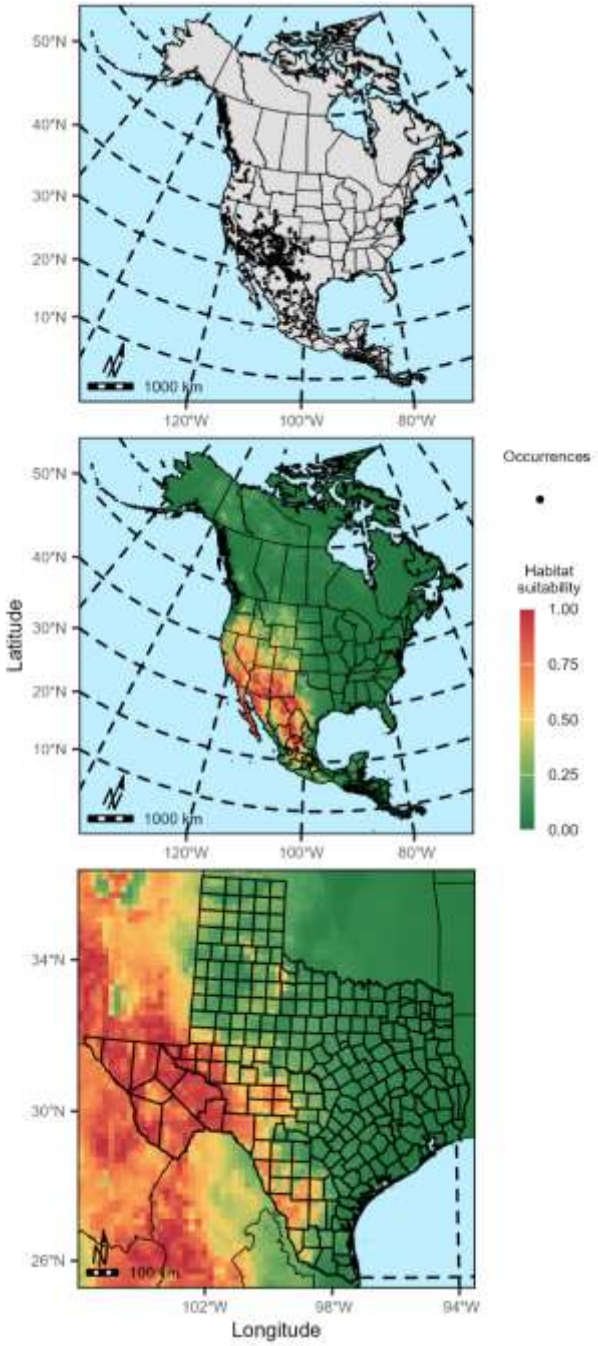
Digital Distribution Maps of the Bats of Texas



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Executive Summary

Of all the terrestrial mammals in Texas, bats (order Chiroptera) are the most imperiled with 23 species (72% of species in the order that occur in Texas) listed by the Texas Parks and Wildlife Department as Species of Greatest Conservation Need (SGCN). Despite so many bat species categorized as SGCN, we have only course understanding of their distribution and little quantitative understanding of the relative imperilment of species stemming from a variety of anthropogenic threats. High resolution estimate of distribution would aid much in directing conservation efforts in the state and could identify species needing the greatest conservation attention. Recent advances in ecological niche modeling allow construction of digital distribution maps that are much more resolved and provide estimates of habitat suitability that reflect the probability of occurrence of species. We generated ecological niche models (ENM's) for 34 species of bats occurring in the state of Texas. Number of records used to generate these ENM's ranged from 41 to 1492 (average = 319). Models were relatively simple with linear feature classes representing the best models for 14 species (41%) and performed well. Omission rates ranged from 0.07 to 0.28 and on average, models were accurate (average omission rate= 0.16). Area under the receiver-operator curve (AUC) ranged from 0.66 to 0.97. Model performance was on average good (average AUC = 0.82). Eight environmental variables were important niche characteristics for at least 10 species. These were 1) Elevation, 2) Bio15-- Precipitation Seasonality, 3) Pasture, 4) Bio19-- Precipitation of Coldest Quarter, 5) Bio14-- Precipitation of Driest Month, 6) Bio2-- Mean Diurnal Range of Temperature, 7) Bio1-- Annual Mean Temperature, and 8) Mixed Grass-Shrubland. Complexity of niches, as measured by the number of important environmental variables ranged from three for *Myotis occultus* to nine for *Lasiurus borealis*. On average the complexity of niches was 6 environmental variables.

Introduction

Compared to other groups of mammals, bats are of elevated conservation concern because their unique life history, in particular long life spans and slow reproductive rates, predisposes them to be particularly sensitive to a number of anthropogenic stressors (Kingston et al. 2020). Of terrestrial mammals, the order Chiroptera (bats) has the greatest number (23) and proportion (72%) of species listed as SGCN (species of greatest conservation need) by the Texas Parks and Wildlife Department (TPWD 2012). Moreover, the US Fish and Wildlife Service is planning on listing one of these species, *Perimyotis subflavus*, as endangered under the Endangered Species Act (USFWS 2022). Responses to anthropogenic stressors are of substantive conservation concern. Nonetheless, an equally important conservation concern is data deficiency whether it be of simple forms such as insufficiently characterized patterns of distribution and abundance or even more complex forms such as knowledge of responses to and degree of exposure to anthropogenic threats. While distribution and abundance of bats are well-characterized in the state of Texas (Ammerman et al. 2012, Schmidly and Bradley 2016) though at low resolution, understanding of the degree to which bat species face anthropogenic threats is in need of substantial improvement. Indeed, decisions as to the protected status of species are often made without even a remote understanding of exposure to risk or how these risks may change in the future.

An important contribution to the ecology, conservation and regulation of bats in the state would be high resolution distribution maps that illustrate variation in habitat suitability of the bats of Texas. Currently, a number of forms of geographic distribution maps for bats in Texas are available (Figure 1) but these lack resolution. For example, maps are available in the Mammals of Texas (Schmidly and Bradley 2016) and the Bats of Texas (Ammerman et al. 2013). These

maps (Figure 1A) resolve presence/absence of species to the county level. Nonetheless, counties range from 150 mi^2 to 6192 mi^2 with an average of 1057 mi^2 (http://www.texascounties.net/statistics/landarea.htm) and this variable and low resolution is not sufficient to provide robust understanding of risk. Also available are maps based on polygons (Figure 1B) made from the marginal records of each species and these are widely and freely

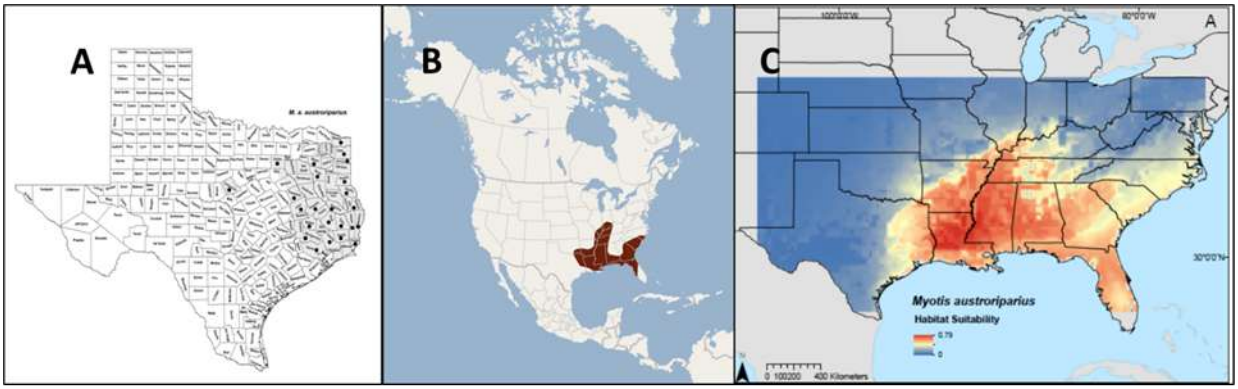


Figure 1.—Three ways of documenting the geographic distribution of a species (*Myotis austroriparius*—southeastern myotis, a native of Texas). A) distribution records resolved to the county level as in the Mammals of Texas (Schmidly and Bradley 2016) or the Bats of Texas (Ammerman et al. (2012). B) distribution demarcated by marginal records and made into a polygon (taken from Wikipedia). C) Digital distribution map produced from an Ecological Niche Model whereby the warmer the color the better the habitat suitability and greater the probability of occurrence of a species (taken from Grimshaw, Ray and Stevens 2021).

available (Marsh et al. 2022). Since these are based on drawing lines around marginal records these maps lack resolution as to the internal structure of the distribution of each species. Digital distribution maps produced from ecological niche models (ENM's, Figure 1c) are of much higher resolution and provide estimates of habitat suitability for each species. Ecological niche models relate georeferenced species records to environmental variables (Phillips et al. 2006, Thuiller 2024). These models can then be used to project over geographic areas to create spatial maps that predict the probability of suitable habitat to better understand occurrence patterns and provide more robust estimates of geographic range extents Herein, we report efforts to construct ENM's for the bats of Texas (34 species) to generate maps representing habitat suitability and offer a much more robust and resolved estimate of each species' potential geographic range.

Methods

Environmental variables.—We evaluated 31 environmental variables in our ecological niche models including measures of temperature, precipitation, elevation, aridity, landcover, above ground lithology, and surface water. We considered temperature and precipitation as they correlate with global bat richness patterns (McCain 2006) and can have direct impacts, such as physiological and thermoregulatory constraints (McNab 1982, Graham 1983, Thomas et al. 1990, McCain 2006, Voigt et al. 2011), and indirect impacts on bats, such as influencing the availability of prey and roosts (Sherwin et al. 2013, Dondini et al. 2025) and impacts on fungal growth rates leading to white-nose syndrome (Verant et al. 2012). We considered elevation as this has also been tied to global bat richness patterns, although this is likely tied to climatic conditions along elevational gradients (McCain 2006). Nevertheless, some bats in our study region, such as *Myotis* in mountainous regions of the southwest, differentiate along elevational gradients (Hoffmeister 1986). We considered aridity as some species are largely known in North America from arid regions (e.g., *Nyctinomops macrotis* (Milner et al. 1990) and *Myotis ciliolabrum* (Halloway and Barclay 2001). We considered available surface water as water bodies provide foraging grounds and/or drinking water, which can be especially important for lactating females and species in arid environments (Vaughan et al. 1996, Racey 1998, Szewczack et al. 1998, Ciechanowski 2002, Adams and Hayes 2008, Campbell 2009, Korine et al. 2015). Lastly, we considered lithology and land cover characteristics to describe the overall habitat and potential roost sites as species differ in their natural histories and recorded habitats. For example, *Nyctinomops femorosaccus* primarily roosts in rocky outcrops or cliff crevices (Cockrum 1956,

Easterla 1973a. Krutzsch 1945) and *Myotis septentrionalis* are forest dwellers (Caire et al. 1979, van Zyll de Jong et al. 1980, Fenton et al. 1983).

To process environmental layers, we used the appropriate functions from the *terra* v1.8-60 (Hijmans 2025) and *sf* v1.0.21 (Pebesma 2018, Pebesma and Bivand 2023) R packages. The landcover, lithology, and surface water data were originally categorical, but we transformed them into continuous variables by calculating the proportions of each category for greater detail and ease of use and interpretation. All layers started in the EPSG:4326 projection so to appropriately calculate these proportions, we reprojected all our layers to the North America Albers Equal Area Conic projection (ESRI: 102008). The bioclimatic variables and DEM elevation layer from WorldClim (Fick and Hijmans 2017) and aridity layer from the Global Aridity Index and Potential Evapotranspiration Database v3 (Zomer et al. 2022) were downloaded at 10 arcminutes, a resolution we considered appropriate for our analyses and occurrence data. These layers were masked down to North America using the appropriate country shapefiles from the Database of Global Administrative Areas (Hijmans et al. 2022) and then reprojected using bilinear resampling to a 19x19km resolution.

We used the World Ecological Land Units (ELUs) 2015 dataset provided by the US Geological Survey (USGS) at a resolution of 30 arcseconds (Sayre 2014) to obtain relevant lithological data (Hartmann and Moosdorf 2012). We masked the layer to North America and recategorized the ELUs to represent the three major rock types, sedimentary, metamorphic, igneous. This layer represented both above and below ground lithology (i.e. bedrock). Therefore, to make it a better representation of possible bat roosts, we used an average soil depth and sedimentary deposit thickness layer (Pelletier et al. 2016) to further classify and measure only above ground rock. We considered this to be rock in areas with an average soil thickness < 1m.

Then after reprojecting this layer using nearest neighbor resampling, we aggregated a final layer for each rock that represented its proportion in each cell at a 19x19km resolution.

For the surface water layer, data representing water bodies for our study area was most readily available through shapefiles. We obtained polylines representing rivers from HydroRIVERS v10 (Lehner and Grill 2013) and polygons representing lakes, ponds, and reservoirs from HydroLAKES v10 (Messager et al. 2016). This was adequate to represent most water ways, except wider rivers such as the Mississippi River, Yukon River, Mackenzie River, and Liard River. To better represent these, we also used rivers from the Global Lakes and Wetlands Database (GLWD) V1, level 2 data (Lehnor and Döll 2004), that had a surface area > 1000km^2. These shapefiles were then used to mask and recategorize a 30 arcsecond (Fick and Hijmans 2017) layer trimmed to North America into water and dry land. This recategorized layer was then reprojected and aggregated similar to the lithology layer to represent the proportion of available surface water in each cell of a 19x19km raster.

Lastly, we obtained land cover data from HILDA+ (Winkler et al. 2020, Winkler et al. 2021) which excels in forest data and has annual data for 1960-2019. Each year was reprojected to the equal-area projection and from the available land cover categories, we investigated cropland, pasture, evergreen broadleaf forest, evergreen needleleaf forest, deciduous broadleaf forest, and mixed grass-shrubland. An aggregate layer for each category and for each year was created using the same aggregate approach to generate proportions at a 19x19km resolution. For each variable, this resulted in a total of 60 layers which we averaged across to obtain a mean proportion and a better estimate than relying on a single layer for such a dynamic variable.

Along this process of preparing, projecting, and at times aggregating our environmental rasters, we masked the final products of layers that originated from different data sources (e.g.,

bioclimatic variables by the lithological and vice versa) to ensure the same cells in each raster contained data.

Occurrences and background points.—We downloaded a total of 148,950 Chiroptera records with GPS coordinates representing museum specimens collected within North America from 1960-2020 from the Global Biodiversity Information Facility (GBIF, 2025). We carefully filtered these records first removing those that were unreliable (e.g., those published by the Comision Nacional para el Conocimiento y Uso de la Biodiversidad (CONABIO) which we found to be duplicate records from other institutions with incorrect identifications). Then, starting with records with coordinate uncertainty values larger than 9,500m (half the width of our raster cell size of 19km) we removed any country, state or province, and county level records. We also removed records that listed only a river or stream name as the locality as many of these span across counties (e.g. Utah's Strawberry River) and at times even states or countries (e.g., the Mississippi River). Several records contained directions in miles or meters from a city, town, landmark, etc. which helped pinpoint a more precise location. Nevertheless, some still had some level of uncertainty as unless otherwise stated, these distances were measured by air and thus may only approximate the area where the bat was truly located. Nevertheless, we retained these records due to the larger cell sizes in our environmental rasters and the mobile nature of bats considering these points to still represent the appropriate environment with enough certainty for our analyses. We also retained records that listed state or national forests, state or national parks or monuments, and wildlife refuges considering these areas to be fairly uniform in their environment. We similarly retained mountains, canyons, and valleys although we also verified that their elevation gradients were less than 2km. We retained urban records as long as the localities were not wildlife care or rehab centers, veterinary offices or labs, or municipal

buildings, as these likely do not represent where the bats were collected and could have been brought in from anywhere. We also removed records from life science and biology buildings, zoological museums and collections, and zoos unless there were details providing strong evidence these bats were indeed wild. As a final check we used the *coordinateCleaner* R package v3.0.1 (Zizka et al. 2019) to highlight records that were dubious, such as those located within 100m of an institution (e.g., zoos, museums, universities), at sea, or within 1000m of a country capital or centroid. After further reviewing the highlighted records, we reprojected these coordinates using the *terra* R package 1.8-60 (Hijmans 2025) to the same projection as our environmental data. Then using the points2nearestcell function in the *rSDM* R package v0.4.1 (Rodriguez 2025) we relocated 52 unique points just outside our raster along the coastlines to the center of the nearest cell. Lastly, we reviewed occurrence maps for each species, highlighting outliers and removing them until they can be further verified for later studies.

In sampling background points, we considered all North America as accessible area for the bats (i.e., M for movement from the BAM Venn diagrams representing dispersal capabilities [Pulliam 2000, Soberón and Peterson 2005]). Although bat home ranges vary in size and little is known about them (Wood et al. 2024), Chiroptera are quite mobile, volant animals. Some members we investigated are known to migrate, e.g., *Lasiurus blossevillii* (Cryan 2003) and *M. velifer* (Fitch et al. 1981), and one, *Lasionycteris noctivagans*, has even been observed 160km off the coast of Long Island while migrating (Mackiewicz and Backus 1956). Thus, we assumed that over our time frame of 1960-2020, each species could access the regions throughout our study region and establish if that region represented suitable habitat. We took all the Chiroptera cleaned records from GBIF and used them as a target-group to approximate sampling effort for a background thickening approach for handling sampling bias. We did this in a similar way to

Barber et al. (2021) with minor differences in how we removed duplicates. We considered duplicates to be records having the same latitude and longitude and collecting event date, regardless of species. Thus, each collecting event should be represented by a single record as multiple species can be collected in a single event. We then used the *ks* R package v1.15.1 (Duong 2025) to estimate a 2D kernel density with cells weighted by the number of unique visits. The resulting kernel was then rasterized and resampled to match the extent and resolution of our environmental rasters and scaled to range from 0-1. We then used this probability surface to sample 7,000 background points using the randomPoints function in the *dismo* R package v1.3-16 (Hijmans et al. 2024). These points were biasedly sampled along the extent of North America where bats have been collected and this excluded the upper portions of Alaska and Canada. However, the lack of bat records in these areas is not due to a lack of sampling, but to unsuitable habitat likely being too cold and barren. Thus, we took an additional 3,000 points randomly throughout this region for a total of 10,0000 background points used in our models.

MaxEnt.—To create a model for each species, we used the MaxEnt v3.4.3 java application (Phillips et al. 2021) implemented through R v4.5.1 (R Core Team 2025) as described below. We chose MaxEnt due to its wide range of customizability (Peterson et al. 2007, Elith et al. 2010, Merow et al., 2013), need for only presence data (Phillips et al. 2006, Merow et al. 2013), and high predictive accuracy compared to other modeling methods (Phillips et al.2006, Elith et al., 2006, Kaky et al., 2020, Fitzgibbon 2022). For each species, records were pulled from the cleaned GBIF records and reduced to one representative per raster cell. We used the varSel function in the *SDMtune* R package v1.3.2 (Vignali et al. 2020) to handle correlation between our environmental layers. This selects representative variables from correlated groups in a data-

driven manner using variable importances in an iterative approach involving model evaluation to find the variables that best fit the occurrence data for each species. We used permutation importances to measure variable importance, Pearson's correlation coefficient (Pearson 1896) to measure collinearity between variables considering those with r>0.70 to be correlated, and the AUC score as our metric for evaluating models when determining which correlated variable to remove.

Default parameter settings in MaxEnt tend to lead to complex, overfit models (Elith and Graham 2009, Radosavljevic and Anderson 2013, Shcheglovitova and Anderson 2013, Merow et al. 2013). In order to balance model complexity and predictive accuracy, we used the *ENMeval* R package v2.0.5.2 (Kass et al. 2021) to tune models and select optimal regularization multiplier (RM) values and feature class (FC) combinations for each species. We explored RM values ranging from 1-4 in 0.5 increments and linear (L), quadratic (Q), hinge (H), product (P), and threshold (T) FC combinations. The auto-features selection process of the MaxEnt java application (Phillips et al. 2021) selects more feature classes for species with more presences and all FC combinations being used if presences > 80 (Phillips and Dudík 2008, Merow et al. 2013). Thus, we assessed L, LQ, H, and LQH for species with 80 or less unique records and additionally the combinations of LQHP, and LQHPT for species with more than 80 records. This resulted in 28 models evaluated for species with 80 or less records and 42 models for those with greater than 80 records. The FC combination selected for the final models for two species, *Diphylla ecaudata* and *Nyctinomops femorosaccus*, after tuning and the following steps for model optimization was H which resulted in models with more covariates than occurrences. Considering these models to be overfit we removed FC combinations with H, leaving L and LQ and 14 models evaluated.

To evaluate each of these possible models as well as their performance we used spatial block fold cross-validation, which divides records as equally as possible into four spatially designated blocks using latitudinal and longitudinal lines (Muscarella et al. 2014, Kass et al. 2021). Additionally, the background points were partitioned into these blocks following what Radosavljevic and Anderson (2013) referred to as 'masked geographically structured' partitioning. This was used over random k-fold cross-validation to reduce the spatial correlation between folds for a more accurate model assessment and to generate models with greater utility for future investigations requiring their transfer across space and/or time, e.g., predicting responses to climate change (Peterson et al. 2011, Muscarella et al. 2014, Kass et al. 2021). As projecting to environments found in the test fold, but not in the training folds is likely with spatial folds, we clamped our variable responses to address the need for extrapolation. Model performance was evaluated using the mean 10% omission rate (Pearson et al. 2007) and mean AUC score (Hanley and McNeil 1982) in that order. We chose the 10% omission rate as it is less sensitive to outliers than the minimum training presence omission rate (Pearson et al. 2007) and selected models with the lowest mean rate to avoid overfitting. We used the mean AUC score to break ties and additionally reviewed this measure for each model selected to ensure adequate model performance. Following Swets (1988) we categorized model performance based on AUC scores as no better than random (0.5-0.6), acceptable (0.6-0.7), fair (0.7-0.8), good (0.8-0.9), and excellent (0.9-1).

After selecting the optimal RM value and FC combination, we then used the full model which included no folds, all the species' occurrences, and all the background points to assess the importance of the environmental variables included. We measured this using both the percent contribution and permutation importance (Phillips 2006). Seeking the most parsimonious model,

we removed variables that contributed little to the model in an iterative approach similar to the reduceVar function in the *SDMtune* R package v1.3.2 (Vignali et al. 2020). Variable importances were ranked using the permutation importance and all those contributing 0% to the model were removed and the model was rerun. We then removed the variable with the lowest permutation importance, reran the model, and repeated this process until there were no variables that contributed less than 2% to the model. We focused on the permutation importance as this measure depends only on the final model instead of relying on the path used by MaxEnt, as with the percent contribution (Phillips 2006).

A final model with the remaining variables was then produced using all the background points and species occurrences. To evaluate this final model we again used spatial cross-validation recording the mean 10% omission rate and mean AUC score which we compared to those from before removing environmental variables to ensure these metrics either improved or were minimally reduced. We applied the same clamping procedure done previously to aid in the spatially structured evaluation of the model as well as in its use for making predictions of habitat suitability across North America. We used the cloglog output from MaxEnt for our predictions with values ranging from 0-1 and representing the probability of encountering suitable habitat. From these final predictions, we emphasize the prediction of suitable habitat in Texas and describe the range of likely suitable habitat across North America and Texas for each species. Additionally, from each final model we saved and plotted the response curves (appendix) to better visualize each species response to the variables included in their models.

General Results

Specimen Records From Smaller Texas Institutions.—We contacted eleven smaller natural history collection in Texas (Museum Request Status.xls in Dryad). Of those, two never

responded, four had no bats in their collection, three agreed to provide data but never did and two provided data. Syl Ross State University provided 519 records from 21 species and Tarleton State University provided 27 records from 8 species. These data as well as all other data and this report have been deposited in the Dryad repository (DOI: 10.5061/dryad.hx3ffbgsz).

We generated ENM's for 34 species of bats occurring in the state of Texas. Number of records used to generate ENM's ranged from 41 to 1492 (average = 319). Models were relatively simple with linear feature classes representing the best models for 14 species (41%). Ecological niche models performed well. Omission rates ranged from 0.07 to 0.28. Models on average were accurate (average omission rate= 0.16). Area under the receiver-operator curve ranged from 0.66 to 0.97. Models were on average good (average AUC = 0.82). Measuring permutation importance, eight environmental variables were important niche characteristics for at least 10 species. These were 1) Elevation, 2) Bio15-- Precipitation Seasonality, 3) Pasture, 4) Bio19-- Precipitation of Coldest Quarter, 5) Bio14-- Precipitation of Driest Month, 6) Bio2-- Mean Diurnal Range of Temperature, 7) Bio1-- Annual Mean Temperature, and 8) Mixed Grass-Shrubland. Complexity of niches, as measured by the number of important environmental variables ranged from three for *Myotis occultus* to nine for *Lasiurus borealis*. On average the complexity of niches was 6 environmental variables.

Table 1.— Maxent results describing ecological niche models (ENM) after tuning. Records are the number of locations used to construct each ENM. Feature classes were linear (L), quadratic (Q), hinge (H), product (P) and/or threshold (T). Coefficients are the number of parameters representing the ENM. Mean Omission Rate is the proportion of actual presence points that are predicted to have a low probability of occurrence. Mean AUC is area under the receiver-operator curve, a measure of accuracy that can be interpreted as the probability that a randomly chosen presence is ranked higher than a randomly chosen background point (Merow et al. 2013).

Species	Records	Feature Classes	Regularization Multiplier	Coefficients	Mean Omission Rate	Mean AUC
Mormoops megalophylla	143	L	2	6	0.11	0.78
Choeronycteris mexicana	124	L	4	6	0.14	0.79
Leptonycteris nivalis	51	L	2.5	9	0.21	0.79
Leptonycteris yerbabuenae	130	L	1.5	4	0.09	0.78
Diphylla ecaudata	48	L	2.5	4	0.17	0.77
Aeorostes cinereus	680	LQ	2.5	12	0.20	0.66
Antrozous pallidus	556	L	4	7	0.20	0.81
Corynorhinus rafinesquii	74	L	4	8	0.28	0.93
Corynorhinus townsendii	521	L	4	6	0.14	0.78
Dasypterus ega	52	H	3	23	0.23	0.70
Dasypterus intermedius	111	L	1	8	0.21	0.77
Dasypterus xanthinus	94	L	3	8	0.15	0.83
Eptesicus fuscus	1496	LQH	2.5	95	0.11	0.72
Euderma maculatum	41	H	4	21	0.17	0.88
Lasionycteris noctivagans	555	H	4	73	0.12	0.81

Lasiurus blossevillii	53	LQH	3	30	0.13	0.82
Lasiurus borealis	605	LQH	4	30	0.13	0.81
Lasiurus seminolus	105	H	2	37	0.14	0.96
Myotis austroriparius	128	H	3.5	26	0.18	0.95
Myotis californicus	593	LQ	4	6	0.12	0.76
Myotis ciliolabrum	442	L	2	8	0.14	0.84
Myotis occultus	82	LQ	2	9	0.15	0.97
Myotis septentrionalis	172	L	1.5	6	0.13	0.84
Myotis thysanodes	341	LQ	4	11	0.12	0.87
Myotis velifer	497	LQH	2.5	84	0.11	0.84
Myotis volans	459	LQ	4	11	0.14	0.85
Myotis yumanensis	499	LQ	3	9	0.13	0.77
Nycticeius humeralis	308	L	4	5	0.22	0.82
Parastrellus hesperus	487	LQ	3.5	6	0.10	0.83
Perimyotis subflavus	373	L	4	5	0.17	0.87
Tadarida brasiliensis	781	LQHPT	3.5	69	0.15	0.73
Nyctinomops femorosaccus	72	L	3	6	0.07	0.88
Nyctinomops macrotis	118	H	4	38	0.25	0.81
Eumops perotis	41	LQ	3.5	4	0.25	0.82

Table 2.—Permutation importances of each environmental variable (31 total) for each of the ENM's constructed for the 34 Texas bat species. -- symbolizes NA, i.e., a variable that was not included in the species model.

	Environmental Variable																														Important
Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Variables
Mormoops megalophylla	2.87	---	4.49	6.85	---	5.51	---	---	---	---	---	---	---	---	---	48.80	---	---	---	31.47	---	---	---	---	---	---	---	---	---	---	---	6
Choeronycteris mexicana	13.08	14.39	---	---	---	---	61.73	2.9	---	---	---	---	---	---	---	---	---	---	4.02	---	---	---	---	---	3.91	---	---	---	---	---	---	6
Leptonycteris nivalis	7.43	4.92	---	6.80	---	4.83	---	2.2	4.46	---	---	---	---	---	---	37.73	4.16	---	---	27.42	---	---	---	---	---	---	---	---	---	---	---	5
Leptonycteris yerbabuenae	11.29	12.56	---	---	---	---	---	---	---	---	---	---	---	---	---	20.80	---	---	---	---	---	---	---	55.34	---	---	---	---	---	---	---	7
Diphylla ecaudata	---	4.51	---	3.02	---	---	---	---	---	---	---	85.06	---	7.40	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	7
Aeorostes cinereus	7.38	5.85	10.53	---	---	2.55	---	---	8.48	---	4.86	57.16	---	---	---	---	---	---	---	---	---	---	---	---	---	3.18	---	---	---	---	---	5
Antrozous pallidus	---	2.11	---	---	---	59.17	---	9.9	13.61	8.86	---	---	2.14	---	---	---	---	---	---	4.17	---	---	---	---	---	---	---	---	---	---	---	5
Corynorhinus rafinesquii	4.34	35.79	---	---	9.03	5.55	---	---	---	3.40	3.49	---	---	---	---	---	---	---	---	---	---	---	---	16.20	---	22.20	---	---	---	---	---	6
Corynorhinus townsendii	38.02	---	---	4.57	---	2.91	---	7.4	---	28.07	---	---	---	---	---	---	---	19.04	---	---	---	---	---	---	---	---	---	---	---	---	---	6
Dasypterus ega	---	21.18	---	---	---	---	---	---	---	---	---	---	---	---	4.4	3.52	---	---	---	70.91	---	---	---	---	---	---	---	---	---	---	---	6
Dasypterus intermedius	2.47	4.32	---	8.48	---	---	58.93	2.2	---	6.95	2.37	---	---	---	14.3	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	6
Dasypterus xanthinus	6.84	5.57	6.27	---	9.09	9.24	---	---	7.58	---	---	47.61	---	---	---	---	---	---	---	---	7.80	---	---	---	---	---	---	---	---	---	---	5
Eptesicus fuscus	---	---	9.29	---	---	---	---	---	---	---	---	37.05	2.49	---	7.4	---	---	---	---	---	4.02	---	---	---	---	---	36.19	3.56	---	---	---	8
Euderma maculatum	46.79	---	4.59	---	---	---	---	---	24.26	---	---	---	---	2.89	---	---	13.02	---	---	---	---	---	---	---	4.29	---	---	4.16	---	---	---	8
Lasionycteris noctivagans	4.87	6.11	6.87	3.00	---	---	---	---	---	12.40	4.75	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	62.01	---	---	---	---	4
Lasiurus blossevillii	---	2.77	7.17	---	32.83	---	---	---	---	---	---	---	---	---	---	2.78	---	---	---	---	3.49	---	---	50.96	---	---	---	---	---	---	---	5
Lasiurus borealis	12.68	---	2.24	4.65	17.28	---	63.15	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	9
Lasiurus seminolus	---	---	---	---	---	2.17	---	---	---	12.10	4.56	---	---	---	49.1	---	---	32.07	---	---	---	---	---	---	---	---	---	---	---	---	---	5
Myotis austroriparius	27.18	---	4.09	10.43	22.12	17.47	8.23	---	---	---	7.39	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	3.09	---	6
Myotis californicus	---	---	4.31	4.17	25.20	---	---	---	---	---	---	---	7.32	---	---	---	---	---	---	---	---	---	---	59.00	---	---	---	---	---	---	---	7
Myotis ciliolabrum	23.17	---	---	3.83	---	15.14	---	2.7	33.53	---	---	---	---	2.41	11.0	---	---	---	---	---	---	8.21	---	---	---	---	---	---	---	---	---	7
Myotis occultus	61.03	4.81	---	---	---	---	---	2.5	---	---	---	7.62	---	6.57	---	---	---	14.04	---	---	---	---	---	---	---	---	---	---	3.44	---	---	3
Myotis septentrionalis	---	7.62	---	---	---	18.60	---	19.9	---	13.48	---	---	---	---	---	---	---	---	---	---	---	37.85	---	---	2.54	---	---	---	---	---	---	6
Myotis thysanodes	27.65	2.23	---	---	4.85	---	---	10.8	---	---	---	---	---	6.26	---	---	---	---	---	---	---	---	48.21	---	---	---	---	---	---	---	---	8
Myotis velifer	---	7.24	2.38	6.42	---	11.84	63.41	---	---	8.71	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	8
Myotis volans	65.49	---	---	3.17	---	15.97	---	2.8	---	---	---	---	---	6.35	---	---	2.19	---	---	---	---	4.07	---	---	---	---	---	---	---	---	---	8
Myotis yumanensis	---	---	3.95	6.08	30.59	---	47.88	---	---	---	3.26	---	8.25	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	8
Nycticeius humeralis	13.88	8.11	---	---	---	---	60.69	---	---	---	6.05	---	---	---	---	---	---	---	---	---	---	---	---	---	---	11.28	---	---	---	---	---	7
Parastrellus hesperus	---	---	3.13	---	24.50	---	---	---	---	---	---	---	5.73	---	---	---	---	---	7.74	---	---	---	58.90	---	---	---	---	---	---	---	---	6
Perimyotis subflavus	---	12.69	---	---	13.66	---	---	---	---	---	---	9.63	---	---	---	---	4.09	59.93	---	---	---	---	---	---	---	---	---	---	---	---	---	7
Tadarida brasiliensis	4.18	---	2.82	2.51	---	---	71.99	3.6	14.95	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	6
Nyctinomops femorosaccus	---	15.96	7.05	---	7.85	---	49.00	---	---	---	---	---	5.77	---	---	---	---	---	14.37	---	---	---	---	---	---	---	---	---	---	---	---	4
Nyctinomops macrotis	---	---	12.85	---	24.21	---	32.69	---	22.05	---	---	---	---	---	---	---	2.82	---	5.39	---	---	---	---	---	---	---	---	---	---	---	---	6
Eumops perotis	8.16	---	---	---	47.61	---	44.22	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	4
Frequency of Importance	20	19	16	14	13	13	11	11	8	8	8	6	6	6	5	5	5	4	4	4	3	3	3	3	3	3	2	2	1	1	0	

Environmental Variables: 1) Elevation, 2) Bio15-- Precipitation Seasonality, 3) Pasture, 4) Bio19-- Precipitation of Coldest Quarter, 5) Bio14-- Precipitation of Driest Month, 6) Bio2-- Mean Diurnal Range of Temperature, 7) Bio1-- Annual Mean Temperature, 8) Mixed Grass-Shrubland, 9) Aridity, 10) Bio18-- Precipitation of Warmest Quarter, 11) Evergreen Broadleaf Forest, 12) Bio4-- Temperature Seasonality, 13) Cropland, 14) Evergreen NeedleLeaf Forest, 15) Bio17-- Precipitation of Driest Quarter, 16) Bio8-- Mean Temperature of Wettest Quarter, 17) Sedimentary Rock, 18) Bio10-- Mean Temperature of Warmest Quarter, 19) Bio12--Annual Precipitation, 20) Bio7-- Temperature Annual Range, 21) Bio13-- Precipitation of Wettest Month, 22) Bio3-- Isothermality, 23) Bio6-- Min Temperature of Coldest Month, 24) Bio9-- Mean Temperature of Driest Quarter, 25) Deciduous Broadleaf Forest, 26) Igneous Rock, 27) Bio5-- Max Temperature of Warmest Month, 28) Surface Water, 29) Bio16-- Precipitation of Wettest Quarter, 30) Metamorphic Rock, 31) Bio11-- Mean Temperature of Coldest Quarter

Species accounts

Mormoops megalophylla—Ghost-Faced Bat

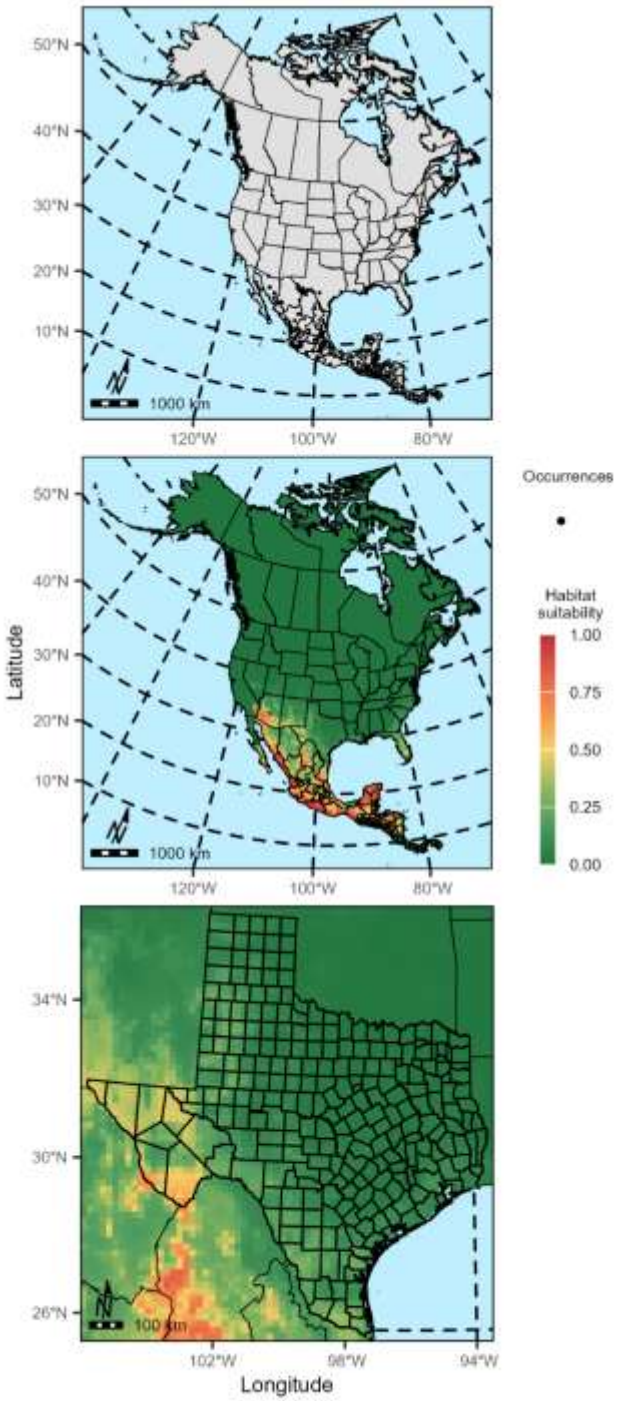


Figure 2. *Mormoops megalophylla* occurrence records and MaxEnt cloglog predictions; Top: occurrence map, Middle: North America MaxEnt prediction map, Bottom: Texas MaxEnt prediction map.

Description.—A medium (average total length = 90mm, average forearm length = 54mm, range of weights = 15-16g) reddish-brown to dark brown bat with short ears that are united across the forehead and form a large pocket below the eye (Schmidly and Bradley 2016). This species also has distinctive leaf-like appendages on the chin.

Distribution.—The geographic range of *M. megalophylla* is represented by 5 disjunct populations (Rezsutek and Cameron 1993). The largest ranges from the Trans-Pecos and southern Texas, New Mexico and Arizona south to but not including Nicaragua. A second occurs on the southern ¾ of Baja California. A third occurs from Southern Colombia, Ecuador and northern Peru. A fourth on the

Caribbean islands of the Netherland Antilles and Trinidad. Finally, a fifth occurs in Northern Colombia and Venezuela.

Systematics.— Four subspecies are recognized (Wilson and Ruff 1999). *Mormoops m. carteri* occurs in Colombia, Ecuador and Northern Peru. *Mormoops m. intermedia* occurs in the Caribbean. *Mormoops m. megalophylla* ranges from the southern United States to Honduras and across much of Baja California. *Mormoops m. tumidiceps* occurs in northern Colombia and Venezuela.

Natural History.—*Mormoops megalophylla* occurs across many humid, arid and semiarid regions below about 3,000m elevation (Rezsutek and Cameron 1993). Ghost-faced bats are insectivorous consuming primarily Macrolepidoptera (Easterla and Whitaker 1972) but also Coleoptera, Diptera, Ephemeroptera, Hemiptera, Hymenoptera, Neuroptera, Orthoptera, Psocoptera and Trichopotera (Arango-Diago et al. 2020, Gordon et al. 2019, Lopez-Wilchis et al. 2025). Ghost-faced bats roost in caves and mineshafts. They interestingly roost in a hyperdispersed fashion with individuals separating themselves by approximately 15cm (Raun and Baker 1958). Reproductive data are sparse, but pregnant females have been observed between February and June and lactating females have been observed from June through August (Rezsutek and Cameron 1993).

Conservation Status.—Population status is listed as declining and *Mormoops megalophylla* is listed as a species of least concern by the IUCN (Davalos et al. 2019). This species is listed as one of greatest conservation need and ranked as S2 (Imperiled) by TPWD (Simon 2023).

Habitat Suitability.— Areas of highest habitat suitability in North America occur throughout southern and western Mexico. Other areas of relatively high habitat suitability are in southern

Arizona and the Trans-Pecos of Texas where it is a relatively common resident. In Texas, relatively high habitat suitability occurs throughout the Trans-Pecos and a few areas of the South Texas Plains.

Most important niche characteristics.—Estimates of permutation importance (Table 2) indicated that the most important environmental niche characteristics for ghost-faced bats from highest to lowest importance were Bio8 (mean temperature in the wettest quarter), Bio7 (temperature annual range), Bio19 (precipitation in the coldest quarter), Bio2 (mean diurnal range of temperature), the amount of pasture and Elevation. Habitat suitability was positively related to Bio8, Bio2 and Elevation and negatively related to Bio7, Bio19, and amount of pasture (Appendix Figure 1).

Ecological Niche Model Evaluation and Performance—The best performing ecological niche model (Table 1) had linear feature classes and a regularization multiplier of 2. Spatially structured cross-validation yielded a mean 10% omission rate of 0.11 and a mean validation AUC value of 0.78, indicating it to be a fair model for predicting the potential distribution of *Mormoops megalophylla*.

***Choeronycteris mexicana*—Mexican Long-Tongued Bat**

Description.— A medium (average total length = 85mm, average forearm length = 44mm, mass= 25g) sooty gray to brown bat with a long slender rostrum and prominent nose leaf.

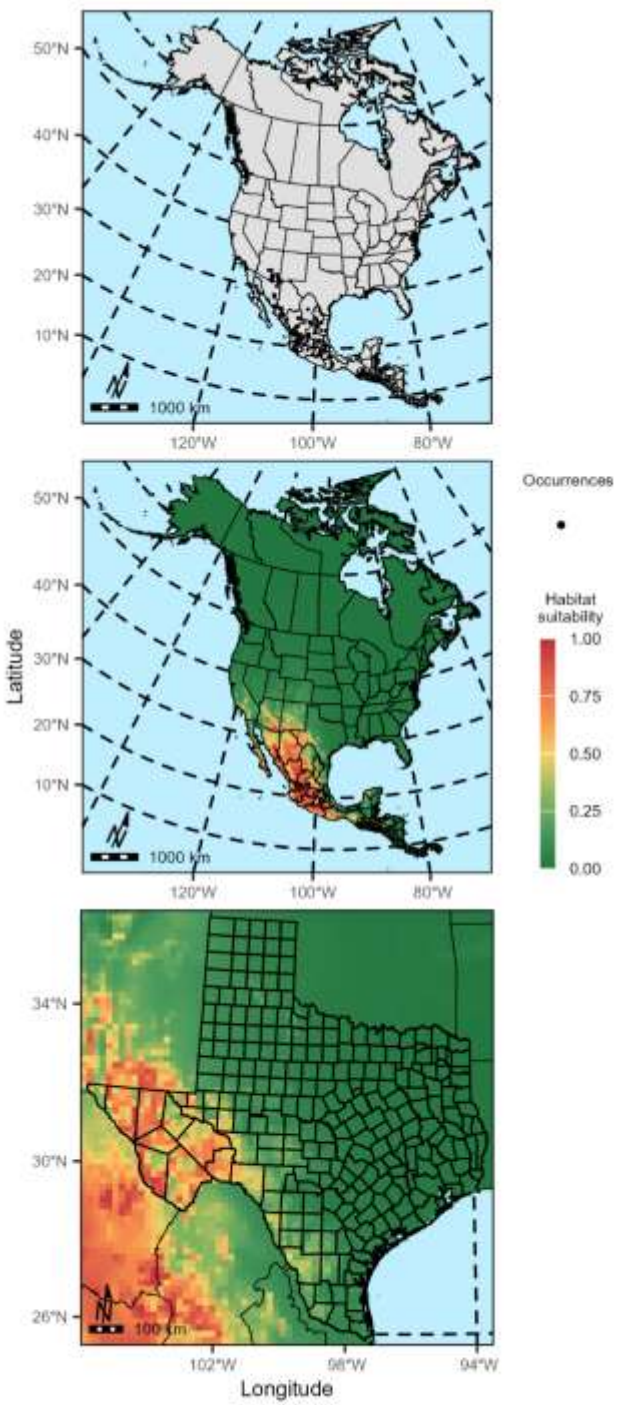


Figure 3. *Choeronycteris mexicana* occurrence records and MaxEnt cloglog predictions; Top: occurrence map, Middle: North America MaxEnt prediction map, Bottom: Texas MaxEnt prediction map.

Distribution.—The Mexican long-tongued bat ranges from southern California, Arizona, New Mexico and Texas south through Mexico, including Baja California, to El Salvador and Honduras (Arroyo-Cabrales et al. 1987).

Systematics.—No subspecies are recognized (Wilson and Ruff 1999).

Natural History.—*Choeronycteris mexicana* occurs across a wide variety of habitats including tropical thorn scrub, tropical deciduous forest, and mixed oak-conifer forest (Arroyo-Cabrales et al. 1987). Mexican long-nosed bats primarily consume pollen but also fruit, nectar and probably insects (Gardner 1977). This species roosts in caves, abandoned mine tunnels, culverts and buildings (Arroyo-Cabrales et al. 1987) but have also been reported roosting in exposed roots of a tree in the side of a ravine (Davis and Russell 1954). Little is known about reproduction. Pregnant

females have been reported in early spring in Mexico and give birth in June in New Mexico and Arizona (Wilson 1979).

Conservation Status.—Population status is listed as unknown and *Choeronycteris mexicana* is listed as a near threatened species by the IUCN (Solari 2018c). This species is not listed as one of greatest conservation need by TPWD (Simon 2023).

Habitat Suitability.— Most areas of high habitat suitability occur across much of mainland Mexico and the Baja peninsula. Other areas of high suitability include portions of the southwestern US including Arizona, New Mexico, the Trans-Pecos and Southwest Texas.

Most important niche characteristics.—Estimates of permutation importance (Table 2) indicated that the most important environmental niche characteristics for Mexican long-tongued bats from highest to lowest importance were Bio1 (annual mean temperature), Bio15 (precipitation seasonality), Elevation, Bio12 (annual precipitation), Broadleaf Forest and Mixed Grass-Shrubland. Habitat suitability was positively related to Bio1, Bio15, Elevation, Deciduous Broadleaf Forest, Mixed Grass-Shrubland and negatively related to Bio 12 (Appendix Figure 2).

Ecological Niche Model Evaluation and Performance—The best performing ecological niche model (Table 1) had linear feature classes and a regularization multiplier of 4. Spatially structured cross-validation yielded a mean 10% omission rate of 0.14 and a mean validation AUC value of 0.79, indicating it to be a fair model for predicting the potential distribution of *Choeronycteris mexicana*.

***Leptonycteris nivalis*—Mexican Long-Nosed Bat**

Description.—*Leptonycteris nivalis* is a large (average total length = 83mm, average forearm length = 58mm, mass= 24g) drab brown bat with short ears and a prominent nose leaf. This

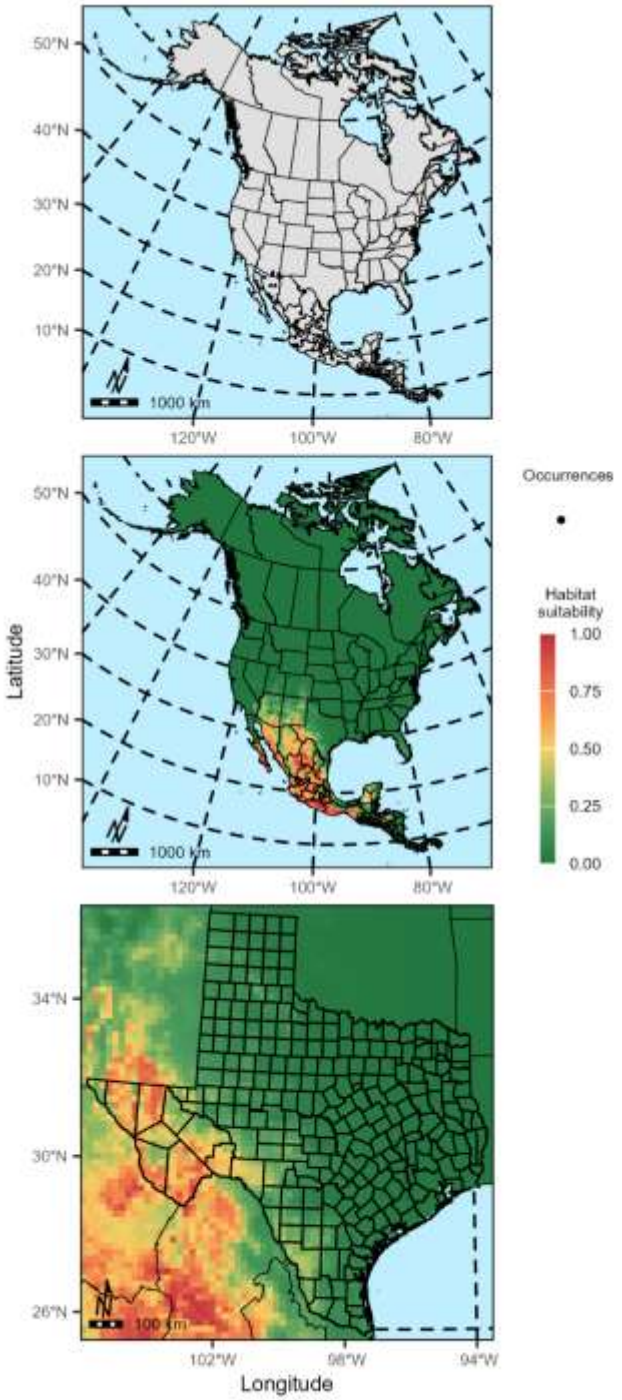


Figure 4. *Leptonycteris nivalis* occurrence records and MaxEnt cloglog predictions; Top: occurrence map, Middle: North America MaxEnt prediction map, Bottom: Texas MaxEnt prediction map.

species has bases of the hairs that are white on the upper parts and hair tips that are silvery on the dorsum. In addition, the forearm is furred on the ventral side up to the elbow (Schmidly and Bradley 2016).

Distribution.—Mexican long-nosed bats are distributed from the southern Trans-Pecos of Texas, south through much of Mexico mostly east of the 102º meridian to Guatemala.

Systematics.—*Leptonycteris nivalis* is monotypic (Wilson and Ruff 1999).

Natural History.—Mexican long-nosed bats most often occur in high elevation pine-oak woodlands from approximately 1,500m to the snowline (Easterla 1972), although there are several records of their occurrence at lower elevations. This species consumes nectar, pollen, insects and likely fruit of succulent cacti (Allen 1940, Hoffmeister 1957, Barbour and Davis 1969). *Leptonycteris nivalis* primarily roosts in caves but also in mines, culverts, hollow trees and buildings (Pfrimmer Hemsley and Wilkins 1988). Little is

known regarding reproduction. Mating and fertilization likely occur in Mexico between April and June (Pfrimmer Hensley and Wilkins 1988). Offspring are likely born in Mexico and migrate to the southern portion of the United States in summer (Easterla 1972, Schmidly 1977).

Conservation Status.—Population status is listed as stable and *Leptonycteris nivalis* is listed as a species of least concern by the IUCN (Medellin 2016a). This species is listed as one of greatest conservation need and ranked as S3S4 (Vulnerable/Apparently secure) by TPWD (Simon 2023).

Habitat Suitability.—Areas of high habitat suitability occur across much of mainland Mexico and the southern half of the Baja peninsula. Patchy areas of high habitat suitability occur in the Trans-Pecos of Texas, New Mexico and Arizona.

Most important niche characteristics.—Estimates of permutation importance (Table 2) indicated that the most important environmental niche characteristics for Mexican long-nosed bats from highest to lowest importance were Bio8 (mean temperature of the wettest quarter), Bio7 (temperature annual range), Elevation, Bio19 (precipitation in the coldest quarter), Bio15 (precipitation seasonality), Bio2 (mean diurnal range of temperature), Aridity, Sedimentary Rock and Mixed Grass-Shrubland. Habitat suitability was positively related to Bio8, Elevation, Bio15, Bio2, Sedimentary Rock and Mixed Grass-Shrubland and negatively related to Bio7, Bio19 (Appendix Figure 3).

Ecological Niche Model Evaluation and Performance—The best performing ecological niche model (Table 1) had linear feature classes and a regularization multiplier of 2.5. Spatially structured cross-validation yielded a mean 10% omission rate of 0.21 and a mean validation AUC value of 0.78, indicating it to be a fair model for predicting the potential distribution of *Leptonycteris nivalis*.

***Leptonycteris yerbabuenae*—Lesser Long-Nosed Bat**

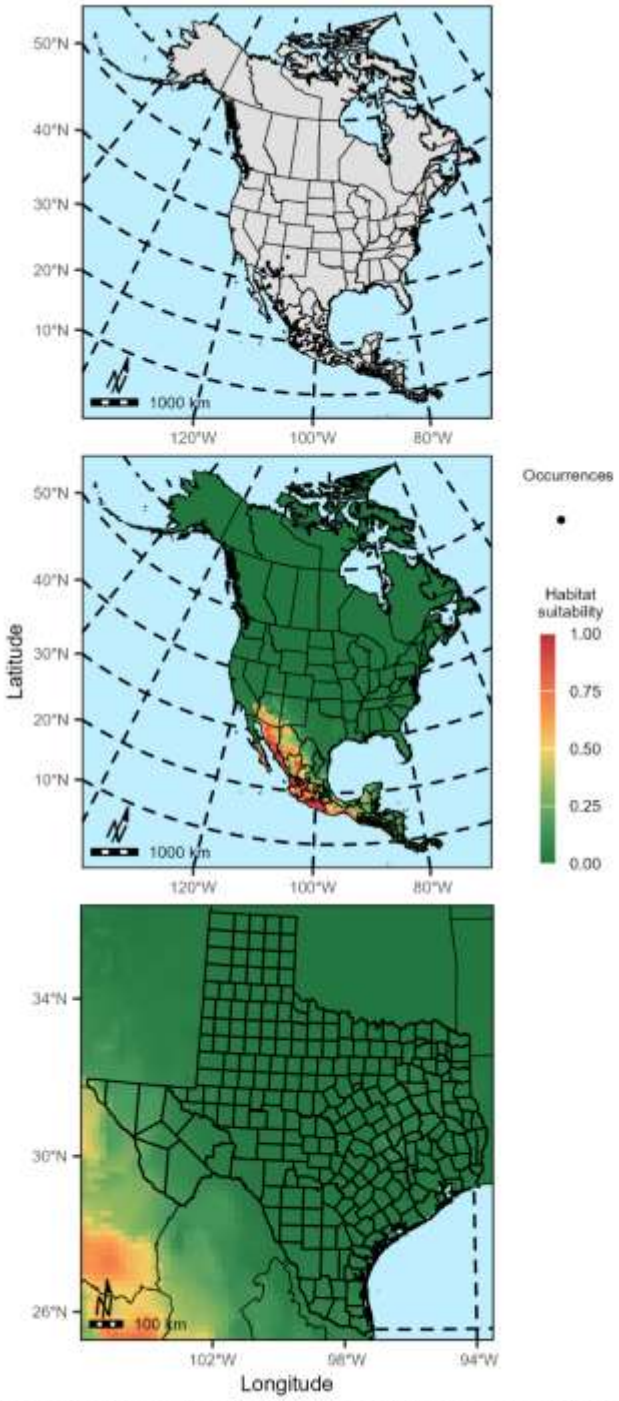


Figure 5. *Leptonycteris yerbabuenae* occurrence records and MaxEnt cloglog predictions; Top: occurrence map, Middle: North America MaxEnt prediction map, Bottom: Texas MaxEnt prediction map.

Description.—This is a large (average total length = 83mm, average forearm length = 54mm, range of masses =25-27g) leaf nosed bat that can be differentiated from *L. nivalis* by its brownish dorsal pelage that is denser and shorter (Yancey et al. 2023).

Distribution.—Lesser long-nosed bats are distributed from southern New Mexico and Arizona south through the arid portions of Mexico, including Baja California to Guatamala, El Salvador and Honduras. It was recently reported based on a single specimen from El Paso in Texas (Krejsa et al. 2020).

Systematics.— *Leptonycteris yerbabuenae* is monotypic.

Natural History.—In southern North America this species occurs in arid scrublands, grasslands and oak forests. In Southern and central Mexico it can be found in these habitats as well but also in thorn forest

(Cole and Wilson 2006). This species roosts in caves. Lesser long-nosed bats migrate seasonally and such migrations cause dramatic fluxes in the number of individuals within roosts. *Leptonycteris yerbabuenae* consumes primarily pollen, nectar and fruit (Hoffmeister and Goodpastor 1954, Gardner 1977), in particular from Saguaro (*Cereus giganteus*) and Organ pipe cactus (*Stenocereus thurberi*) (Fleming et al. 1993). Timing of mating and parturition are geographically variable with two patterns of northern spring births and southern winter births (Ceballos et al. 1997). Females give birth to one offspring per year (Cole and Wilson 2006).

Conservation Status.—Population status is listed as decreasing and *L. yerbabuenae* is listed as near threatened by the IUCN (Medellin 2016b). This species is not listed as one of greatest conservation need by TPWD (Simon 2023).

Habitat Suitability.— In North America, areas of high habitat suitability occur along the Pacific versant of Central America and Mexico, including the lower half of Baja California, North to southern Arizona. As would be expected by the single documented occurrence in Texas, little suitable habitat occurs in the state.

Most important niche characteristics.— Estimates of permutation importance (Table 2) indicated that the most important environmental niche characteristics for Lesser long-nosed bats from highest to lowest importance were Bio9 (mean temperature of the dryest quarter), Bio8 (mean temperature of the wettest quarter), Bio15 (precipitation seasonality) and Elevation. Habitat suitability was positively related to all 4 important niche characteristics (Appendix Figure 4).

Ecological Niche Model Evaluation and Performance—The best performing ecological niche model (Table 1) had linear feature classes and a regularization multiplier of 1.5. Spatially structured cross-validation yielded a mean 10% omission rate of 0.09 and a mean validation

AUC value of 0.78, indicating it to be a fair model for predicting the potential distribution of *Leptonycteris yerbabuenae*.

Diphylla ecaudata—Hairy-Legged Vampire

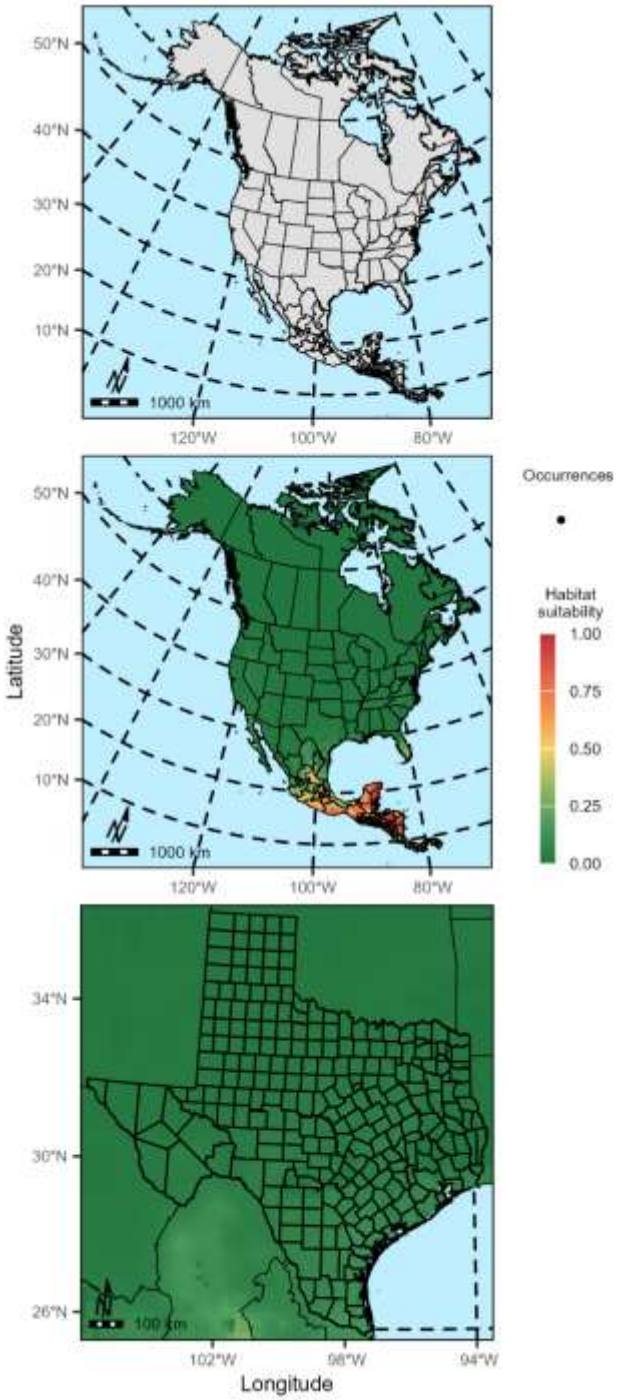


Figure 6. *Diphylla ecaudata* occurrence records and MaxEnt cloglog predictions; Top: occurrence map, Middle: North America MaxEnt prediction map, Bottom: Texas MaxEnt prediction map.

Description.—The hairy-legged vampire is a large sized (average total length = 85mm, average forearm length = 53mm, range of masses =30 – 40g) bat with sooty brown pelage and no tail (Schmidly and Bradley 2016). It can be differentiated from the other two vampire species by its small size and rounded as opposed to pointed ears (Ocampo-Gonzalez et al. 2023).

Distribution.—*Diphylla ecuadata* is distributed from Sothern Texas south though Mexico and Central America into South America ranging as far south as southern Brazil (Ocampo-Gonzalez et al. 2023) and Paraguay Lopez-Gonzalez (2005).

Systematics.—Subspecies of *Diphylla* ecaudata remain unresolved (Ocampo-

Gonzalez et al. 2023). Those that recognize subspecies of this taxon identify *D. c. caudatus* as distributed throughout South America and *D. e. centralis* as occurring throughout Central America and Mexico.

Natural History.—Hairy-legged vampires occur in grasslands and forests at relatively low elevations throughout its distribution (Ocampo-Gonzalez et al. 2023). This species roosts in caves and mines but sometimes uses trees (Uieda 1996). *Diphylla ecaudata* is hematophagous primarily consuming avian blood. At times however, it will consume blood of horses, cows, pigs and humans (Ocampo-Gonzalez et al. 2023). This species exhibits continuous polyestry throughout most of its geographic distribution but reproduction becomes more seasonal at higher latitudes whereby in Mexico and Argentina approximately 92% of births occur in spring and summer (Ocampo-Gonzalez et al. 2023).

Conservation Status.—Population status is stable and *D. ecaudata* is listed as a species of least concern by the IUCN (Sampaio et al 2016). This species is not listed as one of greatest conservation need by TPWD (Simon 2023).

Habitat Suitability.— Areas of high habitat suitability for hairy-legged vampires occur across the southern half of mainland Mexico through Central America. Interestingly there is no suitable habitat in North America, in particular Texas. This provides credence to the hypothesis that the historical occurrence of *D. ecaudata* in Texas is an accidental extralimital occurrence (Schmidly and Bradley 2016).

Most important niche characteristics.— Estimates of permutation importance (Table 2) indicated that the most important environmental niche characteristics for Hairy-legged vampire bats from highest to lowest importance were Bio4 (temperature seasonality), Evergreen Needleleaf Forest,

Bio15 (precipitation seasonality) and Bio19 (precipitation in the coldest quarter). Habitat suitability exhibited a negative relationship with all four variables (Appendix Figure 5).

Ecological Niche Model Evaluation and Performance—The best performing ecological niche model (Table 1) had linear feature classes and a regularization multiplier of 2.5. Spatially structured cross-validation yielded a mean 10% omission rate of 0.17 and a mean validation AUC value of 0.77, indicating it to be a fair model for predicting the potential distribution of *Diphyla ecuadata*.

Aeorostes cinereus—Hoary bat

Description.—This is an unmistakably large (average total length = 136mm, average forearm length = 52mm, range of masses =20-35g) bat with mixed brown and gray fur that is fringed with white to give a hoary appearance (Schmidly and Bradley 2016). The interfemoral membrane is densely furred and the ear is thick and rounded with a black border (Wilson and Ruff 1999).

Distribution.—Hoary bats are one of the most widely distributed bat species in North America. They are distributed throughout the United States with the exception of southern Florida, as well as throughout Mexico east of the Sierra Madre Occidental mountain range (with the exception of the Yucatan peninsula) south to Guatemala. There are also disjunct occurrences in Panama (Gonzalez et al. 2016).

Systematics.—*Aeorostes cinereus* is a monotypic species (Baird et al. 2015).

Natural History.—While often considered a forest-dwelling bat, Hoary bats occur in many nonforested regions as well. This species occurs in most ecoregions of North America. In Texas this species occurs in all ecoregions (Schmidly and Bradley 2016). Hoary bats primarily

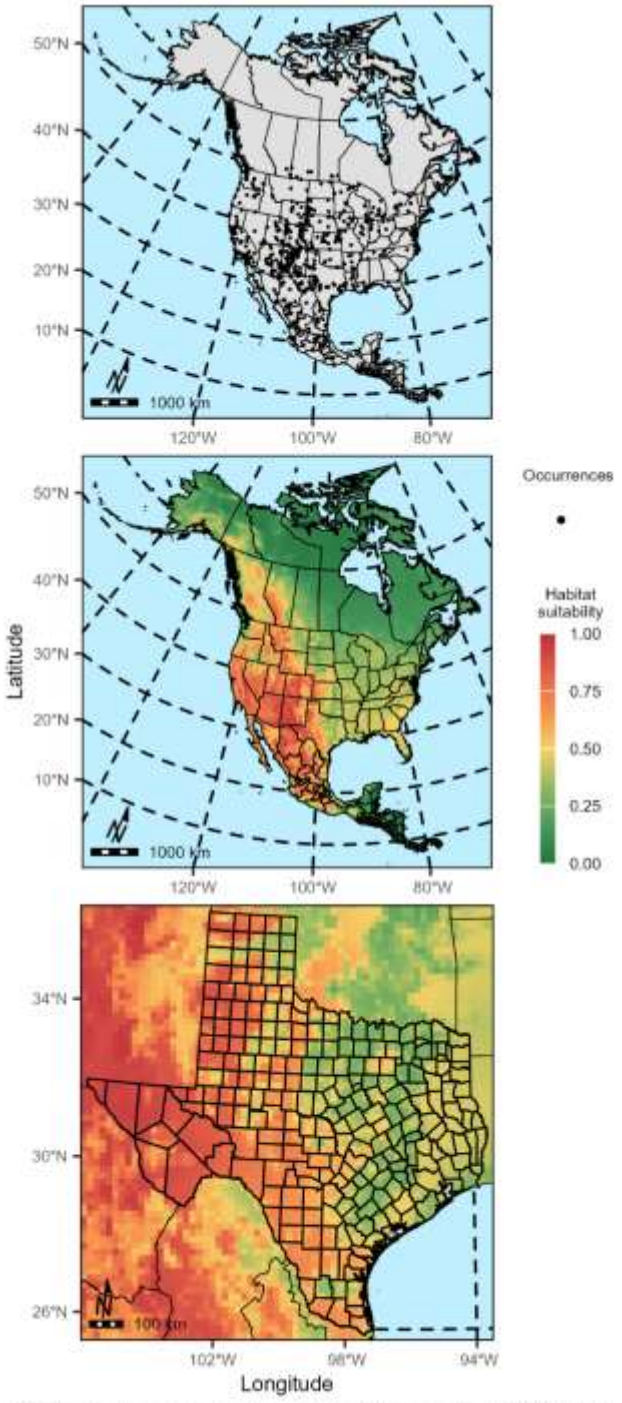


Figure 7. *Aeorostes cinereus* occurrence records and MaxEnt cloglog predictions; Top: occurrence map, Middle: North America MaxEnt prediction map, Bottom: Texas MaxEnt prediction map.

consume moths, but also consume a large variety of other arthropods such as Coleoptera, Diptera, Orthoptera, Isoptera, Odonata, and Hymenoptera skin have been found in the intestinal tract of this species (Whitaker 1967). *Aeorostes cinereus* most often roost in the foliage of trees, coniferous and broadleaf species alike. It has also been reported to roost in woodpecker holes, caves, gray squirrel nests and on the sides of buildings (Shump and Shump 1982). Sexes typically often have different geographic distributions coming together only during the mating season (Findley and Jones 1964). Mating occurs during fall migration and females experience implantation that is delayed until the spring (Shump and Shump 1982). Parturition typically occurs between May and July (Yancey et al. 2023). Females often have two babies but can have as many as 4 (Barbour and Davis 1969).

Conservation Status.—Population status is unknown and this species is listed as one of least concern according to the IUCN Red List (Gonzalez et al.2016). This species does appear to be disproportionately susceptible to mortalities associated with the wind-energy industry (Arnett et al. 2013) and this could be exacerbated by their continental scale pattern of migration (Cryan 2003). The Texas Parks and Wildlife Department lists *A. cinereus* as a species of greatest conservation need (Simon 2023), giving it a state rank of S3 (Vulnerable).

Habitat Suitability.—Areas of high habitat suitability for *A. cinereus* primarily occur throughout the western portion of North America and the Siera Madre mountains of Mexico. In north America, the Colorado Plateau and central and western California represent areas of high habitat suitability. In Texas, habitat suitability is highest in the Trans-Pecos, western High Plains and the Rolling Plains.

Most important niche characteristics.— Estimates of permutation importance (Table 2) indicated that the most important environmental niche characteristics for Hoary bats from highest to lowest importance were Bio4 (Temperature seasonality), Pasture, Aridity, Elevation, Bio15 (precipitation seasonality), Evergreen-Broadleaf Forest, Igneous Rock, and Bio2 (mean diurnal range of temperature). Habitat suitability was positively related to Elevation, Bio15 and Bio2 and negatively related to Pasture, Aridity, Evergreen-Broadleaf Forest, and Igneous Rock. Habitat suitability had a complex modal relationship with Bio4 (Appendix Figure 6).

Ecological Niche Model Evaluation and Performance—The best performing ecological niche model (Table 1) had linear and quadratic feature classes and a regularization multiplier of 2.5. Spatially structured cross-validation yielded a mean 10% omission rate of 0.20 and a mean validation AUC value of 0.66 indicating it is an acceptable model. While the AUC value was

slightly lower than 0.7, it is substantively greater than 0.5 and suggests that the ENM can still adequately predict areas of suitable habitat and presence of *Aeorostes cinereus*.

Antrozous pallidus—Pallid bat

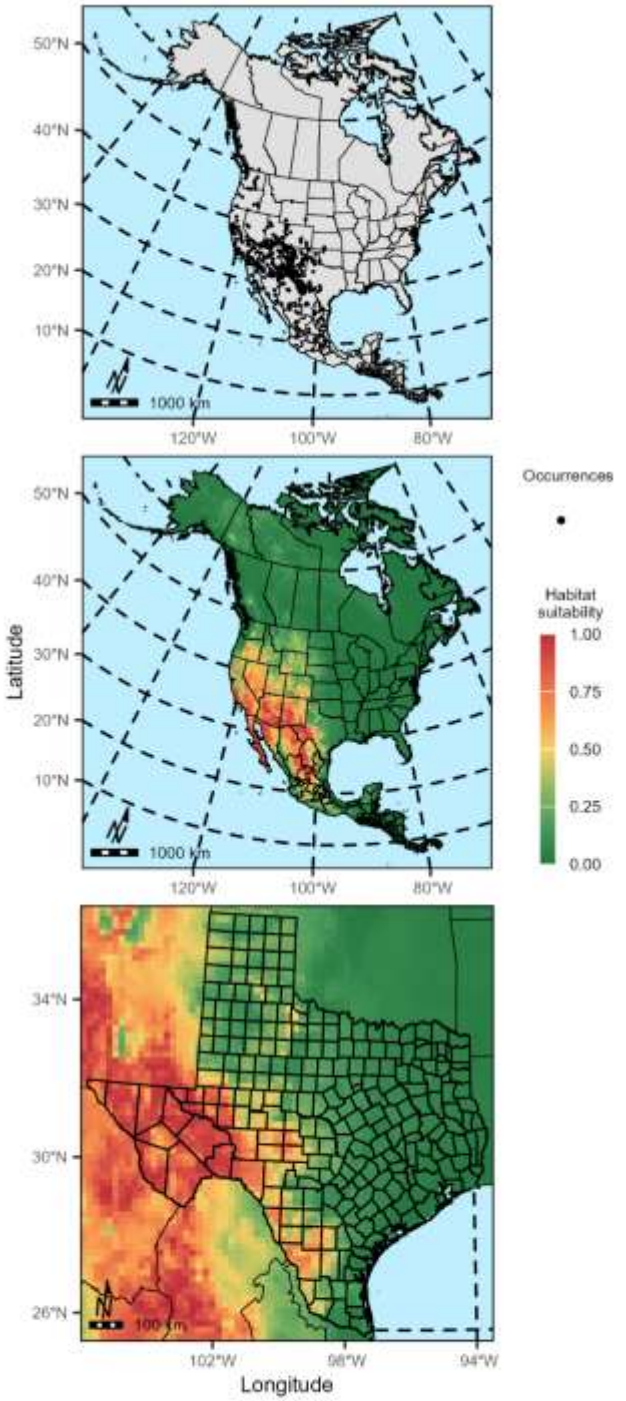


Figure 8. *Antrozous pallidus* occurrence records and MaxEnt cloglog predictions; Top: occurrence map, Middle: North America MaxEnt prediction map, Bottom: Texas MaxEnt prediction map.

Description.—A large (average total length = 113mm, average forearm length = 48mm, range of weights = 12-17g) yellowish-brown bat (Schmidly and Bradley 2016). Distinctive characteristics are large (average = 28mm, Schmidly and Bradley 2016) unattached ears, large eyes and a broad muzzle.

Distribution.—*Antrozous pallidus* is a very common, abundant and geographically widespread taxon inhabiting southern southwest Canada, the southwestern portion of the United States and northern Mexico. It ranges as far east as western Kansas, Oklahoma and Texas as well as the state of Tamaulipas in Mexico (Hall 1981). Pallid bats occur over a wide range of elevations. They are probably

most abundant at lower elevations but inhabit sites as high as 2440 m (Black 1974). In Texas, this species inhabits the western half of the state occurring in the High Plains, Rolling Plains, Trans-Pecos, Edwards Plateau and South Texas Plains ecoregions. It is distributed along the entire Rio Grande in Texas and occurs as far east as Kerr, Bandera and Cameron Counties (Schmidly and Bradley 2016).

Systematics.—Currently six subspecies of *A. pallidus* are recognized (Wilson and Ruff 1999, *bunkeri*, *koopmani*, *minor*, *pacificus*, *packardi* and *pallidus)*. All but *A. p. koopmani* occur in continental North America. *Antrozous p. bunkeri* and *A. p. pallidus* occur in Texas with *A. p. bunkeri* occurring to the north and *A. p. pallidus* occurring in West Texas.

Natural History.—Pallid bats are common at lower elevations in arid and semi-arid regions of North America. They are most common in desert systems. For example, in the Trans-Pecos of Texas they are often the first to third most common bat species in terms of abundance (Easterla 1973a,b, Higginbotham, Stevens 2025). Pallid bats are primarily insectivorous although nectar and pollen of *Agave spp*. (Jaquish and Ammerman 2021) and *Pachycereus pringlei* (Frick et al. 2009) and *Stenocereus thurberi* (Howell 1980) are consumed, sometimes heavily during certain parts of the year. Pallid bats have very general roost preferences and have been observed doing so in rock crevices, caves and mine tunnels but also in attics of houses, under eaves of barns, in hollow trees and in abandoned buildings (Schmidly and Bradley 2016). They also roost in highway infrastructure such as cement pre-stressed concrete box-beam bridges and culverts inside abandoned swallow nests (Stevens et al. 2021, Wilson et al. 2023). In the Trans-Pecos of Texas, mating occurs in October, sperm is stored until ova are released in the spring and maternity colonies form in April to May (Yancey et al. 2023). Females are pregnant from April through July and lactation peaks between June and July (Higginbotham and Ammerman 2002).

Females often have twins (Hermanson and O'Shea 1983) but can carry as many as 4 embryos (Schmidly and Bradley 2016),

Conservation Status.—Populations of pallid bats are listed as stable and they are a species of least concern according to the IUCN (Arroyo-Cabrales and Gammont 2017). This species is one of 14 of the 34 bats that occur in Texas that is not of greatest conservation need (Simon 2023).

Habitat Suitability.—Areas of high habitat suitability for *A. pallidus* extend throughout the southwestern portion of the United States and the northern Chihuahuan Desert of Mexico. In Texas areas of high habitat suitability are throughout the Trans-Pecos, Edwards Plateau, South Texas plains and an area surrounding Palo Duro Canyon in the Rolling Plains.

Most important niche characteristics.—Estimates of permutation importance (Table 2) indicated that the most important environmental niche characteristics for Pallid bats from highest to lowest importance were Bio2 (mean diurnal range of temperature), Aridity, Mixed Grass-Shrubland, Bio18 (precipitation of the warmest quarter), Bio7 (temperature annual range), Cropland and Bio15 (precipitation seasonality). Habitat suitability was positively related to Bio2, Mixed Grass-Shrubland and Bio15 and negatively related to Aridity, Bio18, Bio7 and Cropland (Appendix Figure 7).

Ecological Niche Model Evaluation and Performance—The best performing ecological niche model (Table 1) had linear feature classes and a regularization multiplier of 4. Spatially structured cross-validation yielded a mean 10% omission rate of 0.20 and a mean validation AUC value of 0.81, indicating it to be a good model for predicting the potential distribution of *Antrozous pallidus*.

Corynorhinus rafinesquii—Rafinesque's big-eared bat

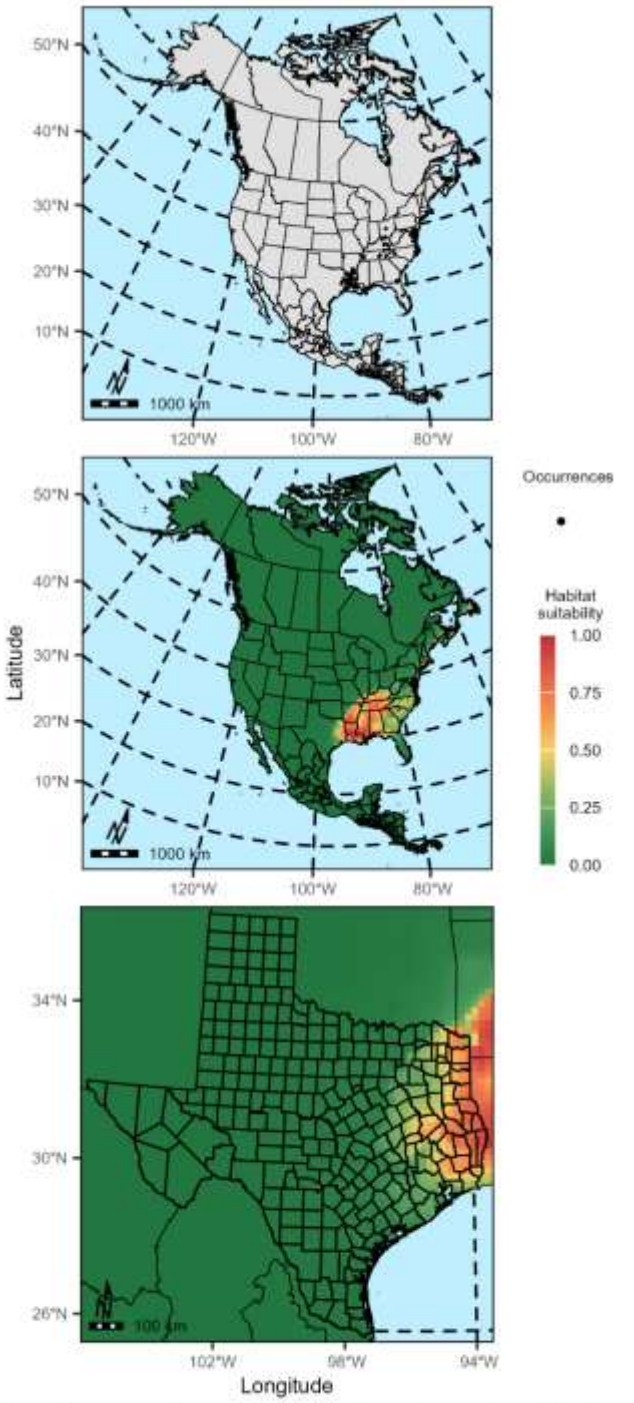


Figure 9. *Corynorhinus rafinesquii* occurrence records and MaxEnt cloglog predictions; Top: occurrence map, Middle: North America MaxEnt prediction map, Bottom: Texas MaxEnt prediction map.

Description.—A medium (average total length = 100mm, average forearm length = 43mm, range of weights = 7-13g) dark brownish bat (Schmidly and Bradley 2016). Distinctive characteristics are large (average = 32mm, Ammerman et al.2012) ears, upper middle incisor with a secondary cusp and long hairs on the foot that extend markedly beyond the nails of toes.

Distribution.—*Corynorhinus rafinesquii* is an uncommon, rare and geographically restricted taxon inhabiting the southeastern portion of the United States. It ranges as far east as the Atlantic Ocean in Virginia, North Carolina, South Carolina, Georgia and Florida; as far north as southern Illinois, Indiana and Ohio, as far south as the Gulf of Mexico and as far west as East Texas (Arroyo-Cabrales and Alvarez-Casteneda 2017). They are most common in the forested regions of the southeastern US. In Texas, this

species inhabits the portions of the Pineywoods ecoregion having been recorded from 15 counties (Schmidly and Bradley 2016).

Systematics.—Currently two subspecies of *C. rafinesquii* are recognized (*macrotis* and *rafinesquii*). *Corynorhinus r. macrotis* occurs in the southern portions of North Carolina, South Carolina Georgia, Alabama and Mississippi as well as all of Louisiana, far east Texas, southern and western Arkansas and southeastern Arkansas. *Corynorhinus r. rafinesquii occurs* in western North Carolina extreme north Mississippi, Alabama Georgia and South Carolina as well as Tennessee, Kentucky Virgina, West Virgina, Ohio, Indiana and Illinois.

Natural History.— *Corynorhinus rafinesquii* is a forest dwelling bat, occurring in nearly every forest association of the Austroriparian and Carolinean biotic provinces of Dice (Jones 1977). This species is insectivorous and with large ears and low intensity echolocation calls, occupy a specialized feeding niche. They consistently consume primarily Macrolepidoptera (Dodd et al. 2015). These long-eared bats typically roost in small groups of less than 100 individuals. Roosting occurs in caves and hollow trees, but these bats also frequently roost in partially lighted anthropogenic structures such as unoccupied buildings or bridges and highway culverts (Jones 1977, Stevens et al. 2017). Parturition occurs between May and June and offspring reach adult size between August and September (Schmidly and Bradley 2016).

Conservation Status.—Populations of Rafinesque's big-eared bats are listed as increasing and they are a species of least concern according to the IUCN (Arroyo-Cabrales and Alvarez-Casteneda 2017a). They typically are rare across their geographic distribution and they were once considered for listing under the Endangered Species Act by the U.S. Fish and Wildlife Service. This is one of the rarest species in Texas, a species of greatest conservation need (Simon 2023) and is listed as Threatened by the Texas Parks and Wildlife Department.

Habitat Suitability.—Areas of high habitat suitability for *C. rafinesquii* are found in the southeast portion of North America, in particular throughout Louisiana and in portions of East Texas, Eastern Arkansas, Mississippi, Alabama, Tennessee, and Kentucky. Scattered and patchily distributed areas of high habitat suitability also occur in Georgia, northern Florida, South Carolina and North Carolina. In Texas, areas of high habitat suitability are found in the eastern part of the state, in particular the Piney Woods ecoregion.

Most important niche characteristics.—Estimates of permutation importance (Table 2) indicated that the most important environmental niche characteristics for *C. rafinesquii* from highest to lowest importance were Bio15 (precipitation seasonality), Igneous Rock, Bio9 (mean temperature in the dryest quarter), Bio14 (precipitation in the dryest month), Bio2 (mean diurnal range of temperature), Elevation, Evergreen Broadleaf Forest and Bio18. Habitat suitability was positively related to Bio9, Bio14, Bio2, and Bio18 and negatively related to Bio15, Igneous Rock, Elevation and Evergreen Broadleaf Forest (Appendix Figure 8).

Ecological Niche Model Evaluation and Performance—The best performing ecological niche model (Table 1) had linear feature classes and a regularization multiplier of 4. Spatially structured cross-validation yielded a mean 10% omission rate of 0.28 and a mean validation AUC value of 0.93, indicating it to be an excellent model for predicting the potential distribution of *Corynorhinus rafinesquii.*

***Corynorhinus townsendii*—Townsend's big-eared bat**

Description.—*Corynorhinus townsendii* is a medium sized (average total length = 100mm, Average forearm length = 44mm, range of masses = 7-12g) bat with large ears (average = 35mm) and facial glands on each side of the snout (Schmidly and Bradley). This species is similar to *C.*

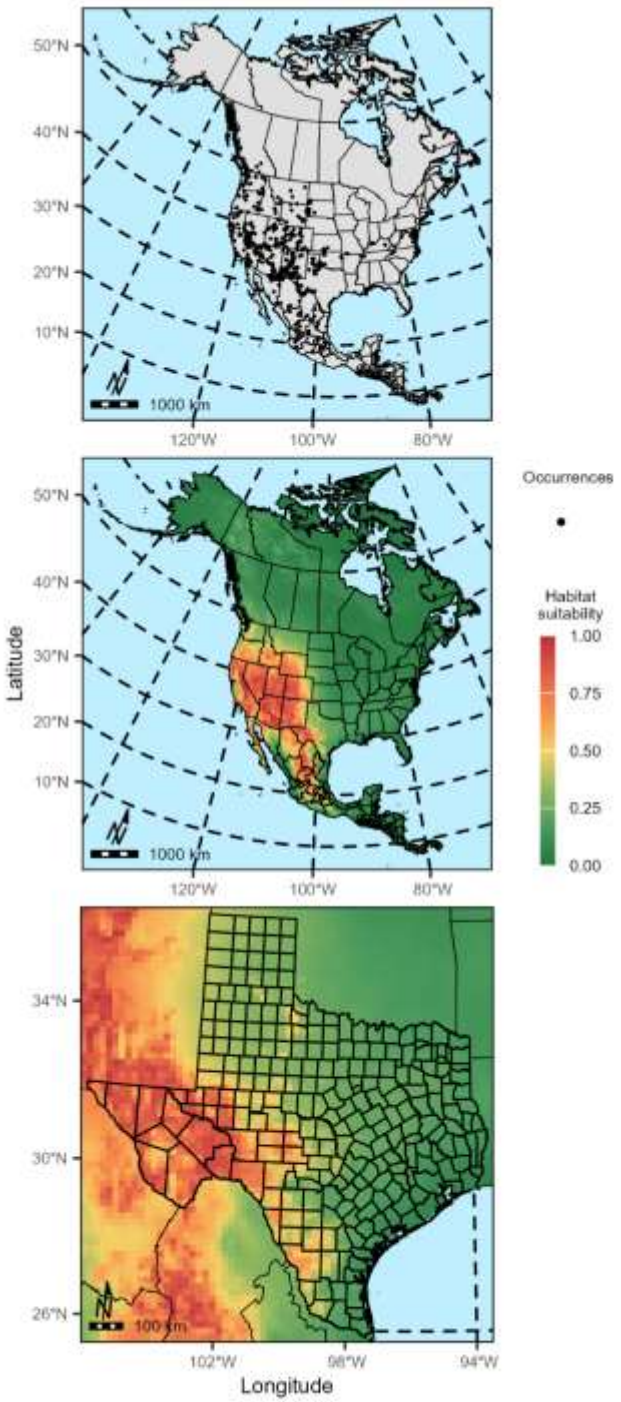


Figure 10. *Corynorhinus townsendii* occurrence records and MaxEnt cloglog predictions; Top: occurrence map, Middle: North America MaxEnt prediction map, Bottom: Texas MaxEnt prediction map.

rafinesquii with the exception that *C. rafinesquii* is darker, has white-frosted ventral hairs with black bases whereas those of *C. townsendii* are brown. *Corynorhinus rafinesquii* also has a middle incisor with a secondary cusp and long hairs on the foot extending beyond the nail.

Distribution.—The geographic range of Townsend's big-eared bat is characterized by a main distribution occupying much of the western half of North America plus two allopatric populations, one at the 4 corners of Kansas, Oklahoma Missouri and Arkansas, and the other occurring in portions of Kentucky, Virginia and West Virginia.

Systematics.—Five subspecies of *C. townsendii* are recognized (Piaggio et al. 2009). *Corynorhinus t. australis* occurs from the Isthmus of Tehuantepec, through the highlands of central Mexico, to Texas, Oklahoma and New Mexico. *Corynorhinus t. ingens* occurs in the Ozark Mountains. *Corynorhinus t. pallescens* occurs in Colorado, New Mexico

and Northern Texas. *Corynorhinus t. townsendii* occurs throughout most of the western US, the southern portion of British Colombia to the state of Sonora Mexico. *Corynorhinus t. virginianus* occurs in the Appalachian Mountains. The exact geographic distributions of *C. t. australis* and *C. t. pallescens* are still uncertain (Smith et al. 2008).

Natural History.— Townsend's big-eared bat occurs in a wide variety of habitats across its geographic range. It commonly occurs in highlands, evergreen forests, deciduous forests, xeric shrub-grasslands, riparian areas and mixed-grass prairies (Kunz and Martin 1982). In Texas, it is found in 6 of 10 ecoregions (Ammerman et al. 2012). This species is insectivorous, feeding principally on microlepidoptera but also consuming Coleoptera, Diptera, Hymenoptera and Neuroptera (Kunz and Martin 1982). These bats roost in hollow trees, caves, mines and buildings (Ammerman et al. 2012. Parturition occurs between late May and early June. Offspring are quite altricial when born being very small, pink and hairless (Schmidly and Bradley 2016).

Conservation Status.—Populations of *C. townsendii* are listed as stable and the species is listed as of least concern by the IUCN (Arroyo-Cabrales and Alvarez-Casteneda 2017b). The Appalachian subspecies is listed as endangered under the Endangered Species Act (U. S. Department of the Interior 2019). In Texas, this species is one of greatest conservation need with a state rank of S3, Vulnerable (Simon 2023).

Habitat Suitability.—Areas of high habitat suitability range across much of the western portion of the United States south of Washington state and Montana and throughout the Chihuahuan desert in Mexico. In Texas high habitat suitability for this species occurs throughout the Trans-Pecos, Permian Basin and South Texas Plains.

Most important niche characteristics.— Estimates of permutation importance (Table 2) indicated that the most important environmental niche characteristics for *C. townsendii* from highest to lowest importance were Elevation, Bio18 (precipitation in the warmest quarter), Bio10 (mean temperature of the warmest quarter), Mixed Grass-Shrubland, Bio19 (precipitation in the coldest quarter), and Bio2 (mean diurnal range of temperature). Habitat suitability was positively related to Elevation, Bio10, Mixed Grass-Shrubland, Bio19, and Bio2 and negatively related to Bio18 (Appendix Figure 9).

Ecological Niche Model Evaluation and Performance—The best performing ecological niche model (Table 1) had linear feature classes and a regularization multiplier of 4. Spatially structured cross-validation yielded a mean 10% omission rate of 0.14 and a mean validation AUC value of 0.78, indicating it to be a fair model for predicting the potential distribution of *Corynorhinus townsendii*.

***Dasypterus ega*—Southern yellow bat**

Description.—A medium sized (average total length = 118mm, average forearm length = 47mm range of masses = 10-15g) bat with yellowish brown fur (Schmidly and Bradley 2016). Fur extents to the proximal one-third to one-half of the uropatagium. Of the three yellow bats occurring in North America, only *D. intermedius* is sympatric with *D. ega*. *D. intermedius* is conspicuously larger (average forearm length = 58mm, Schmidly and Bradley 2016).

Distribution.—Southern yellow bats are distributed from South Texas to the middle of Argentina. In Texas this species has been recorded from as far north as Mongomery and Travis counties.

Systematics.—Four subspecies of *D. ega* are recognized. *Dasypterus e. argentinus* occurs through the middle half of Argentina, all of Paraguay and Uruguay and the southern half of

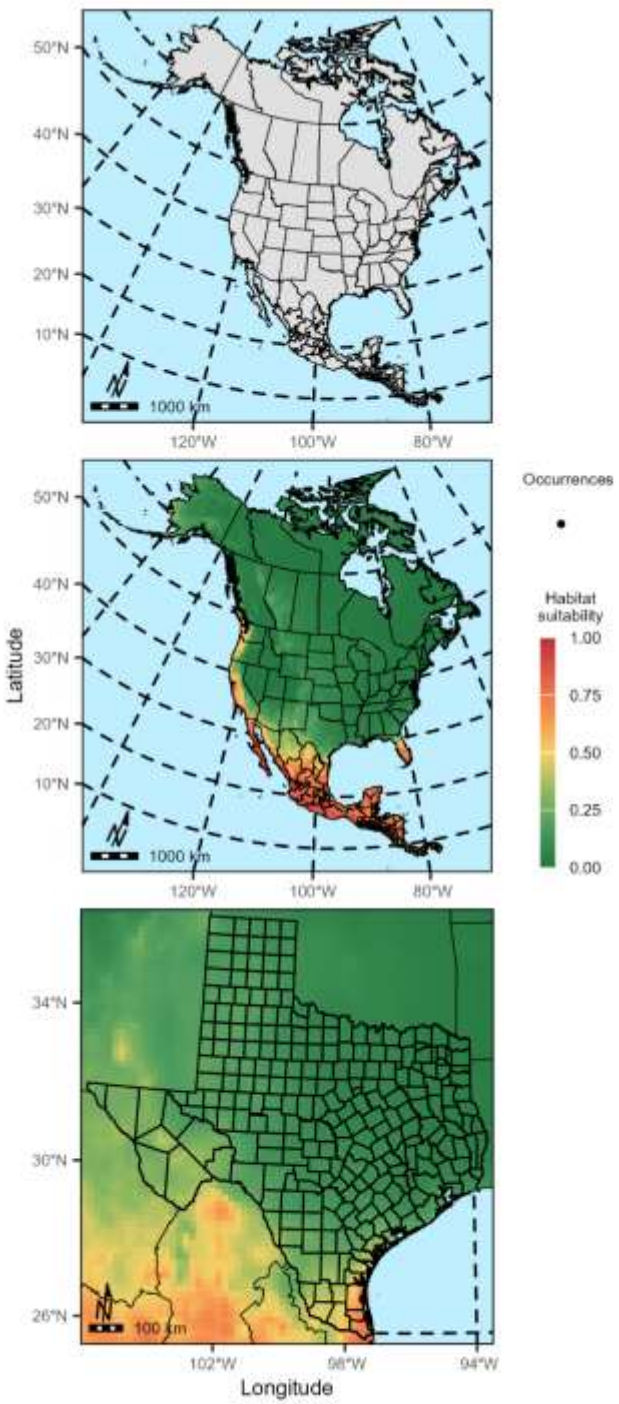


Figure 11. *Dasypterus ega* occurrence records and MaxEnt cloglog predictions; Top: occurrence map, Middle: North America MaxEnt prediction map, Bottom: Texas MaxEnt prediction map.

Brazil. *Dasypterus e. ega* occurs from central Brazil to Central Colombia. *Dasypterus e. fuscatus* occurs west of the Andes in Ecuador and Colombia. *Dasypterus e. panamensis* occurs from northern Colombia and Northern Venezuela to south Texas.

Natural History.— *Dasypterus ega* occurs in a variety of habitats, both mesic and xeric (Kurta and Lehr 1995). For example, it has been captured near a grove of Caranday palms (*Copernicia alba*), in open grassy savanah near secondary forest, over a stream under fig trees, in dry forest, subtropical moist forest, tropical forest, in Caatingas and Edaphic Cerrado habitats and in Interior Atlantic Forest (Myers 1977, Williams and Genoways 1980, Watkins et al. 1972, Handley 1976, Willig 1983, Stevens et al. 2004). In Texas this species is believed to be expanding its range due to the increased use of ornamental palm trees that it prefers to roost in (Ammerman et al. 2012). Dietary preferences are poorly

known. This species is insectivorous consuming a wide variety of night flying insects (Ammerman et al. 2012). In Yucatan, Mexico this species consumes a wide variety of insects but eats beetles more frequently than others (Gaumer 1917). Southern yellow bats are typically solitary roosters and often roost in the dead fronds of palms that very much match their hair color (Ammerman et al. 2012). Other roosts have included Banana and Mango trees as well as inside roof thatch and under the eaves of straw roofs (Kurta and Lehr 1995). Reproductive patterns are highly variable, in particular because of the very wide geographic distribution of this species. In Texas breeding begins in late winter (Schmidly and Bradley 2016). Females captured in April were all pregnant. In June, 9 of 10 females were lactating.

Conservation Status.— Population trends of *D. ega* are listed as unknown and the species is listed as of least concern by the IUCN (Barquez and Diaz 2016). In Texas, this species is one of greatest conservation need (Simon 2023) being given a state rank of S3S4 (Vulnerable to Apparently Secure).

Habitat Suitability.— Areas of high habitat suitability range across much of Mexico and Baja California and much of the Pacific Seaboard of the United States. There is also an area of high habitat suitability in southern Florida. In Texas there is an area of relatively high habitat suitability in extreme southern Texas (though modest).

Most important niche characteristics.— Estimates of permutation importance (Table 2) indicated that the most important environmental niche characteristics for *L. ega* from highest to lowest importance were Bio7 (temperature annual range), Bio 15 (precipitation seasonality), Bio17 (precipitation of the dryest quarter) and Bio8 (mean temperature of the wettest quarter). Habitat suitability was positively related to Bio15 and Bio8 and negatively related to Bio7 and Bio17 (Appendix Figure 10).

Ecological Niche Model Evaluation and Performance—The best performing ecological niche model (Table 1) had hinge feature classes and a regularization multiplier of 3. Spatially structured cross-validation yielded a mean 10% omission rate of 0.23 and a mean validation AUC value of 0.70, indicating it to be an acceptable model for predicting the potential distribution of *Dasypterus ega*.

***Dasypterus intermedius*—Northern yellow bat**

Description.— A large (average total length = 140mm, average forearm length = 58mm range of masses = 14-31g) bat with yellowish brown fur (Schmidly and Bradley 2016). Fur extends to the proximal one-third to one-half of the uropatagium. The ear is more pointed than in other yellow bats.

Distribution.—*Dasypterus intermedius* is distributed from South Carolina USA to the north through the US Gulf Coast states, through Mexico to Honduras with two disjunct marginal records in Virgina and New Jersey (Miller and Rodriguez 2016).

Systematics.—Currently, three subspecies are recognized (Wilson and Ruff 1999). *Dasypterus i. floridanus* ranges from the norther portion of the range along the Atlantic coast to south Texas. *Dasypterus i. insularis* occurs throughout Cuba. *Dasypterus i. intermedius* ranges from south Texas to Honduras.

Natural History.—*Dasypterus intermedius* occurs in wooded areas in the vicinity of permanent water in both coniferous and deciduous forest (Webster et al. 1980). It is reported to roost in clumps of Spanish moss (*Tillandsia usenoides*) in much of the United States. In south Texas it frequently roosts in dead fronds of palm trees (Ammerman et al. 2012) and in Veracruz this species was reported to roost in corn stalks left hanging to dry (Baker and Dickerman 1956).

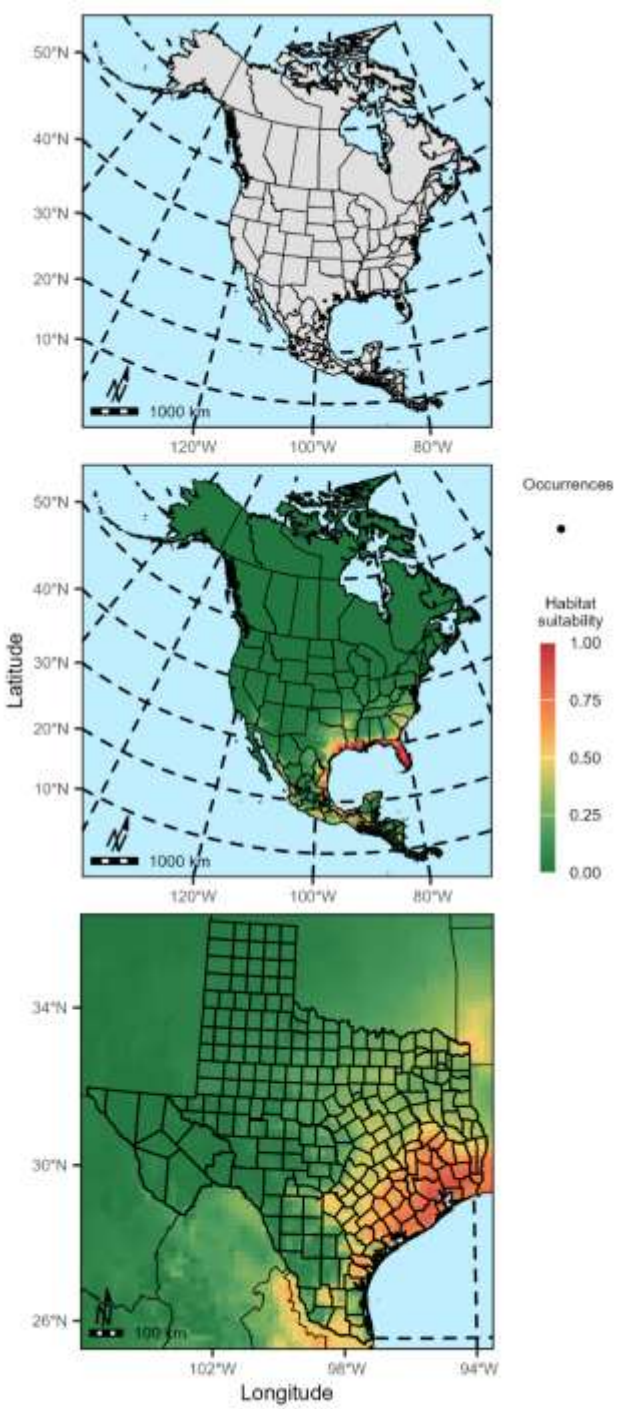


Figure 12. *Dasypterus intermedius* occurrence records and MaxEnt cloglog predictions; Top: occurrence map, Middle: North America MaxEnt prediction map, Bottom: Texas MaxEnt prediction map.

Dasypterus intermedius is insectivorous having been reported to consume Coleoptera, Diptera, Hemiptera, Hymenoptera and Odonata (Sherman 1939). Breeding occurs in fall and winter (Hall and Jones 1961, Barbour and Davis 1969). Pregnant females have been observed in May and June (Webster et al. 1980). Offspring are born in May and June (Lowery 1974, Schmidly and Bradley 2016). Lactation occurs in June and July (Lowery 1936, LaVal 1967). Litter size ranges from two to four (Barbour and Davis 1969). Mating occurs in the fall and winter and parturition occurs in May and June. Females have between 2 and 4 offspring per reproductive bout (Webster et al. 1980).

Conservation Status.—Population trends of *D. intermedius* are unknown and the species is listed as of least concern by the IUCN

(Miller and Rodriguez 2016). In Texas, *D. intermedius* is not listed as a species of greatest conservation need (Simon 2023).

Habitat Suitability.—Areas of high habitat suitability for *D. intermedius* in North America occur in the coastal bend of the entire Gulf of Mexico, patchy and isolated areas through Central America to Nicaragua and portions of the Pacific seaboard of Mexico. In Texas areas of high habitat suitability occur along the coast of the Gulf of Mexico.

Most important niche characteristics.— Estimates of permutation importance (Table 2) indicated that the most important environmental niche characteristics for *D intermedius* from highest to lowest importance were Bio1 (mean annual temperature), Bio17 (precipitation in the driest quarter), Bio19 (precipitation in the coldest quarter), Bio18 (precipitation in the warmest quarter), Bio15 (precipitation seasonality), Elevation, Evergreen Broadleaf Forest and Mixed Grass-Shrubland. Habitat suitability was positively related to Bio1, Bio17, Bio18, and Elevation and negatively related to Bio19, Bio15, Evergreen Broadleaf Forest and Mixed Grass-Shrubland (Appendix Figure 11).

Ecological Niche Model Evaluation and Performance—The best performing ecological niche model (Table 1) had linear feature classes and a regularization multiplier of 1. Spatially structured cross-validation yielded a mean 10% omission rate of 0.21 and a mean validation AUC value of 0.77, indicating it to be a fair model for predicting the potential distribution of *Dasypterus intermediuus*.

***Dasypterus xanthinus*—Western yellow bat**

Description.— This is a medium sized (average total length = 105, average forearm length = 45, range of masses = 12-19g) bat with a pale yellow dorsum (Schmidly and Bradley 2016). Hairs

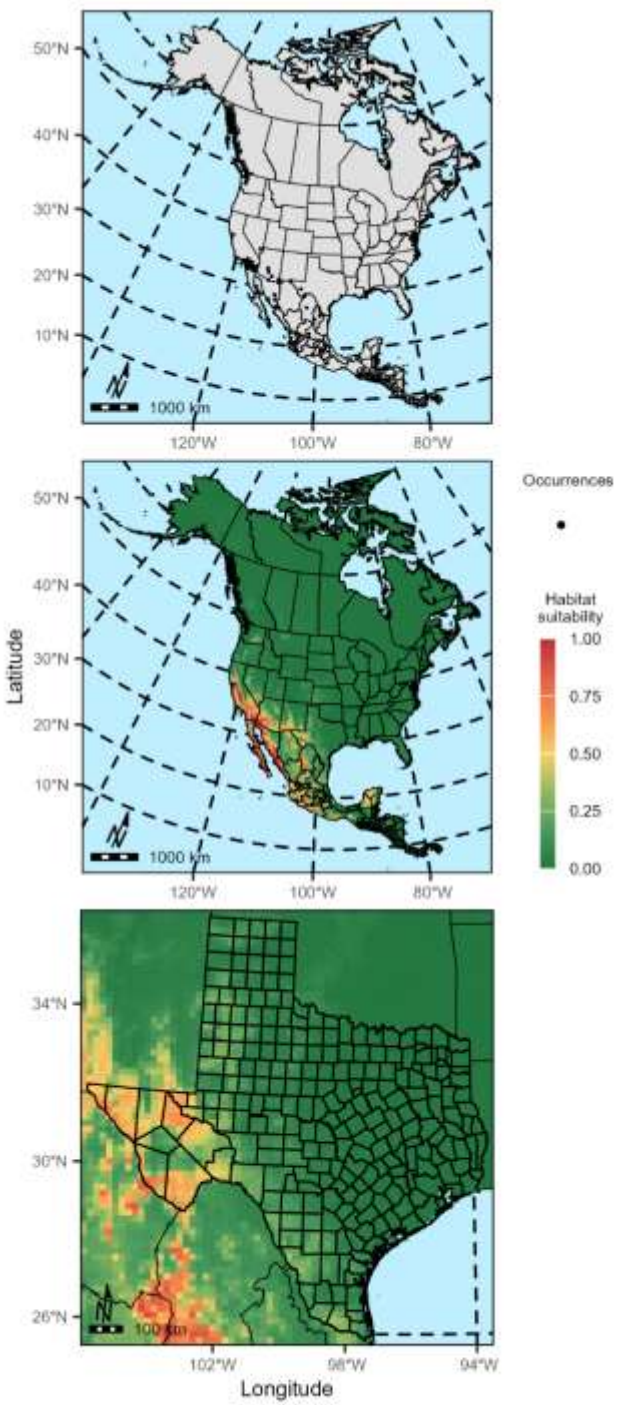


Figure 13. *Dasypterus xanthinus* occurrence records and MaxEnt cloglog predictions; Top: occurrence map, Middle: North America MaxEnt prediction map, Bottom: Texas MaxEnt prediction map.

with a dark base and hair extends to the proximal first half of the uropatagium (Ammerman et al. 2012).

Distribution.—This species occurs in arid regions of Southern California (including Baja California), Arizona and New Mexico and in the Trans-Pecos, through the arid Mexican highlands as far south as the Mexican states of Puebla and Verra Cruz (Ammerman et al. 2012, Arroyo-Cabrales and Alvarez-Casteneda 2017).

Systematics.—*Dasypterus xanthinus* is monotypic (Ammerman et al. 2012).

Natural History.— Little is known of the biology of *Dasypterus xanthinus*. It occurs in arid systems including savannah, woodlands, pastures, croplands and urban areas (Arroyo-Cabrales and Alvarez-Casteneda 2017). It roosts in the dead fronds of palm trees and in Giant daggar yucca (*Yucca carnerosana*) leaves (Higginbotham et al. 2000) and in deciduous trees such as Hackberry (*Celtis spp.*), Sycamore (*Spatanus spp.*), and Cottonwood (*Populus spp.*). This species is insectivorous and

has been reported to consume Diptera, Coleoptera, Hemiptera, Hymenoptera, and Orthoptera (O'Farrell et al. 2004, Higginbotham et al. 2009). Little is known about reproduction. Typical litter size is two (Ammerman et al. 2012). Pregnant females have been captured in May and June (Kurta and Lehr 1995) and lactating females have been captured in August (Mumford and Zimmerman 1963, Bond 1970, Cook 1986). Juveniles have been taken in July and September (O'Farrel et al. 2004).

Conservation Status.—Population trends of *D. xanthinus* are stable and the species is listed as least concern by the IUCN (Arroyo-Cabrales and Alvarez-Casteneda 2017c). In Texas, *D. xanthinus* is listed as a species of greatest conservation need and it has a state rank of S1, critically imperiled (Simon 2023).

Habitat Suitability.—Areas of high habitat suitability for western yellow bats in North America are distributed from California and southern Nevada south across the Baja peninsula and the western coast of Mexico plus scattered areas throughout Mexico. In Texas, areas of highest habitat suitability occur in the Trans-Pecos.

Most important niche characteristics.—Estimates of permutation importance (Table 2) indicated that the most important environmental niche characteristics for *Lasiurus xanthinus* from highest to lowest importance were Bio4 (temperature seasonality), Bio2 (mean diurnal range of temperature), Bio14 (precipitation of the dryest month), Bio13 (precipitation in the wettest month), Aridity, Elevation, Pasture and Bio15 (precipitation seasonality). Habitat suitability was positively related to Bio2 and Bio15 and negatively related to Bio4, Bio14, Bio13, Aridity, Elevation and Pasture (Appendix Figure 12).

Ecological Niche Model Evaluation and Performance—The best performing ecological niche model (Table 1) had linear feature classes and a regularization multiplier of 3. Spatially structured cross-validation yielded a mean 10% omission rate of 0.15 and a mean validation AUC value of 0.83, indicating it to be a good model for predicting the potential distribution of *Dasypterus xanthinus*.

***Eptesicus fuscus*—Big brown bat**

Description.—A medium-sized (average total length 114mm, average forearm length 47mm, range of masses 13-30g) heavy-bodied bat with a large head, broad nose, relatively small, thick and leathery ears, short and broad wings, and a keeled calcar (Kurta and Baker 1990, Schmidly and Bradley 2016).

Distribution.—*Eptesicus fuscus* is widely distributed from the Northwestern Territory of Canada in the north to portions of Colombia and Venezuela in the south. This species is also widely distributed across the Greater Antilles and Bahamas (Wilson and Ruff 1999) and across Dominica in the Lesser Antilles (Hill and Evans 1985).

Systematics.—11 subspecies are recognized (Wilson and Ruff 1999). *Eptesicus f. bahamensis* occurs across the Bahaman islands. *Eptesicus f. bernardinus* ranges from central California to British Colombia. *Eptesicus f. dutertreus* occurs on the Bahaman Islands and Cuba. *Eptesicus f. fuscus* occurs over much of the eastern portion of North America, *Eptesicus f. hispaniolae* occurs across Hispanola and Jamaica. *Eptesicus f. miradornesis* ranges from Colombia and Venezuela to southern Texas. *Eptesicus f. osceolae* occurs across peninsular Florida. *Eptesicus f. pallidus* occurs across the central-west portion of North America. *Eptesicus f. peninsulae* inhabits the

southern Baja Peninsula. *Eptesicus f. petersoni* occurs on the Isle de Pinos, Cuba. *Eptesicus f. wetmorei* occurs on Puerto Rico.

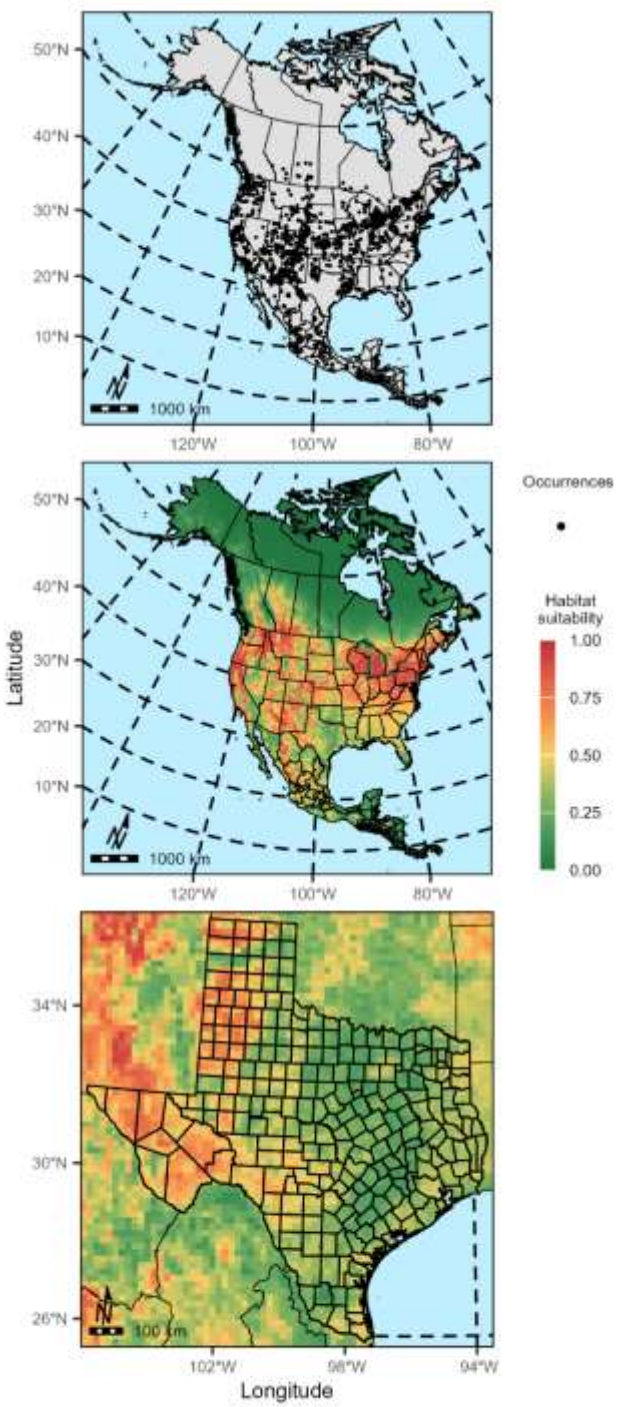


Figure 14. *Eptesicus fuscus* occurrence records and MaxEnt cloglog predictions; Top: occurrence map, Middle: North America MaxEnt prediction map, Bottom: Texas MaxEnt prediction map.

Natural History.—*Eptesicus fuscus* occurs across all ecoregions in eastern and central North America. In the arid west of North America and throughout Mexico and Central America this species is typically restricted to forested highlands. In North America this species shows marked decreases in abundance when going from the deciduous forest biome to the coniferous forest biome (Kurta et al. 1989). In much of the mountainous western North America, males tend to occur at higher elevations than females (Fenton et al. 1980). This species is insectivorous with small beetles making up the majority of the diet of this species (Freeman 1981, Kurta and Baker 1990). Big brown bats also consume insects from the orders Blattodea, Diptera, Ephemeroptera,

Hemiptera, Hymenoptera, Mecoptera, Neuroptera, Plecoptera and Trichoptera (Schmidly and Bradley 2016). Big brown bats are very general in their roosting preferences. Natural roosts include rock crevices as well as hollow oak, pine and beech trees (Christian 1956, Kurta 1980, Brigham 1988). Manmade roosts include barns, houses, churches, bridges and highway culverts (Geluson and Mink 2009, Bender et al. 2010). Copulation occurs between September and March (Mumford 1958). In temperate North America ovulation and fertilization is delayed until after hibernation (Wimsatt 1944). Litter size is 1 to 2 depending on geography (Barbour and Davis 1969). Offspring are born between May and July with earlier parturition at lower latitudes (Barbor and Davis 1969).

Conservation Status.—Population trends of *E. fuscus* are growing and the species is listed as of least concern by the IUCN (Miller et al. 2016). In Texas, *E. fuscus* is not listed as a species of greatest conservation need (Simon 2023).

Habitat Suitability.—*Eptesicus fuscus* is perhaps the most widely distributed bat in North America. Reflective of this is high habitat suitability across much of North America and Mexico. In Texas areas of high habitat suitability are primarily in the Trans-Pecos but also the western Edwards Plateau and northern South Texas Plains.

Most important niche characteristics.—Estimates of permutation importance (Table 2) indicated that the most important environmental niche characteristics for *Eptesicus fuscus* from highest to lowest importance were Bio5 (maximum temperature of the warmest month), Bio4 (temperature seasonality), Pasture, Bio17 (precipitation of the dryest quarter), Bio13 (precipitation of the wettest month), Surface Water and Cropland. Habitat suitability was negatively related to Pasture, Bio17, Surface Water and Cropland. More complex (modal) relationships with habitat suitability existed for Bio5, Bio4, Bio13 (Appendix Figure 13).

Ecological Niche Model Evaluation and Performance—The best performing ecological niche model (Table 1) had linear, quadratic and hinge feature classes and a regularization multiplier of 2.5. Spatially structured cross-validation yielded a mean 10% omission rate of 0.11 and a mean validation AUC value of 0.72, indicating it to be a fair model for predicting the potential distribution of *Eptesicus fuscus*.

***Euderma maculatum*—Spotted bat**

Description.—A large sized (average total length = 124mm, average forearm = 51mm, rage of masses = 16-20) bat with large pale ears (average length = 42mm) and three large white spots on the dorsum, one on each shoulder and one on the rump (Schmidly and Bradley 2016). This is one of the most distinctive bats in North America.

Distribution.—Spotted bats are distributed across much of the western portion of North America, ranging from southern British Colombia to the north, Queretaro to the east and south and southern California to the west (Watkins 1977 Hall 1981).

Systematics.—*Euderma maculatum* is a monotypic species (Wilson and Ruff 1999).

Natural History.—Spotted bats occur in the arid portion of southwestern North America. Within this region they are fairly general in their habitat affinities having been caught in low elevation desert scrub, juniper-sagebrush steppe, ponderosa pine forests, spruce-fir forest and pinyon-juniper woodlands (Ammerman et al. 2012). These bats forage in open areas within ponderosa pine forests and in pinyon juniper woodlands (Navo et al. 1992). Spotted bats primarily roost in cliff crevices but also have been reported roosting in caves, mines and buildings (Miller 1903, Hardy 1941, Easterla 1973, Geluso 2000). *Euderma maculatum* consumes almost exclusively moths (Watkins 1977). Little information exists on reproduction in spotted bats. Scrotal males

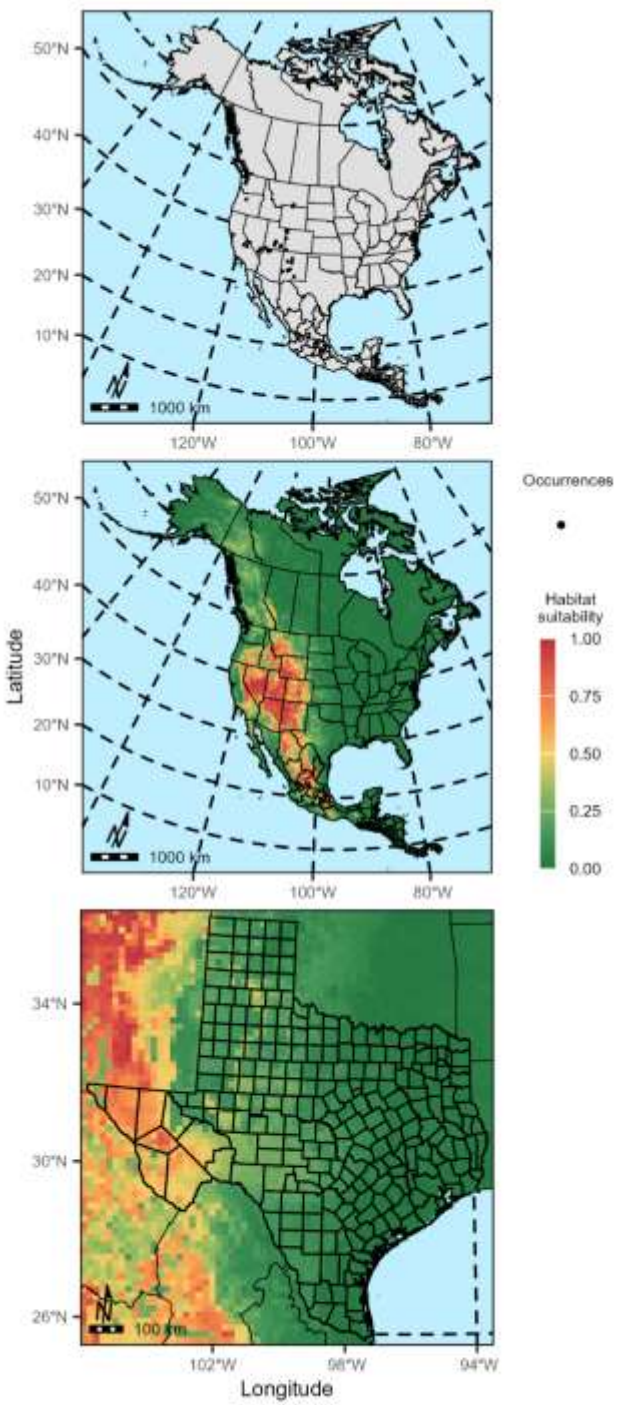


Figure 15. *Euderma maculatum* occurrence records and MaxEnt cloglog predictions; Top: occurrence map, Middle: North America MaxEnt prediction map, Bottom: Texas MaxEnt prediction map.

have been observed in June in Arizona and another in Utah in August (Easterla 1965, Poche 1975, Poche and Ruffner 1975). Pregnant females in Arizona, Nevada and Texas were captured in June (Easterla 1973, Poche 1975, Geluso 2000). Lactating females have been observed in Arizona, Nevada, New Mexico, Texas and Wyoming from June to August (Findley and Jones 1965, Easterla 1973, Berna 1990, Perry et al. 1997, Priday and Luce 1999, Geluso 2000).

Conservation Status.— Population trends of *E. maculatum* are stable and the species is of least concern based on the IUCN (Arroyo-Cabrales and Álvarez-Castañeda 2017f). In Texas, *E. maculatum* is listed as threatened by the Texas Parks and Wildlife Department and also listed as a species of greatest conservation need (Simon 2023).

Habitat Suitability.—Areas in North America of high habitat suitability for *Euderma maculatum* occur throughout the western US particularly in the states of New Mexico, Arizona, California, Nevada, Utah, Colorado and Wyoming. An additional band of high suitability occurs throughout the middle of Mexico extending from the state of Chihuahua to the state of Oaxaca. In Texas, areas of high habitat suitability occur in the Trans-Pecos ecoregion.

Most important niche characteristics.—Estimates of permutation importance (Table 2) indicated that the most important environmental niche characteristics for *Euderma maculatum* from highest to lowest importance were Elevation, Aridity, Sedimentary Rock, Pasture, Deciduous Broadleaf Forest, Surface Water and Evergreen Needleleaf Forest. Habitat suitability was positively related to Elevation, Sedimentary Rock, Surface Water, and Evergreen Needleleaf Forest and negatively related to Aridity. Pasture, and Deciduous Broadleaf Forest (Appendix Figure 14).

Ecological Niche Model Evaluation and Performance—The best performing ecological niche model (Table 1) had hinge feature classes and a regularization multiplier of 4. Spatially structured cross-validation yielded a mean 10% omission rate of 0.17 and a mean validation AUC value of 0.88, indicating it to be a good model for predicting the potential distribution of *Euderma maculatum*.

Lasionycteris noctivagans—Silver-haired bat

Description.—A mediums sized (average total length = 100mm, average forearm length = 41mm, range of masses = 8-12g), dark brown to nearly black bat with dense hair extending to at least half of the length of the uropatagium and often times near to the tip of the tail (Schmidly and Bradley 2016). Hairs have white tips that produce a frosted appearance.

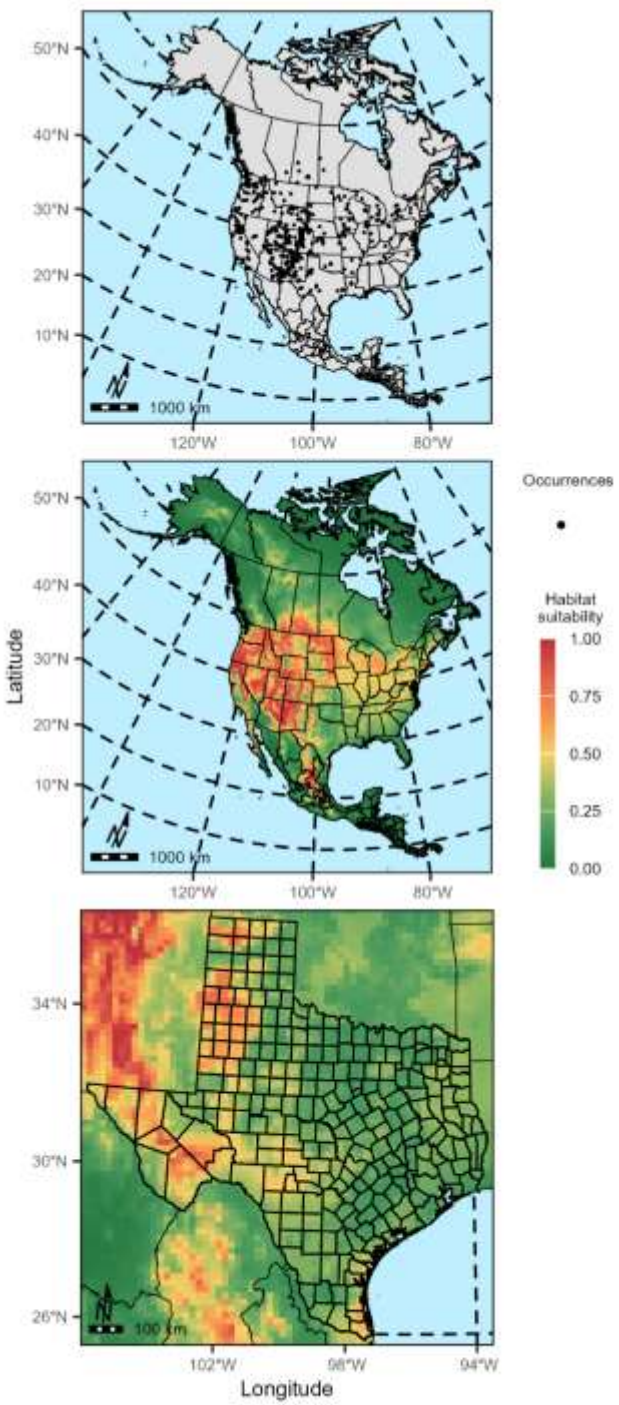


Figure 16. *Lasionycteris noctivagans* occurrence records and MaxEnt cloglog predictions; Top: occurrence map, Middle: North America MaxEnt prediction map, Bottom: Texas MaxEnt prediction map.

Distribution.—Silver-haired bats are widely distributed in North America (Kunz 1982). They occur as far north as southeast Alaska and the lower half of Canada, through much of the United States except southern California, southeastern Arizona, the southern Trans-Pecos and the coastal bend of Texas, southern Louisiana, Mississippi, Alabama Georgia and all of Florida. This species is present in Mexico in the states of Coahuila, Nuevo Leon and Tamaulipas.

Systematics.—*Lasionycteris noctivagans* is a monotypic species (Ammerman et al. 2012).

Natural History.—Silver-haired bats often forage in coniferous or mixed-deciduous forest and adjacent to ponds and streams (Kunz 1982). Siver-haired bats are migratory and tend to overwinter in the southern portion of their distribution (Izor 1979). They have been observed more than 160km off the coast of Long Island while migrating (Mackiewicz and Backus 1956). Silver-haired bats have been reported to roost in caves and

mines (Beer 1956, Layne 1958), rock crevices (Frum 1953), under loose bark (Cowan 1933) in hollow trees (Jackson 1961), in woodpecker holes (Ammerman et al. 2012) and in buildings (Bartsch 1956). *Lasionycteris noctivagans* is considered to be a moth specialist in New Mexico and Arizona (Black 1974, Warner 1985) but has also been reported to consume Coleoptera, Diptera, Hemiptera, Isoptera and Trichopetera (Whitaker 1972, Jones et al. 1973, Whitaker et al. 1977). Mating likely occurs in the fall, followed by delayed fertilization until the spring (Kunz 1982, Ammerman 2012). Peak ovulation occurs in April and May, with approximately 10 days passing between ovulation and implantation followed by a 50 to 60 day gestation period (Drueker 1972). Females give birth to one or two offspring with two being the norm (Turner and Jones 1968, Kunz 1971). At birth, neonates are pink, hairless, with dark wing membranes, closed eyes and folded ears (Kunz 1971). Flying young have been captured on 22 July (Kunz 1982) and most males and females are sexually mature in their first summer (Drueker 1972).

Conservation Status.— Population trends of *L. noctivagans* are listed as stable and the species is of least concern based on the IUCN (Solari 2019a). In Texas, this species is not listed by the Texas Parks and Wildlife Department as a species of greatest conservation need (Simon 2023).

Habitat Suitability.—In North America, areas of highest habitat suitability for *Lasionycteris noctivagans* are primarily in the western portion of the continent, in particular New Mexico, Colorado, Arizona and Utah as well as northern California, and western Oregon and Washington. Similarly in Texas, the western portion of the state, in particular the Trans-Pecos exhibits highest habitat suitability.

Most important niche characteristics.—Estimates of permutation importance (Table 2) indicated that the most important environmental niche characteristics for *Lasionycteris noctivagans* from highest to lowest importance were Bio5 (maximum temperature in the warmest month), Bio18

(precipitation in the warmest quarter), Pasture, Bio15 (precipitation seasonality), Elevation, Evergreen Broadleaf Forest and Bio19 (precipitation of the coldest quarter). Habitat suitability was positively related to Elevation and Bio19 and negatively related to Bio3, Pasture, Bio18, Aridity and Cropland. More complex (modal) relationships with habitat suitability existed for Bio5 and Bio15 (Appendix Figure 15).

Ecological Niche Model Evaluation and Performance—The best performing ecological niche model (Table 1) had hinge feature classes and a regularization multiplier of 4. Spatially structured cross-validation yielded a mean 10% omission rate of 0.12 and a mean validation AUC value of 0.81, indicating it to be a good model for predicting the potential distribution of *Lasionycteris noctivagans*.

Lasiurus blossevillii—Western Red Bat

Description.—A medium sized (average total length = 103mm, average forearm length = 40mm, range of masses = 10-15g), bat that is very similar to *L. borealis* but slightly smaller (Schmidly and Bradley 2016). It has red to brownish pelage that lacks white-tipped hairs (Ammerman et al. 2012). Fur extends 2/3 of the length of the uropatagium.

Distribution.—Western red bats are widely distributed from Argentina and Chile in South America to Southern British Colombia in Canada and across much of the western portion of the United States.

Systematics.—Two subspecies have been described. *Lasiurus b. blossevillii occurs* throughout South America whereas *L. b. frantzii* occurs across Central and North America (Ammerman et al. 2012).

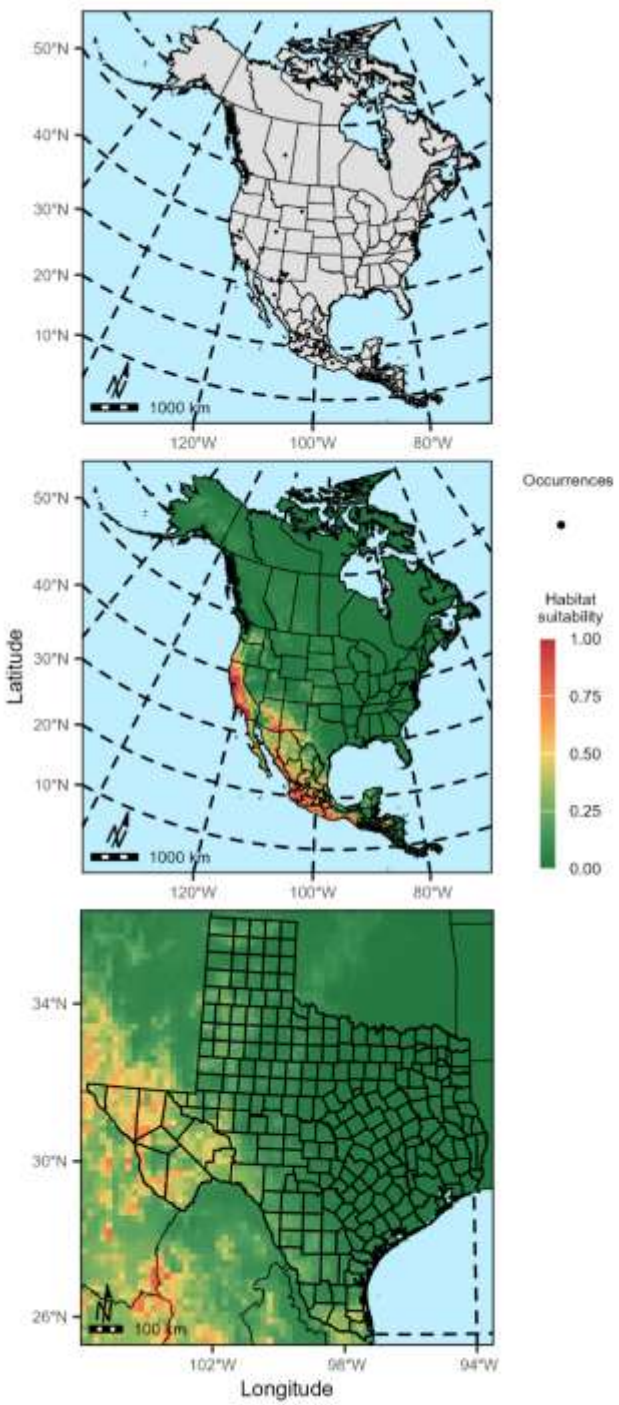


Figure 17. *Lasiurus blossevillii* occurrence records and MaxEnt cloglog predictions; Top: occurrence map, Middle: North America MaxEnt prediction map, Bottom: Texas MaxEnt prediction map.

Natural History.—In arid and semiarid North America, this species forages in riparian habitat dominated by cottonwoods, oaks, sycamores and walnuts. It likely migrates and overwinters in more southern regions (Cryan 2003). *Lasiurus blossevillii* roost in trees with dense foliage and do not appear to select trees based on size or species (Anderson and Geluso 2018). Reproductive patterns are similar to that of *L. borealis* (Yancey et al. 2023). Mating occurs in August and September. Parturition occurs in May to June. Like many vespertilionids, females of this species undergo delayed fertilization.

Conservation Status.—Population trends of Western red bats are unknown and the species is of least concern based on the IUCN (Gonzalez et al. 2016). In Texas, this species is not listed by the Texas Parks and Wildlife Department as a species of greatest conservation need (Simon 2023).

Habitat Suitability.—Areas of high habitat suitability for *Lasiurus blossevillii* occur in the southwestern portion of the United States including Texas, New Mexico, Arizona, California, Oregon and Washington as well as southwestern Mexico ranging from Sonora to Chiapas. In Texas areas of high habitat suitability are in the Trans-Pecos and western Edwards Plateau and scattered areas on the South Texas Plains.

Most important niche characteristics.— Estimates of permutation importance (Table 2) indicated that the most important environmental niche characteristics for *Lasiurus blossevillii* from highest to lowest importance were Bio9 (mean temperature of the driest quarter), Bio14 (precipitation of the dryest month), Pasture, Bio13 (precipitation of the wettest month), Bio8 (mean temperature of the wettest quarter) and Bio15 (precipitation seasonality). Habitat suitability was positively related to Bio9 and negatively related to Bio13, Bio 14 and Pasture. More complex (modal) relationships with habitat suitability existed for Bio8 and Bio15 (Appendix Figure 16).

Ecological Niche Model Evaluation and Performance—The best performing ecological niche model (Table 1) had linear, quadratic and hinge feature classes and a regularization multiplier of 3. Spatially structured cross-validation yielded a mean 10% omission rate of 0.13 and a mean validation AUC value of 0.82, indicating it to be a good model for predicting the potential distribution of *Lasiurus blossevillii*.

Lasiurus borealis—Eastern Red Bat

Description.—This is a medium sized (average total length = 108mm, average forearm length = 40mm, range of masses = 10-15g, Schmidly and Bradley 2016) distinctly red bat with a densely furred uropatagium between the legs. Females are often a lighter shade of red with white tipped hairs whereas males tend to be darker with white tips absent.

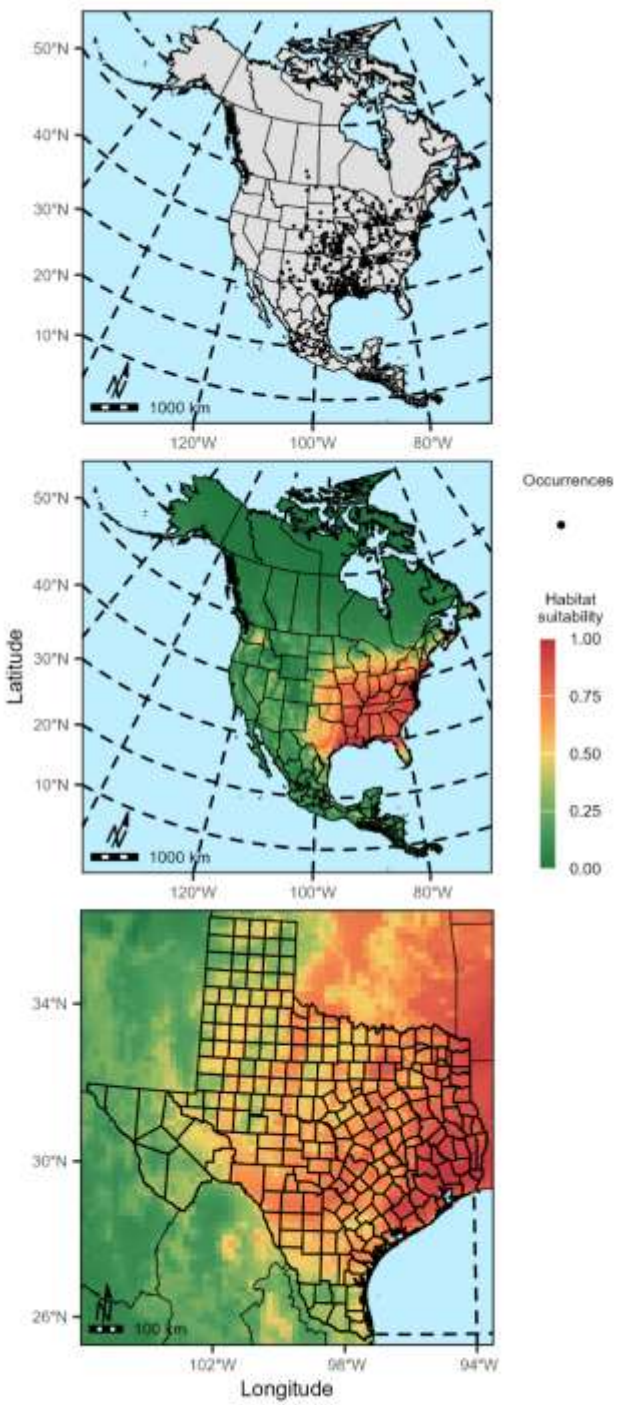


Figure 18. *Lasiurus borealis* occurrence records and MaxEnt cloglog predictions; Top: occurrence map, Middle: North America MaxEnt prediction map, Bottom: Texas MaxEnt prediction map.

Distribution.—Eastern red bats are common and widely distributed across eastern North America into northeastern Mexico.

Systematics.—*Lasiurus borealis is* a monotypic species (Schmidly and Bradley 2016).

Natural History.—Red bats are typically forest dwelling though they likely are common even in prairies as long as there are some trees (Shump and Shump 1982). These bats are solitary, roost primarily in trees but also on the ground in forest duff in winter (Perry 2013). Tree roosts are primarily deciduous hardwoods (Constantine 1966). Nonetheless they will roost in conifers when these trees are common (Elmore et al. 2004). Red bats appear to be dietary generalists consuming insects across a wide variety of orders with Coleoptera, Diptera, HemipteraHymenoptera, and Lepidoptera being common dietary constituents (Mumford 1973, Ross 1967). *Lasiurus borealis* breeds in August and September and fertilization is delayed until the spring (Glass 1966, Stuewer

1948) with records of copulation initiated in flight. Gestation has been estimated to be between 80 and 90 days (Jackson 1961). The estimated median parturition date was 15 June and females lactate for approximately 38 days (Kunz 1971).

Conservation Status.— Population status is stable and Eastern red bats are listed as least concern according to the IUCN (Arroyo-Cabrales et al. 2016). This species is not listed as one of greatest conservation need by TPWD (Simon 2023).

Habitat Suitability.—Areas of high habitat suitability for *Lasiurus borealis* in North America occur across the eastern United States and southern Canada. Similarly in Texas this species has highest habitat suitability in the eastern portion of the state as well as across much of the Edwards Plateau.

Most important niche characteristics.— Estimates of permutation importance (Table 2) indicated that the most important environmental niche characteristics for *Lasiurus borealis* from highest to lowest importance were Bio1 (mean annual temperature), Bio14 (precipitation of the dryest month), Elevation, Bio19 (precipitation of the coldest quarter), and Pasture. Habitat suitability was positively related to Bio14 and negatively related to Elevation, Bio19 and Pasture. A more complex (modal) relationship with habitat suitability existed for Bio1 (Appendix Figure 17).

Ecological Niche Model Evaluation and Performance—The best performing ecological niche model (Table 1) had linear, quadratic and hinge feature classes and a regularization multiplier of 4. Spatially structured cross-validation yielded a mean 10% omission rate of 0.13 and a mean validation AUC value of 0.81, indicating it to be a good model for predicting the potential distribution of *Lasiurus borealis*.

Lasiurus seminolus—Seminole Bat

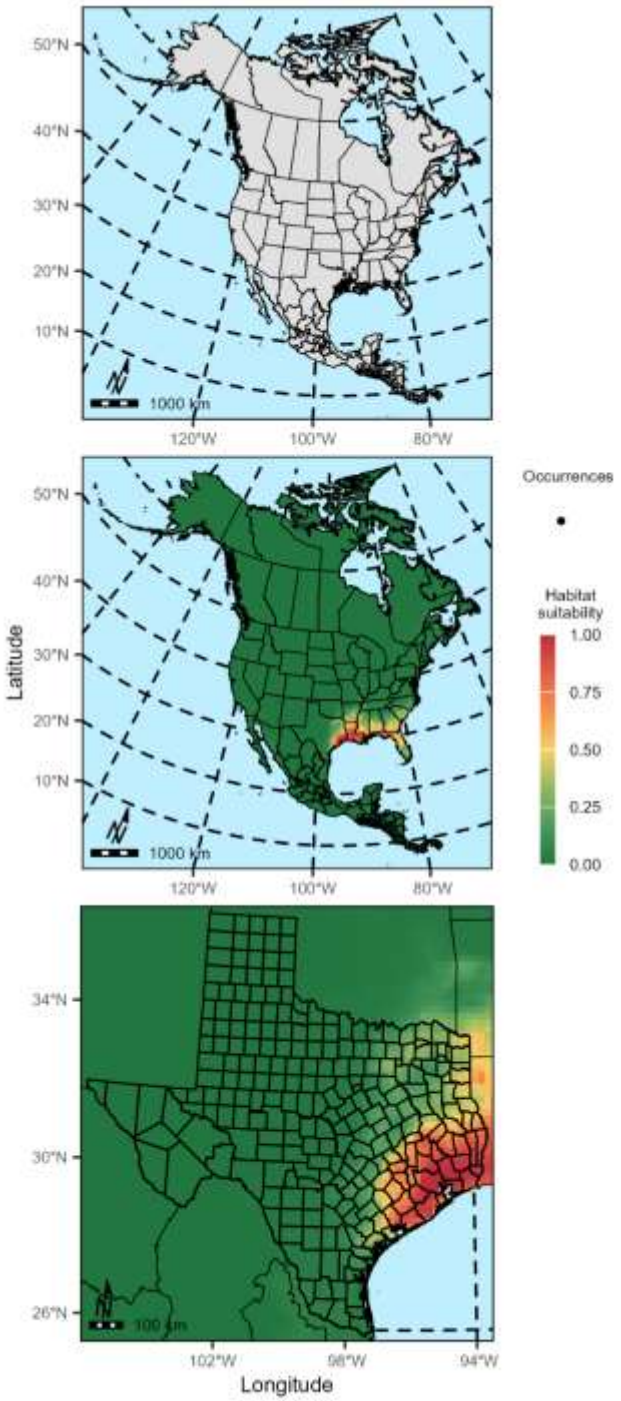


Figure 19. *Lasiurus seminolus* occurrence records and MaxEnt cloglog predictions; Top: occurrence map, Middle: North America MaxEnt prediction map, Bottom: Texas MaxEnt prediction map.

Description.—Seminole bats are of mediums size (average total length = 103mm, average forearm length = 39mm, range of masses = 9-14g, Schmidly and Bradley 2016) and have dark red to mahogany brown pelage with white tipped hairs. The posterior portions of the venter are often lighter than the dorsum. The uropatagium is conspicuously and densely furred.

Distribution.—Seminole bats are distributed throughout the southeastern United States from Florida to North Carolina east to eastern Texas and Southeastern Oklahoma.

Systematics.—*Lasiurus seminolus* is a monotypic species (Wilkins 1987).

Natural History.—Seminole bats tend to occur in wooded low elevation areas that coincide with the geographic distribution of Spanish moss (*Tilandsia usneoides*), a plant that it often roosts in. This species

has also been reported to roost behind loose bark and in clumps of foliage (Sealander 1979). This species is almost exclusively insectivorous consuming species from the orders Coleoptera, Diptera, Hemiptera and Hymenoptera (Wilkins 1987). *Lasiurus seminolus* likely breeds in the fall and parturition occurs during the first part of June (Jennings 1958). Lactating has been documented in June and July (Moore 1949, Coleman 1950).

Conservation Status.— Population status of *Lasiurus seminolus* is unknown and these bats are listed as least concern according to the IUCN (Solari 2019g). This species is listed as one of greatest conservation need by TPWD and has a state rank of S3 (Vulnerable, Simon 2023).

Habitat Suitability.—Areas of highest habitat suitability for *Lasiurus seminolus* in North America occur across the southeastern portion of the United States. In Texas, highest habitat suitability occurs in the southern portion of east Texas.

Most important niche characteristics.— Estimates of permutation importance (Table 2) indicated that the most important environmental niche characteristics for *Lasiurus seminolus* from highest to lowest importance were Bio10 (mean temperature of the warmest quarter), Bio17 (precipitation of the dryest quarter), Bio18 (precipitation in the warmest quarter) and Bio2 (mean diurnal range of temperature). Habitat suitability was positively related to all four of these niche characteristics (Appendix Figure 18).

Ecological Niche Model Evaluation and Performance—The best performing ecological niche model (Table 1) had hinge feature classes and a regularization multiplier of 2. Spatially structured cross-validation yielded a mean 10% omission rate of 0.14 and a mean validation AUC value of 0.96, indicating it to be an excellent model for predicting the potential distribution of *Lasiurus seminolus*.

Myotis austroriparius—Southeastern Myotis

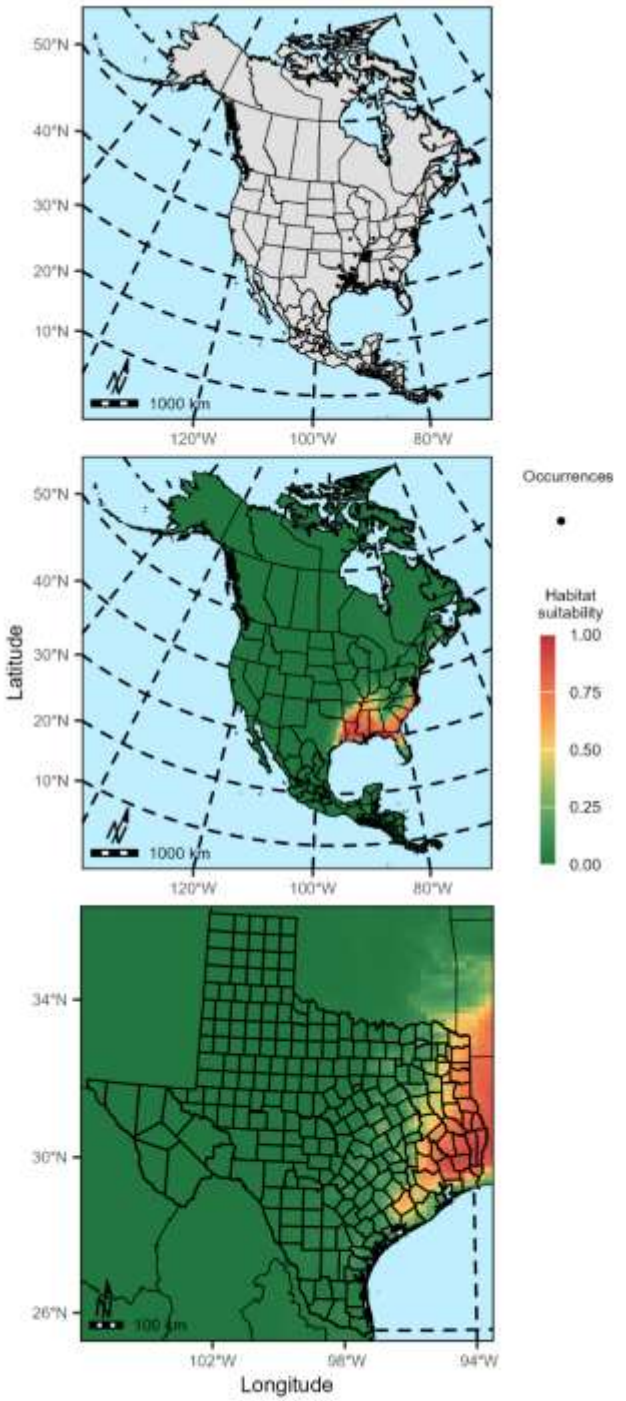


Figure 20. *Myotis austroriparius* occurrence records and MaxEnt cloglog predictions; Top: occurrence map, Middle: North America MaxEnt prediction map, Bottom: Texas MaxEnt prediction map.

Description.— This is a small sized (average total length = 88mm, average forearm length = 38mm, range of masses = 5-7g, Schmidly and Bradley 2016), typically brown bat with thick and woolly fir and calcar absent. There are two color phases (Ammerman et al. 2012). Most typically individuals are gray to gray-brown and less typical is an orange-brown color phase.

Distribution.— This species occurs from southern Illinois and Indiana to southeastern Missouri through eastern to southwestern Arkansas to southeastern Oklahoma, east Texas, Louisiana and Mississippi, south and west Alabama, southern Georgia, northern Florida, eastern north and South Carolina and western Kentucky and Tennessee (Jones and Manning 1989).

Systematics.—*Myotis austroriparius* is monotypic (LaVal 1970).

Natural History.—This species is often associated with habitats around water (Jones and Manning 1989). Upon leaving their day roosts at or after dark, they fly to nearby ponds and slow moving streams to drink (Ammerman et al. 2012). Across much of its geographic distribution, southeastern myotis roosts in caves and mines (Jones and Manning 1989). Nonetheless, in parts of its distribution where there are no caves, such as Louisiana and Texas, this species roosts in a variety of hardwood deciduous trees such as Black gum (*Nyssa sylvatica*), water tupelo (*N. aquatica*), and Sweetgum (*Liquidambar styraciflua*) as well as culverts and buildings (Ammerman et al. 2012). Little is known regarding the diets of southeastern myotis, but Coleoptera, Diptera and Lepidoptera compose the diet of *M. austroriparius* (Zinn and Humphrey 1981, Whitaker and Hamilton 1998). Females are pregnant from April through May and parturition begins in late April to early may (Barbour and Davis 1969). Both sexes reach sexual maturity in their first year, and this species is unique in the genus *Myotis* for typically having twins (Ammerman et al. 2012).

Conservation Status.—Population trends of *M. austroriparius* are stable and the species is of least concern based on the IUCN (Arroyo-Cabrales and Casteneda 2017d). In Texas, this species is listed by the Texas Parks and Wildlife Department as a species of greatest conservation need with a state rank of S3, vulnerable (Simon 2023).

Habitat Suitability.—Areas of highest habitat suitability for *Myotis austroriparius* in North America occur throughout the southeastern portion of the United States extending from Virginia through the Gulf Coast states. In Texas, areas of high habitat suitability occur in the eastern portion of the state, in particular the Piney Woods ecoregion.

Most important niche characteristics.— Estimates of permutation importance (Table 2) indicated that the most important environmental niche characteristics for *Myotis austroriparius* from

highest to lowest importance were Elevation, Bio14 (precipitation in the dryest month), Bio2 (mean diurnal range of temperature), Bio19 (precipitation of the coldest quarter), Bio1 (annual mean temperature), Evergreen Broadleaf Forest, Pasture and Metamorphic Rock. Habitat suitability was positively related to Bio14, Bio2, Bio19, Bio1, and negatively related to Elevation, Pasture, and Metamorphic Rock (Appendix Figure 19).

Ecological Niche Model Evaluation and Performance—The best performing ecological niche model (Table 1) had hinge feature classes and a regularization multiplier of 3.5. Spatially structured cross-validation yielded a mean 10% omission rate of 0.18 and a mean validation AUC value of 0.95, indicating it to be an excellent model for predicting the potential distribution of *Myotis austroriparius*.

Myotis californicus*—*California Myotis

Description.—A small (average total length = 88mm, average forearm length = 32mm, range of masses = 3-5g, Schmidly and Bradley 2016), light reddish brown bat with black-based hairs, black ears, and a black face mask that extends from ear to ear (Ammerman et al. 2012).

Distribution.—California myotis ranges from southwestern Alaska and British Colombia and adjacent islands in the north through much of the western portion of the United States to the end of Baja California and Chiapas, Mexico and northern Guatemala to the south.

Systematics.—Currently 4 subspecies are recognized (Willson and Ruff 1999). *Myotis c. californicus* ranges from southeastern Alaska and British Colombia south through much of the middle of California down to the tip of Baja California, to the east from New Mexico and eastern

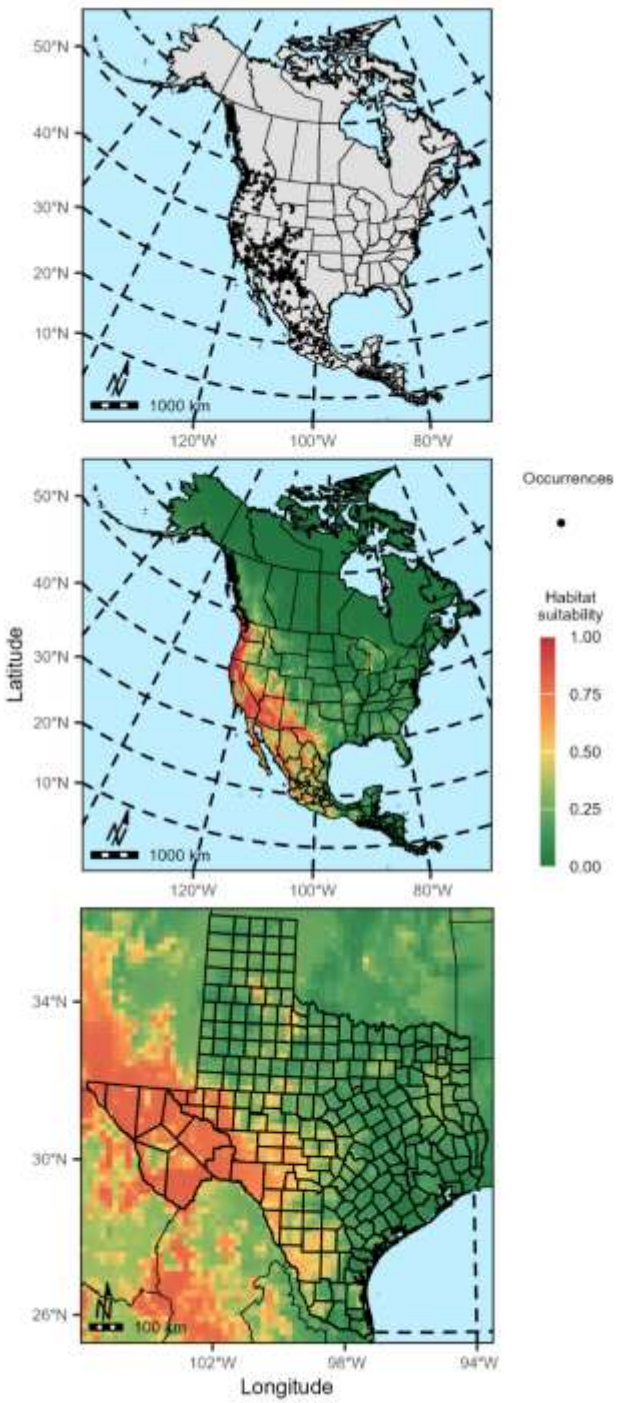


Figure 21. *Myotis californicus* occurrence records and MaxEnt cloglog predictions; Top: occurrence map, Middle: North America MaxEnt prediction map, Bottom: Texas MaxEnt prediction map.

Arizona through northern Mexico. *Myotis c. caurinus* ranges from northwestern California through southwestern British Colombia and adjacent islands. *Myotis c. mexicanus* ranges from Guatemala to southern and central Mexico. *Myotis c. stephensi* ranges from western Nevada, southeastern California, western Arizona, to southeastern Utah and western Colorado.

Natural History.—California myotis are denizens of open deciduous and coniferous forests, wooded canyons and vegetated hillsides (Schmidly and Bradley 2016). They occur across most forested and arid lands of western North America. These bats forage on the margins of forests in forested areas, over water and at relatively high altitude in open areas (Woodsworth 1981). *Myotis californicus* often roosts alone or in small groups within narrow rock crevices, under exfoliating bark, manmade structures, desert shrubs and on the ground (Krutzsch 1954,

Hirshfield et al. 1977). California myotis are insectivorous having been reported to consume primarily small Lepidoptera (Whitaker et al. 1981) but also Coleoptera, Diptera, Hemiptera and Trichoptera (Woodsworth 1981, Black 1974). *Myotis californicus* exhibits delayed fertilization and produces 1 young per year (Kruszsch 1954). Breeding occurs in late fall (Simpson 1993) and birth occurs from late spring to early summer (Ammerman et al. 2012).

Conservation Status.—Population status is unknown and California myotis are a species of least concern according to the IUCN (Arroyo-Cabrales and Perez 2017). This species is one of greatest conservation need with a state listing of S3 (vulnerable) by TPWD (Simon 2023).

Habitat Suitability.—Areas in North America with high habitat suitability for *Myotis californicus* are in the western portion of the continent. In the United States, habitat suitability is highest in the southwestern and western portion of the country, in particular Texas, New Mexico, Arizona, California, Oregon and Washington. Areas of high habitat suitability also occur in Baja California and the mountainous regions of Mexico. In Texas, areas of highest habitat suitability occur in the Trans-Pecos and western portion of the South Texas Plains ecoregions.

Most important niche characteristics.— Estimates of permutation importance (Table 2) indicated that the most important environmental niche characteristics for *Myotis californicus* from highest to lowest importance were Bio6 (minimum temperature of the coldest month), Bio14 (precipitation of the driest month), Cropland, Pasture and Bio19 (precipitation of the coldest quarter). Habitat suitability was positively related to Bio19 and negatively related to Bio14, Cropland and Pasture. Habitat suitability exhibited a unimodal relationship with Bio6 (Appendix Figure 20).

Ecological Niche Model Evaluation and Performance—The best performing ecological niche model (Table 1) had linear and quadratic feature classes and a regularization multiplier of 4. Spatially structured cross-validation yielded a mean 10% omission rate of 0.12 and a mean validation AUC value of 0.76, indicating it to be a good model for predicting the potential distribution of *Myotis californicus*.

Myotis ciliolabrum*—*Western Small-Footed Myotis

Description.—A small (average total length = 79mm, average forearm length = 33mm, range of masses = 4-5g, Schmidly and Bradley 2016), buff brown bat with black-based hairs, black ears, and a black face mask that extends from ear to ear (Ammerman et al. 2012). This bat is very similar and at times indistinguishable from *M. californicus* when in the hand and without examination of the skull. The tail of this species often extends up to 4mm beyond the edge of the uropatagium (Constantine 1998).

Distribution.—Western small-footed myotis occur from southern British Colombia, Alberta and Saskatchewan south to Tlaxcala, Mexico. It ranges to eastern Nebraska and western Oklahoma to the eastern and western portions of Washington, and the western parts of Oregon and California (Halloway and Barclay 2001).

Systematics.—Two subspecies of *M. ciliolabrum* are recognized. *Myotis c. ciliolabrum* occurs east whereas *M. c. melanorhinus* occurs west of the continental divide (Wilson and Ruff 1999)

Natural History.—*Myotis ciliolabrum* are common in many arid and semiarid habitats and deserts of the western portion of North America (Halloway and Barclay 2001). In the southern portion of its geographic range it tends to occur at higher, more mesic elevations (Findley et al. 1975, Ammerman et al. 2012). In British Colombia it occurs at lower elevations down to 850m

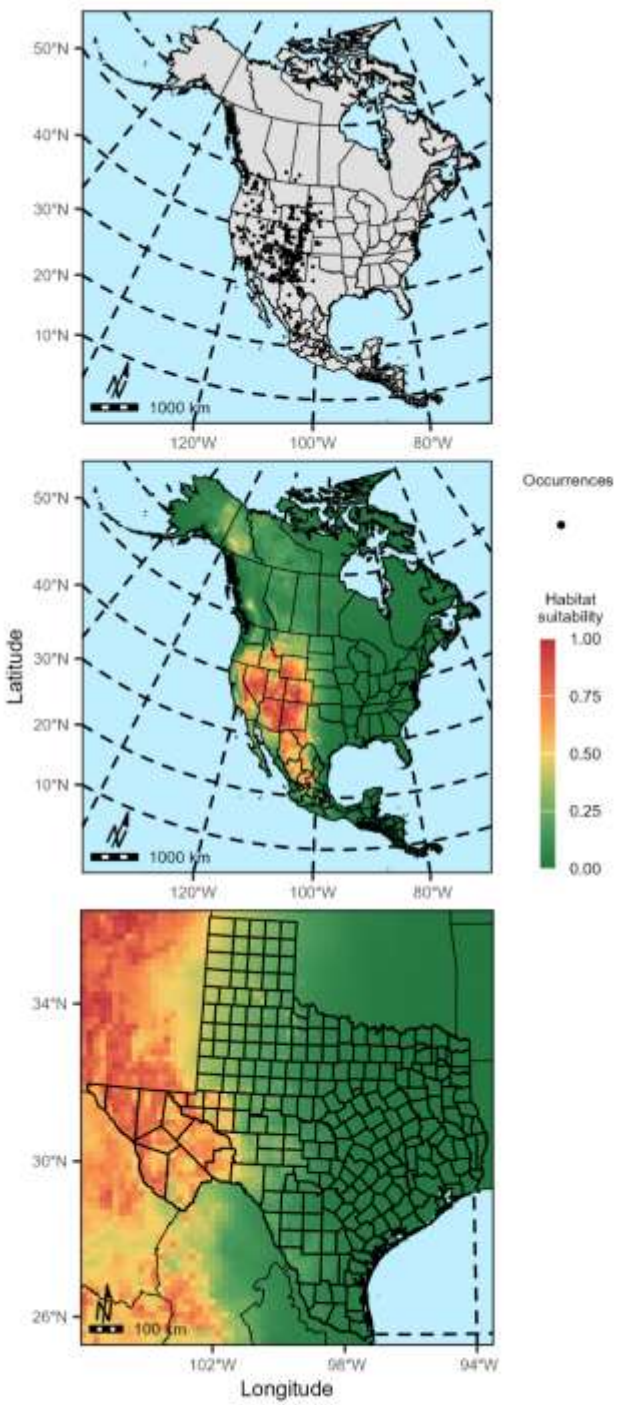


Figure 22. *Myotis ciliolabrum* occurrence records and MaxEnt cloglog predictions; Top: occurrence map, Middle: North America MaxEnt prediction map, Bottom: Texas MaxEnt prediction map.

(Nagorsen and Brigham 1993). This species inhabits riparian zones, grasslands, sandy areas, Pinon-Juniper woodlands and yellow pine forests (Dalquest 1948, Findley et al. 1975, Szewczak et al. 1998, Holloway and Barclay 2000). Western small-footed myotis are insectivorous consuming prey from the orders Coleoptera, Diptera, Hemiptera, Lepidoptera, and Trichoptera (Jones et al. 1973, Warner 1985, Whitaker et al. 1981, Woodsworth 1981). This species roosts in caves, rock crevices, under exfoliating bark, in abandoned swallow nests but also tunnels and box-beam bridges (Merriam 1886, Koford and Koford 1948, Quay 1948, Tuttle and Heaney 1974, Armstrong 1972, Stevens et al. 2021). *Myotis ciliolabrum* typically have one offspring per year (Koford and Koford 1948, Findley et al. 1975). Parturition dates are geographically variable but typically occur from late May into July (Halloway and Barclay 2001).

Conservation Status.—Population status is stable and western small-footed myotis are a species of least concern according to the IUCN (Arroyo-Cabrales and Castaneda 2017e). This species is one of greatest conservation need with a state listing of S3 (vulnerable) by TPWD (Simon 2023).

Habitat Suitability.—Areas of highest habitat suitability in North America for *Myotis ciliolabrum* occur primarily in the intermountain west of the United States, In particular the states of Texas, New Mexico, Colorado, Wyoming, Arizona, Utah and Nevada. In Texas, areas of highest habitat suitability occur in the Trans-Pecos ecoregion.

Most important niche characteristics.— Estimates of permutation importance (Table 2) indicated that the most important environmental niche characteristics for *Myotis ciliolabrum* from highest to lowest importance were Aridity, Elevation, Bio2 (mean diurnal range of temperature). Bio17 (precipitation of the dryest quarter), Bio3 (isothermality), Bio19 (precipitation of the coldest quarter), Mixed Grass-Shrubland and Evergreen Needleleaf Forest. Habitat suitability was positively related to Elevation, Bio2, Bio19, Mixed Grass-Shrubland and Evergreen Needleleaf Forest and negatively related to Aridity, Bio17, Bio3 (Appendix Figure 21).

Ecological Niche Model Evaluation and Performance—The best performing ecological niche model (Table 1) had linear feature classes and a regularization multiplier of 2. Spatially structured cross-validation yielded a mean 10% omission rate of 0.14 and a mean validation AUC value of 0.84, indicating it to be a good model for predicting the potential distribution of *Myotis ciliolabrum*.

Myotis occultus—*Arizona Myotis*

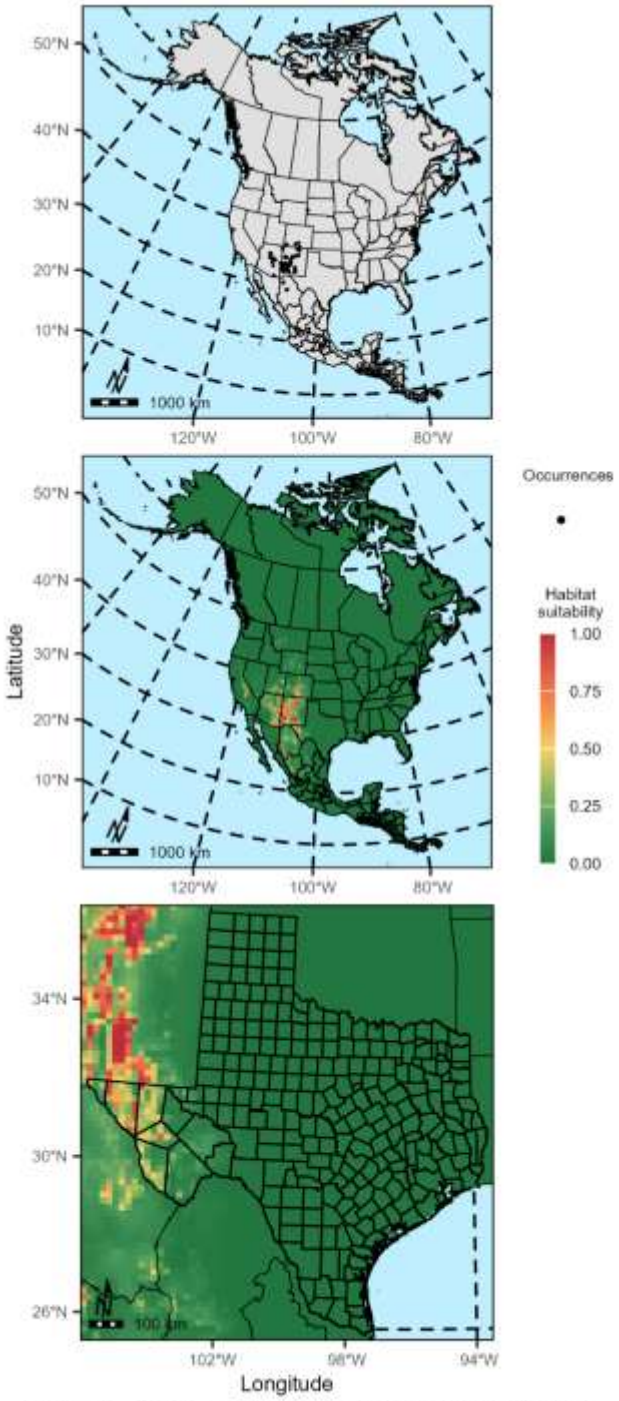


Figure 23. *Myotis occultus* occurrence records and MaxEnt cloglog predictions; Top: occurrence map, Middle: North America MaxEnt prediction map, Bottom: Texas MaxEnt prediction map.

Description.—A large (average total length = 85mm, average forearm length = 39.5mm, range of masses = 7-9g, Schmidly and Bradley 2016), bronzy brown to olive brown *Myotis* with glossy-tipped hairs, a paler venter and sparsely haired uropatagium (Ammerman et al. 2012).

Distribution.—Arizona myotis range from Mexico City north through the western Trans-Pecos of Texas, throughout much of New Mexico and Arizona to southern Colorado and Southeastern California (Ammerman et al. 2012).

Systematics.—*Myotis occultus* is a monotypic species (Schmidly and Bradley 2016).

Natural History.—Very little is known of the natural history of the Arizona myotis. In Arizona it inhabits pine-oak or ponderosa pine forest (Hoffmeister 1986) whereas in

New Mexico it inhabits a variety of habitats and elevations (Findley et al. 1975), even lower elevations such as the Rio Grande River valley (Geluso and Mink 2009). This species is insectivorous and has been recorded to prey on and consume Coleoptera, Diptera, Ephemeroptera, Hemiptera, Hymenoptera, Lepidoptera and Neuroptera, (Warner 1985, Valdez and Bogan 2009). Arizona myotis roost in crevices, under exfoliating bark, in caves and in attics (Ammerman et al. 2012). Mating occurs in the fall followed by delayed fertilization (Hayward 1963). Parturition has been reported in late June (Hoffmeister 1986).

Conservation Status.—Population status is stable and Arizona myotis are a species of least concern according to the IUCN (Solari 2018a). This species is not listed as one of greatest conservation need by TPWD (Simon 2023).

Habitat Suitability.—Areas of highest habitat suitability in North America for *Myotis occultus* are primarily in the states of New Mexico, Colorado and Arizona. In Texas, the area with the greatest habitat suitability is in Jeff Davis County in the Davis Mountains.

Most important niche characteristics.— Estimates of permutation importance (Table 2) indicated that the most important environmental niche characteristics for *Myotis occultus* from highest to lowest importance were Elevation, Bio10 (mean temperature of the warmest quarter), Bio4 (temperature seasonality) Evergreen Needleleaf Forest, Bio15 (precipitation seasonality), Bio16 (precipitation of the wettest quarter), and Mixed Grass-Shrubland. Habitat suitability was positively related to Elevation, Bio10, Bio4, Evergreen Needleleaf Forest, Bio15 and Mixed Grass-Shrubland and negatively related to Bio16 (Appendix Figure 22).

Ecological Niche Model Evaluation and Performance—The best performing ecological niche model (Table 1) had linear and hinge feature classes and a regularization multiplier of

2. Spatially structured cross-validation yielded a mean 10% omission rate of 0.15 and a mean validation AUC value of 0.97, indicating it to be an excellent model for predicting the potential distribution of *Myotis occultus.*

***Myotis septentrionalis*—Northern Long-eared Myotis**

Description.—Northern long eared bats are small (average total length = 78mm, average forearm length = 35mm, range of masses = 6-9g) with large ears (13mm), and an unkeeled calcar (Schmidly and Bradley 2016). The uropatagium of this species connects at the toe as opposed to the ankle (Stevens et al. 2017). Its hair is long, gray-brown at the tips and darker at the base (Ammerman et al. 2012).

Distribution.—This species is distributed throughout the eastern portion of the United States and Canada. It occurs as far south as western Georgia, western Florida, Alabama, northern Mississippi and Louisiana and as far west as British Colombia, Alberta, Montana and Wyoming (Caceres and Barclay 2000).

Systematics.—*Myotis septentrionalis* is a monotypic species (Wilson and Ruff 1999).

Natural History.—Northern long-eared bats are forest dwellers that forage under the canopy over ponds and streams and along forest edges (Caire et al. 1979, van Zyll de Jong et al. 1980, Fenton et al. 1983). *Myotis septentrionalis* aerially captures its prey as well as gleans them off surfaces such as leaves, tree trunks and buildings (Caceres and Barclay 2000). It has been reported to consume Diptera, Coleoptera, Hemiptera, Hemiptera, Hymenoptera, and Neuroptera (Whitaker 1972, LaVal and LaVal 1980, Griffith and Gates 1985, Caceres 1998). In summer, *Myotis septentrionalis* primarily roosts in trees, and often the tallest trees of the most common species in

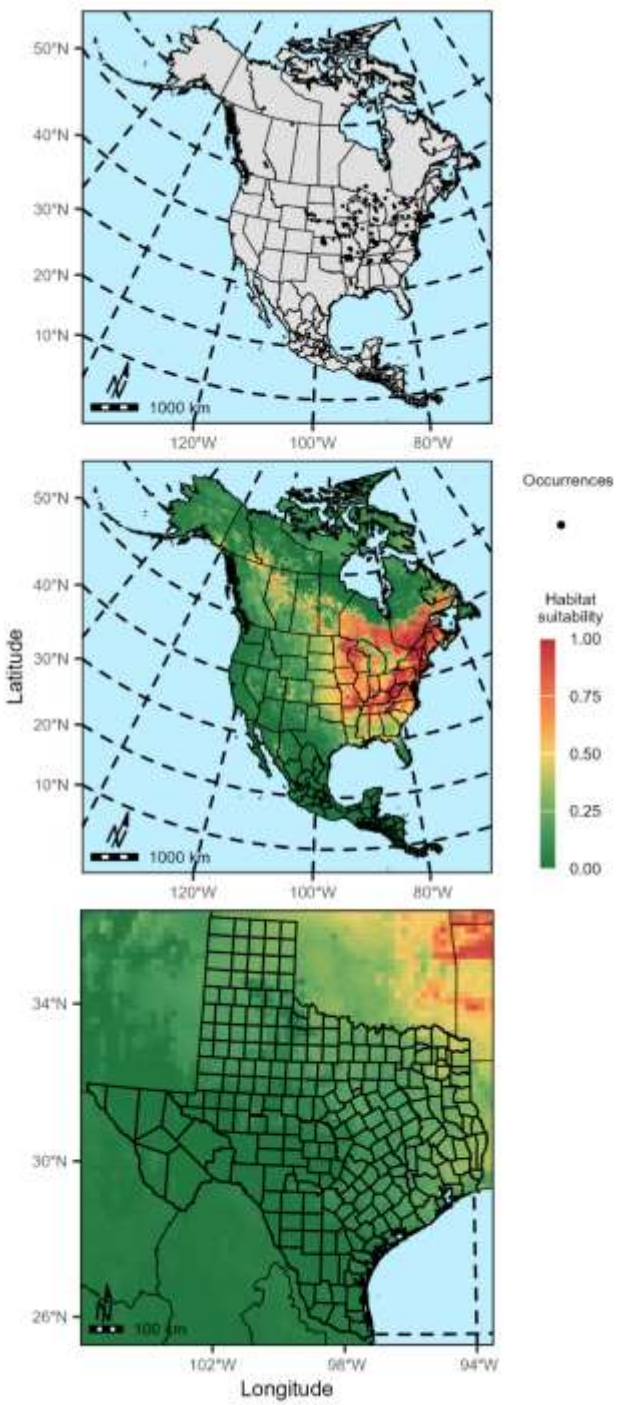


Figure 24. *Myotis septentrionalis* occurrence records and MaxEnt cloglog predictions; Top: occurrence map, Middle: North America MaxEnt prediction map, Bottom: Texas MaxEnt prediction map.

the forest (Garcia et al. 2023) but also occasionally day-roosts in anthropogenic structures (Caceres and Barclay 2000). In winer Northern long-eared bats roost in caves, often times hibernating, and in areas without caves they often roost in culverts (Stevens 2024) or in trees (Garcia et al. 2023). Mating typically occurs from late July to early October and females store sperm over the winter and parturition occurs from mid-May to mid-July (Whitaker and Rissler 1992, Caceres and Barclay 2000). Sub adults have been captured in July and August (Caire et al. 1979, Clark et al. 1987, Sasse and Pekins 1996).

Conservation Status.—Population status is decreasing and Northern long-eared myotis is listed as Near Threatened according to the IUCN (Solari 2018d). It has recently been listed as Endangered under the Endangered Species Act (U.

S. Department of the Interior 2022). This species is not listed as one of greatest conservation need by TPWD (Simon 2023).

Habitat Suitability.—In North America, areas of highest habitat suitability for *Myotis septentrionalis* occur in the northeastern portions of the continent from the midwestern states from Oklahoma to North Dakota east to the Atlantic seaboard and north across the southern provinces of Canada. In Texas, areas of highest habitat suitability are in East Texas, though these are quite modest.

Most important niche characteristics.— Estimates of permutation importance (Table 2) indicated that the most important environmental niche characteristics for *Myotis septentrionalis* from highest to lowest importance were Bio3 (isothermality), Bio2 (mean diurnal range of temperature), Mixed Grass-Shrubland, Bio 18 (precipitation of the warmest quarter), Bio15 (precipitation seasonality) and Deciduous Broadleaf Forest. Habitat suitability was positively related to Bio2, Bio18 and Deciduous Broadleaf Forest and negatively related to Bio3, Mixed Grass-Shrubland, Bio15 (Appendix Figure 23).

Ecological Niche Model Evaluation and Performance—The best performing ecological niche model (Table 1) had linear feature classes and a regularization multiplier of 1.5. Spatially structured cross-validation yielded a mean 10% omission rate of 0.13 and a mean validation AUC value of 0.84, indicating it to be a good model for predicting the potential distribution of *Myotis septentrionalis*.

Myotis thysanodes*—*Fringed Myotis

Description.—A large *Myotis* (average total length = 86mm, average forearm length = 43mm, range of masses = 6-11g) with long ears (average = 9mm), dorsal color a warm buff, ventral

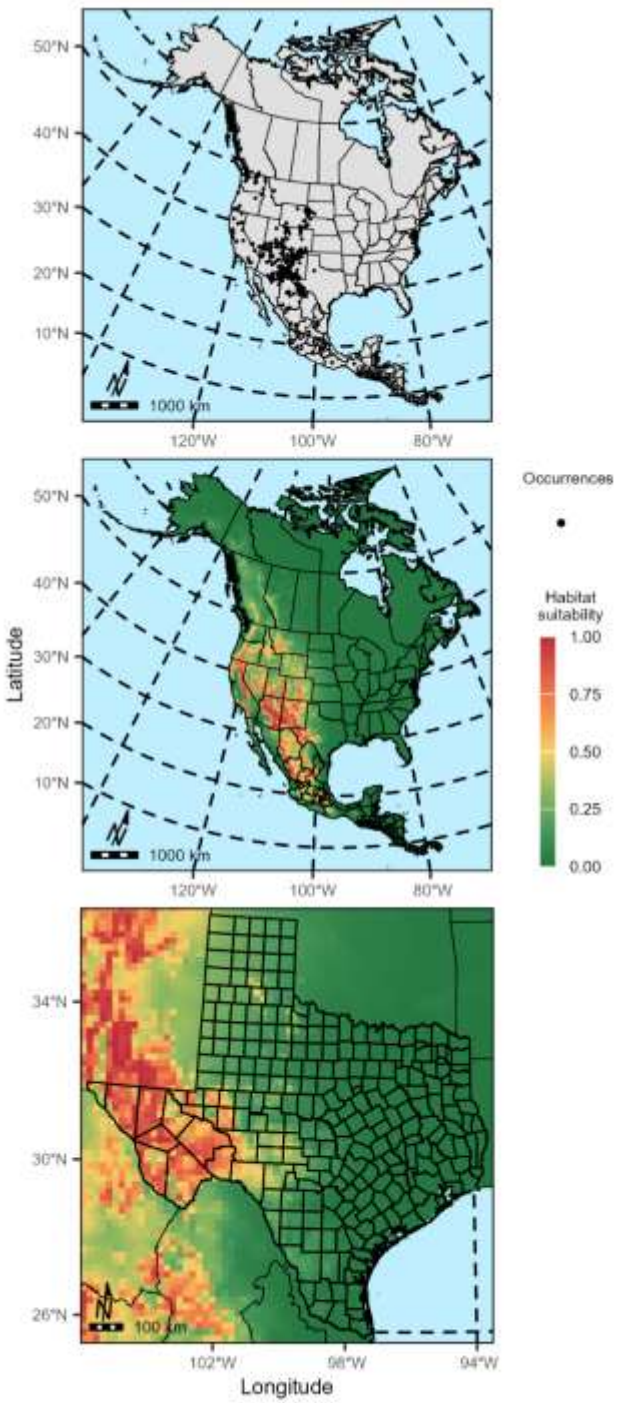


Figure 25. *Myotis thysanodes* occurrence records and MaxEnt cloglog predictions; Top: occurrence map, Middle: North America MaxEnt prediction map, Bottom: Texas MaxEnt prediction map.

color dull whitish and a distinctive fringe of hairs on the edge of the uropatagium between the legs (Schmidly and Bradley 2016).

Distribution.—This species ranges throughout western North America from British Colombia in the north to Chiapas in the south. In the main distribution of the United States Fringed myotis ranges as far east as Colorado, New Mexico and the Trans-Pecos of Texas. There is a disjunct population that occurs in the Black Hills of South Dakota and Wyoming (O'Farrell and Studier 1980).

Systematics.—There are three recognized subspecies of *Myotis thysanodes* (Wilson and Ruff 1999). *Myotis t. aztecus* ranges from Guerrero and Puebla to Chiapas, Mexico. *Myotis t. pahasapensis* is found in the Black Hills of South Dakota and Wyoming. *Myotis t. thysanodes* is found from British Colombia to Guerrero Mexico.

Natural History.—Fringed myotis occur in a variety of habitats ranging from low elevation desert scrub to fir-pine mixed forest with oak and pinyon woodland perhaps the most commonly used (O'Farrell and Studier 1980). Fringed myotis primarily consume beetles and moths, but have also been reported to consume from the orders Diptera, Ephemeroptera, Hemiptera, Hymenoptera, Neuroptera and Araneae (Gordon et al. 2019). Fringed myotis roost in caves, rock crevices, Ponderosa Pine snags, mines, buildings, and bridges (O'Farrell and Studier 1980, Cryan et al. 2001, Lacki and Baker 2007, Stevens et al. 2021). Breeding occurs in the fall (O'Farrell and Studier 1973), Ovulation, fertilization and implantation occur in April and May. Parturition occurs in June and July.

Conservation Status.—Population status is stable and fringed myotis is listed as a species of lease concern by the IUCN (Arroyo-Cabrales and de Grammont 2017b). This species is one of greatest conservation need with a state listing of S3 (vulnerable) by TPWD (Simon 2023).

Habitat Suitability.—In North America, areas of highest habitat suitability for *Myotis thysanodes* are primarily in Arizona and New Mexico, with patchily distributed areas of high habitat suitability spread across the west of the continent. In Mexico, highest habitat suitability areas occur patchily in the Chihuahuan desert. In Texas, habitat suitability is highest in the Trans-Pecos and western Edwards Plateau.

Most important niche characteristics.— Estimates of permutation importance (Table 2) indicated that the most important environmental niche characteristics for *Myotis thysanodes* from highest to lowest importance were Bio6, Elevation, Mixed Grass-Shrubland, Evergreen Needleleaf Forest, Bio14 (precipitation of the dryest month) and Bio15 (precipitation seasonality). Habitat suitability was positively related to Elevation, Mixed Grass-Shrubland, Evergreen Needleleaf

Forest and Bio15 and negatively related to Bio14. Habitat suitability exhibited a modal relationship with Bio6 (Appendix Figure 24).

Ecological Niche Model Evaluation and Performance—The best performing ecological niche model (Table 1) had linear and quadratic feature classes and a regularization multiplier of 4. Spatially structured cross-validation yielded a mean 10% omission rate of 0.12 and a mean validation AUC value of 0.87, indicating it to be a good model for predicting the potential distribution of *Myotis thysanodes*.

Myotis velifer*—*Cave Myotis

Description.—A large *Myotis* (average total length = 90mm, average forearm length = 42mm, range of masses = 12-15g) with dorsal color warm sepia, ventral color much lighter with the tips a pale cream buff (Schmidly and Bradley 2016).

Distribution.—Cave myotis are distributed in the southwestern United States from southeastern California, Nevada and Kansas south through Mexico to Honduras (Fitch et al. 1981).

Systematics.—There are three recognized subspecies of *Myotis velifer* (Wilson and Ruff 1999). *Myotis v incautus* ranges from south Texas to northeastern Mexico. *Myotis v. magnamolaris* ranges from southern Kansas through western Oklahoma into northern Texas. *Myotis v. velifer* ranges from southeastern California and Arizona to Central America.

Natural History.— Cave myotis inhabit lower elevations in Sonoran and Transition life zones of the arid southwestern portion of North America (Barbour and Davis 1969). In the northern portion of their distribution *M. velifer* occurs year-round, spending the winter hibernating in caves whereas more southern populations migrate annually (Fitch et al. 1981). This bat is insectivorous (Fitch et all 1981). The diet of this species is geographically variable whereby in

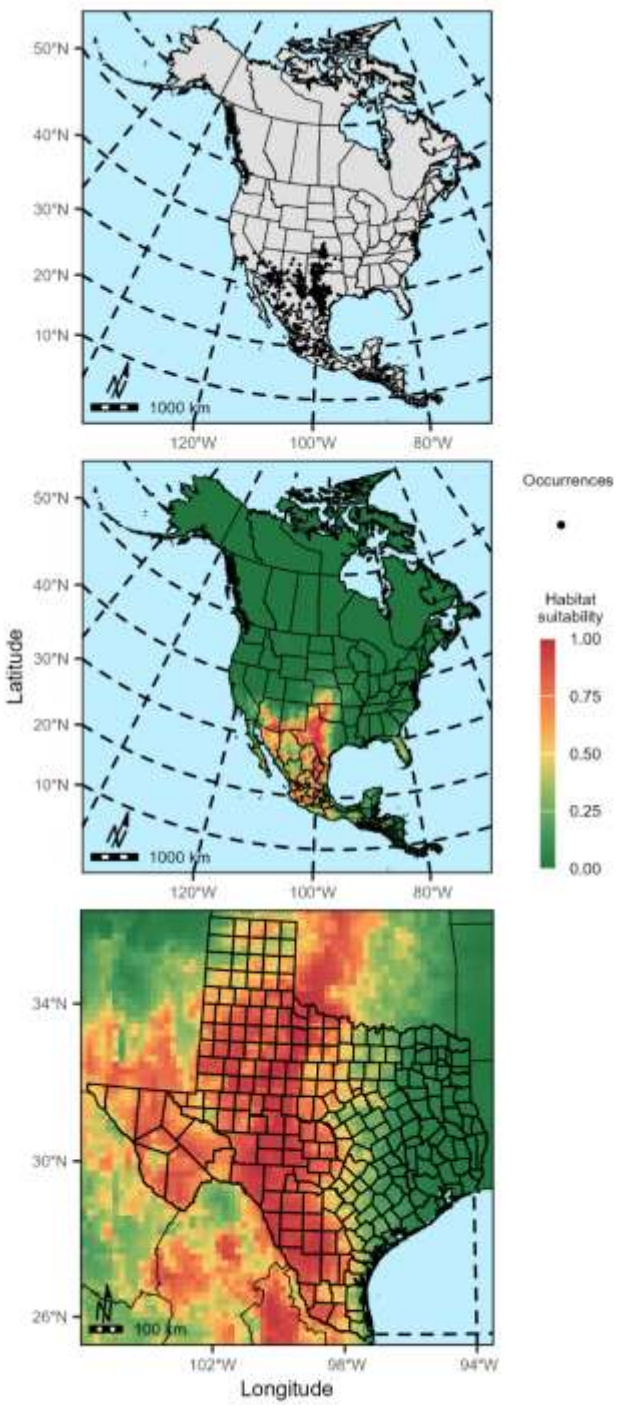


Figure 26. *Myotis velifer* occurrence records and MaxEnt cloglog predictions; Top: occurrence map, Middle: North America MaxEnt prediction map, Bottom: Texas MaxEnt prediction map.

Arizona and Northern Mexico it is represented primarily by moths but in Kansas it is represented primarily by beetles (Ross 1967, Hayward 1970, Kunz 1974). This species has also been reported to consume the following insect orders: Blattodea, Diptera, Ephemeroptera, Hemiptera, Hymenoptera. Neuroptera, Odonata, Orthoptera and Trichoptera (Fitzgerald and Ammerman 2025). Cave myotis often roost in caves, and in large numbers (1000-5000) but also roost in smaller numbers in tunnels, mines, buildings, bridges and culverts (Fitch et al. 1981, Stevens et al. 2021, Wilson et al. 2023). Mating primarily occurs in the fall but also occurs in winter and as late as April (Fitch et al. 1981). Gestation is approximately 60 to 70 days, neonates are born in late June and July, and weaning occurs at approximately 6 weeks of age (Kunz 1973).

Conservation Status.—Population status is stable and cave myotis is listed as a species of least concern by the IUCN (Solari 2019b). This species is one of greatest conservation need with a state listing of S3 (vulnerable) by TPWD (Simon 2023).

Habitat Suitability.— Areas of highest habitat suitability in the United States for *Myotis velifer* are throughout most of Texas, southern New Mexico and Arizona, and much of Oklahoma and Kansas. In Mexico, high habitat suitability occurs across the Chihuahuan Desert. In Texas, areas of high habitat suitability occur over the western half of the state.

Most important niche characteristics.— Estimates of permutation importance (Table 2) indicated that the most important environmental niche characteristics for *Myotis velifer* from highest to lowest importance were Bio1 (mean annual temperature), Bio2 (mean diurnal range of temperature), Bio18 (precipitation in the warmest quarter), Bio19 (precipitation in the coldest quarter), Bio15 (precipitation seasonality) and Pasture. Habitat suitability was positively related to Bio2 and negatively related to Pasture. Habitat suitability exhibited a modal relationship with Bio1, Bio18, Bio19, and Bio15 (Appendix Figure 25).

Ecological Niche Model Evaluation and Performance—The best performing ecological niche model (Table 1) had linear, quadratic and hinge feature classes and a regularization multiplier of 2.5. Spatially structured cross-validation yielded a mean 10% omission rate of 0.11 and a mean validation AUC value of 0.84, indicating it to be a good model for predicting the potential distribution of *Myotis velifer*.

Myotis volans*—*Long-Legged Myotis

Description.—A large *Myotis* (average total length = 93mm, average forearm length = 39mm, range of masses = 5-9g) with a long tibia, large foot, small ear, keeled calcar and fur on the

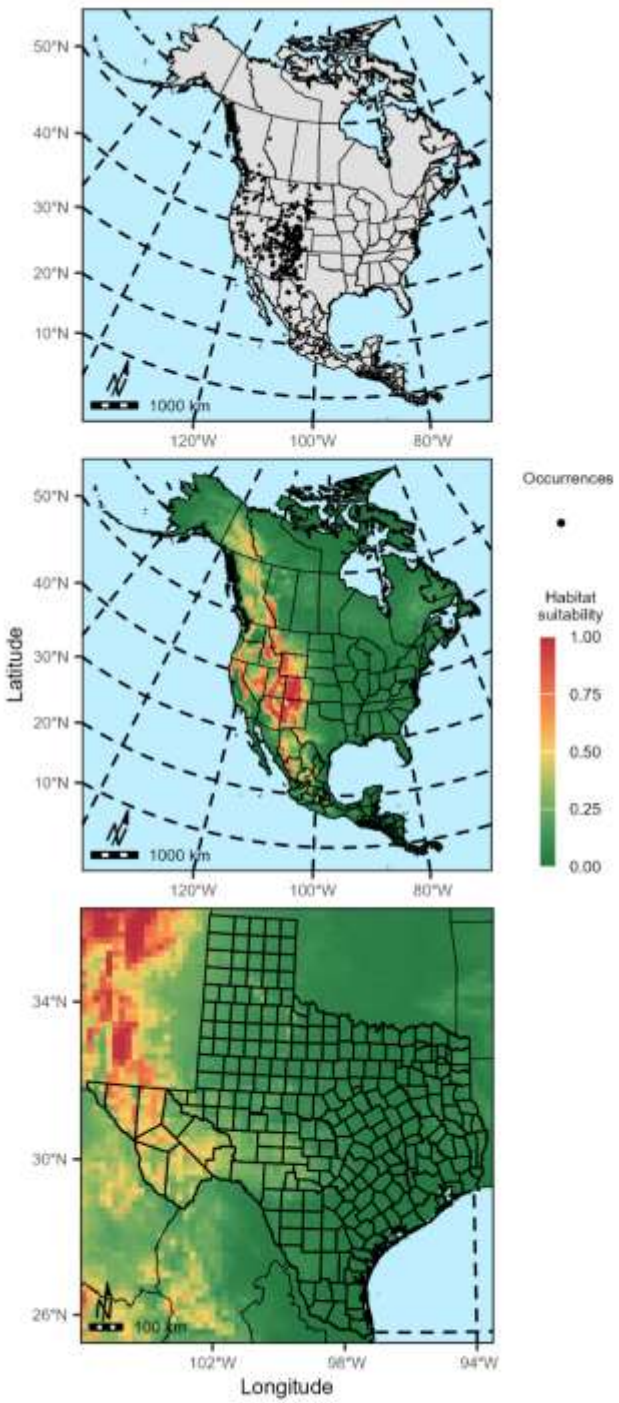


Figure 27. *Myotis volans* occurrence records and MaxEnt cloglog predictions; Top: occurrence map, Middle: North America MaxEnt prediction map, Bottom: Texas MaxEnt prediction map.

ventral side of the uropatagium that extends to the elbow (Schmidly and Bradley 2016). Color ranges from smokey brown to cinnamon brown to pale buff (Miller and Allen 1928).

Distribution.—*Myotis volans* ranges from British Colombia and Alberta in Canada, through most of the western half of the United States, through Baja California and northern and central Mexico (Warner and Czaplewski 1984).

Systematics.—Four subspecies of *M. volans* are recognized (Wilson and Ruff 1999). *Myotis v. amotus* occurs on the Sierra Volcanica Transversal of Mexico. *Myotis v. interior* occurs over much of the western portion of the US Canada and highlands of Mexico between the 100th and 120th meridian. *Myotis v. longricus* occurs from western California north to southeastern Alaska. *Myotis v. volans* occurs in Baja California.

Natural History.—Long-legged myotis typically occur in montane regions in forested areas between 2,000 and 3,000m elevation, although it has also been reported from riparian areas and

desert habitats (Warner and Czaplewski 1984). *Myotis volans* is insectivorous. Although this species primarily consumes moths (Warner and Czaplewski 1984), it has also reported to consume other soft bodied invertebrates such as Diptera, Hemiptera, Hymenoptera, Isoptera, Neuroptera, and small Coleoptera (Black 1974, Jones et al 1973, Warner 1985, Whitaker et al. 1977, 1981). *Myotis volans* roosts in abandoned buildings, underground, in cliff crevices, in mines and tunnels and behind exfoliating tree bark (Dalquest and Ramage 1946, Quay 1948, Baker and Phillips 1965, Martin and Hawks 1972, Davis 1978, Schowalter 1980). Mating occurs in the fall and sperm is stored in the female reproductive tract (Warner and Czaplewski 1984). Ovulation occurs between March and May and parturition occurs from May to August (Druecker 1972). The timing of female reproductive activity is variable and dependent on geography (Warner and Czaplewski 1984).

Conservation Status.—Population status is stable and long-legged myotis is listed as a species of least concern by the IUCN (Solari 2019c). This species is one of greatest conservation need with a state listing of S1S2 (Critically Imperiled/Imperiled) by TPWD (Simon 2023).

Habitat Suitability.— Areas of highest habitat suitability for long-legged myotis are primarily in North America and centered around the Colorado Plateau but also occur in California, Wyoming, Idaho and Montana. In Mexico high habitat suitability occurs in the Sierra Madre Occidental. In Texas, areas of high habitat suitability occur in the Trans-Pecos.

Most important niche characteristics.— Estimates of permutation importance (Table 2) indicated that the most important environmental niche characteristics for *Myotis volans* from highest to lowest importance were Elevation, Bio2 (mean diurnal range of temperature), Evergreen Needleleaf Forest, Bio3 (isothermality), Bio19 (precipitation of the coldest quarter), Mixed Grass-Shrubland and Sedimentary Rock. Habitat suitability was positively related to Elevation,

Bio2, Evergreen Needleleaf Forest, Bio19, Mixed Grass-Shrubland and Sedimentary Rock and negatively related to Bio3 (Appendix Figure 26).

Ecological Niche Model Evaluation and Performance—The best performing ecological niche model (Table 1) had linear and quadratic feature classes and a regularization multiplier of 4. Spatially structured cross-validation yielded a mean 10% omission rate of 0.14 and a mean validation AUC value of 0.85, indicating it to be an excellent model for predicting the potential distribution of *Lasiurus blossevillii*.

Myotis yumanensis*—*Yuma Myotis

Description.—A small *Myotis* (average total length = 78mm, average forearm length = 34mm, range of masses = 4-8g) with upper parts dull, pale-pinkish or cream buff coloration and underparts pale buff, nearly white (Schmidly and Bradley 2016). This species is distinctly bicolored and resembles a smaller version of *M. velifer*.

Distribution.—Yuma myotis are distributed from Hidalgo, Michoacan, Morelos and across the entire Baja California peninsula in Mexico, across much of the southwestern United States from Texas to the Pacific Ocean north to southwestern British Colombia; it is absent from the Great Basin Desert (Braun et al. 2015).

Systematics.— Six subspecies of *M. yumanensis* are recognized (Wilson and Ruff 1999). *Myotis y. lambi* is known only from San Ignacio, Baja California. *Myotis y. lutosus* is distributed from southern Zacatecas and northern Sinaloa south to Morelos in Mexico. *Myotis y. oxalis* ranges across the central valley of California. *Myotis y. saturatus* is distributed from the Mexico border with the US north along the coast and central mountains of the West Coast to southwestern British Colombia. *Myotis y. sociabilis* occurs from Northeastern California, eastern

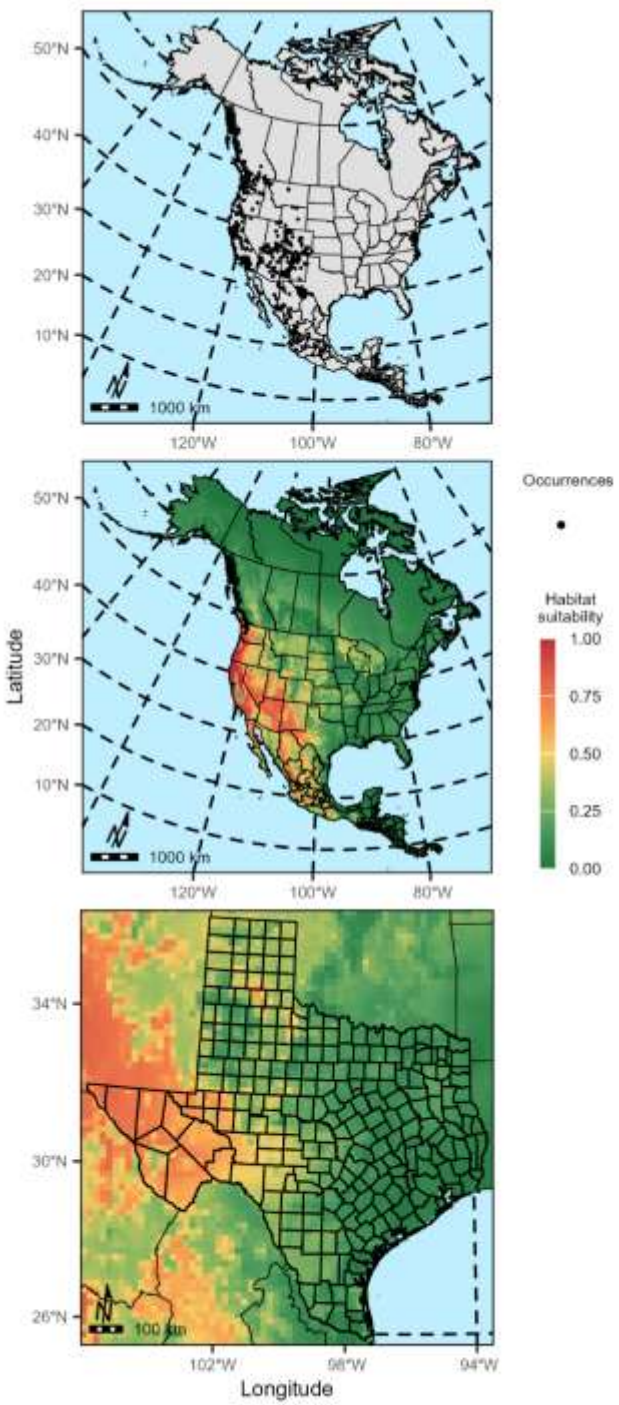


Figure 28. *Myotis yumanensis* occurrence records and MaxEnt cloglog predictions; Top: occurrence map, Middle: North America MaxEnt prediction map, Bottom: Texas MaxEnt prediction map.

Oregon and Washington, western Idaho and Montana and southeastern British Colombia. *Myotis y. yumanensis* ranges across parts of southwestern Nevada, Utah and Colorado south through most of Baja California to Durango, Mexico and east to western Oklahoma and Texas.

Natural History.—*Myotis yumanensis* primarily is a mid-to low elevation species that inhabits areas in close proximity to open water in arid and semiarid regions of much of the western portion of North America (Braun et al. 2015). Yuma myotis are insectivorous and consuming Coleoptera, Diptera, Ephemeroptera, Hemiptera, Hymenoptera, Isoptera, Lepidoptera, Orthoptera, Neuroptera and Trichoptera as well as arachnids (Barboru and Davis 1969, Easterla and Whitaker 1972, Whitaker et al. 1977, Herd and Fenton 1983**,** Brigham et al, 1992, Kelner and Harestad 2005). This species roosts in caves, buildings, bridges, swallow nests, cottonwood

trees, limestone and sandstone cliffs and abandoned swallow nests (Vaughan 1980, Braun et al. 2015, Tye and Geluso 2019, Wilson et al. 2023). Copulation likely occurs in fall and sperms is stored until spring (Dalquest 1947). Peaks in pregnancy and lactation are geographically variable but typically are between May and July, and May and August, respectively (Braun et al. 2015).

Conservation Status.—Population status is stable and Yuma myotis is listed as a species of least concern by the IUCN (Solari 2019d). This species is one of greatest conservation need with a state listing of S3 (Critically Imperiled/Imperiled) by TPWD (Simon 2023).

Habitat Suitability.— Areas of highest habitat suitability for Yuma myotis in North America occur throughout the southwestern portion of the United States ranging from Texas west through Arizona and then north through Washington. In Mexico highest habitat suitability occurs in the Sierra Madre Occidental, in particular in the Chihuahuan Desert. In Texas highest habitat suitability occurs in the Trans-Pecos.

Most important niche characteristics.— Estimates of permutation importance (Table 2) indicated that the most important environmental niche characteristics for *Myotis yumanensis* from highest to lowest importance were Bio1 (annual mean temperature), Bio14 (precipitation of the driest month), Cropland, Bio19 (precipitation of the coldest quarter), Pasture and Evergreen Broadleaf Forest. Habitat suitability was positively related to Bio19, and negatively related to Bio14, Cropland, Pasture and Evergreen Broadleaf Forest. Habitat suitability exhibited a modal relationship with Bio1 (Appendix Figure 27).

Ecological Niche Model Evaluation and Performance—The best performing ecological niche model (Table 1) had linear and quadratic feature classes and a regularization multiplier of

3. Spatially structured cross-validation yielded a mean 10% omission rate of 0.13 and a mean validation AUC value of 0.77, indicating it to be a fair model for predicting the potential distribution of *Myotis yumanensis*.

***Nycticeius humeralis*—Evening Bat**

Description.—A small (average total length = 93mm, average forearm length = 36mm, range of masses = 5-7g) bat with blackish-brown fur that is somewhat bicolored with a lighter venter (Schmidly and Bradley 2016). This species has thick, leathery ears and wing membranes and a broad and blunt tragus (Watkins 1972).

Distribution.—Evening bats are distributed throughout much of the eastern portion of North America from the Atlantic Ocean west to approximately the 100th meridian. They range from San Luis Potosi and Vera Cruz Mexico in the South to southern Michigan in the North.

Systematics.— Three subspecies of *N. humeralis* are recognized (Hall 1982). *Nycticeius h. humeralis* is distributed throughout most of the range except very south Texas and Mexico and southern Florida. *Nycticeius h. mexicanus* is distributed from southern Texas to San Luis Potosi and Vera Cruz Mexico. *Nycticeius h. subtropicalis* occurs in southern Florida.

Natural History.—Evening bats are denizens of temperate deciduous forest. This species is insectivorous consuming a wide variety of arthropods including Coleoptera, Diptera, Hemiptera, Hymenoptera, Lepidoptera, Trichoptera, Ephemeroptera, Neuroptera, Orthoptera, Psocoptera, Odonata, Phthiraptera, Acari, Araneida and Blattodea (Geluso et al. 2008, Munzer et al. 2016). Evening bats roost in a number of manmade and natural structures including trees, caves and buildings. Roosts have been reported in Cypress (*Taxodium distichum*, Herper 1927, Jennings 1958), Winged elm (*Ulmus alata*, Boyles and Robbins 2006), Longleaf pine (*Pinus palustris*,

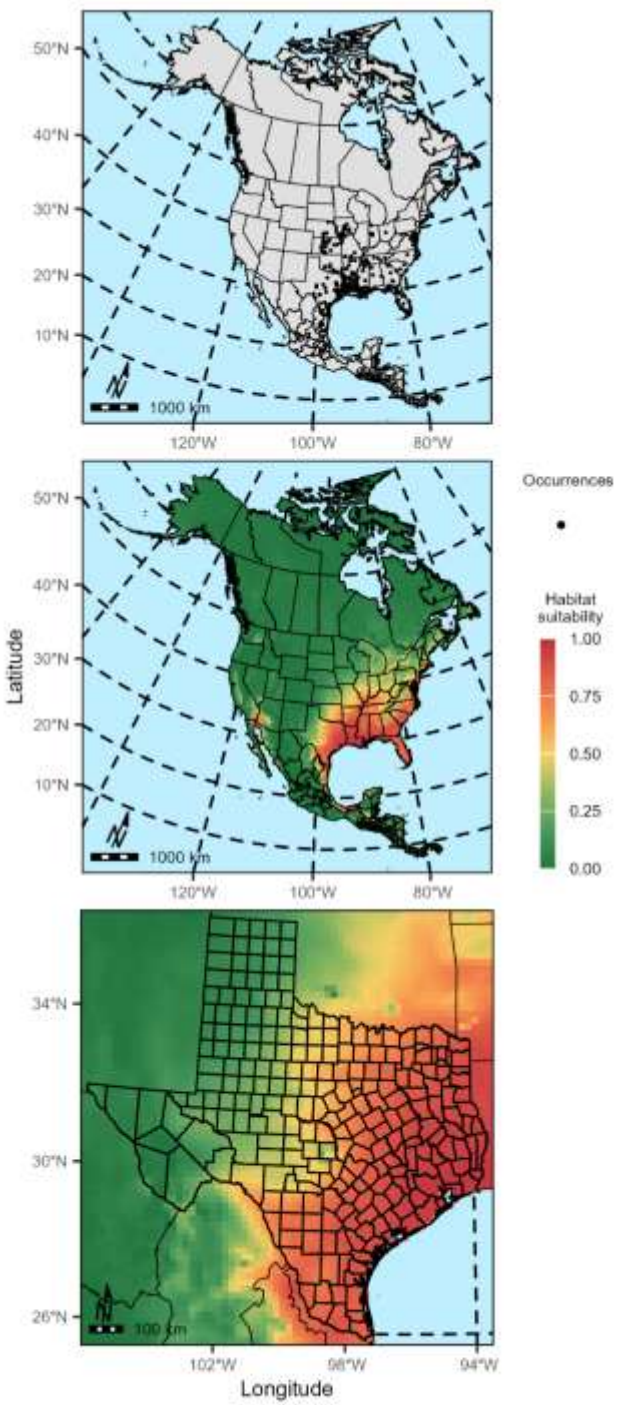


Figure 29. *Nycticeius humeralis* occurrence records and MaxEnt cloglog predictions; Top: occurrence map, Middle: North America MaxEnt prediction map, Bottom: Texas MaxEnt prediction map.

Menzel et al. 2001). Perry and Thill (2008) report that in the Ouachita mountains in Arkansas *N. humeralis* used nine species of trees (*Pinus echinata, Acer rubrum, Cornus florida, Quercus alba, Q. rubrum, Q. velutina, Carya tomentosa, Ulmus alata, Nyssa sylvatica*) as roosts. In Missouri (Timpone et al. 2006), evening bats roosted in Silver maple (*Acer saccharinum*), Pin oaks (*Quercus palistris*), Shellbark hickory (*Carya laciniosa*), Bitternut hickory (*Carya cordiformis*), and River birch (*Betula nigra*). Time of parturition is variable geographically. To the south (Alabama, Florida and Louisiana) offspring are born between mid-May to mid-June whereas in the northern part of the distribution parturition occurs from mid-June to as late as mid-July (Watkins 1972). Females carry between one and four embryos (Cockrum 1955, Asdell 1964).

Conservation Status.—Population status is stable and *Nycticeius humeralis* is listed as a species of least concern by the IUCN (Solari 2019e). This species is not listed as one of greatest conservation need by TPWD (Simon 2023).

Habitat Suitability.— Areas of relatively high habitat suitability for Evening bats are distributed throughout much of the eastern portion of the United States. Areas of highest habitat suitability occur along the southern Atlantic seaboard, the Gulf Coast Plain and southern Mississippi River valley. In Mexico, high habitat suitability for this species occurs on the Tamaulipan plain. In Texas, highest habitat suitability for this species occurs across much of the eastern portion of the state.

Most important niche characteristics.— Estimates of permutation importance (Table 2) indicated that the most important environmental niche characteristics for *Nycticeius humeralis* from highest to lowest importance were Bio1 (mean annual temperature), Elevation, Igneous Rock, Bio15 (precipitation seasonality) and Evergreen Broadleaf Forest. Habitat suitability was positively related to Bio1, and negatively related to Elevation, Igneous Rock, Bio15 and Evergreen Broadleaf Forest (Appendix Figure 28).

Ecological Niche Model Evaluation and Performance—The best performing ecological niche model (Table 1) had linear feature classes and a regularization multiplier of 4. Spatially structured cross-validation yielded a mean 10% omission rate of 0.22 and a mean validation AUC value of 0.82, indicating it to be a good model for predicting the potential distribution of *Nycticeius humeralis*.

Parastrellus hesperus—Canyon Bat

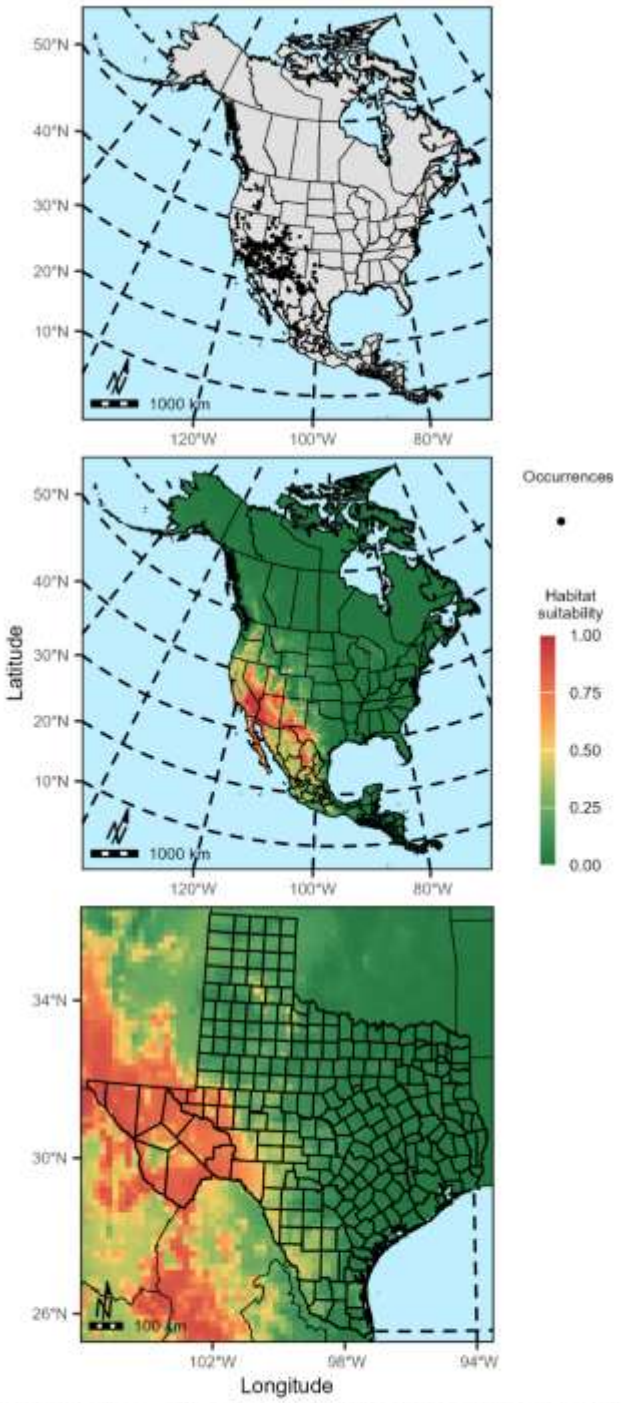


Figure 30. *Parastrellus hesperus* occurrence records and MaxEnt cloglog predictions; Top: occurrence map, Middle: North America MaxEnt prediction map, Bottom: Texas MaxEnt prediction map.

Description.—*Parastrellus hesperus* is a small (average total length = 66mm, average forearm length = 28mm, range of masses = 3-6g) bat with drab-gray or smoke-gray fur and black facemask, ears and membranes (Schmidly and Bradley 2016). The tragus is short and blunt. It is the smallest bat in North America.

Distribution.—Canyon bats are distributed throughout arid regions of the western United States from eastern Washington and Oregon south to Hidalgo and Michoacan of mainland Mexico as well as all of Baja California. It occurs from the Pacific Ocean to the west and east to the panhandle of Texas and eastern Oklahoma.

Systematics.—Two subspecies are recognized (Wilson and Ruff 1999). *Parastrellus h. hesperus* occurs in the Pacific coast states from Washington south to Guerrero, Mexico and to the east from western Colorado and New

Mexico south to Zacatecas and Morelos, Mexico. *Parastrellus h. maximus* inhabits southern Colorado, western Oklahoma, New Mexico and Texas south to Hidalgo, Mexico.

Natural History.—Canyon bats are common across low elevation desert shrub and adjacent woodlands across the arid and semi-arid portions of southwestern north America (Wilson and Ruff 1999). This species is insectivorous consuming a wide variety of arthropods from the orders Coleoptera, Diptera, Ephemeroptera, Hymenoptera, Hemiptera, Lepidoptera, Neuroptera and Aranaea (Gordon et al. 2018, Valdez et al. 2021). *Parastrellus hesperus* often roosts in cracks and crevices of rocks cliff faces (Stager 1943, Cross 1965). It also roosts in mines, buildings and vegetation (Wilson and Ruff 1999). As with most vespertilionids, mating occurs in the fall followed by delayed fertilization in the spring (Krutzsch 1975, Hoffmeister 1986). Females often carry 2 embryos (Genoways et al. 1979, Yancey 1997). Gestation is approximately 40 days and offspring are born between late May and early June (Hayward and Cross 1979).

Conservation Status.—Population status is stable and *Parastrellus hesperus* is listed as a species of least concern by the IUCN (Solari 2019f). This species is listed as one of greatest conservation need and ranked as S3S4 (Vulnerable/Apparently secure) by TPWD (Simon 2023).

Habitat Suitability.— Areas of highest habitat suitability in North America occur in the southwestern portion of the United States from Texas west to southern California and southern Nevada. In Mexico, highest habitat suitability occurs on the Baja Peninsula and in the Chihuahuan Desert. In Texas, highest habitat suitability occurs primarily in the Trans-Pecos ecoregion.

Most important niche characteristics.— Estimates of permutation importance (Table 2) indicated that the most important environmental niche characteristics for *Parastrellus hesperus* from highest to lowest importance were Bio6 (minimum temperature in the coldest month), Bio14 (precipitation of the dryest month), Bio12 (annual precipitation), Cropland and Pasture. Habitat suitability was negatively related to Bio14, Bio12 and Cropland and exhibited a modal relationship with Bio6 and Pasture (Appendix Figure 29).

Ecological Niche Model Evaluation and Performance—The best performing ecological niche model (Table 1) had linear and quadratic feature classes and a regularization multiplier of 3.5. Spatially structured cross-validation yielded a mean 10% omission rate of 0.10 and a mean validation AUC value of 0.83, indicating it to be a good model for predicting the potential distribution of *Parastrellus hesperus.*

Perimyotis subflavus—Tricolored Bat

Description.—Tricolored bats are small (average total length = 85mm, average forearm length = 35mm, range of masses = 4-6g) bats with distinctive tricolored pelage (Schmidly and Bradley 2016). Hairs are dusky at their tips, grayish yellow in the middle and dark at the base.

Distribution.—*Perimyotis subflavus* is distributed throughout the eastern part of North America and Mexico and extends its distribution as far south as Honduras (Fujita and Kunz 1984). One specimen has been recorded from Nicaragua, but this was likely a vagrant (Medina-Fitoria et al. 2015).

Systematics.—Four subspecies are recognized (Fujita and Kunz 1984). *Perimyotis s. clarus* occurs in the states of Nueva Leon and Tamaulipas, Mexico. *Perimyotis s. floridanus* occurs in

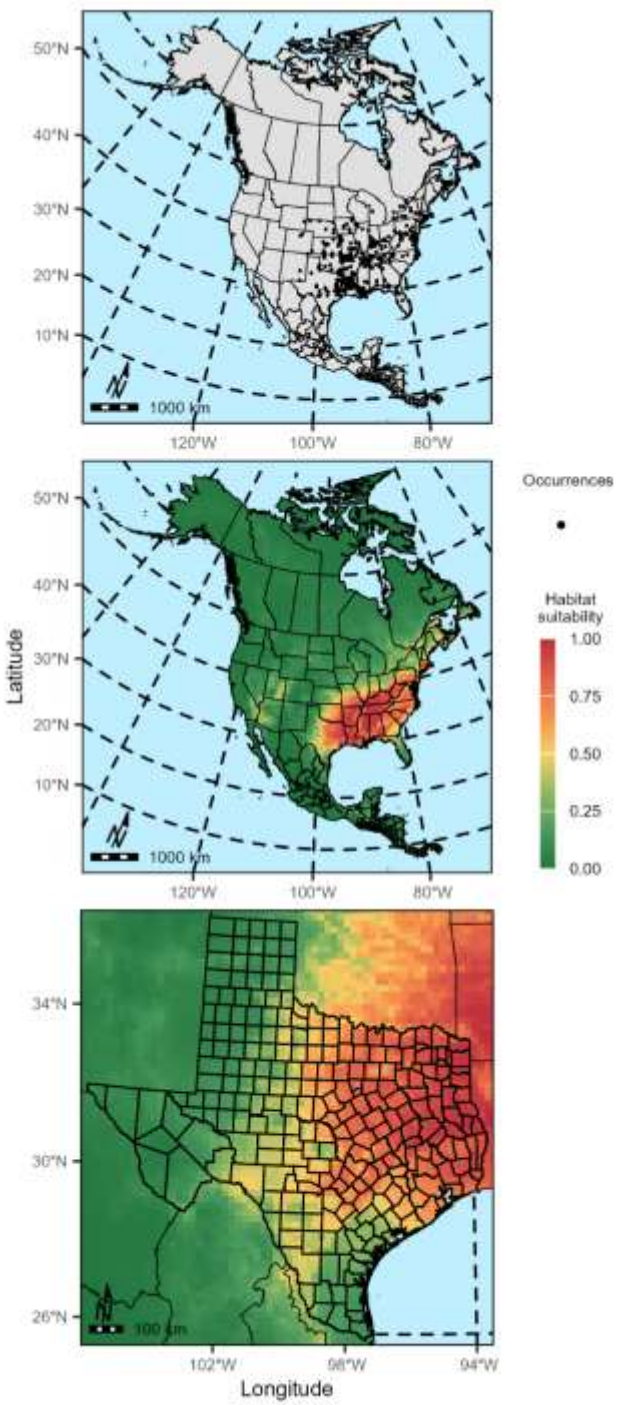


Figure 31. *Perimyotis subflavus* occurrence records and MaxEnt cloglog predictions; Top: occurrence map, Middle: North America MaxEnt prediction map, Bottom: Texas MaxEnt prediction map.

Florida and extreme southeast Georgia. *Perimyotis s. subflavus* occurs throughout the eastern United States. *Perimyoits s. veraecrucis* occurs from Vera Cruz Mexico south to Honduras.

Natural History.—*Perimyotis subflavus* is a widely distributed species that forages over waterways and at forest edges and is one of the earliest species that are active in the evening (Fujita and Kunz 1984). Tricolored bats often overwinter in different roosts than they use during the growing season (Guthrie 1933b, Griffin 1934). In winter, this species roosts (and often hibernates, but not across its entire range [Stevens 2024]) in caves and mines and other manmade structures such as bridges and culverts and during summer they roost in trees, caves, rock crevices and manmade structures such as buildings and bridges (Fujita and Kunz 1984). This species is insectivorous consuming arthropods from the orders Coleoptera, Diptera, Ephemeroptera, Hemiptera, Hymenoptera, Lepidoptera,

Psocodea, Trichoptera and Araneae (Sherman 1939, Ross 1967, Whitaker 1972, Perea et al 2024). Mating occurs in the fall and in the spring, sperm is stored in the female reproductive tract until ovulation, and typically two ova implant in the uterus (Guthrie 1933a, LaVal and LaVal 1980). Gestation typically lasts for approximately 44 days (Wimsatt 1945). Parturition occurs between late May and early July depending on geography (Fujita and Kunz 1984). Young are capable of flight approximately 3 weeks of age and epiphyseal gaps in the 4th digit close at approximately 45 days of age (Hoying 1983).

Conservation Status.—Population status is decreasing and *Perimyotis subflavus* is listed as a vulnerable species by the IUCN (Solari 2018b). This species is listed as one of greatest conservation need and ranked as S2 (Imperiled) by TPWD (Simon 2023).

Habitat Suitability.— Areas of highest habitat suitability for Tricolored bats occur throughout the southeastern and eastern portions of the United States from Connecticut and Rhode Island and Massachusetts to much of Texas. In Texas, areas of high habitat suitability occur across the eastern two-thirds of the state.

Most important niche characteristics.— Estimates of permutation importance (Table 2) indicated that the most important environmental niche characteristics for *Perimyotis subflavus* from highest to lowest importance were Bio10 (mean temperature of the warmest quarter), Bio14 (precipitation of the driest month), Bio15 (precipitation seasonality), Bio4 (temperature weasonality) and Sedimentary Rock. Habitat suitability was positively related to Bio10, Bio14 and Sedimentary Rock and negatively related to Bio15 and Bio4 (Appendix Figure 30).

Ecological Niche Model Evaluation and Performance—The best performing ecological niche model (Table 1) had linear feature classes and a regularization multiplier of 4. Spatially

structured cross-validation yielded a mean 10% omission rate of 0.17 and a mean validation AUC value of 0.87, indicating it to be a good model for predicting the potential distribution of *Perimyotis subflavus.*

Tadarida brasiliensis—Brazilian free-tailed Bat

Description.—*Tadarida brasiliensis* is a medium sized (average total length = 95mm, average forearm length = 42mm, range of masses = 11-14g) bat with the terminal half of the tail free of a membrane which is characteristic of the family (Schmidly and Bradley 2016). The ears are broad and have the appearance of being united but are not. The first phalange of the fourth digit is 6-9mm long (Schmidly and Bradley 2016). Hairs are monocolor from reddish to black.

Distribution.—*Tadarida brasiliensis* is widely distributed across both North and South America. It is distributed in the north to southern North Carolina to northern Georgia, Mississippi and Alabama to Arkansas to northern Nebraska, northern Utah, Nevada and southern Oregon (Wilkins 1989). To the south it extends its distribution to mid Chile and Argentina. It is absent from Amazonia.

Systematics.—Nine subspecies of *Tadarida brasiliensis* are recognized (Wilson and Ruff 1999). *Tadarida b. antillularum* occurs on Puerto Rico and the windward islands of the Lesser Antilles. *Tadarida b. bahamensis* occurs on the Bahama Islands. *Tadarida b. brasiliensis* occurs in South

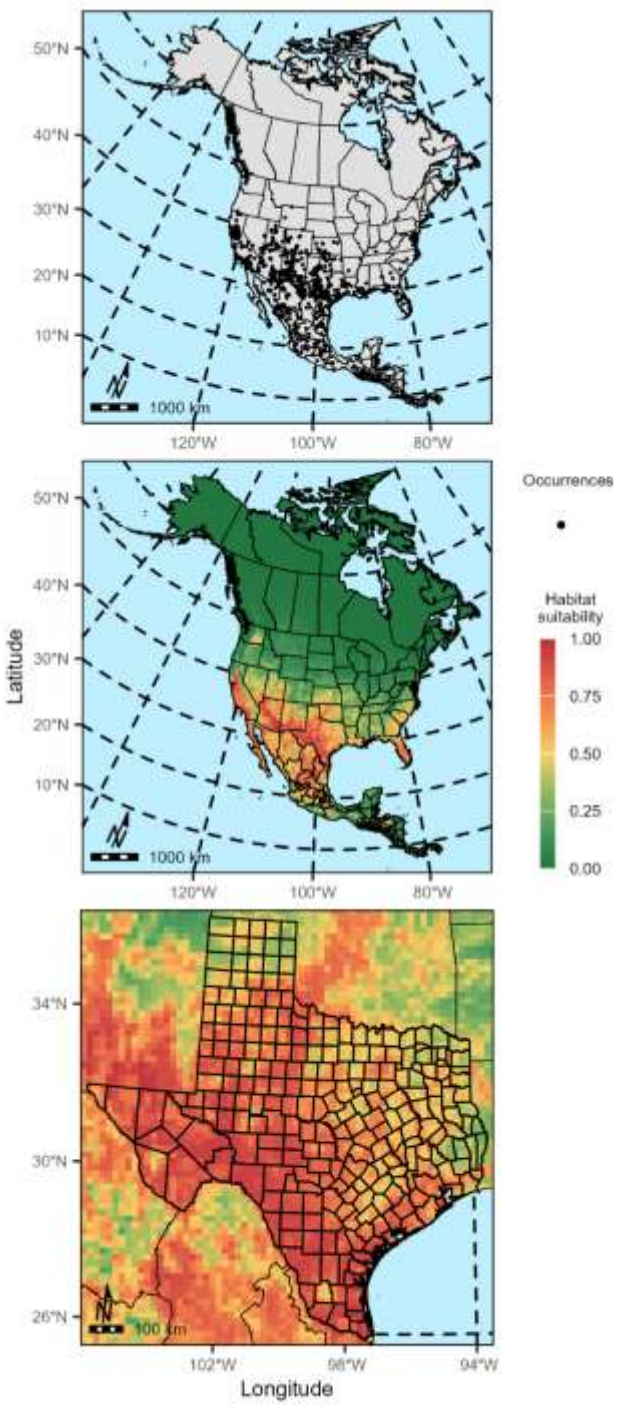


Figure 32. *Tadarida brasiliensis* occurrence records and MaxEnt cloglog predictions; Top: occurrence map, Middle: North America MaxEnt prediction map, Bottom: Texas MaxEnt prediction map.

America north to Panama and Costa Rica. *Tadarida b. constanzae* occurs on the island of Hispanola. *Tadarida b. cynocephala* occurs in the United States from east Texas to the Atlantic Ocean. *Tadarida b. intermedia* occurs in southern Mexico and Guatemala. *Tadarida b. mexicana* is distributed throughout the western portion of the United States and northern and central Mexico. *Tadarida b. murina* occurs on Jamaica. *Tadarida b. muscula* occurs on Cuba and the Grand Cayman Island.

Natural History.—*Tadarida brasiliensis* is insectivorous and consumes primarily moths between 5 and 9mm long (Storer 1926, Ross 1961). These bats also consume arthropods from the orders Aranea, Blattodea, Coleoptera, Diptera, Ephemeroptera, Hemiptera, , Hymenoptera, Mecoptera, Megoloptera, Neuroptera, Odonata, Orthoptera, Plecoptera, Psocoptera and Trichoptera. Brazilian free-tailed bats roost in a variety of natural and manmade structures. Perhaps the most

iconic is the large populations ranging in the millions that roost in limestone caves on the Edwards Plateau of Texas. These bats also roost in culverts, bridges, attics and buildings (Wilkins 1989). In North America ovulation occurs in March and mating occurs for about a five-week period associated with ovulation (Sherman 1937). Typically, one embryo develops but often times females carry twins and even triplets (DiSalvo et al. 1969). Parturition occurs in June and July. Adult weight is attained by about three weeks of age in some individuals and adult length is attained in about two months of age (Pagels and Jones 1974).

Conservation Status.—Population status is stable and *Tadarida brasiliensis* is listed as a species of least concern by the IUCN (Barquez et al. 2015a). This species is not listed as one of greatest conservation need by TPWD (Simon 2023).

Habitat Suitability.—Areas of high habitat suitability for *Tadarida brasiliensis* in North America are widespread across much of the Southern United States and Mexico. Areas of highest habitat suitability occur in Texas, New Mexico, Arizona and California. In Texas, habitat suitability is greatest throughout the western two-thirds of the state.

Most important niche characteristics.— Estimates of permutation importance (Table 2) indicated that the most important environmental niche characteristics for *Tadarida brasiliensis* from highest to lowest importance were Bio1 (annual mean temperature), Aridity, Elevation, Mixed Grass
Shrubland, Pasture and Bio19. Habitat suitability was positively related to Mixed Grass-Shrubland and exhibited complicated modal and multimodal relationships with Bio1, Aridity, Elevation, Pasture and Bio19 (Appendix Figure 31).

Ecological Niche Model Evaluation and Performance—The best performing ecological niche model (Table 1) had linear, quadratic, hinge, product, and threshold feature classes and a regularization multiplier of 3.5. Spatially structured cross-validation yielded a mean 10% omission rate of 0.15 and a mean validation AUC value of 0.73, indicating it to be a fair model for predicting the potential distribution of *Tadarida brasiliensis.*

Nyctinomops femorosaccus—Pocketed Free-Tailed Bat

Description.—The pocketed free-tailed bat is a medium sized (average total length = 112mm, average forearm length = 46mm, range of masses = 10-14g) bat that is similar in appearance to *Tadarida brasiliensis* (Schmidley and Bradley 2016). Distinguishing characteristics are that the second phalanx of the 4th digit is markedly short (< 5mm), bases of the ears are attached, some hairs bicolored and the presence of a skin pocket on the inside of the femur and close to the knee.

Distribution.—*Nyctinomops femorosaccus* is distributed across portions of western North America from all of Baja California to Jalisco, Michoacan and Guerrero Mexico as well as southern California and Arizona, extreme southwestern New Mexico and portions of the Trans-Pecos in Texas (Kumirai and Jones 1990).

Systematics.—*Nyctinomops femorosaccus* is monotypic (Kumirai and Jones 1990).

Natural History.—This species often roosts in rock crevices of cliffs or high rocky outcrops (Cockrum 1956, Easterla 1973a. Krutzsch 1945) but also roosts in caves (Jones et al. 1972, Hoffmeister 1986), buildings and under roofing tiles. Pocketed free-tailed bats are insectivorous consuming prey from the arthropod orders Coleoptera, Diptera, Hemiptera, Hymenoptera, Lepidioptera and Orthoptera (Ross 1967, Easterla and Whitaker 1972, Matthews et al. 2010).

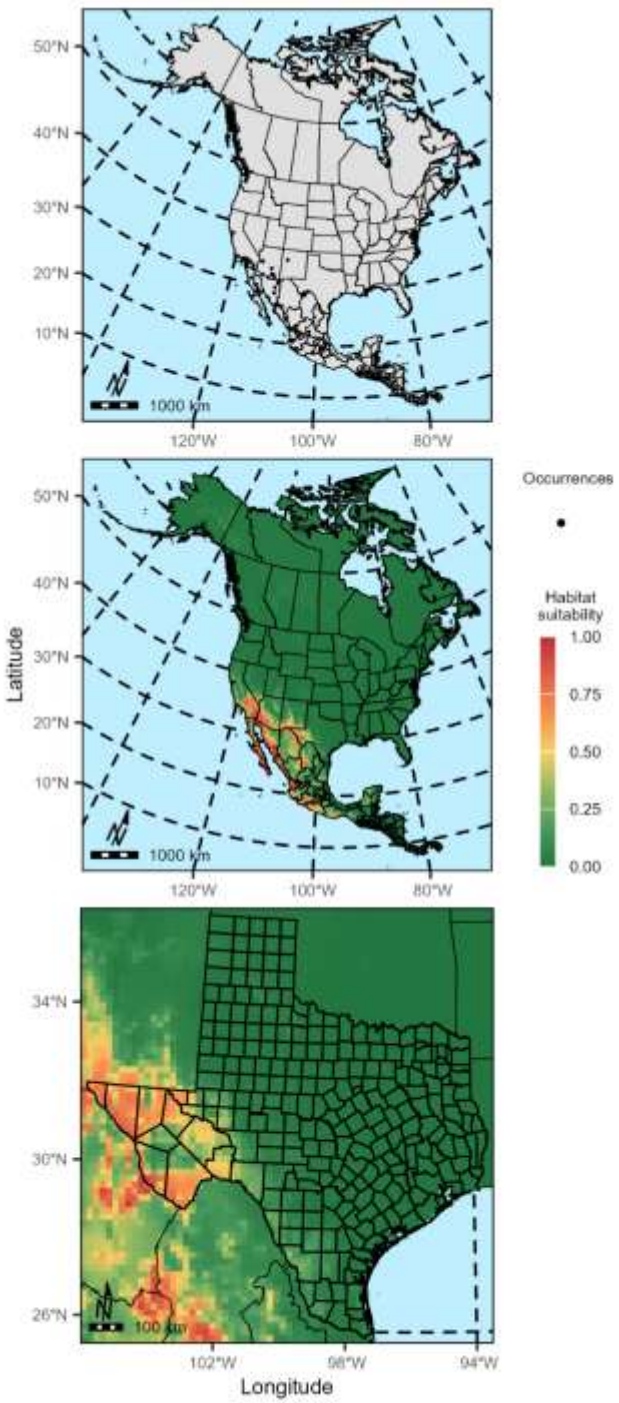


Figure 33. *Nyctinomops femorosaccus* occurrence records and MaxEnt cloglog predictions; Top: occurrence map, Middle: North America MaxEnt prediction map, Bottom: Texas MaxEnt prediction map.

Parturition of a single neonate occurs between late June and early July. Lactating females have been observed between late June and mid-August. Juveniles have been captured from the end of August to the end of November (Ammerman et al. 2012.

Conservation Status.—Population status is stable and *Nyctinomops femorosaccus* is listed as a species of least concern by the IUCN (Arroyo-Cabrales and Castaneda 2015). This species is listed as one of greatest conservation need and ranked as S3S4 (Vulnerable/Apparently secure) by TPWD (Simon 2023).

Habitat Suitability.— Areas of highest habitat suitability for *Nyctinomops femorosaccus* in North America occur across the southern portions of the southwestern states of the United States. Baja California and the Pacific versant of Mexico. In Texas, highest habitat suitability for this species occurs in the Trans-Pecos ecoregion.

Most important niche characteristics.— Estimates of permutation importance (Table 2) indicated that the most important environmental niche characteristics for *Nyctinomops femorosaccus* from highest to lowest importance were Bio1 (mean annual temperature), Bio15 (precipitation seasonality), Bio12 (annual precipitation), Bio14 (precipitation of the dryest month), Pasture, and Cropland. Habitat suitability was positively related to Bio1 and Bio15 and negatively related to Bio12, Bio14, Pasture and Cropland (Appendix Figure 32).

Ecological Niche Model Evaluation and Performance—The best performing ecological niche model (Table 1) had linear feature classes and a regularization multiplier of 3. Spatially structured cross-validation yielded a mean 10% omission rate of 0.07 and a mean validation AUC value of 0.88, indicating it to be a good model for predicting the potential distribution of *Nyctinomops femorrosaccus.*

***Nyctinomops macrotis*—Big Free-Tailed Bat**

Description.—The big free-tailed bat is large (average total length = 134mm, average forearm length = 61mm, range of masses = 22-30g) and similar in appearance to *T. brasiliensis*, but the latter is much smaller (Schmidly and Bradley 2016).

Distribution.—*Nyctinomops macrotis* ranges from northwestern Argentina and Uruguay, through South and Central America to southeastern California and Nevada, southern Utah and Colorado, western Oklahoma and southern and western Texas (Milner et al. 1990).

Systematics.—*Nyctinomops macrotis* is monotypic (Milner et al. 1990).

Natural History.—Big free-tailed bats, at least in North America, occur in rugged rocky country in arid and semi-arid environments (Milner et al. 1990). They have been captured in evergreen forest (2,440 m, Jones 1965) but primarily forage over areas less than 1800m in elevation

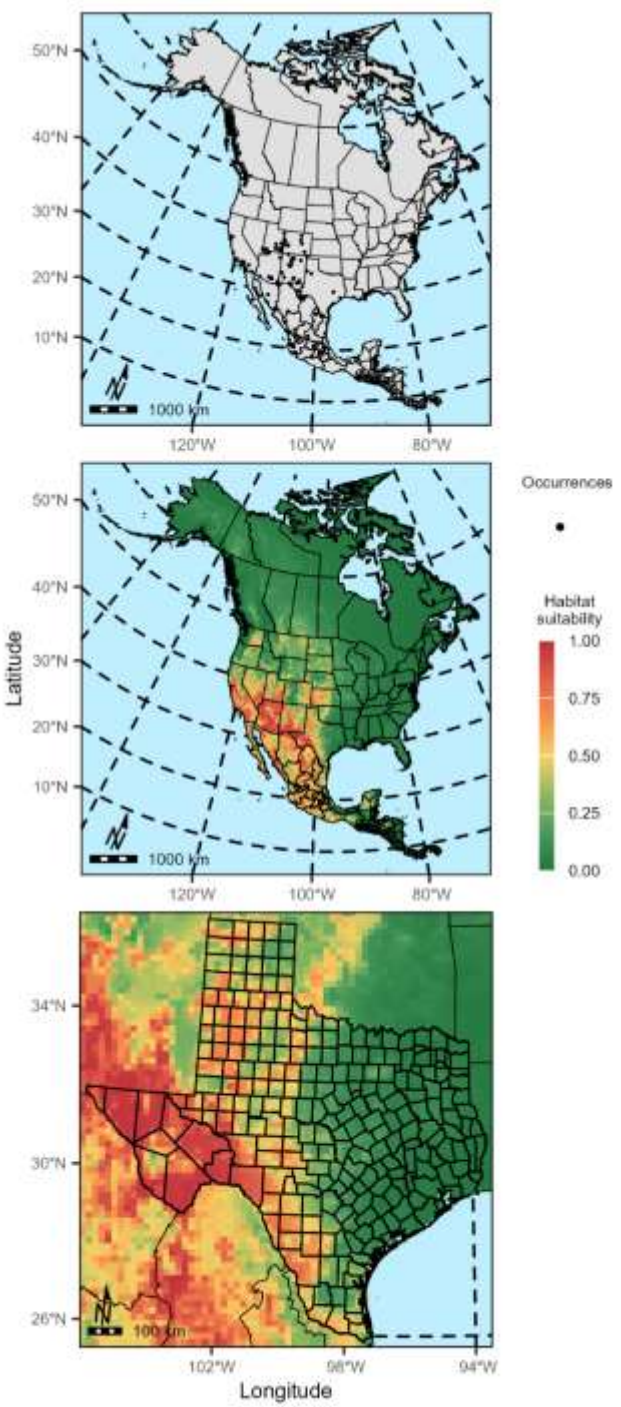


Figure 34. *Nyctinomops macrotis* occurrence records and MaxEnt cloglog predictions; Top: occurrence map, Middle: North America MaxEnt prediction map, Bottom: Texas MaxEnt prediction map.

(Easterla 1973a, Findley et al. 1975). This species is insectivorous (Milner et al. 1990). Although it primarily consumes large Macrolepidoptera it also preys on Coleoptera, Diptera, Hemiptera, Hymenoptera, Neuroptera, Orthoptera, and Trichoptera (Easterla and Whitaker 1972, Easterla 1973a, Sparks and Valdez 2003, Gordon et al. 2018). This species most often roosts in high crevices (Borell and Bryant 1942, Barbour and Davis 1969, Findley et al. 1975) but also has been observed roosting in tree holes, caves and buildings (Sanborn 1951, Schmidly and Bradley 2016, Silva Taboada 1979). Parturition occurs in late spring or early summer (Milner et al. 1990), Lactation occurs from June through August (Easterla 1973a).

Conservation Status.—Population status is unknown and *Nyctinomops macrotis* is listed as a species of least concern by the IUCN (Barquez et al. 2015b). This species is listed as one of greatest conservation need and ranked as S3 (Vulnerable) by TPWD (Simon 2023).

Habitat Suitability.— Areas of high habitat suitability occur across the southwestern United States and into southern Mexico. Habitat suitability was highest in Texas, New Mexico, and Arizona. In Texas, habit suitability is generally highest in the Trans-Pecos, but also on the south Texas Plain and Permian Basin.

Most important niche characteristics.— Estimates of permutation importance (Table 2) indicated that the most important environmental niche characteristics for *Nyctinomops macrotis* from highest to lowest importance were Aridity, Bio1 (mean annual temperature), Bio14 (precipitation of the dryest month), Pasture, Bio12 (annual precipitation) and Sedimentary Rock. Habitat suitability was positively related to Bio1 and Sedimentary Rock and negatively related to Aridity, Bio14, and Pasture. Habitat suitability exhibited a modal relationship with Bio12 (Appendix Figure 33).

Ecological Niche Model Evaluation and Performance—The best performing ecological niche model (Table 1) had hinge feature classes and a regularization multiplier of 4. Spatially structured cross-validation yielded a mean 10% omission rate of 0.25 and a mean validation AUC value of 0.81, indicating it to be a good model for predicting the potential distribution of *Nyctinomops macrotis.*

Eumops perotis—Western Mastiff Bat

Description.—The western mastiff bat is the largest of North American bats (average total length = 167mm, average forearm length = 76mm, range of masses = 60-70g). It is similar in appearance to species of *Tadarida* and *Nyctinomops* (Schmidly and Bradley 2016) but unmistakenly larger. The dorsum is brown to grayish-brown with white bases to the hairs. The venter is paler and this species possesses a glandular pouch on the throat.

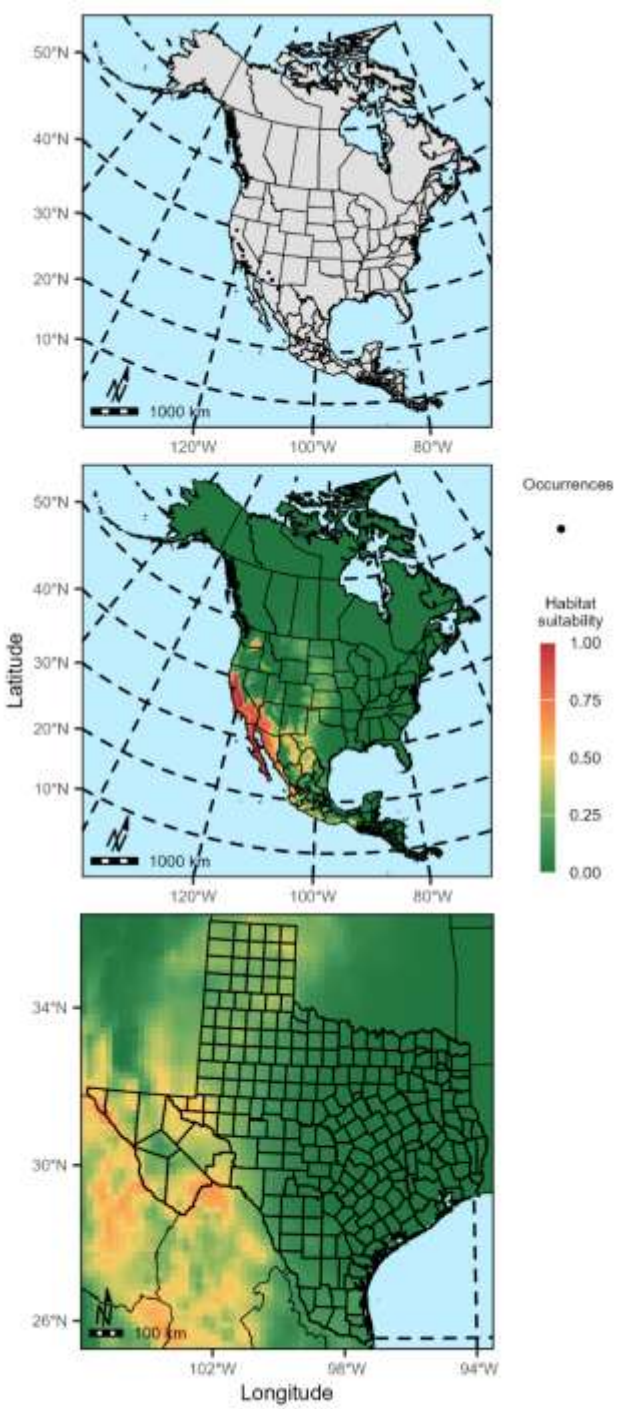


Figure 35. *Eumops perotis* occurrence records and MaxEnt cloglog predictions; Top: occurrence map, Middle: North America MaxEnt prediction map, Bottom: Texas MaxEnt prediction map.

Distribution.—*Eumops perotis* is distributed as two disjunct populations, one in North America and one in South America (Best et al. 1996). In North America, this species is known from the states of the United States that border Mexico to as far south as southern Mexico.

Systematics.—Two subspecies are recognized (Wilson and Ruff 1999). *Eumops perotis californicus* occurs in North America and *E. p. perotis* occurs in South America.

Natural History.—In North America, western mastiff bats inhabit arid and semiarid highlands with much topographic relief (Best et al. 1996). They require substantive clearance (> 2m) in order to attain flight (Hoffmeister 1986). This species is insectivorous (Best, 1996) and consumes prey from the arthropod orders Coleoptera, Diptera, Ephemeroptera, Hemiptera, Hymenoptera, Lepidoptera, Neuroptera, Odonata and Orthoptera (Ross 1961, Ross 1967, Easterla and Whitaker 1972, Easterla 1973b, Gordon et al. 2019). This

species roosts in crevices in high cliffs, shallow caves, rock walls and buildings (Dalquest 1946, Cockrum 1960, Cox 1965, Barbour and Davis 1969). Mating occurs in early spring and offspring are born between June and September (Barbour and Davis 1969, Easterla 1973b).

Conservation Status.—Population status is decreasing and *Eumops perotis* is listed as a species of least concern by the IUCN (Barquez and Diaz 2015). This species is listed as one of greatest conservation need and ranked as S3S4 (Vulnerable/Apparently secure) by TPWD (Simon 2023).

Habitat Suitability.—Areas of highest habitat suitability for western mastiff bats occur throughout the southwestern portions of the United States, from Texas thorough New Mexico and Arizona to California, as well as across Baja California and the Pacific versant of Northern Mexico. In Texas, areas of high habitat suitability occur in the Trans Pecos as well as South Texas Plains ecoregions.

Most important niche characteristics.— Estimates of permutation importance (Table 2) indicated that the most important environmental niche characteristics for *Eumops perotis* from highest to lowest importance were Bio1 (mean annual temperature), Bio14 (precipitation of the dryest month), and Elevation. Habitat suitability was negatively related to Bio14 and elevation and exhibited a modal relationship with Bio1 (Appendix Figure 34).

Ecological Niche Model Evaluation and Performance—The best performing ecological niche model (Table 1) had linear and quadratic feature classes and a regularization multiplier of 3.5. Spatially structured cross-validation yielded a mean 10% omission rate of 0.25 and a mean validation AUC value of 0.82, indicating it to be a good model for predicting the potential distribution of *Eumops perotis*.

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Appendix.—Species-Specific Variable Response Curves

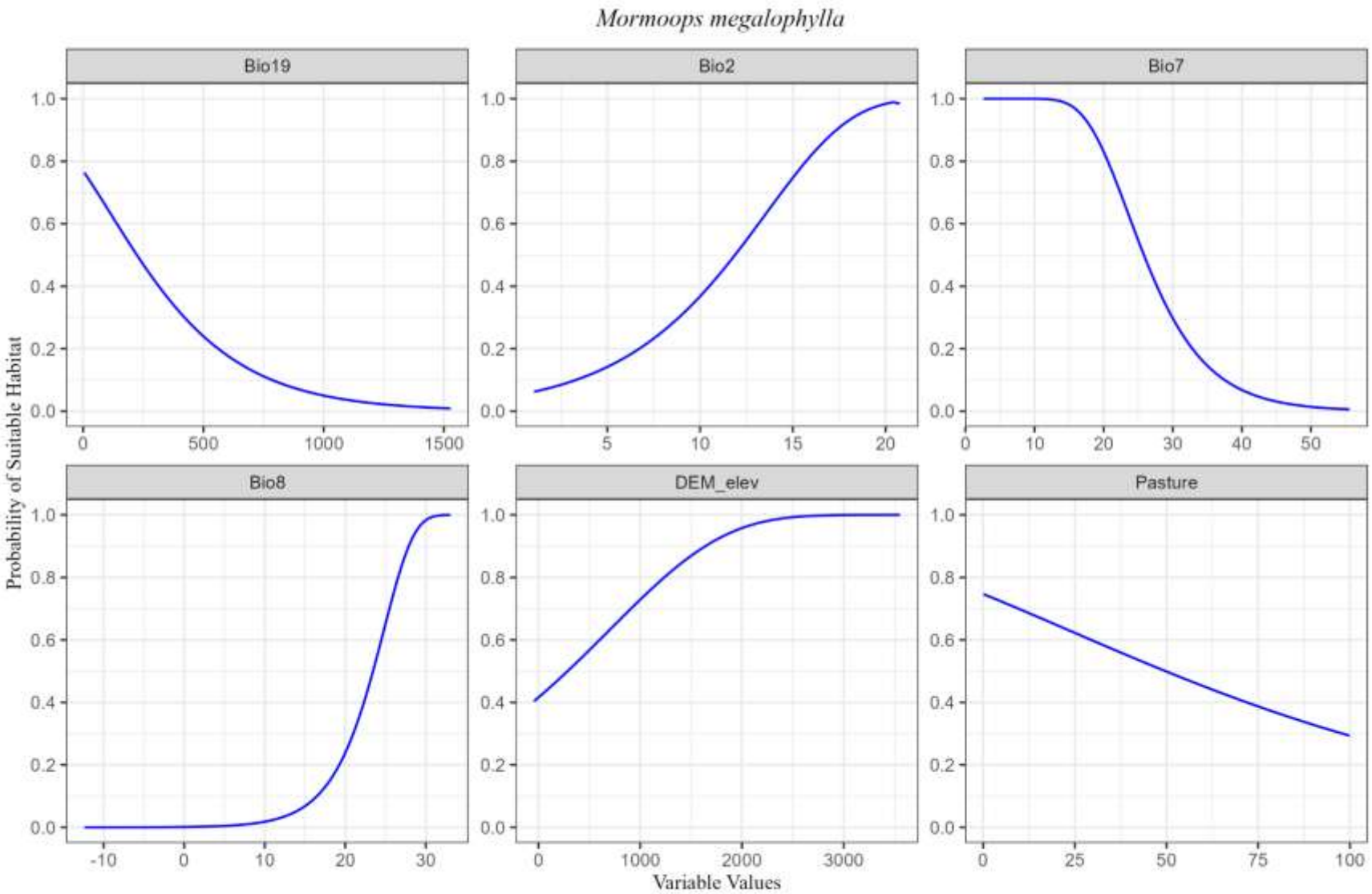


Figure 1. The marginal variable response curves for the environmental variables included in the final MaxEnt model for *Mormoops megalophylla*. Each response curve with the variable values ranging from its respective minimum to maximum on the x axis and the cloglog probability of suitable habitat along the y axis ranging from 0 to 1.

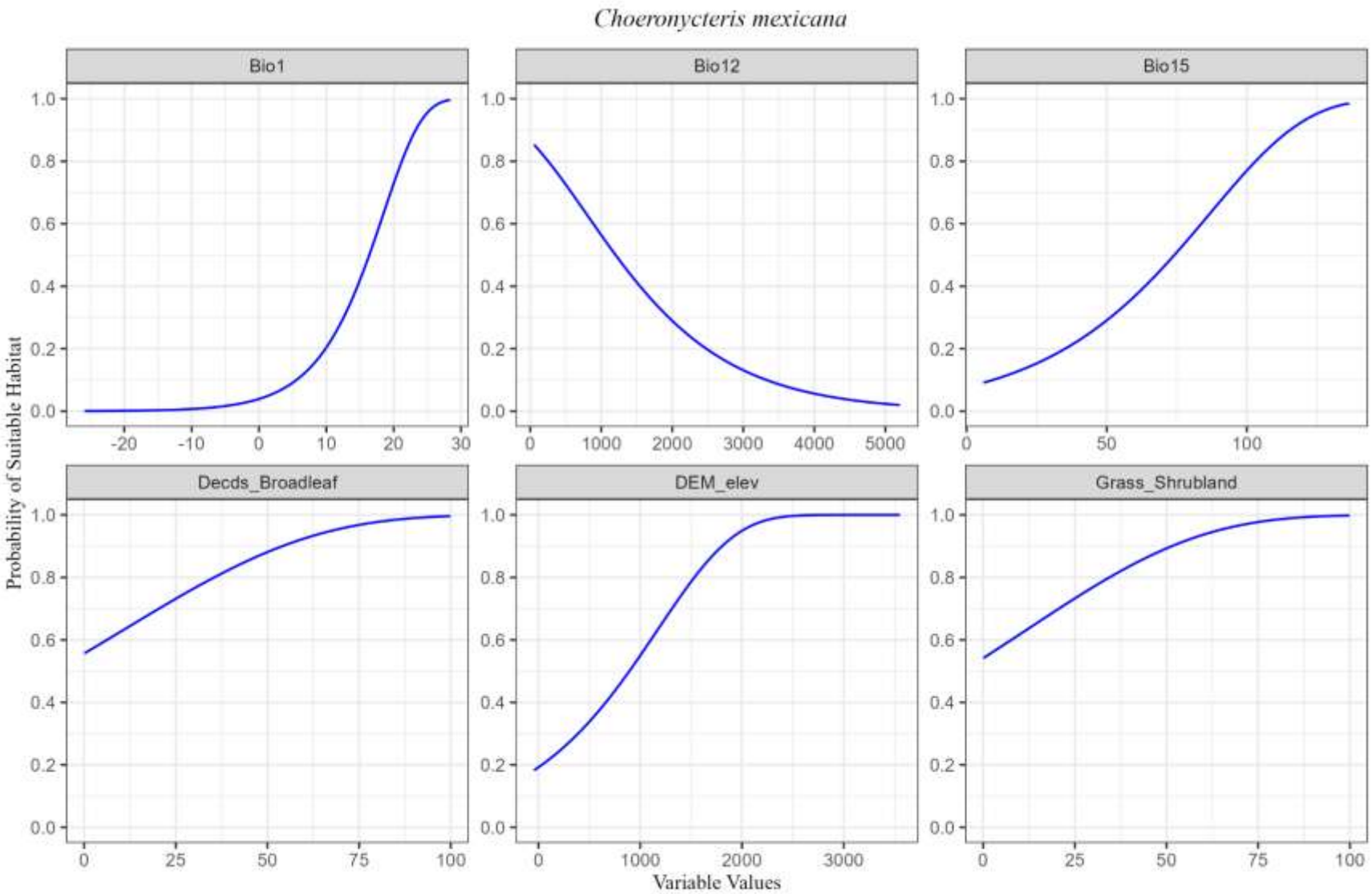


Figure 2. The marginal variable response curves for the environmental variables included in the final MaxEnt model for *Choeronycteris mexicana*. Each response curve with the variable values ranging from its respective minimum to maximum on the x axis and the cloglog probability of suitable habitat along the y axis ranging from 0 to 1.

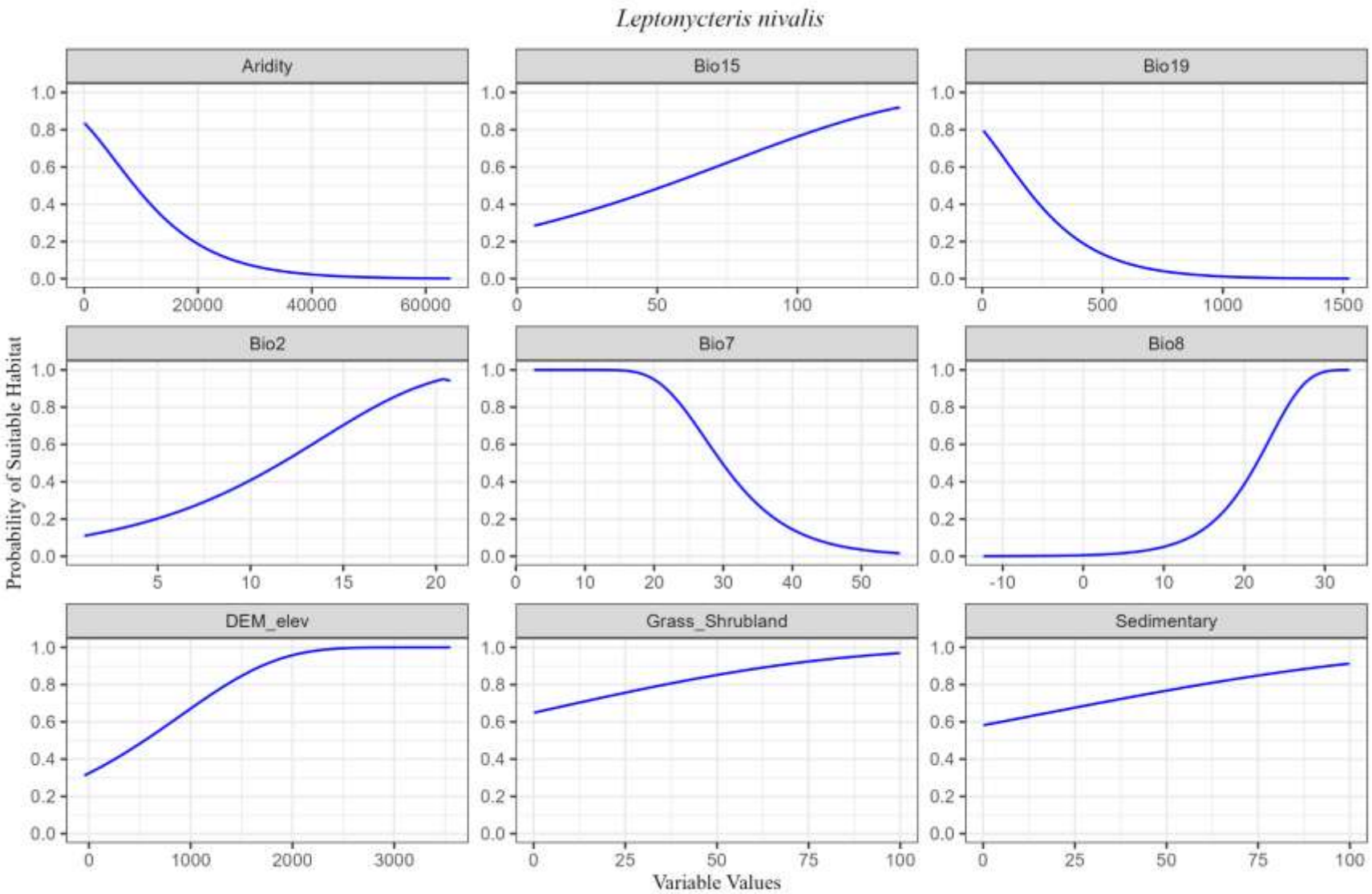


Figure 3. The marginal variable response curves for the environmental variables included in the final MaxEnt model for *Leptonycteris nivalis*. Each response curve with the variable values ranging from its respective minimum to maximum on the x axis and the cloglog probability of suitable habitat along the y axis ranging from 0 to 1.

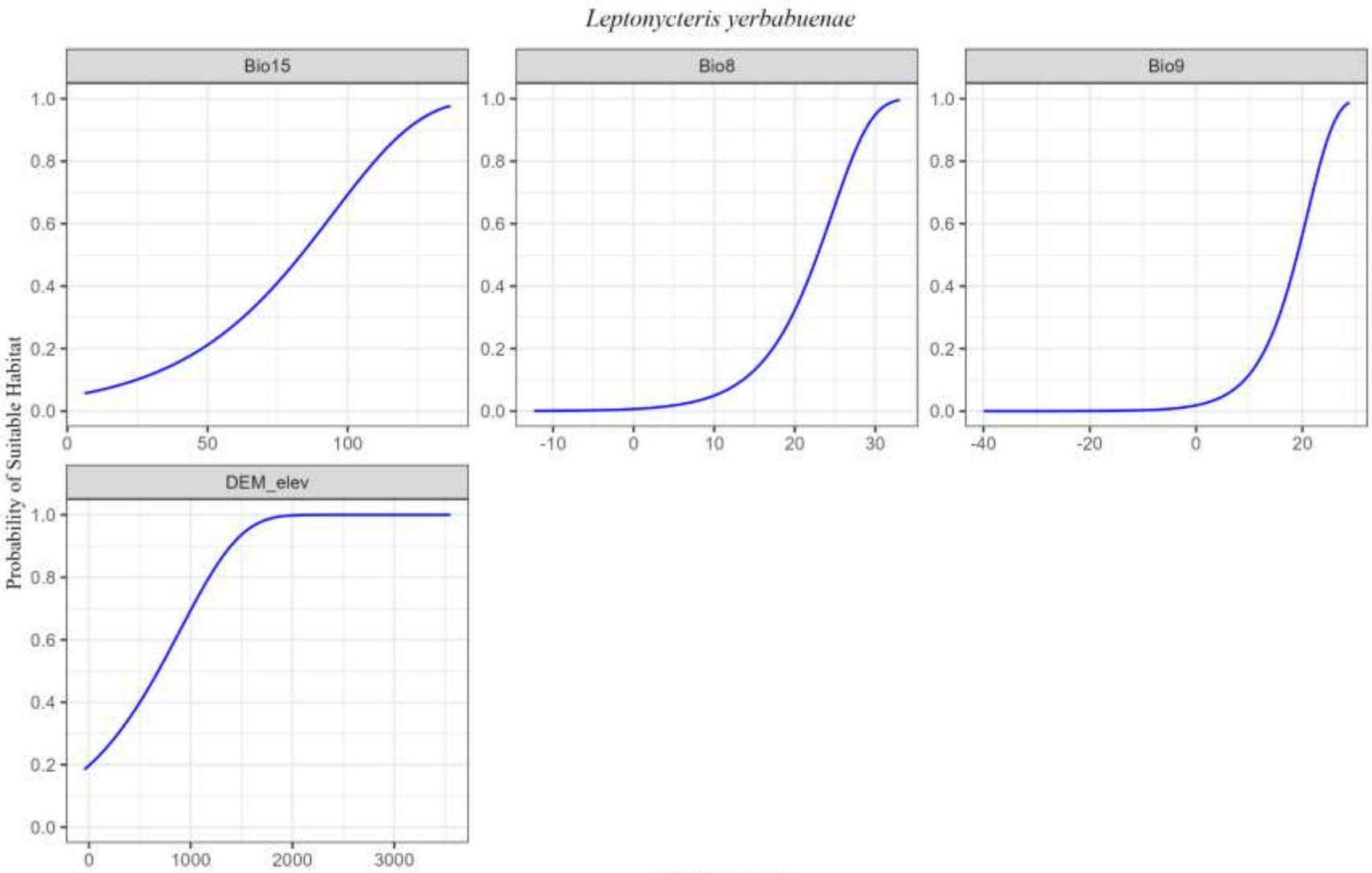


Figure 4. The marginal variable response curves for the environmental variables included in the final MaxEnt model for *Leptonycteris yerbabuenae*. Each response curve with the variable values ranging from its respective minimum to maximum on the x axis and the cloglog probability of suitable habitat along the y axis ranging from 0 to 1.

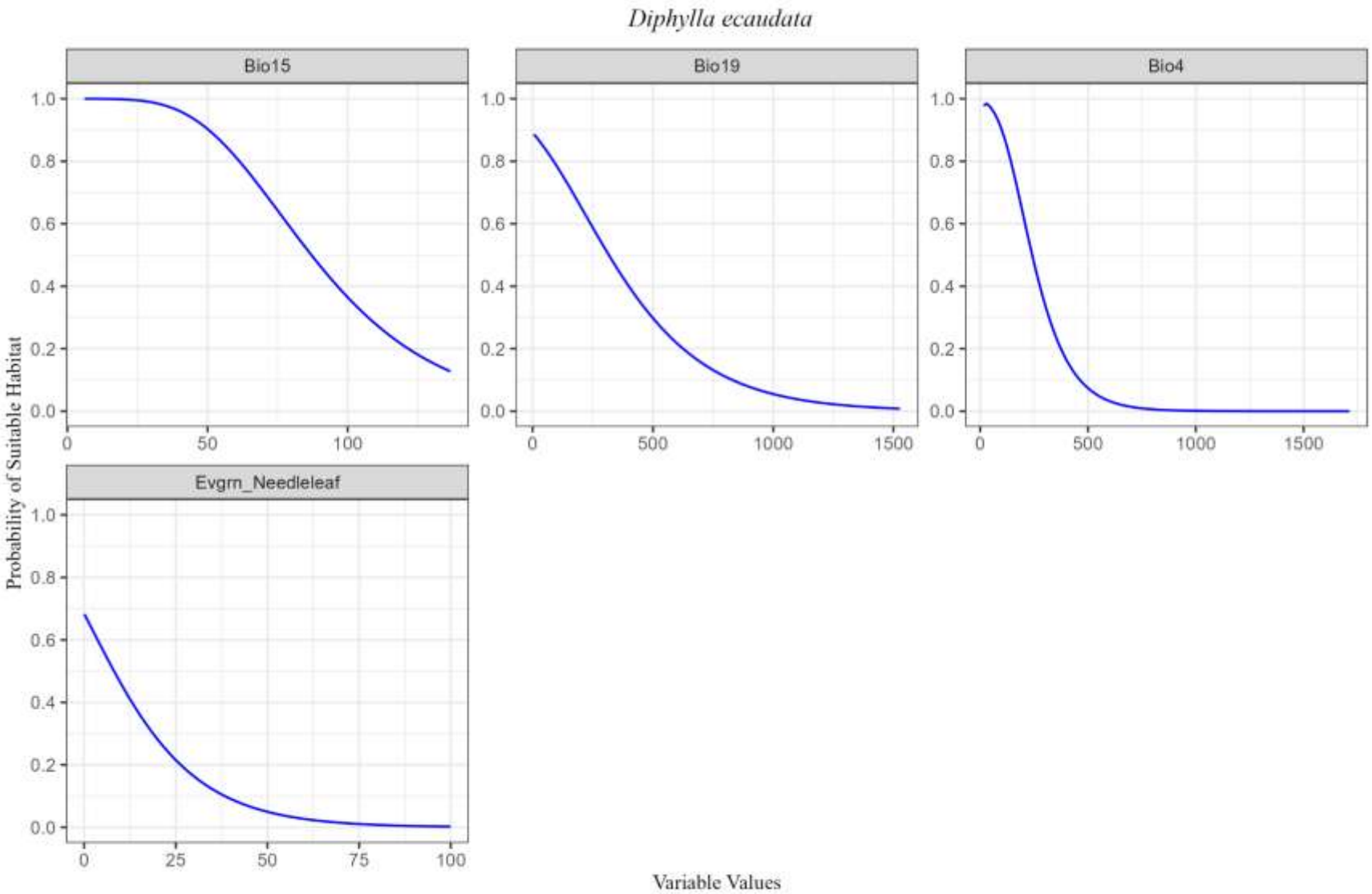


Figure 5. The marginal variable response curves for the environmental variables included in the final MaxEnt model for *Diphylla ecaudata*. Each response curve with the variable values ranging from its respective minimum to maximum on the x axis and the cloglog probability of suitable habitat along the y axis ranging from 0 to 1.

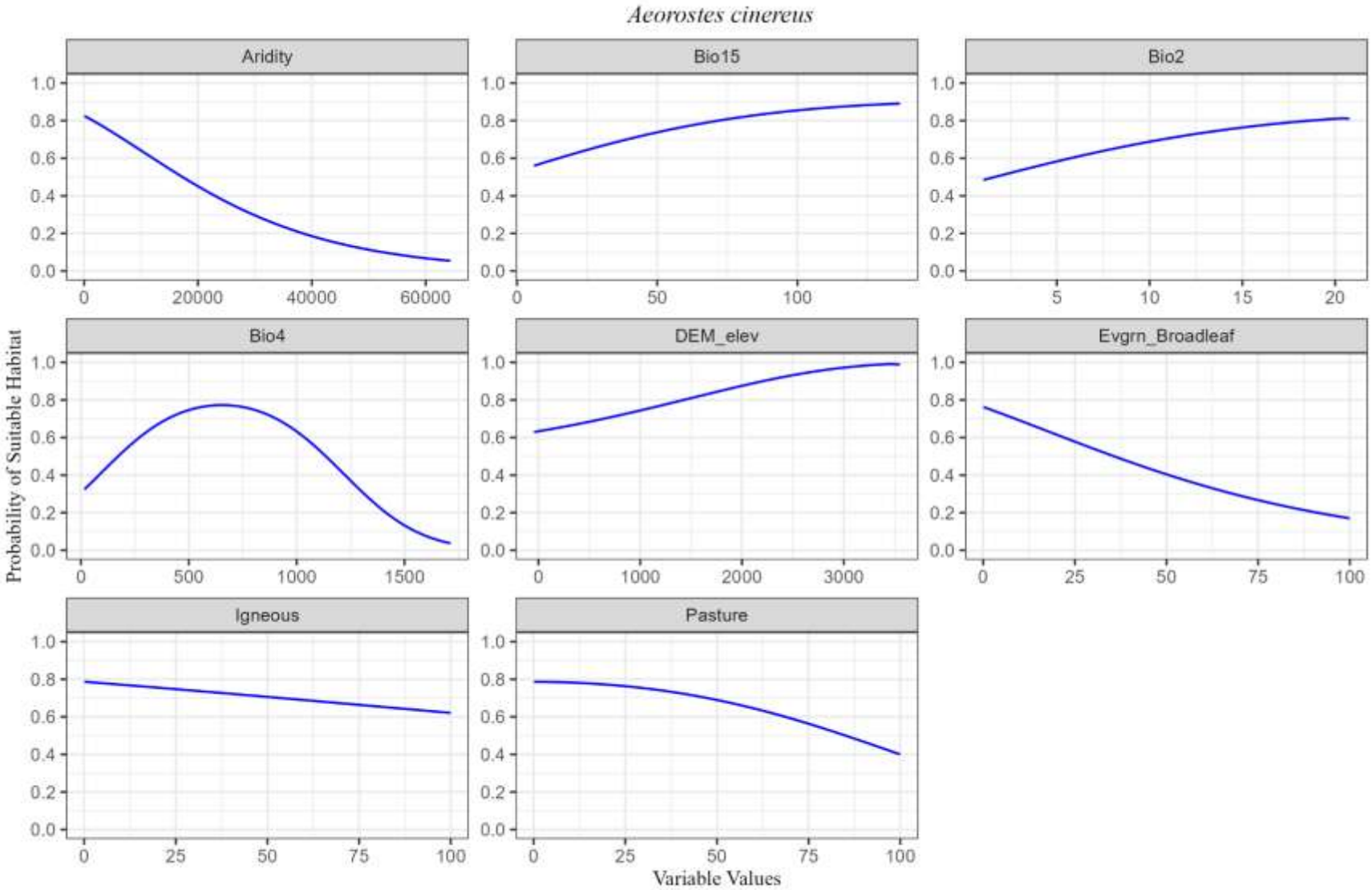


Figure 6. The marginal variable response curves for the environmental variables included in the final MaxEnt model for *Aeorostes cinereus*. Each response curve with the variable values ranging from its respective minimum to maximum on the x axis and the cloglog probability of suitable habitat along the y axis ranging from 0 to 1.

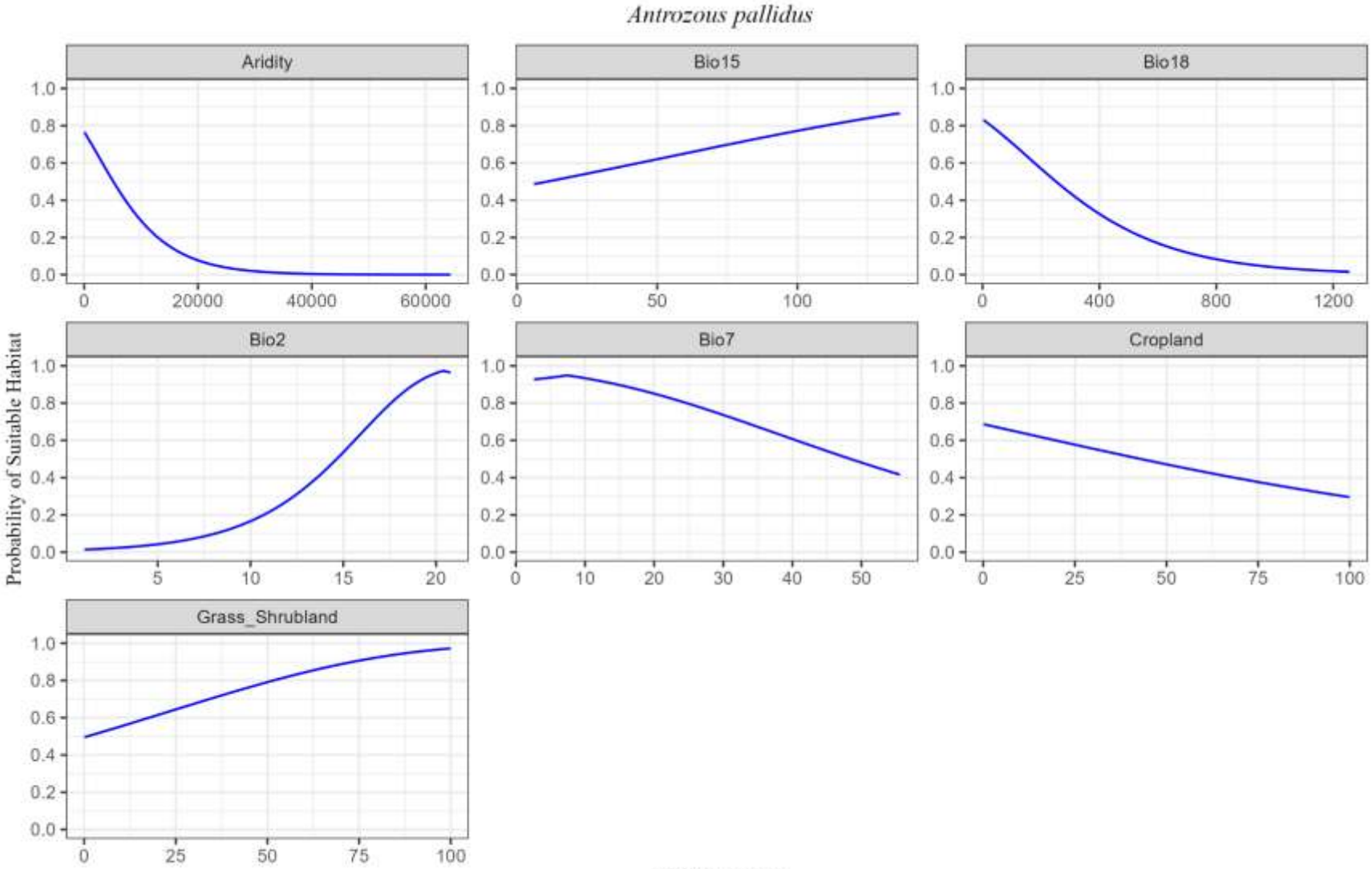


Figure 7. The marginal variable response curves for the environmental variables included in the final MaxEnt model for *Antrozous pallidus*. Each response curve with the variable values ranging from its respective minimum to maximum on the x axis and the cloglog probability of suitable habitat along the y axis ranging from 0 to 1.

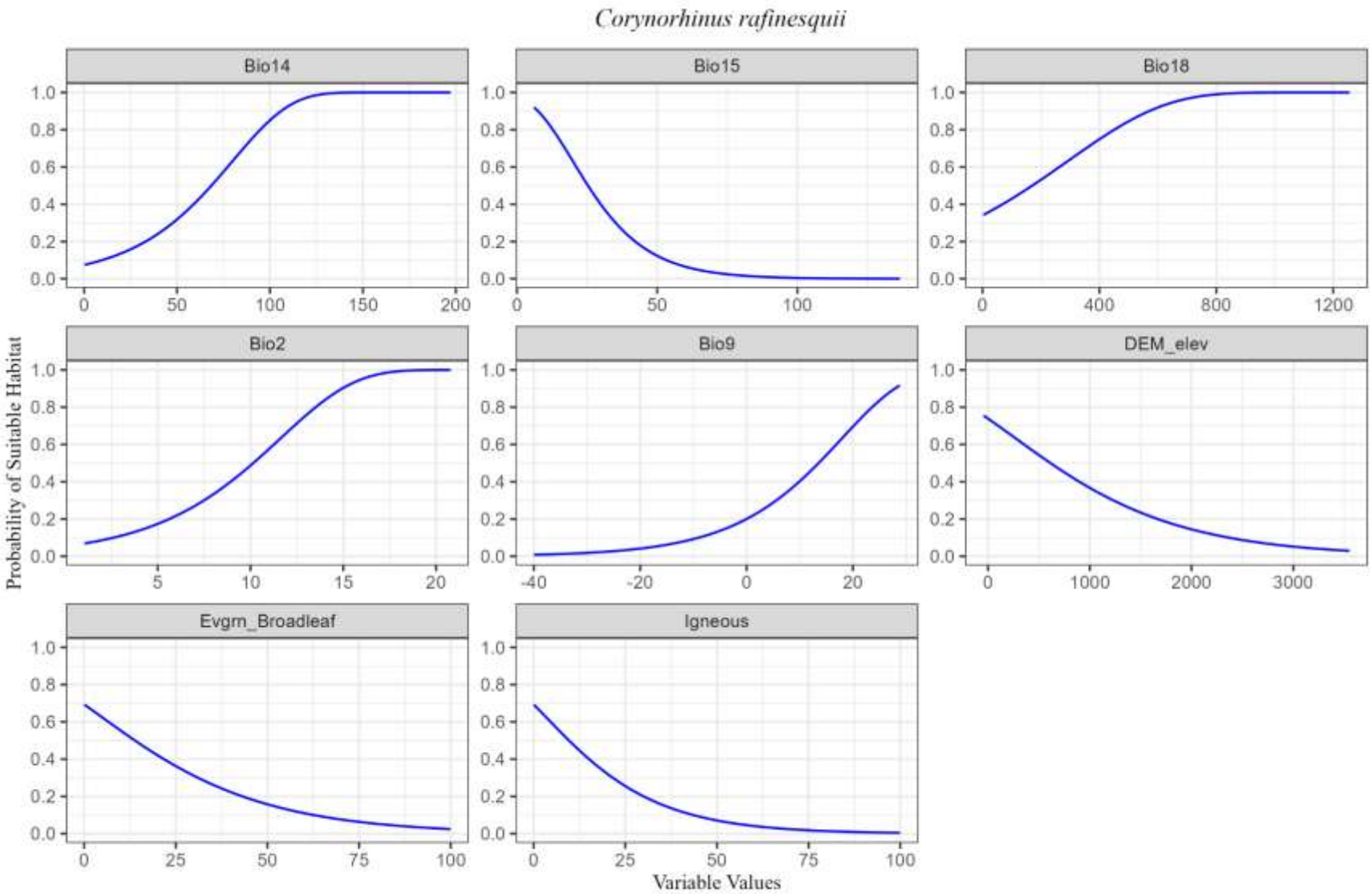


Figure 8. The marginal variable response curves for the environmental variables included in the final MaxEnt model for *Corynorhinus rafinesquii*. Each response curve with the variable values ranging from its respective minimum to maximum on the x axis and the cloglog probability of suitable habitat along the y axis ranging from 0 to 1.

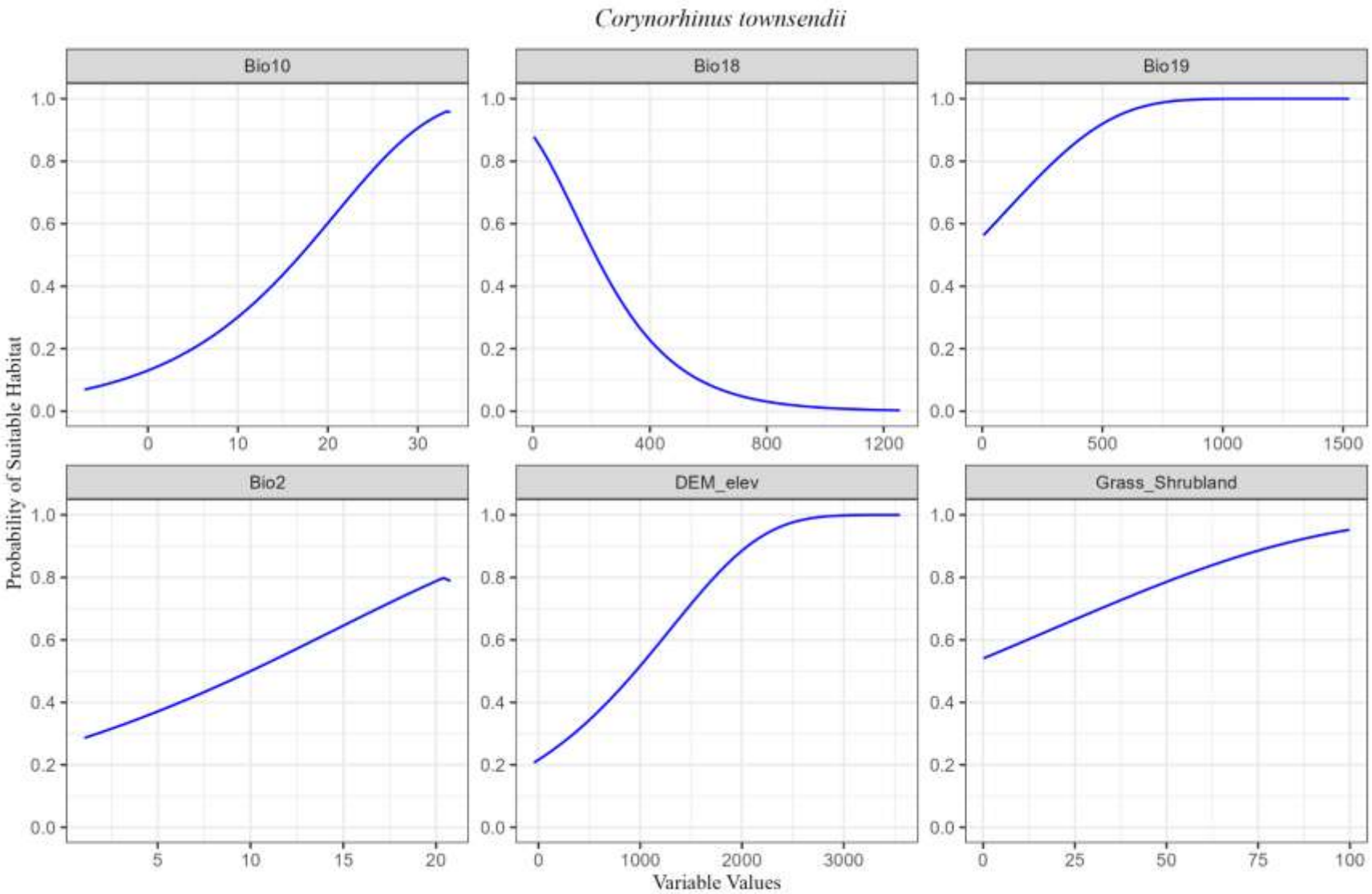


Figure 9. The marginal variable response curves for the environmental variables included in the final MaxEnt model for *Corynorhinus townsendii*. Each response curve with the variable values ranging from its respective minimum to maximum on the x axis and the cloglog probability of suitable habitat along the y axis ranging from 0 to 1.

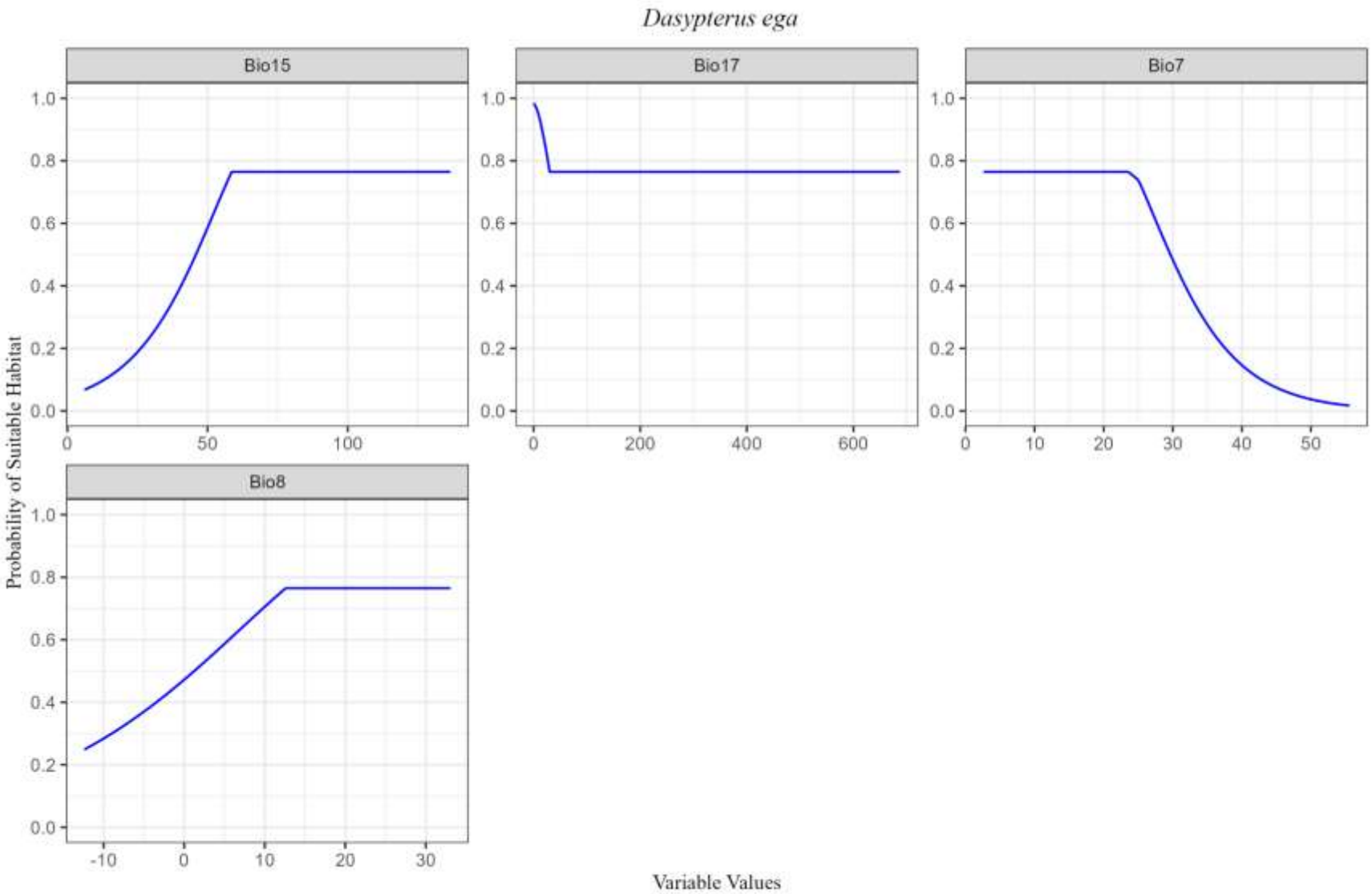


Figure 10. The marginal variable response curves for the environmental variables included in the final MaxEnt model for *Dasypterus ega*. Each response curve with the variable values ranging from its respective minimum to maximum on the x axis and the cloglog probability of suitable habitat along the y axis ranging from 0 to 1.

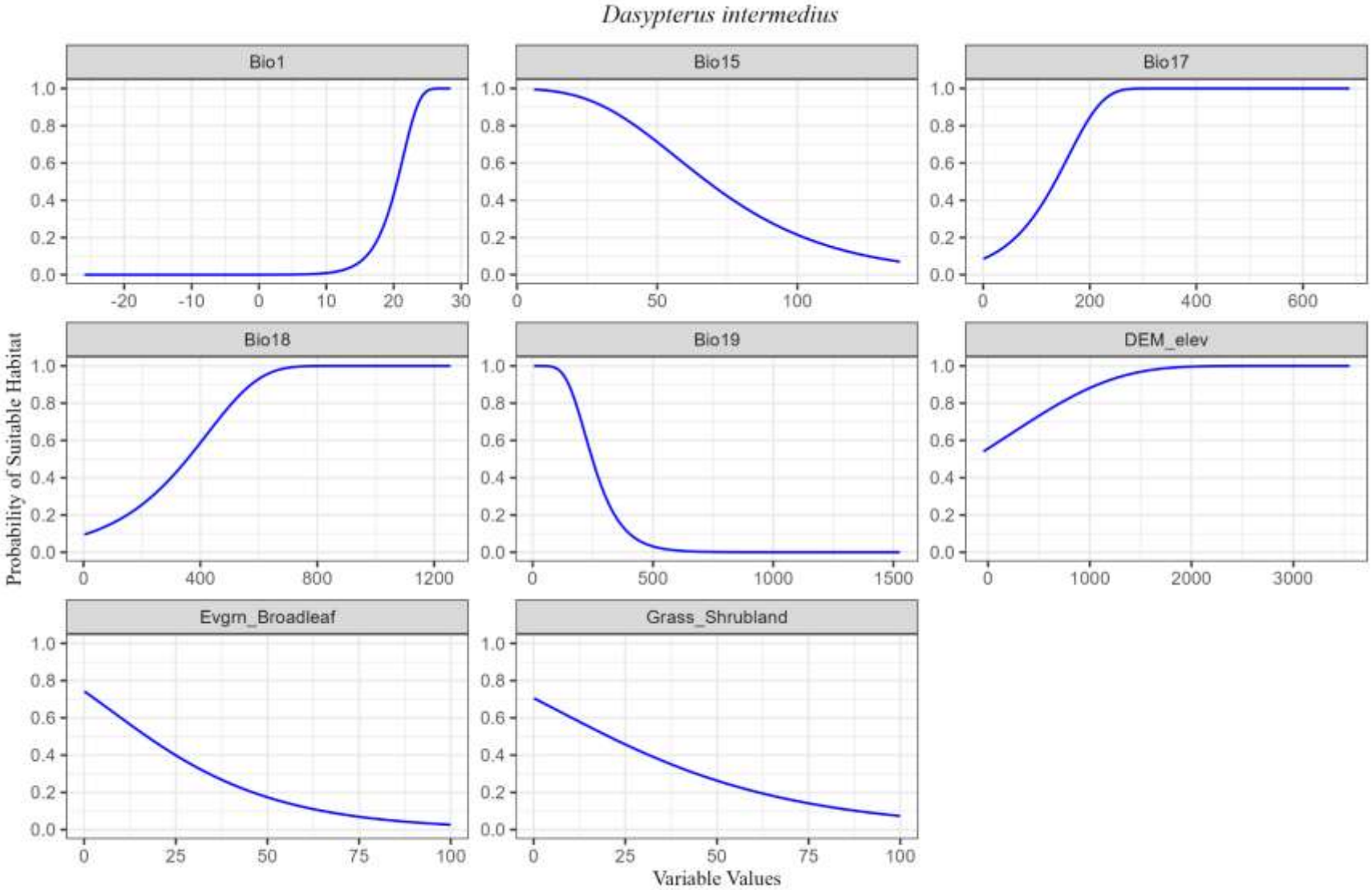


Figure 11. The marginal variable response curves for the environmental variables included in the final MaxEnt model for *Dasypterus intermedius*. Each response curve with the variable values ranging from its respective minimum to maximum on the x axis and the cloglog probability of suitable habitat along the y axis ranging from 0 to 1.

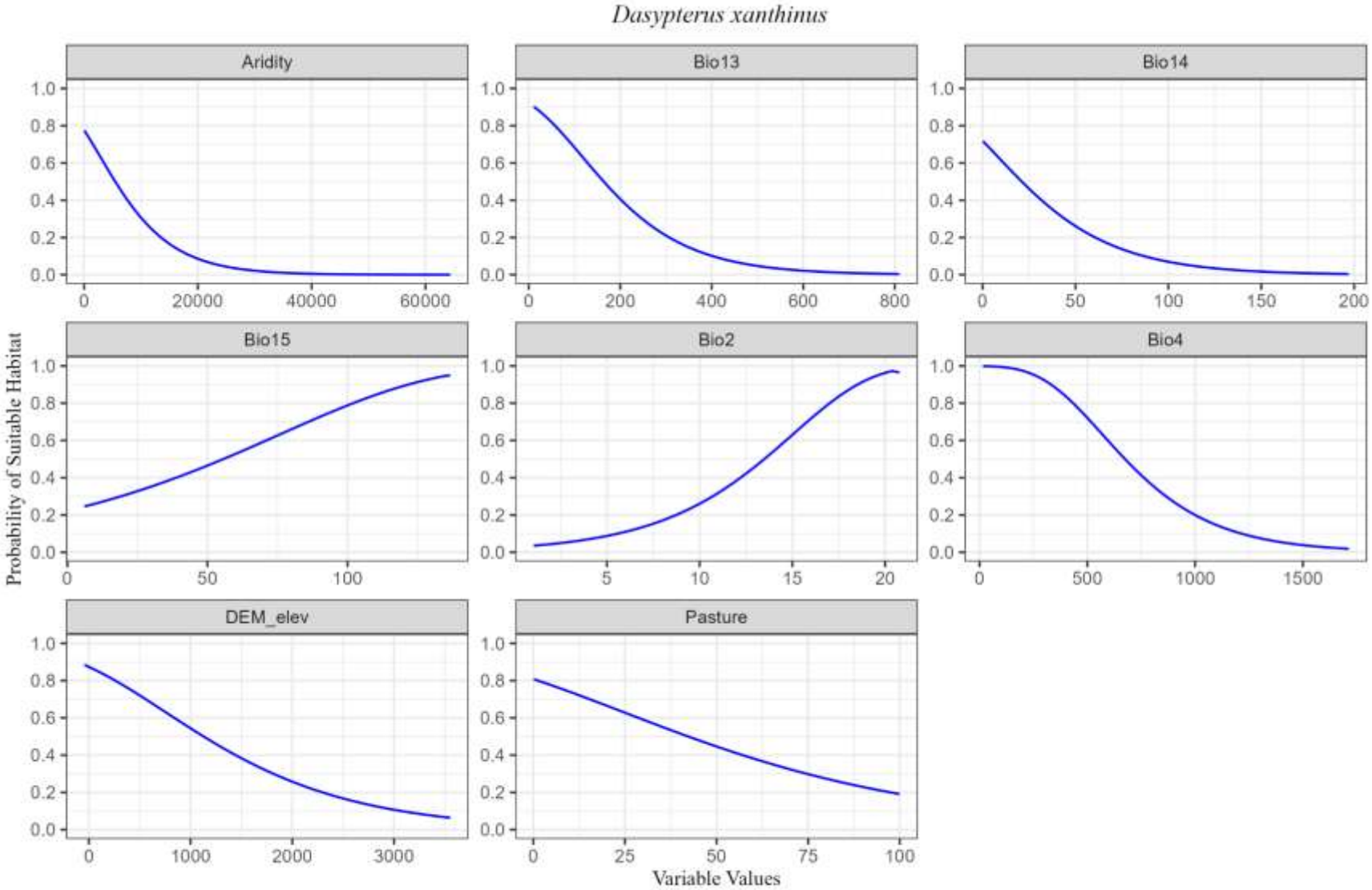


Figure 12. The marginal variable response curves for the environmental variables included in the final MaxEnt model for *Dasypterus xanthinus*. Each response curve with the variable values ranging from its respective minimum to maximum on the x axis and the cloglog probability of suitable habitat along the y axis ranging from 0 to 1.

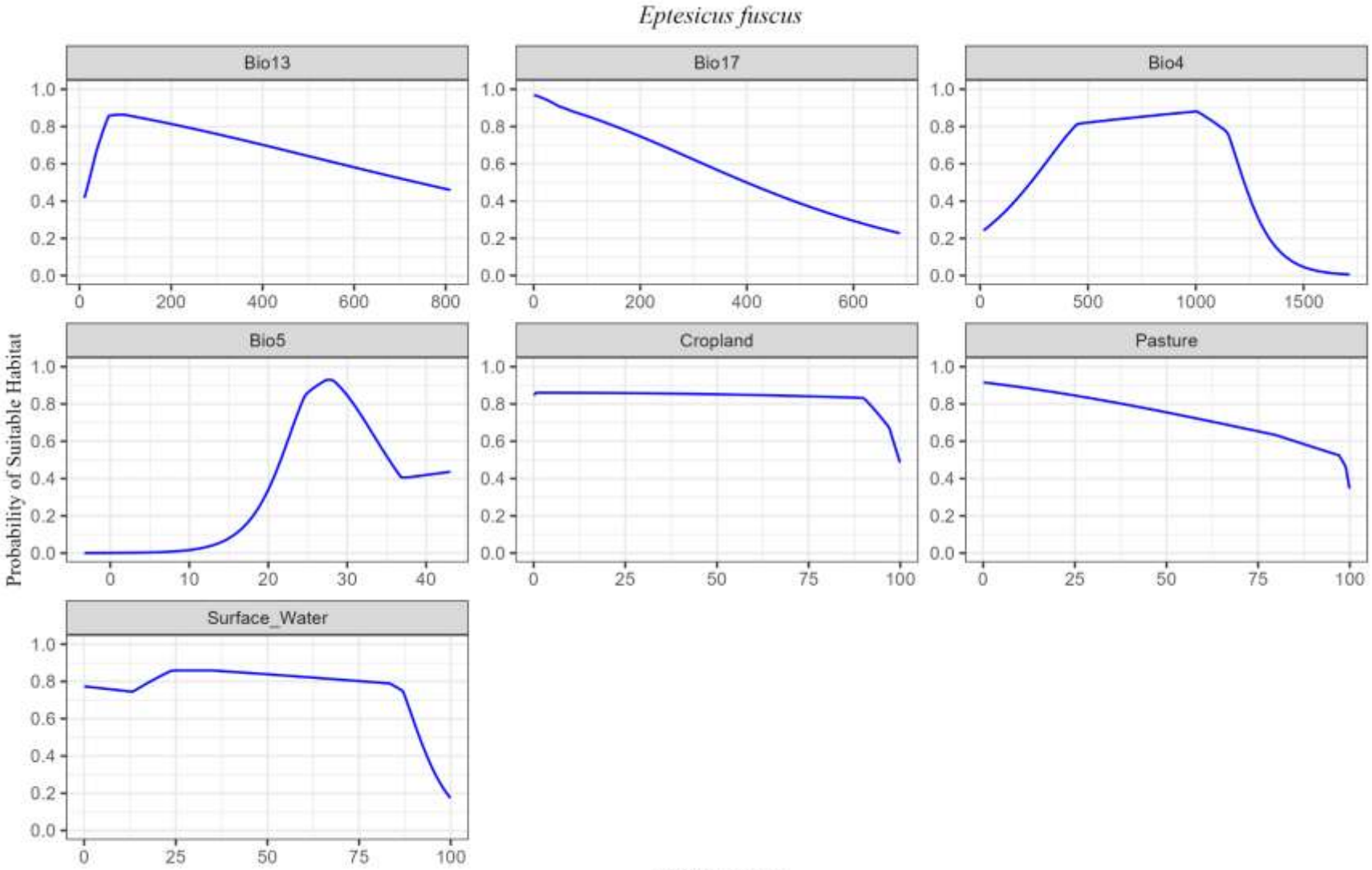


Figure 13. The marginal variable response curves for the environmental variables included in the final MaxEnt model for *Eptesicus fuscus*. Each response curve with the variable values ranging from its respective minimum to maximum on the x axis and the cloglog probability of suitable habitat along the y axis ranging from 0 to 1.

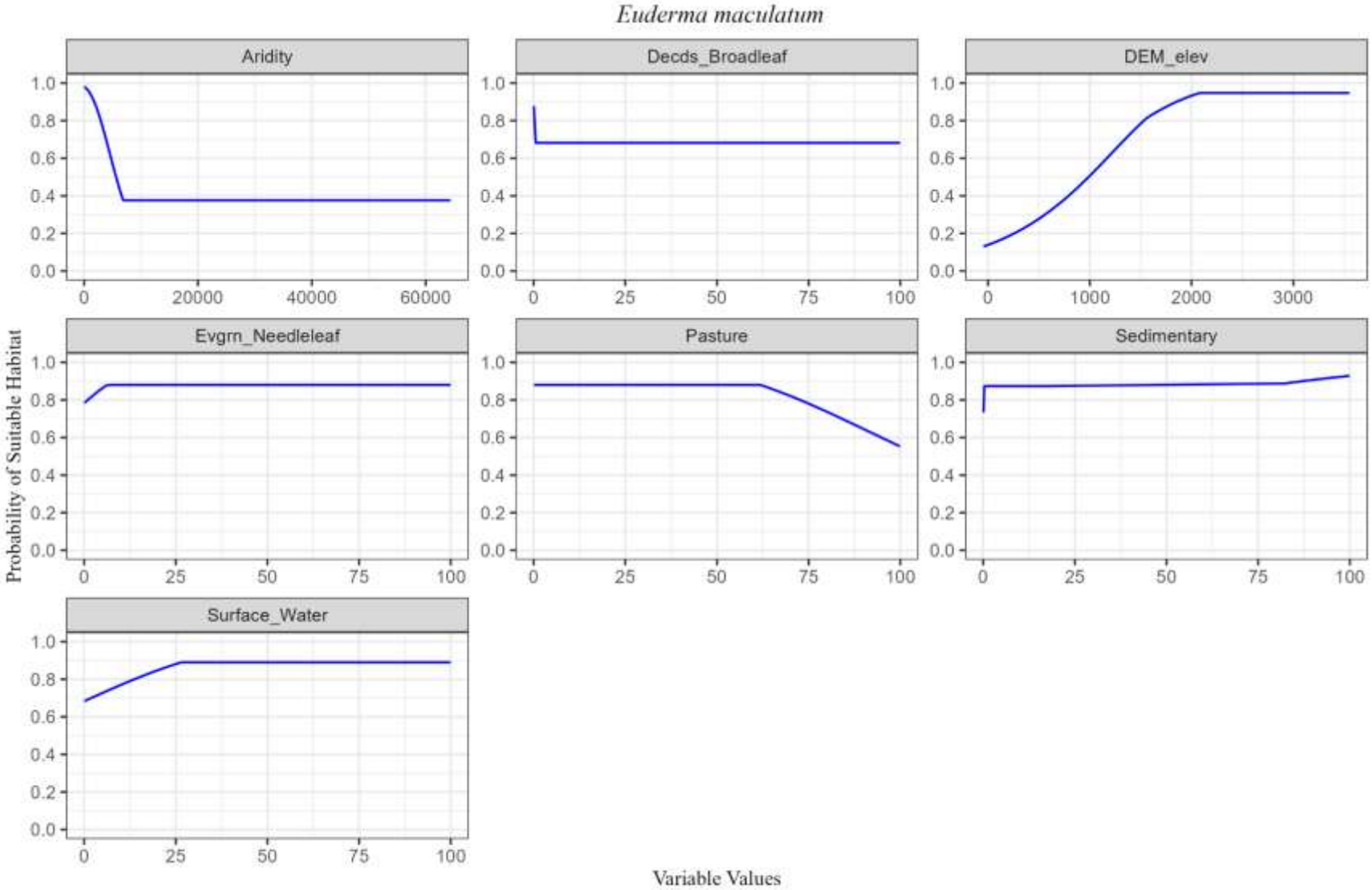


Figure 14. The marginal variable response curves for the environmental variables included in the final MaxEnt model for *Euderma maculatum*. Each response curve with the variable values ranging from its respective minimum to maximum on the x axis and the cloglog probability of suitable habitat along the y axis ranging from 0 to 1.

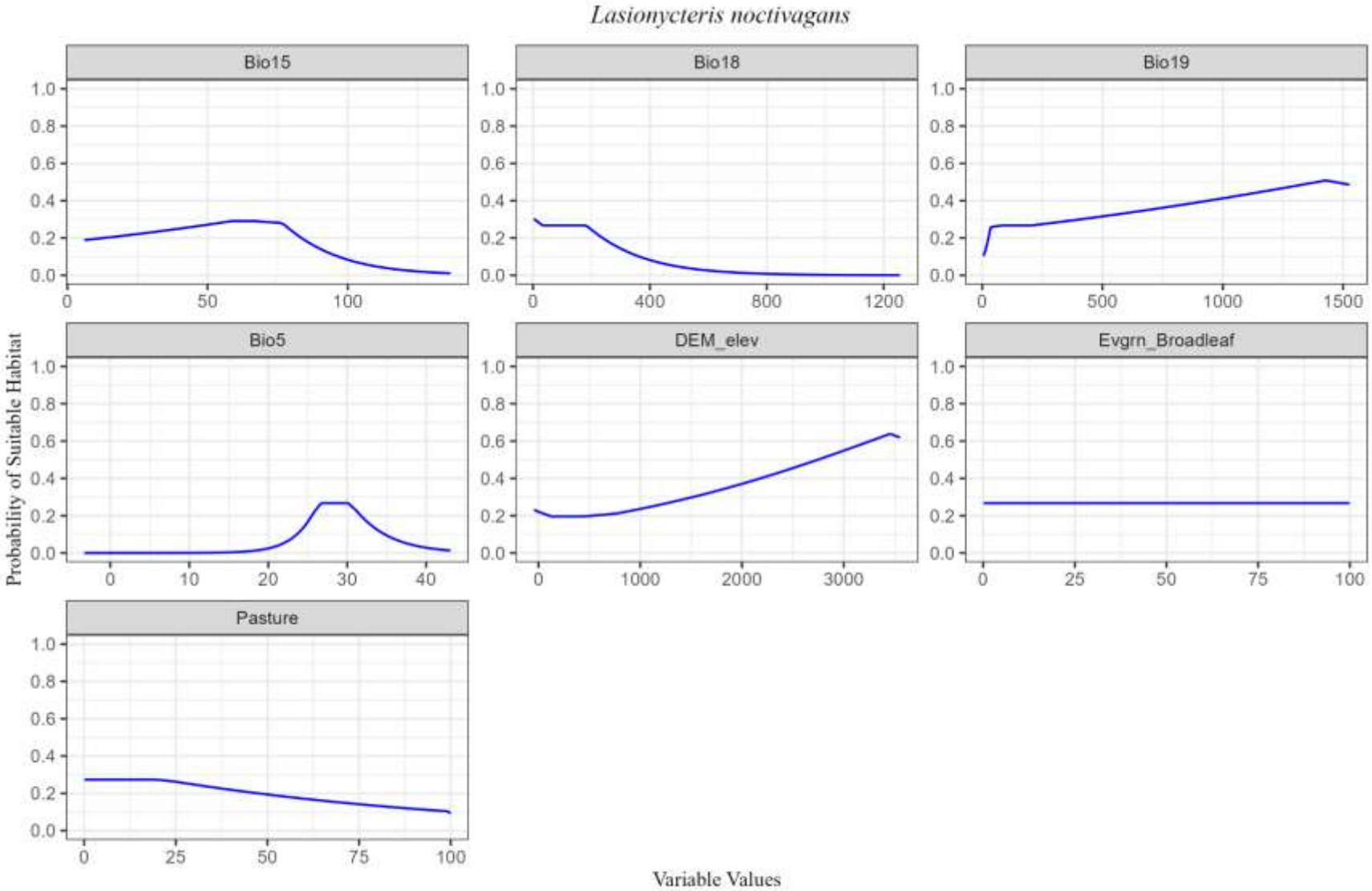


Figure 15. The marginal variable response curves for the environmental variables included in the final MaxEnt model for *Lasionycteris noctivagans*. Each response curve with the variable values ranging from its respective minimum to maximum on the x axis and the cloglog probability of suitable habitat along the y axis ranging from 0 to 1.

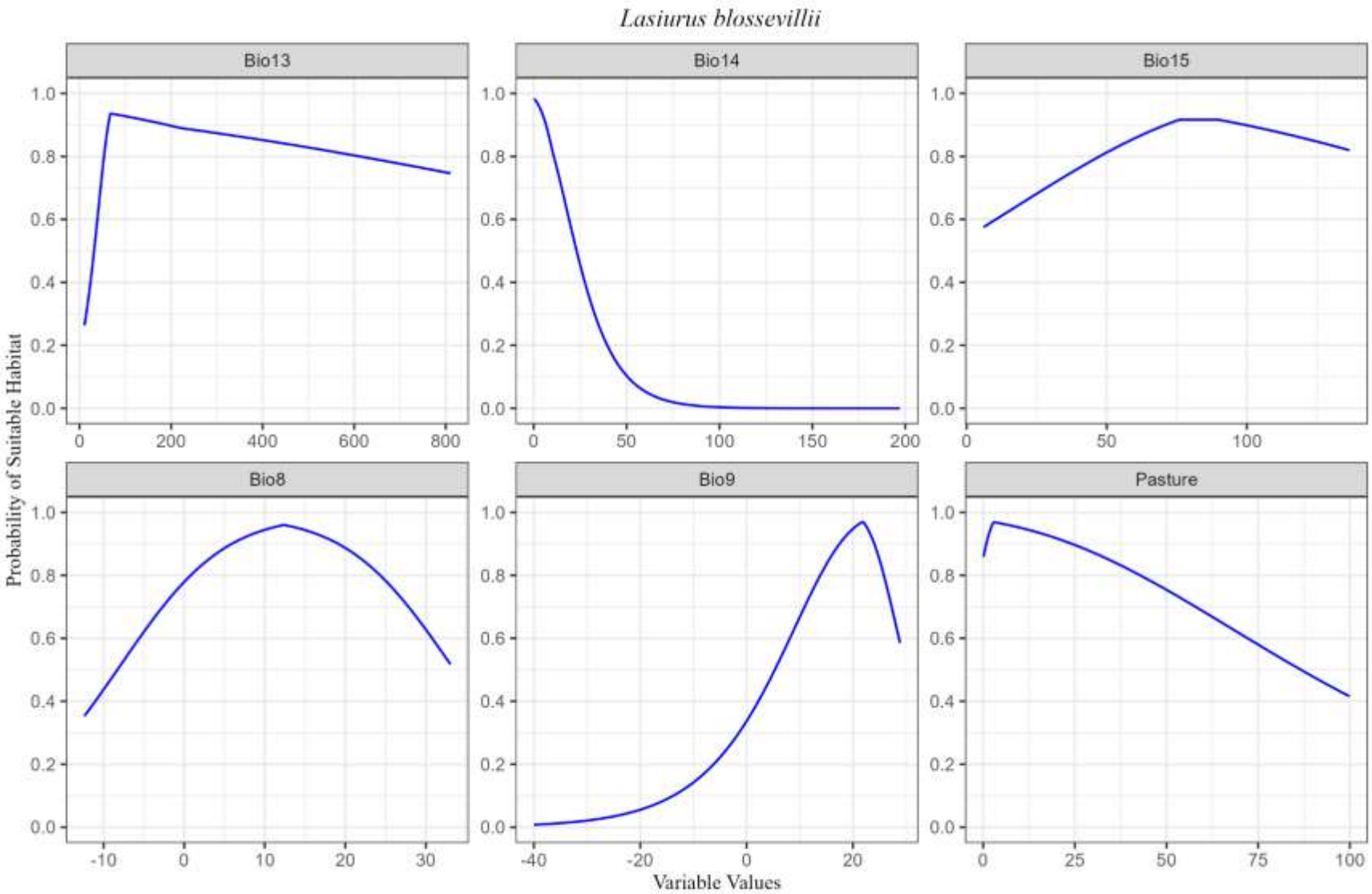


Figure 16. The marginal variable response curves for the environmental variables included in the final MaxEnt model for *Lasiurus blossevillii*. Each response curve with the variable values ranging from its respective minimum to maximum on the x axis and the cloglog probability of suitable habitat along the y axis ranging from 0 to 1.

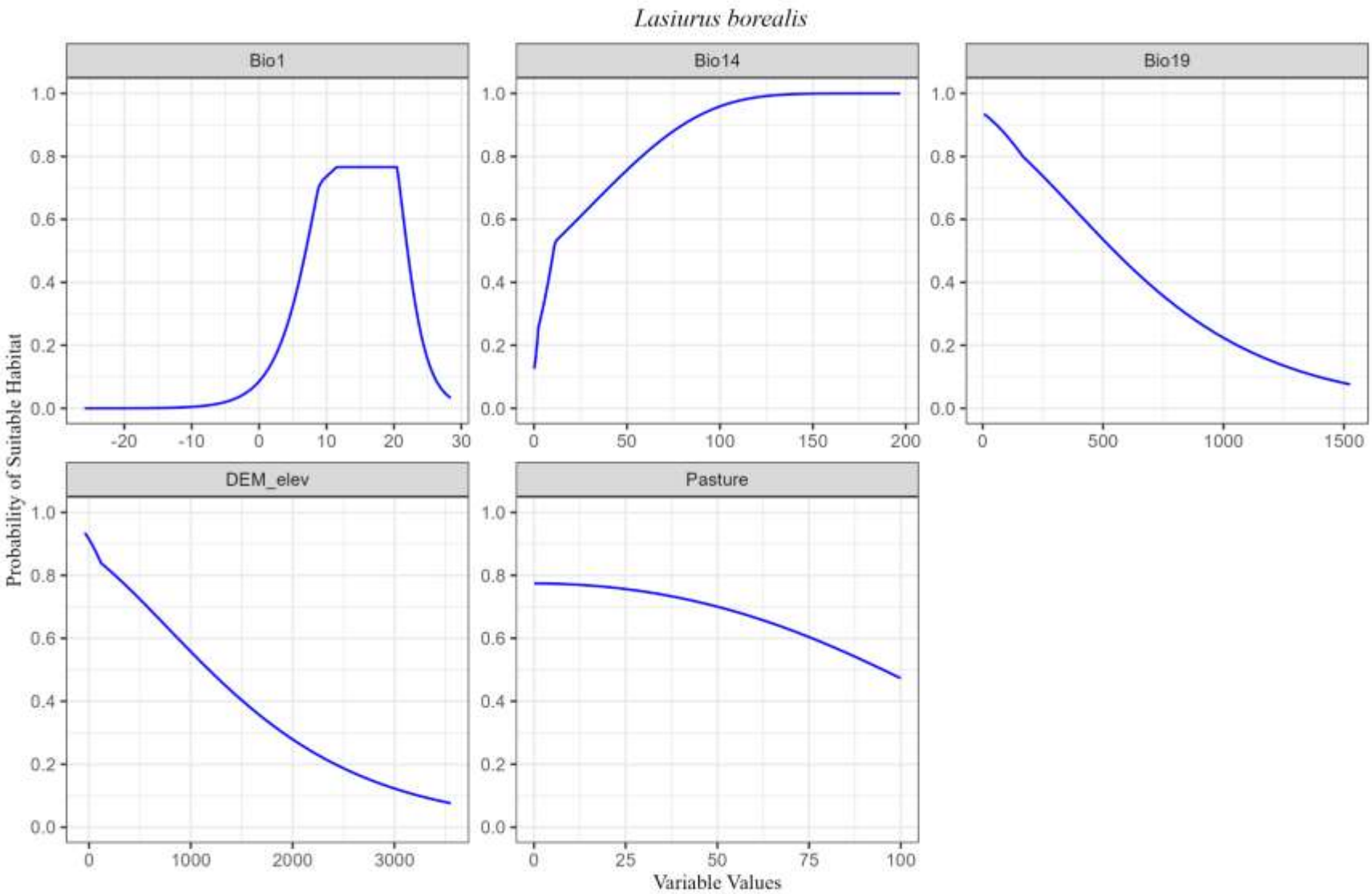


Figure 17. The marginal variable response curves for the environmental variables included in the final MaxEnt model for *Lasiurus borealis*. Each response curve with the variable values ranging from its respective minimum to maximum on the x axis and the cloglog probability of suitable habitat along the y axis ranging from 0 to 1.

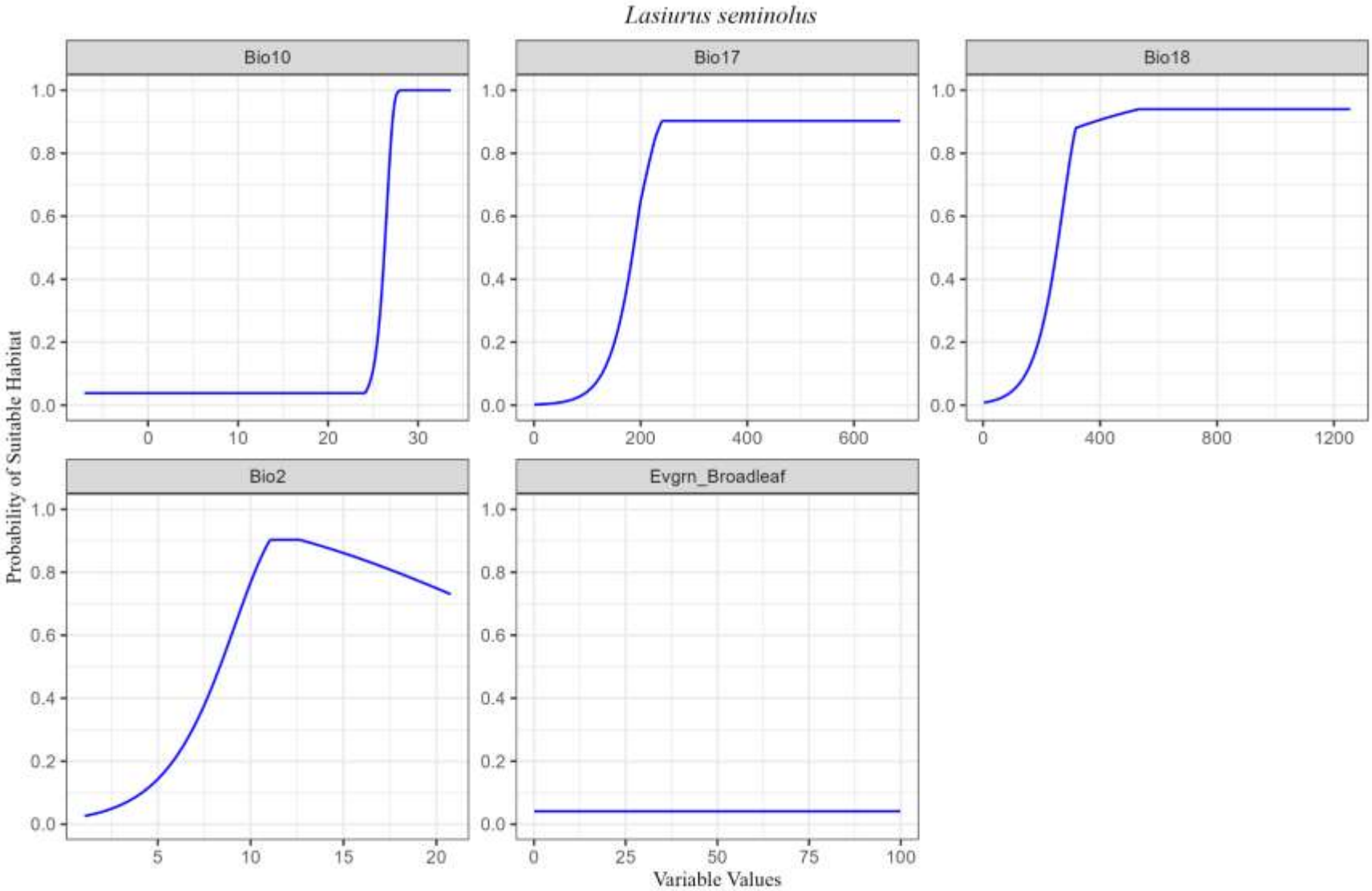


Figure 18. The marginal variable response curves for the environmental variables included in the final MaxEnt model for *Lasiurus seminolus*. Each response curve with the variable values ranging from its respective minimum to maximum on the x axis and the cloglog probability of suitable habitat along the y axis ranging from 0 to 1.

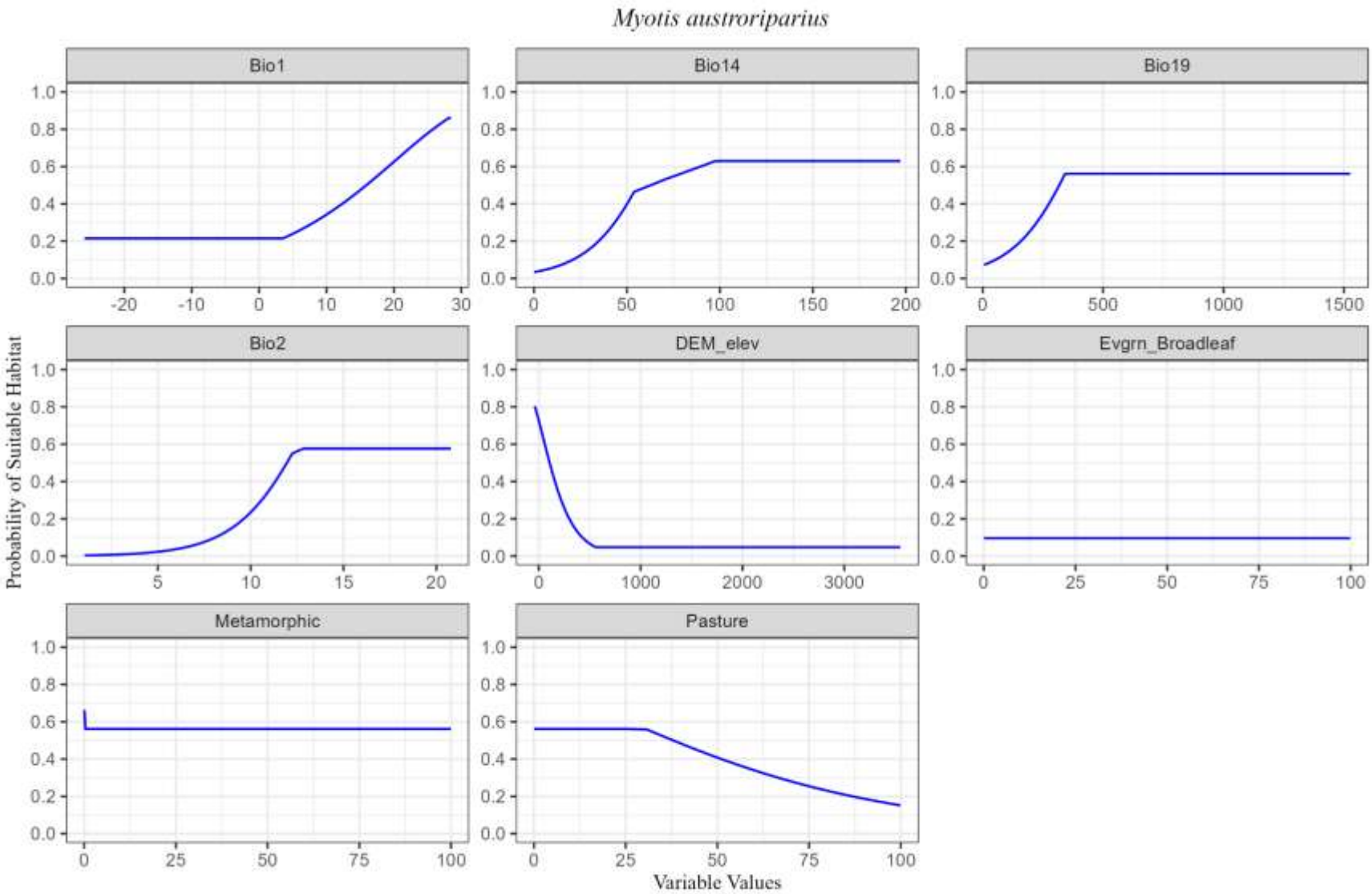


Figure 19. The marginal variable response curves for the environmental variables included in the final MaxEnt model for *Myotis austroriparius*. Each response curve with the variable values ranging from its respective minimum to maximum on the x axis and the cloglog probability of suitable habitat along the y axis ranging from 0 to 1.

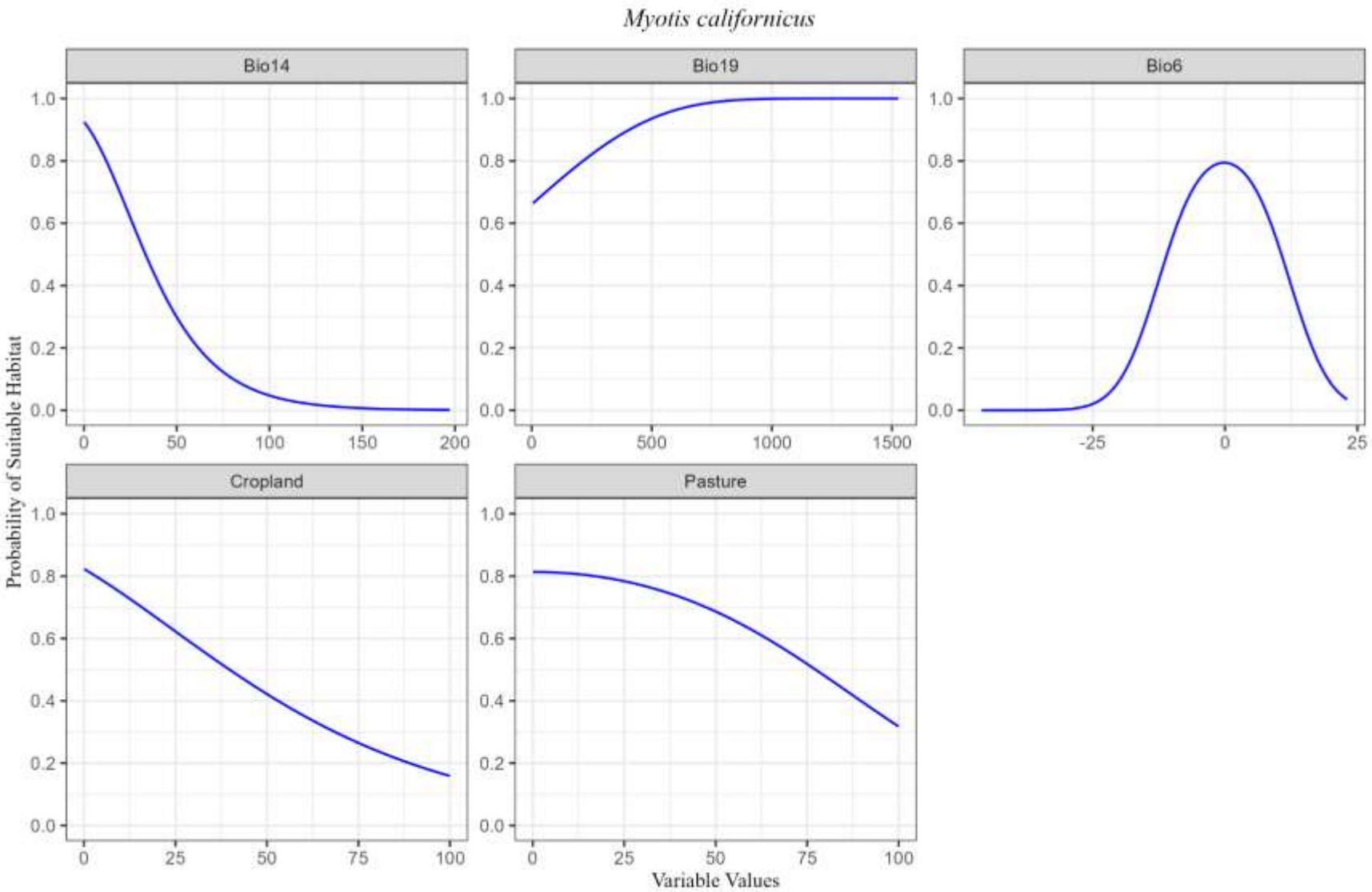


Figure 20. The marginal variable response curves for the environmental variables included in the final MaxEnt model for *Myotis californicus*. Each response curve with the variable values ranging from its respective minimum to maximum on the x axis and the cloglog probability of suitable habitat along the y axis ranging from 0 to 1.

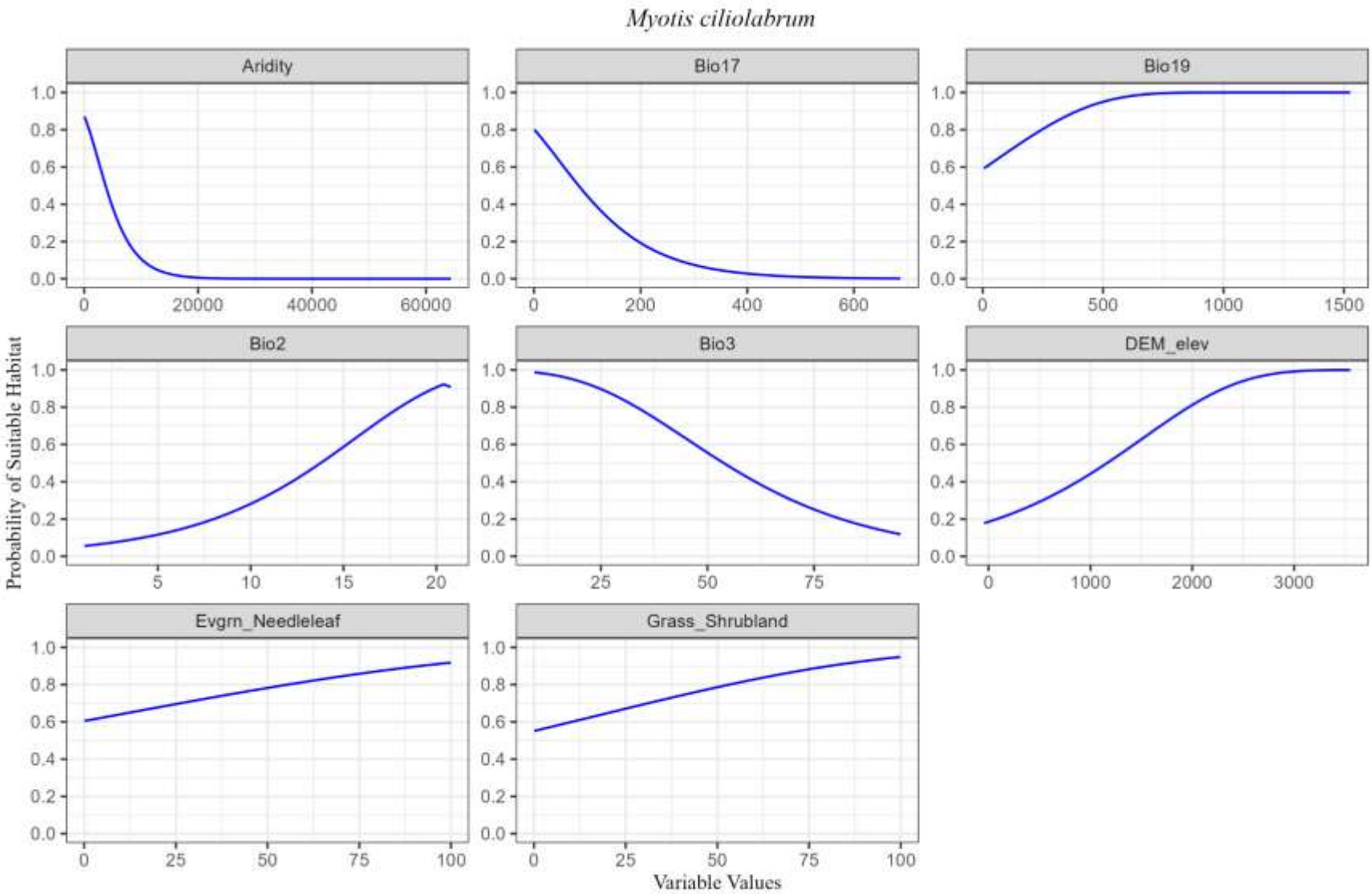


Figure 21. The marginal variable response curves for the environmental variables included in the final MaxEnt model for *Myotis ciliolabrum*. Each response curve with the variable values ranging from its respective minimum to maximum on the x axis and the cloglog probability of suitable habitat along the y axis ranging from 0 to 1.

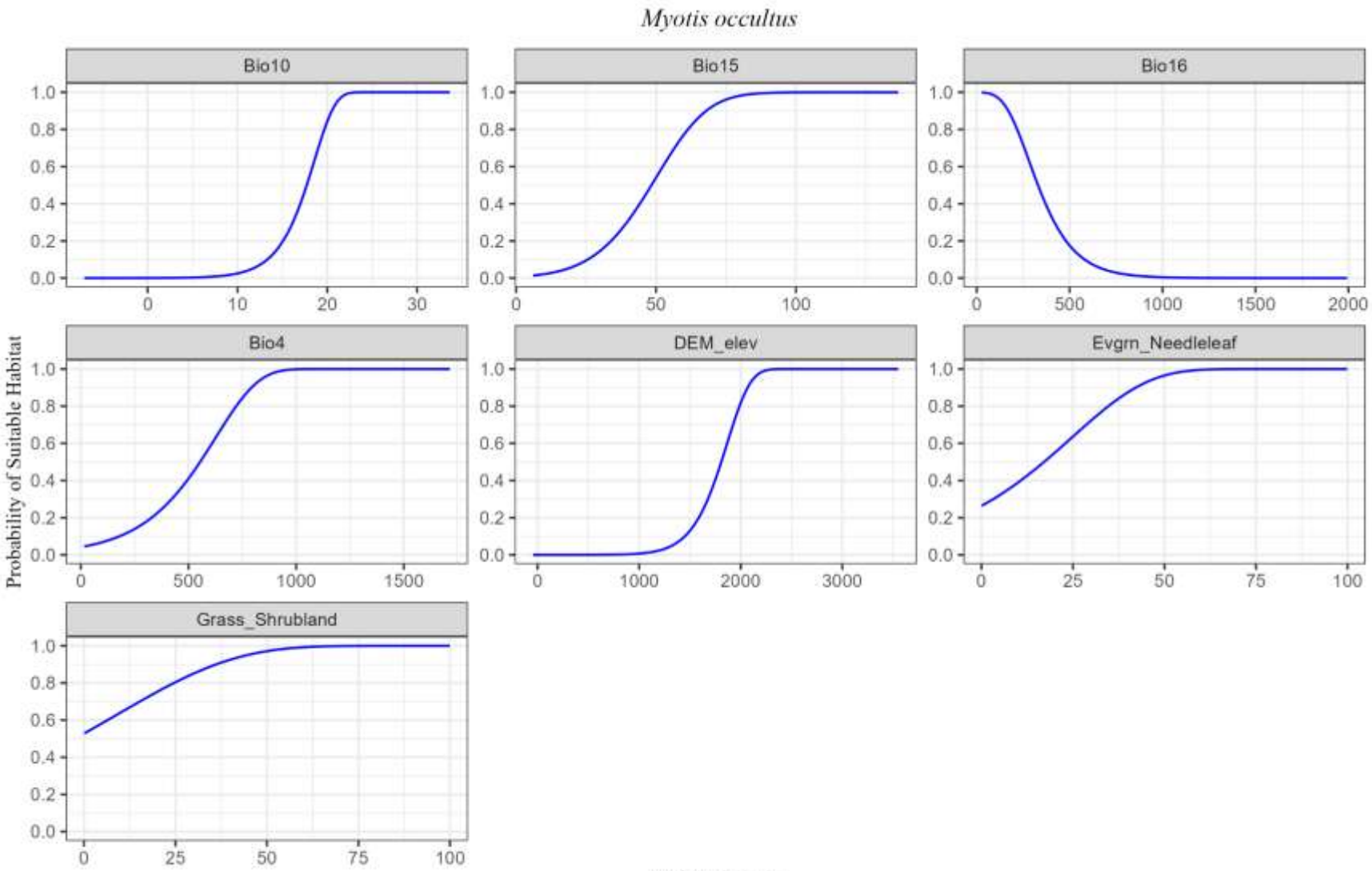


Figure 22. The marginal variable response curves for the environmental variables included in the final MaxEnt model for *Myotis occultus*. Each response curve with the variable values ranging from its respective minimum to maximum on the x axis and the cloglog probability of suitable habitat along the y axis ranging from 0 to 1.

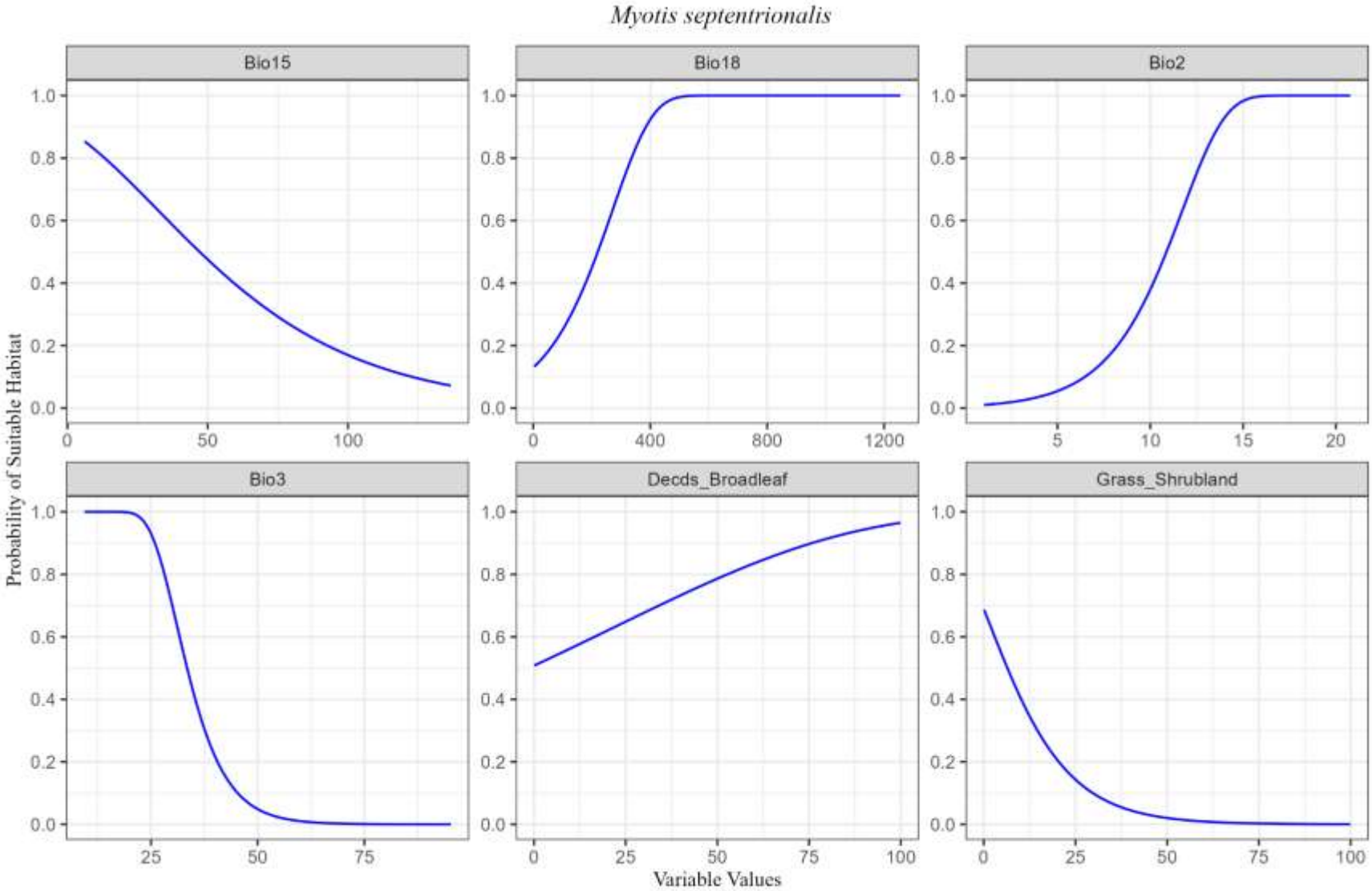


Figure 23. The marginal variable response curves for the environmental variables included in the final MaxEnt model for *Myotis septentrionalis*. Each response curve with the variable values ranging from its respective minimum to maximum on the x axis and the cloglog probability of suitable habitat along the y axis ranging from 0 to 1.

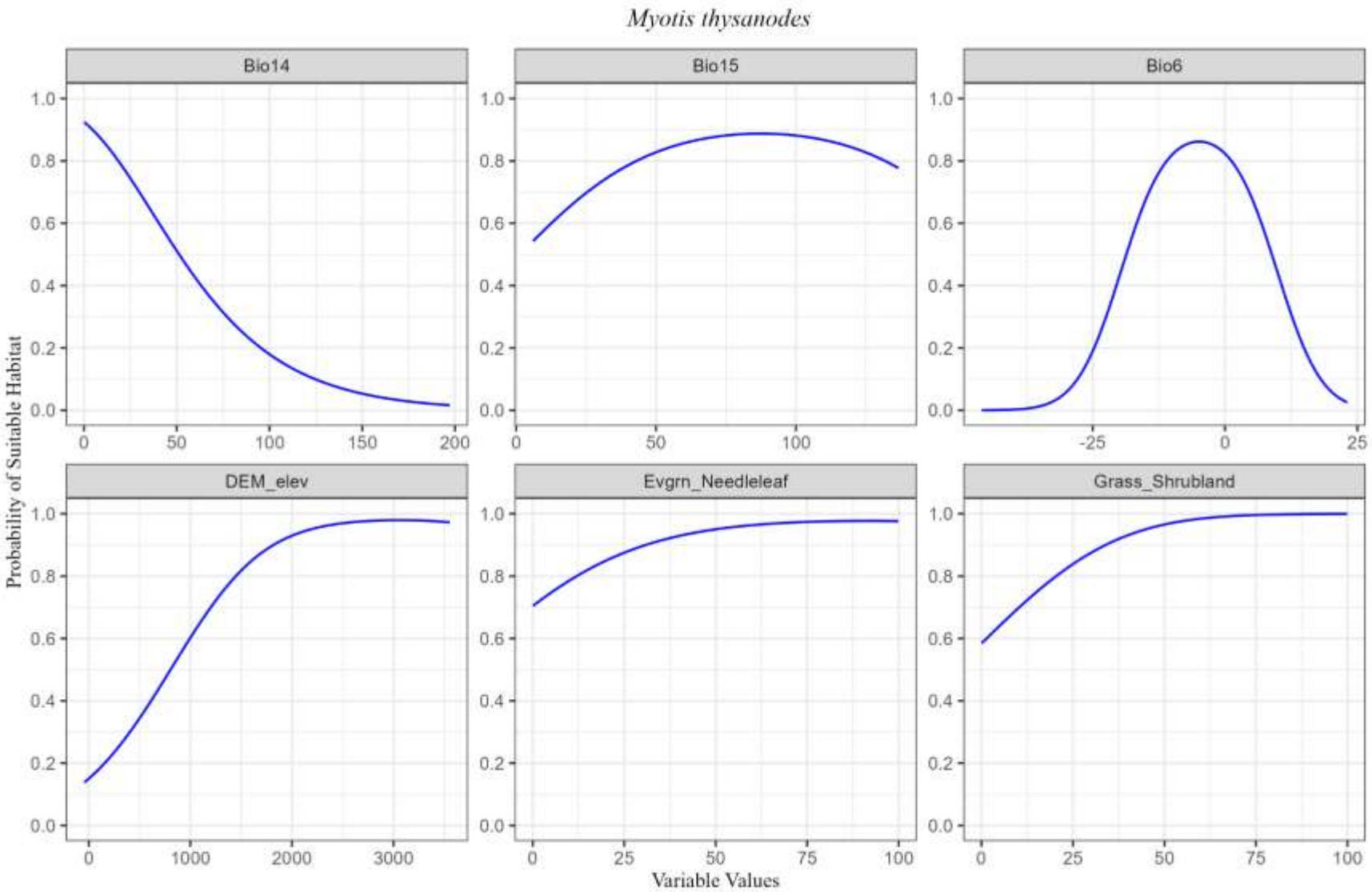


Figure 24. The marginal variable response curves for the environmental variables included in the final MaxEnt model for *Myotis thysanodes*. Each response curve with the variable values ranging from its respective minimum to maximum on the x axis and the cloglog probability of suitable habitat along the y axis ranging from 0 to 1.

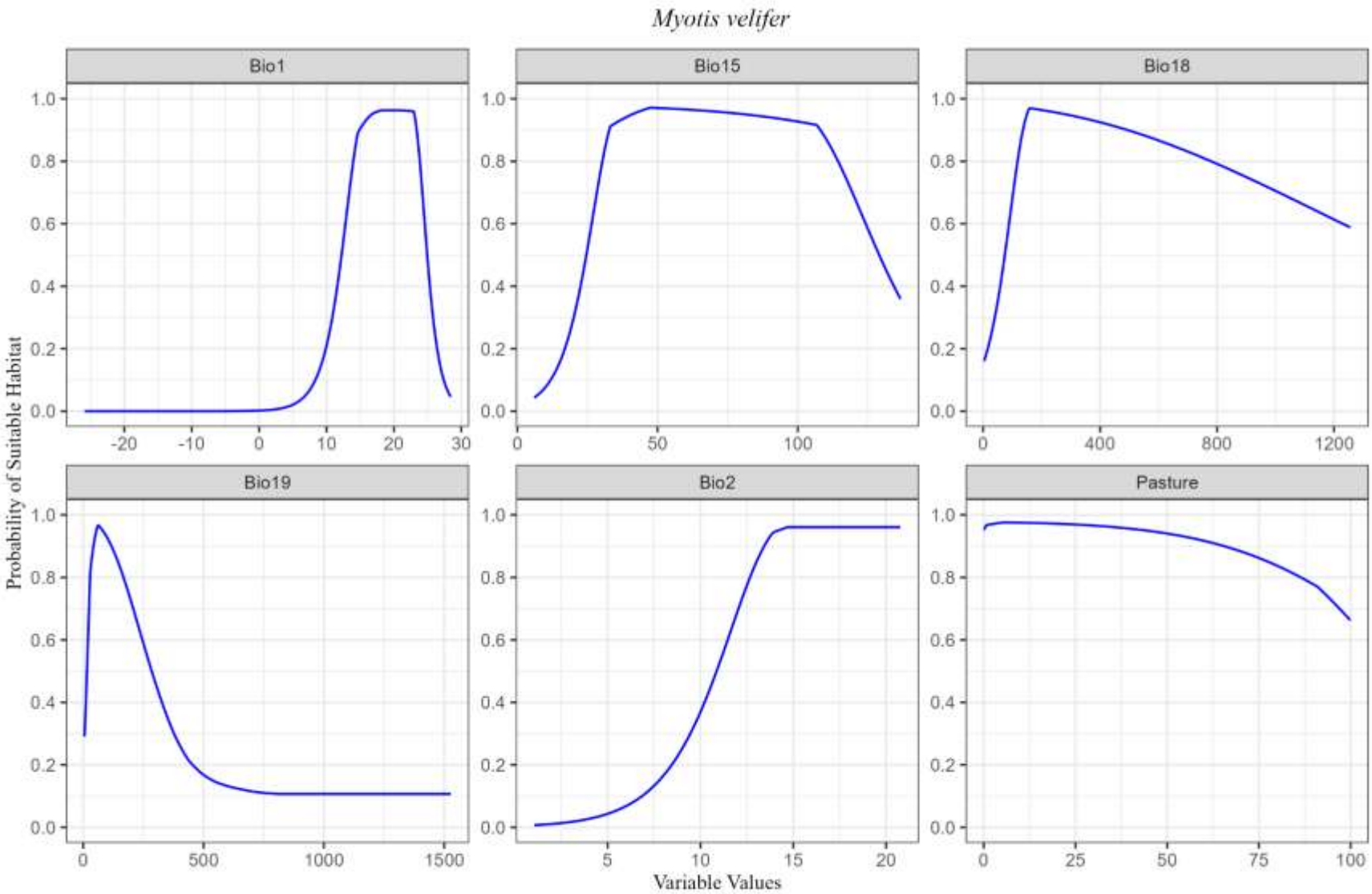


Figure 25. The marginal variable response curves for the environmental variables included in the final MaxEnt model for *Myotis velifer*. Each response curve with the variable values ranging from its respective minimum to maximum on the x axis and the cloglog probability of suitable habitat along the y axis ranging from 0 to 1.

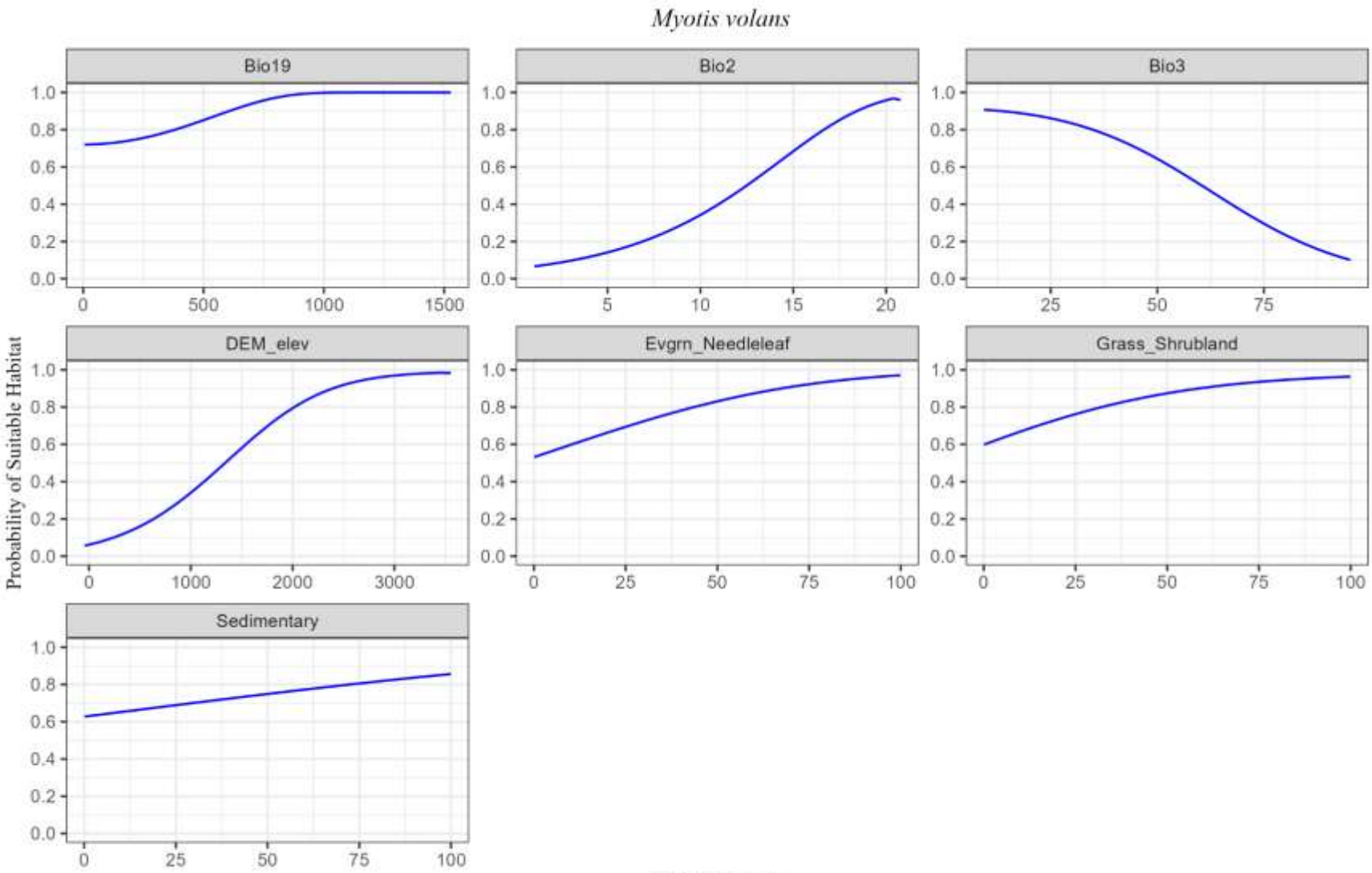


Figure 26. The marginal variable response curves for the environmental variables included in the final MaxEnt model for *Myotis volans*. Each response curve with the variable values ranging from its respective minimum to maximum on the x axis and the cloglog probability of suitable habitat along the y axis ranging from 0 to 1.

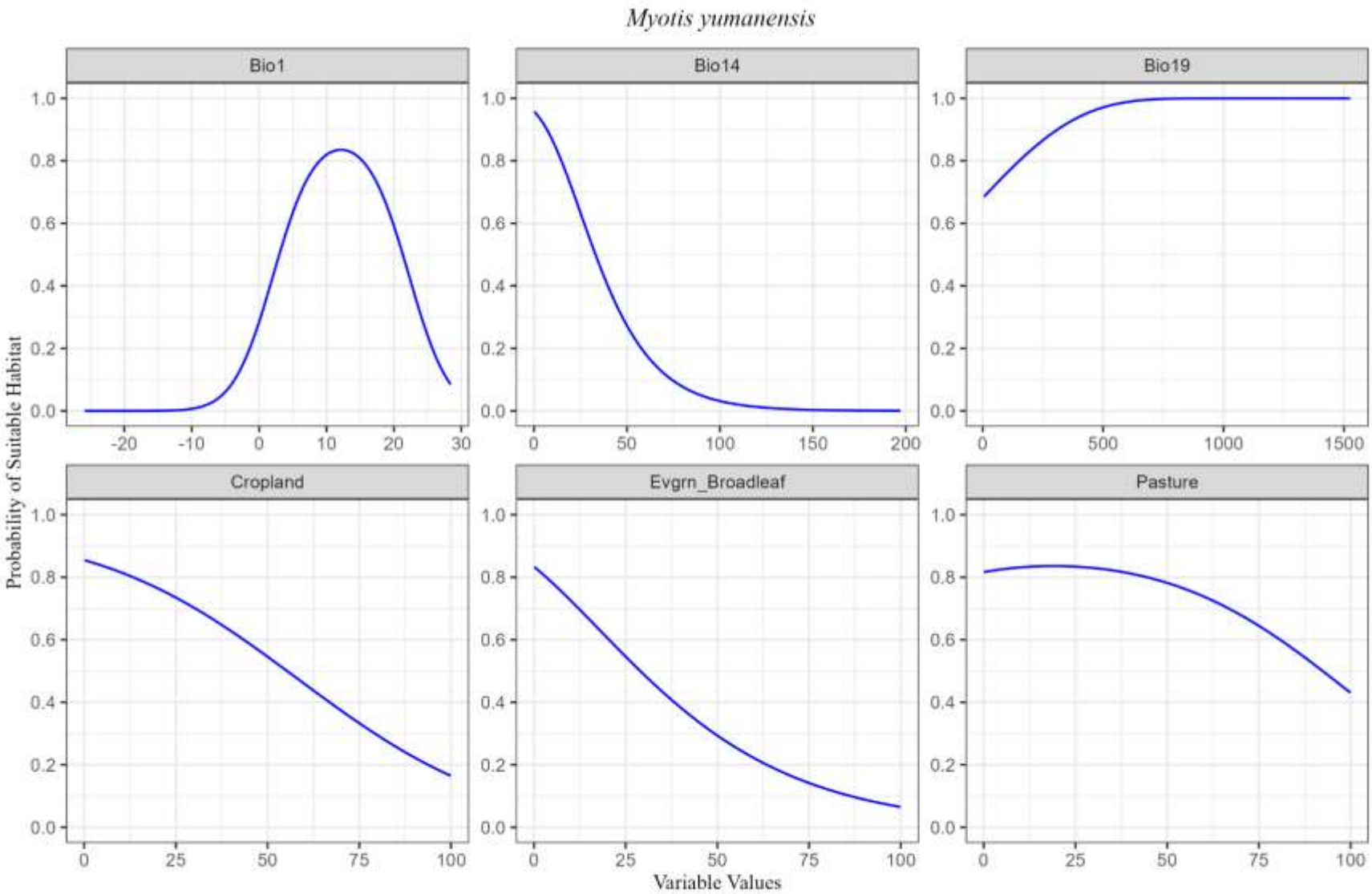


Figure 27. The marginal variable response curves for the environmental variables included in the final MaxEnt model for *Myotis yumanensis*. Each response curve with the variable values ranging from its respective minimum to maximum on the x axis and the cloglog probability of suitable habitat along the y axis ranging from 0 to 1.

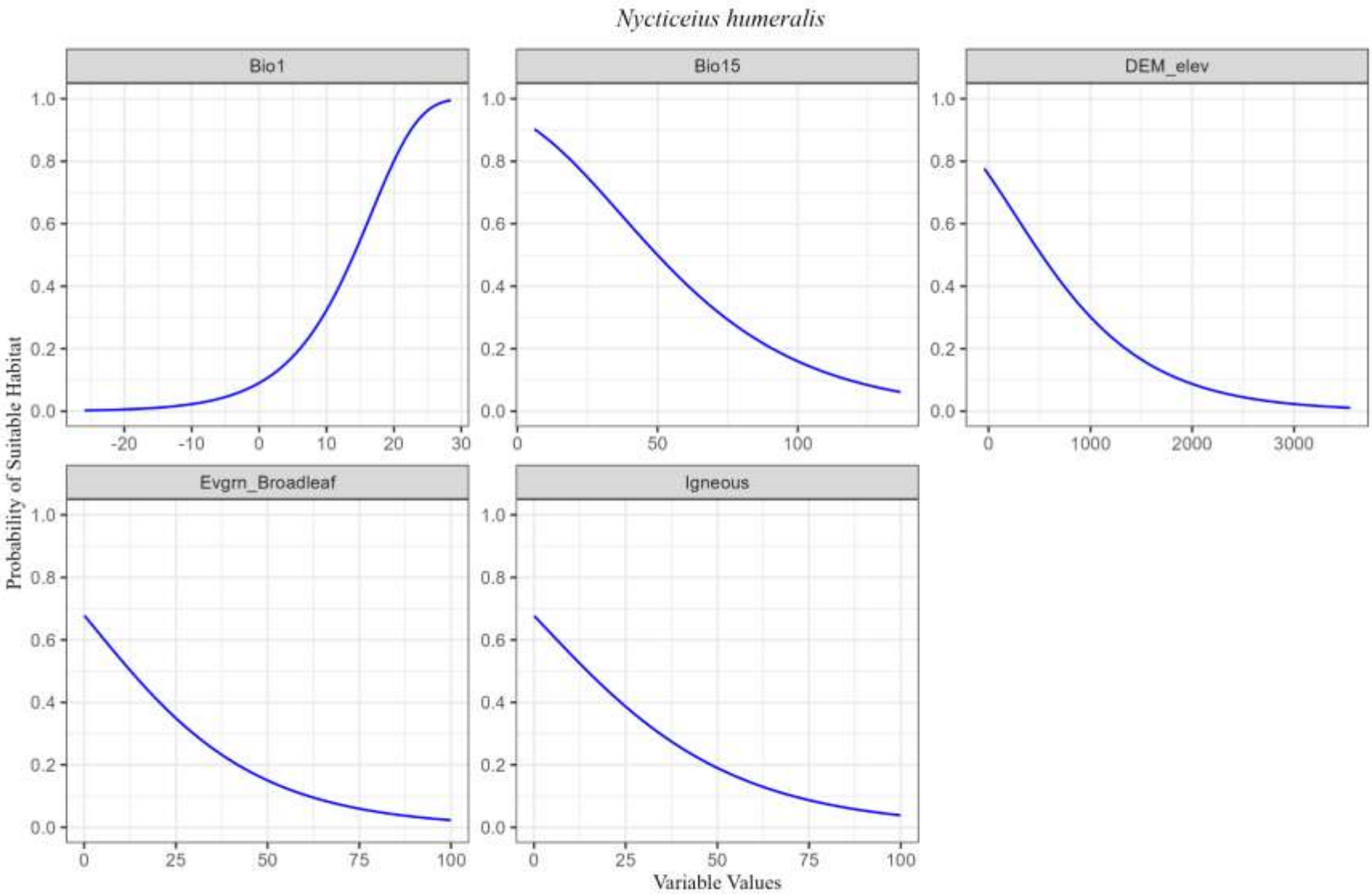


Figure 28. The marginal variable response curves for the environmental variables included in the final MaxEnt model for *Nycticeius humeralis*. Each response curve with the variable values ranging from its respective minimum to maximum on the x axis and the cloglog probability of suitable habitat along the y axis ranging from 0 to 1.

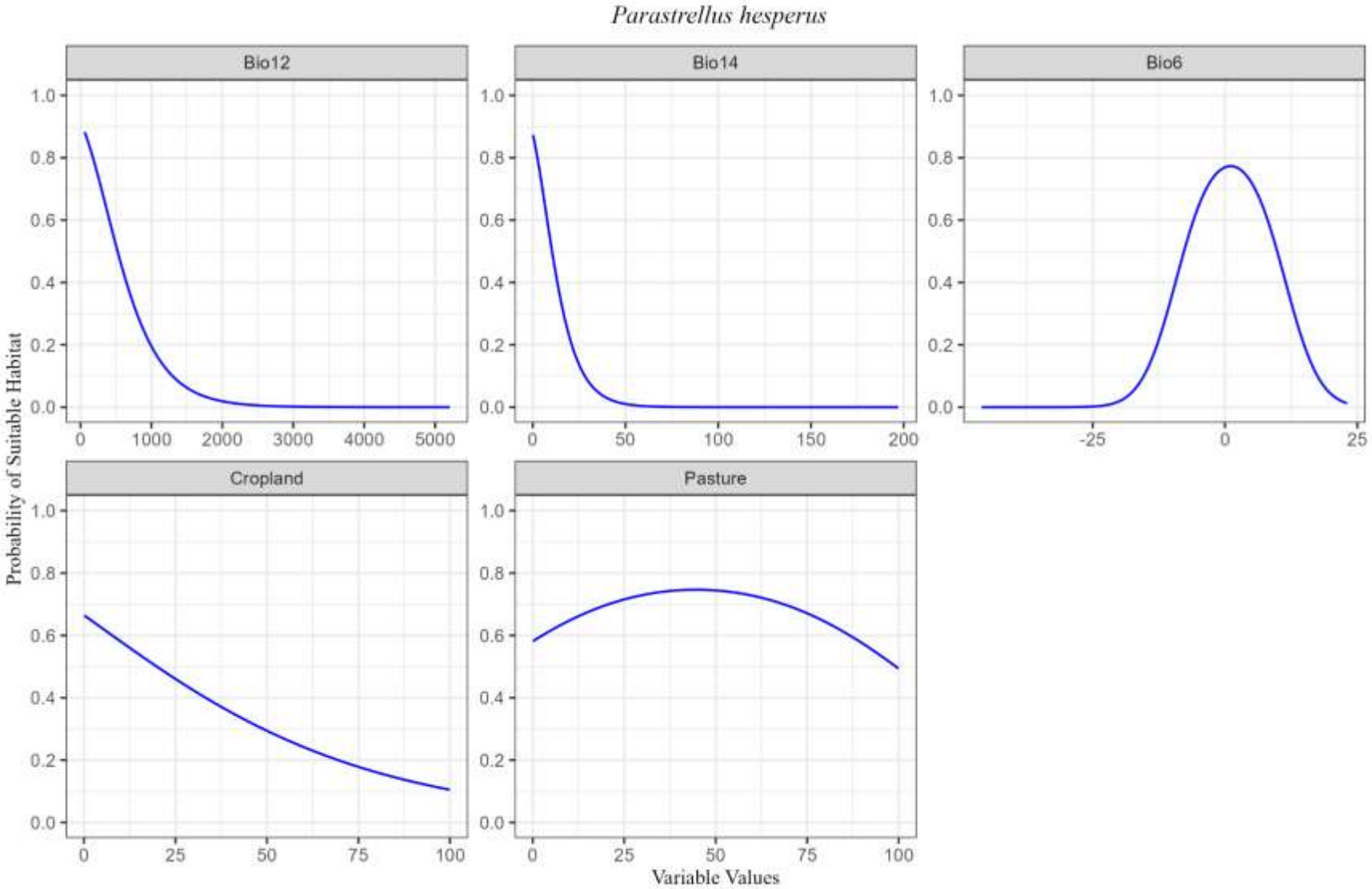


Figure 29. The marginal variable response curves for the environmental variables included in the final MaxEnt model for *Parastrellus hesperus*. Each response curve with the variable values ranging from its respective minimum to maximum on the x axis and the cloglog probability of suitable habitat along the y axis ranging from 0 to 1.

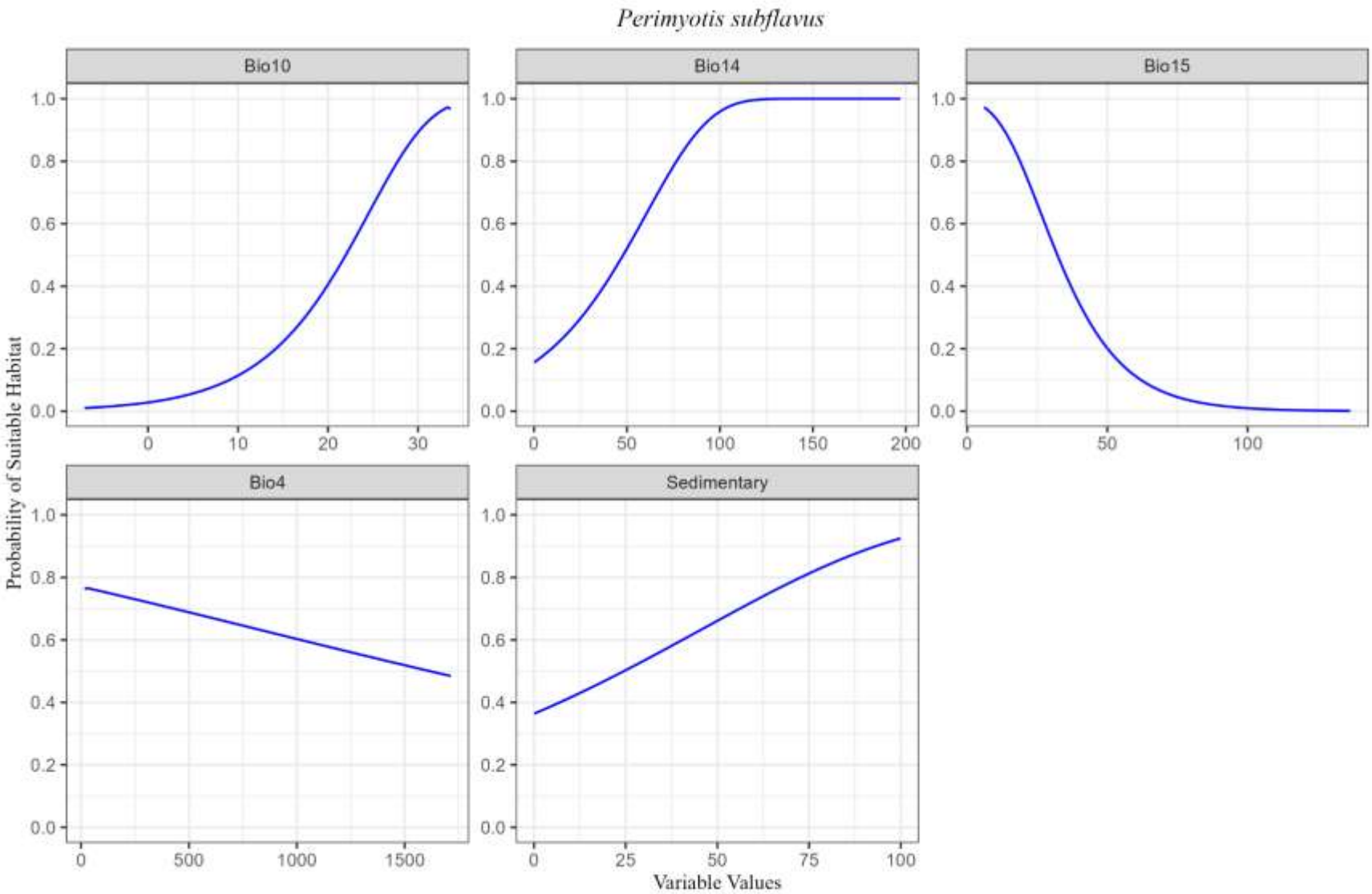


Figure 30. The marginal variable response curves for the environmental variables included in the final MaxEnt model for *Perimyotis subflavus*. Each response curve with the variable values ranging from its respective minimum to maximum on the x axis and the cloglog probability of suitable habitat along the y axis ranging from 0 to 1.

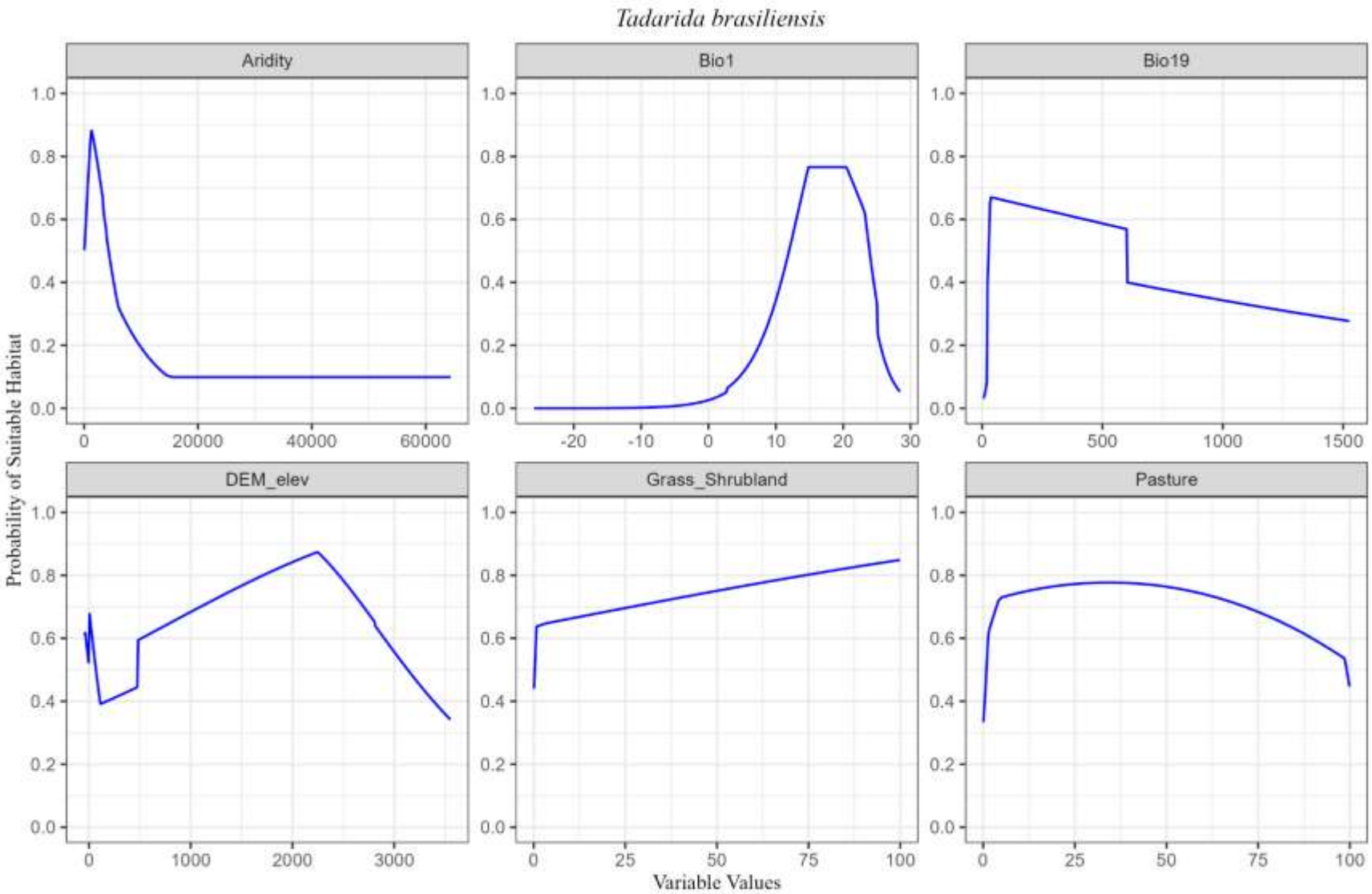


Figure 31. The marginal variable response curves for the environmental variables included in the final MaxEnt model for *Tadarida brasiliensis*. Each response curve with the variable values ranging from its respective minimum to maximum on the x axis and the cloglog probability of suitable habitat along the y axis ranging from 0 to 1.

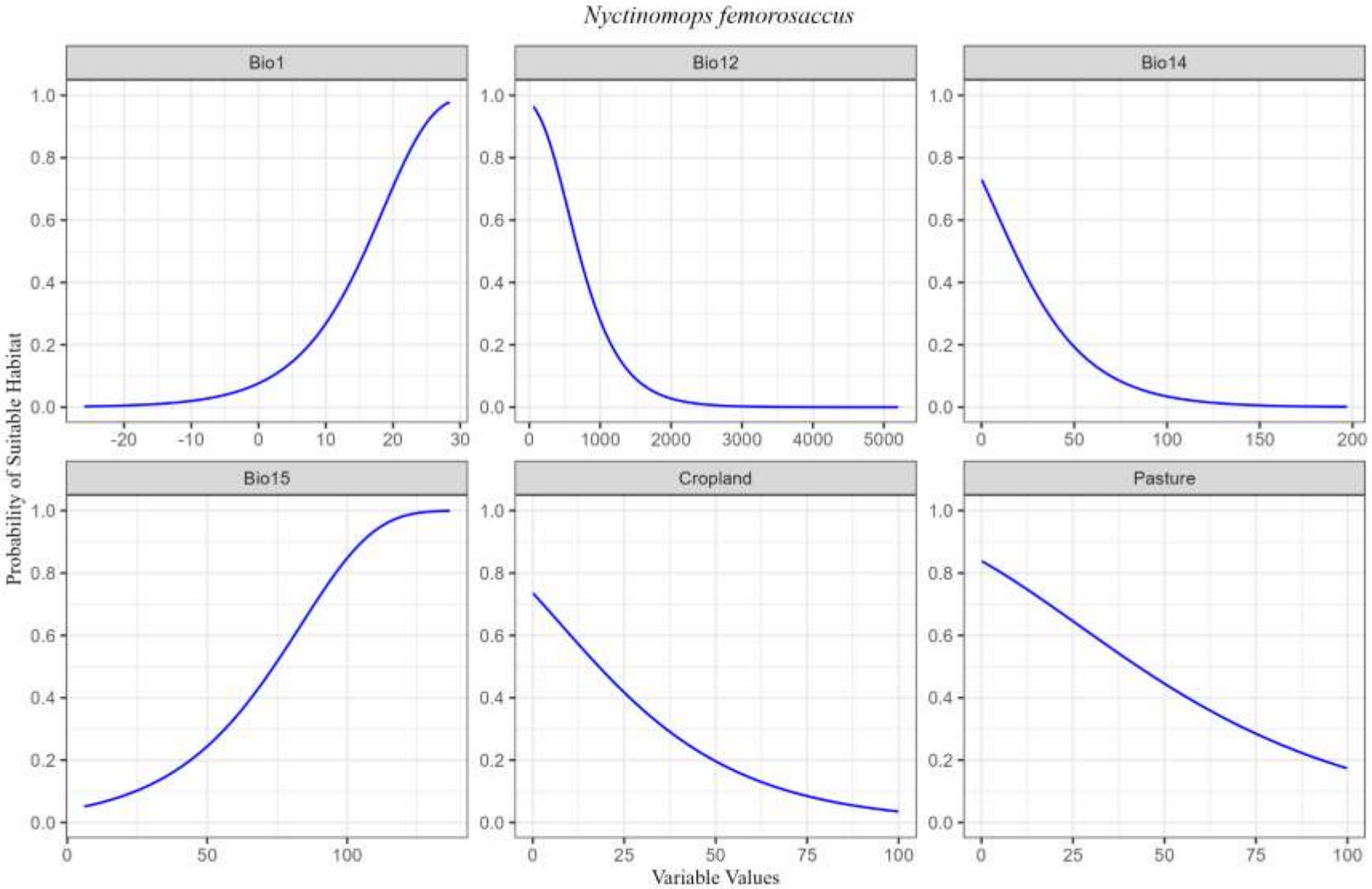


Figure 32. The marginal variable response curves for the environmental variables included in the final MaxEnt model for *Nyctinomops femorosaccus*. Each response curve with the variable values ranging from its respective minimum to maximum on the x axis and the cloglog probability of suitable habitat along the y axis ranging from 0 to 1.

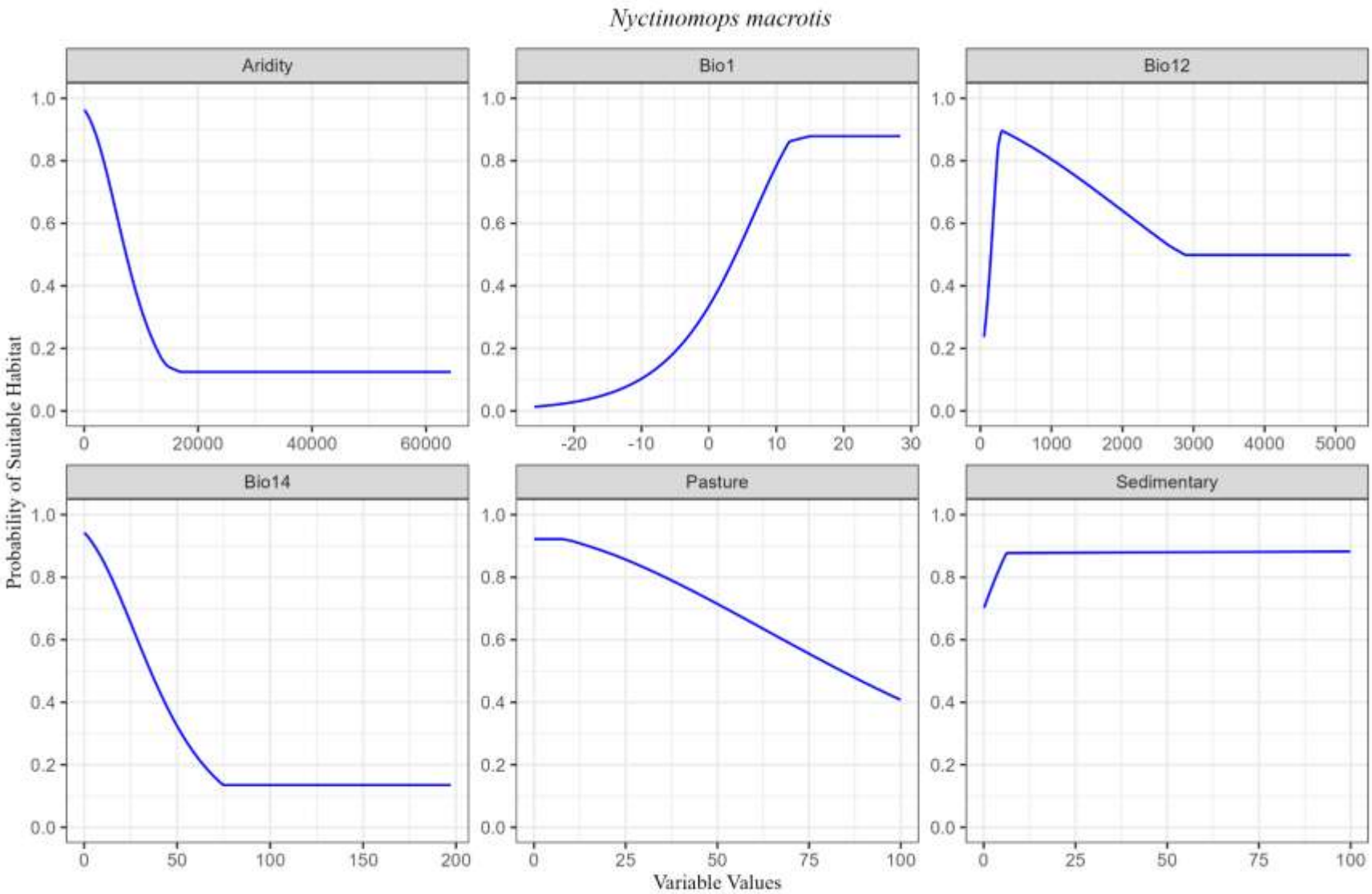


Figure 33. The marginal variable response curves for the environmental variables included in the final MaxEnt model for *Nyctinomops macrotis*. Each response curve with the variable values ranging from its respective minimum to maximum on the x axis and the cloglog probability of suitable habitat along the y axis ranging from 0 to 1.

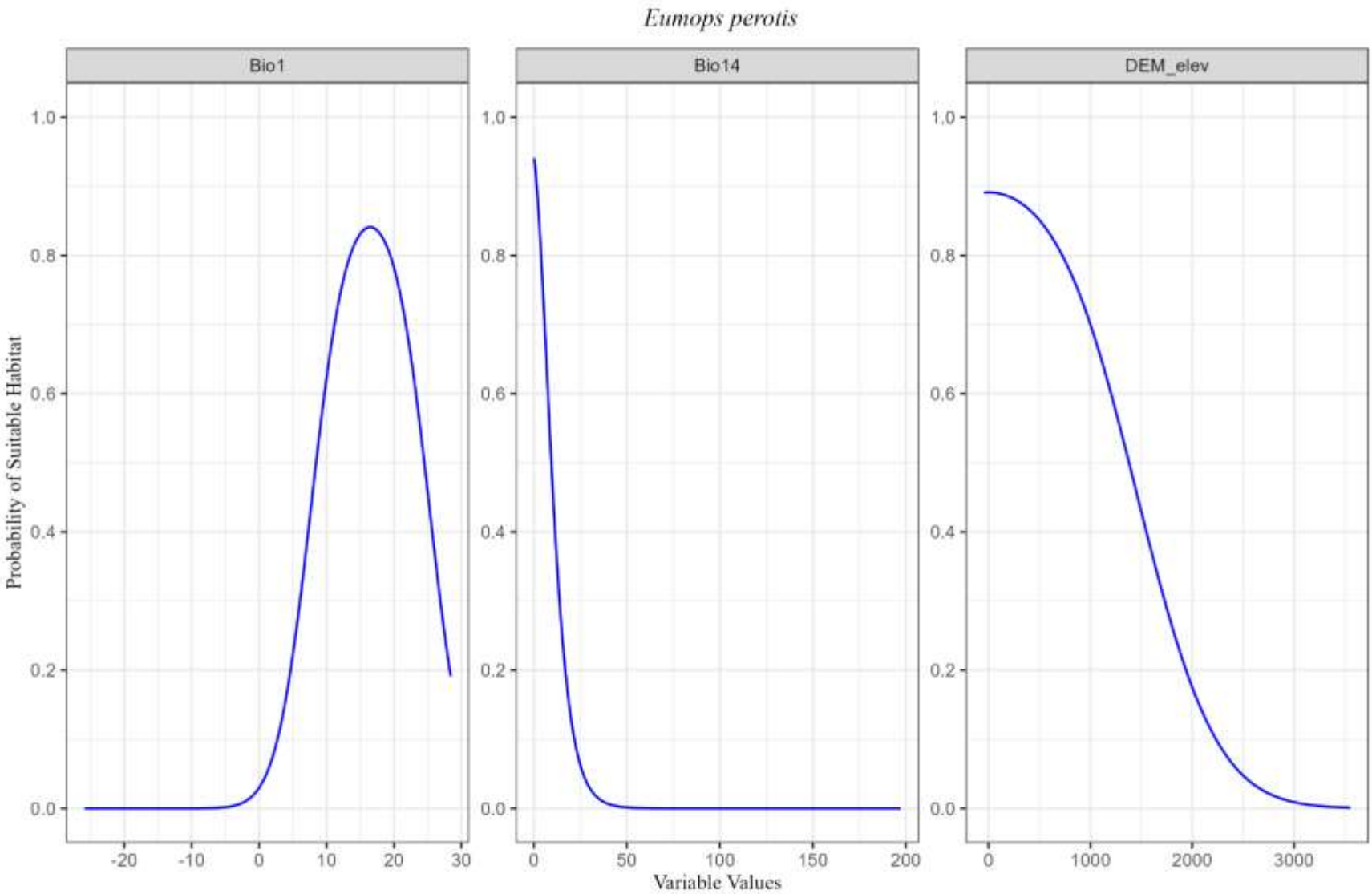


Figure 34. The marginal variable response curves for the environmental variables included in the final MaxEnt model for *Eumops perotis*. Each response curve with the variable values ranging from its respective minimum to maximum on the x axis and the cloglog probability of suitable habitat along the y axis ranging from 0 to 1.