriculture and habitat easements, in protected seasonal wetlands and natural floodplains, wherever feasible).

Coordinate with flood control districts, water districts, water users associations and farmers on conjunctive use projects that protect riparian corridors and groundwater recharge areas, ameliorate flooding, store more runoff as groundwater and enhance wildlife habitats such as seasonal wetlands.

Compile information on current water uses in foothill riparian areas (e.g. community water systems, residential wells, ditch companies), and examine current statutes regulating use of surface flows and groundwater. Determine best strategies for maintaining in-stream flows and saturation of riparian areas.

Work with gravel industry and mine regulators to promote ecologically based reclamation strategies that restore floodplain function and complex riparian vegetation in alluvial mining areas.

Monitoring Recommendations:

Survey riparian areas for continuity and extent of multi-story, native riparian vegetation community along major riparian corridors.

Monitor the occurrence and extent of invasive plants.

Monitor the success of restoration efforts.

Keep track of trends in foothill water withdrawals, effects on foothill waterways and riparian areas, and monitor related policies and enforcement (e.g. proof of water).

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Target: AQUATIC COMMUNITIES

Discussion: With climate change, average annual precipitation is projected to be stable or slightly reduced, but with a greater percentage falling as rain (vs. snow) at high elevations. Winter storm severity is projected to increase, with a greater volume of precipitation delivered per event. Temperatures and evapotranspiration are projected to increase. There is relatively high uncertainty in precipitation prediction as models conflict strongly. However, air temperatures are likely to increase 2-6 degrees; this is predicted with a relatively high certainty (Mauer 2007). All of these changes could have consequences for aquatic communities in rivers, streams, and lakes.

Hypotheses of Change:

Rivers with majority of watershed above 5,000 feet elevation

With rising temperatures and increased evapo-transpiration, the percentage of total precipitation held as snow pack will decline, and the remaining snow pack will melt earlier, shifting peak runoffs to earlier in the wet season (e.g. peak runoff December - March instead of April – July). Soils in areas without snow cover will yield higher, earlier, but temporary peak stream flows than areas with snow pack, especially early in the wet season when forest soils are still hydrophobic from the preceding dry season. These changes, in combination with more severe individual precipitation events, will increase the frequency, severity and extent of winter flooding in the foothills and on the valley floor. Flood pulses thus, may be more frequent, carry greater energy and cause greater flood damage and channel movement, but the duration of flooding, especially in the warm season, or late spring, may be short. Political pressures for engineered flood control measures may increase.

A smaller snow pack will also mean less runoff from snowmelt during late spring and early summer. Increased temperatures and evapotranspiration will further reduce spring runoff. As a result, the spring runoff period (typically April – July) will be shorter, the average volume of late spring/early summer runoff will be less, the extent of spring flooding will decline (e.g., smaller percentage of flood plain inundated, and for shorter period).

Possible outcomes for aquatic communities in these watersheds:

Greater channel movement because of flash flooding (Friedman and Lee 2002).

Shift in fish assemblage from coldwater fishes to primarily warm water assemblages (Omundson et. al 2002).

Shift in streamside vegetation towards younger trees because of scouring action during frequent, short, high intensity floods, this may change the invertebrate community in the aquatic system (Friedman and Lee 2002).

With diminished stream flow, non-native fish abundance and invasions will increase.

With diminished stream flow, environmental toxins will accumulate to higher concentrations.

Rivers with majority of watershed below 5,000 feet elevation

Increased winter storm severity will increase the frequency, severity and extent of winter flooding in the foothills and on the valley floor. Flooding may be exacerbated in low-lying areas with poor drainage lacking natural floodplains to absorb flood flow energy. Peak runoffs will still occur between December and March, but increased temperatures and evapotranspiration will reduce the volume of spring and early summer runoff.

Possible outcomes for aquatic communities in these watersheds:

Riparian communities may contract from their current extent at the lower elevations of these watersheds, this will cause water temperatures to rise, restricting the habitat for cold water fishes and increasing the habitat for non-native fishes (Marchetti *et al*. 2004).

Fine sediment loads may increase, causing declines in important top predators and game fish as well as degraded water quality (Osmundson *et al*. 2002).

Riparian vegetation will be diminished without minimum flows (affect all but the Kings River and Deer Creek), with impacts to recreation, macroinvertebrate and fish communities (Marchetti *et al*. 2004, Omundson *et al*. 2002, Palmer *et al*. 2009).

With diminished stream flow, non-native fish abundance and invasions will increase.

With diminished stream flow, environmental toxins will accumulate to higher concentrations.

Ecosystem Services Affected: More incised streambeds which drain water faster will have multiple consequences, including less groundwater recharge and reduced water storage, leading to water shortages during the dry months.

Changes in the hydrology of rivers could also alter the productivity of hydropower plants.

Changes in species assemblages could affect recreational fishing.

Strategy Implications:

Protect lands along major riparian corridors, especially in areas with topography and soils suitable for groundwater recharge.

Restore wetlands, floodplains and riparian vegetation disrupted by gravel mining, inappropriate grazing, road construction or other human disturbances (e.g. remove barriers to natural patterns of flooding and deposition, plant native riparian vegetation, restore degraded mountain meadows).

Encourage and assist flood control districts to utilize natural flood control measures (e.g. stormwater storage on agriculture and habitat easements, in protected seasonal wetlands and natural floodplains, wherever feasible).

Coordinate with flood control districts, water districts, water users associations and farmers on conjunctive use projects that protect riparian corridors and groundwater recharge areas, ameliorate flooding, store more runoff as groundwater and enhance wildlife habitats such as seasonal wetlands.

Compile information on current water uses in foothill riparian areas (e.g. community water systems, residential wells, ditch companies), and examine current statutes regulating use of surface flows and groundwater. Determine best strategies for maintaining in-stream flows and saturation of riparian areas.

Work with gravel industry and mine regulators to promote ecologically based reclamation strategies that restore floodplain function and complex riparian vegetation in alluvial mining areas.

Monitoring Recommendations:

Keep track of trends in foothill water withdrawals, effects on foothill waterways and riparian areas, and monitor related policies and enforcement (e.g. proof of water).

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APPENDIX G:

GAP ANALYSIS OF SSP TARGETS

SSP Group	WHRNAME	Total Eco-regional Area (Ha)	Total Eco-regional Area (Acres)	Total Protected in Ecoregions (Ha)	Total Protected in Ecoregions (Acres)	% Protected Eco-regions	Total Area in SSP Study Area (Ha)	Total Area in SSP Study Area (Acres)	Total Area Protected in SSP Study Area (Ha)	Total Area Protected in SSP Study Area (Acres)	% Protected in SSP	% of Eco-regional Area in SSP
Alpine and Subalpine	Alpine-Dwarf Shrub	61,414	151,693	61,182	151,120	100%	7,417	18,320	7,416	18,318	100%	12%
Alpine and Subalpine	Subalpine Conifer	208,422	514,802	206,686	510,514	99%	95,410	235,663	95,141	234,998	100%	46%
Alpine and Subalpine Total		**269,836**	**666,495**	**267,868**	**661,634**	**99%**	**102,827**	**253,983**	**102,557**	**253,316**	**100%**	**38%**
Conifer Forest	Jeffrey Pine	149,612	369,542	139,511	344,592	93%	62,397	154,121	56,665	139,963	91%	42%
Conifer Forest	Lodgepole Pine	192,787	476,184	188,234	464,938	98%	65,429	161,610	65,210	161,069	100%	34%
Conifer Forest	Ponderosa Pine	244,074	602,863	145,694	359,864	60%	48,323	119,358	41,268	101,932	85%	20%
Conifer Forest	Red Fir	412,924	1,019,922	390,144	963,656	94%	151,039	373,066	150,534	371,819	100%	37%

Conifer Forest	Sierran Mixed Conifer	1,168,710	2,886,714	875,082	2,161,453	75%	174,836	431,845	164,910	407,328	94%	15%
Oak Woodlands	Montane Hardwood	568,744	1,404,798	244,286	603,386	43%	124,936	308,592	89,324	220,630	71%	22%
Oak Woodlands	Montane Hardwood-Conifer	218,477	539,638	92,639	228,818	42%	7,722	19,073	6,482	16,011	84%	4%
Conifer Forest	Unknown Conifer Type	12,184	30,094	5,014	12,385	41%	7,283	17,989	3,725	9,201	51%	60%
Conifer Forest	White Fir	105,767	261,244	87,672	216,550	83%	358	884	10	25	3%	0%
Conifer Forest Total		**3,073,279**	**7,590,999**	**2,168,276**	**5,355,642**	**71%**	**642,323**	**1,586,538**	**578,128**	**1,427,976**	**90%**	**21%**
Desert Scrub	Alkali Desert Scrub	506,969	1,252,213	256,950	634,667	51%	1,157	2,858	144	356	12%	0%
Desert Scrub	Bitterbrush	11,756	29,037	10,287	25,409	88%	1,220	3,013	398	983	33%	10%
Desert Scrub	Desert Scrub	5,077,087	12,540,405	3,462,358	8,552,024	68%	137,339	339,227	80,029	197,672	58%	3%
Desert Scrub	Desert Succulent Shrub	151,749	374,820	132,896	328,253	88%	2,521	6,227	138	341	5%	2%
Desert Scrub	Desert Wash	149,941	370,354	123,571	305,220		82	203	82	203		

						82%					100%	0%
Desert Scrub Total		**5,897,502**	**14,566,830**	**3,986,062**	**9,845,573**	**68%**	**142,319**	**351,528**	**80,791**	**199,554**	**57%**	**2%**
Freshwater Wetlands and Wet Meadow	Freshwater Emergent Wetland	70,720	174,678	36,568	90,323	52%	500	1,235	4	10	1%	1%
Freshwater Wetlands and Wet Meadow	Wet Meadow	36,991	91,368	28,262	69,807	76%	10,031	24,777	9,460	23,366	94%	27%
Freshwater Wetlands and Wet Meadow Total		**107,711**	**266,046**	**64,830**	**160,130**	**60%**	**10,531**	**26,012**	**9,464**	**23,376**	**90%**	**10%**
Grasslands	Annual Grassland	1,817,901	4,490,215	287,525	710,187	16%	469,014	1,158,465	44,655	110,298	10%	26%
Grasslands Total		**1,817,901**	**4,490,215**	**287,525**	**710,187**	**16%**	**469,014**	**1,158,465**	**44,655**	**110,298**	**10%**	**26%**
Joshua Tree	Joshua Tree	270,167	667,312	248,121	612,859	92%	1,267	3,129	1,024	2,529	81%	0%
Joshua Tree Total		**270,167**	**667,312**	**248,121**	**612,859**	**92%**	**1,267**	**3,129**	**1,024**	**2,529**	**81%**	**0%**
Oak Woodlands	Blue Oak Woodland	613,523	1,515,402	107,079	264,485	17%	264,702	653,814	42,308	104,501	16%	43%
Oak Woodlands	Blue Oak-Foothill	134,557	332,356	32,890	81,238		70,415	173,925	23,737	58,630		

	Pine					24%					34%	52%
Oak Woodlands	Coastal Oak Woodland	2,016	4,980	90	222	4%	1,829	4,518	28	69	2%	91%
Oak Woodlands Total		**750,096**	**1,852,737**	**140,059**	**345,946**	**19%**	**336,946**	**832,257**	**66,073**	**163,200**	**20%**	**45%**
Riparian	Desert Riparian	6,645	16,413	1,762	4,352	27%	1,220	3,013	956	2,361	78%	18%
Riparian	Montane Riparian	23,457	57,939	20,416	50,428	87%	2,639	6,518	2,196	5,424	83%	11%
Riparian	Valley Foothill Riparian	29,179	72,072	8,071	19,935	28%	697	1,722	58	143	8%	2%
Riparian	Valley Oak Woodland	22,482	55,531	1,567	3,870	7%	13,629	33,664	400	988	3%	61%
Riparian Total		**81,763**	**201,955**	**31,816**	**78,586**	**39%**	**18,185**	**44,917**	**3,610**	**8,917**	**20%**	**22%**
Rivers, Lakes, Streams	Lacustrine	3,233	7,986	813	2,008	25%	257	635	75	185	29%	8%
Rivers, Lakes, Streams	Riverine	9,132	22,556	1,389	3,431	15%	87	215	11	27	13%	1%

Rivers, Lakes, Streams Total		**12,365**	**30,542**	**2,202**	**5,439**	**18%**	**344**	**850**	**86**	**212**	**25%**	**3%**
Semi-arid montane	Juniper	56,974	140,726	32,994	81,495	58%	5,535	13,671	2,460	6,076	44%	10%
Semi-arid montane	Montane Chaparral	228,321	563,953	197,341	487,432	86%	49,291	121,749	48,211	119,081	98%	22%
Semi-arid montane	Pinyon-Juniper	184,776	456,397	165,627	409,099	90%	125,795	310,714	108,564	268,153	86%	68%
Semi-arid montane	Sagebrush	261,593	646,135	214,471	529,743	82%	41,711	103,026	28,093	69,390	67%	16%
Semi-arid montane Total		**731,664**	**1,807,210**	**610,433**	**1,507,770**	**83%**	**222,332**	**549,160**	**187,328**	**462,700**	**84%**	**30%**
Shrublands	Chamise-Redshank Chaparral	46,123	113,924	23,910	59,058	52%	9,051	22,356	6,498	16,050	72%	20%
Shrublands	Coastal Scrub	1,295	3,199	885	2,186	68%	2,559	6,321	1,761	4,350	69%	198%*
Shrublands	Mixed Chaparral	240,055	592,936	129,851	320,732	54%	70,845	174,987	38,754	95,722	55%	30%
Shrublands	Unknown Shrub Type	112,184	277,094	22,743	56,175	20%	76,982	190,146	18,284	45,161	24%	69%
Shrublands Total		**399,657**	**987,153**	**177,389**	**438,151**		**159,437**	**393,809**	**65,297**	**161,284**		

					44%					41%	40%
Totals	**13,411,941**	**33,127,494**	**7,984,581**	**19,721,915**	**60%**	**2,105,525**	**5,200,647**	**1,139,013**	**2,813,362**	**54%**	**16%**

* There is a small portion of this type in the SSP area but in the South Coast Ecoregion, which was not included in the set of ecoregions used to calculate the column with the Total Ecoregional Area. Therefore a larger amount is shown in the SSP than in the ecoregions that we included.

APPENDIX H

FIRE RETURN INTERVAL DEPARTURE – MEAN DEPARTURE

Fire Return Interval Departure (FRID/MD)

Dave Schmidt, 12 January 2010

METHODS

There are four similar products that describe the condition of a landscape's fire regime: 1) the national LANDFIRE project's FRCC maps, 2) FRID/TSLF produced by the National Park Service (which they simply call FRID), 3) TSLF or time since last fire, and 4) FRID/MD or fire return interval departure based on mean departure. Because considerable confusion has arisen due to the similarity of these measures they are all described below. The Southern Sierra Partnership analyses below are based on FRID/MD.

The national LANDFIRE project distributes FRCC (fire regime condition class) maps which are based on observed and inferred differences in vegetation structure (primarily canopy cover). Conditional class ranges from 1 to 3 depending on the degree of departure. FRCC maps can be obtained from www.landfire.gov. LANDFIRE's FRCC maps are periodically updated to reflect recent fires and vegetation structural changes.

FRID/TSLF, as produced by the NPS for the southern Sierra Nevada, is computed as time since last fire relative to maximum average pre-settlement FRI (Caprio, Conover et al. 1997). FRID/TSLF is an index that describes the degree of departure. FRID/TSLF is calculated as:

(max FRI-TSLF)/max FRI

TSLF, produced state-wide by the USFS and TNC along with FRID/MD, is simply the number of years since an area has burned. The NPS also maps TSLF in the southern Sierra Nevada. USFS mapping uses a baseline of 1910 while NPS mapping in the southern Sierra Nevada uses 1899.

The U.S. Forest Service Remote Sensing Lab, together with the USFS Region 5 Ecology Program and the California chapter of TNC, has produced a state-wide map and analysis of fire return interval departure. FRID/MD is a comparison of current fire return interval (FRI) and mean pre-settlement FRI. Its output is a percent departure which we categorize into the three FRCC condition classes plus three negative condition classes to represent the case of more frequent fires than before European-American settlement. FRID/MD will be updated annually across California. FRID/MD is calculated as:

if (current FRI >= pre-settlement FRI)

FRID/MD = (1-(pre-settlement FRI/current FRI))*(100%)

else if (current FRI = unburned and pre-settlement FRI >= period)

FRID/MD = 0%

else

FRID/MD = (1-(current FRI/pre-settlement FRI))*(-100%)

The percentages above are aggregated into the condition classes below:

CC 1 and -1: burning within +/- 33% of the natural range of variability

CC 2 and -2: moderate departure; these areas are burning 33-66% more or less frequently than before settlement

CC 3 and -3: severe departure; these areas are returning >66% more or less frequently than before settlement

To some degree FRID/MD and FRID/TSLF are complementary. FRID/MD is more related to how many fires an area has "missed" since the beginning of consistent fire records (roughly 1910) while FRID/TSLF gets at time since last fire (TSLF). FRID/TSLF can be useful for thinking about potential fire behavior and fuel loads while FRID/MD approaches fire as an ecological process but does not address potential fire behavior. For example: if mixed conifer is expected to burn every 15 years and it burned 15 years ago, its FRID is 0 (low departure) [(15-15)/15]. Fuel loads are probably not elevated above the natural range of variability. If TSLF is 90 years or longer, then its FRID is extreme [(90-15)/15] and fuel loads have probably had time to accumulate to elevated levels. With FRID/MD, TSLF does not matter but instead what matters is how many fires the area has missed. If that mixed conifer has only burned once in the 98-year period of record (1910-2008), its current fire return interval is 98/(1+numfires) = 98/2 = 49. Its FRID/MD score is 1-15/49 = 69% (condition class 3) or "severely departed". While the area has a high condition class score, if its single fire happened to have occurred recently it will have a low FRID/TSLF score and its fuel load might not be excessive. However, stand structure and species composition, which are determined in large part by fire frequency, could be very different than historic conditions.

FRID/TSLF can imply a good condition even though many fires have been "missed" as long as the time since last fire is similar to historic return interval. Therefore FRID/TSLF could be more credibly related to fire intensity/severity than FRID/MD. FRID/MD can show a good condition even if the last fire was a long time ago as long as most expected fires weren't missed. This isn't particularly useful for fire risk/susceptibility/intensity/severity but we feel it provides guidance for prioritizing areas for prescribed fire or thinning to restore a more intact fire regime (or, by inference, stand structure).

We often find that chaparral areas are burning much more frequently than historically, even in the Sierra Nevada where fire suppression has been generally effective for many decades. FRID/MD includes negative condition classes to describe this case. We also find forest areas that are burning too frequently but usually this is a small portion of the landscape (typically highway corridors). About 14% of the SQF has "too much" fire currently.

Like FRCC/TSLF, FRCC/MD does not map grasslands, riparian areas, etc. where pre-settlement FRIs are not well described.

RESULTS

Target: Oak Woodlands

Key Ecological attribute: Recruitment

One hypothesis holds that oak recruitment is poor because of altered fire regimes. A pre-settlement fire return interval of 10 years is a common estimate in the literature. Current (1910-2008) fire return intervals within oak-dominated areas of SSP are much longer, in fact more than three-quarters of this landscape has not burned since 1910.

Current FRI (yrs)	% of SSP blue oak woodland
12	0.0%
14	0.0%
16	0.1%
20	0.2%
24	0.8%
33	4.7%
49	18.2%
unburned	75.9%

FRID/MD calculations are based on a pre-settlement FRI of 10 years. Not surprisingly, virtually the entire area is classified as CC 3 (severe departure) (Fig. 1). Increased fire frequency in the future may be beneficial depending on the magnitude of the increase as well as the change in future fire severity.

CC	% of SSP blue oak woodland
1	0.0%
2	1.1%
3	98.8%

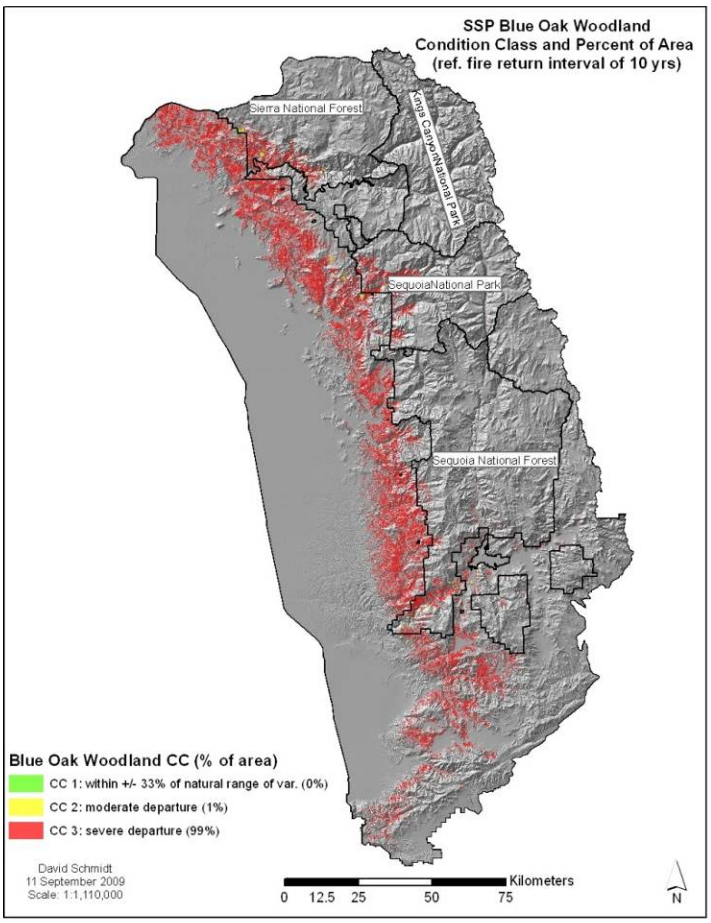

Figure 1. Blue oak woodland condition class within SSP.

Target: Oak Woodlands

Key ecological attribute- Size and area

While mature oaks are generally considered to be fire-tolerant, they can be killed by high severity fire. Flamelength is a convenient, observable, and intuitive measure of fire behavior that describes fire intensity (a physical property) and, indirectly, fire severity (an ecological property). The following table is widely used to categorize flamelengths.

Flamelength (ft)	Category
0 to <4	low
4 to <8	moderate
8 to <12	high
>12	very high

I used USFS fuels data to estimate flamelengths for SSP blue oak woodlands. The USFS fuel map accounts for topography and vegetation and is based on typical mid-season fire weather. While most of the blue oak woodland area would be expected to experience low flamelengths in the event of a wildfire, more than 10% could experience very high flamelengths. Fire intensity, and flamelength, are generally expected to increase under projected future climates.

Flamelength Category	% of SSP blue oak woodlands
low	76.0%
moderate	10.5%
high	2.2%
very high	11.3%
non-burnable	0.3%

I also mapped potential flamelengths for all vegetation types within SSP excluding the Central Valley (Fig. 2). Nearly one third of the SSP area above the Valley could experience high to very high flamelengths. This is not necessarily because chaparral is included (which would be expected to produce high flamelengths). This is likely due in large part to high fuel loads that would cause elevated flamelengths.

Flamelength Category	% of SSP (excluding Valley)
low	36.1%
moderate	21.9%
high	8.1%
very high	23.1%
non-burnable	10.8%

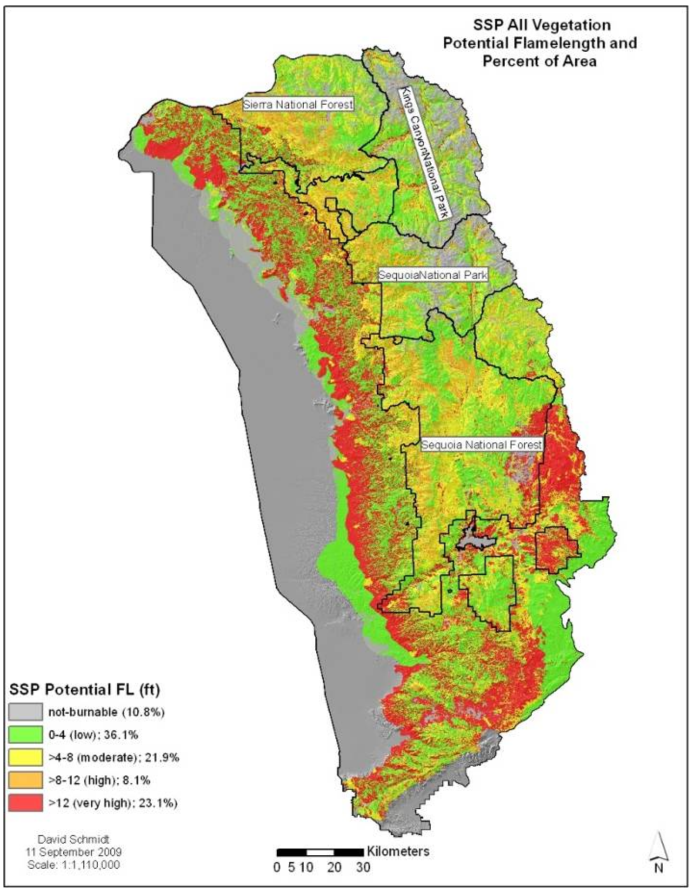

Figure 2. Potential flamelengths for all vegetation within SSP.

Target: Chaparral

Key ecological attribute - Fire regime

Unlike much of the mixed conifer and blue oak woodlands of the Sierra Nevada, chaparral within SSP tends to be burning nearer its pre-settlement fire return interval (Fig. 3). Increasing fire frequency in the future, however, poses a threat to the health of this vegetation type. Approximately 500,000 acres with SSP have been mapped as chaparral. I used a pre-settlement fire return interval (FRI) estimate of 65 years for the chamise-redshank chaparral (WHR type = CRC) and 40 years for mixed chaparral and montane chaparral (WHR type = MCH and MCP) based on the literature. Approximately 43% of the chaparral-dominated areas has not burned since 1910, while about 40% has burned once and has a current FRI of 49 years. Another 16% has a current FRI of 33 years, while roughly 2% has an FRI of 2 or fewer years.

I calculated the following condition classes for chaparral within SSP:

CC	% of SSP chaparral
-3	0.0%
-2	2.6%
-1	14.8%
1	35.6%
2	46.9%

Most chaparral- about 50%- within SSP is burning at roughly the same frequency as before settlement. On the other hand, about 17% is burning more frequently than before settlement, putting it at risk of moving into a more highly-departed condition if fire frequency increases.

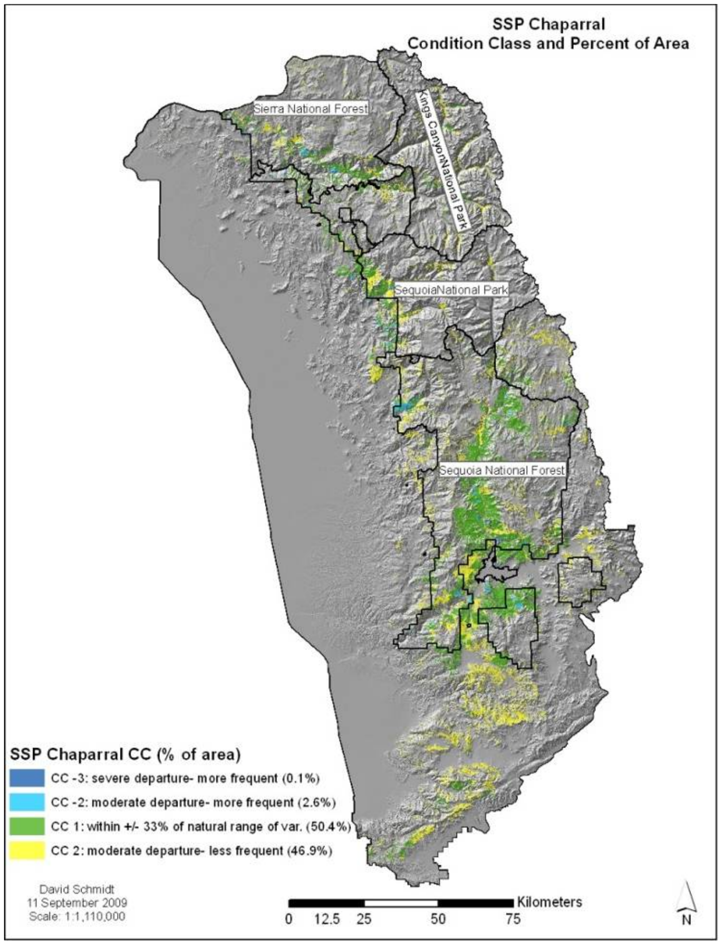

Figure 3. Chaparral condition class within SSP.

Target: Mixed conifer forest

Key attribute: Forest structure

I extracted areas within the Sequoia National Forest that currently are classified as dominated by giant sequoia (Calveg vegtype = BT, MB) and mapped potential flamelength. This area covers about 15,000 acres of the Forest. The situation is slightly better than for mixed conifer in general within SSP (see below) but almost 28% of this area would be expected to experience high or very high flamelengths if burned. Although mature giant sequoias are very fire tolerant, flamelengths of this magnitude would likely result in canopy ignition of surrounding trees that could in turn damage the giant sequoias.

Flamelength Category	% of SQF giant sequoia
Low	43.5%
Moderate	28.6%
High	27.7%
very high	0.1%
not-burnable	0.1%

Next I analyzed only areas of Sequoia National Forest dominated by large trees (greater than 30 in DBH) in westside mixed conifer, eastside mixed conifer, mixed conifer-giant sequoia, giant sequoia, ponderosa pine, and red fir. This area covers about 2,200 acres of the Forest. The potential flamelength distribution is similar to that of giant sequoia-only areas, although with a slightly higher potential for high-very high flamelengths.

Flamelength Category	% of SQF large trees
Low	46.2%
Moderate	23.8%
High	29.8%
very high	0.1%
not-burnable	0.1%

Target: Mixed conifer forest

Key ecological attribute- Fire regime

Fire regimes in SSP mixed conifer are already highly departed from pre-settlement conditions. I used an overall estimate of 14 years between fires which is based on 12 years between fires in ponderosa pine-mixed conifer and 15 years in white fir-mixed conifer. There are approximately 500,000 acres of mixed conifer mapped within SSP. Of that area, 70% has not burned since 1910.

Current FRI (yrs)	% of SSP mixed conifer
20	0.1%
24	0.3%
33	4.1%
49	25.5%
Unburned	70.0%

Not surprisingly, condition class over almost the entire mixed conifer area is mapped as CC 3 (severely departed).

CC	% of SSP mixed conifer
1	0.0%
2	4.4%
3	95.6%

I estimated potential flamelengths for mixed conifer in the same fashion as for blue oak woodlands above (Fig. 4). Roughly one third of the SSP mixed conifer, if burned, could experience high or very high flamelengths. This fire behavior would be expected to kill even mature trees of fire-tolerant species. Much of the area mapped as high to very high potential flamelengths is found south of the Sequoia National Forest.

Flamelength Category	% of SSP mixed conifer
low	32.6%
moderate	29.8%
high	32.8%
very high	3.8%
not-burnable	1.0%

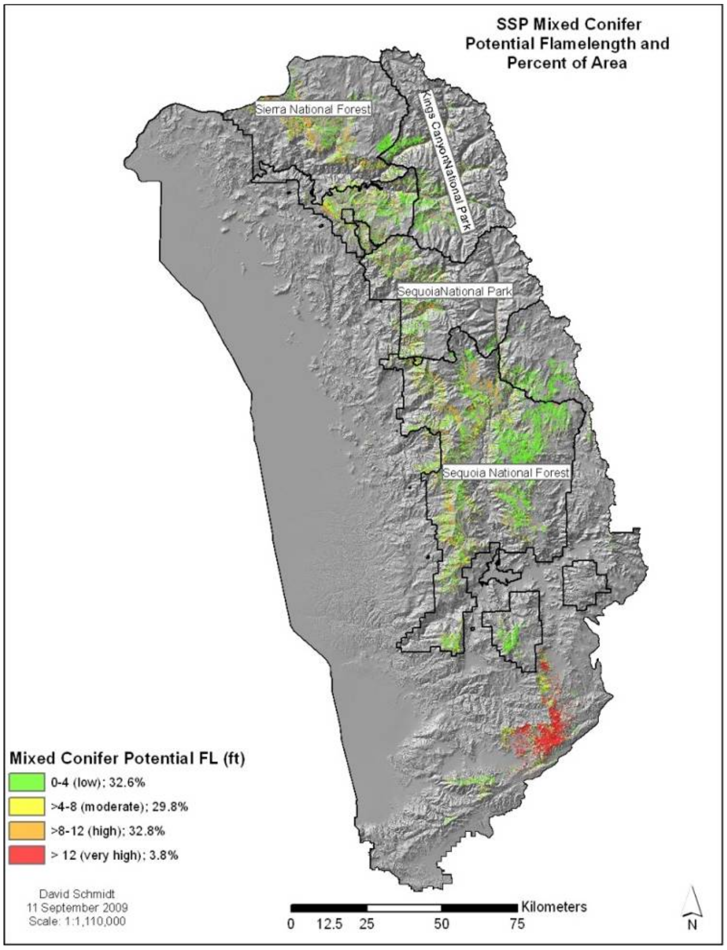

Figure 4. Potential flamelengths for mixed conifer within SSP.

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APPENDIX I

KERN VALLEY RAPTOR RECORDS

Raptors Counted at Kelso Valley Count Site 1999 to 2005 – Kern County, CA.

Data compiled by: Southern Sierra Research Station

Species	1999	2000	2001	2002	2003	2004	2005
Osprey	33	21	9	10	12	12	11
Bald Eagle	-	-	-	-	-	-	-
White-tailed Kite	0	4	0	0	0	-	-
Northern Harrier	5	2	1	3	7	7	3
Sharp-shinned Hawk	6	22	7	15	18	13	10
Cooper's Hawk	16	21	15	16	22	20	12
Northern Goshawk	1	0	1	0	1	9	3
Unidentified Accipiter,	14	23	16	44	20	33	14
Red-shouldered Hawk	0	0	0	0	0	-	-
Broad-winged Hawk	0	3	1	1	1	-	-
Swainson's Hawk	6	6	3	0	3	2	-
Zone-tailed Hawk	0	0	0	?	0	-	-
Red-tailed Hawk	48	20	18	32	37	49	36
Ferruginous Hawk	5	6	1	1	1	6	3
Rough-legged Hawk	0	3	0	0	1	-	-
Unidentified Buteo	4	2	3	6	5	3	5
Golden Eagle	2	1	1	0	0	-	-

American Kestrel	24	7	8	3	3	3	5
Merlin	2	1	0	0	1	-	-
Prairie Falcon	6	4	4	2	2	-	-
Peregrine Falcon	1	0	0	0	1	1	1
Unidentified Falcon	1	1	1	1	0	-	-
Unidentified Raptor	3	4	5	0	1	12	9
Total Raptors	**177** (thru 20 Oct)	**151** (thru 20 Oct)	**94** (thru 20 Oct)	**134** (thru 17 Oct)	**136** (thru 18 Oct)	**170** (thru 12 Oct)	**112** (thru 14 Oct)

1994/2005 Turkey Vulture Data – Count Site Kelso Valley – Kern County CA.

Year	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Total	27,415	27,811	32,926	28,589	25,216	29,590	27,467	28,340	16,479	30,429	23,898	17,792

NOTE: These are the official totals of vultures observed over the Kelso Valley County site which is one of largest documented vulture migrations in North America.

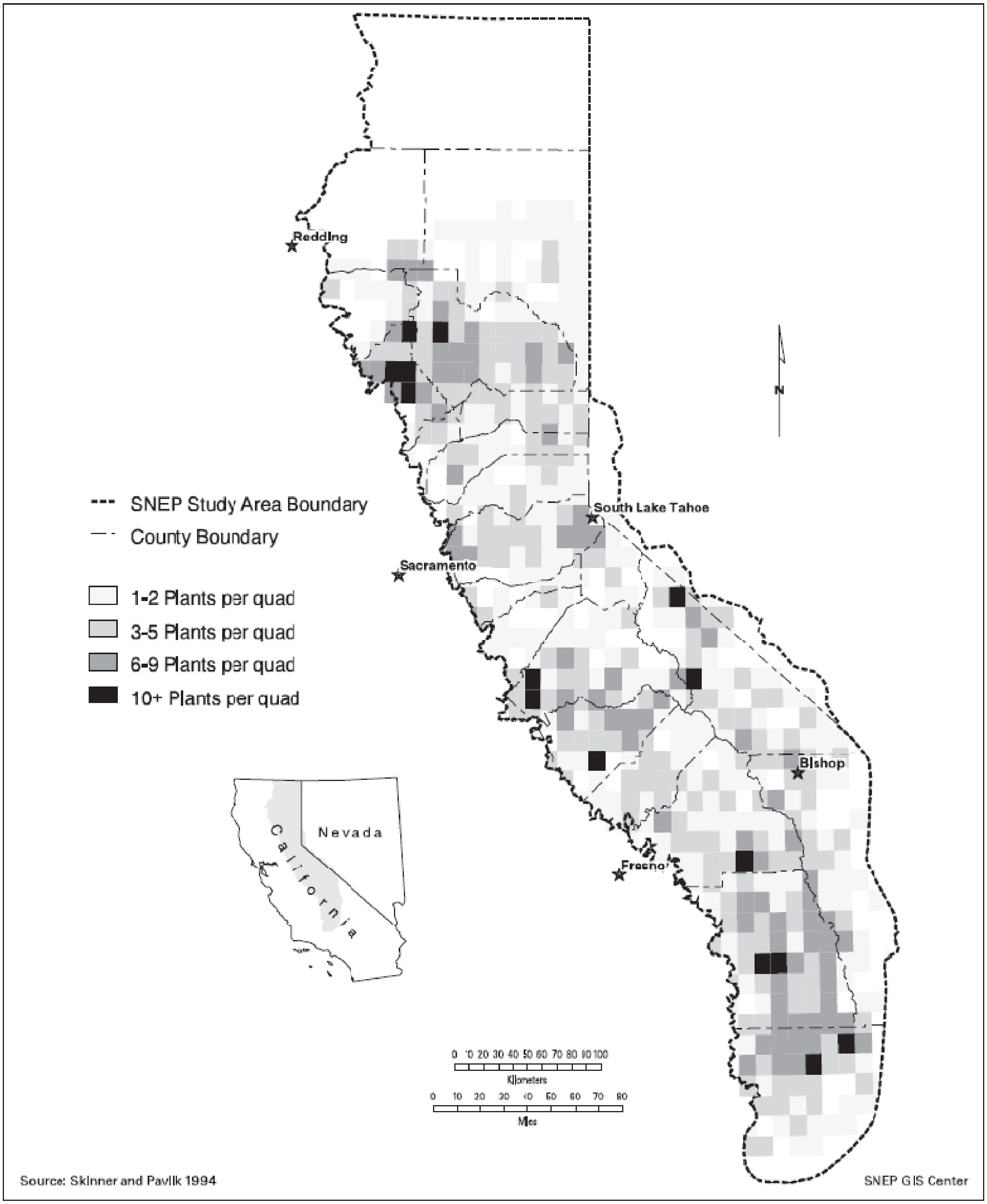

FIGURE 24.3

Distribution of rare plants by topographic quadrangle (Skinner and Pavlik 1994).

Endemic Species in the Southern Sierra and Tehachapi Mountains

Prepared by Bobby Kamansky

P.O. Box 731 Three Rivers, CA 93271 tel. 559.287.3311

Final Version, April, 2010

Climate Sensitivity Chart Idea Credit: Jason McKenzie, TNC; Additional Endemic and Rare Species Information Courtesy of Dick Cameron, TNC and John Austin, Sequoia and Kings Canyon National Park

Methods: Searched CNDDB for rare species, reviewed literature, reviewed range queries for species with 100% of range in Southern Sierra Partnership area, consulted with experts

Summary Statistics:

Sierra Nevada Endemic Vascular Plant Species	**404 (218 rare)**
Number of Endemic Species in Southern Sierra Partnership CAP area:	**60**
Number of Threatened/Endangered of Endemics	**8**
Mammal Endemics	**1**
Amphibians	**6**
Fish	**3**
Plants	**42 (124 identified in SNEP for S. Sierra)**
Invertebrates	**5**
Kern Watershed	**35**
Kaweah	**11**
Tule	**10**
Kings	**3**
Kern Plateau, from Twisselman (Unpublished)	181 named subspecies and varieties for a total of 1,455 kinds of plants currently known on Kern Plateau

Kern County - 17: Allium shevockiiAstragalus ertteraeCamissonia integrifoliaChamaesyce vallis-mortaeClarkia tembloriensis ssp. calientensisClarkia xantiana ssp. parvifloraDelphinium hanseni ssp. kernenseEriogonum breedlovei var. breedloveiEriogonum kenedyi var. pinicolaEschscholzia proceraGalium angustifolium ssp. onycenseHemizonia aridaHeterotheca shevockiiLomatium shevockiiMimulus microphyllusMimulus shevockiiStreptanthus cordatus var. piutensis

Fresno County 7 species: Arabis sp. nov.Carpenteria californicaCordylanthus tenuis ssp. barbatusEriogonum nudum var. regirivumGilia sp. nov.Heterotheca sp. nov.Streptanthus fenestratus

Tulare County - 21: Abronia alpina
Astragalus shevockii
Brodiaea insignis
Castillega praeterita
Ceanothus pinetorum
Clarkia springvillensis
Crythantha incana
Dudleya cymosa ssp. costifolia
Erigeron multiceps
Eriogonum nudum var. murinum
Eriogonum twisselmannii
Erythronium pusaterii
Geranium coccinnum
Horkelia tularensis
Iris munzii
Lotus oblongifolius ssp. cupreus
Mimulus norrisii
Oreonana purpurascens
Phacelia eisenii var. brandegana
Ribes tularense
Silene aperta

Information Status Scale

1 = 1-2 references

2 = 3-4 references

3 = 5-6

4 = 7-8

5 = >8

Climate sensitivity ranking

1 = Little sensitivity - generalist to arid areas

2 =

3 =

4 =

5 = very limited range, dependent on moist, cool conditions

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Water-shed	Scientific Name	Common Name	Fed List	Cal List	CNPS	Endemicity	Occurrences	7.5 Minute Quads	Habitat Notes	Dispersal Ability	Sensitivity to Climate	Status of Information	Number of Quads
Kings													
	Streptanthus fenestratus	Tehipite Valley jewel-flower	None	None	1B	Endemic	10	Slide Bluffs, Cedar Grove, The Sphynx, Hume, Tehipite Dome, Wren Peak	Lower, upper montane coniferous forest, 1065-1750 m	Annual	Unknown	Very little information, 1	
	Batrachoseps regius	Kings River slender salamander	None	None		Endemic to Kings River Watershed	9		well-shaded north-facing slopes with chaparral, bay, buckeye, blue oak, 335 - 2470 m	very limited		Some, 3	
Kaweah	*Brodiaea insignis*	Kaweah brodiaea	None	Endangered	1B	Endemic to Kaweah, Tule Watersheds	27	Camps Nelson, Wishon, Solo Peak, Globe, Case Mtn., Kaweah, Chickencoop Canyon, Dennison Peak, Woodlake	Cis-montane woodland, valley and foothill grassland/granitic or clay, 150-1400 m.	perennial, limited dispersal, edaphic	Unknown	Little information, 2	9
	Batrachoseps kawia	Sequoia Slender Salamander	None	None		Endemic to Kaweah Watershed		Kaweah Drainage only	Habitats with scattered trees, mesic sites with blue and interior live oaks, sycamore, white alder, and CA buckeye, coniferous forest at higher elevations 500-2200 m.	limited dispersal	Sensitive	Little information, 2	
	Streptanthus gracilis	alpine jewel-flower	None	None	1B	Endemic	24	Mt Brewer, Mt Kaweah, Sphinx Lakes, Mt Pinchot, Mt Clarence King, Kearsarge Peak, Cedar Grove, The Sphynx,	sub alpine forest, upper montane coniferous forest, granitic, rocky, 2800-3500 meters	annual, edaphic	Sensitive	Little information, 2	8
	Mimulus norrisii	Kaweah monkeyflower	None	None	1B	Endemic to Kaweah Watershed	10	Case Mtn., Kaweah, Dennison Peak, Lodgepole, Giant Forest, Verplank Ridge	Chaparral, cismontane woodland/ carbonate, rocky; 365-1300m	Annual, limited, edaphic, fewer than 10 occurrences	Sensitive	Little information, 2	6
	Draba cruciata	Mineral King draba	None	None	1B	Endemic to Kaweah Watershed	9	Camps Nelson, Kern Peak, Mineral King, Sphynx Lakes	sub alpine forest gravelly, 2500-3315 meters	Perennial, Limited, edaphic	Sensitive	Very little information, 1	4

	Erythronium pusaterii	Kaweah fawn lily	None	None	1B	Endemic to Kaweah Watershed	8	Camp Nelson, Sentinel Peak, Moses Mountain	Meadows and seeps, subalpine coniferous forest, /granitic or metamorphic, 2100-2775 m; protected in part in Slate Mountain Botanical Area.	perennial bulbiferous herb, limited, edaphic	Sensitive	Some, 3	3
	Lupinus lepidus var. culbertsonii	Hockett Meadows lupine	None	None	1B	Endemic to Kaweah Watershed	2	Silver City, Moses Mountain, Quinn Peak, Mt. Kaweah, Convict Lake	Meadows and seeps, upper montane coniferous forest, mesic, rocky 2440-3000 m	Perennial	Sensitive	Very little information, 1	5
	Iris munzii	Munz's iris	None	None	1B.3	Endemic	2	Camp Wishon, Springville, Giant Forest	Cismontane woodland; 305-800m	perennial herb (rhizomatous)	Sensitive	Very little information, 1	3
	Calicina mesaensis	Table Mountain harvestman	None	None		Endemic	1	Native to Table Mountain, SJR		Limited	Sensitive	Very little information, 1	
	Calicina cloughensis	Clough Cave harvestman	None	None		Endemic to Kaweah Watershed	3	South Fork, Kaweah	Native to Clough Cave, Sequoia NP	Limited	Sensitive	Very little information, 1	
	Lytta hoppingi	Hopping's blister beetle	None	None		Endemic to Kaweah Watershed	7			Limited		Very little information, 1	
Tule	*Pseudobahia peirsonii*	San Joaquin adobe sunburst	Threatened	Endangered	1B	Endemic to SS and valley adobe soils	30	Rio Bravo Ranch, Woody, Sand Canyon, Pine Mountain, Fountain Springs, Quincy School White River, Ducor, Richgrove, Success Dam, Lindsay, Porterville, (Tulare), Woodlake, Exeter, Rocky Hill, Stokes Mountain, Orange Cove North, Wahtoke, (Reedley) Orange Cove South, Round Mountain	Cismontane woodland, valley and foothill grassland,/Adobe clay; 90-800 m	Limited, edaphic	Sensitive, most occurrences are very small	Little info, 2	24
	Eriogonum breedlovei var. shevockii	The Needles buckwheat	None	None	4	Endemic	20	Needles	Pinyon-juniper woodland, upper montane coniferous forest/serpentine; 1000-2345 m	Limited, edaphic	Sensitive	Little info, 2	

	Fritillaria striata	striped adobe-lily	None	Threatened		Endemic	16				Sensitive	Little info, 2	
	Clarkia springvillensis	Springville clarkia	Threatened	Endangered	1.B.2	Endemic	15	Camp Nelson, Camp Wishon, Springville, Porterville, Case Mountain, Dennison Peak	Chaparral (Chprl) Cismontane woodland (CmWld) Valley and foothill grassland (VFGrs)/granitic 245 - 1220 meters	Known from fewer than twenty occurrences in the Tule and Kaweah river drainages. Threatened by non-native plants, overgrazing, vehicles, road maintenance, logging, and residential development. Sequoia NF has adopted species management guidelines.	Not sensitive	Little info, 2. See Madroño 17(7):220 (1964) for original description	
	Mimulus pictus	calico monkeyflower	None	None	1.B.3	Endemic	13	Tehachapi NE, Tehachapi North, Tehachapi South, Keene, Tejon Ranch, Mount Adelaide, Bena, Oiler Peak, Oil Center, Onyx, Weldon, Glennville, Democrat Hot Springs, Miracle Hot Springs, Woody, Sand Canyon, Pine Mountain, Quincy School, White River, Success Dam, Lindsay, Porterville, Chickencoop Canyon, Rocky Hill	Broadleafed upland forest (BUFrs) Cismontane woodland (CmWld)/granitic, disturbed areas 100 - 1300 meters		Sensitive	Little info, 2	
?	*Allium shevockii*	Spanish Needle onion	None	None	1.B.3	Endemic	11	Tehachapi NE, Cinco, Ninemile Canyon, Lamont Peak	Pinyon and juniper woodland (PJWld) Upper montane coniferous forest (UCFrs)/rocky 850 - 2500 meters, Known from fewer than 10 occurrences. See Madroño 34(2):150-154 (1987) for original description		Sensitive	Little info, 2	
?	*Astragalus shevockii*	Shevock's milk-vetch	None	None		Endemic	6	Hockett Peak, Camp Nelson	Upper montane coniferous forest (UCFrs)(granitic, sandy 1890 - 1965 meters		Sensitive	Little info, 2	

	Ribes tularense	Sequoia gooseberry	None	None		Endemic	5	Silver City, Quinn Peak, Case Mountain, Giant Forest	Lower montane coniferous forest (LCFrs) Upper montane coniferous forest (UCFrs) 1500 - 2075 meters	Known from fewer than ten occurrences.	Sensitive	Little info, 2. See North American Flora 22:218 (1908) for original description	
	Leptosiphon serrulatus	Madera leptosiphon	None	None	1.B.2	Southern Sierra Endemic	1	Winters Ridge, Alta Sierra, Glennville, Durrwood Creek, Camp Wishon, Success Dam, Kaweah, Shadequarter Mountain, Sacate Ridge, Luckett Mountain, Trimmer, Pine Flat Dam, Fresno North, Madera, Huntington Lake, Musick Mountain, Shaver Lake, North Fork, Millerton Lake West, Millerton Lake East, Knowles, Raymond, Ahwahnee, Mariposa, Catheys Valley	Cismontane woodland (CmWld)Lower montane coniferous forest (LCFrs)300 - 1300 meters	Threatened by road maintenance, exotic plant control, and erosion.	Sensitive	Little info, 2. A synonym of Linanthus serrulatus in The Jepson Manual. See Erythea 3:120 (1895) for original description, Aliso 19(1):55-91 (2000) for revised nomencl.	
	Talanites moodyae	Moody's gnaphosid spider	None	None		Endemic	6				Sensitive	Very little info, 1	
Kern	*Callitropsis nevadensis*	Piute cypress	None	None		Endemic to Piute mtns, Kern, Tulare counties	39	Emerald Mountain, Lake Isabella North, Lake Isabella South, Woolstalf Creek, Alta Sierra, Miracle Hot Springs, Kernville, Tobias Peak	Pinyon/juniper or oak/pine woodland, chaparral, closed-cone-cypress forest, Cismontane woodland, 750-1800 m	Threatened by grazing and mining. BA and RNA established by USFS and BLM for this plant. See Torreya 19:92 (1919) for original description.	Sensitive	Little info, 2	

	Oreonana purpurascens	purple mountain-parsley	None	None	1B.2	Endemic	29	Camp Nelson, Sentinel Peak, Silver City, Moses Mountain, Quinn Peak, Muir Grove	Broadleafed upland forest (BUFrs) •Subalpine coniferous forest (SCFrs) •Upper montane coniferous forest (UCFrs)/usually metamorphic 2395 - 2865 meters	Threatened by road construction, logging, and trampling. See Madroño 26(3):128-134 (1979) for original description, and Fremontia 9(3):22-25 (1981) for species account.	Sensitive	Little info, 2	
	Delphinium inopinum	unexpected larkspur	None	None	4.3	Endemic to southern Sierra and southern Coast Range	29	Multiple counties	Upper montane coniferous forest (UCFrs)(rocky, metamorphic) 1890 - 2800 meters	Threatened by logging, mining, recreational activities, and vehicles.	Sensitive	Little info, 2	
	Phacelia novenmillensis	Nine Mile Canyon phacelia	None	None	1B.2	Endemic	23	Owens Peak, Ninemile Canyon, Lamont Peak, Fairview, Crag Peak, Bonita Meadows	Broadleafed upland forest (BUFrs) Cismontane woodland (CmWld) Pinyon and juniper woodland (PJWld) Upper montane coniferous forest (UCFrs)/sandy or gravelly 1645 - 2640 meters	Threatened by grazing and recreation.	Sensitive	Little info, 2. See Aliso 3(2):122-124 (1955) for original description.	
	Calochortus westonii	Shirley Meadows star-tulip	None	None	1B	Endemic to Kern and Tule Watersheds	23	Alta Sierra, Johnsondale, Tobias Peak, Camp Nelson, Camp Wishon, Sentinel Peak, Case Mountain	Broad-leaved upland forest, lower montane coniferous forest, meadows and seeps/granitic, 1500-2105 m		Sensitive	Little info, 2	
	Erigeron multiceps	Kern River daisy	None	None	1B.2	Endemic	17	Monache Mountain, Crag Peak, Casa Vieja Meadows, Hockett Peak, Bonita Meadows, Kern Lake, Sphinx Lakes, Triple Divide Peak	Meadows and seeps (Medws)Upper montane coniferous forest (UCFrs)(openings) 1500 - 2500 meters	Known from fewer than twenty occurrences on the Kern Plateau. Possibly threatened by grazing, vehicles, and logging. Sequioa NF has adopted species management guidelines. Similar to E. divergens.	Sensitive	Little info, 2. See Pittonia 2:167 (1891) for original description, and Phytologia 73(3):186-202 (1992) for taxonomic information.	

	Ivesia campestris	field ivesia	None	None	1B.2	Endemic	17	Haiwee Pass, Monache Mountain, Casa Vieja Meadows, Cirque Peak, Templeton Mountain, Johnson Peak, Chagoopa Falls, Kern Lake, Kern Peak, Mineral King, Silver City, Moses Mountain, Mount Silliman, Muir Grove, General Grant Grove, Marion Peak, Slide Bluffs	Meadows and seeps (Medws)(edges) Subalpine coniferous forest (SCFrs) Upper montane coniferous forest (UCFrs) 1975 - 3350 meters	Threatened by grazing.	Sensitive	Little info, 2. See Proceedings of the California Academy of Sciences II 5:679 (1895) for original description, and North American Flora 22:285 (1908) for revised nomencl.	
	Eriogonum twisselmannii	Twisselmann's buckwheat	None	Rare	1B.2	Endemic	15	Camp Nelson, Sentinel Peak	Upper montane coniferous forest (UCFrs)(granitic) 2375 - 2805 meters	Known only from fewer than fifteen occurrences in Sequoia NF.	Sensitive	Little info, 2, See Leaflets of Western Botany 10(1):13 (1963) for original description, and Phytologia 66(4):352 (1989) for taxonomic treatment.	
	Fritillaria brandegeei	Greenhorn fritillary	None	None	1B.3	Endemic	15	Tehachapi South, Mount Adelaide, Alta Sierra, Glennville, Democrat Hot Springs, Miracle Hot Springs, Johnsondale, California Hot Springs, Posey, Tobias Peak, Hockett Peak, Camp Nelson, Camp Wishon, Solo Peak, Sentinel Peak	Lower montane coniferous forest (LCFrs)(granitic) 1415 - 2100 meters		Sensitive	Little info, 2	
?	*Eriogonum breedlovei var. breedlovei*	Breedlove's buckwheat	None	None	1B.2	Endemic	12	Claraville, Piute Peak, Lake Isabella South, Woolstalf Creek	Pinyon and juniper woodland (PJWld) Upper montane coniferous forest (UCFrs)/often carbonate 1890 - 2590 meters Known from fewer than 10 occurrences in the Piute Mtns. See Mentzelia 1:19-21 (1975) for original description, and Phytologia 66(4):323 (1989) for taxonomic		Sensitive	Little info, 2	

									treatment				
?	*Mimulus shevockii*	Kelso Creek monkeyflower	None	None	1B.2	Endemic	11	Pinyon Mountain, Claraville, Cane Canyon, Lake Isabella North, Woolstalf Creek	Joshua tree "woodland" (JTWld)Pinyon and juniper woodland (PJWld)/granitic or metamophic, sandy or gravelly800 - 1340 meters	Known from approximately 10 occurrences. Threatened by residential development, agricultural conversion, grazing, road maintenance, and vehicles.	Sensitive	Little info, 2. See Madroño 33(4):271-277 (1986) for original description.	
	Erigeron aequifolius	Hall's daisy	None	None	1B.3	Endemic	10	Owens Peak, Hockett Peak, Durrwood Creek, Kern Lake, Cedar Grove, The Sphinx, Hume, Wren Peak	Broadleafed upland forest (BUFrs) Lower montane coniferous forest (LCFrs) Pinyon and juniper woodland (PJWld) Upper montane coniferous forest (UCFrs)/rocky, granitic 1500 - 2440 meters	Known from fewer than twenty occurrences.	Sensitive	Little info, 2. See University of California Publications in Botany 6:174 (1915) for original description, and Phytologia 72(3):157-208 (1992) for taxonomic treatment.	
?	*Heterotheca shevockii*	Shevock's golden-aster	None	None	1B.3	Endemic	9	Mount Adelaide, Rio Bravo Ranch, Lake Isabella South, Democrat Hot Springs, Miracle Hot Springs	Chaparral (Chprl) Cismontane woodland (CmWld)/sandy 230 - 900 meters	Known only from the lower Kern River Cyn. in the Greenhorn Mtns. Possibly threatened by road maintenance and recreational activities.	Sensitive	Little info, 2. A synonym of H. villosa var. shevockii in The Jepson Manual. See Phytologia 73(6):453 (1992) for original description, and University of Waterloo Biology Series 37:148	

												(1996) for revised nomencl.	
?	*Eriogonum breedlovei var. breedlovei*	Breedlove's buckwheat	None	None	1B.2	Endemic	12	Claraville, Piute Peak, Lake Isabella South, Woolstalf Creek	Pinyon and juniper woodland (PJWld) Upper montane coniferous forest (UCFrs)/often carbonate 1890 - 2590 meters Known from fewer than 10 occurrences in the Piute Mtns. See Mentzelia 1:19-21 (1975) for original description, and Phytologia 66(4):323 (1989) for taxonomic treatment		Sensitive	Little info, 2	
?	*Mimulus shevockii*	Kelso Creek monkeyflower	None	None	1B.2	Endemic	11	Pinyon Mountain, Claraville, Cane Canyon, Lake Isabella North, Woolstalf Creek	Joshua tree "woodland" (JTWld)Pinyon and juniper woodland (PJWld)/granitic or metamophic, sandy or gravelly800 - 1340 meters	Known from approximately 10 occurrences. Threatened by residential development, agricultural conversion, grazing, road maintenance, and vehicles.	Sensitive	Little info, 2. See Madroño 33(4):271-277 (1986) for original description.	
	Erigeron aequifolius	Hall's daisy	None	None	1B.3	Endemic	10	Owens Peak, Hockett Peak, Durrwood Creek, Kern Lake, Cedar Grove, The Sphinx, Hume, Wren Peak	Broadleafed upland forest (BUFrs) Lower montane coniferous forest (LCFrs) Pinyon and juniper woodland (PJWld) Upper montane coniferous forest (UCFrs)/rocky, granitic 1500 - 2440 meters	Known from fewer than twenty occurrences.	Sensitive	Little info, 2. See University of California Publications in Botany 6:174 (1915) for original description, and Phytologia 72(3):157-208 (1992) for taxonomic treatment.	

?	*Heterotheca shevockii*	Shevock's golden-aster	None	None	1B.3	Endemic	9	Mount Adelaide, Rio Bravo Ranch, Lake Isabella South, Democrat Hot Springs, Miracle Hot Springs	Chaparral (Chprl) Cismontane woodland (CmWld)/sandy 230 - 900 meters	Known only from the lower Kern River Cyn. in the Greenhorn Mtns. Possibly threatened by road maintenance and recreational activities.	Sensitive	Little info, 2. A synonym of H. villosa var. shevockii in The Jepson Manual. See Phytologia 73(6):453 (1992) for original description, and University of Waterloo Biology Series 37:148 (1996) for revised nomencl.	
?	*Delphinium purpusii*	rose-flowered larkspur	None	None	1B.3	Endemic	6	Mount Adelaide, Rio Bravo Ranch, Onyx, Weldon, Lake Isabella North, Lake Isabella South, Alta Sierra, Democrat Hot Springs, Miracle Hot Springs, Pine Mountain, Fairview, Kernville, Springville, Kern Lake	Chaparral (Chprl) Cismontane woodland (CmWld) Pinyon and juniper woodland (PJWld)/rocky, often carbonate 300 - 1340 meters	Limited, edaphic	Sensitive	Very little info, 2. Precise location and endngrmnt. information needed. Historical occurrences need field surveys. See Botanical Gazette 27:444 (1899) for original description	
	Cordylanthus eremicus ssp. kernensis	Kern Plateau bird's-beak	None	None	1B.3	Endemic	6	Ninemile Canyon, Lamont Peak, Haiwee Pass, Monache Mountain, Crag Peak, Bonita Meadows, Cirque Peak, Templeton Mountain, Olancha	Great Basin scrub (GBScr) Joshua tree "woodland" (JTWld) Pinyon and juniper woodland (PJWld) Upper montane coniferous forest (UCFrs) 1675 - 3000 meters	Known only from the Kern Plateau region.	Sensitive	Little info, 2. See Systematic Botany Monographs 10:89-92 (1986) for original description.	
	Horkelia tularensis	Kern Plateau horkelia	None	None	1B.3	Endemic	5	Monache Mountain, Crag Peak, Bonita Meadows	Upper montane coniferous forest (UCFrs)(rocky)2300 - 2875 meters	Known from fewer than ten occurrences. Potentially threatened by mining and recreation. Protected in part in BA (USFS) which includes the type locality.	Sensitive	Little info, 2. See Leaflets of Western Botany 10(13):254-255 (1966) for original description.	

	Astragalus ertterae	Walker Pass milk-vetch	None	None	1B.3	Endemic	4	Walker Pass	Pinyon and juniper woodland (PJWld)(sandy, granitic) 1705 - 1900 meters	Known in CA from only three occurrences near Walker Pass.	Sensitive	Little info, 2. See Aliso 11(4):585-588 (1987) for original description	
	Navarretia setiloba	Piute Mountains navarretia	None	None	1B.1	Endemic	4	Pastoria Creek, Tehachapi NE, Monolith, Oiler Peak, Edison, Lake Isabella South, Glennville, Miracle Hot Springs, Pine Mountain, Posey	Cismontane woodland (CmWld) Pinyon and juniper woodland (PJWld) Valley and foothill grassland (VFGrs)/clay or gravelly loam 305 - 2100 meters	Known from fewer than ten occurrences. Many historical occurrences have been searched without success. Threatened by residential development and vehicles.	Sensitive	Little info, 2. See Cntrbtions. from the U.S. National Herbarium 4:153 (1893) for original description	
?	*Clarkia tembloriensis ssp. calientensis*	Vasek's clarkia	None	None	1B.1	Endemic	3	Bena, Edison	Valley and foothill grassland (VFGrs) 275 - 500 meters	Known from only three occurrences near Caliente Creek. Threatened by grazing and non-native plants.	Sensitive	Little info, 2. Perhaps best treated as C. calientensis. See Systematic Botany 2:252-255 (1977) for original description and 10(2):155-165 (1985) for taxonomic treatment	
	Pyrgulopsis greggi	Kern River pyrg	None	None		Endemic	2				Sensitive	Little info, 2	
	Lomatium shevockii	Owens Peak lomatium	None	None	1B.3	Endemic	2	Owens Peak	Lower montane coniferous forest (LCFrs) Upper montane coniferous forest (UCFrs)/rocky 1770 - 2200 meters	Known from only two occurrences in the Owens Pk. and Mt. Jenkins area.	Sensitive	Little info, 2. See Madroño 35(2):121-125 (1988) for original description	
Kings	*Heterotheca monarchensis*	Monarch golden-aster	None	None	1B.3	Endemic	2	Wren Peak	Cismontane woodland (CmWld)(carbonate) 1095 - 1850 meters	Known from two occurrences in the Kings River Cyn. Not in The Jepson Manual.	Sensitive	Little info, 2. See University of Waterloo Biology Series 37:52 (1996) for original description	

	Layia leucopappa	Comanche Point layia	None	None	1B.1	Endemic	2	Tejon Ranch, Arvin, Mettler, Tejon Hills, Coal Oil Canyon, Edison	Chenopod scrub (ChScr) Valley and foothill grassland (VFGrs) 100 - 350 meters	Reduced by agriculture; also threatened by development and grazing	Sensitive	Little info, 2	
	Nemacladus twisselmannii	Twisselmann's nemacladus	None	Rare	1B.2	Endemic	2	Rockhouse Basin, Kernville, Cannell Peak	Upper montane coniferous forest (UCFrs)(sandy or rocky, granitic)\ 2240 - 2450 meters	Known from only two occurrences.	Sensitive	Little info, 2. See Leaflets of Western Botany 10(3-4):45-46 (1963) for original description.	
	Schizymenium shevockii	Shevock's copper moss	None	None	1B.2	Endemic to CA?	1	Temecula, Kernville, Conejo, Wren Peak, Sacate Ridge, Trimmer, Kinsley	Cismontane woodland (CmWld)(metamorphic , rock, mesic)750 - 1400 metersOccurs on rocks along roads, in same habitat as Mielichhoferia elongata.	Limited. Threatened by road widening.	Sensitive	Little info, 2. See Systematic Botany 25(2):190 (2000) for original description	
	Gilia yorkii	Monarch gilia	None	None	1B.2	Endemic	1	Wren Peak			Sensitive	Little info, 2	
	Abronia alpina	Ramshaw Meadows abronia	None	Candidate	1B.1	Endemic	1	Templeton Mountain, Kern Peak	Meadows and seeps (Medws)(granitic, gravelly margins) 2400 - 2700 meters	Known from only one extant, extended occurrence at Ramshaw Meadows and Templeton Meadows. Possibly threatened by trampling and potentially threatened by meadow succession.	Sensitive	Little info, 2. See Botanical Gazette 27:444-457 (1899) for original description, and Aliso 7(2):201-205 (1970) for discussion of rediscovery.	
												Little info, 2	
	Batrachoseps stebbinsi	Tehachapi slender salamander	None	Threatened		Endemic	10	Oiler Peak, Orange, Lorraine, Tehachapi N	Caliente Creek, moist canyons, oak, mixed pine, leaf litter, 610 - 1400 m	very limited	high, 5	Little info, 2	
	Batrachoseps simatus	Kern Canyon slender salamander	None	Threatened		Endemic	2	Rio Bravo Ranch, Democrat Hot Springs, Micacle Hot Springs, Mount Adelaide	Isolated colonies along stream courses and on ridges and hillsides, N facing slopes, tributary canyons, willows, cottonwoods, live oak, canyon lo, pine, 330 - 1920 m	very limited	high, 5	Little info, 2	

	Batrachoseps sp. 1	Breckenridge Mountain slender salamander	None	None		Endemic	1	Brekenridge Mountain	May be same species as above	very limited	high, 5	Little info, 2	
	B. robustus	Kern Platueau Slender salamander	None	None		Endemic to Kern Watershed		Bonita Meadows	jeffrey pine, red fir, in humid areas; pinon, rabbitbrush, sage, black oak in drier areas, spring and seep areas.	very limited	high, 5	Little info, 2	
	Perognathus alticolus inexpectatus	Tehachapi pocket mouse	None	None		Endemic to Kern Watershed?	4		This taxon historically occurred from the vicinity of Tehachapi Pass, west to MountPinos, and south to Elizabeth and Quail Lakes, at elevations from 1030 to 1830 m. There are no recent records of the species, despite intensive survey efforts	very limited	high, 6	Little info, 2	
	Helminthoglypta callistoderma	Kern shoulderband	None	None		Endemic to Kern Watershed	1					Very little info, 1	
	Onchornychuss mykiss aguabonita	California Golden trout	Threatened	None		Endemic to Kern Watershed		Cold, clear and fast-moving streams	Found in South Fork Kern River and Golden Trout Creek			Little info, 2	
	O. m. whitei	Little Kern Golden Trout	None	None		Endemic to Kern Watershed		Cold, clear and fast-moving streams				Little info, 2	
	O. m. gilberti	Kern Rainbow Trout	None	None		Endemic to Kern Watershed		Cold, clear and fast-moving streams				Little info, 2	

APPENDIX K

Incorporating Climate Change into Conservation Planning: Planning Approach and Lessons Learned (April 30, 2010 with October additions)

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.

As a pilot effort, the Southern Sierra Partnership (SSP) took a rigorous approach to integrating climate change into conservation planning for the southern Sierra Nevada and Tehachapi Mountains in California. The resulting "Climate-adapted Conservation Plan for the Southern Sierra Nevada and Tehachapi Mountains"[1] (SSP plan) is a first iteration climate-adapted conservation plan. This report describes our planning approach and lessons learned. This document is not a methodology, but we do make some recommendations and highlight the replicable parts of our work.

The SSP's planning objectives were to:

1. Characterize the biodiversity, ecosystem services, ownership patterns, and land uses in the southern Sierra Nevada and Tehachapi Mountains.
2. Assess the major threats to biodiversity at regional and project scales.
3. Examine how a changing climate will impact or interact with these threats, and anticipate long-term responses in the landscape.
4. Identify conservation opportunities, at project-specific and regional scales, that would allow adaptation to climate change and ensure maintenance of conservation values.
5. Based on the above, develop a regional conservation vision 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, prioritizes five year strategies for land protection, restoration, adaptive management, and monitoring.

The planning process consisted of three key steps: defining the project, assessing vulnerability and resilience, and defining goals and setting strategies. The flow of the planning approach is presented in Figure 3 of the SSP plan. Through the process, there were numerous "decision points". In Part I of this report, the decision points are described and then followed by a brief discussion that highlights options considered, what worked, and lessons learned. Part II of this report discusses overall lessons learned.

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[1] The final name is *Framework for Cooperative Conservation and Climate Adaptation in the Southern Sierra Nevada and Tehachapi Mountains* (October 2010)

Part I: Planning Approach

1.0 Defining the project

1.1 Planning team and level of effort

The SSP Framework was developed over the course of one year by a team of 12 people, including a full-time project manager. The total cost came to over $450,000 which was mostly staff time. In addition, the SSP was able to capitalize on two years of work by The Nature Conservancy's science team to develop California-wide datasets and models related to climate change and ecosystem services. The SSP collaborated with the Conservancy's science team to explore how we could apply their work to conservation planning for the southern Sierra Nevada and Tehachapi Mountains.

The project management team was comprised of representatives from the four Southern Sierra Partnership organizations: Audubon of California, Sequoia Riverlands Trust, Sierra Business Council and The Nature Conservancy. These organizations had worked collaboratively on other planning efforts, and the SSP conservation plan benefitted from shared familiarity with overall planning concepts and approaches.

Discussion: The collaboration enhanced benefits for the individual member organizations – e.g. we could all learn and strategize about climate change adaptation together instead of each trying to build that expertise from scratch. It helped us make sense of the proliferation of information about climate change.

A full-time process manager greatly enhanced effectiveness of the collaboration by helping make individual roles and responsibilities clearer, building on the specific strengths of each planning team member and each organization, providing the communications "glue" for the team, and enhancing accountability of individual team members to each other and the overall effort.

1.2 Inclusion of stakeholders

Over the course of one year, from April 2009 to March 2010, the methods and findings of the teams were vetted in three workshops, several briefings, and numerous conference calls, reaching numerous resource management agencies, educational institutions and non-profit organizations. The National Park Service, U.S. Geological Survey, U.S. Forest Service and the Sierra Nevada Conservancy. The USDI Bureau of Land Management, U.S. Fish & Wildlife Service, USDA Natural Resources Conservation Service, California Department of Fish and Game, University of California- Merced, Sierra Foothills Conservancy, Tulare Basin Wildlife Partners, Southern Sierra IRWMP Planning Committee, and California Invasive Plants Council were engaged at various stages of the planning process. The wider group of stakeholders has not yet reviewed or discussed the completed plan. We will ensure this occurs in the near future.

Discussion: Our process and this plan benefitted greatly from the input, research, and strategic advice of the entire array of participants. There is a rich depth of knowledge among experts from stakeholder institutions.   We learned that the culture and mission of each institution influences how they approach the challenge of climate change. Many of the strategic insights and decision points of this plan were influenced by the experience of stakeholders who are also working to understand and adapt to the changing climate. We had many helpful and pertinent discussions about the challenges and opportunities of conservation planning in the face of uncertainties about climate change and associated ecological *responses; barriers to adaptive management and cross-jurisdictional collaboration; and strategies for overcoming those challenges.*

While momentum has been building for collaborative science and conservation planning among the federal agencies, the SSP planning process stimulated formation of broader partnerships) for making land management decisions in a regional context (e.g. the nascent Southern Sierra Conservation Cooperative). By involving stakeholders, we established many relationships that will enhance collaborative science, monitoring and management in the future.

1.3 Planning area boundaries

The 7 million-acre regional planning area encompasses the southern sub-region of the Sierra Nevada ecoregion (Sierra Nevada Ecoregional Plan, TNC, 1999). The crest of the Sierra Nevada Mountains was selected as the eastern boundary of the planning region because including the dry eastern side of the Sierras was beyond our planning capacity. The planning area extends south through the Tehachapi Mountains to the Coastal Transverse Range because, from the beginning, we were interested in assessing and conserving the landscape-scale connectivity between the coastal ranges and the Sierra Nevada. The planning area extends west to Highway 99 in the San Joaquin Valley to encompass riparian corridors from their western Sierra headwaters to the San Joaquin Valley, and to complement extensive restoration planning being done by the Tulare Basin Wildlife Partners for the Tulare Lake Basin.

Discussion: The scale and planning area of the SSP plan falls mid-way between an ecoregional assessment and a project-level conservation plan. The sizeable planning area spans public and private lands and all elevations and major ecosystems of the southern Sierra Nevada and Tehachapi Mountains, making it large enough to meet ecological goals. The planning team came to realize that land managers of individual parks, forests, and preserves will face the challenge of scale when assessing the impacts of climate change, as the climatically suitable habitat for their focal targets may end up outside of their jurisdiction. This highlights the importance of conducting climate change planning over broad spatial areas.

1.4 Regional and project level planning

We decided to plan at two geographic scales: regional and project-level. The full regional boundary is defined above. Within the full region, we assessed two project areas, the southern Sierra (4.3 million acres in the northern portion of the region) and the Tehachapi Mountains (1.2 million acres in the southern portion of the region). We produced a regional assessment and plan, plus a project-level CAP for both the southern Sierra and for the Tehachapi Mountains. Three teams were established to manage components of the planning: a southern Sierra Conservation Action Planning (CAP) team for the northern part of the region, a Tehachapi CAP team for the southern part, and a technical team focused on the regional scale synthesis and assessment.

The regional and CAP plans are linked by the set of fundamental challenges that they address: characterizing the current and future viability of our conservation targets by taking into account their distribution, level of current conservation management, and degree of impact from regionally important threats such as climate change. The information, process, and methods unique to each scale of planning allowed us to explore these fundamental issues in the complementary ways described below.

Benefits of regional-scale assessment and planning:

- Regional assessment captured information on target viability, threats and conservation priorities that transcends area of focus for any one organization. Allows local decisions and projects to be more strategic so collectively they have more conservation impact. Also helps clarify which strategies are best implemented by SSP vs. the individual member organizations.
- Characterizes response of targets to climate change at scale of impact – i.e. allowed meaningful "downscaling" of climate change information to inform action in our planning region
- Represents ecosystem service values and dynamics at relevant scale
- Provides a foundation of regional data that serves implementation and project-level planning by all entities making conservation and land management decisions in the region.
- Highlights needs and opportunities for collaboration at a regional scale and among multiple land management jurisdictions.

Benefits of project-level assessment and planning:
- Brings local knowledge to the regional assessment
- Allows for more in-depth analysis of specific factors affecting target viability
- Enables geographically focused data and strategies
- Informs project-level planning, implementation and monitoring strategies

In both the regional and project-level analyses, spatial data played an important role. When considering the viability of our targets, we mapped the basic threats (roads, residential development, potential energy development) together with our targets, giving us the ability to be specific about the condition and vulnerability of targets in a given place. For example, some oak woodlands are much more degraded and fragmented than others based on land use history. The spatial data helped us prioritize conservation actions to abate threats or improve target viability.

Mapping ecosystem services in the assessment also made more sense at the regional scale than the project scale. While the actual resolution of the data is fairly detailed for most services, the assumptions that go into the models make it prudent to consider the variation over a larger region.

Discussion: By planning at two levels, we learned that it is important that localized project plans be embedded in a regional context in order to properly consider climate change impacts. The coarse resolution of the climate models, the high level of uncertainty associated with site-specific response, and the nature of the species distribution modeling (in that it characterizes the target's suitable climate envelope, not the actual habitat suitability) all make it important to set the context for projected changes at a broader scale. This is true for other factors as well. The gap analysis, subregional stratification, and assessment of connectivity all need to be analyzed at a broader scale. The degree of protection is only meaningful when analyzed at a biogeographic scale that represents a significant portion of the target's range. In other words, if a target is 80% protected in a local area but only 20% protected across its range, it should be considered an underrepresented target. Similarly, with connectivity, we are not trying to design the network of conservation areas to be responsive to smaller scale movement of wildlife and resources; we are designing it to be connected across major physiographic and climatic gradients. The CAP areas for this assessment were very large to begin with, but not broad enough to address these regional issues.

We found pros and cons to planning at both the regional and project scale simultaneously. While the two are tightly linked and help to inform each other, this approach stretched staff capacity. For the most part, the same people were doing both regional and project planning. Sequencing these plans would have made the workload more manageable. Completing the regional analyses up front could have flagged specific areas in need of project-level conservation action plans (CAPs), which could have sharpened our project strategies.

We learned that the southern Sierra CAP planning area was probably too large (4.3 million acres. Some of the distant reaches were unfamiliar to the team and there is a tremendous amount of variation in natural communities and threats as one moves from the low elevation Central Valley to the top of the Sierra Nevada at over 14,000 feet in elevation. The large scale made also it more difficult to set project level goals and strategies. In retrospect, the southern Sierra CAP area could have been broken into two or three planning areas.

1.5 Plan Timeframe

We used a 50-year planning timeframe rather than the normal 5 to10-year horizon for traditional conservation planning due to the climate data available to our team and due to the anticipated time scale of response to climate change effects. The IPPC General Circulation Models are commonly summarized for two time periods: 2045-2065 and 2070-2099, and TNC had already processed the mid-century IPCC data. Because uncertainty increases with longer time horizons, we used the mid-century model results, pushing our time horizon out to 2060. Even fifty years is a distant future, so the SSP plan created a 50-year vision accompanied with a five year action plan. Our goal is to start now to abate the impact of the threats that are projected to become even greater in the long-term. By acting early to respond to the projected impacts of climate change, we expect that our actions will have greater chance of success than they would if begun sometime in the more distant future.

Discussion: Developing a 50-year vision with a five year action plan worked well. The 50-year time horizon worked well when developing the climate assessments, setting representation goals, and creating our vision, while the five year action horizon was appropriate for setting realistic short-term objectives and actionable strategies. While the five year horizon was used to define reasonable near-tern steps for action, the assumption was that they were addressing the stresses expected to emerge or accelerate over 50 years. We suggest future planning teams explicitly acknowledge and incorporate broader multi-decade trends in setting priorities and developing strategies.

1.6 Selection of conservation targets

Selecting conservation “targets” (species, natural communities, and/or ecosystems or other focal features selected to serve as the basis for planning and priority setting) was a key decision point for the planning team. At the beginning, we considered numerous planning targets, such as:

- Species, natural communities or ecosystems expected to be sensitive to climate change
- Only aquatic, wetland, and groundwater-dependent species, natural communities and/or ecosystems
- Keystone species, such as blue oaks, gopher tortoises
- Species, species assemblages, and natural communities which are unique or special to the southern Sierra
- Rare species and natural communities

After exploring this range of potential targets, SSP selected “coarse filter” ecosystems as primary targets (defined by broad vegetation types, such as oak woodlands, mixed conifer forest, semi-arid montane shrublands, and riparian communities) for the viability and threats analyses in the CAPs. We were interested in representing the region’s biological diversity rather than assessing individual species, and we wanted targets that covered the as much of the planning geography as possible. In addition, coarse system targets were used because relying on rare species as an index of future climate vulnerability ignores important biological risks climate change poses for flora and fauna that are common today. The regional conservation design encompassed these course-sale targets as well as more restricted species and systems that represent unique biodiversity of the southern Sierra.

Discussion: Target selection is a very important decision which greatly influences the planning process and outcomes. The coarse filter targets gave us wide geographic coverage and nearly complete "capture" or representation of biodiversity in the planning area. The breadth of targets increased the scope of analyses and the challenge of developing specific strategies. In contrast, if we had just selected two targets, such as oak woodlands and low elevation riparian/aquatic systems, our subsequent analyses and strategy deliberations would have been far more limited. The team made an implicit assumption during the target selection process that in order to address climate change we should select biodiversity targets that are broad and inclusive. This conclusion parallels our decision to conduct climate-change planning over broad spatial and temporal scales.

Given the broad focus of the planning effort, and in recognition of past and anticipated future efforts that address individual species in more detail, we incorporated endemic species as a group rather than elevate individual endemic species to target status. Through a contractor, we assembled a compilation of known endemics with general information about their habitats, location, dispersal limitations and climate sensitivity. In developing the regional conservation design, we mapped the available locations of many of the rare, sensitive and imperiled species from the Natural Diversity database, but did not spend significant effort combing other sources of species data or habitat models. In the regional conservation design, we prioritized areas with endemic plants by filtering the soil data to include soil types known to harbor endemic plants.

Priority species like the Pacific Fisher and California condor have been analyzed elsewhere, and through implementation we anticipate that other species-specific issues can be addressed. Moving forward, it will be interesting to compare our results with climate-adapted assessments of a variety of species and system targets. We believe that the SSP plan can serve as a basis for future assessments of diverse targets, but this has not been tested.

Practically, in terms of data, the selection of coarse-filter targets allowed us to easily roll-up readily available data (CalVeg), and it gave us good data coverage across the region. The targets we selected were consistent with the Species Projection Models for common trees and shrubs and the Habitat Projections.

1.7 Incorporating ecosystem services

In the regional assessment, we chose four ecosystem services as targets: aquifer recharge, water yield, forest carbon storage, and forage production. These targets were selected because we had available data to develop spatial models, and because they are relevant to the region. We chose to include them in our plan because ecosystem service targets capture the importance of the southern Sierra ecosystems to people, helping to translate natural resources values into terms that the public and decision-makers care about. These targets anticipate the communication and outreach necessary to implement our plan. TNC had already assessed the projected climate change impacts to stream flow, forest carbon storage and forage production, so we were able to incorporate these targets without the need for significant new data or analyses. As described in sections 4.1.3 and 5.8 of the SSP plan, we incorporated ecosystem targets into goals and strategies and evaluated how well the regional conservation design captured the ecosystem services.

Discussion: Incorporating ecosystem services into our planning process creates a more dynamic, engaging plan and adds a useful layer of information to our work. We elected not to address the valuation of ecosystem services in this plan as it was beyond the scope of the project and expertise of the team. As we develop communications materials, addressing valuation and trade-offs may be very useful. Additional ecosystem services, such as pollination, agricultural production, and recreation were considered, however, because of data gaps, we decided not to present them in the report. Appendix A *presents potential ecosystem service targets and offers an assessment of what can be spatially represented.*

2.0 Assessing climate vulnerability and resilience

2.1 Use and selection of General Circulation Models (Global Climate Models)

We based our climate change estimates on 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 (800m; 0.5 miles) 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. While there are model results available for 25 Global Circulation Models for the A2 scenario, we used a subset of 11 because they provide mid-century data and daily results for projected changes in maximum and minimum temperatures. . (See Appendix D of the SSP plan)

Discussion: The eleven models used by the SSP were chosen because they had maximum and minimum daily temperatures. We did not select or weight models based on their agreement with the historical record, as the models are multi-variate across space and time and no available models succeed with all variables, which is a good argument for using each model independently. We found the differences between models to be less important because of California's wide range of topography.

2.2 Ensemble versus scenario approach to climate modeling

The eleven global models became the basis for an ensemble approach with respect to climate projections. The ensemble approach treats all possible futures as equally likely and then characterizes levels of uncertainty 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 = ≥ 80% models agree; light shades = 60-80% models agree).

Discussion: In general, a good rule of thumb is the more models the better. Fewer than eleven would have made the ensemble approach less effective. The "ensemble" approach shows the degree of agreement between models and ignores the outliers. In contrast, a scenario planning approach focuses on the outlying extreme outcomes. There was energetic debate on whether to use the ensemble or scenarios approach for the SSP analyses. We concluded that 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.

2.3 Whether and how to use Species Projection Models and Habitat Projection Models

In response to conservation priorities established by the California Natural Resources Agency's 2009 California Climate Adaptation Strategy, The Nature Conservancy has modeled state-wide climate impacts for most common California trees and shrubs. These vegetation models were designed to contextualize local and regional impacts while imparting some sense about relative levels of uncertainty. Given the lack of guidance on how to apply projections in conservation planning, stakeholder workshops throughout the SSP planning process promoted rigorous discussions to help shape an emerging set of best practices on why and how to apply biological forecasts in climate adaptive conservation plans.

In terms of why to use model projections, the SSP found regional forecasts offer critical spatial and temporal insights for conservation planning. Our model projections span public and private lands where biological inventories and conservation plans often proved to be fragmented between stakeholders. Forecasts helped us identify potential *refugia* and adaptation linkages for acquisition or restoration, and will soon help guide the design of strategic monitoring programs. In addition to spatial insights, modeling allowed us to assess target risk over a 50 year planning horizon, whereas traditional reliance upon solely extant factors would have limited the relevance (and potential success) of our planning efforts to strictly short term objectives.

With regard to how biological forecasts were eventually applied, species projection models (SPMs) were developed to portray areas where climate is projected to be suitable both today and in the future (*climate refugia*), in contrast to areas where suitable climates are projected to be lost (*climate stress zones*) or gained in the future (*climate expansion zones*). Uncertainty was characterized by levels of model agreement between multiple future climates considered. Our species forecasts depict potential distributions based upon solely climatic factors. Species impacts were primarily used as the basis for habitat projections, but also helped to inform hypotheses of change for oak woodland species, and are currently helping to develop species-based monitoring priorities (methods in Appendix E of SSP plan). Given our planning efforts focused primarily on habitat-based conservation targets, 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 (HP). To minimize uncertainty, only areas with high model agreement from species data were aggregated into HPs. Habitat projections were directly integrated into the Regional Conservation Design by modifying existing CalVeg habitat distributions, which allowed us to prioritize potential *refugia* over areas considered more at risk from climate impacts (methods outlined in Section 5.4 & Appendix E of the SSP plan).

Discussion: Before the SSP planning began, The Nature Conservancy had developed state-wide species projection models (SPM) intended to provide support to projects across the state. However, it was not clear how they might be applied. The SSP plan became a pilot project. In the SSP planning process, there was rigorous discussion about if, and how, to use the SPMs. Below are four issues and how we intend to address them.

a. *It is too "black boxy". In the near future, the details of the SPMs and HPs will be presented in a workshop so scientists can see the layers of details which comprise the models. This will help collaborating scientists from NGOs and federal agencies assess the strengths and weaknesses of available vegetation forecasts, and allow them to consider ways they might apply them within their own planning efforts. Species and habitat projections used by the SSP are to be hosted as data layers by the Conservation Biology Institute for public use.*

b. *They are based only on climate and do not include edaphic conditions, threat, and other factors. The SPMs do not include these factors, but the habitat models combine CalVeg data which is* *where the habitat types currently occur with the climate models. Figure 20 in the SSP plan (oak woodland habitat projections) and Appendix E reflect where the systems currently occur. This is the data incorporated into the regional conservation design.*

c. *It's too hard to anticipate species response to climate change. This is true, which is why a robust monitoring program is necessary so that models can be refined.*

d. *The SPMs forecast contraction zones, but do not forecast what will move in. This is a challenge we have yet to resolve. There are other modeling methods to incorporate ecosystem dynamics in climate, nutrient and water availability and disturbance to forecast vegetation shifts across large region. One approach (Dynamic Global Vegetation Models, or DGVMs) have been used to look at the effects of different climate change scenarios in California. Running these models is computationally challenging at finer scales and was beyond the scope of this assessment.*

Ultimately, we used SPMs primarily to inform hypotheses of climate change for the oak woodland species, characterize levels of future uncertainty, and as the basis for the habitat projection models. The habitat projection models were integrated into the regional conservation design, as outlined in section 5.4 of SSP plan.

We found that models helped us to assess target risk across 50 to 100 year planning horizons, as opposed to more common short-term perspectives. Modeling biological response to climate change can provide guidance on setting climate adaptive priorities by: a) identifying biological refugia and associated climate linkages; b) optimizing future acquisition & restoration; and c) informing the design of field-based monitoring programs.

Moving toward implementation of the SSP's 5 year objectives, monitoring programs are to be designed that combine insights from both local field staff and models of biological forecasts. Models can contribute information about which climate variables, and what tipping points, are expected to drive the most significant climate impacts. Projections for multiple co-dominant oak woodland species (ie blue oak, interior live oak, California buckeye, and foothill pine) suggest stark similarities in the areas where species are projected to be the most vulnerable to climate change. Thus, forecasts should help make efficient and effective use of limited resources and capacity for monitoring.

Collaborative planning efforts in the Southern Sierra should consider developing a comparative framework that explores how climate impacts formally interact with existing threats to conservation (ie land use, fire, disease, invasives etc).

Other uses for SPMs and HPMs have yet to be explored. For instance, the "predictor variables" for the SPMs which indicate weighting of roles of climate factors, such as mean temperature of the driest quarter, the precipitation of the coldest quarter, minimum temperature of the coldest month, or precipitation of the driest month, could be useful in developing CAP key ecological attributes and refining monitoring design.

2.5 Hypothesis of Change (HoC)

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" (HoC) describe the climate factors, identify the targets' climate-sensitive key ecological attributes and 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 strategies and can be used in the future to inform research and monitoring.

Discussion: HoC is a recommendation that came out of The Nature Conservancy's 2009 Climate Adaptation Clinic, a peer learning process for 20 sites with the objective of adjusting the Conservancy's Conservation Action Planning process to integrate the potential impacts of climate change. The SSP presents our first iteration of the HoC in Table 6 and Appendix F of the SSP plan.

Developing the HoC helped put a "face" on climate change. Until the SSP team grappled with identifying climate sensitive key ecological attributes and describing the impact of climate change on them, climate change had been an amorphous concept. The HoC is how we integrated spatial and non-spatial change and documented our initial assumptions. The hypotheses will need continued refinement based on more expert input, modeling, and actual testing and field measurements.

It could be useful to begin this exercise by scanning the literature to learn how the targets have responded to climatic fluctuations in the past. In our discussions, we found it invaluable to have field biologists familiar with the conservation targets who were able to draw on their experience to help put the climate impact into perspective. In the HoC narrative in Appendix 6, there is discussion that compares the impact of climate with other threats. This information was not presented in Table 6 in the SSP plan.

Given that conservation largely focuses on managing human activities and that we know people and communities will respond to climate change, the idea was made to develop "hypotheses of human response to climate change". However, we did not test this idea.

2.6 Incorporating climate factors into CAP

The Conservation Action Planning (CAP) methodology developed by The Nature Conservancy (http://conserveonline.org/workspaces/cbdgateway/cap/index_html) was 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.

Discussion: The Tehachapi CAP (Appendix B of the SSP plan) incorporates climate change into a written CAP. We found that CAPs can readily be adapted to integrate climate change. New processes and tools need to be developed which can be linked. The Conservancy is developing guidance and tools (such as the Miradi software program) for integrating climate change into the CAP process. These will be made available through Conserve Online.

3.0 Defining goals and setting strategies

3.1 Incorporating climate change into regional conservation 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 of SSP plan).

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 of SSP plan). 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.

Discussion: 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. By modifying goals based on projected stress, we prioritized stable areas, but didn't totally abandon areas projected to be stressed. This is partly a hedge against using the model output too literally, and is supported also by the assumption that there will be variation in the timing and severity of effects in the stressed areas. Many of the forested types are made up of long-lived trees, so we would not expect a dramatic type conversion due to adult mortality.

The approach to attract the model to areas with more landscape (physical) resilience by modifying the suitability layer, supports the theory of how we would incorporate climate change into site-selection (i.e. areas that are resilient should be preferentially selected, all else equal). We decided to not directly incorporate these features into the site selection as targets, because by themselves they are not conservation priorities. It is the way in which the distribution of these features interact with the current range of targets to enable adaptation that is the important part. Including resilience in the suitability is an indirect approach, but that was by design

Ideally, we would have tested the sensitivity of our approach of both using the habitat projections and resilience features by varying the amount of weighting for each approach. That is a priority for the next phase of climate change and regional planning.

Also, as mentioned earlier, there are important species-level issues that our approach does not address, such as changes in behavior, habitat use and availability, inter-specific competition and phenology for regionally important species such as Pacific Fisher.

3.2 Addressing ecosystem services in the regional conservation design

Another explicit planning objective was to characterize ecosystem services and to incorporate them into the regional conservation design. We did this by evaluating 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. We focused our analysis on the degree to which the priority areas in the regional design capture the most important areas for service production. Section 5.0 and Appendix C of the SSP plan describe our methodology.

Discussion: We did run some site-selection scenarios with ecosystem services as targets along with other targets, but we did not present the results in the plan. One noticeable difference between those runs and the final design was that many more areas in the Valley floor were selected due to the higher values for aquifer recharge in urban and agriculture areas. We decided that the ecosystem services will be very important in the communication and outreach strategy, but that we would not prioritize any areas only for their service production. That is why we chose to incorporate the services after we generated the draft regional design and evaluate the overlap. Also, the management and conservation of services are typically best addressed at broader scales (surface and groundwater use and policy, fire management, grazing best management practices, land use planning) rather than at specific sites.

3.3 Addressing uncertainty

When setting goals for the regional conservation design, described above in section 3.1, we set higher spatial goals for those areas modeled to be climatically stable for the conservation targets. The ensemble approach, which relies upon a preponderance of evidence principle, was one method we used to incorporate levels of uncertainty into decision-making. For this plan, the threshold for "low uncertainty" was if nine of the eleven models agreed (80%). However, it's possible to change the thresholds to 100% or another percent depending on project goals.

Discussion: In general, conservation planning is conducted in the context of ecological and socio-political uncertainty. Conservation plans are always "hypotheses" that must be revisited over time. Climate is a new uncertainty that adds complexity to traditional conservation planning. Therefore, it is valuable to assess it specifically and in conjunction with other threats.

We decided at this point in the planning process that we did not require high certainty about climate change forecasts or the exact way each plant and animal species will respond to climate change, in order to forge "no regret" adaptation strategies. The strategies may be tested against extreme scenarios that are either data-limited or less likely to occur. Some strategy outcomes may be highly affected by climate. Follow-up planning and strategy development that focuses on fire and/or flooding, which could have catastrophic outcomes, will need more precise information.

3.4 Developing strategies

Strategies emerged through the project-level CAPs, "result chain" discussions in workshops, and deliberations related to the regional conservation design goals, local challenges and immediate opportunities. We did not identify any adaptation strategies designed specifically to address extreme outcomes related to climate change, such as translocation or captive breeding of population of species that could go extinct.

Discussion: Incorporating climate change reinforced the value of the basic principles of conservation biology. We decided that a priority needed to be protecting interconnected spaces and maintain healthy natural communities so that we maintain as many representative native species as possible during this process of change. We developed "no-regret" conservation strategies in a framework of adaptive monitoring where strategies may evolve based on success, failure, and new unforeseen circumstances.

It's important to note that the regional conservation design highlights the scale of conservation necessary for adaption, but does not presuppose particular strategies, such as land acquisition. More discussion is necessary to determine how we will interpret and apply the findings.

Strategy development was difficult for several reasons: targets that represent all of biodiversity in the planning area; a huge spatial area in the planning region; and the presence of multiple partner institutions each with slightly different missions, cultures, and decision-making protocols. In this planning process, we completed many of the technical analyses and then moved on to strategy. One of the lessons learned might be to expend a little effort to identify draft strategic ideas early in the planning process. In other words, it might be useful to use the results of early analyses and early draft work products to identify rough or coarse strategic ideas. Then as the planning process nears its end and strategies must be identified, planners will have a menu of draft ideas to work from. In addition, planning efforts such as this are frequently dominated by scientists and technical staff. Including more strategists and program directors along the way can help ensure conclusions are made and measurable, actionable strategies get developed.

Part II. Lessons learned

Consideration of climate change reinforced our sense of urgency and accentuated the need to abate the diverse suite of top threats, which, if left unabated, will serve to exacerbate the impact of climate change on our conservation targets. Incorporating climate change into the planning process underscored the need to use a longer planning horizon and to collaborate across jurisdictional boundaries in planning and management. It highlighted the necessity of robust regional monitoring to learn and inform adaptive management. Finally, we concluded that we cannot afford not to integrate climate change into conservation planning: climate change is a real threat that will undermine otherwise solid conservation planning and implementation work if not considered.

Below we describe lessons learned from our experience of incorporating climate change into conservation planning, noting what we would do differently and what parts of the process are replicable and recommended. We expect the lessons learned presented in this document to evolve as we share our experience and results with a wider audience.

Lesson #1: It is possible to plan even with ecological, climatic, and social uncertainties.

The primary lesson that we extracted from this process is that it is possible to incorporate climate change into conservation planning even with uncertainty. As described above, we incorporated climate change and the degree of uncertainty in both quantitative and qualitative manner, as well as, through spatial and non-spatial assessments. By presenting hypotheses and transparent assumptions and goals, we allow our findings to be evaluated and refined.

Lesson #2: Climate change impacts cannot be assessed in isolation from other threats, however, it is challenging to prioritize between immediate short-term and long-term threats.

The SSP planning team was surprised when climate change <u>in and of itself</u> did not emerge as the killer threat we expected it to be given the significant projected increase in temperature (at least in next fifty years). Rather its synergy with the other threats is what became alarming. Therefore, we recommend examining climate change and other threats together.

Lesson #3: An open dialogue between climate change modelers, scientists, and place-based ecologists and land managers is essential.

While the models that inform our plan help simplify and reduce the complexity of nature and climate change, they were tested against the experience and judgment of experts familiar with the geography and systems of the southern Sierra as well as the pertinent literature. Such contributors are able to provide important insights, synthesize information, and help draw conclusions. While we involved a diverse suite of stakeholders in our planning workshops, in retrospect, we would devote greater time to soliciting more input from scientists and land managers, especially in the later stages of the project.

Lesson #4: Build in time and effort for drawing conclusions.

We found it challenging to draw conclusions that would help us prioritize between immediate short-term and long-term strategies. Because climate change is not an isolated factor affecting biodiversity health and ecosystem services, and because we looked at the issue through multiple studies (CAPs, a regional assessment, Hypotheses of Climate Change, etc.), it was difficult to reach over-all “black and white” conclusions. Our general conclusions are embedded in the plan and reflected in our strategies and regional conservation design, but if we were to do this over again, we would present them more explicitly and devote more discussion time to this aspect of the planning process. We would also develop a more systematic process for gleaning conclusions from the individual studies and documenting our overall conclusions. It is an iterative process, so we will continue to refine our over-all conclusions and tighten priorities.

Lesson #5: The human aspect of climate impacts and adaptation should be explicitly investigated.

When all is said and done, managing human activities is key to mitigating climate change and fostering adaptation. Our planning process focused upon developing the scientific foundation for regional conservation design and strategies. However, as we developed our strategies we were reminded how important is to better understand the human dimension, as new threats and opportunities will emerge as humans adapt to climate change.

In the future, we would like to assess how well institutions, human communities, and economic activities, such as ranching and agriculture, are prepared to deal with climate change and how they might respond. New threats may become apparent. Analyzing social readiness could illuminate a helpful convergence of adaptation strategies, leading to new alliances and more effective conservation. In addition, although climate change highlights the need to work across borders, there are institutional barriers which prevent this. Identifying and addressing such obstacles are necessary for successful adaptation.

Lesson #6: Creating flexible regional datasets and datasharing is necessary.

As mentioned earlier, we had a wealth of completed or well-developed analyses to draw upon as well as high quality data on target and threat locations. This greatly improved our ability to complete this plan in such a short timeframe and provide the level of synthesis and strategic direction embodied in the plan. Data access, availability and collaborative development will be increasingly critical as multiple agency-led, cross- ownership assessment continue. The ongoing challenge will be linking intensive site-based observations and studies with regional trends and conservation strategies. This challenge is not unique to climate-adapted planning, but climate change will exacerbate it.

Through the year, it became apparent that the individual datasets, models, and analyses that formed the basis of the SSP plan have value in and of themselves. This project pulled together scattered but relevant information from a large number of sources and developed original analyses which together form a very useful and unique regional dataset. The SSP will deposit these datasets into Conservation Biology

Institute’s Data Basin website to make them readily available. We are exploring how best to provide orientation and guidance so that they can most effectively be used by others preparing project-level plans.

Lesson #7: Absent quantitative data, qualitative assessments are very valuable.

While many projects may not have the same depth of available information initially, our over-all process and planning approach, to a large degree, can be adapted. The HoCC, previously described, is an example of a qualitative assessment.

The SSP regional conservation design process utilized the site selection tool Marxan. While many projects will not employ Marxan, the same questions can be asked:

- *What targets are under-represented in existing protected areas?*
- *What areas within the site are most suitable for enduring conservation success? (or conversely, what areas are or will be least suitable?)*
- *What areas are projected to be climatically stable in the face of climate change?*
- *What landscape features (physical and hydrological) favor resilience?*
- *What gradients are important?*
- *What connectivity is necessary to sustain the targets and allow targets to shift and adapt?*
- *What existing conservation lands do you want to build your design around?*

Lesson #8: Incorporating climate change into land management decisions requires additional, in-depth analyses and decision-support tools.

The SSP planning process was not designed to inform land management, but our planning underscored the issues which need in-depth attention. Follow-up in-depth analyses and decision-support tools are necessary related to fire and fuels, hydrologic and groundwater regimes and associated aquatic and riparian communities, invasive non-native species, and endemic species. Land management agencies are beginning to do this. This will provide an opportunity to test if and how the SSP data and findings support management planning.

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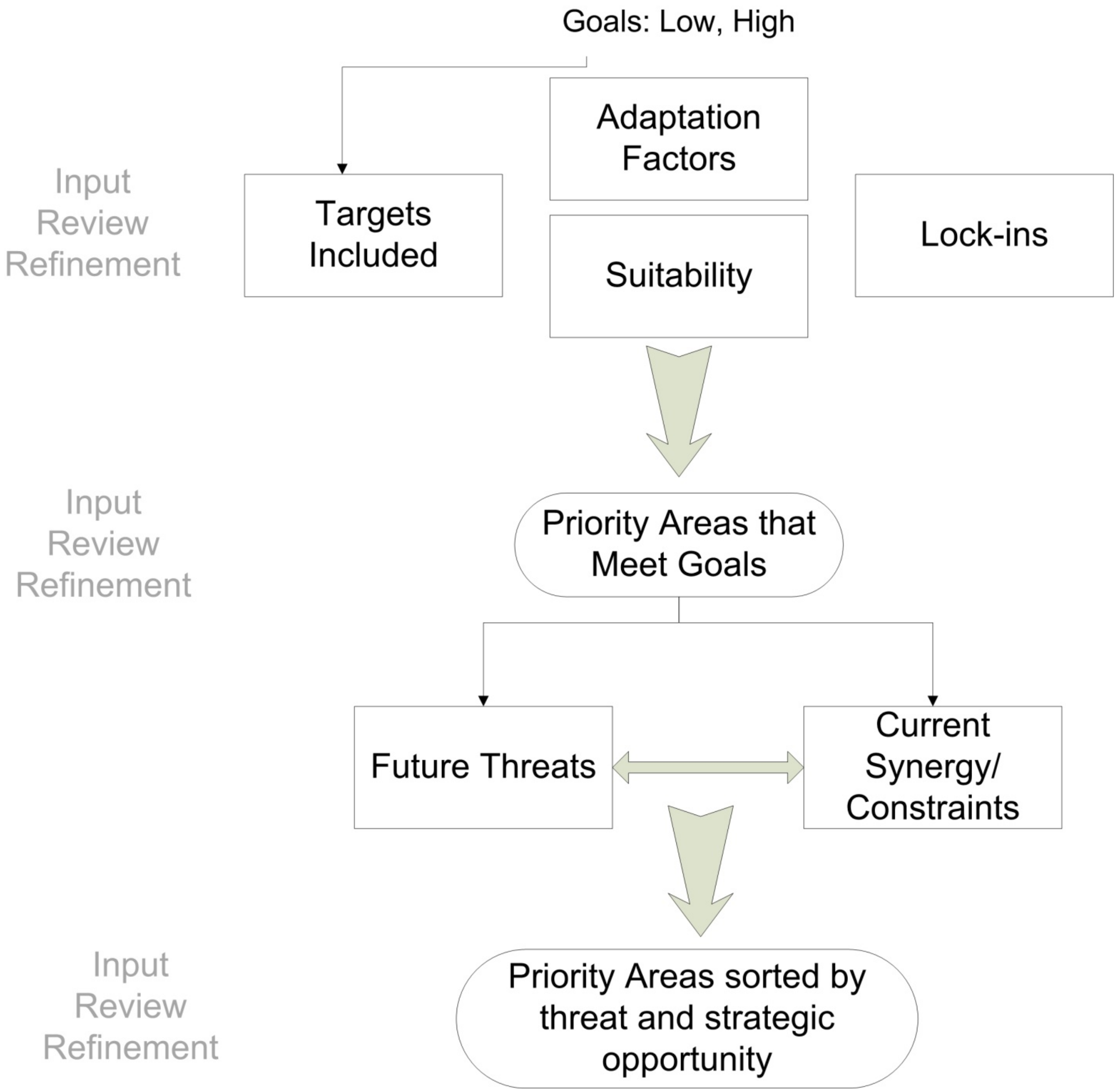
In conclusion, we believe our planning approach and plan provide a useful, real-world example of a climate-adapted conservation plan which can help the conservation field move from the idea stage about adaptation to what climate adaptation actually means in practice. This is an iterative process. We encourage others to test the SSP approach and findings, and to use our experience as a stepping stone to on-going refinements and improvements in incorporating climate change into conservation planning and implementation. For more information, please contact: Susan Antenen, SSP Coordinator, santenen@consbio.org

Appendix A. Ecosystem services important in the SSP region

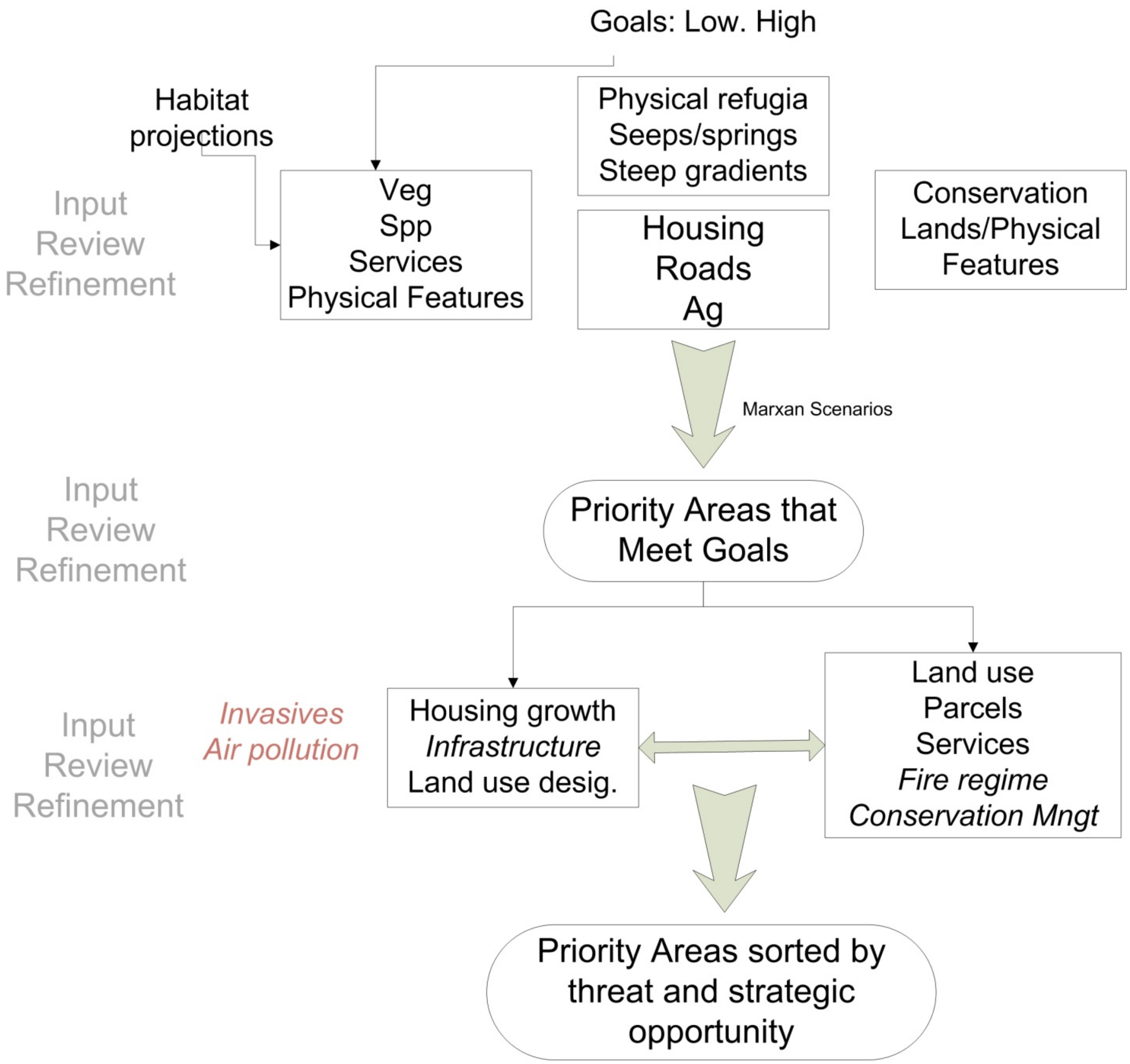
Target	Description	Justification	Direct Beneficiaries	Key factors/ inputs	Mappable
Water retention	Ability of an area to hold water in the soil and slowly release it over longer time periods	Important for base flow in rivers, likely more important in future	Streams & wildlife Agriculture Cities	Soil properties- saturation potential, precipitation amount and type	Yes
Flood control /Storm Peak Mitigation	Ability of landscape to modulate the flow of water and reduce threat of flooding	Important service in California	Cities Agriculture	Land cover in watershed, distance to outlets, existing flood control infrastructure, precip regime	Not currently
Water Yield: Municipal and Irrigation	Water available for use as either surface or groundwater	Main input for water users	Cities Agriculture	Precipitation amount and type, water storage infrastructure	Yes
Carbon storage/ sequestration	Carbon in standing timber and in grassland soils	partial stabilization of climate moderation of weather extremes and their impacts	Everyone; local communities, State, and federal governments striving to meet CO2 goals	Forest type, aboveground biomass, soil characteristics, other growth characteristics	Yes, based on general patterns of forest biomass
Forage production	Grass in rangelands	Food production, Soil stability, maintenance of biodiversity	Ranching Grassland biodiversity	Soil fertility, rainfall, length of growing season, land cover	Yes, based on soil data and land cover
Soil fertility – Agricultural production	Soil processes that generate and preserve soils and renew their fertility	Soil fertility enhances domesticated plants ability to grow and resist pests; maintenance of biodiversity	Agriculture	Soil types	Yes, using existing soil classification (prime, statewide, local imp.),

Biomass (forestry, ag. waste)	Growth of forest	Source of wood for fuel/energy, carbon sequestration, cleansing of air, cooling of the ground; maintenance of biodiversity	Timber and construction industries, communities, utilities	Forest type, growth-related factors, accessibility	Has been assessed in other studies
Pollination	Native species that pollinate native and domesticated plant species	Many plant species are dependent upon pollination by insects and other species; the European honeybee is threatened, so native pollinators are now recognized as being important; maintenance of biodiversity	Agriculture	Habitat for pollinators, presence of animal-pollinated crops and vegetation	Yes, but at very fine scale
Pest control	Bats, raptors, snakes and other predators that eat rodents, insects and pest species	Control of pest species; maintenance of biodiversity	Agriculture, Residents and businesses,	Density of pests and predators, habitat for predators	Not sure
Recreation /Cultural uses	The benefits that people derive from natural areas in terms of the recreational, cultural or spiritual uses	Significant component of ecosystem value in CA	Citizens, Business owners, Federal and state agencies	Accessibility (drive time, land ownership), amenities, number of options	Recreation opportunities can be mapped generally, valuation is harder, often depends on use data

Appendix B. Schematic of Regional Conservation Design Site Selection (General (top), and Specific to the SSP Plan (bottom)). These figures show the primary elements and process to integrate targets, threats, opportunities and existing conservation and land use. The factors in italics in the bottom figure were discussed and analyzed but not fully integrated into the regional design. The factors in red were discussed but not analyzed. We expect that the regional design will be refined as the final two layers are developed through implementation.



Goals: Low, High
Adaptation Factors
Input
Review
Refinement
Targets Included
Suitability
Lock-ins
Input
Review
Refinement
Priority Areas that Meet Goals
Future Threats
Current Synergy/ Constraints
Input
Review
Refinement
Priority Areas sorted by threat and strategic opportunity


Goals: Low. High
Habitat projections
Input
Review
Refinement
Veg
Spp
Services
Physical Features
Physical refugia
Seeps/springs
Steep gradients
Housing
Roads
Ag
Conservation Lands/Physical Features
Marxan Scenarios
Input
Review
Refinement
Priority Areas that Meet Goals
Input
Review
Refinement
Invasives
Air pollution
Housing growth
Infrastructure
Land use desig.
Land use
Parcels
Services
Fire regime
Conservation Mngt
Priority Areas sorted by threat and strategic opportunity