SCIENCE *for* CONSERVATION



Laying the Foundation:

How Existing Conservation Areas Have Helped Prepare California for Climate Change

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The Nature Conservancy

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Synopsis

How well has California done in laying a foundation for conservation in a warming world? We evaluated the existing network of conservation lands in California to determine the extent to which it includes landscape features that may be especially important for biodiversity conservation in the context of climate change. Over half (58%) of the landscapes likely to be more resilient to change due to their topography and location are in that protected network. We also found that over two-thirds of the intact and connected habitat, carbon-rich forests and woodlands, and projected habitat refugia are also already permanently protected from development. Not as well protected (only 35%) are the areas to which coastal marshes will need to migrate as sea levels rise. Past conservation action has thus created an invaluable foundation from which today's conservationists can base conservation strategies specifically tailored to benefit the adaptation of native plants and animals to the changing world. The effective management of these protected areas – and of the adaptation potential of private lands outside of those protected areas – will be critical to maintain California's conservation values into the future.

Introduction

Rapid and extreme climate change poses a significant threat to the conservation of California's native plants and animals. For many species, the climate to which they are adapted will shift, or the natural community in which they currently exist may be fundamentally altered. If species cannot adapt to those changes, they may well face extinction.

The steep hills and valleys in the Mount Hamilton region create a resilient landscape because they generate diverse microclimates that can help plants and animals persist during heat waves and droughts. © Kirk Klausmeyer

The past decade has seen marked progress in developing the science foundations needed to understand potential impacts of climate change and to incorporate those considerations into conservation plans. Prior to that, few conservation plans and conservation actions explicitly incorporated climate change considerations into the prioritization of places to protect. Fortunately, however, many of the principles that had been developed over recent decades by conservation biologists for systematic conservation planning have called for including elements that many analyses now highlight as being foundational for adaptation plans. For example, "traditional" conservation planning has long emphasized the importance of protecting expansive interconnected networks of conservation areas that represent the full suite of biological diversity and that include a variety of landscape features such as elevational gradients. Today, explicitly incorporating these into conservation plans as climate considerations is becoming standard practice.

Conservation science has identified characteristics of landscapes that can help facilitate the adaptation of plants and animals to climate change and/or help reduce greenhouse gasses in the atmosphere. They include:

- Landscape resiliency
- Landscape intactness and inter-connectedness

- Habitat refugia
- Coastal marsh migration zones
- Carbon rich forest and woodland

In this analysis, we assess how well these features are represented in the existing network of public and private conservation areas in California, even though the climate adaptation and mitigation benefits of the features were perhaps not initially recognized. We also highlight areas where additional conservation efforts could focus in order to make the greatest contribution to conservation in a changing world.

We present this analysis emphasizing two important caveats.

1) The analysis is based on "gap status", which indicates ownership and allowable uses of land[1]. While level of "protection" is important (since it can preclude habitat loss due to conversion), protection alone should not be construed as sufficient to address climate impacts, because adaptation potential is highly dependent upon ongoing management activities on those lands. Furthermore, this ranking may under-represent the contribution private land owners can make toward enhancing climate adaption of California's native species. Private lands hold many of the high value landscape features, and in some cases private landowners may have greater flexibility than public landowners in how they manage resources under a changing climate.

2) A growing literature emphasizes that species and natural systems will respond to climate change in often idiosyncratic ways, and that conservation may require addressing climate change adaptation by planning for needs at the population, species, or community-level. The analysis we present here should be considered as a "coarse filter" analysis, or one that captures the general elements of adaptation potential. Additional "fine filter" considerations like how changes in local climate might affect a particular focal species also need to be addressed to refine conservation strategies. Those considerations require additional, finer scale analysis – analyses in which coarse filter inputs like those presented here can be especially helpful.

The following five pages begin to answer the question: *How well has California done in laying a foundation for conservation in a warming world?* We then summarize and discuss recommendations.

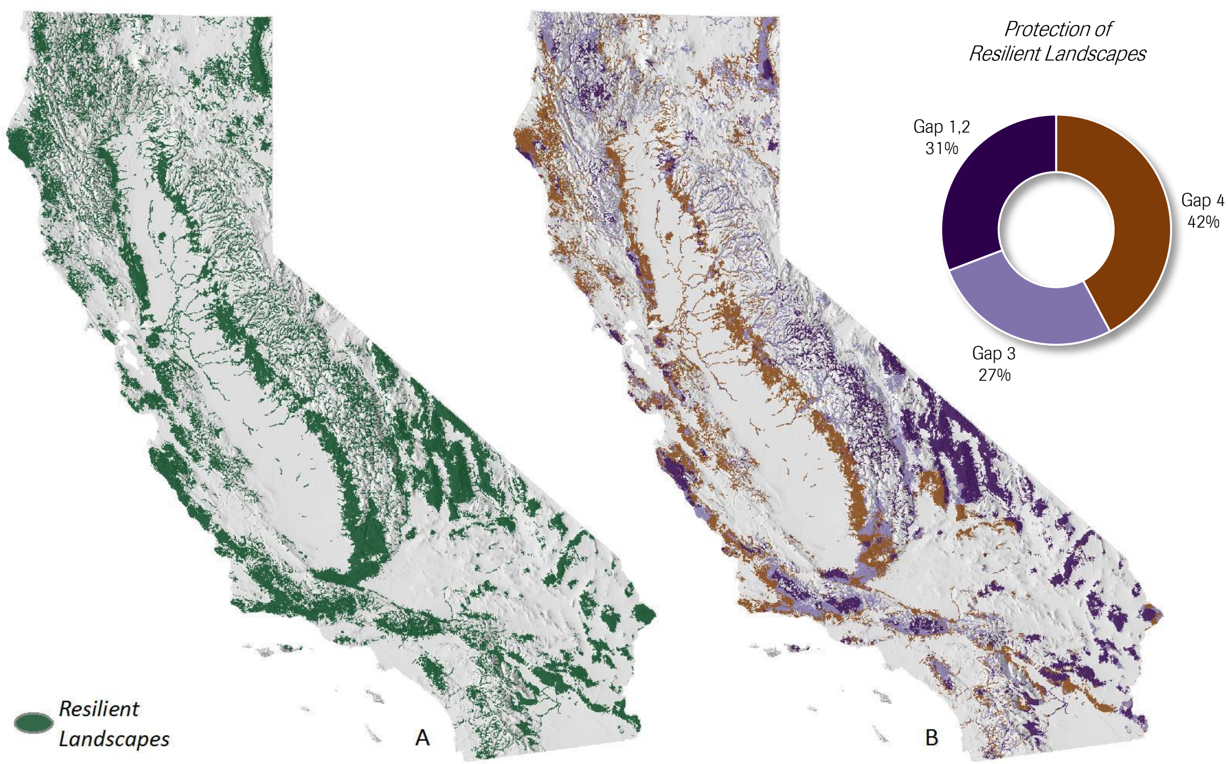
[1] Complete definitions of the GAP status categories available at: http://www.gap.uidaho.edu/padus/gap_iucn.html

Resilient Landscapes

Resilient landscapes are natural areas that give plants and animals the best opportunity to adapt to climate change because they support diverse and relatively stable microclimates and water sources. We anticipate that these landscapes will provide a refuge to plants and animals during extreme weather events like drought.

We identified resilient landscapes in California by mapping the areas that support high topographic diversity, water sources, elevation gradients, riparian corridors, and that are close to the moderating effect of the ocean [1]. We mapped the most resilient 25% of the landscape in each of the nine complete or partial ecoregions in the state (green areas in Figure 1A below).

Figure 1



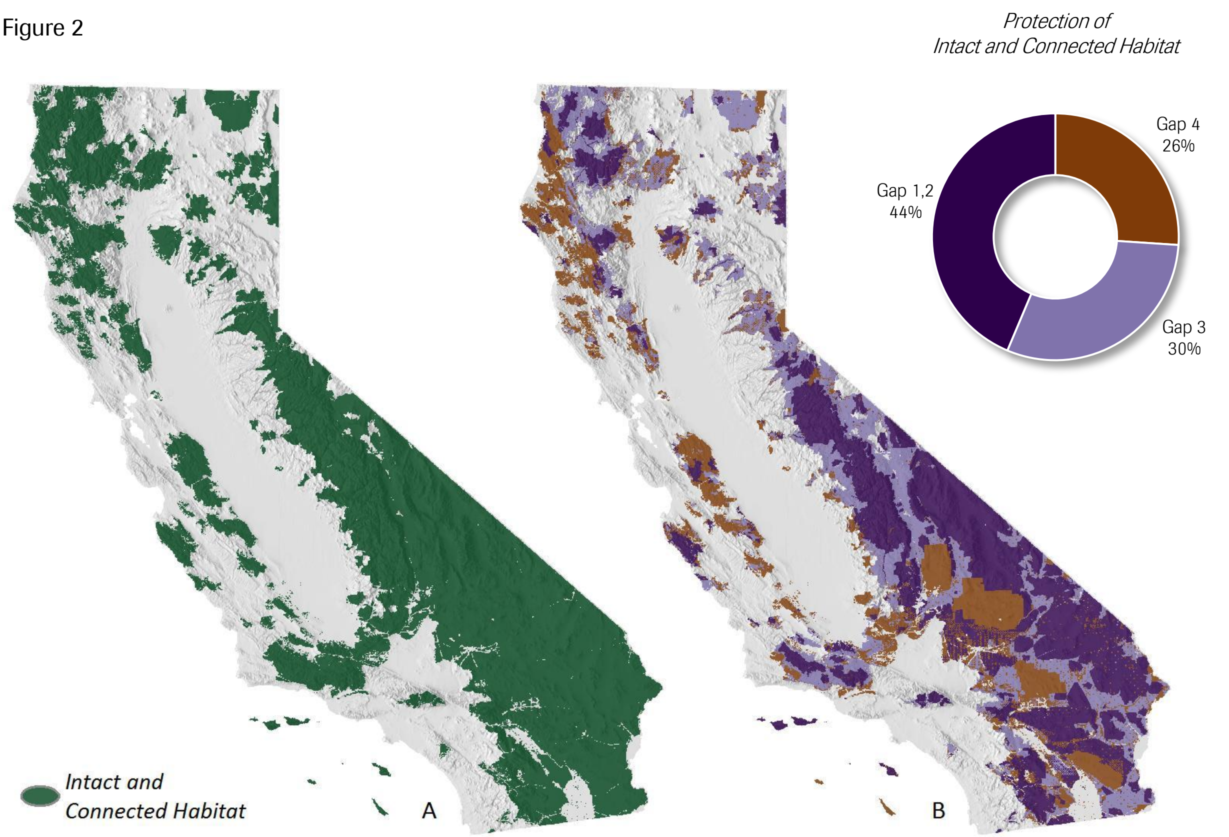
The existing network of conservation lands has protected just over half (58%) of California's most resilient landscapes (light and dark purple areas in Figure 1B above). Thirty one percent are currently managed for biodiversity (Gap categories 1 and 2), while 27% are public lands managed for multiple uses including logging, mining, and off road vehicle use (Gap 3). The habitat in the remaining 42% has no explicit protection for biodiversity (Gap 4), and thus is vulnerable to fragmentation and conversion. The private lands in the North Coast, portions of the Central Coast, and in the foothills around the Central Valley include the most resilient, yet unprotected areas.

Intact and Connected Habitat

As the climate changes, many plants and animals will need to move across the landscape to new areas to find suitable habitat. Large blocks of intact and connected habitat are essential for this to happen. While millions of acres of California's natural habitats have been converted to roads, crops, and urban areas, almost half of the state remains relatively intact and connected.

We identified intact and connected habitat using land cover data and a metric of landscape-scale fragmentation [1-3]. We mapped the most intact and connected 50% of the state (green areas in Figure 2A below).

Figure 2



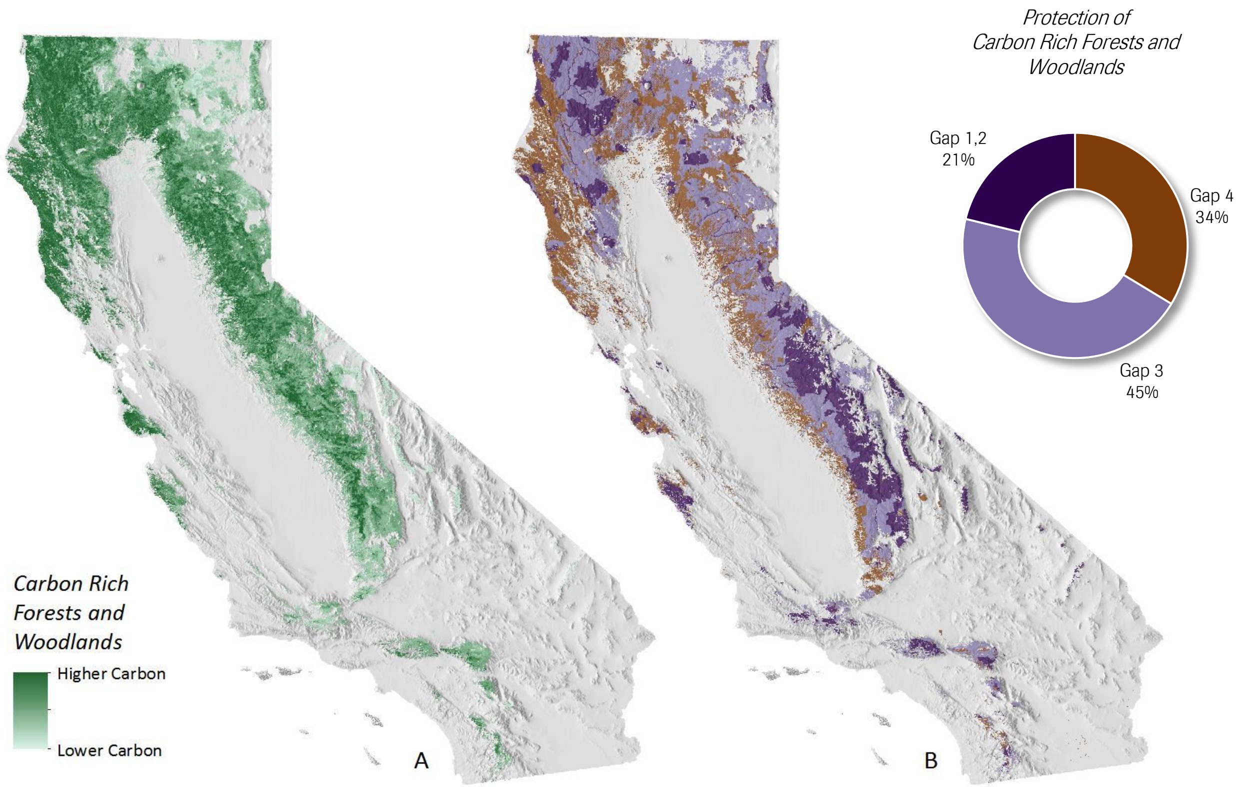
The existing network of conservation lands has protected 74% of the most intact and connected habitat in the state (light and dark purple areas in Figure 2B above). Forty-four percent are currently managed for biodiversity (Gap 1 and 2), while 30% are public lands managed for multiple uses (Gap 3). Over a quarter (26%) of the intact and connected habitat has no explicit protection for biodiversity (Gap 4), and thus is vulnerable to future fragmentation and conversion. The private lands in the North Coast, portions of the Central Coast, and in the large military bases in the desert regions of the state contain the largest blocks of intact and connected, yet unprotected, habitat.

Carbon Rich Forests and Woodlands

Ecosystems naturally store and emit carbon through a variety of abiotic and biotic processes. Healthy forests and woodlands can be especially efficient at sequestering carbon from the atmosphere, carbon that can be released if forests are converted to human land uses, degraded by land uses or pests or suffer catastrophic wildfire. Well-managed forests and woodlands can help slow the pace of climate change, giving people, plants, and animals more time to adapt.

The U.S. Forest Service has estimated the amount of carbon stored in California's forests and woodlands using tree measurements at select locations, satellite images, and geospatial data on land cover, topography, and climate [4](Figure 3A below).

Figure 3



California's forests and woodlands store over 1 billion metric tons of carbon in aboveground biomass (about the same amount as emitted by 921 coal fired power plants in one year). Well-managed selective timber harvest operations have little long-term effect on forest carbon stocks, but conversion of forest to other lands uses reduces the amount of carbon stored and removes the future sequestration benefit that the forest would have provided.

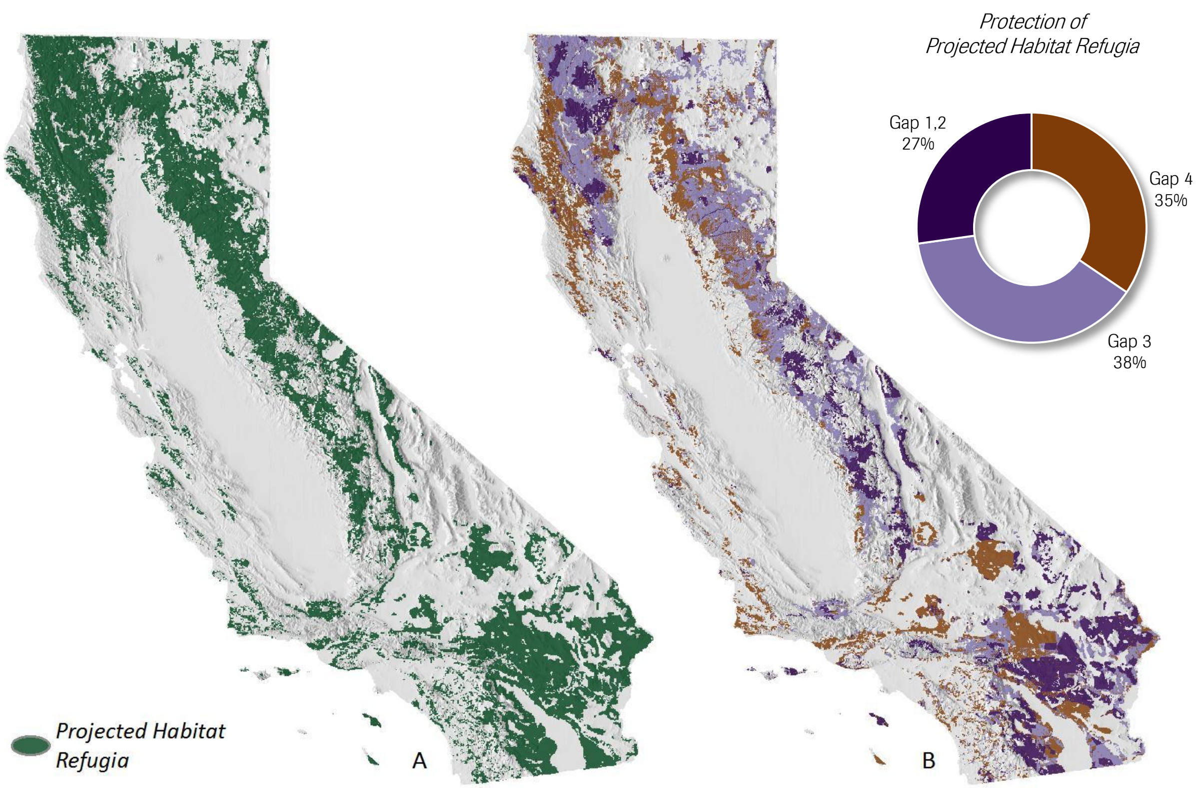
Two thirds of this carbon is protected from permanent conversion because of its public or private conservation status (Gap 1-3). The remaining third is privately held (brown areas in Figure 3B above), which may make it more vulnerable to fragmentation and conversion. These private forests and woodlands are found mostly in the North Coast, portions of the Klamath basin, and the foothills of the Sierra Mountains.

Protected Habitat Refugia

California's diverse climates, soils and terrain support a variety of habitat types. Major habitat types are often defined by the presence of a few dominant species that shape the broader ecological community. As climates change, we expect dominant species to die out in some portion of their range, and expand into new areas. For most species, some portion of their current range will likely remain suitable through the next century. These refugia are important to protect because they will likely have lower rates of change in community composition, and may serve as stronghold habitat for key species.

We identified projected habitat refugia in California by comparing known observations of a dominant species with the current climate and then modeling where future climatically suitable areas will be using eleven different future climate projections. An area was mapped as refuge for a habitat if (1) a majority of climate models predict an area will be suitable in 2100 for at least one of the dominant species for a habitat type, and (2) the location currently supports the habitat [5]. The combined projected habitat refugia for the major forest, woodland and shrublands habitats are shown as green in Figure 4A below.

Figure 4



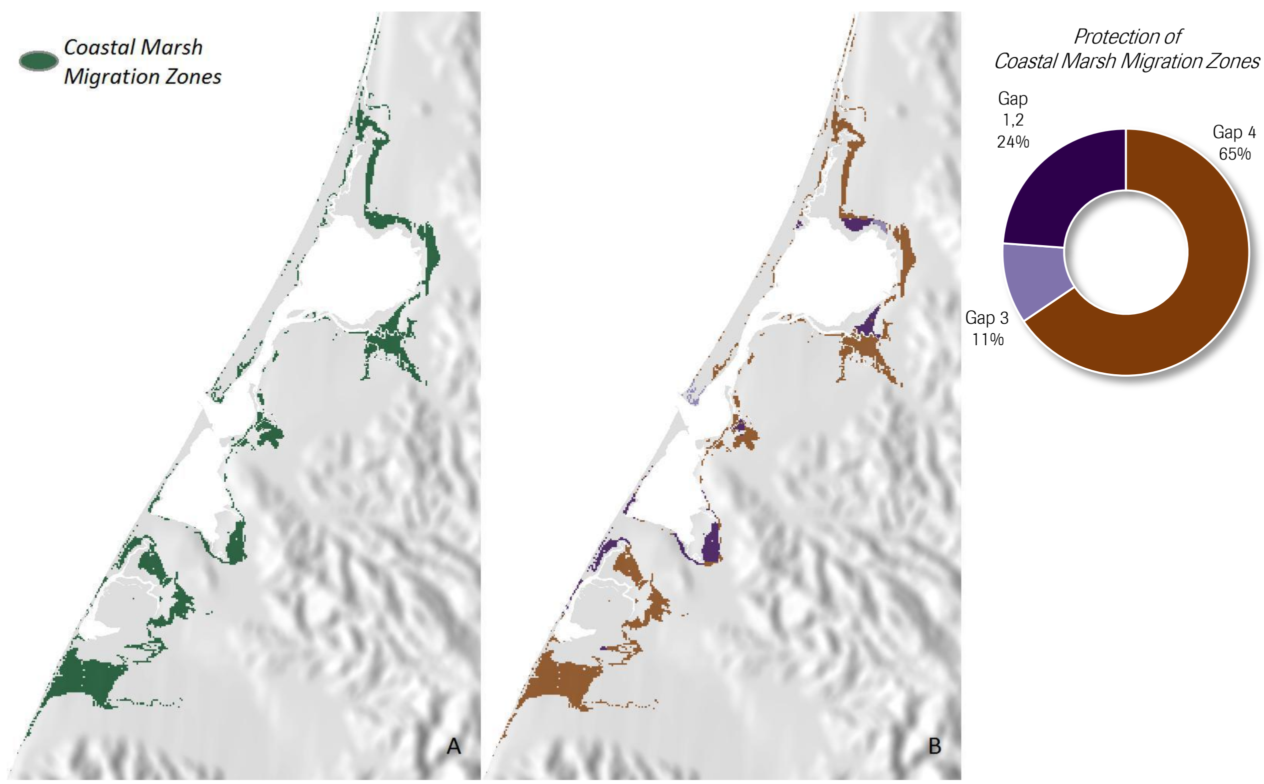
The existing network of conservation lands has protected 65% of the projected habitat refugia (light and dark purple areas in Figure 4B above), with 27% in the highest categories of protection (Gap 1 and 2). The unprotected refugia are concentrated in the North Coast and in the desert, but are also distributed through the Klamath, Sierra, and Central and South Coast ecoregions.

Coastal Marsh Migration Zones

Sea level rise will have significant impacts on California's highly productive coastal wetlands and estuaries. If the land adjacent to these coastal ecosystems is developed or armored with a sea wall or levee, wetlands will be unable to migrate inland and adapt to the changes in sea level. Thus, the future of coastal marshes in California depends on there being undeveloped "coastal marsh migration zones" that can accommodate that migration.

A recent study by the Pacific Institute mapped areas where coastal wetlands will need to migrate given a 1.4 meter sea level rise and then intersected that area with current land use [6]. We mapped all migration areas that are not already developed for urban and suburban land uses (green areas in Figure 5A below; because these areas are relatively small and difficult to see on a statewide map, we only show the results for Humboldt Bay).

Figure 5



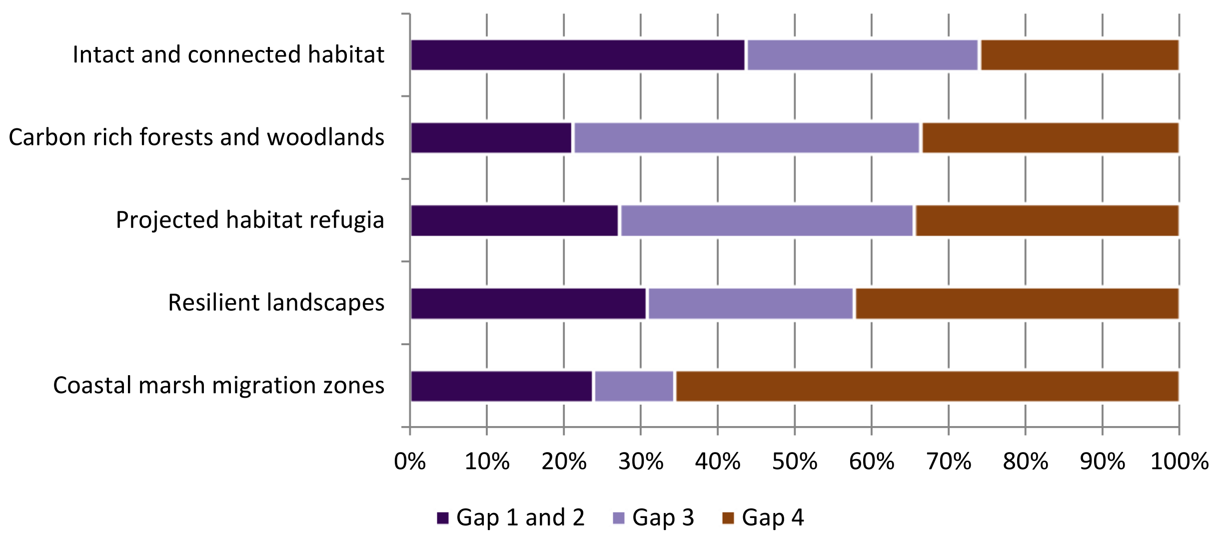
Thirty percent of coastal marsh migration zones have already been developed, and the remaining areas are generally poorly protected. The existing conservation reserve network has protected just over one third (35%) of these areas (light and dark purple areas in Figure 5B above). The remaining 65% is privately held and subject to future residential and commercial development. The areas with the most unprotected marsh migration zone include Humboldt Bay, San Francisco Bay, Monterey Bay, and the Oxnard Plain. Statewide, there are only 60,000 acres of land that is suitable for marsh migration and not developed, and 40,000 of those acres are not protected.

Summary Results

California has a long history of land protection, which has resulted in roughly 50% of the state now being managed at least in part for the protection of plants and animals. Given that preparation for climate change was not a consideration when much of that foundation was laid, how well does the existing network of conservation lands protect features that may contribute most to conservation in a changing and warming world?

California's existing conservation lands provide an important foundation to support climate change adaptation of – and climate change adaptation strategies for – native plants and animals.

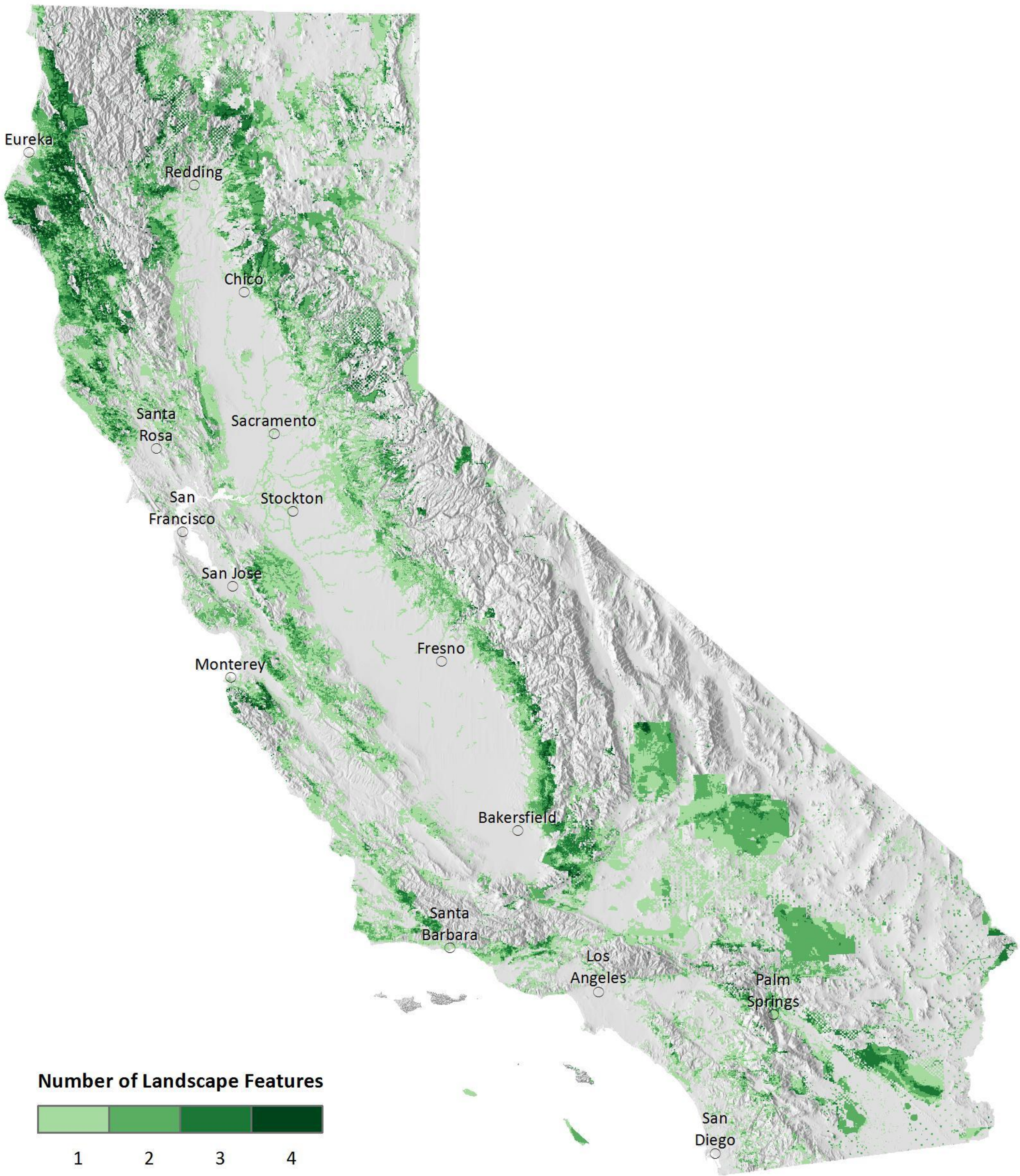
Figure 6



The majority of California's intact and connected habitat, as well as its carbon rich forests and woodlands, have some degree of protection from conversion (Figure 6). In contrast, coastal marsh migration zones have generally low protection, and many could be developed ahead of the otherwise inevitable migration of the coastline. Habitat refugia and resilient landscapes will likely have disproportionate importance for biodiversity conservation efforts; it is especially important to manage these areas to maximize the contribution they may provide for adaptation.

Can these results help illuminate areas where future conservation investment may be able to deliver especially high adaptation return? Figure 7 on the following page maps the landscape features we have discussed herein – landscapes that may contribute most to the adaptation/carbon sequestration potential in the state – but depicts only those that do not have formal land protections (i.e., Gap 4); darker brown indicates places that may provide multiple climate benefits. The privately-owned areas that emerge as areas of potential high adaptation return on investment include the timberlands of the North Coast, the foothills along the Central Valley, the Upper Carmel River watershed south of Monterey, and the military lands in the Mojave. In all, 13.75 million acres of the state have no legal conservation status but, if well managed into the future, have the potential to provide multiple (>2) climate benefits.

Figure 7: Landscapes that provide high climate adaptation benefit outside of California's protected area network. These landscapes have one or more of the following characteristics: landscape resiliency, landscape intactness and inter-connectedness, habitat refugia, coastal marsh migration zones, and carbon rich forest and woodland. No landscape has all five characteristics.



Conclusions

Past land protection in California has safeguarded half of the state from future development, and half of that area is managed explicitly for the protection of the state's biodiversity, among other values. California's network of conservation lands also has protected many of the landscape features that will help its native biota persist in a warming world. The network already includes almost three-fourths of the intact and connected habitat, two-thirds of the projected climate refugia, over half of the resilient landscapes, and one-third of the coastal marsh migration zones. Two-thirds of the aboveground carbon stored in the state's forests and woodlands is in some level of conservation management. Thus, the legacy of conservation action in the state has indeed helped prepare the state for an uncertain and changing future. Moreover, California's network of conservation lands provides a foundation from which to base additional efforts to help ensure past and future conservation investments will be durable through time. Analyses like those presented here can help identify protection priorities and management strategies that are explicitly focused on delivering the highest return on investment of limited conservation funds.

Key insights from this analysis:

California's network of conservation areas is not complete. The conservation and adaptation value of the existing reserve network will be enhanced and more secure if it better represented the full suite of species and habitats of the state, and included a fuller array of landscape features that best support adaption, such as habitat linkages and wildlife corridors that support movement of plants and animals.

Private lands play a critical role for conservation in the face of climate change. Private landowners will determine the degree to which many landscape features will support adaptation into the future, and incentives that encourage climate-smart management practices – and discourage actions that cause a net loss in carbon storage, habitat connectivity, and resilience – will be increasingly important conservation tools.

Land management is essential. Land protection alone will not be sufficient for successful climate adaption – nor is it always even necessary. Biodiversity conservation in the face of climate change depends on effective adaptive management of the mosaic of public and private lands. Restoring natural disturbance regimes where they've been disrupted will create conservation and adaptation benefits.

Conservation investments can also deliver a variety of co-benefits to people, including helping society adapt to climate change. Nature conservation offers a variety of benefits and services for people, ranging from improving water security to providing recreation opportunities. Conservation actions for natural areas often can be designed explicitly to help buffer humans from adverse effects of climate change. For example, protection of natural areas that would allow for migration of the coastal ecosystems also would reduce development in what would be harm's way. Similarly, a better managed forest can sequester carbon and reduce risk of catastrophic wildfire.

Appendix A: Methods

For this analysis, we focused on the entire terrestrial area of the state of California as a study area. We stratified the state by 11 ecoregions developed by The Nature Conservancy from an earlier ecoregion map developed by the U.S. Forest Service [7]. To aid spatial analysis, all data were converted to 100 meter by 100 meter resolution grid cells. All analysis was done in ESRI's ArcGIS Desktop version 10.

Carbon Rich Forest: A redwood tree like these in Humboldt State Park can store over a ton of carbon each. © Harold Malde

To measure contributions of the existing network of conservation lands we used the U.S. Geological Survey's Protected Area Database (v. 1.2) [8]. This database represents protected open space in the United States and includes public lands held in trust by national, state and some local governments, and by some non-profit conservation organizations. Each protected area is ranked with a "gap" code. Gap codes of 1 and 2 are lands managed for different levels of biodiversity protection; Gap 3 indicates multiple use lands that may support extractive uses; and Gap 4 indicates no known mandate for permanent protection. This database includes Native American Lands and lands managed the Department of Defense (primarily Gap code 4). For this analysis, we consider protected areas with a Gap code of 1-3 as protected. We also include conservation fee and easement data maintained by The Nature Conservancy, California, and a representation of the protected areas on the Tejon Ranch (in the Tehachapi Mountains of southern California) provided by the Tejon Ranch Conservancy, because these data were not all included in the U.S. Protected Area Database. We assigned a Gap code of 2 to Conservancy fee lands and of 3 to Conservancy and Tejon Ranch easement lands.

We combined the spatial data for ecoregions, protected area management, and the five focal landscape features into one database for analysis. We analyzed the percent protection statewide and by ecoregion for each of the five landscapes. We also combined the five focal landscape features to map the areas in most need of future protection.

Note that in this analyses we draw from some existing published sources, and those original sources should be reviewed to understand the limitations of that particular analysis. For example, the overlay of carbon "accounting" used here does not account for the complex relationships between forest management, climate change, wildfire and greenhouse gas emissions. Meanwhile, the overlay of habitat connectivity may overestimate habitat connectivity in, for example, the North Coast forests because it does not incorporate timber harvest. In sum, there may be assumptions/limitations in the input data that are important considerations when interpreting results.

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