SEA LEVEL RISE PROJECT BRIEF

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Impact of Sea Level Rise on Plant Species: A Threat Assessment for the Central California Coast

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Coastal plants; life on the edge

Sea level rise (SLR) poses a threat to the survival of rare plant species along the central California coast. While global mean sea level has been steadily increasing for at least 20,000 years, this trend has accelerated in the last 15 to 20 years in response to climate change. Projecting into the future, the State of California estimates that the Pacific Ocean will rise 1.4 meters by 2100.

As coastal plant species are increasingly exposed to SLR, they must adapt by moving to safer ground. However, being sedentary, plants are highly susceptible to fast changes in sea level. Adaptive migration can be difficult for rare plant species with small populations, which may be constrained by dispersal ability, genetic diversity, and available habitat.


Castilleja ambigua ssp insalutata

As an additional pressure, many migrating plant populations will be squeezed on the inland side by urban development. Finally, climate change is likely to cause dramatic shifts in suitable habitat.

Extinction: the future of rare coastal plant species in California?

Despite these concerns, the threat of SLR to plant species has received relatively little attention. The U.S. Fish and Wildlife Service (USFWS) would like to evaluate the impact of SLR in listing decisions and recovery plans for threatened and endangered species. By assessing the impact of SLR, the agency can better comply with its mission under the Endangered Species Act of 1973 to protect vulnerable species from extinction.

Project Objectives

1. Quantify the exposure of plant species to sea level rise in the Tri-County region.
2. Identify future suitable habitats for threatened species throughout California.

THREATS ANALYSIS

We assessed the exposure of plant species to three physical processes that are exacerbated by SLR: inundation, flooding, and erosion. SLR will increase the inland extent of all three processes, which could submerge populations or reduce their available habitat.

Inundation is defined as the tidal submergence of seaside land.

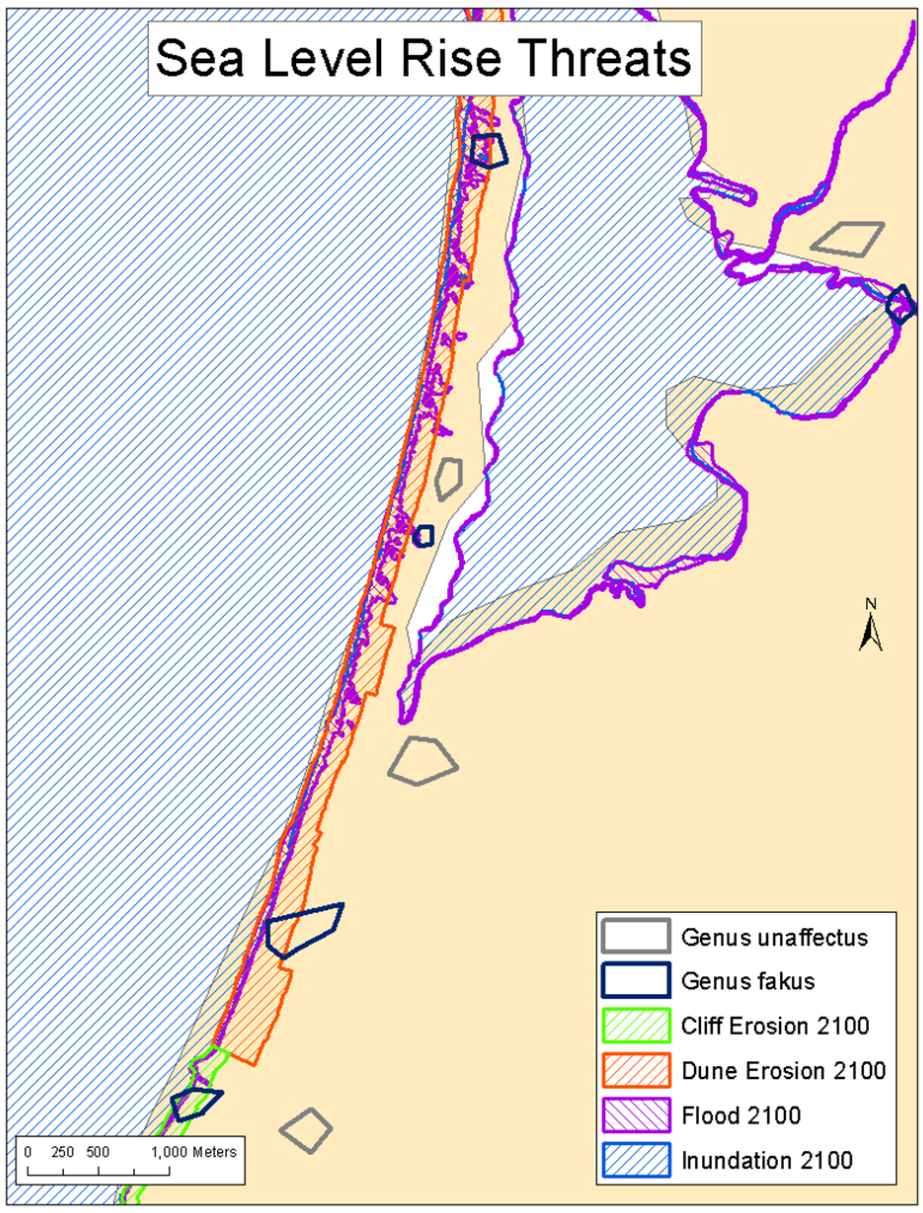
Flooding during storm events occurs less frequently than inundation but can extend much farther inland.

Erosion is the wearing away of land through the removal of dune or cliffs along the shoreline.

Our SLR threats assume a 1.4-meter rise in sea level by 2100, a figure widely used by the State of California for climate-change planning purposes. We analyzed the threats across three time horizons: 2025, 2050, and 2100.

For in-depth analysis, we chose nine rare plant species that represented a diverse range of life histories, habitats, elevation, level of endemism, and listing status within the Tri-County Area (San Luis Obispo, Santa Barbara, Ventura).

To identify larger trends, we expanded our scope to 88 coastal species in the Tri-County Area. Overlaying the locational data for species on top of the threat data, we analyzed the potential threat for each of these occurrences.



Modeling Species Distributions

After quantifying the exposure of our species of interest to SLR, we undertook a secondary analysis to estimate the available area to which a species could move in the future. We used Maximum Entropy (MaxEnt), a species distribution model, to gain insight as to where the species may occur currently and in the future.

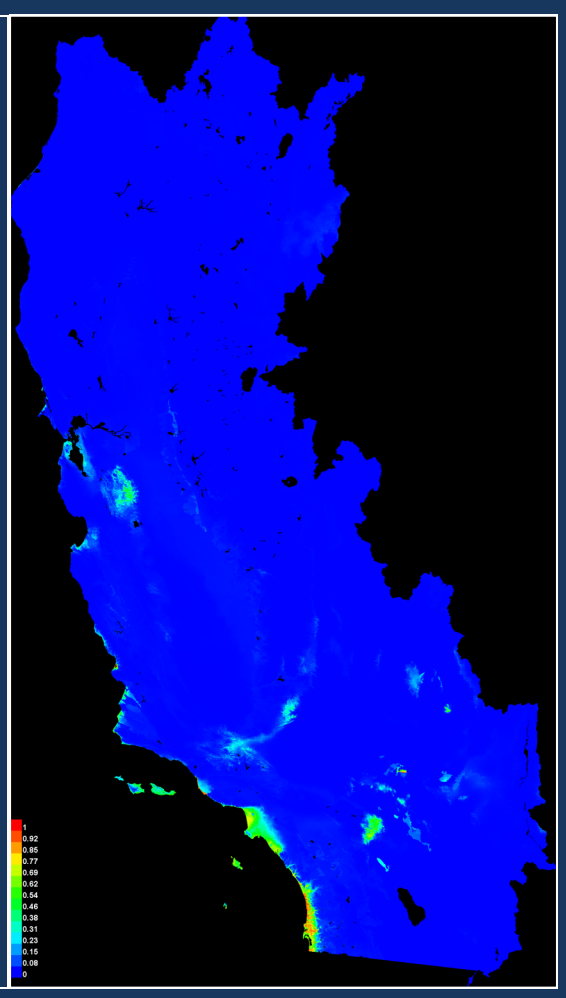
To take into account SLR, we then overlaid SLR-related threats on top of future habitat areas to determine non-threatened habitat in 2100.


C. maritmúm spp. *maritimum*

We ran this analysis on one of our species, *Chloropyron maritmum* spp. *maritimum*, which was shown to be extensively threatened by SLR.

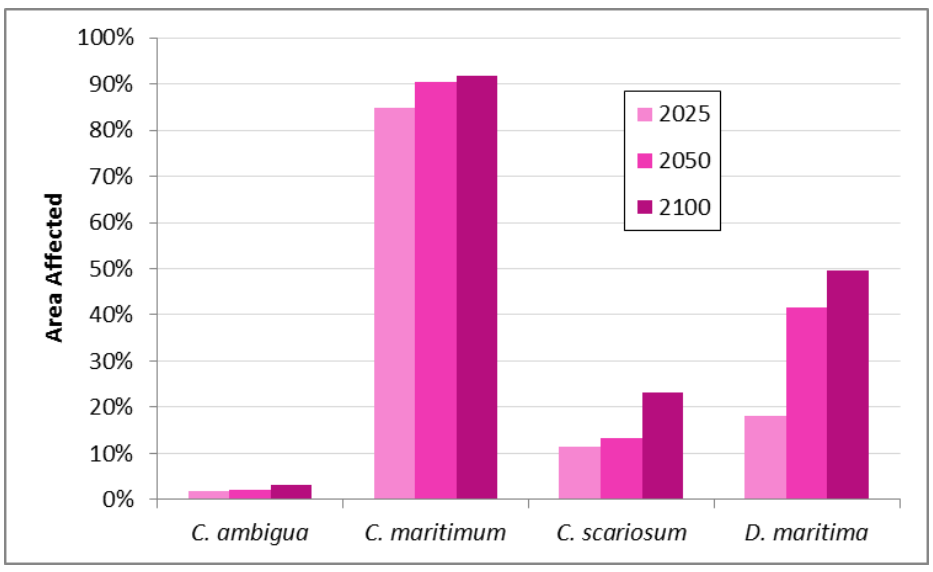
To project future suitable area, we used two downscaled general circulation models (GCM) under the IPCC A2 emissions scenario: the NOAA Geophysical Fluid Dynamics Laboratory (GFDL), which predicts a hotter drier climate and the Parallel Climate Model (PCM), which predicts a warmer, wetter California. We compared these two projections against the PRISM projection, which predicts current suitable habitat The PRISM GCM shows an area of 2,842km^2 in California with only 4% (114km^2) in the Tri-County region.

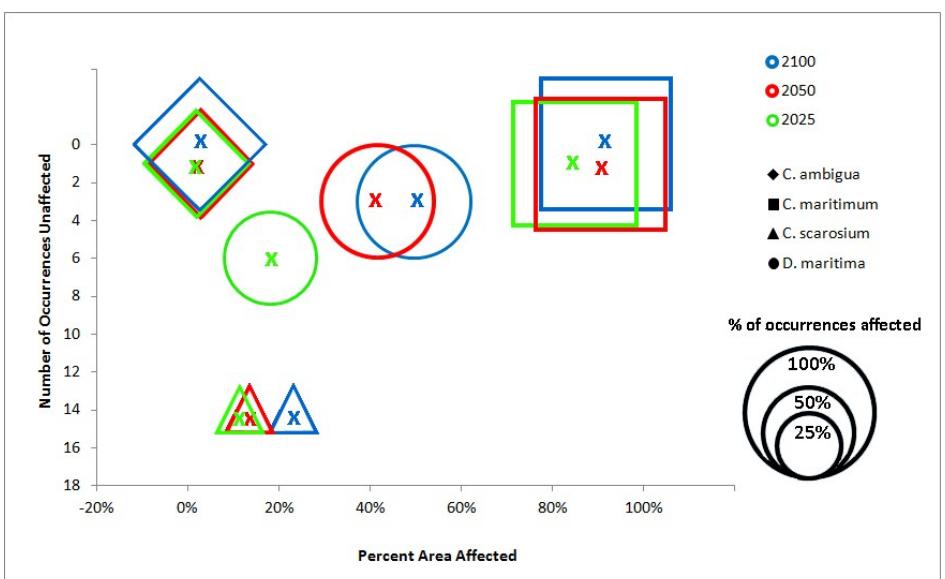
PRISM GCM: Current projected range



RESULTS

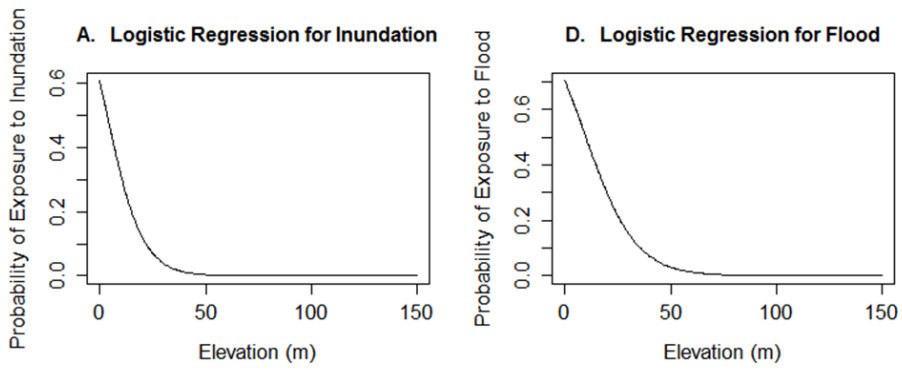
From our in-depth analysis, we found that **four of the nine species were exposed to at least one of the SLR-related threats**. The following graphs show the results of analysis, the first graph showing area affected while the second graph takes into account species' occurrences and area.

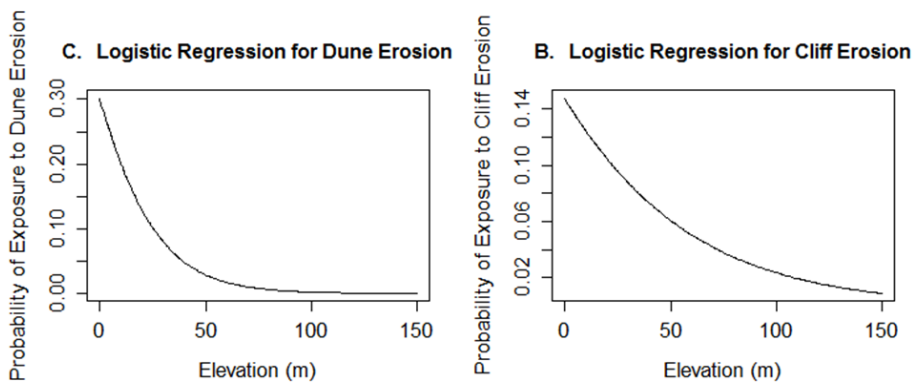




Our results show that *C. maritimum* will be most severely affected with regards to both area and occurrences. *C. ambigua* has a marginal amount of its area affected yet all of its occurrences will be impacted.

In the broader analysis of 88 species, we found that **as elevation increased, the odds that a species would be threatened decreased** by 0.94 to one.



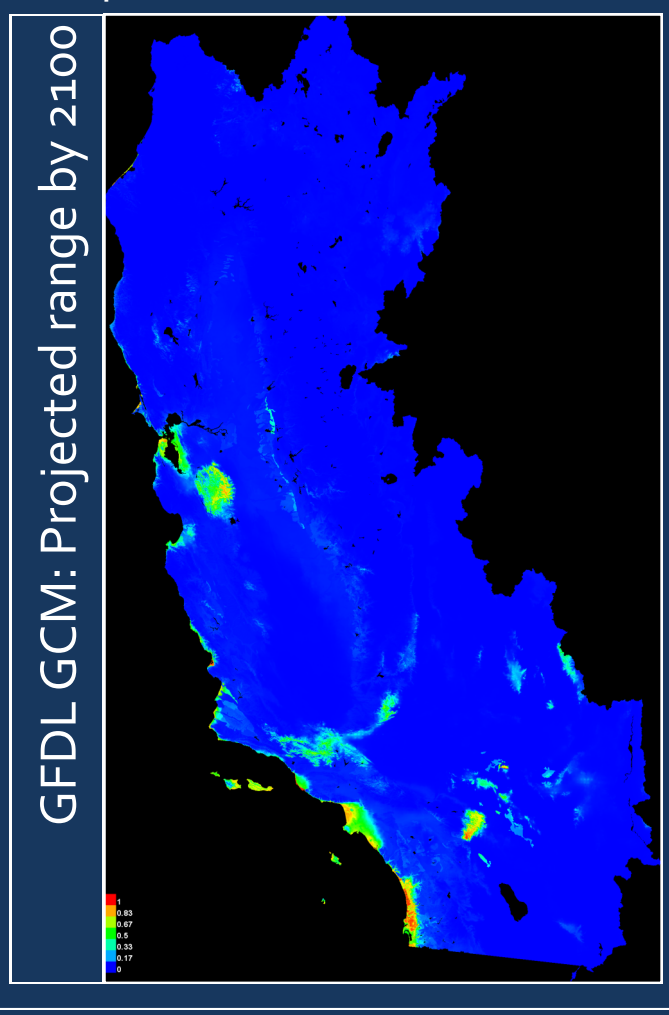


Our results suggest that a range of species occupying coastal wetlands, dunes, and bluffs will be threatened.

Our projections show available future habitat for *C. maritimum*, although this area varied between the two climate projections.

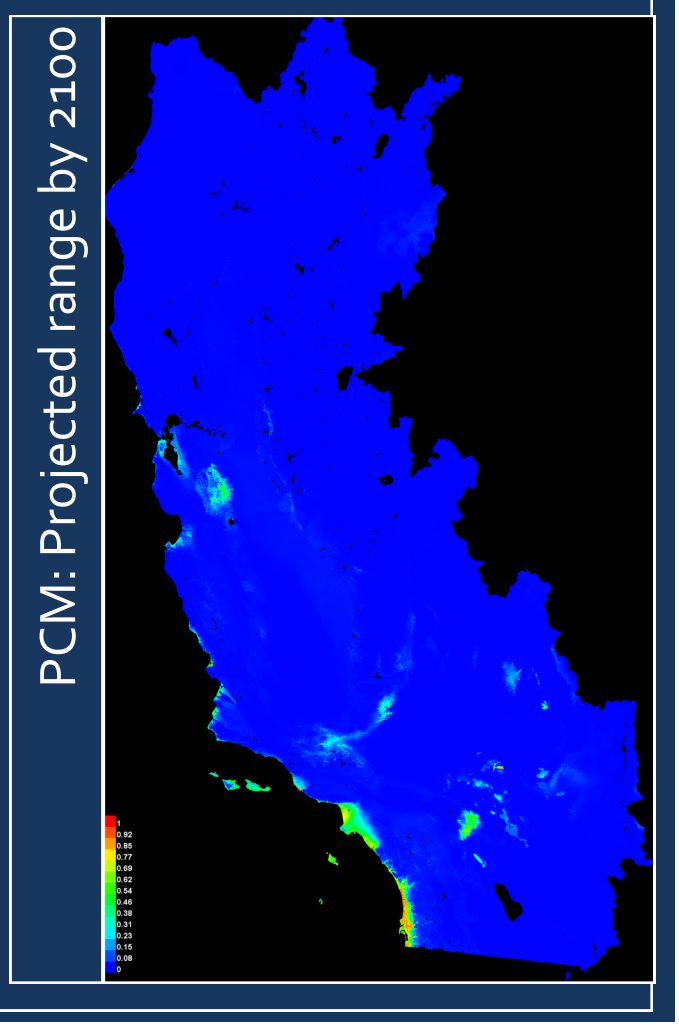
The GFDL model projects an increase in suitable habitat to 7,170km^2. This is an increase of 252% when compared with PRISM's current projections.

12.7% of the area is located in the Tri-County region. Overlaying threats reduced this potential habitat by 9.3% or 84.5km^2 .



Unlike the GFDL model, our PCM projection shows a decrease in suitable habitat to 2,630km^2: a 0.075% decrease when compared to PRISM's projections. Of this, 77.6km^2 of suitable habitat is located within the Tri-County Area, with 42.8% (33.2km^2) found to be threatened by SLR threats projected for 2100.

By incorporating SLR in species distribution modeling we hope this analysis will aid USFWS to create more informed management practices for this threatened species.



Discussion

Our results suggest that elevation is an important indicator of whether a species is affected by SLR. This suggests that other rare species found at lower elevations may also be in danger from sea level rise. Furthermore, our in-depth analysis was corroborated by the larger analysis of 88 species, in that the proportion of species projected to the exposed to SLR remained approximately the same. Finally, cliff erosion seemed to have the smallest effect on species, while flooding remained the most important threat factor overall. This information would be especially important for managers who may concentrate on measures that would reduce threat of flooding rather than erosion.

SLR may not be the largest threat to each species when compared to the dramatic geographic shift in species' climatic ranges. However, SLR will likely serve as an additive impact, exacerbating habitat loss from potential range contraction, urban development, and competition from invasive species in addition to the problems that rare, threatened, and endangered species already face.

Recommendations

Our results can help USFWS to argue for the listing of rare species under the Endangered Species Act, enabling greater protection for such at-risk species since two of the four affected species in our in-depth analysis are not currently listed.

Additional SLR threats resulting from this analysis may warrant keeping *C. maritimum* spp. *Maritimum*'s endangered status until management actions can increase resistance or resiliency to these threats.

Information from this project can allow agencies to issue mitigation or permitting requirements from potential development under the California Environmental Quality Act (CEQA) and the California Coastal Act.

USFWS may use the threats analysis output from our model to avoid future mitigation, transplanting, and other resource-intensive management efforts in the areas identified as SLR threat zones.

More work is needed to evaluate the feasibility of options, better define the cost-effectiveness, and provide additional guidance for management. The specific effects of climate-related stressors on microhabitats and individual organisms are still highly uncertain, as are the expected responses that will result from implementing adaptation strategies.

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