CA LCC FY2013 Project Summary Report September 16, 2013

Confronting Uncertainty in Species Distribution Projections

Healy Hamilton, PI, Independent Scientist
Sam Veloz, coPI, Point Blue Conservation Science (formerly PRBO)

Our project is conducting a comprehensive analysis among multiple sources of uncertainty in the process of modeling species distributions under climate change. The overarching goal is to increase the applicability of range shift models as a tool of management action by identifying the relative importance of different sources of variation in model outcomes. Focal species for our modeling effort are a representative sample of 50 species of California breeding birds and 50 species of plants endemic to the California floristic province. Deliverables according to the original proposal included 1) metrics of the degree of projected change across bioclimatic requirements for 100 plant and bird species, and quantification of the uncertainty in those projections, 2) identification of areas of climate refugia and high climate turnover for the modeled bird and plant species, 3) spatial data layers demonstrating the proportion of variation explained by each source of uncertainty tested, and 4) dissemination of synthesis maps via the Environmental Change Network and other data portals, as appropriate.

1) Personnel

Technical staff are assisting PIs with this data and modeling intensive project. Dennis Jongsomjit, GIS specialist at Point Blue, has worked closely with Sam Veloz on modeling bird distributions and all aspects of bird and environmental data creation, curation, and management. Cynthia Powell, GIS technician at CalFlora, has been the primary technician working with Healy Hamilton, and has been responsible for all plant species data acquisition and modeling. Miguel Fernandez, a graduate student in the Hamilton lab, has been contributing since the proposal inception to project design and analysis. During the most intensive modeling phase, it was necessary to bring in Otto Alvarez, a computer programmer and spatial analyst in the Hamilton lab, to assist C. Powell with the modeling effort.

2) Plant species selection and locality data acquisition

To assemble the required dataset of 50 plant species and associated locality data, we began with the 591 species modeled in Loarie et al's 2008 publication on climate change impacts to the California endemic flora. We filtered out all species with less than 70 occurrences, and circulated the remaining list among land managers from CA state parks, US Forest Service, NPS, and county municipal districts. With feedback from these managers about their priority plant species, we then filtered a final list by assessing the quality of point locality data available from the combined databases of the California Consortium of Herbaria and CalFlora.

3) Bird species selection and locality data

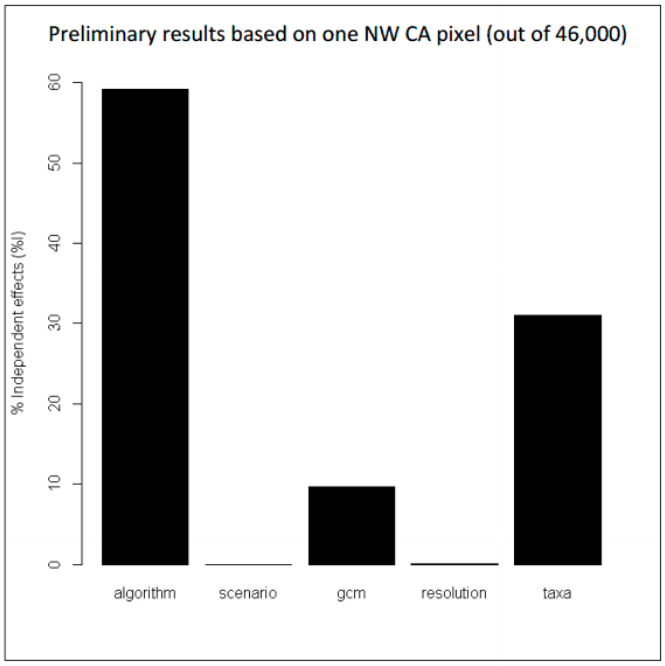
The species selected and the locality data available for each species were derived from previous Point Blue research, as described in Stralberg et al 2009.

4) Current and future climate data
Multiple sets of current and future spatial climate data layers were created at 3 spatial resolutions. Current climate was derived from PRISM 800m data, which was then converted from 36 layers: monthly minimum and maximum temperature and monthly total precipitation, to 19 bioclimatic variables more ecologically relevant in determining species distributions. These were further reduced to a final set of bioclimatic variables to minimize autocorrelation among related variables. Future climate conditions were derived from 16 different global climate models, each run under a high emissions and low emissions scenario. Every layer was then resampled at 4km and 10 km resolution to support testing of the influence of spatial resolution on model outcome.

5) Modeling algorithms
We expanded the number of modeling algorithms from the four we originally proposed to a total of six. By including a greater number of modeling algorithms, we then had the flexibility to drop one or more poorly performing algorithm for any given taxon. Our rationale was to improve our results by retaining only high performing models. This additional effort is aimed at reducing the variability attributable to modeling algorithm by excluding poorly performing algorithm prior to our partition analysis.

6) Individual species modeling effort
Species distribution models were created for 100 plant and bird species, using 6 SDM algorithms, for the current and the midcentury future, run under 16 different climate models and 2 alternative emission scenarios, for 3 different spatial resolutions. A total of 59,400 individual species distribution models were generated for the analysis of variance across different sources of uncertainty.

7) Analysis of variance
The final analysis step in this project is currently underway. This lengthy and computationally intensive step required loading all individual species model outputs, and querying every pixel in California for all resolutions as to the variation in model results. An example of a preliminary result for a single pixel in northwestern California is shown. For this pixel, the results suggest that spatial resolution and emissions scenario have very little influence on model variation, and



choice of GCM has only a moderate contribution, whereas SDM algorithm and plant or bird species have lager influences.

8) Timeline

The timeline for this project has been significantly affected by the elimination of Hamilton's position at the California Academy of Sciences. The legal, logistic, contractual, personnel, and infrastructural issues resulting from this job loss negatively impacted many aspects of the project. The restructuring that has been necessary to fulfill project obligations has so far added one year to the original project timeline. As noted above, the final analysis phase is currently underway. We anticipate a timeline of approximately 4 months from the completion of the analysis of variance to manuscript submission.

9) Funding & Infrastructure

The financial resources originally requested for this project were based on supporting contributions from the Academy of Sciences and PRBO. The Academy broke the contract with FWS and returned the project funds, resulting in loss of CAS' in-kind salary contribution and loss of the computational infrastructure required to conduct this computationally intensive project. As a first move to overcome this critical obstacle, Hamilton purchased 10 TB of data storage to expand the capacity of PRBO, with the Hamilton lab remotely accessing PRBO's servers. However, this solution did not prove tenable due to slow internet connections and insufficient server capacity. The Hamilton lab subsequently purchased a new server with funds from other projects, and each group conducted parts of the modeling effort on their respective systems. These unexpected challenges significantly delayed the project timeline.

Sound Science, LLC, stepped in as fiscal sponsor for the portion of the original funding intended for the Academy of Sciences. Besides the computer equipment purchased for PRBO, all of the project funds administered by Sound Science have gone to Hamilton lab personnel Powell, Fernandez, and Alvarez. All project funds have been disbursed to accomplish work completed to date.

10) Literature Cited

Loarie SR, Carter BE, Hayhoe K, McMahon S, Moe, R, *et al* (2009) Climate change and the future of California's endemic flora. *PLoS One* 3:e2502

Stralberg D., Jongsomjit D., Howell CA, Snyder MA, Alexander, JA, *et al* (2009). Reshuffling of species with climate disruption: a no analog future for California birds? *PLoS One* 4:36825