To Be Or Not To Be: The Fate of Ten Amphibians in Sierra Nevada in a Warming Climate

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INTRODUCTION

Amphibians worldwide are facing a severe problem of biodiversity decline. In California, 22 out of 69 salamander, frog, and toad species are facing conservation risks. With multiple underlying environmental factors, the effects of climate change and it induced snowpack reduction are still controversial and undetermined.

Current studies infer that climate change is indirectly driving the decline of amphibian biodiversity in California. The snowpack in Sierra Nevada serves as a source of water supply which replenishes mountainous streams and lakes laying inside amphibian habitats in summer. Observations and projections support in the future a warmer winter and spring temperature, more precipitation falling as rain and less as snow, reducing amount of accumulated snow after wet season, and earlier snowmelt in spring. Sensitive to climate warming, the reducing size of snowpack is presumptive to become another factor linked to amphibian biodiversity decline.

OBJECTIVES

1. How well would the model perform given current climate and snowpack levels?
2. How would species response under projected climate and snowpack levels in 2050 and 2070?
3. How would the two RCP levels influence the projection outcomes?

MATERIAL & METHOD

Sierra Nevada Region

I used Sierra Nevada Conservancy (SNC) Region map to define the study area.

Studied Species

I picked 10 species from 5 families: *Ambystoma macrodactylum, Batrachoseps gregarius, Hydromantes platycephalus, Taricha sierrae, Anaxyrus boreas, Anaxyrus canorus, Rana muscosa, Rana sierrae, Rana cascadae,* and *Rana boylii*.

Species Occurrence Data

I collected historical occurrence data using specimen records in the Museum of Vertebrate Zoology from 1950 to 2000, removed occurrences without coordinates or outside SNC, and checked environmental outliers and geographical errors with GIS.

Environmental Data

Time Interval and Projection Scenarios

Current climate levels were averages from 1960 to 1990 and snowpack levels were averages from 1950 to 2000. I made projection in 2050 and 2070 under RCP 4.5 and RCP 8.5. The 2050's levels were averages from 2041 to 2060 while those for the 2070's were from 2061 to 2080.

Data Sources

I used 7 bioclimate variables (BV) from WorldClim: annual mean temperature (bv_1); mean diurnal temperature range (bv_2); maximum temperature of the warmest month (bv_5); minimum temperature of the coldest month (bv_6); annual precipitation (bv_12); precipitation seasonality (bv_15); and precipitation of the driest quarter (bv_17).

The 7 BV were initially used in Graham and Hijmans's research in 2006. In this project, model using these 7 BV as climate variables outperformed other models that combined temperature seasonality, precipitation of wettest quarter, and precipitation of the coldest quarter as climate variables.

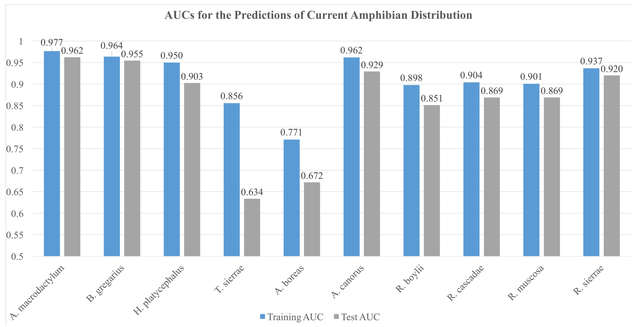
I obtained snow water equivalent (SWE) data from Cal-Adapt and computed the average and range for the period from January to April. Both current and future values were based on HadGEM2-ES model.

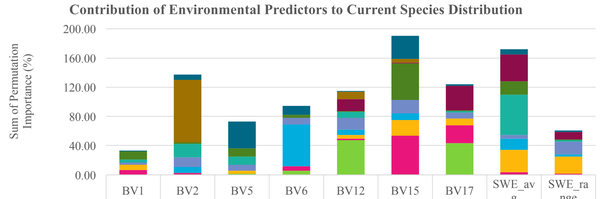
Data Analysis

With BV and SWE, I used Maxent, a maximum entropy modelling method, to make predictions on current species distribution and projections into future climate scenarios. I ran with replicates for both predictions and projections and used average AUCs, variable contributions, and thresholds to make comparison and create binary maps.

RESULTS-1

Model Performance under Current Climate and Snowpack Levels





	BV1	BV2	BV5	BV6	BV12	BV15	BV17	SWE_avg	SWE_range
R. sierrae	0.66	7.55	36.46	12.01	0.96	31.65	2.04	6.45	2.21
R. muscosa		85.83			9.79	4.38			
R. cascadae					16.97	1.54	34.27	37.25	9.97
R. boylii	11.27	2.18	11.30	3.86	0.89	49.25	1.40	17.92	1.93
A. canorus	3.93	18.02	11.86		7.45	0.23	1.44	55.66	1.40
A. boreas	3.33	13.42	7.48	9.32	16.94	18.96	8.49	4.61	17.44
T. sierrae		7.71		57.48	7.00	8.78		15.70	3.33
H. platycephalus	6.71	0.16	4.17		5.54	21.21	8.91	30.38	22.92
B. gregarius	7.07	1.81	0.52	5.84	1.62	53.62	25.01	3.15	1.36
A. macrodactylum		0.83	1.45	5.68	47.51	0.35	43.02	0.56	0.61

CONCLUSION

1. Key environmental variables:
   a. Average snow water equivalence from January to April
   b. Precipitation seasonality
   c. Annual precipitation
   d. Mean diurnal temperature range
2. Two groups that need conservation attention:
   a. High-elevation endemic species
   b. Species from the family of Plethodontidae
3. New species interaction due to change of range.
4. RCP4.5 is more bearable than RCP8.5 for most species.
5. Future studies should fully cover the current range for potential declining species to project their fate more accurately.

RESULTS-2

Species Response under Projected Climate and Snowpack Levels

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