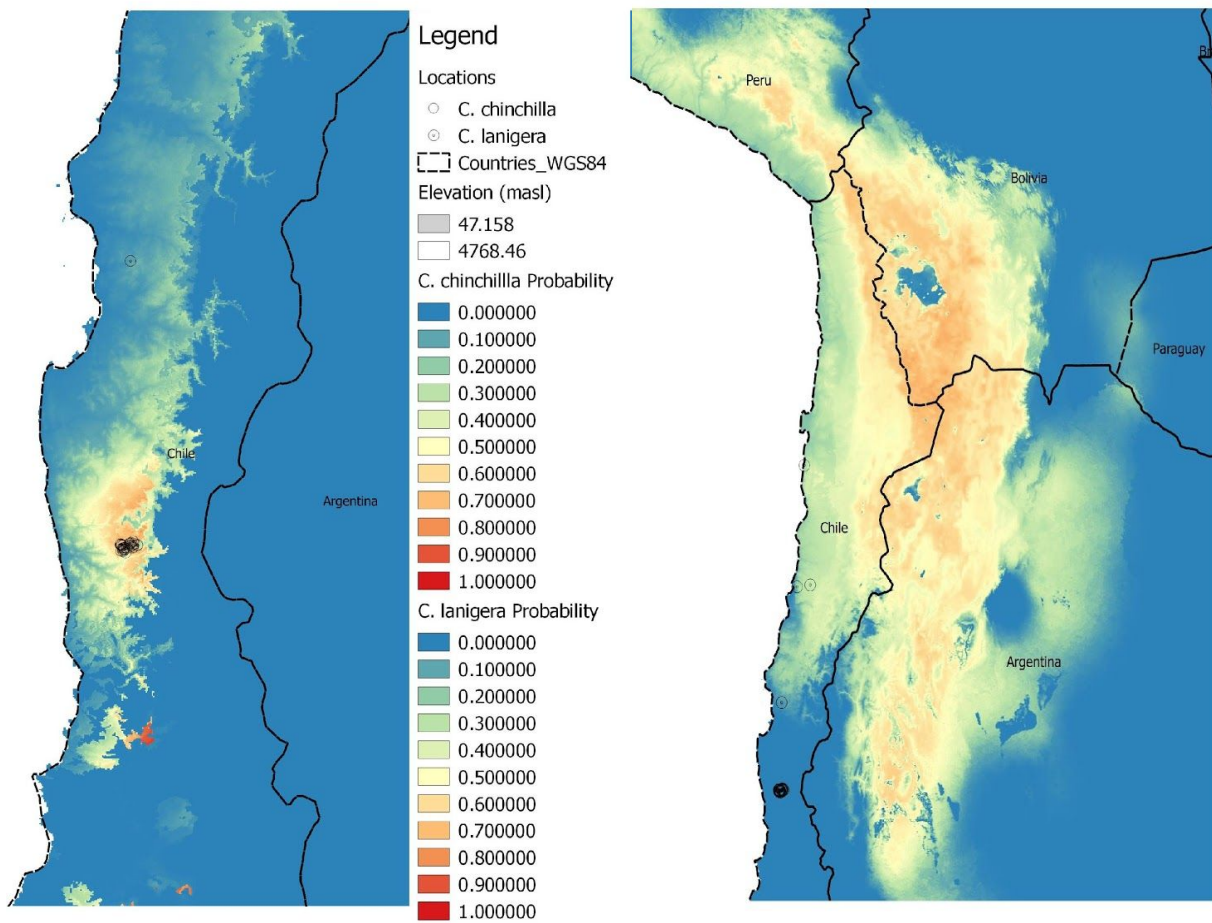


Potential Distributions of *Chinchilla chinchilla* and *Chinchilla lanigera*

Amy L. Deane

Save the Wild Chinchillas, IUCN, SSC, SMSG



Potential locations of *C. lanigera* in Chile (left), and *C. chinchilla* in Peru, Chile, Bolivia and Argentina (right) based upon MAXENT.

Introduction:

Chinchillas are caviomorph rodents which once roamed the mountains and foothills of South America. Chinchillas are nocturnal and live together groupings called colonies. Both species of chinchillas and their range decreased dramatically as millions were exported during colonial South America for the fur trade (ALBERT 1900). Chinchilla are endangered because of hunting and trapping of the animals for its pelts. Between 1895 and 1921 over three million chinchilla pelts including a small number of live animals were exported from Chile. Some authors report that more than 21 million chinchillas were killed between 1840 and 1916 and only a fraction of those caught were able to be exported (JIMÉNEZ 1996).

Chinchilla chinchilla (brevicaudata), short-tailed chinchilla was believed to be extinct in the wild (JIMÉNEZ 1996). In 2001, Jimenez found remains of short-tailed chinchillas in fresh fecal material of foxes in northern Chile. Copa et al. published research that mapped the probability of short-tailed chinchillas existing in Bolivia using once existing locations and MAXENT (COPA et al. 2014). In 2017, a wild colony was discovered in an area that was suggested as having a high probability and this was the first documented wild colonies in Bolivia since 1939 (Copa pers. comm. 2017). Currently, *C. chinchilla* is listed as critically endangered (CE) in both Chile and Bolivia (ROACH and KENNERLEY 2016). Its native range included the Andes of Peru, Bolivia, Chile and Argentina.

C. lanigera, the long-tailed species, is endemic to Chile was thought to be extirpated from its original range which included the foothills of the Andes from northwest of Potrerillos south to Region IV (JIMENEZ 1996). Upon rediscovery of wild *C. lanigera* in central Chile, beginning in the mid-1970's, a series of studies on these endangered rodent populations have tried to understand chinchillas, their habitat and population dynamics. Wild long-tailed chinchillas are listed as endangered (EN) by the IUCN and the Chilean government and are protected from international trade by the Convention on International Trade in Endangered Species of Wild Fauna and Flora, Appendix 1 (CONAF 1988; ROACH and KENNERLEY 2016).

Methods:

Since 2001, four small colonies of *C. chinchilla* species have been located in Chile and one colony in Bolivia (Jimenez and Copa personal comm. 2001-2017). These locations, as well as eight other

historical locations in Bolivia and Argentina, were used to extrapolate the locations of highest probability for short-tailed chinchillas. Thirty-six known locations of *C. lanigera* were used in this analysis. The majority of the points are clustered around Reserva Nacional Chinchillas in the IV Region of Chile. All locations were entered into a database of a geographical spatial program. Each locational point was coded by the corresponding species. All locational data was exported as point locations to ascii format and loaded into the MAXENT program (PHILLIPS 2009).

Environmental variables for predicting spatial distribution for each species were obtained from WorldClim (<https://www.worldclim.org/> 2019). The following climatic variables at a 30 arc second resolutions were loaded into MAXENT:

BIO1 = Annual Mean Temperature
BIO2 = Mean Diurnal Range (Mean of monthly (max temp - min temp))
BIO3 = Isothermality (BIO2/BIO7) (* 100)
BIO4 = Temperature Seasonality (standard deviation *100)
BIO5 = Max Temperature of Warmest Month
BIO6 = Min Temperature of Coldest Month
BIO7 = Temperature Annual Range (BIO5-BIO6)
BIO8 = Mean Temperature of Wettest Quarter
BIO9 = Mean Temperature of Driest Quarter
BIO10 = Mean Temperature of Warmest Quarter
BIO11 = Mean Temperature of Coldest Quarter
BIO12 = Annual Precipitation
BIO13 = Precipitation of Wettest Month
BIO14 = Precipitation of Driest Month
BIO15 = Precipitation Seasonality (Coefficient of Variation)
BIO16 = Precipitation of Wettest Quarter
BIO17 = Precipitation of Driest Quarter
BIO18 = Precipitation of Warmest Quarter
BIO19 = Precipitation of Coldest Quarter

MAXENT was run with to create response curves for each environmental variable, create output maps images, and conduct a jackknife analysis to measure the importance of each variable in predicting probability locations. Files were saved as both grid and ascii formats to aid in further analysis in QGIS and spreadsheets. Default output for MAXENT analysis is in logistic format. Values ranged from zero to one. Higher values correspond to locations whose variables most likely correlate with the known point locations for each species.

RESULTS

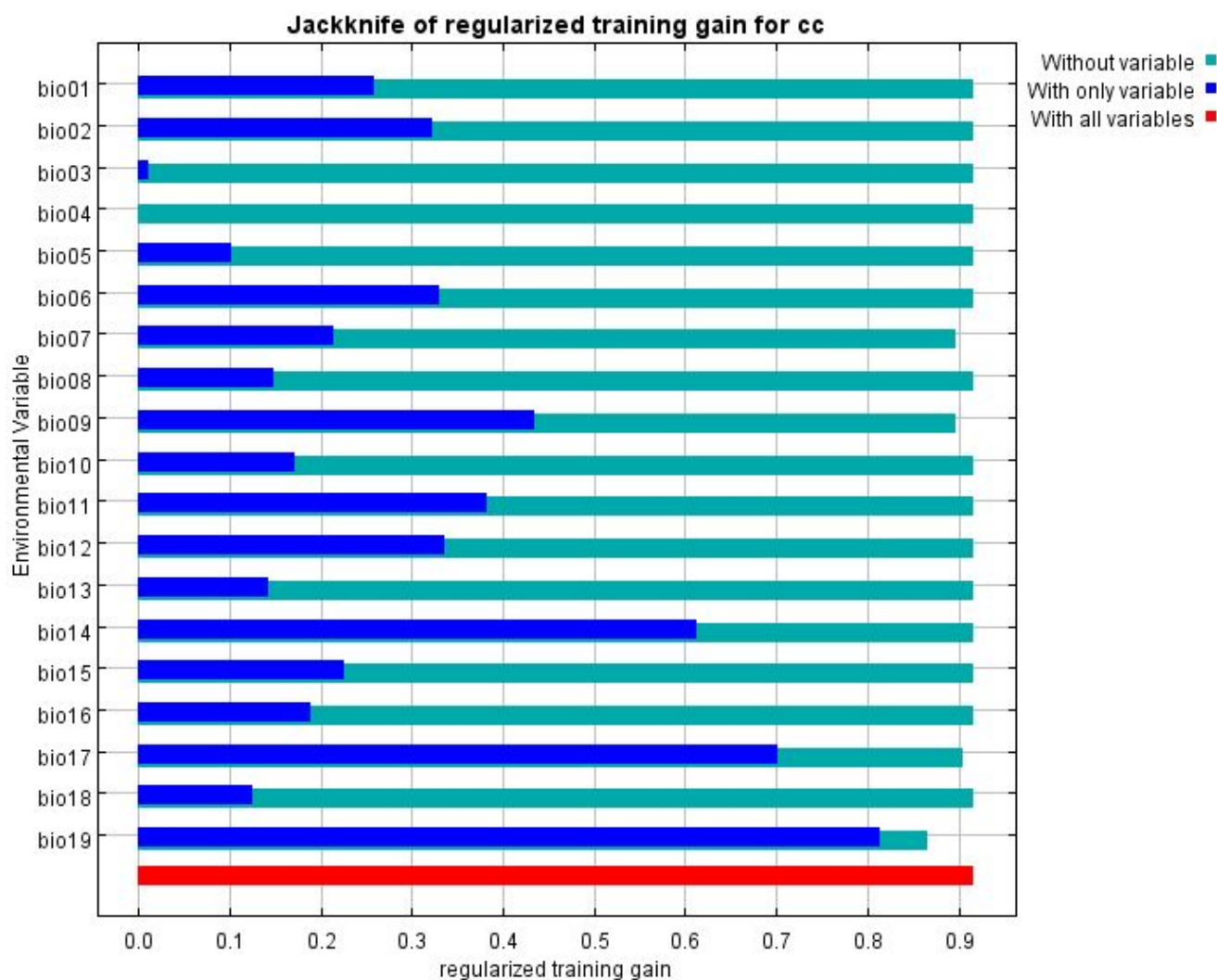
Chinchilla chinchilla

MAXENT used all 13 locations to identify locations of high probability of *C. chinchilla*. Training data from short-tailed chinchilla locations had an AUC of 0.865, while a random prediction was AUC=0.5. According to the MAXENT program, the most important bioclimatic factors affecting the probability distribution for *C. chinchilla* are BIO19 = Precipitation of Coldest Quarter, and BIO9 = Mean Temperature of Driest Quarter. These two variables contributed 84.5% of the model results. BIO17 = Precipitation of Driest Quarter, BIO19 = Precipitation of Coldest Quarter, BIO9 = Mean Temperature of Driest Quarter, and BIO7 = Temperature Annual Range (BIO5-BIO6) make up 99.9% of the environmental variables permutation. Based on a jackknife analysis of variables, the most bioclimatic layers with high variable importance are BIO19 = Precipitation of Coldest Quarter and BIO17 = Precipitation of Driest Quarter.

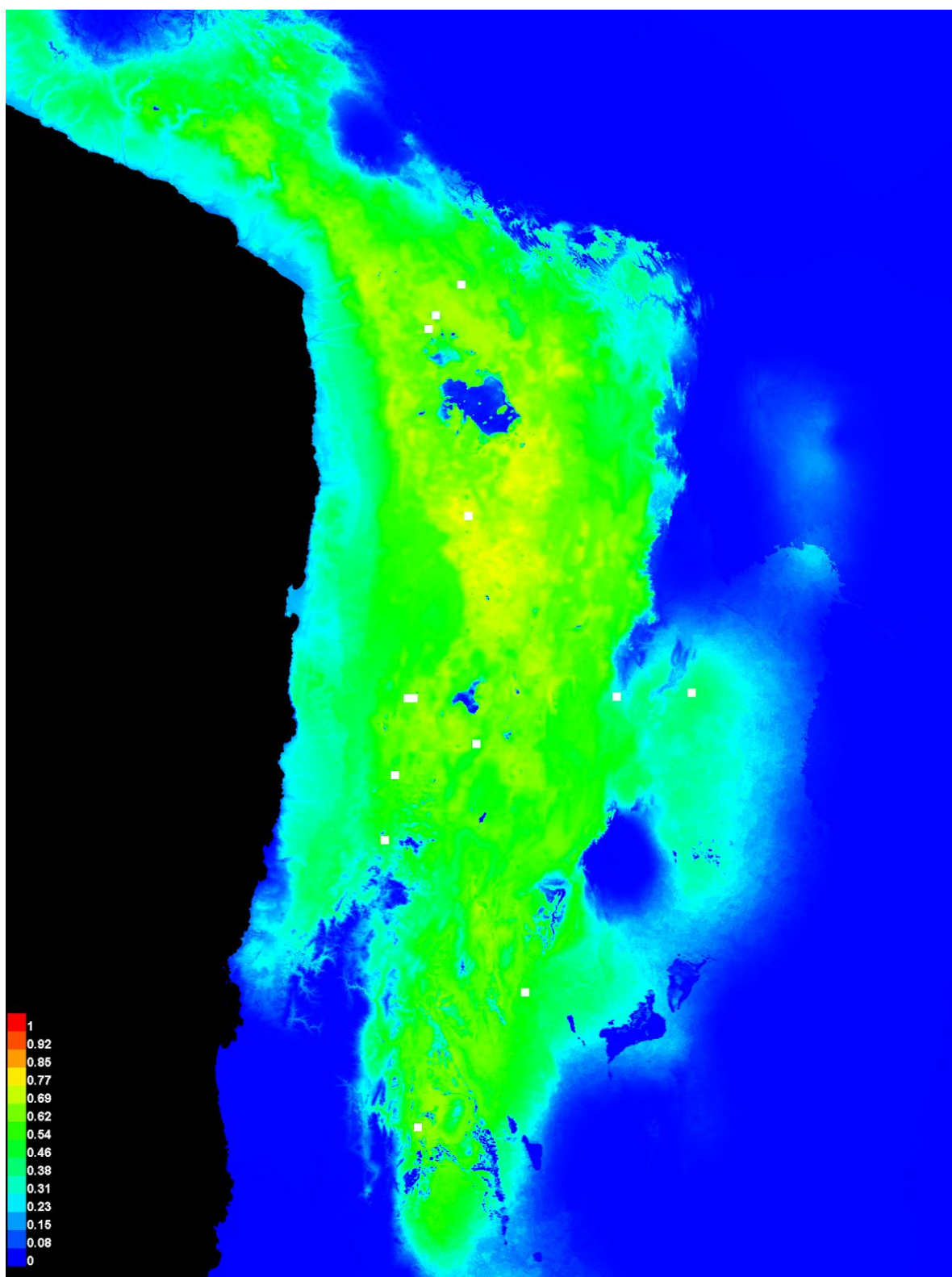
The table below displays the percent each variable contributed and its permutation importance (or feature importance) in deriving the spatial range probability distribution.

Variable	Percent contribution	Permutation importance
bio19	49.3	24.2
bio09	35.2	15.1
bio17	6	55.1
bio07	2.9	5.5
bio02	2.5	0
bio14	2.4	0
bio06	1.7	0
bio15	0	0.2

Jackknife assessment of variable importance. Based on this graph, Bio19 is the most important for determining the spatial distribution for *C. chinchilla*.



Map for the results of MAXENT for *C. chinchilla*



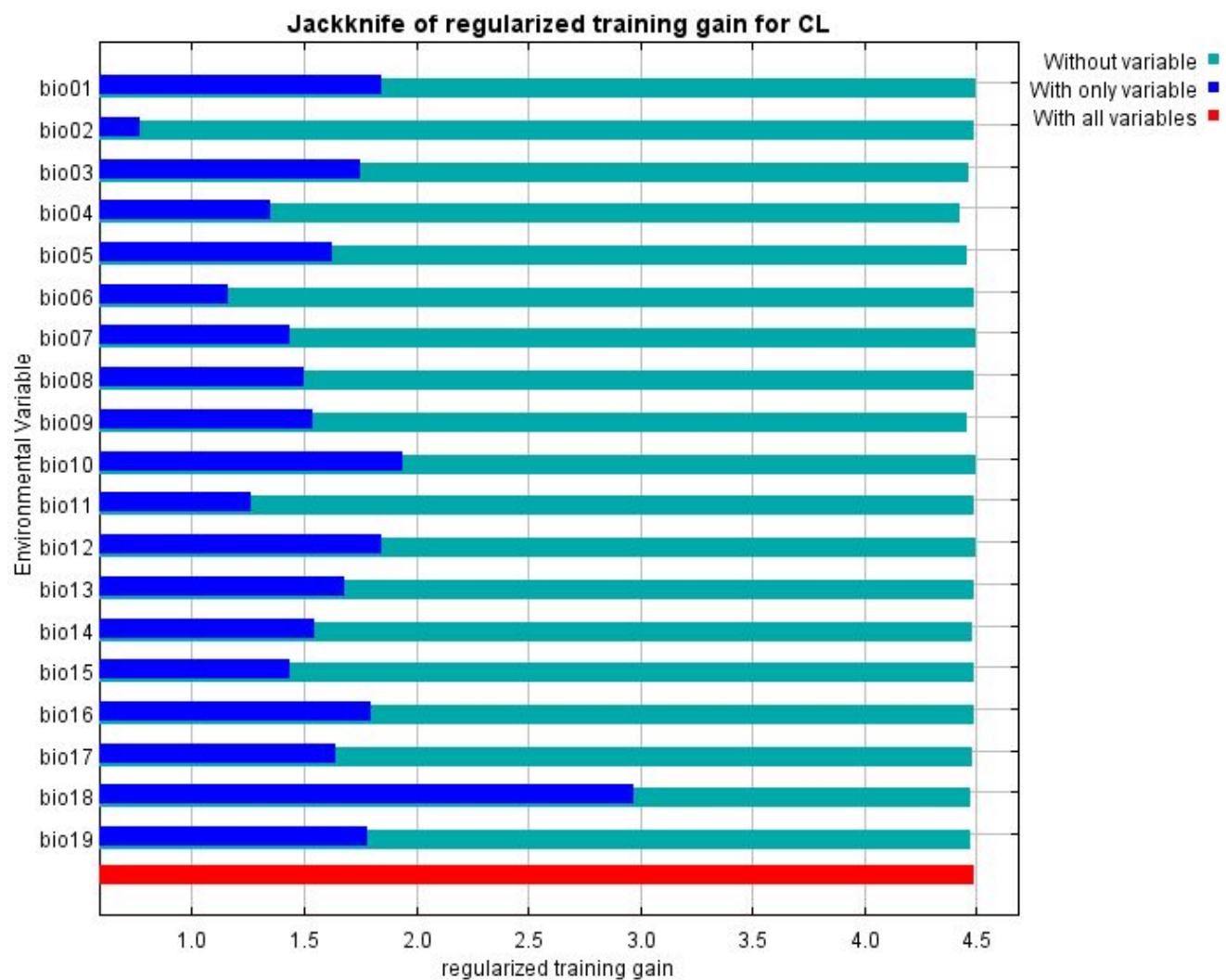
Chinchilla lanigera

MAXENT utilized 32 of the 36 known *C. lanigera* points in this investigation. A few locations were located within the same grid in MAXENT. These four points were eliminated by the program. Training data from long-tailed chinchilla locations reported an AUC of 0.996, while a random prediction was AUC=0.5. According to the MAXENT program, the most important bioclimatic factors affecting the probability distribution for *C. lanigera* are BIO18 = Precipitation of Warmest Quarter and BIO19 = Precipitation of Coldest Quarter, which makeup 80.8% contribution to the model. The bioclimatic features with the highest permutation importance are BIO14 = Precipitation of Driest Month at 38%, and BIO17 = Precipitation of Driest Quarter at 24.4%. A jackknife test of variable importance shows BIO18 = Precipitation of Warmest Quarter has being the climatic layer with the most useful information for this predictive model.

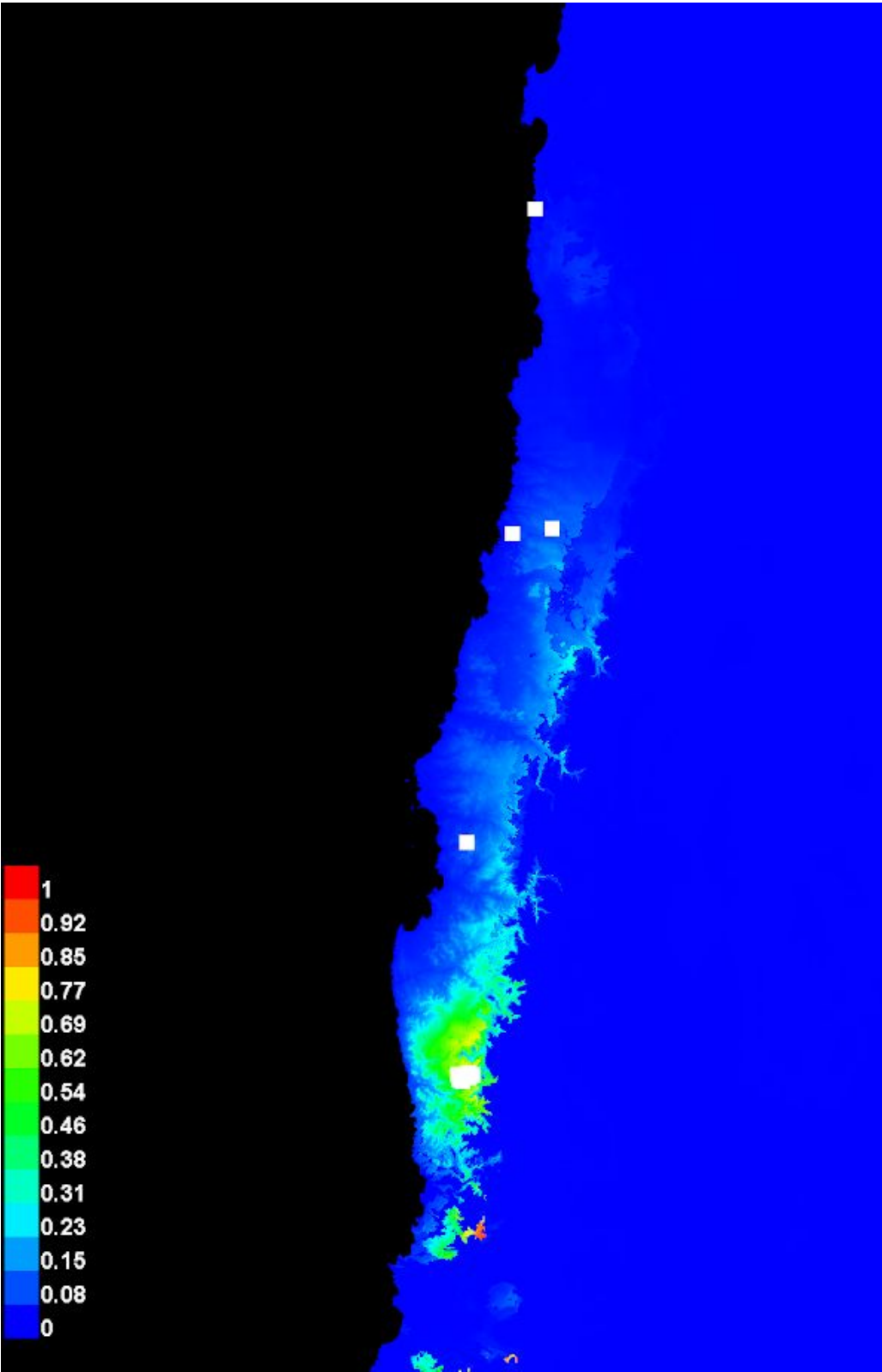
The climate data layers most important in predicting suitable locations for *C. lanigera* are:

Variable	Percent contribution	Permutation importance
bio18	55.8	15.2
bio19	25	0
bio14	8.1	38
bio08	4.5	4.7
bio09	2.5	6.4
bio02	1.7	0
bio06	1.2	0
bio04	0.8	6.7
bio05	0.2	2.9
bio17	0.2	24.4
bio03	0.1	0.9
bio12	0	0.7

Jackknife test of variable importance.results for *C. lanigera*:



Results of MAXENT for *C. lanigera*



DISCUSSION

For species with small geographical ranges such as wild chinchillas the AUC levels reported are expected and acceptable for valid analysis (PHILLIPS 2009). It was not surprising that precipitation was the most important environmental factor based on the arid and mediterranean climate characteristic of much of the study area. Winter or the cold trimester is the seasonal period of the year with most precipitation in *C. lanigera*'s natural habitat. One discrepancy is the lack of areas predicted near the northern most known location for *C. lanigera*. It is interesting to see the highest probability of some colonies of long-tailed chinchillas existing farther south than previously documented. These maps should be used to guide expeditions to the areas of highest possible locations in search of these endangered species.

REFERENCES

- ALBERT, F. (1900): La chinchilla. Act. Soc. Scient. Chile. 10:379-407.
- CONAF-Corporación Nacional Forestal. (1988): Brochure of endangered Chilean mammals. Santiago.
- COPA ALVARO, M.E. et al. (2014): Distribución potencial de la chinchilla de colo corta (*Chinchilla chinchilla*, Rodentia) en el sudeste de Bolivia. Ecología Bolivia, 49(2):65-76.
- JIMÉNEZ, J.E. (1996): The extirpation and current status of wild chinchillas *Chinchilla lanigera* and *C. brevicaudata*. Biological Conservation, 77:1-6
- MAXENT https://biodiversityinformatics.amnh.org/open_source/maxent/ Downloaded on 07 September 2019.
- ROACH, N. & KENNERLEY, R. (2016): *Chinchilla chinchilla*. The IUCN Red List of Threatened Species 2016: e.T4651A22191157.
<http://dx.doi.org/10.2305/IUCN.UK.2016-2.RLTS.T4651A22191157.en>. Downloaded on 01 October 2019.
- ROACH, N. & KENNERLEY, R. (2016): *Chinchilla lanigera* (errata version published in 2017). The IUCN Red List of Threatened Species 2016: e.T4652A117975205.
<http://dx.doi.org/10.2305/IUCN.UK.2016-2.RLTS.T4652A22190974.en>. Downloaded on 01 October 2019.
- PHILLIPS, S.J. 2009. A Brief Tutorial on Maxent. Network of Conservation Educators and Practitioners, Center for Biodiversity and Conservation, American Museum of Natural History. Lessons in Conservation, Vol. 3, pp. 108-135.
- Worldclim <https://www.worldclim.org/> Downloaded on 07 September 2019.