Final Report
Covered Species Model Updates 2024
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Contents

Executive Summary

Clark County is currently in the process of updating its permit with the US Fish and Wildlife Service (USFWS) to allow for continued development, while planning for the management and conservation of species of concern that reside within the county. The original Clark County Multi-Species Habitat Conservation Plan (MSHCP) included 79 Covered Species, 103 Evaluation Species, and 51 Watch List species (Clark County 2000). The goal of this project was to update habitat models previously generated for 12 species with additional data, and to generate models and species accounts for three species that were absent models.

Our approach was to use the species accounts that were produced in earlier efforts to drive conceptual models that were used to choose appropriate environmental covariates to use in building SDM's. We received localities for many of the species from the Clark County Desert Conservation Program (DCP), and acquired more localities from a variety of sources to allow for the most accurate modeling possible - given the data. We used four or more commonly used modeling algorithms to create SDM's; Gradient Boosting Machines (GBM), MaxEnt, General Additive Models [GAM], and Random Forest [RF]. Within each of these modeling algorithms performed assessments on variable inclusion and model accuracy. We used ensembles of the best models in each algorithm weighted by their performance to create an ensemble model that is meant to overcome assumptions shortcomings of any one algorithm (Araujo and New 2006).

Methods

Species locality data

Species locality data were obtained from our earlier modeling efforts (e.g. Nussear and Simandle 2019, SWECO 2018), and were updated with current searches at iNaturalist and GBIF using research grade/unobscured observations, as well as with data updates from Clark County NV which were supplied to us by John Ellis.

Modeling Methods

We used an ensemble modeling approach that incorporated four modeling algorithms commonly used in species distribution modeling. These were: generalized additive models (GAM; using the “mgcv” method Wood 2006), random forests (RF; implemented in the R package “randomForest,” Liaw and Wiener 2002), MaxEnt (version 3..4.1, Phillips et al. 2006) implemented in the Maxnet algorithm in R (maxnet v 0.1.4, Phillips 2021) and Generalized boosted regression models (GBM) implemented in the ‘gbm’ package (version 2.1.8.1, Greenwell et al 2022). All models were executed using custom species distribution modeling code developed by Nussear for an upcoming package for R (WhereTheWildThingsR - Nussear et al in Prep 2025). Employing multiple algorithms in ensemble models reduces reliance on the biases, assumptions, or constraints of a single method, while enabling the detection of a wider range of environmental response patterns (Araujo and New 2006). Empirical studies have consistently identified GAM, RF, MaxEnt, and GBM as top-performing algorithms for modeling species habitat distributions (Franklin 2010).

To assess the influence of vegetation structure on habitat suitability, Clark County requested models for each species both with and without a categorical vegetation layer provided by the Desert Conservation Program. Because this layer was categorical, not all modeling algorithms could accommodate it (e.g., generalized additive models), and additional model types were excluded either due to convergence issues or because none of their candidate runs exceeded the mean model performance threshold used for ensemble inclusion. We note that modeling habitat suitability strictly within a limited area of interest can limit ecological inference by reducing the sample size of both dependent and independent variables, omitting informative combinations or ranges of environmental conditions, and inflating spatial autocorrelation among samples. Moreover, such politically or administratively constrained boundaries often fail to reflect the biological or environmental processes that structure species distributions, thereby limiting the ecological relevance and generality of the resulting models.

Because verified absences were unavailable, we fit all models using pseudo-absences generated with a surface range envelope (SRE) via the bioclim function (dismo v1.3; Hijmans et al. 2023). We randomly sampled background points equal in number to the observed occurrences (Barbet-Massin et al. 2012) from areas outside the SRE, defined as bioclim values < 0.1. The use of pseudo-absences in such models is well established, and used widely when creating SDMs (Busby 1991; Wisz and Guisan 2009; Barbet-Massin et al. 2012).

Presence records are largely spatially clustered, which can bias predictions, we first rasterized them to the modeling resolution so that no grid cell contained more than one presence. We then applied a geographically weighted resampling scheme in which, on a uniform grid four times coarser than the modeling resolution (e.g., a 1-km grid for 250-m resolution), no more than four observations were sampled per grid cell. This systematic, grid-based thinning approach has been shown to reduce spatial bias under diverse conditions (Fourcade et al., 2014). To further mitigate bias, we fit and evaluated all habitat models using cross-validation: each algorithm was trained on 20 replicate sets of randomly selected, spatially thinned presences, withholding a random 20% (without replacement) for evaluation in each iteration (i.e., 80% for training and 20% for testing). Background points were also randomly drawn similarly for each cross-validation.

Metrics of model prediction accuracy were calculated based on the evaluation data for each of the cross-validation runs, and subsequently averaged across runs. Performance metrics included several threshold-independent measures: AUC, the True Skill Statistic (TSS) and the Boyce Index (See Box 1). The use of CBI alongside AUC/TSS allows for a fuller picture of model performance.

Box 1. Interpreting AUC, TSS, and BI

• AUC (Area Under the ROC Curve) — A threshold-independent rank discrimination (0.5 = random; 1.0 = perfect): higher AUC means presences tend to receive higher suitability than background/absences across thresholds (Fielding and Bell 1997). Note that AUC can be sensitive to prevalence (Lobo et al. 2008), to background/pseudo-absence sampling (Phillips et al. 2009), and to spatial/temporal sorting (Roberts et al. 2017).

• TSS (True Skill Statistic) — is a thresholded performance metric where: TSS = sensitivity + specificity − 1, and ranges from −1 to 1 (Allouche et ak, 2006). Values >0.7 are commonly treated as high and >0.9 as very high for SDM applications, but interpretation depends on prevalence and the use case.

• Continuous Boyce Index (CBI) — The Boyce index only requires presences and measures how much model predictions differ from random distribution of the observed presences across the prediction gradients (Boyce et al. 2002). BI summarizes rank performance (−1 to 1): evaluation presences occur more often in higher predicted-suitability bins than expected under a random distribution of scores. Bins are computed using (e.g., deciles or equal-area bins); for each bin, the observed frequency of evaluation presences is compared to a random expectation, and the relationship is summarized without choosing a threshold (Hirzel et al 2006). Values near 1 indicate strong ranking (presences concentrated at the top of the scale); 0 ≈ random; <0 indicates worse-than-random ranking (Hirzel et al 2006).

Habitat distribution models vary in their ability to effectively discriminate different classes of habitat along the full range of habitat suitability values (0 – 1; Hirzel et al. 2006). To evaluate this property, we also calculated the continuous Predicted / Expected (P/E) ratio curves based on the BI (Hirzel et al. 2006) using the ecospat package (v 3.0) in R. This is termed the "Continuous Boyce Index). These curves reflect how well each model deviates from random expectation, and inform the interpretation of biologically meaningful suitability categories by indicating the effective resolution of suitability scores for each model (i.e., the model's ability to distinguish different classes of suitability; Hirzel et al. 2006).

To generate predictive layers of habitat suitability for each species, we selected the top candidate models from each algorithm, based upon model performance metrics across cross-validation runs where the TSS was greater than the mean of all models. Ensemble predictions for each species were generated by taking the weighted average among higher performing candidate models for all algorithm types (i.e., one ensemble prediction each for

GAM, RF, GBM, and MaxEnt models), with the weights determined by TSS scores for each of the included models. Layers representing the standard error of the overall ensemble habitat suitability layer were calculated as the standard deviation in model predictions across all candidate models, divided by the square root of the number of candidate models considered.

Quantitative model interpretation

To facilitate biological interpretations of the ensemble models, we calculated the relative importance of environmental predictors across candidate models for each algorithm. To illustrate the shape of the relationships between predicted habitat suitability and important environmental covariates, we derived partial response curves for the top 4 environmental parameters for each of the algorithms, and averaged these across all models to create ensemble partial response curves. Partial response curves show the predicted habitat suitability across a single covariate's range of values, while holding all other covariates at their mean value (e.g., Elith et al. 2005). To indicate the overall distribution of covariate values across the study region, we overlaid the response curve plots with histograms representing each environmental covariate. These histograms were calculated from the environmental values sampled at the combined presence and pseudo absence locations.

Model Standard Error

The standard error for all of the ensemble models generated indicated relatively low error (< 0.05) throughout almost all of the study area, and therefore, are not shown here. Overall, these low errors indicate agreement among the models used in the ensemble.

Table 1 Environmental covariate names and their source.

Variable	Code	Source	Calculation	Units
Mean temperature	MeanTemp.r	https://prism.oregonstate.edu/	Mean of temperature through period	degrees C
Winter precipitation	wp.r	https://prism.oregonstate.edu/	Mean of winter precipitation through period	mm H2O
CV Winter Precipitation	wpcv.r	https://prism.oregonstate.edu/	Coefficient of variation of annual winter precipitation	mm H2O
Absolute maximum temperature	tmax.r	https://prism.oregonstate.edu/	Absolute maximum temperature in dataset	degrees C
Absolute minimum temperature	tmin.r	https://prism.oregonstate.edu/	Absolute minimum temperature in dataset	degrees C
CV maximum temperature	CVMaxTemp.r	https://prism.oregonstate.edu/	Coefficient of variation of maximum temperature	degrees C
CV minimum temperature	CVMinTemp.r	https://prism.oregonstate.edu/	Coefficient of variation of minimum temperature	degrees C
Vapor Pressure Deficit Maximum	vpdMax.r	https://prism.oregonstate.edu/	Daily maximum vapor pressure deficit [difference between the Saturated Vapor Pressure and the Vapor Pressure of the air (VPsat – VPair).	Hectopascals (hPa) = millibars
NDVI Length of Season	NDVIDuration.r	https://www.usgs.gov/special-topics/remote-sensing-phenology	Mean of length of NDVI season	Julian days
NDVI Timing of maximum	NDVIMaxT.r	https://www.usgs.gov/special-topics/remote-sensing-phenology	Mean of the timing of Maximum NDVI	Julian date
NDVI Amplitude	NDVIamplitude.r	https://www.usgs.gov/special-topics/remote-sensing-phenology	Mean of the amplitude of NDVI	unitless
Slope	slope.r	https://www.usgs.gov/core-science-systems/national-geospatial-program/national-map	Calculated from USGS National Map.	degrees
Surface roughness	rough.r	see citation	Inman and others. 2014	unitless
Depth to bedrock	bedrock.r	https://www.soilgrids.org/	Imported from the Soil Grids 250m project. Hengl and others. 2017	m
Distance to water	d2h2o.r	https://www.epa.gov/waterdata/waters-geospatial-data-downloads	Calculated as straight line distance to permanent water	m
Aspect	aspect.r	https://www.usgs.gov/core-science-systems/national-geospatial-program/national-map	Calculated from USGS National Map.	degrees
Fractional component bare ground	bare.r	https://www.usgs.gov/centers/eros/science/national-land-cover-database	NA	%
Fractional component sagebrush	sage.r	https://www.usgs.gov/centers/eros/science/national-land-cover-database	NA	%
Fractional component shrub	shrub.r	https://www.usgs.gov/centers/eros/science/national-land-cover-database	NA	%
Fractional component herbaceous	herb.r	https://www.usgs.gov/centers/eros/science/national-land-cover-database	NA	%
Soil Principal component 1 (Soil PC1)	soil1.r	https://www.soilgrids.org/	First principal component of % sand, silt, and clay	unitless
Coarse fragments	coarse.r	https://www.soilgrids.org/	Downloaded from the Soil Grids 250m project. Hengl and others. 2017	cm2/dm3
Silica index	silicaIndex.r	https://terra.nasa.gov/data/aster-data		unitless
Gypsum content	gypsum.r	https://www.soilgrids.org/	Downloaded from the Soil Grids 250m project. Hengl and others. 2017	%
Distance to Cliffs	D2cliff.r	https://pubs.usgs.gov/of/2014/1134/pdf/ofr2014-1134.pdf	Inman et al, 2014	m

Results

ANMI – Arizona toad (Anaxyrus microscaphus)

ANMI modeled with Clark County vegetation divisions, without buffered area.

This model could not be created because there are only two points for the species within the defined area.

ANMI modeled without Clark County vegetation divisions and with buffered area.

Habitat Model Performance

The ensemble model's performance values indicate a robust model with the ability to discriminate areas of suitable habitat well (ANMI Table 1b). The testing AUC = 0.9995 (SD = 0.0010) and TSS = 0.9900 (SD = 0.0205), indicates strong rank discrimination across thresholds (AUC) and high thresholded accuracy at the selected cutoff (TSS) (see Box 1; ANMI Table 1b). Test CBI = 0.8283 (SD = 0.1286); the CBI curve shows presences enriched by ~40× relative to random for suitability ≥ 0.8 (ANMI Figure 1b; see Box 1).

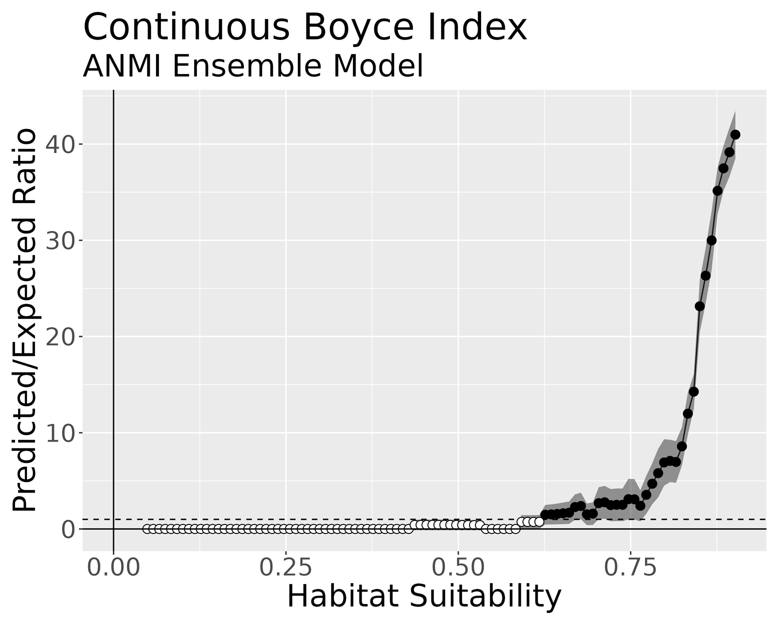
The variables used in the ensemble model of habitat suitability for the Arizona toad for each model type indicate that some variables are of consistent importance across algorithms (ANMI Table 2b). Overall, the top four most important variables in the ensemble model were examined to identify any important patterns for those variables (ANMI Figure 2b). The coefficient of variation in winter precipitation (wpcv) was an important variable in all four models used (ANMI Table 2b), and shows that habitat suitability is highest when the coefficient is low, indicating a more stable environment for that variable (ANMI Figure 2b). The coefficient of variation of the minimum temperature (CVMinTemp) was also an important variable for one model (ANMI Table 2b). In this case, habitat suitability is highest when the coefficient reaches approximately 2.0, and decreases slightly before increasing again as the coefficient increases(ANMI Figure 2b). The distance to water (dist2h2o) was also an important variable in three of the four models (ANMI Table 2b). This variable shows an unexpected pattern where habitat suitability is low when the distance to water is low, and higher estimates of habitat suitability are found with greater distance from water, but peaking before the greatest distances (ANMI Figure 2b). This may reflect the distance to water layer creation focusing on larger water bodies, and permanent river flows, while the species frequents intermittent sources. In addition – given the point locality concentration in the extreme northeast of the study area, the position is by configuration further from most of the permanent water sources. The first principal component of sand/silt/clay (soil1) was also an important variable in three of the four models used (ANMI Table 2b). High habitat suitability exists when the value of the principal component was below -4, but habitat suitability declines quickly and asymptotically when values of the principal component exceed -4 (ANMI Figure 2b).

ANMI Table 1b. Model performance values for Anaxyrus microscaphus models giving Area under the Receiver Operator Curve (AUC), Boyce Index (BI), and True Skill Statistic (TSS) for the ensemble model.

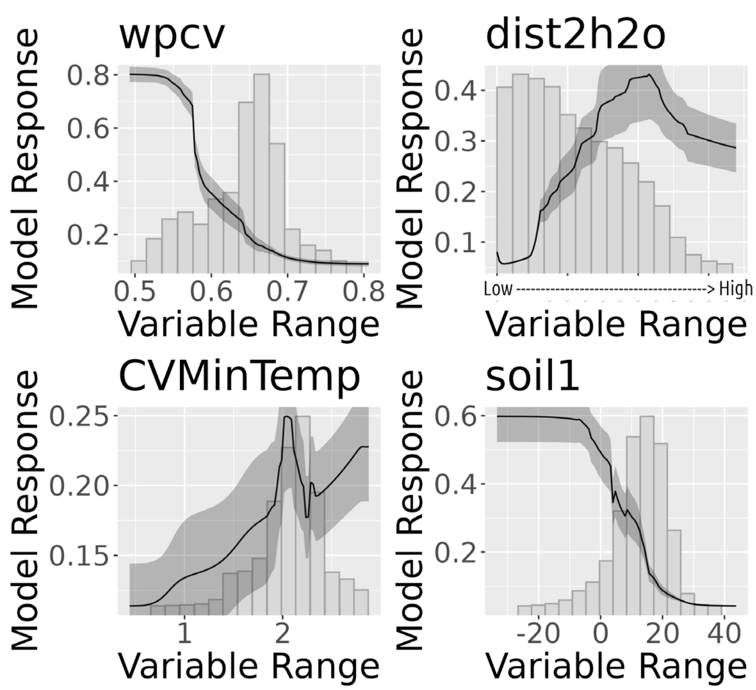
Stat	Training	Training SD	Testing	Testing SD
AUC	0.9999	0.0001	0.9995	0.0010
TSS	0.9919	0.0061	0.9900	0.0205
BI	0.9286	0.0384	0.8283	0.1286

ANMI Table 2b. Percent contributions for input variables for Anaxyrus microscaphus for ensemble models using available algorithms. The top four contributing variables are highlighted.

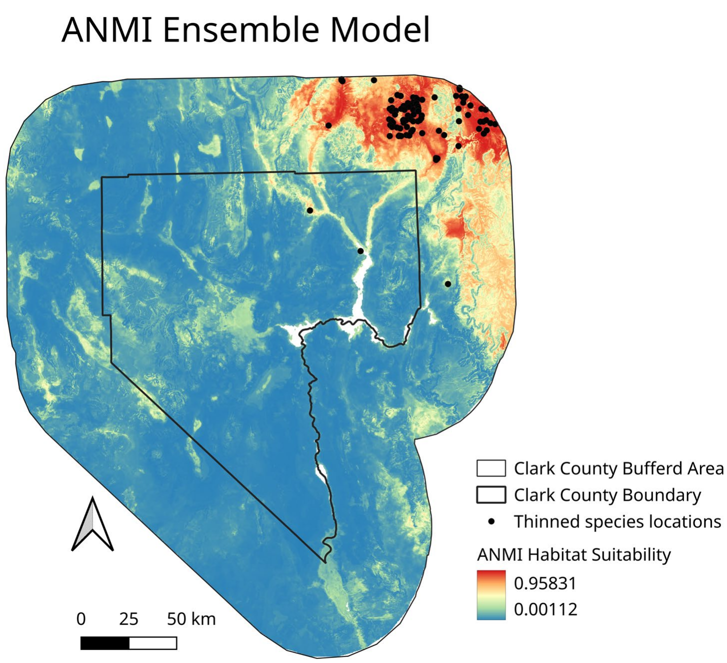
Variable	gam	gbm	mx	rf
aspect.r	6.0	0.0	0.0	1.9
bare.r	0.0	0.0	0.0	2.4
bedrock.r	0.0	0.9	0.0	4.8
CVMinTemp.r	8.0	0.0	9.4	8.4
slope.r	12.0	0.2	0.3	4.2
soil1.r	15.0	0.9	0.2	10.5
tmin.r	7.0	0.0	1.2	9.6
vpdMax.r	19.0	2.2	0.4	6.9
wpcv.r	20.0	93.3	88.3	37.4
dist2h2o.r	13.0	2.5	0.0	13.9



ANMI Figure 1b. Continuous Boyce Indices [CBI] for the Anaxyrus microscaphus ensemble model prediction



ANMI Figure 2b. Partial response curves for the four most influential variables in the ensemble model for Anaxyrus microscaphus . The black solid line indicates the changes in predicted habitat suitability (y-axis - "Model Response") across the range of the x-axis variable (in units of that variable), when all other variables are held at their mean value. The dark gray shading adjacent to the line indicates the 95% confidence interval of the estimate. Light gray shaded bars indicate the distribution of that variable in the environment.



ANMI Figure 3b. Ensemble model of habitat suitability for Anaxyrus microscaphus in the vicinity of Clark County, NV. Hotter colors indicate higher predicted habitat values, and filled black circles show thinned species locations.

Model Discussion

Highly suitable habitat for Anaxyrus microscaphus is predicted to occur in northeast Clark County near the Muddy River at Moapa, as well as the extent of the Meadow Valley Wash and Virgin River within the County (ANMI Figure 3b). While only two species locations were within Clark County, many other individuals were found in the nearby Tule Springs Hills area, and this area is also predicted to be highly suitable habitat (ANMI Figure 3b).

The locality data for this species consisted of 104 records within the buffered modeling area, which had a very high degree of overlap. Spatial thinning of the data reduced the number of localities used for training and testing to 100 records.

ASLE – Straw Milkvetch (Astragalus lentiginosus var. stramineus)

ASLE modeled with Clark County vegetation divisions, without buffered area.

Habitat Model Performance

The performance metrics of the ensemble model suggest it is highly effective at accurately identifying suitable habitat areas (ASLE Table 1a). The testing AUC = 1.0000 (SD = 0.0000) and TSS = 1.0000 (SD = 0.0000), indicating strong rank discrimination across thresholds (AUC) and high thresholded accuracy at the selected cutoff (TSS) (see Box 1; ASLE Table 1). Test CBI = 0.7257 (SD = 0.2153); the CBI curve shows presences enriched by ~500× relative to random for suitability ≥ 0.8 (ASLE Figure 1; see Box 1).

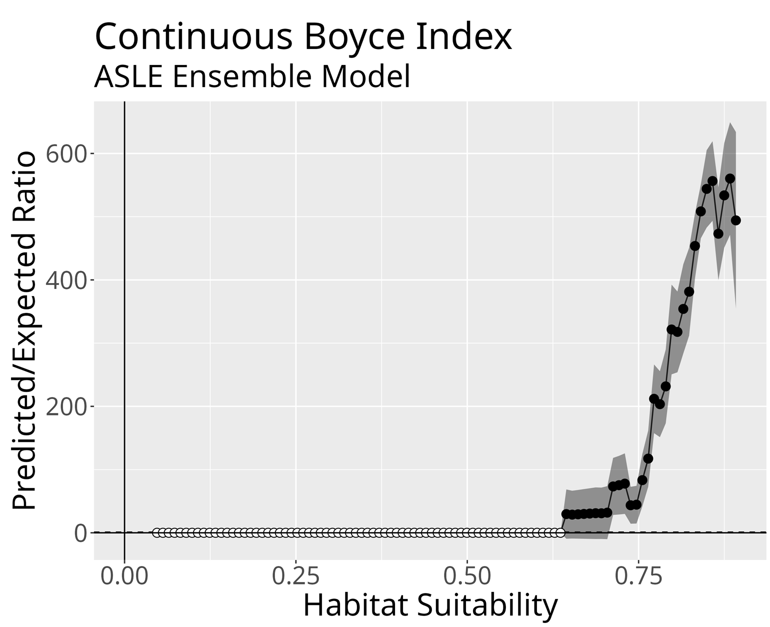
Each model type within the ensemble habitat suitability model for the Straw milkvetch highlights certain variables as particularly significant.(ASLE Table 2a). The ensemble model's top four most significant variables were analyzed to examine patterns associated with them. (ASLE Figure 2a). The silica index (silicaIndex) was one of the most important variables in all three models (ASLE Table 2a). Habitat suitability is low when the silica index is below a value of 1. Thereafter, habitat suitability increases rapidly with higher values of the silica index until habitat suitability is maximized and remains high at silica index values above 1.65 (ASLE Figure 2a). The coefficient of variation in winter precipitation (wpcv) was an important variable in all three models (ASLE Table 2a). Habitat suitability is highest when the coefficient is low, indicating a more stable environment for that variable (ASLE Figure 2a). The fractional composition of bare ground (bare) was also an important variable in two of the three models (ASLE Table 2a). In this case, habitat suitability is low when the fractional component of bare ground is less than 90%. Habitat suitability increases rapidly and remains high when the fractional component of bare ground is greater than 90%.(ASLE Figure 2a). The gypsum value was also an important contributor to one of the three models (ASLE Table 2a). Habitat suitability is low when gypsum is less than 10 percent, but increases rapidly and remains high when gypsum content exceeds 10 percent (ASLE Figure 2a).

ASLE Table 1a. Model performance values for Astragalus lentiginosus var. stramineus models giving Area under the Receiver Operator Curve (AUC), Boyce Index (BI), and True Skill Statistic (TSS) for the ensemble model.

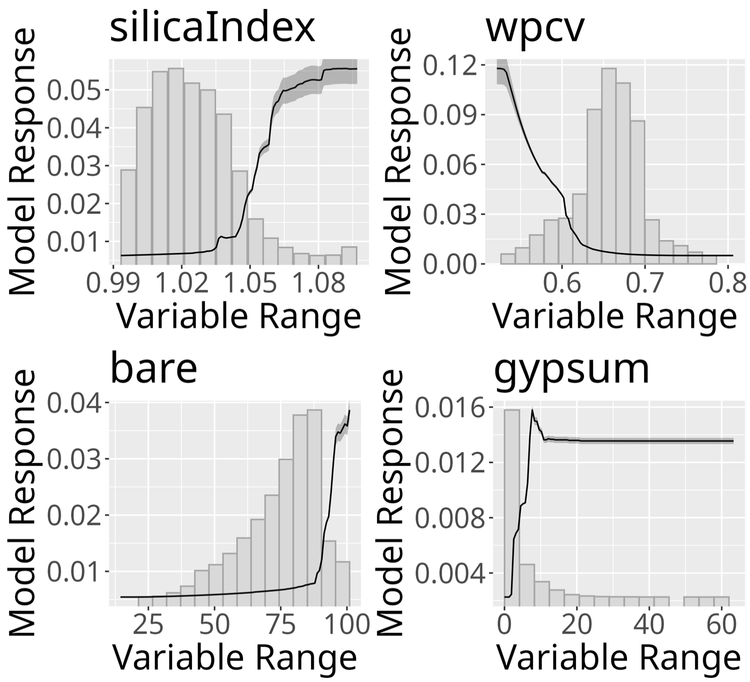
Stat	Training	Training SD	Testing	Testing SD
AUC	1.0000	0.0000	1.0000	0.0000
TSS	1.0000	0.0000	1.0000	0.0000
BI	0.9677	0.0135	0.7257	0.2153

ASLE Table 2. Percent contributions for input variables for Astragalus lentiginosus var. stramineus for ensemble models using available algorithms. The top four contributing variables are highlighted.

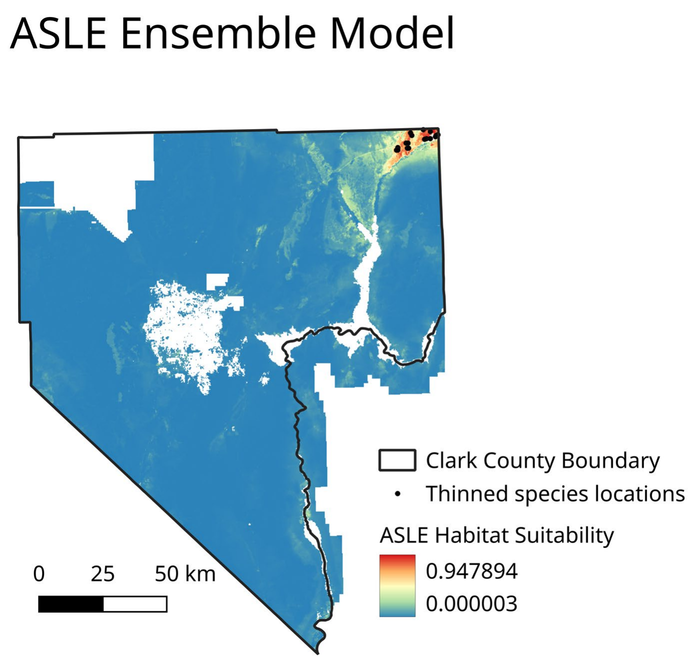
Variable	**gbm**	**mx**	**rf**
bare.r	1.8	0.2	10.1
bedrock.r	0.0	0.0	3.6
NDVIDuration.r	0.1	0.0	1.0
slope.r	0.0	0.1	1.7
tmin.r	0.0	0.1	6.4
vpdMax.r	0.0	0.1	9.9
wp.r	0.0	0.0	11.1
wpcv.r	4.8	45.5	14.3
soilpH.r	0.9	0.2	3.0
silicaIndex.r	81.7	53.9	22.0
gypsum.r	5.3	0.0	8.3
VegetationDivisionsCC.f	5.4	0.0	8.6



ASLE Figure 1a. Continuous Boyce Indices [CBI] for the Astragalus lentiginosus var. stramineus ensemble model prediction.



ASLE Figure 2a. Partial response curves for the four most influential variables in the ensemble model for Astragalus lentiginosus var. stramineus. Lines and bars indicate the variables as described in ANMI Figure 2b.



ASLE Figure 3a. Ensemble model of habitat suitability for Astragalus lentiginosus var. stramineus in the vicinity of Clark County, NV. Hotter colors indicate higher predicted habitat values, and filled black circles show thinned species locations.

Model Discussion

Areas of high habitat suitability for Astragalus lentiginosus var. stramineus are predicted to occur in northeast Clark County near the Virgin River north of Lake Mead (ASLE Figure 3a).

The locality data for this species consisted of 120 records within the buffered modeling area, which had a very high degree of overlap. Spatial thinning of the data reduced the number of localities used for training and testing to 19 records.

ASLE modeled without Clark County vegetation divisions and with buffered area.

Habitat Model Performance

The performance metrics of the ensemble model suggest it is highly effective at accurately identifying suitable habitat areas.(ASLE Table 1b). The continuous Boyce Index (CBI) curve indicates that as the habitat suitability estimate increases above ca. 80%, species presence is predicted up to 500 times greater than would be expected at random (ASLE Figure 1b). Testing AUC = 1.0000 (SD = 0.0000) and TSS = 1.0000 (SD = 0.0000), indicating strong rank discrimination across thresholds (AUC) and high thresholded accuracy at the selected cutoff (TSS) (see Box 1; ASLE Table 1b). Test CBI = 0.9436 (SD = 0.0360) (ASLE Figure 1b; see Box 1).

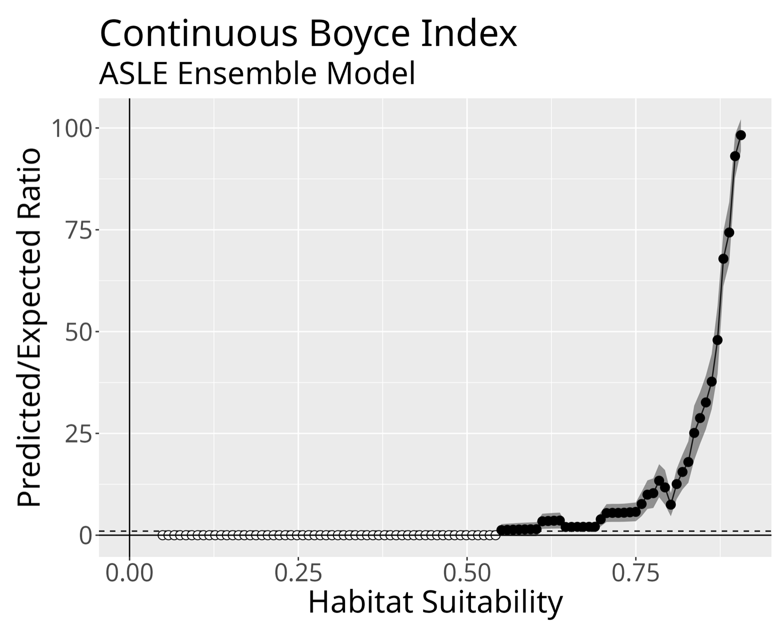
In the ensemble habitat suitability model for Straw milkvetch, two variables emerged as particularly influential across all model types (ASLE Table 2b). The four most impactful variables identified in the ensemble model were analyzed in greater detail (ASLE Figure 2b). The maximum vapor pressure deficit (vpdMax) was an important variable in all four models (ASLE Table 2b). Habitat suitability is low when vpdMax is less than 30 hPa, but increases rapidly and remains high as vpdMax increases above 30 hPa (ASLE Figure 2b). The coefficient of variation in winter precipitation (wpcv) was an important variable in three of the four models (ASLE Table 2b). Habitat suitability is highest when the coefficient is low, indicating a more stable environment for that variable (ASLE Figure 2b). The coefficient of variation of winter precipitation (wpcv) was an important variable in three of the four model types used (ASLE Table 2b). Habitat suitability is highest whenever the wpcv is below 0.58, but suitability decreases rapidly to a minimum as the value of wpcv approaches 0.60, thereafter habitat suitability remains low as the value of wpcv exceeds 0.7 (ASLE Figure 2b). The silica index (silicaIndex) was the most important variables for only one of the four models (ASLE Table 2b). Habitat suitability is low when the silica index is below a value of 1. Thereafter, habitat suitability increases rapidly with higher values of the silica index until habitat suitability is maximized and remains high at silica index values above 1.65 (ASLE Figure 2b).

ASLE Table 1b. Model performance values for Astragalus lentiginosus var. stramineus models giving Area under the Receiver Operator Curve (AUC), Boyce Index (BI), and True Skill Statistic (TSS) for the ensemble model.

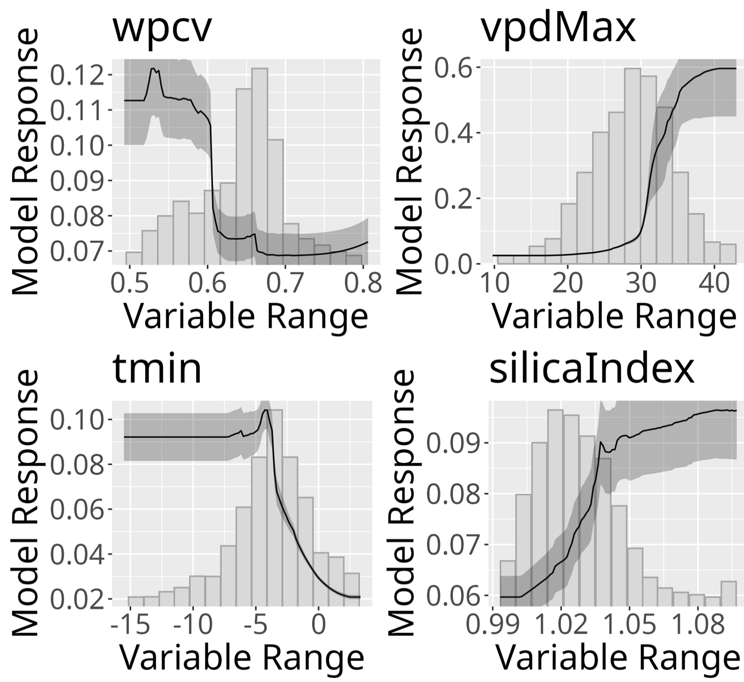
Stat	Training	Training SD	Testing	Testing SD
AUC	1.0000	0.0000	1.0000	0.0000
TSS	1.0000	0.0000	1.0000	0.0000
BI	0.9805	0.0082	0.9436	0.0360

ASLE Table 2b. Percent contributions for input variables for Astragalus lentiginosus var. stramineus for ensemble models using available algorithms. The top four contributing variables are highlighted.

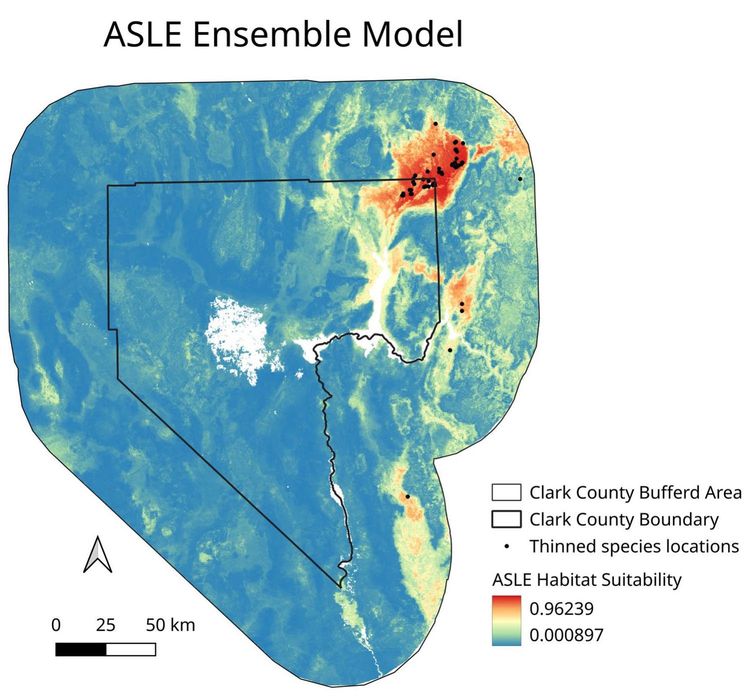
Variable	gam	gbm	mx	rf
bare.r	0.0	2.8	0.1	7.0
bedrock.r	1.0	12.0	0.0	11.9
NDVIDuration.r	2.0	0.0	0.0	2.2
slope.r	0.0	0.0	0.2	2.1
tmin.r	25.3	5.7	3.3	9.8
vpdMax.r	30.3	27.2	2.8	17.1
wp.r	19.2	0.0	0.3	8.3
wpcv.r	1.0	33.0	64.0	19.2
soilpH.r	21.2	0.0	0.9	3.0
silicaIndex.r	0.0	1.2	28.3	5.5
gypsum.r	0.0	18.1	0.1	13.9



ASLE Figure 1b. Continuous Boyce Indices [CBI] for Astragalus lentiginosus var. stramineus ensemble model prediction.



ASLE Figure 2b. Partial response curves for the four most influential variables in the ensemble model. Lines and bars indicate the variables as described in ANMI Figure 2b.



ASLE Figure 3b. Ensemble model of habitat suitability for Astragalus lentiginosus var. stramineus in the vicinity of Clark County, NV. Hotter colors indicate higher predicted habitat values, and filled black circles show thinned species locations.

Model Discussion

Highly suitable habitat for Astragalus lentiginosus var. stramineus is predicted to occur in northeast Clark County near the Muddy River at Moapa, as well as the extent of the Meadow Valley Wash and Virgin River within the County (ASLE Figure 3b). While only two species locations were within Clark County, many other species were found in the nearby Tule Springs Hills area, and this area is also predicted to be highly suitable habitat (ASLE Figure 3b).

The locality data for this species consisted of 120 records within the buffered modeling area, which had a very high degree of overlap. Spatial thinning of the data reduced the number of localities used for training and testing to 61 records.

CAST - Akali mariposa lily (Calochortus striatus)

CAST modeled with Clark County vegetation divisions, without buffered area.

Habitat Model Performance

The ensemble model exhibits strong performance, effectively distinguishing areas of suitable habitat (CAST Table 1a). The continuous Boyce Index (CBI) curve shows that once habitat suitability exceeds approximately 80%, species presence is predicted to be up to 1,000 times more likely than random expectation (CAST Figure 1a). Test results are exceedingly high—AUC = 1.0000 (SD = 0.0000) and TSS = 1.0000 (SD = 0.0000)—indicating excellent rank discrimination across thresholds (AUC) and high thresholded accuracy at the chosen cutoff (TSS) (see Box 1; CAST Table 1a). While impressive, these results might be a bit too high, perhaps due to full containment within one or more vegetation strata. In additon only two modeling algorithms were possible/high performing due to the limited data within vegetation strata.

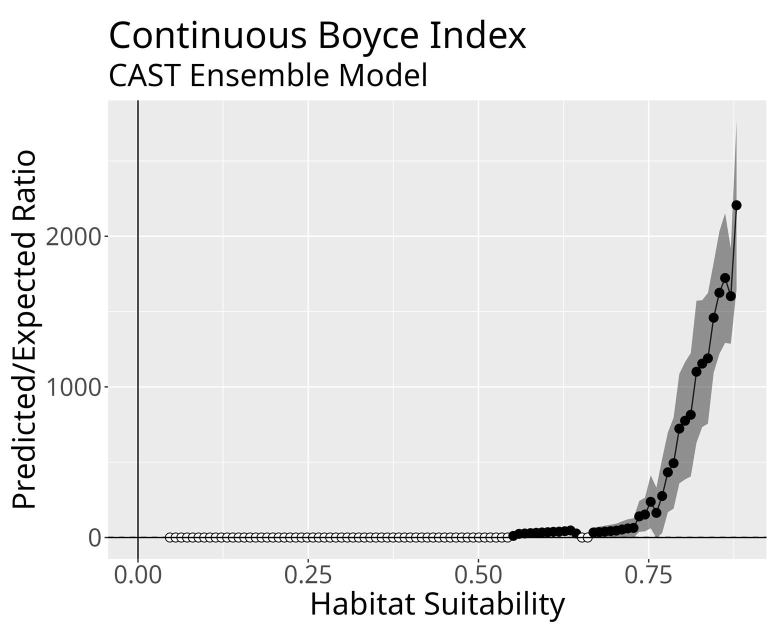
To explore patterns in the covariate data, we evaluated the four most influential variables in the ensemble; however, the maxent model identified only one variable as important, which is problematic (CAST Figure 2a). The silica index was an important variable in two of the models (CAST Table 2a). Habitat suitability is low when the silica index is below a value of 1. Thereafter, habitat suitability increases rapidly with higher values of the silica index until habitat suitability is maximized and remains high at silica index values above 1.055 (CAST Figure 2a). The vapor pressure deficit maximum (vpdMax) was also an important variable for one model (CAST Table 2a). In this case, habitat suitability is higher when the vpdMax is less than 30 hPa. Habitat suitability decreases almost immediately and remains low when vpdMax exceeds 30 hPa (CAST Figure 2a). The pH value for the soil (soilpH) was an important contributor for one model (ASLE Table 2a). Habitat suitability is low when soilpH is low, but increases rapidly as soilpH reaches a value of eight, and declines precipitously with higher pH values (CAST Figure 2a). The absolute minimum temperature (tmin) was an important variable to the ensemble model, but was not important to any of the models used independently (CAST Table 2a). Habitat suitability is highest when tmin is below -5 C (CAST Figure 2a).

CAST Table 1a. Model performance values for Calochortus striatus models giving Area under the Receiver Operator Curve (AUC), Boyce Index (BI), and True Skill Statistic (TSS) for the ensemble model.

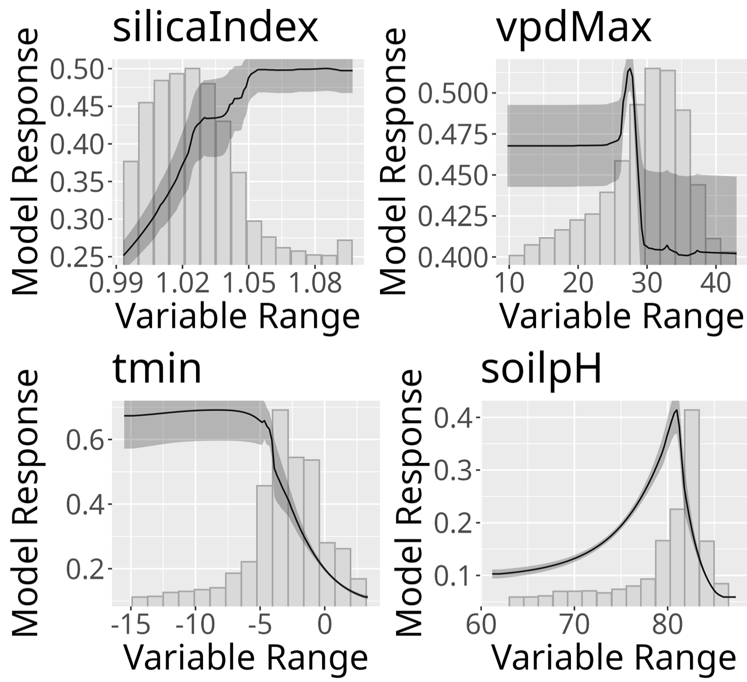
Stat	Training	Training SD	Testing	Testing SD
AUC	1.0000	0.0000	1.0000	0.0000
TSS	1.0000	0.0000	1.0000	0.0000
BI	0.9581	0.0277	0.7907	0.2108

CAST Table 2a. Percent contributions for input variables for Calochortus striatus for ensemble models using available algorithms. The top four contributing variables are highlighted, except for the maxent model, which had only one meaningful contributing variable.

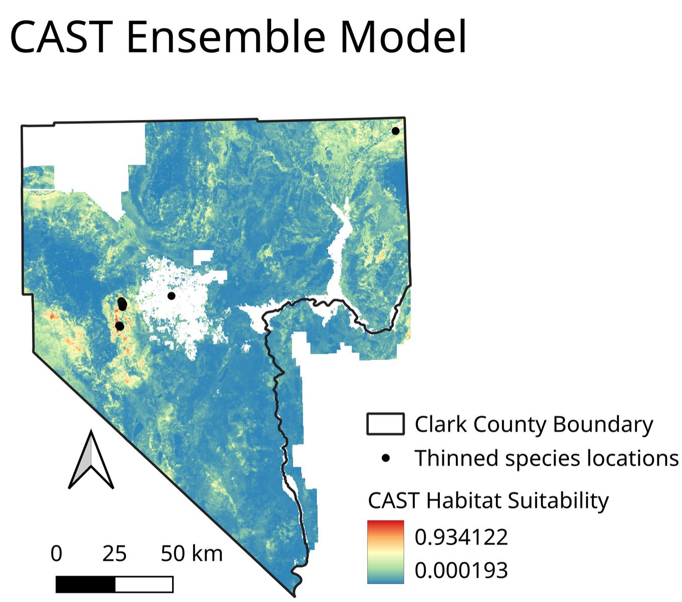
Variable	mx	rf
bare.r	0	6.4
bedrock.r	0	8.4
slope.r	0.1	4.8
tmin.r	0.7	14
vpdMax.r	0.1	17.7
soilpH.r	0.6	12.5
silicaIndex.r	98.1	13.1
gypsum.r	0.2	12.3
VegetationDivisionsCC.f	0.1	10.7



CAST Figure 1a. Continuous Boyce Indices [CBI] for the Calochortus striatus ensemble model prediction



CAST Figure 2a. Partial response curves for the four most influential variables in the ensemble model. Lines and bars indicate the variables as described in ANMI Figure 2b.



CAST Figure 3a. Ensemble model of habitat suitability for Calochortus striatus in the vicinity of Clark County, NV. Hotter colors indicate higher predicted habitat values, and filled black circles show thinned species locations.

Model Discussion

In this ensemble model, highly suitable habitat for Calochortus striatus is predicted to occur primarily on the southeast and southwest perimeter of the Spring Mountains (CAST Figure 3a). A small area of relatively suitable habitat also exists in northeast Clark County, near the Mesquite, however, our records indicate that only one individual has been located in this area. A smaller area of moderate habitat suitability also occurs on the southern end of Tramp Ridge, just north of Gold Butte, although no individuals have been located in this area (CAST Figure 3a).

The locality data for this species consisted of 56 records within the buffered modeling area, which had a very high degree of overlap. Spatial thinning of the data reduced the number of localities used for training and testing to 13 records.

CAST modeled without Clark County vegetation divisions, and with buffered area.

Habitat Model Performance

Performance metrics for the ensemble model demonstrate a robust, dependable capacity to differentiate suitable habitat within the study area (see CAST Table 1b). The continuous Boyce Index indicates that once predicted suitability exceeds roughly 80%, the likelihood of species presence becomes up to 300 times greater than expected under randomness (CAST Figure 1b).

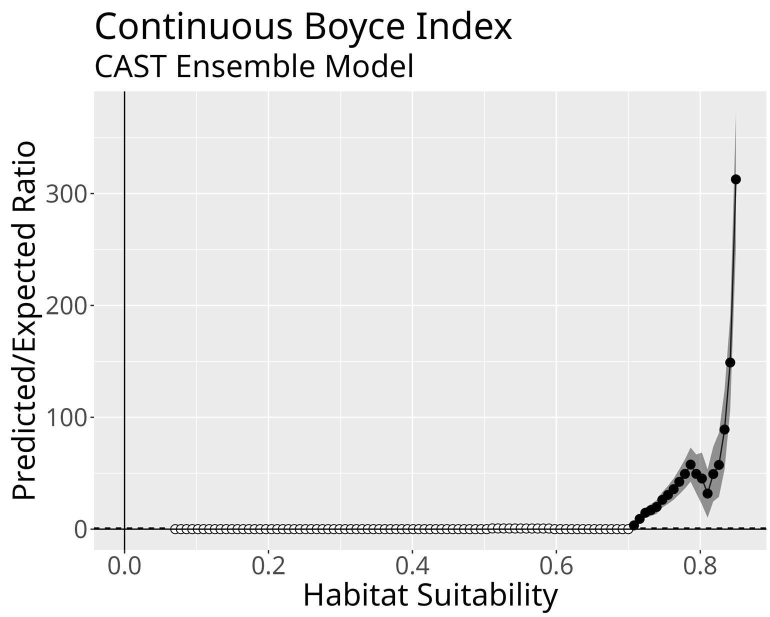
Across model types in the Alkali mariposa lily ensemble, several predictors emerged as influential (ASLE Table 2b). We focused on the four most impactful variables to assess common patterns (ASLE Figure 2b). Absolute minimum temperature (tmin) was important in all three models (ASLE Table 2b), with suitability peaking near −5 °C and declining at both warmer and colder values (CAST Figure 2b). Maximum vapor pressure deficit (vpdMax) was influential in one model (CAST Table 2b); suitability is higher when vpdMax is below 30 hPa, then drops sharply and remains low beyond that threshold (CAST Figure 2b). Soil pH (soilpH) contributed in one model (CAST Table 2b), but the response shape and wide 95% confidence interval preclude confident interpretation (CAST Figure 2b). The silica index (silicaIndex) also ranked among top variables in one model (CAST Table 2b), yet its partial response and broad 95% confidence interval do not reveal a clear relationship (CAST Figure 2b).

CAST Table 1b. Model performance values for Calochortus striatus models giving Area under the Receiver Operator Curve (AUC), Boyce Index (BI), and True Skill Statistic (TSS) for the ensemble model.

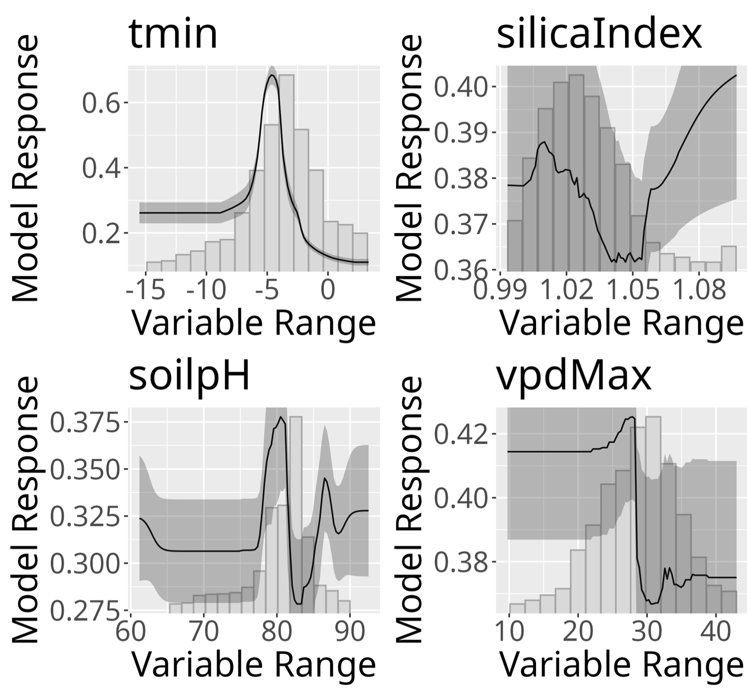
Stat	Training	TrainingSD	Testing	TestingSD
AUC	1.0000	0.0000	1.0000	0.0000
TSS	1.0000	0.0000	1.0000	0.0000
BI	0.8805	0.0334	0.8133	0.2779

CAST Table 2b. Percent contributions for input variables for Calochortus striatus for ensemble models using available algorithms. The top four contributing variables are highlighted, except for the gam model which had only two meaningful contributing variables.

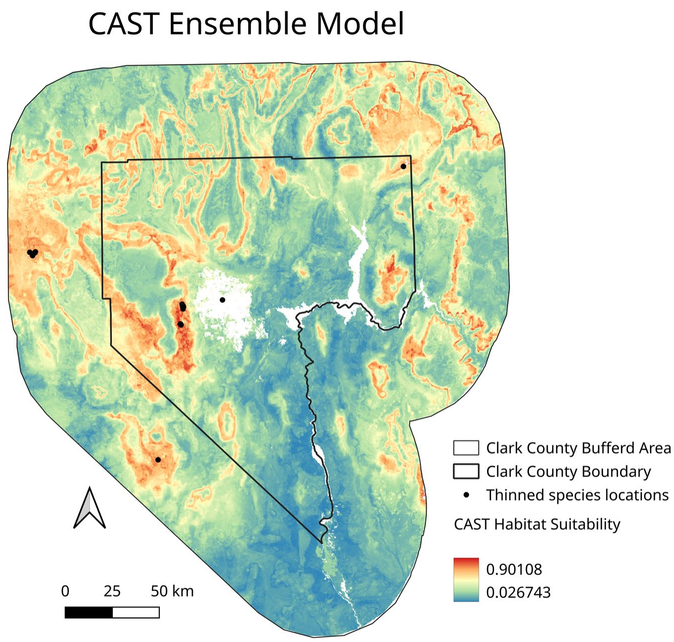
Variable	gam	mx	rf
bare.r	0.0	0.5	12.2
bedrock.r	0.0	0.0	12.7
slope.r	0.0	2.7	9.0
tmin.r	81.0	6.8	23.1
vpdMax.r	0.0	3.9	11.0
soilpH.r	18.0	1.1	10.2
silicaIndex.r	1.0	84.4	10.1
gypsum.r	0.0	0.7	11.7



CAST Figure 1b. Continuous Boyce Indices [CBI] for the Calochortus striatus ensemble model prediction



CAST Figure 2b. Partial response curves for the four most influential variables in the ensemble model. Lines and bars indicate the variables as described in ANMI Figure 2b.



CAST Figure 3b. Ensemble model of habitat suitability for Calochortus striatus in the vicinity of Clark County, NV. Hotter colors indicate higher predicted habitat values, and filled black circles show thinned species locations.

Model Discussion

Highly suitable habitat for Calochortus striatus is relatively broadly distributed across Clark County and the buffered area. In general, highly suitable habitat is found around the periphery of mountain ranges, as is the case for the Spring, Sheep, Birdsprings, McCullough, and Virgin Ranges (CAST Figure 3b). Elsewhere in the region, highly suitable habitat can be found near Tramp Ridge, and the White Hills (CAST Figure 3b).

The locality data for this species consisted of 56 records within the buffered modeling area, which had a very high degree of overlap. Spatial thinning of the data reduced the number of localities used for training and testing to 22 records.

COAM - Yellow-billed cuckoo, (Coccyzus americanus)

COAM modeled with Clark County vegetation divisions, without buffered area.

Habitat Model Performance

Performance metrics for the ensemble indicate a highly robust model of suitable habitat (COAM Table 1a). The continuous Boyce Index (CBI) curve shows that once predicted suitability exceeds approximately 80%, species presence is up to 500 times more likely than random expectation (COAM Figure 1a). Test results yielded AUC = 0.9992 (SD = 0.0026) and TSS = 0.9917 (SD = 0.0256), demonstrating excellent rank discrimination across thresholds (AUC) and high thresholded accuracy at the chosen cutoff (TSS) (see Box 1; COAM Table 1a).

Variable contributions in the Yellow-billed cuckoo habitat-suitability ensemble indicate a few strongly influential predictors (COAM Table 2a). Among the four top predictors examined, depth to bedrock ranked as one of the most important in three of the four component models (COAM Table 2a). Suitability is low where bedrock is shallow, rises sharply as bedrock depth increases, and then shows a slight decline at greater depths (COAM Figure 2a).

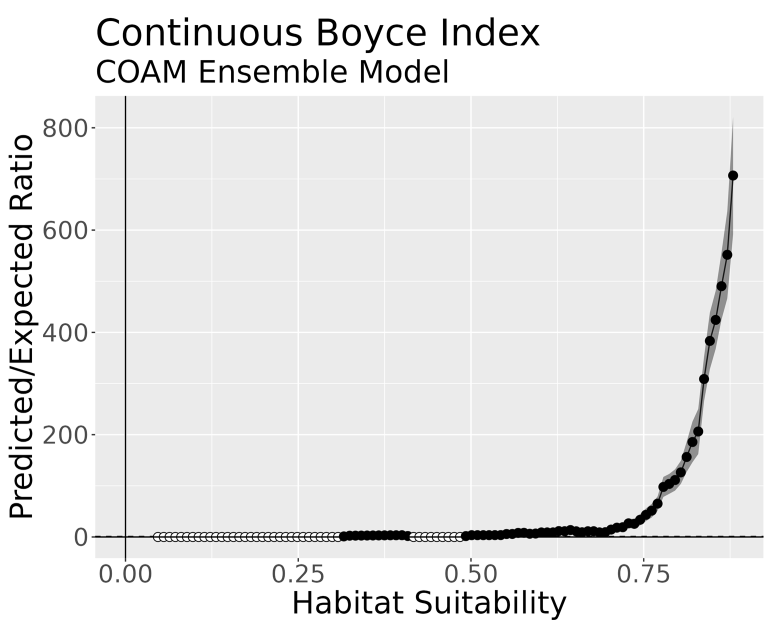
The coefficient of variation of minimum temperature (CVMinTemp) was important in one model (CAST Table 2a). Suitability is low when CVMinTemp is below 2, then increases rapidly with greater variability, suggesting that less predictable thermal regimes correspond to higher suitability (CAST Figure 2a). The coefficient of variation of winter precipitation (wpcv) was also important in one model (COAM Table 2a): suitability is low when wpcv is below 0.75, increases almost immediately above that threshold, and remains high thereafter; as with CVMinTemp, higher variability reflects less predictable environments (CAST Figure 2a). Absolute minimum temperature (tmin) contributed notably in two models (COAM Table 2a). Suitability is highest when tmin is below -9 C, though wide 95% confidence intervals in that range make the precise pattern uncertain (COAM Figure 2a).

COAM Table 1a. Model performance values for Coccyzus americanus models giving Area under the Receiver Operator Curve (AUC), Boyce Index (BI), and True Skill Statistic (TSS) for the ensemble model.

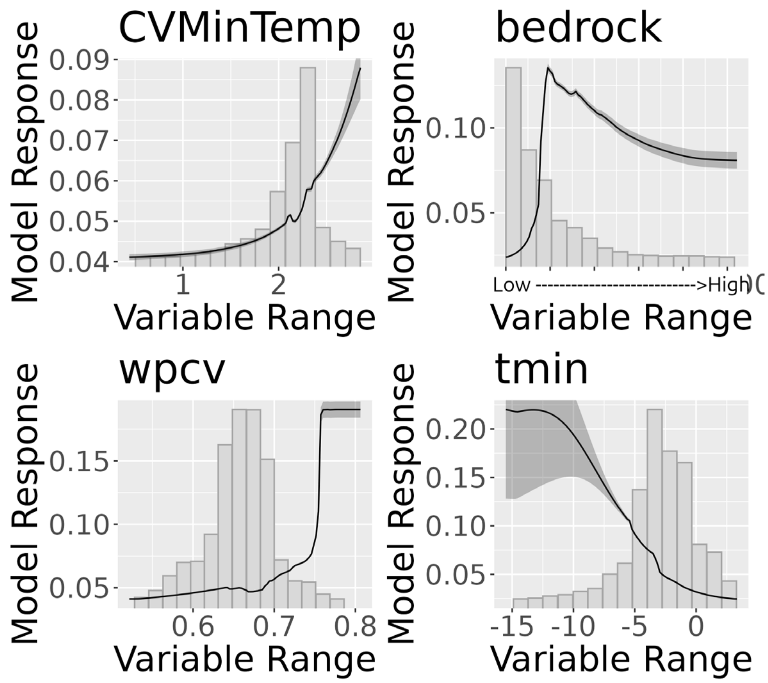
Stat	Training	Training SD	Testing	Testing SD
AUC	0.9994	0.0004	0.9992	0.0026
TSS	0.9840	0.0095	0.9917	0.0256
BI	0.9629	0.0285	0.9392	0.0535

COAM Table 2a. Percent contributions for input variables for Coccyzus americanus for ensemble models using available algorithms. The top four contributing variables are highlighted, except that the gbm and mx models only had three meaningful contributing variables.

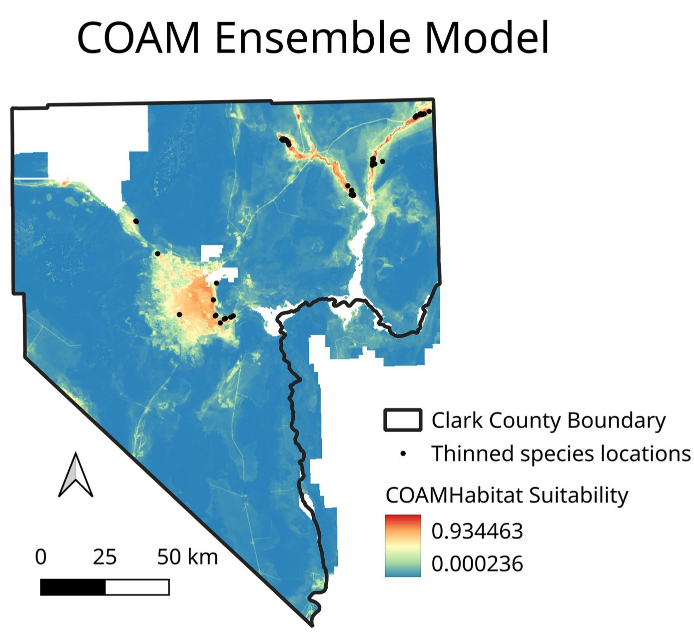
Variable	gam	gbm	mx	rf
bedrock.r	33.0	61.0	0.0	17.7
CVMinTemp.r	0.0	0.0	73.3	8.1
sage.r	0.0	15.6	0.2	5.7
shrub.r	16.0	0.0	0.3	9.8
soil1.r	34.0	0.0	0.1	8.4
tmin.r	14.0	0.0	6.9	9.3
vpdMax.r	1.0	0.0	0.3	11.8
wpcv.r	2.0	0.0	18.9	8.3
dist2h2o.r	0.0	0.0	0.0	4.4
VegetationDivisionsCC.f	0.0	23.4	0.1	16.5



COAM Figure 1a. Continuous Boyce Indices [CBI] for the Coccyzus americanus ensemble model prediction



COAM Figure 2a. Partial response curves for the four most influential variables in the ensemble model. Lines and bars indicate the variables as described in ANMI Figure 2b.



COAM Figure 3a. Ensemble model of habitat suitability for Coccyzus americanus in the vicinity of Clark County, NV. Hotter colors indicate higher predicted habitat values, and filled black circles show thinned species locations.

Model Discussion

Highly suitable habitat for Coccyzus americanus is restricted to areas near the Meadow Valley Wash, the Muddy River, and the Virgin River (COAM Figure 3a). A smaller area of suitable habitat is found on the eastern side of the City of Las Vegas, and adjacent areas of the Las Vegas Wash as it joins Lake Mead (COAM Figure 3a).

The locality data for this species consisted of 228 records within the buffered modeling area, which had a very high degree of overlap. Spatial thinning of the data reduced the number of localities used for training and testing to 51 records.

COAM modeled without Clark County vegetation divisions, and with buffered area.

Habitat Model Performance

Performance metrics for the ensemble indicate a robust model that identifies suitable habitat (COAM Table 1b). Discrimination was exceptional, with AUC = 1.000 for both training and testing (COAM Table 1b), reflecting near-perfect ranking of presences over background. Threshold-based results were likewise flawless (TSS = 1.000 for training and testing; COAM Table 1b), implying sensitivity and specificity of 1.0 at the optimal cutoff. While such ideal values are rare and merit continued checks for overfitting, the matching test scores suggest true separability. Calibration was strong to excellent, with Boyce Index/CBI of 0.951 (training) and 0.802 (testing) (COAM Table 1b). Consistent with these metrics, the CBI curve shows that predictions above roughly 0.80 correspond to presence enrichment up to about 40-fold over random, reinforcing high confidence in the top-ranked habitat (COAM Figure 1b).

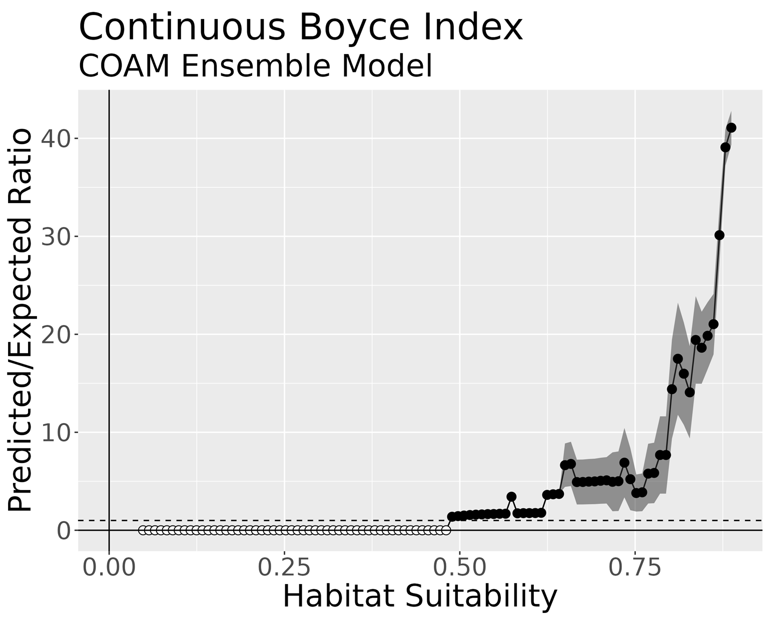
The ensemble habitat suitability model for the Yellow-billed Cuckoo identifies several variables as particularly influential (COAM Table 2b). We examined the four most important to detect key patterns (COAM Figure 2b). Shrub fractional cover was important in three of the four models: suitability is very low below 25% shrub cover, then increases sharply and remains high once it exceeds 25%. Absolute minimum temperature (tmin) mattered in two models; suitability peaks near -5 C and declines at warmer minima. The first principal component of soil texture (soil1; sand/silt/clay) was also important in two models: suitability is high when soil1 is below 0, but drops quickly and stays low above 0. The coefficient of variation of minimum temperature (CVMinTemp) was important in one model, with low suitability below 2 and rapid increases as CVMinTemp rises (COAM Figure 2b).

COAM Table 1b. Model performance values for Coccyzus americanus models giving Area under the Receiver Operator Curve (AUC), Boyce Index (BI), and True Skill Statistic (TSS) for the ensemble model.

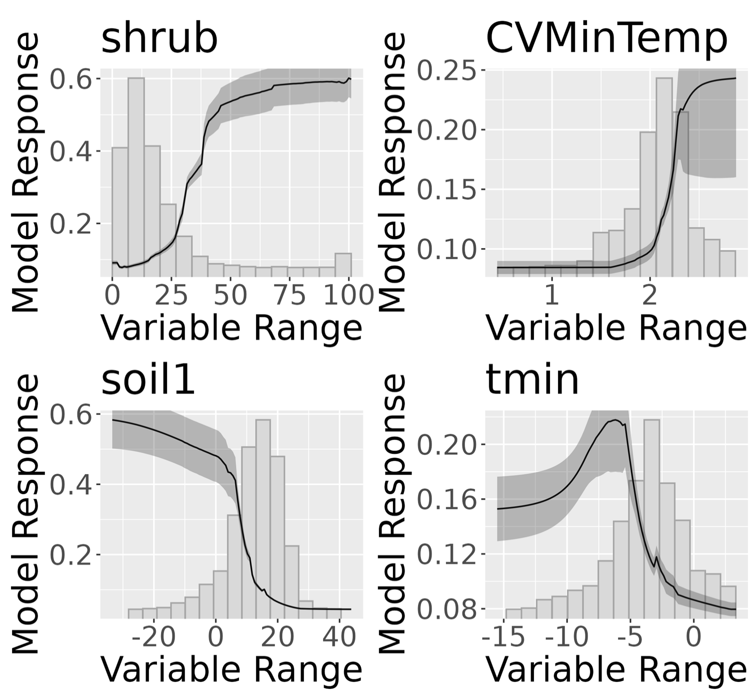
Stat	**Training**	**Training SD**	**Testing**	**Testing SD**
AUC	1.0000	0.0000	1.0000	0.0000
TSS	1.0000	0.0000	1.0000	0.0000
BI	0.9506	0.0318	0.8019	0.1657

COAM Table 2b. Percent contributions for input variables for Coccyzus americanus for ensemble models using available algorithms. The top four contributing variables are highlighted, except that the gbm model only had two meaningful contributing variables.

Variable	gam	gbm	mx	rf
bedrock.r	13.3	0.3	0.0	6.0
CVMinTemp.r	6.1	0.0	66.3	4.3
sage.r	0.0	0.0	0.3	13.1
shrub.r	33.7	64.2	0.7	31.3
soil1.r	7.1	33.2	0.3	26.0
tmin.r	24.5	0.0	8.5	2.2
vpdMax.r	10.2	2.3	1.9	10.4
wpcv.r	0.0	0.0	21.9	2.6
dist2h2o.r	5.1	0.0	0.0	4.0

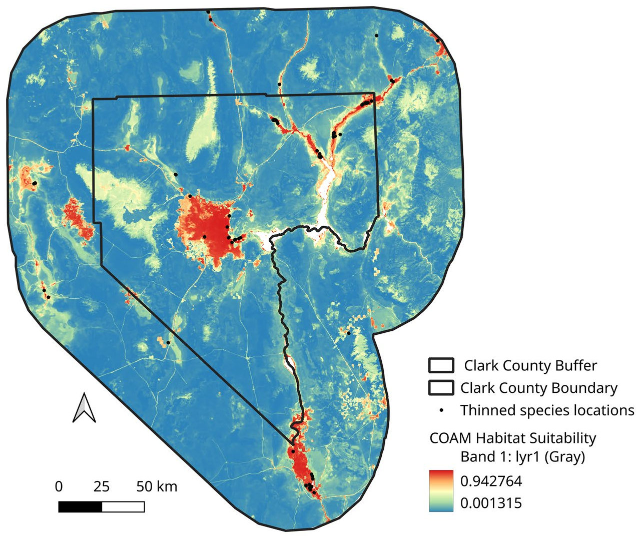


COAM Figure 1b. Continuous Boyce Indices [CBI] for the Coccyzus americanus ensemble model prediction



COAM Figure 2b. Partial response curves for the four most influential variables in the ensemble model. Lines and bars indicate the variables as described in ANMI Figure 2b.

COAM Ensemble Model



COAM Figure 3b. Ensemble model of habitat suitability for Coccyzus americanus in the vicinity of Clark County, NV. Hotter colors indicate higher predicted habitat values, and filled black circles show thinned species locations.

Model Discussion

Areas of high habitat suitability for Coccyzus americanus are relatively narrowly distributed across Clark County and the buffered area. In general, high habitat suitability for this species is restricted to areas near the Meadow Valley Wash, the Muddy River, and the Virgin River (COAM Figure 3b). An area of highly suitable habitat is found across the City of Las Vegas, and adjacent areas of the Las Vegas Wash as it joins Lake Mead (COAM Figure 3b). Highly suitable habitat is also found along the Colorado River and Lake Mojave, continuing on through Bullhead City and into the Mohave Valley (AZ; COAM Figure 3b). A few smaller areas of highly suitable habitat are also noted in Coyote Springs Valley, the Indian Springs Valley, and Pahrump Valley (COAM Figure 3b.)

The locality data for this species consisted of 228 records within the buffered modeling area, which had a very high degree of overlap. Spatial thinning of the data reduced the number of localities used for training and testing to 76 records.

COTO - Townsend's big-eared bat, (Corynorhinus townsendii)

COTO modeled with Clark County vegetation divisions, without buffered area.

Habitat Model Performance

Performance metrics for the ensemble model indicate a robust approach that does a good job of distinguishing areas of suitable habitat (COTO Table 1a). The continuous Boyce Index (CBI) curve shows that when predicted suitability exceeds approximately 80%, species presence is up to 10 times more likely than expected by chance (COTO Figure 1a). Testing produced AUC = 1.0000 (SD = 0.0000) and TSS = 1.0000 (SD = 0.0000), indicating strong rank discrimination across thresholds (AUC) and high thresholded accuracy at the selected cutoff (TSS) (see Box 1; COTO Table 1a). Additionally, the limited data within vegetation strata meant that only two modeling algorithms were viable and high-performing.

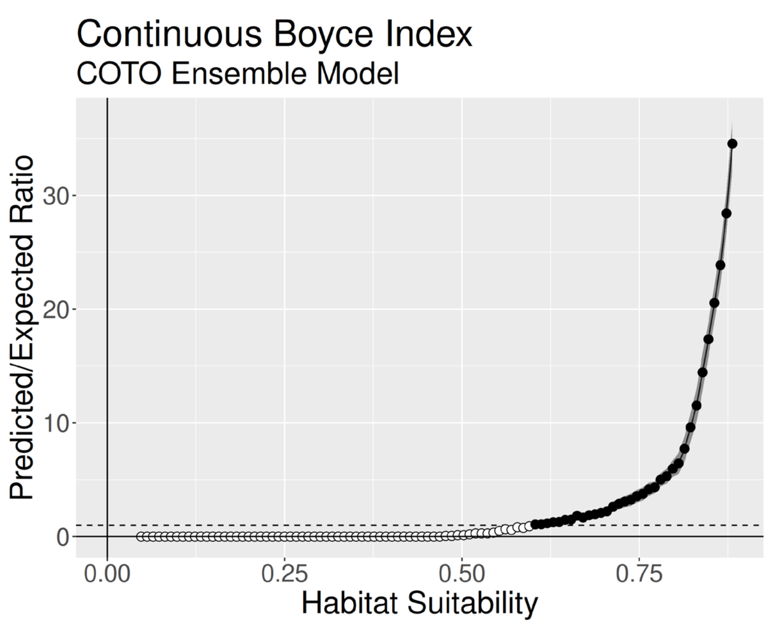
In the ensemble habitat-suitability model a small set of predictors exerted the greatest influence (COTO Table 2a). Only two algorithms (Maxent and Random Forest) had high performing models. We evaluated the four top-ranked variables to identify patterns. Distance to water (d2h2o) was influential in one of the two constituent models; suitability is low at short distances and rises, remaining elevated as distance increases (COTO Figure 2a). Terrain slope was also highly influential in one model, with suitability peaking between about 5 and 20 degrees and declining at steeper slopes (COTO Figure 2a). The coefficient of variation of minimum temperature (CVMinTemp) was important in one model, with maximum suitability near 2.4 and lower suitability at other values (COTO Figure 2a). Winter precipitation variability (wpcv) was important in one model as well; suitability is low at small wpcv, increases nearly linearly, and stays high once wpcv exceeds roughly 0.75 (COTO Figure 2a).

COTO Table 1a. Model performance values for Corynorhinus townsendii models giving Area under the Receiver Operator Curve (AUC), Boyce Index (BI), and True Skill Statistic (TSS) for the ensemble model.

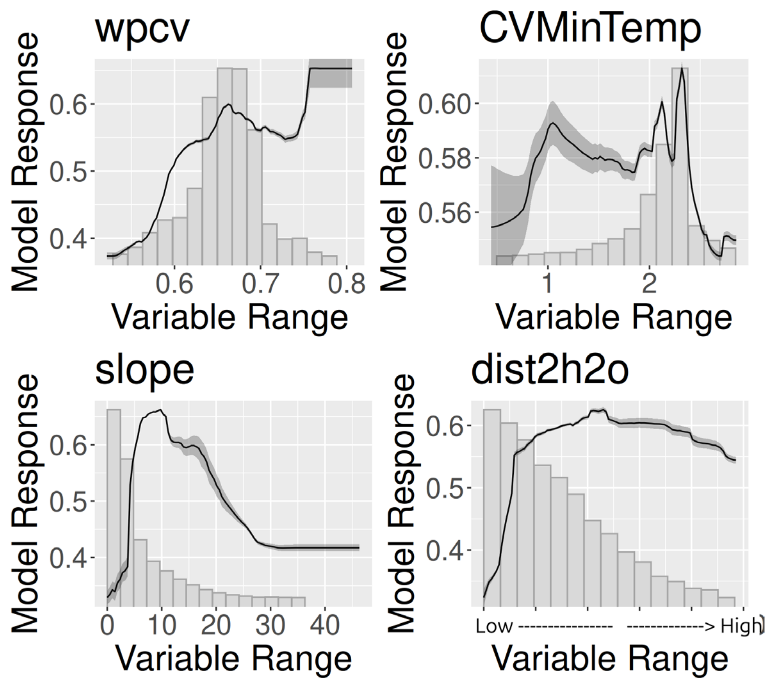
Stat	Training	Training SD	Testing	Testing SD
AUC	1.0000	0.0000	1.0000	0.0000
TSS	1.0000	0.0000	1.0000	0.0000
BI	0.9993	0.0011	0.9682	0.0279

COTO Table 2a. Percent contributions for input variables for Corynorhinus townsendii for ensemble models using available algorithms. The top four contributing variables are highlighted, except for the mx model which had only two meaningful contributing variables.

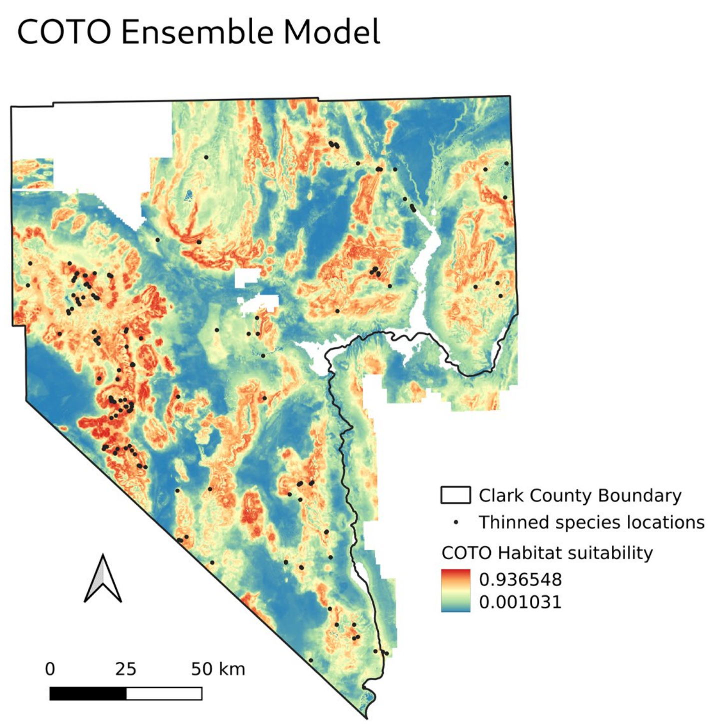
Variable	mx	rf
Dist2Cliff.r	0	9.2
bare.r	0	6.5
bedrock.r	0	9.5
CVMinTemp.r	31.7	7.3
slope.r	0.4	11.7
soil1.r	0.2	9.3
tmin.r	1.7	7
vpdMax.r	0.7	8.3
wpcv.r	65.1	9.1
dist2h2o.r	0	11.1
Vegetation Division.f	0	11



COTO Figure 1a. Continuous Boyce Indices [CBI] for the Corynorhinus townsendii ensemble model prediction



COTO Figure 2a. Partial response curves for the four most influential variables in the ensemble model. Lines and bars indicate the variables as described in ANMI Figure 2b.



COTO Figure 3a. Ensemble model of habitat suitability for Corynorhinus townsendii in the vicinity of Clark County, NV. Hotter colors indicate higher predicted habitat values, and filled black circles show thinned species locations.

Model Discussion

Areas of high habitat suitability for Corynorhinus townsendii are broadly distributed across Clark County. In general, high habitat suitability for this species occurs at higher elevation, whereas habitat suitability is low in valleys and lowlands (COTO Figure 3a). An area of highly suitable habitat is found across the Spring Mountains, and adjacent areas of the Birdsprings Range (COTO Figure 3a). Highly suitable habitat is also found along the Las Vegas Range, Sheep Range, and the Muddy Mountains (COTO Figure 3a).

The locality data for this species consisted of 225 records within the buffered modeling area, which had a very high degree of overlap. Spatial thinning of the data reduced the number of localities used for training and testing to 133 records.

COTO modeled without Clark County vegetation divisions, and with buffered area.

Habitat Model Performance

Performance metrics show the ensemble modelhad excellent performance overall (COTO Table 1b). The continuous Boyce Index (CBI) indicates that once predicted suitability exceeds approximately 80%, observed presences occur up to five times more often than expected at random (COTO Figure 1b). Testing AUC = 0.9914 (SD = 0.0061) and TSS = 0.9314 (SD = 0.0328) further support strong rank discrimination across thresholds (AUC) and high thresholded accuracy at the selected cutoff (TSS) (see Box 1; COTO Table 1).

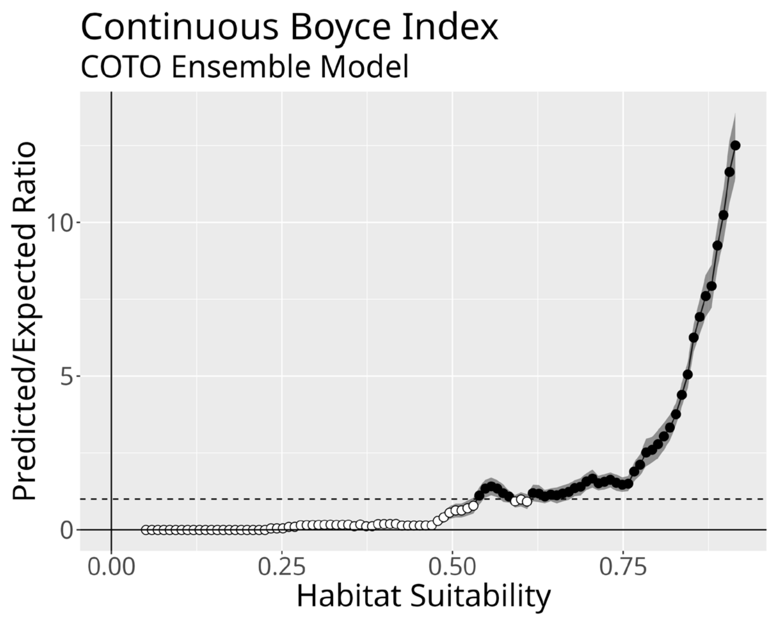
Predictor importance across model types highlights several key variables for Townsend's big-eared bat (COTO Table 2b). Examination of the four most influential variables reveals consistent patterns with three variables influential across all algroithms. The coefficient of variation in winter precipitation (wpcv) was important in all four models; suitability is low when wpcv is low, increases nearly linearly, and remains high once wpcv exceeds 0.7 (COTO Figure 2b). Terrain slope (slope) was influential in two models, with peak suitability around 10 degrees and lower suitability at other values (COTO Figure 2b). The first principal component of soil sand/silt/clay composition (soil1) was important in two models; suitability is high when soil1 < 10, then drops sharply and stays low when soil1 > 10 (COTO Figure 2b). The coefficient of variation of minimum temperature (CVMinTemp) mattered in one model, with highest suitability below 2 and lower suitability at higher values (COTO Figure 2b).

COTO Table 1b. Model performance values for Corynorhinus townsendii models giving Area under the Receiver Operator Curve (AUC), Boyce Index (BI), and True Skill Statistic (TSS) for the ensemble model.

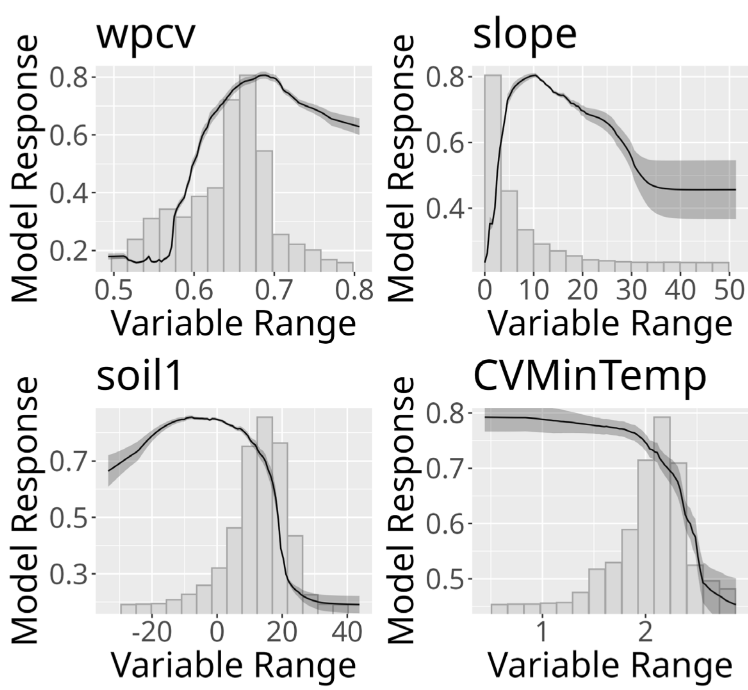
Stat	**Training**	**Training SD**	**Testing**	**Testing SD**
AUC	0.9915	0.0015	0.9914	0.0061
TSS	0.9250	0.0103	0.9314	0.0328
BI	0.9603	0.0172	0.8932	0.0686

COTO Table 2b. Percent contributions for input variables for Corynorhinus townsendii for ensemble models using available algorithms. The top four contributing variables are highlighted, except that the gam and gbm models only had three important variables and the mx model had only two meaningful contributing variables.

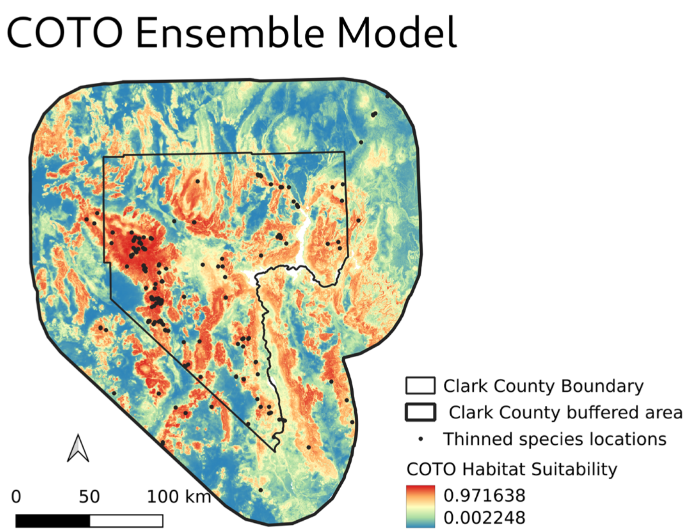
Variable	gam	gbm	mx	rf
bare.r	0	0	0	6.6
bedrock.r	0	2.1	0	11
CVMinTemp.r	4	0	20.6	6.8
slope.r	20	54	0.1	20.6
soil1.r	34	31.5	0.4	15.8
tmin.r	2	0	1.9	6.2
vpdMax.r	6	1	0.2	10.6
wpcv.r	33	11.4	76.8	15.2
dist2h2o.r	1	0	0	7.1



COTO Figure 1b. Continuous Boyce Indices [CBI] for the Corynorhinus townsendii ensemble model prediction



COTO Figure 2b. Partial response curves for the four most influential variables in the ensemble model. Lines and bars indicate the variables as described in ANMI Figure 2b.



COTO Figure 3b. Ensemble model of habitat suitability for Corynorhinus townsendii in the vicinity of Clark County, NV. Hotter colors indicate higher predicted habitat values, and filled black circles show thinned species locations.

Model Discussion

Areas of high habitat suitability for Corynorhinus townsendii are broadly distributed across Clark County. In general, high habitat suitability for this species occurs at higher elevation, whereas habitat suitability is low in valleys and lowlands (COTO Figure 3b). An area of highly suitable habitat is found across the Spring Mountains, and adjacent areas of the Birdsprings Range (COTO Figure 3b). Highly suitable habitat is also found along the Las Vegas Range, Sheep Range, and the Muddy Mountains (COTO Figure 3b). Within the buffered area, highly suitable habitat is also found in the Ivanpah Mountains, Mesquite Mountains and New York Mountains in California, as well as the Black Mountains in Arizona (COTO Figure 3b). Moderately suitable habitat is widely distributed throughout this region.

The locality data for this species consisted of 225 records within the buffered modeling area, which had a very high degree of overlap. Spatial thinning of the data reduced the number of localities used for training and testing to 157 records.

CYMU - Blue Diamond cholla (Cylindropuntia multigeniculata)

CYMU modeled with Clark County vegetation divisions, and without buffered area.

Habitat Model Performance

Performance statistics show the ensemble model reliably distinguishes suitable habitat (CYMU Table 1a). The continuous Boyce Index curve indicates that once predicted suitability exceeds about 80%, observed presences occur up to 50 times more often than expected by chance (CYMU Figure 1a). Testing AUC = 0.9999 (SD 0.0003) and TSS = 0.9981 (SD 0.0083) demonstrate excellent rank discrimination across thresholds (AUC) and very high accuracy at the chosen cutoff (TSS) (Box 1; CYMU Table 1a).

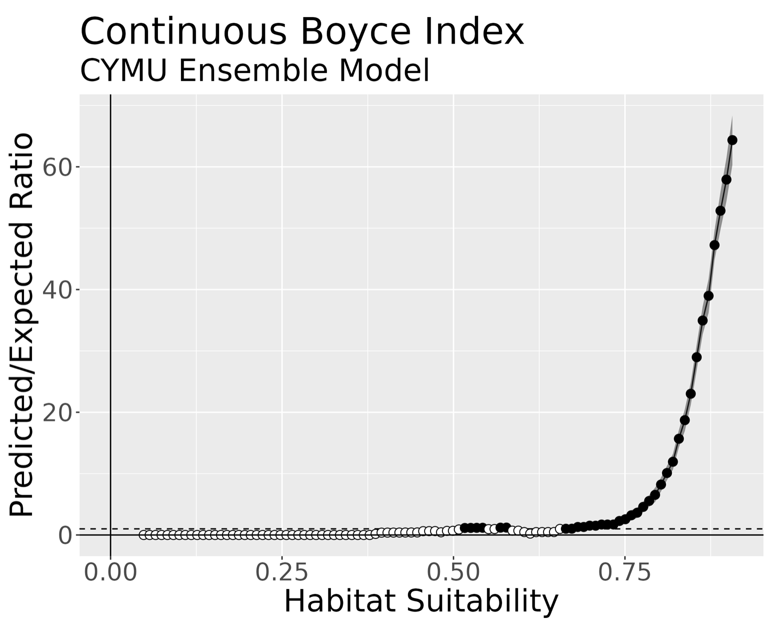
Predictor importance for the Blue Diamond cholla ensemble highlights several influential variables (CYMU Table 2a). We examined the top four for their relative influence. Depth to bedrock (bedrock) was among the most influential in two of the three contributing models (CYMU Table 2a). Suitability is high where bedrock is shallow, roughly less than 1000 m; it drops sharply above 1000 m and remains low at greater depths (CYMU Figure 2a). The silica index (silicaIndex) elevates suitability when values exceed 1.05 (CYMU Figure 2a). The fractional cover of bare ground (bare) supports high suitability when below 75%; above 75% suitability declines immediately and stays low (CYMU Figure 2a). Soil pH (soilpH) is associated with low suitability below pH 7, with suitability increasing as pH rises above 7 (CYMU Figure 2a).

CYMU Table 1a. Model performance values for Cylindropuntia multigeniculata models giving Area under the Receiver Operator Curve (AUC), Boyce Index (BI), and True Skill Statistic (TSS) for the ensemble model.

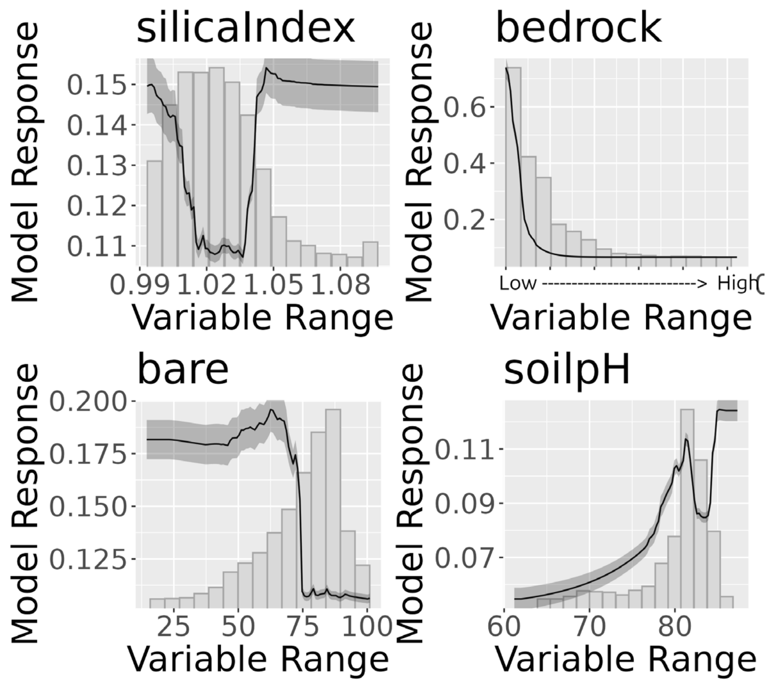
Stat	Training	Training SD	Testing	Testing SD
AUC	0.9999	0.0001	0.9999	0.0003
TSS	0.9934	0.0044	0.9981	0.0083
BI	0.8951	0.0473	0.9476	0.0607

CYMU Table 2a. Percent contributions for input variables for Cylindropuntia multigeniculata for ensemble models using available algorithms. The top four contributing variables are highlighted, except that the mx model had only two meaningful contributing variables.

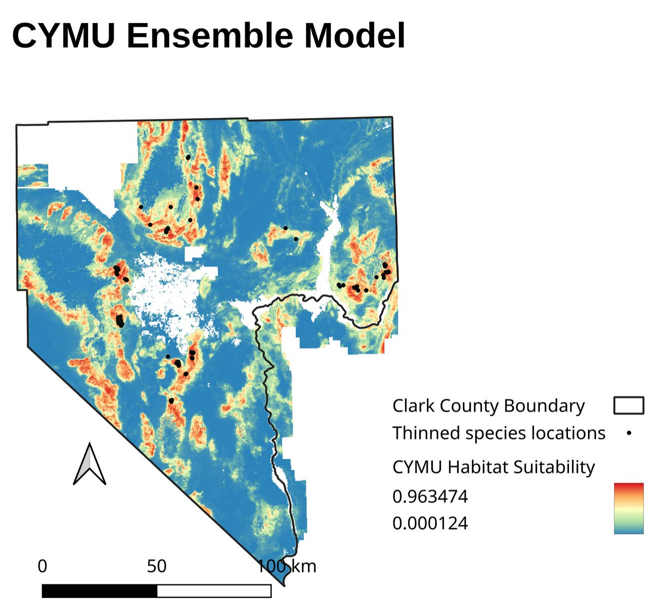
Variable	gbm	mx	rf
bare.r	12.2	0.6	10.4
bedrock.r	45.8	0.0	18.0
NDVIDuration.r	0.0	0.0	2.8
slope.r	2.4	1.0	9.1
soil1.r	0.0	1.1	8.1
tmin.r	0.3	3.5	11.7
vpdMax.r	0.0	0.5	10.6
soilpH.r	0.3	12.1	10.0
silicaIndex.r	0.0	79.0	3.1
gypsum.r	0.0	1.5	2.8
VegetationDivisionsCC.f	38.8	0.8	13.3



CYMU Figure 1a. Continuous Boyce Indices [CBI] for the Cylindropuntia multigeniculata ensemble model prediction



CYMU Figure 2a. Partial response curves for the four most influential variables in the ensemble model. Lines and bars indicate the variables as described in ANMI Figure 2b.



CYMU Figure 3a. Ensemble model of habitat suitability for Cylindropuntia multigeniculata in the vicinity of Clark County, NV. Hotter colors indicate higher predicted habitat values, and filled black circles show thinned species locations.

Model Discussion

Areas of high habitat suitability for Cylindropuntia multigeniculata are broadly distributed across Clark County. In general, high habitat suitability for this species occurs at mid-level elevation, whereas habitat suitability is low in valleys and lowlands, and also low at high elevations (CYMU Figure 3a). An area of highly suitable habitat is found around the periphery of the Sheep Range, and adjacent areas of the Las Vegas Range, and in the Muddy Mountains (CYMU Figure 3a). Highly suitable habitat is also found along the Spring Mountains and the McCullough Range (CYMU Figure 3a). Moderately suitable habitat is also distributed throughout this region.

The locality data for this species consisted of 52,587 records within the buffered modeling area, which had a very high degree of overlap. Spatial thinning of the data reduced the number of localities used for training and testing to 1164 records.

CYMU modeled without Clark County vegetation divisions, and with buffered area.

Habitat Model Performance

Performance metrics for the ensemble model indicate a strong, high performing model (CYMU Table 1b). The continuous Boyce Index (CBI) shows that once predicted suitability exceeds roughly 80%, observed presences occur up to 20 times more often than expected by chance (CYMU Figure 1b). Test AUC = 0.9985 (SD = 0.0024) and TSS = 0.9794 (SD = 0.0283), demonstrating excellent rank discrimination across thresholds (AUC) and high thresholded accuracy at the chosen cutoff (TSS) (see Box 1; CYMU Table 1b).

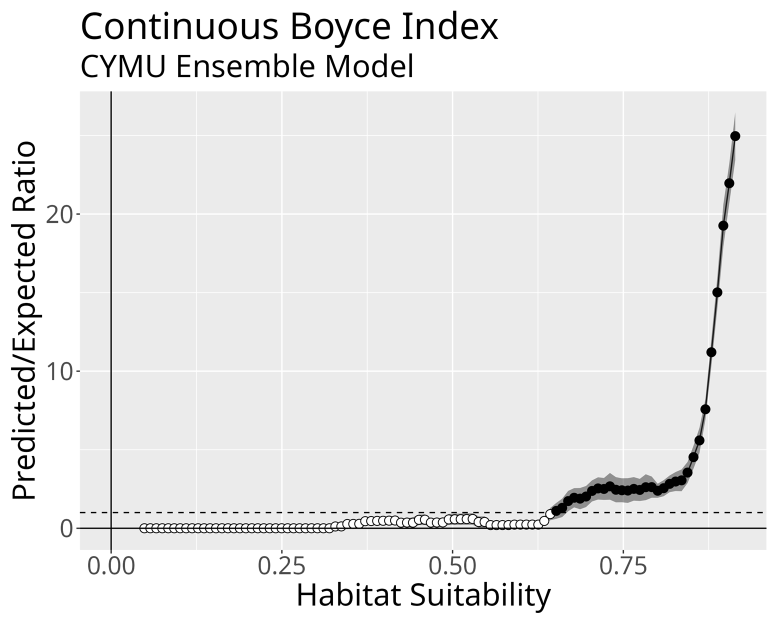
Variable importance results for the Blue Diamond cholla highlight several key predictors across model types (CYMU Table 2b). Among the top four predictors, the coefficient of variation in winter precipitation (wpcv) was influential in all four models: suitability is low around wpcv = 0.5, rises to a peak near 0.7, and declines thereafter (CYMU Figure 2b). Depth to bedrock (bedrock) ranked among the most important in three of four models: suitability is high when depth is relatively shallow—about 1000 m—and decreases as depth increases (CYMU Figure 2b). Absolute minimum temperature (tmin) was important in two models, with highest suitability between -5 and 0 C and lower suitability outside that range (CYMU Figure 2b). The silica index (silicaIndex) was influential in one model; suitability is greatest when values exceed 1.05, with some evidence that values below 1 also correspond to high suitability (CYMU Figure 2b).

CYMU Table 1b. Model performance values for Cylindropuntia multigeniculata models giving Area under the Receiver Operator Curve (AUC), Boyce Index (BI), and True Skill Statistic (TSS) for the ensemble model.

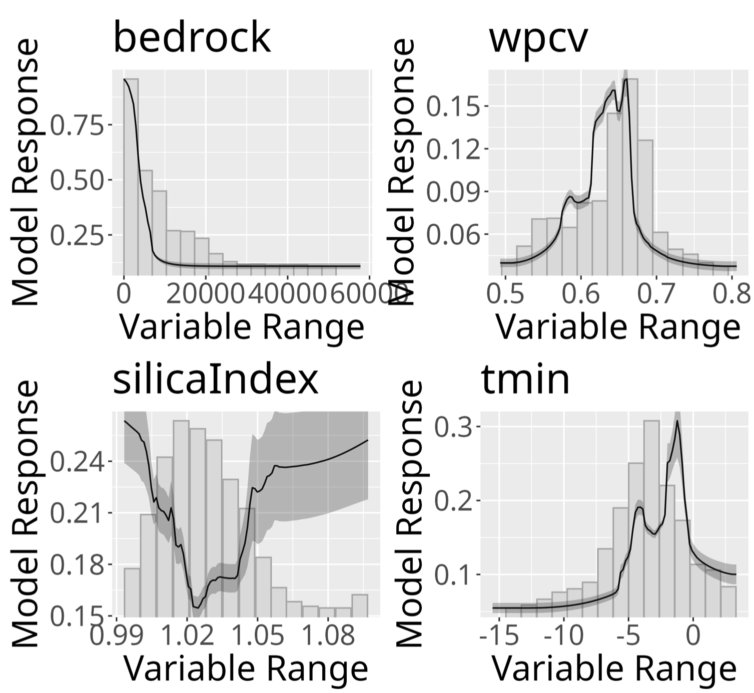
Stat	Training	Training SD	Testing	Testing SD
AUC	0.9989	0.0004	0.9985	0.0024
TSS	0.9717	0.0075	0.9794	0.0283
BI	0.8751	0.0403	0.8142	0.1111

CYMU Table 2b. Percent contributions for input variables for Cylindropuntia multigeniculata for ensemble models using available algorithms. The top four contributing variables are highlighted, except that the mx model had only two meaningful contributing variables.

Variable	gam	gbm	mx	rf
bare.r	1.0	0.0	0.4	5.5
bedrock.r	31.0	79.5	0.0	25.1
NDVIDuration.r	0.0	0.0	0.0	2.3
slope.r	6.0	3.4	0.6	12.1
tmin.r	19.0	6.5	2.4	10.2
vpdMax.r	1.0	0.0	1.0	7.2
wpcv.r	28.0	9.4	32.2	17.8
soilpH.r	12.0	0.7	3.9	12.6
silicaIndex.r	2.0	0.6	58.1	4.1
gypsum.r	0.0	0.0	1.4	3.1

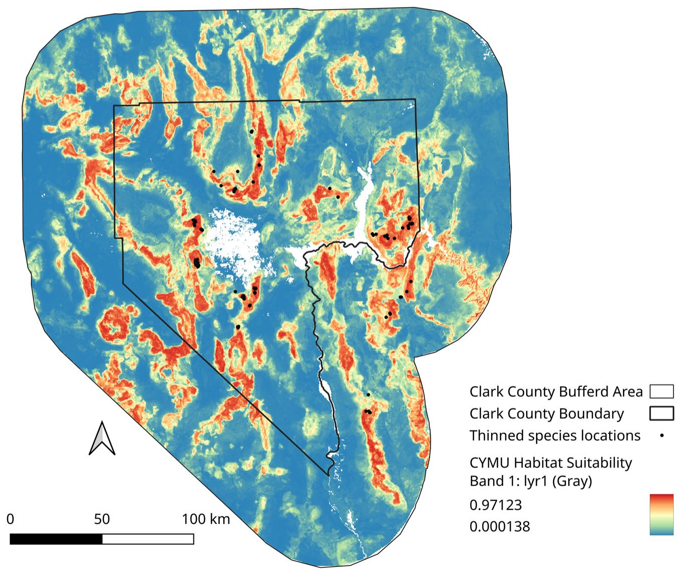


CYMU Figure 1b. Continuous Boyce Indices [CBI] for the Cylindropuntia multigeniculata ensemble model prediction



CYMU Figure 2b. Partial response curves for the four most influential variables in the ensemble model. Lines and bars indicate the variables as described in ANMI Figure 2b.

CYMU Ensemble Model



CYMU Figure 3b. Ensemble model of habitat suitability for Cylindropuntia multigeniculata in the vicinity of Clark County, NV. Hotter colors indicate higher predicted habitat values, and filled black circles show thinned species locations.

Model Discussion

Areas of high habitat suitability for Cylindropuntia multigeniculata are broadly distributed across Clark County. In general, high habitat suitability for this species occurs at mid-level elevation, whereas habitat suitability is low in valleys and lowlands, and also low at the highest elevations (CYMU Figure 3b). An area of highly suitable habitat is found around the periphery of the Sheep Range, and adjacent areas of the Las Vegas Range, and in the Muddy Mountains (CYMU Figure 3b). Highly suitable habitat is also found along the Spring Mountains and the McCullough Range (CYMU Figure 3b). Within the buffered area, highly suitable habitat is apparent in the Nopah Range, Mesquite mountains, Kingston Range and New York Mountains in California. In nearby portions of Arizona, the Black Mountains and Grapevine Mesa also show high habitat suitability (CYMU Figure 3b).

The locality data for this species consisted of 52,578 records within the buffered modeling area, which had a very high degree of overlap. Spatial thinning of the data reduced the number of localities used for training and testing to 1177 records.

DAPL - Monarch butterfly, (Danaus plexippus)

DAPL modeled with Clark County vegetation divisions, and without buffered area.

Habitat Model Performance

Performance metrics show the ensemble model reliably identifies suitable habitat (DAPL Table 1a). The CBI profile indicates that once predicted suitability surpasses roughly 80%, observed presences occur up to 50 times more often than expected by chance (DAPL Figure 1a). Test results were AUC = 1.0000 (SD = 0.0000) and TSS = 1.0000 (SD = 0.0000), reflecting perfect rank discrimination and thresholded accuracy at the chosen cutoff (see Box 1; DAPL Table 1a).

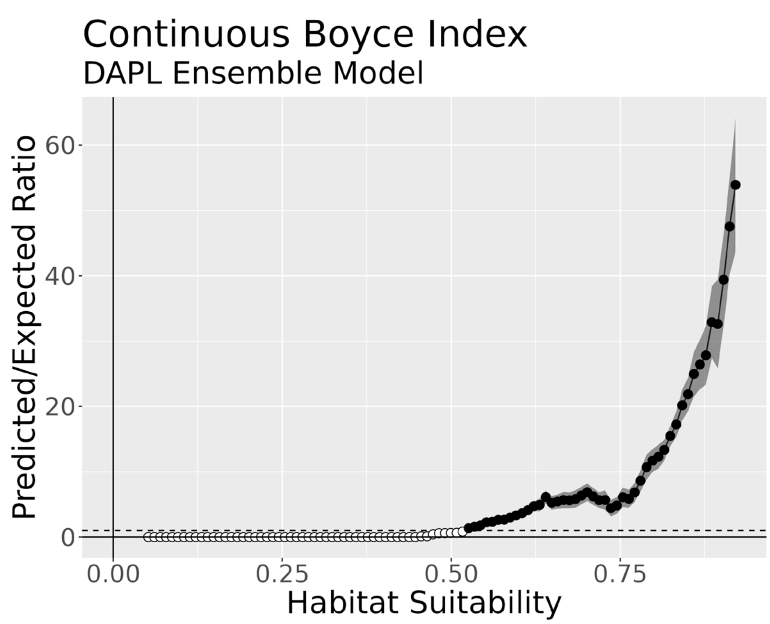
Across model types, a few predictors contributed disproportionately to performance (DAPL Table 2a). Milkweed suitability—derived with the same workflow using GBIF occurrence data and then included as a predictor—was among the top variables in all three constituent models (DAPL Table 2a). Monarch suitability closely tracks milkweed suitability, with higher milkweed suitability corresponding to higher monarch habitat suitability (DAPL Figure 2a). Terrain aspect influenced suitability in two models: conditions are most favorable on northeast-facing slopes (0–90°), decline for other orientations, and are especially poor on south- or west-facing aspects (DAPL Figure 2a). The silica index was important in one model; suitability peaks when silicaIndex exceeds 1.00 and stays moderately high at larger values (DAPL Figure 2a). The coefficient of variation in winter precipitation (wpcv) was also influential in one model; suitability is low when wpcv < 0.7, then rises sharply and remains high for wpcv > 0.7 (DAPL Figure 2a).

DAPL Table 1a. Model performance values for Danaus plexippus models giving Area under the Receiver Operator Curve (AUC), Boyce Index (BI), and True Skill Statistic (TSS) for the ensemble model.

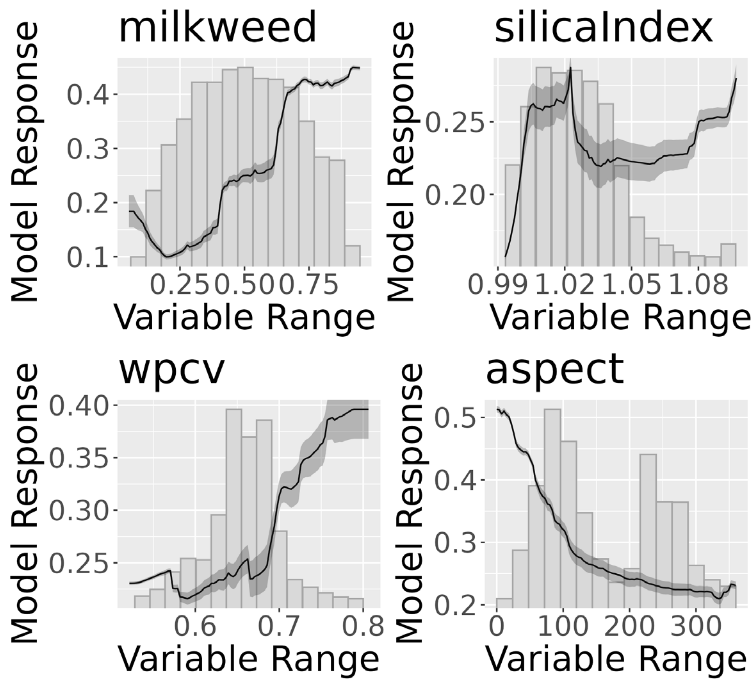
Stat	Training	Training SD	Testing	Testing SD
AUC	1.0000	0.0000	1.0000	0.0000
TSS	1.0000	0.0000	1.0000	0.0000
BI	0.9727	0.0159	0.9020	0.0581

DAPL Table 2a. Percent contributions for input variables for Danaus plexippus for ensemble models using available algorithms. The top four contributing variables are highlighted, except that the gbm model only had three meaningful contributing variables.

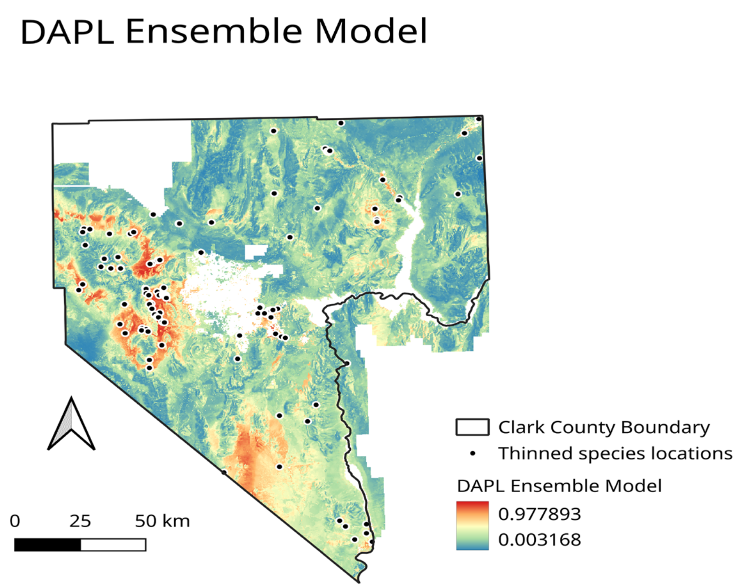
Variable	gbm	mx	rf
aspect.r	15	0.1	9.4
CVMinTemp.r	0	4.1	6.6
slope.r	0	0.2	5.6
vpdMax.r	0	0.2	6
wp.r	0	0.1	7.5
wpcv.r	0	16.9	7.8
soilpH.r	0	2.3	5.1
silicaIndex.r	0	25.5	6.3
gypsum.r	0	0.2	4.6
dist2h2o.r	0	0	9.5
milkweed.r	78	50.4	19.3
VegetationDivisions	7	0.1	12.3



DAPL Figure 1a. Continuous Boyce Indices [CBI] for the Danaus plexippus ensemble model prediction



DAPL Figure 2a. Partial response curves for the four most influential variables in the ensemble model. Lines and bars indicate the variables as described in ANMI Figure 2b.



DAPL Figure 3a. Ensemble model of habitat suitability for Danaus plexippus in the vicinity of Clark County, NV. Hotter colors indicate higher predicted habitat values, and filled black circles show thinned species locations.

Model Discussion

Areas of high habitat suitability for Danaus plexippus are somewhat broadly distributed across Clark County. In general, high habitat suitability for this species occurs at mid-level elevation, whereas habitat suitability is low in valleys and lowlands, and also low at high elevations (DAPL Figure 3a). An area of highly suitable habitat is found around the southeastern periphery of the South McCullough Mountains (DAPL Figure 3a). Highly suitable habitat is also found north of the Muddy Mountains and near the Muddy River at Overton (DAPL Figure 3a). Moderately suitable habitat is distributed broadly across this region (DAPL Figure 3a).

The locality data for this species consisted of 517 records within the buffered modeling area, which had a very high degree of overlap. Spatial thinning of the data reduced the number of localities used for training and testing to 108 records.

DAPL modeled without Clark County vegetation divisions, and with buffered area.

Habitat Model Performance

Performance metrics indicate a robust ensemble that effectively discriminates suitable habitat (DAPL Table 1b). The continuous Boyce Index shows that once predicted suitability exceeds roughly 80%, presence is up to 15 times more likely than random expectation (DAPL Figure 1b). Testing AUC = 0.9799 (SD 0.0103) and TSS = 0.8668 (SD 0.0419) further demonstrate excellent rank discrimination and high thresholded accuracy (see Box 1; DAPL Table 1b).

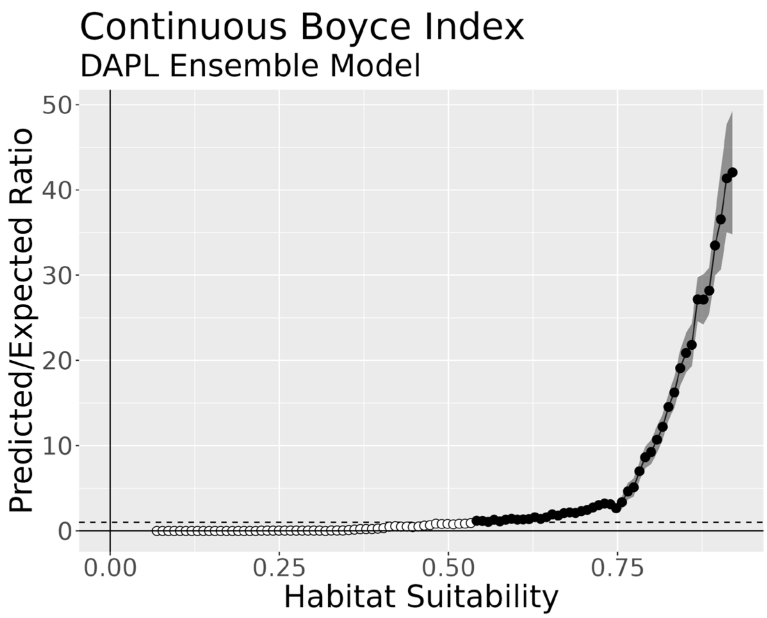
Variable importance across model types highlights several key predictors (DAPL Table 2b). We examined the four most influential variables to characterize their response patterns. Milkweed habitat suitability, modeled using the same methods, was included as a predictor and ranked among the top variables in all four constituent models (DAPL Table 2b). Monarch suitability closely mirrors milkweed suitability: areas favorable to milkweed tend to be favorable to Monarchs (DAPL Figure 2b). The silica index (silicaIndex) was influential in two models, with suitability peaking near ~1.0 and declining at both lower and higher values (DAPL Figure 2b). The coefficient of variation of winter precipitation (wpcv) was also important in two models, with suitability low at small wpcv values and increasing approximately linearly as wpcv grows (DAPL Figure 2b). Finally, the coefficient of variation in minimum temperature (CVMinTemp) mattered in two models; suitability is highest when CVMinTemp is low (<2) and decreases as it increases (DAPL Figure 2b).

DAPL Table 1b. Model performance values for Danaus plexippus models giving Area under the Receiver Operator Curve (AUC), Boyce Index (BI), and True Skill Statistic (TSS) for the ensemble model

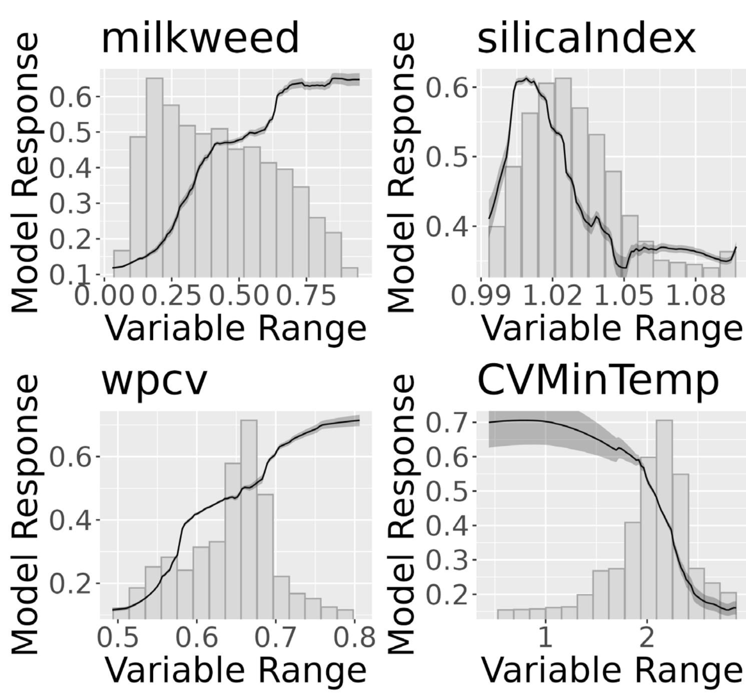
Stat	Training	Training SD	Testing	Testing SD
AUC	0.9822	0.0024	0.9799	0.0103
TSS	0.8620	0.0101	0.8668	0.0419
BI	0.9959	0.0009	0.9396	0.0454

DAPL Table 2b. Percent contributions for input variables for Danaus plexippus for ensemble models using available algorithms. The top four contributing variables are highlighted.

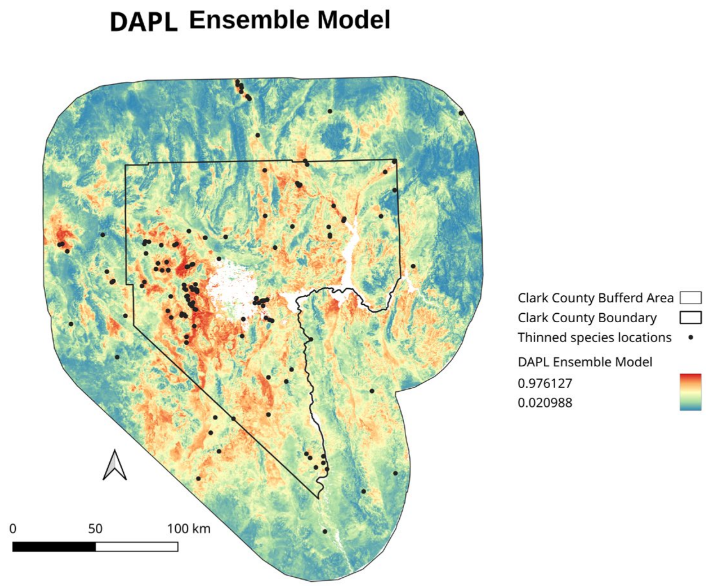
Variable	gam	gbm	mx	rf
aspect.r	5.1	8.3	0.0	9.1
CVMinTemp.r	21.4	2.8	13.7	8.3
slope.r	0.0	1.1	0.1	7.2
vpdMax.r	13.3	0.0	0.6	6.4
wp.r	5.1	0.7	0.0	8.3
wpcv.r	11.2	3.6	24.8	11.0
soilpH.r	1.0	0.0	0.5	5.1
silicaIndex.r	13.3	3.9	49.6	8.8
gypsum.r	6.1	8.3	0.2	8.6
dist2h2o.r	0.0	0.0	0.0	9.1
milkweed.r	23.5	71.5	10.5	18.1



DAPL Figure 1b. Continuous Boyce Indices [CBI] for the Danaus plexippus ensemble model prediction



DAPL Figure 2b. Partial response curves for the four most influential variables in the Ensemble model. Lines and bars indicate the variables as described in ANMI Figure 2b.



DAPL Figure 3b. Ensemble model of habitat suitability for Danaus plexippus in the vicinity of Clark County, NV. Hotter colors indicate higher predicted habitat values, and filled black circles show thinned species locations.

Model Discussion

Areas of highly suitable habitat for Danaus plexippus are somewhat broadly distributed across Clark County and the buffered area. In general, high habitat suitability for this species occurs at mid-level elevation, whereas habitat suitability is low in valleys and lowlands, and also low at the highest elevations (DAPL Figure 3b). An area of highly suitable habitat is found around the southeastern periphery of the South McCullough Mountains (DAPL Figure 3b). Highly suitable habitat is also found north of the Muddy Mountains and near the Muddy River at Overton (DAPL Figure 3b). Outside of the Clark County boundary, highly suitable habitat is found adjacent to the Virgin River, and on the south shore of Lake Mead, east of Arch Mountain (DAPL Figure 3b). Moderately suitable habitat is distributed broadly across this region (DAPL Figure 3b).

The locality data for this species consisted of 517 records within the buffered modeling area, which had a very high degree of overlap. Spatial thinning of the data reduced the number of localities used for training and testing to 141 records.

EUMA – Spotted Bat, (Euderma maculatum)

EUMA modeled with Clark County vegetation divisions, and without buffered area.

No model could be produced because too few data points were avaiable to be modeled with point locations.

EUMA modeled without Clark County vegetation divisions, and with buffered area.

Habitat Model Performance

The ensemble model's performance values indicate a robust model with the ability to discriminate areas of suitable habitat well (EUMA Table 1b). The continuous Boyce Index (CBI) curve indicates that as the habitat suitability estimate increases above ca. 80%, species presence is predicted up to 30 times greater than would be expected at random (EUMA Figure 1b). Testing AUC = 1.0000 (SD = 0.0000) and TSS = 1.0000 (SD = 0.0000), indicating strong rank discrimination across thresholds (AUC) and high thresholded accuracy at the selected cutoff (TSS) (see Box 1; EUMA Table 1b).

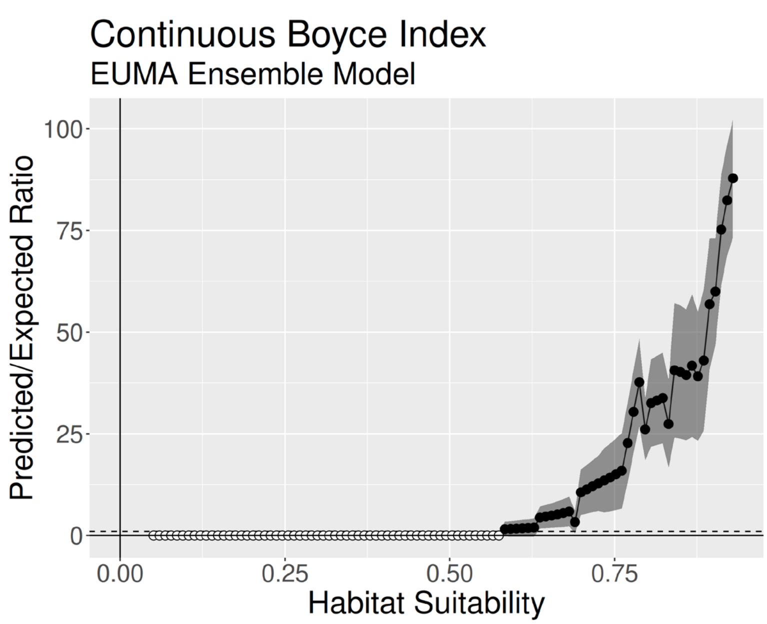
The variables used in the ensemble model of habitat suitability for Euderma maculatum for each model type indicate that some variables are of great importance (EUMA Table 2b). The top four most important variables in the ensemble model were examined to identify any important patterns for those variables. The coefficient of variation in minimum temperature (CVMinTemp) was an important variable in all four models (EUMA Table 2b). Habitat suitability is low when the CVMinTemp is low (< 2.2), with higher values of CVMinTemp resulting in rapidly increasing habitat suitability that peaks near 2.4 and declines moderately thereafter (EUMA Figure 2b). The first principal component of sand/silt/clay (soil1) was an important variable in three of the four models (EUMA Table 2b). Habitat suitability is highest when the value of the principal component was below zero, and habitat suitability declines rapidly as values of the principal component increase above zero (EUMA Figure 2b).The fractional component of bare ground (bare) was also an important variable in two of the four models (EUMA Table 2b). Habitat suitability is very low when the bare is less than ca. 85 percent and suitability increases rapidly to a maximum when bare exceeds 85 percent (EUMA Figure 2b). The coefficient of variation of winter precipitation (wpcv) was also an important variable in one model (EUMA Table 2b). Habitat suitability is lower whenever the wpcv is low, but generally increases as the wpcv increases. Relatively high 95 percent confidence intervals of the estimate precludes further interpretation. (EUMA Figure 2b).

EUMA Table 1b. Model performance values for Euderma maculatum models giving Area under the Receiver Operator Curve (AUC), Boyce Index (BI), and True Skill Statistic (TSS) for the ensemble model

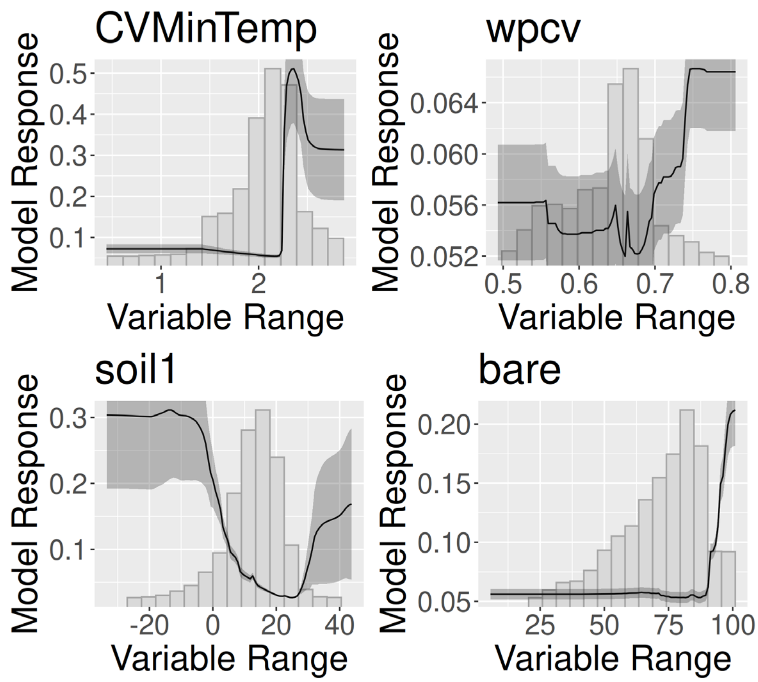
Stat	Training	Training SD	Testing	Testing SD
AUC	1.0000	0.0000	1.0000	0.0000
TSS	1.0000	0.0000	1.0000	0.0000
BI	0.9738	0.0155	0.8129	0.1765

EUMA Table 2b. Percent contributions for input variables for Euderma maculatum for ensemble models using available algorithms. The top four contributing variables are highlighted, except that the gam model only had three meaningful variables and the mx model had only two meaningful contributing variables.

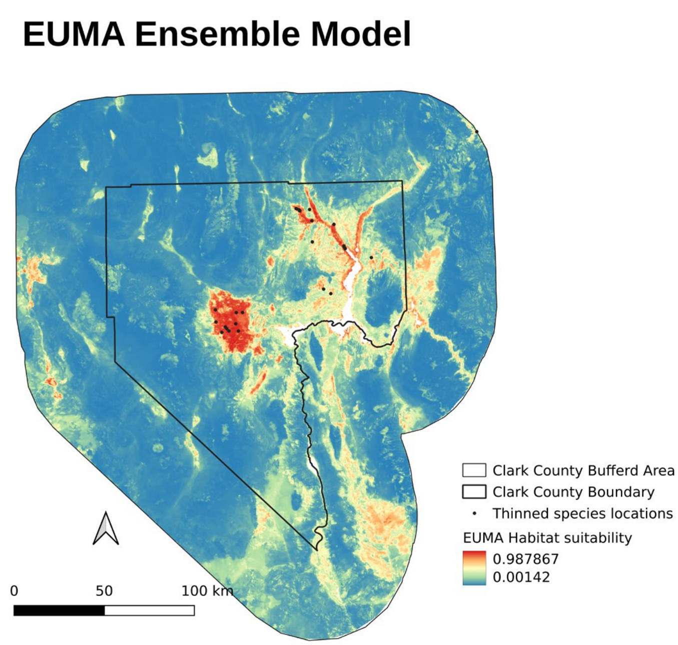
Variable	gam	gbm	mx	rf
aspect.r	1.00	10.50	0.00	7.60
bare.r	0.00	41.00	0.10	17.60
bedrock.r	6.00	0.70	0.00	4.20
coarse.r	0.00	2.70	0.30	7.30
CVMinTemp.r	57.00	20.60	31.30	13.40
ppt.r	0.00	1.30	0.60	5.30
slope.r	1.00	3.00	0.50	6.30
soil1.r	33.00	17.90	0.20	14.80
tmin.r	0.00	0.40	2.10	6.50
vpdMax.r	0.00	1.90	0.30	7.90
wp.r	2.00	0.00	1.10	3.80
wpcv.r	0.00	0.00	63.50	5.20



EUMA Figure 1b. Continuous Boyce Indices [CBI] for the Euderma maculatum ensemble model prediction



EUMA Figure 2b. Partial response curves for the four most influential variables in the Ensemble model. Lines and bars indicate the variables as described in ANMI Figure 2b.



EUMA Figure 3b. Ensemble model of habitat suitability for Euderma maculatum in the vicinity of Clark County, NV. Hotter colors indicate higher predicted habitat values, and filled black circles show thinned species locations.

Model Discussion

Areas of high habitat suitability for Euderma maculatum are somewhat narrowly distributed across Clark County and the buffered area. Areas of highly suitable habitat are found near the Virgin River, the Muddy River and the Meadow Valley Wash in northeastern Clark County (EUMA Figure 3b). Highly suitable habitat is also found in and around the City of Las Vegas (EUMA Figure 3b). Outside of the Clark County boundary, moderately suitable habitat is found adjacent to Lake Mead, near the Million Hills (EUMA Figure 3b). We caution against relying heavily on the analysis of important variables in this case because the species primarily occurs in and around the City of Las Vegas, and it is known that the environmental variables used are NOT represented correctly in urban areas. Indeed, this is the reason that most available datasets mask (or omit) the unreliable environmental variables in urban or other highly modified environments.

The locality data for this species consisted of 27 records within the buffered modeling area. Spatial thinning of the data reduced the number of localities used for training and testing to 25 records.

HESU - Banded Gila monster, (Heloderma suspectum cinctum)

HESU modeled with Clark County vegetation divisions, and without buffered area.

Habitat Model Performance

Performance metrics for the ensemble model indicate strong ability to distinguish suitable habitat (HESU Table 1a). The continuous Boyce Index (CBI) shows that once habitat suitability exceeds roughly 80%, observed presence is up to three times higher than random expectation (HESU Figure 1a). Test results of AUC = 0.9975 (SD = 0.0013) and TSS = 0.9543 (SD = 0.0153) confirm excellent rank discrimination (AUC) and high thresholded accuracy at the chosen cutoff (TSS) (see Box 1; HESU Table 1a).

Variable importance across the four model types highlights several key predictors for Gila monster habitat (HESU Table 2a) that are consistent among models. Among the top four, the coefficient of variation of winter precipitation (wpcv) was influential in all four models. Suitability is low when wpcv is below 0.6, increases sharply toward 0.7, and then declines quickly beyond 0.7 (HESU Figure 2a). Maximum vapor pressure deficit (vpdMax) was important in three of the four models, with suitability low below about 26 hPa, peaking near 32 hPa, and decreasing at higher values (HESU Figure 2a). Distance to cliffs (Dist2Cliff) also mattered in three models, with highest suitability near cliffs and a rapid, sustained drop in suitability as distance increases (HESU Figure 2a). The coefficient of variation in minimum temperature (CVMinTemp) was important in two models; suitability is low at small

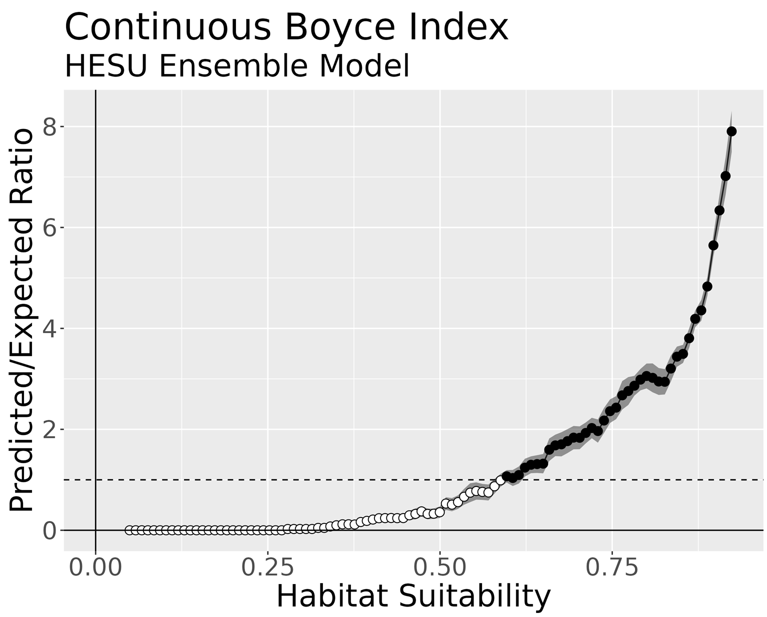
CVMinTemp values, rises to a peak around 2.3, and then diminishes at greater values (HESU Figure 2a).

HESU Table 1a. Model performance values for Heloderma suspectum cinctum models giving Area under the Receiver Operator Curve (AUC), Boyce Index (BI), and True Skill Statistic (TSS) for the ensemble model.

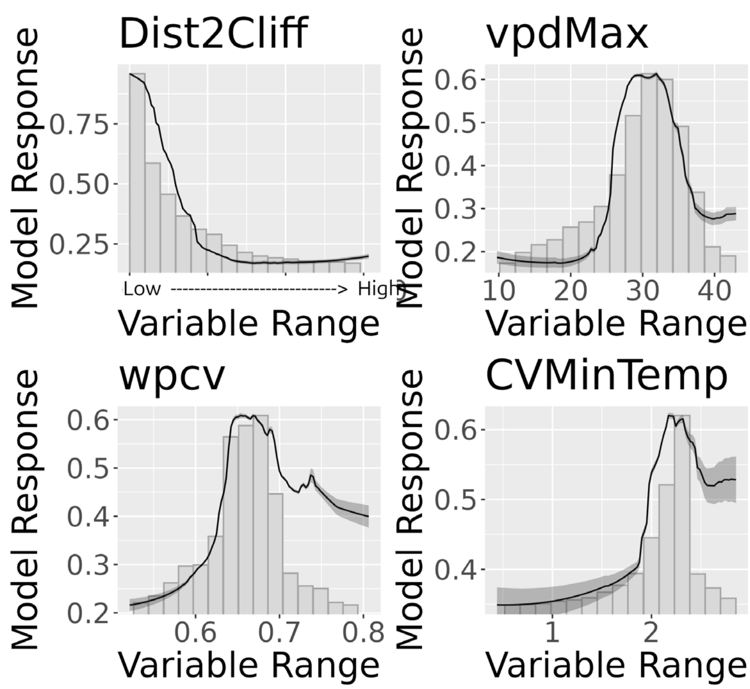
Stat	**Training**	**Training SD**	**Testing**	**Testing SD**
AUC	0.9976	0.0003	0.9975	0.0013
TSS	0.9523	0.0047	0.9543	0.0153
BI	0.9985	0.0005	0.9693	0.0256

HESU Table 2a. Percent contributions for input variables for Heloderma suspectum cinctum for ensemble models using available algorithms. The top four contributing variables are highlighted, except that the mx model only had three meaningful contributing variables.

Variable	gam	gbm	mx	rf
aspect.r	6.9	0.0	0.0	7.4
bare.r	5.0	0.0	0.1	5.8
CVMinTemp.r	1.0	1.7	41.7	10.7
slope.r	5.9	0.0	0.2	8.5
soil1.r	2.0	0.0	0.1	6.4
tmin.r	3.0	2.1	2.1	10.1
vpdMax.r	23.8	23.2	1.1	14.8
wpcv.r	6.9	3.9	54.4	10.6
Dist2Cliff.r	45.5	39.0	0.0	19.1
VegetationDivisionsCC.f	0.0	30.0	0.3	6.5

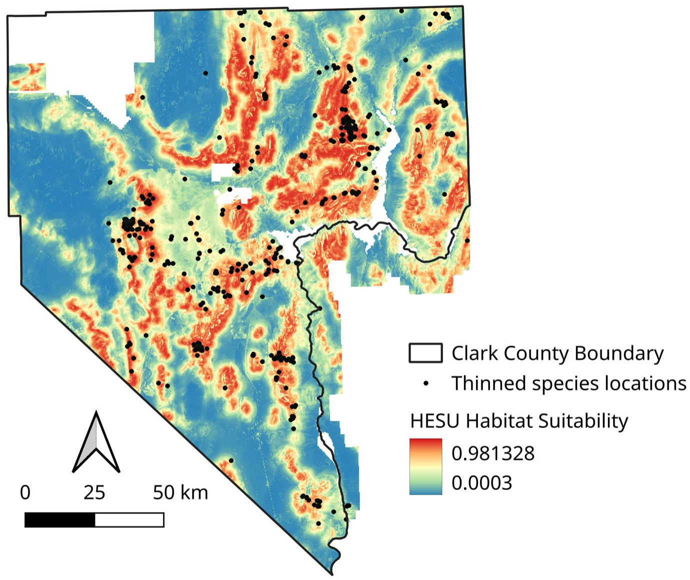


HESU Figure 1a. Continuous Boyce Indices [CBI] for the Heloderma suspectum cinctum ensemble model prediction



HESU Figure 2a. Partial response curves for the four most influential variables in the Ensemble model. Lines and bars indicate the variables as described in ANMI Figure 2b.

HESU Ensemble Model



HESU Figure 3a. Ensemble model of habitat suitability for Heloderma suspectum cinctum in Clark County, NV. Hotter colors indicate higher predicted habitat values, and filled black circles show thinned species locations.

Model Discussion

Areas with high habitat suitability for Heloderma suspectum cinctum are broadly distributed across Clark County. In general, high habitat suitability for this species occurs in areas with mid- to higher elevation, whereas habitat suitability is low in valleys and lowlands (HESU Figure 3a). In northern Clark County, an area of highly suitable habitat is found in the Sheep Range, and adjacent areas of the Las Vegas Range, and in the Muddy Mountains (HESU Figure 3a). Highly suitable habitat is also found along the southeast edge of the Spring Mountains and the McCullough Range (HESU Figure 3a). Moderately suitable habitat is also distributed widely throughout this region.

The locality data for this species consisted of 3157 records within the buffered modeling area, which had a very high degree of overlap. Spatial thinning of the data reduced the number of localities used for training and testing to 501 records.

HESU modeled without Clark County vegetation divisions, and with buffered area.

Habitat Model Performance

Performance metrics for the ensemble model show strong discriminatory power for identifying suitable habitat (HESU Table 1b). The continuous Boyce Index (CBI) curve indicates that once habitat suitability exceeds roughly 80%, predicted species presence is up to 20 times higher than random expectations (HESU Figure 1b). Testing results of AUC = 0.9938 (SD = 0.0019) and TSS = 0.9162 (SD = 0.0165) confirm excellent rank discrimination across thresholds (AUC) and high accuracy at the chosen cutoff (TSS) (see Box 1; HESU Table 1b).

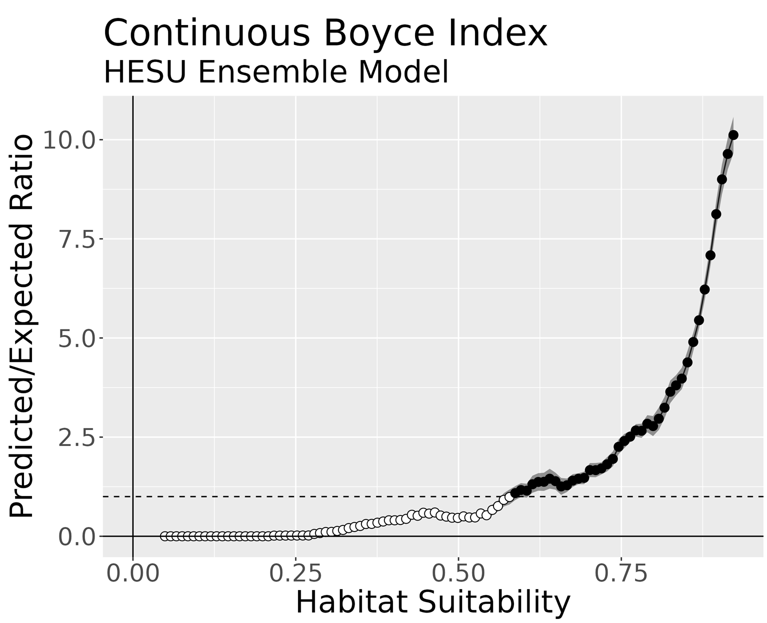
Variable importance analyses across model types highlight several key predictors for Gila monster habitat suitability (HESU Table 2b). We examined the top four to assess response patterns. The coefficient of variation in minimum temperature (CVMinTemp) was influential in all four model types. Suitability is low at low CVMinTemp, increases to a peak near 2.4, and then declines at higher values (HESU Figure 2b). The coefficient of variation of winter precipitation (wpcv) was important in three of the four models; suitability is moderate below 0.6, rises sharply toward 0.66, then declines steeply once wpcv exceeds 0.68 (HESU Figure 2b). Maximum vapor pressure deficit (vpdMax) mattered in two models; suitability is low below about 22 hPa, climbs rapidly to a maximum around 35 hPa, and then decreases somewhat at higher values (HESU Figure 2b). Distance to cliffs (Dist2Cliff) was also important in three models, with suitability highest near cliffs and dropping quickly with increasing distance (HESU Figure 2b).

HESU Table 1b. Model performance values for Heloderma suspectum cinctum models giving Area under the Receiver Operator Curve (AUC), Boyce Index (BI), and True Skill Statistic (TSS) for the ensemble model.

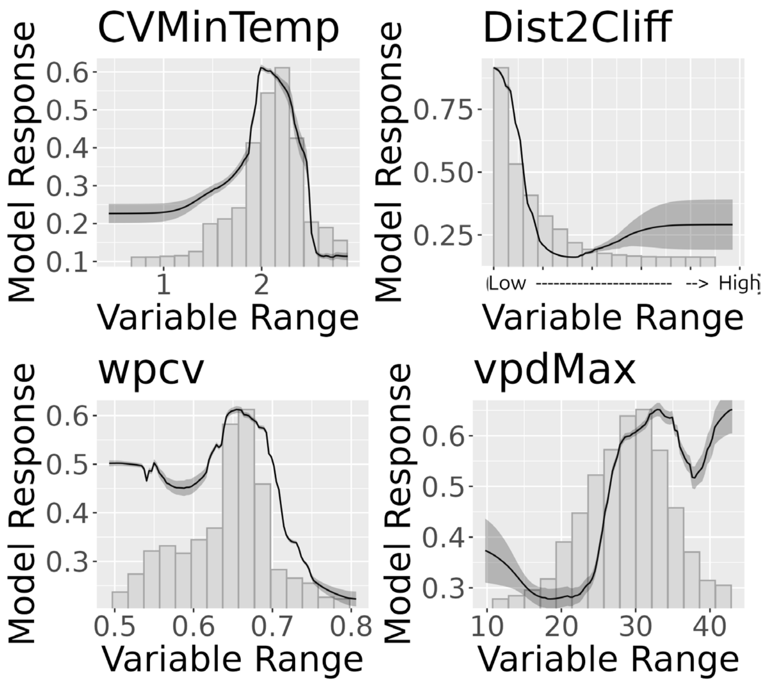
Stat	Training	Training SD	Testing	Testing SD
AUC	0.9948	0.0004	0.9938	0.0019
TSS	0.9199	0.0053	0.9162	0.0165
BI	0.9901	0.0039	0.9585	0.0243

HESU Table 2b. Percent contributions for input variables for Heloderma suspectum cinctum for ensemble models using available algorithms. The top four contributing variables are highlighted, except that the gam and gbm models only had three meaningful variables, and the mx model only had two meaningful variables.

Variable	gam	gbm	mx	rf
aspect.r	9.00	0.00	0.00	7.40
bare.r	16.00	0.90	0.40	9.30
CVMinTemp.r	17.00	26.20	64.20	16.60
slope.r	7.00	0.00	0.30	9.10
soil1.r	2.00	0.00	0.10	6.50
tmin.r	5.00	5.80	4.50	10.80
vpdMax.r	9.00	7.70	1.90	10.40
wpcv.r	9.00	0.00	28.50	10.60
Dist2Cliff.r	26.00	59.40	0.00	19.20

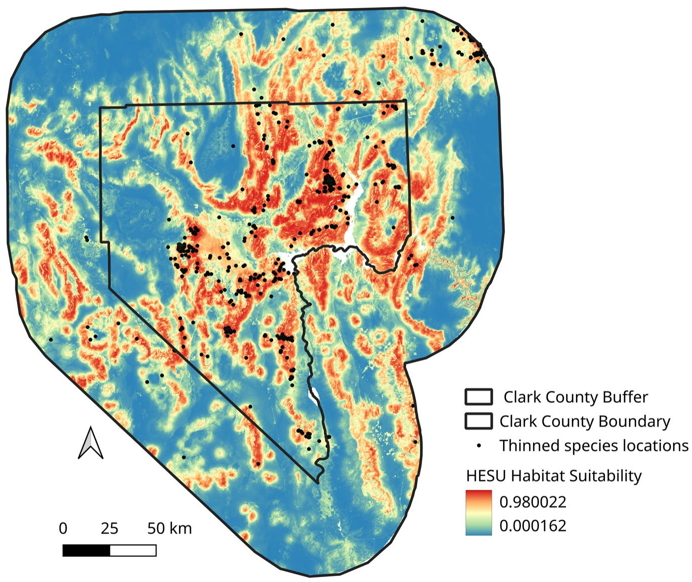


HESU Figure 1b. Continuous Boyce Indices [CBI] for the Heloderma suspectum cinctum ensemble model prediction



HESU Figure 2b. Partial response curves for the four most influential variables in the Ensemble model. Lines and bars indicate the variables as described in ANMI Figure 2b.

HESU Ensemble Model



HESU Figure 3b. Ensemble model of habitat suitability for Heloderma suspectum cinctum in the vicinity of Clark County, NV. Hotter colors indicate higher predicted habitat values, and filled black circles show thinned species locations.

Model Discussion

Areas with high habitat suitability for Heloderma suspectum cinctum are broadly distributed across Clark County and the buffered area. High habitat suitability for this species occurs in areas with mid- to higher elevation, whereas habitat suitability is low in valleys and lowlands, and at extremely high elevations (HESU Figure 3b). Moderately suitable habitat is also distributed widely throughout this region. Notably, an area of highly suitable habitat is found in the Sheep Range, and adjacent areas of the Las Vegas Range, and in the Muddy Mountains (HESU Figure 3b). Highly suitable habitat is also found along the southeast edge of the Spring Mountains and the McCullough Range (HESU Figure 3b).

The locality data for this species consisted of 3157 records within the buffered modeling area, which had a very high degree of overlap. Spatial thinning of the data reduced the number of localities used for training and testing to 594 records.

MEPO - Polished blazing star, (Mentzelia polita)

MEPO modeled with Clark County vegetation divisions, and without buffered area.

Habitat Model Performance

Performance metrics for the ensemble model indicate a highly robust ability to distinguish suitable habitat (MEPO Table 1a). The continuous Boyce Index (CBI) curve shows that when predicted suitability exceeds about 80%, observed presences occur up to 30 times more often than expected by chance (MEPO Figure 1a). Testing AUC was 1.0000 (SD = 0.0000) and TSS was 1.0000 (SD = 0.0000), indicating perfect rank-based discrimination across thresholds and perfect thresholded accuracy at the selected cutoff (Box 1; MEPO Table 1a).

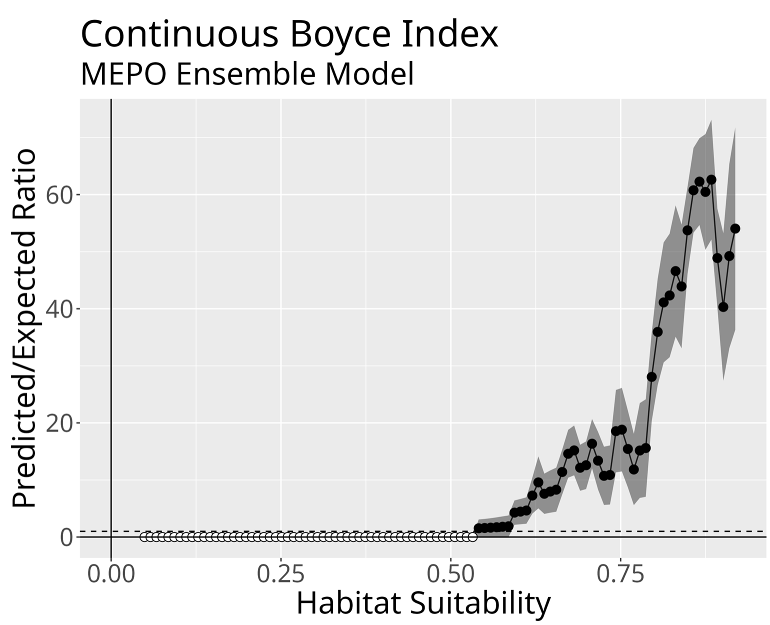
Predictor importance for the Polished blazing star ensemble highlights several key variables across model types (MEPO Table 2a). We assessed the four most influential predictors for emergent trends. The silica index (silicaIndex) was important in all three constituent models (MEPO Table 2a); suitability is highest when silicaIndex is below 1.0 and declines asymptotically as values increase (MEPO Figure 2a). Terrain slope (slope) ranked among the top predictors in two of the three models (MEPO Table 2a); suitability is very low at slopes under 5°, then rises and remains high at slopes ≥10° (MEPO Figure 2a). The coefficients of variation for winter precipitation (wpcv) and minimum temperature (CVMinTemp) were also influential (MEPO Table 2a), but no clear response patterns could be inferred owing to wide confidence intervals and generally weak or inconsistent relationships (MEPO Figure 2a).

MEPO Table 1a. Model performance values for Mentzelia polita models giving Area under the Receiver Operator Curve (AUC), Boyce Index (BI), and True Skill Statistic (TSS) for the ensemble model.

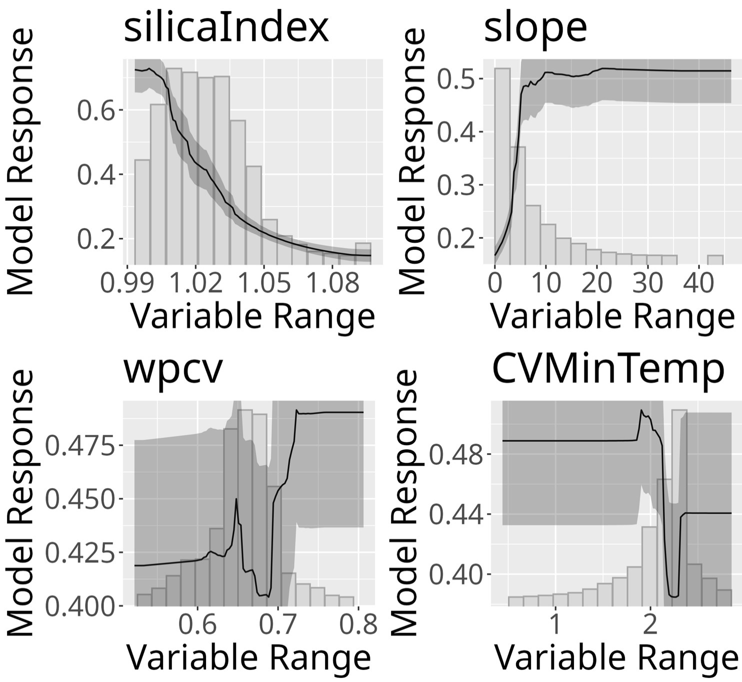
Stat	Training	Training SD	Testing	Testing SD
AUC	1.0000	0.0000	1.0000	0.0000
TSS	1.0000	0.0000	1.0000	0.0000
BI	0.9349	0.0389	0.8018	0.1873

MEPO Table 2a. Percent contributions for input variables for Mentzelia polita for ensemble models using available algorithms. The top four contributing variables are highlighted, except for the mx model had only three meaningful contributing variables.

Variable	gbm	mx	rf
bare.r	0.0	0.0	5.0
bedrock.r	1.3	0.0	7.5
CVMinTemp.r	1.8	3.5	10.4
NDVIDuration.r	0.4	0.0	3.5
slope.r	6.9	0.1	9.5
tmin.r	0.5	0.3	9.2
vpdMax.r	0.0	0.2	9.0
wp.r	0.0	0.0	6.9
wpcv.r	0.0	9.8	5.8
soilpH.r	0.6	0.8	6.1
silicaIndex.r	6.3	85.0	12.5
gypsum.r	4.9	0.1	5.7
VegetationDivisionsCC.f	77.5	0.2	8.9

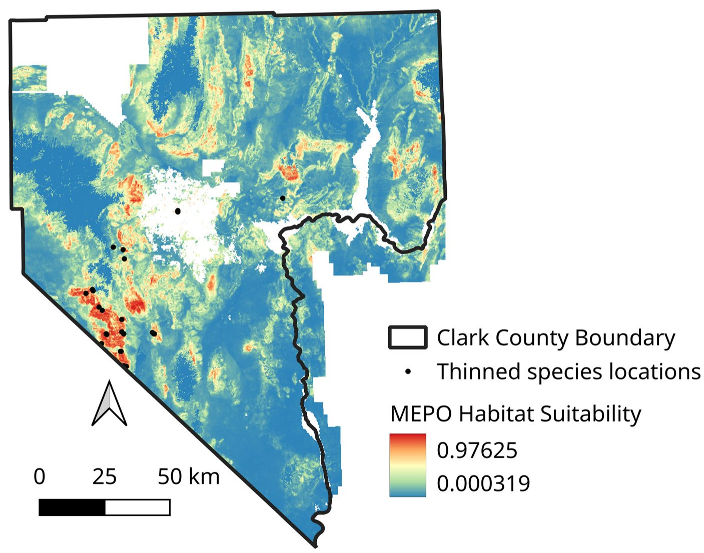


MEPO Figure 1a. Continuous Boyce Indices [CBI] for the Mentzelia polita ensemble model prediction



MEPO Figure 2a. Partial response curves for the four most influential variables in the Mentzelia polita Ensemble model. Lines and bars indicate the variables as described in ANMI Figure 2b.

MEPO Ensemble Model



MEPO Figure 3a. Ensemble model of habitat suitability for Mentzelia polita in the vicinity of Clark County, NV. Hotter colors indicate higher predicted habitat values, and filled black circles show thinned species locations.

Model Discussion

Areas with high habitat suitability for Mentzelia polita have a scattered distribution across Clark County. An area of highly suitable habitat is found from east of La Madre Mountain to the City of Las Vegas(HESU Figure 3a). Highly suitable habitat is also found in the hills surrounding Sandy Valley and in the nearby Birdsprings Range (HESU Figure 3a). Other areas of highly suitable habitat can be found near the Muddy Mountains and Lime Ridge in eastern Clark County (HESU Figure 3a).Moderately suitable habitat is also distributed widely throughout this region (HESU Figure 3a).

The locality data for this species consisted of 76 records within the buffered modeling area, which had a very high degree of overlap. Spatial thinning of the data reduced the number of localities used for training and testing to 25 records.

MEPO modeled without Clark County vegetation divisions, and with buffered area.

Habitat Model Performance

Performance metrics show the ensemble effectively distinguishes suitable habitat (MEPO Table 1b). The continuous Boyce Index (CBI) indicates that once suitability exceeds roughly 80%, expected presence can be up to 10 times higher than random (MEPO Figure 1b). Test

AUC = 0.9970 (SD 0.0057) and TSS = 0.9750 (SD 0.0444) confirm excellent rank discrimination (AUC) and high thresholded accuracy at the chosen cutoff (TSS) (see Box 1; MEPO Table 1b).

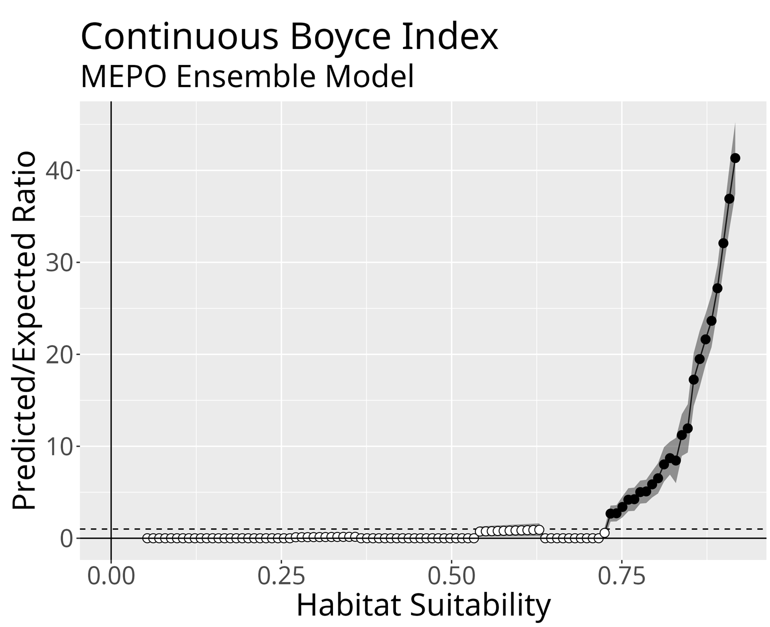
Predictor importance for the Polished blazing star highlights several key variables across model types (MEPO Table 2b). We examined the four most influential variables to characterize their response patterns. Silica index (silicaIndex) was important in three of the four models, with suitability peaking near 1.0 and declining asymptotically as values increase (MEPO Figure 2b). Terrain slope (slope) was among the top predictors in two models: suitability is very low below 5°, rises and remains high at ≥10°, then decreases somewhat beyond 20° while staying moderate at steeper slopes (MEPO Figure 2b). Winter precipitation variability (wpcv) mattered in two models; suitability is low at 0.5–0.6, increases rapidly above 0.6, and peaks near 0.75 (MEPO Figure 2b). Absolute minimum temperature (tmin) was important in three model types, with highest suitability around −3°C and lower suitability at both warmer and colder values (MEPO Figure 2b).

MEPO Table 1b. Model performance values for Mentzelia polita models giving Area under the Receiver Operator Curve (AUC), Boyce Index (BI), and True Skill Statistic (TSS) for the ensemble model.

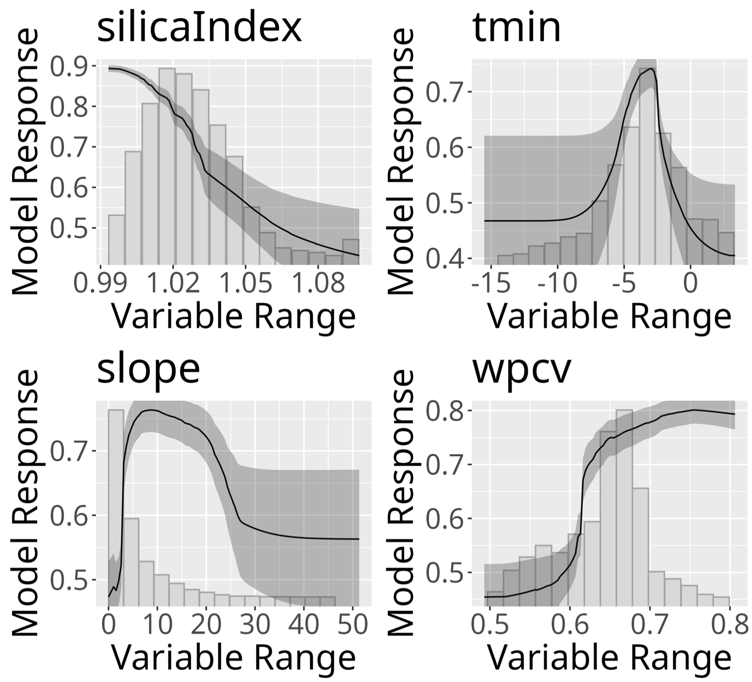
Stat	Training	Training SD	Testing	Testing SD
AUC	0.9992	0.0008	0.9970	0.0057
TSS	0.9849	0.0127	0.9750	0.0444
BI	0.9631	0.0098	0.9516	0.0468

MEPO Table 2b. Percent contributions for input variables for Mentzelia polita for ensemble models using available algorithms. The top four contributing variables are highlighted, except that the mx model only had two meaningful contributing variables.

Variable	gam	gbm	mx	rf
bare.r	1.0	0.0	0.0	3.8
bedrock.r	3.9	1.6	0.0	7.3
CVMinTemp.r	2.0	2.1	8.4	9.8
NDVIDuration.r	3.9	2.5	0.0	4.7
slope.r	19.6	12.2	0.0	9.7
tmin.r	22.5	10.4	0.6	13.2
vpdMax.r	2.9	8.0	0.1	9.5
wp.r	1.0	0.0	0.0	4.4
wpcv.r	2.0	5.3	24.4	10.3
soilpH.r	18.6	1.8	0.2	6.7
silicaIndex.r	7.8	55.4	66.1	17.3
gypsum.r	14.7	0.7	0.0	3.3

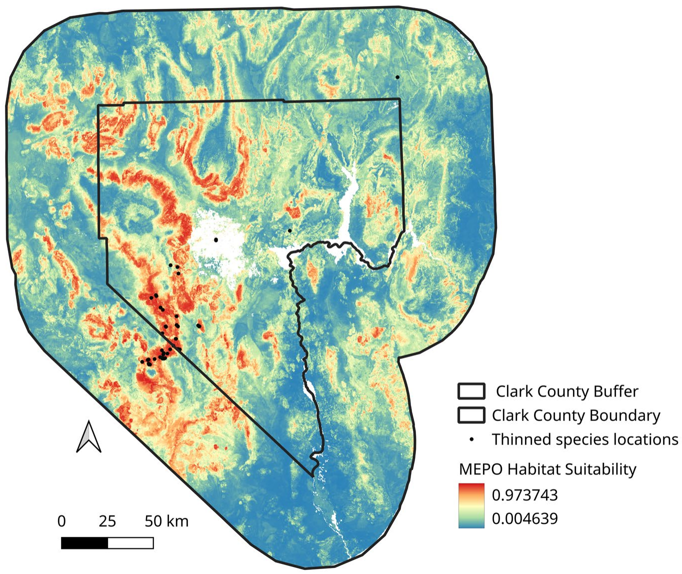


MEPO Figure 1b. Continuous Boyce Indices [CBI] for the Mentzelia polita ensemble model prediction



MEPO Figure 2b. Partial response curves for the four most influential variables in the Mentzelia polita Ensemble model. Lines and bars indicate the variables as described in ANMI Figure 2b.

MEPO Ensemble Model



MEPO Figure 3b. Ensemble model of habitat suitability for Mentzelia polita in the vicinity of Clark County, NV. Hotter colors indicate higher predicted habitat values, and filled black circles show thinned species locations.

Model Discussion

Areas of highly suitable habitat for Mentzelia polita have a scattered distributed across region, most commonly occurring along the periphery of Mountain ranges (MEPO Figure 3b). Areas of highly suitable habitat can be found around the edges of the Spring Mountains, Half Pint Range, Spotted Range, Pintwater Range, Sheep Range, Las Vegas Range, and nearby areas (MEPO Figure 3b). Highly suitable habitat is also found near Sandy Valley, in the nearby Birdsprings Range, as well as the Mesquite Mountains and Ivanpah Mountains in California (MEPO Figure 3b). Smaller areas of highly suitable habitat can be found near the Muddy Mountains and Wilson Ridge (MEPO Figure 3b).Moderately suitable habitat is distributed widely throughout this region (MEPO Figure 3b).

The locality data for this species consisted of 76 records within the buffered modeling area, which had a very high degree of overlap. Spatial thinning of the data reduced the number of localities used for training and testing to 49 records.

PEBIbi - Yellow Two-toned beardtongue, (Penstemon bicolor var. bicolor)

PEBIbi modeled with Clark County vegetation divisions, and without buffered area.

Habitat Model Performance

The ensemble model's performance values indicate a robust model with the ability to discriminate areas of suitable habitat well (PEBIbi Table 1a). The continuous Boyce Index (CBI) curve indicates that as the habitat suitability estimate increases above ca. 80%, species presence is predicted up to eight times greater than would be expected at random (PEBIbi Figure 1a). Testing AUC = 1.0000 (SD = 0.0000) and TSS = 1.0000 (SD = 0.0000), indicating strong rank discrimination across thresholds (AUC) and high thresholded accuracy at the selected cutoff (TSS) (see Box 1; PEBIbi Table 1a). Test CBI = 0.8817 (SD = 0.1005), indicating evaluation presences occur more often in high-suitability bins than expected at random (PEBIbi Figure 1a; see Box 1).

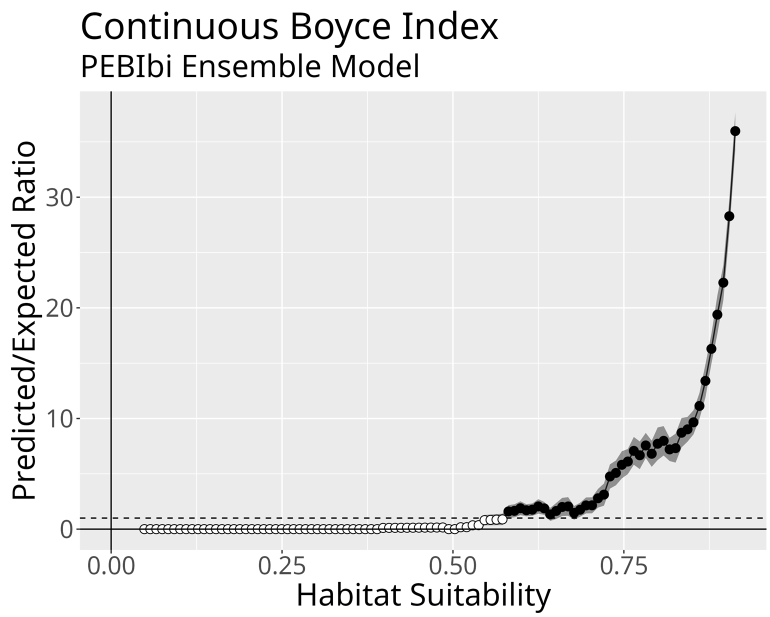
The variables used in the ensemble model of habitat suitability for the Yellow two-toned beardtongue for each model type indicate that some variables are of great importance (PEBIbi Table 2a). The top four most important variables in the ensemble model were examined to identify any important patterns for those variables. The maximum vapor pressure deficit (vpdMax) was an important variable in all three of the model types (PEBIbi Table 2a). Habitat suitability is low when the vpdMax is less than ca. 25 hPa but increases rapidly to a maximum at 28 hPa, thereafter, higher values of vpdMax have lower habitat suitability (PEBIbi Figure 2a). The coefficient of variation in minimum temperature (CVMinTemp) was also an important variable for each of the three model types (PEBIbi Table 2a). Habitat suitability is moderately high when CVMinTemp is low, but rises to a peak as CVMinTemp approaches a value ca. 2.1, higher values of CVMinTemp result in a dramatic and immediate reduction in habitat suitability (PEBIbi Figure 2a). The gypsum composition (gypsum) was an important variable in two of the three models used. Habitat suitability is low, only when the gypsum value is below a value of about three, high habitat suitability is indicated whenever the gypsum value exceeds five (PEBIbi Figure 2a). The coefficient of variation of winter precipitation (wpcv) was an important variable in two of the three model types used (PEBIbi Table 2a). Habitat suitability is low whenever the wpcv is below 0.6, but suitability increases rapidly to a maximum as the value of wpcv approaches 0.67, thereafter habitat suitability declines rapidly as the value of wpcv exceeds 0.7 (PEBIbi Figure 2a).

PEBIbi Table 1a. Model performance values for Penstemon bicolor ssp. bicolor models giving Area under the Receiver Operator Curve (AUC), Boyce Index (BI), and True Skill Statistic (TSS) for the ensemble model.

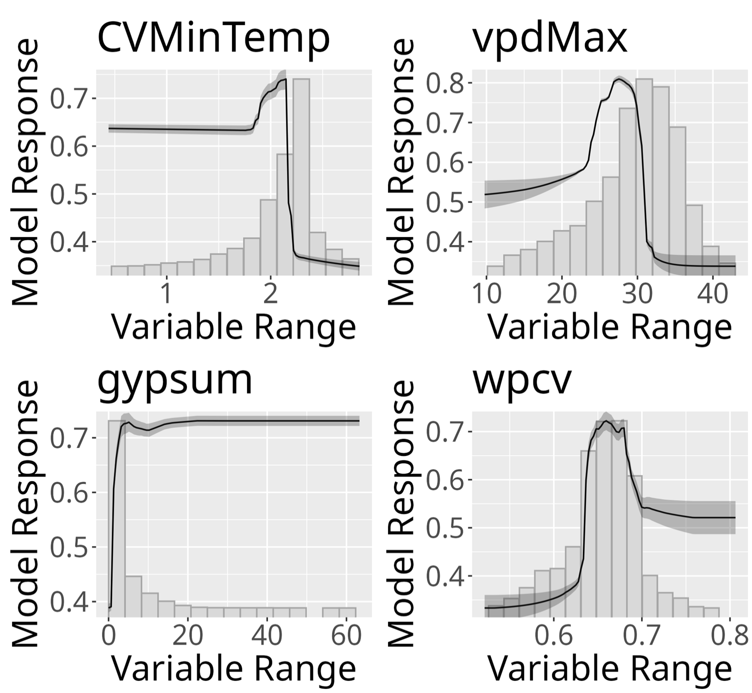
Stat	Training	Training SD	Testing	Testing SD
AUC	1.0000	0.0000	1.0000	0.0000
TSS	1.0000	0.0000	1.0000	0.0000
BI	0.9797	0.0088	0.8817	0.1005

PEBIbi Table 2a. Percent contributions for input variables for Penstemon bicolor ssp. bicolor for ensemble models using available algorithms. The top four contributing variables are highlighted.

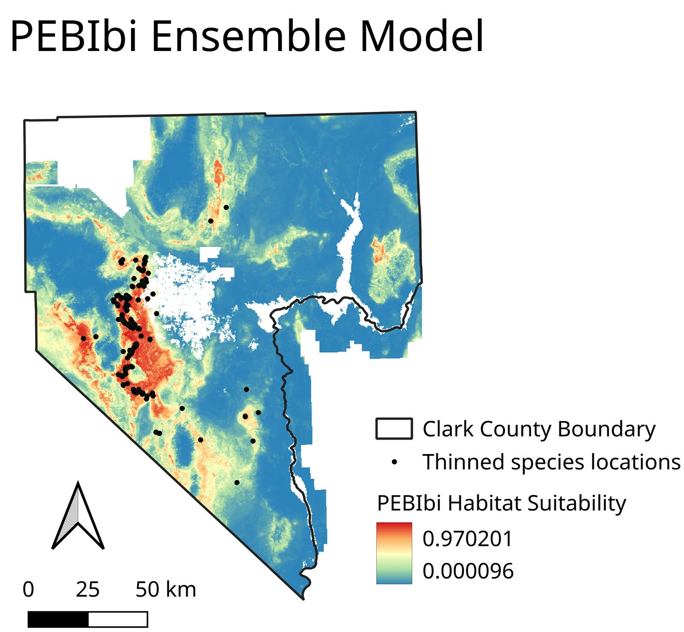
Variable	gbm	mx	rf
bare.r	0.0	0.2	2.7
bedrock.r	0.0	0.0	3.3
CVMinTemp.r	38.2	33.9	17.2
NDVIDuration.r	0.0	0.0	2.3
slope.r	0.0	1.3	3.1
tmin.r	0.0	2.0	9.4
vpdMax.r	10.8	2.9	16.2
wp.r	0.0	0.2	9.0
wpcv.r	2.8	19.7	9.5
soilpH.r	0.0	7.4	4.8
silicaIndex.r	0.0	31.7	3.1
gypsum.r	14.0	0.6	12.1
VegetationDivisionsCC.f	34.2	0.1	7.3



PEBIbi Figure 1a. Continuous Boyce Indices [CBI] for the Penstemon bicolor ssp. bicolor ensemble model prediction



PEBIbi Figure 2a. Partial response curves for the four most influential variables in the Penstemon bicolor ssp. bicolor Ensemble model. Lines and bars indicate the variables as described in ANMI Figure 2b.



PEBIbi Figure 3a. Ensemble model of habitat suitability for Penstemon bicolor ssp. bicolor in the vicinity of Clark County, NV. Hotter colors indicate higher predicted habitat values, and filled black circles show thinned species locations.

Model Discussion

Areas of highly suitable habitat for Penstemon bicolor ssp. bicolor have a scattered distributed across Clark County at lower to mid-level elevations, and is absent from high elevation areas (PEBIbi Figure 3a). An area of highly suitable habitat is found on the southeastern and southwestern periphery of the Spring mountains, in the area surrounding Sandy Valley, and in the periphery of the Birdsprings Range, inclusive of Birdsprings Valley (PEBIbi Figure 3a). Other areas of highly suitable habitat can be found near the Las Vegas Range, and the Lime Ridge in eastern Clark County (PEBIbi Figure 3a).

The locality data for this species consisted of 375 records within the buffered modeling area, which had a very high degree of overlap. Spatial thinning of the data reduced the number of localities used for training and testing to 175 records.

PEBIbi modeled without Clark County vegetation divisions, and with buffered area.

Habitat Model Performance

Performance metrics show a highly reliable ensemble with strong discrimination of suitable habitat (PEBIbi Table 1b). The continuous Boyce Index curve indicates that once habitat suitability exceeds roughly 80%, observed presences occur up to five times more often than expected by chance, increasing rapidly with higher suitability values (PEBIbi Figure 1b). Test AUC = 0.9990 (SD = 0.0012) and TSS = 0.9790 (SD = 0.0237) demonstrate excellent rank discrimination and high thresholded accuracy at the chosen cutoff (see Box 1; PEBIbi Table 1b). Test CBI = 0.9369 (SD = 0.0474) further confirms that evaluation presences are concentrated in high-suitability bins (PEBIbi Figure 1b; see Box 1).

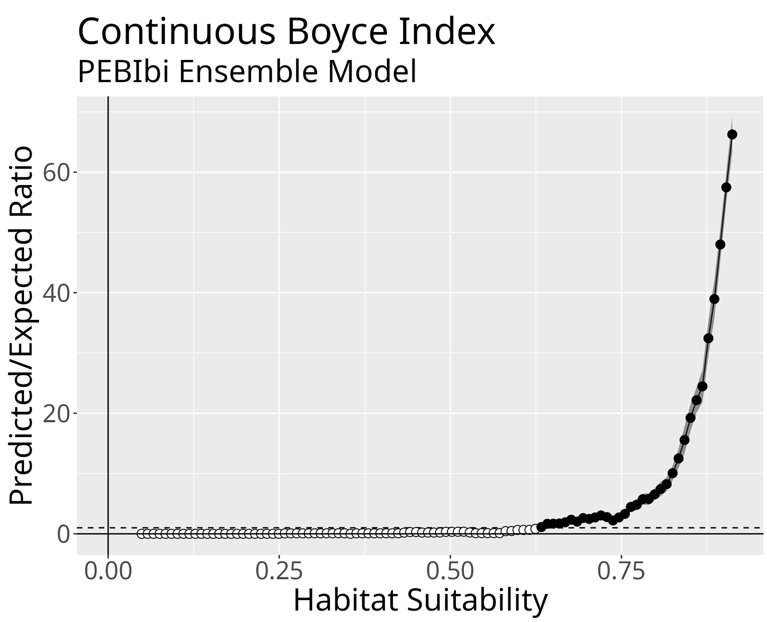
Across model types, several predictors strongly influenced the Yellow two-toned beardtongue ensemble (PEBIbi Table 2b). The four most influential variables were examined for response patterns. The coefficient of variation in winter precipitation (wpcv) was important in all four models; suitability is low below 0.6, rises steeply to a peak near 0.68, and then declines moderately at higher values (PEBIbi Figure 2b). The silica index (silicaIndex) was important in two of the four models; suitability is highest around 1.0 and decreases asymptotically as silicaIndex increases (PEBIbi Figure 2b). Vapor pressure deficit maximum (vpdMax) was important in three of the four models; suitability is moderate at low values, increases to a maximum around 28 hPa, then drops sharply and remains low above 30 hPa (PEBIbi Figure 2b). The coefficient of variation in minimum temperature (CVMinTemp) was important in three of the four models; suitability is high when CVMinTemp is below 2, but declines precipitously once it exceeds 2 (PEBIbi Figure 2b).

PEBIbi Table 1b. Model performance values for Penstemon bicolor ssp. bicolor models giving Area under the Receiver Operator Curve (AUC), Boyce Index (BI), and True Skill Statistic (TSS) for the ensemble model.

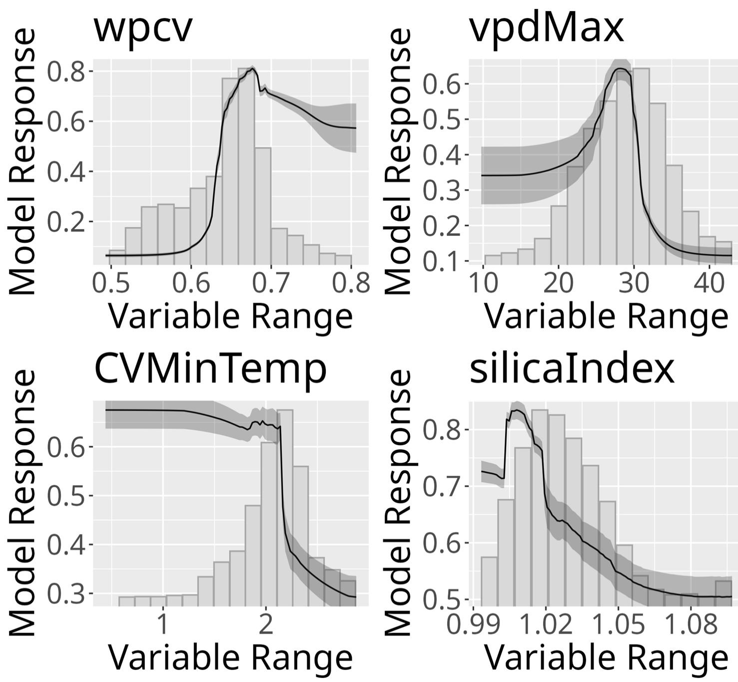
Stat	Training	Training SD	Testing	Testing SD
AUC	0.9991	0.0003	0.9990	0.0012
TSS	0.9763	0.0069	0.9790	0.0237
BI	0.9786	0.0144	0.9369	0.0474

PEBIbi Table 2b. Percent contributions for input variables for Penstemon bicolor ssp. bicolor for ensemble models using available algorithms. The top four contributing variables are highlighted, except that the mx model only had three meaningful contributing variables.

Variable	gam	gbm	mx	rf
bare.r	1.0	0.0	0.0	2.8
bedrock.r	9.0	0.0	0.0	5.9
CVMinTemp.r	2.0	25.4	8.3	16.6
NDVIDuration.r	0.0	0.0	0.0	2.2
slope.r	0.0	0.0	0.2	2.3
tmin.r	4.0	3.8	0.5	13.5
vpdMax.r	16.0	39.6	0.2	17.3
wp.r	8.0	0.0	0.1	5.6
wpcv.r	22.0	29.3	47.8	16.4
soilpH.r	13.0	0.0	1.2	5.5
silicaIndex.r	13.0	0.0	41.5	4.8
gypsum.r	12.0	1.9	0.3	7.1

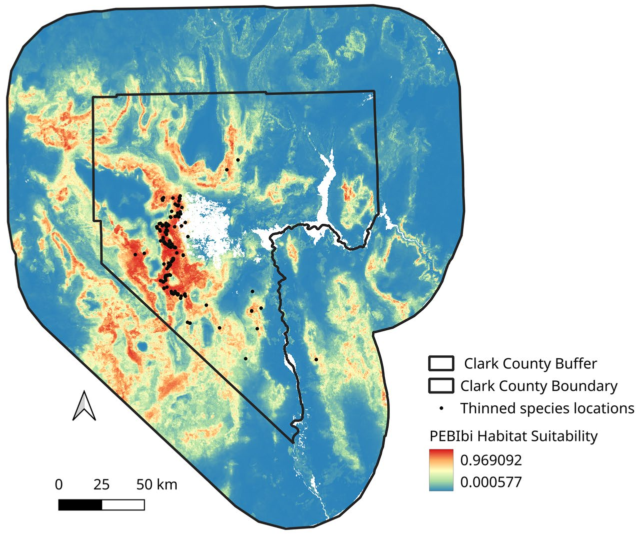


PEBIbi Figure 1b. Continuous Boyce Indices [CBI] for the Penstemon bicolor ssp. bicolor ensemble model prediction



PEBIbi Figure 2b. Partial response curves for the four most influential variables in the Penstemon bicolor ssp. bicolor Ensemble model. Lines and bars indicate the variables as described in ANMI Figure 2b.

PEBIbi Ensemble Model



PEBIbi Figure 3b. Ensemble model of habitat suitability for Penstemon bicolor ssp. bicolor in the vicinity of Clark County, NV. Hotter colors indicate higher predicted habitat values, and filled black circles show thinned species locations.

Model Discussion

Areas of high habitat suitability for Penstemon bicolor ssp. bicolor have a scattered distributed across Clark County buffered area at lower to mid-level elevations, and is absent from high elevation areas (PEBIbi Figure 3b). An area of highly suitable habitat is found on the southeastern and southwestern periphery of the Spring mountains, in the area surrounding Sandy Valley, and in the periphery of the Birdsprings Range, inclusive of Birdsprings Valley and Goodsprings Valley (PEBIbi Figure 3b). Other areas of highly suitable habitat can be found near the Rock Valley, and the southern periphery of the Spotted, Pintwater, Desert, Sheep and Las Vegas Ranges (PEBIbi Figure 3b).

The locality data for this species consisted of 375 records within the buffered modeling area, which had a very high degree of overlap. Spatial thinning of the data reduced the number of localities used for training and testing to 177 records.

PEBIro - Rosy Two-toned beardtongue, (Penstemon bicolor ssp. roseus)

PEBIro modeled with Clark County vegetation divisions, and without buffered area.

Habitat Model Performance

Performance metrics show a highly capable ensemble model with strong discrimination of suitable habitat (PEBIro Table 1a). The continuous Boyce Index (CBI) curve indicates that once the suitability estimate exceeds roughly 80%, observed presences occur up to five times more frequently than expected under randomness (PEBIro Figure 1a). Testing AUC = 1.0000 (SD = 0.0000) and TSS = 1.0000 (SD = 0.0000), confirming perfect rank discrimination (AUC) and perfect thresholded accuracy at the chosen cutoff (TSS) (see Box 1; PEBIro Table 1a). The test CBI is 0.8490 (SD = 0.0787), indicating evaluation presences are concentrated in high-suitability bins beyond random expectation (PEBIro Figure 1a; see Box 1).

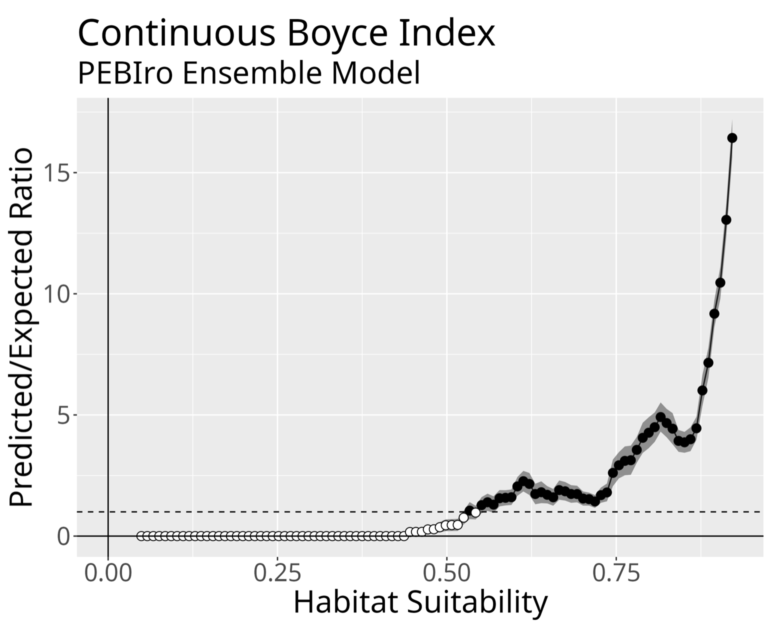
Predictor importance for the Rosy two-toned beardtongue shows several key variables across model types (PEBIro Table 2a). The four leading predictors were examined for response patterns. The coefficient of variation of winter precipitation (wpcv) was influential in all three model types. Suitability is low below 0.64, climbs rapidly to a maximum near 0.68, and then declines sharply once wpcv exceeds 0.70 (PEBIro Figure 2a). Maximum vapor pressure deficit (vpdMax) was important in two of three model types. Suitability is moderate below about 25 hPa, peaks at 28 hPa, and decreases at higher values (PEBIro Figure 2a). Absolute minimum temperature (tmin) was also important in two models: suitability is very low below −5 C, rises steeply to a maximum at −2 C, and diminishes for values warmer than −2 C (PEBIro Figure 2a). The silica index (silicaIndex) mattered in one model type; suitability is moderate at low values, reaches a peak near 1.00, and drops abruptly at higher values (PEBIro Figure 2a).

PEBIro Table 1a. Model performance values for Penstemon bicolor ssp. roseus models giving Area under the Receiver Operator Curve (AUC), Boyce Index (BI), and True Skill Statistic (TSS) for the ensemble model.

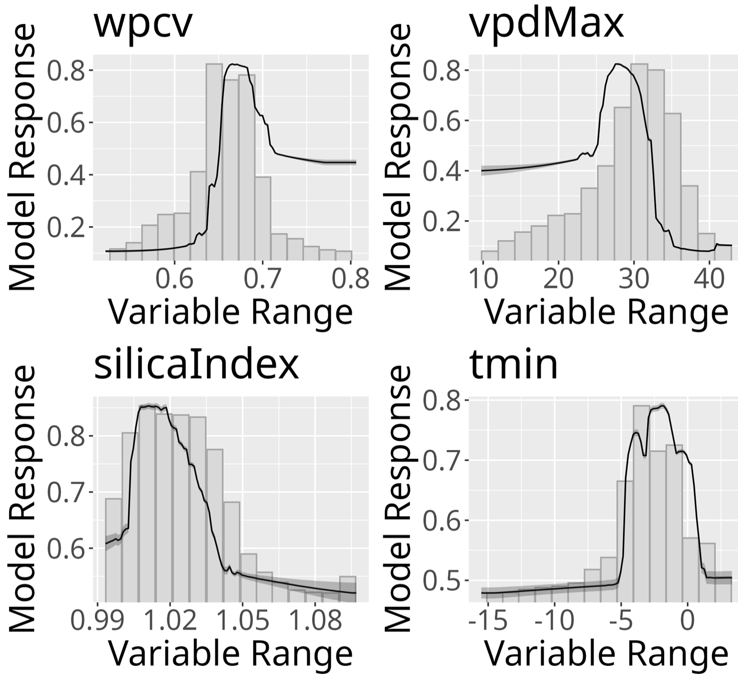
Stat	Training	Training SD	Testing	Testing SD
AUC	1.0000	0.0000	1.0000	0.0000
TSS	1.0000	0.0000	1.0000	0.0000
BI	0.9403	0.0223	0.8490	0.0787

PEBIro Table 2a. Percent contributions for input variables for Penstemon bicolor ssp. roseus for ensemble models using available algorithms. The top four contributing variables are highlighted, except that the mx model only had two meaningful contributing variables.

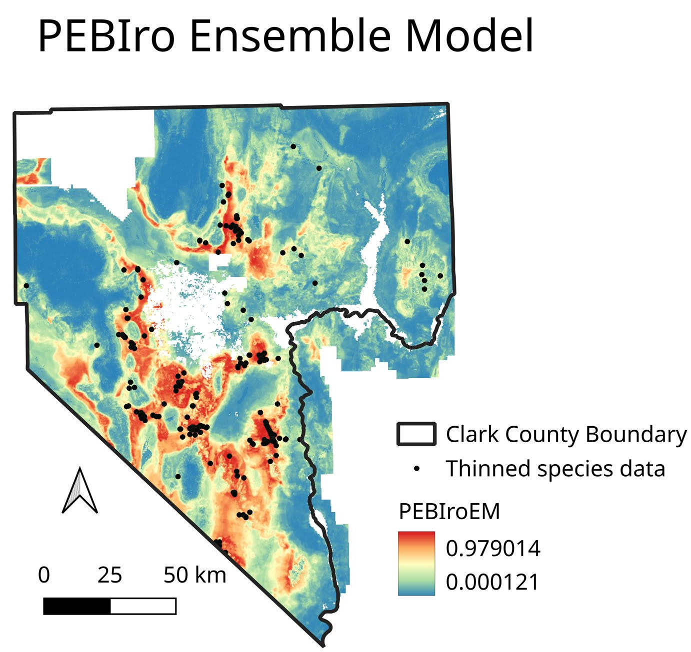
Variable	gbm	mx	rf
bedrock.r	0.0	0.0	7.4
slope.r	0.0	0.4	5.7
tmin.r	2.9	1.1	10.7
vpdMax.r	22.9	1.1	22.8
wp.r	0.0	0.1	11.0
wpcv.r	33.0	31.3	19.4
soilpH.r	0.0	0.6	4.8
silicaIndex.r	0.0	65.2	8.7
VegetationDivisionsCC.f	41.3	0.1	9.5



PEBIro Figure 1a. Continuous Boyce Indices [CBI] for the Penstemon bicolor ssp. roseus ensemble model prediction



PEBIro Figure 2a. Partial response curves for the four most influential variables in the Penstemon bicolor ssp. roseus Ensemble model. Lines and bars indicate the variables as described in ANMI Figure 2b.



PEBIro Figure 3a. Ensemble model of habitat suitability for Penstemon bicolor ssp. roseus in the vicinity of Clark County, NV. Hotter colors indicate higher predicted habitat values, and filled black circles show thinned species locations.

Model Discussion

Areas of high habitat suitability for Penstemon bicolor ssp. roseus have a scattered distributed across Clark County at lower to mid-level elevations, and is absent from high elevation areas (PEBIro Figure 3a). An area of highly suitable habitat is found on the southeastern and southwestern periphery of the Spring mountains, in the area surrounding Sandy Valley, and in around the periphery of the Birdsprings, McCullough, Highlands, and Eldorado Ranges (PEBIro Figure 3a). Other areas of highly suitable habitat can be found near the southern edge of the Sheep Range, in Hiddden Valley, in the Dry Lake Range and in the River Mountains (PEBIro Figure 3a).

The locality data for this species consisted of 349 records within the buffered modeling area, which had a very high degree of overlap. Spatial thinning of the data reduced the number of localities used for training and testing to 223 records.

PEBIbi modeled without Clark County vegetation divisions, and with buffered area.

Habitat Model Performance

Performance metrics for the ensemble model indicate strong discriminatory power for identifying suitable habitat (PEBIro Table 1b). The continuous Boyce Index (CBI) curve shows that once habitat suitability estimates exceed roughly 80%, observed presences occur up to five times more often than expected at random, increasing rapidly with higher suitability scores (PEBIro Figure 1b). Test AUC = 1.0000 (SD = 0.0000) and TSS = 1.0000 (SD = 0.0000), reflecting perfect rank discrimination and perfect thresholded accuracy at the chosen cutoff (see Box 1; PEBIro Table 1b). Test CBI = 0.6120 (SD = 0.2860), indicating evaluation presences are concentrated in high-suitability bins beyond random expectation (PEBIro Figure 1b; see Box 1).

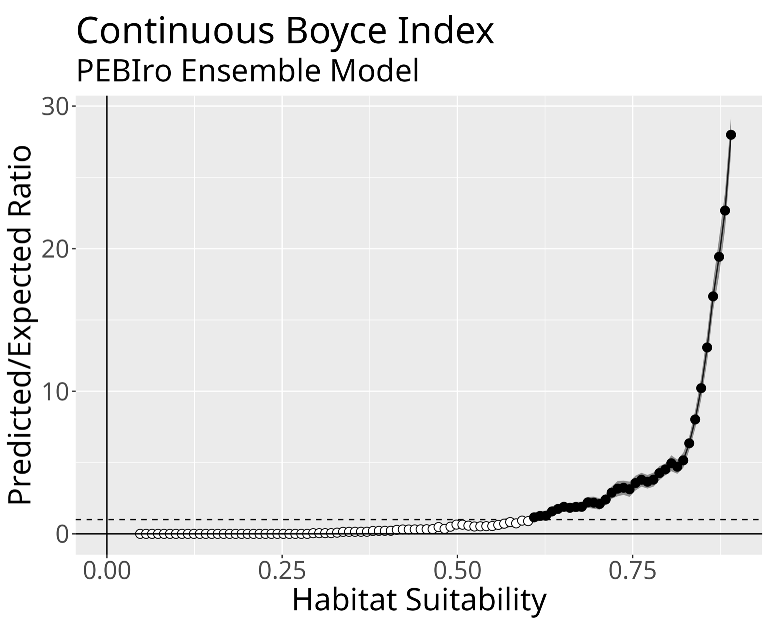
Variable importance for the ensemble habitat mode for this species highlights several key predictors (PEBIro Table 2b). We examined the top four to characterize response patterns. The winter precipitation coefficient of variation (wpcv) was influential across all three models (PEBIro Table 2b): suitability is low when wpcv is below about 0.6, increases sharply above 0.6 to a maximum near 0.68, then declines moderately at higher values (PEBIro Figure 2b). The silica index (silicaIndex) was important in all three models, with highest suitability near 1.0 and an asymptotic decline once values exceed about 1.1 (PEBIro Figure 2b). Maximum vapor pressure deficit (vpdMax) was important in two models (PEBIro Table 2b): suitability is low to moderate at low vpdMax, peaks around 28 hPa, then drops quickly and remains low when vpdMax exceeds 29 hPa (PEBIro Figure 2b). Absolute minimum temperature (tmin) was important in two models (PEBIro Table 2b): suitability is low when tmin is less than -5 C, rises to a maximum near -4.1 C, and then declines slightly but remains moderate when tmin is greater than -4 C (PEBIro Figure 2b).

PEBIro Table 1b. Model performance values for Penstemon bicolor ssp. roseus models giving Area under the Receiver Operator Curve (AUC), Boyce Index (BI), and True Skill Statistic (TSS) for the ensemble model.

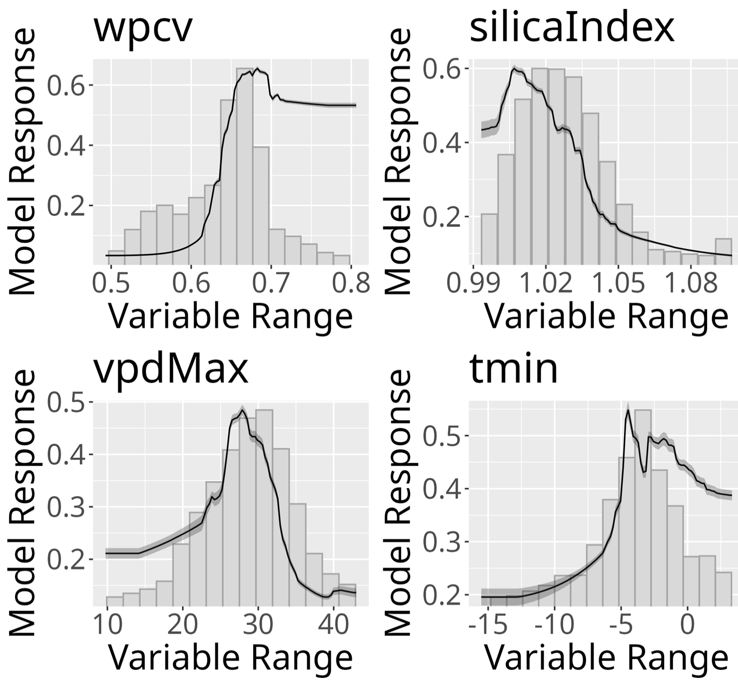
Stat	Training	TrainingSD	Testing	TestingSD
AUC	0.9973	0.0005	0.9959	0.0023
TSS	0.9420	0.0084	0.9489	0.0226
BI	0.9931	0.0099	0.9427	0.0382

PEBIro Table 2b. Percent contributions for input variables for Penstemon bicolor ssp. roseus for ensemble models using available algorithms. The top four contributing variables are highlighted, except that the mx model only had two meaningful contributing variables.

Variable	gbm	mx	rf
bedrock.r	0.0	0.0	8.0
slope.r	0.0	0.2	7.3
tmin.r	7.9	0.5	13.9
vpdMax.r	2.9	0.4	16.8
wp.r	0.0	0.0	9.5
wpcv.r	64.7	35.8	22.7
soilpH.r	0.0	0.3	6.8
silicaIndex.r	24.6	62.8	15.0

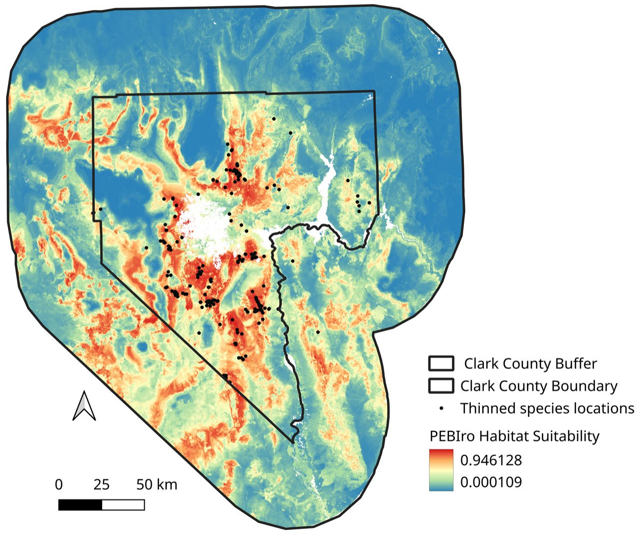


PEBIro Figure 1b. Continuous Boyce Indices [CBI] for the Penstemon bicolor ssp. roseus ensemble model prediction



PEBIro Figure 2b. Partial response curves for the four most influential variables in the Penstemon bicolor ssp. roseus Ensemble model. Lines and bars indicate the variables as described in ANMI Figure 2b.

PEBIro Ensemble Model



PEBIro Figure 3b. Ensemble model of habitat suitability for Penstemon bicolor ssp. roseus in the vicinity of Clark County, NV. Hotter colors indicate higher predicted habitat values, and filled black circles show thinned species locations.

Model Discussion

Areas of high habitat suitability for Penstemon bicolor ssp. roseus have a scattered distributed across Clark County at lower to mid-level elevations, and are absent from the highest and lowest elevation areas (PEBIro Figure 3b). An area of highly suitable habitat is found on the southeastern and southwestern periphery of the Spring mountains, in the area surrounding Sandy Valley, and in around the periphery of the Birdsprings, McCullough, Highlands, and Eldorado Ranges (PEBIro Figure 3b). Near the City of Las Vegas, highly suitable habitat is found in an area near Hidden Valley and the norhthern extent of the McCullough Range (PEBIro Figure 3b). Other areas of highly suitable habitat can be found near the southern edge of the Sheep Range, in the Dry Lake Range and in the River Mountains (PEBIro Figure 3b).

The locality data for this species consisted of 349 records within the buffered modeling area, which had a very high degree of overlap. Spatial thinning of the data reduced the number of localities used for training and testing to 228 records.

PEME - Mojave poppy bee, (Perdita meconis)

PEME modeled with Clark County vegetation divisions, and without buffered area.

Habitat Model Performance

Performance metrics for the ensemble indicate a strong model that effectively discriminates suitable habitat (PEME Table 1a). The continuous Boyce Index (CBI) curve shows that when predicted suitability exceeds about 80%, observed presence is up to five times higher than expected by chance (PEME Figure 1a). Test AUC = 1.0000 (SD = 0.0000) and TSS = 1.0000 (SD = 0.0000), reflecting perfect rank discrimination across thresholds and perfect thresholded accuracy at the chosen cutoff (see Box 1; PEME Table 1a). Test CBI = 0.6120 (SD = 0.2860), indicating that evaluation presences are concentrated in high-suitability bins more than random expectation (PEME Figure 1a; see Box 1).

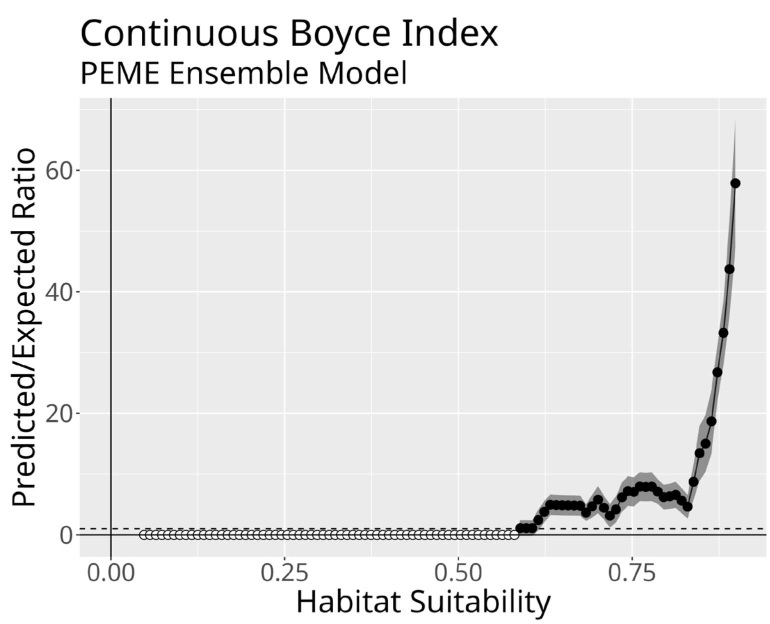
Variable importance for the Mojave poppy bee ensemble shows several predictors with substantial influence (PEME Table 2a). We examined the top four to assess key patterns. Soil gypsum content emerged as important in two of the three algorithms (PEME Table 2a): suitability is low when gypsum is below 5.0, rises steeply with higher values, reaches a maximum around 18, and remains high beyond that level (PEME Figure 2a). The remaining influential predictors—the soil silica index (silicaIndex), the coefficient of variation in winter precipitation (wpcv), and the coefficient of variation in minimum temperature (CVMinTemp; PEME Table 2a)—are harder to interpret due to wide confidence intervals and because each was flagged as important by only one of the three models (PEME Figure 2a).

PEME Table 1a. Model performance values for Perdita meconis models giving Area under the Receiver Operator Curve (AUC), Boyce Index (BI), and True Skill Statistic (TSS) for the ensemble model.

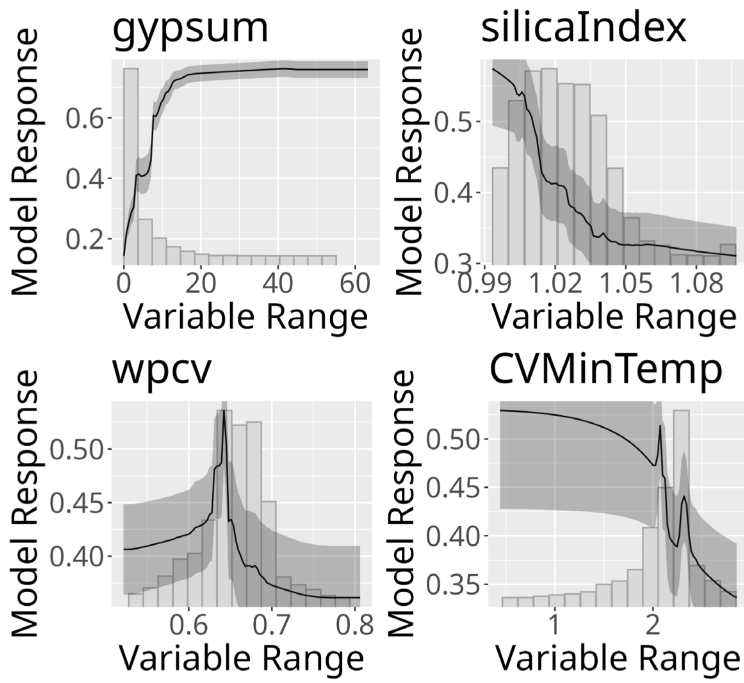
Stat	Training	Training SD	Testing	Testing SD
AUC	1.000	0.000	1.000	0.000
TSS	1.000	0.000	1.000	0.000
BI	0.826	0.056	0.612	0.286

PEME Table 2a. Percent contributions for input variables for Perdita meconis for ensemble models using available algorithms. The top four contributing variables are highlighted, except that the gbm model only had two meaningful contributing variables, and the mx model had only three important variables.

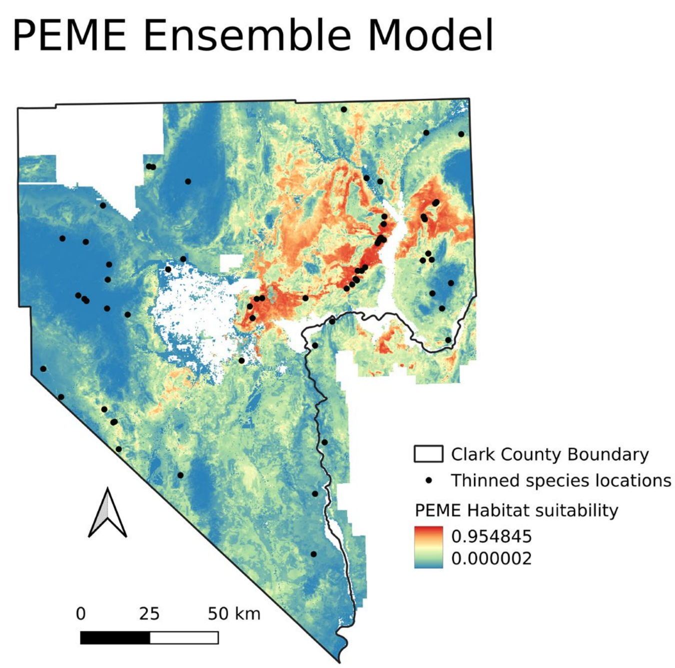
Variable	gbm	mx	rf
bare.r	0.00	0.00	3.40
CVMinTemp.r	0.00	22.10	10.10
slope.r	0.00	0.10	4.80
tmin.r	0.00	1.90	11.10
vpdMax.r	0.00	0.50	7.10
wpcv.r	0.00	30.00	5.00
soilpH.r	0.00	0.50	3.90
silicaIndex.r	0.00	44.40	5.20
gypsum.r	70.40	0.40	31.90
dist2h2o.r	0.00	0.00	5.20
Vegetation Divisions	29.60	0.10	12.20



PEME Figure 1a. Continuous Boyce Indices [CBI] for the Perdita meconis ensemble model prediction



PEME Figure 2a. Partial response curves for the four most influential variables in the Perdita meconis Ensemble model. Lines and bars indicate the variables as described in ANMI Figure 2b.



PEME Figure 3a. Ensemble model of habitat suitability for Perdita meconis in the vicinity of Clark County, NV. Hotter colors indicate higher predicted habitat values, and filled black circles show thinned species locations.

Model Discussion

Areas with high habitat suitability for Perdita meconis are primarily distributed in northeastern Clark County at lower to mid-level elevations, and is absent from high elevation areas (PEME Figure 3a). Highly suitable habitat is found in an area from Rainbow Gardens, northeast to the southern periphery of the Virgin Mountains (PEME Figure 3a). Smaller areas of highly suitable habitat can be found east of the Birdsprings Range, and on the southern shore of Lake Mead near the Big Gypsum Ledges (PEME Figure 3a).

The locality data for this species consisted of 486 records within the buffered modeling area, which had a very high degree of overlap. Spatial thinning of the data reduced the number of localities used for training and testing to 31 records.

PEME modeled without Clark County vegetation divisions, and with buffered area.

Habitat Model Performance

Performance metrics show the ensemble habitat suitability model is highly robust, with strong discrimination of suitable areas (PEME Table 1b). The continuous Boyce Index (CBI) indicates that once predicted suitability exceeds roughly 80%, observed presences occur up to three times more often than expected by chance, increasing rapidly at higher suitability values (PEME Figure 1b). Testing AUC = 1.0000 (SD = 0.0000) and TSS = 1.0000

(SD = 0.0000) confirm perfect rank discrimination across thresholds and excellent thresholded accuracy at the chosen cutoff (see Box 1; PEME Table 1b).

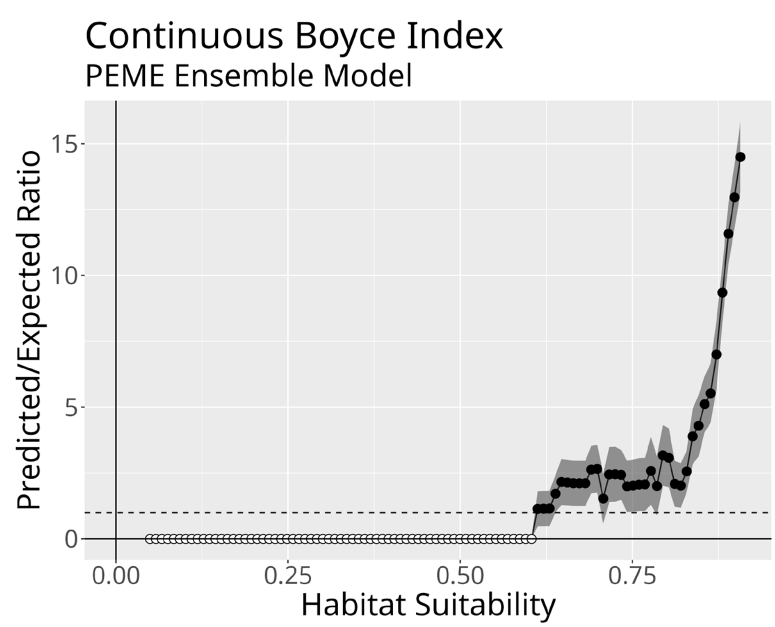
Variable importance across model types in the Mojave poppy bee ensemble highlights several key predictors (PEME Table 2b). We examined the four most influential variables for pattern interpretation. The coefficient of variation in minimum temperature (CVMinTemp) was important in all four models (PEME Table 2b). Suitability is very low when CVMinTemp is below 1.6, rises steeply to a peak at 2.2, then drops sharply at higher values (PEME Figure 2b). Vapor pressure deficit maximum (vpdMax) was influential in three of the four models (PEME Table 2b). Suitability is very low below 20 hPa, increases to a maximum around 35 hPa, and then declines somewhat but remains relatively high beyond 35 hPa (PEME Figure 2b). Soil gypsum content (gypsum) was important in two models (PEME Table 2b). Suitability is low at low gypsum, increases rapidly to a maximum, and remains high above a value of 8 (PEME Figure 2b). The silica index (silicaIndex) mattered in only one model (PEME Table 2b). Suitability is highest near 1.0 and decreases asymptotically as silicaIndex increases; however, the pattern is uncertain due to wide confidence intervals for this predictor (PEME Figure 2b).

PEME Table 1b. Model performance values for Perdita meconis models giving Area under the Receiver Operator Curve (AUC), Boyce Index (BI), and True Skill Statistic (TSS) for the ensemble model.

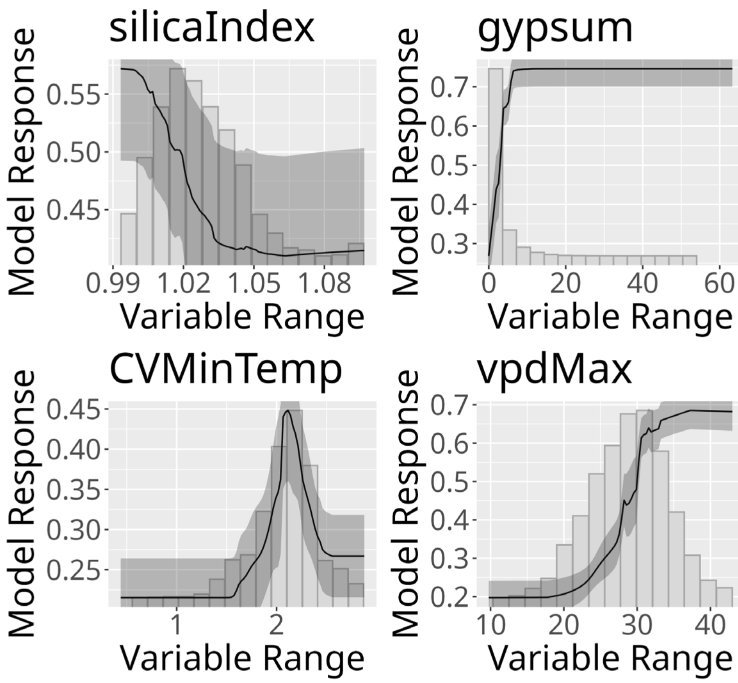
Stat	Training	TrainingSD	Testing	TestingSD
AUC	1.0000	0.0000	1.0000	0.0000
TSS	1.0000	0.0000	1.0000	0.0000
BI	0.7913	0.1094	0.5276	0.2060

PEME Table 2b. Percent contributions for input variables for Perdita meconis for ensemble models using available algorithms. The top four contributing variables are highlighted, except that the gbm and mx models only had three meaningful contributing variables.

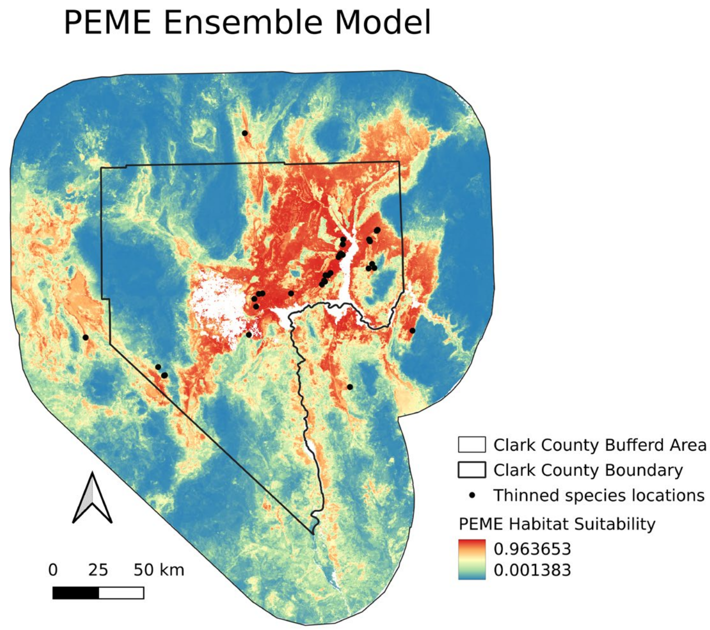
Variable	gam	gbm	mx	rf
bare.r	3.0	1.1	0.1	5.3
CVMinTemp.r	24.0	17.1	9.6	16.6
slope.r	36.0	0.0	0.1	5.2
tmin.r	0.0	0.0	0.4	6.2
vpdMax.r	9.0	24.5	0.7	18.9
wpcv.r	10.0	2.8	15.8	9.8
soilpH.r	0.0	0.0	0.4	3.1
silicaIndex.r	4.0	0.0	72.3	3.5
gypsum.r	7.0	54.5	0.5	25.7
dist2h2o.r	7.0	0.0	0.0	5.7



PEME Figure 1b. Continuous Boyce Indices [CBI] for the Perdita meconis ensemble model prediction



PEME Figure 2b. Partial response curves for the four most influential variables in the Perdita meconis Ensemble model. Lines and bars indicate the variables as described in ANMI Figure 2b.



PEME Figure 3b. Ensemble model of habitat suitability for Perdita meconis in the vicinity of Clark County, NV. Hotter colors indicate higher predicted habitat values, and filled black circles show thinned species locations.

Model Discussion

Areas with high habitat suitability for Perdita meconis are primarily distributed in northeastern Clark County at lower to mid-level elevations, and is absent from high elevation areas (PEME Figure 3b). Highly suitable habitat is found in an area from Rainbow Gardens, northeast to the southern periphery of the Virgin Mountauns (PEME Figure 3b). The areas to the south and west of the Spring Mountains shows moderate to highly suitable habitat, while smaller areas of highly suitable habitat can be found east of the Birdsprings Range, and on the southern shore of Lake Mead near the Big Gypsum Ledges (PEME Figure 3b).

The locality data for this species consisted of 486 records within the buffered modeling area, which had a very high degree of overlap. Spatial thinning of the data reduced the number of localities used for training and testing to 36 records.

PHFI - Clarke Phacelia, (Phacelia filiae)

PHFI modeled with Clark County vegetation divisions, and without buffered area.

Habitat Model Performance

Performance metrics for the ensemble indicate a model that effectively distinguishes suitable habitat (PHFI Table 1a). Test evaluations were not calcuable for the testing BI due to exteremely small sample sizes in the testing set for this species due to the limited extent of the vegetaion layer. The continuous Boyce Index curve shows that when predicted suitability surpasses roughly 80%, species presence is up to 9,000 times more likely than random expectation (PHFI Figure 1a). However the pravalence curve does not increase until the highest habitat prediction levels. Test evaluations yielded AUC = 1.0000 (SD = 0.0000) and TSS = 1.0000 (SD = 0.0000), reflecting perfect rank discrimination across thresholds (AUC) and perfect thresholded accuracy at the chosen cutoff (TSS) (see Box 1; PHFI Table 1a).

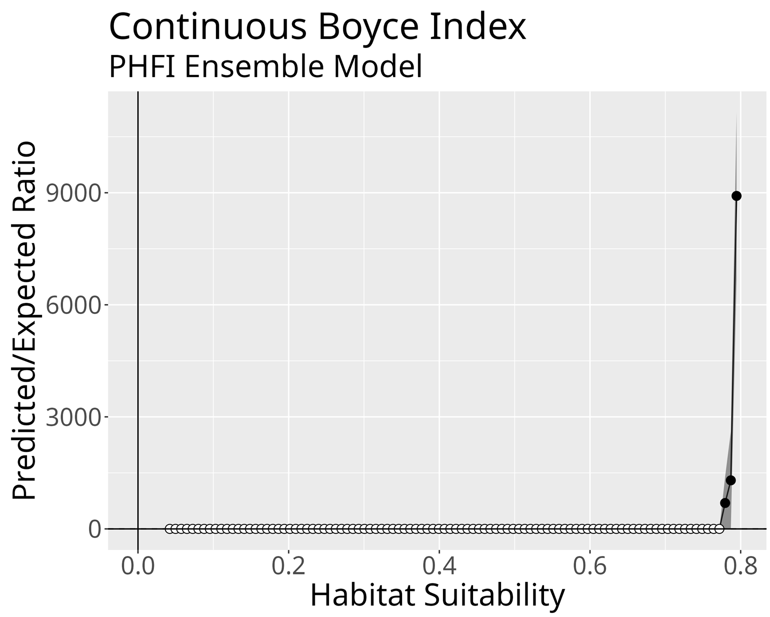
The variables used in the ensemble model of habitat suitability for the Clarke Phacelia for each model type indicate that some variables are of great importance (PHFI Table 2a). The top four most important variables in the ensemble model were examined to identify any important patterns for those variables. The coefficient of variation of winter precipitation (wpcv) was an important variable in two of the three model types used (PHFI Table 2a). Habitat suitability is highest whenever the wpcv is below 0.6, and suitability decreases asymptotically as the value of wpcv increases (PHFI Figure 2a). The duration of plant growth from the Normalized Difference Vegetation Index (NDVIDuration) was also an important variable for two of the three model types (PHFI Table 2a). Habitat suitability is moderately high when NDVIDuration is less than ca. 180 days, but rises to a peak as NDVIDuration approaches 190 days, longer duration values result in a dramatic and immediate reduction in habitat suitability until NDVIDuration reaches 240 days and increases and remains at a moderate level (PHFI Figure 2a). The gypsum composition (gypsum) was an important variable in one of the three models used (PHFI Table 2a). Habitat suitability is highest when gypsum is below a value of about 5, suitability declines rapidly when the gypsum value exceeds five and reaches a minimum when the value of gypsum reaches 20, and suitability remains low with higher values of gypsum (PHFI Figure 2a). The silica index of the soil (silicaIndex) was an important variable in one of the three model types (PHFI Table 2a). Habitat suitability is highest when the silicaIndex is low (ca. 1), and suitability decreases nearly linearly as the value of silicaIndex increases (PHFI Figure 2a).

PHFI Table 1a. Model performance values for Phacelia filiaemodels giving Area under the Receiver Operator Curve (AUC), Boyce Index (BI), and True Skill Statistic (TSS) for the ensemble model.

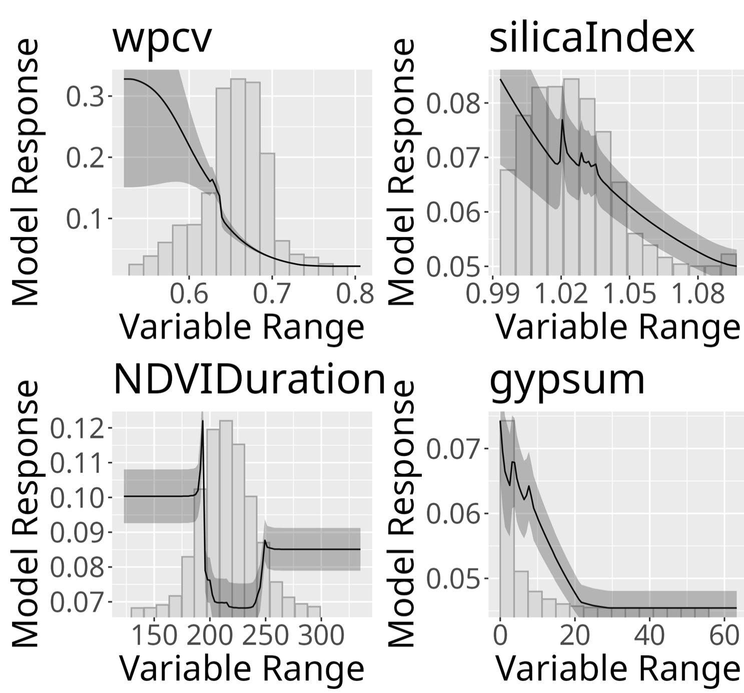
Stat	Training	Training SD	Testing	Testing SD
AUC	1.0000	0.0000	1.0000	0.0000
TSS	1.0000	0.0000	1.0000	0.0000
BI	1.0000	0.0000	NA	NA

PHFI Table 2a. Percent contributions for input variables for Phacelia filiae for ensemble models using available algorithms. The top four contributing variables are highlighted, except that the mx model only had two meaningful contributing variables.

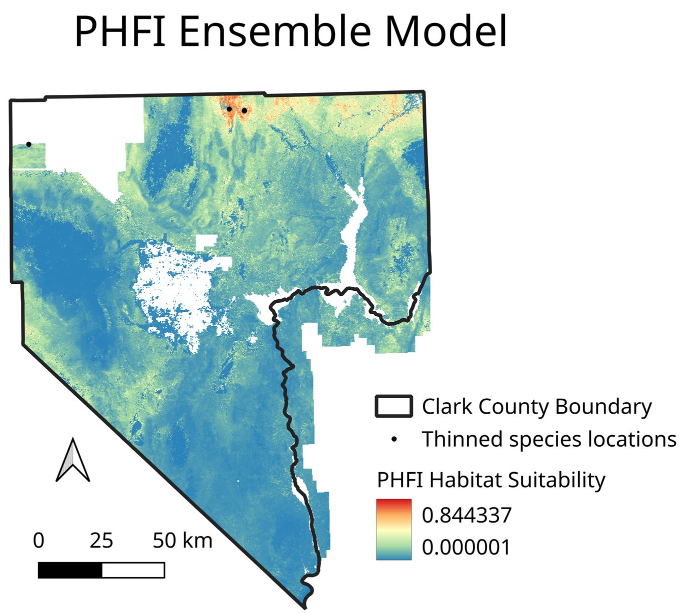
Variable	gbm	mx	rf
bare.r	0.0	0.1	7.8
bedrock.r	0.8	0.0	6.1
coarse.r	0.8	0.1	6.2
NDVIDuration.r	18.0	0.0	8.0
slope.r	0.0	0.5	5.8
tmin.r	0.8	0.4	7.9
vpdMax.r	0.0	0.5	7.7
wp.r	0.0	0.1	7.0
wpcv.r	4.6	69.6	16.1
soilpH.r	4.9	0.5	4.3
silicaIndex.r	2.4	28.0	7.1
gypsum.r	6.1	0.1	7.2
VegetationDivisionsCC.f	61.5	0.1	8.8



PHFI Figure 1a. Continuous Boyce Indices [CBI] for the Phacelia filiae ensemble model prediction



PHFI Figure 2a. Partial response curves for the four most influential variables in the Phacelia filiae Ensemble model. Lines and bars indicate the variables as described in ANMI Figure 2b.



PHFI Figure 3a. Ensemble model of habitat suitability for Phacelia filiae in the vicinity of Clark County, NV. Hotter colors indicate higher predicted habitat values, and filled black circles show thinned species locations.

Model Discussion

Areas with high habitat suitability for Phacelia filiae are rare in Clark County, existing primarily at the southern end of Coyote Springs Valley, with only a few other highly suitable areas immediately to the east, near the Meadow Valley Wash at the northern border of the County (PHFI Figure 3a).

The locality data for this species consisted of 66 records within the buffered modeling area, which had a very high degree of overlap. Spatial thinning of the data reduced the number of localities used for training and testing to 5 records.

PHFI modeled without Clark County vegetation divisions, and with buffered area.

Habitat Model Performance

The ensemble model's performance values indicate a robust model with the ability to discriminate areas of suitable habitat well (PHFI Table 1b). The continuous Boyce Index (CBI) curve indicates that as the habitat suitability estimate increases above ca. 80%, species presence is predicted up to ten times greater than would be expected at random and increases rapidly with higher values for habitat suitability (PHFI Figure 1b). Testing AUC = 1.0000 (SD = 0.0000) and TSS = 1.0000 (SD = 0.0000), indicating strong rank discrimination across thresholds (AUC) and high thresholded accuracy at the selected cutoff (TSS) (see Box 1; PHFI Table 1b). Test CBI = 0.9324 (SD = 0.0867), indicating evaluation presences occur more often in high-suitability bins than expected at random (PHFI Figure 1b; see Box 1).

The variables used in the ensemble model of habitat suitability for the Clarke Phacelia for each model type indicate that some variables are of great importance (PHFI Table 2b). The top four most important variables in the ensemble model were examined to identify any important patterns for those variables. The vapor pressure deficit maximum (vpdMax) was an important variable in three of the four models (PHFI Table 2b). In this case, habitat suitability is moderate when vpdMax is low, and increases until suitability is maximized when the vpdMax is between 25 and 28 hPa. Habitat suitability decreases almost immediately and remains low when vpdMax exceeds 28 hPa (PHFI Figure 2b). The pH of the soil (soilPh) was an important variable in three of the models (PHFI Table 2b). Habitat suitability is very low when the value of soilpH is below a value of 82, but suitability increases rapidly to a maximum at a value of 85, thereafter, habitat suitability declines with higher values of soilpH (PHFI Figure 2b).

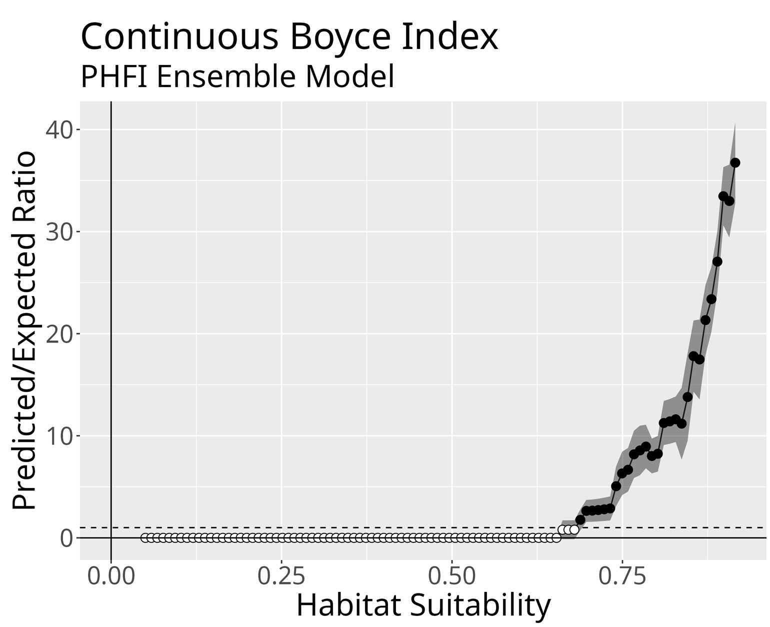
The variables silica content of the soil (silicaIndex), and the coefficient of variation of wither precipitation (wpcv), were only important to the mx model (PHFI Table 2b). The large confidence intervals around the habitat suitability estimates precludes further interpretation(PHFI Figure 2b).

PHFI Table 1b. Model performance values for Phacelia filiae models giving Area under the Receiver Operator Curve (AUC), Boyce Index (BI), and True Skill Statistic (TSS) for the ensemble model.

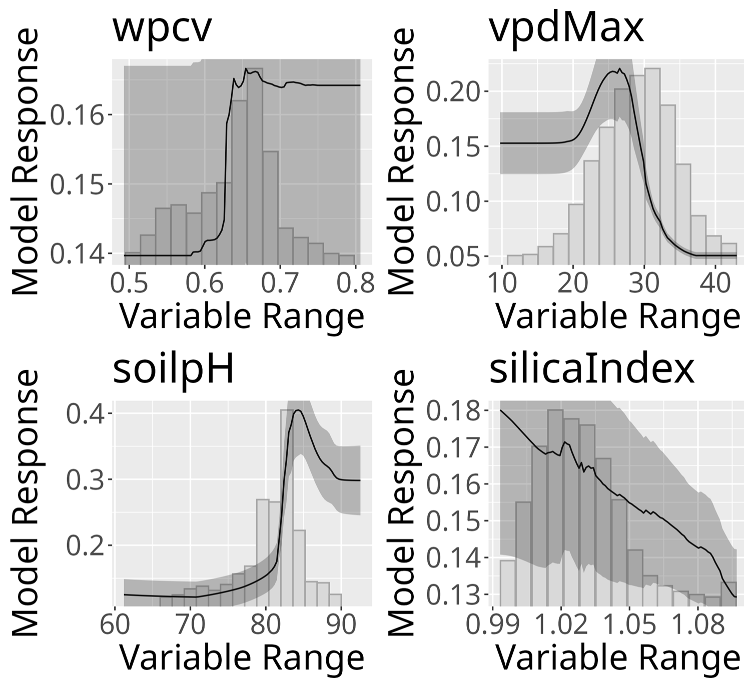
Stat	Training	Training SD	Testing	Testing SD
AUC	1.0000	0.0000	1.0000	0.0000
TSS	1.0000	0.0000	1.0000	0.0000
BI	0.9910	0.0072	0.9324	0.0867

PHFI Table 2b. Percent contributions for input variables for Phacelia filiae for ensemble models using available algorithms. The top four contributing variables are highlighted, except that the mx model only had two meaningful contributing variables.

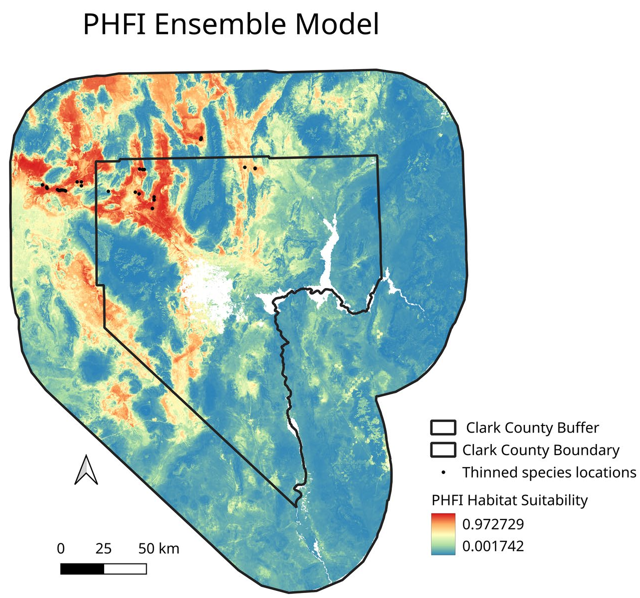
Variable	gam	gbm	mx	rf
bare.r	14.0	4.5	0.1	7.6
bedrock.r	9.0	5.4	0.0	10.2
coarse.r	5.0	3.1	0.1	6.2
NDVIDuration.r	0.0	7.4	0.0	4.1
slope.r	19.0	0.0	0.5	4.6
tmin.r	0.0	9.2	0.7	11.9
vpdMax.r	41.0	12.1	0.6	11.3
wp.r	0.0	20.3	0.2	14.9
wpcv.r	0.0	3.3	58.8	7.8
soilpH.r	10.0	33.4	1.0	14.4
silicaIndex.r	2.0	0.4	37.8	4.3
gypsum.r	0.0	1.0	0.1	2.7



PHFI Figure 1b. Continuous Boyce Indices [CBI] for the Phacelia filiae ensemble model prediction



PHFI Figure 2b. Partial response curves for the four most influential variables in the Phacelia filiae Ensemble model. Lines and bars indicate the variables as described in ANMI Figure 2b.



PHFI Figure 3b. Ensemble model of habitat suitability for Phacelia filiae in the vicinity of Clark County, NV. Hotter colors indicate higher predicted habitat values, and filled black circles show thinned species locations.

Model Discussion

Areas of high habitat suitability for Phacelia filiae are rare in Clark County, existing primarily in Indian Springs Valley, Three Lakes Valley, and the northwestern end of Las Vegas Valley (PHFI Figure 3b). In this region, but outside of the County boundary, highly suitable habitat is also found near Rock Valley and Jackass Flats (PHFI Figure 3b). Smaller areas of moderately high habitat suitability are found along the eastern and southern periphery of the Spring Mountains, in the Pahrump Valley and in the Goodsprings and Ivanpah Valleys (PHFI Figure 3b).

The locality data for this species consisted of 66 records within the buffered modeling area, which had a very high degree of overlap. Spatial thinning of the data reduced the number of localities used for training and testing to 31 records.

PHPA - Parish phacelia, (Phacelia parishii)

PHPA modeled with Clark County vegetation divisions, and without buffered area.

Habitat Model Performance

The ensemble model's performance values indicate a robust model with the ability to discriminate areas of suitable habitat well (PHPA Table 1a). We could not compute test evaluations for the BI because the species' test set contained too few samples as a consequence of the vegetation layer's limited extent.The continuous Boyce Index (CBI) curve indicates that as the habitat suitability estimate increases above ca. 80%, species presence is predicted up to ten thousand times greater than would be expected at random (PHPA Figure 1a) yet the confidence limits were broad at higher habitat predictions. Testing AUC = 1.0000 (SD = 0.0000) and TSS = 1.0000 (SD = 0.0000), indicating strong rank discrimination across thresholds (AUC) and high thresholded accuracy at the selected cutoff (TSS) (see Box 1; PHPA Table 1a).

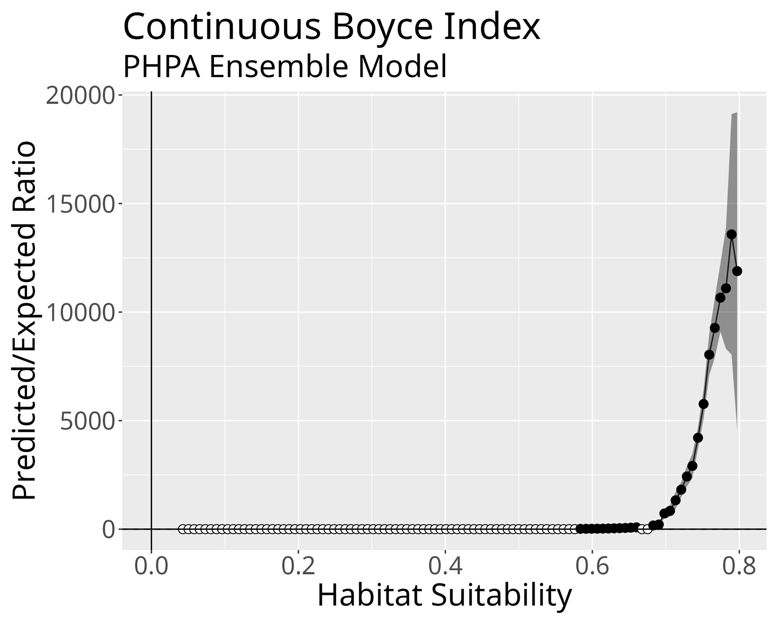
The variables used in the ensemble model of habitat suitability for the Parish phacelia for each model type indicate that some variables are of great importance (PHPA Table 2a). The top four most important variables in the ensemble model were examined to identify any important patterns for those variables. The coefficient of variation of winter precipitation (wpcv) was an important variable in all three of the model types used (PHPA Table 2a). Habitat suitability is low when the wpcv is low, but suitability increases linearly to a maximum as the value of wpcv approaches 0.72, thereafter habitat suitability remains high as the value of wpcv exceeds 0.72 (PHPA Figure 2a). The coefficient of variation in minimum temperature (CVMinTemp) was also an important variable for each of the three model types (PHPA Table 2a). Habitat suitability is low when CVMinTemp is low, but rises nearly linearly as CVMinTemp increases (PHPA Figure 2a).The silica index (silicaIndex) was also an important variable in one of the three models (PHPA Table 2a). Habitat suitability is highest when the silica index is lowest and suitability decreases linearly with higher values of the silicaIndex, although the 95% confidence values for these estimates are broad (PHPA Figure 2a). The gypsum content of the soil was also an important variable for one model (PHPA Table 2a), however the large 95% confidence interval of the habitat suitability estimate preclude the description of any pattern (PHPA Figure 2a).

PHPA Table 1a. Model performance values for Phacelia parishii models giving Area under the Receiver Operator Curve (AUC), Boyce Index (BI), and True Skill Statistic (TSS) for the ensemble model.

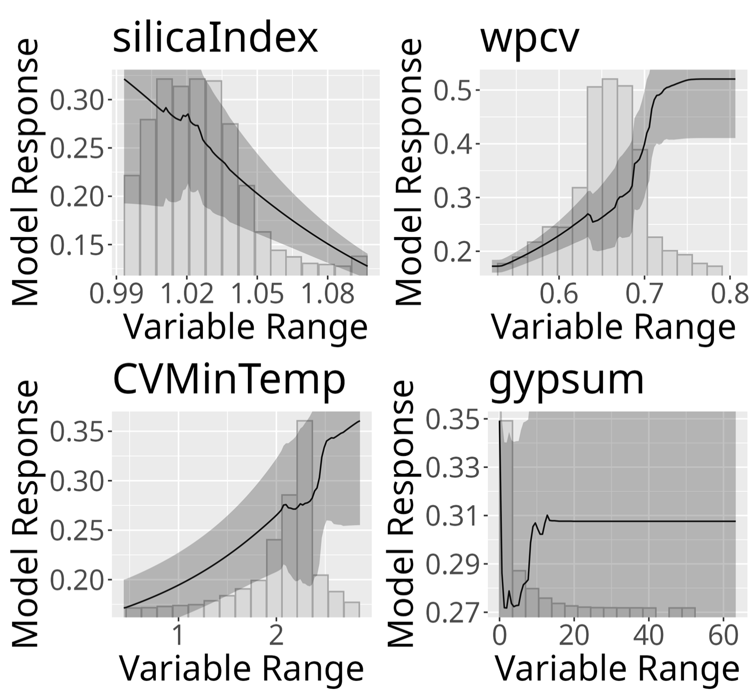
Stat	**Training**	**Training SD**	**Testing**	**Testing SD**
AUC	1.0000	0.0000	1.0000	0.0000
TSS	1.0000	0.0000	1.0000	0.0000
BI	0.9625	0.0126	NA	NA

PHPA Table 2a. Percent contributions for input variables for Phacelia parishii for ensemble models using available algorithms. The top four contributing variables are highlighted.

Variable	gbm	mx	rf
bare.r	2.2	0.1	10.4
CVMinTemp.r	1.1	20.5	7.9
NDVIDuration.r	5.8	0.0	7.5
slope.r	0.6	0.1	7.8
tmin.r	3.2	0.6	11.8
vpdMax.r	0.0	1.2	7.3
wpcv.r	11.3	23.6	14.2
soilpH.r	1.6	0.6	5.0
silicaIndex.r	0.0	52.9	6.8
gypsum.r	1.7	0.2	13.2
VegetationDivisionsCC.f	72.4	0.1	8.0

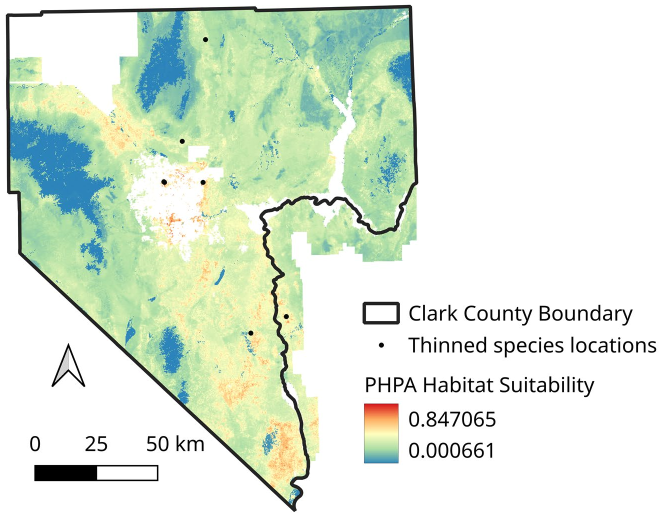


PHPA Figure 1a. Continuous Boyce Indices [CBI] for the Phacelia parishii ensemble model prediction



PHPA Figure 2a. Partial response curves for the four most influential variables in the Phacelia parishii Ensemble model. Lines and bars indicate the variables as described in ANMI Figure 2b.

PHPA Ensemble Model



PHPA Figure 3a. Ensemble model of habitat suitability for Phacelia parishii in the vicinity of Clark County, NV. Hotter colors indicate higher predicted habitat values, and filled black circles show thinned species locations.

Model Discussion

Areas of highly suitable habitat for Phacelia parishii are rare in Clark County (PHPA Figure 3a). Scattered areas of moderately highly suitable habitat can be found in Indian Springs Valley, the Las Vegas Valley, on the eastern periphery of the McCullough Range, in the Highland Range, the Eldorado Mountains, and in the vicinity of Searchlight, NV (PHPA Figure 3a).

The locality data for this species consisted of 80 records within the buffered modeling area, which had a very high degree of overlap. Spatial thinning of the data reduced the number of localities used for training and testing to 7 records which made modeling difficult.

PHPA modeled without Clark County vegetation divisions, and with buffered area.

Habitat Model Performance

Performance metrics show the ensemble reliably distinguishes suitable habitat (PHPA Table 1b). The continuous Boyce Index (CBI) curve indicates that once suitability exceeds about 80%, predicted presence occurs up to ten times more often than expected at random and increases sharply with higher suitability values (PHPA Figure 1b). Testing yielded AUC = 1.0000 (SD = 0.0000) and TSS = 1.0000 (SD = 0.0000), demonstrating strong rank discrimination across thresholds (AUC) and high thresholded accuracy at the chosen cutoff (TSS) (see Box 1; PHPA Table 1b).

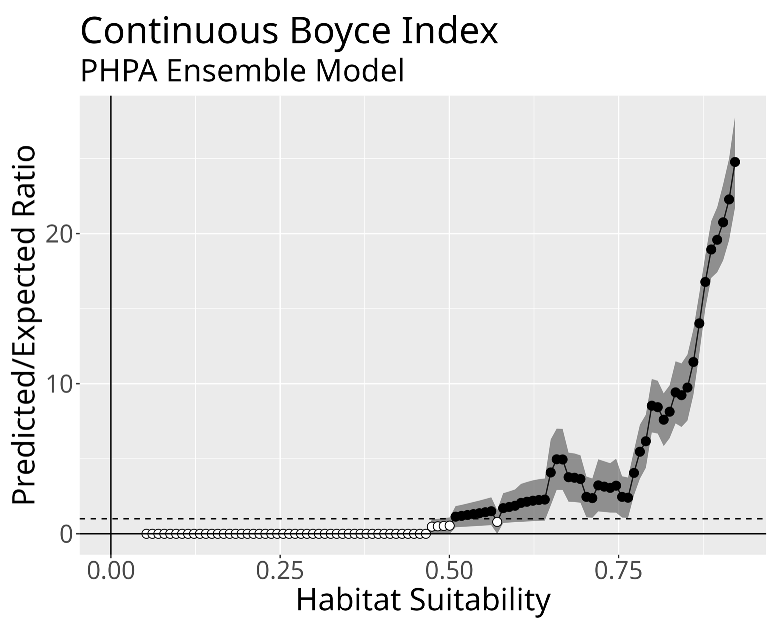
In the Parish phacelia ensemble habitat-suitability models, predictor importance highlights several key variables (PHPA Table 2b). We examined the four highest-ranked predictors for response patterns. The coefficient of variation in winter precipitation (wpcv) was important in all three models (PHPA Table 2b). Suitability is low when wpcv is below 0.6, rises quickly above 0.6, peaks as wpcv approaches 0.73, and remains high beyond 0.73 (PHPA Figure 2b). Soil pH (soilpH) was important in two of the four models (PHPA Table 2b). Suitability is low when soilpH is under 80, climbs rapidly to a maximum near 85, and stays high at greater values (PHPA Figure 2b). Slope was influential in two of the three models (PHPA Table 2b). Suitability is greatest on very gentle terrain (less than 10 degrees) and becomes very low as slope increases (PHPA Figure 2b). The silica index (silicaIndex) was important in one of the three models (PHPA Table 2b). Suitability is highest at the lowest silica values and declines almost linearly with increasing silicaIndex (PHPA Figure 2b).

PHPA Table 1b. Model performance values for Phacelia parishii models giving Area under the Receiver Operator Curve (AUC), Boyce Index (BI), and True Skill Statistic (TSS) for the ensemble model.

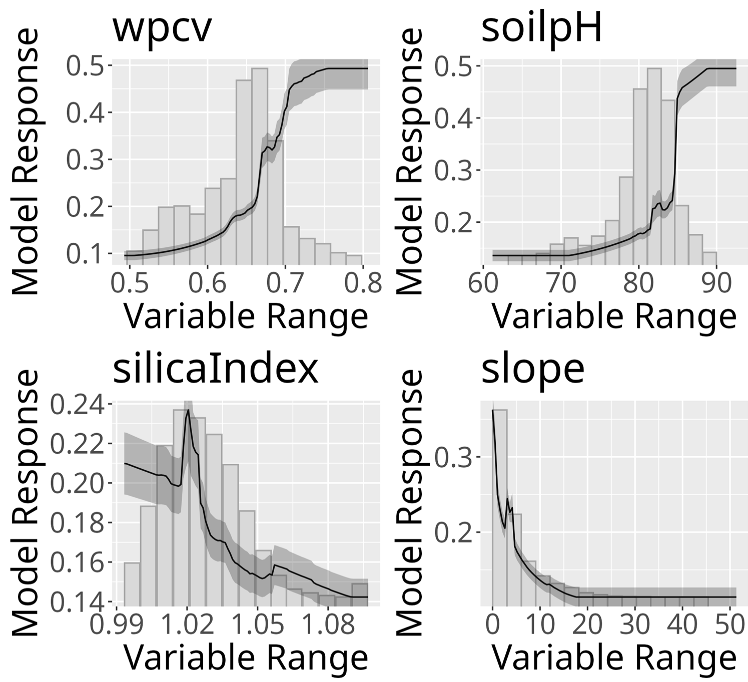
Stat	Training	Training SD	Testing	Testing SD
AUC	1.0000	0.0000	1.0000	0.0000
TSS	1.0000	0.0000	1.0000	0.0000
BI	0.9301	0.0311	0.7012	0.1563

PHPA Table 2b. Percent contributions for input variables for Phacelia parishii for ensemble models using available algorithms. The top four contributing variables are highlighted, except that the mx model only had two meaningful contributing variables.

Variable	gbm	mx	rf
bare.r	11.3	0.0	11.8
CVMinTemp.r	0.0	7.4	3.6
NDVIDuration.r	0.0	0.0	5.3
slope.r	21.8	0.4	17.3
tmin.r	0.0	0.3	5.4
vpdMax.r	0.0	0.1	5.0
wpcv.r	17.8	44.7	14.5
soilpH.r	37.8	0.5	22.4
silicaIndex.r	0.0	46.5	4.3
gypsum.r	11.3	0.1	10.3

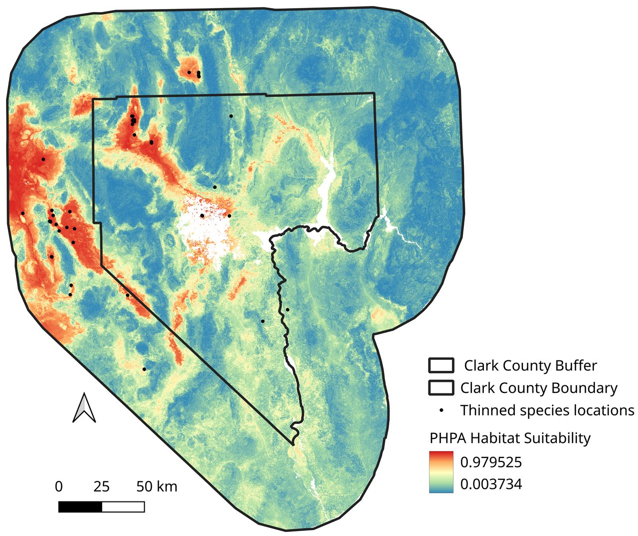


PHPA Figure 1b. Continuous Boyce Indices [CBI] for the Phacelia parishii ensemble model prediction



PHPA Figure 2b. Partial response curves for the four most influential variables in the Phacelia parishii Ensemble model. Lines and bars indicate the variables as described in ANMI Figure 2b.

PHPA Ensemble Model



PHPA Figure 3b. Ensemble model of habitat suitability for Phacelia parishii in the vicinity of Clark County, NV. Hotter colors indicate higher predicted habitat values, and filled black circles show thinned species locations.

Model Discussion

Areas of highly suitable habitat for Phacelia parishii can be found within Clark County in the Amargosa Desert, Pahrump Valley, Mesquite Valley, Ivanpah Valley and the northern portions of the Eldorado Valley (PHPA Figure 3b). Scattered areas of moderately highly suitable habitat can be found in Indian Springs Valley, the Las Vegas Valley, on the eastern periphery of the McCullough Range, in the Highland Range, the Eldorado Mountains, and in the vicinity of Searchlight, NV (PHPA Figure 3b). Additional areas with highly suitable habitat can be found in Rock Valley, Indian Springs Valley and the Las Vegas Valley (PHPA Figure 3b).

The locality data for this species consisted of 80 records within the buffered modeling area, which had a very high degree of overlap. Spatial thinning of the data reduced the number of localities used for training and testing to 48 records.

RAOB - Ridgway's rail, (Rallus obsoletus yumanensis)

RAOB modeled with Clark County vegetation divisions, and without buffered area.

Habitat Model Performance

Performance metrics for the ensemble indicate a highly robust model that effectively distinguishes areas of suitable habitat (RAOB Table 1a). The continuous Boyce Index (CBI) shows that once predicted suitability exceeds roughly 80%, observed presence is up to 150-fold greater than random expectation (RAOB Figure 1a), although the shape of the curve is flatter than expected at higher predicted habitat values. Testing returned AUC = 1.0000 (SD = 0.0000) and TSS = 1.0000 (SD = 0.0000), evidencing perfect rank discrimination across thresholds (AUC) and perfect thresholded accuracy at the chosen cutoff (TSS) (see Box 1; RAOB Table 1a).

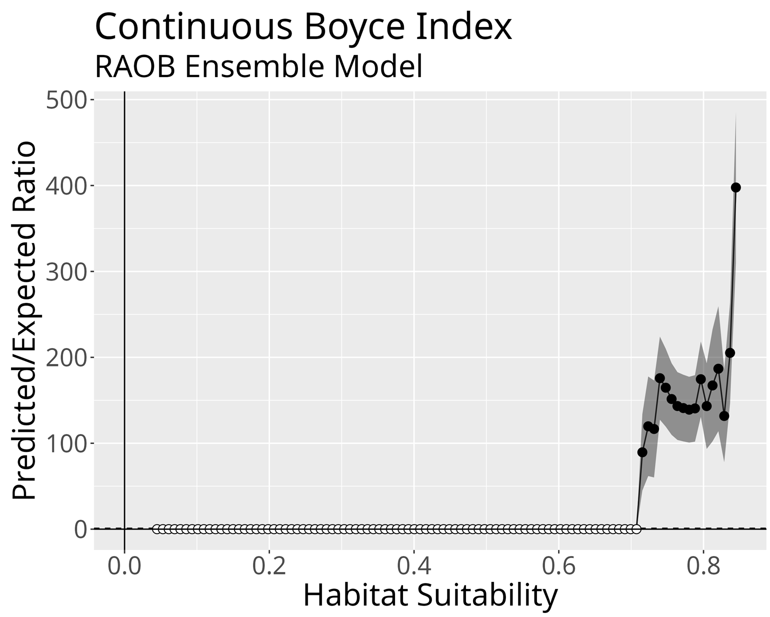
The variables used in the ensemble model of habitat suitability for the Ridgeway's rail for each model type indicate that some variables are of great importance (RAOB Table 2a). The top four most important variables in the ensemble model were examined to identify any important patterns for those variables. The coefficient of variation in winter precipitation (wpcv) was an important variable in all three of the models (RAOB Table 2b). Habitat suitability is low when the value of wpcv is below 0.68, but suitability increases rapidly above a value of 0.68, to a maximum as wpcv nears 0.76, habitat suitability remains high as wpcv increases above 0.76 (PHPA Figure 2a). The coefficient of variation in minimum temperature (CVMinTemp) was also an important variable for each of the three model types (RAOB Table 2a). Habitat suitability is low when CVMinTemp is less than 2.2, but rises to a peak as CVMinTemp approaches a value ca. 2.8 (RAOB Figure 2a). The first principal component of sand/silt/clay (soil1) was also an important variable in two of the three models (RAOB Table 2a). Habitat suitability is highest when the value of the principal component was lowest (ca. -20), and habitat suitability declines rapidly and asymptotically as values of the principal component increase (RAOB Figure 2a). Coarse fragments of the soil (coarse) was also an important variable overall, but was not in the top four variables in any model (RAOB Table 2a). Habitat suitability is highest when the percentage of coarse fragments is lowest, and suitability declines rapidly and remains low as the percentage of coarse fragments increases (RAOB Figure 2a). We caution against relying on the analysis of important variables in this case because the species primarily occurs in and around the City of Las Vegas, and it is known that the environmental variables used are NOT represented correctly in urban areas. Indeed, this is the reason that most available datasets mask (or omit) the unreliable environmental variables in urban or other highly modified environments.

RAOB Table 1a. Model performance values for Rallus obsoletus yumanensis models giving Area under the Receiver Operator Curve (AUC), Boyce Index (BI), and True Skill Statistic (TSS) for the ensemble model.

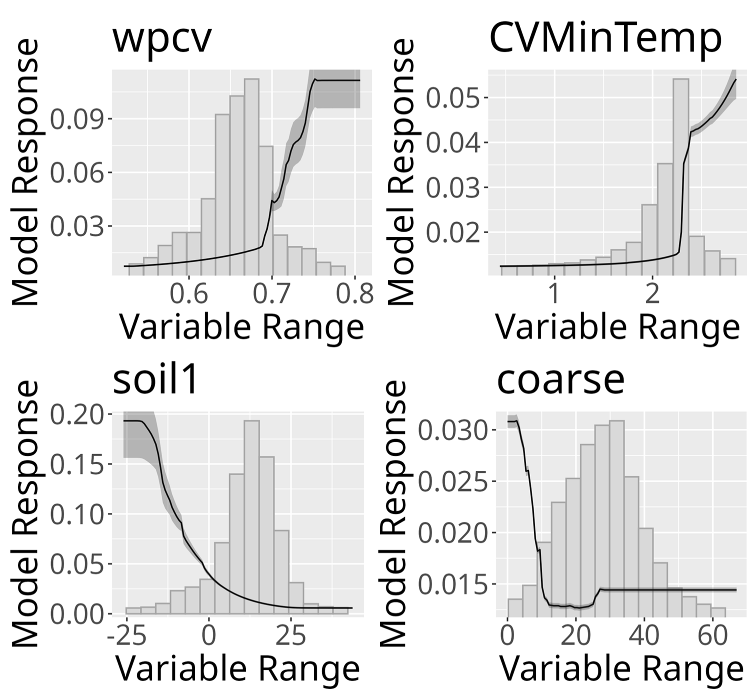
Stat	**Training**	**Training SD**	**Testing**	**Testing SD**
AUC	1.0000	0.0000	1.0000	0.0000
TSS	1.0000	0.0000	1.0000	0.0000
BI	0.5477	0.2599	0.3447	0.4379

RAOB Table 2a. Percent contributions for input variables for Rallus obsoletus yumanensis for ensemble models using available algorithms. The top four contributing variables are highlighted, except that the mx model only had two meaningful contributing variables.

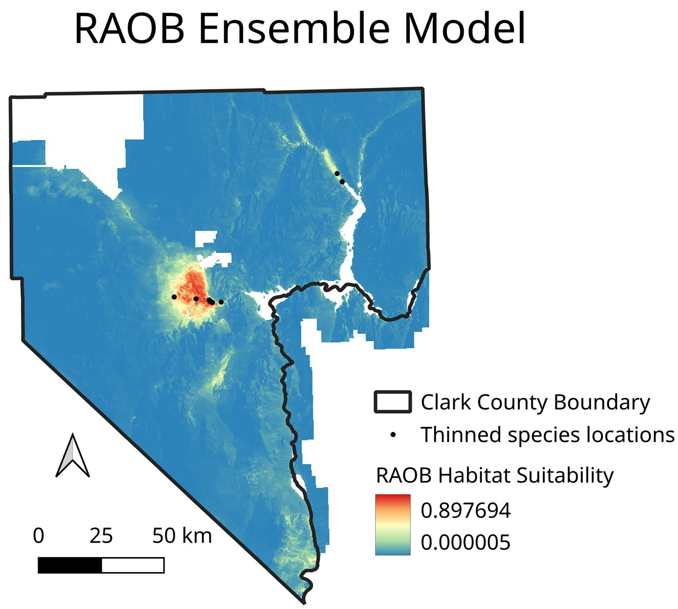
Variable	gbm	mx	rf
aspect.r	0.1	0.0	7.9
bare.r	0.5	0.0	3.1
bedrock.r	0.6	0.0	7.8
coarse.r	3.4	0.1	5.7
CVMinTemp.r	4.4	10.0	10.2
soil1.r	11.4	0.2	12.2
tmin.r	0.0	1.0	6.7
vpdMax.r	0.0	0.5	6.2
wpcv.r	62.9	87.9	24.7
VegetationDivisions	16.7	0.2	15.6



RAOB Figure 1a. Continuous Boyce Indices [CBI] for the Rallus obsoletus yumanensis ensemble model prediction



RAOB Figure 2a. Partial response curves for the four most influential variables in the Rallus obsoletus yumanensis Ensemble model. Lines and bars indicate the variables as described in ANMI Figure 2b.



RAOB Figure 3a. Ensemble model of habitat suitability for Rallus obsoletus yumanensis in the vicinity of Clark County, NV. Hotter colors indicate higher predicted habitat values, and filled black circles show thinned species locations.

Model Discussion

Areas of high habitat suitability for Rallus obsoletus yumanensis are rare and narrowly distributed in Clark County (RAOB Figure 3a). An area of highly suitable habitat is found on the eastern side of the City of Las Vegas, inclusive of North Las Vegas, Sunrise Manor, East Las Vegas, and Paradise (RAOB Figure 3a). However, we caution against relying on the distribution of highly suitable habitat in this case because the species primarily occurs in and around the City of Las Vegas, and it is known that the environmental variables used to create the models are not represented correctly in urban areas.

The locality data for this species consisted of 87 records within the buffered modeling area, which had a very high degree of overlap. Spatial thinning of the data reduced the number of localities used for training and testing to 11 records.

RAOB modeled without Clark County vegetation divisions, and with buffered area.

Habitat Model Performance

The ensemble's metrics indicate a highly reliable model with strong ability to distinguish suitable habitat (RAOB Table 1b). The continuous Boyce Index (CBI) curve shows that once predicted suitability exceeds about 80%, observed presences are up to five times more frequent than expected by chance, with a steep increase at higher suitability values (RAOB Figure 1b). Testing produced AUC = 1.0000 (SD = 0.0000) and TSS = 1.0000 (SD = 0.0000), demonstrating perfect rank discrimination across thresholds and excellent threshold-based accuracy at the chosen cutoff (see Box 1; RAOB Table 1b). The test CBI = 0.8585 (SD = 0.1383) further indicates that evaluation presences are concentrated in high-suitability bins more than would occur at random (RAOB Figure 1b; see Box 1).

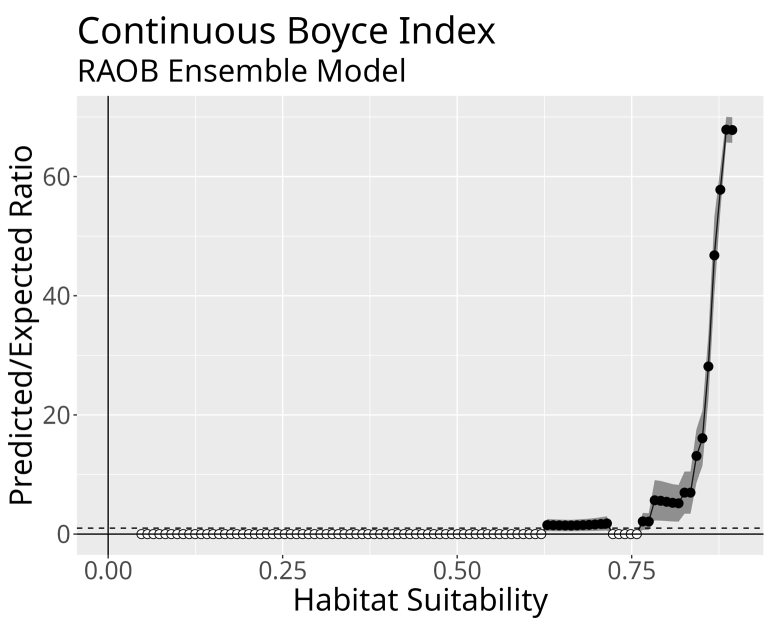
Across model types, the ensemble habitat-suitability analysis for the Ridgeway's rail identifies several variables as highly influential (RAOB Table 2b). We examined the four top-ranked predictors to characterize their response patterns. The first principal component of sand/silt/clay (soil1) was important in all four models (RAOB Table 2a); suitability is greatest at the lowest PC1 values and then declines rapidly, approaching an asymptote as PC1 rises above −5 (RAOB Figure 2b). The coefficient of variation in minimum temperature (CVMinTemp) was also important in all four models (RAOB Table 2b). Suitability is very low when CVMinTemp is below 2.2, but once it exceeds 2.2, suitability increases sharply to a maximum (RAOB Figure 2b). Maximum vapor pressure deficit (vpdMax) was important in three of the four models (RAOB Table 2b); suitability is very low at low vpdMax and increases rapidly to a maximum when vpdMax exceeds 32 hPa (RAOB Figure 2b). The coefficient of variation in winter precipitation (wpcv) was important in one of the four models (RAOB Table 2b). Suitability is low when wpcv is under 0.7, but rises steeply above 0.7, reaching a maximum as wpcv approaches 0.76 (RAOB Figure 2b).

RAOB Table 1b. Model performance values for Rallus obsoletus yumanensis models giving Area under the Receiver Operator Curve (AUC), Boyce Index (BI), and True Skill Statistic (TSS) for the ensemble model.

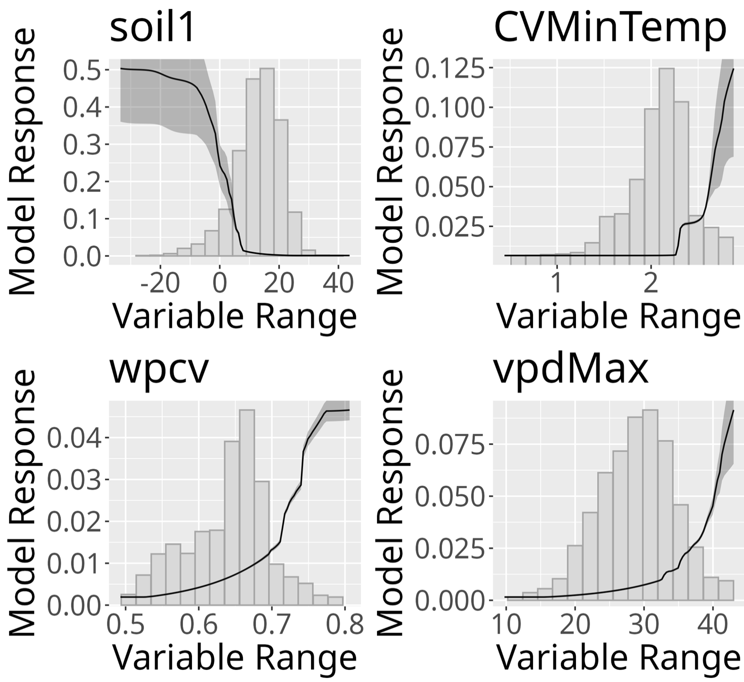
Stat	Training	Training SD	Testing	Testing SD
AUC	1.0000	0.0000	1.0000	0.0000
TSS	1.0000	0.0000	1.0000	0.0000
BI	0.9313	0.0132	0.8585	0.1383

RAOB Table 2b. Percent contributions for input variables for Rallus obsoletus yumanensis for ensemble models using available algorithms. The top four contributing variables are highlighted, except that the mx model only had three meaningful contributing variables.

Variable	gam	gbm	mx	rf
aspect.r	0.0	0.0	0.0	0.5
bare.r	0.0	0.0	0.1	0.7
bedrock.r	10.0	0.0	0.0	2.7
coarse.r	12.0	2.4	0.3	9.5
CVMinTemp.r	14.0	32.6	26.2	24.8
soil1.r	39.0	62.7	1.6	34.3
tmin.r	0.0	0.0	0.0	6.2
vpdMax.r	20.0	2.3	0.7	16.1
wpcv.r	5.0	0.0	71.0	5.1

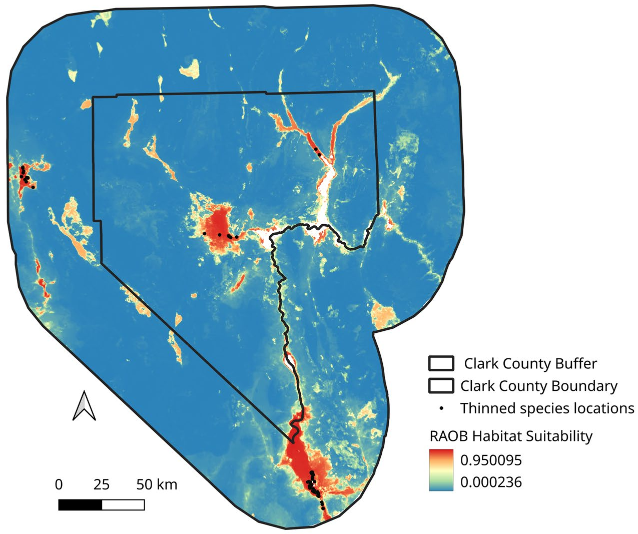


RAOB Figure 1b. Continuous Boyce Indices [CBI] for the Rallus obsoletus yumanensis ensemble model prediction



RAOB Figure 2b. Partial response curves for the four most influential variables in the Rallus obsoletus yumanensis Ensemble model. Lines and bars indicate the variables as described in ANMI Figure 2b.

RAOB Ensemble Model



RAOB Figure 3b. Ensemble model of habitat suitability for Rallus obsoletus yumanensis in the vicinity of Clark County, NV. Hotter colors indicate higher predicted habitat values, and filled black circles show thinned species locations.

Model Discussion

Areas of high habitat suitability for Rallus obsoletus yumanensis have a scattered distributed across the Clark County buffered area at lower elevations, and is absent from high elevation areas (RAOB Figure 3b). Areas of highly suitable habitat are found along the Meadow Valley Wash, the Muddy River, the Virgin River, and northern shores of Lake Mead (RAOB Figure 3b). Other areas of highly suitable habitat can be found along the Colorado River in the Cottonwood Valley, and near Bullhead City and the Mohave Valley. An area in the southeast end of the Amargosa Desert also shows highly suitable habitat (RAOB Figure 3b). Finally, an area in and around the City of Las Vegas appears to be highly suitable habitat (RAOB Figure 3b). However, we caution against relying on the distribution of highly suitable habitat in and around the City of Las Vegas, because it is known that the environmental variables used to create the models are NOT represented correctly in urban areas.

The locality data for this species consisted of 87 records within the buffered modeling area, which had a very high degree of overlap. Spatial thinning of the data reduced the number of localities used for training and testing to 68 records.

SAAT – Common Chuckwalla, (Sauromalus ater)

SAAT modeled with Clark County vegetation divisions, and without buffered area.

Habitat Model Performance

The ensemble model's performance values indicate a robust model with the ability to discriminate areas of suitable habitat well (SAAT Table 1a). The continuous Boyce Index (CBI) curve indicates that as the habitat suitability estimate increases above ca. 80%, species presence is predicted up to three times greater than would be expected at random (SAAT Figure 1a). Testing AUC = 0.9983 (SD = 0.0009) and TSS = 0.9610 (SD = 0.0148), indicating strong rank discrimination across thresholds (AUC) and high thresholded accuracy at the selected cutoff (TSS) (see Box 1; SAAT Table 1).

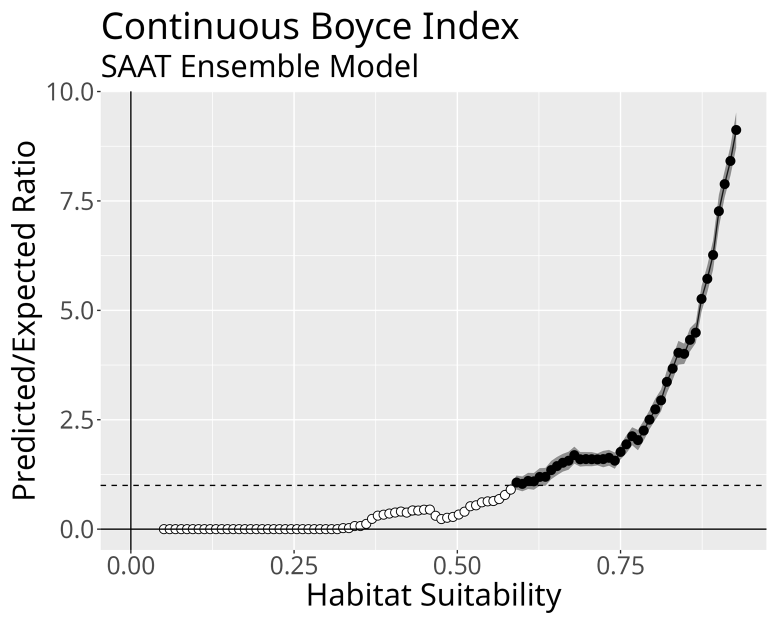
The variables used in the ensemble model of habitat suitability for the Common Chuckwalla for each model type indicate that some variables are of great importance (SAAT Table 2a). The top four most important variables in the ensemble model were examined to identify any important patterns for those variables. The coefficient of variation of winter precipitation (wpcv) was an important variable in all four of the model types used (SAAT Table 2a). Habitat suitability is low whenever the wpcv is below 0.62, but suitability increases rapidly to a maximum as the value of wpcv approaches 0.68, thereafter habitat suitability remains moderately high as the value of wpcv exceeds 0.7 (SAAT Figure 2a). The geometric distance to cliffs (D2Cliff) was an important variable in three of the four models used (SAAT Table 2a). Habitat suitability is highest when the D2cliffs is low (i.e., cliffs are nearby), but suitability rapidly declines and remains low as D2Cliff increases (SAAT Figure 2a). The silica index (silicaIndex) was one of the most important variables in two of the four models used (SAAT Table 2a). Habitat suitability is low when the silica index is below a value of low. Thereafter, habitat suitability increases nearly linearly with higher values of the silica index SAAT Figure 2a). The absolute minimum temperature (tmin) was an important variable in two of the four models used (SAAT Table 2a). Habitat suitability is highest when tmin is above zero, and suitability is lower at all colder temperatures (SAAT Figure 2a).

SAAT Table 1a. Model performance values for Sauromalus ater models giving Area under the Receiver Operator Curve (AUC), Boyce Index (BI), and True Skill Statistic (TSS) for the ensemble model.

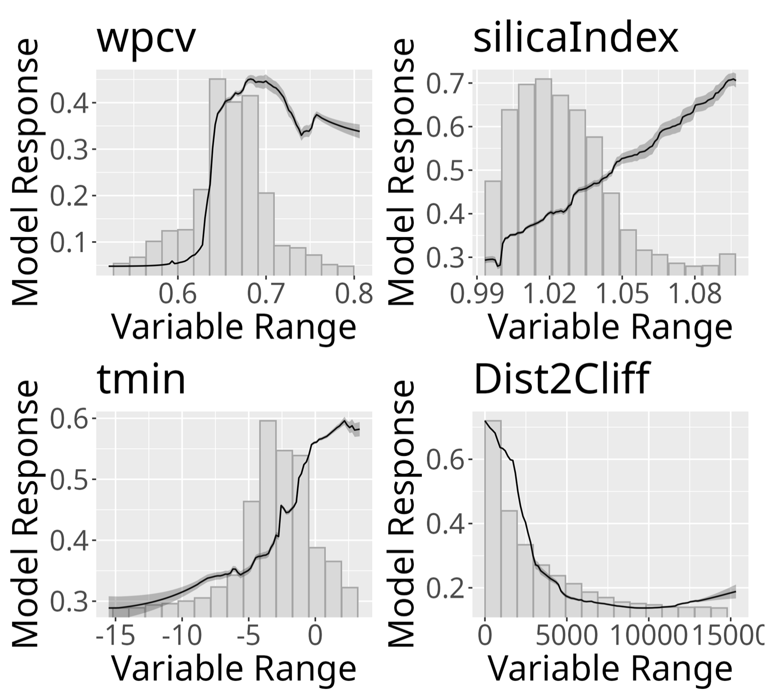
Stat	Training	Training SD	Testing	Testing SD
AUC	0.9984	0.0002	0.9983	0.0009
TSS	0.9536	0.0053	0.9610	0.0148
BI	0.9834	0.0052	0.9531	0.0278

SAAT Table 2a. Percent contributions for input variables for Sauromalus ater for ensemble models using available algorithms. The top four contributing variables are highlighted, except that the mx model only had two meaningful contributing variables.

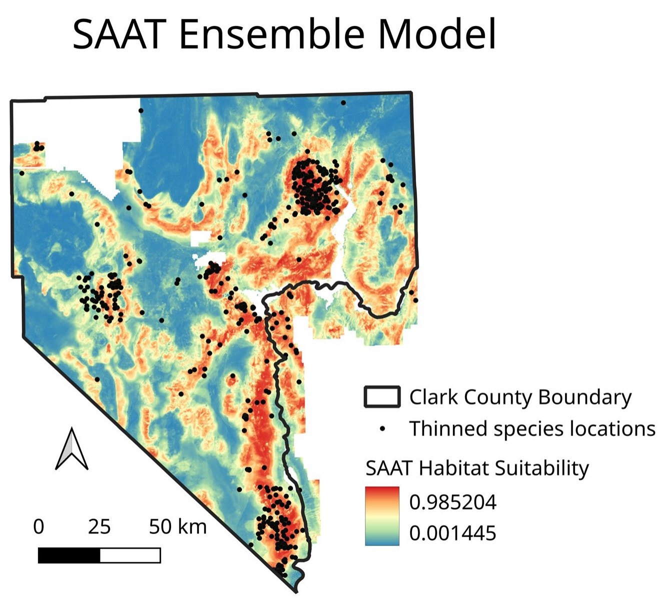
Variable	gam	gbm	mx	rf
Dist2Cliff.r	23.2	9.7	0.0	11.8
aspect.r	12.1	0.0	0.0	6.8
bare.r	0.0	0.0	0.0	6.1
bedrock.r	6.1	0.0	0.0	9.3
CVMinTemp.r	2.0	8.8	1.2	11.9
tmin.r	2.0	36.9	0.6	12.0
vpdMax.r	11.1	0.0	0.1	10.9
wpcv.r	26.3	25.6	41.1	15.4
silicaIndex.r	17.2	8.2	56.9	10.1
VegetationDivisionsCC.f	0.0	10.7	0.0	5.6



***SAAT Figure 1a*.** Continuous Boyce Indices [CBI] for the Sauromalus ater ensemble model prediction



***SAAT Figure 2a*.** Partial response curves for the four most influential variables in the Sauromalus ater ensemble model. Lines and bars indicate the variables as described in ANMI Figure 2b.



SAAT Figure 3a. Ensemble model of habitat suitability for Sauromalus ater in the vicinity of Clark County, NV. Hotter colors indicate higher predicted habitat values, and filled black circles show thinned species locations.

Model Discussion

Areas of highly suitable habitat for Sauromalus ater are broadly distributed across Clark County at mid-level elevations, and is absent from lowest and highest elevation areas (SAAT Figure 3a). The highly suitable habitat is found on lower elevation mountain ranges, along the periphery of high elevation mountain ranges and at in the foothills surrounding many valleys (SAAT Figure 3a).

The locality data for this species consisted of 2184 records within the buffered modeling area, which had a very high degree of overlap. Spatial thinning of the data reduced the number of localities used for training and testing to 1133 records.

SAAT modeled without Clark County vegetation divisions, and with buffered area.

Habitat Model Performance

The ensemble model shows strong performance, indicating robust discrimination of suitable habitat (SAAT Table 1b). The continuous Boyce Index (CBI) curve reveals that once habitat suitability exceeds roughly 80%, predicted species presence is up to five times higher than random expectation and rises rapidly with further increases in suitability (SAAT Figure 1b). Testing AUC = 0.9868 (SD = 0.0032) and TSS = 0.8812 (SD = 0.0211) demonstrate excellent rank discrimination (AUC) and high thresholded accuracy at the chosen cutoff (TSS) (see Box 1; SAAT Table 1b).

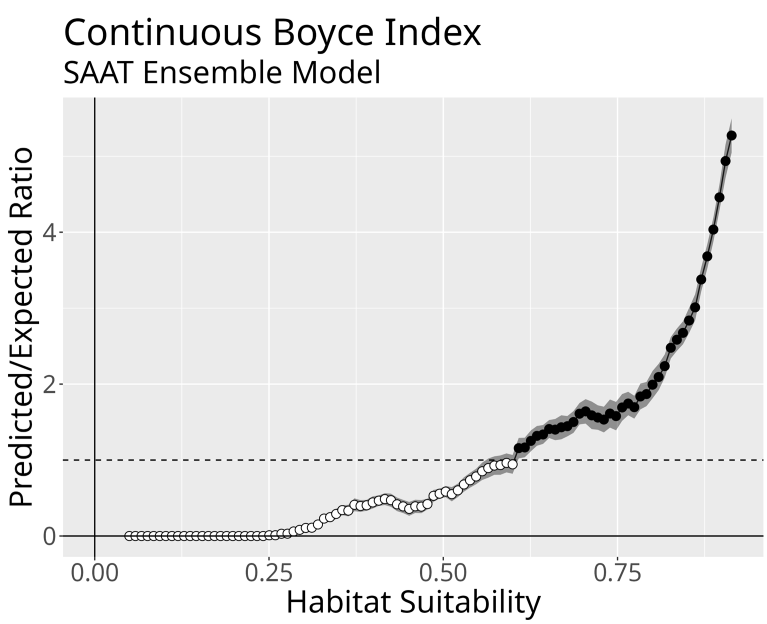
Predictor importance in the Common Chuckwalla ensemble model highlights several key variables (SAAT Table 2b). We examined the four most influential predictors to assess their response patterns. The coefficient of variation in winter precipitation (wpcv) was important in all four models (SAAT Table 2b). Suitability is low when wpcv is below 0.6, increases sharply above 0.6 to a peak near 0.7, and then becomes more variable with a moderate decline at higher values (SAAT Figure 2b). The coefficient of variation in minimum temperature (CVMinTemp) was influential in three of the four models (SAAT Table 2b). Suitability is moderately high when CVMinTemp is under 2, reaches a maximum between 2.1 and 2.5, and then drops steeply beyond 2.6 (SAAT Figure 2b). The geometric distance to cliffs (D2Cliff) was important in two models (SAAT Table 2b), with suitability highest near cliffs and falling quickly—and remaining low—as distance increases (SAAT Figure 2b). The silica index (silicaIndex) was important in only one model (SAAT Table 2b), where suitability is generally high across most values but declines rapidly at the lowest and highest extremes (SAAT Figure 2b).

SAAT Table 1b. Model performance values for Sauromalus ater models giving Area under the Receiver Operator Curve (AUC), Boyce Index (BI), and True Skill Statistic (TSS) for the ensemble model.

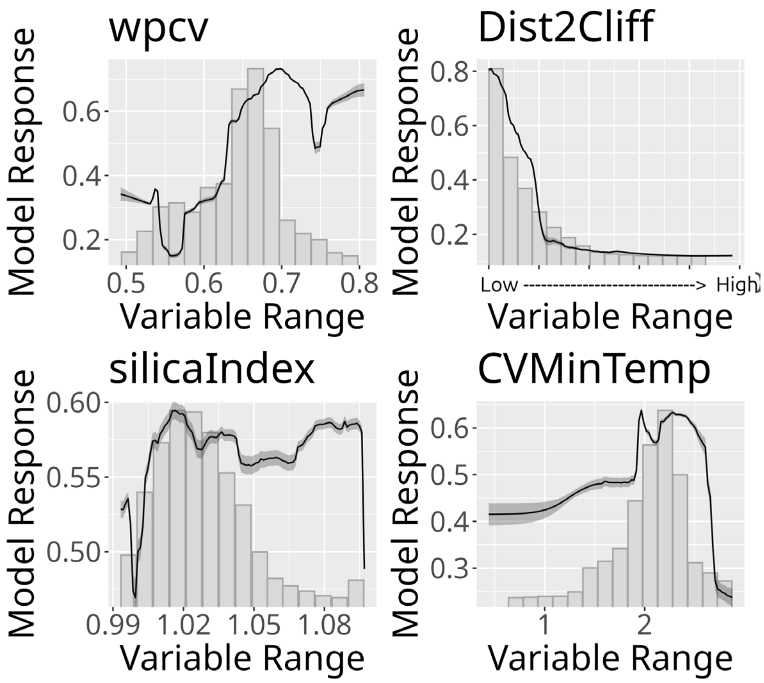
Stat	Training	Training SD	Testing	Testing SD
AUC	0.9877	0.0008	0.9868	0.0032
TSS	0.8789	0.0055	0.8812	0.0211
BI	0.9913	0.0030	0.9612	0.0211

SAAT Table 2b. Percent contributions for input variables for Sauromalus ater for ensemble models using available algorithms. The top four contributing variables are highlighted, except that the mx model only had three meaningful contributing variables.

Variable	gam	gbm	mx	rf
Dist2Cliff.r	28.3	38.5	0.0	15.2
aspect.r	11.1	0.0	0.0	8.6
bare.r	0.0	0.0	0.1	7.7
bedrock.r	16.2	2.5	0.0	12.5
CVMinTemp.r	7.1	5.3	6.9	12.3
tmin.r	3.0	0.0	0.8	8.4
vpdMax.r	4.0	4.8	0.2	10.5
wpcv.r	29.3	48.9	49.0	17.9
silicaIndex.r	1.0	0.0	43.0	7.0

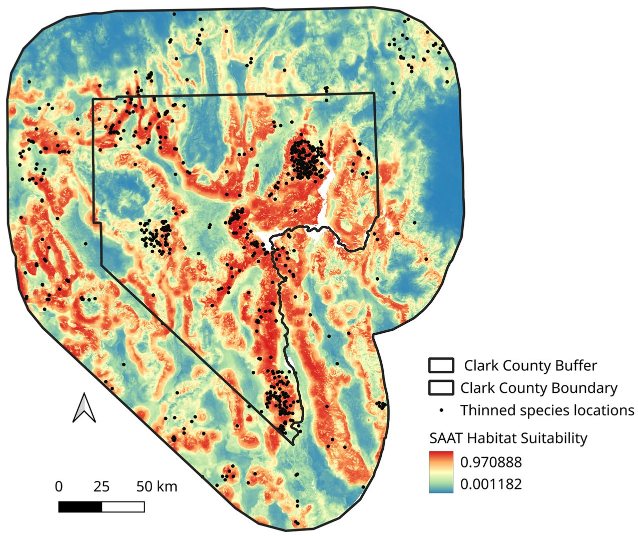


SAAT Figure 1b. Continuous Boyce Indices [CBI] for the Sauromalus ater ensemble model prediction



SAAT Figure 2b. Partial response curves for the four most influential variables in the Sauromalus ater ensemble model. Lines and bars indicate the variables as described in ANMI Figure 2b.

SAAT Ensemble Model



SAAT Figure 3b. Ensemble model of habitat suitability for Sauromalus ater in the vicinity of Clark County, NV. Hotter colors indicate higher predicted habitat values, and filled black circles show thinned species locations.

Model Discussion

Areas of high habitat suitability for Sauromalus ater are broadly distributed across Clark County and the buffered area at mid-level elevations, and is absent from lowest and highest elevation areas (SAAT Figure 3b). The highly suitable habitat is found on lower elevation mountain ranges, along the periphery of high elevation mountain ranges and at in the foothills surrounding many valleys (SAAT Figure 3b).

The locality data for this species consisted of 2184 records within the buffered modeling area, which had a very high degree of overlap. Spatial thinning of the data reduced the number of localities used for training and testing to 1358 records.

SIRA - St. George blue-eyed grass, (Sisyrinchium radicatum)

SIRA modeled with Clark County vegetation divisions, and without buffered area.

Habitat Model Performance

Performance metrics for the ensemble indicate a highly reliable model that effectively distinguishes suitable habitat (SIRA Table 1a). The continuous Boyce Index curve shows that once predicted suitability surpasses about 80%, the probability of species occurrence can be up to 20 times higher than random expectation (SIRA Figure 1a). Test results yielded AUC = 1.0000 (SD = 0.0000) and TSS = 1.0000 (SD = 0.0000), demonstrating perfect rank discrimination across thresholds and perfect thresholded accuracy at the chosen cutoff (see Box 1; SIRA Table 1a).

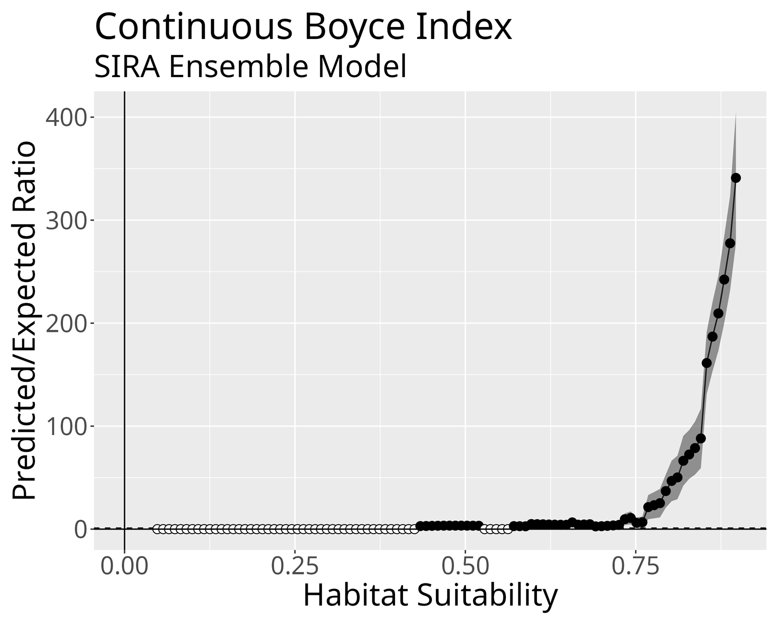
The variables used in the ensemble model of habitat suitability for the St. George blue-eyed grass for each model type indicate that some variables are of great importance (SIRA Table 2a). The top four most important variables in the ensemble model were examined to identify any important patterns for those variables. The silica index (silicaIndex) was one of the most important variables for all three model types used (SIRA Table 2a). Habitat suitability is low when the silica index is low. Thereafter, habitat suitability increases nearly linearly with higher values of the silica index until habitat suitability is maximized at the highest values for silicaIndex (SIRA Figure 2a). The coefficient of variation of winter precipitation (wpcv) was an important variable in two of the three model types used (SIRA Table 2a). Habitat suitability is high when the wpcv is below 0.6, but suitability decreases and remains low when wpcv is between 0.62 and 0.70, and habitat suitability increases rapidly and remains high as wpcv exceeds 0.69 (SIRA Figure 2a). The geometric distance to water (dist2h2o) was an important variable for two of the three models (SIRA Table 2a). Habitat suitability is low when the dist2h2o is low, but suitability increases as dist2h2o increases (SIRA Figure 2a). The coefficient of variation in minimum temperature (CVMinTemp) was also an important variable for each of the three model types (SIRA Table 2a). Habitat suitability is very high when CVMinTemp is less than 2.0, but habitat suitability declines rapidly and remains low when CVMinTemp exceeds a value of 2.0 (SIRA Figure 2a).

SIRA Table 1a. Model performance values for Sisyrinchium radicatum models giving Area under the Receiver Operator Curve (AUC), Boyce Index (BI), and True Skill Statistic (TSS) for the ensemble model.

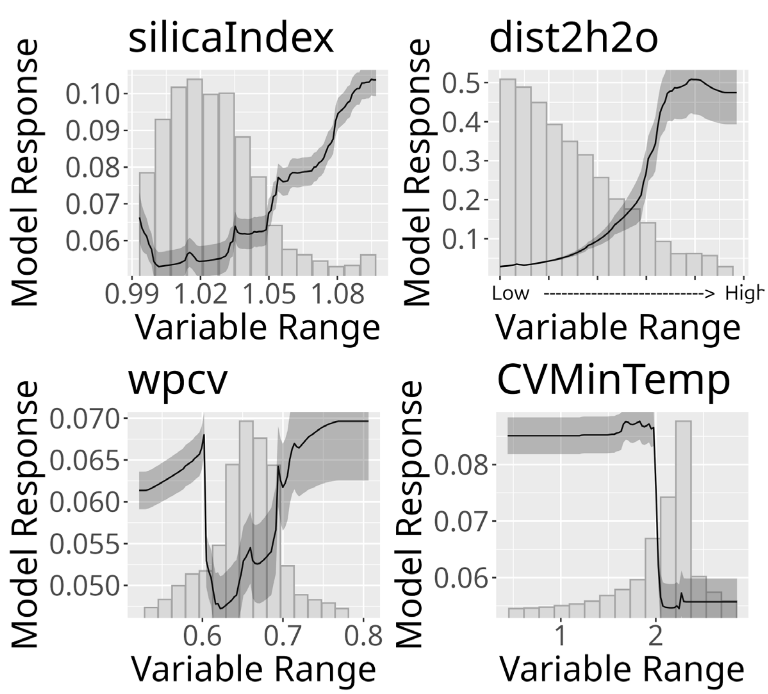
Stat	Training	Training SD	Testing	Testing SD
AUC	1.0000	0.0000	1.0000	0.0000
TSS	1.0000	0.0000	1.0000	0.0000
BI	0.8085	0.0515	0.8499	0.1122

SIRA Table 2a. Percent contributions for input variables for Sisyrinchium radicatum for ensemble models using available algorithms. The top four contributing variables are highlighted, except that the mx model only had three meaningful contributing variables.

Variable	gbm	mx	rf
aspect.r	0.6	0.0	5.4
bare.r	4.0	0.2	6.1
CVMinTemp.r	0.0	9.8	9.7
tmin.r	0.0	1.1	7.9
vpdMax.r	0.0	0.5	7.4
wpcv.r	0.0	20.1	9.9
soilpH.r	0.0	1.2	7.4
silicaIndex.r	16.6	66.4	8.9
gypsum.r	0.6	0.4	4.8
dist2h2o.r	58.7	0.0	22.9
VegetationDivisionsCC.f	19.4	0.2	9.6

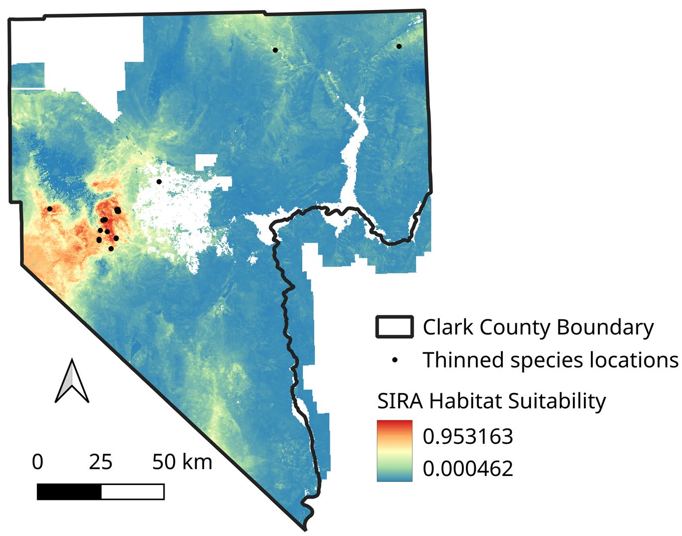


SIRA Figure 1a. Continuous Boyce Indices [CBI] for the Sisyrinchium radicatum ensemble model prediction



SIRA Figure 2a. Partial response curves for the four most influential variables in the Sisyrinchium radicatum ensemble model. Lines and bars indicate the variables as described in ANMI Figure 2b.

SIRA Ensemble Model



SIRA Figure 3a. Ensemble model of habitat suitability for Sisyrinchium radicatum in the vicinity of Clark County, NV. Hotter colors indicate higher predicted habitat values, and filled black circles show thinned species locations.

Model Discussion

Areas of highly habitat suitability for Sisyrinchium radicatum are distributed primarily to the southeast and south of the Spring Mountains in Clark County at lower to mid-level elevations, and is absent from high elevation areas (SIRA Figure 3a). An area of moderately suitable habitat is found near the Pahrump Valley (SIRA Figure 3a).

The locality data for this species consisted of 38 records within the buffered modeling area, which had a very high degree of overlap. Spatial thinning of the data reduced the number of localities used for training and testing to 21 records.

SIRA modeled without Clark County vegetation divisions, and with buffered area.

Habitat Model Performance

Performance metrics for the ensemble indicate a highly robust model that effectively distinguishes suitable habitat (SIRA Table 1b). The continuous Boyce Index (CBI) curve shows that once predicted suitability surpasses roughly 80%, observed presences occur up to five times more often than expected at random, with a steep increase at higher suitability values (SIRA Figure 1b). Testing produced AUC = 1.0000 (SD = 0.0000) and TSS =

1.0000 (SD = 0.0000), indicating strong rank discrimination across thresholds (AUC) and high threshold-based accuracy at the selected cutoff (TSS) (see Box 1; SIRA Table 1b).

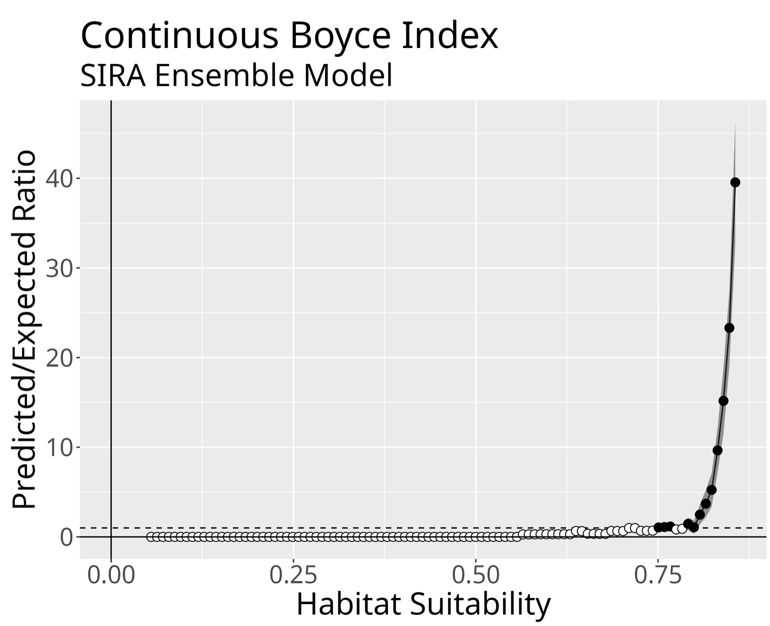
The variables used in the ensemble model of habitat suitability for the St. George blue-eyed grass for each model type indicate that some variables are of great importance (SIRA Table 2b). The top four most important variables in the ensemble model were examined to identify any important patterns for those variables. The coefficient of variation in winter precipitation (wpcv) was an important variable in all three of the models (SIRA Table 2b). Habitat suitability is low when the value of wpcv is below low, but suitability increases nearly linearly until it is maximized and remains high above a value of 0.68 (SIRA Figure 2b). The silica index (silicaIndex) was an important variable in two of the three models used (SIRA Table 2b). Habitat suitability is low when the silica index is below a value of 1.3, and suitability increases rapidly and remains high as the value for silicaIndex increases above 1.3 (SIRA Figure 2b). The absolute minimum temperature (tmin) was an important variable in two of the three models used (SIRA Table 2b). Habitat suitability is highest when tmin is below -5, but suitability declines slightly when tmin becomes more negative(SIRA Figure 2a). The coefficient of variation in minimum temperature (CVMinTemp) was an important variable for two of the three models (SIRA Table 2b). Habitat suitability is high whenever the value of CVMinTemp is less than 2.0, when CVMinTemp exceeds a value of 2.0, habitat suitability declines precipitously (SIRA Figure 2b).

SIRA Table 1b. Model performance values for Sisyrinchium radicatum models giving Area under the Receiver Operator Curve (AUC), Boyce Index (BI), and True Skill Statistic (TSS) for the ensemble model.

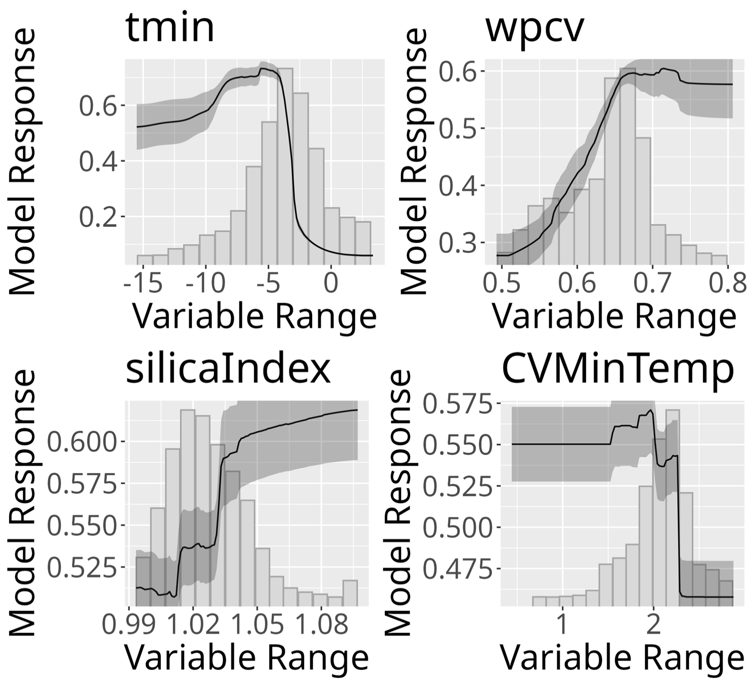
Stat	Training	Training SD	Testing	Testing SD
AUC	1.0000	0.0000	1.0000	0.0000
TSS	1.0000	0.0000	1.0000	0.0000
BI	0.8318	0.1107	0.7479	0.2929

SIRA Table 2b. Percent contributions for input variables for Sisyrinchium radicatum for ensemble models using available algorithms. The top four contributing variables are highlighted, except that the mx model only had three meaningful contributing variables.

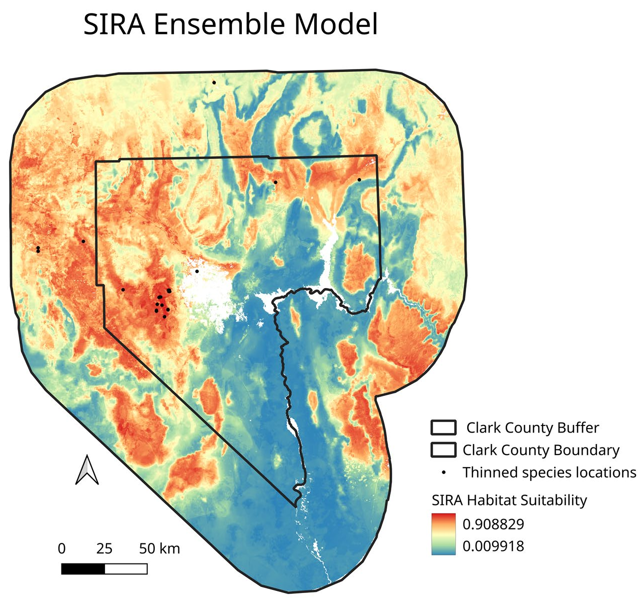
Variable	gam	mx	rf
aspect.r	0.0	0.0	5.6
bare.r	23.8	0.0	6.3
CVMinTemp.r	0.0	7.8	17.2
tmin.r	37.6	0.8	32.0
vpdMax.r	7.9	0.3	6.3
wpcv.r	9.9	44.7	8.0
soilpH.r	20.8	0.5	4.8
silicaIndex.r	0.0	45.7	8.9
gypsum.r	0.0	0.2	4.2
dist2h2o.r	0.0	0.0	6.8



SIRA Figure 1b. Continuous Boyce Indices [CBI] for the Sisyrinchium radicatum ensemble model prediction



SIRA Figure 2b. Partial response curves for the four most influential variables in the Sisyrinchium radicatum ensemble model. Lines and bars indicate the variables as described in ANMI Figure 2b.



SIRA Figure 3b. Ensemble model of habitat suitability for Sisyrinchium radicatum in the vicinity of Clark County, NV. Hotter colors indicate higher predicted habitat values, and filled black circles show thinned species locations.

Model Discussion

Areas of high habitat suitability for Sisyrinchium radicatum are broadly distributed across Clark County buffered area at mid-level to higher elevation areas, and is absent from the lowest elevation areas, and the very highest elevation areas (SIRA Figure 3b). An area of especially highly suitable habitat is found around the mid-elevation and periphery of the Spring Mountains (SIRA Figure 3b).

The locality data for this species consisted of 38 records within the buffered modeling area, which had a very high degree of overlap. Spatial thinning of the data reduced the number of localities used for training and testing to 26 records.

SWFL - Southwestern willow flycatcher, (Empidonax traillii extimus)

SWFL modeled with Clark County vegetation divisions, and without buffered area.

Habitat Model Performance

The ensemble model's performance values indicate a robust model with the ability to discriminate areas of suitable habitat well (SWFL Table 1a). The continuous Boyce Index (CBI) curve indicates that as the habitat suitability estimate increases above ca. 80%, species presence is predicted up to 10 times greater than would be expected at random

(SWFL Figure 1a). Testing AUC = 0.9988 (SD = 0.0019) and TSS = 0.9813 (SD = 0.0236), indicating strong rank discrimination across thresholds (AUC) and high thresholded accuracy at the selected cutoff (TSS) (see Box 1; SWFL Table 1a).

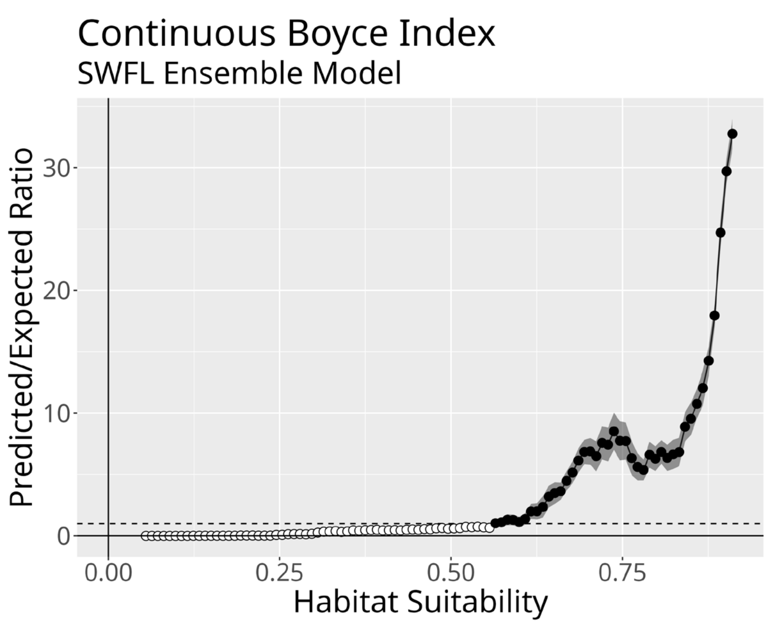
The variables used in the ensemble model of habitat suitability for the Southwestern willow flycatcher for each model type indicate that some variables are of great importance (SWFL Table 2a). The top four most important variables in the ensemble model were examined to identify any important patterns for those variables. Coarse fragments (coarse) was an important variable for one of the three models used (SWFL Table 2a). Habitat suitability is highest when coarse is near zero, and suitability declines almost linearly and remains low as coarse exceeds 40 (SWFL Figure 2a). The coefficient of variation of winter precipitation (wpcv) was an important variable in one of the three model types used (SWFL Table 2a). Habitat suitability is low whenever the wpcv is below 0.7, but suitability increases rapidly and linearly as the value of wpcv increases (SWFL Figure 2a). The coefficient of variation in minimum temperature (CVMinTemp) was an important variable in one of the three models (SWFL Table 2a). Habitat suitability is highest when CVMinTemp is low, suitability decreases to a minimum as CVMinTemp reaches a value of 2, and remains relatively low thereafter (SWFL Figure 2a). The silica index (silicaIndex) was also an important variable in one of the three models (SWFL Table 2a). Habitat suitability is low when the silica index is less than 1.07, but increases rapidly and remains high at higher values of silicaIndex (SWFL Figure 2a).

SWFL Table 1a. Model performance values for Empidonax traillii extimus models giving Area under the Receiver Operator Curve (AUC), Boyce Index (BI), and True Skill Statistic (TSS) for the ensemble model.

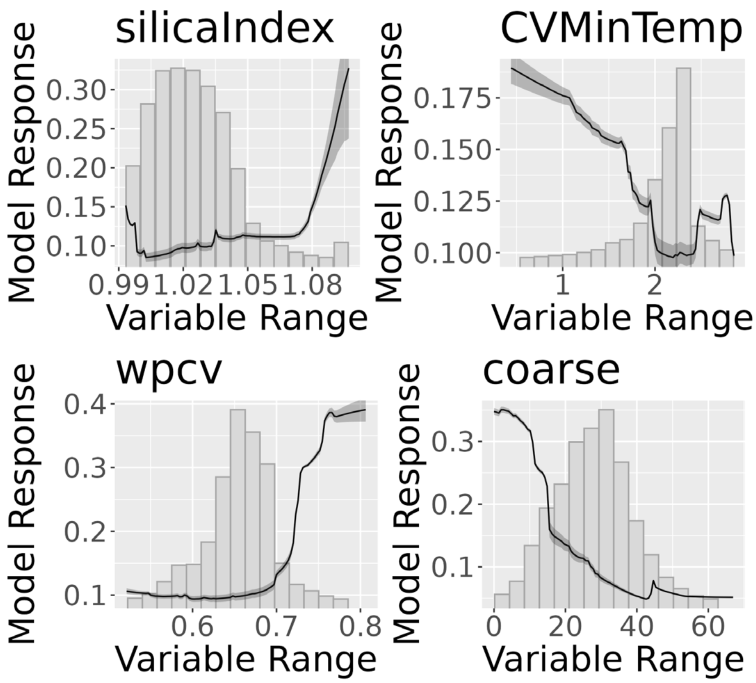
Stat	Training	Training SD	Testing	Testing SD
AUC	0.9992	0.0004	0.9988	0.0019
TSS	0.9841	0.0061	0.9813	0.0236
BI	0.9970	0.0019	0.9477	0.0427

SWFL Table 2a. Percent contributions for input variables for Empidonax traillii extimus for ensemble models using available algorithms. The top four contributing variables are highlighted, except that the mx model only had three meaningful contributing variables.

Variable	gam	mx	rf
coarse.r	6.00	0.10	16.00
CVMinTemp.r	0.00	19.50	5.50
slope.r	13.00	0.80	12.20
soil1.r	30.00	0.10	9.10
tmin.r	13.00	2.60	5.90
vpdMax.r	4.00	0.30	8.90
wpcv.r	12.00	14.40	7.40
soilpH.r	15.00	0.60	5.20
silicaIndex.r	7.00	61.50	7.30
dist2h2o.r	0.00	0.00	6.70
Vegetation Division.f	0.00	0.20	15.80

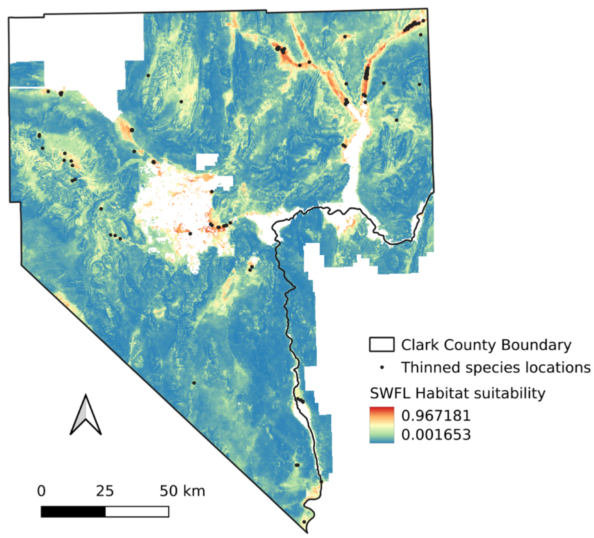


SWFL Figure 1a. Continuous Boyce Indices [CBI] for the Empidonax traillii extimus ensemble model prediction



SWFL Figure 2a. Partial response curves for the four most influential variables in the Empidonax traillii extimus ensemble model. Lines and bars indicate the variables as described in ANMI Figure 2b.

SWFL Ensemble Model



SWFL Figure 3a. Ensemble model of habitat suitability for Empidonax traillii extimus in the vicinity of Clark County, NV. Hotter colors indicate higher predicted habitat values, and filled black circles show thinned species locations.

Model Discussion

Highly suitable habitat for Empidonax traillii extimus has a limited distributed across Clark County (SWFL Figure 3a). The primary areas of highly suitable habitat are found near the Meadow Valley Wash, the Muddy River, and the Virgin River (SWFL Figure 3a). Surprisingly, there are no apparent areas of highly suitable habitat along the Colorado River south of Lake Mead (SWFL Figure 3a).

The locality data for this species consisted of 601 records within the buffered modeling area, which had a very high degree of overlap. Spatial thinning of the data reduced the number of localities used for training and testing to 119 records.

SWFL modeled without Clark County vegetation divisions, and with buffered area.

Habitat Model Performance

The ensemble model's performance values indicate a robust model with a good ability to discriminate areas of suitable habitat(SWFL Table 1b). The continuous Boyce Index (CBI) curve indicates that as the habitat suitability estimate increases above ca. 80%, species presence is predicted up to six times greater than would be expected at random and increases rapidly with higher values for habitat suitability (SWFL Figure 1b). Testing AUC = 0.9844 (SD = 0.0063) and TSS = 0.8802 (SD = 0.0314), indicating strong rank discrimination across thresholds (AUC) and high thresholded accuracy at the selected cutoff (TSS) (see Box 1; SWFL Table 1b). Test CBI = 0.9257 (SD = 0.0386), indicating evaluation presences occur more often in high-suitability bins than expected at random (SWFL Figure 1b; see Box 1).

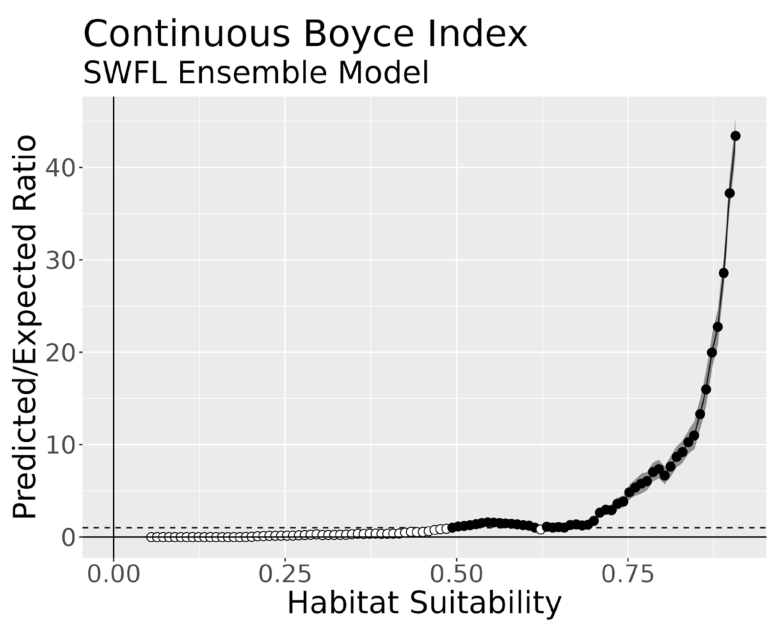
The variables used in the ensemble model of habitat suitability for the Southwestern willow flycatcher for each model type indicate that some variables are of great importance (SWFL Table 2b). The top four most important variables in the ensemble model were examined to identify any important patterns for those variables. The coarse fragments (coarse) was an important variable in two of the four models (SWFL Table 2b). Habitat suitability is highest when the value of coarse fragments is low, but suitability decreases nearly linearly as the value of coarse fragments increases (SWFL Figure 2b). The first principal component of sand/silt/clay (soil1) was an important variable for two of the four models used (SWFL Table 2b). Habitat suitability is highest when soil1 is less than zero, and suitability declines linearly as soil1 increases (SWFL Figure 2b). The silica index (silicaIndex) was also an important variable in two of the four models (SWFL Table 2b). Habitat suitability is highest when the silica index is low, but suitability decreases linearly to a minimum as the silica index reaches 1.05, and remains low at higher values of silicaIndex (SWFL Figure 2b). The coefficient of variation of winter precipitation (wpcv) was an important variable in one of the four model types used (SWFL Table 2b). Habitat suitability is low whenever the wpcv is low, suitability increases nearly linearly as wpcv increases (SWFL Figure 2b).

SWFL Table 1b. Model performance values for Empidonax traillii extimus models giving Area under the Receiver Operator Curve (AUC), Boyce Index (BI), and True Skill Statistic (TSS) for the ensemble model.

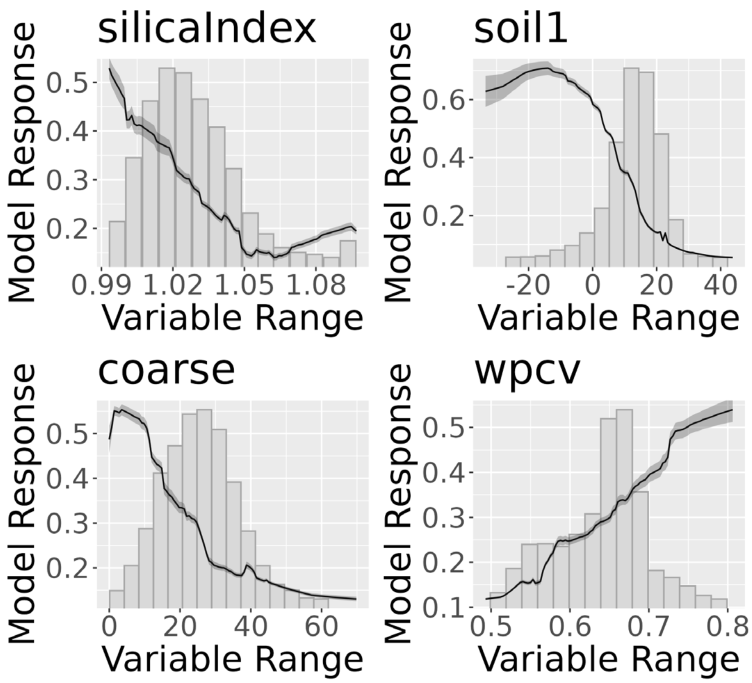
Stat	Training	Training SD	Testing	Testing SD
AUC	0.9856	0.0014	0.9844	0.0063
TSS	0.8634	0.0091	0.8802	0.0314
BI	0.9676	0.0131	0.9257	0.0386

SWFL Table 2b. Percent contributions for input variables for Empidonax traillii extimus for ensemble models using available algorithms. The top four contributing variables are highlighted, except that the gbm and mx models each had only two meaningful contributing variables.

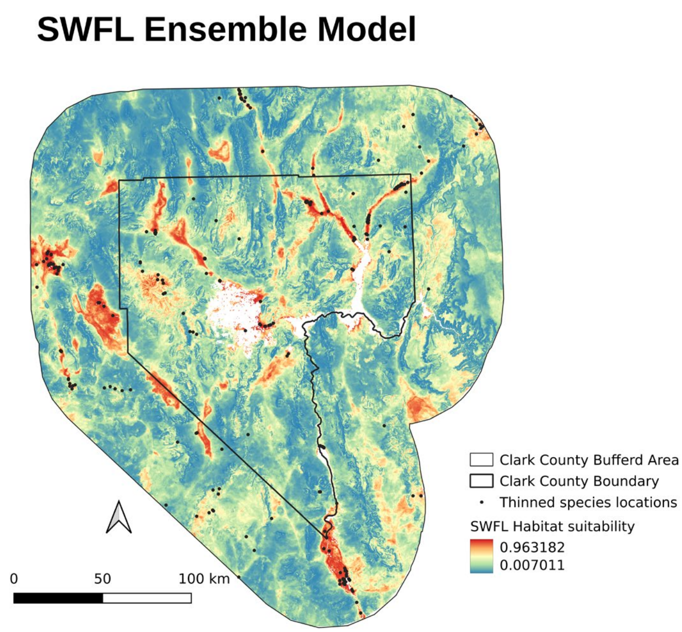
Variable	gam	gbm	mx	rf
coarse.r	5.9	46.4	0.1	18.7
CVMinTemp.r	20.6	0	5.2	6
slope.r	14.7	4.8	0.3	12.1
soil1.r	14.7	44.6	0.2	20.8
tmin.r	1	0	0.7	4.8
vpdMax.r	15.7	3.9	0.2	11.3
wpcv.r	8.8	0	22.7	5.9
soilpH.r	2	0	0.2	5.3
silicaIndex.r	15.7	0	70.5	7.4
dist2h2o.r	1	0.3	0	7.6



SWFL Figure 1b. Continuous Boyce Indices [CBI] for the Empidonax traillii extimus ensemble model prediction



SWFL Figure 2b. Partial response curves for the four most influential variables in the Empidonax traillii extimus ensemble model. Lines and bars indicate the variables as described in ANMI Figure 2b.



SWFL Figure 3b. Ensemble model of habitat suitability for Empidonax traillii extimus in the vicinity of Clark County, NV. Hotter colors indicate higher predicted habitat values, and filled black circles show thinned species locations.

Model Discussion

Highly suitable habitat for Empidonax traillii extimus has a limited distributed across the Clark County buffered area (SWFL Figure 3b). The primary areas of highly suitable habitat are found near the Meadow Valley Wash, the Muddy River, and the Virgin River (SWFL Figure 3b). Highly suitable habitat is also found in northwest Las Vegas Valley and in Indian Springs Valley (SWFL Figure 3b). Other areas of highly suitable habitat are found near Pahrump, Sandy Valley, and along the Colorado River in the areas near Bullhead City and the Mohave Valley (SWFL Figure 3b).

The locality data for this species consisted of 601 records within the buffered modeling area, which had a very high degree of overlap. Spatial thinning of the data reduced the number of localities used for training and testing to 243 records.

YUJA – Eastern Joshua Tree (Yucca jaegeriana)

YUJA modeled with Clark County vegetation divisions, without buffered area.

Habitat Model Performance

Performance metrics for the ensemble indicate a marginally reliable model that effectively distinguishes suitable habitat as teh Boyce Index was only 0.68 – the lowest of any model to date (YUJA Table 1a). The continuous Boyce Index curve shows that predicted suitability becomes positive at values of around 0.5, but fluctuates at higher levels (YUJA Figure 1a). Test results yielded AUC = 1.0000 (SD = 0.0000) and TSS = 1.0000 (SD = 0.0000), demonstrating perfect rank discrimination across thresholds and perfect thresholded accuracy at the chosen cutoff (see Box 1; SIRA Table 1a), however given the BI and CBI results this could be due to overfitting.

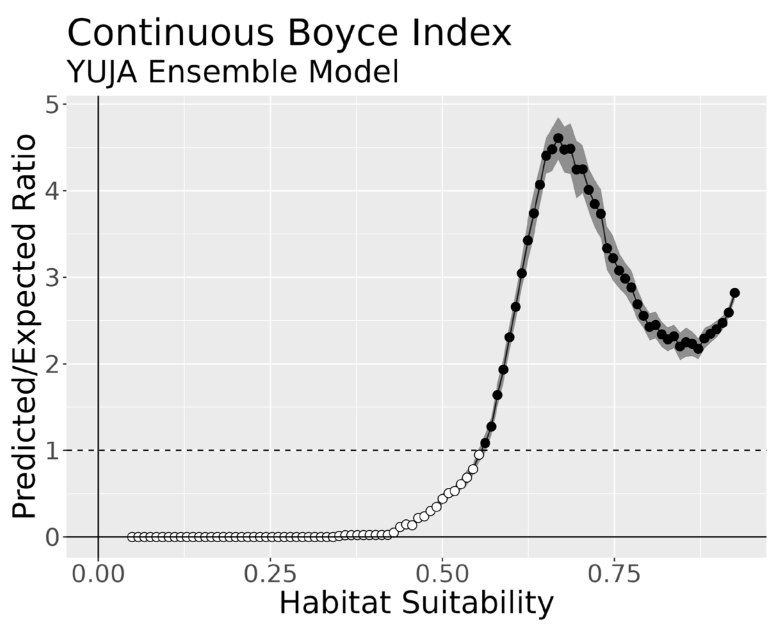
The variables used in the ensemble model of habitat suitability for the Eastern Joshua tree for each model type indicate that some variables are of great importance (YUJA Table 2a). The top four most important variables in the ensemble model were examined to identify any important patterns for those variables. The vapor pressure deficit maximum (vpdMax) was an important variable in two of the three models used (YUJA Table 2a). Habitat suitability is highest when vpdMax is about 30 millibars and suitability is lower with either higher or lower values of vpdMax (YUJA Figure 2a). The minimum temperature (tmin) was an important variable in two model types used (YUJA Table 2a). Habitat suitability is high whenever the tmin is below -2 C, and suitability decreases rapidly when tmin exceeds 0 C (YUJA Figure 2a). The coefficient of variation in winter precipitation (wpcv) was an important variable for one of the three models used (YUJA Table 2a). Habitat suitability is high when wpcv is about 0.6, and suitability declines with as wpcv increases to 0.73, higher values of wpcv result in a dramatic increase in suitability above values of 0.78 (YUJA Figure 2a). The first principal component of sand/silt/clay (soil1) was an important variable for one of the three models used (YUJA Table 2a). Habitat suitability is highest when the value of soil1 is about 24, but suitability decreases with either higher or lower values of soil1 (YUJA Figure 2a).

YUJA Table 1a. Model performance values for Yucca jaegeriana models giving Area under the Receiver Operator Curve (AUC), Boyce Index (BI), and True Skill Statistic (TSS) for the ensemble model.

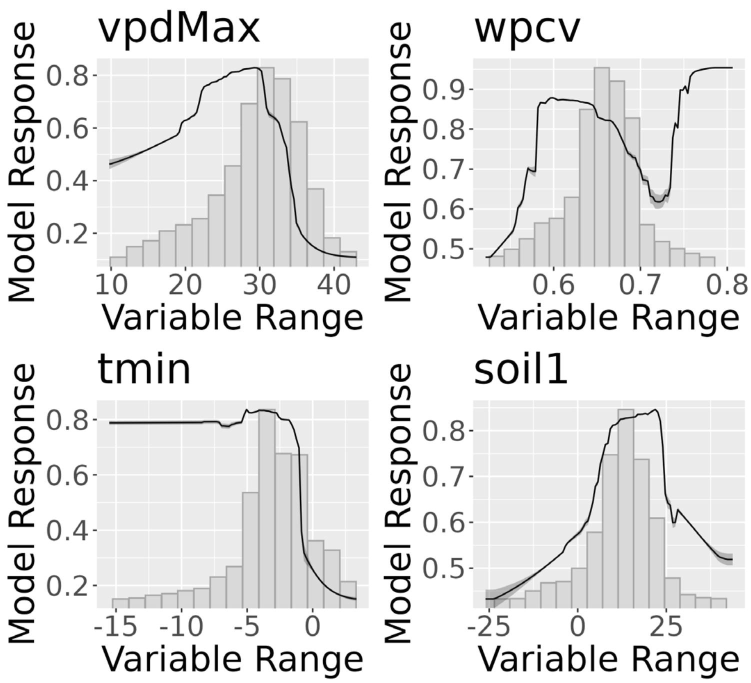
Stat	Training	TrainingSD	Testing	TestingSD
AUC	1.0000	0.0000	1.0000	0.0000
TSS	0.9976	0.0006	0.9977	0.0016
BI	0.6870	0.0355	0.5898	0.0824

YUJA Table 2a. Percent contributions for input variables for Yucca jaegeriana for ensemble models using available algorithms. The top four contributing variables are highlighted, except that the mx models that had only one meaningful contributing variable.

Variable	gbm	mx	rf
Coars Fragments	0	0.1	13.2
Soil PC 1	12.6	0.6	11.7
T min	11.8	0.6	16.4
vpdMax	65.2	2.1	20.2
wp	0	0.2	13.2
wpcv	0	95.2	11.7
soilpH	0	0.7	9.2
Vegetation CC	10.4	0.5	4.4

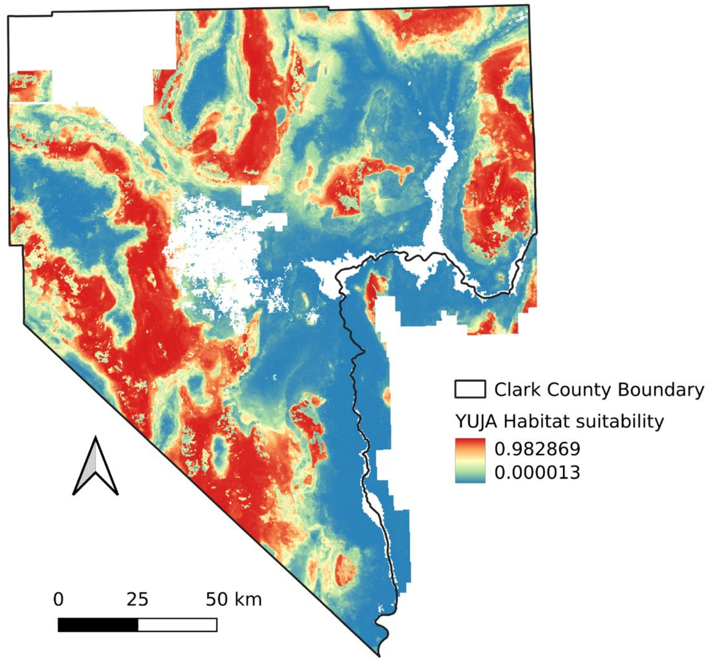


YUJA Figure 1a. Continuous Boyce Indices [CBI] for the Yucca jaegeriana ensemble model prediction



YUJA Figure 2a. Partial response curves for the four most influential variables in the Yucca jaegeriana ensemble model. Lines and bars indicate the variables as described in ANMI Figure 2b.

YUJA Ensemble model



YUJA Figure 3a. Ensemble model of habitat suitability for Yucca jaegeriana in the vicinity of Clark County, NV. Hotter colors indicate higher predicted habitat values, thinned species locations are not shown to avoid obscuring the model.

Model Discussion

Highly suitable habitat for Yucca jaegeriana has is broadly distributed across the Clark County buffered area (YUJA Figure 3a). The primary areas of highly suitable habitat are found at mid-range elevations. Habitat suitability is generally high along the periphery of mountain ranges, and low in valley bottoms (YUJA Figure 3a).

The locality data for this species consisted of very large number of records within the buffered modeling area, which had a very high degree of overlap. Points are not displayed here as they saturate the map and make the model values unreadable.

YUJA modeled without Clark County vegetation divisions, and with buffered area.

Habitat Model Performance

The ensemble model's performance values indicate a robust model with the ability to discriminate areas of suitable habitat well (YUJA Table 1b). The continuous Boyce Index (CBI) curve indicates that as the habitat suitability estimate increases above ca. 80%, species presence is predicted up to three times greater than would be expected at random and increases with higher values for habitat suitability (YUJA Figure 1b). Testing AUC =

0.8645 (SD = 0.0008) and TSS = 0.7708 (SD = 0.0042), indicating strong rank discrimination across thresholds (AUC) and high thresholded accuracy at the selected cutoff (TSS) (see Box 2; YUJA Table 1b). Test CBI = 1.0 (SD = 0.0), indicating evaluation presences occur more often in high-suitability bins than expected at random (YUJA Figure 1b; see Box 1).

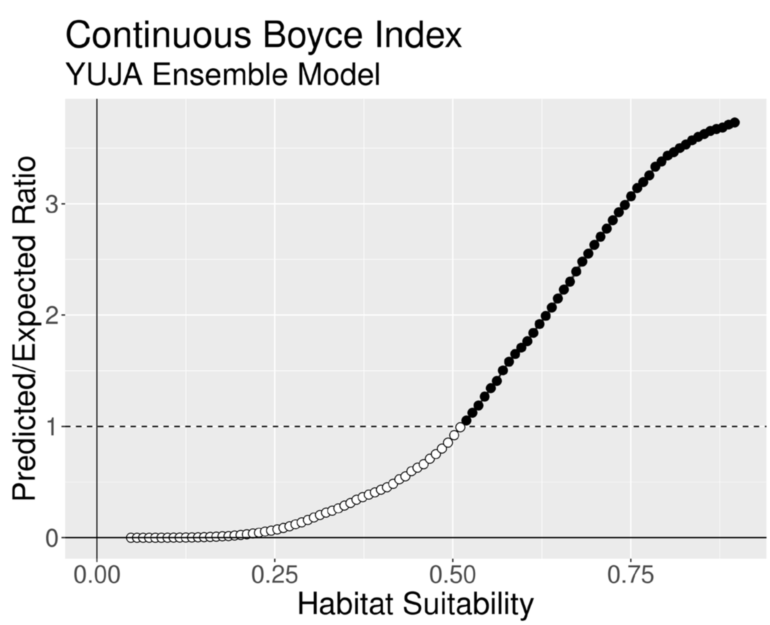
The variables used in the ensemble model of habitat suitability for the Eastern Joshua tree for each model type indicate that some variables are of great importance (YUJA Table 2b). The top four most important variables in the ensemble model were examined to identify any important patterns for those variables. The coefficient of variation of minimum temperature (CVMinTemp) was an important variable in all four model types used (YUJA Table 2b). Habitat suitability is moderate whenever the CVMinTemp is very below a value of two, suitability increases to a maximum when the value of CVMinTemp is ca. 2.2, and suitability decreases dramatically as CVMinTemp exceeds 2.5 (YUJA Figure 2b). Winter precipitation (wp) was an important variable for two of the models used. Habitat suitability is highest when wp is about 160 mm (YUJA Table 2b). The coefficient of variation in winter precipitation (wpcv) was an important variable for two of the four models used (YUJA Table 2b). Habitat suitability is highest when wpcv is between 0.55 and 0.68 and suitability declines with any increase in wpcv (YUJA Figure 2b). The annual precipitation (ppt) was also an important variable in two of the four models (YUJA Table 2b). Habitat suitability is highest when the ppt is about 180 mm, but suitability decreases with either higher or lower values of ppt (YUJA Figure 2b).

YUJA Table 1b. Model performance values for Yucca jaegeriana models giving Area under the Receiver Operator Curve (AUC), Boyce Index (BI), and True Skill Statistic (TSS) for the ensemble model.

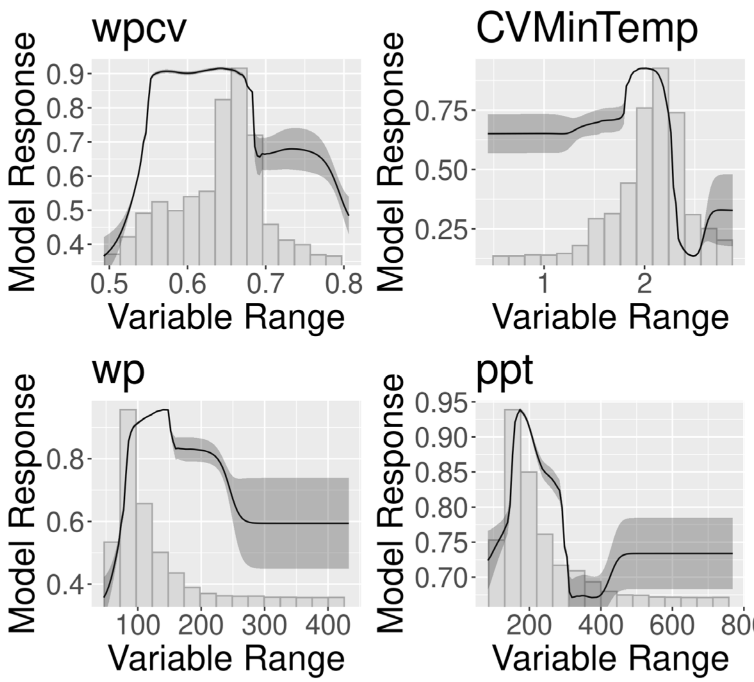
Stat	Training	Training SD	Testing	Testing SD
AUC	0.9666	0.0002	0.9645	0.0008
TSS	0.7773	0.0010	0.7708	0.0042
BI	1.0000	0.0000	1.0000	0.0000

YUJA Table 2b. Percent contributions for input variables for Yucca jaegeriana for ensemble models using available algorithms. The top four contributing variables are highlighted, except that the gbm and rf models each had only three meaningful contributing variables, and the mx model only had two meaningful variables.

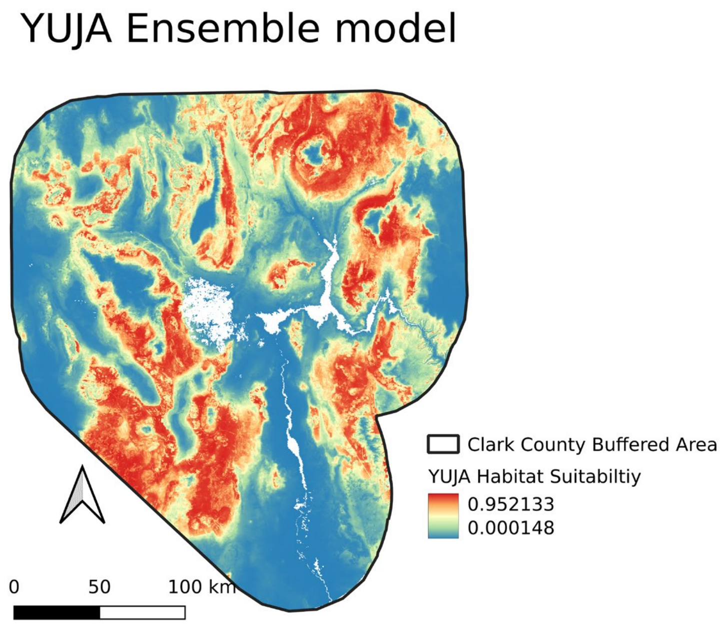
Variable	gam	gbm	mx	rf
bedrock.r	1	0	0	5.1
coarse.r	9	0	0.1	6.1
CVMinTemp.r	20	43.6	15.3	15.9
herb.r	3	0	0.1	4.9
ppt.r	7	22.2	0.2	10.9
slope.r	5	0	0.4	5.3
soil1.r	5	0	0.6	5.6
tmin.r	6	1	2.2	10.6
vpdMax.r	7	0	1	7.4
wp.r	8	33.2	0.4	10.7
wpcv.r	12	0	79.4	8.2
soilpH.r	17	0	0.2	9.3



YUJA Figure 1b. Continuous Boyce Indices [CBI] for the Yucca jaegeriana ensemble model prediction



YUJA Figure 2b. Partial response curves for the four most influential variables in the Yucca jaegeriana ensemble model. Lines and bars indicate the variables as described in ANMI Figure 2b.



YUJA Figure 3b. Ensemble model of habitat suitability for Yucca jaegeriana in the vicinity of Clark County, NV. Hotter colors indicate higher predicted habitat values, thinned species locations are not shown to avoid obscuring the model.

Model Discussion

Highly suitable habitat for Yucca jaegeriana has is broadly distributed across the Clark County buffered area (YUJA Figure 3b). The primary areas of highly suitable habitat are found at mid-range elevations. Habitat suitability is generally high along the periphery of mountain ranges, and is low at extreme elevations, or in valley bottoms (YUJA Figure 3b).

The locality data for this species consisted of very large number of records within the buffered modeling area, which had a very high degree of overlap. Spatial thinning of the data reduced the number of localities used for training and testing to 54,653 records. Points are not displayed here as they saturate the map and make the model values unreadable.

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