Final Report

Project Title: Incorporating the geography of climate change into conservation planning for the California Landscape Conservation Cooperative

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Project Performance Period: 8/2010 - 3/2015

Award Total: $67,332

Report Date: 3/31/2017

Project Goals:

1. Acquire downscaled data and historical products to establish baseline conditions

2. Generate ecologically relevant climate-related data

3. Generate scripts to analyze climate data and compute rates of change

4. Assess climate conditions and vulnerability of PAs within as subset of the CA LCC

5. Prepare report (OFR) on the methodology and results of PA subset, send out for review, and incorporate comments into methodology

6. Assess climate conditions and vulnerability for entire CA LCC

7. Priority analysis of corridors within the CEHC, report, journal paper

8. Design of future research projects capitalizing on this data

Goals Completed:

1. The original data the project proposed to use was developed for CMIP3 and downscaled for the Basin Characterization Model (BCM) of the USGS. While this project was ongoing, the next version of this climate dataset (CMIP5 - http://cmip-pcmdi.llnl.gov/cmip5/) was completed, downscaled, and made available for the project area. This resulted in a broader set of projections to be considered for the climate stability metric and other analyses. CMIP5 and the 2014 BCM (http://climate.calcommons.org/dataset/2014-CA-BCM) datasets are currently the most relevant climate and hydrological datasets available for California.
2. Workshops with the Terrestrial Biodiversity and Climate Change Cooperative (TBC3.org, to which the PI is a Primary Investigator) led to the development and testing of the climatological and hydrological variables that best explain the heterogeneity of vegetation groups in the greater Bay Area of California. These three variables, DJF Tmin (winter average minimum temperature), JJA Tmax (summer average maximum temperature, and CWD (climatic water deficit) were then used in subsequent analyses to understand the spatial variation of climatic condition through time across California.
3. This project developed a technique to measure the climate stability of a given geography and compute the similarity between different time periods or climate projections to understand how much change a given location would experience with climate change. For any given place, a convex hull can be created based on the variables considered important to describe that places climatic conditions. This *n*-dimensional climate hull represents the conditions vegetation or biodiversity has adapted to, but is not static. To understand how it might change under future conditions, we calculate the overlap in climate space between the historical climate hull, and a climate hull based on a climate projection. If the two overlap, there is some amount of stability between present and future. If the two hulls do not overlap, they can be considered departed.

4. To demonstrate the climate stability method, the Bay Area was used as a case study to assess the climate stability of the current protected area network, and to understand how additions to the protected area network could increase climate resiliency. This case study, Heller et al. (2015), was published in the journal Ecosphere, and illustrated how the climate stability methods could be combined with conservation area design to inform systematic conservation planning in light of climate change.

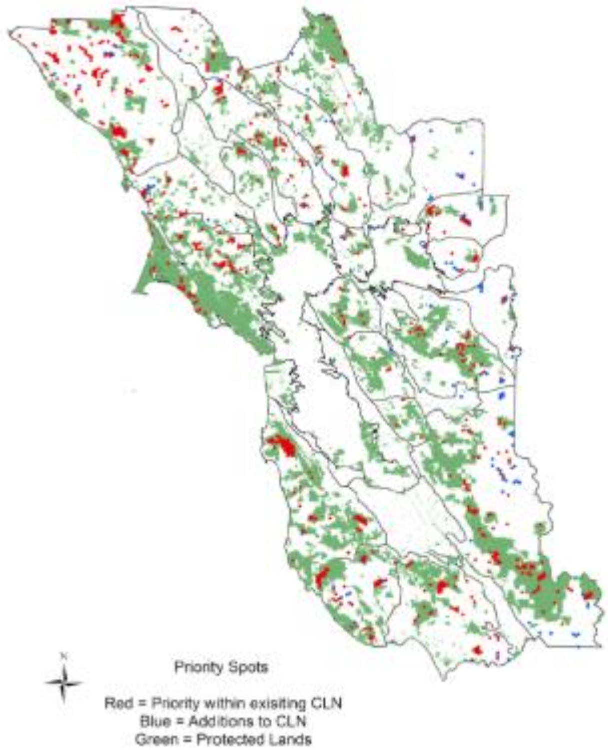

Figure 1: Climate priority spots for conservation investment within landscape units in the San Francisco Bay Area. Red shows climate priority spots identified within the existing 2011 CLN, and blue shows climate priority spots not already identified within the CLN. Blue spots warrant additional investigation for conservation. Green areas show existing protected lands (Figure 9 from Heller et al. 2015).

5. To demonstrate how the climate stability method could be used to assess the climate contribution of a conserved habitat corridor, a separate analysis was completed. Here, the goal was to analyze data from the Bay Area Critical Linkages project, to determine where the conservation of defined linkages would maximize the climate stability of the Bay Area protected area network. Each corridor was assessed and ranked based on its increase in stable area. Land use change threats to those corridors were also used to determine which corridors contributed to climate stability and were likely to be lost without conservation intervention. In the Bay Area, three defined corridors are at threat from land use change, and highlighted below in figure 2.

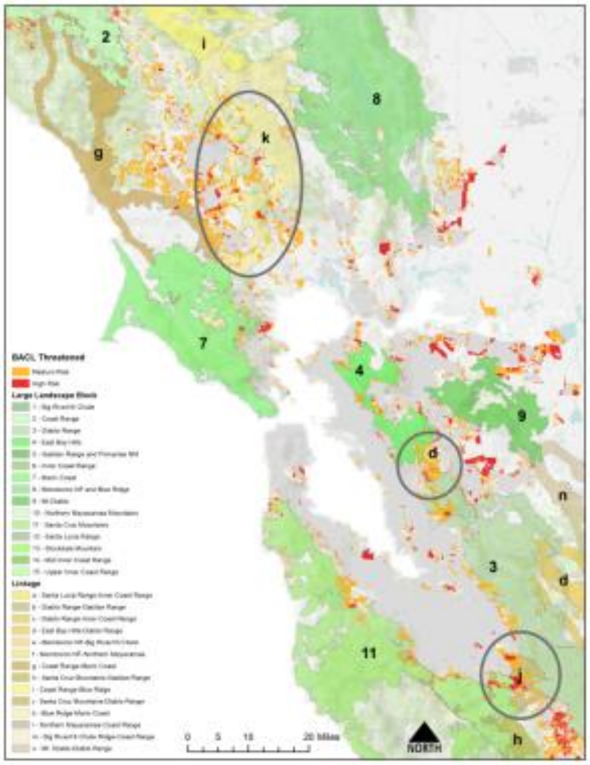

Figure 2: The large landscape blocks and linkages from the Bay Area Critical Linkages project. Land use change threats show areas threatened by development that would transition natural habitats to developed land uses. The three linkages circled (d, j, and k) are areas that provide connectivity among large landscape blocks, and if that connectivity were lost a subsequent large loss of connected climate space would occur.

6. To assess the climate conditions and vulnerability of the entire CA LCC the climate stability methods were applied to the California network of protected areas. These include lands with GAP management status of 1-3 (typically land protected from development, ranging from National and State Parks to National Forests and BLM land). For purposes of analysis and to maintain continuity with the California Essential Habitat Connectivity Project (CEHC), the thousands of protected areas were combined by adjacency, resulting in 304 natural landscape blocks (NLB). These blocks represent contiguous tracks of protected areas. The NLBs formed the geometry used in the climate stability methods to determine the change in climate stability over time, and with the different climate scenarios and models. An example using the A2 emissions scenario is below in figure 3.

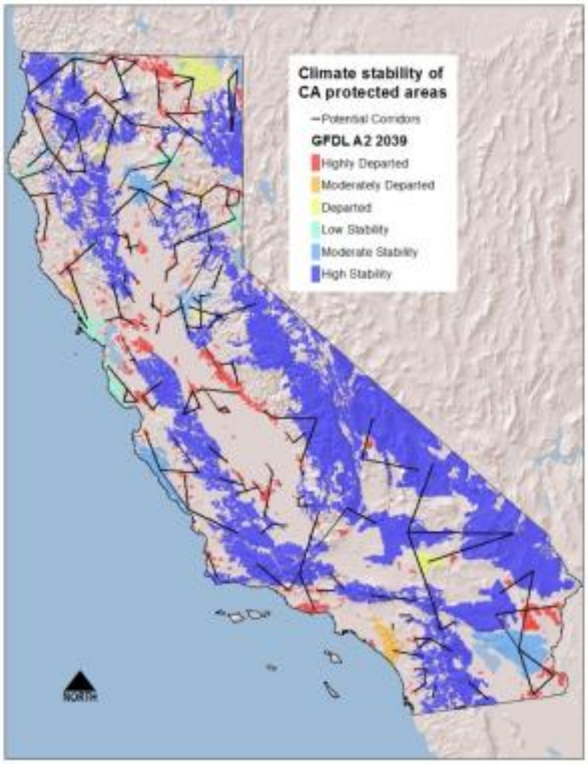

Figure 3: The climate stability of NLBs in California according to the GFDL model, under scenario A2, for year 2039. Black lines represent named corridors from the CEHC project that connect the NLBs.

7. The final step in this project was to assess, at the state level, how protecting corridors from the CEHC project could result in increased climate stability for the whole California protected area network. Specifically, the objective was to prioritize corridors based on their contribution towards increasing protected area resilience to climate change. This was implemented by maximizing the climate stability of the entire protected area network through corridor conservation. The prioritization routine used a stepwise algorithm to rank corridors based on the largest increase in climate stability per acre of corridor. By standardizing the contribution of each corridor based on a measure of approximate cost (area in this case), corridors were prioritized cost-effectively. To allow comparison across climate scenarios, a constraint of 250,000 acres was used to create a corridor prioritization. Using this prioritization, several analyses shed light on the effect of conserving corridors. Specifically, the implementation of the top 250k acres of corridors would result in 30.7 million climatically stable acres within the CA protected area network, compared to 25 million without corridors (GFDL A2 2039 scenario). This selection is shown in figure 4a, below. Also, when comparing prioritization results across four model/scenario combinations, there was a high degree of similarity (pairwise correlation of 0.78-91) indicating that regardless of whether the future more closely represents an A2 or B1 scenario, the corridor prioritization is relatively robust (figure 4b). A manuscript describing tasks 6 and 7 is in preparation for submission to an ecology or conservation journal.

8. A project goal was to use this data and understanding to hopefully create new research projects that would capitalize on this project. This work has led to a number of different efforts, and is described in the Project Impacts section, below.

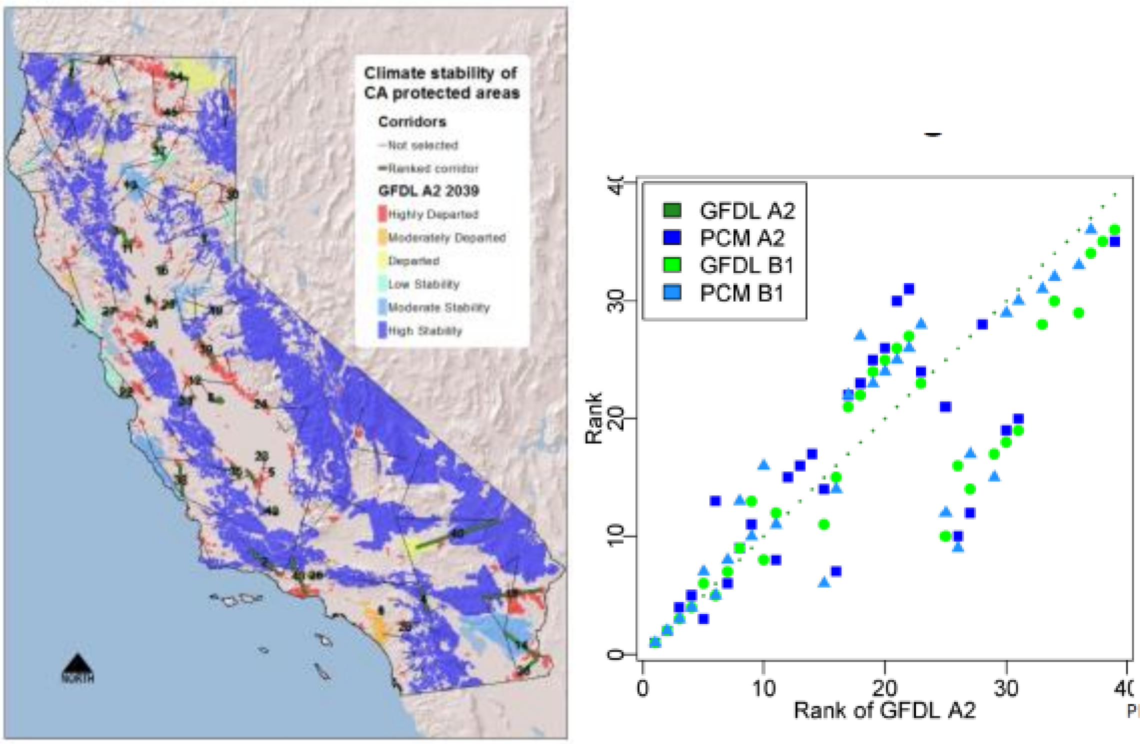

Figure 4: (A - left panel) A prioritization of corridors from the CEHC based on their contribution towards maximizing total stable area of the CA protected area network. Corridors are numbered based on their rank of importance according to the selection algorithm (1 being highest). The algorithm uses the change in stable area/corridor area to rank corridors, but change in stability (red through purple color scheme) is not shown in this figure. (B - right panel) Comparing the rank of the different scenarios to the GFDL A2 scenario shows the prioritizations according to each scenario are very similar, particularly for the tope 10 corridors. This indicates the procedure is robust to the choice of scenario.

Project Impacts:

This project has contributed to other research and in unintended ways. Current research by TBC3 is using a modified version of the climate stability method to calculate climate heterogeneity for a given geography. This is useful to understand how the variation of climate heterogeneity compares for different locations. In conservation planning, a popular research theme is to 'conserve the stage', in hopes that having a wide variety of land facets will facilitate future reorganization of biodiversity across the landscape, and is in response to the complication of predicting where individual species (and interspecies competition) will shift under future climates. The TBC3 research thread follows this original CALCC funded project and Heller et al. (2015).

The Heller et al. (2015) publication was not originally planned in this project's proposal, but work in the Bay Area and with TBC3 co-authors seemed like a good first test of the climate stability method. Similarly, the evaluation of the Bay Area Critical Linkages from a climate stability perspective was not initially conceived as a research project, but the Moore Foundation and Bay Area Open Space Council provided add-on funding to assess their specific geography.

Finally, the Central Valley Landscape Conservation Project (CV LCP) may benefit from this research in two major ways. First, by understanding the direction and magnitude of climate stability of CV LCP protected areas (the NLBs described above) according to the 2014 BCM scenarios and data. And second, by using the CEHC corridors and prioritization information from this project to assess corridor importance from the perspective of the LCP, recognizing that certain species and their connectivity requirements may change the climate priority developed in that project.