# Integrated Scenarios and Outreach for Threat Assessments on California Rangelands: Metrics and Economic Analysis for Decision Support


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## 1. Abstract


In California there are over 18 million acres of rangelands in the Central Valley and the interior Coast Range, most of which are privately owned and managed for livestock production. Ranches provide extensive wildlife habitat and generate multiple ecosystem services that carry considerable market and non-market values. These rangelands are under threat of urbanization and conversion to intensive agriculture, as well as climate change that can alter the flow of these services. To understand how land use and climate change might affect rangeland ecosystem services, we developed six spatially explicit climate/land use/hydrological change scenarios for the Central Valley and oak woodland regions of California organized around our main management question: how to analyze costs, benefits and tradeoffs of different strategies for rangeland conservation? Scenarios integrate downscaled land use change scenarios, downscaled global climate models and related hydrologic data on climatic water deficit, runoff, and recharge that follow IPCC emission scenarios A2, A1B and B1. Modeling of scenarios produced maps of plausible future distributions of development, irrigated agriculture, and conservation lands, and changes to climate and hydrology. Model results are being used to quantify wildlife habitat, water supply and carbon sequestration benefits of rangelands, and to conduct an economic analysis associated with changes in these services. An outreach program through the Defenders of Wildlife is targeting the California Rangeland Conservation Coalition network to communicate how results can be applied to conservation and land management decisions.


## 2. Addressing Threats to Rangeland Ecosystem Services

Ranches generate multiple ecosystem services including drinking and irrigation water, wildlife habitat, carbon sequestration, livestock production, open space, and cultural values. In California 20,000 acres of rangelands are lost every year. Land conversion and climate change lead to loss of grazing land, water availability, and altered species distribution.

The California Rangeland Conservation Coalition is a partnership of over 100 organizations that have pledged to work together to preserve and enhance California's rangeland for species of special concern, while supporting the long-term viability of the ranching industry. The Rangeland Coalition Focus Area Map (Figure 1) (TNC, 2007) identifies priority areas for conservation and enhancement. These areas have high biodiversity value and require conservation action in the next 2-10 years.

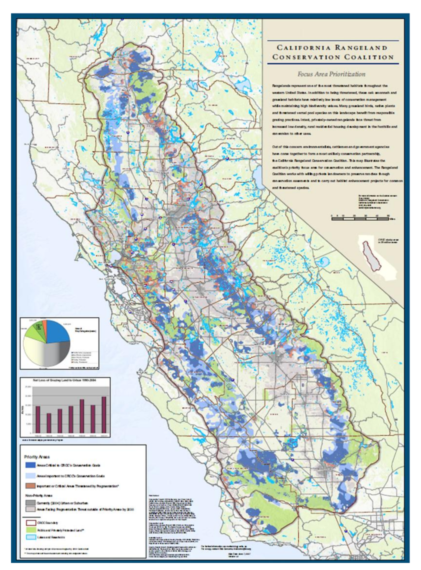


Figure 1. Rangeland Coalition Focus Area Map

## 3. Project Goals

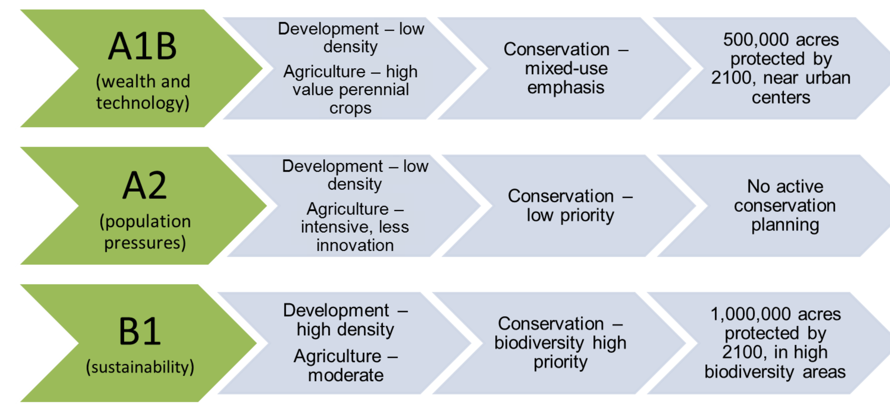
1. Six spatially-explicit climate change/land use change scenarios from years 2000 – 2100 consistent with three IPCC emission scenarios and two global climate models

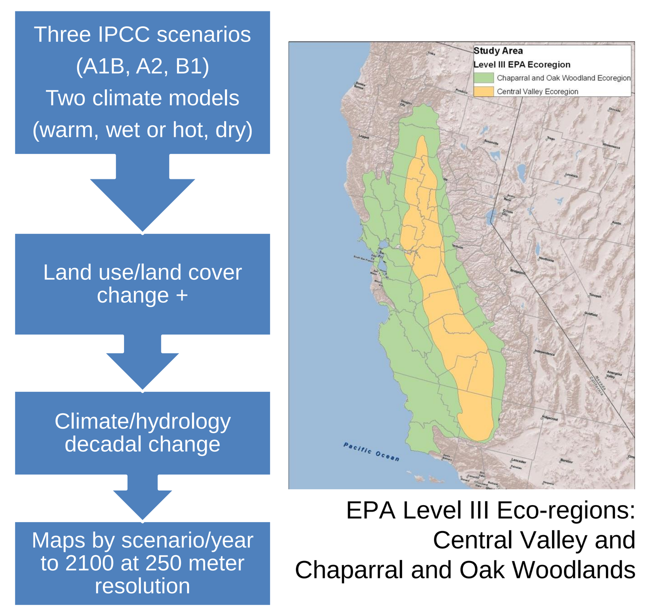
| B1 (sustainability) | A1B (wealth and technology) | A2 (population pressures) |
|---|---|---|
| 1. PCM (warm, wet future) | 1. CSIRO Mark 3.5 GCM (warm, wet future) | 1. PCM (warm, wet future) |
| 2. GFDL CM 2.1 (hot, dry future) | 2. MIROC 3.2 (medres) (hot, dry future) | 2. GFDL CM 2.1 (hot, dry future) |

2. Assess potential threats to rangeland ecosystem services
   1. wildlife habitat
   2. water availability
   3. carbon sequestration
4. An economic analysis of scenarios to quantify economic costs and benefits
5. A web-based visualization tool, and
6. An outreach program that will target the Rangeland Coalition network to communicate how results can be applied to conservation and land management decisions.

## 4. Scenario Development

Figure 2. Scenario Narratives: Scenarios vary by area and distribution of new development and intensive agriculture, and future conservation priorities.




EPA Level III Eco-regions: Central Valley and Chaparral and Oak Woodlands

Figure 3. The FORE-SCE model (FOREcasting SCEnarios of land-use change) integrates land use scenarios and future climate to produce annual maps of future land use change from 2006 to 2100 for each scenario at 250 meter resolution. Map extent covers two EPA level III eco-regions.

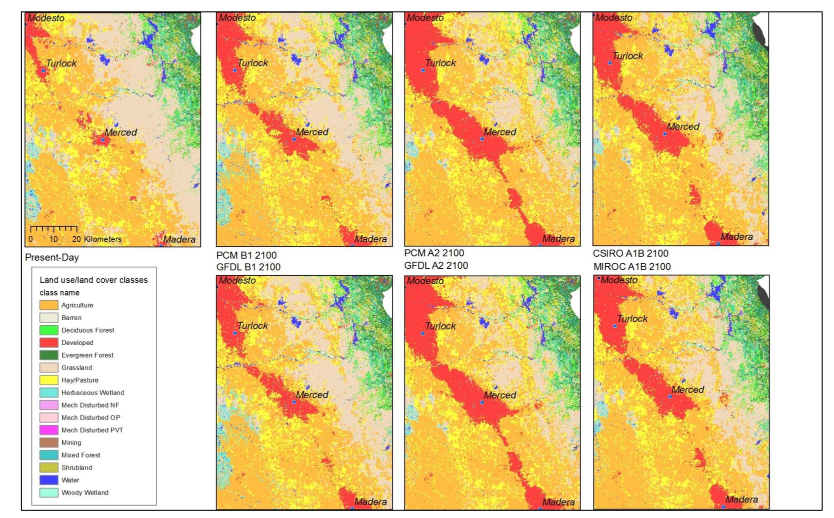


Figure 4. FORE-SCE land use change model results. While all scenarios show an increase in growth, less agricultural expansion and development occur in the B1 scenarios than in the A2 and A1B scenarios.

## 5. Modeling Ecosystem Services Change

| WATER | HABITAT | CARBON |
|---|---|---|
| Basin Characterization Model (Flint et al. 2011) | Change to Priority Conservation Areas (TNC, 2007) | GEMS biogeochemical model (Zhu et al. 2012) |
| Runoff, Recharge, Stream Discharge | Decadal change 2010 – 2100 | Total Ecosystem Carbon 2006 – 2050 |
| 2010, 2040, 2070, 2100 | | |

The Basin Characterization Model is used to examine the effect of urbanization and changing climate on watershed hydrology. Habitat loss is determined by quantifying change to priority conservation areas, and change in total ecosystem carbon is modeled with the General Ensemble Biogeochemical Modeling System (GEMS).

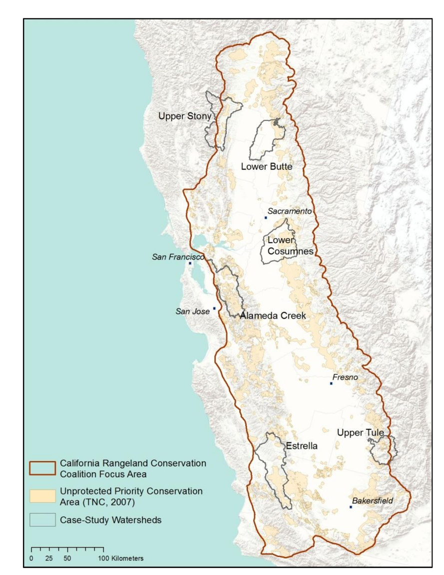


Figure 5. Ecosystem services changes are analyzed at the landscape scale and for six case-study watersheds.

## 6. Water-Wildlife Hotspots

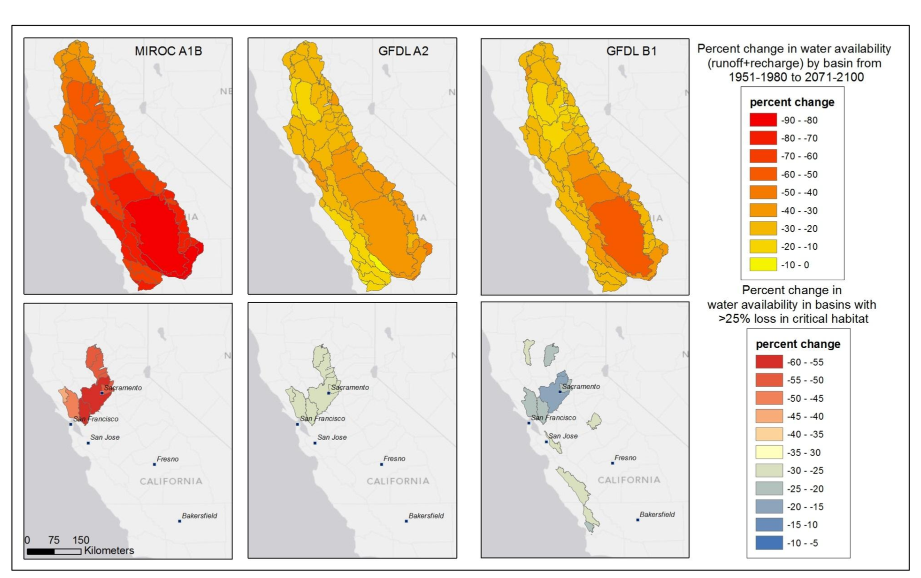
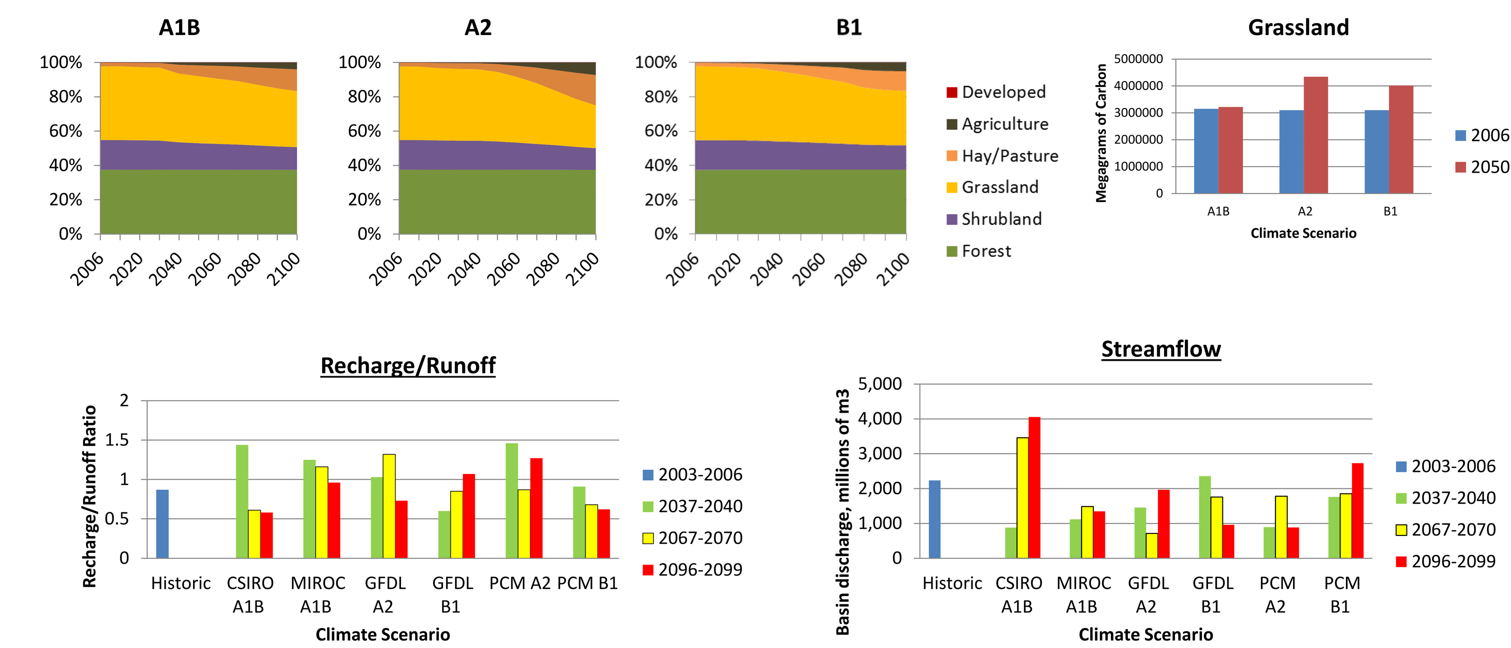


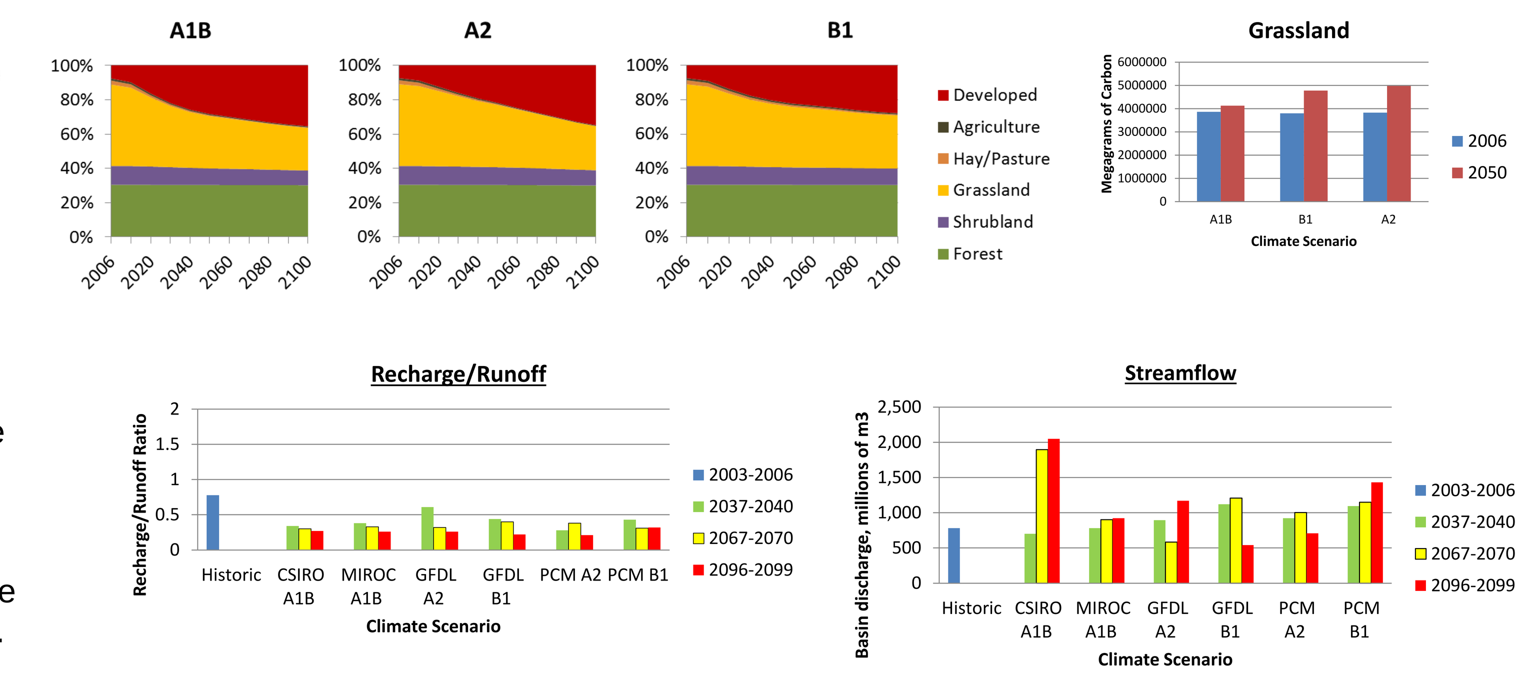
Figure 6. "Water and wildlife hotspots" are areas where changes in water availability and wildlife habitat coincide. We define water availability as runoff+recharge. In each hot, dry scenario, each watershed in the focus area loses water by late century compared to the historical time period of 1951-1980, with losses of approximately 10 to 90% depending on location and scenario (top). Watersheds that lose greater than 25% of critical habitat by 2100 consistently fall within the San Francisco-Sacramento corridor and North San Francisco Bay Area, and experience varying levels of water loss (bottom).

## 7. Two Watersheds – Urbanized and Non-Urbanized

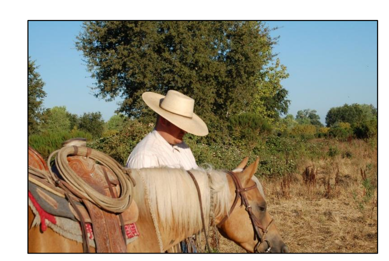
**Upper Stony**: This watershed experiences up to 40% loss in grassland by 2100, primarily due to agriculture conversion. Loss occurs faster in the A1B scenario, resulting in a loss of carbon sequestration capacity up to 37% by 2050. The ratio of recharge to runoff increases in dry years and decreases in wet years, and streamflow is inversely related to recharge:runoff.



**Alameda Creek**: This watershed experiences up to 48% loss in grassland by 2100, primarily due to urbanization. Loss occurs faster in the A1B scenario, resulting in a loss of carbon sequestration capacity up to 24% by 2050. With the combined effects of climate change and urbanization, the ratio of recharge to runoff decreases in all cases, and streamflow is influence by precipitation patterns and rate and location of future growth.



## 8. Outreach



a) Key messages:
   - Inform stakeholders of impacts of climate change and land use change to rangeland ecosystem services
   - Decision-making tool for prioritization of climate change mitigation strategies (i.e restoration sites, conservation easements)
   - Raise awareness about the importance of rangelands in providing ecosystem services

b) Targets: Ranchers and land managers, Government agencies, Non-profits: Ag and conservation organizations, Others: researchers, planners, legislators, general public

## 9. Future Economic Analysis

- Quantify the social cost of carbon emissions associated with grassland conversion
- Link decreases in recharge to costs associated with less availability of water for consumptive and environmental uses
- Link increases in run-off to potential costs associated with mitigating increased sedimentation and other water quality issues
- Analyze changes in stream flow with respect to economic impacts on aquatic habitat
- Analyze land use changes with respect to potential economic impacts on wildlife habitats, including use and non-use values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## 10. Acknowledgments


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