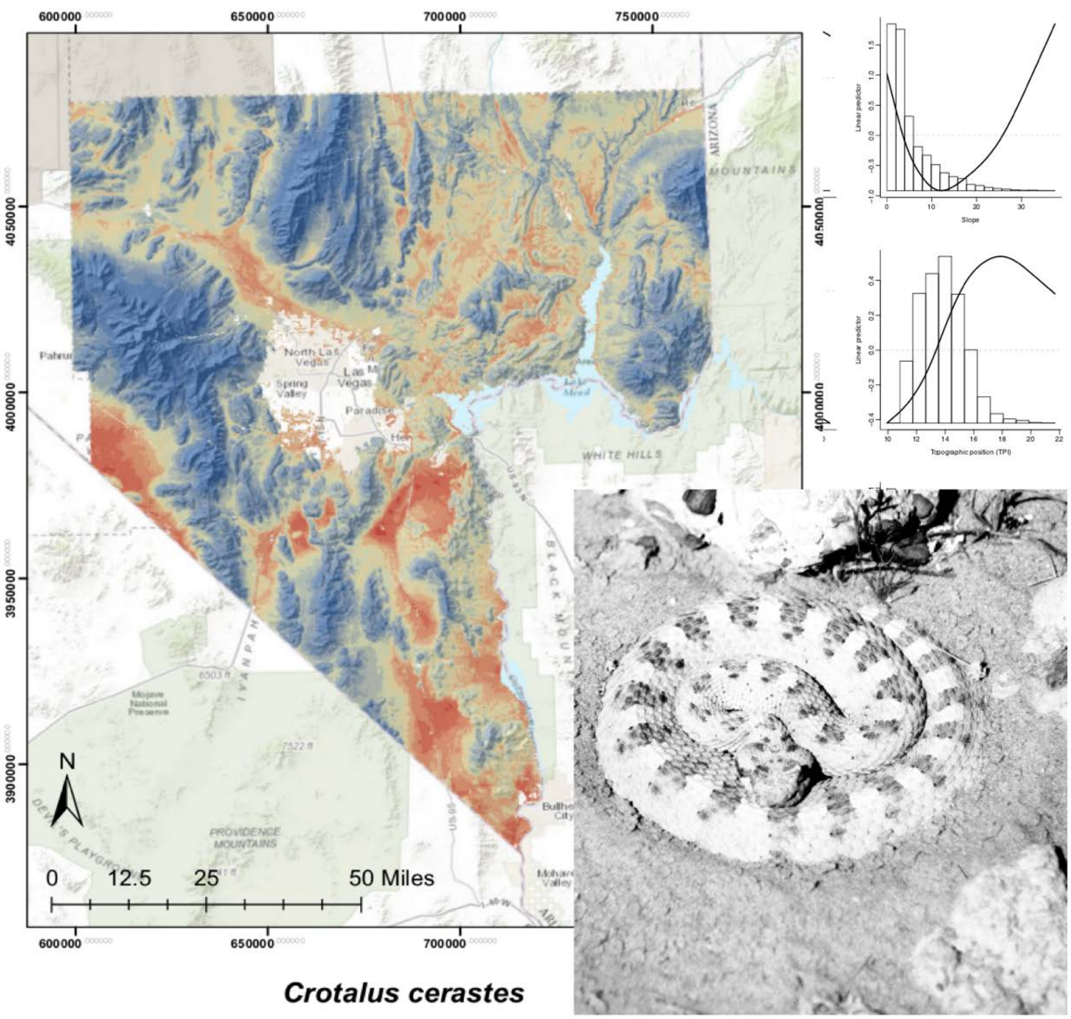
Covered Species Analysis Support –Final Report

2011-SWECO-901B



Crotalus cerastes
Habitat Suitability Map

Photo by Ken Nussear

Final report for 2011-SWECO-901B – Submitted to Clark County Desert Conservation Program. March 2018 by Southwest Ecology LLC.

Southwest Ecology

Executive Summary

Clark County is currently in the process of updating it's 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 review existing, and provide new information on 56 species that come from a combination of these species lists in the CCMSCHP. This information was in the form of 1) species accounts, which give general species information on biology, status and trends, and habitat considerations; and species habitat models – either existing or produced under this project – to provide an understanding on the amount and extent of potential habitat for these species.

Habitat suitability models are frequently used as a species management tool for tasks such as the design of conservation and monitoring programs, species richness assessments, and the evaluation of potential changes in species distributions as a result of climate change and anthropogenic disturbance. (Araújo and Williams 2000, Elith et al. 2006). Species distribution models (SDMs) can be valuable tools for use in planning efforts toward the conservation of species (Johnson et al. 2004, Kremen et al. 2008, Leathwick et al. 2008). Models that include relevant information matching species needs and limitations (e.g. physiological tolerances) are more likely to accurately reflect species distributions as well as their reactions to changing conditions (Guissan et al. 2006).

Our approach was to use the species accounts that were produced to drive conceptual models that were used to choose appropriate environmental covariates to use in building SDM's for 31 of the 56 species. 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 three commonly used modeling algorithms to create SDM's; 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 to create an ensemble model that is meant to overcome assumptions shortcomings of any one algorithm (Araujo and New 2006). For species that already had models produced in prior research efforts, we reviewed the approach and merits of each model.

Habitat models were re-classified into predictions of High, Medium and Low suitability, and these classes were intersected with the ecosystems recognized within the county to give an approximate area of predicted habitat within each. These suitability classes were also intersected with areas to be conserved, those that may be impacted in future development, and those likely already disturbed to quantify the current and future status of conservation and potential impact to each species. Some (but relatively few) models produced in prior efforts did not have data in a sufficient format to conduct this assessment.

Collectively we updated 18 species accounts, and produced 28 new species accounts. We reviewed SDMs for 25 species, and produced new SDMs for 31 species.

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Introduction

For this project, species accounts were reviewed for eighteen species, and new species accounts were created for 36 species. Species habitat models were reviewed for 25 species that had models created prior to this effort, and new habitat modes were created for 29 species for this project (Table 1). Of these 29 habitat models, all but 4 were conducted using quantitative modeling methods, however too few localities existed for some species models, and quantitative models were produced instead. All species localities and covariate Geographic Information System (GIS) layers used in modeling, as well as final modeling products are being submitted with this report.

Methods

Species data

This report summarizes habitat distribution modelling conducted for 33 species that occur within Clark County, Nevada and are covered under the MSHCP (Table 2). Many of these species are rare and / or limited in their spatial distributions. Therefore, we searched available public databases (the Global Biodiversity Information Facility - http://www.gbif.org/; iNaturalist - http://www.inaturalist.org/; Southwest Environmental Information Network, SEInet - http//:swbiodiversity.org/; the Consortium of CA Herbaria - http://ucjeps.berkeley.edu/consortium/; Vertnet - http://vertnet.org/; and HerpNET- http://www.herpnet.org) to supplement species observation records provided by Clark County, the Nevada Department of Wildlife (NDOW), the Nevada Natural Heritage Program (NNHP), the National Park Service (NPS), the US Forest Service (USFS), the Bureau of Land Management (BLM), the Nature Conservancy (TNC), and other independent contractors under the MSHCP (Table 2). Observations were visually assessed for accuracy prior to model fitting, and duplicate records and / or those without sufficient locality information were removed. For species that had undergone recent revisions in taxonomy, we used both historical and current names during searches.

For each species under consideration, we developed a conceptual model of suitable habitat based upon a review of the available scientific literature. We then selected environmental covariates describing the range of environmental conditions necessary for establishment, growth, reproduction, and survival. Habitat distribution models were based upon biologically relevant variables for which we had *a priori* hypotheses relating to each species' life-history. This approach reduces the risk of spurious associations and potentially results in models with greater biological relevance (Austin 2002; Guisan and Thuiller 2005). Based on these criteria, we selected approximately 10 environmental covariates to include in habitat models for each species that were thought to influence their geographic distributions.

Environmental covariates

We evaluated a range of environmental covariates that might effectively discriminate habitat for multiple species within Clark County, including spatial layers available from the County, previously published datasets (Inman et al. 2014; Nussear et al. 2009), climatic interpolations (Hamann et al. 2013; Wang et al. 2016), satellite-based vegetation indices from the United States Geological Survey (USGS) Eros Center (http://phenology.cr.usgs.gov/), and topographic features derived from a Digital Elevation Model (USGS National Elevation Dataset; http://ned.usgs.gov/). In total, we derived 34 covariate layers for potential inclusion in habitat distribution models (Table 3). These layers included climatic averages and extremes for precipitation and temperature, topographic features, and remotely-sensed vegetation indices (e.g., Normalized Difference Vegetation Index [NDVI]). Environmental covariates were assessed for collinearity prior to model fitting, and variables that showed strong correlations ($r > 0.75$) were not included within the same models for a given species. Because many variables were expressed in different units, we standardized all variables prior to model fitting. Impervious surfaces were masked from the modelling extent based on the National Land Cover Database 2011 percent developed imperviousness layer (Xian et al. 2011; https://www.mrlc.gov/). Grid cells were defined as impervious when greater than 20 % of their surface area were covered by at least 20 % imperviousness.

Table 1. Species addressed in this project. Account Deliverable numbers are in accordance with the Schedule within the Scope of Work for Project 2011-SWECO-901B

Species Code	Common Name	Scientific Name	Review Model	New Model	New Species Account	Update Species Account	Species Acct Deliverable	Modeling Deliverable
ANLE	Sticky Ringstem	*Anulocaulis leiosolenus*	Yes		Yes		D15	D17
ANPA	Pallid Bat	*Antrozous pallidus*		Yes	Yes		D05	D07
AQCH	Golden Eagle	*Aquila chrysaetos*	Yes		Yes		D02	D04
ARCA	Las Vegas Bearpoppy	*Arctomecon californica*	Yes			Yes	D09	D11
ARME	White Bearpoppy	*Arctomecon merriamii*	Yes		Yes		D18	D21
ARNE	Bell's Sparrow	*Artemisiospiza belli*		Yes	Yes		D18	D21
ASGETR	Threecorner Milkvetch	*Astragalus geyeri var. triquetrus*	Yes	Yes		Yes	D09	D11/D21
ASLEST	Straw Milkvetch	*Astragalus lentiginosus var. stramineus*		Yes	Yes		D15	D17
ASMOHE	Halfring Milkvetch	*Astragalus mohavensis var. hemigyrus*		Yes	Yes		D12	D14
ASMOK	Mokiak Milkvetch	*Astragalus mokiacensis*		Yes	Yes		D12	D14
ATCU	Western Burrowing Owl	*Athene cunicularia hypugea*	Yes	Yes		Yes	D02	D04/D21
CACO	Costa's hummingbird	*Calypte costae*	Yes		Yes		D05	D07
CAST	Alkali Mariposa Lily	*Calochortus striatus*		Yes	Yes		D12	D14

Species Code	Common Name	Scientific Name	Review Model	New Model	New Species Account	Update Species Account	Species Acct Deliverable	Modeling Deliverable
CHOC	Mojave shovel-nosed snake	*Chionactis occipitalis*		Yes	Yes		D02	D04
CHPE	Desert Pocket Mouse	*Chaetodipus penicillatus*	Yes			Yes	D12	D14
COAM	Yellow-Billed Cuckoo	*Coccyzus americanus*	Yes			Yes	D15	D14
COCH	Gilded Flicker	*Colaptes chrysoides*	Yes		Yes		D05	D07
COTO	Townsend's big-eared bat	*Corynorhinus townsendii*		Yes		Yes	D05	D07
CRCE	sidewinder	*Crotalus cerastes*		Yes	Yes		D02	D04
CYMU	Blue Diamond Cholla	*Cylindropuntia multigeniculata*		Yes	Yes		D12	D11
DIDE	Desert Kangaroo Rat	*Dipodomys deserti*	Yes			Yes	D02	D04
DIDO	Desert Iguana	*Dipsosaurus dorsalis*		Yes	Yes		D02	D04
DINE	Gold Butte Moss	*Didymodon nevadensis*		Yes	Yes		D18	D21
DIPU	Regal ringneck snake	*Diadophis punctatus*		Yes	Yes		D02	D21
EMTR	Southwestern Willow Flycatcher	*Empidonax traillii extimus*	Yes			Yes	D15	D17
ENAR	Silverleaf Sunray	*Enceliopsis argophylla*		Yes	Yes		D12	D14
ERBI	Pahrump Valley Buckwheat	*Eriogonum bifurcatum*	Yes			Yes	D18	D21
ERCO	Las Vegas Buckwheat	*Eriogonum corymbosum var. nilesii*	Yes			Yes	D18	D21

Species Code	Common Name	Scientific Name	Review Model	New Model	New Species Account	Update Species Account	Species Acct Deliverable	Modeling Deliverable
ERVI	Sticky Buckwheat	*Eriogonum viscidulum*	Yes			Yes	D09	D11
EUEX	Catchfly Gentian	*Eustoma exaltatum*		Yes	Yes		D15	D17
EUMA	Spotted Bat	*Euderma maculatum*		Yes		Yes	D05	D21
GOAG	Mojave Desert Tortoise	*Gopherus agassizii*	Yes			Yes	D02	D04
HEGR	MacNeill's Saltbush Sootywing	*Hesperopsis gracielae*		Yes	Yes		D15	D17
HESU	banded Gila Monster	*Heloderma suspectum cinctum*		Yes		Yes	D05	D04
LABL	Western Red Bat	*Lasiurus blossevillii*		Yes	Yes		D09	D11
LACI	Hoary Bat	*Lasiurus cinereus*		Yes	Yes		D09	D07
LALU	Loggerhead Shrike	*Lanius ludovicianus*	Yes		Yes		D15	D14
LANO	Silver-haired Bat	*Lasionycteris noctivagans*		Yes	Yes		D09	D11
MACA	California Leaf-nosed Bat	*Macrotus californicus*		Yes	Yes		D09	D11
MEPO	Polished Blazingstar	*Mentzelia polita*		Yes	Yes		D18	D17
PEAL	White-margined Beardtongue	*Penstemon albomarginatus*	Yes			Yes	D09	D11
PEBIBI	yellow twotone beardtongue	*Penstemon bicolor ssp. bicolor*	Yes	Yes		Yes	D18	D21
PEBIRO	Rosy Two-tone Beardtongue	*Penstemon bicolor ssp. roseus*		Yes	Yes		D12	D11

Species Code	Common Name	Scientific Name	Review Model	New Model	New Species Account	Update Species Account	Species Acct Deliverable	Modeling Deliverable
PECA	Beaver Dam Breadroot	*Pediomelum castoreum*	Yes		Yes		D18	D21
PHDE	Spotted Leaf-nosed Snake	*Phyllorhynchus decurtatus*		Yes	Yes		D05	D07
PHFI	Clarke Phacelia	*Phacelia filiae*		Yes	Yes		D12	D14
PHNI	Phainopepla	*Phainopepla nitens*	Yes		Yes		D05	D07
RAOB	Ridgway's rail	*Rallus obsoletus yumanensis*	Yes			Yes	D15	D17
SIRA	St. George Blue-eyed Grass	*Sisyrinchium radicatum*		Yes	Yes		D18	D17
TABR	Mexican Free-tailed Bat	*Tadarida brasiliensis*		Yes	Yes		D09	D07
THBO	Botta's Pocket Gopher	*Thomomys bottae*		Yes	Yes		D02	D04
TOBE	Bendire's Thrasher	*Toxostoma bendirei*	Yes		Yes		D05	D07
TOLE	Le Conte's Thrasher	*Toxostoma lecontei*	Yes		Yes		D15	D17
VIBE	Arizona Bell's Vireo	*Vireo bellii arizonae*	Yes			Yes	D12	D14
	Totals		25	31	38	18		

Table 2. Species covered under the MSHCP for which habitat distribution models were derived, the number of unique observation records found, the number of observation records remaining after geographically-weighted resampling (spatial points thinning), and the sources from which observation records were compiled.

Scientific name	*Model type*	*Model extent*	*Occurrence in Model*	*Thinned occurrences*	*Point sources*[1]
Antrozous pallidus	Quantitative	Mojave Desert	112	103	NDOW, USFS, NNHP, GBIF
Artemisiospiza belli	Quantitative	Clark County	64	45	GBBO, NDOW, GBIF, Inaturalist, NPS
Astragalus geyeri var. triquetrus	Quantitative	Clark County	350	209	NPS, BLM, TNC, NNHP, ICF
Astragalus lentiginosus var. stramineus	Quantitative	Mojave Desert	21	18	NNHP, SEInet
Astragalus mohavensis var. hemigyrus	Quantitative	Clark County	113	75	BLM, NNHP, SEInet
Astragalus mokiacensis	Quantitative	Mojave Desert / Clark County	44 / 28	36 / 24	BLM, NNHP, NPS, SEInet
Athene cunicularia	Quantitative	Clark County	208	178	NDOW, NV FWS, USGS, GBBO, ICF
Calochortus striatus	Quantitative	Mojave Desert	58	47	BLM, TNC, Calflora, SEInet, CC
Chionactis occipitalis	Quantitative	Clark County	116	94	NDOW, USGS, Vertnet
Corynorhinus townsendii	Quantitative	Mojave Desert	100	85	NDOW, USFS, NNHP, BLM, GBIF
Crotalus cerastes	Quantitative	Clark County	257	241	NDOW, BLM, Vertnet
Cylindropuntia multigeniculata	Quantitative	Clark County	63	48	NNHP, BLM, SEInet

Scientific name	*Model type*	*Model extent*	*Occurrence in Model*	*Thinned occurrences*	*Point sources*[1]
Diadophis punctatus	Qualitative	Clark County	4	N / A	NDOW, Vertnet, GBIF
Didymodon nevadensis	Qualitative	Clark County	17	N / A	NNHP, GBIF
Dipsosaurus dorsalis	Quantitative	Clark County	342	333	NDOW, USGS, NNHP, Vertnet
Enceliopsis argophylla	Quantitative	Clark County	130	101	NPS, NNHP, SEInet
Euderma maculatum	Qualitative	Clark County	13	N / A	NNHP, BLM, NDOW
Eustoma exaltatum	Quantitative	Mojave & Sonoran Deserts	42	42	BLM, NNHP, Calflora, SEInet
Heloderma suspectum cinctum	Quantitative	Clark County	238	229	NDOW, NNHP, Vertnet
Hesperopsis gracielae	Quantitative	Mojave & Sonoran Deserts	48	46	NNHP, BAMONA, BLM, Inaturalist, Pratt 2011
Lasionycteris noctivagans	Quantitative	Mojave Desert	28	28	NNHP, USFS, BLM, GBIF, Inaturalist, TetraTech, O'Farrell
Lasiurus blossevillii	Quantitative	Mojave Desert	20	20	NDOW, NNHP, BLM, USFS, GBIF, O'Farrell, TetraTech
Lasiurus cinereus	Quantitative	Mojave Desert	42	42	NDOW, USFS, NNHP, BLM, NPS, GBIF
Macrotus californicus	Quantitative	Mojave Desert	24	23	NDOW, NNHP, BLM, NPS, GBIF, O'Farrell

Scientific name	*Model type*	*Model extent*	*Occurrence in Model*	*Thinned occurrences*	*Point sources*[1]
Mentzelia polita	Quantitative	Mojave Desert	29	29	NNHP, Calflora, SEInet
Penstemon bicolor ssp. bicolor	Quantitative	Clark County	128	113	NNHP, BLM, ICF, Inaturalist
Penstemon bicolor ssp. roseus	Quantitative	Clark County	187	157	BLM, NPS, NNHP, SEInet, EITP
Phacelia filiae	Quantitative	Mojave Desert	21	21	NNHP, SEInet
Phyllorhynchus decurtatus	Quantitative	Clark County	135	128	NDOW, BLM, GBIF, Vertnet
Sisyrinchium radicatum	Qualitative	Clark County	14	N / A	NNHP, SEInet, Inaturalist
Tadarida brasiliensis	Quantitative	Mojave Desert	105	92	NDOW, USFS, NNHP, BLM, NPS, GBIF, Inaturalist
Thomomys bottae	Quantitative	Clark County	111	109	BLM, NDOW, USGS, UNR, GBIF

[1]Point sources include: BAMONA – Butterflies and Moths of North America, https://www.butterfliesandmoths.org/; BLM – Bureau of Land Management; Calflora – Consortium of California Herbaria, http://ucjeps.berkeley.edu/consortium/; GBBO – Great Basin Bird Observatory; GBIF – Global Biodiversity Information Facility, http://www.gbif.org; ICF - ICF Jones & Stokes, 2010; Inaturalist - https://www.inaturalist.org/; O'Farrell - O'Farrell 2002, 2006; NDOW – Nevada Department of Wildlife; NNHP – Nevada Natural Heritage Program; NPS – US National Park Service; Pratt 2011 – Pratt and Wiesenborn 2011; SEInet – Southwest Environmental Information Network, http://swbiodiversity.org/; TetraTech – Mohave County Wind Farm Bat Conservation Strategy (TetraTech 2012); TNC – The Nature Conservancy; UNR – University of Nevada, Reno; USFS – US Forest Service; USGS – US Geological Survey; Vertnet - http://vertnet.org/

Table 3. Environmental covariates used in developing habitat distribution models, along with their units, resolution, and data sources.

Term	Units	Resolution	Description	Source(s)
Annual Heat/Moisture Index	index	250 m	Mean annual temperature in Celsius divided by mean annual precipitation in mmm (MAT+10)/(MAP/1000))	PRISM data (Daly et al. 2008) downscaled by ClimateNA program (Wang et al. 2012, 2016)
Annual Temperature Range (satellite)	°C x 100	1 km	Annual Temperature Range was defined as the difference between summer and winter daytime MODIS MOD11A1 Land Surface Temperature (LST) 8-day Global 1 km for six periods in the summer and six periods in the winter during 2001–2010. The value for each 1 km cell is the average of the yearly differences (°C x 100) between the summer and winter daytime LST for 2001 to 2010.	Inman et al. 2014
Distance to Cliffs	km	1 km	Distance to nearest grid cell with slope > 20°	
Distance to mines	km	250 m, 1 km	Distance to mines in km	BLM rapid ecoregional assessment for the Mojave and Central Basin and Range, abandoned mines geodatabase; USGS mineral resources database; and Nevada Bureau of Mines and Geology (NBMG), Nevada Abandoned Mines Database

Diurnal Temperature Range	°C	250 m, 1 km	Mean of the monthly temperature ranges (monthly maximum minus monthly minimum) for the climatic normal period 1980-2010. The is mathematically equivalent to calculating the temperature range for each day in a month, and averaging these values for the month.	PRISM data (Daly et al. 2008) downscaled by ClimateNA program (Wang et al. 2012, 2016)
Elevation	m	90 m, 250 m, 1 km	Resampled from a 30 m Digital Elevation Model	USGS National Elevation Dataset
Gypsum potential	Ordinal rating	250 m	Potentially gypsiferous soils identified using ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) image classification in conjunction with medium and large scale geological maps, and NRCS SSURGO soils data.	TerraSpectra Geomatics (TerraSpectra 2011).
Heat Load Index	index	250 m	Aspect / slope transformation index from McCune and Keon 2002, representing the range in heat load from coolest (northeast slope) to warmest (southwest slope).	Calculated from 30 m DEM (USGS National Elevation Dataset), upscaled to 250 m

Mine Density	index	250 m, 1 km	Gaussian kernel density estimate of mine density (bandwidth = 20 km)	BLM rapid ecoregional assessment for the Mojave and Central Basin and Range, abandoned mines geodatabase; USGS mineral resources database; and Nevada Bureau of Mines and Geology (NBMG), Nevada Abandoned Mines Database
NDMI (Landsat)	Index	90 m	The Normalized Difference Moisture Index was calculated from a mosaic of 5 Landsat 8 scenes captured during November 2016. The index was calculated following the formula in the USGS Landsat Spectral Indices Product Guide.	https://earthexplorer.usgs.gov/
NDVI (Landsat)	Index	90 m	The Normalized Difference Vegetation Index was calculated from a mosaic of 5 Landsat 8 scenes captured during November 2016. The index was calculated following the formula in the USGS Landsat Spectral Indices Product Guide.	https://earthexplorer.usgs.gov/
NDVI Amplitude	Index	250 m, 1 km	Maximum increase in canopy photosynthetic activity above the baseline. Derived from MODIS satellite bands.	USGS EROS center (http://phenology.cr.usgs.gov/)

NDVI greeness timing	Time	1 km	Date of the maximum value of the Normalized Difference Vegetation Index (MODIS MOD13Q1 Global 250 m 16-day index of NDVI). Dates ranged from early spring to late summer, and the average of 2001 to 2010 for the dates March 6, March 22, April 7, April 23, May 9, May 25, June 10, June 26, and July 12 were used.	Inman et al. 2014
NDVI Maximum	Index	250 m, 1 km	NDVI at the maximum level of photosynthetic activity in the canopy. Derived from MODIS satellite bands.	USGS EROS center (http://phenology.cr.usgs.gov/)
NDVI Standard Deviation	Index	1 km	Standard deviation of 250 m^2 MODIS NDVI grid cell values in a 1 km^2 neighborhood	USGS EROS center (http://phenology.cr.usgs.gov/)
NDVI Start-of-Season	Index	250 m, 1 km	NDVI value at the beginning of measurable photosynthesis in the vegetation canopy	USGS EROS center (http://phenology.cr.usgs.gov/)
NDWI (Landsat)	Index	90 m	The Normalized Difference Water Index was calculated from a mosaic of 5 Landsat 8 scenes captured during November 2016. The index was calculated following the formula in Gao 1996.	https://earthexplorer.usgs.gov/

Rocky Surfaces	%	1 km	Rocky surfaces were identified from summer night time Land Surface Temperature (LST) and elevation at a spatial scale of 250 m. MODIS MOD11A1 nighttime LST 8-day global data were downscaled to 250 m and regressed against elevation to remove the elevation trend. Residuals were categorized into "rock" and "nonrock" categories using 100 known sample locations in Nevada and California. The value given for each 1 km cell is the percentage covered by 250 m cells identified as rock.	Inman et al. 2014
Sandy soil potential	Ordinal rating	250 m	Potentially sandy soils identified using ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) image classification in conjunction with medium and large scale geological maps, and NRCS SSURGO soils data.	TerraSpectra Geomatics (TerraSpectra 2011).

Sandy Soils	Index	1 km	Sandy Surfaces were identified from summer night time Land Surface Temperature (LST) and elevation at a spatial scale of 250 m. MODIS MOD11A1 nighttime LST 8-day global data were downscaled to 250 m and regressed against elevation to remove the elevation trend. Residuals were categorized into sand and non-sand categories using 100 known sample locations in Nevada and California. The value given for each 1 km cell is the percentage covered by 250 m cells labeled as sand.	Inman et al. 2014
Silica Index	Index	250 m		
Slope	Degrees	250 m, 1 km	Derived from a 30 m DEM (USGS National Elevation Dataset) and upscaled to 250 m and 1 km resolutions	USGS National Elevation Dataset
Soil Water Stress	Index	1 km	Soil Water Stress is an index of the in situ top layer soil moisture, and was derived as the mean of the Shortwave and Infrared Water Stress Index (SIWSI; Fensholt and Sandholt, 2003) for 46 dates in each year from 2001 to 2010 using the	Inman et al. 2014

			MODIS MOD09A1 surface reflectance 8-day Global data product. Prior to calculating the SIWSI, each of the MODIS MOD09A1 surface reflectance 8-day Global 500 m data products was aggregated to a spatial scale of 1 km. The value for each 1 km cell in this layer is the mean across all years and dates.	
Spring Density	density / km^2	250 m	Gaussian kernel density estimate of spring density (bandwidth = 1 km)	Spring coordinates were extracted as point features from the National Hydrography Dataset (NHD; https://nhd.usgs.gov/) at the highest available resolution
Summer heat / moisture index	°C	250 m	Mean temperature of the warmest month divided by mean summer precipitation ((MWMT)/(MSP/1000))	PRISM data (Daly et al. 2008) downscaled by ClimateNA program (Wang et al. 2012, 2016)
Summer Maximum Temperature	°C	250 m, 1 km	Average maximum temperature from Jun - Aug, based on the climatic normal period 1980-2010	PRISM data (Daly et al. 2008) downscaled by ClimateNA program (Wang et al. 2012, 2016)
Summer Precipitation	mm	250 m, 1 km	Average total precipitation received from May - Oct, based on the climatic normal period 1980-2010	PRISM data (Daly et al. 2008) downscaled by ClimateNA program (Wang et al. 2012, 2016)
Surface Roughness (TRI)	Index	250 m, 1 km	The mean of the absolute differences between the value of a grid cell and the value of its 8 surrounding cells (Wilson et al. 2007). Derived from a 30 m DEM	USGS National Elevation Dataset

			((USGS National Elevation Dataset) and upscaled to 250 m and 1 km resolution	
Surface Texture (ATI)	°C x 100	1 km	Surface Texture was modeled by taking the difference between the mean daytime and nighttime surface temperatures for 6 periods in the summer during the years of 2001–2010. Surface temperatures were obtained from MODIS MOD11A1 Land Surface Temperature 8-day Global 1 km data products for daytime and nighttime during the summer dates of July 12, July 20, July 28, August 5, August 13, and August 21. The value for each 1 km cell is the average of the yearly differences between the daytime and nighttime temperatures (°C x 100) for the dates listed above.	Inman et al. 2014
Tasseled cap greenness	Index	90 m	The Tasseled Cap Greenness coefficient is a linear combination of Landsat bands that captures photosynthetically active vegetation. We calculated TC greenness from a mosaic of 5 Landsat 8 scenes captured during	https://earthexplorer.usgs.gov/

			November 2016. The linear combination coefficients were based on Baig et al. 2014.	
Temperature Range	°C	250 m	Difference between winter minimum temperature and summer maximum temperature	PRISM data (Daly et al. 2008) downscaled by ClimateNA program (Wang et al. 2012, 2016)
Topographic Position (TPI)	Index	90 m, 250 m, 1 km	Steady state wetness index expressed as a function of both the slope and the upstream contributing area per unit width orthogonal to the flow direction (Moore et al. 1993). Derived from a 100 m DEM ((USGS National Elevation Dataset) and upscaled to 250 m and 1 km resolutions	USGS National Elevation Dataset
Winter Minimum Temperature	°C	250 m, 1 km	Average minimum temperature from Dec - Feb, based on the climatic normal period 1980-2010	PRISM data (Daly et al. 2008) downscaled by ClimateNA program (Wang et al. 2012, 2016)
Winter Precipitation	mm	250 m, 1 km	Average total precipitation received from Nov - April, based on the climatic normal period 1980-2010	PRISM data (Daly et al. 2008) downscaled by ClimateNA program (Wang et al. 2012, 2016)

Quantitative statistical modelling

The largest source of variability in habitat distribution model output stems from the type of algorithm used to generate predictions (e.g., Watling et al. 2015). For this reason, we used an ensemble modeling approach that incorporated three different algorithms: generalized additive models (GAM; implemented in the R package "mgcv," Wood 2006), random forests (RF; implemented in the R package "randomForest," Liaw and Wiener 2002), and MaxEnt (version 3.3.3k, Phillips et al. 2006; executed from the "dismo" package in R, Hijmans et al. 2016). The use of multi-algorithm ensembles renders predictions less susceptible to the biases, assumptions, or limitations of any individual algorithm, while broadening the types of environmental response functions that can be identified (Araujo and New 2006). Moreover, empirical evaluations have found GAM, RF, and MaxEnt to be consistently strong performers among habitat distribution modeling algorithms (Franklin 2010). All modeling was conducted in R version 3.3.2 (R Core Team 2016).

True absence points were not available for any of the study species at this time. For this reason, all models were fit using randomly generated background points (pseudo-absences). Random selections of background points are already implemented in MaxEnt software, and are also considered a reliable method for regression techniques including GAM (Wisz and Guisan 2009; Barbet-Massin et al. 2012). Background points were randomly selected from within the modelling extent (**Error! Reference source not found.**) from all grid cells where the study species was not present, excluding impervious surfaces. Following the recommendations in Barbet-Massin et al. (2012), GAM models were fit with random samples of 1000 background points equally weighted to the presence points (i.e., the weighted sum of presence points equals the weighted sum of background points). However, because prevalence (the ratio of presences / absences) has a larger influence on RF models, these were fit with an equal number of presences and background points (Barbet-Massin et al. 2012).

For each algorithm, we generated models reflecting all combinations of the selected environmental covariates for each species, while restricting the maximum number of terms within any one model to five for GAM and six for RF and MaxEnt. This criterion reduces the potential for overfitting, and potentially results in models that are more biologically relevant (Rushton et al. 2004). To keep models interpretable and to improve their generalization across the study area, we also did not include interaction terms. Because presence points tended to be spatially aggregated, which can lead to substantial bias in model predictions, we first rasterized the presence points to the modeling resolution (i.e., such that only one presence point could occur within each grid cell) and subsequently applied a geographically-weighted resampling procedure in which a maximum of three observations could be sampled from cells on a uniform grid at a spatial resolution 10 times larger than the modelling extent (e.g., 2.5 km^2 for a 250 m^2 model, and 10 km^2 for a 1 km^2 models). This systematic grid sampling approach for spatial thinning of presence points can be effective at reducing spatial bias under a variety of conditions (Fourcade et al. 2014). To further reduce bias in our predictions, we used cross-validations to fit and evaluate all habitat models. In this process, each individual model was fit across 75 samples of randomly selected, spatially thinned presence points, with a 20% random sample (without replacement) withheld for model evaluation at each iteration (i.e., 80 % of presence points were used in model fitting, and 20% in model evaluation). Background points were also randomly drawn for each cross-validation. For both presences and background points, we required that each model be cross-validated using the same 75 random samples, which allowed performance measures to be reliably compared across models.

Because occurrence records for several of the species were highly aggregated, we applied an additional procedure to weight occurrence records that had fewer neighbors in geographic space, thereby accounting for spatial bias due to under-sampling in these areas relative to better-sampled areas (following Elith et al. 2010). Accordingly, bias grids were calculated for both MaxEnt and GAM. For MaxEnt, the bias grid was calculated as a Gaussian kernel density function of species observation records with a bandwidth of 15 km, rescaled to range from 1-20 (Elith et al. 2010). This layer was then incorporated via the "biasfile" argument in MaxEnt (Phillips et al. 2006). For GAM, we took the reciprocal of the kernel density grid and rescaled this layer to range from 1 – 3 (e.g., geographically isolated points had higher weight). These values were then used to weight the presence points in each binomial GAM model, such that geographically isolated observations could count as much as three times more than spatially aggregated observations (Elith et al. 2010).

Metrics of model prediction accuracy were calculated based on the evaluation data for each of the 75 cross-validation runs, and subsequently averaged across runs. Performance metrics included several threshold-independent measures: AUC (the area under the receiver operating characteristic; Fielding and Bell 1997), the Boyce Index (BI; Boyce et al. 2002; Hirzel et al. 2006), and the True Skill Statistic (TSS; Allouche et al. 2006). TSS takes into account both omission and commission errors and is insensitive to data prevalence (Allouche et al. 2006). To assess model goodness-of-fit, we examined explained deviance (GAM and RF), as well as the point biserial correlation between presences / background points and predicted habitat suitability. For GAM and MaxEnt models, we also evaluated AIC statistics for each model (Burnham and Anderson 2002), calculated as the average AIC value across cross-validation runs (where each model was fit to the same subsets of data). AIC values for MaxEnt models were calculated using the "ENMeval" package in R (Muscarella et al. 2014), which follows the approach developed by Warren and Seifert (2011).

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 calculated the continuous Predicted / Expected (P/E) ratio curves based on the BI (Hirzel et al. 2006). 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 assess a binary value of habitat suitability reflecting the cut-off between habitat and non-habitat predicted by each model, we considered both the habitat suitability value at which the P/E curve exceeded one (i.e., the point at which the model predicts more presences than expected by chance) and the threshold at which the sum of the sensitivity (true positive rate) and specificity (true negative rate) was highest (Hijmans et al. 2016).

To generate predictive layers of habitat suitability for each species, we selected approximately 10 candidate models from each algorithm, based upon the averages and standard deviations of model performance metrics across cross-validation runs (AUC, BI, TSS, and AIC where applicable). Models were selected that consistently performed among the top 10 across different metrics, while exhibiting low variability in their scores. For GAM and MaxEnt, the model with the lowest average AIC value was always included in the candidate model sets. Raster surfaces representing each of the selected candidate models were generated by averaging model predictions across the 75 cross-validation runs, such that each model's prediction surface corresponded directly to its average performance scores. This procedure also limits the influence of sampling bias on individual model predictions. Ensemble predictions for individual algorithms were generated by taking the weighted average among candidate models for each algorithm type (i.e., one ensemble prediction each for GAM, RF, and MaxEnt models), with the weights determined by TSS scores. Finally, an overall ensemble habitat suitability layer was generated by taking the average of the three individual algorithm ensembles. 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. The same approach was used to derive standard error layers within each individual algorithm type. This ensemble approach is similar to that of the modeling platform BIOMOD (Thuiller 2003).

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. For MaxEnt and RF, the calculations were already implemented in the respective software (Phillips et al. 2006; Liaw and Wiener 2002). However, no such procedure was currently implemented for GAM. Therefore, we derived a measure of relative importance based on a covariate's average expected degrees of freedom (edf) across all candidate GAM models in which a term appeared. In practice, edf values reflect the degree of influence each term has in a fitted GAM model (Wood 2006); hence, the edf can be interpreted as a measure of relative importance. These values were relativized among terms to range from 0 to 1.

Next, to illustrate the shape of the relationships between predicted habitat suitability and important environmental covariates, we derived partial response curves from each of the three algorithms.

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). Although covariates were standardized prior to model fitting, we back-transformed all variables to their original scales for display in response curve to aid interpretation. Following procedures implemented in the software for each algorithm, we derived partial response curves for the top nine covariates within each candidate model set, based on the covariates relative importance values. For GAM models, these response curves are on the scale of the linear predictor, where values above zero reflect increasing suitability of habitat, and values below zero reflect increasingly unsuitable habitat. 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 a random sample of 10,000 locations.

Qualitative models

For several species, the number of available occurrence records was insufficient to support development of quantitative habitat distribution models (Table 2). In these cases, rather than fit models likely to be biased by small sample sizes, we developed qualitative habitat models based on our knowledge of the species and their known distributions. Detailed methods for qualitative models are provided separately for each species in the respective sections below.

Ecosystem and Impact Assessments.

For species with quantitative habitat models that were produced during this project, the ensemble model was reclassified into categorical indices of suitability as: 0-0.33 = Low, 0.33 – 0.66 = Medium, and 0.66 – 1 = High. Shapefiles provided by the Clark County Desert Conservation Program (DCP) representing Impacts, Conservation layers (ACECs etc.), and Disturbed layers (e.g. urban areas, power plants, landfills, etc.) were converted to rasters at a 30m cell size as these layers had inconsistencies in topography that hindered habitat intersects (Figure 1). The categorical Ecosystem raster provided by the Clark County Desert Conservation Program (DCP) developed by Heaton et al. (2011) was used for ecosystem intersections with the categorical habitat rasters (Figure 1). For each of the High, Medium and Low habitat categories for each species, the intersection of the habitat category with the Impact and Ecosystem assessment layers was calculated using standard raster algebra techniques. For species models that were reviewed during this assessment, the most appropriate (quantitative where possible) models were reclassified per the methods above. Some models contained binary estimates of habitat, and these were categorized only as "high" or "low" suitability. Where Great Basin Bird Observatory (GBBO) models were used for some of the bird species without continuous habitat representation the estimated density was classified in place of habitat suitability – as some studies have shown that habitat suitability and population density can be correlated (e.g. Carrascal et al. 2017). No models sufficiently depicted habitat for Ridgeway's rail / Yuma clapper rail and thus quantitative impact assessment was not performed for this species. For the species produced in the sand and gypsiferous species modeling conducted by Hamilton and Kokos (2011) polygon files were converted to categorical rasters using the "Class" attribute, where the High, Medium, and Low classes were given. The total number of 30 m cells within each intersected fraction was quantified to estimate the total number of Hectares (100 m x 100m) that were within each category. Tables and summaries of these intersections are included in each species account.

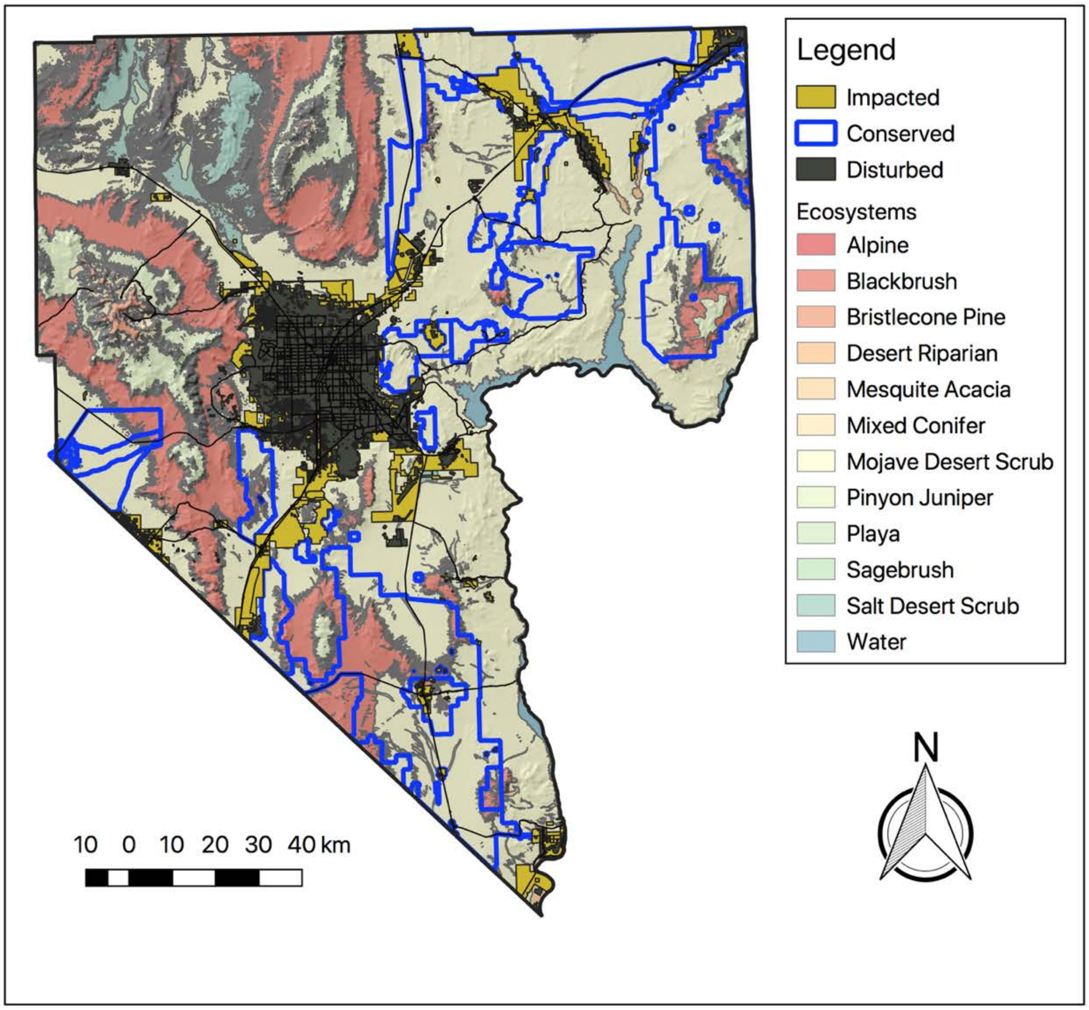

Figure 1. Disturbed areas (charcoal), and projected areas that will be impacted (mustard), conserved (blue outline), and ecosystems located within Clark County, Nevada.

ANLE - Sticky Ringstem (Anulocaulis leiosolenus)

Anulocaulis leiosolenus (formerly *Boerhavia leiosolena*) is a perennial forb in the Nyctaginaceae (Four-O'Clock) family. Members of the genus have flowers that bloom near dawn and close by mid-day (Holmgren et al. 2012). The flowers have greenish bronze tubes and white, pink, or rose-pink lobes flared from tube (Spellenberg 2003). The leaves occur in 2-3 pairs in basal quarter of plant and have small purple pustules (blister-like formations) (Spellenberg and Wootten 1999). The species was first recorded in 1858 in the Rio Grande Valley in western Texas. The name "*Anulocaulis*" was chosen to describe the prominent sticky bands that encircle the internodes, *anulus* meaning "ring" and *caule* meaning "stem" (Spellenberg 1993). The first collection of the species in Nevada was collected in 1938 by Percy Train (TNC 2007). There are four varieties of this species in North America (Spellenberg 2003). Sticky Ringstem is the only variety that occurs in Clark County, Nevada. It is considered to be a gypsophile, meaning it lives on gypsum soils (Spellenberg and Wootten 1999). Sticky Ringstem can be distinguished from other varieties by dull green leaves, the presence of hairs on the leaves, white to pale pink flowers, and a flower bud that is glabrous at the apex (Spellenberg 2003).

The US population flowers from May-June and again in October. Sphingid moths have been recorded visiting Sticky Ringstem in areas of its range outside of Clark County (Spellenberg 1993). As of 2007, no pollination studies specific to var. *leiosolenus* had been done, but moths have been visiting flowers, and are thought be pollinators (TNC 2007). Pollinators that have been reported to visit other *A. leiosolenus* varieties include Sphingid moths, bumblebees, and wasps (Spellenberg 1993). According to Meyer (1987), Sticky Ringstem has low seed output, and is thought to be long-lived.

Species Status

US Fish and Wildlife Service Endangered Species Act: Not listed
US Bureau of Land Management (Nevada): Sensitive
US Forest Service (Region 4): No status
State of Nevada (NAC 527): No status
NV Natural Heritage Program: Global Rank G4T3 State Rank S2
IUCN Red List (v 3.1): No status
CITES: No status

Range

Sticky Ringstem is endemic to arid regions of the southwestern U.S and adjacent Mexico. *Anulocaulis leiosolenus* var. *leiosolenus* has the largest range out of all of the varieties of Sticky Ringstem and also occurs in extreme western Texas, south-central New Mexico, north-central Arizona, and northern Chihuahua, Mexico (Spellenberg and Wootten 1999, Spellenberg 2003). It is considered to have two distribution centers (southern Nevada in Clark County and northeast Arizona in Coconino and Yavapai counties, and the second distribution center in New Mexico in Chaves and

Doña Ana counties, in western Texas in Culberson, El Paso, Hudspeth, and Presidio counties, and in adjacent northern Mexico, northwest Chihuahua in Guadalupe and Coyame municipios) (Hernandez-Ledesma et al 2010).

Population Trends

Very little specific data exist for viability estimates of Sticky Ringstem populations. In the 1980's, Meyer measured an average density of 0.6 plants per 100 m^2 (Meyer 1987 in TNC 2007). The westernmost population, Lava Butte, has been documented as the largest area, but the plants are not abundant. The range-wide trend was reported to be stable as of 2000 (USFWS 2000), but not enough information is available to determine trends of populations in Nevada. NPS and BLM monitoring reports note that habitat condition for Las Vegas Bearpoppy may be applicable to Sticky Ringstem habitat (TNC 2007).

Few inventories include Sticky Ringstem, and surveys for the species have been sporadic in Clark County (Niles et al. 1999 in TNC 2007).

Habitat Model Review.

Sticky Ringstem was included in a model for the gypsophile species within Clark County, NV (along with the Las Vegas Bearpoppy, and White Bearpoppy - Hamilton and Kokos 2011). Models were first produced by creating a soils based model by identifying soils high in gypsum content using SSURGO data. These soil models were further refined using ASTER data and surficial geology mapping for the County. This proved insufficient for modeling gypsum species as they occurred on a broader range of soil types than just the gypsum base layer. Rankings were created for the ASTER identified sub classes using ASTER and non-ASTER classifications by counting the numbers of individual plants within soil polygon types (See table 2-1 in Hamilton and Kokos 2011). Sticky Ringstem was predicted to be high in gypsiferous units (both ASTER and non-ASTER) and medium in non-ASTER identified spring deposits, and non-gypsiferous units, and low in ASTER class spring deposits. One model was created for the entire class of gypsiferous plant species, rather than being based on individual species preferences. This initial soil base model was used as a basis to construct further sampling for the species at 100 sampling sites. Sampling was stratified based on habitat potential with most points in habitat considered highly suitable (70%) and fewer sites in moderate (20%) or poor (10%) predicted habitat. There were only 2 occurrences for this species at 547 survey points over a 2-year period, and 3 additional observations were made as incidental encounters. All of the observations were either in the soil type classified as high, or on the edge of that soil type.

After additional surveys were conducted habitat suitability was modeled using MaxEnt using the combined point set of all occurrences and climate inputs. The model created in MaxEnt was constructed based on only climatic inputs from a standard climate dataset (BIOCLIM), without using known climatic limitations specific to the species, or the soil models as potential inputs. The model had seemingly high performance (judging only by AUC), and high contribution of Isothermality (58% influence on model performance) and Precipitation of Wettest

Month (20%). The MaxEnt for this species was then deemed by Hamilton and Kokos (2011) not to be useful for refining the soil-based habitat models (although no soils were included in their modeling effort). The SSURGO based soils models then were further refined using remotely sensed imagery and the resulting gypsum soils model was then manually refined to better suit the species by "selecting suitable polygons" – but explicit rules or guidelines used for this process are not described other than relying on refinement of the soils models themselves and then applying an elevation constraint (360 to 725 meters for this species). No precision or performance estimates are given for the refined model based on soils and elevation and other adjustments that were applied.

Technical Considerations – The MaxEnt model was produced using 500 iterations of 67 presence records used for training, 7 for testing (10 % withholding). The data layers used encompassed only the BIOCLIM dataset despite their assertion that soils likely play an important role in defining the distribution of this species. The MaxEnt Model outputs yielded stronger influences of Isothermality (58% influence on model performance), Precipitation of Wettest Month (20%), and Minimum Temperature of Coldest Month (6%). The partial response curves indicate climatic "preferences" of this species toward sites with low Isothermality values, with low precipitation, and moderately warmer coldest month temperatures.

Distribution and Habitat Use within Clark County

A. leiosolenus var. *leiosolenus* populations have been observed in Clark County in the following areas:

1. Lava Butte (BLM)
2. Gypsum Wash (BLM)
3. West Black Mountains
4. East Black Mountains (NPS)
5. Bitter Spring Valley (NPS and BLM)
6. Overton Arm (NPS)
7. Muddy River (Unmanaged Area)
8. Gold Butte (BLM)

The Clark County populations of Sticky Ringstem represent the westernmost region of the species' range. Within Clark County the species overlaps with habitat for another rare plant, the Las Vegas Bearpoppy (*Arctomecon californica*) (TNC 2007), but has a narrower range and is much less abundant than the bearpoppy in Clark County (Newton 2010).

The 2009 management strategy showed the distribution of known Clark County spatial data points by major landowner category for Sticky Ringstem as follows; 64.4% BLM, 31.7% NPS, 2.9 % Private, and 1% Water (NPS or BoR depending on fluctuating reservoir level) (Figure 2, TNC 2007).

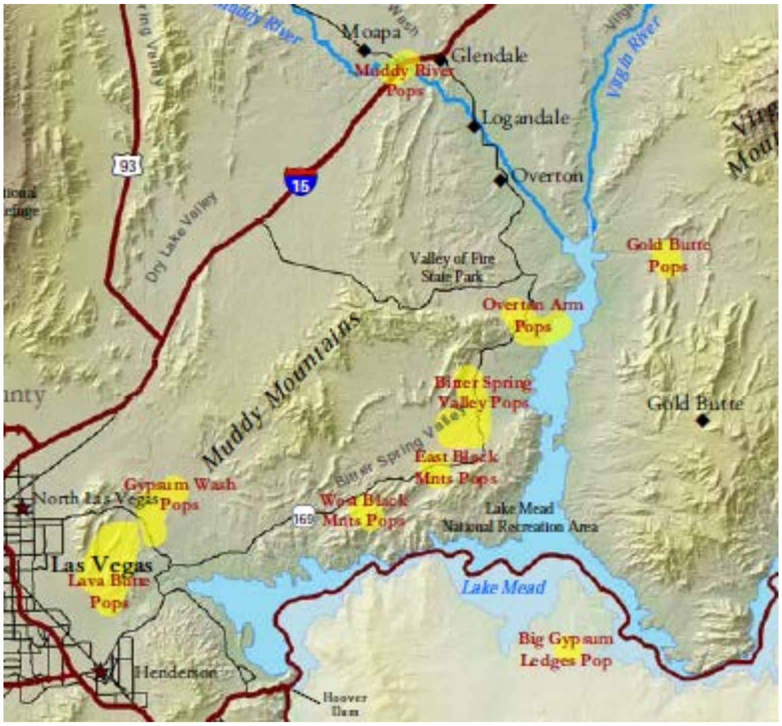

Figure 2. Sticky Ringstem management areas, from (TNC 2007)

Sticky Ringstem occurs in desert scrub on small to steep hillsides or flat ground, with alluvium, gypsum, limestone, rocky, slat, or clay soils from 400-1200 meters (Hernandez-Ledesma et al. 2010). It is only known to occur on gentle slopes around four degrees, and not exceeding 13 degrees (TNC 2007). The species is strongly associated with cryptogamic crusts, which are known to stabilize soil (Ladyman et al. 1998 in TNC 2007), increase germination and seedling success, and release essential nutrients such as nitrogen and chelating agents into the soil (Harper and Pendleton 1993). Sticky Ringstem occurs on gypsum outcrops, rolling hills, and terraces in Mojave Desert scrub (which includes primarily creosote bush-white bursage) and salt desert scrub matrix ecological systems (Niles et al. 1999 in TNC 2007). Some common plants associated with Sticky Ringstem in Clark County include *Ephedra torreyana, Lepidium fremontii, Petalonyx parryi, Psorothamnus fremontii, Arctomecon californica, Enceliopsis argophylla, Mentzelia pterosperma, Tiquilia latior, Eriogonum insigne, Phacelia palmeri, Phacelia pulchella, and Psathyrotes pilifera* (Mistretta et al. 1996 in TNC 2007). Ecosystems within the county that contain both high and moderate predicted habitat suitability are largely restricted to Mojave Desert Scrub (Table 4).

In a 2010 inventory and monitoring study conducted by the National Park Service (Newton 2010), a correlation was found between Sticky Ringstem and certain soil attributes. The following elements were found in significant levels on sites inhabited by Sticky Ringstem: Calcium, Iron, Nickel, Cobalt, Sulfate, Nitrate, Sodium, Magnesium, Boron, Lead, Chlorine, and sand. Sticky Ringstem presence was also associated with lower available Phosphorous, total Nitrogen, pH, Copper, clay, silt, Total Energy, and bulk density.

When sites inhabited by Sticky Ringstem were compared to sites where it is absent, there was a negative correlation of ringstem presence with an increase in copper site Total Nitrogen had a negative correlation with Sticky Ringstem density among sites containing Sticky Ringstem.

In the results of this study it was suggested that to gain understanding in Sticky Ringstem's soil associations, it may be beneficial to sample more gypsum soil series across a wider range of rare plant locations that were sampled in their study. It was also suggested that future soil surveys should include topographic position, as well as comparisons of distributions of other gypsophile and gypsocline species to further develop habitat models (Newton 2010).

Table 4. Ecosystems within Clark County, and the area (Ha) of Low Medium and High predicted suitability within each ecosystem.

Ecosystem	Low	Medium	High
Alpine	0	0	0
Blackbrush	5129	73	12
Bristlecone Pine	0	0	0
Desert Riparian	1177	8	1
Mesquite Acacia	1125	201	60
Mixed Conifer	0	0	0
Mojave Desert Scrub	124873	27949	9677
Pinyon Juniper	0	0	0
Sagebrush	0	0	0
Salt Desert Scrub	5729	556	56

Ecosystem Level Threats

Among the ecosystems listed as present in the MSHCP, this species is found in Salt Desert Scrub habitats, and is further distinguished by being gypsophilic. The limitation to gypsum soils further limits the distribution of this species and gypsum dominated soils are fairly well known for this county.

Sticky Ringstem is one of numerous rare plant species covered under the Clark County Multiple Species Habitat Conservation Plan (MSHCP). A Conservation Management Strategy (CMS) sponsored by Clark County and The Nature Conservancy (TNC 2007) identifies several direct and indirect threats to rare plants in Clark County that increase loss, degradation, and fragmentation of habitat. Clark County's CMS lists threats to the species which also pose threats at an ecosystem level including catastrophes, chance events, and climate change (TNC 2007). The sources of these threats include Off Highway Vehicle use (OHV), invasive species, rural development, land disposal, fire, utility corridor and rights-of way development, highway and road development, agricultural practices, military activities, Lake Mead inundation, gypsum mining, and commercial development (TNC 2007).

Threats to Species

The 2007 CMS (TNC 2007) lists direct threats to Sticky Ringstem in Clark County including gypsum mining, vehicle use and trail development, feral horse and burros, rural and urban development, utility corridor construction and maintenance related sprawl, federal land disposal, invasive plant species, legal recreation use, habitat inundation and shoreline fluctuation, and trespass grazing.

Wild horse and burros pose a threat as they can easily damage gypsum and cryptobiotic surface crusts where Sticky Ringstem grows. Once damaged, these areas are susceptible to erosion and plant invasion. A population discovered in Echo Wash was in an area with heavy burro damage (Niles et al. 1999 in TNC 2007). Feral horses and burros may also pose a threat from grazing Sticky Ringstem at Lake Mead National Recreation Area, particularly in the drier months (Powell 2004 in TNC 2007). Enforcement of the laws that protect these habitats is important. For example, the Lava Butte area has regulations in place for OHV use, but it is not effectively enforced (TNC 2007). The threats listed above have resulted in population losses by direct mortality, and further loss or fragmentation of habitat (TNC 2007).
During field surveys in summer 2009 and spring 2010 conducted by ICF Jones and Stokes, a private consulting company, it was observed that trail evidence and OHV use was more common on Sticky Ringstem and Las Vegas Bearpoppy habitat than on other rare plant habitats surveyed. It was speculated that the habitat is easier to navigate in using OHVs, due to the open, mostly un-vegetated, soft soils, lacking large rocks, etc. (ICF Jones & Stokes 2010).

Existing Conservation Areas/Management Actions

Monitoring:

Lake Mead National Recreation Area (managed by the National Park Service) developed monitoring protocols for Sticky Ringstem (as well as other species) and pilot monitoring was implemented in 2007 (Sutter et al. 2009). The monitoring protocols were reviewed and revised in 2008 and 2009. In 2007, Clark County completed a "Conservation Management Strategy for Nine Low Elevation Rare Plants in Clark County, Nevada", including *Anulocaulis leiosolenus* var. *leiosolenus.* As of 2009, Sticky Ringstem was actively monitored (Sutter et al. 2009).
The 2007 CMS suggests that in order to manage the species, more applied research needs to be done to fill information gaps on population viability in order to develop management plans in Clark County. The CMS suggests that this species has inadequate, dated, missing, or confounded information to assess current viability of populations and that more additional landscape scale research is needed for management strategies. The CMS states that revision is needed for the monitoring protocols to improve power analyses and increase efficiency of conservation measures (TNC 2007).

In 2009, habitat models were developed for eight rare plant species including Sticky Ringstem using pre-existing soil models and presence/absence survey data that were collected (Terra Spectra 2011, Sutter et al. 2009). The Sticky Ringstem habitat model was grouped with the Las Vegas Bearpoppy model due to their similar predictive habitat models (Hamilton and Kokos 2011). During field surveys for this study, Sticky Ringstem was recorded two times within survey plots, and two times incidentally when traveling to or from the survey plot (ICF Jones & Stokes 2010). In a 2010 inventory and monitoring study, transects (200-300 m long) were placed randomly in sites previously known to contain populations. Sticky Ringstem was present in 5 out of 9 transects (Newton 2010).

Management:

Sticky Ringstem is found in an area known as the Sunrise Management Area. One stated objective of the Sunrise Management Area Interim Management Plan is to protect sensitive species including Sticky Ringstem, by specific protections, habitat rehabilitation, and instituting law enforcement measures while still providing recreational opportunities (BLM 2000 in TNC 2007). The BLM has designated some Sticky Ringstem habitat as Areas of Critical Environmental Concern (ACEC). The 2003 Lake Mead Management Plan outlines direction for management of rare plants (including Sticky Ringstem) on sandy soils along the Lake Mead shoreline in heavy recreational use areas (National Park Service 2003 in TNC 2007).
As of 2007, no management actions had been implemented by Clark County specifically for Sticky Ringstem, but some populations were protected as a result of measures taken to protect gypsum habitat and Las Vegas Bearpoppy. Some populations occur in Wilderness Areas and designated ACECs and have some protection as a result. The Gold Butte, Gypsum Wash, and Lava Butte populations occur at least partially in ACECs, National Conservation Areas (NCA), or Wilderness Areas. As of 2007 no measures had been taken to restore the species on previously disturbed habitat in Clark County (TNC 2007).

The majority of presence points data known for Sticky Ringstem (as of 2007) occur in the highest protective management category of Intensively Managed Areas (IMA), but not on the next level of protective management category, Less Intensively Managed Areas (LIMAs). These categories were developed by Clark County's Multiple Species Habitat Conservation Plan (MSHCP) (TNC 2007).
Conservation Action Number BLM (220) in Clark County's MSHCP (Multiple Species Habitat Conservation Plan) calls to designate important bearpoppy habitat in Lovell Wash, Muddy Mountains, and Bitter Springs as ACECs, and recommends that the areas be closed to OHV competitive evens, and limited to road and trail use. Because Sticky Ringstem and bearpoppy occupy similar habitats, this plan has the potential to also protect Sticky Ringstem habitat (TNC 2007).

The 2000 Clark County MSHCP outlines a CMS which identified nineteen objectives aimed to reduce existing and potential threats of rare plants and their habitats on Federal lands and improve indicators of population viability (Clark County 2000) Some of these objectives which apply to Sticky Ringstem include removing OHV impacts by 2020, controlling invasive plant species by 2020, addressing altered fire regimes over the next century, ensuring gypsum mining will not significantly impact habitats, ensuring long-term viability is not significantly impacted by rural development and sprawl, ensuring disposal of federal lands will not significantly impact populations, and managing viable populations in utility corridors and within potential rights-of-way corridors. These objectives are detailed in the CMS (TNC 2007).

Summary of Direct Impacts

Because Sticky Ringstem often occurs on gypsum soils (TNC 2007, Hamilton and Kokos 2011), gypsum mining poses a direct threat, which has the potential to affect other species that occur on gypsum soil including Las Vegas Bearpoppy. Thirty-six of the 98 km^2 of predicted highly-suitable habitat is located within conservation areas. Twenty-eight km^2 of habitat is likely to be impacted by future development, while 10 km^2 are already disturbed. Collectively, 98 km^2 of high and moderate habitat will be conserved under the proposed amendment (Table 5).

Table 5. Categorized modeled habitat values (High, Medium, and Low) and the average area (Hectares) predicted in the potential impact areas, conservation areas, already disturbed areas, and overall area.

Habitat Level	Impact	Conserved	Disturbed	Area (Hectares)
High	1279	3606	439	9789
Med	1616	7216	9605	28789
Low	16993	47744	20098	138048

ANPA - Pallid Bat (Antrozous pallidus)

The Pallid Bat (*Antrozous pallidus*) has a relatively large body size and its woolly fur is yellowish to cream-colored above, and whitish below (Nowak 1991). This insectivorous bat has exceptionally long and wide ears. They are a highly social species (Hall 1946). For example, after bouts of evening foraging, they locate one another vocally and gather together at night roosting sites (O'Shea and Vaughan 1977). While their roosts may be in elevated locations to avoid terrestrial predators, their foraging flights are often 10 to 100 centimeters above the ground as they course the habitat in search of many types of ground-dwelling invertebrates or small vertebrates (Bell 1982).

Feeding behavior in Pallid Bats seems to be quite flexible and opportunistic. Food species include, but are not limited to: sphinx moths (*Hyles* sp., and *Manduca* spp.), crickets (*Gryllus* spp.), beetles (Scarabaeidae and Cerambycidae), and scorpions (Scorpiones). They also eat small lizards (*Phrynosoma douglasii*), smaller bats, and pocket mice (*Perognathus* spp.) (Hermanson and O'Shea 1983). Pallid Bats will also take flying insects, but may not compete for these as well as other bat species that are more maneuverable in flight (Bell 1982). One observer recorded over 150 hours of feeding observations and never saw a capture by the Pallid Bat in flight (Bell 1982).

Mating usually takes place from October through December, but ovulation is delayed until April, and the young stay in a colony that protects them from thermal extremes and potentially from falling into harmful locations (Hermanson and O'Shea 1983). The colonies are usually small with fewer than 100 individuals (Tuttle 1988). Roosts are important resources for bats at any time of year. During spring and autumn these bats often occupy deep vertical crevices. In contrast, summer roosts are located in deep horizontal crevices where the ambient temperatures are about 30° C and the bats' temperatures are similar. During winter, the larger colonies may disperse into smaller groups. Winter activity in Clark County seems to be sporadic and restricted to temperatures above freezing (O'Farrell et al. 1967).

Pallid Bats are among the latest to emerge from their roosts and it is usually quite dark before their appearance (Nowak 1991). Similarly, Pallid Bats appeared at watering sites about two hours after sunset during winter and spring sampling in Clark County (O'Farrell et al. 1967). Bat activity is somewhat restricted by wind in southern Nevada, with no Pallid Bats observed at wind speeds above four miles per hour. Bats are known for their great longevity relative to their small body size. One wild Pallid Bat is known to have lived over nine years (Cockrum 1973).

Species Status

The Pallid Bat is wide-spread and locally common, and has been identified as a species of Least Concern by IUCN (Arroyo-Cabrales and de Grammont 2008). Nevertheless, the Pallid Bat is a California Species of Special Concern, and considered a vulnerable species by the California Department of Fish and Wildlife. The species is also considered Sensitive by both the Forest Service, Region 5, and USDI-Bureau of Land Management. It is considered a protected species in Nevada Administrative Code and as a species with Moderate Risk by the Western Bat Working Group (Bradley et al. 2006). No listing petitions have been found for this species at the federal level.

US Fish and Wildlife Service Endangered Species Act: No Status
US Bureau of Land Management (Nevada): Sensitive
US Forest Service (Region 4): No Status
State of Nevada: Protected
NV Natural Heritage Program: Global Rank G5, State Rank S3,
NV Wildlife Action Plan: No Status
IUCN Red List (v 3.1): Least Concern
CITES: No Status

Range

The Pallid Bat is a New World bat ranging from southern British Columbia and Montana to central Mexico and is also known from Cuba (Hermanson and O'Shea 1983). They are found throughout Nevada at low to middle elevations (420 to 2,580 meters). Over 140 localities have been identified in Clark County, with the majority near steeper terrain in the Spring Mountains, and located in the northern extent of the County.

Population Trends

The current status of the Pallid Bat in Clark County, Nevada is not well known. Due to lack of reliable data in Clark County we consider the only data available from nearby California and Arizona. Recent studies of bat population trends in the southern coastal region of California indicated that several bat species, including Pallid Bats, have experienced population declines and could be seriously threatened – particularly at lower elevations (Miner and Stokes 2005). Populations are expected to continue to decline in that region as urban expansion increases. In contrast, populations are thought to be stable in Arizona (AGFD 2017).

Habitat Model

The GAM models for Pallid Bats generally predicted suitable habitat more broadly than the RF models, although most of this was in the lower habitat suitability scored areas, while there were similar areas of predicted high suitability habitat for these two algorithms. The MaxEnt models `predicted much less habitat in the county (Figure 3). Standard errors were most widespread in the MaxEnt model, with the least in the GAM model (Figure 4). Boyce indices indicated generally good model performance for all models (Hirzel et al. 2006), with bins for the ensemble model based on the continuous BI of 0-0.4 unsuitable, 0.4-0.5 marginal, 0.5-0.8 suitable, 0.8 -1 optimal habitat; with a suggest cutoff threshold of 0.05 (Figure 5) which corresponded closely with that calculated from ROC statistics (Table 6). RF had the highest performance scores across three of the four performance metrics (Table 6), and the second best performing model was the ensemble model of the three algorithms.

Table 6. Model performance values for *Antrozous pallidus* models

Performance	GAM	RF	MaxEnt	Ensemble
AUC	0.78	0.977	0.865	0.927
BI	0.595	0.693	0.662	0.788
TSS	0.511	0.905	0.624	0.756
Correlation	0.492	0.84	0.623	0.735
Cut-off*	0.495	0.625	0.367	0.526

*threshold at which sum of sensitivity (true positive rate) and specificity (true negative rate) is highest

Table 7. Percent contributions for input variables for *Antrozous pallidus* for ensemble models using GAM, MaxEnt and RF algorithms

Term	GAM	RF	Max	Avg
Surface Texture (ATI)	30.145	13.682	12.803	18.877
Winter Min Temp.	11.932	19.172	25.26	18.788
Winter Precipitation	15.16	14.394	12.621	14.058
NDVI Maximum	15.643	13.553	6.798	11.998
Annual Temp. Range	3.182	11.597	14.728	9.836
Topographic Position (TPI)	8.584	7.61	10.359	8.851
Diurnal Temp. Range	0.795	10.761	6.397	5.984

Term	GAM	RF	Max	Avg
Seasonal Greenness Ratio	4.486	6.615	4.684	5.262
Distance to Cliffs	4.502	5.371	3.726	4.533
Roughness (TRI)	5.568	0	2.61	2.726

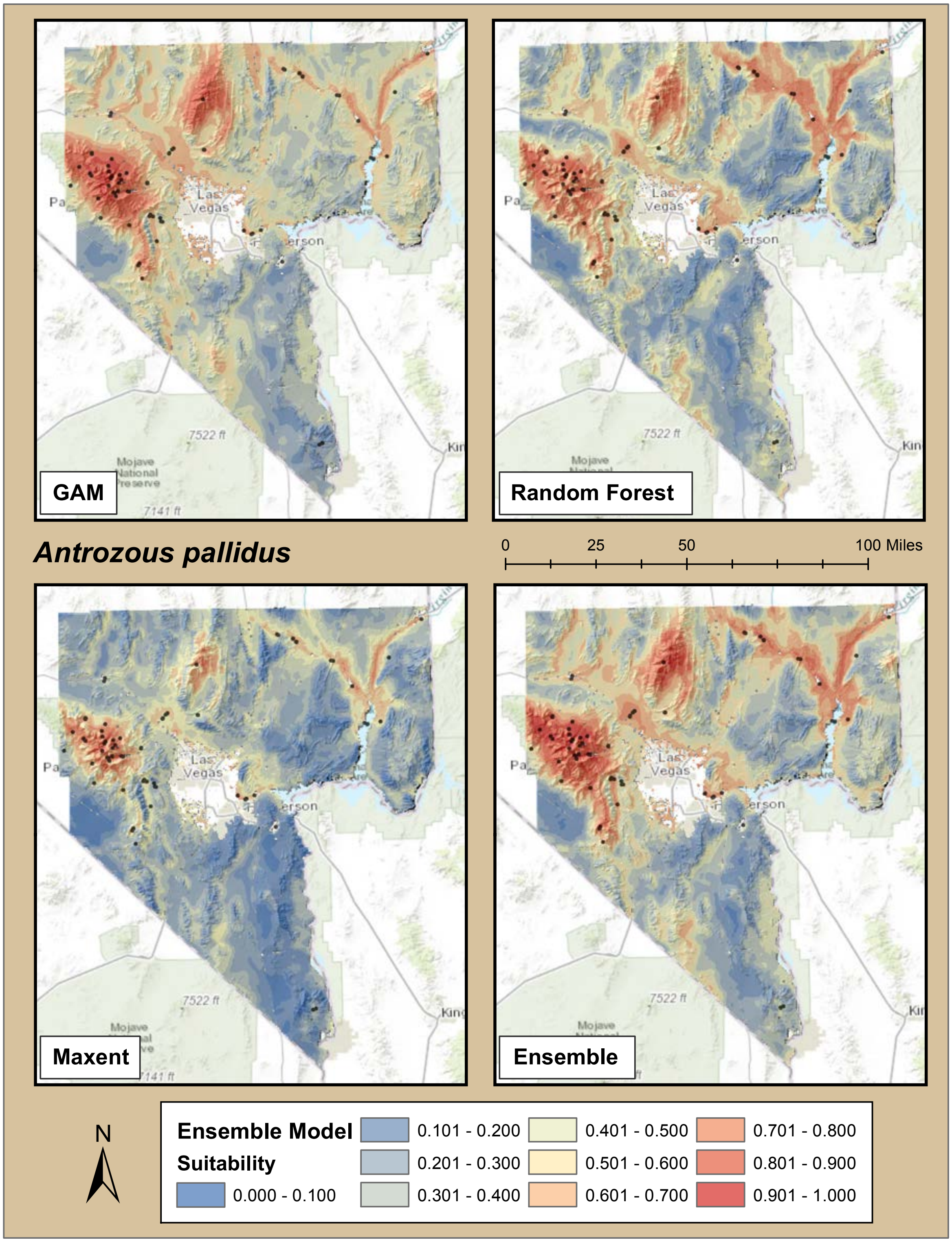

Figure 3. SDM maps for *Antrozous pallidus* model ensembles for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

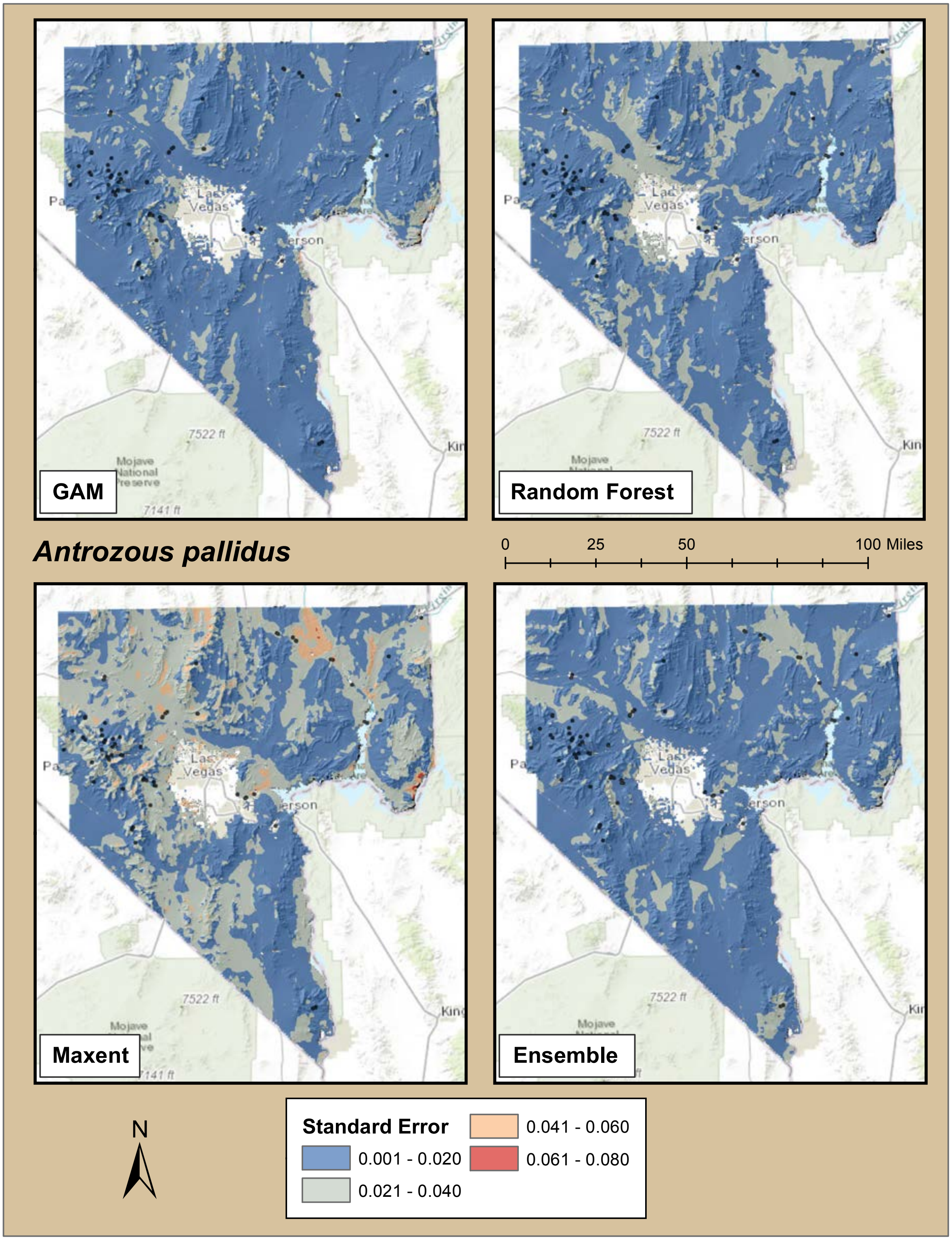

Figure 4. Standard error maps for *Antrozous pallidus* models for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

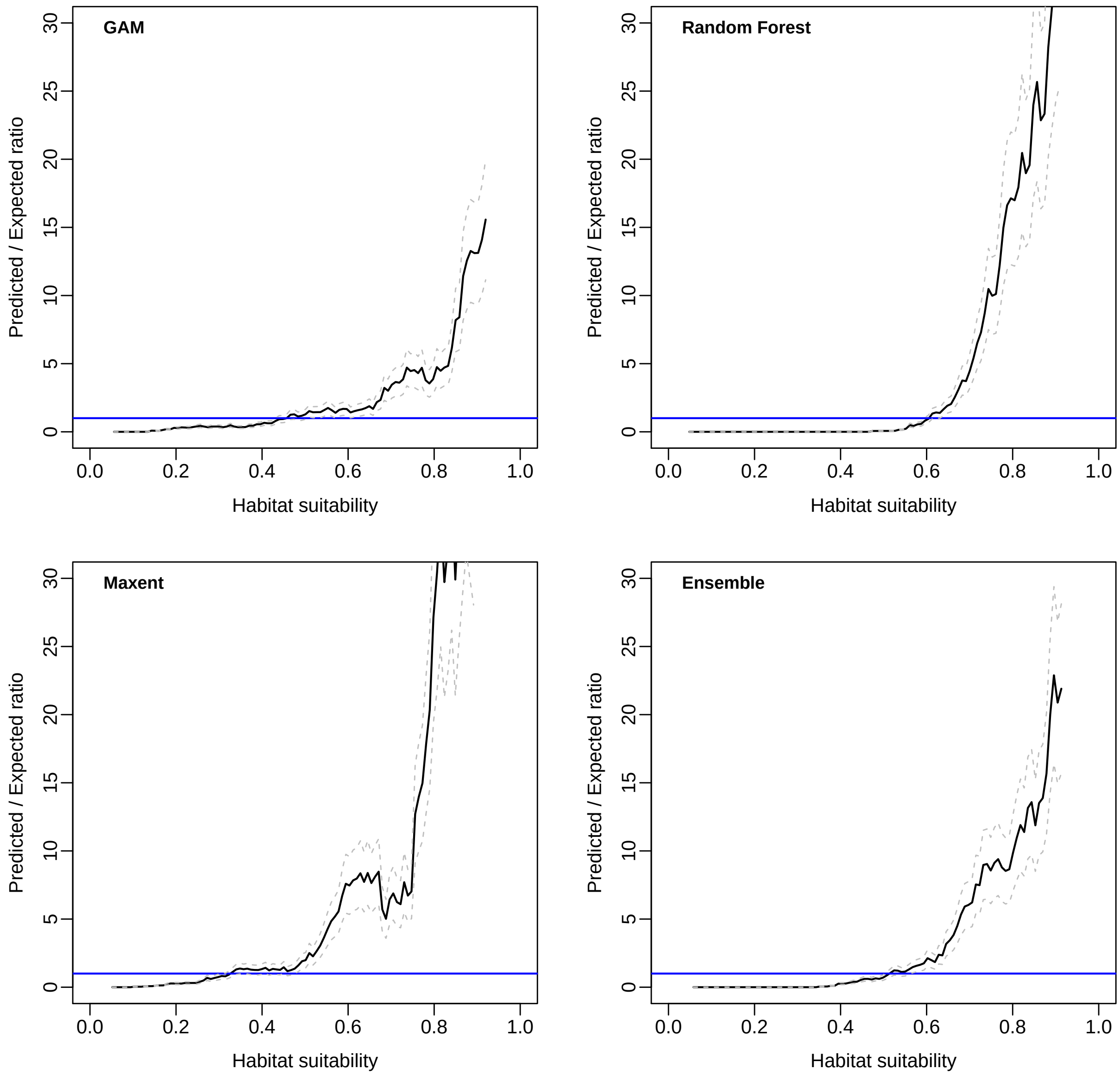

Figure 5. Continuous Boyce Indices for *Antrozous pallidus* models for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

General Additive Model

Rankings of the relative contributions for the GAM models identified Surface Texture, NDVI Maximum, and Winter Precipitation, and Winter Minimum Temperature, as the highest contributing environmental predictors, collectively accounting for 72% of the model influence (Table 7). Habitat suitability was predicted to be highest with lower Surface Texture values, characteristic of rocky areas, which are more likely to be associated with caves and potential roosting areas (Figure 6), suitable habitat predicted by the GAM models peaked above the average values of NDVI Maximum and Winter Precipitation, and was lowest in areas of high winter minimum temperatures, likely reflecting the association of this species with higher elevations, but which could also be influenced by a higher sampling bias in these areas (e.g. in and around the Spring Mountains in Clark County).

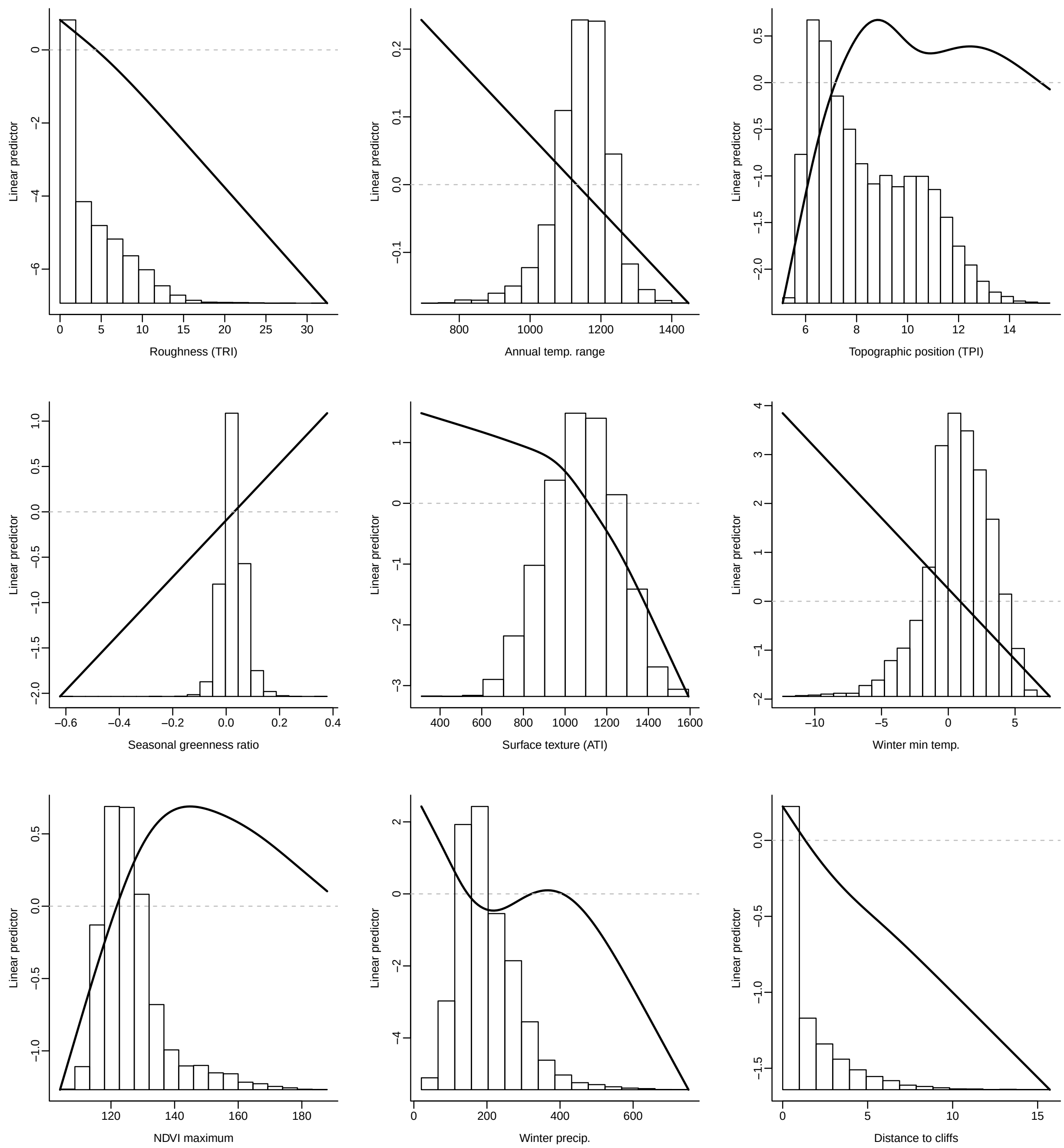

Figure 6. GAM partial response curves overlaid over distribution of environmental variable inputs in the study area.

MaxEnt Model

The MaxEnt model contributions of Winter Minimum Temperature and Annual Temperature Range were the top 2 contributing variables, followed by Surface Texture and Winter Precipitation, and Topographic Position, collectively accounting for 75% of model contributions (Table 7). MaxEnt model predictions for *Antrozous pallidus* habitat were higher in areas with lower minimum temperatures, and lower minimum temperature ranges, characteristic of higher elevation areas. Habitat prediction tended to decrease generally linearly for these two variables. Surface Texture had a generally negative relationship with habitat, with increased habitat in rockier areas. The fitting function for this variable was stepped and characteristic of the gate fitting function in MaxEnt. Predicted habitat was steeply negatively correlated with Winter Precipitation (Figure 7).

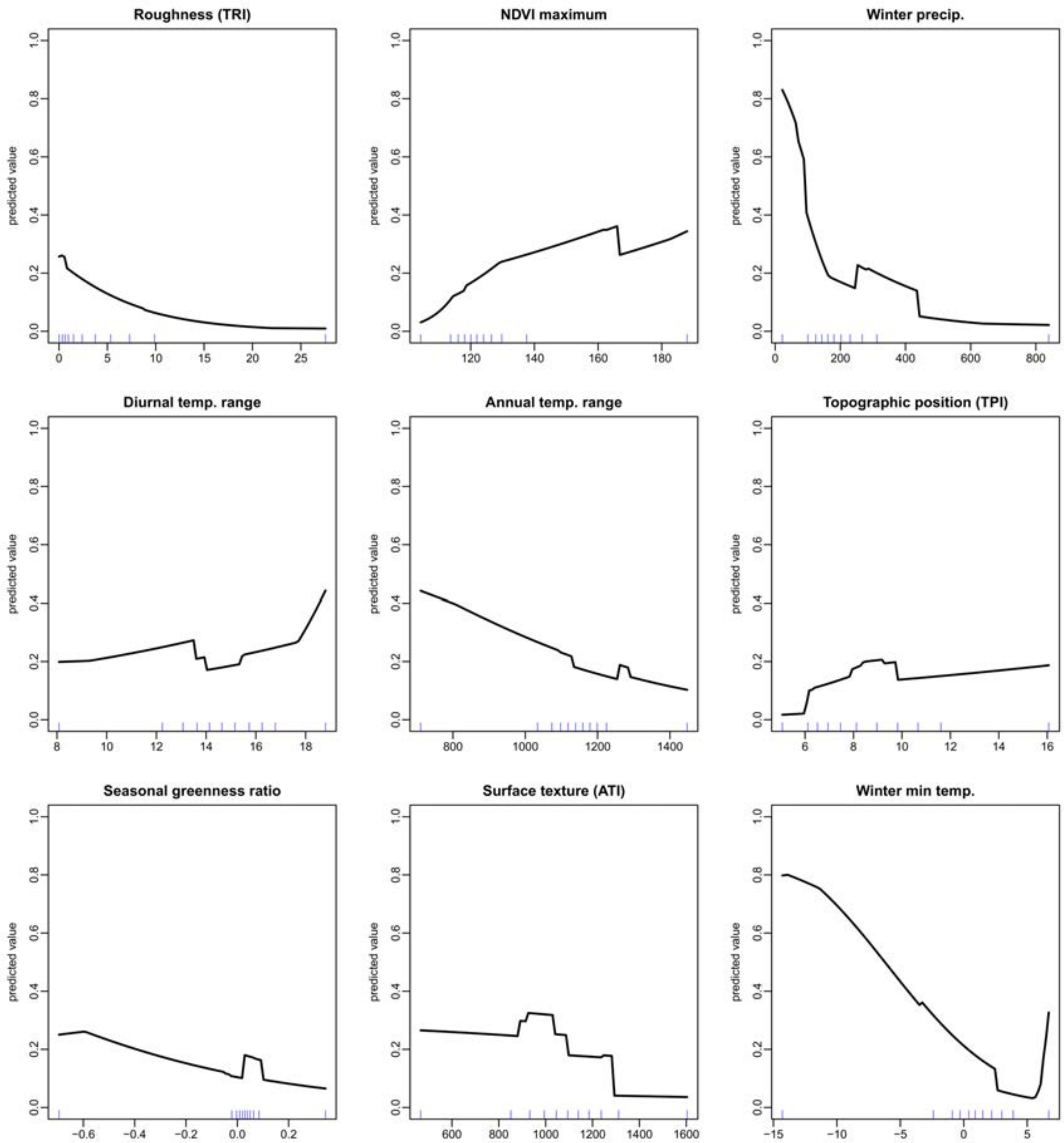

Figure 7. Response surfaces for the top 9 environmental variables included in the MaxEnt ensemble model for *Antrozous pallidus.*

Random Forest Model

RF models showed highest contributions from Winter Minimum Temperature, Winter Precipitation, Surface Texture, and NDVI Maximum (Table 7). Habitat prediction tended to be moderate at low winter minimums and decreasing with higher temperatures, increasing with increased winter precipitation, and highest at low values of Surface Texture (Rocky areas) and areas with a high Maximum NDVI – perhaps associated with tree canopy (Figure 8). Annual Temperature Range and diurnal temperature range were the next highest contributing environmental variables (Table 7).

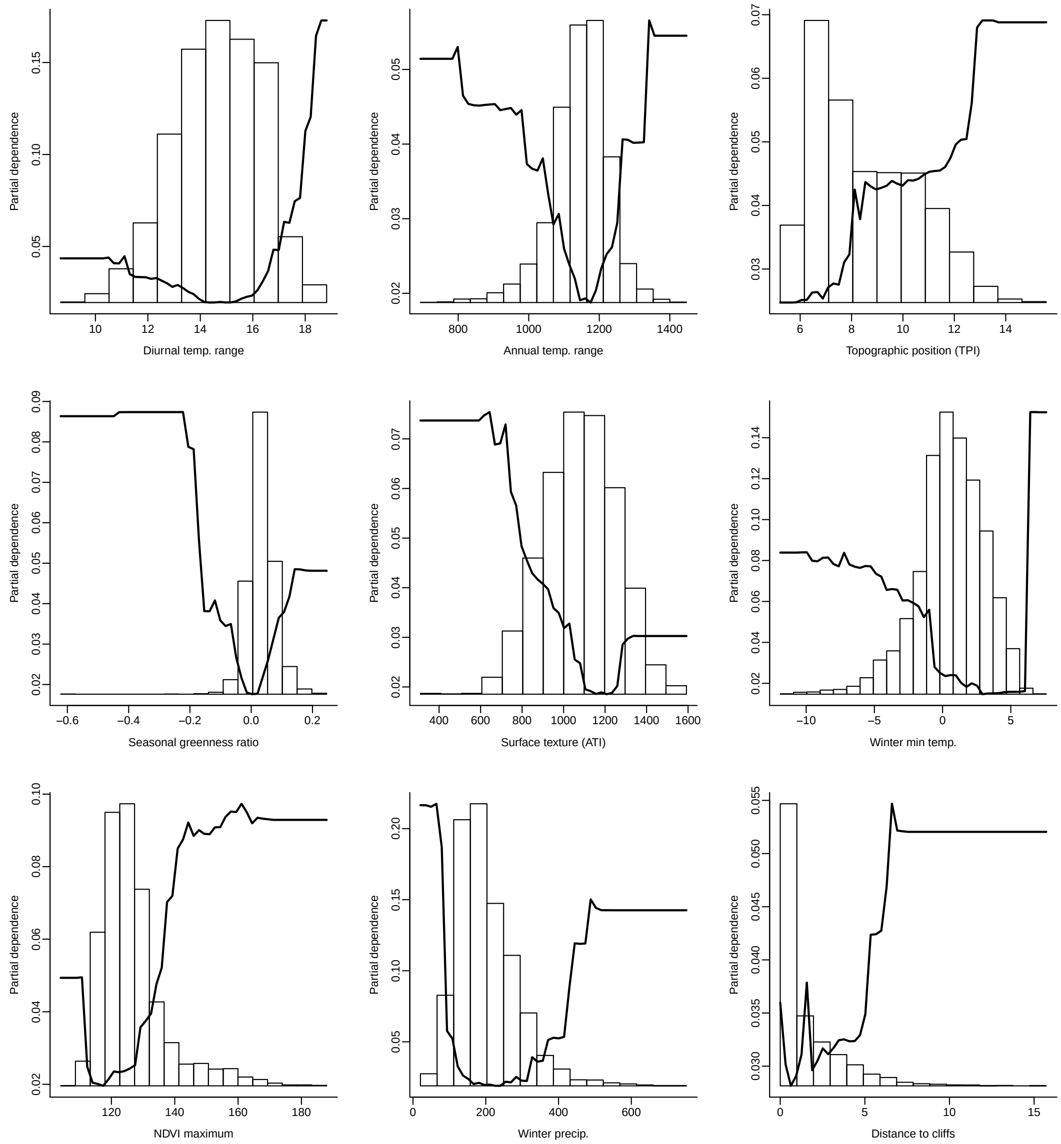

Figure 8. Response surfaces for the environmental variables included in the RF ensemble model for *Antrozous pallidus.* Histograms represent the range of each environmental variable across the x-axis, and predicted dependence relative to habitat suitability values are on the y-axis.

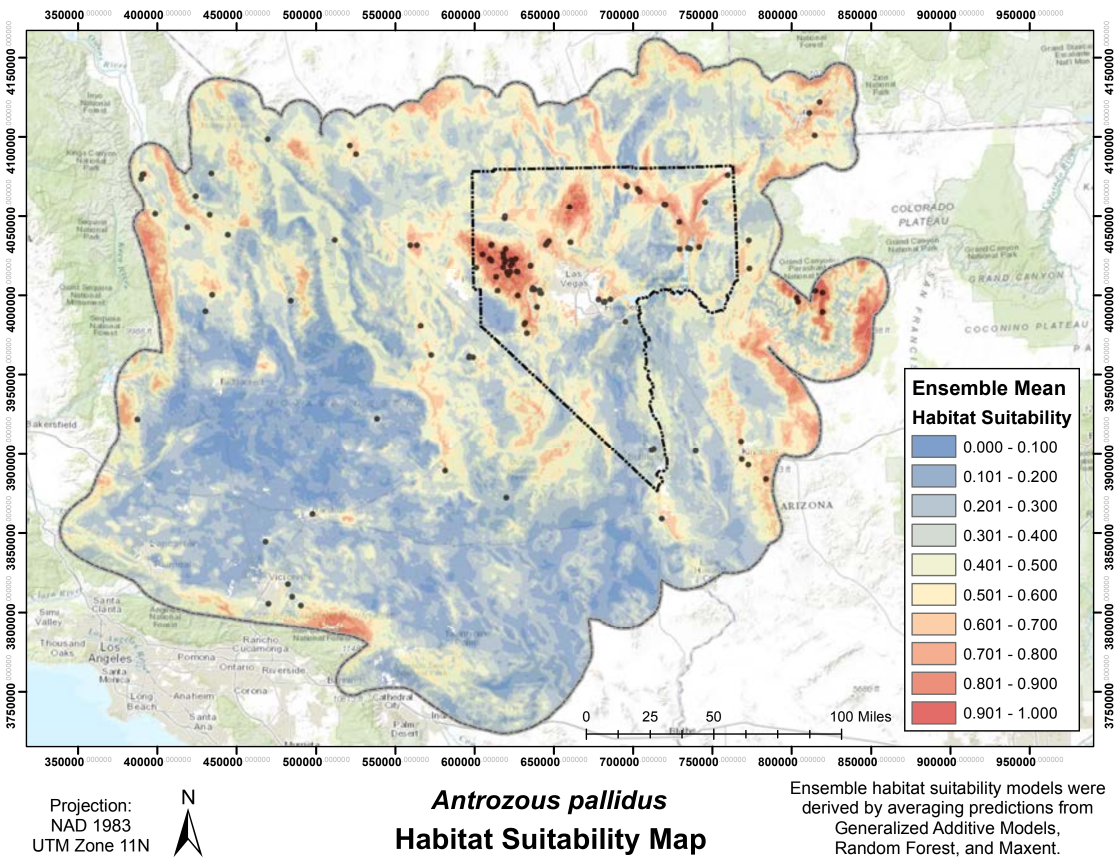

Figure 9. Mojave wide SDM map for the *Antrozous pallidus* ensemble model

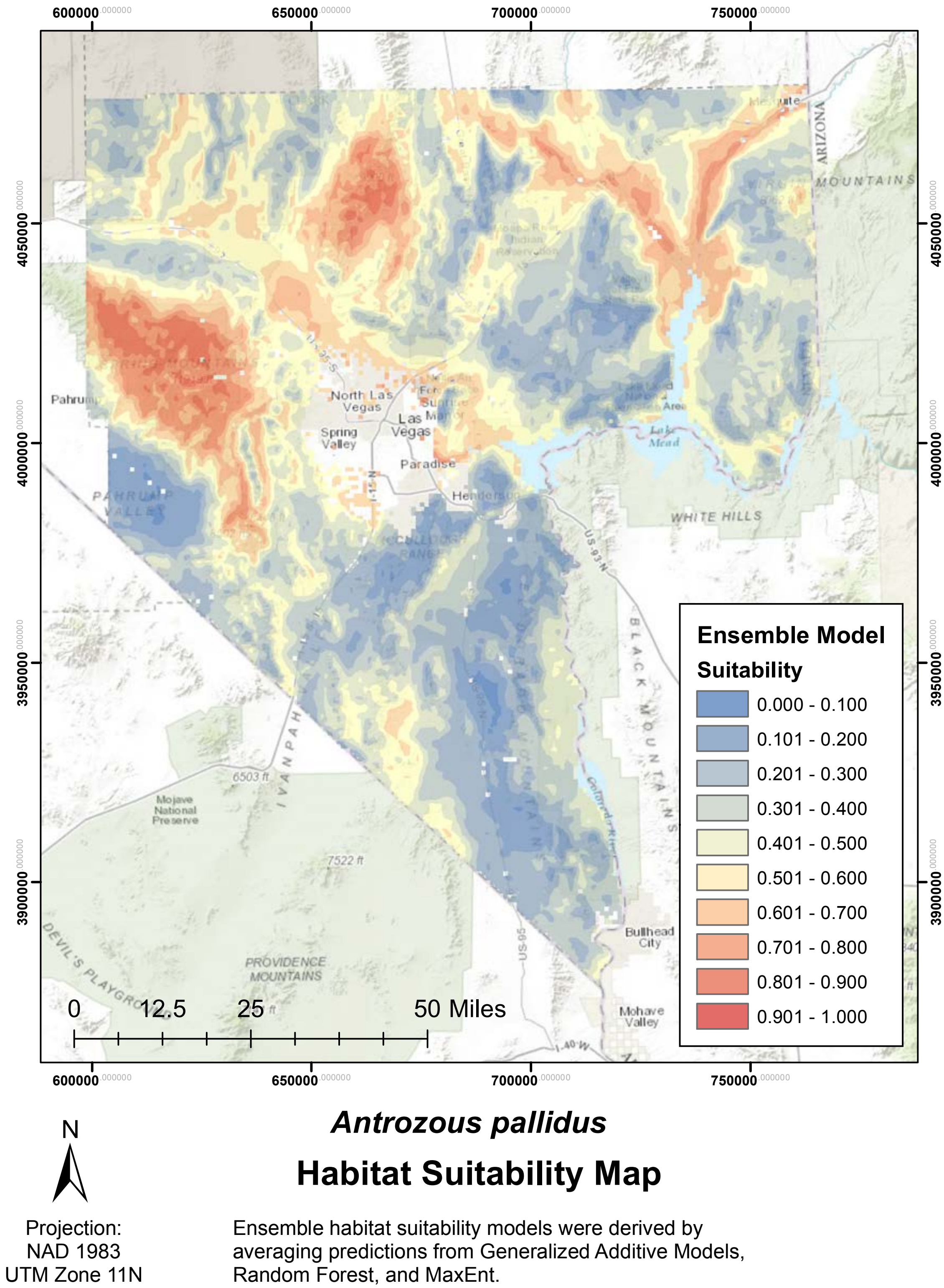

Figure 10. SDM map for the *Antrozous pallidus* ensemble model

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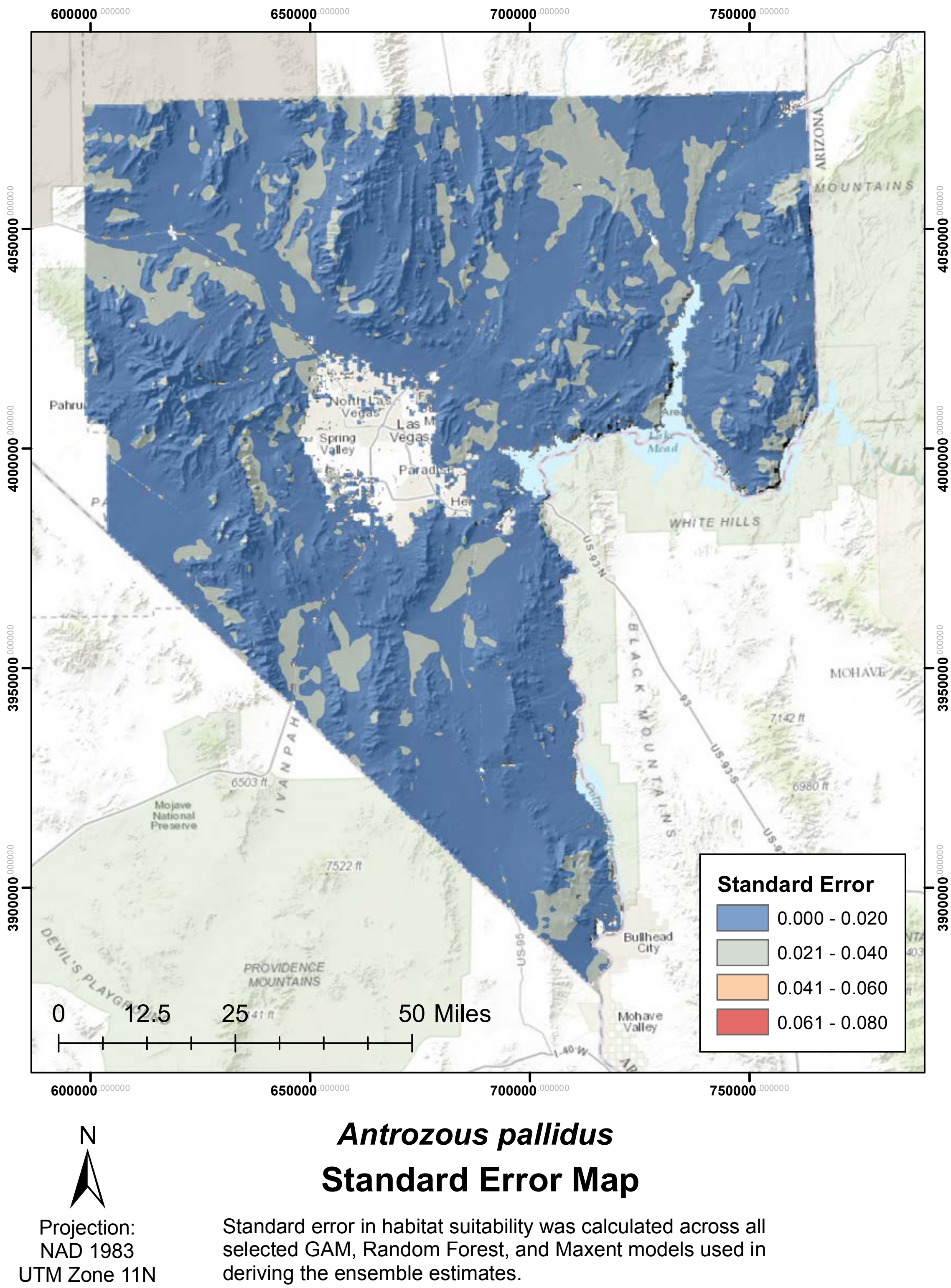


Antrozous pallidus

Standard Error Map

Standard error in habitat suitability was calculated across all selected GAM, Random Forest, and Maxent models used in deriving the ensemble estimates.

Figure 11. Standard Error map for *Antrozous pallidus* ensemble model

Model Discussion

Data Distribution

While known localities for the Pallid Bat are generally uncommon across the Mojave Desert, Clark County, NV has some of the highest densities of locality points for this species in the desert (Figure 9). In Clark County, Pallid Bat localities are concentrated mostly in the Spring Mountains, followed by the upper Overton Arm of Lake Mead and extending upstream along the Muddy and Virgin Rivers. A third area of concentrated sightings is the Henderson, NV and a fourth the Desert National Wildlife Refuge. Outside those locations, the only other area in the Mojave Ecoregion with concentrated sightings is on the Grand Canyon/Parashaunt National Monument, near the rim of the Grand Canyon, where elevations are moderately high 1220m to1830m (4,000’ to 6000’) and open forest and woodland habitats are common. Elsewhere localities for Pallid Bats are quite uncommon in the Mojave Desert and especially the lower elevation areas. We believe apparent distribution may be somewhat biased due to the difficulty of capturing and identifying bats in general, because these bats are widely known as desert shrubland bats (Hoffmeister 1986).

Standard Error for Habitat Suitability Modeling

The stand error map (Figure 11) provided for analysis of how well the model was able to predict habitat across Clark County indicates relatively low error throughout all of Clark County.

Distribution and Habitat Use within Clark County

The Pallid Bat is expected to have a wide distribution in Clark County below 6,000 feet (O’Farrell et al. 1967, Tuttle 1982). While Pallid Bats may be found in a variety of habitat types, a study in Clark County found that 88 percent of their activity was detected in riparian woodland habitats (Williams et al. 2006). However, they are known to be opportunistic and flexible in their use of foraging habitat (Bell 1982). Within Clark County predicted habitat is widespread, with large habitat areas of high and moderate categories in Mojave Desert Scrub, Blackbrush, Mixed Conifer, Pinyon Juniper, Bristlecone Pine, and Alpine ecosystems (Table 8). Roost availability and prey abundance, [and water availability] are considered to be primary determinants of high quality bat habitat (Fenton 1997) – however, their large size and ability to travel efficiently may indicate that Pallid Bats use key habitat characteristics that are comparatively far apart (Nowak 1991). Cover is important to them. Different types of protection may be required for maternal roosts, hibernation roosts, and roosts used for breaks during nocturnal foraging (Fenton 1997). They frequently inhabit a variety of cover locations including crevices in rock faces and cliffs, similar sites in buildings and bridges, mine adits and shafts, caves, hollow trees, and even holes in the ground (in desert localities). Pallid Bats are not thought to undertake large migrations but have reduced activity during winter months. Bradley et al. (2006) list the Pallid Bat as a year round resident.

In Clark County, NV modeled habitat suitability occurs in four main areas of the county that closely reflect locality points (Figure 10). Outside the four large polygons of habitat there are scattered smaller patches dispersed throughout the Mojave Desert, including Clark County. High concentrations of high suitability habitat directly on the outer model boundaries (for the greater Mojave, Figure 9) should be considered very carefully due to the way the modeling algorithm behaves in those areas – possibly due to distance the distance to cliffs layer. If such areas are important to the project, further consideration should be given to the reasons for the pattern observed. The Clark County habitat suitability model for the Pallid Bat is free of that problem because Clark County was totally surrounded the larger modeled habitat area of the Mojave Desert (compare Figure 10 and Figure 9). Suitable habitat identified by modeling includes a wide range of habitat types from valley bottoms characterized by spring mounds (alkaline mineral spring deposits from the bottoms of Pleistocene lakes) and very sparse vegetation north of Las Vegas near Corn Creek (2856' elevation), through habitats to the top of the Spring Mountains, near Fletcher Peak (10,252' (3124m)). The Spring Mountains provide a great variety of habitat types from desert shrub habitat, woodland, forest, meadow, tundra, and riparian habitat at all elevations. All of the habitat types in the Spring Mountains also provide an abundance of rocky outcrop and cliff habitat for all seasonal roosting sites. The Sheep Range of the Desert National Wildlife Refuge is a second mountainous area of high habitat suitability. While often considered a bat of the desert shrublands (Hoffmeister 1986), or desert riparian habitats (Williams et al. 2006), Pallid Bats are also captured in forested areas (Hoffmeister 1986). A third area that models identified as high suitability for the Pallid Bat includes extensive riparian areas along the Muddy and Virgin Rivers, their confluence, and the upper Overton Arm of Lake Mead (Figure 10). Much of this region is classical desert riparian habitat, with some open water or pools that attract and abundance of insects and bats, but also provides a gallery of cottonwood trees, an understory of willow or tamarisk and other shrubbier species, plus nearby open areas for the particular benefit to Pallid Bats because of their preference to coarse areas while hunting near the ground surface. The Pallid Bat may feed on more ground dwelling insects than any other bat in the United States, and may even be caught in mousetraps (Hoffmeister and Durham 1971). Another area of Pallid Bat habitat in Clark County that might be less anticipated is in Henderson and Las Vegas city limits and primarily in the area of Las Vegas Wash. The immediate vicinity of Las Vegas Wash is similar in physiognomy to the Muddy and Virgin river habitats, because of the intermittent running or pooled watered lined by water loving shrubs and trees and open habitats interspersed throughout. There is likely more use by bats in the valley than indicated by the habitat map, because we masked the city-proper to avoid confusion for most wildlife species will that inhabit the urban areas. However, Pallid Bats are not opposed to using abandoned buildings that provide very dark cover sites, but may be easily disturbed Hermanson and O'Shea 1983). If they are disturbed they may abandon those areas (Hoffmeister 1986).

Ecosystem Level Threats

Pallid Bats are expected to inhabit a variety of ecosystems at low to middle elevations including: Blackbrush, Desert Riparian, Mesquite/Acacia, Mixed Conifer, Mojave

Desert Scrub, Pinyon-Juniper, Sagebrush, and Salt Desert Scrub. They also frequently inhabit abandoned human habitations and other buildings.

Disturbances to roosting sites and the widespread use of pesticides that either directly harm bats or reduce prey availability are listed as threats (ADGD 2017). This species appears to be intolerant of urban development, as demonstrated by large population declines in the south coast region of California. Hypothetically, activities that reduce hydrologic function or community composition of vegetation along riparian corridors may negatively influence bat populations (Williams et al. 2006).

Table 8. Ecosystems within Clark County, and the area (Ha) of Low Medium and High predicted suitability within each ecosystem.

Ecosystem	Low	Medium	High
Alpine	0	0	124
Blackbrush	51341	278565	84293
Bristlecone Pine	0	0	7565
Desert Riparian	0	2807	7957
Mesquite Acacia	4952	9412	5448
Mixed Conifer	0	116	27221
Mojave Desert Scrub	387863	715789	180929
Pinyon Juniper	212	22458	93105
Sagebrush	88	669	3947
Salt Desert Scrub	5740	52946	20703

Threats to Species

Threats to the Pallid Bat are mostly related to habitat disturbance. These include large-scale urbanization, mine closures and abatement, industrial scale farming, recreation, prescribed/wild fire, and renewable energy developments. Large-scale urban development can destroy large areas of foraging and roosting habitats. Building transportation corridors often destroys riparian habitats or results in loss of cliff habitats used for roosts (Miner and Stokes 2005). Prescribed fire activities usually take into consideration sensitive wildlife and mitigate potential impacts; however, wildfires cannot be controlled and may cause significant loss of foraging habitat.

Renewable energy development can threaten bat habitat. First, there is the direct loss of habitat. In this regard, solar arrays may be the most destructive to foraging areas for desert bats in Clark County, while wind farms have a smaller surface area disturbance. In contrast, wind turbines can have direct impacts to bats through collisions or barotrauma Cryan and Barclay 2009, Cryan 2011) which occurs in the extreme low pressure area that occurs surrounding the moving windmill propeller and is sufficient to kill the bats. Wind turbines may directly impact Pallid Bats as they leave roosting sites to forage, because on emergence they fly at the right altitude to be susceptible to propellers, but while foraging may be mostly outside this area (O'Shea and Vaughan 1977).

Recreational activity such as mine and cave exploration or rock climbing can cause disturbances to bat colonies (Bradley et al. 2006) especially during the breeding period.

The white-nosed fungus (*Pseudogymnoascus destructans*) that is dangerous to many hibernating bat species has not been located in the southwestern US, yet, and Pallid Bats have not been documented as PD-positive (whitenosesyndrome.org 2017). However, because of their social behavior Pallid Bats may be susceptible to this disease if it moves into the region.

Existing Conservation Areas/Management Actions

The Nevada Bat Conservation Plan assesses the state of bat conservation in Nevada and suggests strategies, actions, and research needed to promote healthy bat populations and habitats (Bradley et al 2006). The plan designates Pallid Bat populations and habitats as a medium priority for funding, planning, and conservation actions. However, a lack of information about this species is a concern, and the lack of information prevents an adequate assessment of the species' status (Bradley et al. 2006).

The Overton Wildlife Management Area (OWMA) consists of 17,229 acres in the Moapa Valley managed by the Nevada Department of Wildlife. The conceptual management plan for OWMA calls for protecting and enhancing mammal habitats and populations. Recommended management actions are to determine the occurrence and habitat functionality on the OVWMA for warm desert riparian bats, including the Pallid Bat (NDOW 2014).

Ideally, bat conservation/management programs should take into account summer/nursery roosts (both daytime and nighttime), winter roosts, food and water availability, habitat availability, population trends, and increasing public awareness of the benefits of bats (Fenton 1997).

To better understand the status of bats it is important to establish baseline trend data with which to compare the status of populations in the future. To improve habitat for Pallid Bats, newly proposed conservation areas should be large enough to include a great variety of habitat types required for healthy bat populations. Emphasizing protection for known bat colonies is an important step toward conservation. Recreational activities in caves and at rock climbing sites might be restricted seasonally, during times when bats are most sensitive, to reduce disturbances for bats. Appropriate bat gates can reduce disturbances around mine shafts, and as such measures are implemented, regular inspections should be scheduled to ensure the integrity of conservation measures. Damage resulting from prescribed fires or wildfires could be mitigated by considering the construction of bat-appropriate shelter sites. Such activities require fixed budgets that are planned in advance for upkeep and monitoring.

Summary of Direct Impacts

High and moderate predicted habitat suitability is widespread throughout the county, and similar amounts of habitat area are in Impact and Conserved areas. Far more moderate habitat is located in Conserved areas than in either Impacted or Disturbed areas (Table 9). While 337 km^2 of high category habitat is likely to be impacted, and 254 km^2 is already disturbed, this is only 13% of high quality habitat located within the county (Table 9).

Table 9. Categorized modeled habitat values (High, Medium, and Low) and the average area (Hectares) predicted in the potential impact areas, conservation areas, already disturbed areas, and overall area

Habitat Level	Impact	Conserved	Disturbed	Area (Hectares)
High	33692	39067	25411	438484
Med	59902	282956	20439	1114117
Low	28826	190305	5459	459363

AQCH - Golden Eagle (Aquila chrysaetos)

As top avian predators, there is interest in Golden Eagles (*Aquila chrysaetos*) globally. Successful conservation and education efforts have formed around this iconic species since the time when they were shot for sport on their annual migrations in the eastern United States. While those types of losses have certainly been reduced, new threats have developed with the recent national thrust to create greater amounts of renewable energy. Since about 2010 there are re-doubled efforts to understand the status of Golden Eagle populations in North America and learn about their life histories and ecology on a continental basis. Golden Eagles in the hot desert regions of the southwestern United States are among the least known populations in North America. The Desert Renewable Energy Conservation Plan (DRECP 2015) of southern California has invested some resources to improve our understanding of this species. Much more work will be required to better understand this far-ranging species.

Species Status

US Fish and Wildlife Service Endangered Species Act: No Status
Migratory Bird Treaty Act: Protected
Bald and Golden Eagle Protection Act: Protected
US Bureau of Land Management (Nevada): Sensitive
US Forest Service (Region 4): No Status
State of Nevada: Protected (NAC 503.050.1)
NV Natural Heritage Program: Global Rank G5, State Rank S4
NV Wildlife Action Plan: Species of Conservation Priority
IUCN Red list (v 3.1): Least Concern
CITES: Appendix ii

Range

The distribution of Golden Eagles is circumpolar in the northern hemisphere (Bent 1961). They generally occupy relatively open areas that are not densely forested. Similarly, expansive grassland biomes are often suitable for establishing breeding territories where nesting substrate is present (e.g. cliffs or trees), and may be used by wintering eagles as well (Watson 2010). Currently, Golden Eagle populations are most robust west of the Great Plains with additional populations in northeastern Canada and isolated locations in the eastern US (Kochert et al. 2002, DeLong 2004). There are six subspecies of Golden Eagle worldwide, however only *A. c. canadensis* occurs in North America. Golden Eagles occupy mostly remote open country that is isolated from human activities. Foraging habitats for nesting eagles include many North American habitat types including: the fringes of Arctic habitats; mountains of the Pacific northwest; the taiga of North America; foothills and shortgrass steppe east of the Rocky Mountains; cold deserts of the Great Basin and Colorado Plateau; the Mojave and Sonoran hot desert ecoregions, mountains and coastal areas of California and Mexico; and mountains of eastern North America (Watson 2010, Longshore In Prep., Daniel Driscoll – AERIE, personal communication). Wintering Golden Eagles use these above habitat types when prey is available year-round and climatic conditions allow. They may also parts of the Great Plains, but in that region nesting is limited by lack of appropriate nesting substrate. In North America nesting substrates usually include cliffs and trees.

Habitat Model Review

The Model -Golden Eagle nest sites were used to map potential nest sites in Clark County based on cliffs (especially those greater than 70 ft – see Figure 12), aspect, elevation, slope, distance to water, and distance to urban areas, however the latter three did not provide useful contributions to the model, and the final model was based only on three variables.

Technical Considerations - It would be useful to know the functions of the relationships between actual nest locations and the parameters used in the model that were provided. For example, knowing the aspect and elevational limits for nesting could be useful in site-based evaluation of new development projects in Clark County. Similarly, there may be an upper elevational limit to known nesting sites and that would be useful for habitat evaluations. While the methods are not explicit it may be that simple logistic regressions were used to generate the parameters used to create the predicted habitat. If this were the method used, then linear combinations of the three input variables would have been used to predict habitat. No performance statistics regarding the accuracy and precision of the predictive model in relation to the locality data were presented in the report, and thus its accuracy is not known. However, it appears that almost all the known nests in the database occur on cliffs within the parameters defined by the model and thus the model predicts all of the known nest at the scale that is provided.

Future Model Consideration – The authors reference using an upcoming product for the possibility of a more accurate model to be produced by the USGS and USFWS and in the future. In addition to that, data and models for the distribution of prey bases could be useful in assessing the value of Golden Eagle habitat. Preliminary work on Golden Eagle prey base availability is also in preparation by the USGS and collaborators. This model presents solely nesting habitat, but mentions that hunting areas occur in open areas throughout the county. Analyses of actual hunting behavior derived from radio-tagged eagles would be very useful for defining the characteristics of Golden Eagle hunting areas in the future.

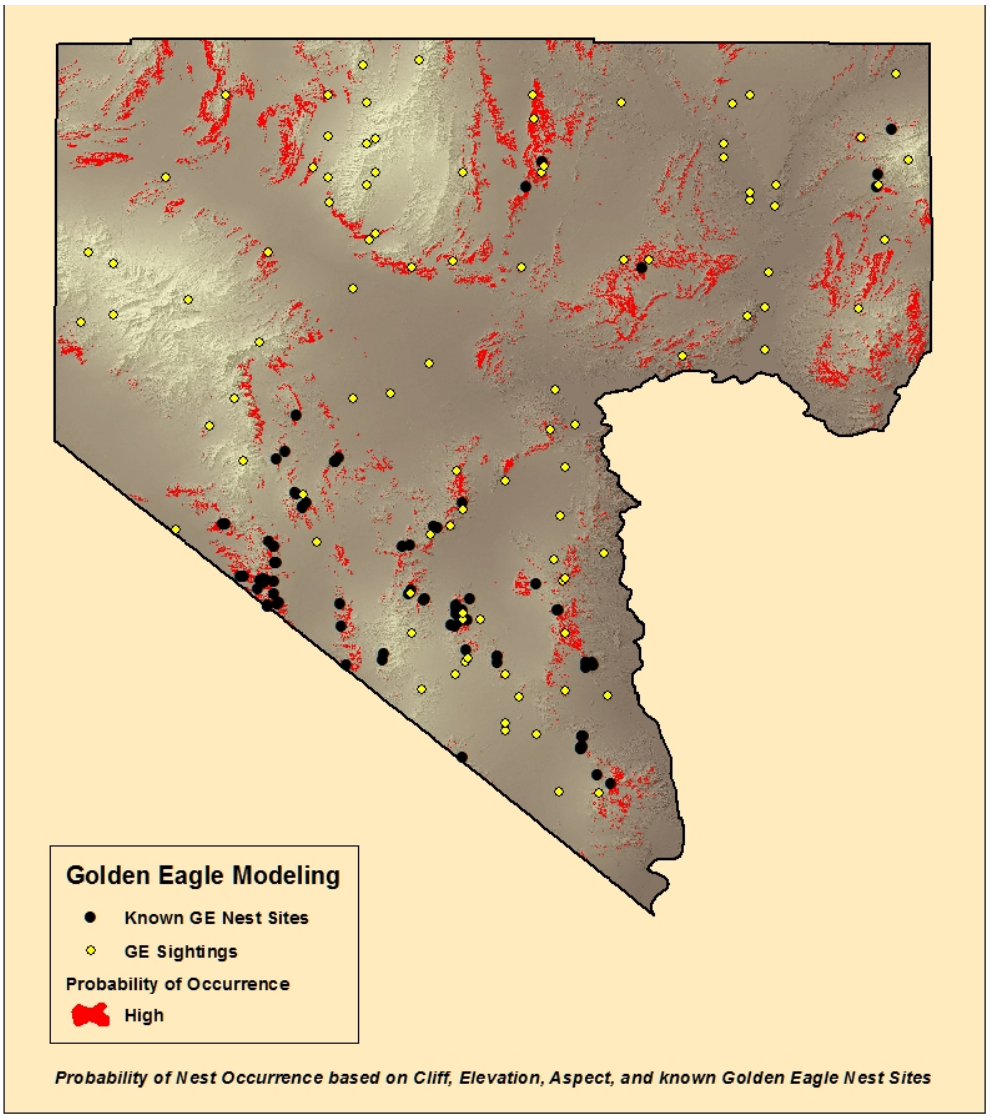


Figure 12. Golden Eagle habitat model from Amman et al. 2015

Distribution and Habitat Use within Clark County

Golden Eagles nest in limited numbers throughout Clark County, Nevada. Every major mountain range and several smaller ones are occupied by resident Golden Eagles (unpublished NDOW raptor nest database). For example, there are multiple nests known from the Spring Mountains, Newberry Mountains, and McCullough Mountains. Modeled nesting habitat by the Great Basin Bird Observatory (Ammon

2015) was located largely within ecosystems classified as Mojave Desert Scrub and Blackbrush although it was restricted to mountains and cliffs within these ecosystems (Table 10).

Breeding pairs of Golden Eagles occupy and defend large home ranges with little overlap between the territories of pairs (Marzluff et al. 1997, Kochert 2002, DeLong 2004). Breeding season territories range in size from 20 to 54 km^2 (Kochert 2002). By contrast, in the Mojave Desert of southern California, Golden Eagle home ranges averaged 307.8 km^2 (SE± 66.4) (Braham et al. 2015). New technology that provides a high degree of spatial returns could partially account for the increased numbers on the newer analysis. In high density population with abundant nest substrate and high prey availability, occupied nests could be situated as closely as <1 km between neighboring pairs in some areas (Kochert et al. 2002). In Clark County, known adjacent nests are considerably further apart than reported in the literature (unpublished USGS Golden Eagle nesting database, NDOW raptor nest database).

Foraging has been documented in most the habitat types occurring in Clark County. Mojave desert scrub habitats in the expansive valley bottoms and outwash plains of Clark County comprise a great deal of the foraging areas, as do mountain slopes, and peaks (Longshore et al. *In Prep.*). Much of what we know about eagle habitat use comes from prey base studies. However, recent advances in tracking technology have provided opportunities to collect data on Golden Eagle movements relative to habitat use and foraging bouts. Golden Eagles also forage near rural communities. Furthermore, eagles also fly over urban areas, and have been observed flying directly over the city of Las Vegas (Longshore et al. *Unpublished Data*). While Golden Eagles are capable of taking large prey such as bighorn sheep (*Ovis canadensis*) lambs or mule deer (*Odocoileus hemionus*) fawns, studies of prey delivered at nests in Clark County indicate black-tailed jackrabbits (*Lepus californicus*), rock squirrels (*Otospermophilus variagatus*), and cottontail rabbits (*Sylvilagus auduboni*) comprise a great deal of prey items delivered to young eagles (Dawson 1923, Bent 1961, Johnson et al. 2015). Other items include many medium-sized mammals, birds, reptiles and even fish. Golden Eagles also will eat carrion that is scavenged from road kill, escapees from sportsmen, or as refuse from agricultural activities (Olendorff 1976, Brown 1992, Kochert et al. 2002, Longshore et al. *In Prep.*).

Golden Eagle nesting areas are frequently in remote mountainous areas, although a few are surprisingly close to human recreation sites (unpublished NDOW raptor nesting database). The known Golden Eagle nests in Clark County are all on cliff substrate. There are no known tree nests. In southwest Idaho, nesting density was found to depend on availability of good nesting substrate and territorial intolerance, but nesting substrate was more important than the latter factor (Beecham and Kochert 1975). Nests are large and made of sticks, often six feet across on the nesting platform with a central area lined with fine grasses, yucca leaves, pine boughs, and other materials. The accumulation of materials may be several feet thick, with extreme examples measuring upwards to 20 feet tall (Ellis et al. 2009). Most eagle nests have a commanding view of the surrounding area (Dawson 1923).

Resident Golden Eagle pairs generally remain in long-term pair bonds, but mates are sometimes lost due to a variety of reasons (e.g. mortality, intraspecies agonistic encounters), and in that case a mate may be replaced. Mates can be replaced rapidly, ranging from 1-8 days to replacement in Wyoming, if there are sufficient non-breeding adults in the local population (Philips et al. 1991). Courtship begins in December or January. Territories are often identified by the undulating flight of pairs, which is a behavior associated with courtship or territory defense in Golden Eagles (Harmata 1982). The behavior consists of a rise upward, tucking of the wings while continuing on a forward trajectory that dips, only to open the wings again and rise up and repeat that behavior (Dawson 1923). Fresh sprigs of vegetation such as pine boughs or *Ephedra* spp. In the Mojave Desert (Joe Barnes – NDOW, Pers. Comm.) may be brought to the nest as well, which is an indication of an occupied territory. Activity near the nest is generally very secretive; however, undulating flights often occur in front of the nest cliff face. Usually one or two eggs are laid, but there has been documentation of three eggs and rarely four (Beecham and Kochert 1975). Eggs may be laid in February or March and require 41-45 days to hatch (see Kochert et al. 2002 and Watson 2010 for associated citations). For the first three weeks, nestlings are not able to thermoregulate on their own, thus are particularly vulnerable to disturbance. For about 4 weeks, the eaglets are downy white. Another four weeks their plumage emerges as dark brown feathers, and for the next three weeks they continue to develop. Fledgling plumage is a little darker than adults with white windows in the wings and at the base of the tail persists for one year. Full adult plumage is acquired at about four years of age. Fledgling eagles in Clark County are known to have travelled as far as the Pinacate Region of northern Sonora, Mexico on their first summer (Joe Barnes – NDOW, *personal communication*). Eagles that are too young to breed or unpaired adult birds are also known as floaters and may range continentally as they mature and seek their own territories (DeLong 2004).

Table 10. Ecosystems within Clark County with the area of predicted nesting suitability (Hectares) within each ecosystem.

Ecosystem	Nesting Habitat
Alpine	0
Blackbrush	47466
Bristlecone Pine	0
Desert Riparian	12
Mesquite Acacia	96
Mixed Conifer	0
Mojave Desert Scrub	68859
Pinyon Juniper	2783

Sagebrush	190
Salt Desert Scrub	8879

Ecosystem Level Threats

Widely known and direct ecosystem level threats include electrocution from landing on small poorly configured power poles, collision with transmission wires, gunshots, vehicular collisions while pursuing prey or scavenging road kill, and toxicants such as lead shot from carcasses and misuse or non-targeted mortality by insecticides and rodenticides (DeLong 2004). With recent emphasis on renewable energy the proliferation of wind turbines to generate energy are the newest threat with considerable impacts to Golden Eagles in some areas of the western United States. Those direct threat factors can often permeate the entire landscape. Indirect ecosystem level threats include lack of prey availability and habitat degradation due to land use changes from renewable energy development (particularly solar arrays), transportation and utility corridors, and urban development.

Power poles are an attractant to raptors, especially at locations with few natural perches, because they provide an aid to habitat surveillance for prey (APLIC 2006). Areas of higher prey density, may increase the attraction to these features. The broad wingspan of Golden Eagles increase their risk of electrocution by allowing them to span the distances between energized conductors and (APLIC 2006). The rates of Golden Eagle electrocutions may have declined during the past 30 years due to utility company efforts to reduce risk (APLIC 2006); however, electrocution risk is still great on many older or non-retrofitted utility lines in rural areas of Nevada (Joe Barnes and Cris Tomlinson – NDOW, Pers. Comm.).

While electrocution has long been known as a source of increased mortality on Golden Eagles, one study of 126 eagle carcasses along power lines indicated that 84% of the carcasses were killed by gunshot rather than electrocution (Olson 2001).

How wildfires affect prey populations for Golden Eagles is currently unknown, but the loss of cover over large areas of desert habitat could reduce jackrabbit abundance. Under similar circumstances of habitat conversion from shrubland to annual grassland in the Great Basin, eagles switched prey bases and average annual clutch sizes decreased (Steenhoff and Kochert 1988).

Population Trends

The population trends for Golden Eagles in the west are no doubt reduced from Pre-Columbian levels due to three primary factors. First, organized and sustained predator and prey controls have been instituted in some parts of the region for nearly a century. Second, active hunting by shooting, as well as poisoned baits (e.g. carcasses laced with poison), and non-target poisoning with eagles consuming rodents laced with rodenticide have reduced eagle populations. And third, the endeavor of egg-collecting for the science of oology is considered to have detrimentally influenced Golden Eagle populations early in the last century. However, the greatest influence of previous egg collection was usually closer to heavily populated municipalities like San Diego or San Francisco, California in the past.

While there are several large scale efforts to determine population trends across the nation, the estimates tend to have wide margins of error. For example, a recent investigation of the Golden Eagle population in the western United Sates, based on the detection of 172 eagles in 148 aerial line transects across 12 western states, estimated a total population of 27,392, with a 90% confidence interval of 21,352 to 35,140, eagles (Good et al. 2007). However, this survey dealt primarily with the interior west; and large portions of the west, i.e. most of California, southern Nevada, southern Arizona, and southern New Mexico were not surveyed in this investigation, nor were coastal Oregon and Washington. Recent surveys by West Inc. reported low detections generally, and wide error on estimates of Golden Eagle density in the Mojave Desert of NV and California.

Threats to Species

All of the direct and indirect threats listed above are influential with this species.

Two of three eagles that were studied by USGS in Clark County in 2015 were killed prematurely. While one of them likely died in an encounter with a rival eagle, it also had measurable levels of rodenticide in its system. A second eagle, which also contained measurable levels of rodenticide, died from a collision with a car on Interstate 15 south of Mountain Pass, California. More data will be required to understand the role of poisoning in Golden Eagle populations.

Renewable energy development presents threats to Golden Eagles as well. First, wind energy is well documented for Golden Eagle mortalities due to wind turbine blade strikes. While wind energy is currently not a factor in Clark County, there are plans for increased use of this energy source in the future. Secondly, renewable energy (e.g. wind and solar) industries require extensive open spaces in open flat country that were once prime foraging areas for resident Golden Eagles. Thus, if enough habitat is converted to solar and wind farming there could be an influence on Golden Eagles, potentially through expanded territory sizes needed to support reproduction. Whether this would reduce fecundity, or the number if territories in the region is unknown. One important consideration of this scenario is that travelling greater areas may place the eagles in contact with more risk factors for mortality (Wiens et al. 2017).

Urban encroachment on Colorado's Front Range (i.e., at the eastern foot of the Rocky Mountains), was attributed to the abandonment of historically-used Golden Eagle nests (Phillips 1986). Human disturbance or activity may cause nest abandonment, render a nest less productive, or prevent a suitable nest site from being used (GBBO 2010). Subsidized predators may also reduce the prey base in proximity to the ever-increasing boundaries of municipalities in Clark County (Esque et al. 2010).

Summary of Direct Impacts

Primary direct impacts most important to Golden Eagles include electrocution due to small gauge power lines (Benson 1982), vehicular collisions from eating road kill, secondary poisoning due to lead shot and rodenticides in the environment, and loss of habitat due to renewable energy and urban development. Nesting habitat located within conserved area comprises 337 km^2 of the total 1284 km^2 located within the county. While only 3 km^2 are estimated to be disturbed, an additional 22 km^2 are likely to be impacted by the project (Table 11).

Table 11. Categorized modeled habitat values (High, Medium, and Low) and the average area (Hectares) predicted in the potential impact areas, conservation areas, already disturbed areas, and overall area

Habitat Level	Impact	Conserved	Disturbed	Area (Hectares)
Nesting Habitat	2190	33790	331	128419

Existing Conservation Areas/Management Actions

The Golden Eagle is federally protected by the Migratory Bird Treaty Act, the Bald and Golden Eagle Protection Act, and the Lacey Act. The Nevada Wildlife Action Plan considers the Golden Eagle a Species of Conservation Priority, and recommends the following actions: protection of nesting and roosting sites, research to develop non-lethal wind turbine designs, and the continuation of helicopter surveys to monitor the population (Wildlife Action Plan Team 2012).

The Nevada Comprehensive Bird Conservation Plan considers the Golden Eagle a Conservation Priority Species, and recommends adequately managing habitat, including cliff nesting sites; managing habitats to encourage healthy prey populations; using Eagle Guards on transmission lines to minimize electrocution deaths; and the burial of mining drip lines to minimize risk of poisoning (GBBO 2010). Partners in Flight's population objective for the Golden Eagle is to increase the statewide population from 6,200 individuals to 6,800 individuals (Rosenberg 2004).

Both the Nevada Wildlife Action Plan and Bird Conservation Plan emphasize a need for improved monitoring to inform adequate and quantified population trends. Recent state-wide efforts by NDOW have been focused on compiling an inventory of existing cliff-nesting raptor nests, with emphasis on Golden Eagles, and were not designed to assess territory status or population size (Joe Barnes and Cris Tomlinson – NDOW, *personal communication*).

ARCA - Las Vegas Bearpoppy (Arctomecon californica)

Arctomecon californica is precinctive to three counties in the Mojave Desert: Clark County, Nevada; Washington County, Utah (introduced by seed); and Mohave County, Arizona. This species is taxonomically distinct with restricted distributions in Clark County (Hickerson and Wolf 1998). It was named after the territorial name at the time which was a region of Mexico, Alta Californica, where the explorer, Frémont, first collected the species (Mistretta et al. 1996). *A. californica* has been found at 610 – 1710 m on south- and east-facing aspects with population numbers typically declining above 608 m (Nelson and Welsh 1993; Childers 2004). According to Mistretta et al. (1996), 12% of the population has been extirpated due to development activities in the Las Vegas Valley, and another 16% were likely to be lost due to development after 1996. It is unclear what development activities Mistretta et al. (1996) refers to, and whether those populations have been extirpated. The Las Vegas Bearpoppy is a short-lived perennial herb in the poppy family (*Papaveraceae*) with showy yellow flowers that bloom in March-June. Germination occurs during winter months in years with sufficient rainfall (Thompson and Smith 1997, Meyer 1997, Megill et al. 2011). Plants are most vulnerable in the early life stage, and losses of buds may hinder reproduction in years with low rainfall (Thompson and Smith 1997). Its limited range and dependence on gypsum soil outcrops, and reduced viability in fragmented habitat make it particularly vulnerable to local extirpation.

Species Status

The Las Vegas Bearpoppy is a former Category 2 candidate for threatened or endangered status under the Endangered Species Act of 1973. The last ruling on the status of this species was published in the Federal Register on September 30, 1993 where it was determined that the Las Vegas Bearpoppy proposal for listing may be appropriate, but that insufficient data on biological vulnerability and threats were available to support the listing at that time (US Fish and Wildlife Service 1993).

US Fish and Wildlife Service Endangered Species Act: Not listed
US Bureau of Land Management (Nevada): Sensitive
US Forest Service (Region 4): No status
State of Nevada (NAC-527): Critically endangered
NV Natural Heritage Program: Global Rank G3, State Rank S3
IUCN Red List (v 3.1): No Status
CITES: No Status

Range

The Las Vegas Bearpoppy is found in Clark County, Nevada and Mohave County, Arizona (NNHP 2001). *Arctomecon californica* occurs from the western edge of Las Vegas in Clark County, Nevada, extending to the north of Lake Mead and west of the Virgin River and Overton Arm of Lake Mead, with a few sites south of Lake Mead eastward to the lower Grand Canyon in Mohave County, Arizona (TNC 2007, Thompson and Smith 1997, Megill et al. 2011), although the Arizona populations are thought to represent an undescribed variant which lives on limestone (Mistretta et al. 1996).

Population Trends

The Las Vegas Bearpoppy was described as declining rapidly in the state of Nevada in 2001 (Nevada Natural Heritage Program 2001). The species is considered critically endangered by the state of Nevada, with extirpation of 30 out of 91 potential populations due to rapid urban expansion (Mistretta et al. 1996). A more recent assessment, however, indicates a more stable trend on federal lands when population fluctuations due to climate variability are taken into account (TNC 2007).

Habitat Model Review

Models for *Arctomecon californica* were produced by Hamilton and Kokos (2011) first by creating a soils-based model (for all gypsophiles) to identify potential habitat areas. This model was created using SSURGO data and further refinements were attempted, but problems with the data prevented its further use. However, it was appropriately used as a basis to conduct further sampling for the species. Sampling was stratified based on habitat potential with most survey points in habitat considered highly suitable and fewer survey points in moderate or poor predicted habitat. New occurrences for this species as a result of additional sampling included 10 occurrences in High, 2 in medium, and 0 in low-predicted habitat and areas considered non-habitat. Although additional testing of the soils-based model included incidental occurrences and supported model categorizations used – 18% of the plants encountered were in areas classified as low and non-habitat (see tables 2-3 and 2-4 in Hamilton and Kokos 2011). After additional surveys were conducted habitat suitability was modeled using MaxEnt including the combined point set of all occurrences. The bearpoppy model created in MaxEnt was constructed based on only climatic inputs from standard Bioclim dataset.

The MaxEnt model for this species was deemed by Hamilton and Kokos (2011) to not be useful for refining the soil-based habitat models (although no soils were included in their modeling effort). The SSURGO based soils model was further refined (Figure 13) using remotely sensed imagery and the resulting gypsum soils model was then manually refined to better suit the species by "selecting suitable polygons" – but explicit rules or guidelines used for this process are not described other than relying on refinement of the soils models themselves and then applying an elevation constraint (300 to 1120 meters for this species). No precision or performance estimates are given for the refined model based on soils and elevation and other adjustments that were applied.

Technical Considerations – The MaxEnt model was produced using 500 iterations of a 374 presence records used for training, 41 for testing (10% withholding). The data layers used encompassed only the Bioclim dataset despite their assertion that soils likely play an important role in defining the distribution of this species. The MaxEnt model outputs yielded stronger influences of:

- Bioclim 02 - Mean Diurnal Temperature Range
- Bioclim 03 – Isothermality
- Bioclim 10 - Mean temperature of warmest quarter (°C)
- Bioclim 04 - Temperature seasonality (C of V)

The partial response curves indicate climatic "preferences" of this species toward warmer sites with lower ranges of diurnal temperatures (typical of lower elevations) and low isothermality. Model performance was indicated as high relative to AUC, no other test statistics are provided.

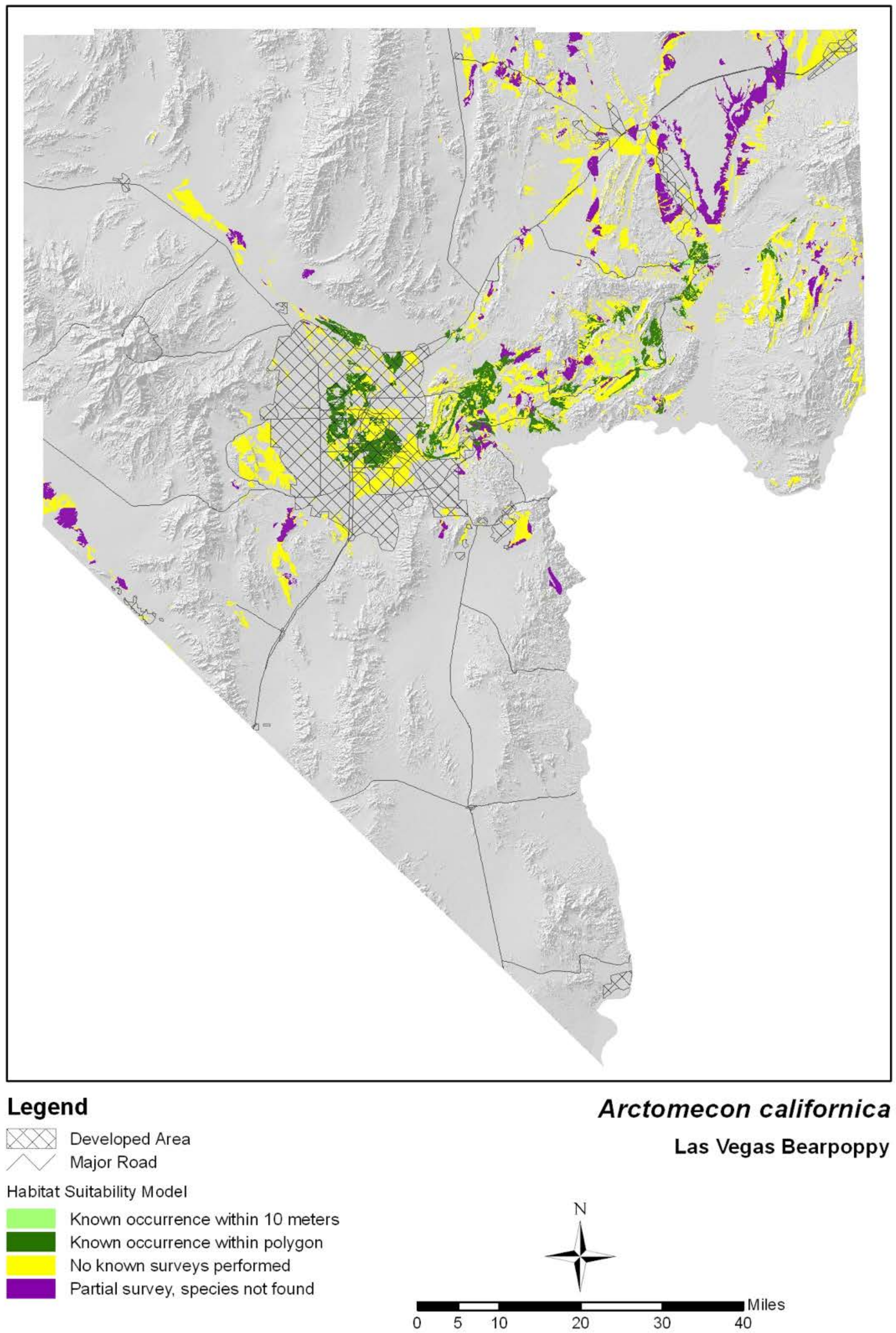


Figure 13. The refined soils-based model for Arctomecon californica from Appendix A of Hamilton and Kokos 2011.

Distribution and Habitat Use within Clark County

Las Vegas Bearpoppy is found in the central and eastern portion of Clark County, from the Las Vegas Valley, along the north and west side of Lake Mead, and east of Lake Mead in Gold Butte (TNC 2007). In Clark County 91 populations at 78 sites have been documented and are presumed extant (Mistretta et al. 1996). Surveys have been conducted in most areas of suitable habitat and Mistretta et al. (1996) considered that the remaining un-surveyed habitat was unlikely to add more than 25% to the existing population estimate. In Clark County, Las Vegas Bearpoppy is restricted to soils with high gypsum contents—up to 69 percent of the soil at some sites (Meyer 1987 in Mistretta et al. 1996)—that often support a well-developed cryptogamic crust (NNHP 2001). Thompson and Smith (1997) reported that *Arctomecon* populations occurred on gypsum soil outcrops with a "badlands" appearance in which the soils are whitish in color, fluffy in texture, and tend to form raised crusts that are easily disturbed, while flatter areas with rockier surfaces and desert pavement tended to be absent of this species. These gypsum soils form relatively barren, low-competition sites that support a distinctive gypsum-tolerant herbaceous plant community within creosote bush, saltbush, and occasionally blackbrush scrub ecosystems (TNC 2007). The gypsum soils in which this species grow are higher in sulfur, calcium, and soluble salts, with lower phosphorous contents and pH than the surrounding habitats supporting the shrub community (Thompson and Smith 1997). Estimated high and medium suitability habitat for this species is predicted to be nearly exclusive to the Mojave Desert Scrub ecosystem (Table 12).

Table 12. Ecosystems within Clark County, and the area (Ha) of Low Medium and High predicted suitability within each ecosystem

Ecosystem	Low	Medium	High
Alpine	0	0	0
Blackbrush	5129	73	12
Bristlecone Pine	0	0	0
Desert Riparian	1177	8	1
Mesquite Acacia	1125	201	60
Mixed Conifer	0	0	0
Mojave Desert Scrub	124873	27949	9677
Pinyon Juniper	0	0	0
Sagebrush	0	0	0
Salt Desert Scrub	5729	556	56

Ecosystem Level Threats

The primary threat to the Las Vegas Bearpoppy is habitat clearing for urban and residential development and associated highway construction and maintenance (Thompson and Smith 1997, TNC 2007). Damage from off-road vehicle use has been observed at most sites (Thompson and Smith 1997, TNC 2007). Other threats include gypsum mining, flood-control projects, dumping, and pollinator declines due to habitat fragmentation (Meyer 1986, Mistretta et al. 1996, Nevada Natural Heritage Program 2001, TNC 2007). This species is also sensitive to the destruction of the cryptogamic soil crust from trampling by feral horses and burros—this crust is believed to be critical to the maintenance of seed banks of this species and may enhance soil-surface nutrient levels and water retention (Mistretta et al. 1996). Invasive plants may be an emerging threat for some populations (TNC 2007).

Threats to Species

Las Vegas Bearpoppy is the best studied of Clark County's rare plants. Demographic data that have been collected for over 30 years have enabled the development of a population viability analysis that has provided useful information on conservation approaches (Meyers and Forbis 2006). This analysis showed that reproductive output depends on three factors: genetic variation, plant age, and precipitation, the most important environmental variable; the authors concluded that even large, intact populations are at risk of extirpation if a series of several dry years prevent seedling germination and recruitment and that small, fragmented populations suffer severe pollen limitation and set few seed—these small, fragmented populations were predicted to have low production.

As a short-lived perennial, Las Vegas Bearpoppy populations are susceptible to local extirpation during long runs of dry years when adult plants produce few seeds and most or all plants may die; the survival of populations then depends on a viable seed bank and sufficient rain for germination and survival of young plants (Meyer and Forbis 2006). Once a population is locally extirpated and the seed bank is diminished, recolonization is unlikely because of low seed dispersal and the isolated distribution of the gypsum habitats (Meyer 1987 in Mistretta et al. 1996).

Another threat to this species – a result of small, isolated, and fragmented populations – is reduced numbers of pollinators and low seed set as this species has little ability to self-fertilize (Mistretta et al. 1996, Hickerson 1998, Megill et al. 2011). This has resulted in measurable reductions in genetic variation in fragmented areas (Hickerson 1998). Some collection pressure has occurred by local residents and scientific collectors. Most transplants of this species are unsuccessful and this likely only serves to deplete local populations and impact local soils (Mistretta et al. 1996). This species has been observed with infestations by an unknown, dark blue, leaf fungus; effects on the Las Vegas Bearpoppy by this fungus are currently unknown and will need to be studied further (Mistretta et al. 1996), and no further research has been found on this fungus.

Existing Conservation Areas/Management Actions

A conservation strategy specific to this species was developed by The Nature Conservancy for the Clark County Desert Conservation Program (TNC 2007). The recommended conservation actions for this species include the following:

- proactively protect and manage for long-term viability of all populations on federal lands;
- manage viable populations by removing significant casual off-road vehicle use;
- control weeds in low-elevation rare plant habitats;
- ensure that disposal of federal lands in Clark County will not significantly impact conservation of rare plant populations;
- manage viable populations of all covered rare plants in utility corridors and potential rights-of-way corridors;
- management of viable populations on federal lands; and ensure that gypsum mining will not significantly impact the habitat of the Las Vegas Bearpoppy;
- manage populations of Las Vegas Bearpoppy at Nellis to ensure positive long-term viability trend within ten years;
- ensure gypsum mining will not significantly impact habitat of Las Vegas Bearpoppy by 2008;
- conserve Las Vegas Bearpoppy's remaining genetic diversity in its western populations in Las Vegas Valley (by 2015); and
- alleviate loss of Las Vegas Bearpoppy and habitat from BLM recreation management actions at Nellis (Las Vegas) Dunes (TNC 2007).

Under a 2007 permit granted by the Nevada Division of Forestry for the Nellis Air Force Base to develop a portion of the base's land, the Air Force will set aside more than 230 acres for permanent conservation of bearpoppy habitat in an agreement in cooperation with USFWS and the Nevada Natural Heritage Program (Nevada Department of Conservation and Natural Resources 2007, USFWS 2014). In addition, a ~300 acre conservation easement was also established near the North Las Vegas Airport (USFWS 2014).

Summary of Direct Impacts

The habitat and extent for this species is relatively low, with only 384 km^2 of high and moderate habitat combined projected within the county. Of this 100 km^2 are estimated to have already been disturbed, and another 28 km^2 are estimated to be impacted. A combined 108 km^2 of high and moderate habitat are estimated to be within the conservation areas (Table 13).

Table 13. Categorized modeled habitat values (High, Medium, and Low) and the average area (Hectares) predicted in the potential impact areas, conservation areas, already disturbed areas, and overall area

Habitat Level	Impact	Conserved	Disturbed	Area (Hectares)
High	1279	3606	439	9789
Med	1616	7216	9605	28789
Low	16993	47744	20098	138048

ARME - White Bearpoppy (Arctomecon merriamii)

Arctomecon merriamii is a perennial forb of the Papaveraceae family. The leaf blades are notably long-pilose, along with the sepals, and are nearly unlobed to shallowly lobed apically. The showy, large, white flowers are borne on a naked stem. The plant flowers in mid-spring and fruits in early summer (Coville 1892). White Bearpoppy is a C4 species with kranz anatomy (Knight and Clemmer 1987). The plant outcrosses in addition to self-pollinating, which is a trait unusual for members of Papaveraceae. Thompson and Smith (1997) suggest that this strategy may be an adaptation in response to ecological isolation in its specific habitats.

The holotype of White Bearpoppy was collected in 1891 by Merriam and Bailey (Coville 1892) a few miles west of Vegas Ranch in Clark County (Blomquist el al. 1995). The type locality was described as “level” with soil of a limestone, gravel, and sediment mixture (Clokey 1951). It is likely that the type locality was extirpated as a result of development surrounding Las Vegas (Rhoads and Williams 1977).

Species Status

US Fish and Wildlife Service Endangered Species Act: No status
US Bureau of Land Management (Nevada): Sensitive
US Forest Service (Region 4): No status
State of Nevada (NAC-527): No status
NV Natural Heritage Program: Global Rank G3 State Rank S3
IUCN Red List (v 3.1): No status
CITES: No status

Range

White Bearpoppy is found in small populations from the Meadow Valley Wash near Moapa, NV to Death Valley (Coville 1892). It has been recorded in Inyo County, California, and Lincoln, Nye, and Clark counties in Nevada (Blomquist el al. 1995) and is endemic to this region. None of the populations contain abundant plants or cover a large area (Beatley 1977).

On and around the Nevada Test Site (NTS), 11 locations of White Bearpoppy were found prior to 1978 (Rhoads and Williams 1977). Population estimates ranged from 1 to 2,000 plants (Blomquist et al. 1995). In 1981, *A. merriamii* had been documented at 135 locations on Nellis Air Force Range (NAFR) (Ackerman 1981) with population estimates ranging from 1 to >3,000 plants (Knight and Smith 1994).

As of 1995 the range of White Bearpoppy reached north to the Desert Range in Lincoln County, west to the western boundary of Death Valley National Park in Inyo County, California, east to Kane Spring Valley in Lincoln County, Nevada, and south to the Clark Mountain Range of San Bernardino County, California. At that time, *A. merriamii* was known from around 355 locations, across an area of around 25,000 km^2 (Blomquist et al. 1995). White Bearpoppy populations were estimated to contain over 20,000 individuals across Nevada and occupy 974 acres as of 2001 (Morefield 2001).

Population Trends

The baseline data for White Bearpoppy prior to development around the Las Vegas Valley and in rural communities is poor, thus, the range of habitat loss since development is incomplete (TNC 2007). Range wide trends for White Bearpoppy are stable, yet Nevada and Las Vegas Valley populations are declining (USFWS 2000, Morefield 2001).

Habitat Model Review

Two SSURGO-based soils models (*i.e.* gypsum and sand) were used to create preliminary species-specific habitat models for ten rare plant species covered under the MSHCP by Hamilton and Kokos (2011). The preliminary models used the soils layers in combination with presence and absence data for the species' localities to delineate potential habitat. These initial models were used to design survey efforts to obtain more presence and absence data to improve previously developed habitat models, and to obtain additional information on lesser known species - e.g. *Arctomecon merriami*. In addition to these surveys the soils models were refined using SSURGO combined with remote sensing data from the ASTER platform for use in future modeling. MaxEnt was explored for further modeling, but was generally discounted for reasons that appear to be due to lack of experience in using this modeling algorithm. For example, the environmental variables that the modelers used were limited to available BioClim layers somewhat arbitrarily (i.e. without regard to their potential influence on the species). Furthermore, no substrate relevant layers, or other biophysical layers were explored – despite the apparent importance of soils on the distribution of these species (e.g. gypsum and sand content among other constituents). No precision or performance estimates are given for the refined models based on soils and elevation and other adjustments that were applied. MaxEnt Models were not compared with the soil based models, nor were outputs provided to calculate other performance scores.

Technical Considerations – The MaxEnt models were all run using 500 iterations with 10 % of points withheld for testing. The data layers used encompassed only the BioClim dataset despite their assertion that soils likely play an important role in defining the distribution of this species, and no other topographic layers were considered. Model performance scores for each MaxEnt model were indicated as VERY high relative to AUC (and models appeared to be over fit), no other test statistics are provided. There were also no performance metrics produced for the soil based models, and thus their accuracy cannot be assessed beyond the reported AUC scores. Models from the soils based models do not have a continuous scale output (Figure 14) and thus exploring the potential proposed development scenarios on different predicted habitat values (e.g. High, Medium, Low) will be difficult.

Arctomecon merriamii was not modeled using soils only layers as it occurs on both Gypsum and calcareous soils, the latter of which was not modeled. The MaxEnt model for this species was favored by Hamilton and Kokos (2011), but as with the other models included only BioClim variables. The variables contributing the most were: Min Temperature of Coldest Month, which contributed 28%, Mean Temperature of Wettest Quarter 18.8%, Precipitation Seasonality (Coefficient of Variation) 23.8%, and 16.2% Precipitation of Wettest Month. Contributions of other variables that were likely important were not considered.

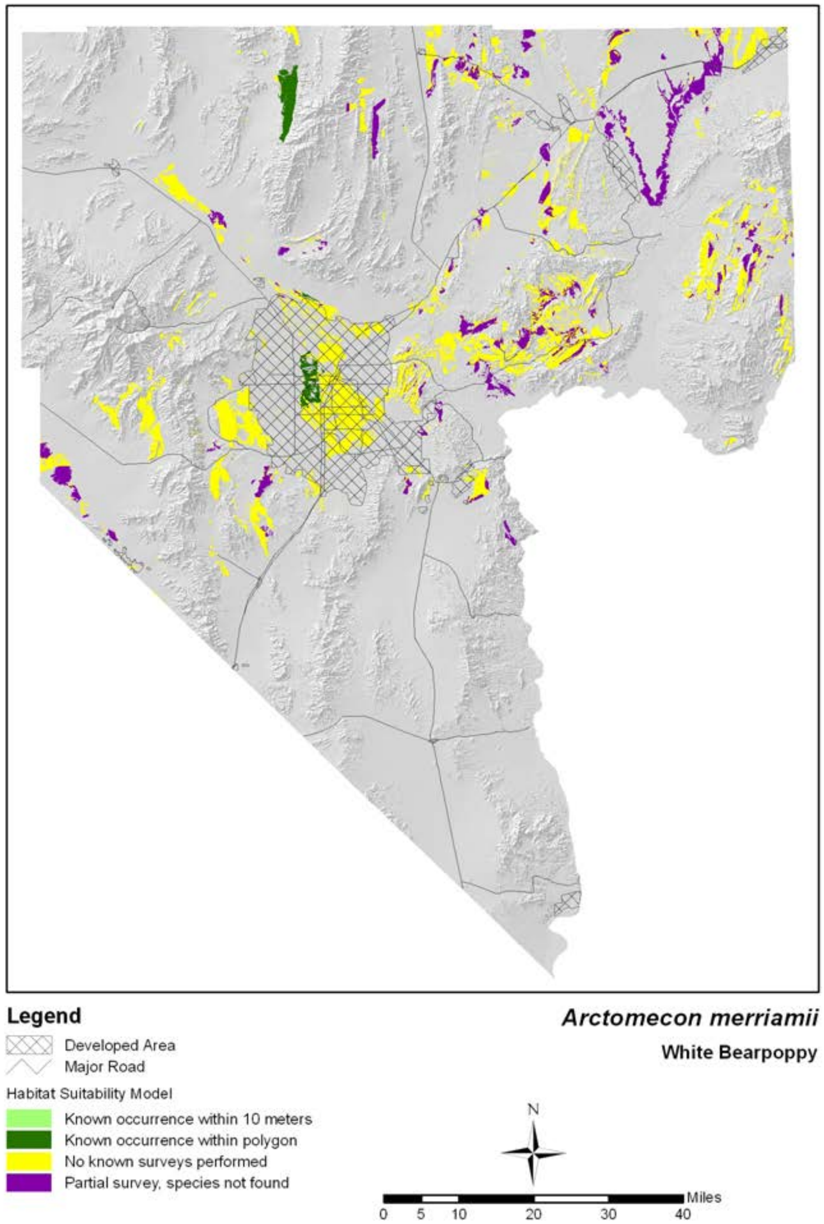


Figure 14. Modeled habitat for Arctomecon merriamii from Hamilton and Kokos (2011).

Distribution and Habitat Use within Clark County

The distribution of known localities for White Bearpoppy by land ownership (TNC 2007) are as follows:
Department of Defense: 54%
Bureau of Land Management: 22%
Private: 13.8%
US Fish and Wildlife Service: 10.1%

Twelve of the 33 known populations of White Bearpoppy occur in Clark County. Eleven of those twelve populations occur on federal lands. Eight of these populations are recommended for special designation and one is recommended for a protected conservation network within the scope of MSHCP by The Nature Conservancy. These populations were classified into three distinct geographical locations; north of the Spring Mountains (Spotted Range, Indian Springs, Pintwater Range, Desert Range, Black Hills, North Desert Range, Three Lakes Valley), west of the Spring Mountains (Pahrump Valley), and east of the Spring Mountains (Las Vegas Valley, Calico Hills, Bird Spring Range, and Devil Canyon). The largest known population within Clark County occurs in the northwest region of the county, and is thus important for long term success (TNC 2007).

Arctomecon merriamii grows in creosote and blackbrush zones, on barren, calcareous, scree slopes and weakly gypsiferous shales embedded with marine limestones at elevations between 600 and 1700 m (Coville 1892). It occurs on fine sandy loams (TNC 2007), limestone and dolomite ridges, gravelly canyon washes, and occasionally on flats and old lake beds of carbonate rock sources (Blomquist et al. 1995). Within Clark County one model predicted that high and moderate habitat categories are largely within blackbrush and Mojave Desert Scrub ecosystems (Hamilton and Kokos 2011; Table 14). The plant grows on a variety of basic soils in addition to calcareous and gypsiferous soils including alkaline clay, alkaline sand, calcareous alluvial gravels, and carbonate rock outcrops (Morefield 2001). In addition to creosote and blackbrush, plant associates also include *Atriplex* spp., *Ambrosia dumosa*, and *Chrysothamnus* spp. (Blomquist et al. 1995). Plants commonly associated in the Spotted and Desert ranges of the Spring Mountains include *Atriplex confertifolia*, *Sphaeralcea ambigua*, *Ephedra torreyana*, *Acamptopappus shockleyi*, and *Lepidium fremontii* (Pritchett and Smith 1999). The Ash Meadows population has been observed growing on calcareous travertine (Harper and Van Buren 1995). Knight and Clemmer (1987) observed the following other associated species in Ash Meadows; *Enceliopsis nudicaulis* var. *corrugata*, *Mentzelia leucophylla*, and *Astragalus phoenix*. Populations on Ash Meadows were recorded to be growing on arid, alkaline soils. On all sites just outside of Ash Meadows, Knight and Clemmer recorded the associated species *Haplopappus brickellioides*, *Agave utahensis*, *Gilia ripleyi*, *Perityle intricata*, and *Salvia funerea*.

Table 14. Ecosystems within Clark County, and the area (Ha) of Low Medium and High predicted suitability within each ecosystem.

Ecosystem	Low	Medium	High
Alpine	0	0	0
Blackbrush	20502	329	286
Bristlecone Pine	0	0	0
Desert Riparian	20	0	0
Mesquite Acacia	772	100	7

Ecosystem	Low	Medium	High
Mixed Conifer	0	0	0
Mojave Desert Scrub	98782	19872	3860
Pinyon Juniper	2573	0	0
Sagebrush	27	0	0
Salt Desert Scrub	5963	521	26

Ecosystem Level Threats

Rolling hills of gypsum outcrops are popular for OHV use (Nelson and Welsh 1993). OHV use, the most significant threat to White Bearpoppy populations, result in direct damage to plants and soil crusts, decrease in soil stability, infiltration, water resistance, and resistance to erosion, opportunity for invasive plant invasions, decreased drought tolerance, soil loss, soil moisture and nutrient loss, and increased dust accumulation leading to reduced growth (TNC 2007). Cryptogamic crusts, which are found on *A. californica* and *A. humilis* populated areas, have been shown to increase nutrients in the top layer of soil (Harper and Pendleton 1993) which may contribute to success of *Arctomecon* species occurring on gypsum soils including possibly *A. merriamii*. The increase in the nutrients accumulated by cryptogams also may increase invasive species (DeFalco et al. 2001). Cryptogamic crusts also influence surface water balance and may protect gypsum outcrops from wind erosion, which could also contribute to survival of *Arctomecon* species on gypsum soils (Nelson and Welsh 1993).

Utility corridors not only impact populations directly through habitat fragmentation and direct loss, but they also have the potential to introduce exotic invasive plants that could out-compete White Bearpoppy and other native species (TNC 2007). Habitat loss due to development and urban expansion in the Las Vegas area was reported to have resulted in the elimination of entire subpopulations of *A. californica* and *A. merriamii* (Nelson and Welsh 1993) and could continue to be a potential threat as development expands.

Threats to Species

Threats to White Bearpoppy were ranked from highest to lowest; "rural development and sprawl, military activities, casual OHV use and trail development, invasive exotic plant species competition, urban development and sprawl, wild horse and burrow management, groundwater developments, highway and road construction maintenance, utility corridor construction and maintenance, BLM land disposal to private development, livestock grazing management, legal OHV use, gypsum mining, and legal concentrated recreation use" (TNC 2007).

Blomquist et al. (1995) claimed that threats to the species on the Nevada Test Site had been unaffected by past activities, and that threats to the continued existence of the species is minimal. The authors go on to suggest that some land-disturbing activities have appeared to create suitable habitat for the species and opportunities for recruitment of new seeds into new locations.

Known locations of *A. merriamii* in Desert National Wildlife Refuge, Ash Meadows National Wildlife Refuge, and Death Valley National Park fall under the protection of the conservation and land management policies of each area. At Nellis Air Force Range, which had the largest concentration of plants in 1994, populations were exposed to impacts of off-road travel (Knight and Smith 1994).The continued existence of the plant around Las Vegas continues to be threatened by urban development (WESTEC 1980). As of 1995, threats to the Kane Spring Valley and Clark Mountain Range populations were unknown (Blomquist el al. 1995).

Because members of the Papaveraceae family contain large quantities of alkaloids, which is toxic to most organisms, predation is not considered to be primary threat (Lawrence 1951).

Existing Conservation Areas/Management Actions

Populations of White Bearpoppy occurring in Clark County fall under four different land ownerships; BLM (Bird Spring Range, Calico Hills, Devil Canyon, and Pahrump Valley), USFWS Desert National Wildlife Refuge (Black Hills), Department of Defense (Spotted Range), and Private (TNC 2007).

White Bearpoppy is included in a Conservation Management Strategy (CMS, TNC 2007) for nine low elevation rare plants and their habitats within an adaptive framework. The CMS included collection and analysis on status and threats, development of necessary conservation measures for effectively protecting populations and habitats, the development of implementation requirements for the strategy, adaptive management requirements, and measurements of success in conserving the species (TNC 2007).

The Clark County population of White Bearpoppy is of particular special concern because the majority of the populations exist on Nellis Air Force Range, part of the Department of Defense. That organization is not a participant of the Multiple Species Habitat Conservation Plan (MSHCP). Though Nellis Airforce Range is not a signatory participant in the MSHCP, lands managed by the Airforce range are categorized and included in acreage figures for protected lands in Clark County. There are five important populations of White Bearpoppy within Nellis AFB (Spotted Range, Pintwater Range, Three Lakes Valley, North Desert Range, and Desert Range) (TNC 2007).

Four of the Clark County populations occur on BLM land and as these are public lands, have the possibility of benefiting from future conservation efforts. More conservation management for these four populations is necessary in order to meet MSHCP goals. It’s possible that management plans for Las Vegas Bearpoppy could be adapted and be applied to White Bearpoppy based on their close biological and ecological relationship, but additional research is still needed to better understand the species and its ecology. The Nature Conservancy lists the top ranked research and management needs for White Bearpoppy as geospatial-based threats analysis, effectiveness and status monitoring, effects of fire and invasive plant species interactions, effective restoration techniques, habitat patch connectivity requirements, and impacts of global climate change (TNC 2007).

In 1987, Knight recommended that Purgatory Spring be included within the Ash Meadows National Wildlife Refuge boundary due to its abundance of rare plants including *Arctomecon merriamii*. Knight also recommended that driving in that area be done along one designated road (closing all others) and that the roads around the county roads junction be fenced in order to prevent road widening (Knight and Clemmer 1987).

On the Nevada National Security Site (formerly the Nevada Test Site) in 1995, recommendations were made to reduce protection for *A. merriamii*, by changing its status from a Category 2 species to a Category 3C candidate species based on distribution, population trends, and potential threats. The plant had been found at several new locations in years prior and no significant threats were identified. *A. merriamii* was moved to a Category 3C species due to the species being more widespread than previously believed with no identifiable threats (Blomquist et al. 1995).

Conservation objectives specific to White Bearpoppy in the Nature Conservancy's CMS include; removing significant OHV impacts by 2020 (in Calico hills, Spotted Range, and Bird Spring Range), manage viable populations in utility corridors on BLM lands and potential rights of way corridors at Lake Mead National Recreation Area and on Federal highways and roads (along highway 95), remove wild horse and burro use in populations (south of the foothills of the Spring Mountains) by 2020, address impacts of urban sprawl by 2020, ensure long term viability trends within ten years, control weeds by 2020, and avoid military activities on White Bearpoppy habitat at Nellis Airforce Base. The CMS states several other non species-specific objectives that could impact White Bearpoppy (TNC 2007).

Gypsum mining management was listed as a management objective for Las Vegas Bearpoppy, and may also be a management action that could protect White Bearpoppy because it occurs occasionally on gypsum soil (TNC 2007).

More compete landscape scale research is needed to improve understanding of management needs (TNC 2007). They list highest priority research and management needs for White Bearpoppy as follows; geospatial-based threats analysis, status monitoring and effectiveness, effects of invasive plants and fire, effective restoration techniques, requirements for habitat patch connectivity, and global climate change impact. The Nature Conservancy (2007) ranked each species by management priority, and ranked White Bearpoppy in the lowest priority group due to the low percent of the global population occurring in Clark County (TNC 2007).

In Conservation Actions underlined in the Clark County MSHCP, conservation actions specific to White Bearpoppy state that if proposed actions result in the disturbance of the surface near a White Bearpoppy population, soil should be removed with seed source, relocated to a potential habitat, and monitored (DNWR in TNC 2007). In 2009, a plan was developed to understand the distribution of rare plants covered under the Clark County Multiple Species Habitat Conservation Plan (MSHCP). Soil GIS models were developed using ASTER Imagery, soil survey data, and geological data along with presence/absence to create species specific habitat models, including a model for White Bearpoppy (TerraSpectra 2011). For presence/absence surveys, a requirement was established to obtain at least 20% of the surveys from areas with no known occurrences of *A. merriamii*. Predictive habitat models were used to maximize the potential for finding new plants. Out of nine plots surveyed, eight contained White Bearpoppy, and four incidental observations were made with a total of 13 observations. Climate based habitat models, rather than gypsum based models may be the best option for predicting presence, as the former misses many known occurrences within Clark County and plants that grow in non-gypsiferous soils such as on calcareous soils, on which it is also known to grow (Hamilton and Kokos 2011). Statistical models including climatic variables and better soils and geology layers (including carbonate soil types may improve predictions for the habitat of the White Bearpoppy (Hamilton and Kokos 2011).

A long- term monitoring program for the species at Nellis Air Force Base Gunnery and Bombing Range (NAFBGR) was established (Pritchett and Smith 1999), but as of 2007, no data had been collected or reported to the USFWS (Frank Smith, personal communication, 2005 in TNC 2007). The objective was to collect demographic data throughout many years biannually, pending sufficient funding. The survey would include measurements of plant rosette diameter, number of buds, flowers and fruits, and the nearest neighbor identity and distance. Rosette diameter was found to have a positive correlation with reproductive output in previous baseline studies (Pritchett and Smith 1999).

Most mortality in Arctomecon spp. (A. californica, A. merriamii, A. humilis) occurs during the seedling state, and because of this it is especially important to protect and monitor areas with many seedlings to increase the probability that sufficient plants will make it to reproductive age to replenish the seed bank Palmer (1987). Palmer also suggest that conservation of unoccupied but suitable habitat be conserved for long term conservation of the species.

Summary of Direct Impacts

Habitat categories indicted a relatively small area for this species within the county, with ~ 42 km^2 of high suitability (Hamilton and Kokos 2011) habitat within the county (Table 14). The largest proportion of this among the Impact, Conserved and Disturbed habitat layers was in the Conserved (23 km^2). Far more areas of predicted moderate habitat were present, with 208 $km^2$of habitat, of which 82 $km^2$are disturbed, 14 km^2 are likely to be impacted, and 412 $km^2$are in conservation areas (Table 15).

Table 15. Categorized modeled habitat values (High, Medium, and Low) and the average area (Hectares) predicted in the potential impact areas, conservation areas, already disturbed areas, and overall area

Habitat Level	Impact	Conserved	Disturbed	Area (Hectares)

High	831	2347	412	4179
Med	1375	5304	8179	20822
Low	11765	41164	16605	128639

ARNE - Bell's Sparrow (Artemisiospiza belli)

The Sage Sparrow is a medium-sized passerine, brownish grey in color. It forages on the ground and is thus sometimes difficult to detect during surveys. There has been recent reorganization in the taxonomic status of this species group and *Artemisiospiza belli* (formerly *Amphispiza belli* – Klicka and Spellman 2007, Klicka and Banks 2011) now includes only the birds in California residing in coastal scrub (Chase and Carlson 2002). More recently this species was listed as a Nevada species (abundant in Nevada with migration and winter habitat in Clark County (GBBO 2010), although this appears to be concordant with the revised taxon *Artemisiospiza nevadensis* (Martin and Carlson 1998, Chesser et al. 2013). Cicero and Koo (2012) note that *Artemisiospiza belli canescens* is composed of two genetically distinct, yet morphologically indistinguishable forms, one in the San Joaquin Valley in California, and the other in the Mojave. Further they note secondary contact and sympatry with broad niche overlap between *A. b. canescens* from the Mojave Desert and *A. b. nevadensis* from the Great Basin, but with both morphological and genetic distinction with separation occurring in a contact zone east of the Sierra Nevada range in the Owens Valley near Lone Pine, CA while *A. b. nevadensis* occupies Nevada and the Northeastern Mojave (Cicero and Koo 2012).

Species Status

US Fish and Wildlife Service Endangered Species Act: Not Listed
US Bureau of Land Management (Nevada): No status
US Forest Service (Region 4): No status
State of Nevada (NAC-527): Protected
NV Natural Heritage Program: Global Rank G5 State Rank S4B, S4N
NV Wildlife Action Plan: Species of Conservation Priority
IUCN Red List (v 3.1): Least Concern
CITES: No status

Range

This is a broadly distributed species spanning from eastern Washington and Oregon in the western part of its range, to Montana and western Wyoming in the east, and southward into Nevada, with predicted occurrence throughout the whole state – with habitat diminishing in Clark County (Cicero and Koo 2012). In breeding season this species is found in the Great Basin in sagebrush (*Artemisia tridentata*) and saltbush desert scrub, and it is considered to be a shrub steppe obligate (Chesser et al. 2013, Hethcoat and Chalfoun 2015, Knick et al. 2014). Sagebrush sparrows overwinter in the southerly extents of their range (Chesser et al. 2013), although there are few observations in Clark County (Knick et al. 2014).

Population Trends

IUCN lists this species as one of least concern due to its large range, but with declining numbers at the population level (BirdLife international 2016), as they are sensitive to loss of sagebrush dominated shrub steppe (Knick et al. 2014), where habitat loss can result in increased nest failures as predator numbers increase (Hethcoat and Chalfoun 2015). Habitat loss in wintering ranges may also contribute to declining populations, which may be affected by habitat composition, structure, and herbicides (Rotenberry and Knick 1999).

Habitat Model

Bell's Sparrow was modeled using 254 point localities distributed broadly throughout valleys and lower elevation areas within the County. The three modeling algorithms had similar patterns of predicted distribution with the broadest predictions in the GAM model followed by the MaxEnt Model, with slightly more restricted habitat predictions by the RF model. The consensus among models are predictions of areas of higher habitat suitability in many of the lower bajada and valley areas in the County, especially along the US 95 highway corridor, the northern portion of the Las Vegas Valley, The Apex area, Mesquite and Ivanpah Valleys, Eldorado Valley, and in the Virgin and Muddy Rivers (Figure 15).

Performance was highest in three of the four performance metrics for the RF model followed by the Ensemble model and MaxEnt models, with the GAM model the lowest among all four (Table 16). The RF had a markedly higher AUC, TSS and Correlation scores than the other 3 algorithms, and was second to the ensemble model in the fixed Boyce Index (BI) (Table 16). The Ensemble model performed second highest overall with high AUC and BI values, and somewhat lower TSS and Correlation Values than the RF model (Table 16).

The Continuous Boyce Index [CBI] indicated good performance among all models with an irregular dip just above 0.8 for the GAM and MaxEnt models, which influenced the Ensemble model CBI as well (Figure 17). The GAM model had the highest values of Standard error (SE 0.06 – 0.1), which was localized and centered around Mt Charleston, while the MaxEnt model had more widespread moderately low error (SE 0.04 – 0.06). The RF and Ensemble models generally had lower error (SE 0.02 – 0.04), where areas of error in the Ensemble model were fairly widespread, an appear to be at middle elevations in upper bajadas (Figure 16). Approximated bins for the Ensemble model based on the CBI were 0-0.5 unsuitable, 0.4-0.5 marginal, 0.5 to 0.6 suitable, and > 0.66 optimal habitat; with a suggested cutoff threshold between 0.4 and 0.5 (Figure 17) and the threshold value calculated from the AUC analysis for the ensemble model was 0.49 (Table 16).

Table 16. Model performance values for *Artemisiospiza nevadensis* models

Performance	GAM	RF	MaxEnt	Ensemble
AUC	0.767	0.977	0.834	0.909
BI	0.622	0.678	0.676	0.745
TSS	0.551	0.924	0.656	0.761

Performance	GAM	RF	MaxEnt	Ensemble
Correlation	0.466	0.849	0.593	0.703
Cut-off*	0.507	0.574	0.483	0.485

*threshold at which sum of sensitivity (true positive rate) and specificity (true negative rate) is highest

Table 17. Percent contributions for input variables for *Artemisiospiza nevadensis* in an ensemble model combining GAM, MaxEnt, and RF algorithms

Term	GAM	RF	Max	Average
Annual Heat/Moisture Index	0	12.461	7.246	5.612
Winter Precipitation	0	13.885	9.263	6.65
Winter Minimum Temperature	0	0	0	0
Summer Maximum Temperature	6.317	4.998	2.612	4.259
Temperature Range	0	9.675	0.604	2.684
NDVI Amplitude	0	3.983	0	1.022
NDVI Maximum	36.438	6.213	6.242	15.821
NDVI Standard Deviation	9.516	11.438	7.687	8.669
Topographic Position (TPI)	19.219	29.098	62.115	34.577
Slope	28.508	0	0	9.503
Surface Texture (ATI)	0	8.249	4.231	3.527

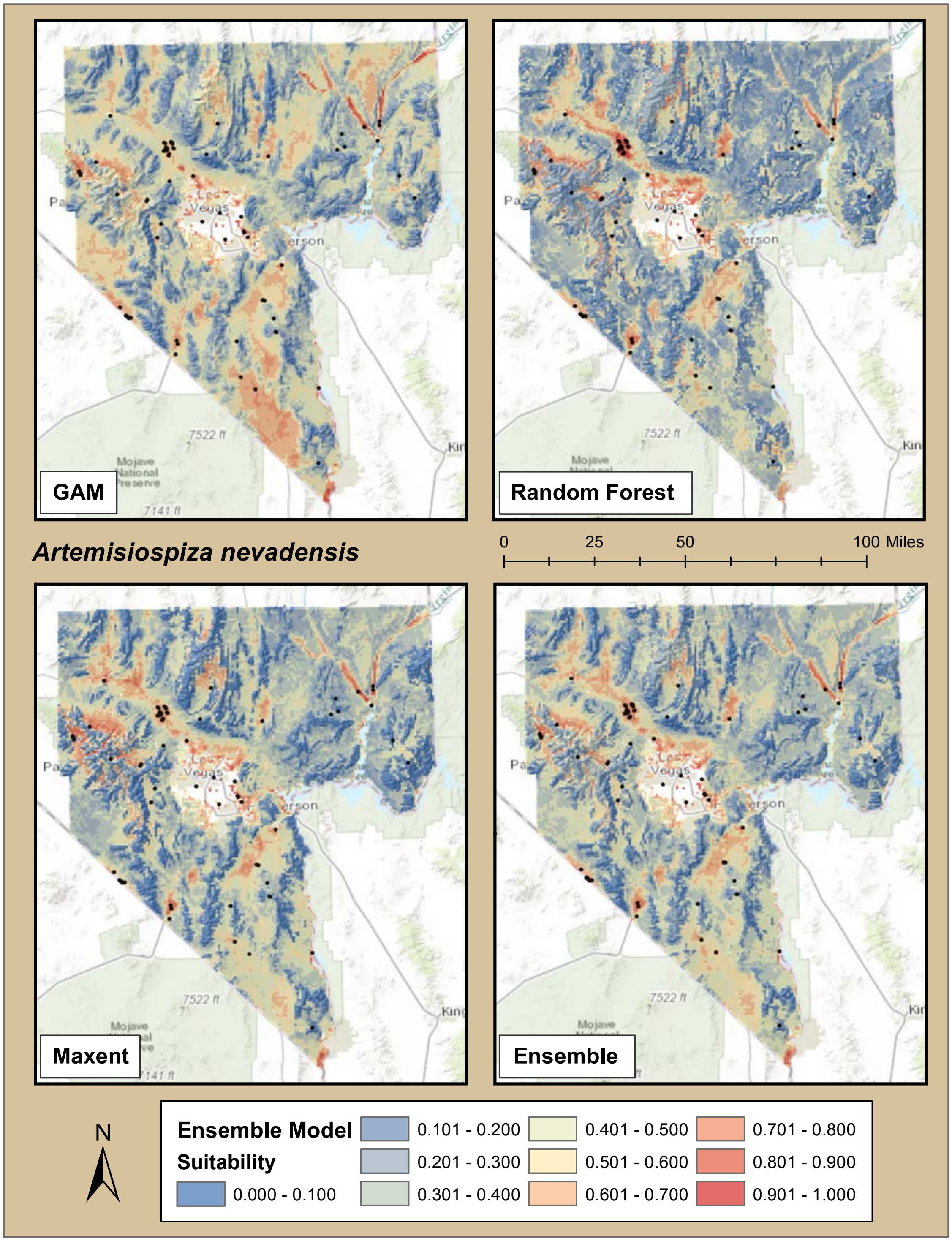


Figure 15. SDM maps for *Artemisiospiza nevadensis* for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

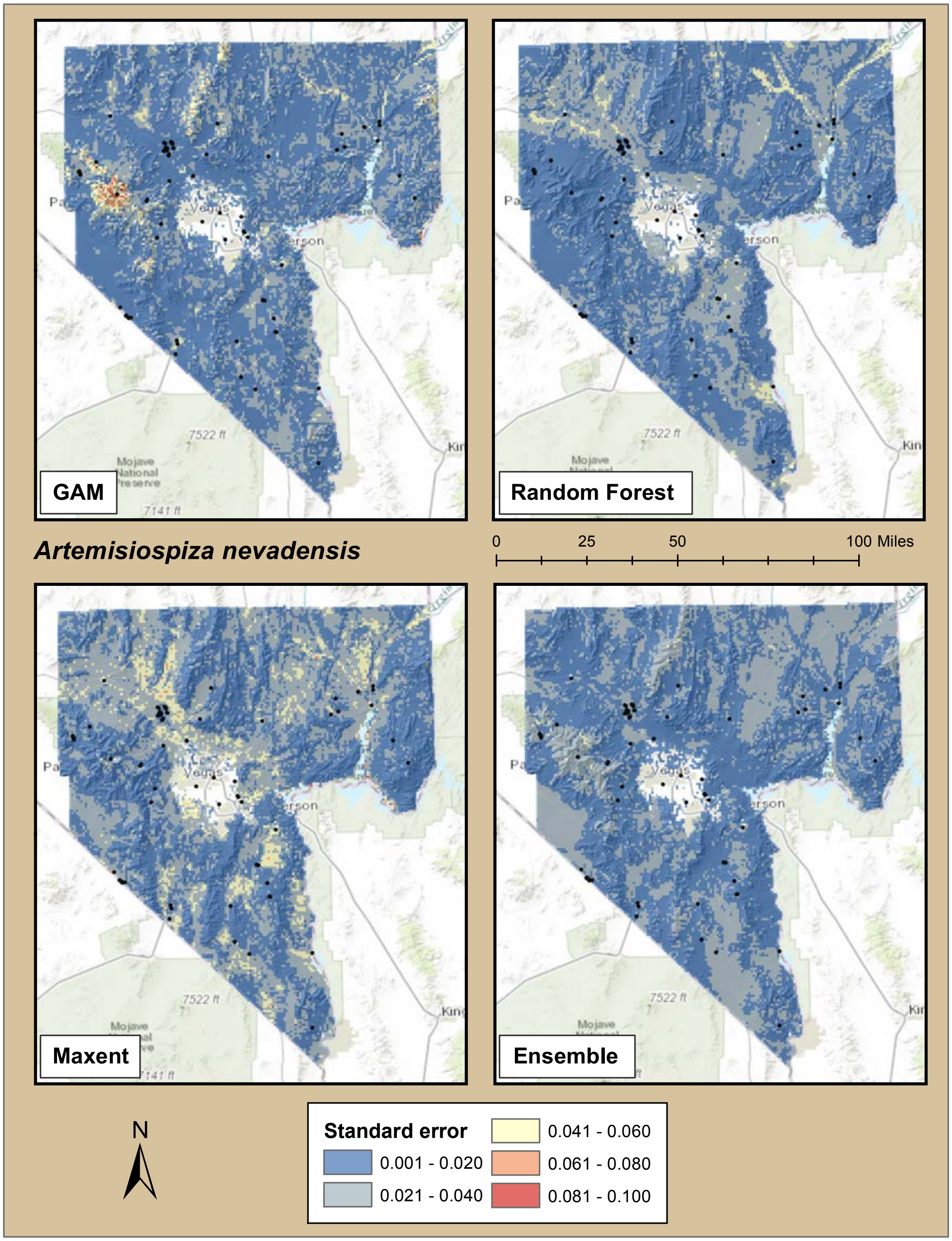


Figure 16. Standard error maps for *Artemisiospiza nevadensis* models for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

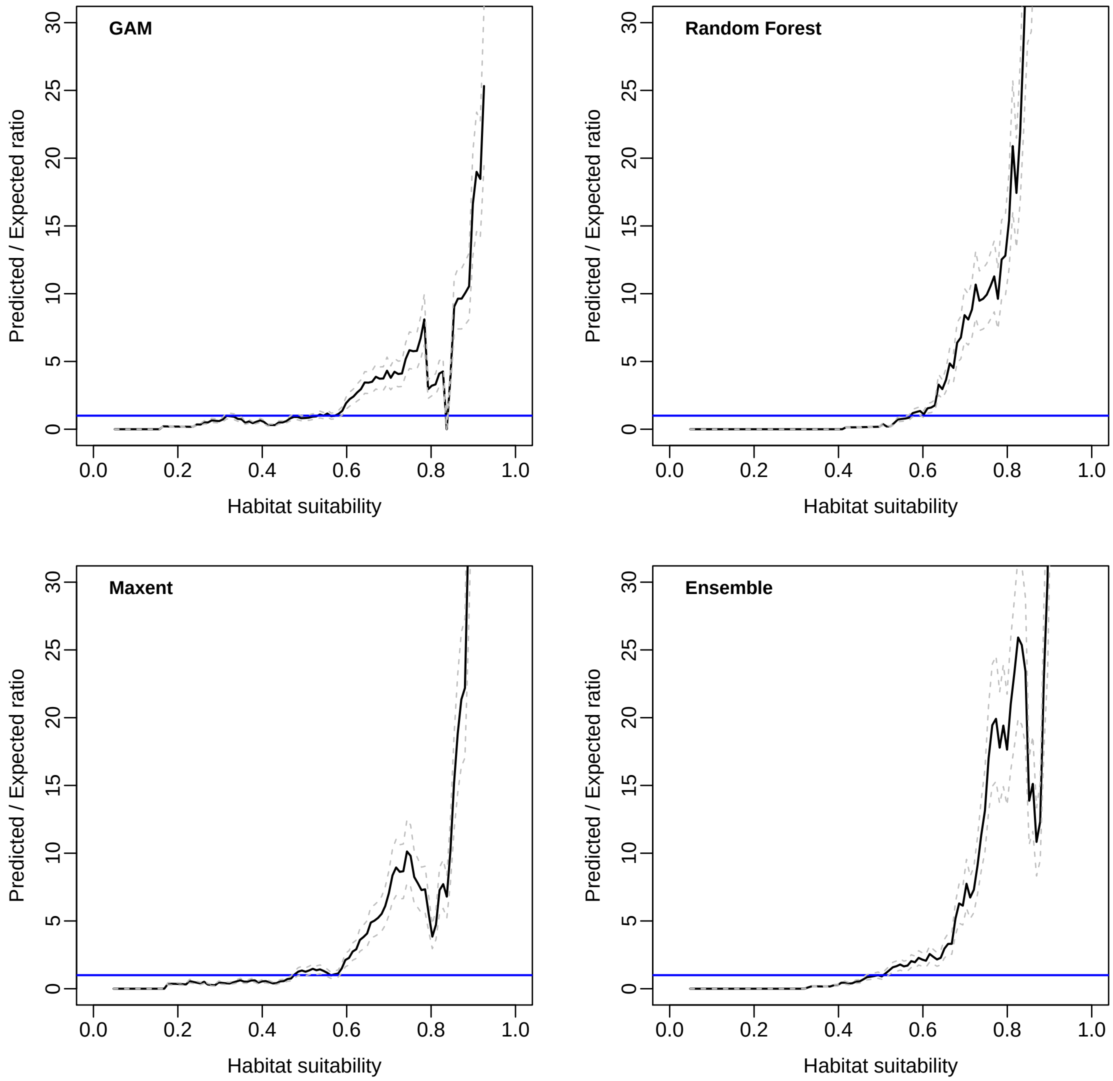


Figure 17. Graphs of Continuous Boyce Indices [CBI] for *Artemisiospiza nevadensis* models for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

GAM Model

The GAM models identified 5 contributing variables total (NDVI Maximum, Slope, Topographic Index, NVDI Standard Deviation, and Summer Maximum Temperature), and 4 of the 5 variables had a ~10% or greater contribution toward the model representing 93% of the model contribution (Table 17). NDVI Maximum was the largest contributor with 36% influence, with a positive relationship between max NDVI and predicted suitability (Figure 18). Slope was negatively associated with habitat suitability and the Topographic Index positively related, indicating a predicted preference for flatter areas lower in the watershed. NDVI Standard Deviation was positively associated with habitat for this species, and summer maximum temperature was negative (Figure 18).

The GAM model predicted habitat for this species throughout the County in lower valleys and upland bajadas, including Paiute and Eldorado valleys, the Mesquite and Ivanpah Valleys, Valleys north of Mt Charleston (although this area had the highest standard error – Figure 16), and the Mormon Mesa, and Muddy and Virgin Rivers, and in the Needles area at the extreme southern tip of the state (Figure 15). This algorithm had low to moderate standard area throughout the County (Figure 16).

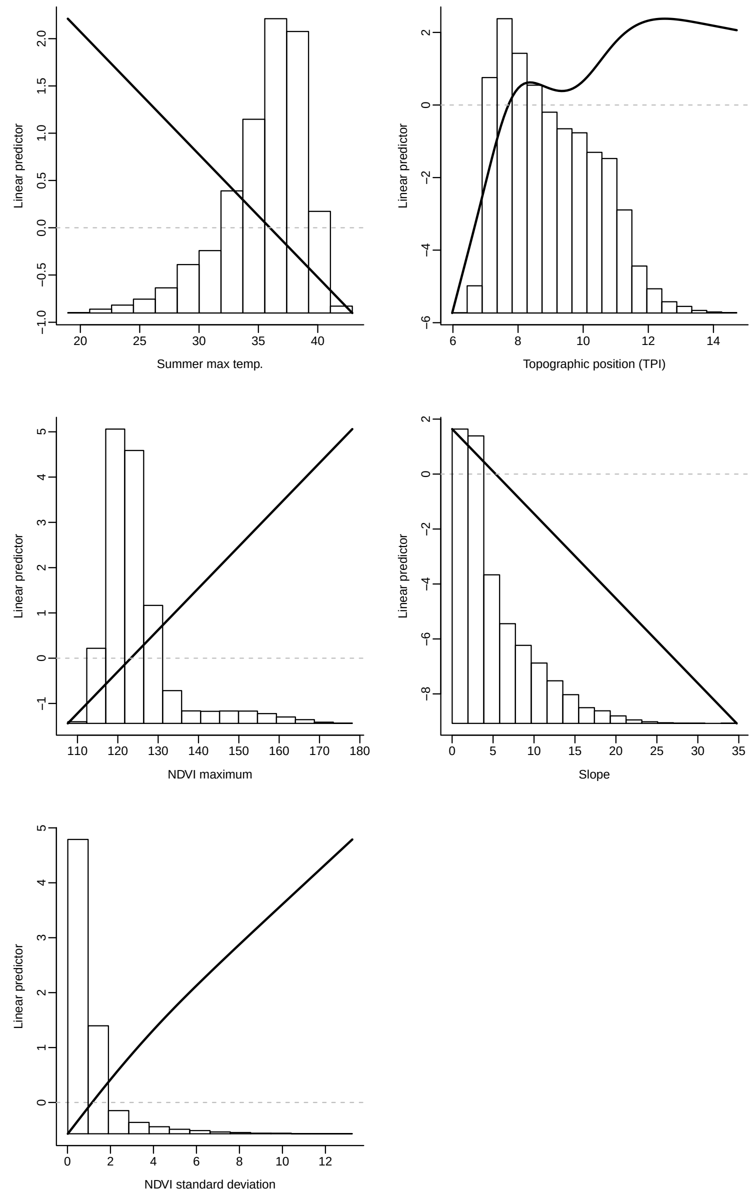


Figure 18. GAM partial response curves for the *Artemisiospiza nevadensis* model overlaid over distribution of environmental variable inputs in the study area.

MaxEnt Model

The MaxEnt model had five variables contributing 5% or more each, accounting for 93% of model contribution, with an additional three variables contributing minimally (Table 17). By and large the Topographic index was the highest contributing variable (62%) with a positive relationship, indicating increased habitat suitability in lower parts of the watersheds. Winter Precipitation (9%) was also positively associated with predicted habitat (Figure 19). NDVI Standard Deviation (7%) was also positively associated with predicted habitat suitability, likely indicative of the vegetation response to the variable rainfall in these lower elevation areas. Annual Heat/Moisture Index (7%) had complex relationship, where the relationship was high for areas that were cool and moist, and then generally negative, with a small increase in areas with higher indices ~ 250 of Temperature/Moisture. (Figure 19).

Notable locations of moderate uncertainty (SE of 0.04 to 0.06) among the MaxEnt models were the USFWS reserve and Nellis Bombing Range, and the Mormon Mesa area. Error throughout the rest of the County was predicted to be low to moderate (Figure 16).

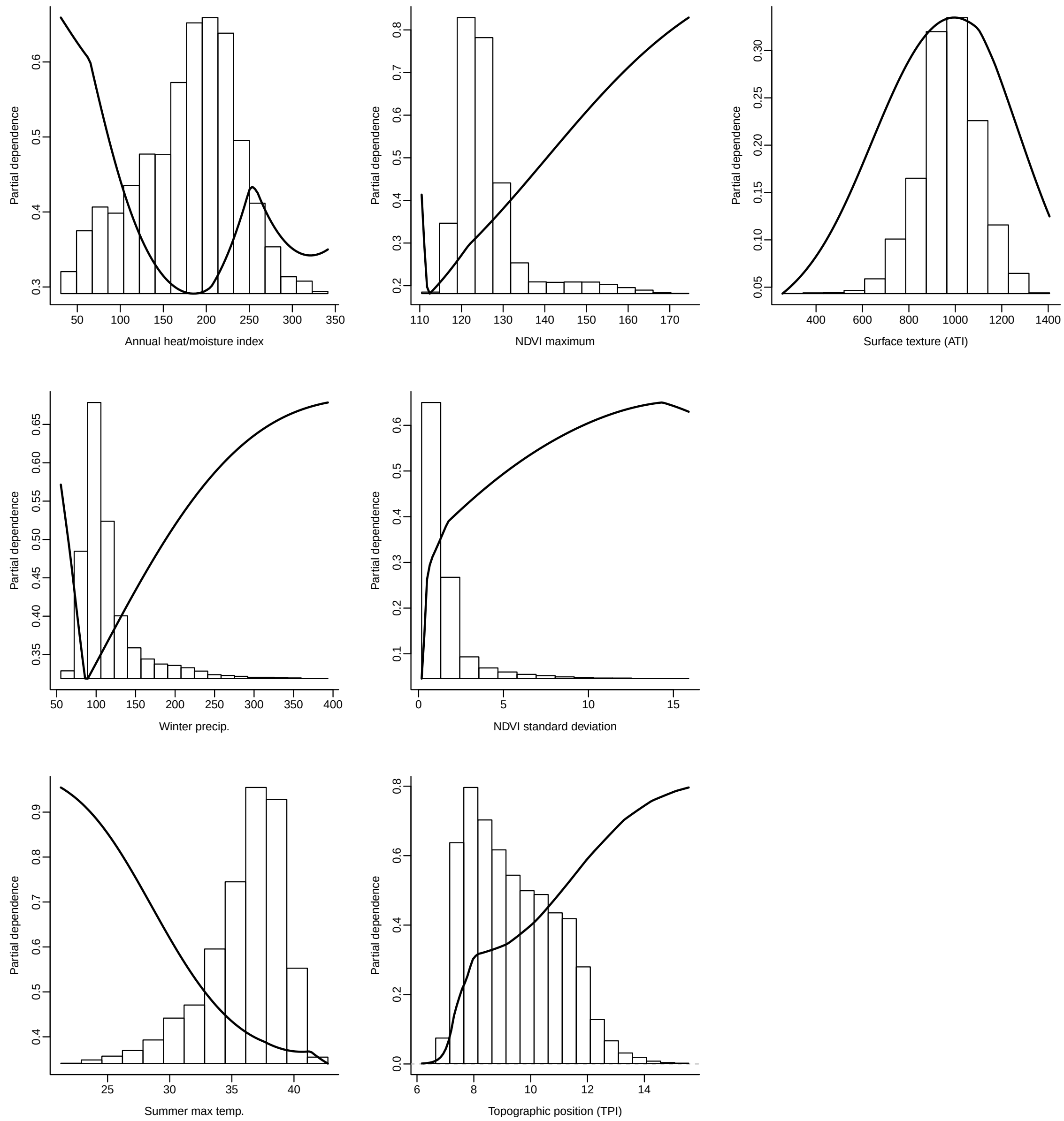


Figure 19. Response surfaces for the top 7 environmental variables included in the MaxEnt ensemble model for *Artemisiospiza nevadensis.*

Random Forest Model

The RF models had five environmental variables contributing ~ 10% or more collectively accounting for 77% of the total model influence. These were Topographic Position, Winter Precipitation, Annual Heat/Moisture Index, NDVI Standard Deviation, and Temperature Range, with four other variables contributing at lower levels (Table 172). Topographic Position was the top contributor with a 29% contribution, and a positive relationship with predicted habitat suitability with the highest habitat suitability predicted for areas lower in the watershed (bajadas and valleys, Figure 20). Winter Precipitation contributed 14% to the overall model, and had a thresholded response, with the highest habitat suitability predicted for areas receiving more than 200 mm of precipitation over the winter, and a secondary peak at lower levels as well. Annual Heat/Moisture Index (12.5%) also had a threshold type response with higher habitat suitability predicted at values above 250, which represented hotter more arid areas, typical of valleys within the County (Figure 20). NDVI Standard Deviation contributed 11%, and had a positive relationship, with higher habitat in areas that experienced change in the vegetation (e.g. annual greenup). Temperature Range (10%) had a threshold type response with higher habitat suitability in areas with lower annual temperature variability, and a potential artifact response at the highest levels (Figure 20). Standard error maps for this model indicated low (0.02 to 0.04) to relatively moderate (0.04 to 0.06) habitat suitability areas in the US 95 corridor and adjacent valleys, the Apex area, the Virgin and Muddy rivers, and along the Piute and Eldorado valleys in the southern part of the County (Figure 16). Areas of higher habitat suitability are predicted for Corn Creek, the US 95 corridor, the northern Las Vegas Valley, Apex, the Muddy and Virgin rivers, Eldorado and Ivanpah valleys, and a few other areas throughout the county (Figure 15). Areas of moderately high habitat suitability surround the higher elevation areas, providing additional habitat in the Piute Valley, and throughout the Nevada National Security Site, Nellis Bombing Range, and the Desert National Wildlife Refuge Reserve (Figure 15).

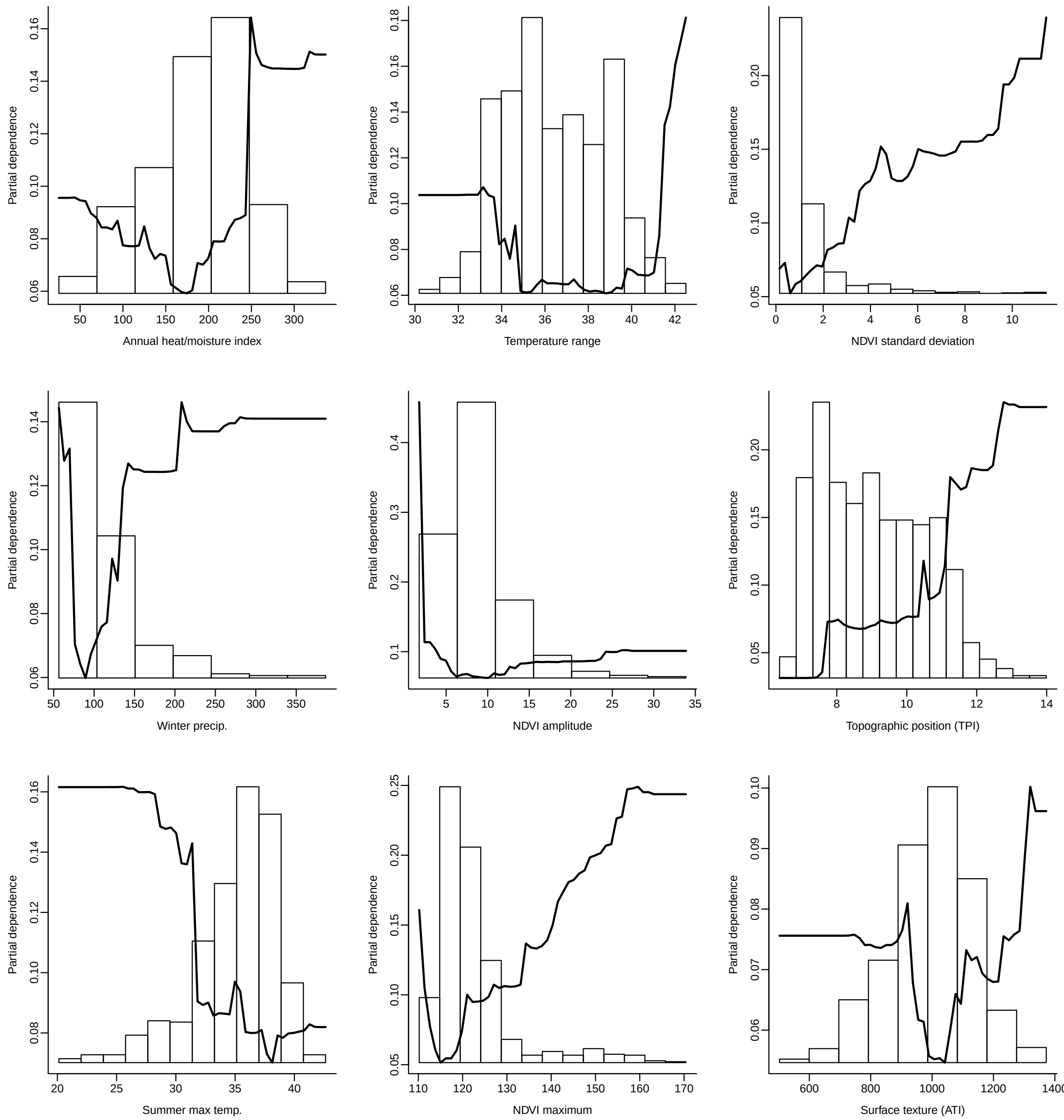
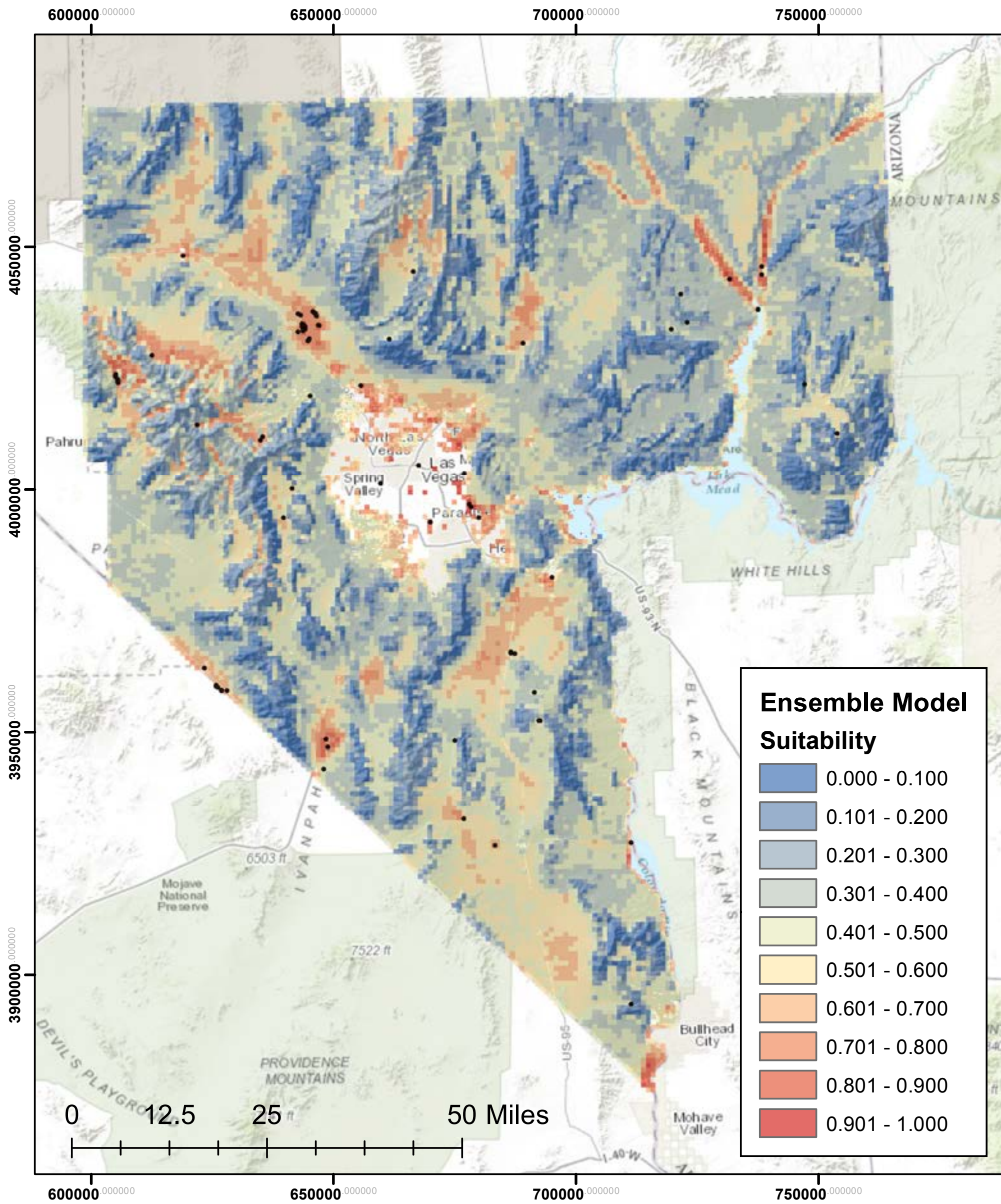


Figure 20. Partial response surfaces for the environmental variables included in the RF ensemble model for *Artemisiospiza nevadensis*. Histograms represent the range of each environmental variable across the x-axis, and predicted dependence relative to habitat suitability values are on the y-axis.



N

Artemisiospiza nevadensis
Habitat Suitability Map

Projection:
NAD 1983
UTM Zone 11N

Ensemble habitat suitability models were derived by averaging predictions from Generalized Additive Models, Random Forest, and MaxEnt.

Figure 21. SDM map for *Artemisiospiza nevadensis* Ensemble model.

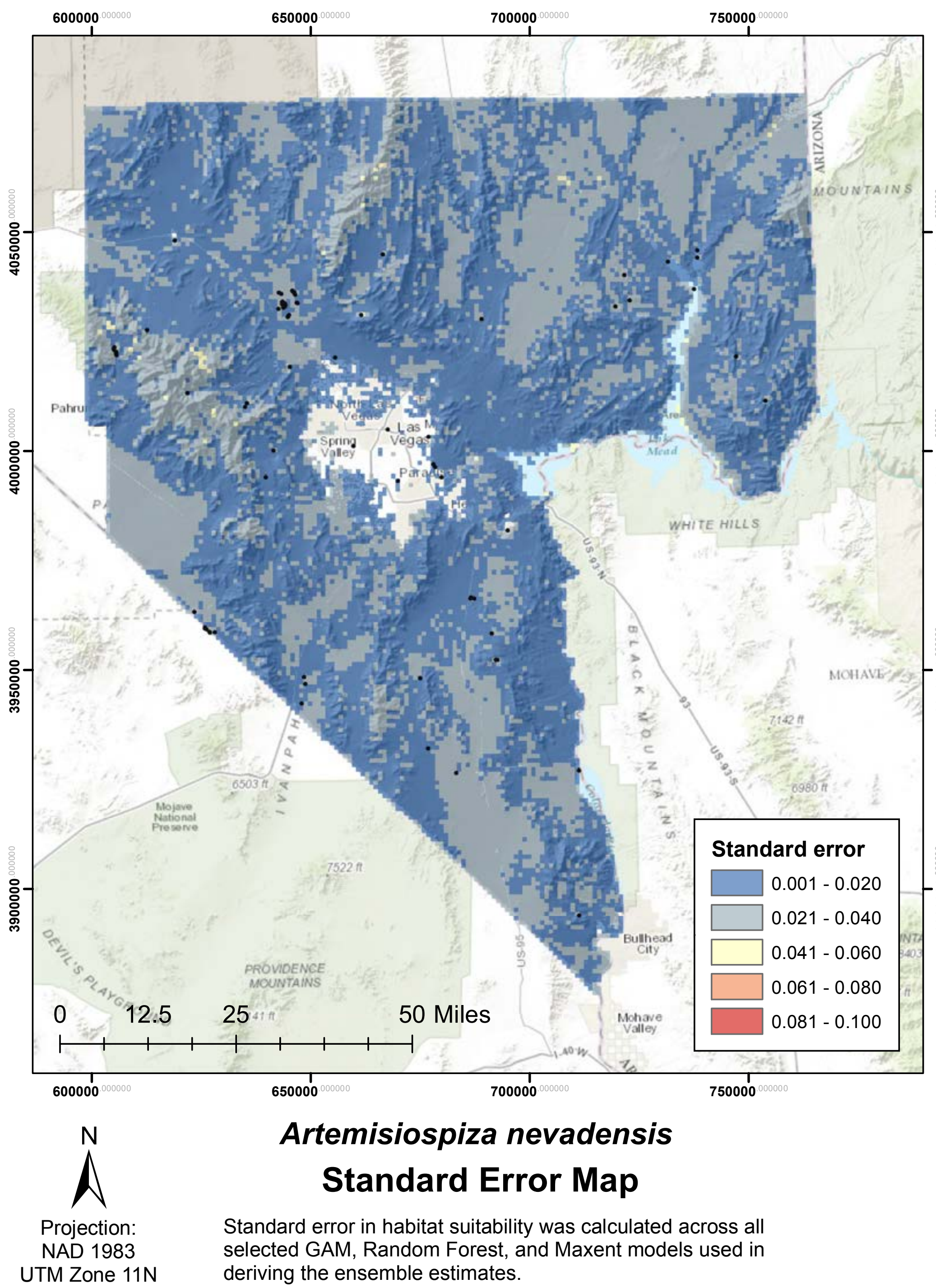


Figure 22. Standard Error map for *Artemisiospiza nevadensis* Ensemble model.

Distribution of Localities

Localities (N=254) for *Artemisiospiza nevadensis* are distributed throughout Clark County in lower elevation areas. The observations were largely concentrated in and around the Corn Creek area (N=143), and thus the geographic thinning employed was important to allow for a less biased model. No observations occurred in the northern extent of the County roughly above a line from Amargosa Junction to Moapa (Figure 21). These point localities represent field observations gathered in every month of the year. About 50% of the observations were recorded during March, April, and May between 1992 and 2017. Habitats where Sage Sparrows were recorded include: montane riparian, mesquite-catclaw, salt desert scrub, Mojave scrub, pinyon-juniper, saltbush-mesquire, Joshua tree woodland, creosotebush, and marsh. The Bird Conservation plan (GBBO 2017) indicates that breeding habitat occurs in a small area on the northern slopes of the Spring Mountains in this county. In the Spring Mountains, the sagebrush occurs in a mixed shrubland rather than the more common near-monocultures of the Great Basin proper. Additional information provided by Great Basin Bird Observatory staff indicates that Sage Sparrows also breed near Pahrump and the Corn Creek facility of the Desert National Wildlife Refuge, and that they breed among Salt Desert Scrub in those locations Jennifer Ballard – GBBO, 28 July 2017- *Personal Communication*). It is not clear how much seasonal sampling intensity influenced the seasonal abundance results. Many of the observations were from spring field trips.

Standard Error

Figure 22 shows the among algorithm Standard Error, where wide spread areas of low standard error were predicted for most of the county (SE 0 – 0.04). Very few patches of moderate error (0.05 – 0.06) were present, with small patches in the Spring and Sheep ranges (Figure 22).

Distribution and Habitat Use within Clark County

This species has limited distribution within the county, with only predicted habitat during wintering or migration (GBBO 2010), backed by relatively few locations with observations for this species (< 30). Modeled habitat for this species indicates a fairly broad mix of ecosystems that comprise high and moderate suitability levels (Table 18). Mojave Desert Scrub and Salt Desert Scrub comprise the largest ecosystem components collectively, with habitat also occurring in Pinyon Juniper, and Blackbrush – especially at moderate habitat levels (Table 18).

Modeled Habitat in the County is predicted to be highest in the Virgin river and Muddy River, Corn Creek and the valley along the US 95 corridor, with habitat extending into the valleys within the Nevada National Security Site, and the bajadas surrounding the Spring Mountains. High habitat suitability is also predicted in Eldorado Valley, Ivanpah Valley, Avi, and Trout Canyon (Figure 21). Data from the northern tier of Clark County and nearby Lincoln and Nye counties would be a valuable asset toward future modeling efforts.

Table 18. Ecosystems within Clark County, and the area (Ha) of Low Medium and High predicted suitability within each ecosystem.

Ecosystem	Low	Medium	High
Alpine	119	5	0
Blackbrush	198877	207858	8103

Ecosystem	Low	Medium	High
Bristlecone Pine	6187	1348	1
Desert Riparian	230	2358	8610
Mesquite Acacia	1597	14297	4292
Mixed Conifer	13830	11369	2016
Mojave Desert Scrub	345416	886299	91168
Pinyon Juniper	58468	42071	15001
Sagebrush	1109	2004	1562
Salt Desert Scrub	24957	35138	21926

Ecosystem Level Threats

A. nevadensis is susceptible to losses of and fragmentation of its habitat (Sagebrush, Saltbush scrub). Reduced patch size is thought to threaten survivorship during overwintering and migration, which are the likely activities for this species within Clark County.

Threats to Species

Sage Sparrows can be influenced by alterations of habitat composition and structure (e.g. loss of sage/shrubsteppe habitats, and fragmentation of those habitats). Increased fragmentation may influence nesting success (Hethcoat and Chalfoun 2015), as well as migration and overwintering for this species (Rotenberry and Knick 1999).

Existing Conservation Areas/Management Actions

Sage Sparrows are protected at the federal level by the Migratory Bird Treaty Act, and are considered a Species of Conservation Priority by the Nevada Wildlife Action Plan because their sagebrush habitat is at risk of large-scale conversion and loss, and because this species is moderately vulnerable to climate change (Wildlife Action Plan Team 2012). The plan recommends protecting large expanses of high quality sagebrush and mixed xeric shrub habitat from wildfire, cheatgrass invasion, heavy OHV use, and urban and suburban development (Wildlife Action Plan Team 2012).

The Sage Sparrow is considered a Conservation Priority species by the Nevada Comprehensive Bird Conservation Plan due to historical, and possibly recent, range-wide population declines and habitat threats (2010). Conservation, research, and monitoring strategies recommended by the plan include: protecting large expanses of high-quality sagebrush habitat from fire; minimizing the amount of habitat fragmented by development; identifying and mapping large patches of intact, mature sagebrush that contain dense shrubs and limited cheatgrass; and developing a management strategy that prioritizes fire suppression in high quality habitat (GBBO 2010).

Partners in Flight's (PIF) North American Landbird Conservation Plan identified the Sage Sparrow as a species of continental importance for the US and Canada (Rich 2004). The plan's state population objectives for Nevada are to maintain the current population (Rosenberg 2004).

Summary of Direct Impacts

Direct impacts are likely to affect 239 km^2 of high quality and 874 $km^2$of moderate quality habitat for this species (Table 19). Conserved areas are most prominently protecting moderate habitat, while 99 $km^2$of higher suitability habitat is protected. Habitat that is already disturbed comprises 813 $km^2$of high and moderate level habitat in the county (Table 19).

Table 19. Categorized modeled habitat values (High, Medium, and Low) and the average area (Hectares) predicted in the potential impact areas, conservation areas, already disturbed areas, and overall area.

Habitat Level	Impact	Conserved	Disturbed	Area (Hectares)
High	23928	9936	44165	167023
Med	87453	342036	36209	1248126
Low	14186	160824	905	666855

ASGETR - Threecorner Milkvetch (Astragalus geyeri var. triquetrus)

Threecorner Milkvetch is a tiny, prostrate, sand-loving (i.e., psammophylic), winter annual plant in the bean family (Fabaceae) and is one of the first plants to bloom in early spring (Swearingen 1981, Bangle 2012). Their abundance is highly variable, likely due to variable precipitation and temperature for this region (Powell 1999). Originally this species was described as occupying consolidated dunes (Niles et al. 1995), however, recent observations describe the Threecorner Milkvetch on unconsolidated dunes as well (Powell 1999). Because this rare plant inhabits unconsolidated dunes, it is possible that shifting dune surfaces would either bury or expose propagules in the seed bank intermittently, thus potentially increasing the variability of abundance that might be measured during surveys in any given year (Powell 1999), and this must be considered when assessing population trends.

Species Status

Threecorner Milkvetch is a former Category 2 candidate for threatened or endangered status under the Endangered Species Act of 1973. The last ruling on the status of this species was published in the Federal Register on September 30, 1993 where it was determined that the Threecorner Milkvetch proposal for listing may be appropriate, but that insufficient data on biological vulnerability and threats were available to support the listing at that time (USFWS 1993, USFWS 2009).

US Fish and Wildlife Service Endangered Species Act: Not listed
US Bureau of Land Management (Nevada): Sensitive
US Forest Service (Region 4): No status
State of Nevada (NAC-527): Critically endangered
NV Natural Heritage Program: Global Rank G4T2T3, State Rank S2S3
IUCN Red List (v 3.1): No Status
CITES: No Status

Range

Almost the entire range of Threecorner Milkvetch is in Clark County, with the northeast extreme of the range crossing into Lincoln County at Sand Hollow Wash, extreme eastern Clark County in the sands near St. Thomas Gap, and to the northeast at Coon Creek, in Mohave County, Arizona (Swearingen 1981, Bangle 2012). The southernmost range is on the north shore of Boulder Basin at Lake Mead National Recreation Area (LMNRA) and the westernmost known limit is in Dry Lake Valley, Clark County (Bangle 2012). Sixteen of the 17 known population groups occur in northeast Clark County (TNC 2007).

Population Trends

Population data are insufficient to derive population trends for this species (Powell 1999, Bangle 1012, NNHP 2001, TNC 2007). As an annual plant species the population numbers fluctuate greatly from year to year in response to rainfall and winter and spring temperatures. As a result, the species may not be seen for years at a time because it requires average to above-average rainfall to germinate (TNC 2007).

In 2007/08, monitoring plots identified and mapped 3,968 individual plants at Sandy Cove on LMNRA. Several sites that were surveyed and known to produce plants in previous years did not yield any observation of the plant during this survey. Seed bank studies might be used to reduce variability in surveys for this and other species with irregular germination.

Habitat Model

Threecorner Milkvetch had 1234 point localities available for modeling distributed largely in the northeastern quarter of the County. Similar patterns of predicted suitability were produced by the three modeling algorithms with a slightly broader range of higher suitability predicted by the GAM model than the others. The consensus model predicted areas of higher habitat suitability in the Muddy and Virgin river areas, the margins of Mormon Mesa, Moapa Valley, and Gold Butte, and the Apex/Crystal area (Figure 23).

Performance was high in all models, with the highest overall for the Ensemble model. The RF had the second highest performance, followed by MaxEnt and then GAM models (Table 20). AUC was nearly equivalent among all models, but the Ensemble model had higher BI, and Correlations than the others, while the RF model had a higher TSS score than the others (Table 20).

The Continuous Boyce Index [CBI] indicated good performance among all models with an irregular pattern in the MaxEnt model (Figure 25). Standard Errors were generally low among the three modeling algorithms, with low error in the predictions near the confluence of the Muddy and Virgin Rivers. The among model error shown in the Ensemble model indicated moderately low error (0.04 – 0.06) in the same area, and low (0.02 – 0.04) SE along the I-15 corridor. Approximated bins for the ensemble model based on the CBI were 0-0.3 unsuitable, 0.3-0.375 marginal, 0.4 to 0.5 suitable, and > 0.5 optimal habitat; with a suggested cutoff threshold near 0.4 (Figure 25) and the threshold value calculated from the AUC analysis for the ensemble model was 0.39 (Table 20).

Table 20. Model performance values for *Astragalus geyeri* models.

Performance	GAM	RF	MaxEnt	Ensemble
AUC	0.97	0.99	0.98	0.98
BI	0.83	0.85	0.78	0.89
TSS	0.88	0.93	0.89	0.90
Correlation	0.68	0.76	0.84	0.89
Cut-off*	0.54	0.45	0.14	0.39

*threshold at which sum of sensitivity (true positive rate) and specificity (true negative rate) is highest

Table 21. Percent contributions for input variables for *Astragalus geyeri* in an ensemble model combining GAM, MaxEnt, and RF algorithms

Term	GAM	RF	Max	Average
Winter Precipitation	0.0	8.0	3.4	8.2
Summer Maximum Temperature	31.4	13.9	45.7	37.9
Winter Minimum Temperature	37.0	9.7	17.3	26.7
Temperature Range	2.9	12.2	4.6	13.2
NDVI Amplitude	0.0	0.0	0.2	0.1
NDVI Maximum	0.0	5.6	0.6	5.2
NDVI (Landsat 8)	0.0	10.9	0.9	9.9
Slope	0.0	6.6	0.3	6.0
Topographic Position (TPI)	0.0	5.8	0.5	5.2
Silica Index	22.0	16.9	23.7	30.1
Sandy Soils	6.7	10.4	2.8	12.3

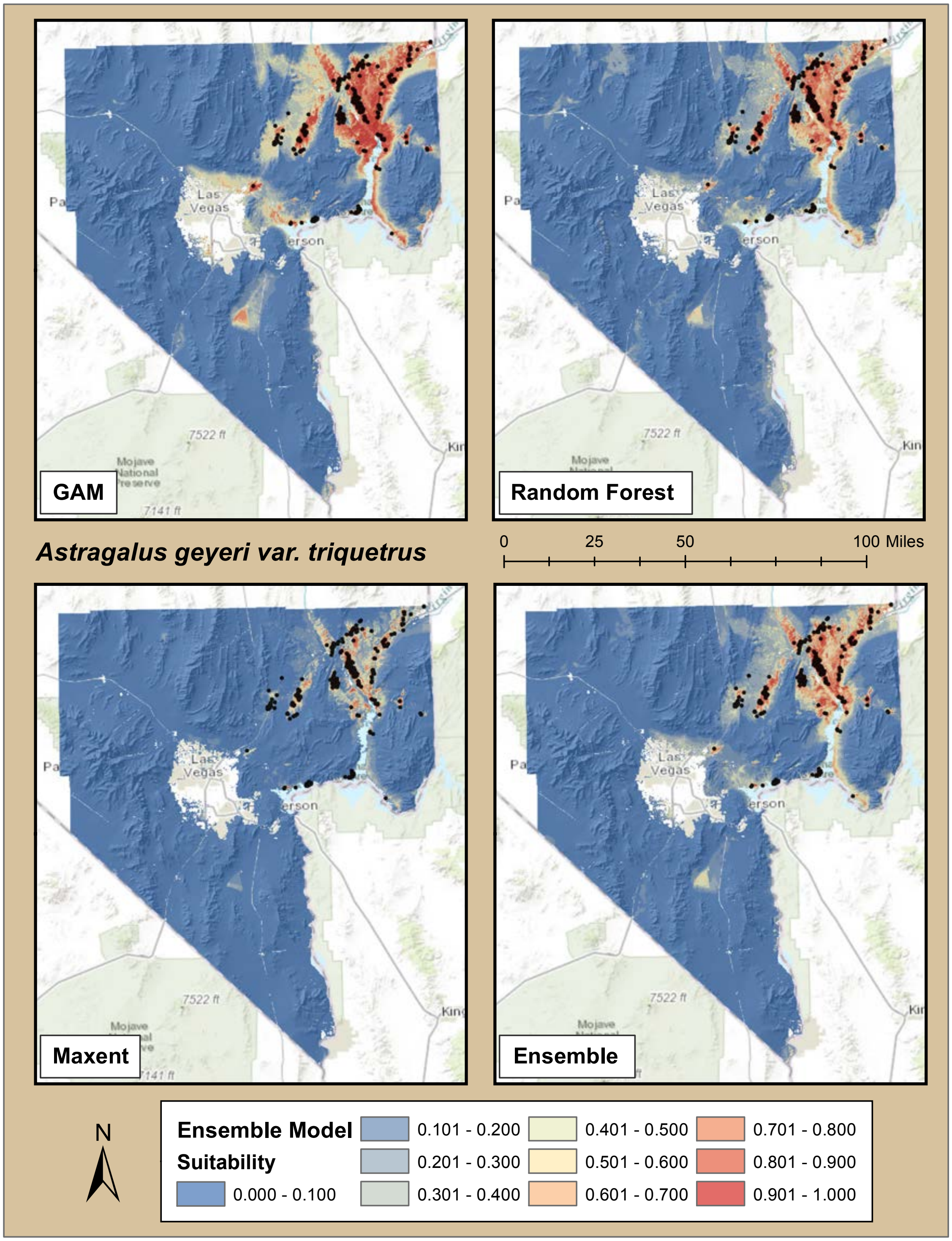


Figure 23. SDM maps for *Astragalus geyeri* for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

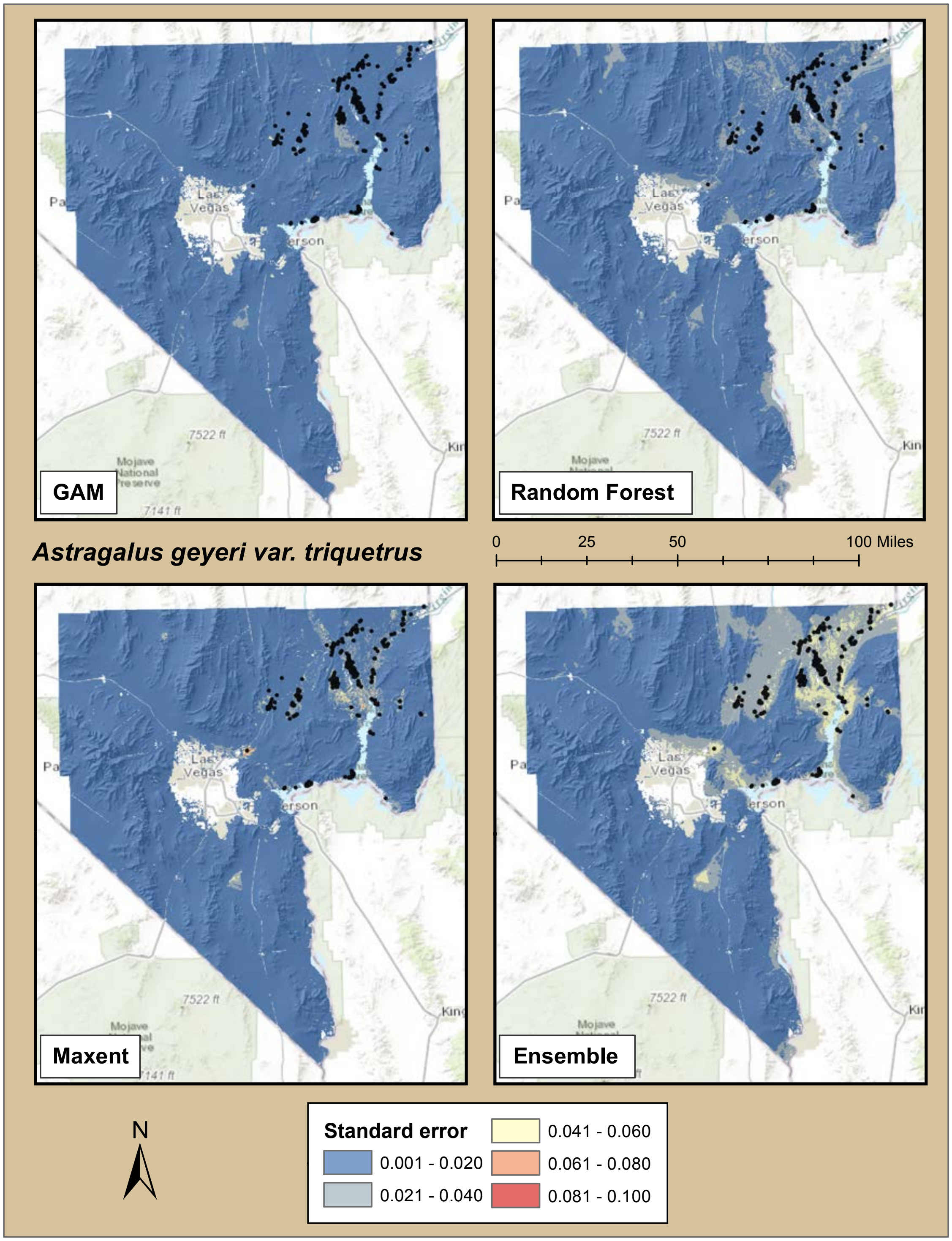


Figure 24. Standard error maps for *Astragalus geyeri* models for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an Ensemble model averaging the previous three (Lower Right).

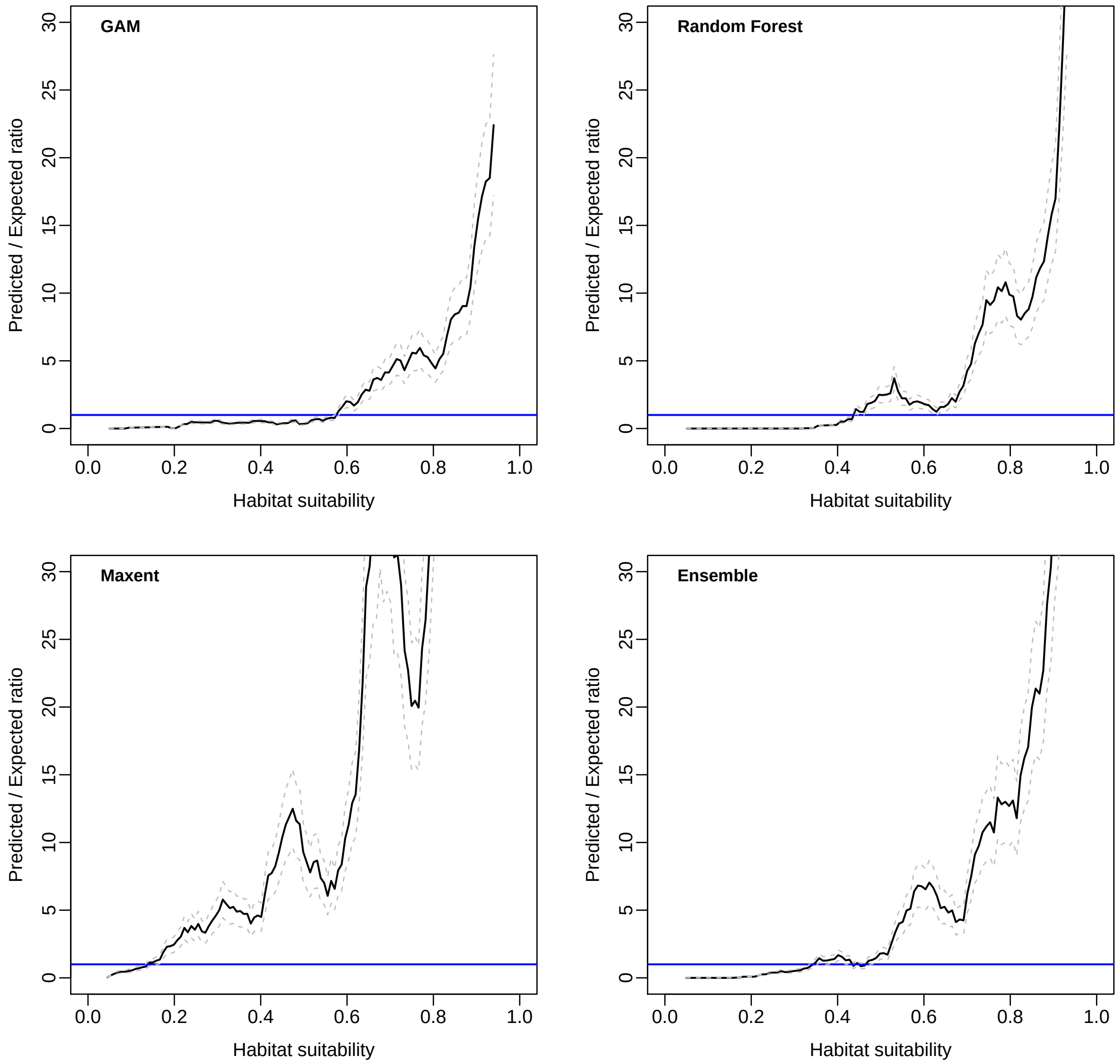


Figure 25. Graphs of Continuous Boyce Indices [CBI] for *Astragalus geyeri* models for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

GAM Model

Three variables contributed 20% or more from the GAM model ensemble totaling 90% of model contribution (Table 21). Winter Minimum Temperature was the strongest contributor with 37% model contribution, and peaked relationship, where habitat suitability was higher in areas that had relatively warmer minimum temperatures, but leveling off above 2 ºC and decreasing above 4 ºC (Figure 26). Summer Maximum Temperature (31%) was generally linear and positive, with positive predictions of habitat above 35 ºC (Figure 26). Silica Index contributed 22% to the overall model, and had a positive relationship, with positive habitat predictions above levels of 1.03, consistent with this species preference for sandy substrates. The sandy soils layer, had a 6% contribution (Table 21).

The GAM model predicted the largest extent of habitat for this species. Highest habitat predictions were in the Overton and Mormon Mesa areas, with habitat predicted all along the Gold Butte Shoreline along the Virgin River and Lake Mead. High habitat suitability was also predicted for the Apex and I-15 corridor areas, the Las Vegas Bay and Government Wash, and near Nellis AFB (Figure 23). One pocket of habitat was predicted hear the Roach Lake/Jean area, but no localities are reported there, and this was also an area of higher Standard Error in the Ensemble model due to this (Figure 24). Standard error for the models within this algorithm were generally low throughout the County (Figure 24).

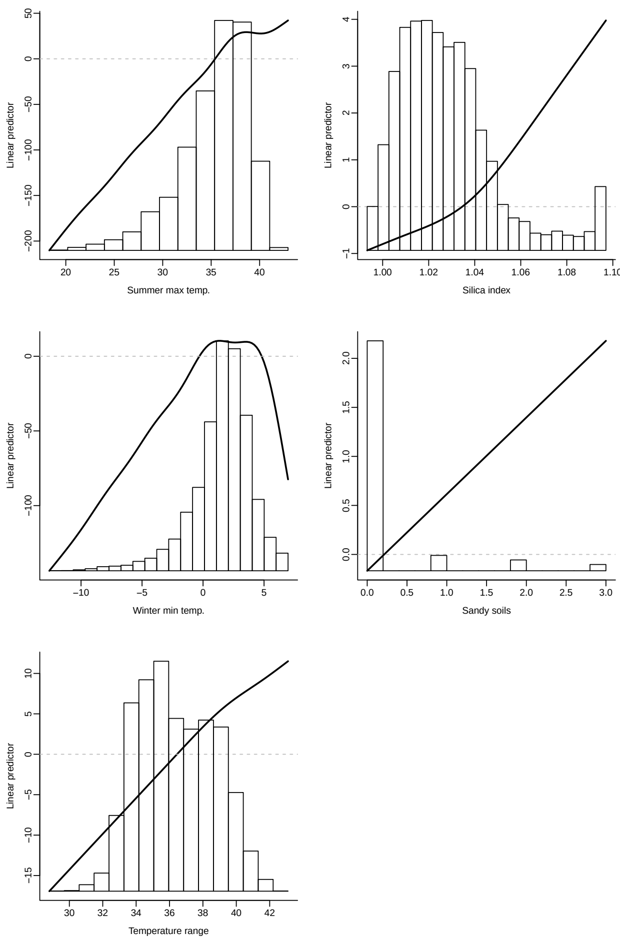


Figure 26. GAM partial response curves for the *Astragalus geyeri* model overlaid over distribution of environmental variable inputs in the study area.

MaxEnt Model

The MaxEnt model had the same three variables as the GAM model contributing 15% or more each, accounting for 87% of model contribution. Three additional variables contributed minimally (Table 21). Summer Maximum Temperature was the largest model contributor (46%) and had a strongly positive relationship with predicted habitat suitability above 37ºC (Figure 27). Silica Index was the next most important (24%), with a non-linear positive relationship with predicted habitat. Winter Minimum Temperature contributed 17%, with a peaked response – where habitat was highest between 0 ºC and 4 ºC, peaking at 2.5 ºC and falling at higher values (Figure 27).

Habitat prediction for this model was concordant with the point locations for the species (Figure 24), with habitat centered in the Moapa Valley, and Virgin River, Beaver Dam Wash, Apex and the I-15 Corridor (Figure 24).

Standard Error was low (0.02 – 0.04) to moderate (0.04 – 0.06) where habitat was predicted, with the highest levels (0.06 – 0.08) in a few small patches (e.g. near Nellis AFB, and Near Valley of Fire State Park). Error throughout the rest of the County was predicted to be low (Figure 24).

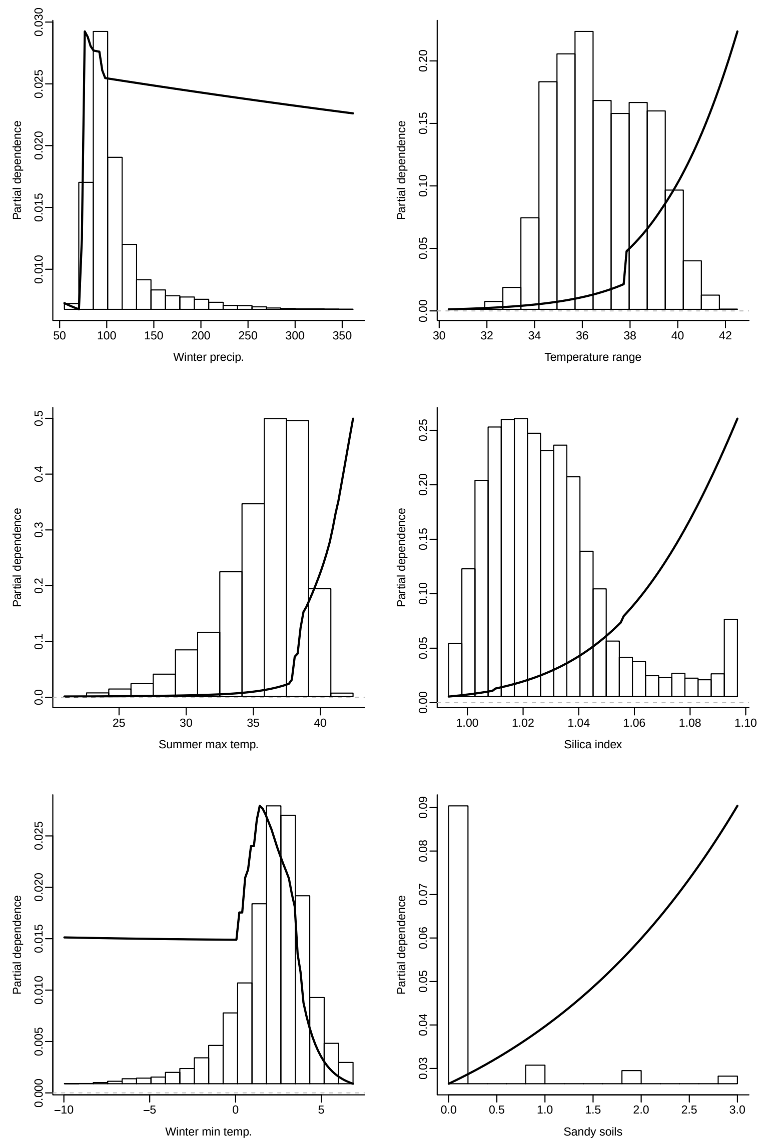


Figure 27. Response surfaces for the top environmental variables included in the MaxEnt ensemble model for *Astragalus geyeri*.

Random Forest Model

The RF models had six environmental variables contributing ~ 10% or more collectively accounting for 74% of the total model influence, with four additional variables contributing lesser, but not minimal amounts (Table 21).

Silica Index had the highest influence (17%), with a strong logistic shaped threshold curve, with higher habitat suitability predicted at indices above 1.05 (Figure 28). Summer Maximum Temperature contributed 14%, and also had a strong threshold response, with suitable habitat predicted at max summer temperatures above 37 ºC. Annual Temperature Range (12%) had a similar threshold response at temperature ranges above 37 (Figure 28), NDVI derived from Landsat 8 contributed 11% also had a threshold response, with higher habitat suitability predicted above 0.05. Sandy Soils

(10%) also contributed positively. Winter Minimum Temperature (10%) had a peaked response as seen in the other models, where habitat suitability was highest between 0 ºC and 5 ºC minimum winter temperature, peaking at 2.5 ºC (Figure 28).

Standard error maps for this model indicated low (0.02 to 0.04) error rates generally surrounding areas of predicted habitat (Figure 24, Figure 23). Low SE was also predicted in the southern extent of Eldorado Valley, Extreme north Las Vegas Valley, and on the Nevada National Security Site (Figure 24). Habitat suitability was predicted to be highest in the Moapa Valley, and Virgin River, Mormon Mesa, and along the Western Shoreline of Gold Butte. One patch of marginal habitat is predicted for southern Eldorado Valley (Figure 23).

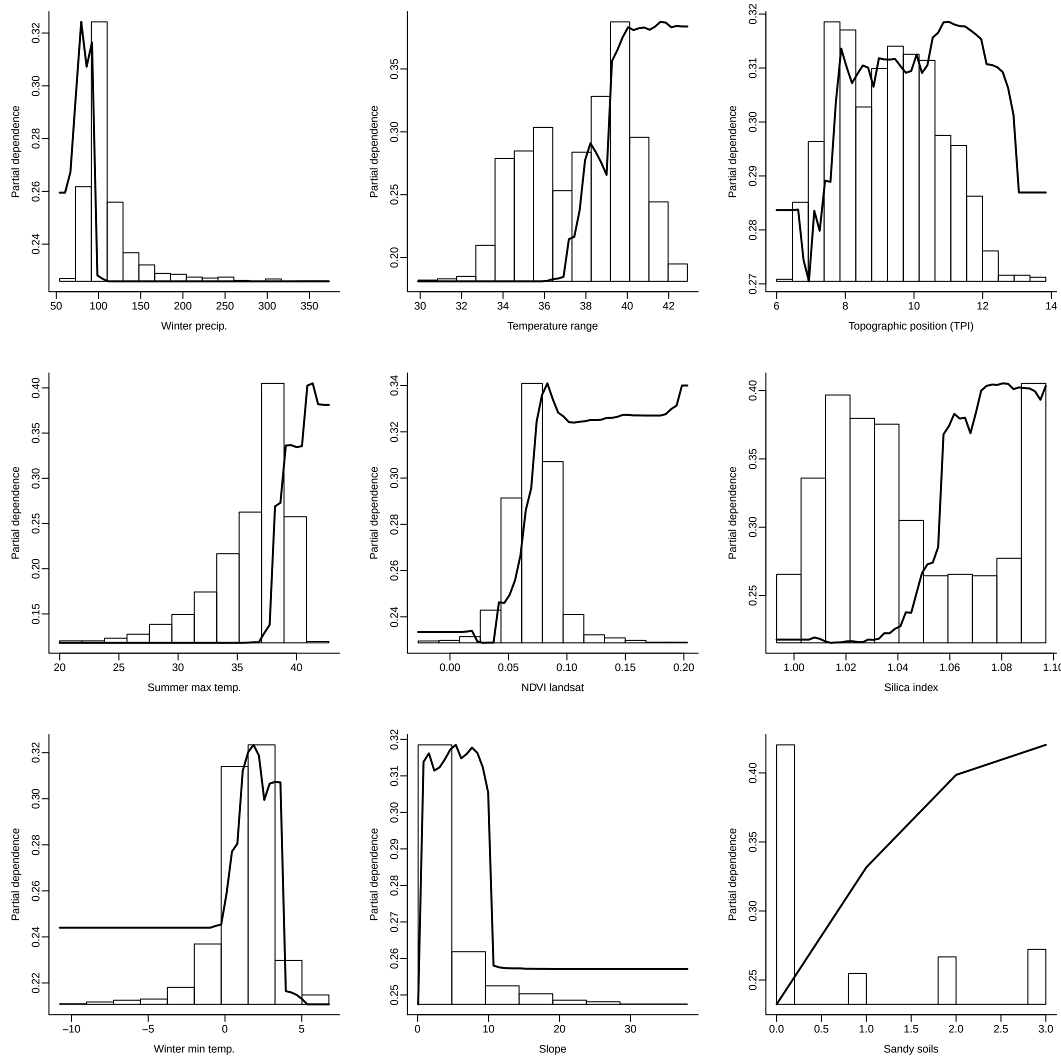


Figure 28. Partial response surfaces for the environmental variables included in the RF ensemble model for *Astragalus geyeri*. Histograms represent the range of each environmental variable across the x-axis, and predicted dependence relative to habitat suitability values are on the y-axis.

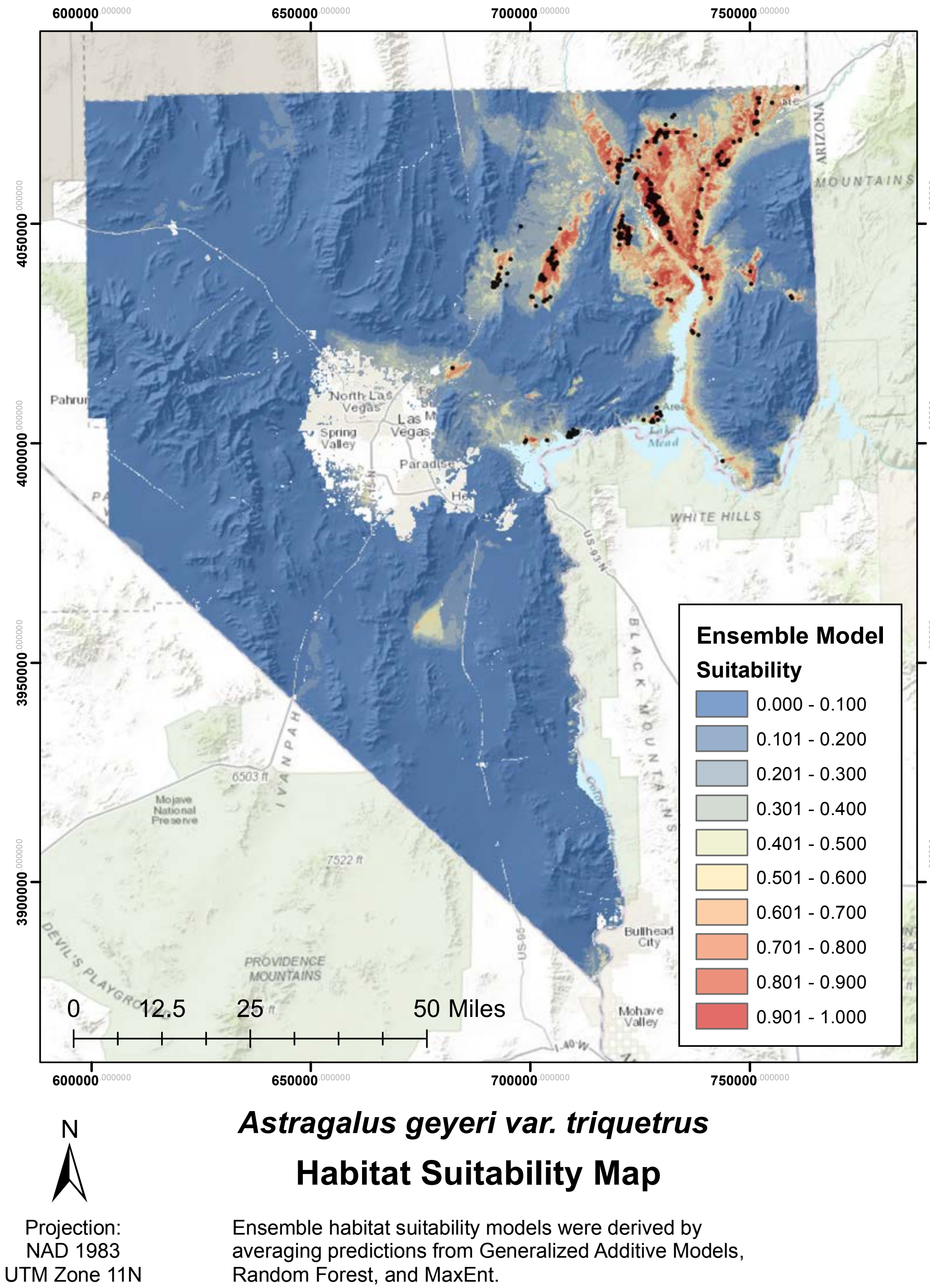


Figure 29. SDM map for the *Astragalus geyeri* Ensemble model.

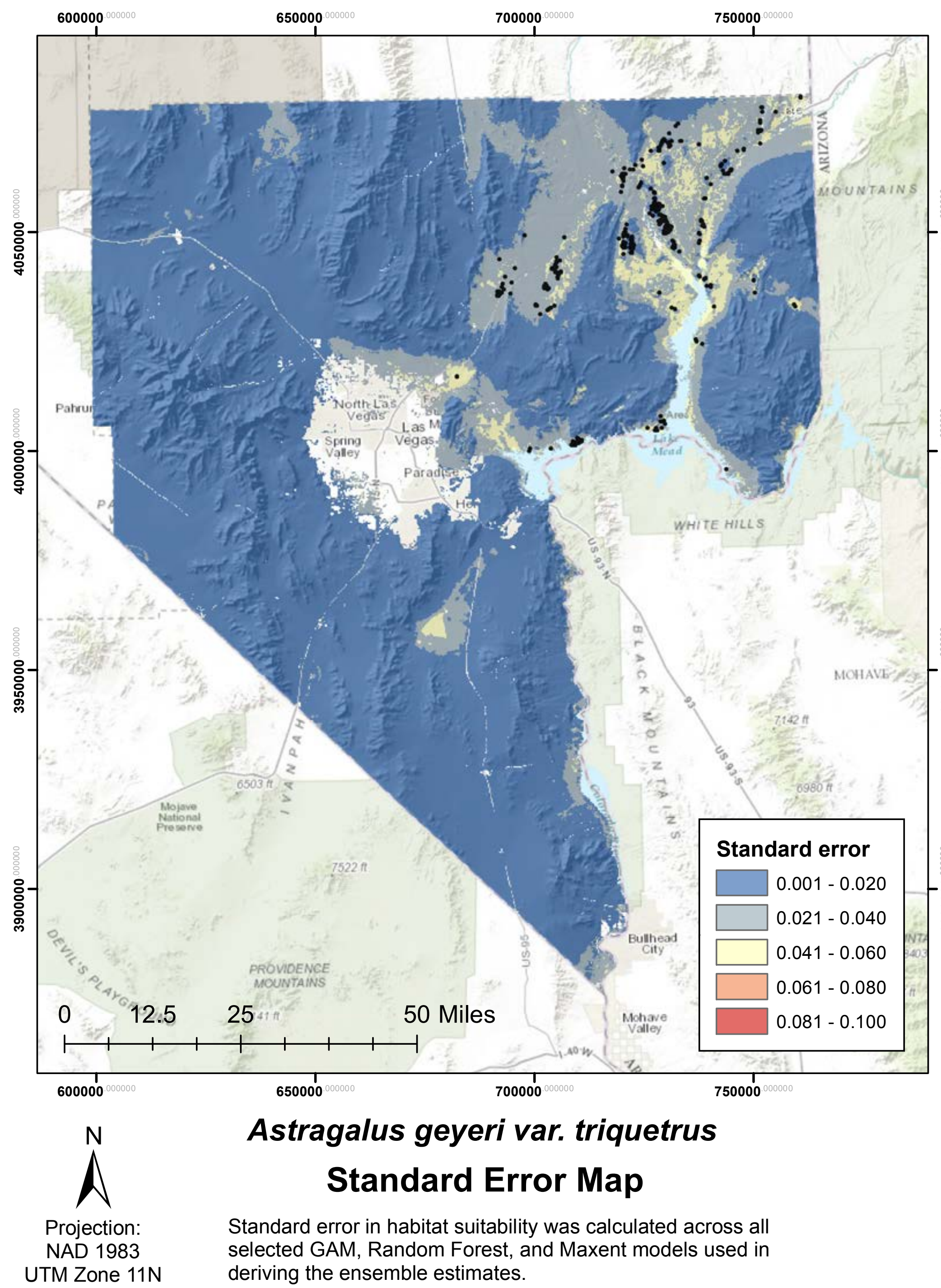


Figure 30. Standard Error map for *Astragalus geyeri* Ensemble model.

Model Discussion

Distribution of Localities – Localities (N=1234) for Astragalus geyeri are distributed only in Northeastern Clark County especially in sandy areas along the Moapa and Virgin river valleys, within the large wash bisecting Gold Butte, and in the Apex and

I-15 corridor area especially South of Glendale, NV, and on the I-15 corridor from north of the Logandale exit extending all the way to Mesquite (Figure 29). Additional points are located along the northern Shoreline of Lake Mead near Government Wash and Las Vegas Bay (Figure 29).

Standard Error - Moderate Standard Error (0.04 – 0.06) is indicated in Figure 30, with patches near Las Vegas Bay, Nellis AFB, and the Badlands area in and around Boulder Beach, and the corresponding latitude across Lake Mead in Gold Butte. Southern Eldorado valley also has a patch of moderate SE in the drainage area coming in from the Highlands Range (Figure 30).

Distribution and Habitat Use within Clark County

Within Clark County, three-corner milkvetch occurs on sandy soils derived from the Tertiary-aged Muddy Creek Formation and redistributed as Aeolian and fluvial deposits along the Muddy and Virgin rivers and the Overton Arm of Lake Mead from Sandy Cove and Middlepoint to the Mormon Mesa (NNHP 2001, Niles et al. 1995, Bangle 2012). The range extends from Dry Lake Valley in the west to the confluence of the Muddy and Virgin rivers in the east, and from Sandy Cove and Ebony Cove on the north shore of Boulder Basin at Lake Mead in the south to the Virgin River drainage in the far northeast of the county, including populations near the Muddy River drainage (Niles et al. 1995, TNC 2007, Bangle 2012).

Native plants associated with Threecorner Milkvetch include *Ambrosia dumosa, Larrea tridentata, Krameria erecta, Ephedra torreyana, Tiquilia canescens, Opuntia basilaris,* and *Psorothamnus fremontii* (Powell 1999). Native annuals include *Chamaesyce polycarpa, Plantago ovata, Palafoxia arida, Chorizanthe brevicornu, Eriogonum inflatum,* and *Oenothera deltoids* (Powell 1999). Ecosystems associated with higher suitability habitat include Sagebrush, Blackbrush and Mixed Conifer, and Mojave Desert Scrub (Table 22). Moderate habitat is found within the same ecosystems.

Modeled habitat in the County is predicted to be highest in the Virgin and Muddy river valleys, and the valley along the I-15 corridor South of Glendale, with habitat extending northward along I-15 and on Mormon Mesa all the way to Mesquite. The low-elevation areas bisecting Gold Butte from east and west, is also indicated as habitat. (Figure 29). Within that area, the red Aeolian sands of Devil's Kitchen and St. Thomas Gap are habitat hotspots for this species. The North Shore of the Boulder Basin of Lake Mead is also predicted to be habitat from the Narrows extending westward to Las Vegas Bay (Figure 29).

Table 22. Ecosystems within Clark County, and the area (Ha) of Low Medium and High predicted suitability within each ecosystem

Ecosystem	Low	Medium	High
Alpine	119	5	0
Blackbrush	198877	207858	8103

Ecosystem	Low	Medium	High
Bristlecone Pine	124	0	0
Desert Riparian	415493	0	0
Mesquite Acacia	7565	0	0
Mixed Conifer	3274	4972	2390
Mojave Desert Scrub	16461	2596	626
Pinyon Juniper	27339	0	0
Sagebrush	1076863	121514	82707
Salt Desert Scrub	115854	0	0

Ecosystem Level Threats

Threecorner Milkvetch occupies habitats identified by the DCP as desert riparian, mesquite/acacia, and Mojave desert scrub ecosystems. The primary threats to this ecosystem include modification and destruction of habitat by urban and suburban development, off-road vehicle use, surface water development, invasive plant species (especially Sahara mustard, *Brassica tournefortii*, and Mediterranean grass (*Schismus* spp.), utility corridor construction and maintenance, agriculture, and inundation by shoreline fluctuations; other identified threats include livestock grazing, sand and gravel mining, wild horse and burro management, and legal and illegal ORV use (TNC 2007, Bangle 2012, Powell 1999).

Threats to Species

Within Clark County, some reports identify OHV and boater recreation as burgeoning threats to Threecorner Milkvetch, and others have identified trespassing livestock and feral burros as potential threats (Powell 1999, Bangle 2012), but there was not broad agreement on these items in the available references. Sahara mustard (*B. tournefortii*) and Mediterranean grass (*Schismus* sp.) were both identified as potential habitat threats. Active control of *B. tournefortii* has been undertaken in Threecorner Milkvetch habitats at LMNRA (Powell 1999).

Existing Conservation Areas/Management Actions

A conservation strategy specific to this species was developed by The Nature Conservancy for the Clark County Desert Conservation Program. The ten recommended conservation actions for this species include:

- proactively protect and manage for long-term viability of all populations on federal lands;
- manage viable populations by removing significant casual off-road vehicle use;
- control weeds in low elevation rare plant habitats;
- ensure that long term viability of low elevation rare plants is not significantly impacted by rural development and sprawl;

- ensure that disposal of federal lands in Clark County will not significantly impact conservation of rare plant populations;
- manage rare plants in sandy habitats for long term viability by addressing altered fire regimes (increased fire frequency and intensity) over the next century;
- manage viable populations of all covered rare plants in utility corridors and potential rights-of-way corridors;
- management of viable populations on federal lands;
- protect Threecorner Milkvetch populations along Muddy and Virgin rivers from significant agricultural impacts over the next fifty year;
- ensure conservation management for Threecorner Milkvetch populations at LMNRA above high water line and manage populations below high water line during Lake Mead low water years; and
- ensure construction of the Mesquite Airport does not significantly impact viability of Threecorner Milkvetch on public lands (TNC 2007).

NPS controls the invasive Sahara mustard in and around Threecorner Milkvetch populations along the north shoreline of Lake Mead and conducts annual monitoring of the Sandy Cove population (TNC 2007). Four populations growing on lands managed by BLM occur at least partly within designated ACECs.

It is clear that actively managing landscapes for such rare species as the Threecorner Milkvetch has high priority and many useful management recommendations are provided. However, in the absence of population monitoring there is no way of accurately determining the population status of these species. Furthermore, it is clear that monitoring plants as they are expressed in sample populations can yield volumes of highly variable data. Quantifying propagules in the seed bank is a relatively straightforward endeavor in very sandy soils – such as those where the Threecorner Milkvetch occurs. While seedbank estimates are also notoriously variable it is possible that they may provide a more reliable and cost effective estimate of population status than monitoring plants on an annual basis. Furthermore, a seed bank investigation could also be used to determine the efficacy of invasive species control programs in these high-value habitats.

Summary of Direct Impacts

Relatively little high-quality habitat is currently disturbed, and 102 km^2 is likely to be impacted in the future. Conserved areas contain 171 km^2 of predicted higher quality habitat. Moderate habitat is also impacted at a relatively low level with 171 km^2 likely to be impacted and 50 km^2 already disturbed (Table 23). Conservation areas for moderate habitat contain 271 $km^2$of habitat.

Table 23. Categorized modeled habitat values (High, Medium, and Low) and the average area (Hectares) predicted in the potential impact areas, conservation areas, already disturbed areas, and overall area

Habitat Level	Impact	Conserved	Disturbed	Area (Hectares)
High	10231	17145	1986	85918
Med	17079	26711	5067	131050
Low	95236	469846	32943	1761124

ASLEST - Straw Milkvetch (Astragalus lentiginosus var. stramineus)

Astragalus lentiginosus var. stramineus (syn. *Cystium stramineum*) is monocarpic (flowering and fruiting only once in its life) or a short-lived perennial with pale purple flowers (Barneby 1989). This species is also known as freckled milkvetch (USDA NRCS 2016). It is found in sandy and gravelly valley flats, washes, and dunes at elevations between 620 m and 1000 m in *Larrea*, *Coleogyne,* and other mixed desert shrub communities in the Virgin River Valley (Barneby 1989, NNHP 2017). Nevada Natural Heritage Program lists a slightly more restrictive elevation range between 480 m and 603 m based on five occurrences (NNHP 2017), which is logical because Nevada is lower in the Virgin River watershed than Utah. The first specimen of *A. lentiginosus var. stramineus* was collected by E. Palmer in 1870 in southeast Utah and described much later (Barneby 1945). *A. lentigosus var. stramineus* is critically imperiled in Nevada (NatureServe 2015). The species was listed as locally common and restricted in 1975 (Schoener 1975).

Species Status

The Straw Milkvetch was placed on the Nevada Native Plant Society watch list in 2002.

US Fish and Wildlife Service Endangered Species Act: No status
US Bureau of Land Management (Nevada): Sensitive
US Forest Service (Region 4): No status
State of Nevada (NAC 527): No status
NV Natural Heritage Program: Global Rank G5T2T3 State Rank S1S2
IUCN Red List (v 3.1): No status
CITES: No status

Range

While the species is widespread, the variety *A.l. stramineus* is restricted to Clark Co., Nevada, Washington Co., Utah, and Mohave Co., Arizona (Barneby 1989, Schoener 1975).

Population Trends

There is insufficient population data on this species to determine population trends.

Habitat Model

There were too few locations of Straw Milkvetch available within Clark County to create county specific models for this species as only 8 of the 29 available localities were located within the County, thus we expanded to a broader footprint to include points that also occurred in Utah and Arizona. The three modeling algorithms had qualitatively different habitat predictions, which was not surprising given the low number of points available for modeling. While each of the models predicted high habitat suitability along the Virgin and Muddy rivers, the GAM and RF models also included broader predictions extending westward in Lake Mead National Recreation Area (Government Wash area) and southwestern Las Vegas (Figure 31). Performance was highest in 3 of the four overall metrics for the RF model followed by the Ensemble model and GAM models. While all models had similar AUC and TSS scores, the RF had a much higher Boyce Index (BI) than the others, while correlations were higher for the MaxEnt and Ensemble models (Table 24).

The Continuous Boyce Index [CBI] indicated somewhat elevated values for the positive response among all models, with erratic performance above 0.5, especially in the MaxEnt model (Figure 33). Standard errors were greatest for the GAM model, with elevated error relative to the other algorithms in the low to mid-range habitat predicted in the northwest corner of the county, the Government Wash area of Lake Mead, and in the southern portion of Gold Butte. (Figure 32).

The CBI for the Ensemble mode indicated good model performance (Figure 33), and was the second highest reported BI compared to the three algorithms (Table 24). Approximated bins for the ensemble model based on the CBI were 0-0.3 unsuitable, 0.3-0.4 marginal, 0.4 to 0.6 suitable, and > 0.6 optimal habitat; with a suggested cutoff threshold between 0.4 and 0.5 (Figure 33) and the threshold value calculated from the AUC analysis for the ensemble model was 0.42 (Table 24).

Table 24. Model performance values for *Astragalus lentiginosus* models

Performance	GAM	RF	MaxEnt	Ensemble
AUC	0.987	0.991	0.987	0.991
Boyce Index	0.544	0.758	0.492	0.593
TSS	0.968	0.986	0.953	0.976
Correlation	0.73	0.764	0.843	0.814
Cut-off*	0.694	0.56	0.214	0.428

*threshold at which sum of sensitivity (true positive rate) and specificity (true negative rate) is highest

Table 25. Percent contributions for input variables for *Astragalus lentiginosus* in an ensemble model combining GAM, MaxEnt, and RF algorithms.

Term	GAM	RF	Max	Average
Winter Precipitation	0	6.8	0.7	1.8
Summer Precipitation	52.7	19.4	21.8	29.4

Term	GAM	RF	Max	Average
Summer Maximum Temperature	5.4	20.8	10.6	10.2
Winter Minimum Temperature	17.8	12.8	33.4	20.1
Temperature Range	20.0	23.6	32.7	23.2
Surface Texture (ATI)	0	0	0	0
Slope	1.2	0	0.3	0.5
Topographic Position (TPI)	0	6.3	0.5	1.7
NDVI Maximum	0	5.1	0	1.2
Sandy Soils	2.9	5.3	0	2.2
Soil Water Stress	0	0	0	0

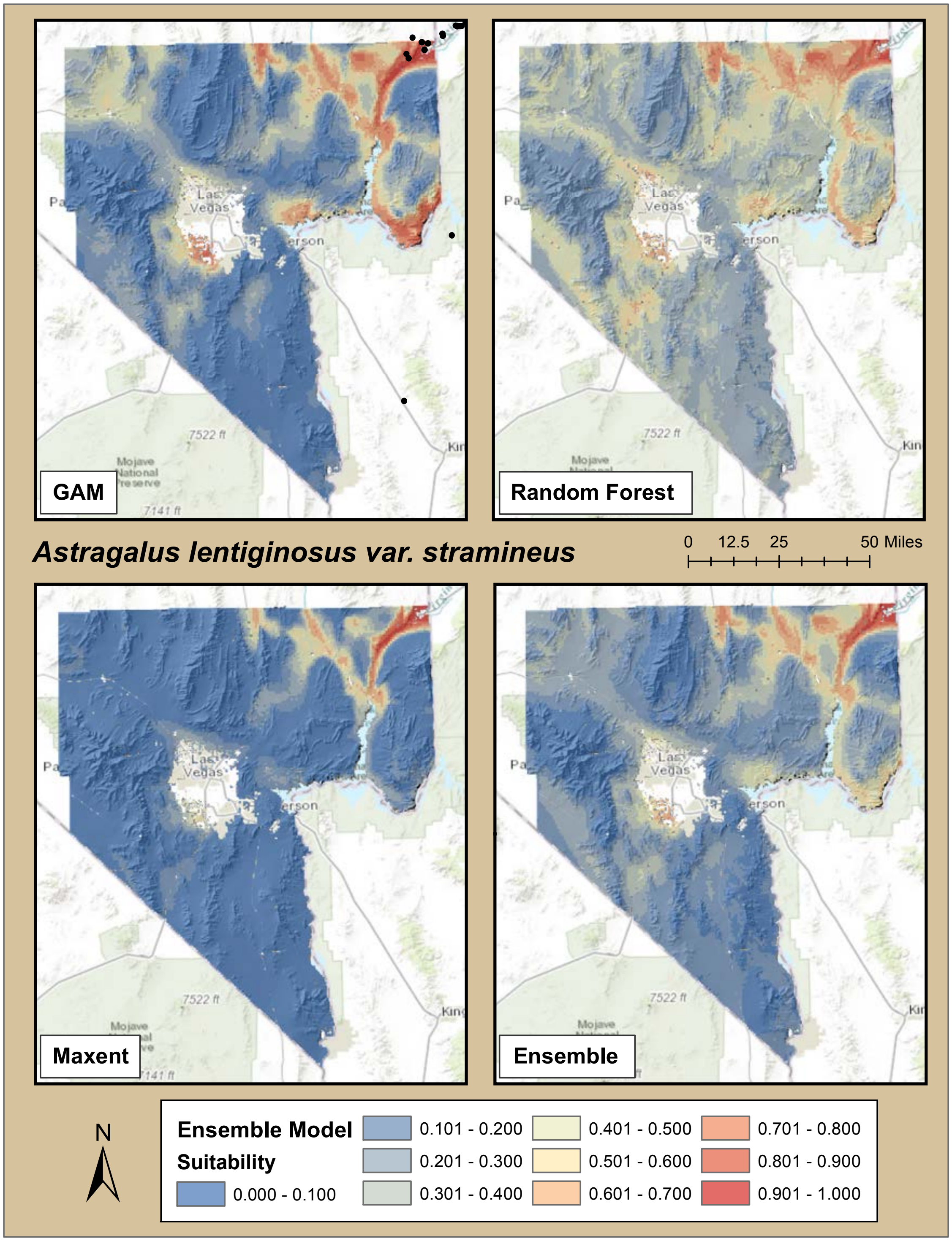


Figure 31. SDM maps for *Astragalus lentiginosus var. straminea* for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

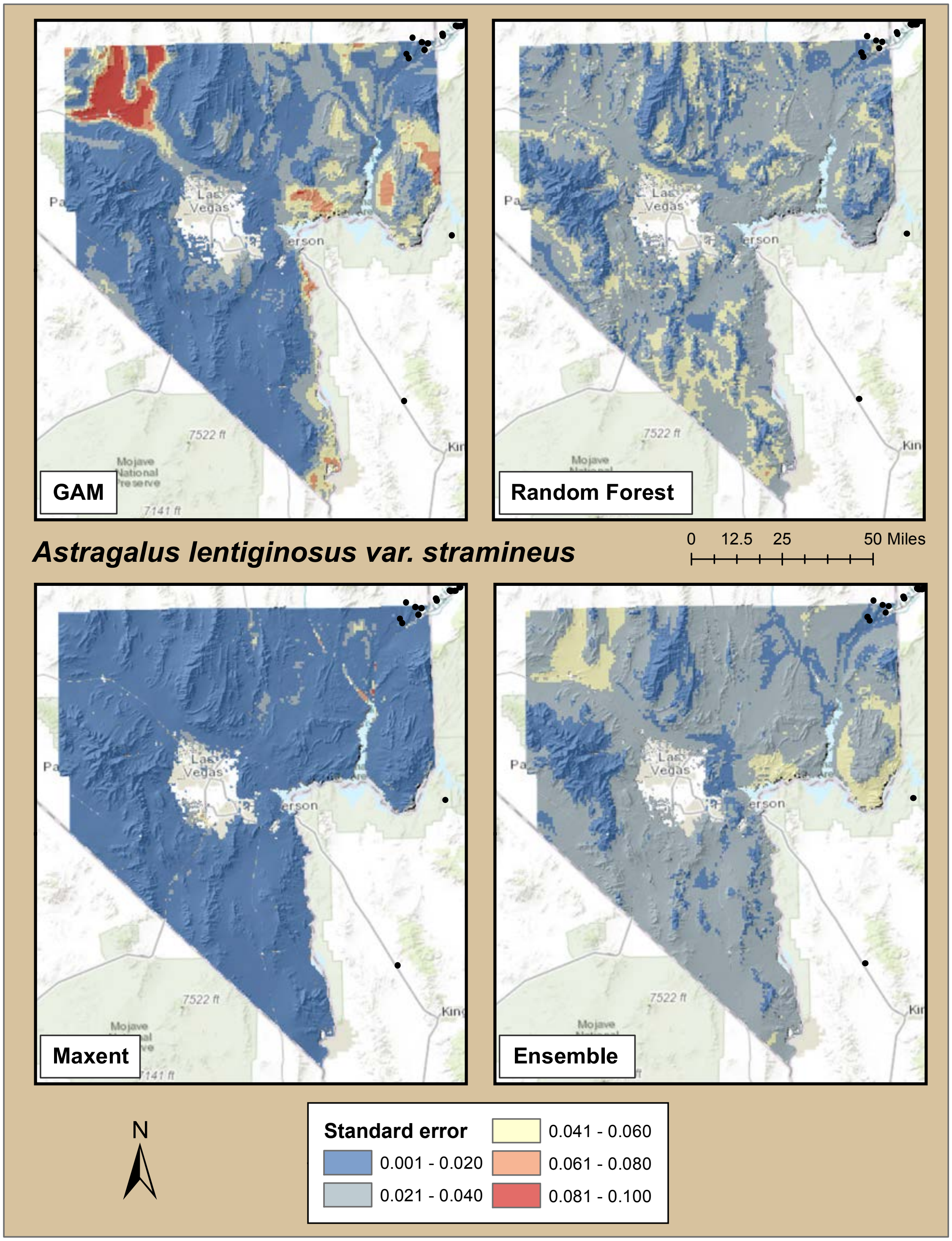


Figure 32. Standard error maps for *Astragalus lentiginosus* models for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

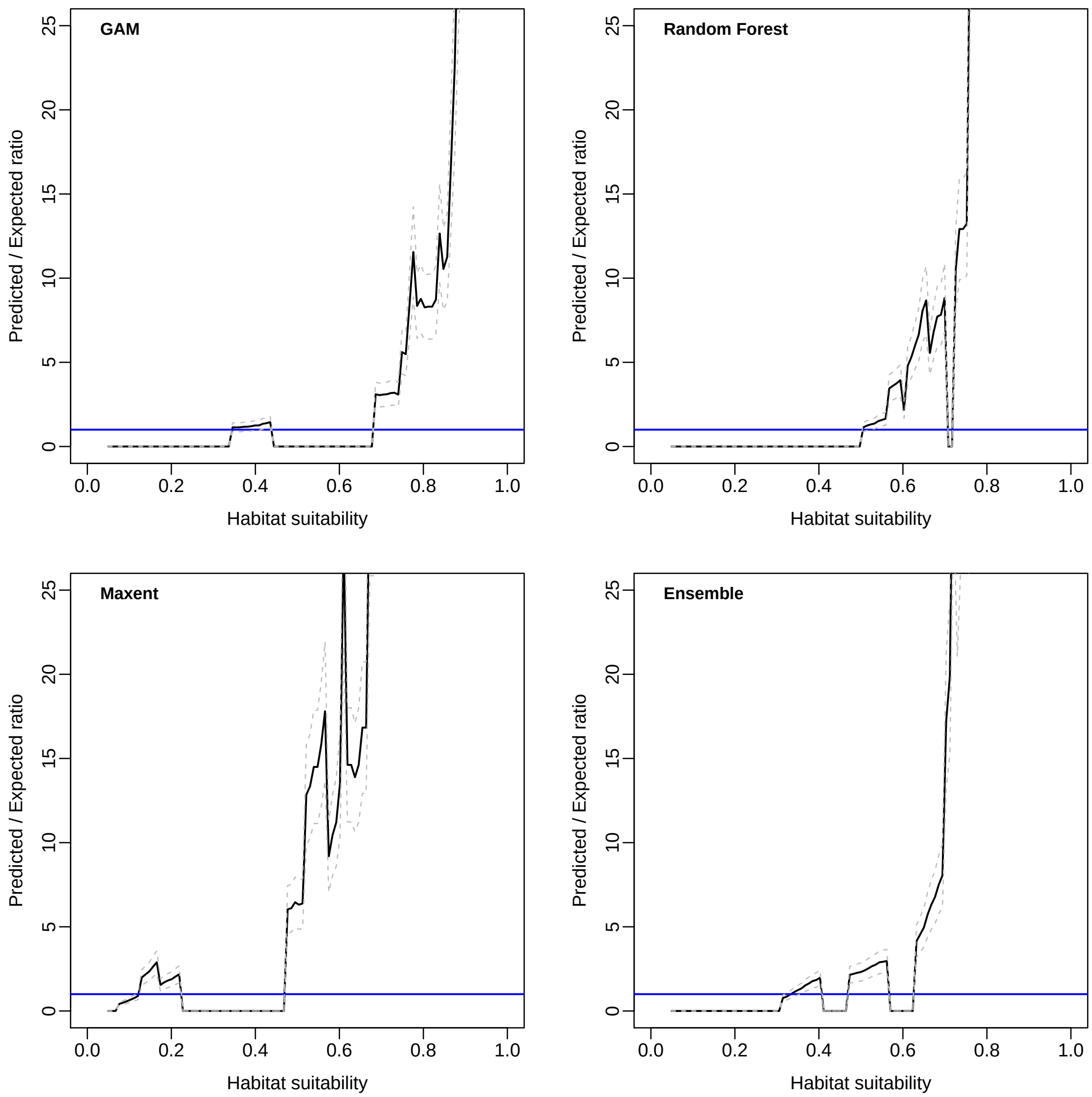


Figure 33. Graphs of Continuous Boyce Indices [CBI] for *Astragalus lentiginosus* models for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

GAM Model

The GAM model ensemble identified 3 contributing variables (Summer Precipitation, Temperature Range, Winter Minimum Temperature) with more than 10% contribution toward the model representing 91% of the model contribution (Table 25). Summer Precipitation had a 53% contribution and had peaked response of predicted habitat suitability, with positive influence of the predictor at values between 45 and 225 mm with a peak at ~ 90 (Figure 34). Temperature Range was the second highest contributor with 20% influence. It had a predicted linear response to habitat suitability, with positive influence on habitat scores at values above 37 (Figure 34).

Winter Maximum Temperature contributed 18% to the model and also had a peaked response with positive influence on predicted habitat values above -1 ºC, peaking at 0ºC, falling gently above the peak (Figure 34). Summer Maximum Temperature, Sandy Soils, and Slope Winter Precipitation each contributed 5 % or less, while five additional environmental variables had zero contribution to the GAM model (Table 25).

The GAM model predicted habitat for this species generally in Virgin and Muddy River corridors, with continued strong predicted habitat along the Lake Mead shoreline in Gold Butte, and near the Government Wash area. Hither areas of habitat were also predicted in the southwestern portion of the Las Vegas Valley, with areas of low to moderate habitat predicted in several of the larger valley areas in the county (Figure 31). This algorithm had higher standard error values (i.e., 0.06 to 0.1) than the other models, with high standard errors in several areas, but most strongly in the northwest corner of the County (Figure 32).

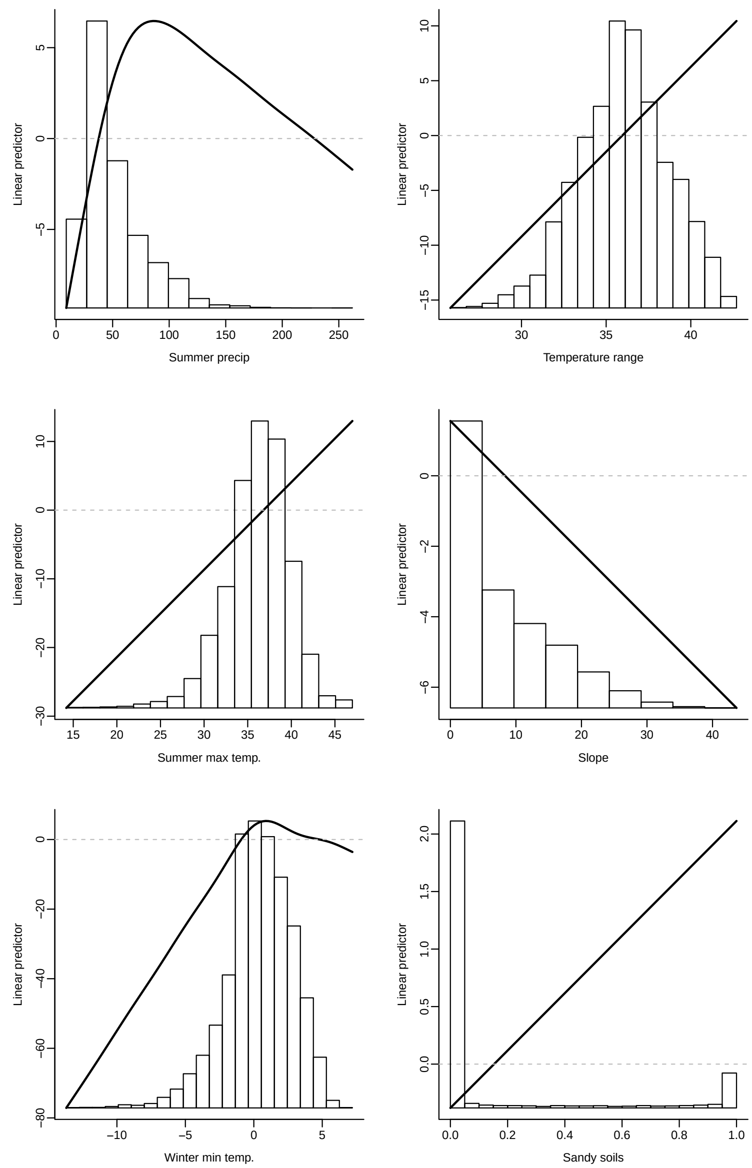


Figure 34. GAM partial response curves for the *Astragalus lentiginosus* model overlaid over distribution of environmental variable inputs in the study area.

MaxEnt Model

The MaxEnt model had four variables contributing 10% or more each, accounting for 98% of model contribution, with an additional four contributing minimally (Table 25). Winter Minimum Temperature was the highest contributing covariate (33%) with a peaked response mirroring the distribution of this metric within the county highest at ~ 1 ºC (Figure 35). Temperature Range also contributed ~ 33%, with an increasing positive response at temperature ranges above 35 ºC, and among the higher temperature ranges within the county (Figure 35). Summer Precipitation had 22% contribution with a nearly linear response starting at values of 30 mm or above, and predicting higher habitat suitability for values above well the average value for the county (Figure 35). Summer Maximum Temperature contributed 11%, with a strong positive response for values above 35 ºC. Collectively habitat was predicted to be in areas of average winter precipitation, but with higher summer precipitation, and with high summer temperatures and annual temperature ranges (Figure 35).

The standard error map for this algorithm showed a few areas of relatively high uncertainty among the models (SE of 0.08 to 0.1), and these near the confluence of the Muddy and Virgin rivers at the northern end of Lake Mead. Error throughout the rest of the County was predicted to be low (Figure 32).

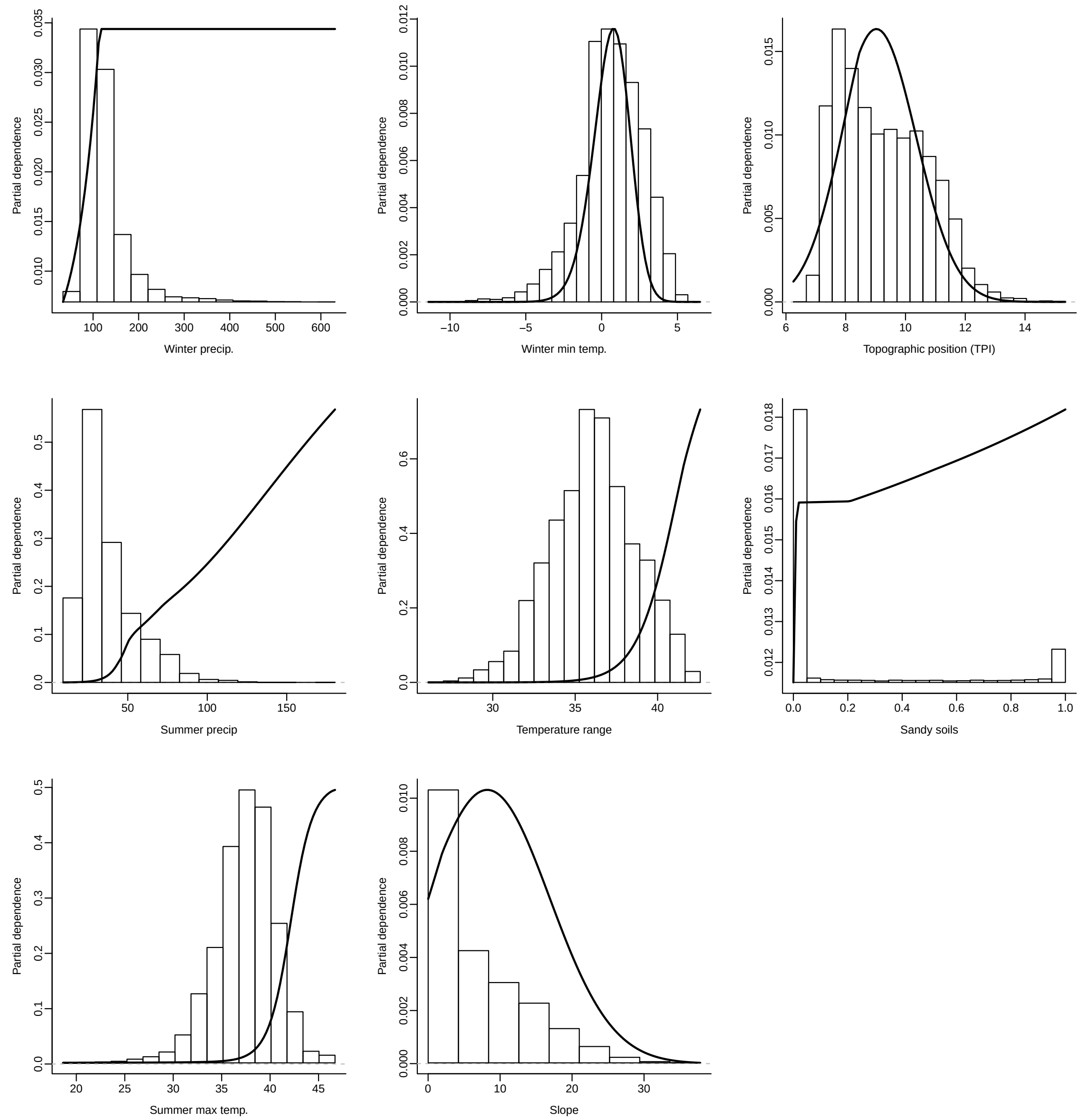


Figure 35. Response surfaces for the top 9 environmental variables included in the MaxEnt ensemble model for *Astragalus lentiginosus.*

Random Forest Model

The RF models had four environmental variables contributing 10% or more totaling 77% of total model influence. The highest contributing environmental variables were Temperature Range, Summer Maximum Temperature, Summer Precipitation, and Winter Minimum Temperature (Table 25). Higher habitat suitability was predicted in areas with higher temperature rages, notably 38 and above, and near the higher end of the values present within the county (Figure 36). Higher Summer Maximum Temperatures were also associated with higher habitat suitability, with a strongly positive response above 37 ºC, and at the higher end of maximum summer temperatures in the county. Summer Precipitation was also positively associated with habitat predicted for areas with ~ 47 mm and higher (Figure 36). Standard error maps for this model indicated relatively moderate SE levels (0.04 to 0.06) in lower bajada areas throughout the County (Figure 32), largely in areas of predicted low to moderate habitat (Figure 31). This was the best performing model overall among all models, with the exception of the Correlation measure which was the third highest among the four (Table 24).

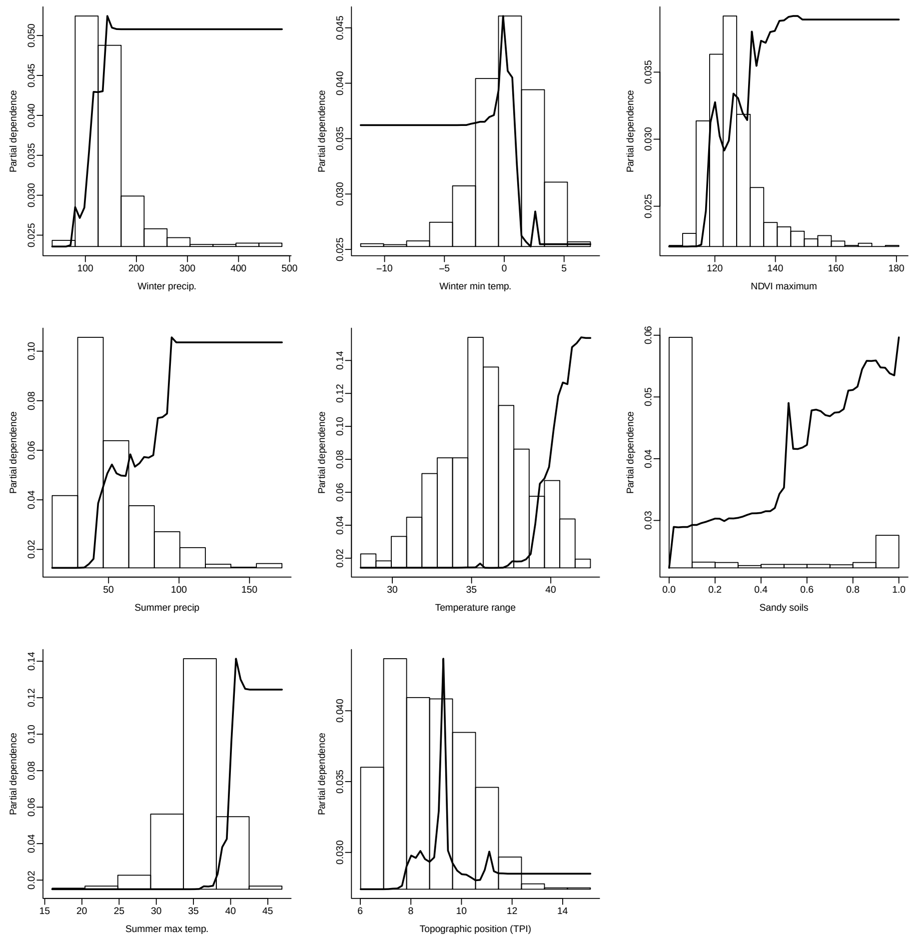


Figure 36. Partial response surfaces for the environmental variables included in the RF ensemble model for *Astragalus lentiginosus*. Histograms represent the range of each environmental variable across the x-axis, and predicted dependence relative to habitat suitability values are on the y-axis.

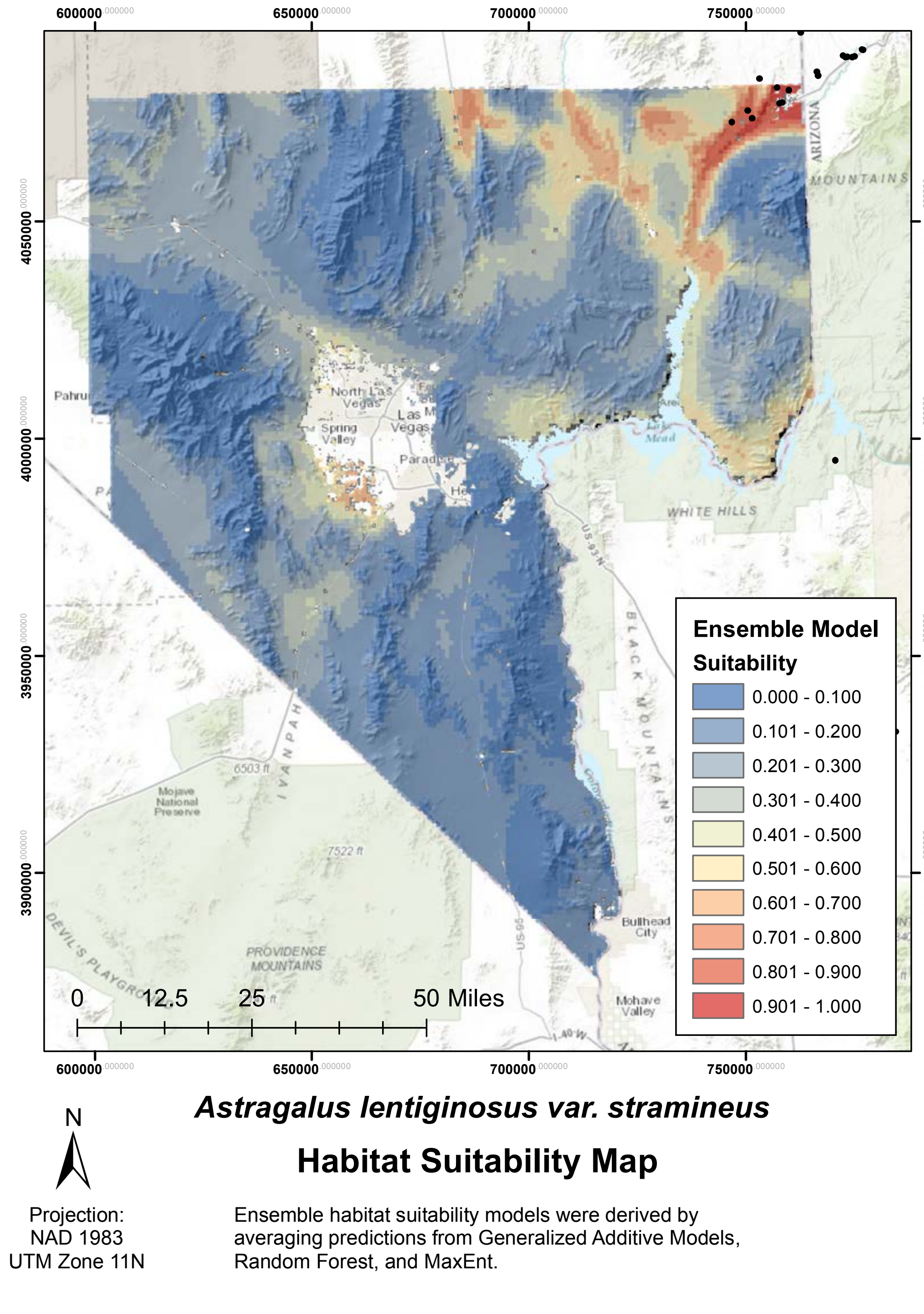


Figure 37. SDM map for the *Astragalus lentiginosus* Ensemble model.

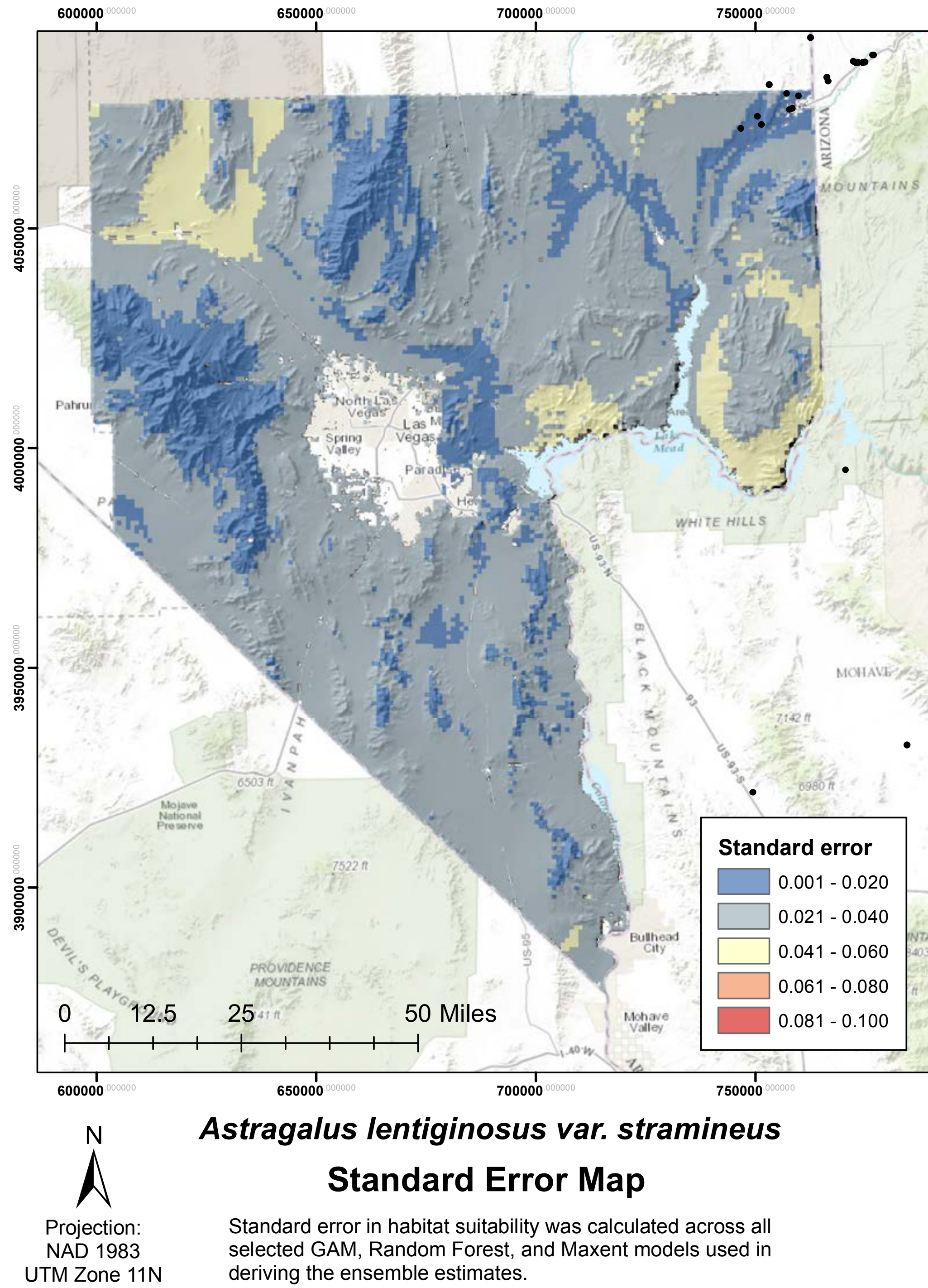


Figure 38. Standard Error map for the *Astragalus lentiginosus* Ensemble model.

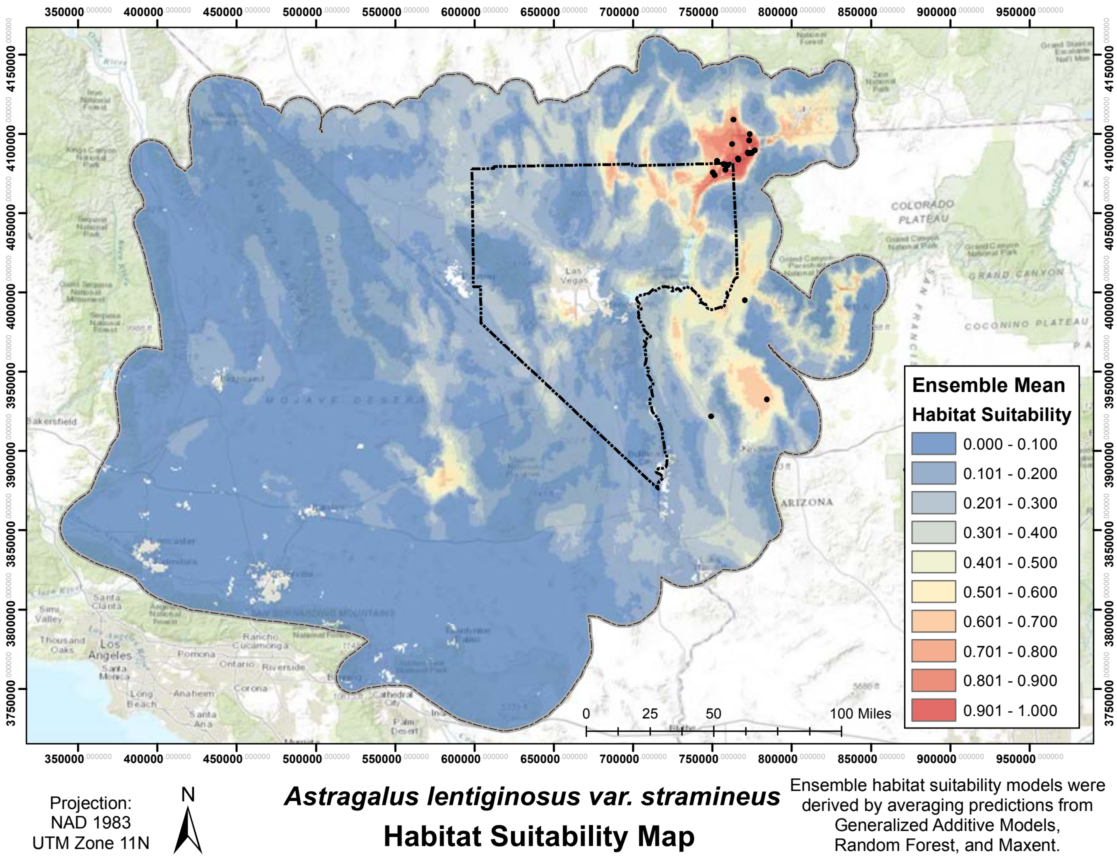


Figure 39. Habitat suitability map for the *Astragalus lentiginosus* ensemble model for the entire Mojave Desert.

Distribution of Localities

Localities (N=29) for Straw Milkvetch are distributed in Clark County, generally only in the upper extent of the Virgin River and Beaver Dam Wash area near Mesquite (Figure 37), other localities used in modeling at the broader extent were in extreme southwestern Utah, and the Arizona strip, with the other isolated locations in Arizona (Figure 39).

Standard Error

The standard error for the ensemble habitat suitability model for Straw Milkvetch indicates fairly widespread low level error (SE 0.02 – 0.04) throughout the lower elevation areas within the County. Areas of moderate error (SE 0.04 – 0.06) are in the southern extent of Gold Butte, Government Wash, and areas on the Nevada National Security Site north of highway 95 in the northwestern portion of the County (Figure 38).

Distribution and Habitat Use within Clark County

Within Clark County, *A. lentiginosus var. stramineus* is known to occur along the Virgin River's main stem, and along its intermittent tributaries and nearby roads

(SEINet 2017). *A. l. stramineus* is dependent on deep sand or sand dunes in Nevada and occur on deep, loose, sandy soils (BLM LCLA Environmental Impact Statement 2009). The highest predicted habitat for the species is contained within the Mojave Desert Scrub ecosystem, with lesser area within Desert Riparian, and Mesquite Acacia ecosystems (Table 26). Moderate habitat is also predicted in Blackbrush and Salt Desert Scrub, although in much smaller total area (Table 26)

Modeled habitat in the County is predicted to be highest in the Virgin river and Beaver Dam Wash, with relatively high habitat also predicted in the Moapa Valley, and in and around Alamo (Figure 37). Broader regions of moderate habitat are predicted along the Lake Mead shorelines along gold butte, Government wash, and along the I=15 corridor (Figure 37).

Table 26. Ecosystems within Clark County, and the area (Ha) of Low Medium and High predicted suitability within each ecosystem.

Ecosystem	Low	Medium	High
Alpine	124	0	0
Blackbrush	408959	6286	0
Bristlecone Pine	7565	0	0
Desert Riparian	2972	2284	5499
Mesquite Acacia	13604	4800	1444
Mixed Conifer	27339	0	0
Mojave Desert Scrub	904498	314444	67452
Pinyon Juniper	115879	15	0
Sagebrush	4707	0	0
Salt Desert Scrub	71622	7963	0

Ecosystem Level Threats

This species is directly threatened by development within its habitat. It is known to occur within a has a very limited range in the Mesquite area (Figure 31), which is also an area of growing urban populations. Conversion of BLM lands to private ownership may further reduce relatively more protected habitat for this species (NNNPS 2003). Among the DCP ecosystems listed as present in the MSHCP, modeled habitat for this species is largely found in Mojave Desert Scrub, with areas of higher habitat suitability also found in Desert Riparian, and Mesquite Acacia ecosystems (Table 26). Moderate habitat for this species also occurs in Blackbrush and Salt Desert Scrub ecosystems, but most of the predicted habitat is within Mojave Desert Scrub (Table 26).

Threats to Species

The Clark County Multiple Species Habitat Conservation Plan (2000) lists several potential threats for Mojave Desert Scrub habitat. Some that may apply more to Straw Milkvetch than others, The listed threats include:

1) Commercial collection
2) Habitat degradation
3) Fires and fire management
4) Recreation activities
5) Pesticides and herbicides
6) Highways, roads, and trials
7) Grazing
8) Mining
9) Development
10) Exotic and introduced species

This species is directly threatened by development and habitat loss. Since this species has a small distribution near Mesquite, Nevada local land development for urbanization and associated infrastructure are the most proximate direct threats. For example, the Environmental Assessment for a recent expansion of electric power transmission near Overton Nevada, found this species present in the project area, and identified potential impact (BLM 2014). This species is locally common in sandy habitats, and thus populations could be impacted by OHV and grazing activities that frequent those areas (Contu 2012, BLM 2014).

Existing Conservation Areas/Management Actions

While the species in particular has not been monitored or managed, it is known to occur in Mojave Desert Scrub which is home to other species of interest including the Mojave Desert Tortoise (Clark County 2000). It frequently occurs with other sensitive species (BLM 2014) and thus habitat protections afforded others may aid in the conservation of this species (e.g. Threecorner Milkvetch, Sticky Buckwheat, and dune sunflower, BLM 2014).
Mojave Desert Scrub habitat land ownership within Clark County is distributed as follows:

BLM (64.2%)
NPS (13.6%)
USFWS (USFWS and NAFR) (1.3%)
Boulder City (Boulder City Easement) (2.6%)
State of Nevada (State Parks) (1.0%)
NDOW (Overton Wildlife Management Area) (<1%)
Private holdings, Native American reservations, and portions of the USAF ISAFAF and NAFB (8.7%)

Summary of Direct Impacts

Nearly 1/3 of the total high suitability habitat for this species is located within conserved areas (Table 27). While 76 km^2 are already disturbed, another 155 km^2 will be potentially impacted in the current plan. Moderate habitat will also be conserved to a large degree (819 km^2), 202 km^2 is already disturbed, and an additional 384 km^2 is likely to be impacted (Table 27).

Table 27. Categorized modeled habitat values (High, Medium, and Low) and the average area (Hectares) predicted in the potential impact areas, conservation areas, already disturbed areas, and overall area

Habitat Level	Impact	Conserved	Disturbed	Area (Hectares)
High	15550	24698	7640	75831
Med	38442	81943	20262	345392
Low	68479	406768	23413	1593995

ASMOHE - Halfring Milkvetch (Astragalus mohavensis var. hemigyrus)

The Halfring Milkvetch (*Astragalus mohavensis* var. *hemigyrus*) is an annual or short-lived perennial species (Spellenberg 1993). Clokey (1942) originally described it as a "low bushy, silvery perennial". The variety is 5-35 cm tall and the petals are cream or purple. *Astragalus mohavensis* var. *hemigyrus* has a close relative that occurs in similar types of habitats, but on opposite sides of the Spring Mountains in Clark County, Nevada. The fruits differ between the two varieties, where *A. m.* var *hemigyrus* has a reflexed tip of the fruit, the *A. m.* var. *mohavensis* fruit is straight (Spellenberg 1993). This species is usually inventoried from April through June, but detailed phenological information is not available (NNHP 2001).

Species Status

US Fish and Wildlife Service Endangered Species Act: Not listed
US Bureau of Land Management (Nevada): No Status
US Forest Service (Region 4): No Status
State of Nevada (NAC 527): No Status
NV Natural Heritage Program: Global Rank G3G4T2T3; State Rank S2S3
IUCN Red List (v 3.1): No status
CITES: No status

Range

Astragalus mohavensis var. *hemigyrus* has been located in Clark, Lincoln, and Nye counties, Nevada (NNHP 2001). The elevational range for this species is 914-1670 m (NNHP 2001). This species was once reported from Darwin Mesa in Death Valley, Inyo County, California (1941), but is currently thought to be extirpated at that site. This species is currently only known from Nevada, which is where the type locality was collected (Spellenberg 1993).

Population Trends

Population trends are unknown for this species, however, it is thought to be extirpated from California (Spellenberg 1993). There were 43 individuals counted in an area of 164 ha during censuses (NNHP 2001).

Habitat Model

Localities collected for 208 Halfring Milkvetch locations were used to create statistical habitat suitability models. The three modeling algorithms predicted habitat in similar geographic areas, but with differing areal extent. GAM models predicted the most area, followed by the RF model, which had diminished values overall, and reductions in habitat in the Bird Spring/Goodsprings area and the Ivanpah Valley, while MaxEnt predicted very restricted habitat patches relative to the other two models (Figure 40). Performance was highest in 3 of the four overall metrics for the RF model followed by the Ensemble model and GAM models. While all models had similar AUC scores TSS scores, and Correlation values, the MaxEnt had a much - reduced Boyce Index (Table 28). Similarly, the continuous Boyce index indicated performance issues with the MaxEnt model, specifically in the habitat suitability in the 0.6 to 0.8 range where a significant reduction in performance occurs (Figure 42). Standard errors were greatest for the GAM model, with elevated error relative to the other algorithms in the habitat predicted in the Nevada National Security Site, the Wee Thump Wilderness Area west of Searchlight, and the Mesquite area in the northeastern extent of the county (Figure 41).

The CBI for the Ensemble mode indicated good model performance (Figure 42), and was the second highest reported BI compared to the three algorithms. Approximated bins for the ensemble model based on the CBI were 0-0.45 unsuitable, 0.5-0.6 marginal, 0.6 to 0.65 suitable, and 0.7 -1 optimal habitat; with a suggested cutoff threshold of ~ 0.5 (Figure 42) and the threshold value calculated from ROC statistics for the ensemble model was 0.5 (Table 28).

Table 28. Model performance values for *Astragalus mohavensis* models.

Performance	GAM	RF	MaxEnt	Ensemble
AUC	0.968	0.982	0.966	0.974
BI	0.643	0.678	0.493	0.694
TSS	0.889	0.911	0.875	0.903
Correlation	0.852	0.887	0.808	0.874
Cut-off	0.691	0.606	0.206	0.499

*threshold at which sum of sensitivity (true positive rate) and specificity (true negative rate) is highest

Table 29. Percent contributions for input variables for *Astragalus mohavensis* for ensemble models using GAM, MaxEnt, and RF algorithms

Term	GAM	RF	Max	Avg
Surface Texture (ATI)	28.917	15.10	31.586	29.384
Winter Min Temp	23.509	17.33	35.574	30.271
Summer Max Temp	22.334	15.17	7.719	19.278
Temperature Range	12.017	9.71	2.537	10.781
Surface Roughness (TRI)	8.877	11.51	20.164	16.703
NDVI Maximum	2.083	4.84	0.673	3.871

Term	GAM	RF	Max	Avg
Heat Load Index (HLI)	1.485	4.90	0	3.484
Annual Heat/Moisture Index	0.777	9.69	1.01	6.507
Winter Precipitation	0	6.27	0.633	4.04
Slope	0	5.49	0.104	3.383

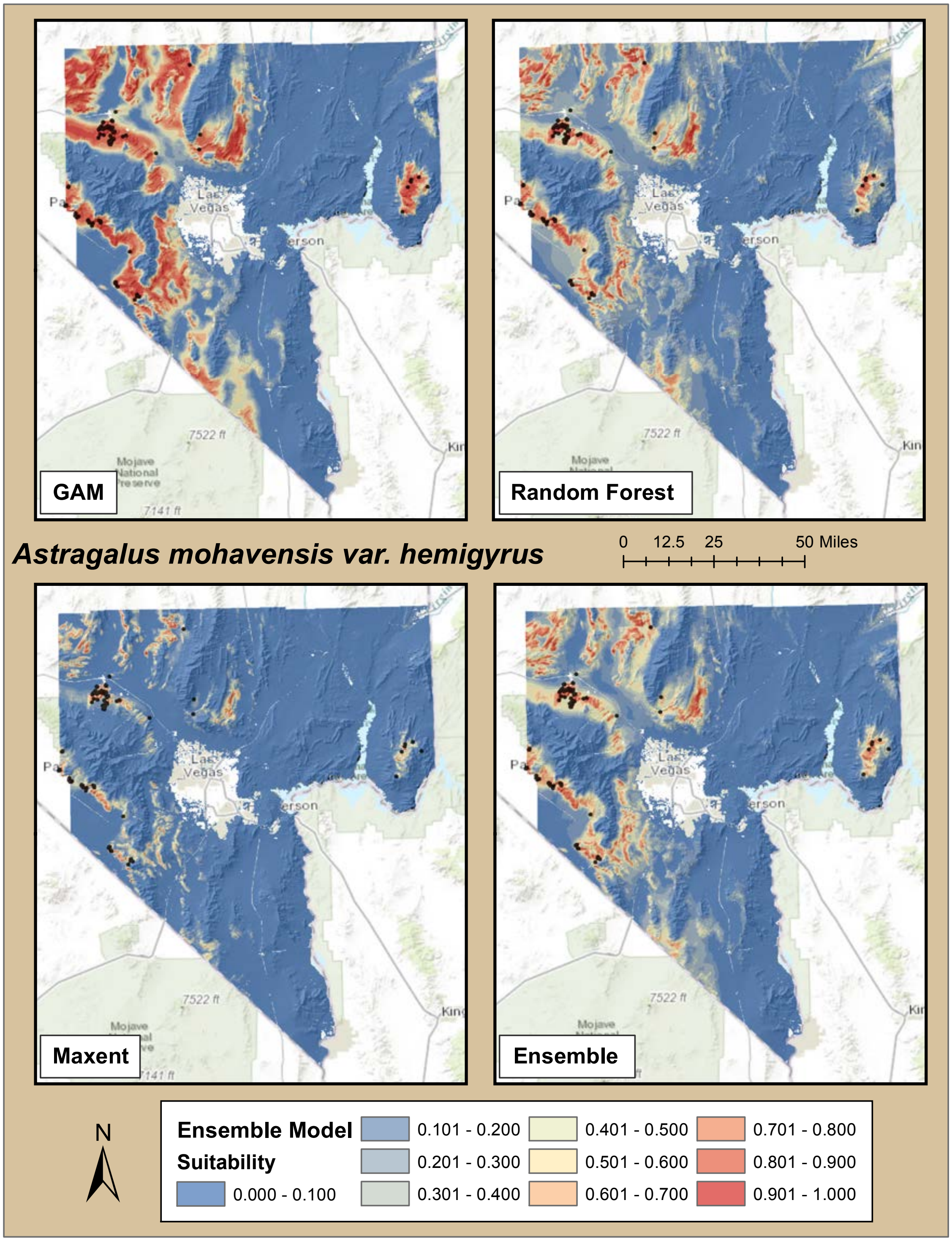


Figure 40. SDM maps for *Astragalus mohavensis* for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

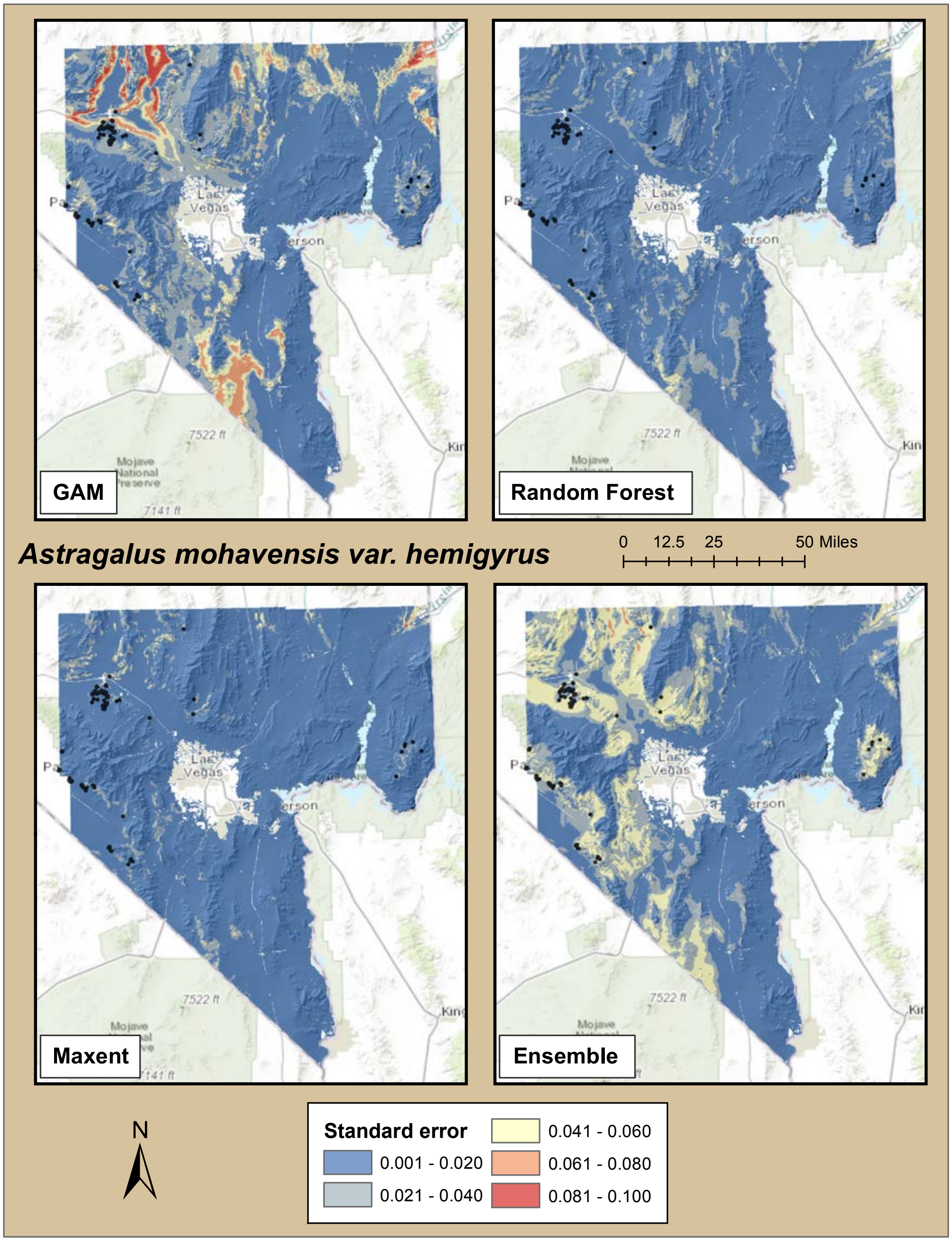


Figure 41. Standard error maps for *Astragalus mohavensis* models for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

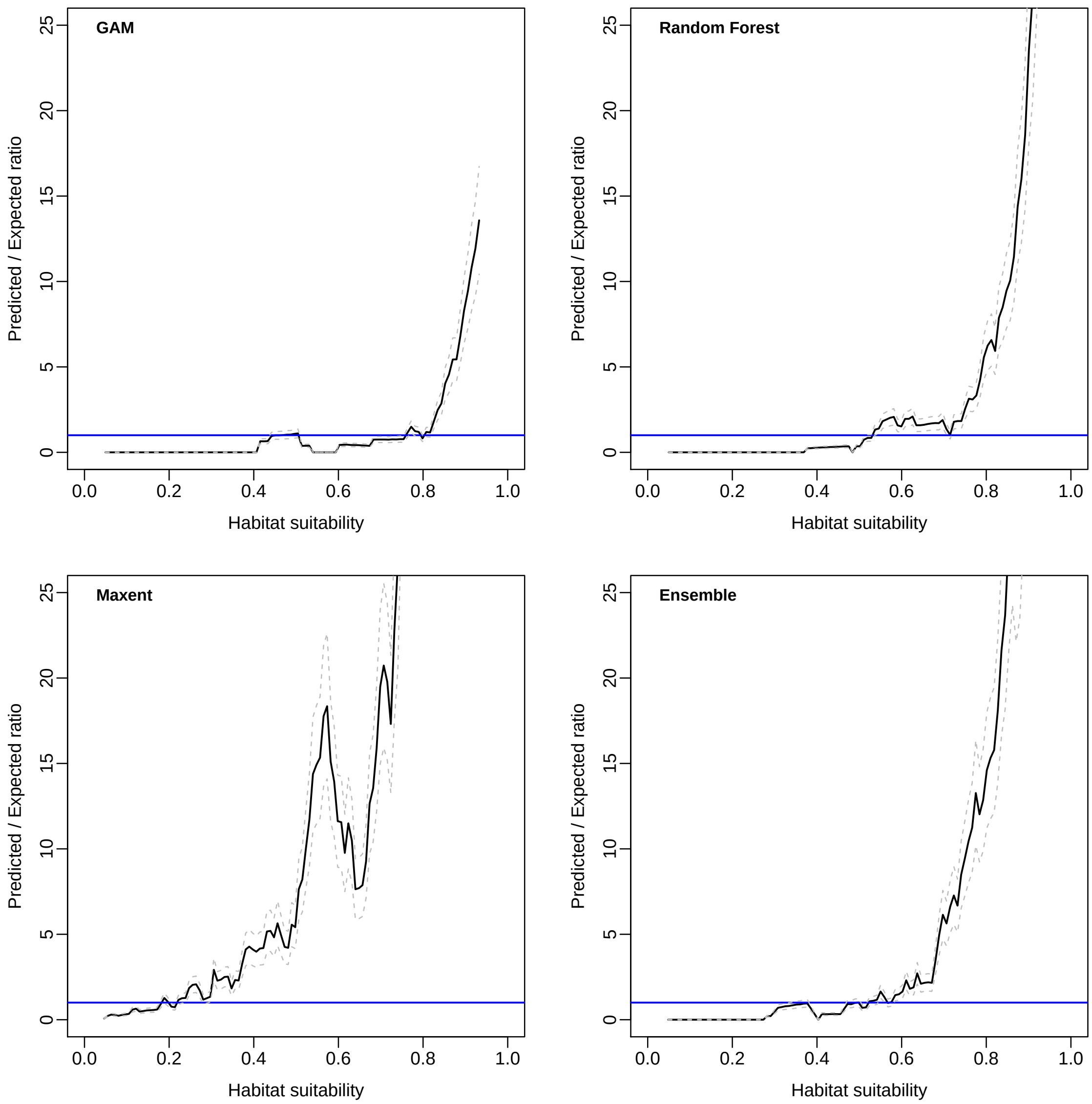


Figure 42. Continuous Boyce Indices for *Astragalus mohavensis* models for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

GAM Model

The GAM model ensemble identified 4 contributing variables (i.e., Surface Texture, Winter Minimum Temperature, Summer Maximum Temperature, and Annual Temperature Range) with more than 10% contribution toward the model representing 87% of the model contribution (Table 29). The Surface Texture index had 29% contribution and had a thresholded response to predicted habitat suitability, with positive influence of the predictor at values between 900 and 1200, and similar to the relative distribution of Surface Texture values throughout the study area (Figure 43). Winter Minimum Temperature was the second highest contributor with 24% influence, with a partial response curve indicating higher suitability at cooler winter temperatures with a negative influence on suitability decreasing linearly up to with a sharp decrease in predicted suitability above 1 ºC, and the influence becoming negative with respect to the predictor above 2 ºC. Summer Maximum Temperature contributed 22% to the model and had a thresholded response with suitability where temperature had a positive influence on habitat suitability only at temperatures between ~ 30 – 37 ºC, with strong negative influence below 30 ºC. Annual Temperature Range had a contribution of 12% with negative influence below a range of 33, and a positive influence between 33 and 38 ºC, tending lower above that range with some indication of a statistical artifact above 40 (Figure 43). Contributions from Surface Roughness, NDVI Maximum, Heat Load Index, and Annual Heat / Moisture Index were also in the model. Winter Precipitation and Slope each had zero contribution to the GAM model (Table 29).

The GAM model predicted habitat for this species generally in the western half of the county, with habitat predicted in foothill locations at the bases of taller mountains. There was also one patch of habitat predicted in Gold Butte NM (Figure 40). This algorithm had higher standard error values (i.e., 0.06 to 0.1) than the other models (Figure 41).

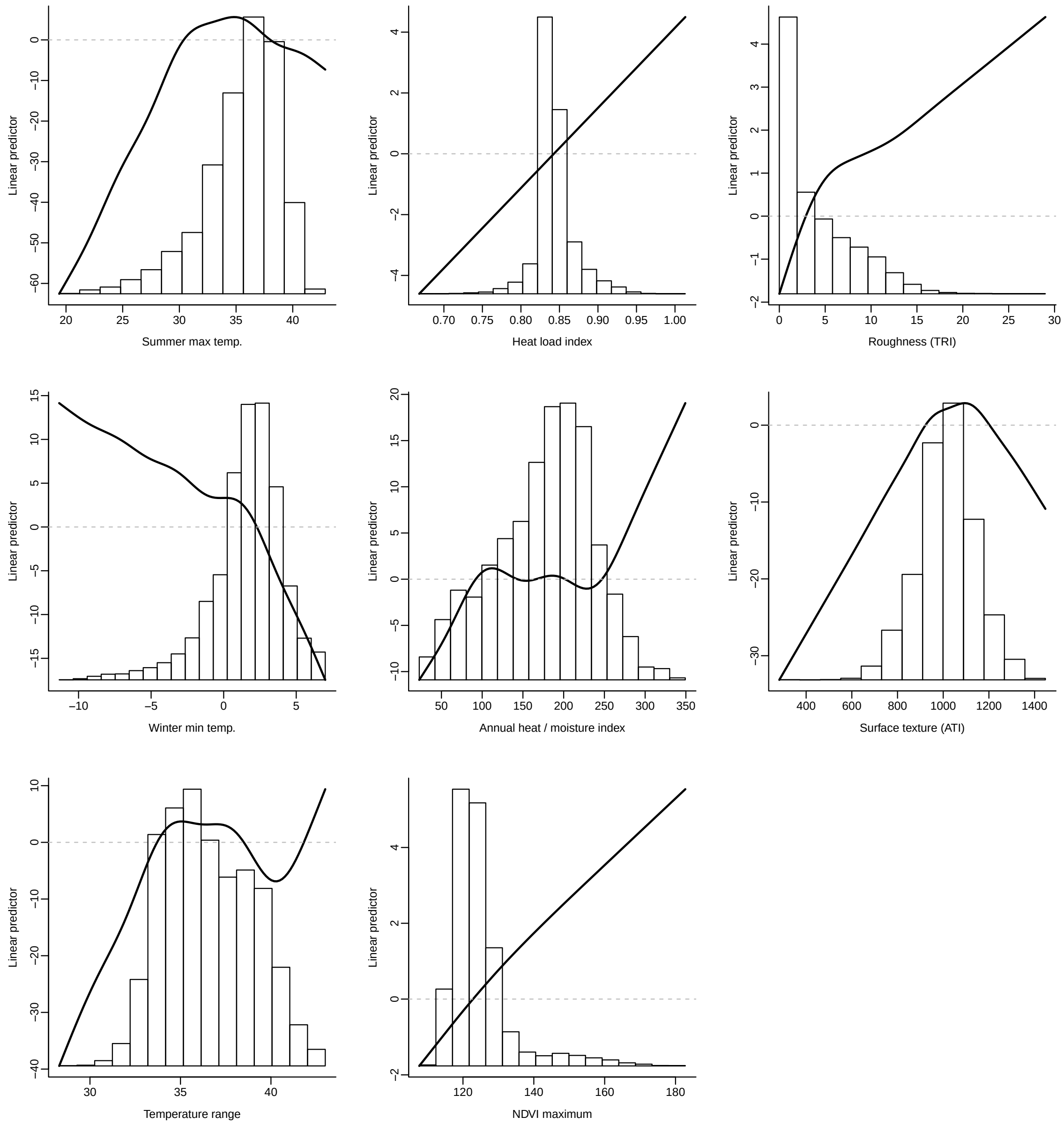


Figure 43. GAM partial response curves for the *Astragalus mohavensis* model overlaid over distribution of environmental variable inputs in the study area.

MaxEnt Model

The MaxEnt model had three variables contributing 10% or more each, accounting for 87% of model contribution, with an additional six contributing 12% collectively (Table 29). Winter Minimum Temperature was the highest contributing covariate (36%) with lower suitability in areas with a lower Winter Minimum Temperature (in contrast to the GAM model, increasing to a peak influence at 0 ºC, falling off sharply above that temperature). Surface Texture had a peaked response that corresponded with the values of this index found throughout the county. Surface Roughness had a generally positive influence, with predicted habitat increasing with increasing roughness values (Figure 44). Summer Maximum Temperature, Temperature Range, Annual Heat/Moisture Index, NDVI Maximum, Winter Precipitation, and Slope each contributed at lower levels, and the Heat Load Index had no influence on the model (Table 29).

The standard error map for this algorithm showed a few areas of relatively low uncertainty among the models (SE of 0.01 to 0.04), and only one small area of elevated SE near Mesquite, Nevada (Figure 41).

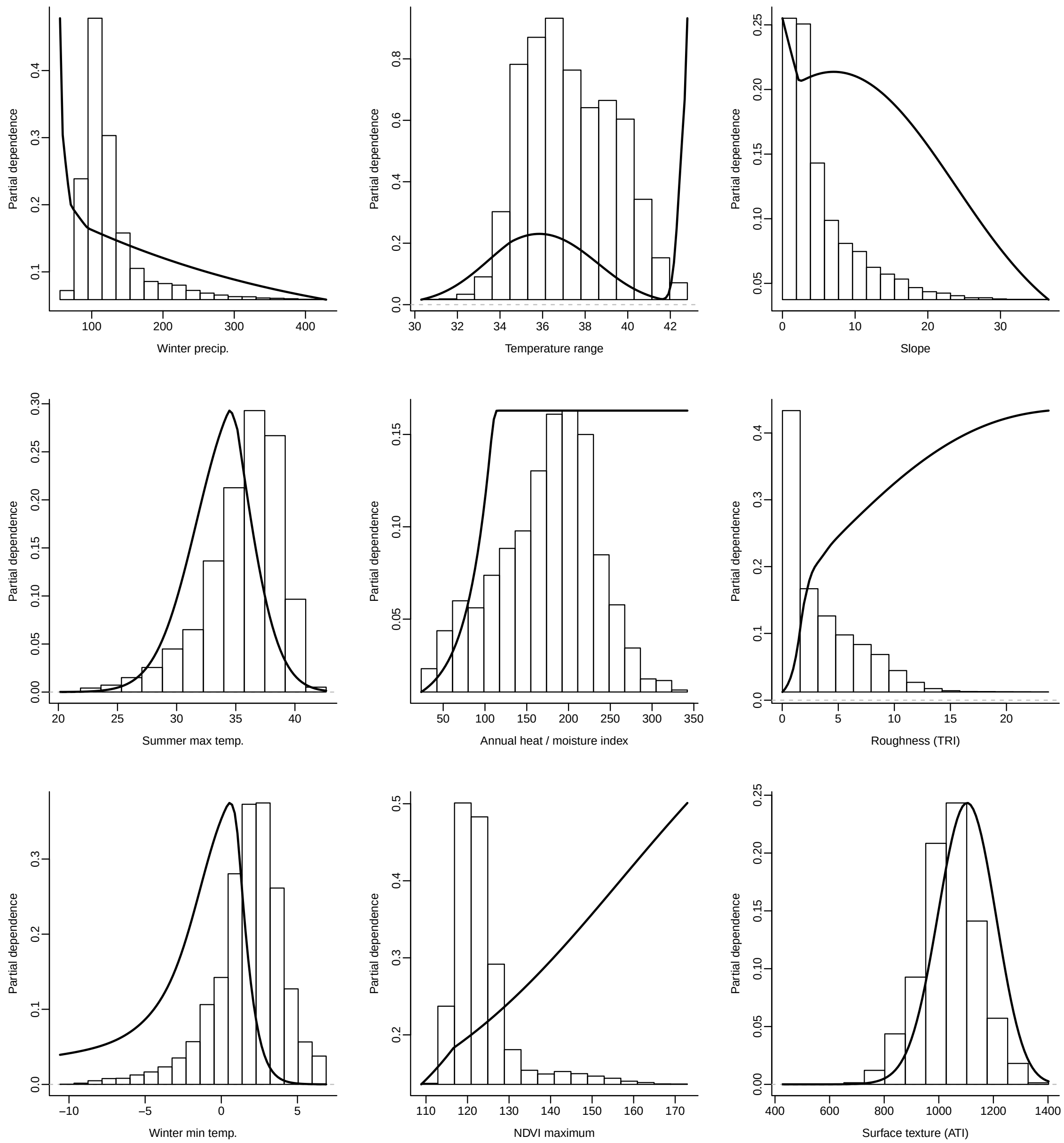


Figure 44. Response surfaces for the top 9 environmental variables included in the MaxEnt ensemble model for *Astragalus mohavensis.*

Random Forest Model

The RF models had six environmental variables contributing 9% or more totaling 78% of total model influence. The highest contributing variables were: Winter Minimum Temperature, Summer Maximum Temperature, Surface Texture, Surface Roughness, Temperature Range, and Annual Heat/Moisture Index (Table 29). Habitat suitability was predicted in areas with lower Winter Precipitation and Summer Maximum Temperatures but an increased temperature range, with higher Roughness and Surface Texture values (Figure 45). Standard error maps for this model indicating relatively few areas of low to moderate error (SE 0.02 – 0.06), with the most prominent of these near the southern end of the McCullough range (Figure 41). This was the best performing model overall among all models, with the exception of the Boyce Index which was the second highest among the four (Table 28).

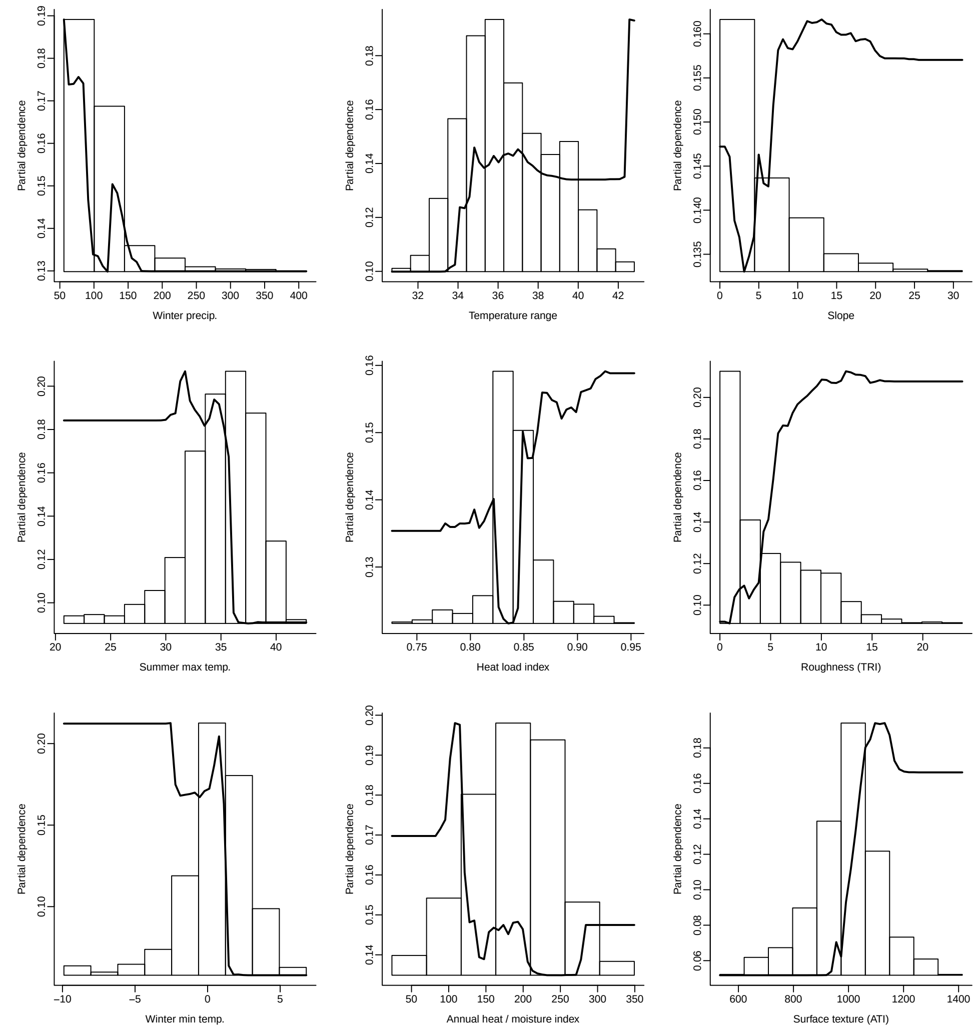


Figure 45. Partial response surfaces for the environmental variables included in the RF ensemble model for *Astragalus mohavensis*. Histograms represent the range of each environmental variable across the x-axis, and predicted dependence relative to habitat suitability values are on the y-axis.

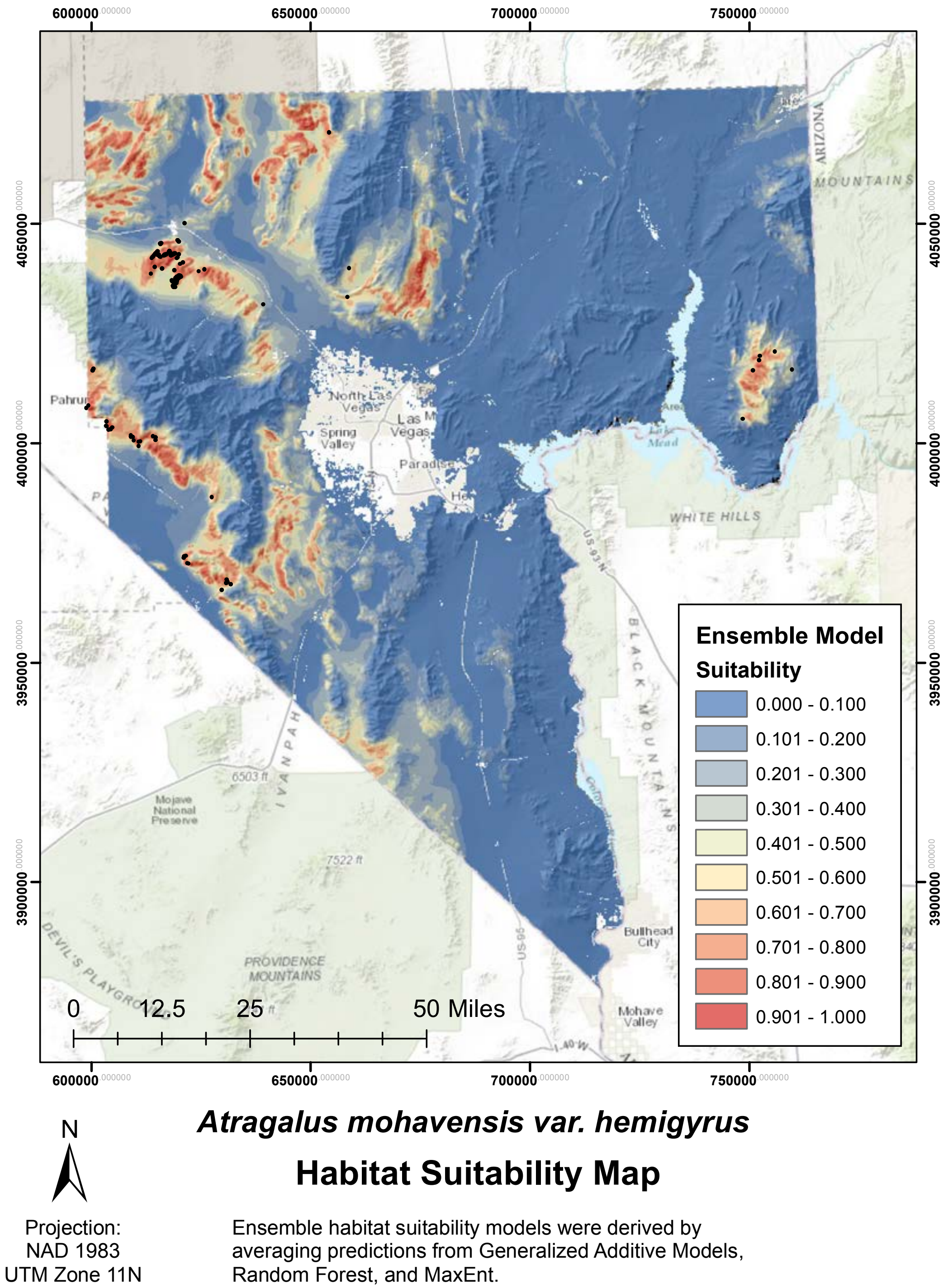


Figure 46. SDM map for the *Astragalus mohavensis* Ensemble model.

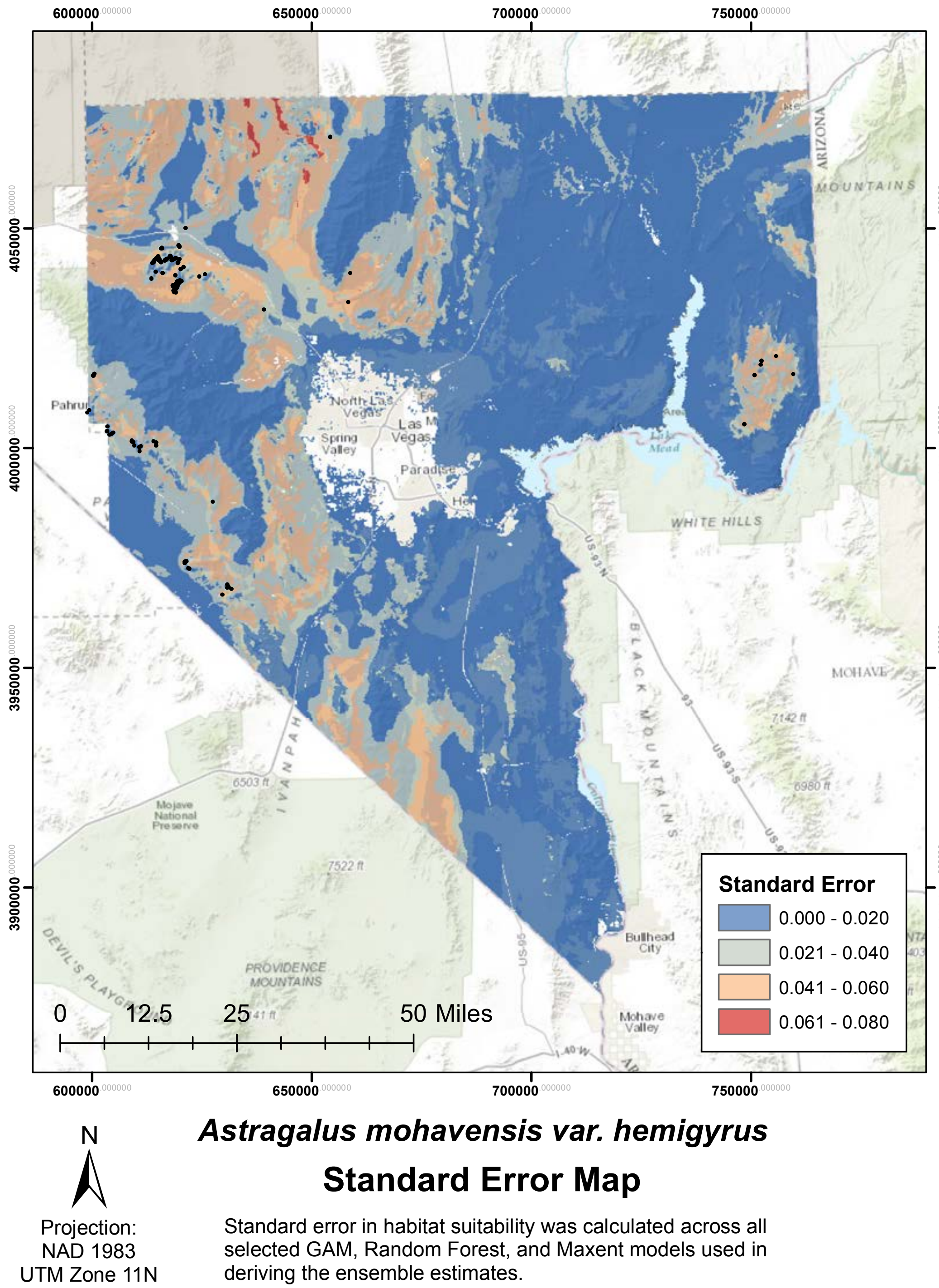


Figure 47. Standard Error map for the *Astragalus mohavensis* Ensemble model.

Distribution of Localities

Localities (N=208) for *Astragalus mohavensis* are distributed in Clark County, generally in the lower foothills of the spring range on the upper alluvial fans, with one population in the lower mountains south central Gold Butte. A few isolated observations are also near the base of the Sheep range north of Las Vegas, and on the Nellis Bombing Range (Figure 46).

Standard Error

The standard error for the habitat suitability model for Halfring Milkvetch indicates fairly widespread but moderate to moderately high (> 0.041) error levels (SE 0.02 – 0.06) throughout the majority of predicted habitat within Clark County (Figure 47). Smaller areas of high standard error exist in the north Desert Range, and the Nellis Bombing Range.

Distribution and Habitat Use within Clark County

Halfring Milkvetch is known from the west slopes of the Spring Mountains and in the Indian Ridge area (Niles and Leary 2007). This species has also been located in the Sheep Range of the Desert National Wildlife Refuge (Ackerman 2003). Predicted high suitability habitat for this species is largely contained within Blackbrush and Mojave Desert Scrub ecosystems, with some incursion into Salt Desert Scrub. Moderate habitat follows this general pattern as well (Table 30).

Halfring Milkvetch has been found among limestone derived soils (Spellenberg 1993). The geomorphic surfaces where it can be found include terraces, hillslopes, and along washes (Niles and Leary 2007). This species is known from creosote-bursage (*Larrea*/*Ambrosia*), mixed desert shrub, and blackbrush (*Coleogyne ramosissima*) communities (NNHP 2001). Clokey (1942) notes that this species is scattered and scarce but located in gravelly soils in the juniper belt from 1500 – 1800 meters in Kyle Canyon at Harris Springs Road on the eastern side of the Spring Mountain range, which is significantly higher than that reported by NNHP (2001).

Please Note: The Jepson Manual chapter on *Astragalus* (Spellenberg 1993, P. 600) presents confounding information wherein the dichotomous key states that the species occurs in “[Desert mountains] (immediately w of Death Valley)”. That statement is confounded later on the same page, where the account of the variety *hemigyrus* states that it is “PRESUMED EXTINCT in CA”. Also, a typographical error occurs where this species and variety is excluded from the index of the manual, and it is spelled *A. Mo**j**avensis* instead of *A. Mo**h**avensis* as it appears elsewhere in the literature.

Modeled habitat in the county is predicted to be high in the foothill areas surrounding the Spring Range, and on the Nevada National Security Site (Figure 46). The Bird Spring, Goodsprings, and Trout Canyon areas are also predicted to be habitat (Figure 46). One isolated patch of habitat is also indicated in Gold butte in the area surrounding the localities there.

Table 30. Ecosystems within Clark County, and the area (Ha) of Low Medium and High predicted suitability within each ecosystem.

Ecosystem	Low	Medium	High
Alpine	124	0	0
Blackbrush	200673	136852	77055

Ecosystem	Low	Medium	High
Bristlecone Pine	7565	0	0
Desert Riparian	10563	27	0
Mesquite Acacia	18860	715	117
Mixed Conifer	27339	0	0
Mojave Desert Scrub	1175078	79878	22498
Pinyon Juniper	112162	2982	681
Sagebrush	4151	418	135
Salt Desert Scrub	43193	26411	9056

Ecosystem Level Threats

The ecosystems where *Astragalus mohavensis* var. *hemigyrus* are found include Mojave Desert Scrub and lower Pinyon/Juniper (*Pinus*/*Juniperus*). These community types are susceptible to invasive grass infestations and wildfire across the northeast Mojave Desert including all of Clark County (Brooks et al. 2007, Van Linn et al. 2013), and plants are potentially susceptible to incineration, loss of seed bank, and competition from invasive grasses (Esque et al. 2010).

Threats to Species

Potential threats to *Astragalus mohavensis* var *hemigyrus* may include off-road vehicle use, and feral horse and burro trampling (NNHP 2001).

Existing Conservation Areas/Management Actions

This species occurs on lands administered by US Bureau of Land Management, US Fish and Wildlife Service, Department of Defense-United States Air Force, USDA-Humboldt-Toiyabe National Forest, and possibly private lands (NNHP 2001). The federal lands provide at least minimum protections through the National Environmental Policy Act. While this species is listed as sensitive and even "critically endangered" within Nevada no active management directed specifically toward this species was found, beyond its presence on lists of species of concern that may occur within jurisdictional boundaries (e.g. Clark County. 2000, NAWS 2002, USFWS 2009)

Summary of Direct Impacts

Direct impacts to this species are limited in high quality habitat (3 km^2) and 38 km^2 are expected to be impacted in the near future. Conserved areas of 113 km^2 of high and 374 km^2 of moderate habitat have been identified. Very little habitat is currently disturbed (Table 31).

Table 31. Categorized modeled habitat values (High, Medium, and Low) and the average area (Hectares) predicted in the potential impact areas, conservation areas, already disturbed areas, and overall area.

Habitat Level	Impact	Conserved	Disturbed	Area (Hectares)
High	290	11321	11	110409
Med	3836	37354	324	248694
Low	118560	464986	39723	1613617

ASMOK - Mokiak Milkvetch (Astragalus mokiacensis)

Astragalus mokiacensis is a robust perennial herbaceous plant species named after Mokiak Canyon, Arizona where it was first found (Barneby 1994). This plant has erect stems growing in ascending clumps and is pubescent overall (McDougall 1973). It has purple flowers that bloom from April through June and the plant can be as tall as 40 cm. Many species of the *Astragalus* genus concentrate poisonous selenium, nitrotoxins, or alkaloids that lead to various illnesses in livestock, but the seeds and plants are favored foods of some wildlife such as the Mojave Desert Tortoise (Esque et al 2015). While presumed close relatives concentrate selenium, it is not known at this time if *A. mokiacensis* concentrate selenium.

Astragalus mokiacensis is very similar to a close relative known as *Astragalus preussii* which grows in similar habitat. The only reliable way to distinguish the two is by examining the seed pods.

Species Status

US Fish and Wildlife Service Endangered Species Act: Not listed
US Bureau of Land Management (Nevada): No Status
US Forest Service (Region 4): No Status
State of Nevada (NAC 527): No Status
NV Natural Heritage Program: Global Rank G2G3Q; State Rank S1S2
IUCN Red List (v 3.1): No status
CITES: No status

Range

Mokiak Milkvetch is found in Clark County, Nevada; Mohave County, Arizona; and Washington County, Utah. The elevational range for this species is documented to be 2461 to 5020 ft (750 – 1530 m, NNHP 2001). It is found between 3000 and 4000 ft. at sites in Arizona, and is known to bloom from April to June (McDougall 1973). Recent research suggests that variants of *Astragalus lentiginosus* are more appropriately population level variants of *A. mokiacensis*, comprising four populations located within northeastern Clark County in Gold Butte and in and around the northern end of Lake Mead National Park, and also across the river on the Shivwits Plateau in Mohave County AZ, through the Arizona Strip, and in Washington County UT (Anderson 2005). Interestingly, the four populations identified all exist in seemingly different habitats, where populations in Gold Butte, Shivwits Plateau and Beaver Dam Mountains are each on different substrates e.g. Beaver Dam plants appear on granitic or basaltic soils, while the others are located on sandstone or limestone substrates, and rarely on areas of wash habitat or mixed alluvial soils (Alexander 2005).

Population Trends

No trend data are available for this species. However, a population estimate of over 550 individuals was noted (NNHP 2001).

Habitat Model

Only 48 localities were available for modeling Mokiak Milkvetch habitat at a 250 m resolution within Clark County NV. In general, low sample size influences habitat suitability modeling negatively and this is manifested in highly variable habitat suitability and error outputs in some of the models. However, expanding the model footprint to the greater Mojave, which required modeling at a 1 km resolution, provided substantially more localities (N = 97). We modeled at both scales, and the Ensemble maps for both resolutions predict habitat in very similar areas (Figure 48, Figure 49), and individual model performance for the Mojave Scale Model appears to be similar, with exception of the Continuous Boyce Indices (Figure 52). Generally, the models predicted habitat in the larger mountain ranges and their upper bajadas within Clark County both at the 250 m and 1 km scales. While most of the points for Clark County are located in the Virgin Mountains, there is one outlier across the Overton Arm of Lake Mead, and the models do not account for this single locality very well. All other known sites are further north, east, or south of Clark County in Utah and Arizona. For the Clark County model the GAM and RF Models predicted similar habitat areas, with some differences in the strength of the habitat prediction, especially around the southern McCullough range. The MaxEnt models predicted much less habitat throughout the county than the other two algorithms, and this is similar to some other species with very low numbers of locality sites (e.g., *Phacelia filiae*) The MaxEnt habitat suitability model predicting mostly only a limited amount of habitat restricted to the mountains in the southern portion of Gold Butte National Monument (Figure 48). Individual models at the scale of the Mojave predicted much more similar area, with differing intensity, but few differences among models (Figure 49). Patterns in model error were also similar between the 250 m vs 1 km scales, but varied considerably among model algorithms. RF had the least error and of the lowest values, followed by the Ensemble, MaxEnt, and Gam models.

The RF model had the highest overall performance measures with the highest AUC and BI scores, and the second highest TSS and Correlation values (Table 32). The Ensemble and GAM models both had equal second ranking – where the ensemble model had higher TSS and correlation scores than all models, but scored 3rd and 4th on AUC and BI. MaxEnt was the poorest performing model, with lower scores than all others except for the BI, for which it was higher than the Ensemble model score (Table 32). Continuous Boyce Index curves were best for the RF Models. Most models had anomalous spikes near habitat suitability values of 0.8 (GAM and RF) or

0.5 (MaxEnt), which carried through to the ensemble model (Figure 52). This is likely due to the relatively small sample size used for modeling. Cutoff values from the BI curves were difficult to interpret, but calculated values were high, with values for all models at 0.6 and above (Table 32).

Table 32. Model performance values for *Astragalus mokiacensis* models.

Performance	GAM	RF	MaxEnt	Ensemble
AUC	0.988	0.991	0.965	0.986
BI	0.529	0.642	0.525	0.471
TSS	0.955	0.966	0.949	0.968
Correlation	0.914	0.914	0.910	0.927
Cut-off	0.742	0.693	0.592	0.677

*threshold at which sum of sensitivity (true positive rate) and specificity (true negative rate) is highest

Table 33. Percent contributions for input variables for *Astragalus mokiacensis* for ensemble models using GAM, MaxEnt, and RF algorithms at the Clark County 250 m resolution model scale, and at the Mojave Desert Ecoregion 1km scale given in the bottom

Term	GAM	RF	Max	Avg
Winter Precipitation	48.005	17.366	48.93	38.1
NDVI Maximum	21.35	18.476	16.67	18.832
Annual Heat/Moisture Index	14.067	17.746	17.5	16.438
Summer Max Temperature	16.0425	6.754	9.056	10.618
Temperature Range	0.535	7.681	1.578	3.265
Surface Texture (ATI)	0	4.364	4.472	2.945
Winter Min Temperature	0	4.513	1.665	2.059
Roughness (TRI)	0	4.89	0	1.63
Slope	0	1.131	0	0.377
Heat Load Index (HLI)	0	0.943	0.126	0.356
Topographic Position (TPI)	0	0	0	0
Mojave Desert 1 km				
Winter Precipitation	19.897	20.976	36.624	25.832
Surface Texture (ATI)	30.3018	7.512	33.245	23.686
NDVI Maximum	25.249	17.134	13.418	18.6
Annual Temperature Range	17.247	10.143	7.744	11.711
Topographic Position (TPI)	7.1741	7.737	4.296	6.402
Slope	0	10.419	1.405	3.941
Summer Max Temperature	0.131	6.027	1.558	2.572
Winter Min Temperature	0	6.027	0.36	2.129
Roughness (TRI)	0	6.311	0	2.104
Soil Water Stress	0	2.905	1.349	1.418

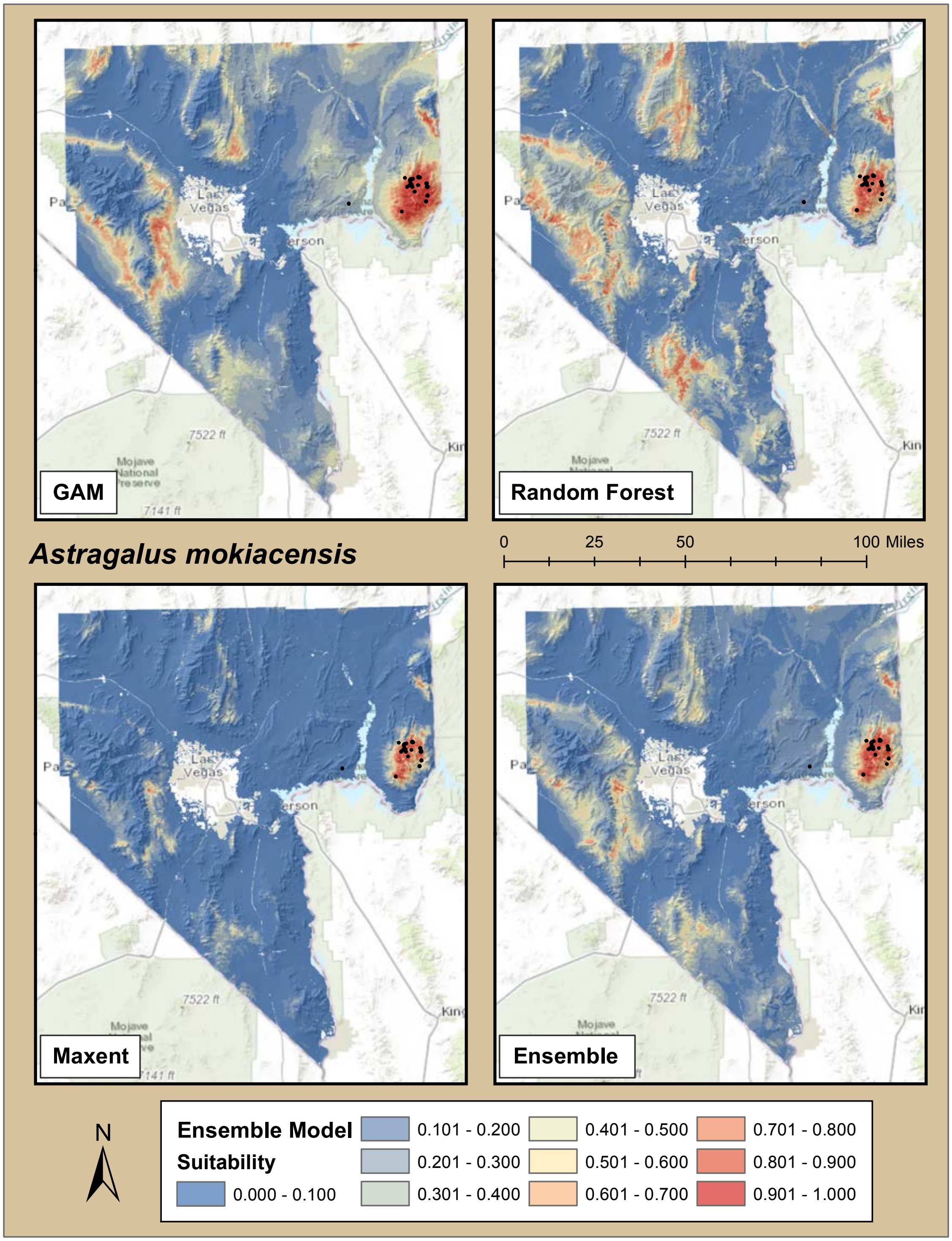


Figure 48. SDM maps for *Astragalus mokiacensis* for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

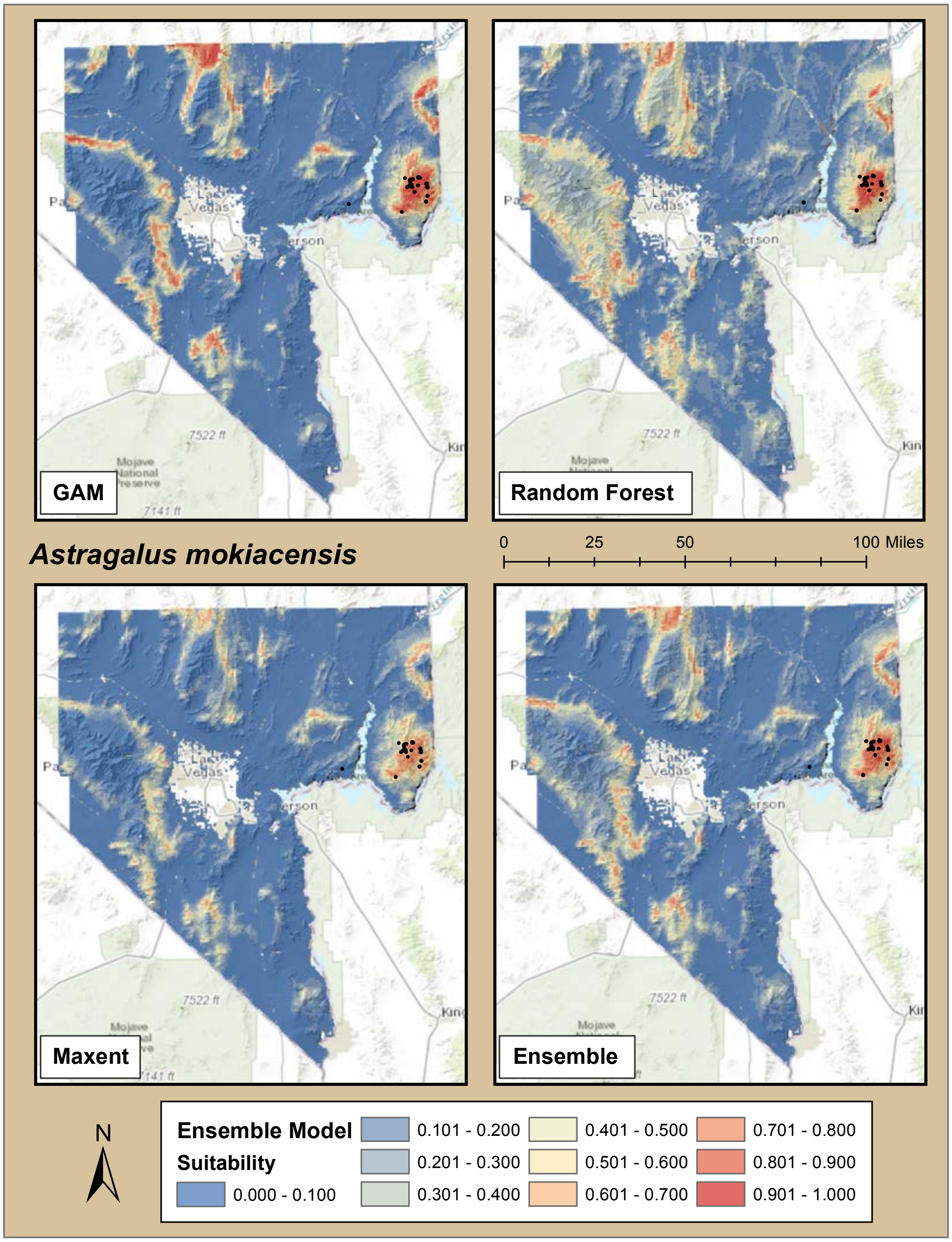


Figure 49. SDM maps for *Astragalus mokiacensis* constructed at a 1km resolution at the scale of the Mojave desert for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

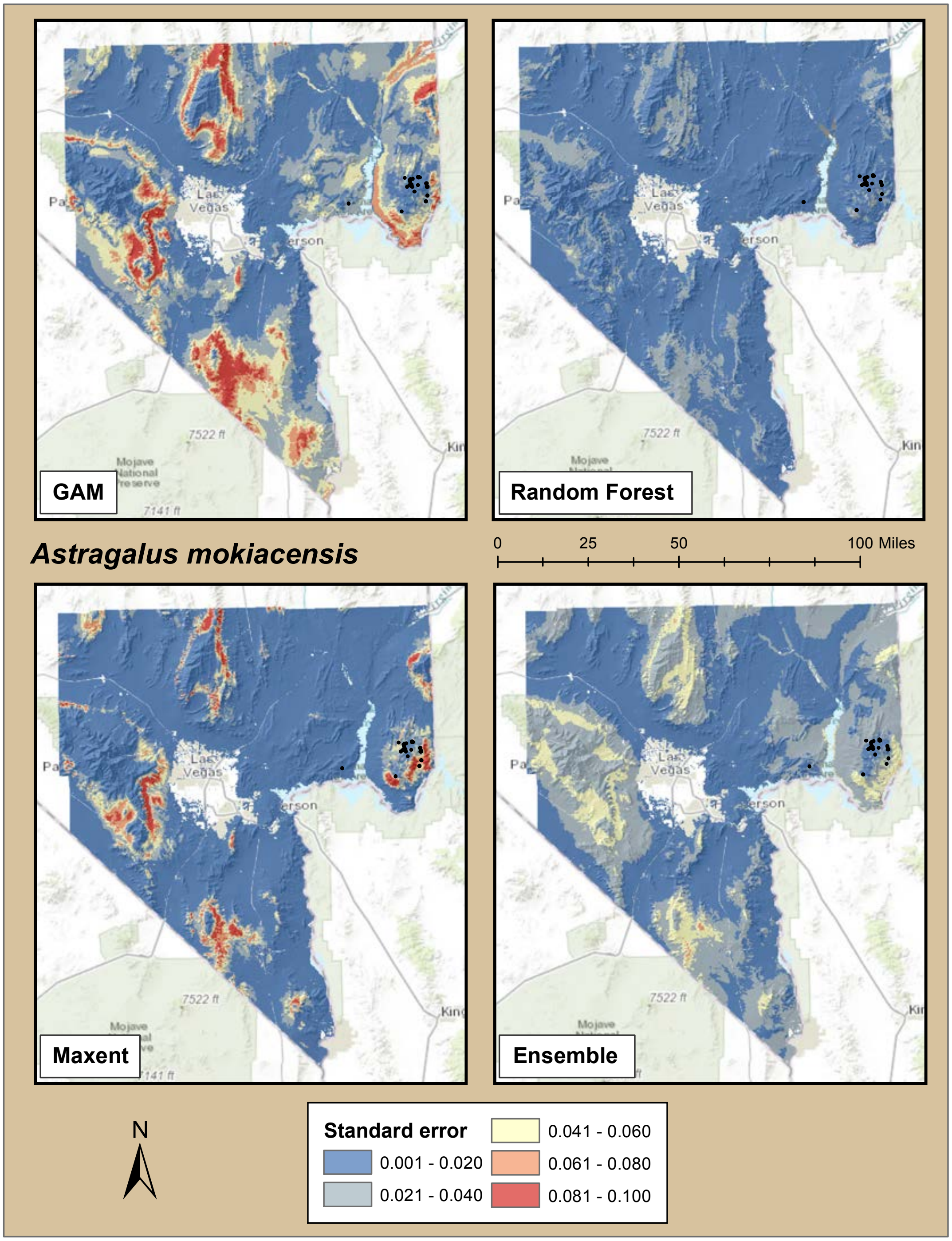


Figure 50. Standard error maps for *Astragalus mokiacensis* models for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

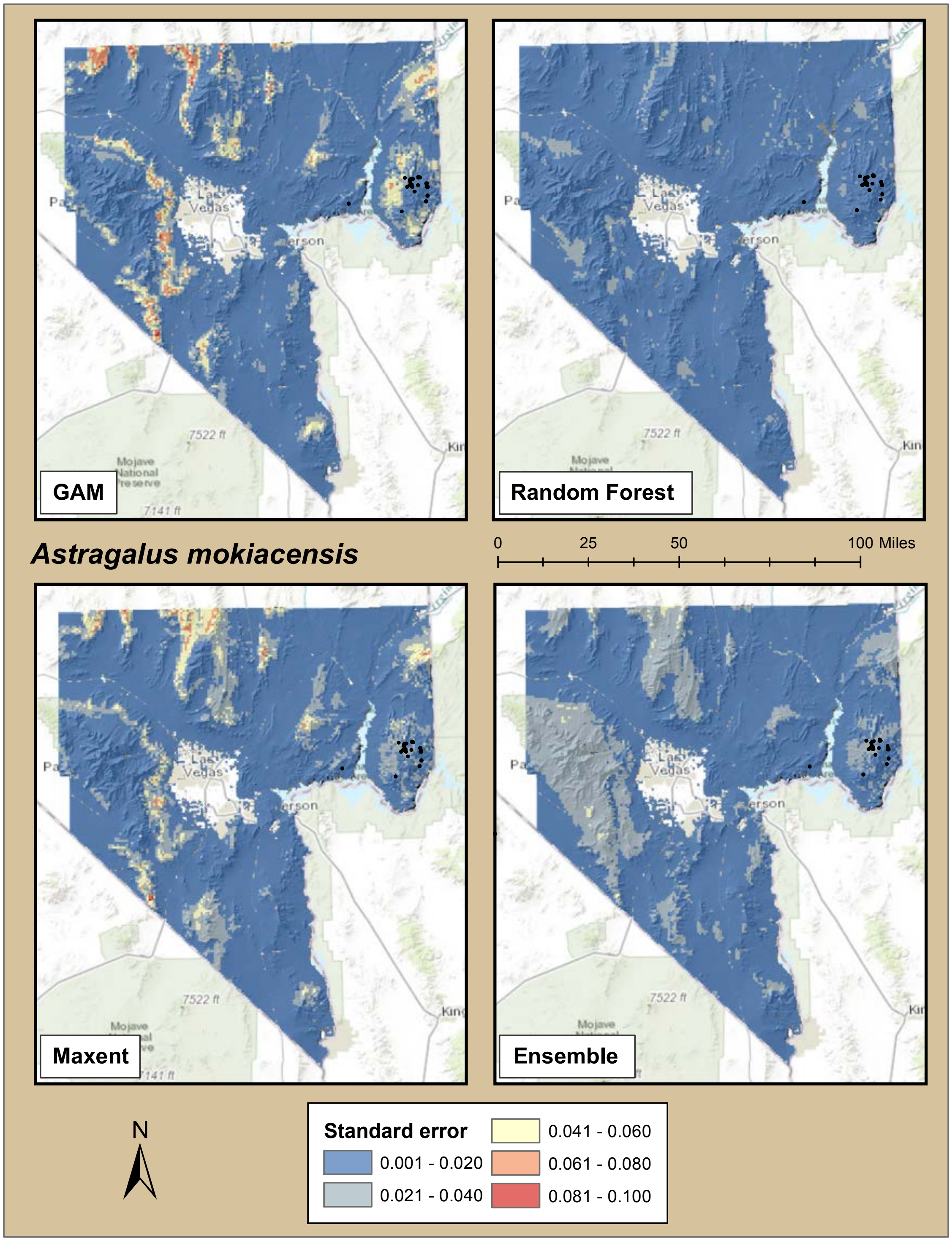


Figure 51. Standard error maps for *Astragalus mokiacensis* modeled at the scale of the Mojave at 1 km resolution for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

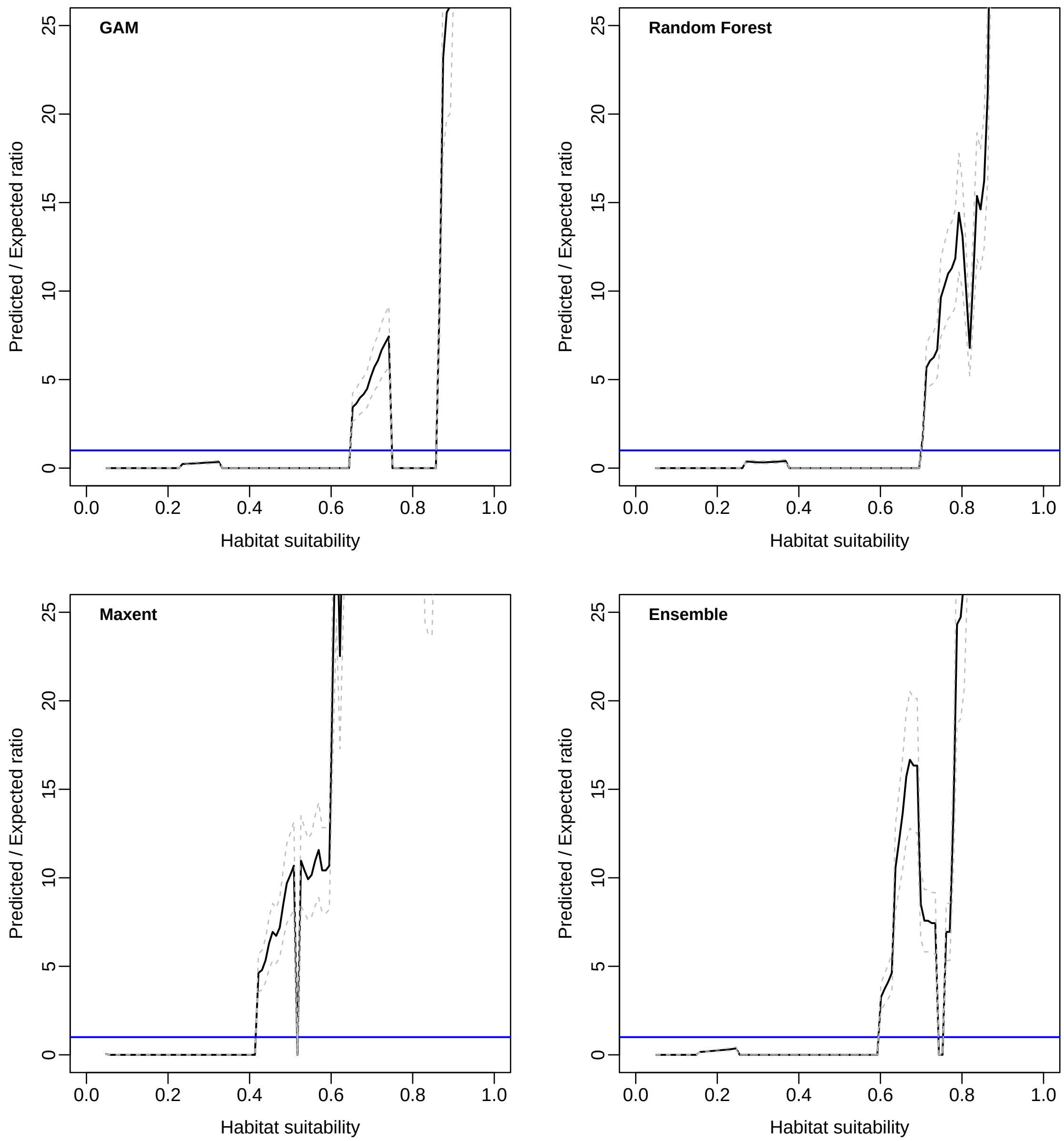


Figure 52. Continuous Boyce Indices for *Astragalus mokiacensis* models for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

GAM Model

The GAM model ensemble for the Clark County footprint identified only 4 contributing variables with more than 10% contribution to the model. Those variables accounted for 99% of the model contribution (Table 33). Winter Precipitation was by far the highest contributor with 48% model contribution, and had a positive influence on predictive habitat at lower amounts (up to ~ 150 mm), with a strongly negative influence at values above ~175 mm (Figure 53). NDVI Maximum contributed to 21%

of the model contribution, and had a thresholded response with positive contributions to suitability at values above values of ~ 120 and leveling off at values above ~140, decreasing thereafter as higher values became rare in the study area generally (Figure 53). Summer Maximum Temperatures contributed 16% where there was a linear relationship with predicted habitat, becoming a positive influence above ~ 25 ºC. The Annual Heat / Moisture Index, contributed 14%, and had a linearly decreasing relationship, becoming a negative influence at values above ~175 (Figure 53). None of the other 7 potential predictive variables provided substantial contributions to the model (Table 33). The Mojave wide GAM model selected similar input values, with the exception that Surface Texture, and Annual Temperature Range were also included in the model. There was no Moisture Index layer at the Mojave Desert Ecoregion 1 km scale.

The Clark County 250 m scale GAM model had relatively high standard error (0.08 – 0.1) in several areas throughout the county, including the lower elevation margins of Gold Butte NM, and the Sheep and Spring ranges. Higher error was also present east of the Lucy Grey and Newberry mountains, in southern Clark County (Figure 50). The model developed at the Mojave Desert Ecoregion scale had much lower error generally for this model, with some areas of moderate error along the eastern boundary of the Spring range, and on the Nevada National Security Site (Figure 51).

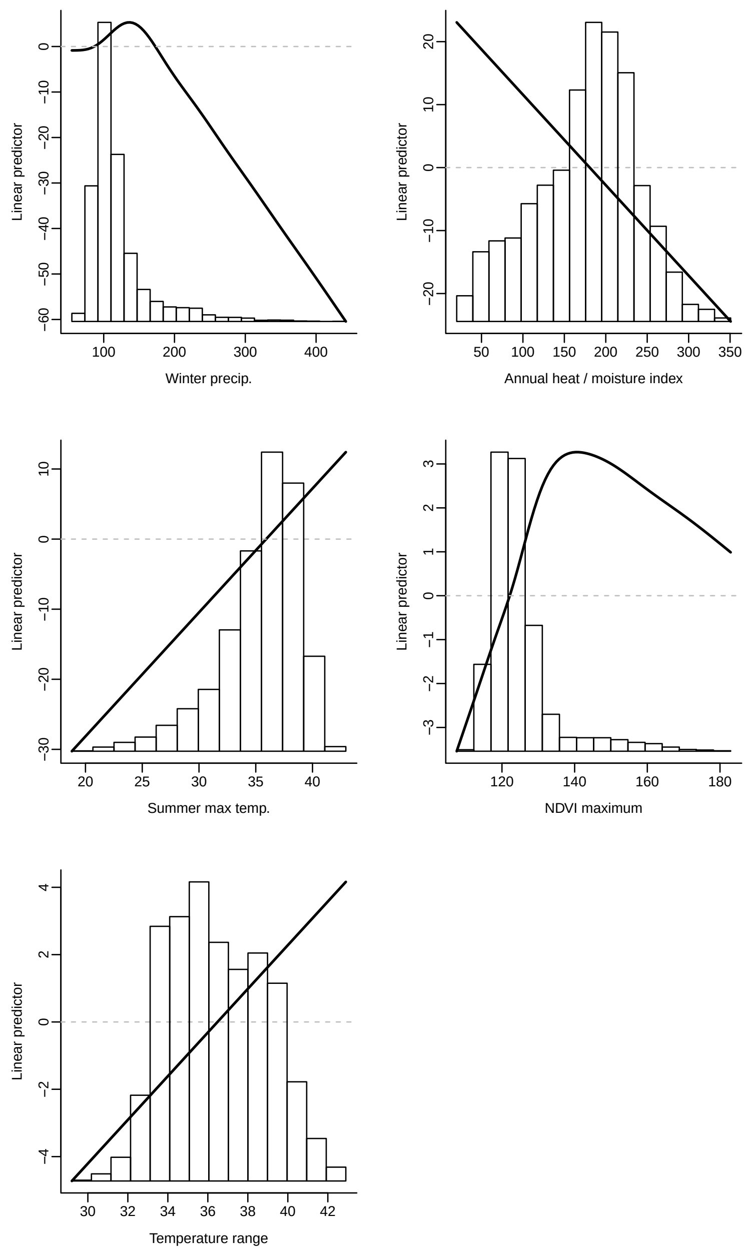


Figure 53. GAM partial response curves for the *Astragalus mokiacensis* model overlaid over distribution of environmental variable inputs in the study area.

MaxEnt Model

The MaxEnt model had the same four variables contributing 10% or more each, but accounting for slightly less of the variation at 84% contribution (Table 33). Winter Precipitation was the highest contributing covariate (38%) with a peak habitat predicted at ~ 150 mm and falling off sharply above and especially below that amount of precipitation (Figure 54), which was similar to the partial response output predicted in the GAM model. Higher habitat values were predicted for lower levels of the Annual Heat / Moisture Index, falling sharply above levels of ~ 125 which is similar to the level at which the GAM models began to have negative influence (Figure 54). NDVI Maximum contributed 18% and had a peaked response at values between 140 and 150, also similar to the GAM response, but with a sharper decline in predicted suitability at higher values. Finally Summer Maximum Temperature also showed a peaked response, with highest habitat values predicted at ~ 37 ºC Summer Maximum Temperature, but decreasing at higher values – in contrast to the GAM model (Figure 54, Figure 53).

The standard error map for this algorithm had several areas of higher standard error (SE 0.06 – 0.1) in similar areas as the GAM model, but with far less in terms of area, e.g. the northern boundary of the Sheep Range, the eastern edge of the Spring Range and Tout Canyon, and the valley east of the Lucy Grey mountains (Figure 50).

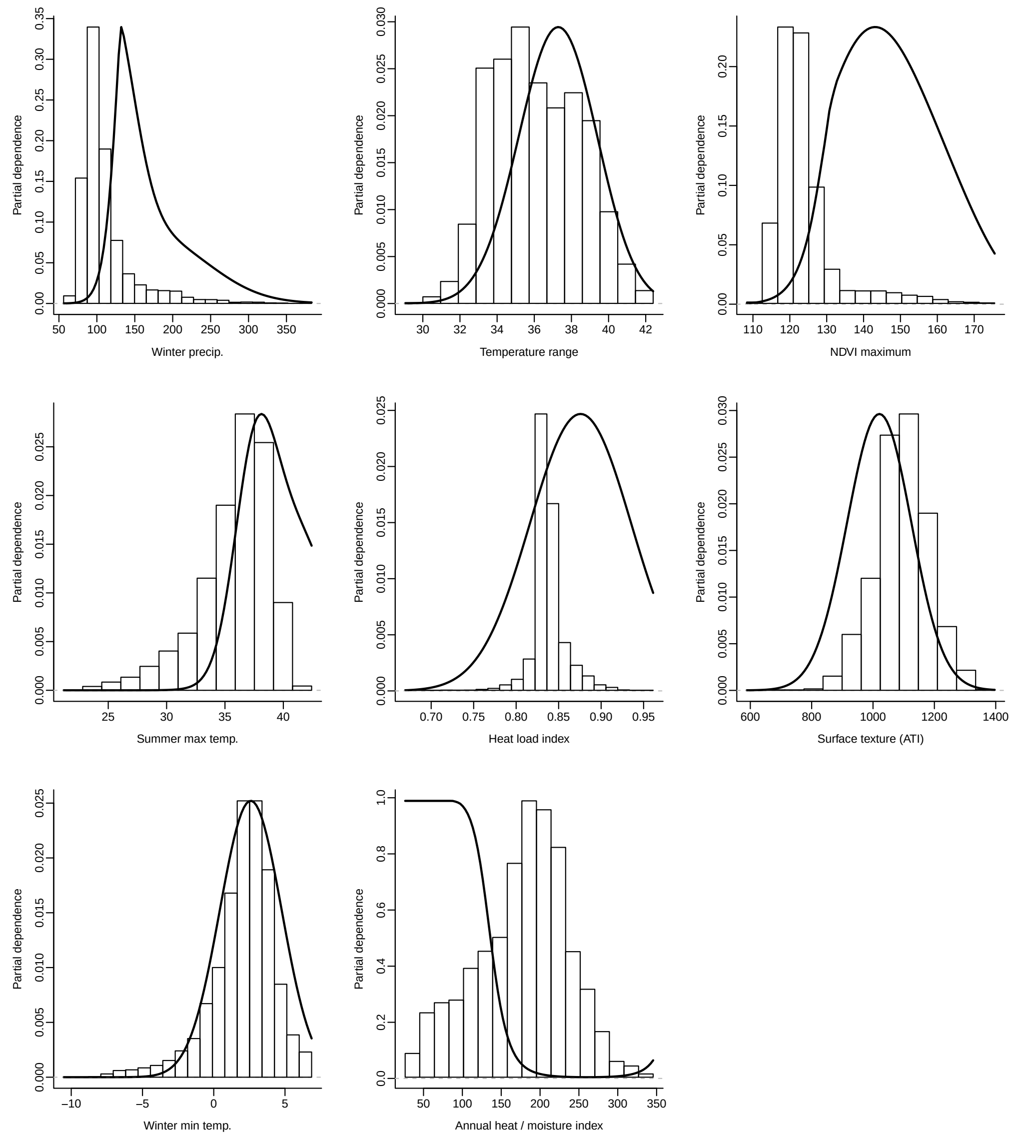


Figure 54. Response surfaces for the top 9 environmental variables included in the MaxEnt ensemble model for *Astragalus mokiacensis.*

Random Forest Model

The RF models had three environmental variables contributing 10% or more totaling 53% of total model influence. The highest contributing variables were: NDVI Maximum, Annual Heat / Moisture Index, and Winter Precipitation (Table 32). NDVI Maximum has a sharp increase at values near 125 m and leveled off – remaining high for the rest of the range, which differed for the other two algorithms in the upper range for this variable (Figure 55). Habitat suitability was highest for lower values of the Annual Heat / Moisture Index, decreasing sharply after ~ 100 as was seen in the MaxEnt Model (Figure 55, Figure 54). Habitat suitability was low for levels of Winter Precipitation below ~130 mm, and a thresholded response above that value indicated moderately high habitat prediction, which differed from the other models for the upper range of winter precipitation values (Figure 55).

Standard error maps for this model indicated relatively low error (SE 0.02 – 0.04) that was limited to the margins of mountain ranges, similar to where the MaxEnt model had higher standard error values (Figure 50).

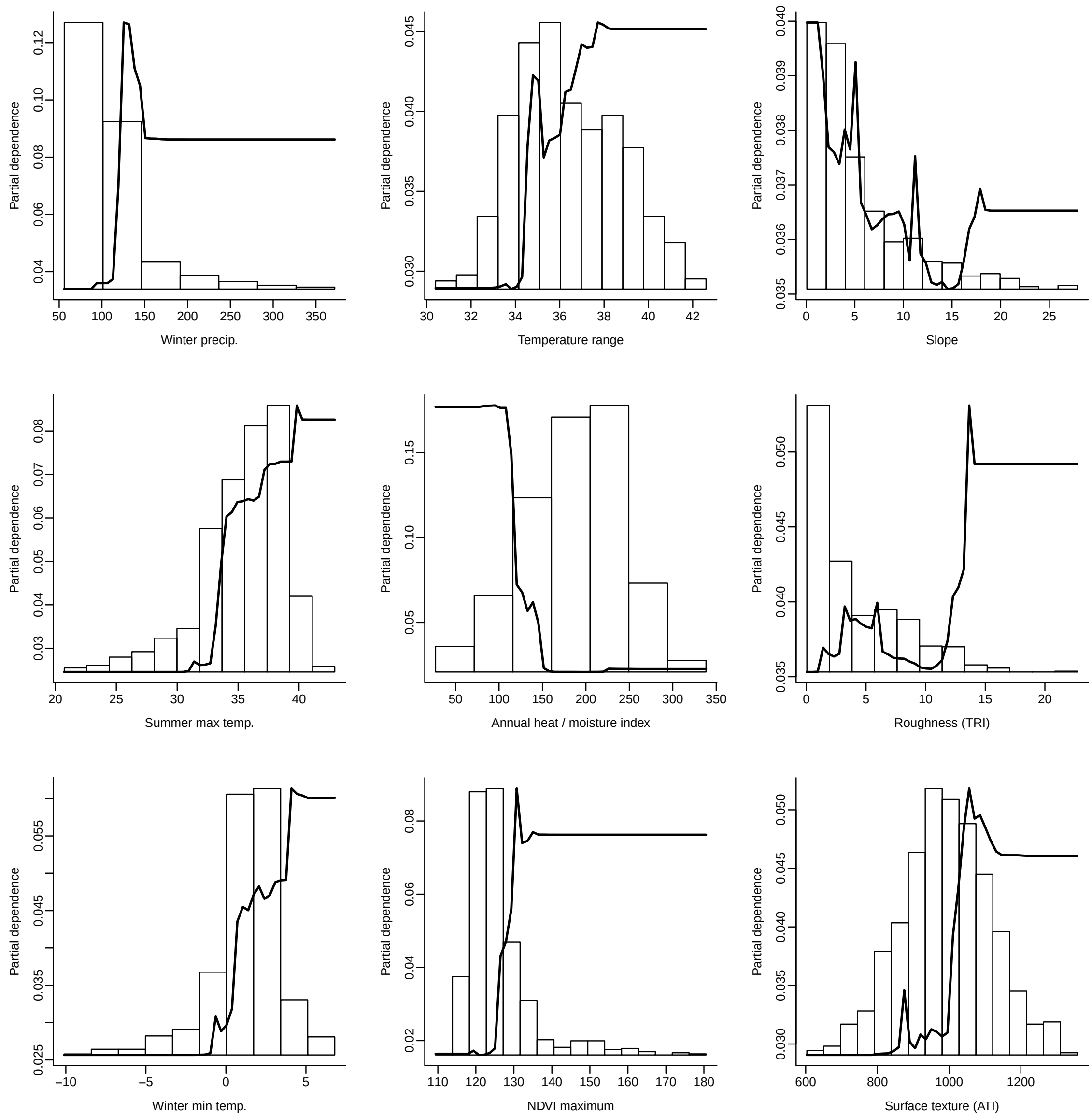


Figure 55. Response surfaces for the environmental variables included in the RF ensemble model for *Astragalus mokiacensis*. Histograms represent the range of each environmental variable across the x-axis, and predicted dependence relative to habitat suitability values are on the y-axis.

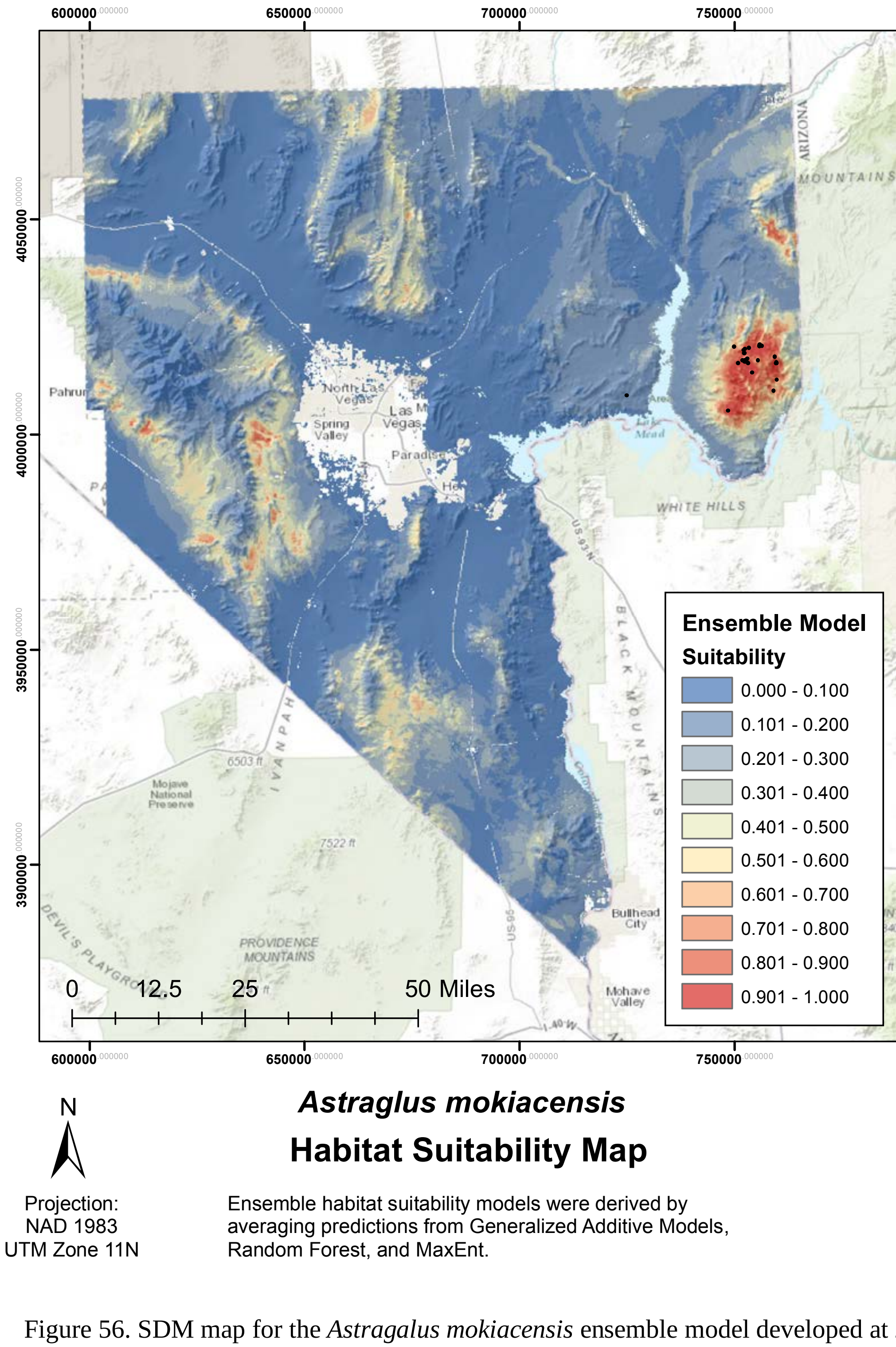


Figure 56. SDM map for the *Astragalus mokiacensis* ensemble model developed at 250 m resolution and at the scale of Clark County

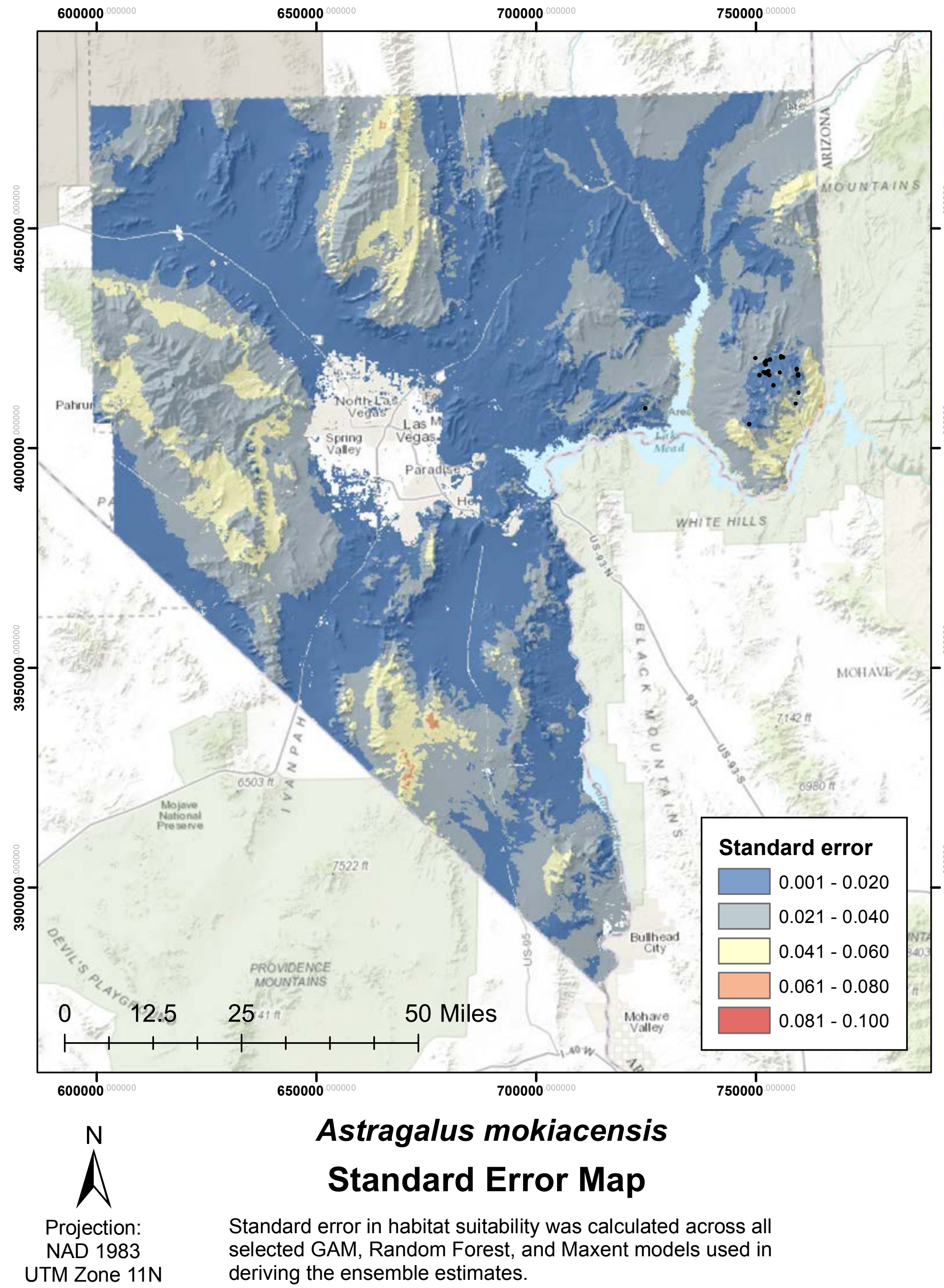


Figure 57. Standard Error map for the *Astragalus mokiacensis* ensemble model.

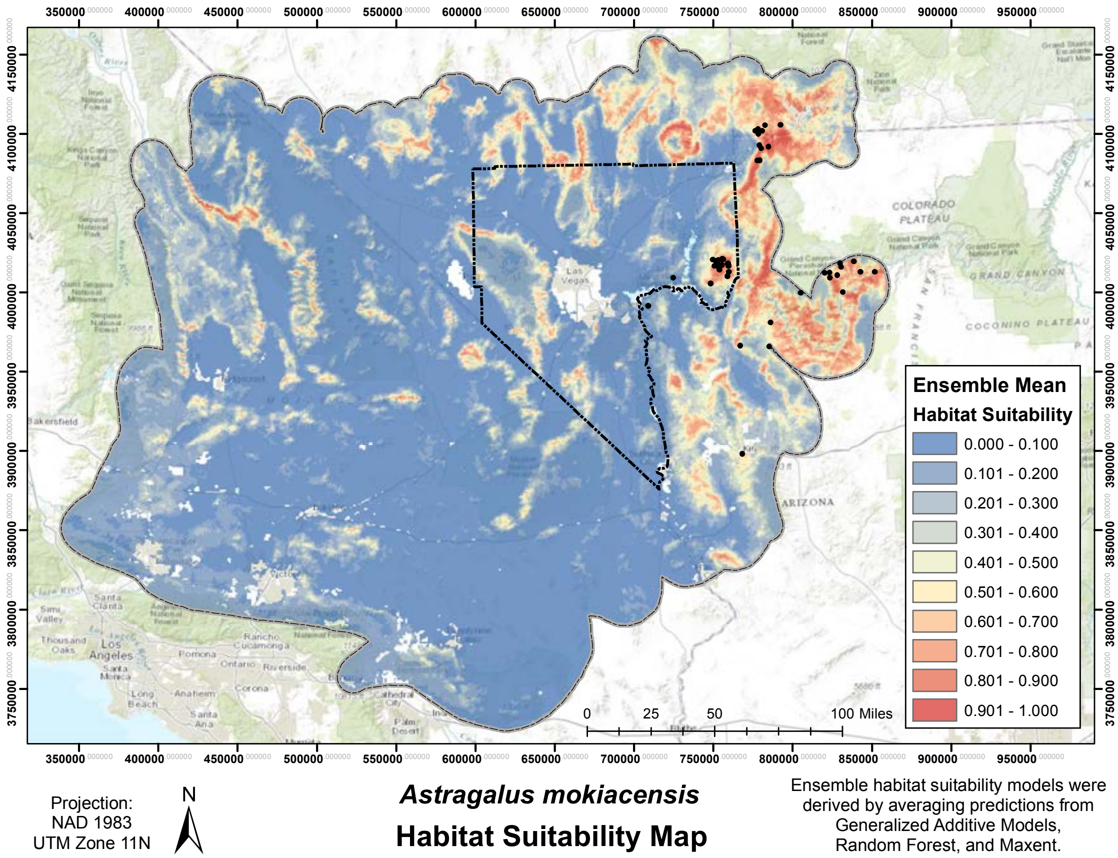


Figure 58. SDM map for the *Astragalus mokiacensis* ensemble model developed at 1km resolution and at the scale of the Mojave desert

Distribution of Localities

Known localities (N=48) for Mokiak Milkvetch are distributed in Clark County only in the southern extent of Gold Butte, with one observation east of The Narrows and south of Echo Bay on the Overton Arm of Lake Mead (Figure 56). Additional localities are available for modeling when considering the greater Mojave Desert Ecoregion, however, several of the extralimital localities to Clark County truly exist in the Colorado Plateau Ecoregion. There are 49 additional points available largely to the north, east, and south of the Clark County distribution, in the greater Dixie Valley of southwestern Utah and the Arizona Strip of northern Utah, on the Tonto Bench in the lower Grand Canyon, and as far south as Kingman, AZ (Figure 58).

Standard Error

Within Clark County, the standard error for the habitat suitability model for Mokiak Milkvetch indicates almost no error in the proximity to known locality points, but moderate error levels (SE 0.04– 0.06) generally around the bases of mountains ranges in the same locations as where habitat suitability was predicted but has not been documented (Figure 57).

Distribution and Habitat Use within Clark County

Mokiak Milkvetch is found on sandy soils on a variety of geomorphic features such as stony hillsides, bluffs, terraces, badlands, dry washes, gravelly outwash fans and disturbed areas along streams (Barneby 1964, NNHP 2001). This *Astragalus* is found in upper cholla/creosotebush (*Cylindropuntia/Larrea*) associations and into low pinyon/juniper (*Pinus/Juniperus*) woodland associations. Parent substrate materials include limestone and volcanics (Barneby 1989). The Gold Butte variant of the species is found in blackbrush and pinyon-juniper communities, and only rarely in mixed shrub communities (e.g. Larrea). The population is found in gravelly washes and granitic alluvial fans (Alexander 2005). Distribution in Clark County ranges from Cedar Basin, Gold Butte and Mica Peak and extends southward to Garnet Valley and Bonelli Peak. They are also found in the Black Mountains from Pyramid Peak near Lake Las Vegas in Clark County, and extend into Mohave County, Arizona (Alexander 2005). Within Clark County predicted high suitability for this species is Blackbrush, Mojave Desert Scrub, and to a lesser extent Pinyon Juniper ecosystems (Table 34). Moderate habitat extends that pattern, with the broadest increase being in Blackbrush. This species is predicted to be absent from the highest elevation ecosystems (e.g. Alpine, Bristlecone Pine and Mixed Conifer; Table 34.

Modeled habitat in the county is predicted to be high in the mountains of Southern Gold Butte NM (Figure 56). While there are other predicted areas of suitable habitat (e.g. on the bajadas of the Spring Mountains, Sheep Range, Muddy, Lucy Grey, and McCullough mountains, and south of Las Vegas) these likely coincide with areas where conditions are similar given the predictors, but no individuals of this species have been reported in those locations. At the scale of the county both the 250 m prediction and the 1km prediction are very similar, and in the greater view of the species Gold Butte NM is the western stronghold of its known range (Figure 58).

Table 34. Ecosystems within Clark County, and the area (Ha) of Low Medium and High predicted suitability within each ecosystem.

Ecosystem	Low	Medium	High
Alpine	124	0	0
Blackbrush	212460	174235	27577
Bristlecone Pine	7565	0	0
Desert Riparian	8671	1966	0
Mesquite Acacia	18260	996	445
Mixed Conifer	27339	0	0
Mojave Desert Scrub	1211904	59661	10040

Ecosystem	Low	Medium	High
Pinyon Juniper	97831	13600	4294
Sagebrush	3770	918	6
Salt Desert Scrub	77870	935	2

Ecosystem Level Threats

Mokiak Milkvetch is found in the upper Mojave Desert Scrub and lower Pinyon-Juniper ecosystems. Wildfire or fuel control projects may be the most prominent current ecosystem threats to this species. The occupation of hillslopes and generally rough country provides some level of protection for this species, and there is currently not a great demand for development in pinyon/juniper habitat types.

Threats to Species

Because fire and fuel reduction projects may be the most prominent current threats to this species, monitoring these and any other surface disturbing activities (e.g. roadbuilding, new trails, OHV activity) related to the habitats would be the most efficacious way to reduce potential losses.

Existing Conservation Areas/Management Actions

Protected habitats around the bases of mountains likely provide the best protection for this species. Many such habitats in Clark County and surrounding areas within Mokiak Milkvetch habitat are under some level of protection or are being considered. Lake Mead National Recreation Area, Red Rocks National Recreation Area, Desert National Wildlife Refuge are currently under some level of protection. The Gold Butte Area is under consideration.

Summary of Direct Impacts

The areas of highest suitability for this species have been identified as being largely within conserved habitat areas – such as BLM ACES's, and National Parks and Monuments, etc. More than half of the predicted high suitability habitat area is considered to be conserved. Current and future development appears to avoid high quality habitat for this species (a total of 51 hectares may be impacted), and moderate habitat is also located predominantly in conserved areas, or outside of what is likely to be developed – with only 25 km^2 of moderate habitat likely to be impacted (Table 35).

Table 35. Categorized modeled habitat values (High, Medium, and Low) and the average area (Hectares) predicted in the potential impact areas, conservation areas, already disturbed areas, and overall area

Habitat Level	Impact	Conserved	Disturbed	Area (Hectares)
High	29	26763	22	42437
Med	2465	71207	1478	253709
Low	120210	415472	38538	1681057

ATCU - Western Burrowing Owl (Athene cunicularia hypugaea)

The Burrowing Owl was classified by the US Fish and Wildlife Service (USFWS) as a Category 2 candidate for consideration to be listed as threatened or endangered from 1994 to 1996 before the classification was discontinued in 1996 without listing. The species is currently listed as a Bird of Conservation Concern by the USFWS within the Mojave Desert Bird Conservation Region (BCR: USFWS 2008), is protected under the Migratory Bird Treaty Act (MBTA) of 1918 as amended (16 USC 703-712), and is listed on the Convention on International Trade in Endangered Species, Appendix II species list (McDonald et al. 2004).

Species Status

US Fish and Wildlife Service Endangered Species Act: No Status
Migratory Bird Treaty Act: Protected
US Bureau of Land Management (Nevada): Sensitive
US Forest Service (Region 4): No Status
State of Nevada: Protected
NV Natural Heritage Program: Global Rank G4T4, State Rank S3B
NV Wildlife Action Plan: Species of Conservation Priority
IUCN Redlist (v 3.1): Least Concern
CITES: Appendix ii

Range

The western Burrowing Owl is one of two subspecies of Burrowing Owl that currently reside in the US The western subspecies (*A. c. hypugaea*) of Burrowing Owl ranges across most of the western North America from south-central Manitoba, south to Brownsville, Texas, west to the California coast, and north to southern British Columbia (Neel 1999).

Habitat Model

We modeled Burrowing Owl habitat using 382 point localities distributed largely in the center of the County in a North to South band. The patterns of predicted suitability produced by the three modeling algorithms represent gradient of broad to reduced habitat area being predicted. The GAM model predicted suitable habitat most broadly, followed by the RF model, and finally with the MaxEnt model predicting the most restrictive habitat (Figure 59). As a result, the Ensemble model was most similar to the RF model. Habitat is predicted throughout southern and northeastern Clark County, especially within the valleys and bajadas. (Figure 59).

The random Forest Model had the highest performance among all four models, followed by the Ensemble model (Table 36). The MaxEnt and Ensemble models had similar measures overall, while the GAM model had the lowest performance across all 4 metrics, with TSS and Correlation scores 10 points below the others (Table 36).

The Continuous Boyce Index [CBI] indicated strong performance among all models with an indication of an underperforming model in the GAM (Figure 61). Standard Errors were lowest for the GAM model (which had the lowest performance), the RF model had low to moderately low error patches, while the MaxEnt model had patches of higher Standard Error in the Moapa valley area. The Ensemble model indicated moderately low error (0.04 – 0.06) in the northeastern portion of the County (Figure 60). Approximated bins for the ensemble model based on the CBI were 0-0.5 unsuitable, 0.5-0.55 marginal, 0.55 to 0.6 suitable, and > 0.62 optimal habitat; with a suggested cutoff threshold near 0.58 (Figure 61) and the threshold value calculated from the AUC analysis for the ensemble model was 0.55 (Table 36).

Table 36. Model performance values for Athene cunicularia models.

Performance	GAM	RF	MaxEnt	Ensemble
AUC	0.90	0.98	0.94	0.96
BI	0.85	0.89	0.89	0.89
TSS	0.70	0.90	0.78	0.82
Correlation	0.71	0.87	0.79	0.81
Cut-off	0.56	0.59	0.43	0.55

*threshold at which sum of sensitivity (true positive rate) and specificity (true negative rate) is highest

Table 37. Percent contributions for input variables for Athene cunicularia in an ensemble model combining GAM, MaxEnt, and RF algorithms.

Term	GAM	RF	Max	Average
Annual Heat/Moisture Index	4.1	11.9	2.8	13.2
Winter Precipitation	11.4	9.8	6.0	14.8
Summer Precipitation	0	0	0	0
Summer Maximum Temperature	0	11.5	5.0	12.3
Winter Minimum Temperature	46.7	11.5	24.5	34.3
Temperature Range	0	8.7	6.5	10.2
NDVI Amplitude	0.7	4.9	0.5	4.9
NDVI Maximum	0	0	0	0
Surface Texture (ATI)	0	12.3	9.4	14.4
Slope	9.2	12.5	1.5	15.1
Topographic Position (TPI)	27.9	16.9	43.7	39.4

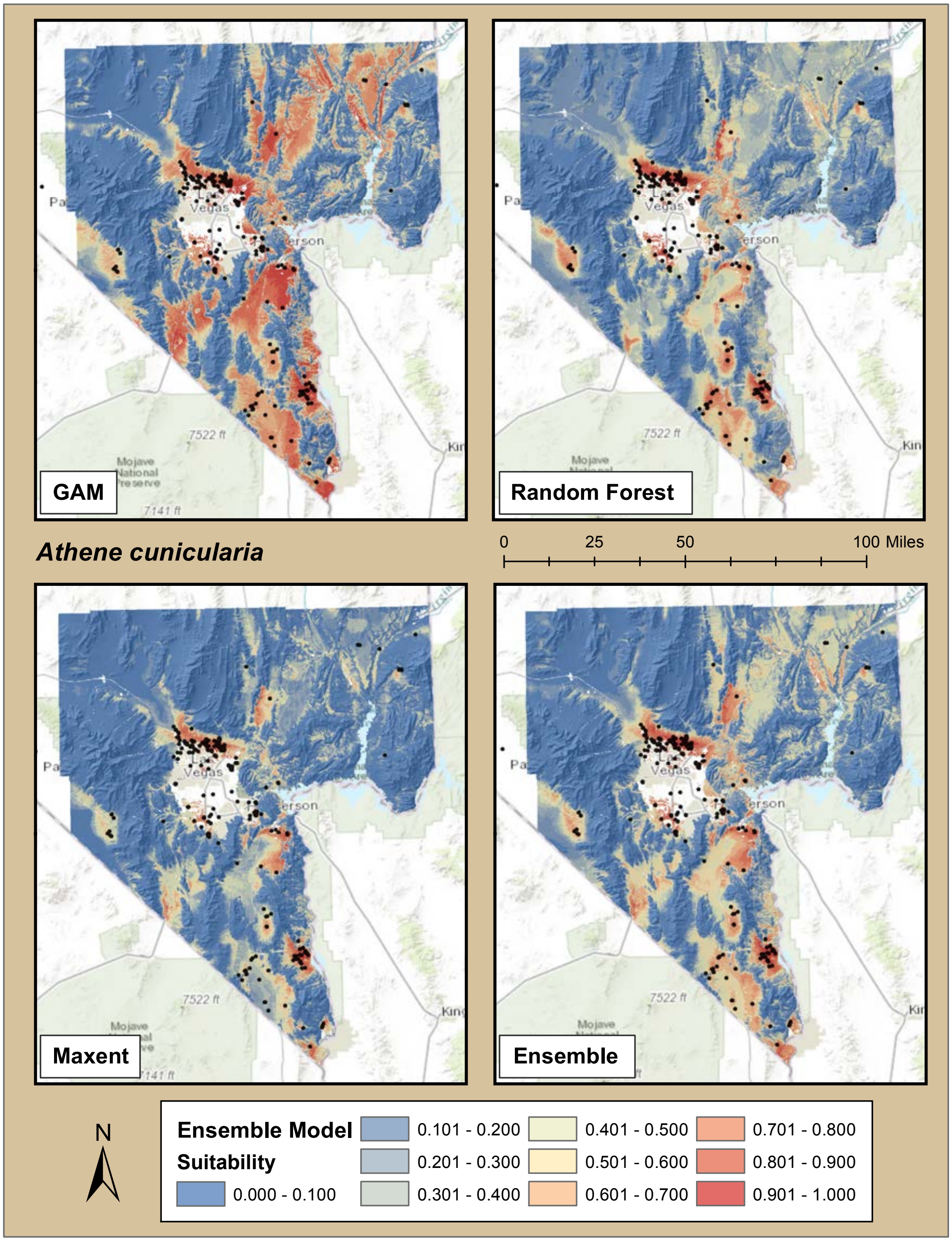


Figure 59. SDM maps for *Athene cunicularia* for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

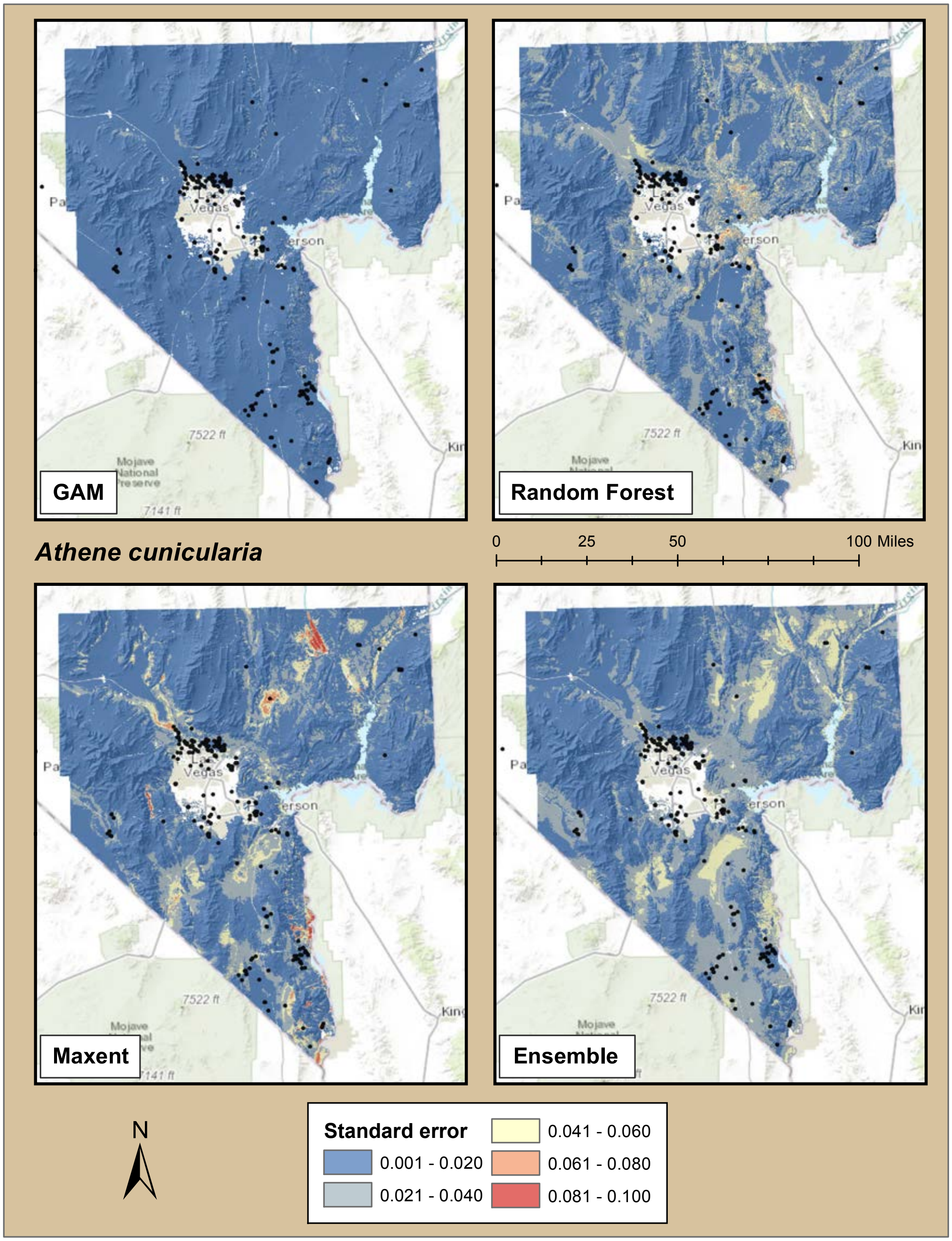


Figure 60. Standard error maps for *Athene cunicularia* models for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

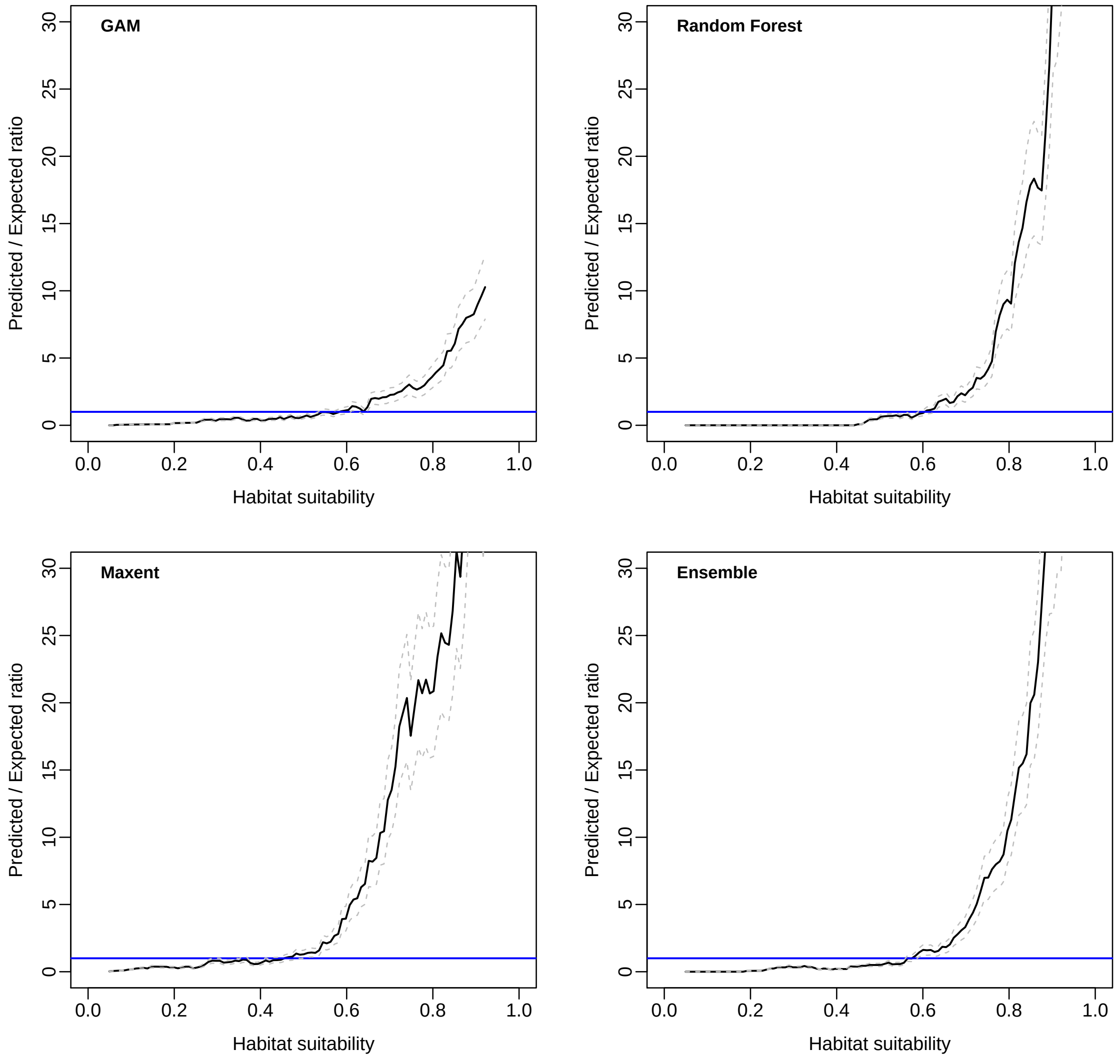


Figure 61. Graphs of Continuous Boyce Indices [CBI] for *Athene cunicularia* models for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

GAM Model

Four variables in the GAM ensemble contributed 9% or more to the models, collectively accounting for 95% of total model contribution (Table 37). Winter Minimum Temperature had the largest contribution (47%), and predicted a threshold type response, with positive suitability predicted above average minimum temperatures of 0 ºC (Table 37, Figure 62). Topographic Position (28%) had a peaked response, where habitat was predicted to be positive above 9, peaking at ~ 11.5, and declining afterward with the prevalence of this feature within the County (Figure 62). Winter Precipitation contributed 11% to the model, and had a positive response above ~ 150 mm, and also as lower levels below 70 mm, which is perhaps an artifact of the curve fitting. (Figure 62). The GAM model had a 9% influence due to slope, which had a negative relationship with predicted habitat suitability (Figure 62).

Like many other species, the GAM model predicted the largest extent of habitat for this species. There were large areas of highly suitable habitat predicted for southern through northeastern Clark County (Figure 59). General areas of the highest prediction included valleys and bajadas near Jean, Ivanpah, Piute, Eldorado, Laughlin, Avi, North Las Vegas Valley, Coyote Springs, Hidden Valley, Apex, Mormon Mesa, and Moapa Valley (Figure 59). Standard error for the models within this algorithm were generally low throughout the County, indicating that models within this ensemble predicted similar habitat (Figure 60), but this did not equate with the highest performance (Table 36).

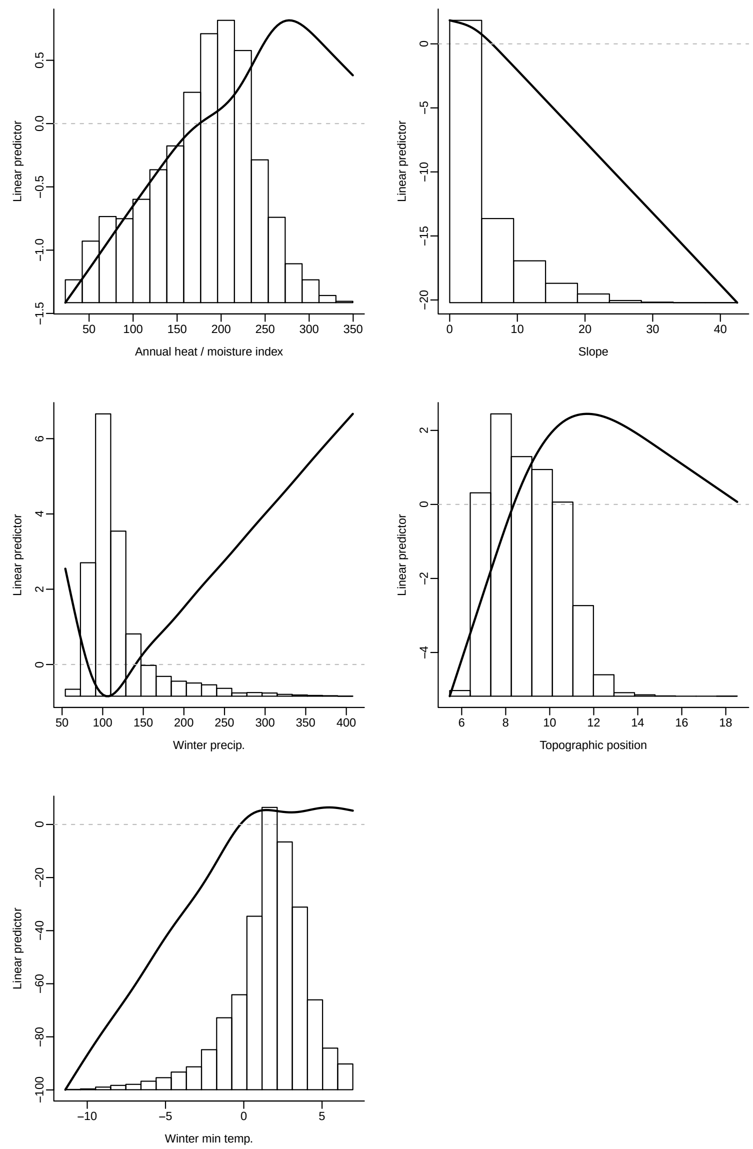


Figure 62. GAM partial response curves for the *Athene cunicularia* model overlaid over distribution of environmental variable inputs in the study area.

MaxEnt Model

The MaxEnt model had three variables contributing 10% or more each, accounting for 78% of model contribution. Topographic Position (44%) was the strongest contributor, with a strongly positive non-linear response with predicted suitability (Figure 63). Winter Minimum Temperature accounted for 25% of model performance, with a generally positive response to increasing average minimum winter temperature with a strong positive influence above 0ºC. Surface Texture (9.4%) also had a positive response with increasing values, corresponding with reduced substrate size, indicative of surfaces that are very smooth, such as soils comprised primarily of sand, loam, and silt, or sandier areas (Figure 63). Three additional variables contributed 5-7% (i.e. Temperature Range, Winter Precipitation, Summer Maximum Temperature - Table 37). Habitat prediction for this model indicated suitable habitat in Piute and Eldorado valleys with areas of mixed quality, patches of high suitability habitat near Laughlin, and the Nelson area, north Las Vegas Valley, and Apex (Figure 60). Despite the concentration of localities in nearby North Las Vegas the northeastern extent of the county has a paucity of known localities and little habitat was predicted there by this algorithm (Figure 59). It is not clear if this is a true representation of habitat, or an artifact of a truncated sampling effort – but more surveys in this area would be beneficial to determine the underlying causes of this modeled pattern. Standard Error was low (0.02 – 0.04) to moderate (0.04 – 0.06) in Eldorado and Jean, and in the US 95 habitat corridor (Figure 60). Patches of high Standard Error (0.08 – 1.0) were seen in Apex, and Moapa, with some sections along the Colorado River as well (Figure 60).

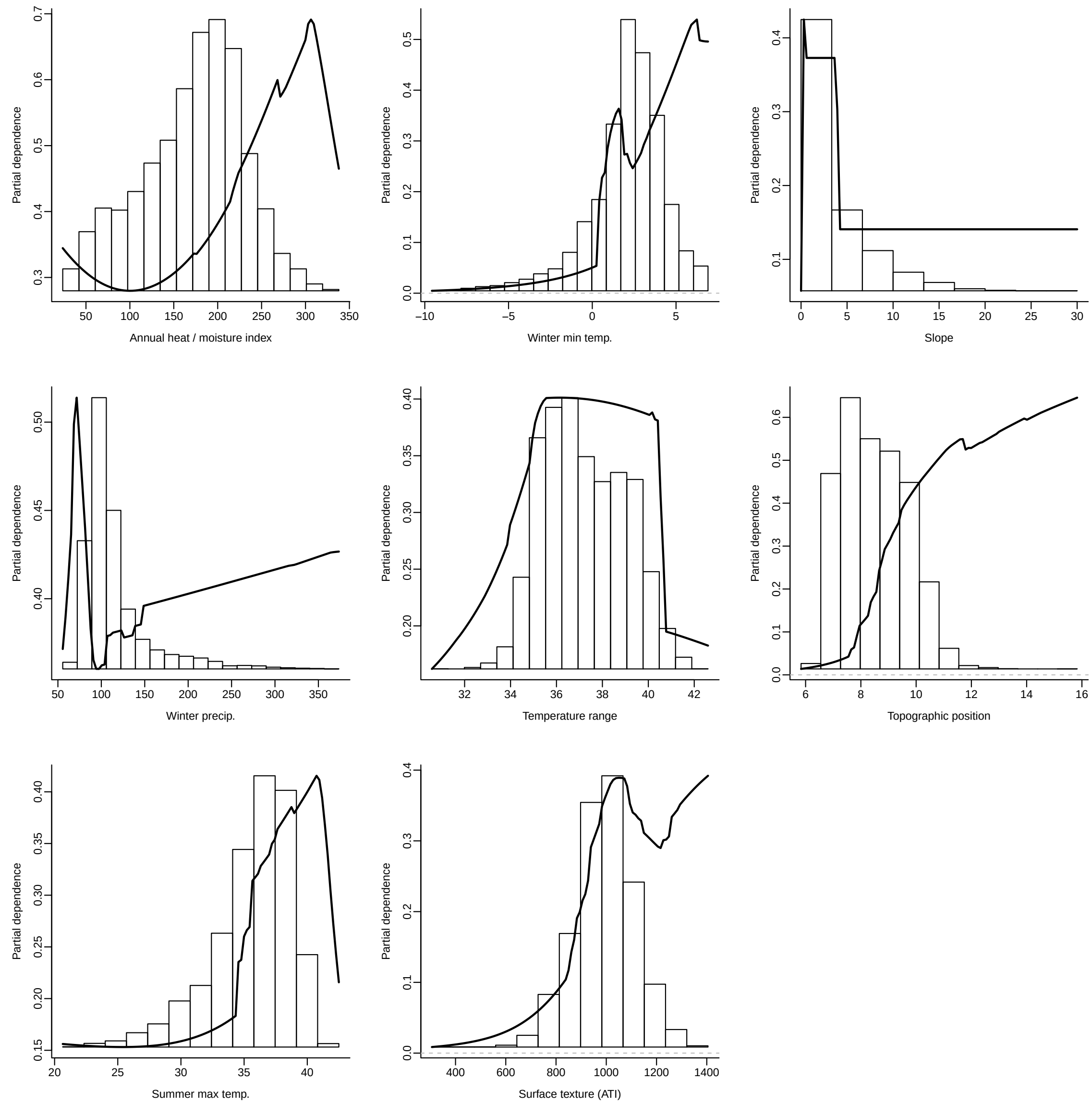


Figure 63. Response surfaces for the top environmental variables included in the MaxEnt ensemble model for *Athene cunicularia*.

Random Forest Model

The RF models had seven environmental variables contributing ~ 10% or more collectively accounting for 86% of the total model influence, with two additional variables also contributing (Table 37). The most significant contributing variables were: Topographic Position (TPI), Slope, Surface Texture (ATI), Annual Heat/Moisture Index, Winter Minimum Temperature, Summer Maximum Temperature, and Winter Precipitation.

Topographic Position (17%) was the highest contributing variable, with a threshold type response predicting habitat to be suitable above levels of 8 and peaking at 11 (Figure 64). Slope was the second highest contributor (13%), with a strongly negative relationship, and habitat unsuitable in areas with greater than 5º slope (Figure 64). Surface Texture (12%) had an irregular response in this model, with habitat predicted to be higher in areas with both low and high levels of this metric. Annual Heat/Moisture Index (12%) also had a threshold response, with suitability increasing strongly at levels above 200, indicating an association with hotter dryer areas (Figure 64). Winter Minimum Temperature (12%) and Summer Maximum Temperatures (12%) had similar responses, with habitat predicted for areas with higher overall temperatures. Habitat was also predicted to be higher in areas with lower Winter Precipitation (Figure 64), which had a contribution of 10%, and likely indicating the preference of Burrowing Owls for open areas with low density and structure of perennial vegetation.

Standard error maps for this model indicated mostly low (0.02 to 0.04) error rates generally on bajadas throughout the southern and northeastern portions of the County (Figure 60). There are a few relatively small patches of moderate (0.04 – 0.06) SE intermixed throughout the eastern portion of the county (Figure 60). Habitat suitability was predicted to be highest on the northern edge of Las Vegas Valley, the large valley between Searchlight and Cottonwood Cover, Piute Valley, Laughlin, Avi, Sloan Canyon, Trout Canyon, and Apex. In the Eldorado Valley there is a noticeable area of higher habitat suitability predicted toward the eastern side of the valley and above the lowest portions of the drainage in the Boulder City Conservation Easement area (Figure 59).

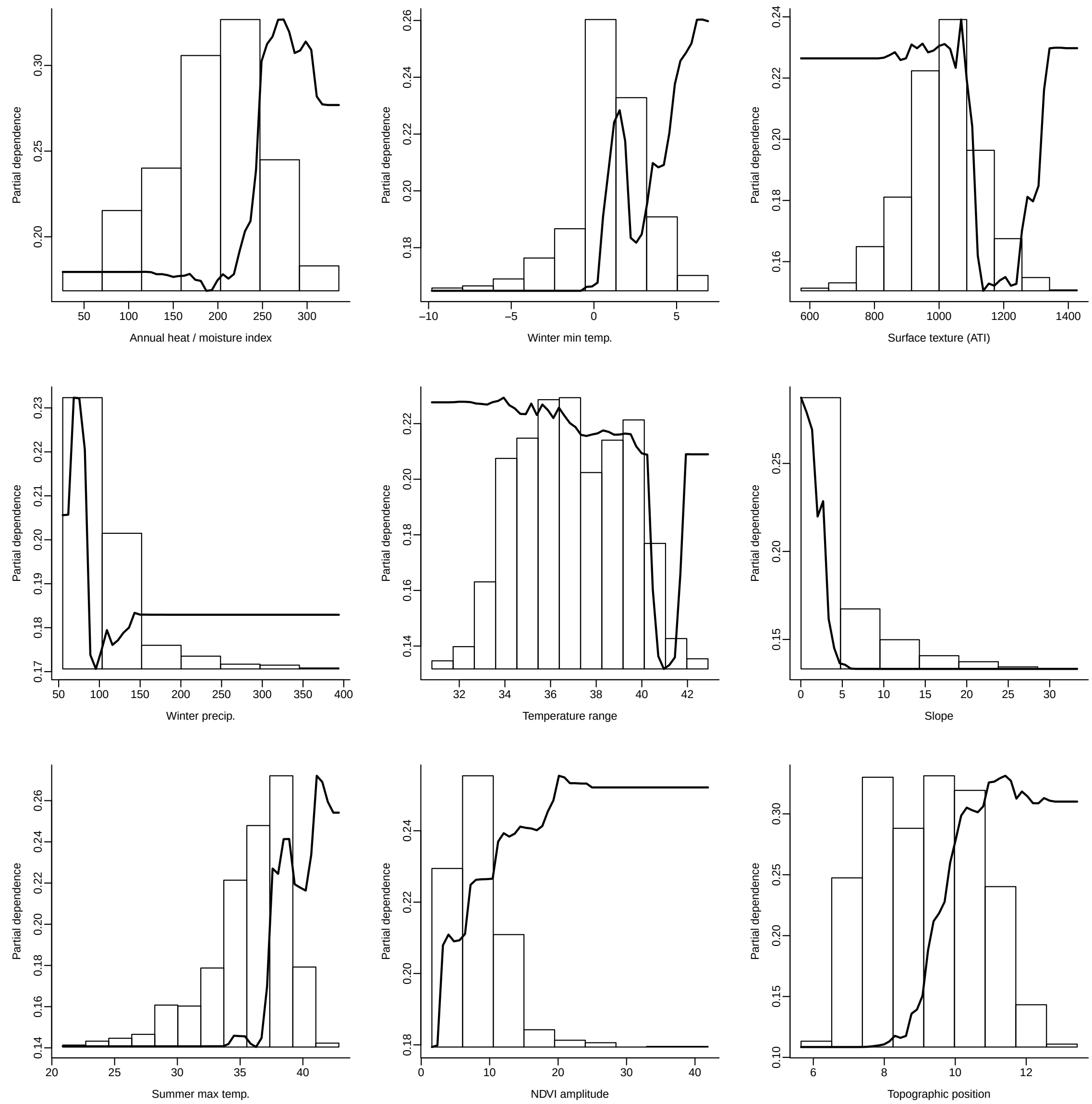


Figure 64. Partial response surfaces for the environmental variables included in the RF ensemble model for *Athene cunicularia*. Histograms represent the range of each environmental variable across the x-axis, and predicted dependence relative to habitat

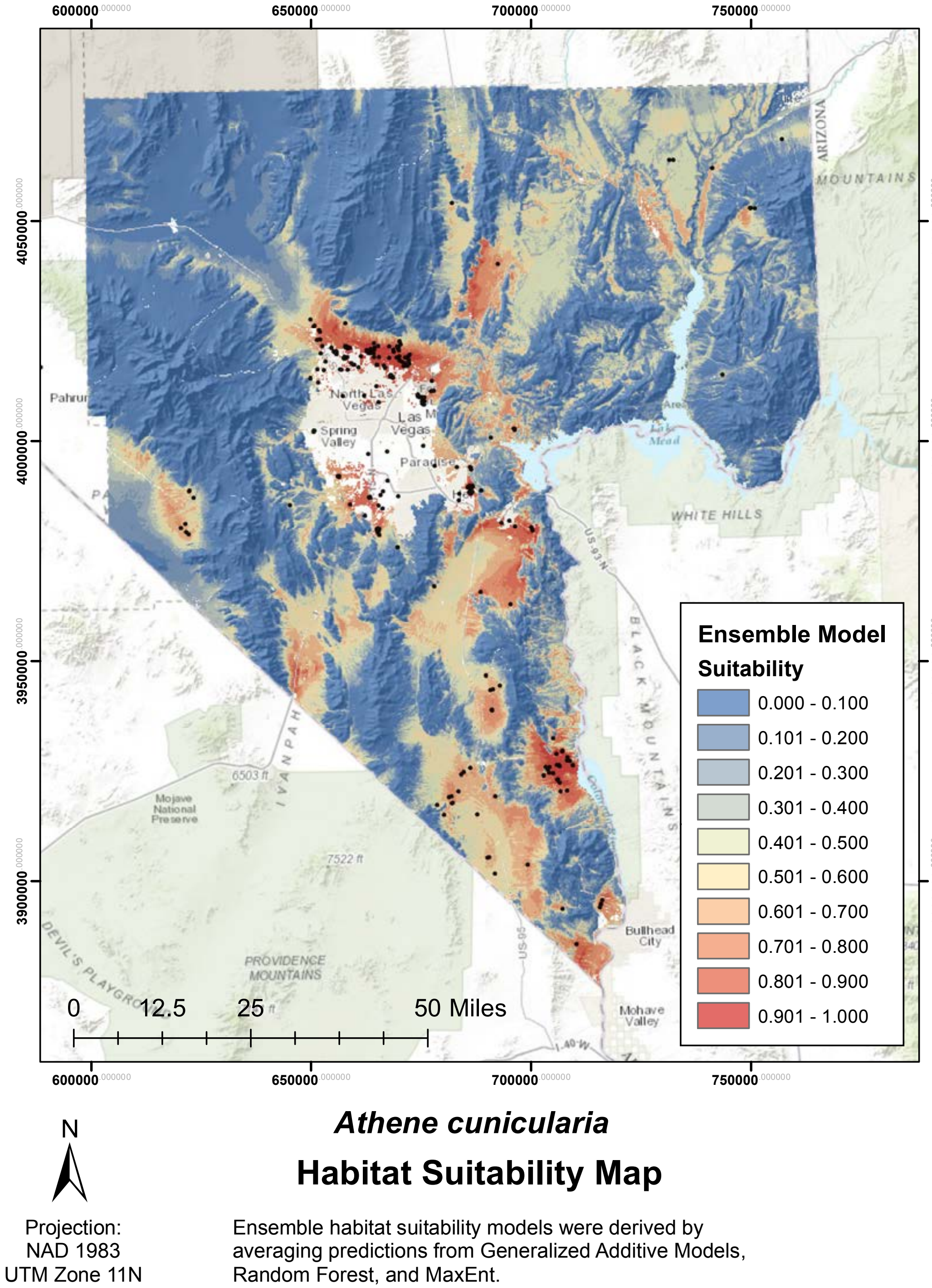


Figure 65. SDM map for the *Athene cunicularia* Ensemble model.

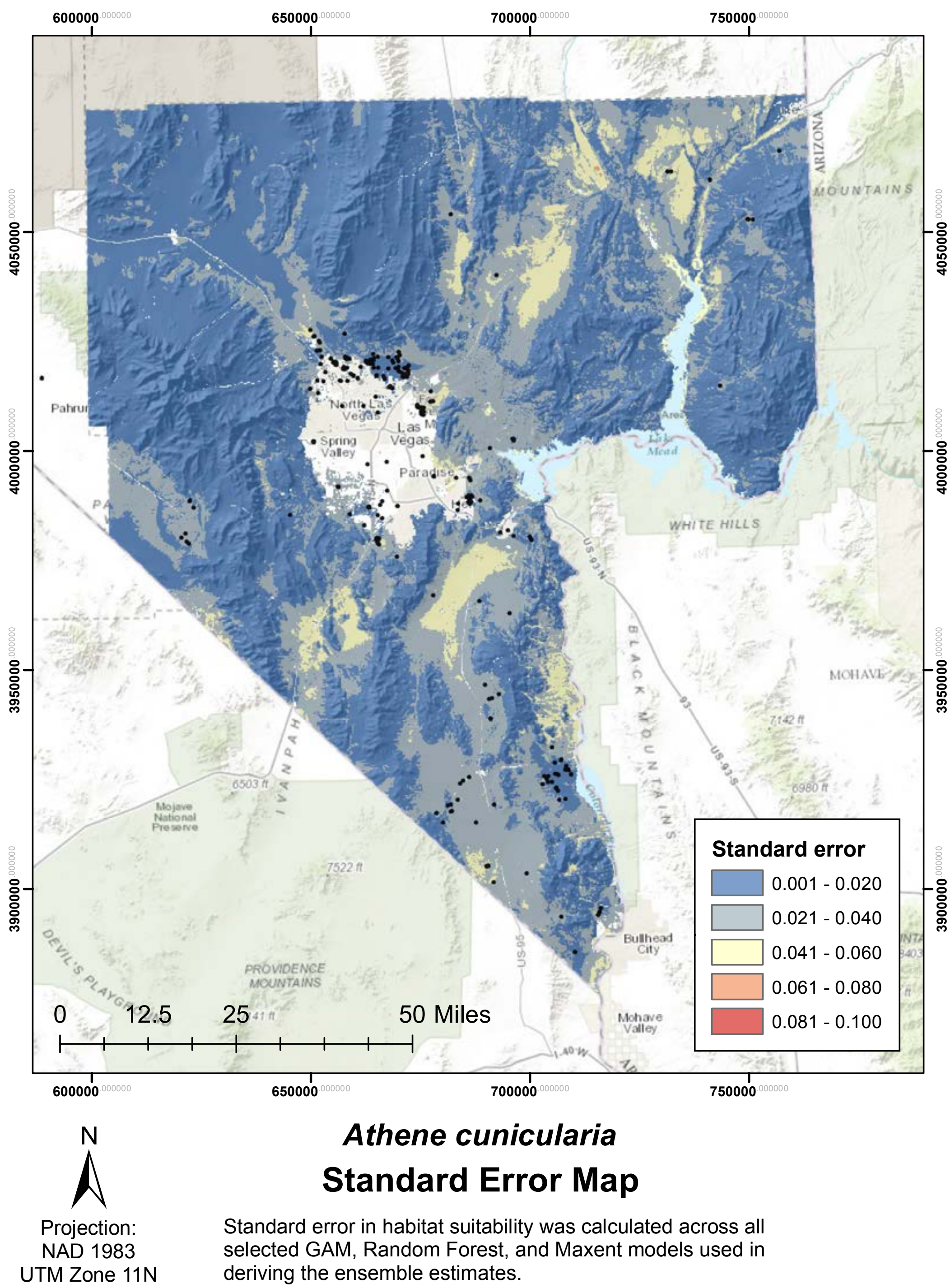


Figure 66. Standard Error map for the *Athene cunicularia* Ensemble model.

Distribution of Localities

Localities (N=382) for *Athene cunicularia* were used for modeling, and are distributed along the eastern edge of the county below Las Vegas, all around the Las Vegas Valley, with a few smaller pockets of points in Apex, Mormon Mesa, and northern Gold Butte, and Trout Canyon (Figure 65). The marked absence of observation points and predicted habitat in the northwest portion of the county on the Nellis Bombing Range and the Nevada National Security Site should be considered further to determine if this pattern represents the species accurately or is an artifact represented by a lack of survey points in this area.

Standard Error

Moderate Standard Error (0.04 – 0.06) is predicted along the I-15 corridor northeast of Las Vegas, in Moapa, Mormon Mesa, and in Eldorado and Ivanpah valleys, as well as some of the area between Cottonwood Cove and Nelson (Figure 66).

Distribution and Habitat Use within Clark County

The Burrowing Owl is a breeding resident in southern Nevada, generally preferring open, arid, and treeless landscapes. Some individuals may reside year-round; however, most will migrate south to the extreme southern US and Mexico during the winter months (Haug et al. 1993). This species is not known to construct their own burrows, and tends to be most common in habitats where suitable burrows already exist (Floyd et al. 2007). In the north end of their range they are largely dependent on prairie dog (*Cynomys* spp.) colonies for burrow sites, while in the southern portion of their range, owls may use a variety of mammal burrows (ground squirrel [*Spermophilus* spp.], skunk [*Spilogale* spp., *Conepatus* spp., *Mephitis* spp.], fox [*Urocyon* spp., *Vulpes* spp.], or coyote [*Canus latrans*]) and will use Mojave Desert Tortoise (*Gopherus agassizii*) burrows throughout the Mojave and Sonoran deserts (Klute et al. 2003, McDonald et al. 2004). In southern Nevada, Burrowing Owls most used Mojave Desert Tortoise burrows. For this reason, the distribution of Burrowing Owls in Clark County largely overlaps that of the Mojave Desert Tortoise. Burrowing Owls have also been known to breed in isolated desert patches within urban landscapes and in these situations will often respond positively to habitat enhancement, such as the installation of artificial nest sites (Klute et al. 2003). Burrowing Owls are fairly tolerant of human disturbance and will often breed around the fringes of agricultural lands and use crop and pasture lands for foraging throughout the breeding season (Nevada Partners in Flight 1999). In 2008, the Urban Burrowing Owl Monitoring Project, sponsored by the USFWS and the Red Rock Audubon Society, reported a relatively high number of breeding Burrowing Owls in urban areas in the north end of the Las Vegas Valley with some even nesting in man-made structures, including a hole under a sidewalk and under an old box spring mattress (Manville 2009).

The Western Burrowing Owl is a widely ranging species that is found in open habitats containing several vegetation types including intermountain cold desert scrub, sagebrush, grasslands and meadows, Mojave Scrub (shrub), and some developed landscapes throughout Clark County (Haug et al. 1993, Johnsguard 2002, Wildlife Action Plan Team 2012). Earlier efforts at species distribution modeling efforts for the Mojave Desert in southern Nevada confirmed these general preferences, and reported positive associations with winter and summer precipitation, and negative associations with slope and perennial cover (Crowe and Longshore 2010).

The highest modeled habitat area was in the Mojave desert scrub ecosystem, which also contained the most moderate habitat (Table 38). Moderate habitat was also high in blackbrush, although much more habitat area in blackbrush was scored as low. Recent transects in Clark County detected low densities of owls in Mojave Desert Scrub habitats, and no observations of owls in blackbrush or pinyon-juniper habitats (Crowe and Longshore 2010b), while our model/ecosystem overlay indicates a gradient of habitat possible in blackbrush, and confirms that Pinyon Juniper Habitats are unlikely to coincide with Burrowing Owl habitat. Higher numbers of owls, were noted in Gold Butte, Piute Valley, eastern slopes of Eldorado Valley, and bajadas on the western side of Lake Mojave in Lake Mead National Recreation Area (Crowe and Longshore 2010b).

*Modeled h*abitat in the County is predicted to be highest in north of Las Vegas, within Eastern Eldorado Valley, Ivanpah Valley, most of Piute Valley, and especially the bajadas above Laughlin (Figure 65). Slightly lower habitat suitability is predicted along the I-15 corridor, through the Moapa Valley, Mormon Mesa and Virgin and Muddy river valleys, in the valley east of Searchlight and all the way to the Colorado River, and also habitat patches predicted in Gold Butte (Figure 65). This model greatly extends the predicted habitat identified in the model constructed by Crowe and Longshore (2010b), which predicted similar habitat extent in the Piute and Eldorado Valley, but did not include the areas of high suitability identified here in northern and southwestern Las Vegas (Figure 65).

Table 38. Ecosystems within Clark County, and the area (Ha) of Low Medium and High predicted suitability within each ecosystem

Ecosystem	Low	Medium	High
Alpine	124	0	0
Blackbrush	393636	21254	482
Bristlecone Pine	7565	0	0
Desert Riparian	1182	4453	5015
Mesquite Acacia	6507	8234	4924
Mixed Conifer	27339	0	0
Mojave Desert Scrub	675979	425286	178538
Pinyon Juniper	115854	0	0
Sagebrush	4707	0	0
Salt Desert Scrub	67415	7788	3551

Ecosystem Level Threats

Burrowing Owls are declining throughout much of North America with declining populations and range contractions throughout southern Canada, the Great Plains, and many western states. Declines are associated with habitat loss and fragmentation due to agricultural and urban development (Sheffield 1997, Milsap and Bear 2000, Ayers 2003). The most recent cause for loss of habitat is large-scale renewable energy development for solar and wind energy generation. Many reported population declines of this species have been correlated with the declines of mammal species, particularly prairie dogs, on which the Burrowing Owl relies for burrow sites (Haug et al. 1993, Desmond et al. 2000), although, prairie dogs do not occur in Clark County. However, Burrowing Owls in the Mojave Desert also nest in Mojave Desert Tortoise burrows. Mojave Desert Tortoises populations are also in decline which may have a negative effect on Burrowing Owls (Tracy et al. 2006). Burrowing Owls are heavily impacted by ingestion of rodenticides intended to control mammal species. Threats to this species' habitat also include off-road vehicular activity, and overharvest of reptiles (Wildlife Action Plan Team 2012).

Population Trends

The western Burrowing Owl was on the Audubon Society's Watch List (formerly referred to as the Blue List) of declining bird populations since 1972 (McDonald et al. 2004), but was recently removed from this list (Audubon Society 2007). The Blue List is intended to provide an early warning for those North American species that are undergoing population or range reductions, and is meant to identify patterns of impending or ongoing serious losses in regional bird populations. Breeding Bird Survey (BBS) data from the last 30 years indicate that the Burrowing Owl is in decline nation-wide. They are also declining in much of western North America and precipitously in Canada (Holroyd et al. 2001). The survey data also indicate that Burrowing Owls may be increasing in numbers throughout the Mojave and Sonoran deserts (Sauer et al. 2008), but survey densities are fairly low, and more data would be useful to clarify these patterns. In Nevada and other arid parts of the west trends are harder to interpret with conclusions ranging from "declining" to "increasing", depending on sources consulted (GBBO 2010). The primary reason for the contradictory results is that survey data on Burrowing Owls are inadequate to determine trends in Nevada including Clark County (GBBO 2010).

The USFWS Urban Burrowing Owl Monitoring Project has established a three-year monitoring program to determine the success of Burrowing Owls nesting within the Las Vegas Valley and the general population trend of urban-nesting Burrowing Owls. The results of this study are not yet available, but preliminary results indicate that Burrowing Owls will successfully breed within some urbanized areas of Las Vegas (Manville 2009). However, the success of urban-nesting pairs relative to non-urban nesting pairs is unknown at this time.

Modified survey techniques were developed for the Mojave Desert and conducted transect surveys, including sites in Clark County (Crowe and Longshore 2010a and 2010b). While their surveys were not of sufficient time to document trends, they did quantify relative abundances of owls in areas within the county, and found on average

0.12 owl territories per km^2, nest success of approximately 60 percent, and approximately 3 fledged young per nesting attempt over the span of the two year study (Crowe and Longshore 2010b).

NDOW is in the initial stages of developing a western Burrowing Owls monitoring protocol that may be used as a statewide monitoring program. But very early stages and starting at sites in northern portion of Nevada (Cris Tomlinson – Pers. Comm.).

Threats to Species

The USFWS cites habitat loss and fragmentation, primarily due to agriculture and urban growth, as one of the most significant causes of population declines in this species. The most recent cause for loss of habitat is large-scale renewable energy development for solar and wind energy generation. This activity will result in direct loss of habitat by surface disturbance and compaction. Some artificial perches will no doubt result from these activities, but the net gains or losses to owls have not been calculated. Furthermore, there could be direct losses of owls to wind turbines or other injuries from energy generation. Indirect losses result from the loss of foraging habitat. Other threats include the elimination of suitable burrow sites through rodent control programs, predation from domestic and feral cats (*Felis catus*), and dogs (*Canis familiaris*), vehicle collisions, and pesticides or other contaminants (Klute et al. 2003)

Because Burrowing Owls demonstrate a strong preference for burrow sites and foraging areas that are open and relatively sparse with vegetation, there is indication that this species may respond positively to habitats that have recently burned or are subject to cattle grazing (Klute et al. 2003), however, this idea has not been studied, and the many negative aspects of burning or overgrazing desert systems likely outweigh any short-term benefits (e.g. due to loss of reptile diversity). Burrowing Owls are declining in many areas due to habitat degradation (Milsap and Bear 2000) and a reduction in other fossorial species that provide burrows for this owl (Desmond et al. 2000). Direct mortality as a result of rodenticides, and shooting also impact Burrowing Owl populations.

Existing Conservation Areas/Management Actions

The western Burrowing Owl is protected under the Migratory Bird Treaty Act, and a detailed conservation plan has been developed by the USFWS (Klute et al. 2003). The primary management actions outlined in this plan include: maintaining large, contiguous areas of suitable habitat; enhancing habitat features (i.e. provide artificial burrows, elevated perch sites, or maintain short vegetation); conserving mammalian species that provide Burrowing Owls with potential nest sites; reintroduction reintroduction or encouraging re-occupation of under-occupied and suitable habitats; and increasing public education and awareness of the species. In addition, recommended conservation actions specific to this subspecies and its habitat are included in the Nevada Wildlife Action Plan. This plan's recommended approach is to conserve burrowing mammal colonies, adequately manage short-grass habitats, provide protection from shooting, and protect nesting areas and burrows from disturbance during the incubation and nesting stages. Further, the recommended conservation strategies to conserve occupied habitat include: maintaining this species habitat at its current distribution in stable or increasing condition trend; and sustaining stable or increasing populations of wildlife in key habitats (Wildlife Action Plan Team 2012).

This species is also covered under the Nevada Partners in Flight Bird Conservation Plan. Specific objectives for this species outlined in this plan include mitigating the effects of off-road race events, protecting and maintaining populations of other species of animal that provide burrow sites, preserving open space within urban and suburban development, and constructing artificial burrow sites in suitable alternative habitat (Neel 1999, GBBO 2010).

In addition, the western Burrowing Owl is covered under the Spring Mountains Conservation Agreement. This agreement was developed between state and federal agencies to provide long-term protection for the rare and sensitive flora and fauna of the Spring Mountains National Recreation Area (USFS et al. 1998).

The conceptual management plan for the Overton Wildlife Management Area (OWMA) calls for determining the extent of Burrowing Owl occurrences at the OWMA, and for determining if there is a need for artificial burrows. If such a need is found, the installation of artificial burrows is recommended (NDOW 2014).

The Nevada Comprehensive Bird Conservation Plan considers the Burrowing Owl a Special Status Species and recommends the following actions: establish and implement effective monitoring programs to determine population status and trends; maintain short vegetation and healthy prey populations near known colony locations; establish a no-disturbance buffer zone of 60 m (200 ft) around active nest burrows; provide artificial burrows to help restore populations; and discourage the use of pesticides within 600 m of nest burrows (GBBO 2010).

Summary of Direct Impacts

The western Burrowing Owl is widely distributed, but uncommon, throughout Clark County. Suitable habitat for this species was modeled for this Permit Amendment; methods are described in this report. Approximately 665469 hectares of medium and high modeled habitat exist within Clark County. However, the model may overestimate the amount of suitable breeding habitat because such sites must have the right combination of factors to successfully support breeding Burrowing Owls. It is estimated that approximately 7 percent of western Burrowing Owl habitat in Clark County could be impacted by activities covered under the Amendment, although this number likely overestimates impacts due to the scattered distribution of occurrences.

Based on surveys and habitat modeling conducted by Crowe and Longshore (2010), Clark County contains 5,476 km^2 of habitat with relatively higher probability of owl occurrence, 10,731 km^2 of habitat with a relatively moderate probability of occurrence, and 3,898 km^2 of habitat with a relatively low probability of occurrence of Burrowing Owls. The current modeling effort indicated 1,947 km^2 of high quality habitat, 4,707 km^2 of medium suitability habitat, and 13,111 km^2 of lower quality habitat (Table 39). Impact areas were predominantly in medium suitability habitat (505 km^2, and similar areas of high and low habitat are projected to be impacted ~

350 km^2 each). Proposed conservation areas for the species are higher than those projected to be impacted -461 vs 383 km^2 of high quality habitat, and 1670 vs 505 km^2 of medium habitat respectively (Table 37).

Table 39. Categorized modeled habitat values (High, Medium, and Low) and the average area (Hectares) predicted in the potential impact areas, conservation areas, already disturbed areas, and overall area

Habitat Level	Impact	Conserved	Disturbed	Area (Hectares)
High	38312	46140	20813	194745
Med	50584	167014	12500	470724
Low	33551	299912	6683	1311156

COCA - Costa's Hummingbird (Calypte costae)

Costa's Hummingbird is a true desert hummingbird. Hummingbirds are among the smallest animals capable of physiologically maintaining their body temperatures independent of the surrounding temperature. The heart rate of Costa's Hummingbirds can be as high as 1,200 beats per minute (Lasiewski 1963). Because they are so small and have such high energy requirements, they may rely on a state of torpor to survive when energy reserves are low, or they are stressed by molting their feathers (Lasiewski 1963). During torpor, their heart rate and temperature drop to save energy. The body temperature of torpid hummingbirds can drop to within 1ºC of surrounding temperatures (Bartholomew et al. 1957); however, sub-zero temperatures can be lethal, and to survive the winter (as some do in Clark County), they must find refuges to protect them from the cold (Lasiewski 1963). Female hummingbirds that are incubating eggs do not use torpor. Hummingbird eggs are the smallest of any bird, thus the temperature rapidly approaches surrounding temperatures if the female leaves the eggs to feed or is disturbed (Vleck 1981). Costa's Hummingbirds are important pollinators for a variety of flowers (Fetscher and Kohn 1998, Waser 1979, Krupnick et al. 1999, Spira 1980).

Species Status

This species has a very large range and is considered a Species of Least Concern by the IUCN Redlist (Birdlife International 2010). No federal or Nevada state listing petitions have been filed, however it has been listed as a Species of Conservation Concern in California.

US Fish and Wildlife Service Endangered Species Act: No Status
Migratory Bird Treaty Act: Protected
US Bureau of Land Management (Nevada): No Status
US Forest Service (Region 4): No Status
State of Nevada: Protected
NV Natural Heritage Program: Global Rank G5, State Rank S3B

NV Wildlife Action Plan: No Status
IUCN Red List (v 3.1): Least Concern
CITES: Appendix ii

Range

Costa's Hummingbird has a breeding range encompassing southern California, southern Nevada, southwest Arizona, Baja Norte, and Baja del Sur, Mexico, and western Sonora, Mexico. There is also an isolated breeding group in northwest Nevada. They generally winter south of Sonora in western Mexico. Individuals occasionally winter in urban areas of southern Nevada and likely in other urban areas where feeders and cultivated plants provide year-round food sources.

Population Trends

Few population trends are noted for this species, and although the IUCN and some reports consider populations to be stable (Baltosser and Scott 1996, Latta et al 1999, Birdlife International 2012), breeding bird surveys have reported declining trends. These interpretations have been questioned due to low sample sizes and detection rates, and subsequent high variability in estimates (Dunne et al. 2005, Sauer et al. 2008, Wethington and Carlson 2009).

Habitat Model Review

Densities of Costa's Hummingbirds were modeled County wide by the GBBO reported in Developing Habitat Models and Monitoring Techniques for Nine Bird Species of Clark County submitted to the DCP in 2015 under project number CBE 2011-GBBO-901A, using the same methods as reported for Bendire's Thrashers in the 2013 report for 2005-GBBO-581-P (Figure 67).

Technical Considerations – GBBO modeled County wide densities of Costa's Hummingbirds by using point count surveys using models generated from cover associations collected at point count sampling sites. Dominant vegetation was assessed at each sampling site within 100 meters of the survey point, which was then mapped to its corresponding vegetation type of a LandFire classification (Provencher and Anderson 2011) for the state that was then used to model density projections for humming birds within the Mojave desert in Nevada.

Statistical models of densities for this species were conducted to calculate densities per vegetation stratum (e.g. Joshua tree woodlands, Mesquite-catclaw, etc.). Neither densities nor confidence intervals per stratum are given in the report and thus their accuracy cannot be evaluated. There are average densities for Costa's Hummingbirds given in Appendix 2 of GBBO (2013) including data from surveys spanning from 2003 to 2013 which are likely the data used for the model presented in this report, but these estimates were presented without confidence limits (Table 40). Resolution of the models is limited to the size of the polygons containing vegetation projections, as they are effectively provided as a classified layer, which limits the gradations between vegetation patches. Thus, there are 8 habitat classes for the State-wide model, which cover broad areas without finer resolution. In addition, other factors that could contribute to hummingbird densities aside from vegetation type are not considered in this type of model.

Localities used for modeling are located throughout Clark County, encompassing most areas, but with noted absence around the Moapa/Apex area and the I-15 corridor North and East of Las Vegas.

A statistical model was also produced that recorded presence/absence relative to specific site features such as vegetation height and presence of key species. While these models may be useful for site assessments, the predictors used are not amenable to County or Range wide predictions as GIS layers for this level of detail do not yet exist, and are unlikely to be available with current sensing and mapping technologies.

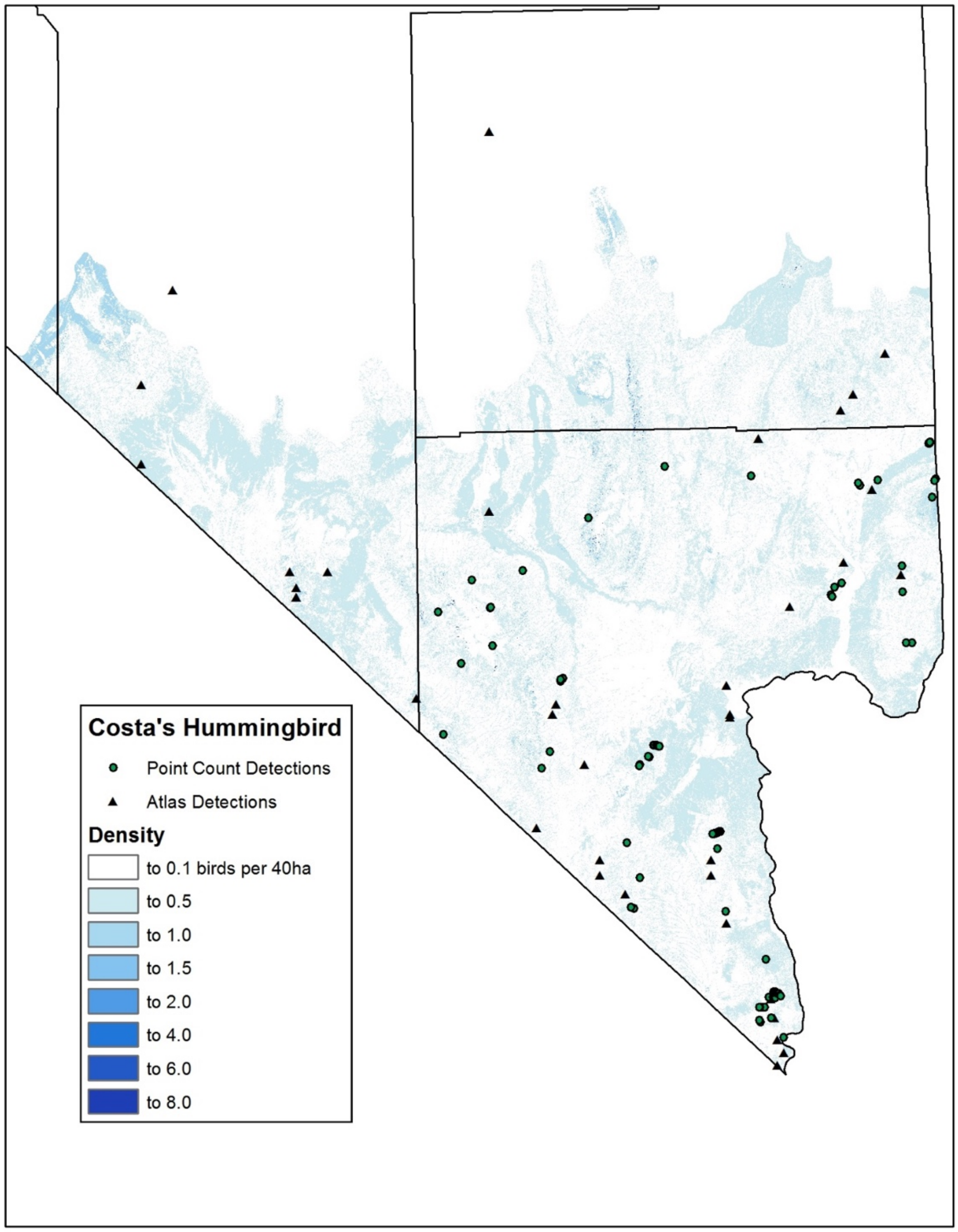


Figure 67. Modeled distribution from GBBO 2015. Predictive model map for Costa's Hummingbird's breeding distribution in Clark County and the greater Mojave region, overlaid with actual detections of the species within the past 10 years.

Table 40. Costa's Hummingbird density estimates from Appendix 2, GBBO 2013.

Ecosystem	Number encountered	Density
Agriculture	(n = 33 surveys)	
Aspen	(n = 10 surveys)	X

Ecosystem	Number encountered	Density
Coniferous Forest	(n = 49 surveys)	0.03
Joshua Tree	(n = 221 surveys)	0.18
Lowland Riparian	(n = 211 surveys)	0.25
Mesquite-Catclaw	(n = 116 surveys)	0.3
Mojave Scrub	(n = 147 surveys)	0.15
Montane Riparian	(n = 49 surveys)	0.08
Montane Sagebrush	(n = 8 surveys)	0.16
Montane Shrublands	(n = 39 surveys)	X
Pinyon-Juniper	(n = 116 surveys)	0.06
Salt Desert	(n = 68 surveys)	
Number of Habitats Used		10

Distribution and Habitat Use within Clark County

In Clark County, Costa's Hummingbirds are most associated with areas with washes, water, deciduous vegetation, or *Yucca* species (GBBO 2015). Costa's Hummingbirds inhabit desert riparian habitats (Austin 1970), although they are not restricted to these habitats and can also be found near desert springs (GBBO 2015). They use a variety of native vegetation as food resources and they are not closely tied to hummingbird feeders in urban areas (Baltosser and Scott 1996, GBBO 2015). Modeled density for this species (GBBO 2015) was widespread across all ecosystems within the county, with high, medium, and low density estimates for these birds throughout (Table 41).

Table 41. Ecosystems within Clark County, and the area (Ha) of Low Medium and High predicted density within each ecosystem.

Ecosystem	Low	Medium	High
Alpine	47	18	59
Blackbrush	164023	142775	102794
Bristlecone Pine	4573	2697	294
Desert Riparian	5956	4495	406
Mesquite Acacia	9486	7143	3554
Mixed Conifer	1867	16011	9461
Mojave Desert Scrub	664083	606502	93339
Pinyon Juniper	14855	44381	56506

Ecosystem	Low	Medium	High
Sagebrush	1556	1600	1331
Salt Desert Scrub	36365	34254	11695

Ecosystem Level Threats

As Costa's Hummingbirds are associated with riparian areas and desert springs, development in these areas would reduce habitat available to the species and likely their persistence in these areas.

Threats to Species

Direct threats are likely linked to habitat removal issues noted above in the Ecosystems Level Threats section.

Cross-breeding resulting in hybrid birds was documented in southern California many years ago, where similar urban habitats exist (Wells et al. 1978). The existence of year-round urban habitats for hummingbirds has provided an opportunity for outcrossing of Costa's Hummingbirds with Anna's hummingbirds. In recent years Anna's hummingbirds have become year-round and breeding residents of urban areas in Clark County, Nevada.

Existing Conservation Areas/Management Actions

Costa's Hummingbird is protected at the federal level by the Migratory Bird Treaty Act, and is designated a species of Conservation Priority by the Nevada Comprehensive Bird Conservation Plan (GBBO 2010). Conservation, research, and monitoring strategies recommended by the plan include: protecting areas with well-developed flowering shrubs and forbs from grazing pressure; implementing weed control programs; developing and implementing a monitoring program and developing better estimates of current trends; conducting studies to clarify habitat requirements, use of urban food sources, and threats; monitoring effects of groundwater pumping on flowering plant communities; and developing strategies to control fires that threaten desert spring vegetation (GBBO 2010).

Partners in Flight's (PIF) North American Landbird Conservation Plan identified Costa's Hummingbird as a Species of Continental Importance for the US and Canada, further designating it as a Watch List species with restricted distribution or low population size (Rich et al. 2004). PIF considers Costa's Hummingbird a priority species in Nevada, and set the objective of increasing the statewide population (Rosenberg 2004). Because state population numbers were not available, specific numerical targets were not set (Rosenberg 2004). Costa's Hummingbird is not covered by the Clark County Multiple Species Habitat Conservation Plan (RECON 2000).

Summary of Direct Impacts

High modeled densities for this species are largely located within the conservation areas, where 22% of all habitat in the highest density and 16% of moderate density habitat are located within the conserved areas (Table 42). Habitat likely to be impacted in the higher density category is limited (14 km^2), although 139 km^2 of moderate density habitat may be impacted. Disturbed areas comprise 28 km^2 of higher density habitat, and 72 km^2 of moderate density habitat, which reflects only 5% of moderate density habitat in total (Table 42).

Table 42. Categorized modeled habitat values (High, Medium, and Low) and the average area (Hectares) predicted in the potential impact areas, conservation areas, already disturbed areas, and overall area

Habitat Level	Impact	Conserved	Disturbed	Area (Hectares)
High	1416	14396	2771	65240
Med	13995	43157	7203	275534
Low	77950	254191	86960	949195

CAST - Alkali Mariposa Lily (Calochortus striatus)

Alkali Mariposa Lily (*Calochortus striatus*) is a rare bulbiferous perennial forb (USDA 2016 2016) in the Liliaceae family. It was originally described in 1901 from a collection at Rabbit Springs in San Bernardino County, California (Parish 1902). The plant grows 1-5 cm tall with 10-20 cm long basal leaves. It has an umbel-like inflorescence with 1-5 erect flowers with irregularly toothed, white to lavender, purple veined petals with sparse hairs near the densely hairy nectary. The conspicuously purple-veined petals lacking spots is a defining feature of this species (Baldwin 2002).

The plant is reported to be pollinated by bees and flies. It flowers from April to June and spreads seeds via gravitational dispersal (Baldwin 2002). It is unknown whether reproduction occurs primarily from bulb division or seedling establishment (Green and Sanders 2006). The bulb remains dormant in drought years (Bagley 1989).

Little is known about this species of Calochortus. There are minimal recent data and minimal data on the Clark County populations in Red Rock Canyon National Conservation Area.

Species Status

US Fish and Wildlife Service Endangered Species Act: Not listed
US Bureau of Land Management (Nevada): No Status
US Forest Service (Region 4): No Status
State of Nevada (NAC 527): No Status
NV Natural Heritage Program: Global Rank G2; State Rank S1
IUCN Red List (v 3.1): No status
CITES: No status

In 1975, in accordance with the Endangered Species Act of 1973, the Smithsonian Institution submitted a report to the US Department of the Interior identifying the Alkali Mariposa Lily, along with over 3,000 other plants, as a candidate for endangered or threatened status (40 FR 27924). The US Fish and Wildlife Service

(USFWS) considered the report to be enough justification to warrant a review (40 FR 27924). In 1990 (55 FR 6184), and again in 1993 (58 FR 51144), USFWS determined that the proposal to list *Calochortus striatus* as endangered or threatened was possibly appropriate, but that additional data on biological vulnerability and threat were needed before a final determination could be made.

Range

C. striatus has been found in five counties in southern California (CNPS 2016) and two counties in southern Nevada (Morefield and Knight 1991, NNHP 2001). It grows in desert meadows formed by springs and streams, and in low-laying mountain meadows on the leeward side of slopes (McDonald 1997). In Nevada, the species has not been systematically surveyed for (Morefield 2001), and is known only to occur in Ash Meadows National Wildlife Refuge in Nye County (Knight and Clemmer 1987, Ballard 2012), and in Red Rock Canyon National Conservation Area in Clark County (BLM 2005). It is not seen every year at those locations (Mozingo and Williams 1980).

Population Trends

While the species occurs in several areas, most populations are small (Bowen 1984 cited in Greene and Sanders 2006).

The following are records published by the California Department of Fish and Game in 1997:

- 1982: 100 plants reported below Box “S” Springs (north of Cushenbury Springs) (CDFG, 1997b)
- 1988: 400 plants reported at three sites around Lancaster in LA County (CDFG, 1997b)
- 1988-1992: 6,000 plants reported for Kern County (CDFG, 1997b)
- 1989: 1,500 plants reported at Paradise Springs near Fort Irwin (CDFG, 1997b)
- 1990: 133 plants reported at Red Cock Canyon (CDFG, 1997b)
- 1993: 50 plants reported at Cushenbury Springs (CDFG, 1997b)
- 1993: 100 plants reported at Rabbit Springs (CDFG, 1997b)
- 1998: 165,000 plants in 67 areas documented on EAFB (Los Angeles and Kern Counties: Bagley, *pers. comm.*, 1998 – *cited in* Greene and Sanders 2006 dmg.gov paper).

Habitat Model

We modeled habitat with 127 localities for the Mariposa Lily which were largely concentrated on the eastern slopes of the Spring Range, near Red Rock Canyon

National Conservation Area (NCA) and the community of Blue Diamond, with other localities in the Virgin River drainage at the extreme northeast extent of the county, near Mesquite. Habitat was predicted quite differently among the three model algorithms. The GAM models predicted large areas of marginal habitat, typically in low elevation drainages, but with "hot spots" of higher suitability habitat values predicted near springs (Figure 68). The RF model was less influenced by these springs, which were predicted as moderately suitable habitat, but predicted broad areas of higher suitability habitat in the Trout Canyon and Goodsprings/Red Rock Canyon NCA areas. The MaxEnt model was highly restrictive, predicting habitat only where springs are located (Figure 68).

The three modeling algorithms predicted habitat in similar geographic areas, but with differing areal extent and suitability values. GAM models predicted the most area, followed by the RF model, which had diminished values overall, and reductions in habitat in the Bird Spring Range/Goodsprings area and the Ivanpah Valley, while MaxEnt predicted very restricted habitat patches relative to the other two models (Figure 68).

While all models had similar AUC scores, TSS scores, and Correlation values, performance was highest in those scores for the RF model followed by the Ensemble, MaxEnt, and finally, the GAM models (Table 43). The MaxEnt model had a much reduced Boyce Index (BI) (Table 43). Similarly, the continuous Boyce Index indicated performance issues with the MaxEnt model, specifically with habitat suitability in the 0.6 to 0.8 range where a significant reduction in performance occurred (Figure 70). Continuous Boyce Indices (CBI) were similar for the GAM and RF models indicating good performance, but with a few dips at higher habitat suitability values in the GAM curve, and one in the RF model. The MaxEnt model also had a rather erratic CBI, peaking early (where Habitat Suitability = ~ 0.5), and becoming unstable above that point (Figure 70). The Fixed BI for this algorithm was also the lowest among the group (Table 43). The CBI for the ensemble model indicated good performance, with a short transition area from unsuitable to suitable habitat occurring at predicted habitat suitability values of 0.4 (Figure 70), which was similar to the Precision Recall Break Even (PRBE) cutoff value (Table 43). Standard errors were greatest for the GAM model, with elevated error (i.e., 0.6 to 1.0) relative to the other algorithms.

Table 43. Model performance values for *Calochortus striatus* models.

Performance	GAM	RF	MaxEnt	Ensemble
AUC	0.956	0.987	0.965	0.976
BI	0.738	0.695	0.617	0.751
TSS	0.827	0.943	0.873	0.923
Correlation	0.603	0.699	0.727	0.694
Cut-off	0.476	0.578	0.202	0.408

*threshold at which sum of sensitivity (true positive rate) and specificity (true negative rate) is highest

Table 44. Percent contributions for input variables for *Calochortus striatus* ensemble models using GAM, MaxEnt, and RF algorithms.

Term	GAM	RF	Max	Avg
Winter Precipitation	33.1452	14.69	25.598	25.69
Winter Min Temp	26.889	16.85	29.634	25.85
Summer Maximum Temp	21.169	10.25	13.767	15.909
Spring Density	13.427	19.68	20.916	19.631
Topographic Position (TPI)	2.7398	10.01	4.681	6.637
NDVI Maximum	1.628	3.64	1.392	2.521
Slope	1.0016	11.50	3.708	6.355
NDVI Amplitude	0.0001	3.83	0.233	1.669
Surface Texture (ATI)	0	6.47	0	2.692
Soil Water Stress	0	3.07	0.069	1.301

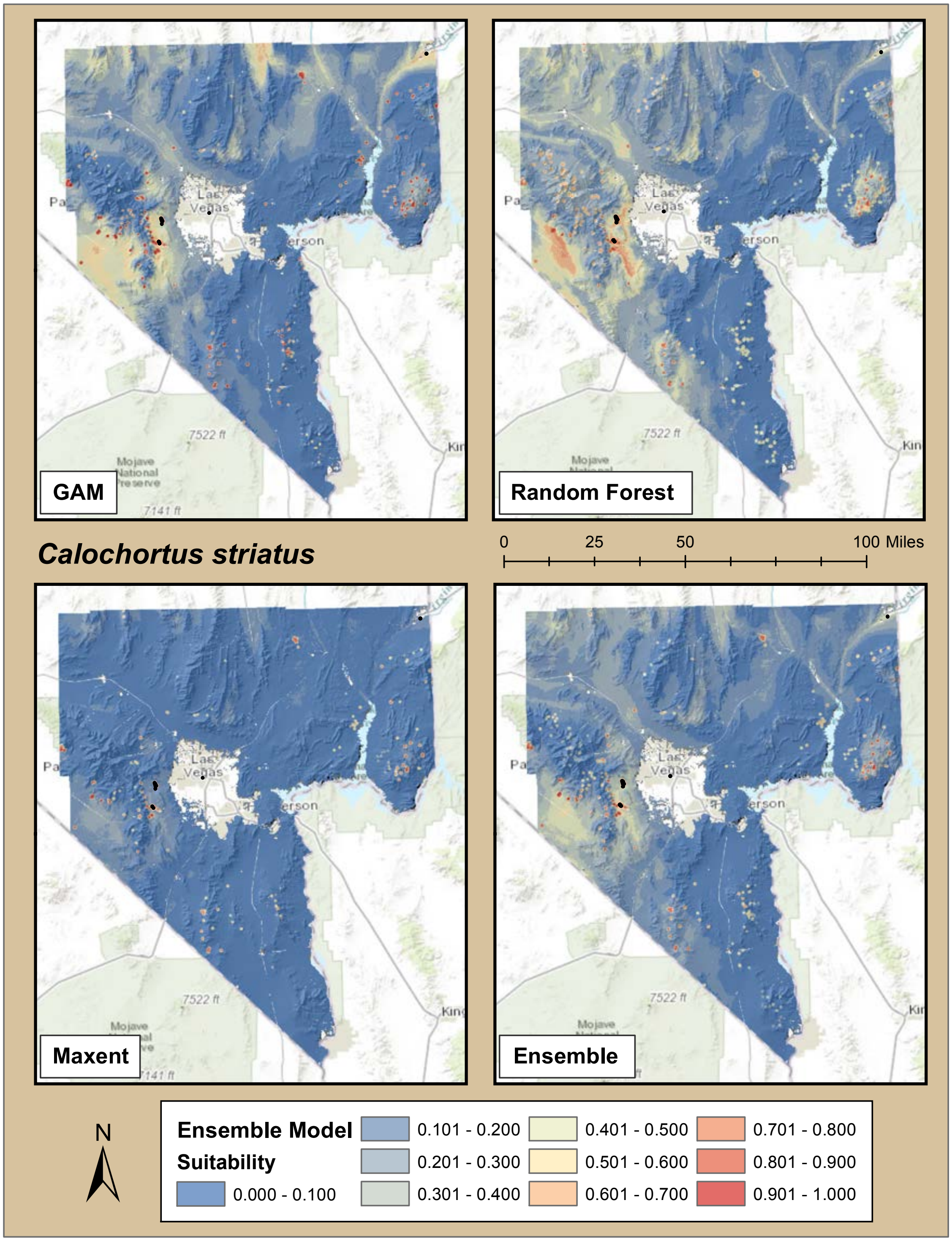


Figure 68. SDM maps for *Calochortus striatus* for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right). Black dots indicate presence points for the Calo

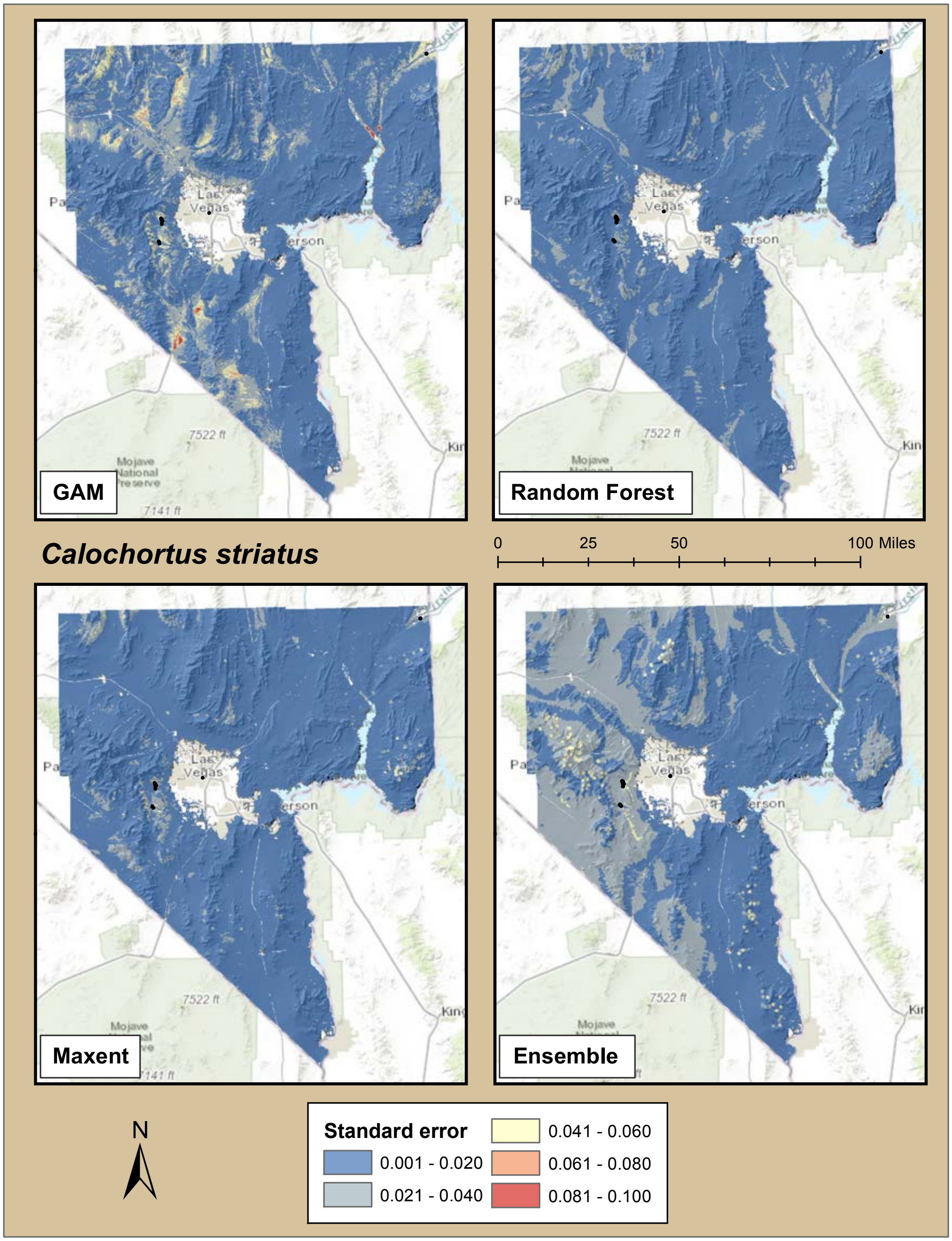


Figure 69. Standard error maps for *Calochortus striatus* models for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

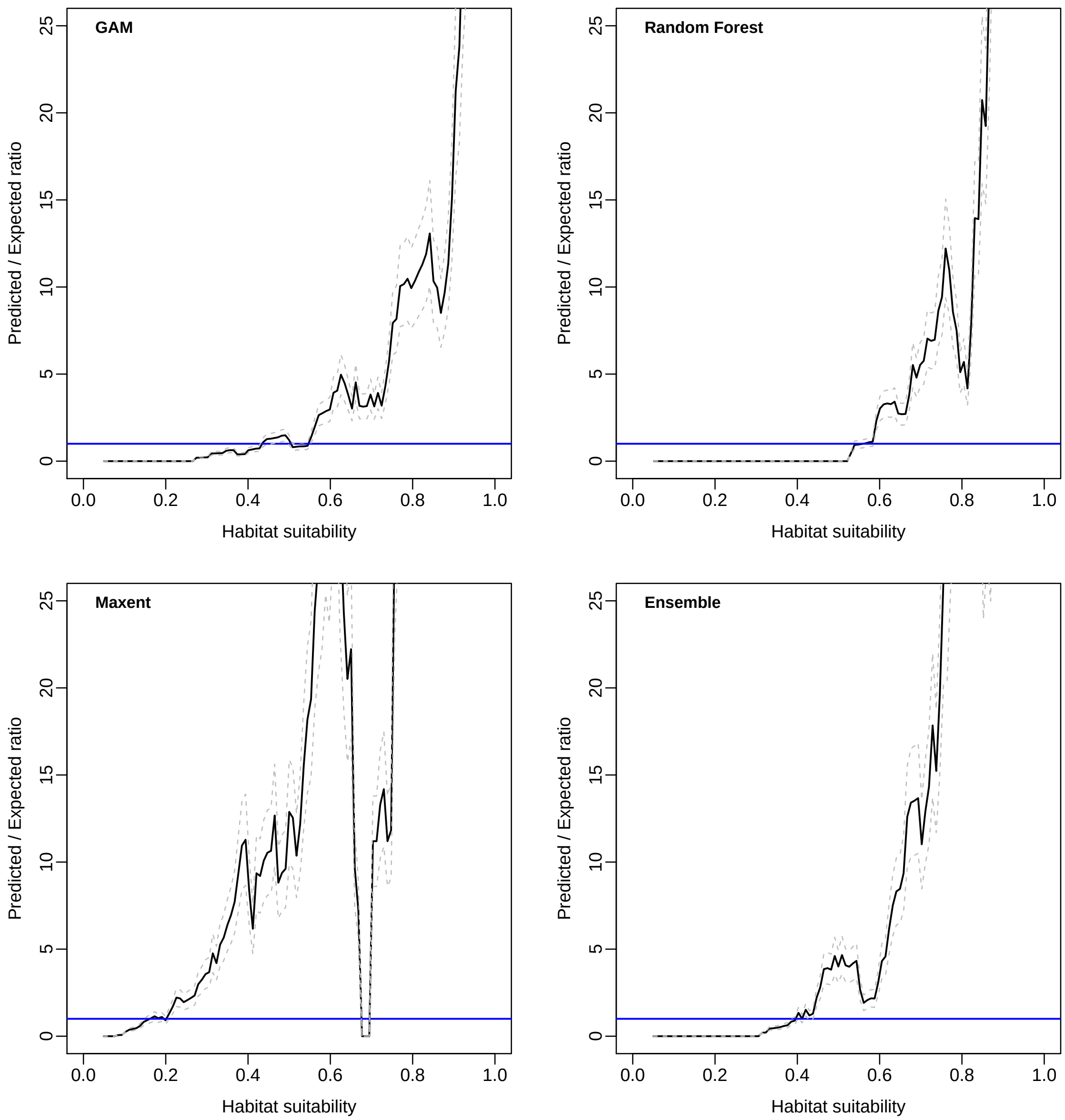


Figure 70. Continuous Boyce Indices for *Calochortus striatus* models for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an Ensemble model averaging the three (Lower Right).

GAM Model

The partial model contributions for the GAM model covariates identified 4 variables with more than 10% contribution toward the model, and representing 95% of the model contribution (Table 44. Winter Precipitation was the highest contributor (33%), and had a peaked response, with positive contribution to habitat suitability at values above 100 mm, peaking at 350 mm, and becoming a negative influence above 500 mm (Figure 71). Winter Minimum Temperature (27%) also had a peaked response, with positive associations with habitat suitability above ~ -5 ºC, peaking for areas at -2 ºC and becoming negative in areas above 2 ºC, which was reflective of the pattern in this measure within the county (see histograms, Figure 71). There was a positive linear relationship with Summer Maximum Temperature (21%), with a predicted positive influence on habitat suitability at temperatures above ~ 37 ºC. Spring Density was also influential in the model with a 13% contribution, and a strong positive contribution at all levels (Figure 71). The remaining 6 environmental variables provided little to no contribution (Table 44).

The GAM model predicted habitat for this species at isolated spring sites throughout the county (Figure 68). With medium levels of suitable habitat throughout the Pahrump/Trout Canyon area, and around the points concentrated in the Red Rock Canyon NCA/Blue Diamond Area, with other areas of moderate habitat near the Coyote Springs valley west of Moapa, and the upper Virgin River drainage in the county. There were several areas of higher standard error (0.06 to 0.1) in the habitat predicted on the outwash plains south of Indian Springs, in the southern valleys on the Nellis Bombing Range, north and south of Fossil Ridge in the Desert National Wildlife Area (DNWA), the lower reaches of the Virgin and Muddy rivers (and along the eastern shore of the Overton Arm of Lake Mead, west of Searchlight in the Wee Thump Wilderness Area and northern Piute Valley, Roach/Jean Dry Lake Valley, and in eastern Ivanpah Valley (Figure 69).

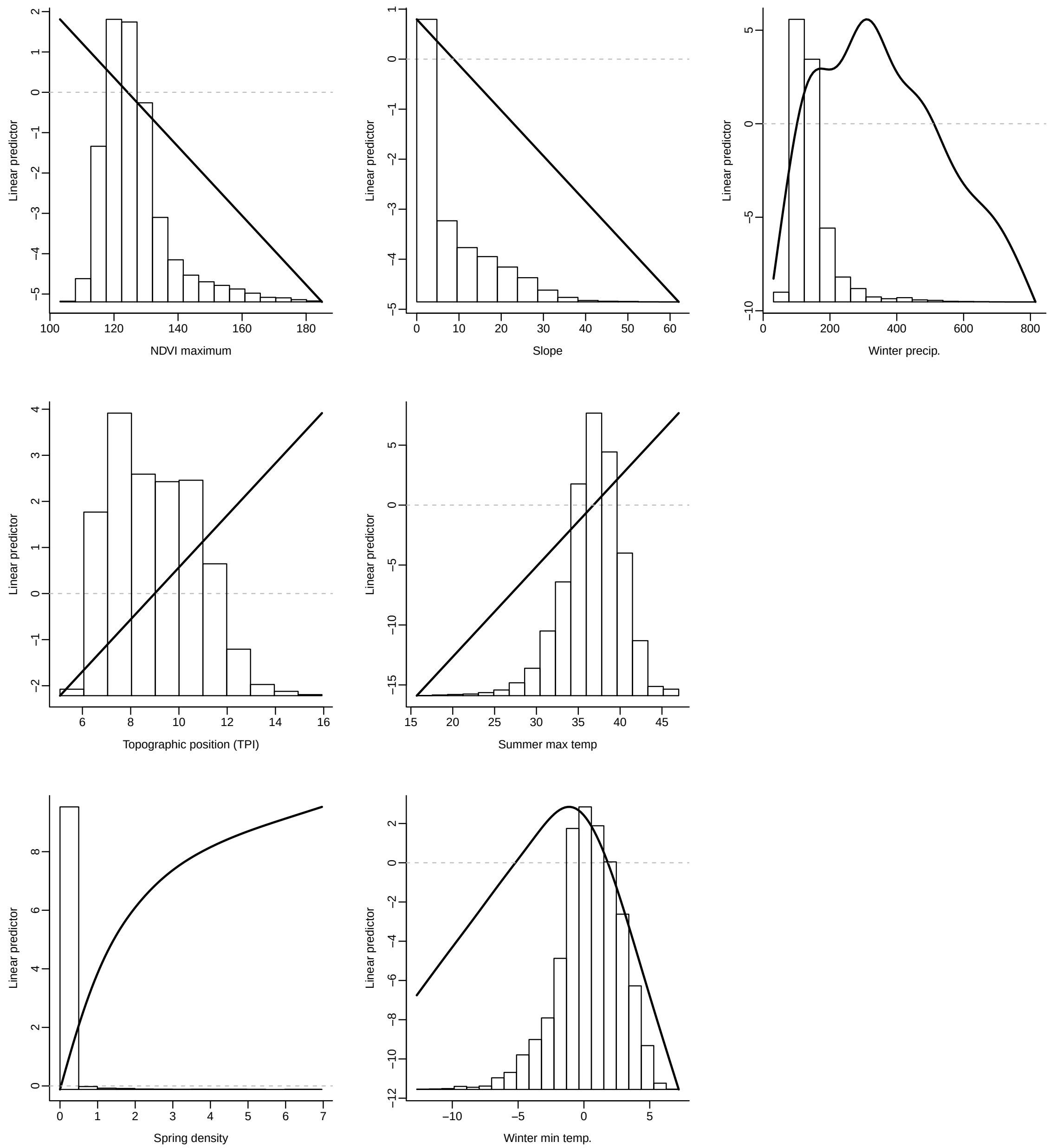


Figure 71. GAM partial response curves for the *Calochortus striatus* model illustrated over the distribution of environmental variable inputs in the study area.

MaxEnt Model

The MaxEnt model had four variables contributing 10% or more each, accounting for 90% of model contribution (Table 44). The four environmental variables were the same as those contributing to the GAM model, but with different orders of contribution. Winter Minimum Temperature had the highest model contribution (29%) and a peaked response with the highest influence at -2 ºC which is slightly lower than the mean minimum winter temperature distribution across the study area (Figure 72). Winter Precipitation also had a peaked response – predicting increased habitat suitability for *Calochortus striatus* in areas with the highest precipitation values in the county. Spring Density had a response curve similar to that of the GAM model, with a positive correlation as spring density increased. Summer Maximum Temperature was positively associated with habitat suitability, increasing sharply at levels above 35 ºC (Figure 72).

Predicted habitat area for the MaxEnt model was extremely limited, with higher levels of habitat predicted only near springs, and with very low, but somewhat widespread levels of habitat suitability in the Pahrump/Trout Canyon and Red Rock Canyon NCA/Blue Diamond areas than the GAM model (Figure 68). The standard error map for this algorithm also had the least areas illustrated with standard error level, and these occurred mostly in and around the areas of predicted habitat (Figure 69).

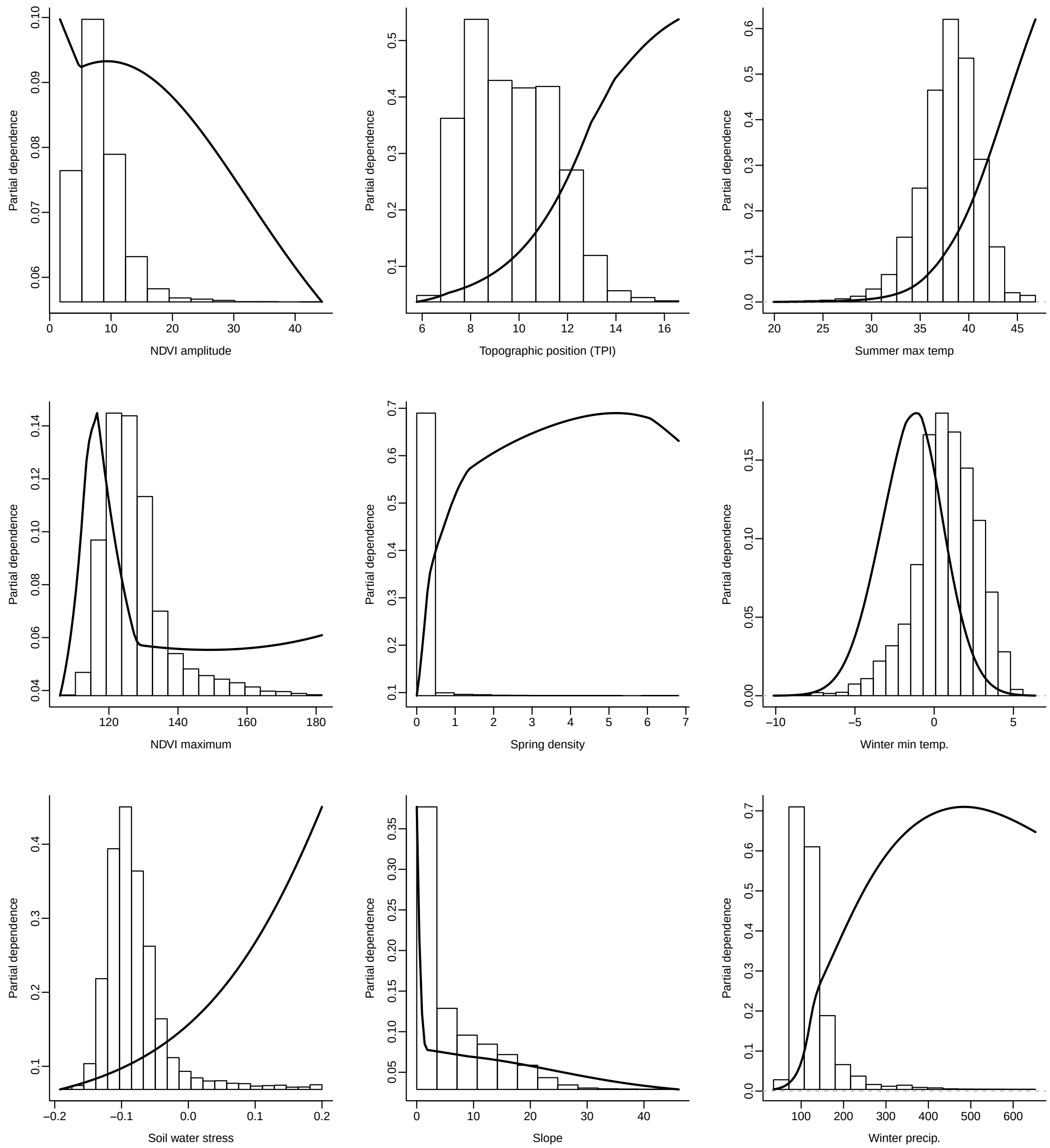


Figure 72. Response surfaces for the top 9 environmental variables included in the MaxEnt ensemble model for *Calochortus striatus.*

Random Forest Model

The RF models had six environmental variables contributing 10% or more totaling 83% of total model influence. Spring Density was the highest contributing covariate with 20% model contribution (Table 44), and again, sharp positive contributions to all levels with Spring Density above zero (Figure 73). Habitat suitability was higher at lower Winter Minimum Temperatures, and decreased sharply as winter minimum approached 0 ºC. Winter Precipitation had a threshold response, with higher habitat predicted above 100 mm, and peaking above 300mm (Figure 73). Habitat suitability was high only in flatter areas (low slope) with a high Topographic Position index (bottoms of local drainages). Habitat suitability was also higher in areas with a Summer Maximum Temperature above 35 ºC (Figure 73). The RF models also highlighted habitat around springs, but had broader connecting habitat of mid to upper range suitability in and around spring sites. Areas of higher habitat prediction were in the Red Rock Canyon NCA/Blue Diamond area on the west side of the Las Vegas Valley, and the eastern portion of the Pahrump Valley. Other low-level habitat areas are predicted in valleys on the western side of the county and in the springs in the southern portion of Gold Butte National Monument (Figure 68). Standard errors were low throughout the county, with low level error highlighted along the US 95 corridor, Mormon Mesa, and valleys dispersed throughout the county (Figure 69).

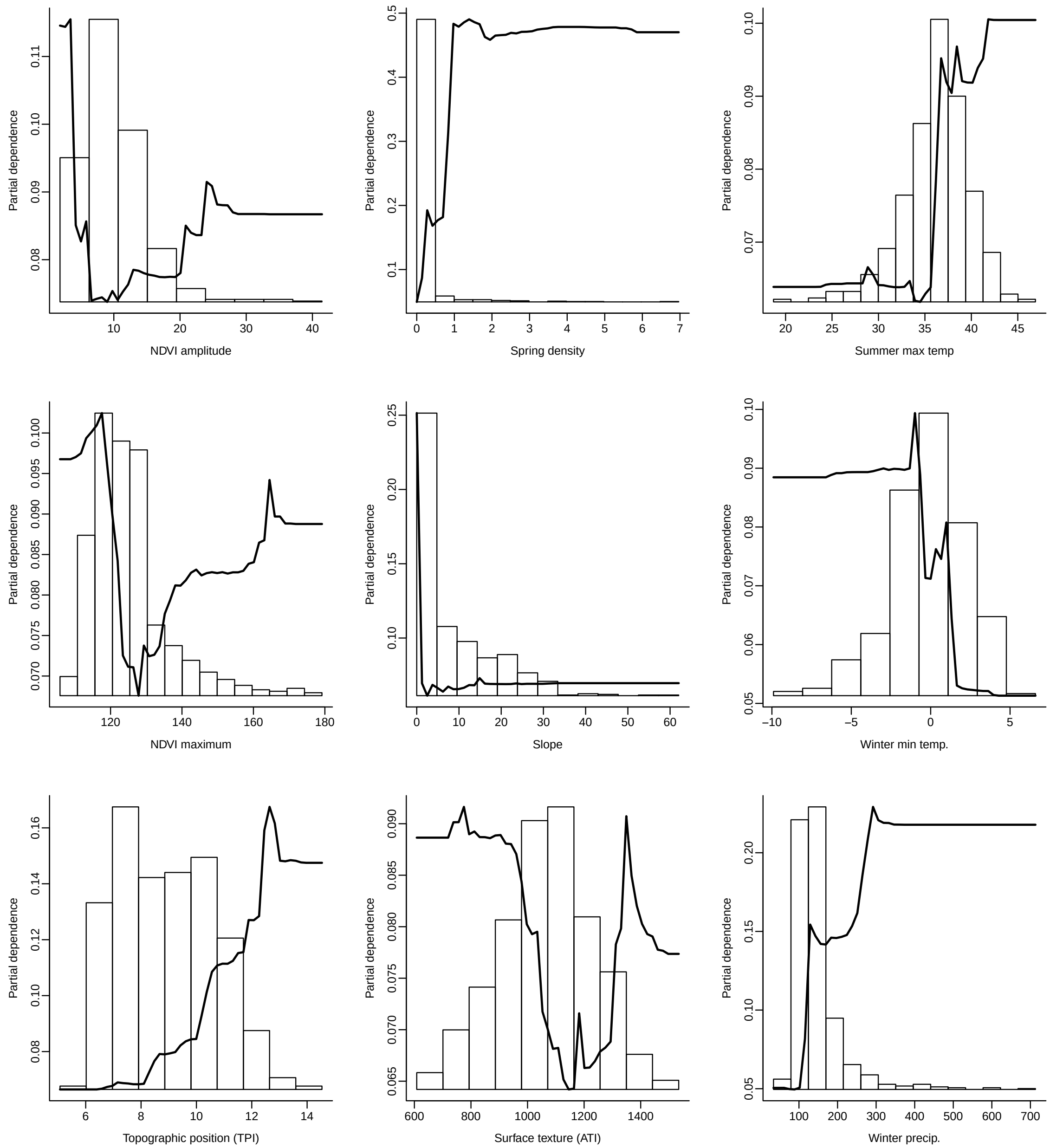


Figure 73. Response surfaces for the environmental variables included in the RF ensemble model for *Calochortus striatus*. Histograms represent the range of each environmental variable across the x-axis, and predicted dependence relative to habitat suitability

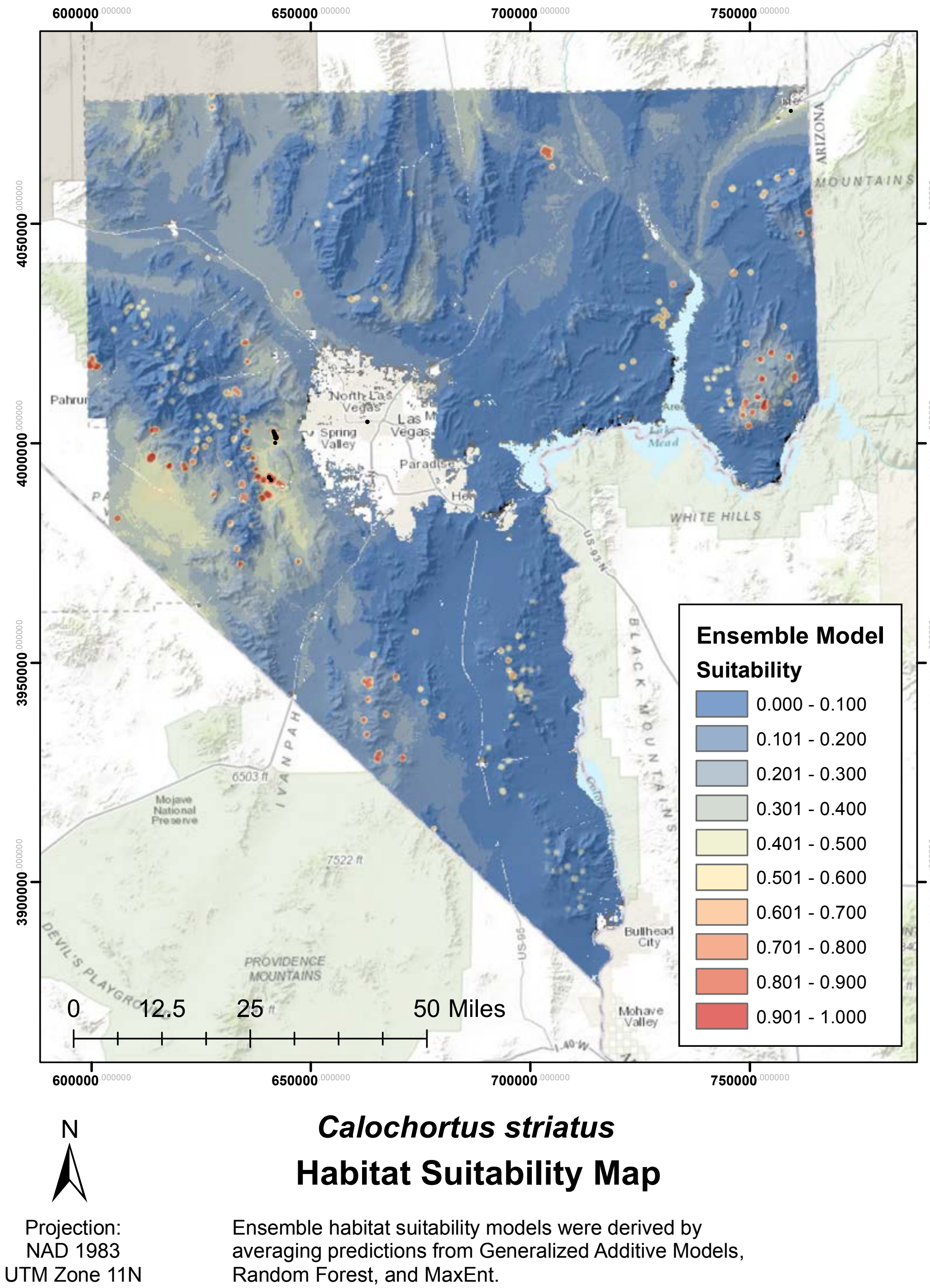


Figure 74. SDM map for the *Calochortus striatus* ensemble model

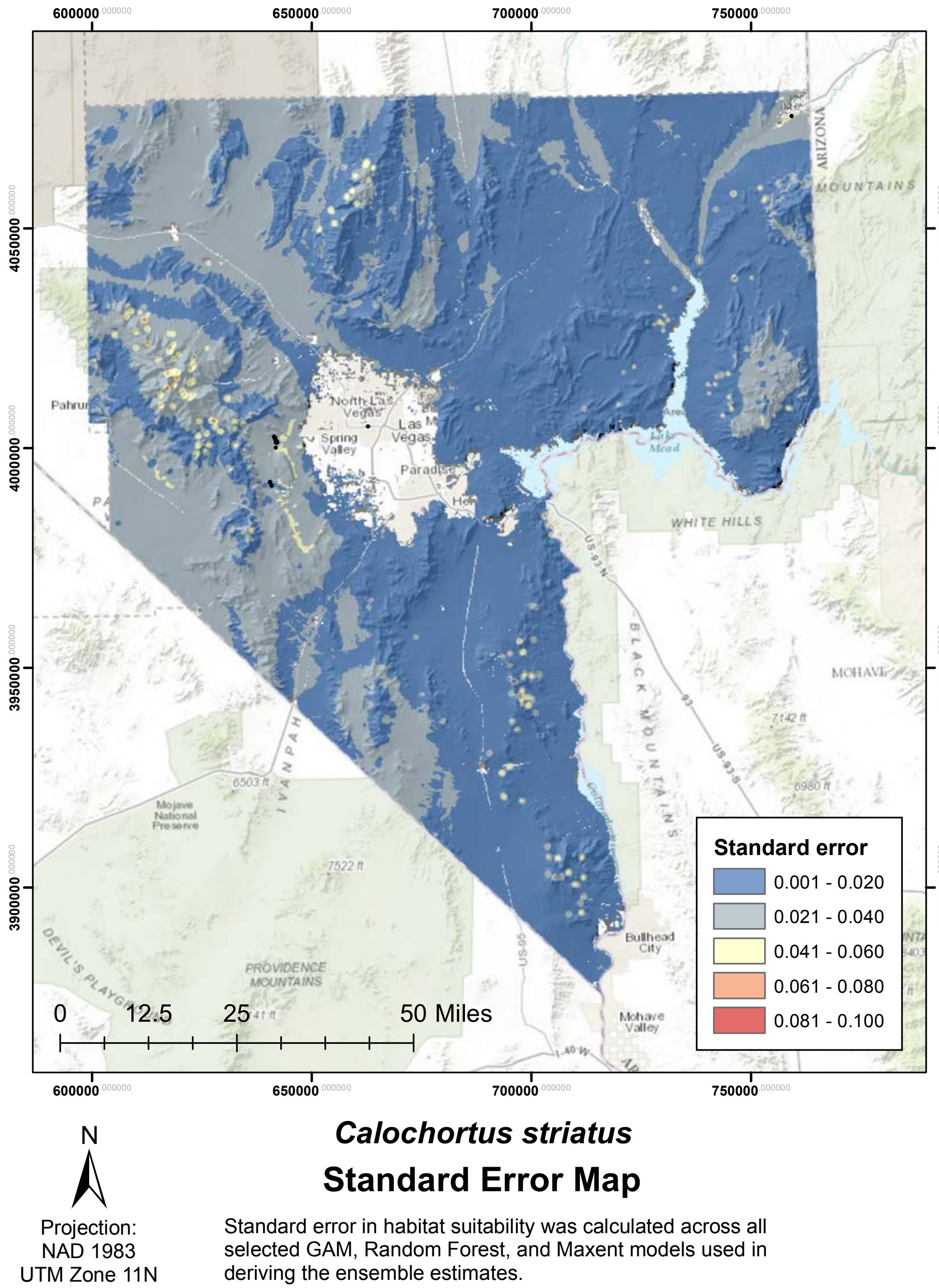


Figure 75. Standard Error map for the *Calochortus striatus* ensemble model.

Distribution of Localities

Localities (N=127) for *Calochortus striatus* are known in Clark County only in the Red Rock Canyon NCA, near Mesquite, and the Blue Diamond area west of Las Vegas (Figure 74).

Standard Error

Moderate levels of SE (0.04 – 0.06) are indicated in most spring areas, with lower error levels in valleys throughout the western portion of the county, typically but not always in lower elevation areas (Figure 75).

Distribution and Habitat Use within Clark County

In Clark County, Alkali Mariposa Lily is known to occur within Red Rock Canyon National Conservation Area, specifically at Calico Springs, Red Springs, Ash Springs, and Lone Willow Springs (Mozingo and Williams 1980, BLM 2005).

This species is found in alkaline meadows and moist creosote-bush scrub ranging in elevation from 800-1400 meters (Baldwin 2002). It grows in calcium-rich sandy soil (Fiedler 1985) in seasonally moist alkaline habitats (Mozingo and Williams 1980), ephemeral washes, vernal moist depressions, at seeps within saltbush scrub (*Atriplex* spp.) (Fiedler and Ness 1993), in chaparral habitat, and in Mojave Desert scrub (CNPS 2016). The plant is not found on soil with surface salts, or in wetter areas with permanent standing water (Mitchell 1988 *cited in* Green and Sanders 2006). Associated plants include *Distichlis spicata var. stricta*, *Cleomella brevipes*, *Iva acerosa*, *Anemopsis californica*, and *Dodecathon pulchellum var. pulchellum* (Knight and Clemmer 1987). Its predicted habitat among Clark County ecosystems indicates that this is likely a rare/sparsely distributed species, with low areas of high suitability habitat predicted in Blackbrush, and to a lesser extent Mojave Desert Scrub (Table 45). Moderate habitat is predicted more broadly in these habitats, among many others with the lowest habitat area predicted for the higher elevation ecosystems (Table 45).

Modeled habitat in the county is predicted to be high in the foothill areas generally surrounding the localities. Pockets of habitat are predicted at springs throughout the county due to the strong association of known localities to springs (Figure 74. Lower levels of habitat suitability are found surrounding the localities east of the spring range, and in the Pahrump/Trout Canyon/Sandy valley area (Figure 74). However, consistent with current databases, Alkali Mariposa Lily is not documented in the Desert Range at this time (Ackerman 2003). Other isolated patches of habitat are predicted throughout the county, typically associated with springs (e.g., Warm Springs – northwest of Moapa, Rogers Spring, and southern Gold Butte NM).

Table 45. Ecosystems within Clark County, and the area (Ha) of Low Medium and High predicted suitability within each ecosystem.

Ecosystem	Low	Medium	High
Alpine	124	0	0
Blackbrush	352595	54112	7950
Bristlecone Pine	7513	50	0
Desert Riparian	7733	2190	137
Mesquite Acacia	17554	1182	521

Ecosystem	Low	Medium	High
Mixed Conifer	26911	422	0
Mojave Desert Scrub	1177042	78426	2619
Pinyon Juniper	110078	4302	1443
Sagebrush	4620	61	26
Salt Desert Scrub	71652	5216	111

Ecosystem Level Threats

Threats to the alkaline meadow habitat of Alkali Mariposa Lily include grazing and urbanization, trampling, road construction, and hydrological alterations such as water diversions that result in lowering the water table. Horticultural collecting and non-native plant invasions are also thought to be possible potential threats (Baldwin 2002, CNPS 2016).

Lowering water tables is thought to be the greatest threat to *C. striatus*. Another imminent threat is urbanization, especially in Lancaster, California, where the largest populations exist. Trampling and grazing have the potential to reduce reproductive capacity of the species (Tollefson 1992). Road construction is also a threat. One known population was extirpated at Whiskey Springs in the 1920's by the construction of Highway 18 (CDFG 1997b). The Cushenbury Springs population was indirectly affected by the expansion of Kaiser Cement in 1988, which resulted in diversion of water flow from the spring and the addition of a parking lot (CDFG 1997b). In the Kern River Preserve, it is suspected that competition among taller grasses and non-native barley species may be contributing to population declines, but this may not be an applicable threat to all populations (Tollefson 1992).

Threats to Species

According to Greene and Sanders (2006) *Calochortus striatus* faces four major threats:

1) Lowering water tables
2) Grazing
3) Competition with weedy species
4) Land development

These are all potential threats faced by the known populations of *C. striatus* in Clark County, all of which lie within Red Rock Canyon National Conservation Area (RRCNCA). The Conservation Area is used heavily for recreational purposes, receiving approximately half a million visitors annually. The proximity of private property to wildlife habitat and riparian systems within RRCNCA is also a concern (BLM 1998, BLM 2005).

Greene and Sanders (2006) suggest that negotiating with local water authorities is necessary to maintain/restore water tables to historic water levels and removing and/or modifying obstructions to natural springs or seep flows.

Feral horses and burros can cause extensive damage to riparian areas by residing near water sources and springs, causing trampling and grazing of vegetation, soil churning, erosion, and the reduction of spring flow. *C. striatus* depends on sheet flows (CNPS 2016) and thus could be exposed to these indirect effects from horse and burro activity. Soil and vegetation disturbance from horses and burros could also indirectly increase the amount of invasive plants (BLM 2005). This resulting competition with non-native plants could have the potential to outcompete populations of *C. striatus* (Tollefson 1992). Horse and burro trails have the potential to further increase human activity, which could bring human-related disturbance to these sensitive populations of *Calochortus striatus*. Greene and Sanders (2006) suggest fencing off known populations to prevent livestock from trampling and grazing, as well as non-native weed management in order to improve reproductive success of the species.

Existing Conservation Areas/Management Actions

The known Clark County populations of *Calochortus striatus* exists within Red Rock Canyon National Conservation Area (RRCNCA), an established conservation area managed by the Bureau of Land Management. Because of this, some of the threats to populations that exist in other areas are not applicable to the Clark County population.

The Red Rock Canyon National Conservation Area Resource Management Plan recommends conducting an ongoing program of population monitoring for this species (BLM 2005). It also recommends the management of humans, burros, and horses to protect riparian habitat (BLM 2005).

Authorized off-roading recreation and development are not pertinent concerns to the Clark County population of *Calochortus striatus*, as all motor vehicles are limited to designated roads in the RRCNCA (BLM 2005).

The RRCNCA management plan states that the management plan for Red Spring requires further review due to its ecological sensitivity, but should continue to provide interpretive and picnicking opportunities (BLM 2005).

The plan also calls for the removal of burros from Calico Basin, rerouting trails out of riparian areas near Red Springs, fencing spring sources where needed, and eliminating tamarisk from 15 springs which will reduce salt loading to the surface water and reduce competition among native species (BLM 2005). These could all have potential beneficial effects for existing *Calochortus striatus* populations within RRCNCA.

Due to its requirements for wetter environments and sheet flows, hydrology plays an essential role in maintaining existing *C. striatus* populations (CNPS 2016). Periodic natural inundation for the species is important (Edwards AFB 2002). As of 2003, The California Native Plant Society does not accept maintaining sheet flow as an acceptable long-term conservation strategy as they do not recognize any guarantees in maintaining sheet flows that the species relies on. The CNPS suggests appropriating water rights as an option for assuring continued water to Alkali Mariposa Lily habitat. CNPS supports the acquisition of isolated springs, seeps, and meadows from sellers for species conservation, but warns that these should not be counted on as assurance for conservation due to these types of acquisitions/conservation areas would not be assured. The CNPS supports the establishment of conservation areas within the range of *Calochortus striatus*. CNPS suggests grazing restrictions through the fruit maturation period at Green Spring in Kelso Valley to allow for seed dispersal as opposed to take permits (CNPS 2016).

Long term monitoring is required to protect this species due to large fluctuations in population numbers (Tollefson 1992).

Summary of Direct Impacts

Very little habitat is already disturbed, or expected to be impacted under the amended plan (1.4 and 4.6 km^2 respectively). More than a third of the total high suitability habitat predicted for C. striatus is located within conserved areas. Moderate habitat reflects similar proportions, where 115 km^2 of moderate habitat may be lost due to existing or future development, but where 520 km^2 of moderate habitat is to be conserved, which is ~ 1/3 of the total habitat of this level for the species county wide (Table 46).

Table 46. Categorized modeled habitat values (High, Medium, and Low) and the average area (Hectares) predicted in the potential impact areas, conservation areas, already disturbed areas, and overall area

Habitat Level	Impact	Conserved	Disturbed	Area (Hectares)
High	462	3344	144	12924
Med	8749	50997	2814	146846
Low	107329	459226	25404	1791020

CHOC - Chionactis occipitalis – Shove-Nosed Snakes

Shovel-Nosed Snakes (*Chionactis occipitalis*) are small colubrid snakes that live on valley floors and bajadas of the southwestern deserts (i.e. Mojave, Colorado, and Sonoran) of the United States (Wood et al. 2008). They have a distinct flat nasal scale making the fronts of their heads flatter than most other snakes and countersunk lower jaw (Stebbins 2003). Their bodies are specially adapted to “swim” through loose sand rather than dig like other snakes. In southern Nevada these snakes usually have brown bands against a yellow-brown background coloration. There may be secondary bands between the broader and bolder brown bands that are red to orange. Nomenclature follows Crother (2008) for this species and its subspecies. There are four recognized subspecies and two of them, the Mojave shovel-nosed snake (*C. o. occipitalis*), and the Nevada shovel-nosed snake (*C. o. talpina*) live in southern Nevada but the geographic distributions are not well known (Stebbins 2003, Wood et al. 2008, and Dustin Wood – USGS, Pers. Comm.). They are typically nocturnal snakes that may be 200 to 430 millimeters in length as adults.

Species Status

US Fish and Wildlife Service Endangered Species Act: No Status
US Bureau of Land Management (Nevada): Sensitive
US Forest Service (Region 4): No Status
State of Nevada: No Status
NV Natural Heritage Program: Global Rank G5, State Rank S4
NV Wildlife Action Plan: Species of Conservation Priority
IUCN Red list (v 3.1): Least Concern
CITES: No Status

Range

Shovel-Nosed Snakes range west and northwestward from near Tucson, Arizona and their eastern range limit runs in a diagonal line to Nye County, Nevada. They occupy appropriate habitats in most of the hot deserts of southern California. They also occur in far northeastern Baja del Norte, Mexico and far northwestern Sonora in the areas just north of the Gulf of California. This range encompasses appropriate habitat in all of southwestern Arizona (Stebbins 2003). Elevational distribution ranges roughly from 84 meters (275 feet) below sea level in Death Valley, California (Turner and Wauer 1963) to 1433 meter (4700 feet) in Saline valley and Amargosa Desert, California and Nevada (Elvin 1963).

Habitat Model

Among the different modeling algorithms, GAM models generally predicted more habitat, MaxEnt predicted less, with the least habitat area was predicted by RF (Figure 76). Performance metrics among modeling algorithms did not agree on one method. RF had higher TSS and AUC, while the ensemble model had higher BI than the others (Table 47). The continuous Boyce Indices for the models indicated the best performance for the RF and Ensemble models, while the GAM and MaxEnt models had lower overall predictability for points in higher habitat suitability (Figure 78). Standard error maps also showed that the MaxEnt model had higher standard error, especially in lowland areas, even where there were observations to support the habit prediction (Figure 77).

Table 47. Model performance values for Chionactis occipitalis models

Model	Presences	AUC	BI	TSS
Ensemble	116	0.909	0.922	0.694
GAM		0.835	0.869	0.576
RF		0.969	0.894	0.884
MaxEnt		0.817	0.874	0.563

Table 48. Percent contributions for input variables for Chionactis occipitalis for ensemble models using GAM, MaxEnt and RF algorithms

Variable	GAM	MaxEnt	RF
Elevation			
NDVI Amplitude	7.20	4.02	11.67

Variable	**GAM**	**MaxEnt**	**RF**
NDVI Maximum	2.40	4.88	12.60
NDVI Start of Season			
NDVI Total Integrated			
Sandy Soils (TerraSpectra)	0.80	4.60	
Slope	29.32	25.10	
Summer Maximum Temperature	25.12	9.33	16.81
Surface Roughness			
Temperature Range (Annual Max - Min)	2.40	21.19	13.66
Terrain Position Index	0.80	2.51	
Texture (ATI)			38.71
Washes	0.80	2.85	
Winter Minimum Temperature	6.40	14.55	15.02
Winter Precipitation	24.76	10.96	15.42

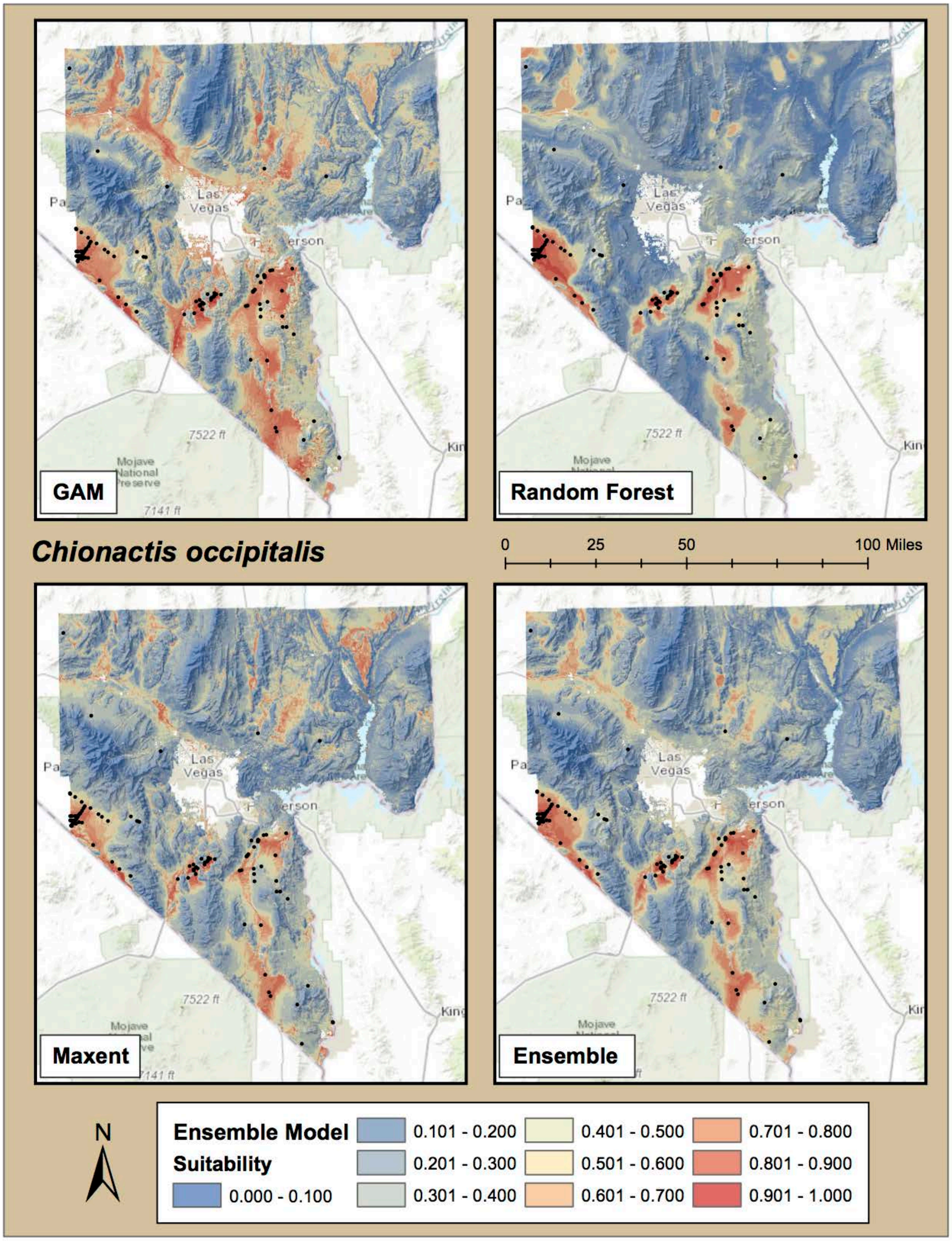


Figure 76. SDM maps for *Chionactis occipitalis* model ensembles for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and ensemble model averaging the three (Lower Right).

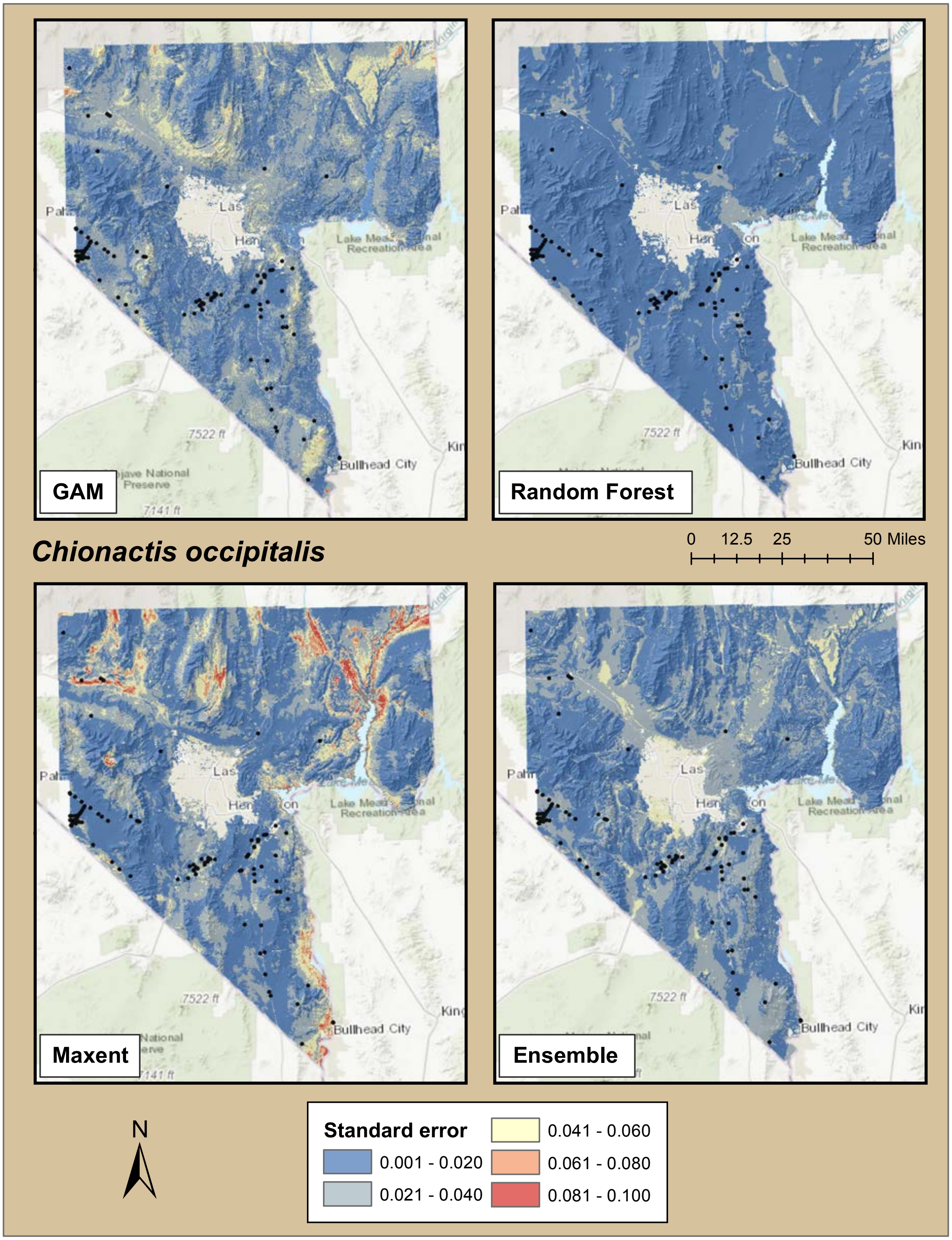


Figure 77. Standard error maps for *Chionactis occipitalis* models for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

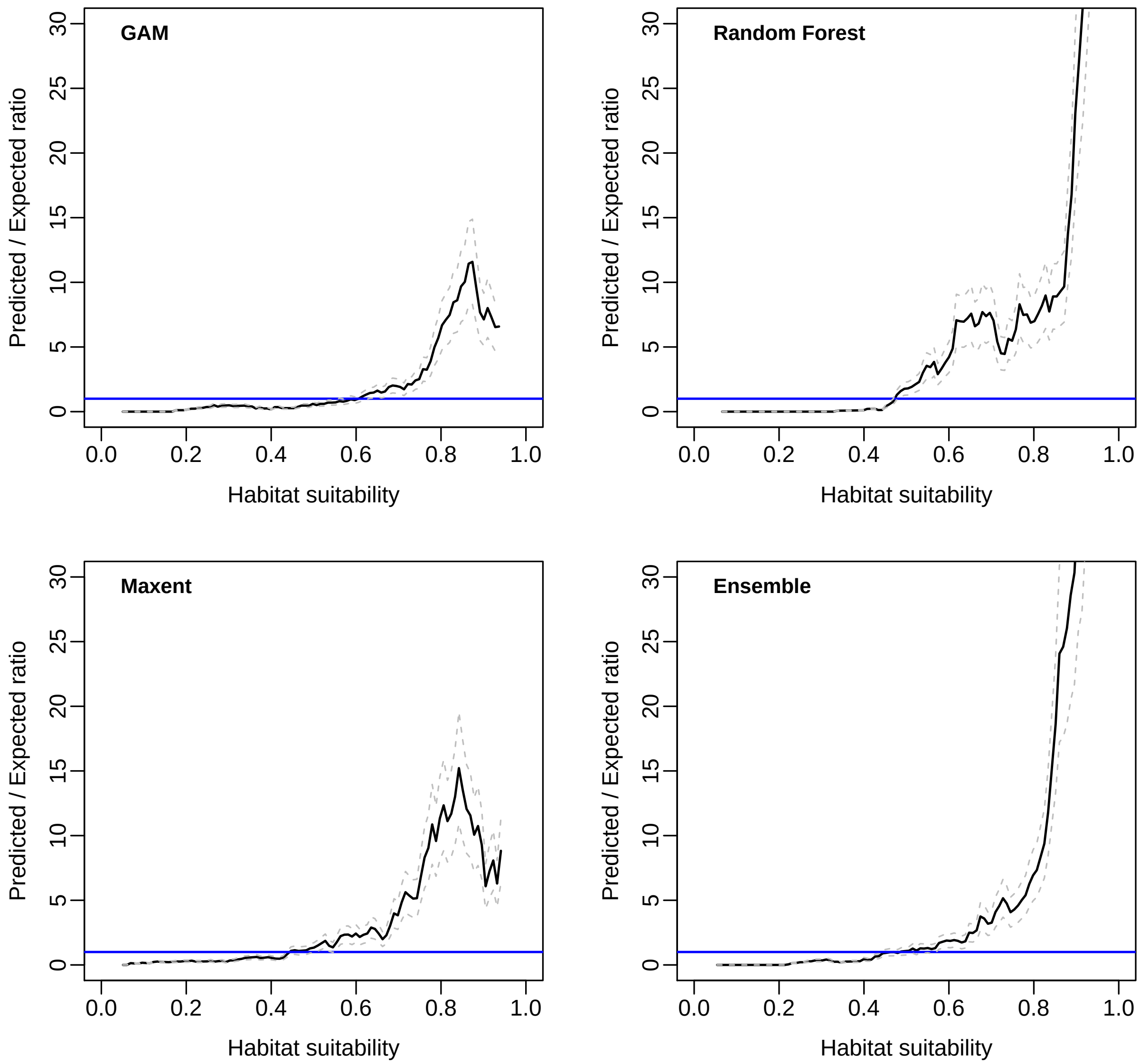


Figure 78. Graphs of Continuous Boyce Indices [CBI] for *Chionactis occipitalis* models for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

General Additive Model

Of the 15 variables considered for inclusion in the SDM for Shovel-Nosed Snakes – 10 were included in the top models selected for the ensemble model using the GAM algorithm (Table 48). These included Minimum Temperature, Maximum NDVI, Topographic Position Index, Temperature Range, NDVI Amplitude, and % Washes. Both temperature variables had generally positive relationships with the input variables with greater variability in suitability at higher temperatures, the

Topographic Position Index had a positive relationship, and Winter Precipitation had a strong negative response at lower values (< 200 mm). Maximum NDVI, Slope, and % Washes had generally negative relationships with predicted habitat, and NDVI Amplitude and maximum temperature both had predictions showing peaks in predicted habitat at low to median values, and high values respectively (Figure 79).

Model contributions were highest and most influenced by for Slope, Summer Max Temperature, and Winter Precipitation, followed by NDVI Amplitude and Winter Minimum Temperature with lower contributions of NDVI Maximum, Annual Temperature Range, with lower contributions from Sandy Soils, Terrain Position Index, and Washes.

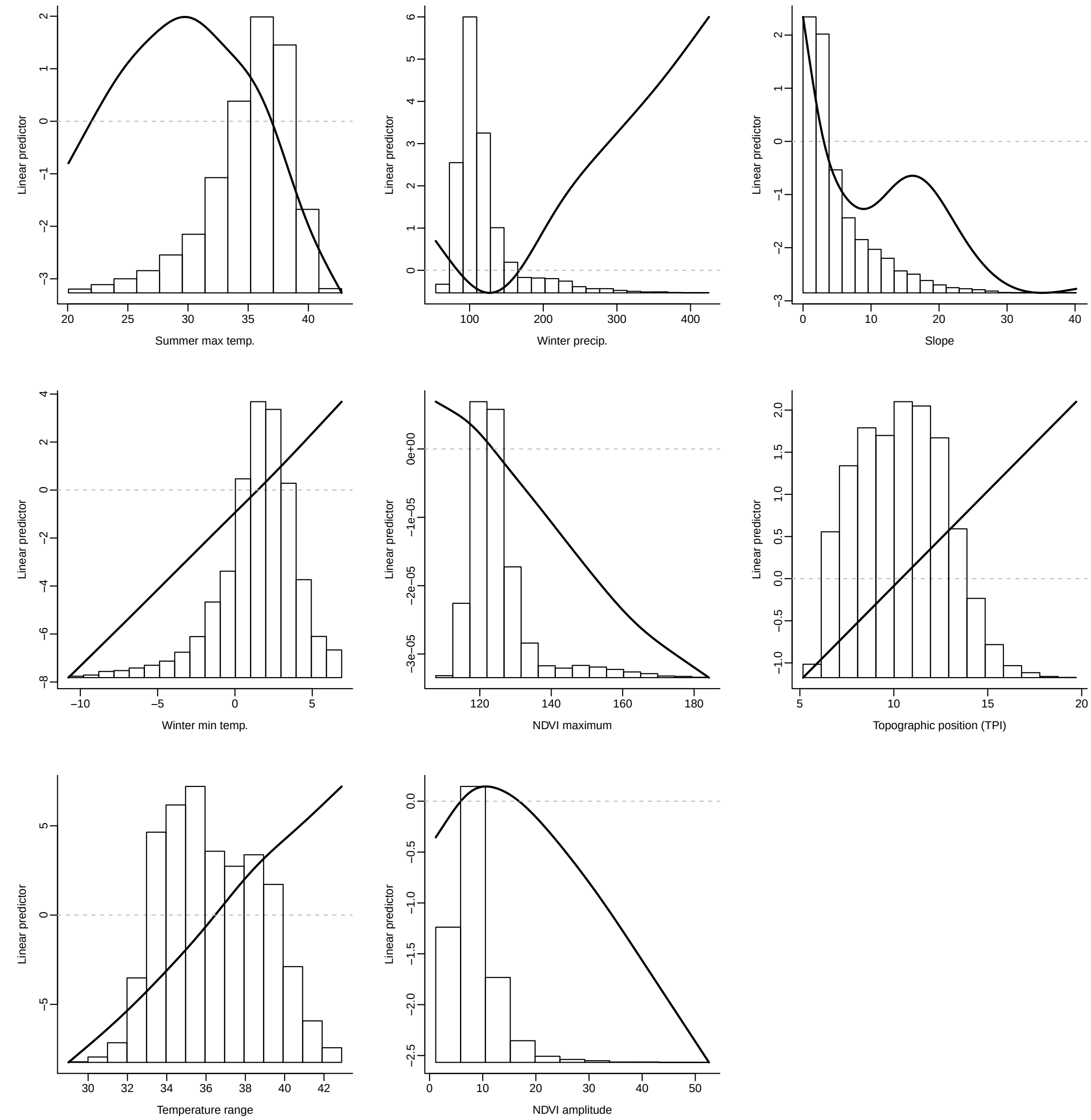


Figure 79. GAM partial response curves for the *Chionactis occipitalis* model overlaid over distribution of environmental variable inputs in the study area.

MaxEnt Model

MaxEnt model selection resulted in the same 10 variables as those in the GAM model, but with different contributions. Model contributions were highest from Slope, and Annual Temperature Range, followed by Winter Minimum Temperature, Winter Precipitation, Summer Max Temperature, moderate contributions from NDVI Maximum, Sandy Soils, NDVI Amplitude, with the lowest percent contributions from Washes and Terrain Position Index. Model responses were similar across all covariates, with a slightly tighter relationship with slope than predicted for the GAM model for this species (Figure 80).

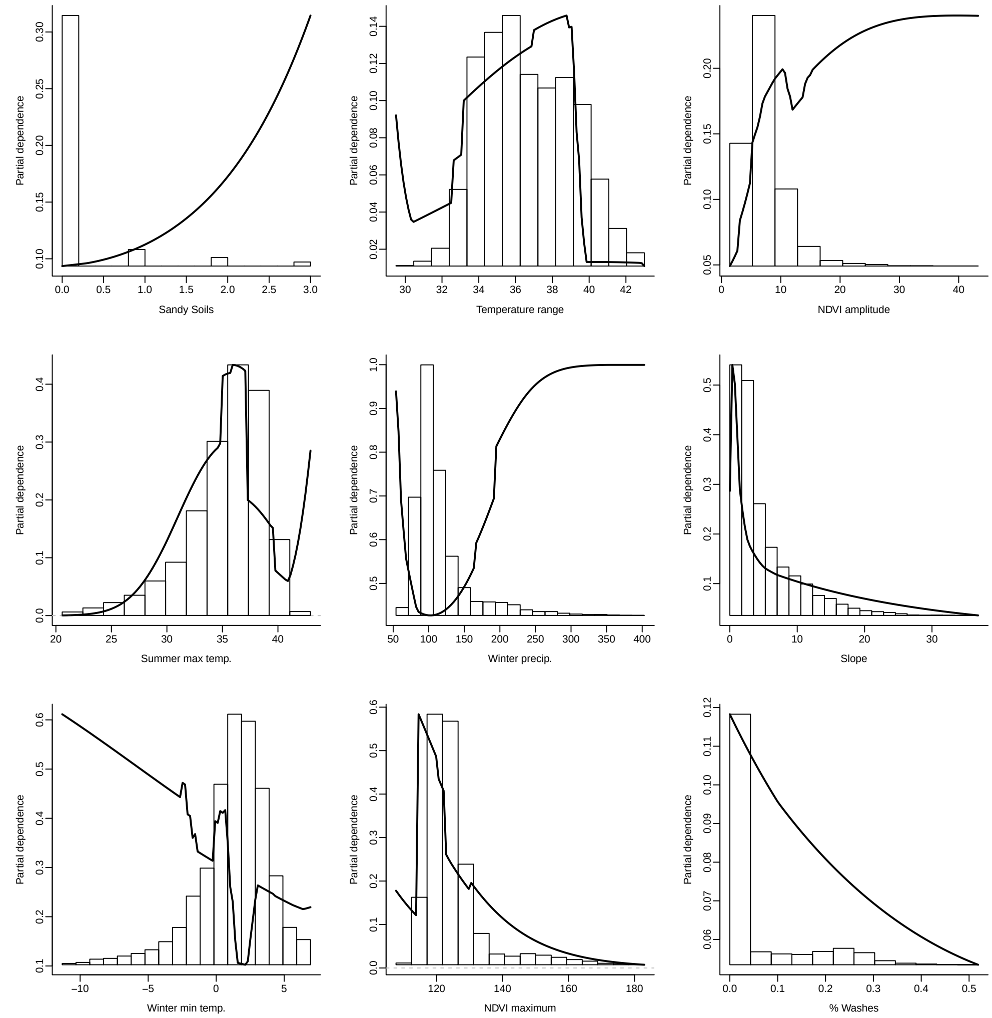


Figure 80. Response surfaces for the top environmental variables included in the MaxEnt ensemble model for *Chionactis occipitalis.*

Random Forest Model

RF ensemble models were composed of only 7 of the 15 variables, with 6 in common with the GAM and MaxEnt models, dropping support for Slope, Sandy Soils, Terrain Position Index and Percent Washes, and adding support for Surface Texture as the highest contributing factor. Summer Maximum Temperature and Winter Precipitation, Winter Minimum Temperature and Annual Temperature Range were next in rank, and NDVI Maximum and NDVI Amplitude were the final two contributing variables. General responses were similar, but with apparently more complex functions driving the relationships of Surface Texture, Summer Maximum Temperature, and Winter Precipitation to predicted habitat, which may indicate reduced biological significance (Figure 81).

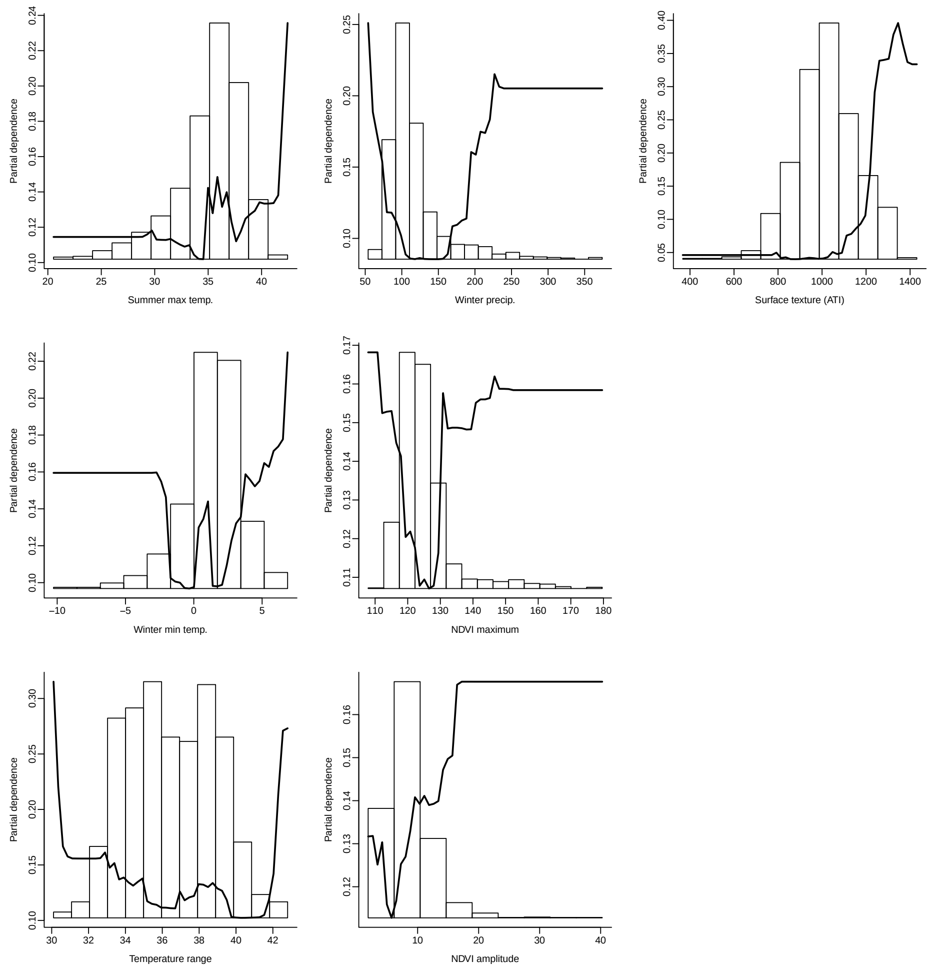


Figure 81. Partial response surfaces for the environmental variables included in the RF ensemble model for *Chionactis occipitalis*. Histograms represent the range of each environmental variable across the x-axis, and predicted dependence relative to habitat suitability values are on the y-axis

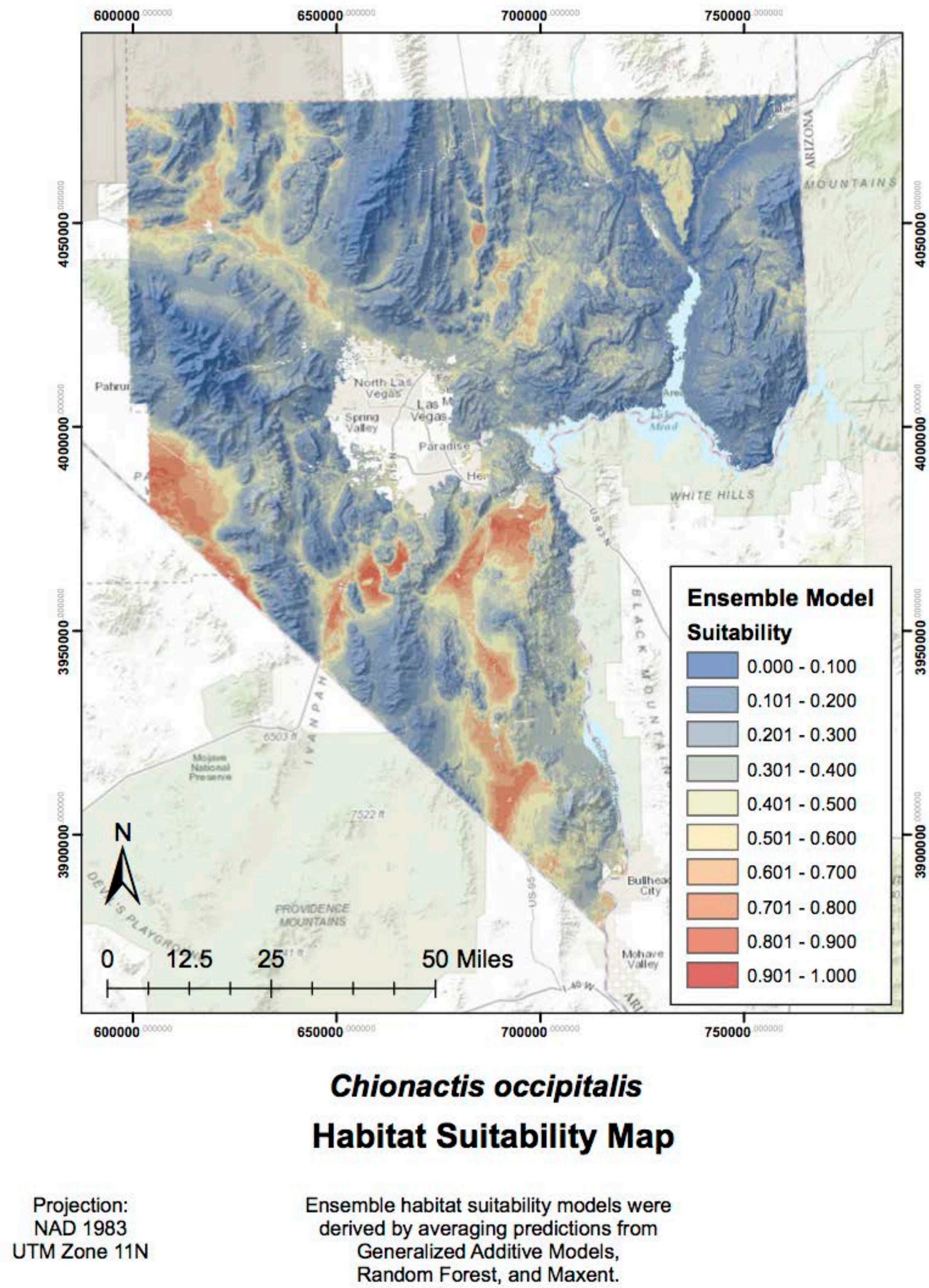


Figure 82. SDM map for the *Chionactis occidentalis* Ensemble model.

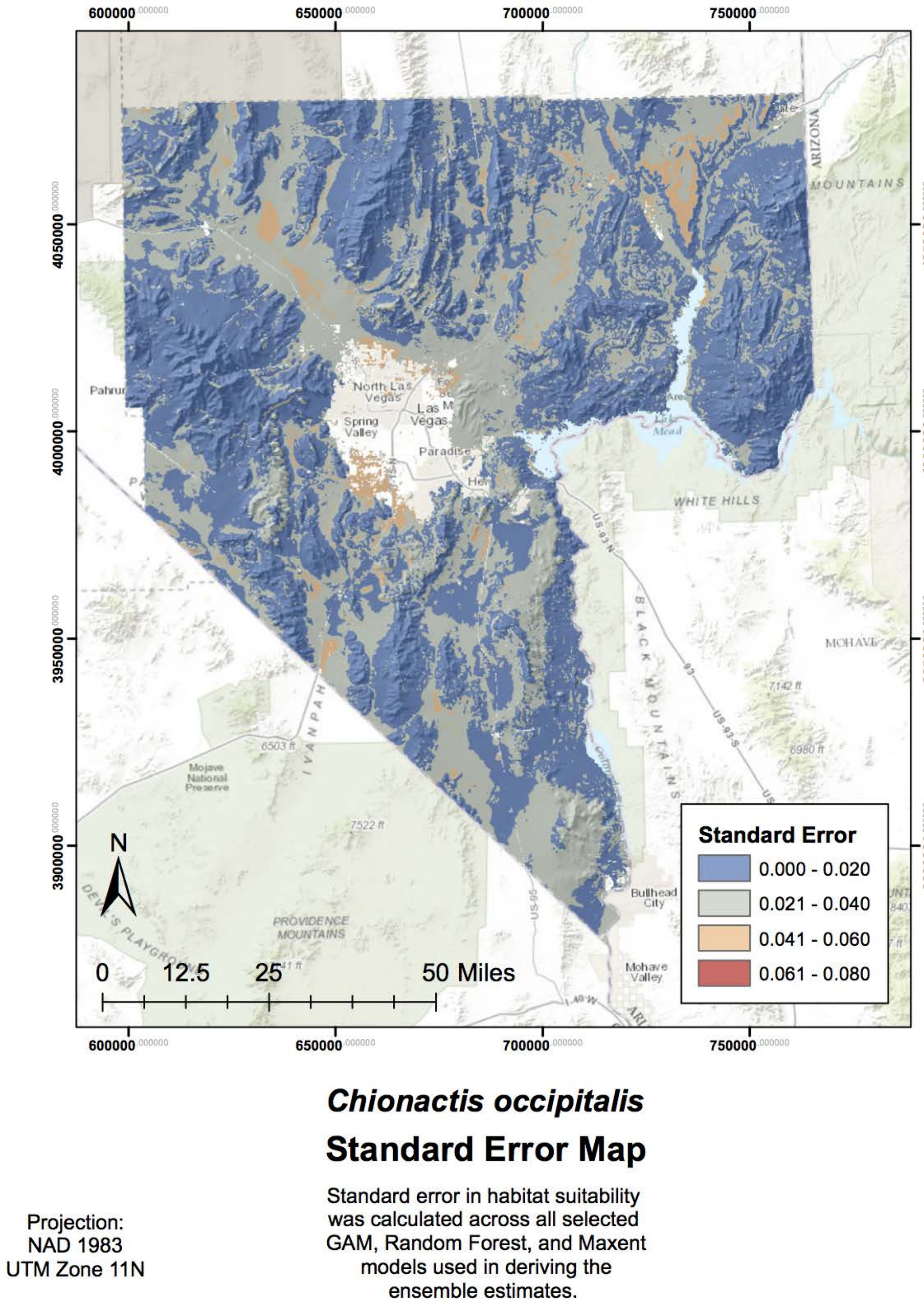


Figure 83. Standard Error map for the ensemble *Chionactis occipitalis* ensemble model for Clark County, NV.

Distribution and Habitat Use within Clark County

Shovel-Nosed Snakes typically occur in dry, sandy areas that are relatively flat and low in elevation, such as valley bottoms and alluvial fans (Klauber 1951, Funk 1967, Stebbins, 2003). They also occur in sand dunes if sufficient vegetation and soil islands are present, as they are not often found in sand dunes or areas with extensive sand that are nearly devoid of vegetation altogether (Klauber 1951), and they are known to reside in burrows between the roots of shrubs growing in the firmer soil (Mosauer 1933). They can move across dune areas by "swimming" across the sand, but can also travel beneath the surface using the same technique (Mosauer 1932).

Like all ectotherms, shovel-nosed snake behavior is affected by the temperature of its immediate environment, and requires specific temperatures for activity (Klauber, 1951). Throughout most of its range, the shovel-nosed snake is generally nocturnal and is active when air temperatures are between 20 ºC and 32 ºC (70 ºF to 90 ºF; Rosen et al. 1996), and typically found at body temperatures between 18 ºC and 34 ºC (-8 ºF to 1 ºF; Brattstrom 1965).

Subspecies of Shovel-Nosed Snakes likely to inhabit Clark County, Nevada include *C. occipitalis talpina* and *C. occipitalis occipitalis*, although genetic differentiation between the two is not well defined and hypotheses of the coloration differences used to classify them originally may be explained by temperature differences caused by elevational separation (Wood et al. 2008). Klauber first described the Nevada subspecies *Chionactis occipitalis talpina* in Nye and Esmeralda counties in 1951, and these were later found in the Amargosa Desert of Nye County Nevada, and across the border in Saline Valley in California (Elvin 1963). These latter specimens were found only in rocky or vegetative desert, and none were found in sand dunes in the area (Elvin 1963). Surveys at the Nevada National Security Site (*formerly* Nevada Test Site) in the 1960s noted that these were among the most common snakes sampled, and were frequently found in areas dominated by the spiny hopsage/wolfberry (*Grayia*/*Lycium*), and creosote bush/burro brush (*Larrea*/*Ambrosia*) plant alliances (Tanner and Jorgensen 1963). Habitat modeling indicated that the highest areas predicted to be highly suitable were located within Mojave desert scrub and Salt Desert Scrub ecosystems, indicative of lower bajadas, and sandier valley bottoms within the county (Table 49). Medium suitability habitat was largely predicted to be within the Mojave desert scrub, salt desert scrub, blackbrush, and Mesquite/Acacia habitat, with some inclusion in blackbrush ecosystems (Table 49).

The modeled distribution for Shovel-Nosed Snakes illustrated in Figure 76 indicate that this species is widespread in lower bajada and valley bottom habitats, as well as flat mesa tops that have a sand component (e.g., Mormon Mesa) throughout the western two-thirds of Clark County. The northeastern edge of this species' range may currently exist at the Overton Arm of Lake Mead and the main stem of the Virgin River, and this is supported by a lack of any credible locality records east of these features in Nevada. The Standard Error Map (Figure 83) for this model highlights this area by indicating that Mormon Mesa has a high error due to a lack of verified locality points there. Similarly, there is an expansive area of potential habitat in the northwest corner of Clark County where locality records are sparse and our Standard Error map illustrates high error in that region. However, Shovel-Nosed Snake abundance is well documented just west of that area near Mercury, Nevada, as shown in recent habitat modeling efforts for the species (Inman et al. 2014) lending credibility to this area of otherwise sparse data in Clark County. While ensemble models (Figure 82) are often used to minimize errors within any one modeling algorithm (Marmion et al. 2006), we had Phil Medica give a general review of the models for this species and he thought the GAM model was probably the best representation (Medica pers. comm.).

Continuing efforts to define the eastern edge of the species' distribution would benefit this SDM, especially searches on Mormon Mesa and along the northwestern highway 95 corridor.

Table 49. Ecosystems within Clark County, and the area (Ha) of Low Medium and High predicted suitability within each ecosystem.

Ecosystem	Low	Medium	High
Alpine	124	0	0
Blackbrush	337990	75104	1540
Bristlecone Pine	7565	0	0
Desert Riparian	4825	3952	1862
Mesquite Acacia	5174	11264	3207
Mixed Conifer	27334	4	0
Mojave Desert Scrub	539754	590916	148055
Pinyon Juniper	107896	7828	31
Sagebrush	3636	1056	0
Salt Desert Scrub	34671	26800	17084

Ecosystem Level Threats

Habitat loss and alteration over the last 25 years have led to decreased population sizes and range for *C. occipitalis klauberi* (Tucson shovel-nosed snake) in the Tucson area prompting a petition for listing under the Endangered Species Act (Wood et al. 2008). Primary influences on the Mohave and Nevada Shovel-Nosed Snakes are agriculture, alternative energy development, off-highway vehicle use, urbanization, and utility and transportation infrastructure combined with all forms of development contributing to habitat fragmentation (Wildlife Action Plan Team 2012).

Population Trends

Shovel-nosed snake populations in Arizona have been declining for 25 years. The population status of Shovel-Nosed Snakes in Nevada has not been studied, however, considering that Agriculture and urbanization are primary causes of declines in Arizona, there is reason to believe that similar declines would be expected in Nevada with the combination of urbanization, renewable energy development, and a small amount of agriculture (Wildlife Action Plan Team 2012). Furthermore, recent analyses presented at a public hearing of the Nevada State Wildlife Board (23 Sept 2017) illustrated that for commercial collectors to maintain their previous levels of capture, they had to spend more time and cover more area. This is a classic pattern of resource over-exploitation that is very familiar from historic studies of commercial fisheries. The data that were presented illustrated an index of population declines for many reptile species in the state. Shovel-Nosed Snakes are particularly susceptible to capture in pitfall traps that were used extensively in Clark and Nye counties, Nevada. Thus, it is likely that there have been population declines in the recent past throughout their range in southern Nevada.

Threats to Species

Threats to this species include urbanization, agriculture, military training areas, off-highway vehicle use, solar and wind energy development, and utility and transportation infrastructure development. All of these factors contribute to soil compaction that is incompatible with this soil-dwelling species, and contributes to population fragmentation, and precludes populations that do decline from being rescued by immigration from nearby populations. Commercial reptile collecting has also been documented as a threat to this species that is particularly vulnerable to illegal pitfall traps that have been used extensively in southern Nevada (Nevada State Wildlife Board hearing – 23 Sept 2017).

Direct impacts include crushing these small fossorial snakes from soil compaction due to urbanization, renewable energy development, military training, off-highway vehicle recreation, and utility and transportation infrastructure. Being killed by vehicular traffic (i.e. road kill) is also a factor in direct losses. Commercial collection of Shovel-Nosed Snakes is an important source of loss to populations.

Summary of Direct Impacts

Habitat area within Clark County likely to be impacted includes 262 km^2 of high, and 590 km^2 of medium quality habitat (Table 50). Low and Moderate habitat were the largest amounts of habitat located within conserved areas, with only 698 km^2 of high suitability habitat located within conserved areas. Most of the areas that are categorized as already disturbed were within moderate habitat for this species (Table 50).

Table 50. Categorized modeled habitat values (High, Medium, and Low) and the average area (Hectares) predicted in the potential impact areas, conservation areas, already disturbed areas, and overall area

Habitat Level	Impact	Conserved	Disturbed	Area (Hectares)
High	26243	69799	4776	175624
Med	59052	192437	26159	725459
Low	37098	250535	9047	1073353

Existing Conservation Areas/Management Actions

Existing conservation areas in Clark County, Nevada include the Desert National Wildlife Refuge, Ash Meadows National Wildlife Refuge, Bureau of Land Management designated Areas of Critical Environmental Concern, and Red Rock Canyon National Conservation Area. Among these natural reserve areas there are expansive valley bottoms and shallow hillslopes with sandy to rocky soils that are in good vegetative condition and provide appropriate habitat for Shovel-Nosed Snakes to inhabit, and they occur within the known range of one of Nevada's subspecies. The Nevada Wildlife Action Plan recommends determining status and distribution information, including surveys in association with suitable habitat, maintaining transect/survey areas in locations with sufficient numbers of snakes to detect population trends, preserving habitat, and maintaining connectivity among populations (Nevada Wildlife Action Team 2012).

CHPE - Desert Pocket Mouse (Chaetodipus penicillatus)

The Desert Pocket Mouse (*Chaetodipus penicillatus*) is a medium-sized, bipedal rodent, with a long tail that is mostly naked, but for a crest of hairs along the dorsal edge and a tufted tip (Mantooth and Best 2005). It is among a subgroup of pocket mice known as the coarse-haired pocket mice (Nowak 1991). This species is one of three pocket mouse species occupying southern Nevada. The little pocket mouse (*Perognathus longimembris*) is smaller, and the long-tailed pocket mouse (*Chaetodipus formosus*) is about the same size (Burt and Grossenheider 1976). Pocket mice eat green vegetation, seeds and insects (Hoffmeister 1986). While earlier work recognized a sub species (*Chaetodipus penicillatus sobrinus*) in Clark County (Lee et al. 1996), subsequent genetic analysis recognized only two distinct groups (1 Mojave and 1 Sonoran) of Pleistocene origin separated by the Colorado River, thus invalidating the formerly recognized subspecies within this genus (Jezkova et al. 2009, Wood et al. 2013).

Species Status

US Fish and Wildlife Service Endangered Species Act: Not listed
US Bureau of Land Management (Nevada): No Status
US Forest Service (Region 4): No Status
State of Nevada (NAC 503): No Status
NV Natural Heritage Program: Global Rank G5; State Rank S1S2
NV Wildlife Action Plan: Species of Conservation Priority
IUCN Red List (v 3.1): Least Concern
CITES: No Status

The IUCN Redlist – lists this as a species of least concern with a current stable population, and with abundant habitat, wide distribution and presumed large population (Lindzey 2008). Although this species has no federal or state status, rapid growth and natural habitat loss in Clark County in concert with local interest in the species may result in listing over the permit term.

Range

The Desert Pocket Mouse is found in shrubland habitats of the Mojave Desert in California, Nevada, Utah, and northwest Arizona. It also occurs in shrubland habitats of the Sonoran Desert in Arizona, and the Chihuahuan Desert of southeast Arizona, and throughout much of Sonora Mexico (Mantooth and Best 2005, Hoffmeister 1986). The Desert Pocket Mouse is found throughout Clark County, neighboring southwest Utah, and extreme northwest Arizona (Williams et al. 1993, Hall 1981). The elevational range for this species is 36–1,585 m (Lowe 1964).

Population Trends

Desert Pocket Mouse populations are stated to be stable by NatureServe (2009) and the IUCN; however, population trends for this subspecies are unknown.

Habitat Model Review

We found two models in the provided materials for *Chaetodipus penicillatus.* The first was produced by the EPA (2008), and the second by USGS (2014, Figure 84).

The EPA model was first produced in 2004 as a part of the SWReGAP analysis that modeled habitat for many species (Boykin et al. 2008). The habitat methods included reviewing literature to establish habitat associations and plant alliance associations, and then modeling habitat as a series of overlay and intersections of relevant environmental layers. They were then rendered at 30 m and 250 m resolutions. As these models were not based on occurrence points, and statistical estimations were not produced this is likely the least useful model for the upcoming covered species assessments.

The USGS model was part of a modeling effort for multiple species (N=15) at the scale of the Mojave desert (Inman et al. 2014). While this was a multiple species effort, each species was modeled independently by first creating conceptual models for each to aid in identifying appropriate layers to be used as environmental covariates for statistical modeling. Locality data were obtained from a variety of sources and 99 observations were included in the model. Modeling was conducted using General Additive Models (GAM) and MaxEnt models, and outcomes form both algorithms were averaged to create an Ensemble model. Statistical model contributions and partial response curves are provided in the report. Important environmental contributions to the model were Elevation (45%), Seasonal Change in Surface Temperature (23%), Surface Texture (22%), Winter Precipitation, and a physiographic layer called Mountain Bases (2%). The final habitat model was the average of the 12 selected GAM and MaxEnt models and had an AUC score of 0.79 and a BI score of 0.64 (Inman et al. 2014). Model standard error maps are also presented.

Technical Considerations – Models were run for the entire extent of the Mojave Desert at a 1 km resolution. This may be overly coarse for the county’s needs if finer resolution is needed to make smaller scale conservation decisions.

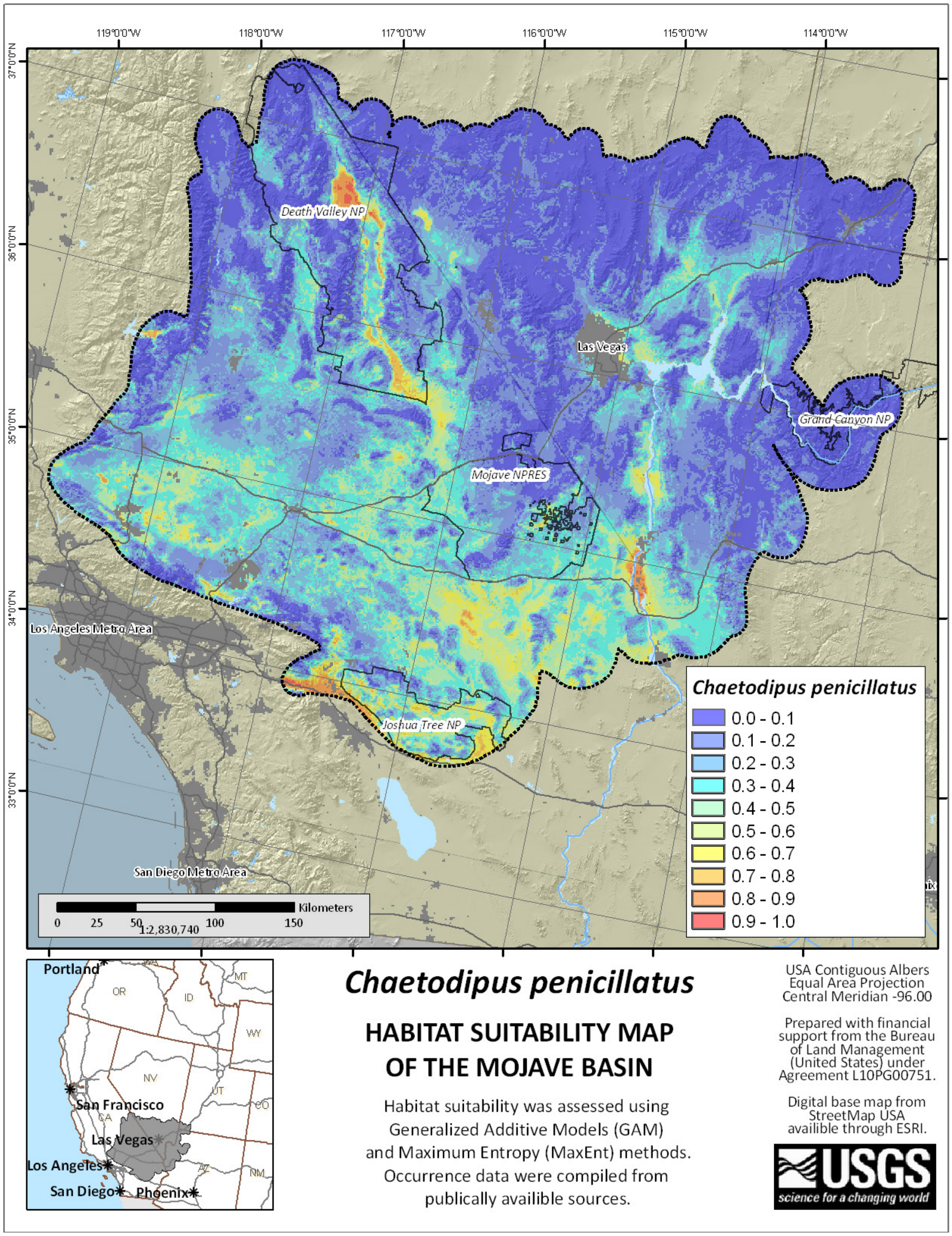


Figure 84. *Chaetodipus penicillatus* habitat suitability model from Inman et al. 2014.

Distribution and Habitat Use within Clark County

Chaetodipus penicillatus sobrinus occurs throughout Clark County from the Arizona and Utah borders and south to the southern tip of Clark County and southern Lincoln

County (Wildlife Action Plan Team 2012). This Desert Pocket Mouse inhabits sandy soils in creosote bush (*Larrea tridentata*) and saltbush (*Atriplex* spp.) communities (Mantooth and Best 2005), mesquite bosques, and desert washes, and Mojave-Sonoran warm desert scrub (Wildlife Action Plan Team 2006). This species prefers rock-free bottoms of creeks and rivers (NatureServe 2009). Habitat within the lower Colorado drainage system is considered to be highly fragmented, reducing resilience to disturbance and extirpation. Remnant populations may exist within urban areas, but with limited dispersal habitats they are unlikely to articulate with surrounding populations (Micone 2002). Ecosystems within Clark County that contain larger areas of high suitability modeled habitat (Inman et al. 2014) include Desert Riparian and Mojave Desert Scrub. Moderate habitat expands the area in these systems and includes Blackbrush, Salt Desert Scrub, and Mesquite/Acacia ecosystems (Table 51).

Table 51. Ecosystems within Clark County, and the area (Ha) of Low Medium and High predicted suitability within each ecosystem.

Ecosystem	Low	Medium	High
Alpine	124	0	0
Blackbrush	413644	2006	0
Bristlecone Pine	7565	0	0
Desert Riparian	1883	6303	2580
Mesquite Acacia	12787	6863	54
Mixed Conifer	27339	0	0
Mojave Desert Scrub	1072048	204133	2123
Pinyon Juniper	115873	30	0
Sagebrush	4707	0	0
Salt Desert Scrub	76470	1264	24

Ecosystem Level Threats

Threats to Desert Pocket Mouse habitats include conversion of habitat through urban and suburban development, invasive species, off-highway vehicle use, and recreational activities (Wildlife Action Plan Team 2006). Additionally, off-highway vehicle activity can result in structural damage to shrubs and soil disturbance can lead to accelerated erosion, reducing habitat suitability for Desert Pocket Mouse (Wildlife Action Plan Team 2012). Concern has been expressed for the viability of the Nevada population of Desert Pocket Mouse (Marshall et al. 2004) because its narrow habitat preference has resulted in fragmentation of local populations. Densities of this species are generally concordant with increasing shrub cover and diversity (Brown et al. 1997, Micone 2002).

Threats to Species

Invasive species and fire present a threat to habitat degradation that destroys important food and cover vegetation, increases erosion, and soil instability thus affecting important soil substrates for burrowing. Off-highway vehicle activity can result in direct mortality, and potentially reduced fitness due to hearing loss and subsequent vulnerability to predation (Brattstrom and Bondello 1983, Bowles 1995).

Existing Conservation Areas/Management Actions

Recommended conservation actions specific to this species and species habitat are included in the NWAP. The NWAP recommended approach is to develop a conservation plan based on outcome of research needs and candidacy for the Nevada state conservation list. Further, the recommended conservation strategies to conserve the habitat that this species occurs in include: maintaining this species habitat at its current distribution in stable or increasing condition trend; expand protected status for mesquite bosques and desert wash habitats, maintaining the disturbance in sand dune and badland habitats without compromising the sustainability of vegetation and wildlife communities; and sustaining stable or increasing populations of wildlife in key habitats (Wildlife Action Plan Team 2012).

This species is also covered under the Lower Colorado River Multi-Species Conservation Program. The goal of this program is to conserve habitat of threatened and endangered species and reduce any additional species being listed; accommodate present water diversions and power production; and provide the basis for incidental take authorizations (Lower Colorado River Multi-Species Conservation Program 2004).

Summary of Direct Impacts

The Desert Pocket Mouse is a moderately common to rare year-round resident of Clark County. Approximately 116 km^2 of high suitability modeled habitat (Inman et al. 2014) occurs within the county (Table 52). Approximately 20% of this may be impacted by proposed development, while only 2% are in either already disturbed or conservation areas. Moderate habitat is far more widespread, and 16% of the 3829 km^2 are expected to be conserved, while a combined 12% may be impacted or already disturbed (Table 52)

Table 52. Categorized modeled habitat values (High, Medium, and Low) and the average area (Hectares) predicted in the potential impact areas, conservation areas, already disturbed areas, and overall area

Habitat Level	Impact	Conserved	Disturbed	Area (Hectares)
High	2356	316	214	11634
Med	39485	60856	8678	382898
Low	90227	427774	78165	2925077

COAM - Yellow-Billed Cuckoo (Coccyzus americanus)

The Yellow-Billed Cuckoo is a neo-tropical migrant that is widespread throughout North America, but is less common in the western United States due to losses in breeding habitat. The species is characterized as a mid-sized (30 cm in length) primarily insectivorous bird, with a long, tapered tail with white spotted margins continuing to prominent white spots on the ventral surface of the tail. *Coccyzus americanus* are dorsally brown with a white/cream-colored breast, rufous-colored inner wings, and a characteristic long arched bill – where the lower bill is yellow and the upper is black. They have a yellow to gray eye-ring, and both sexes look alike. The entire family has zygodactyl feet (having two toes pointing forward, and two pointing backward), and many of the species are widely known as brood parasites, laying their eggs in the nests of other birds, although in *C. americanus* both parents usually brood and feed the young in their own nests (Payne 2005). New-world cuckoos have the shortest incubation time and nesting periods of any birds (Payne 2005). There are size differences between subspecies of *C. americanus* in the eastern and western US (where western birds are considered larger), and taxonomic status is frequently contested (Ridgway 1887, Laymon 1998, Banks 1988,1990, Pruett et al. 2001, Fleischer 2001), but they are most recently considered a single species (Fleischer 2001, Payne 2005, Farrell 2013, Federal Register 2014).

Species Status

A petition to list the Yellow-Billed Cuckoo as endangered within the states of California, Washington, Idaho, Oregon, and Nevada was filed in 1986. The final ruling on this petition determined that the action was not warranted because the petitioned area did not encompass a distinct subspecies or a distinct population segment (DPS) (Johnson et al. 2007). Subsequently, a petition to list the western Yellow-Billed Cuckoo, a DPS of the Yellow-Billed Cuckoo, (*C. a. occidentalis*; populations west of the continental divide) was filed on February 9, 1998. On July 25, 2001 the USFWS determined that the western Yellow-Billed Cuckoo did meet the criteria for designation as a DPS and published a final rule that the petition to list the western DPS of the Yellow-Billed Cuckoo was warranted but was precluded by other higher-priority listing actions. Ongoing listing petitions and actions were continued from 2000 to 2013, and on November 3, 2014 the western population of the Yellow-Billed Cuckoo was listed as a threatened species under the Endangered Species Act (ESA) (Federal Register 79 FR 59991 60038). The US Fish and Wildlife Service determined that listing of Yellow-Billed Cuckoo as a DPS was warranted in 12 western states, Canada, and Mexico. In the US, the DPS covers parts of Arizona, California, Colorado, Idaho, Nevada, New Mexico, Texas, Utah, Wyoming, Montana, Oregon and Washington. The species is also protected under the Migratory Bird Treaty Act of 1918, as amended (16 USC 703-712). While the western DPS is listed by the USFWS, the IUCN lists this species as one of least concern as it is wide spread with large population sizes (BirdLife International 2016).

US Fish and Wildlife Service Endangered Species Act: Threatened
US Bureau of Land Management (Nevada): Sensitive
US Forest Service (Region 4): Threatened

State of Nevada (NAC 503): Sensitive
NV Natural Heritage Program: Global Rank G5 State Rank S1B
NV Wildlife Action Plan: SOCP
IUCN Red List (v 3.1): Least Concern
CITES: No status

Range

The breeding range of the Yellow-Billed Cuckoo occurs throughout much of North America, south to Mexico, and throughout the Greater Antilles (Hughes 1999). However, this species becomes increasingly rare towards the western portions of the US where suitable breeding habitat – once abundant – is now uncommon. The western subspecies formerly encompassed much of the western US, but is now confined to small pockets of breeding birds in California, southern Nevada, Arizona, and New Mexico, where they inhabit riparian woodlands and scrub habitat along major rivers in the region (Payne 2005). The Yellow-Billed Cuckoo is a migratory species that winters primarily in South America east of the Andes, and western and eastern birds appear to winter in similar habitats (Hughes 1999, Payne 2005). Western populations have been reduced drastically from historic numbers due to the widespread loss of riparian habitat through clearing for agriculture, flood control, and urbanization.

Population Trends

Major declines in western populations over the last century have been reported by several sources (Alcorn 1988; Hughes 1999; McKernan and Braden 2001; Wiggins 2005; Johnson et al. 2007, Federal Register 2014). The Breeding Bird Survey has not been able to detect this species adequately enough to determine trends within the Mojave and Sonoran Desert region (Sauer et al. 2008). NatureServe estimates global long-term declines of the western Yellow-Billed Cuckoo to be greater than 90 percent over the last century (NatureServe 2009).

Habitat Model Review

Models under consideration - We found two models in the provided materials for *Coccyzus americanus.* Separate habitat models were conducted by EPA and SWCA. A potential third model that appears to be a shapefile model attributed to PBSnJ was located, but the associated report was not attached, so it could not be evaluated.

The EPA model was first produced in 2004 as a part of the SWReGAP analysis that modeled habitat for many species (Boykin et al. 2008). The habitat modeling methods included reviewing literature to establish habitat associations and plant alliance associations, and then modeling habitat as a series of overlay and intersections of relevant environmental layers. They were then rendered at 30m and 250 m resolutions. As these models were not based on occurrence points, and statistical estimations were not produced this is likely the least useful model for the upcoming covered species assessments.

The SWCA model had a limited extent within the county. The project area for this modeling effort was limited to the Virgin River from the Stateline at Mesquite, to the junction with Lake Mead at the northern extent of the Overton Arm (Figure 85). Habitat rankings (unsuitable or potential breeding habitat) were assigned according to vegetation/structural types (Cottonwood, Willow, Saltcedar, and Saltcedar-Screwbean Mesquite). There were only 6.6 acres of habitat identified as suitable for the species, as Yellow Billed Cuckoos require large expanses of riparian habitat for breeding (SWCA 2010).

Technical Considerations –There were no attempts at statistical modeling, or providing measures of error associated with the classification of habitat by vegetation or category. The geographic extent of the model provides limited insight into Yellow Billed Cuckoo habitat at the scale of Clark County.

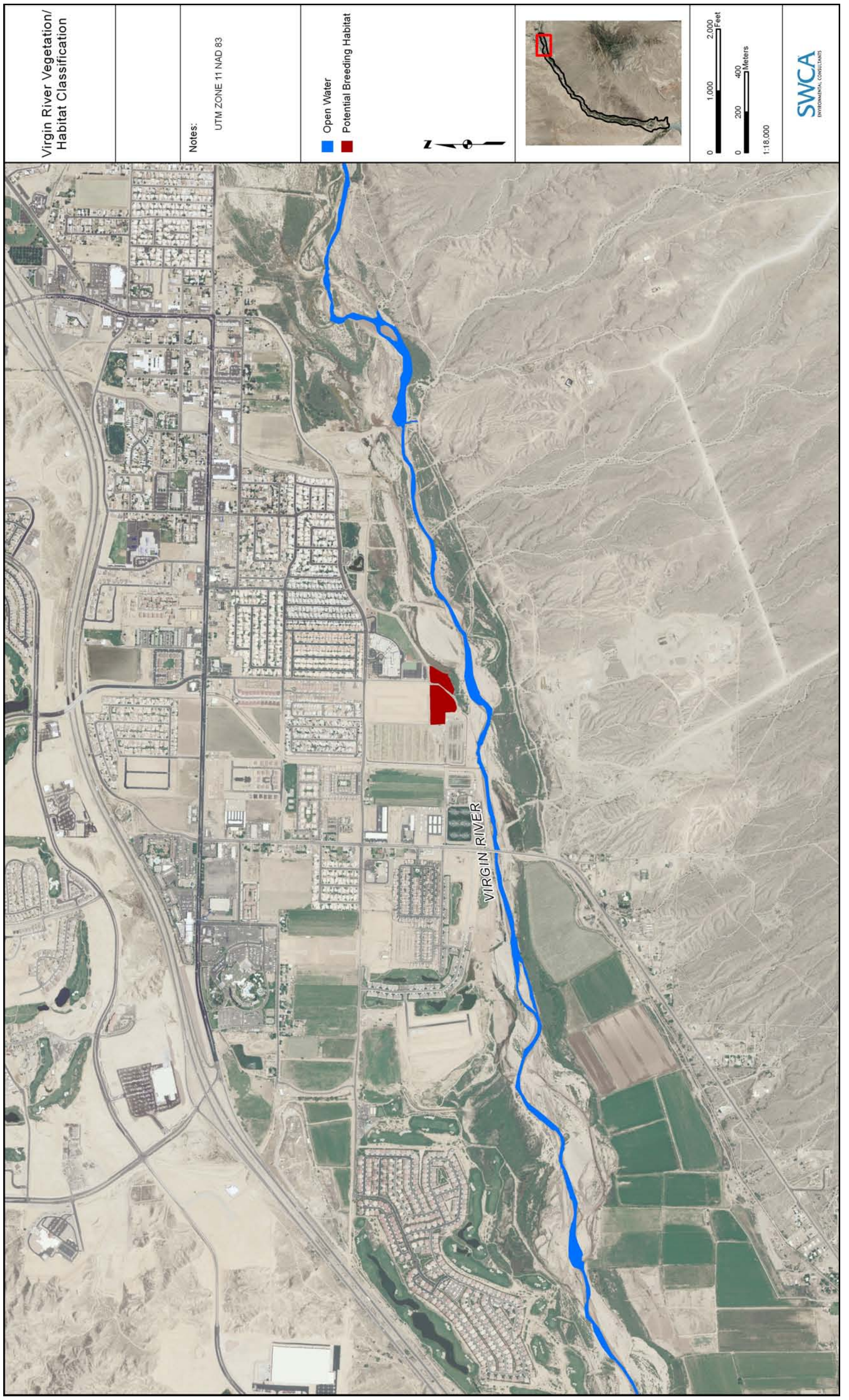


Figure 85. SWCA predicted Yellow Billed Cuckoo habitat in the lower Virgin River in Clark County NV.

Distribution and Habitat Use within Clark County

The Yellow-Billed Cuckoo requires riparian habitats with a dense understory. In the southwestern US Yellow-Billed Cuckoos prefers to nest in low-elevation riparian habitat consisting of open woodlands with an understory of dense vegetation. Yellow-Billed Cuckoos depend on large tracts of riparian forest and show a strong preference for nesting in areas with at least 10 hectares of contiguous forest (Wiggins 2005). There is very little of this habitat type that remains within Clark County today due to conversion of the land for agriculture and urban development. It was once thought that breeding populations of Yellow-Billed Cuckoo were possibly extinct in southern Nevada (Alcorn 1988). This species is a very rare summer resident in southern Nevada with very few breeding sites confirmed, and to date, there are only two known confirmed breeding locations in Clark County (McKernan and Braden 2001, Floyd et al. 2007). They are reported from two of the seven Important Bird Areas of Clark County: Moapa Valley and Virgin River (McIvor 2005). Modeled habitat for this species within the county (Boykin et al. 2008) identified potential habitat within the Desert Riparian and Mesquite Acacia, and Mojave Desert Scrub bordering the former two ecosystems (Table 53). A series of surveys conducted from 2000 to 2006 detected Yellow-Billed Cuckoos in Corn Creek and Moapa Valley during most survey years, but breeding was not confirmed at either of these sites (Klinger and Furtek 2007). The US Geological Survey (USGS) has also detected cuckoos in the Overton Wildlife Management Area, but was unable to confirm breeding, and cuckoos were not detected around Lake Mohave, despite the existence of suitable habitat (Johnson et al. 2007). Yellow-Billed Cuckoo have also been detected in the Las Vegas Wash with breeding still unconfirmed. The Nevada Breeding Bird Atlas has, however, reported breeding cuckoos on a private ranch on the upper Muddy River (Floyd et al. 2007). This property has since been purchased by the Southern Nevada Water Authority (SNWA). Breeding was also confirmed along the Virgin River in 2001 during surveys conducted by San Bernardino County Museum (SBCM) (McKernan and Braden 2001). SBCM also detected cuckoos in the Mormon Mesa area of the Virgin River in 2006 and 2007 (Braden et al. 2007, 2008, 2009).

Table 53. Ecosystems within Clark County, and the area (Ha) of Low and High predicted suitability within each ecosystem.

Ecosystem	Low	High
Alpine	124	0
Blackbrush	415483	189
Bristlecone Pine	7565	0
Desert Riparian	4575	6642
Mesquite Acacia	18935	1302
Mixed Conifer	27317	22
Mojave Desert Scrub	1360626	6381
Pinyon Juniper	115808	94

Ecosystem	Low	High
Sagebrush	4704	3
Salt Desert Scrub	82612	78

Ecosystem Level Threats

Ecosystem threats include habitat fragmentation and loss (Nevada Partners in Flight 1999). Principal causes of riparian habitat losses are conversion to agricultural and other uses, dams and river flow management, stream channelization and stabilization, and livestock grazing (Wiggins 2005).

Habitat degradation is also a significant ecosystem threat affecting this species. Significant habitat degradation in the southwest has been caused by the invasion of tamarisk (*Tamarix* spp.) in riparian habitats. Tamarisk changes riparian forests by destroying community structure, replacing three or four vegetation layers with one monotypic layer. However, Yellow-Billed Cuckoos have been observed occupying stands of mixed tamarisk and native vegetation (Sogge et al. 2008). Extensive cattle grazing in the southwest has also contributed to degradation of existing riparian habitats. The overuse of riparian habitats by livestock has been a major factor in the degradation and modification of these areas. The effects include changes in plant community structure and species composition and in relative abundance of species and plant density.

Threats to Species

The primary threats currently facing the Yellow-Billed Cuckoo include the destruction and modification of habitat, and pesticide application. Available breeding habitat for cuckoos have also been substantially reduced in area and quality by groundwater pumping and the replacement of native riparian habitats by invasive nonnative plants, particularly tamarisk. While tamarisk is indeed potentially influencing breeding habitat, care must be made if eradication/restoration plans are implemented to ensure breeding birds have sufficient nesting habitat (Sogge et al. 2008). Pesticides are a potential threat to this species. When DDT was widely used there were reports of significant accumulation of toxins in body tissues and eggs, and even direct mortality of adults following DDT applications to foliage. While DDT is no longer used in the US it is still used in Central and South America. It has also been noted that population declines occur in areas where heavy pesticide use is common in agricultural areas bordering cuckoo habitat (Wiggins 2005). Prey scarcity (linked at least in part to pesticide use) may also play a role in declines even where suitable habitat remains.

Existing Conservation Areas/Management Actions

The western DPS of the Yellow-Billed Cuckoo is protected under the US Endangered Species Act (Federal Register 2014), critical habitat designation is ongoing, and a recovery plan has not been published to date.

The Yellow-Billed Cuckoo is also protected under the Migratory Bird Treaty Act. This species is also included in the Nevada Partners in Flight Bird Conservation Plan (Nevada Partners in Flight 1999). The goal for this species under the plan is to establish two breeding pairs of Yellow-Billed Cuckoos by 2010. To achieve this goal, the plan proposes to maintain and increase riparian habitat consisting of cottonwood and willow forests in southern Nevada. Conservation of this species is also addressed in the Lower Colorado River Multi-species Conservation Plan.

The Virgin River Habitat Conservation and Recovery Program, Clark County, NV proposed preservation of habitat for this and other species within the 100-year flood plain of the Virgin River, extending from Mesquite to the confluence of the Virgin River into Lake Mead near Fish Island on the Overton Arm, however the plan was never completed (USFWS 2007).

Much of the cattle grazing rights were purchased by Clark County after the Mojave Desert Tortoise was listed as threatened. This act has served to reduce the understory grazing of many historic breeding areas, in turn making them more suitable for Yellow-Billed Cuckoo nesting. The Nevada Department of Wildlife (NDOW) is also working with private land owners and federal agencies in order to manage grazing in areas that contain populations of Yellow-Billed Cuckoos (NDOW 2003).

SNWA purchased a 1,218-acre property formerly known as the Warm Springs Ranch in 2007, which supports one of the two recent breeding sites for Yellow-Billed Cuckoo in Clark County. The primary purpose of this acquisition was to protect the endangered Moapa dace (*Moapa coriacea*) and its habitat, and to restore and manage the area as an ecological reserve. SNWA has purchased this property exclusively for environmental management purposes and does not intend to develop the groundwater resources of the site (Curtis 2006). The Virgin River Conservation Partnership, composed of federal, state, and local agencies including SNWA, has been established to coordinate conservation and water development issues in the lower Virgin River Valley.

Summary of Direct Impacts

The Yellow-Billed Cuckoo is a very rare summer resident of Clark County that nests in riparian habitat. Approximately 178 km^2 of modeled habitat exist within Clark County (Boykin et al, 2008), although the proportion that is suitable for cuckoo nesting is estimated to be much less. This species occurs rarely in the plan area, although covered activities have the potential to impact species habitat. It is estimated that approximately 18% of this species' modeled habitat within Clark County could be impacted by activities covered under the Amendment, while 13% is already disturbed, and 13% is located within proposed or existing conservation areas (Table 54).

Table 54. Categorized modeled habitat values (High, and Low) and the average area (Hectares) predicted in the potential impact areas, conservation areas, already disturbed areas, and overall area

Habitat Level	Impact	Conserved	Disturbed	Area (Hectares)
High	3254	2296	2331	17843
Low	120733	482598	121338	3427479

COCH - Gilded Flicker (Colaptes chrysoides)

Gilded Flicker (*Colaptes chrysoides*) habitats can be found in desert riparian habitats with well-developed tree-lined corridors (e.g. along the lower Colorado River and its tributaries), Mojave Desert scrub, and suburban areas with appropriate vegetation, including housing developments, golf courses, and parks. Key to the nesting habitat of these large woodpeckers are columnar cacti (e.g. saguaro – *Carnegiea gigantea*), Joshua tree (*Yucca brevifolia*), or other tall trees (e.g. Frémont cottonwood – *Populus fremontii*) where they may excavate large nesting cavities. Gilded Flickers in Nevada are clearly associated with Joshua trees and other tall yuccas which provide a substrate for nest cavities (GBBO 2010). The cavities may be used by a variety of other cavity nesting birds including: western screech owl (*Megascops kennicottii*), pygmy owl (*Glaucidium californicum*) ash-throated flycatchers (*Myiarchus cinerascens*), and European starlings (*Sternus vulgaris*; Hardy and Morrison 2001). Gilded Flickers also require open habitat such as bare ground, which can include lawns or golf course fairways, where they can forage on the ground for invertebrates (Turner 2006) such as ants and beetles. While beneficial to some bird species, the presence of a Gilded Flicker nest in a giant saguaro cactus increased the mortality rate for the cactus (McAuliffe and Hendricks 1988). The same may be true for Joshua trees.

Species Status

Gilded Flicker was formerly considered a subspecies of northern flicker (*Colaptes auratus cafer*), but was later elevated to its own generic status (Eisenman et al. 1973). This species is not declining sufficiently range-wide to be considered a Species of Concern (Birdlife International 2012). Thus, no federal or state of Nevada listing petitions were found specifically for this species. However, the taxon *Colaptes auratus chrysoides*, was petitioned for listing in California by the California Department of Fish and Game in 1987, citing loss of saguaro and other habitat needs, and hybridization with *Colaptes auratus cafer* in Joshua tree woodlands near Cima Dome, San Bernardino, County, California.

US Fish and Wildlife Service Endangered Species Act: No Status
Migratory Bird Treaty Act: Protected
US Bureau of Land Management (Nevada): No Status
US Forest Service (Region 4): No Status

State of Nevada: Protected
NV Natural Heritage Program: Global Rank G5, State Rank S1
NV Wildlife Action Plan: Species of Conservation Priority
IUCN Red List (v 3.1): Least Concern
CITES: No Status

Range

The Gilded Flicker has a large range and is found primarily in the Arizona Upland of the Sonoran Desert (Hardy and Morrison 2001). Its range potentially includes all of the Sonoran Desert in Arizona, US, and Sonora, Mexico – where sufficient nesting substrate are available. Gilded Flickers are also found in the Colorado Desert of southern California, and through eastern and southern Baja del Norte, and Baja del Sur, Mexico.

Population Trends

The Gilded Flicker is thought to be declining throughout its range (Wildlife Action Plan Team 2012). The known population of Gilded Flickers in Nevada is currently very small and has remained that way for several years. Records from the Breeding Bird Atlas (Floyd 2007 – as conveyed by C. Tomlinson-NDOW, pers. comm.) note 20 pairs in the foothills of the Eldorado Range. Furthermore, an adult male and adult female were observed together, just south of the Highland Range, near Walking Box Ranch and it was stated that this is a breeding population (GBBO 2015); however, no breeding data are currently known to be available. The potential for Gilded Flickers to use other Joshua tree habitats or suburban areas in Clark County may exist and analysis of data emerging from bird surveys should be scrutinized to determine if the population is growing in extent.

Habitat Model Review

Densities of Gilded Flickers were modeled County wide by the GBBO reported in Developing Habitat Models and Monitoring Techniques for Nine Bird Species of Clark County submitted to the DCP in 2015 under project number CBE 2011-GBBO-901A, using the same methods as reported for Bendire's Thrashers in the 2013 report for 2005-GBBO-581-P.

Technical Considerations – GBBO modeled County wide densities of Gilded Flickers by using point count surveys using models generated from cover associations collected at point count sampling sites. Dominant vegetation was assessed at each sampling site within 100 meters of the survey point, which was then mapped to its corresponding vegetation type of a LandFire classification (Provencher and Anderson 2011) for the state that was then used to model density projections within the Mojave desert in Nevada.

Statistical models of densities for this species were conducted to calculate densities per vegetation stratum. Neither densities nor confidence intervals per stratum are given in the report and thus their accuracy cannot be evaluated. There are average densities for Gilded Flickers given in Appendix 2 of GBBO (2013) including data from surveys spanning from 2003 to 2013 which are likely the data used for the model presented in this report, but these estimates were presented without confidence limits, and contained estimates for only 1 of the Strata – Joshua Tree at 0.04 birds per 40 ha. As far as we know there are only 11 confirmed sightings in the county for this species. Resolution of the models is limited to the size of the polygons containing vegetation projections, as they are effectively provided as a classified layer, which limits gradations in vegetative habitat patches. Thus, there are 8 habitat "classes" for the state-wide model, which cover broad areas and preclude finer resolution. In addition, other factors that could contribute to Flicker densities aside from vegetation type are not considered in this type of model, although with so few points it is unlikely that more precise modeling is possible without further survey efforts.

Localities used for modeling are located nearly exclusively in the southern McCullough mountains west of Searchlight NV, likely associated with the dense aggregations of Joshua trees in the Wee Thump area. The report mentions that timing of surveys may have influenced their detection rates for this species, and perhaps additional survey efforts may reveal other areas that are inhabited by this species.

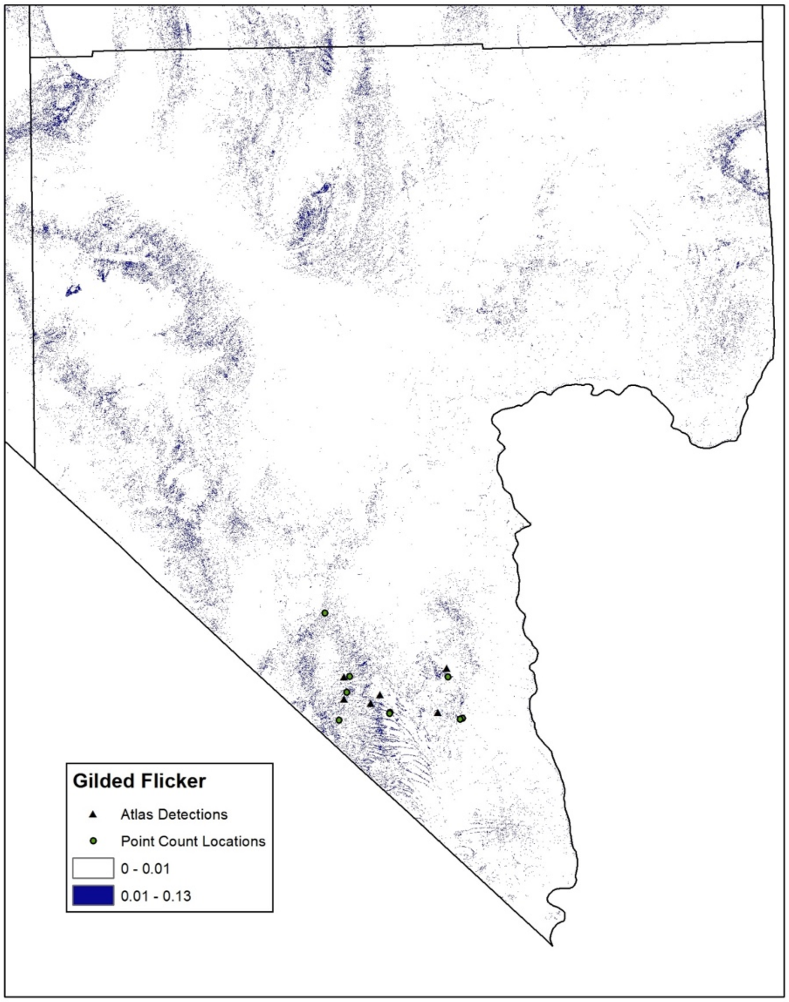


Figure 86. Predictive model map for Gilded Flicker breeding distribution in Clark County and the greater Mojave region, overlaid with actual detections of the species within the past 10 years. Adapted from Figure 5 in GBBO (2015).

Distribution and Habitat Use within Clark County

In Clark County, Nevada, Gilded Flickers are known only from area surrounding the southern Highland and Eldorado mountain ranges, just north and northwest of Searchlight, Nevada (GBBO 2015). There have been 10 sightings there in the past two decades including a male and female observed at the same place on the same day. This area is visually dominated by the Joshua tree, where it is presumed the Gilded Flicker could nest. There are many other valleys in Clark County where Joshua trees occur and Gilded Flickers may exist, but have not been detected to date. Besides Joshua tree woodlands, suburban areas supporting large shade trees also provide potential habitat for Gilded Flickers. Ecosystems within Clark county that contain modeled higher densities of these species are Blackbrush, and Mojave Desert Scrub Ecosystems, while moderate densities are expected including Mesquite Acacia and Pinyon Juniper ecosystems (GBBO 2011; Table 55). Hybrids of the Gilded Flicker and the Northern Flicker also exist, and were collected for museum specimens nearby in the riparian corridor of the Virgin River, Washington County, Utah (Behle 1976).

Table 55. Ecosystems within Clark County, and the area (Ha) of Low Medium and High predicted suitability within each ecosystem.

Ecosystem	Low	Medium	High
Alpine	124	0	0
Blackbrush	315440	74110	20043
Bristlecone Pine	7537	21	7
Desert Riparian	10671	143	42
Mesquite Acacia	17194	2436	552
Mixed Conifer	26982	126	231
Mojave Desert Scrub	1300348	56414	7162
Pinyon Juniper	110588	4267	888
Sagebrush	3879	422	186
Salt Desert Scrub	76505	5220	589

Ecosystem Level Threats

Within Clark County the Gilded Flicker is known to occupy blackbrush and Mojave Desert Scrub ecosystems. They may also occupy Desert Riparian or suburban ecosystems (Table 55).

Ecosystem level threats likely to impact this species due to habitat conversion are effects of climate change on Joshua trees; solar and wind development, where habitat is removed for utility scale facilities; and the potential for localized changes in local climate due to heat island effects caused by increasing temperatures in proximity to solar facilities. Invasive grasses and wildfire result in loss of nesting habitat because trees in riparian areas and Joshua trees do not respond well to fire. The Gilded Flicker may be more adaptable than many native species due to their ability to occupy suburban areas, parks, and golf courses.

Threats to Species

Threats to the species include any disturbance that reduces nesting substrate of large plants that provide nesting substrate such as cottonwood, and Joshua tree. Disturbances that can reduce nesting habitat include invasive species that lead to wildfire, urban development, military training, and large scale energy development. Wind turbines are also known to cause losses in a variety of bird species.

Existing Conservation Areas/Management Actions

The Gilded Flicker is protected at the federal level by the Migratory Bird Treaty Act, and is considered a Species of Conservation Priority by the Nevada Wildlife Action Plan due to its restricted range within Nevada, and its declining population trends range-wide (Wildlife Action Plan Team 2012). Conservation actions recommended by the plan include: monitoring status and trends; determining their level of dependence on Joshua tree and paloverde-mixed cactus habitat, which is predicted to expand into Nevada with climate change; and determining the Gilded Flicker's capability to adapt away from paloverde-cactus habitats typically used in Arizona.

The Nevada Comprehensive Bird Conservation Plan designates the Gilded Flicker as a Conservation Priority species. Population declines, significant threats, dependence on restricted or threatened habitats, or small population size can all contribute to this designation and exist for the Gilded Flicker (GBBO 2010). This plan's recommendations include: protecting current known habitat from development and heavy recreational use; aggressively fighting fire that threatens known habitat; searching for additional breeding locations, including in Wee Thump Joshua Tree Wilderness Area; conducting research to determine habitat needs, patch size, and seasonal movements; and continuing and enhancing monitoring to estimate population size and determine needs (GBBO 2010).

The Gilded Flicker is a Covered species under the Lower Colorado River Multi-Species Conservation Plan (LCR MSCP 2004). Conservation measures to avoid, minimize, and mitigate impacts include: creating, maintaining, and adaptively managing 4,050 acres of cottonwood-willow habitat; installing artificial snags to provide nest sites; avoiding and minimizing the impact of covered activities (operation, maintenance, and replacement of hydroelectric generation and transmission facilities, dredging, bank stabilization and other river management activities) on habitat; avoiding and minimizing disturbance during the breeding season; conducting surveys and research to better identify habitat requirements; and conducting research to determine and address effects of nest site competition with European starlings on reproduction (LCR MSCP 2004).

Summary of Direct Impacts

Direct impacts may include mining activities in the Searchlight, Nevada mining district, invasive grasses and related wildfires, large scale renewable energy development, utility and transportation infrastructure, and military training. Higher densities for this species encompass approximately 302 km^2 of area within the county, 27% of which is located within conservation areas, while very minimal amounts of high density habitat are likely to be impacted or are already disturbed (Table 56). Moderate density habitat is much more extensive, and 24% of this area is located within conservation areas, 5 % is already disturbed and only 3% is likely to be impacted under the plan amendment (Table 56).

Table 56. Categorized modeled habitat values (High, Medium, and Low) and the average area (Hectares) predicted in the potential impact areas, conservation areas, already disturbed areas, and overall area

Habitat Level	Impact	Conserved	Disturbed	Area (Hectares)
High	480	8303	1212	30204
Med	3758	36019	6660	145774
Low	126754	448054	130131	1933770

COTO - Townsend's Big-eared Bat (Corynorhinus townsendii)

Townsend's Big-eared Bat is a medium-sized bat (90 to 100 millimeters in length) with large ears (30 to 39 millimeters) that inhabits most of the western United States, north through British Columbia, Canada, and south into Mexico. They migrate only short distances (greater than 30 kilometers) between seasons (Kunz and Martin 1982, Dobkin et al. 1995), and typically roost in large open caves and other suitable areas (e.g. abandoned mines, tunnels, and buildings), and inhabit a wide variety of habitats from pine woodlands, to desert scrub ecosystems, but are not common in extreme desert habitats (Kunz and Martin 1982, Pierson and Rainey 1998). They are insectivorous, eating principally small moths, and forage late in the day. Females form small maternity colonies, typically with fewer than 100 individuals, and males are solitary at this time. They typically mate in the fall and winter, and females store sperm and embryos are fertilized in the spring, with one pup produced in late spring or early summer. Young fly within three weeks and are weaned by six weeks (Kunz and Martin 1982).

Species Status

Townsend's Big-eared Bat is thought to be declining throughout its range, with noted declines in Arizona, Colorado, and New Mexico in the late 1960's and continuing through the end of the 20^{th} century in Washington, Oregon, and California (Pierson and Rainey 1998). Distributions in California are restricted by available roosting sites, and declines are largely attributed to anthropological factors, as these animals are particularly sensitive to disturbance in their roosting sites, and many roosting sites have been lost due to vandalism or conversion to other uses.

Townsend's Big-eared Bat was formerly a Category 2 species in consideration for federal listing under the Endangered Species Act, however these categorical listings were dissolved in 1996 due to insufficient information (USFWS 1996). A petition to list all populations of Townsend's Big-eared Bat in California was filed in 2012 by the Center for Biological Diversity (CBD 2012) citing widespread population declines throughout the state due to a combination of disturbance of cave and mine sites, loss of mine and cave habitat to mining, logging and urban development, white-nose syndrome and other factors (Pierson and Rainey 1998). The California Fish and Game Commission recommended acceptance of the petition, and acknowledged that the petitioned listing may be warranted (CFW 2013), and at this time is under consideration by the Commission for listing.

The Big-eared Bat is considered a Species of Concern in the state of Nevada due to rarity (Bradley et al. 2006).

US Fish and Wildlife Service Endangered Species Act: No Status
US Bureau of Land Management (Nevada): Sensitive
US Forest Service (Region 4): Sensitive
State of Nevada: Sensitive
NV Natural Heritage Program: Global Rank G3G4, State Rank S2
NV Wildlife Action Plan: Species of Conservation Priority
IUCN Red List (v 3.1): Least Concern
CITES: No Status

Range

Townsend's Big-eared Bat is found in suitable habitat throughout central Mexico, the western United States and southwestern British Columbia, Canada (Arroyo-Cabrales and Álvarez-Castañeda). The habitats in Nevada where Townsend's Big-eared Bats occur include juniper-mountain mahogany, sagebrush, desert scrub (Rahn 2000), agricultural areas, and occasionally urban areas. Suitable roosting habitat includes caves, cliffs, lava tubes, buildings, and especially mines, all of which are limiting factors in distribution (Bradley et al. 2006, Dalquest 1947, 1948; Graham 1966, Pearson et al. 1952, Kunz and Martin 1982, Pierson et al. 1991, Dobkin et al. 1995). Townsend's Big-eared Bats have also been found to night roost in clear-span bridges and tree cavities.

During hibernation, Townsend's Big-eared Bats typically prefer habitats with relatively cold (but above freezing) temperatures in quiet, undisturbed places. These areas are often in the deeper, more thermally stable portions of caves and mines (Barbour and Davis 1969, Dalquest 1947, Humphrey and Kunz 1976, Pearson et al. 1952, Zeiner et al. 1990). Hibernating bats are also often found in ceiling pockets (Pierson et al. 1991). In central California, solitary males and small clusters of females are also known to hibernate in buildings (Pearson et al. 1952, Kunz and Martin 1982). Females may roost in colder places than males during these periods (Pearson et al. 1952).

Population Trends

Townsend's Big-eared Bat is rare throughout its range in North America. The species is thought to be declining in abundance throughout its range; a number of recent studies show decreases in overall population status and abandonment of traditional roost sites (Pierson 1988, Perkins 1994, Gruver and Keinath 2006). In all regions where it is found, the species is considered a high priority by the Western Bat Species Working Group regional priority matrix (Western Bat Species Working Group 2007). Declines have been documented statewide in California (Pierson and Rainey 1998, CBD 2012), and also in Nevada (Bradley et al. 2006). Little trend information exists for Clark County, although recent surveys along the Colorado River corridor indicate the species was rare, the survey effort may not have overlapped with the typical foraging habitat for this species (Williams et al. 2006).

Habitat Model

The three modeling algorithms for Townsend's Big-eared Bat predicted similar areas around prominent higher elevations mountain ranges, centering on the Spring and Sheep ranges, the Virgin Mountains, the southern portion of the McCullough Range in Clark County, and the Newberry Mountains at the southern tip of the state, while they differed in predictions among valleys (Figure 87). The RF model had the highest performance scores among the four performance measures reported, followed by the Ensemble model, which had a higher fixed BI score than the RF model (Table 57). Model standard error appeared highest in Bajadas and lowland areas in Eldorado Valley, and the Moapa area (Figure 88). Continuous Boyce indices indicated generally good model performance each of the modeling approaches, as well as the ensemble model (Hirzel et al. 2006)(Figure 89). The CBI for the MaxEnt model had some fluctuation at model values of ~ 0.8, and the CBI for the GAM had a later increase than the others. Bins for the ensemble model based on the CBI were 0-0.45 unsuitable, 0.45-0.55 marginal, 0.55-0.8 suitable, and 0.8 -1 optimal habitat; with a suggested cutoff threshold of 0.5 (Figure 89) which corresponded closely with that calculated from ROC statistics for the ensemble model (Table 57).

Table 57. Model performance values for *Corynorhinus townsendii* models

Performance	GAM	RF	MaxEnt	Ensemble
AUC	0.79	0.95	0.81	0.90
BI	0.55	0.66	0.62	0.75
TSS	0.56	0.83	0.59	0.75
Correlation	0.50	0.80	0.53	0.70
Cut-off*	0.45	0.62	0.33	0.47

*threshold at which sum of sensitivity (true positive rate) and specificity (true negative rate) is highest

Table 58. Percent contributions for input variables for *Corynorhinus townsendii* for ensemble models using GAM, MaxEnt and RF algorithms

Term	GAM	RF	Max	Avg
Winter Min Temp.	44.66	15.53	39.20	33.13
Annual Temp. Range	11.98	16.02	22.98	16.99
Winter Precip.	13.20	8.33	14.95	12.16
NDVI Maximum	11.16	11.83	3.79	8.93
Diurnal Temp. Range	5.31	10.07	3.91	6.43
Distance to Cliffs	5.39	6.33	7.25	6.32
NDVI Amplitude	2.76	6.42	2.73	3.97
Surface Texture (ATI)	1.84	8.95	0.98	3.93
Topographic Position (TPI)	1.84	5.15	3.56	3.52
Annual Temp. Range	24.08	17.87	26.13	22.6

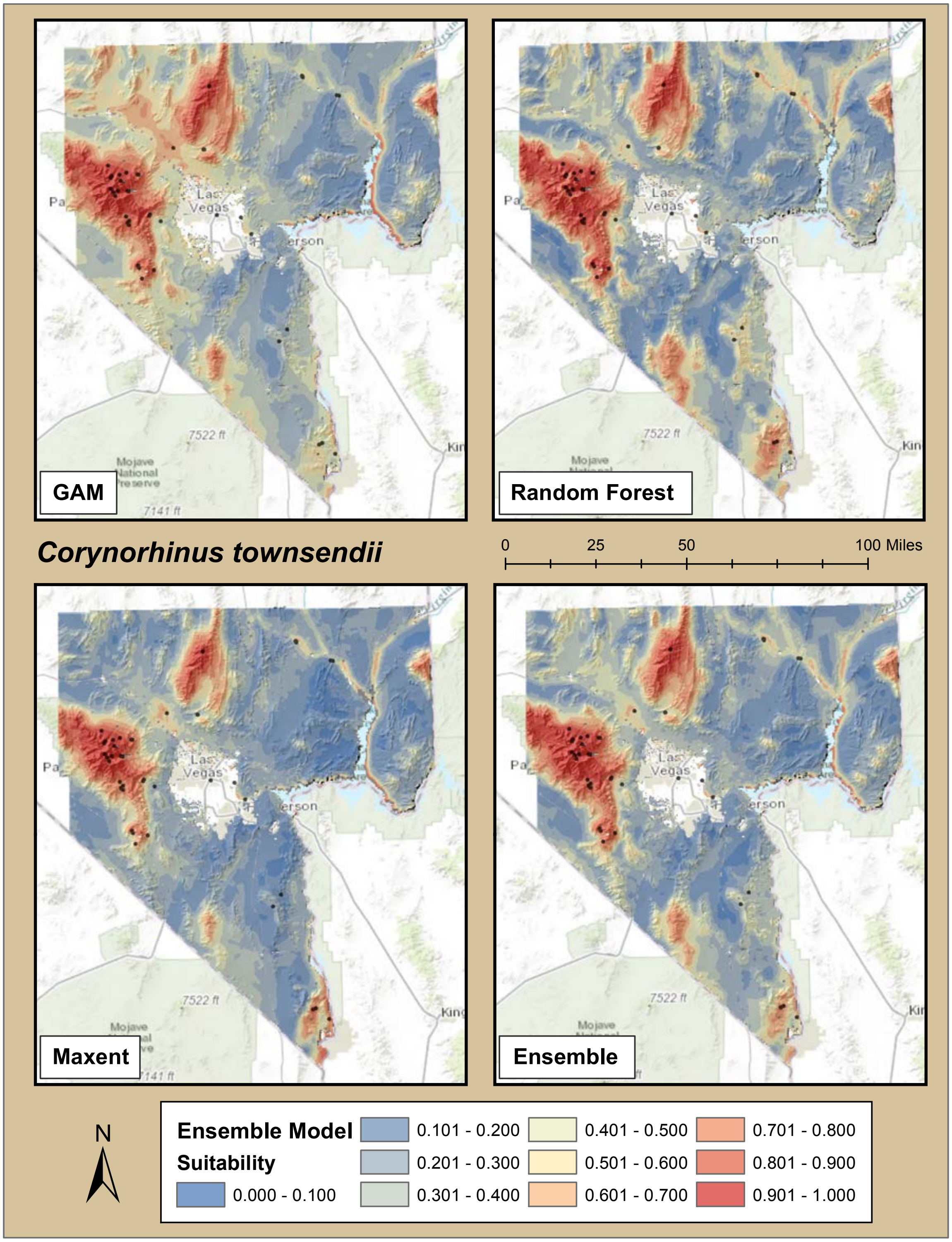


Figure 87. SDM maps for *Corynorhinus townsendii* model ensembles for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

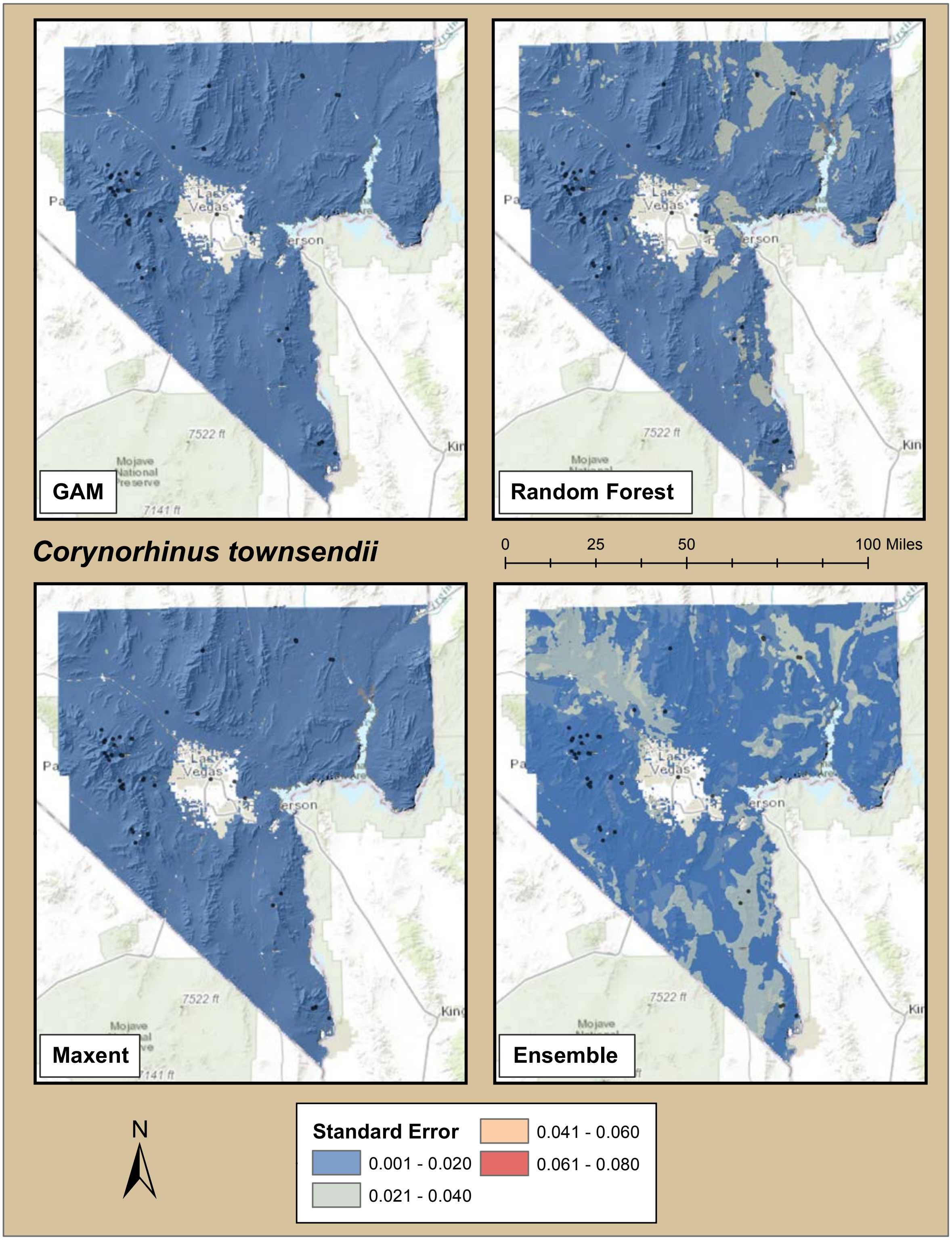


Figure 88. Standard error maps for *Corynorhinus townsendii* models for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

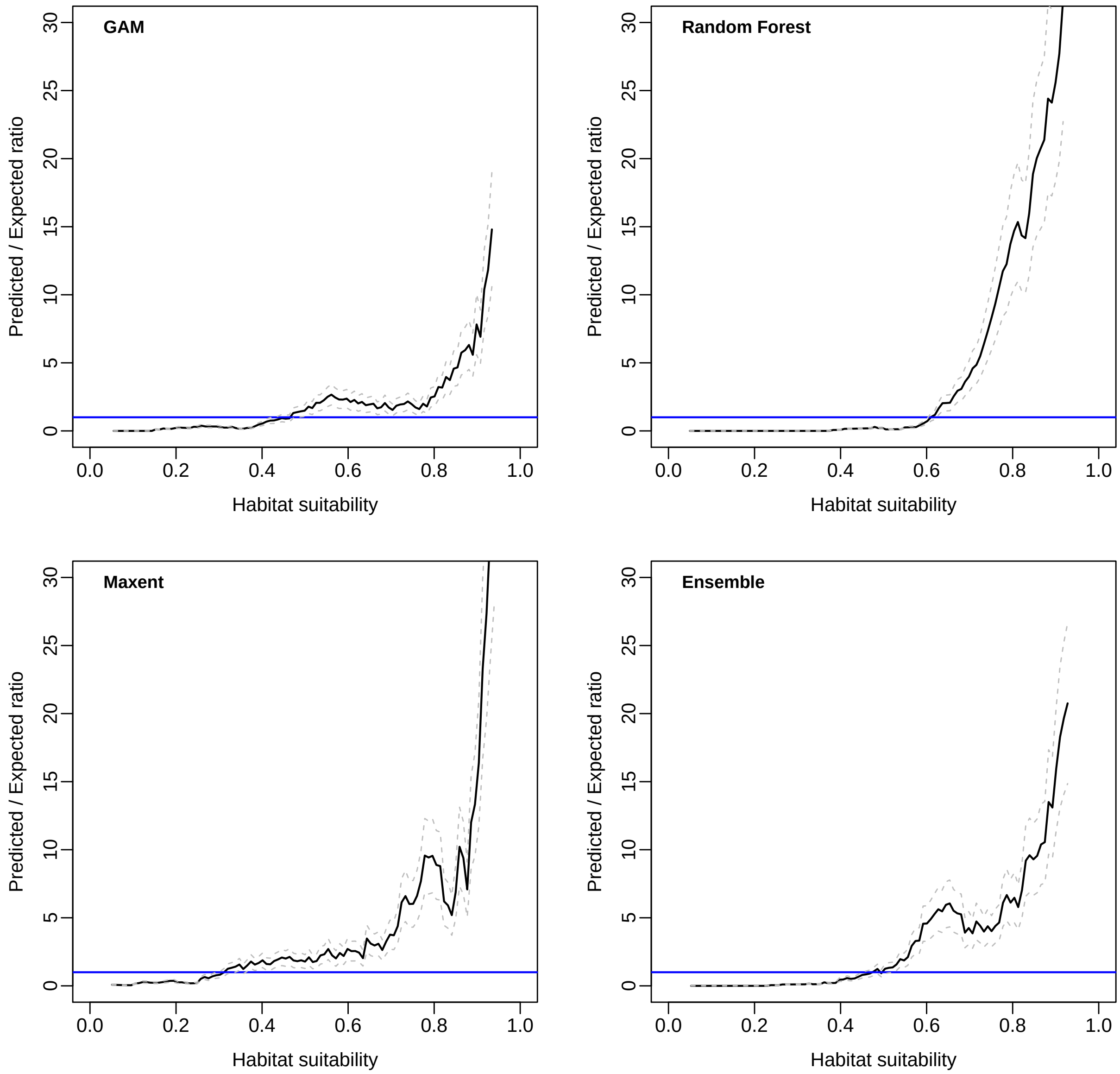


Figure 89. Continuous Boyce Indices for *Corynorhinus townsendii* models for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

General Additive Model

The top 4 contributing variables to the GAM model were Winter Minimum Temperature, Winter Precipitation, Annual Temperature Range, and NDVI Maximum, collectively representing 80% of the overall environmental contributions to the model (Table 58). Habitat suitability was negatively associated with the two temperature metrics, and winter precipitation, with cooler winter temperatures, with lower temperature difference between summer and winter, and lower precipitation contributing to suitable habitat. The temperature associations with highest habitat suitability were markedly lower than the average habitat values (Figure 90). Habitat suitability relative to NDVI Maximum had the highest values in areas with later greenup than average, but not at the extreme for this variable. The continuous BI curve for the GAM model had a much lower peak at the highest habitat values than those for the other models (Figure 89).

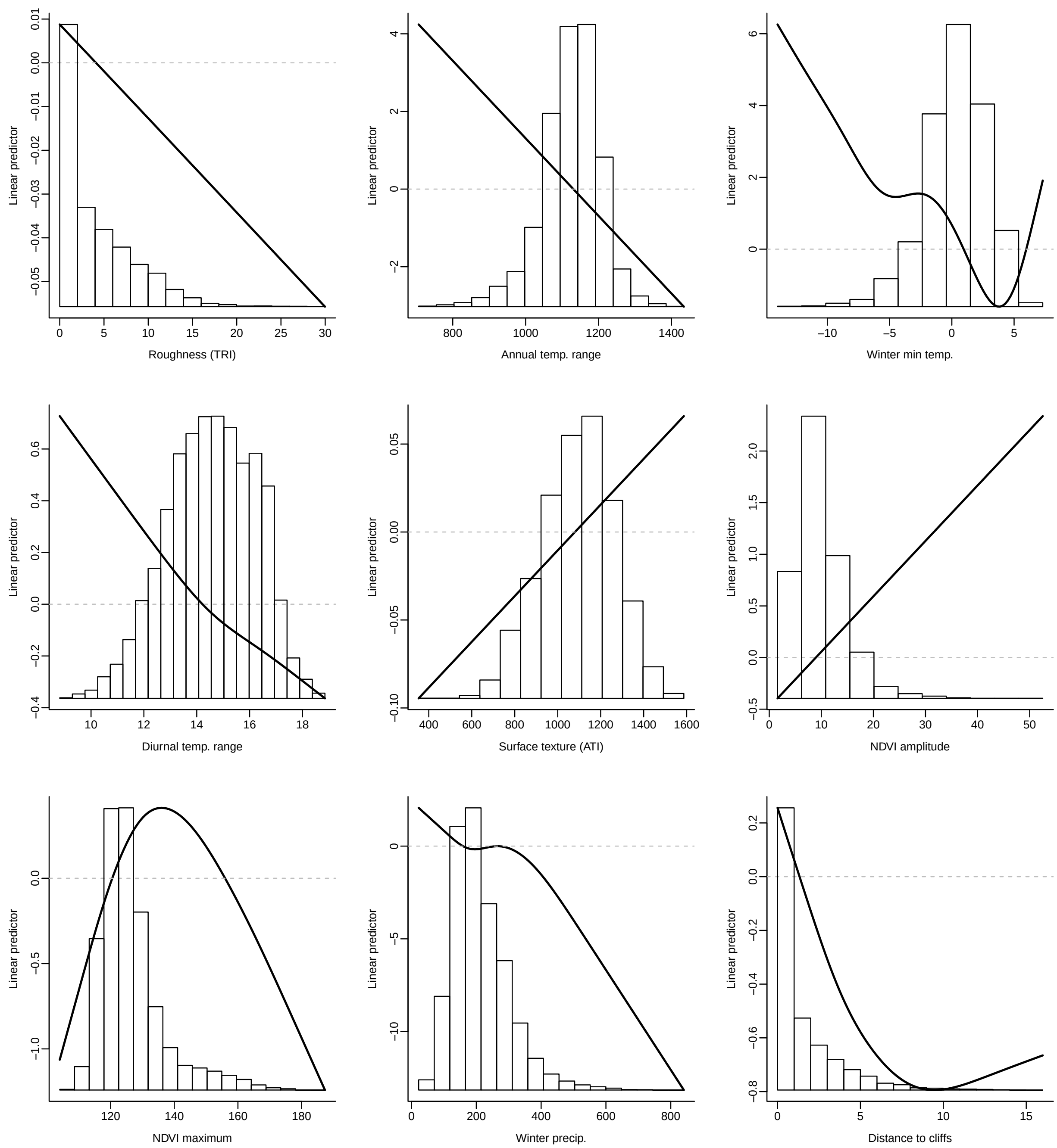


Figure 90. GAM partial response curves for the *Corynorhinus townsendii* model overlaid over distribution of environmental variable inputs in the study area.

MaxEnt Model

Three variables had the strongest contributions to the MaxEnt models for this species, providing 77% of the overall environmental contributions (Table 58). These were: Winter Minimum Temperature, Annual Temperature Range, and Winter Precipitation, which were also the top three in the GAM models. The partial response curves depicting the relationships of these variables were all similar to those for the GAM models, which was not surprising given the similarities in predicted habitat (Figure 91). Differences between the two were most prominently visible along the US 95 corridor northwest of Las Vegas (predicted to have relatively higher suitability by the GAM model), and in the Newberry mountains (predicted to have relatively higher suitability by the MaxEnt model) (Figure 87).

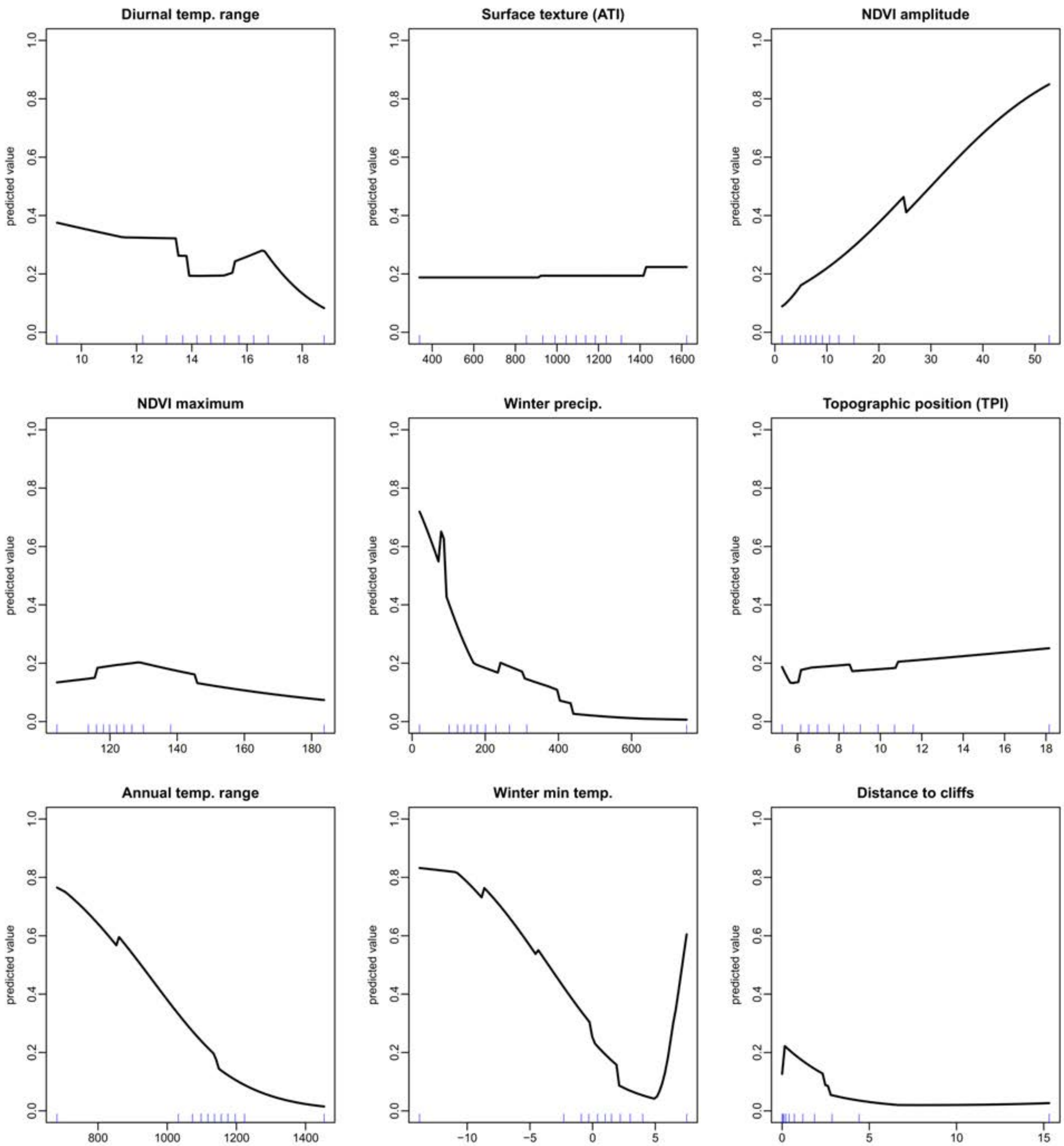


Figure 91. Response surfaces for the top 9 environmental variables included in the MaxEnt ensemble model for *Corynorhinus townsendii*.

Random Forest Model

The RF models had a much more diverse influence of environmental variables, with six variables contributing to achieve 70% of environmental variable influence, and without a sharp reduction to the last four (Table 58). Highest contributions were from Annual Temperature Range, Winter minimum temp, NDVI Maximum, Diurnal

Temperature Range, Surface Texture, and Winter Precipitation (Table 58). There were differences in the pattern of influence indicated by the RF response curves from the other two models. For example, habitat suitability was high for both low and high values of Annual Temperature Range, with the lowest suitability for moderate values. Habitat suitability was highest in areas with lower Winter Minimum Temperatures, but the response was non-linear, and had a negative sigmoidal relationship. Diurnal Temperature Range was positively associated with habitat suitability for all three of the modeling approaches. Suitable habitat for this species was associated with lower Surface Texture values – indicating rockier areas (Figure 92). The Continuous Boyce Index had the best relationship for this algorithm (Figure 89).

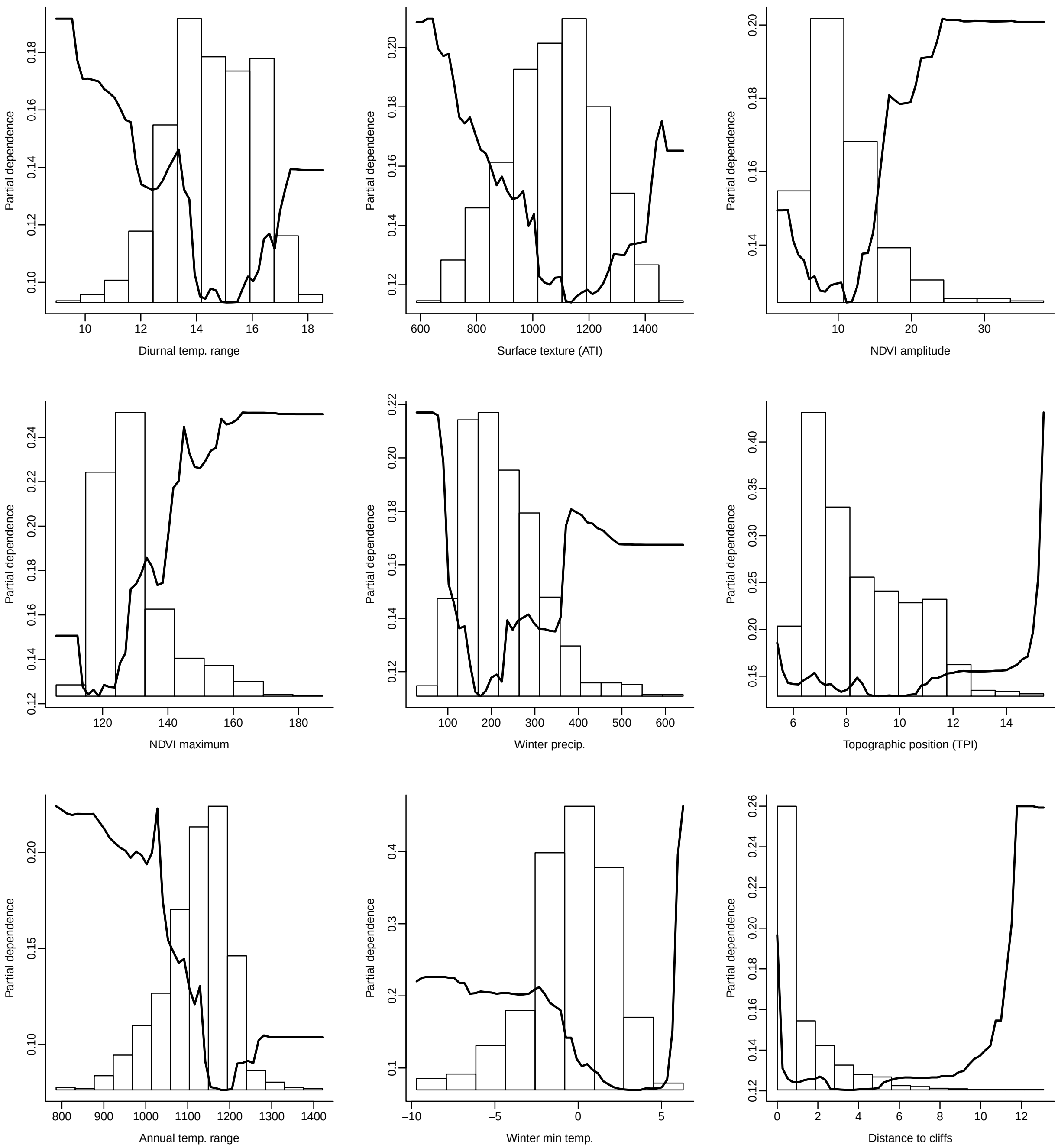


Figure 92. Response surfaces for the environmental variables included in the RF ensemble model for *Corynorhinus townsendii*. Histograms represent the range of each environmental variable across the x-axis, and predicted dependence relative to habitat suitability values are on the y-axis.

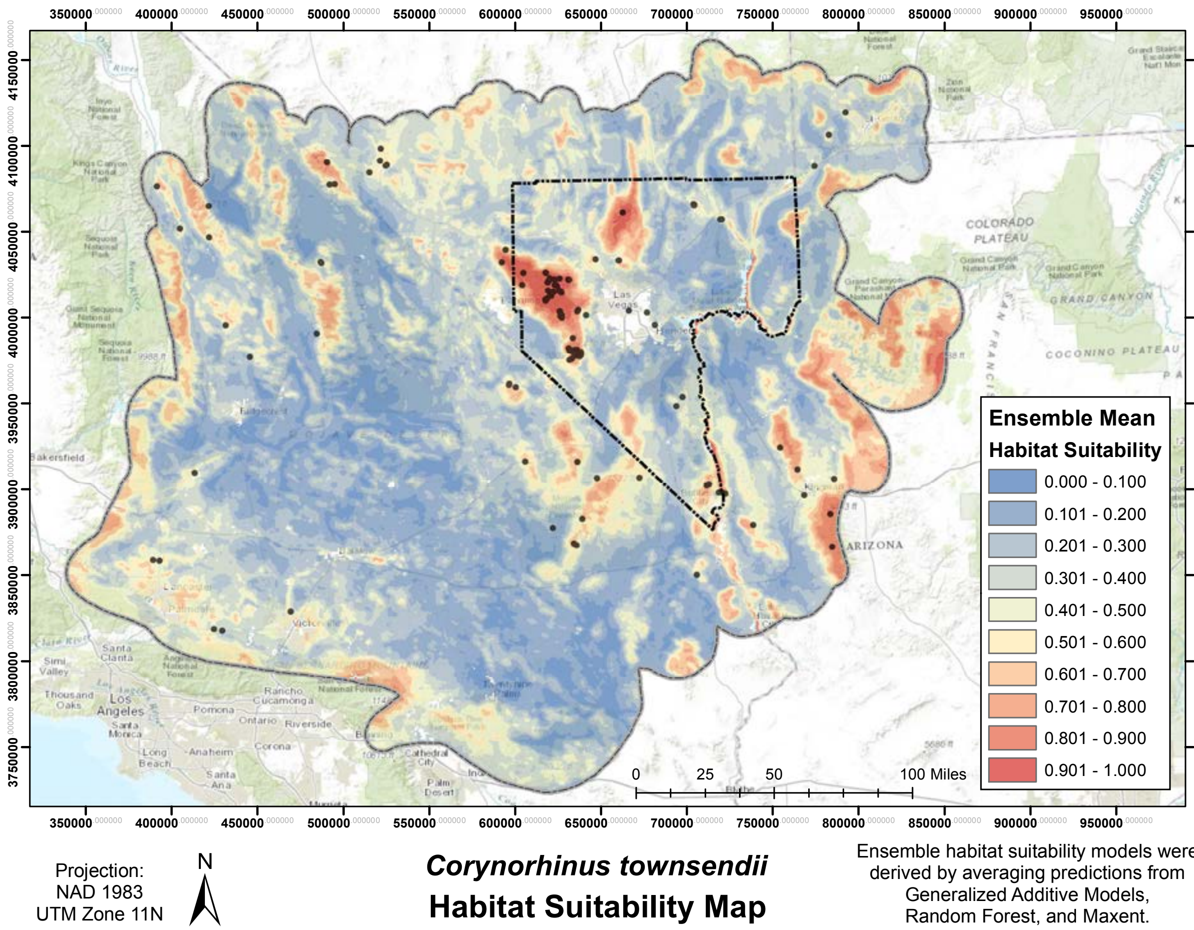


Figure 93. Mojave wide SDM map for the *Corynorhinus townsendii* ensemble model

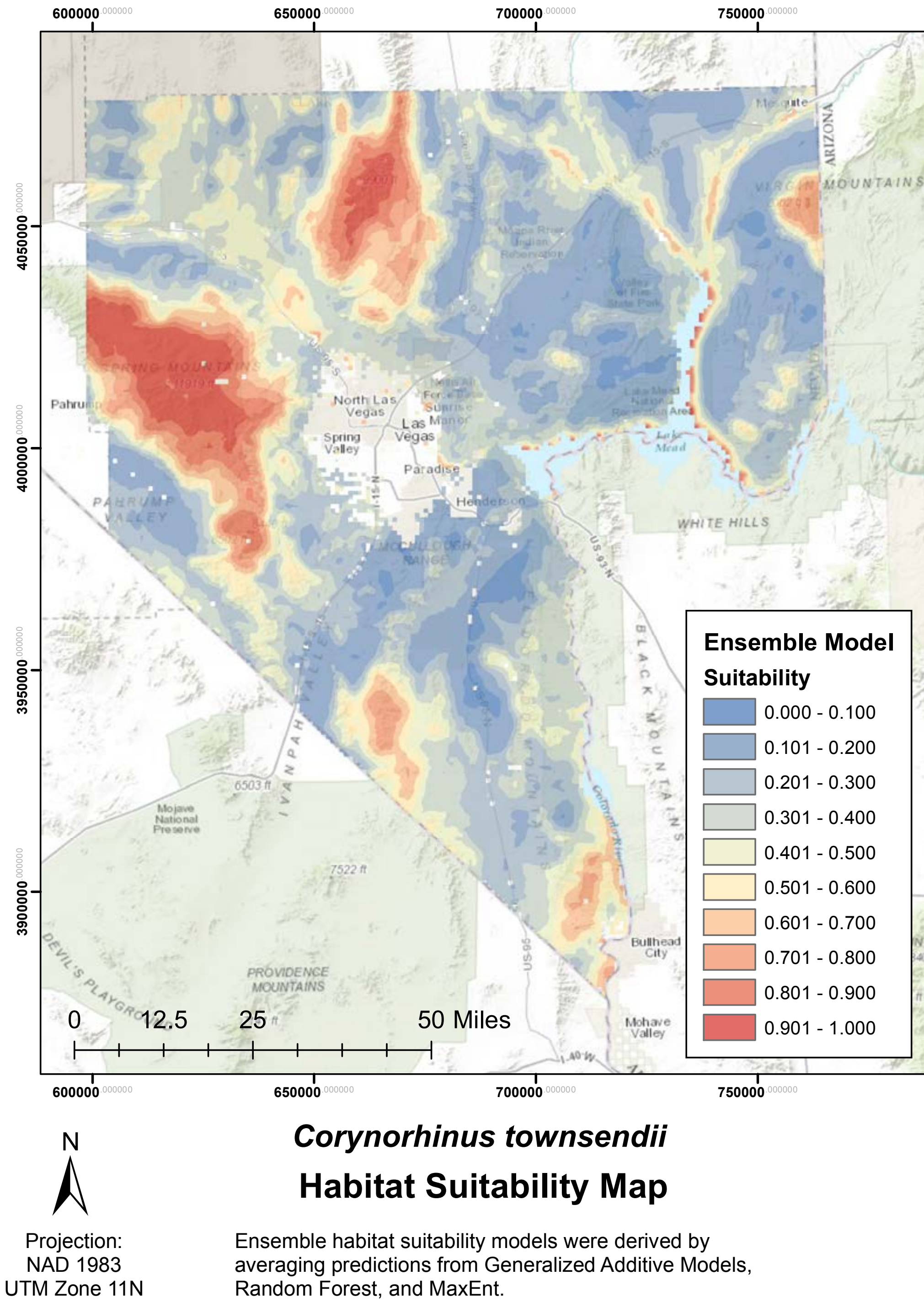


Figure 94. SDM map for the *Corynorhinus townsendii* ensemble model

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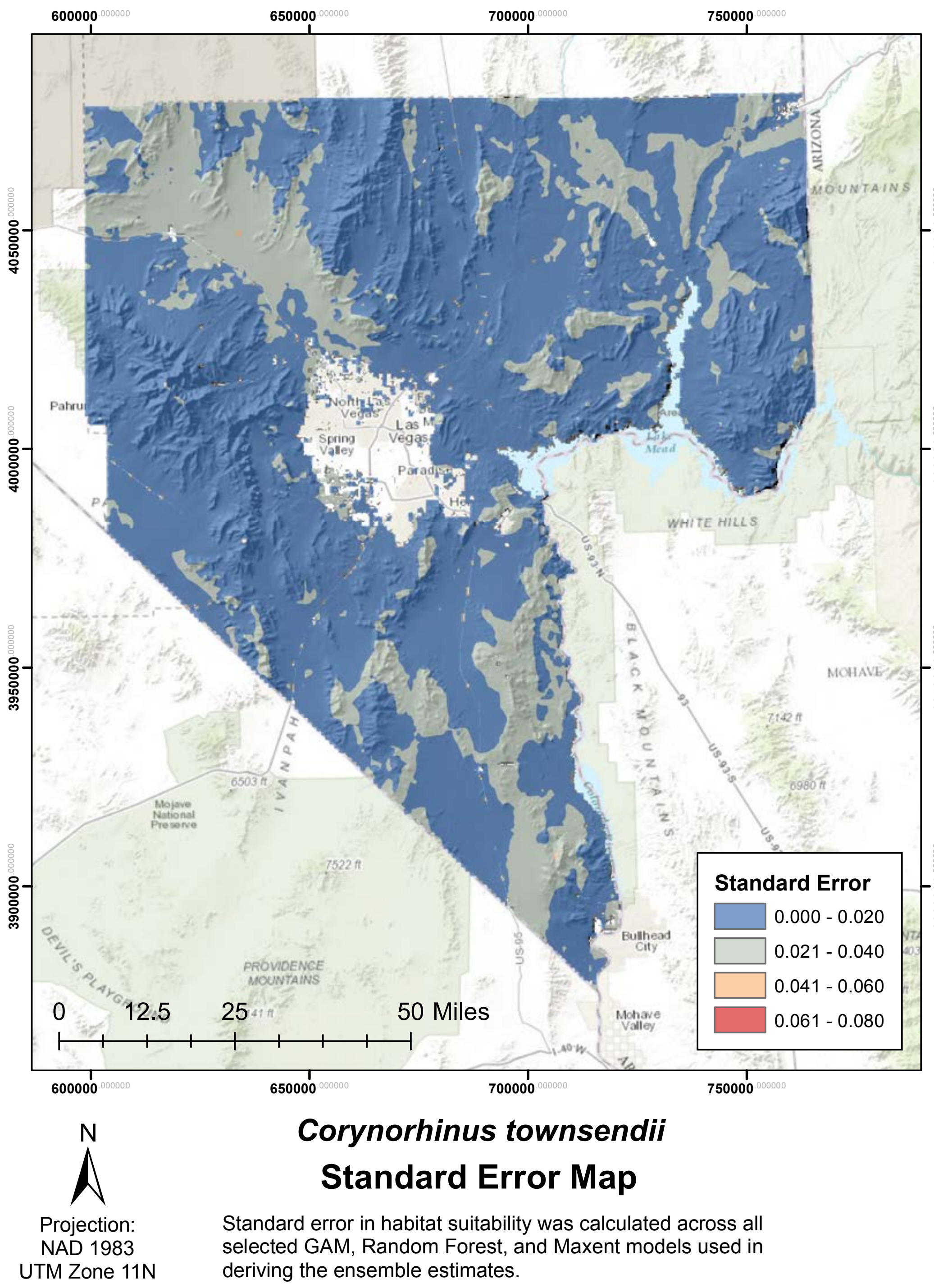


Figure 95. Standard Error map for the *Corynorhinus townsendii* ensemble model

Locality Distribution

Townsend's Big-eared Bats are known to occur across the Mojave Desert Ecoregion, but specifics of their habitat are poorly known with few verified locality points (Figure 93). The locality database used in this modeling exercise had the fewest locality points of any of the bat species we have modeled. Townsend's Big-eared Bat are equally widespread throughout Nevada from low desert to high mountain habitats. As an example of its ecological amplitude, it has been observed in Krumholz (windblown trees near timberline) bristlecone pines as high as 3,500m in the Snake Range of eastern White Pine County (Bradley et al. 2006). Similar to *Antrozous* and *Tadarida*, *Corynorhinus* is extremely sparse in the western Mojave Desert across most of California's desert without any verified localities in most of the central basin and range there (Figure 93). The greatest concentrations of verified Townsend's Big-eared Bat localities in the Mojave Desert are in the Spring Mountains of western Clark County. While there were many observations in Clark County, Nevada, there were far fewer localities in the urban areas around Las Vegas for this species than either *Antrozous* or *Tadarida*.

Standard Error on Habitat Suitability

The standard error analysis for Townsend's Big-eared Bat models indicates a homogenous pattern of very low error values presenting very little to be concerned about with respect to this model (Figure 95). The pattern is qualitatively similar to *Antrozous* and *Tadarida* however, there is one small patch of moderately high error near the southern margin of the Nellis Bombing Range just north of US Highway 95.

Mojave Desert Ecoregion Habitat Suitability

Models of habitat suitability for Townsend's Big-eared Bats in the Mojave Desert Ecoregion indicate mostly relatively small patches of moderately high habitat suitability across the desert occurring in association with higher elevation areas. The heart of California's Mojave Desert, known as the west Mojave in the context of the whole desert is nearly void of suitable habitat with the exception of a very small patch east of Barstow in San Bernardino County, between the I40 and I15 highways (Figure 93). This small patch is also ranked as moderately high suitability for *Antrozous* and *Tadarida* to the exclusion of most of the surrounding landscapes. The few other patches of moderately high suitability occur in montane environments such as the Panamint Range, and the White Mountains. On the east side of the Mojave Desert, both rims of the Grand Canyon, as well as the Cerbat and Hualapai mountains on the north and south of Kingman; respectively, in Mohave County, Arizona also supports moderately high habitat suitability. The only habitat ranked as the highest quality habitat in the Mojave Desert Ecoregion is in Clark County, Nevada. As noted for other bat species there are many small and intermittent patches of moderate habitat suitability on the very periphery of the Mojave Desert habitat suitability model. Those habitat patches should probably not be considered solely on the basis of this model due to the behavior of the modeling algorithms on the periphery of their boundaries, although the metric most likely to have edge effects (distance to cliffs) was not among the higher contributing environmental variables.

Distribution and Habitat Use within Clark County

This species has been observed at fewer than 50 locations throughout Clark County. In Clark County, Townsend's Big-eared Bats have been observed near the eastern end of Lake Mead and in the Newberry Mountains (RECON 2000), physically captured and acoustically recorded in the upper Muddy River (Williams et al. 2006), and acoustically recorded at several sites within the Spring Mountains. While this species is widespread throughout the county, predicted higher suitability habitat occurs in the uplands near Blackbrush, Pinyon Juniper, Mixed Conifer, and Alpine Ecosystems (Table 59). Its occurrence in lowlands is thought to be primarily for foraging, and thus the presence of moderate habitat in Mojave Desert Scrub, Mesquite Acacia, Desert Riparian, as well as the upland ecosystems (Table 59).

Clark County, Nevada hosts the largest contiguous area of predicted highest suitability rating in the Spring Mountains. An almost equally high level of predicted suitability habitat exists on the Sheep Range, although this area is smaller in size (Figure 94). Townsend's Big-eared Bats are probably widespread among the low desert to montane habitats of these high mountain ranges. In those areas, these moth specialists likely inhabit pinyon/juniper and mountain mahogany woodlands, and forests of ponderosa pine, white fir, aspen and cottonwood (Bradley 2000). The only other areas where the models identify high suitability habitat patches occur along the eastern shoreline of the Overton Arm of Lake Mead and small intermittent patches along the main stem of the Colorado River. There are patches of moderately high suitability in both the Virgin and McCullough mountains, though less extensive areas than the Spring Mountains and Sheep Range.

Table 59. Ecosystems within Clark County, and the area (Ha) of Low Medium and High predicted suitability within each ecosystem.

Ecosystem	Low	Medium	High
Alpine	0	0	124
Blackbrush	77481	227031	109806
Bristlecone Pine	0	0	7565
Desert Riparian	104	5863	4760
Mesquite Acacia	7599	9967	2218
Mixed Conifer	0	0	27339
Mojave Desert Scrub	825987	433242	26165
Pinyon Juniper	199	5573	110101
Sagebrush	19	631	4055
Salt Desert Scrub	16532	61719	1352

Ecosystem Level Threats

In addition to urbanization, activities that can result in significant disturbance or loss of habitat include mine reclamation, renewed mining, water impoundments, recreational caving, rock climbing, loss of building roosts, and bridge replacement (Kunz and Martin 1982, Pierson et al. 1999). Additional threats to the species include the loss of foraging habitat through timber harvesting and development and the reduction of prey base through the use of pesticides (Piaggio 2005).

Threats to Species

Townsend's Big-eared Bats are very sensitive to roost disturbance and may abandon roosts after human visitation. Disturbance of roosts, including recreational caving and mine exploration and resumed mining are the primary threats to Townsend's Big-eared Bats (Piaggio 2005). Pesticide contamination may also threaten this species in agricultural areas (Geluso et al. 1976). There is some evidence that predation from rats could be suppressing certain populations (Fellers 2000).

White-nosed fungus (*Pseudogymnoascus destructans* or Pd*)* has the potential to impact the species (Gargas et al. 2009). Although incidence of white-nosed fungus – a cold-loving fungus that affects hibernating bat species -- has not been reported in Nevada, this disease has the potential to affect all hibernating bat species, including Townsend's Big-eared Bats. Colonies of hibernating bats exposed to the fungus can suffer mortality rates of 81-97 percent (http://www.fort.usgs.gov/wns/).

Renewable energy development can threaten bat habitat in a couple of ways. First there is the direct habitat disturbance. In this regard, solar arrays may be the most destructive to foraging areas for desert bats in Clark County, while wind farms have a smaller surface area disturbance. In contrast, wind turbines can have direct impacts to bats through collisions or barotrauma (Cryan and Barclay 2009, Cryan 2011).

Gates have been installed to protect some mines from human disturbance and people from mine hazards, however many gates installed are not bat friendly and may interfere with local colony survivorship (Pierson and Rainey 1998), as there is some evidence of collisions of this species with bat gates, particularly with younger animals (Diamond and Diamond 2014).

Nevada has an abundance of former mining sites that are suitable roosts for this species. As the species is known to abandon roosts when disturbed by human visitation, threats are likely a result of recreational use of known or potential roost sites. Closure of sites, and of routes leading to these sites, could be considered as a mitigation strategy to reduce disturbance. Further, renewed starts on formerly closed mines are also documented to disturb this species. The potential effects on the species by permitting for renewed mining activities should be considered.

Existing Conservation Areas/Management Actions

The Nevada Wildlife Action Plan sets a strategic vision for wildlife conservation at the landscape level in Nevada, and identifies the species of greatest conservation need within the state (2012). The plan designates Townsend's Big-eared Bat a Species of Conservation Priority because of its patchy distribution, range-wide population status concerns, and possible susceptibility to white-nose syndrome (Wildlife Action Plan Team 2012). Plan objectives relevant for this species include: maintaining stable or increasing populations, conducting 200 bat surveys within mines per year, and installing 50 bat-friendly closure structures per year through 2022. Research and conservation actions recommended for Townsend's Big-eared Bat include: mapping and monitoring winter, maternity, bachelor, lekking, and night roosts; developing and implementing temporal and spatial use recommendations in known roost areas in order to minimize human disturbance; supporting and advocating technological research to develop non-lethal wind turbine designs to minimize collision mortality; using alternative mine closure methods such as hazard signs, fencing, and/or bat gates in order to retain habitat; and monitoring for white-nose syndrome (Wildlife Action Plan Team 2012).

The Nevada Bat Conservation Plan assesses the state of bat conservation in Nevada and suggests strategies, actions, and research needed to promote healthy bat populations and habitats (Bradley et al. 2006). The plan considers Townsend's Big-eared Bat populations and habitats a high priority for funding, planning, and conservation actions, and states the species is imperiled or at high risk of imperilment (Bradley et al. 2006).

Townsend's Big-eared Bat is considered a Very High Priority species in the Spring Mountain Conservation Agreement. This agreement has been developed between various agencies to provide long-term protection for the rare and sensitive flora and fauna of the Spring Mountains National Recreation Area (USFS et al. 1998). Out of the seven species of bats that occur in the Spring Mountains, Townsend's is of greatest concern because it is highly susceptible to disturbance. Conservation actions listed in the plan include: developing a bat monitoring plan, emphasizing roost site and water source monitoring; developing and implementing a plan to protect bat roosts in mines and caves; working with volunteers to provide nest boxes for roosting bats to replace lost habitat; and developing and implementing a monitoring program for assessing effects of recreational use on bats and their habitats (USFS et al. 1998).

The Overton Wildlife Management Area (OWMA) consists of 17,229 acres in the Moapa Valley managed by the Nevada Department of Wildlife. The conceptual management plan for OWMA calls for protecting and enhancing mammal habitats and populations. Recommended management actions are to determine the occurrence and habitat functionality on the OVWMA for warm desert riparian bats, including Townsend's bat-eared bat (NDOW 2014).

Townsend's Big-eared Bat is an Evaluation species under the Lower Colorado River Multi-Species Habitat Conservation Plan (LCR MSCP 2004). Conservation measures to avoid, minimize, and mitigate impacts include: conducting surveys and research to locate roost sites and better identify habitat requirements; creating habitat near existing roost sites; monitoring and adaptively managing created habitat; and reducing the risk of losing created habitat to wildfire (LCR MSCP 2004). The plan states that created cottonwood-willow and honey mesquite habitat will support a substantially greater density and diversity of plant species that will in turn support a greater abundance of insect prey species.

Summary of Direct Impacts

There are few occurrences of Townsend's Big-eared Bat in Clark County. However, Townsend's Big-eared Bat has been identified acoustically, and many unpublished records exist in association with abandoned mines on BLM property (Christy Klinger, NDOW, pers comm.). Habitat for this species is generally widespread, and predicted higher suitability habitat is largely outside of the current disturbed and impact layers, and indeed outside of even conservation areas for the most part. However, 128 km^2 of Conserved highly suitable habitat is identified, as well as 1461 km^2 of moderate habitat (Table 60). More impact is expected in moderate habitat, and some disturbance in that category has already occurred there as well.

Table 60. Categorized modeled habitat values (High, Medium, and Low) and the average area (Hectares) predicted in the potential impact areas, conservation areas, already disturbed areas, and overall area

Habitat Level	Impact	Conserved	Disturbed	Area (Hectares)
High	2299	12838	3157	300469
Med	55302	146139	26970	763796
Low	64985	353810	21179	948804

CRCE - Mojave Desert Sidewinder (Crotalus cerastes cerastes)

Sidewinder rattlesnakes are sit-and-wait predators that ambush small prey such as kangaroo rats, pocket mice, deer mice, small lizards and birds. They locate a prospective ambush point, form their bodies into a tight circle and coil into the soil such that the top of their bodies are even with the surrounding surface. The color of their skins usually is a close match with local soil color, which is not surprising due to their partial diurnal activity patterns (Norris and Lowe 1964). Like other rattlesnakes, sidewinders are pit-vipers, which describes another unique adaptation (Fowlie 1965). The "pit" of the pit-viper is a directional heat-sensing organ located on the front of their heads, just below the nostril and in front of – and below the eye (Lowe et al. 1989). The pits allow sidewinders to sense and locate prey that varies no more than 1.0 ºC (1.8 ºF) from their surroundings such that they can apprehend prey in total darkness (Lowe et al. 1989). With head facing outward in the direction of passing wildlife, a passing prey species is lunged toward like an uncoiled spring a venomous bite is delivered through hollow fangs in the front of the upper jaw. Sidewinders have low venom yields and moderate to low toxicity, but a bite is still serious (Lowe et al. 1989). Observing them at a safe distance is the best way to avoid injury. Sidewinders up to 0.82 meters (2.7 feet) long are probably near the maximum size for this species, and males are smaller than females. The Mojave subspecies is slightly smaller than the Sonoran subspecies.

The Mojave Desert Sidewinder (Crotalus cerastes cerastes) (Crother et al. 2008) is considered a Species of Conservation Priority in the Nevada Wildlife Action Plan (Wildlife Action Plan Team 2012). This species generally inhabits open desert terrain with fine windblown sand, desert flats with sandy washes, or dunes sparsely vegetated with creosote or mesquite (Klauber 1997). They are generally nocturnal, but in the early spring sidewinders are active at dusk or even occasionally during the day. They are sit-and-wait predators that curl into a neat, flat, round shape, like a Danish pastry. Sidewinders nestle into the sand surface where their cryptic coloration hides them from prey and predators. Sidewinders are one of our few true Mojave Desert endemics and may be relatively recent arrivals in geological time (Lowe et al. 1989). Sidewinders have a dark stripe along the side of their heads that runs through the eye. They also have a modified supraocular scale that is shaped like a horn, and are sometimes called horned rattlesnakes (Stebbins 2003). Both are likely adaptations to improve eyesight in contrasting light conditions of open desert country. More recently it has been hypothesized that the movable horny scale can protect the eye from rough shrubs and soil (Lowe et al. 1989). They also move in a unique and peculiar manner that is described as sidewinding. While moving, their bodies are held in an “S” shape. They cast their head and the front 1/3 of their bodies laterally, and the rest of the body follows, frequently creating a series of “J” shaped marks in the sand. The movement works very well on fine loose sand (Mosauer 1933, Secor 1994).

Species Status

US Fish and Wildlife Service Endangered Species Act: No Status
US Bureau of Land Management (Nevada): Sensitive
US Forest Service (Region 4): No Status
State of Nevada: No Status
NV Natural Heritage Program: Global Rank G5, State Rank S4 (for Crotalus cerastes, C. c. cerastes not listed in this database at present)
NV Wildlife Action Plan: Species of Conservation Priority
IUCN Red list (v 3.1): Least Concern
CITES: No Status

Range

The Mojave Desert Sidewinder is one of three subspecies of sidewinder found in the US The Mojave Desert Sidewinder ranges in western and northwestern Arizona, the eastern Mojave Desert of California, southern Nevada, and southwest Utah into the Dixie Valley near St. George Utah. The Sonoran subspecies (*C. c. cercobombus*) occurs solely in Arizona and Sonora, Mexico. The Colorado Desert subspecies (*C. c. laterorepens*) occurs in southwest Arizona, southern California and Baja del Norte, Mexico. All three subspecies are similar in appearance, making identification difficult without knowledge of their origins (Lowe et al. 1989) or genetic data. The Mojave Desert Sidewinder inhabits the greatest elevational range among the three subspecies from -76 meters (-250 feet) below sea level, found near Furnace Creek Ranch, California, to at least 1,371 meters (4,500 feet) at Quartz Spring, Lincoln County, NV Klauber 1997).

Habitat Model

The GAM models for Mojave Desert Sidewinders generally predicting more habitat, than either the MaxEnt or RF models, where the latter two were similar in prediction (Figure 96). RF models had the highest performance scores across all three performance metrics (Table 61). None of the model algorithms included Elevation, NDVI Start of Season, or total integrated NDVI. Standard error for the models The Continuous Boyce Index showed strong predictive performance for all but the GAM model, with the best performance for the RF and Ensemble Models (Figure 98). Spatial arrangement of model prediction standard error was low for each of the modeling algorithms (Figure 97).

Table 61. Model performance values for *Crotalus cerastes* models

Crotalus **cerastes**	**Presences**	**AUC**	**BI**	**TSS**
Ensemble	257	0.876	0.935	0.629
GAM		0.757	0.874	0.477
RF		0.958	0.954	0.814
MaxEnt		0.83	0.944	0.548

General Additive Model

Rankings of the relative contributions for the GAM models identified Winter Minimum Temperature, Slope, and Terrain Position Index and Surface Roughness as the highest, with predicted habitat increasing with higher winter temperatures, and position index (indicative of valley bottoms in landscape scale drainages), and decreasing sharply with higher Slope and Surface Roughness (Table 62, Figure 99). Surface Texture and Annual Temperature Range each provided moderate contributions where sidewinders were predicted to be in areas with greater annual temperature range, and higher Surface Texture indices which correspond with sandier surfaces (Table 62, Figure 99). NDVI Amplitude, Winter Precipitation, Summer Maximum Temperature, and NDVI Maximum provided the least contribution (Table 62).

Table 62. Percent contributions for input variables for Crotalus cerastes for ensemble models using GAM, MaxEnt and RF algorithms.

Variable	**GAM**	**Maxent**	**RF**
Elevation			
NDVI Amplitude	3.89		12.739
NDVI Maximum	0.972	9.196	15.211
NDVI Start of Season			
NDVI Total Integrated			
Sandy Soils (TerraSpectra)		2.503	2.787
Slope	22.512	12.465	19.224
Summer Maximum Temperature	1.945	6.49	15.972
Surface Roughness	11.256	16.268	20.231
Temperature Range (Annual Max - Min)	5.321	9.64	

Variable	GAM	Maxent	RF
Terrain Position Index	18.689	6.16	14.273
Texture (ATI)	6.266		20.075
Washes		3.796	
Winter Minimum Temperature	26.057	29.47	20.973
Winter Precipitation	3.091	3.991	15.35

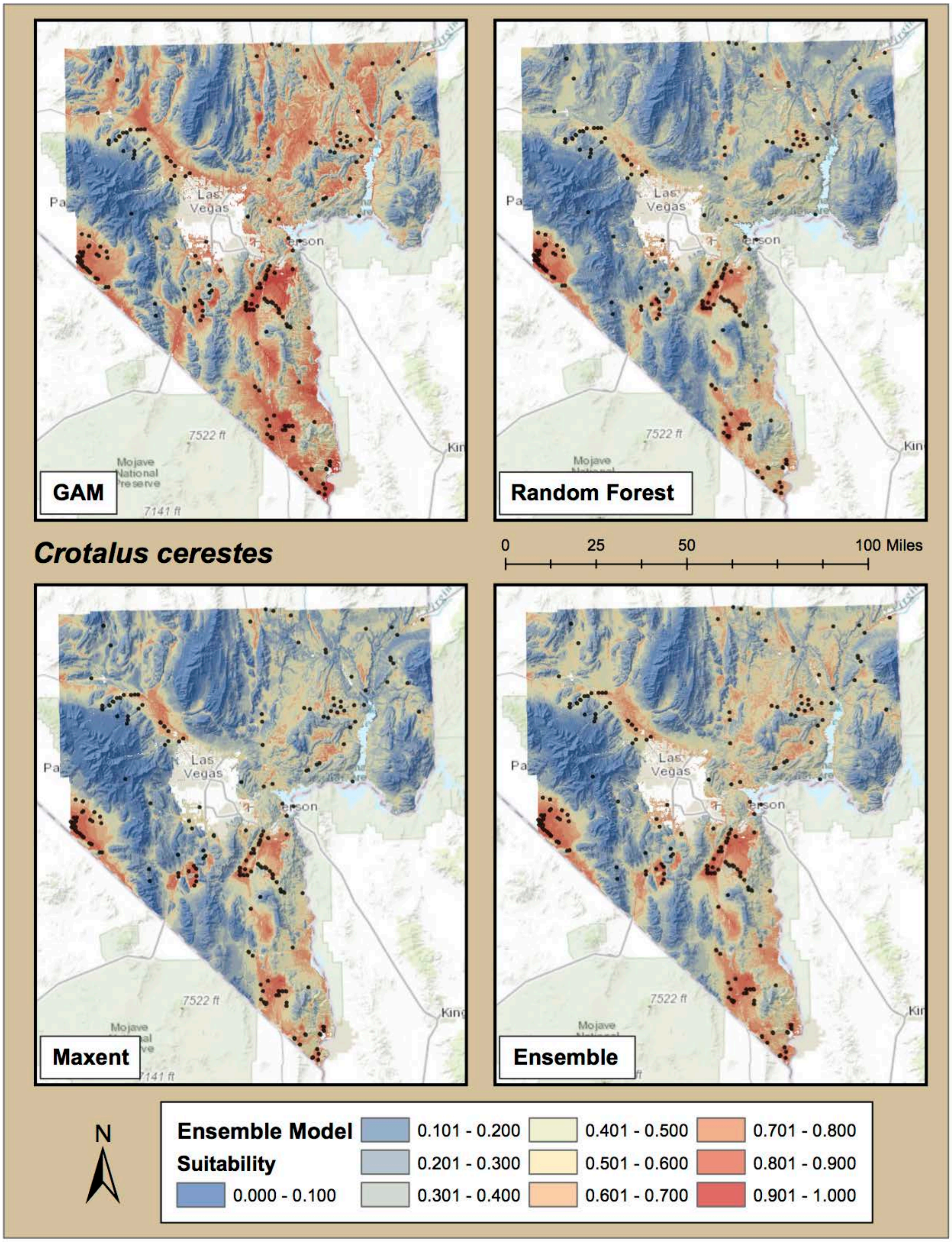


Figure 96. SDM maps for *Crotalus cerastes* model ensembles for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and ensemble model averaging the three (Lower Right).

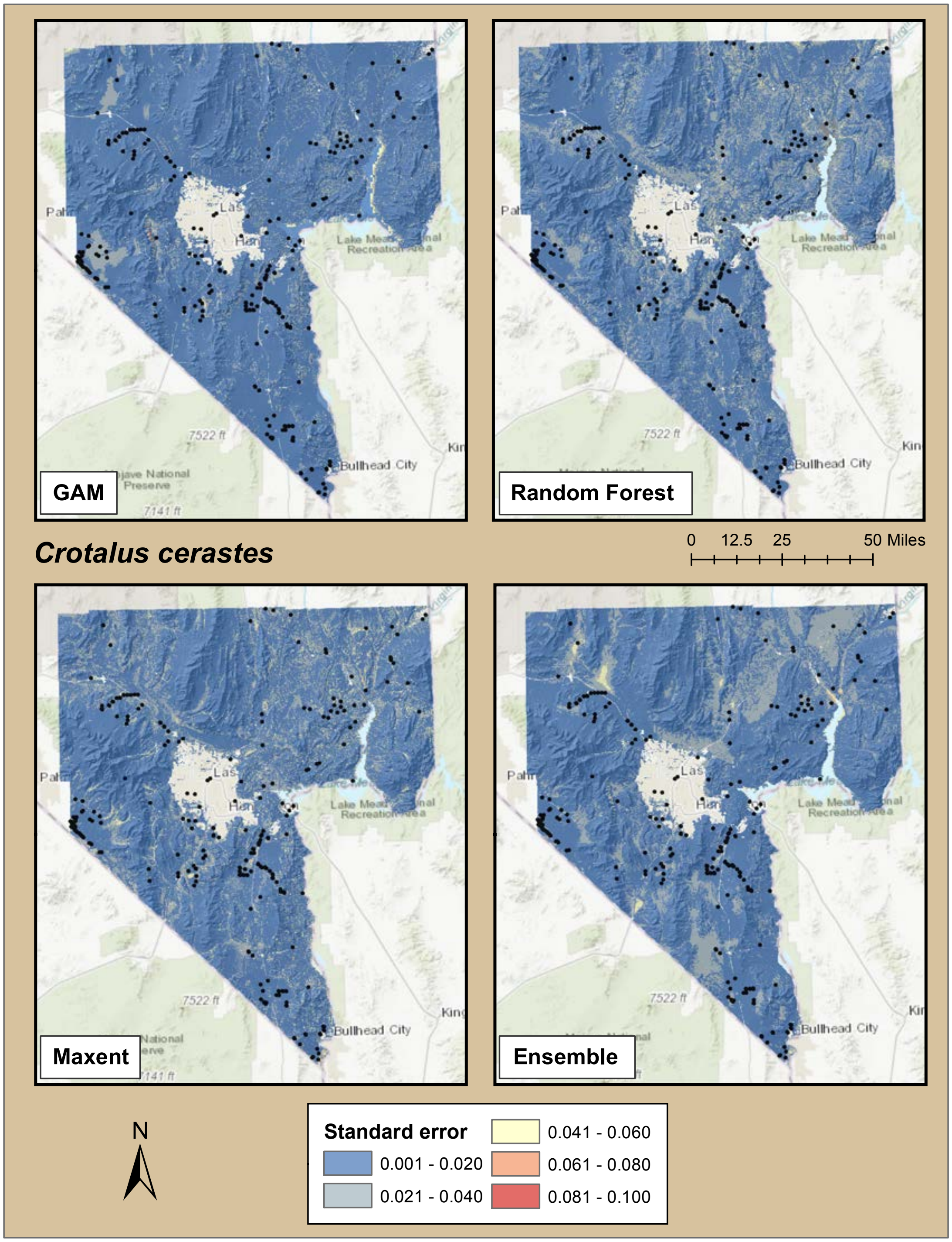


Figure 97. Standard error maps for *Crotalus cerastes* models for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

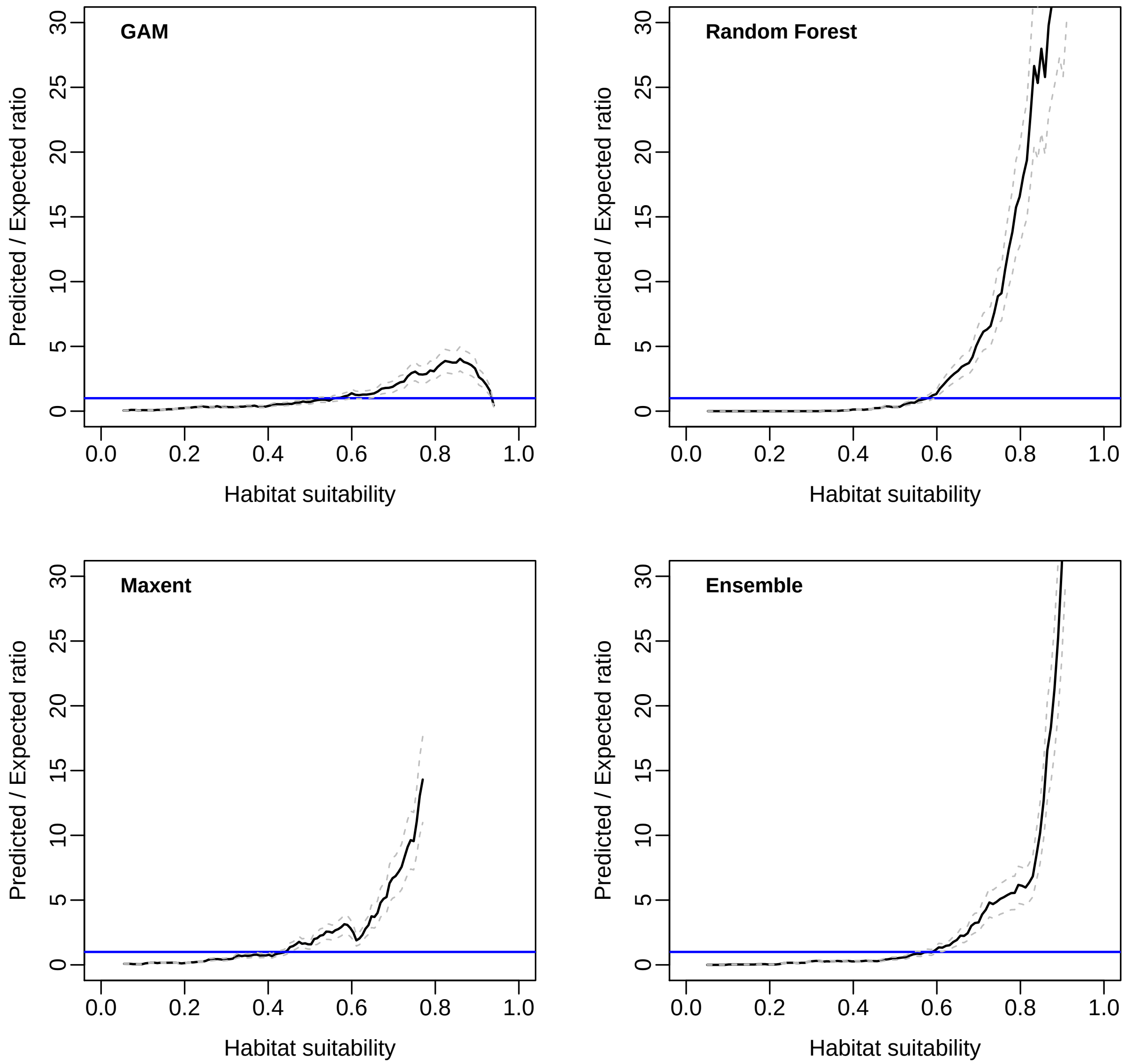


Figure 98. Graphs of Continuous Boyce Indices [CBI] for *Crotalus cerastes* models for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

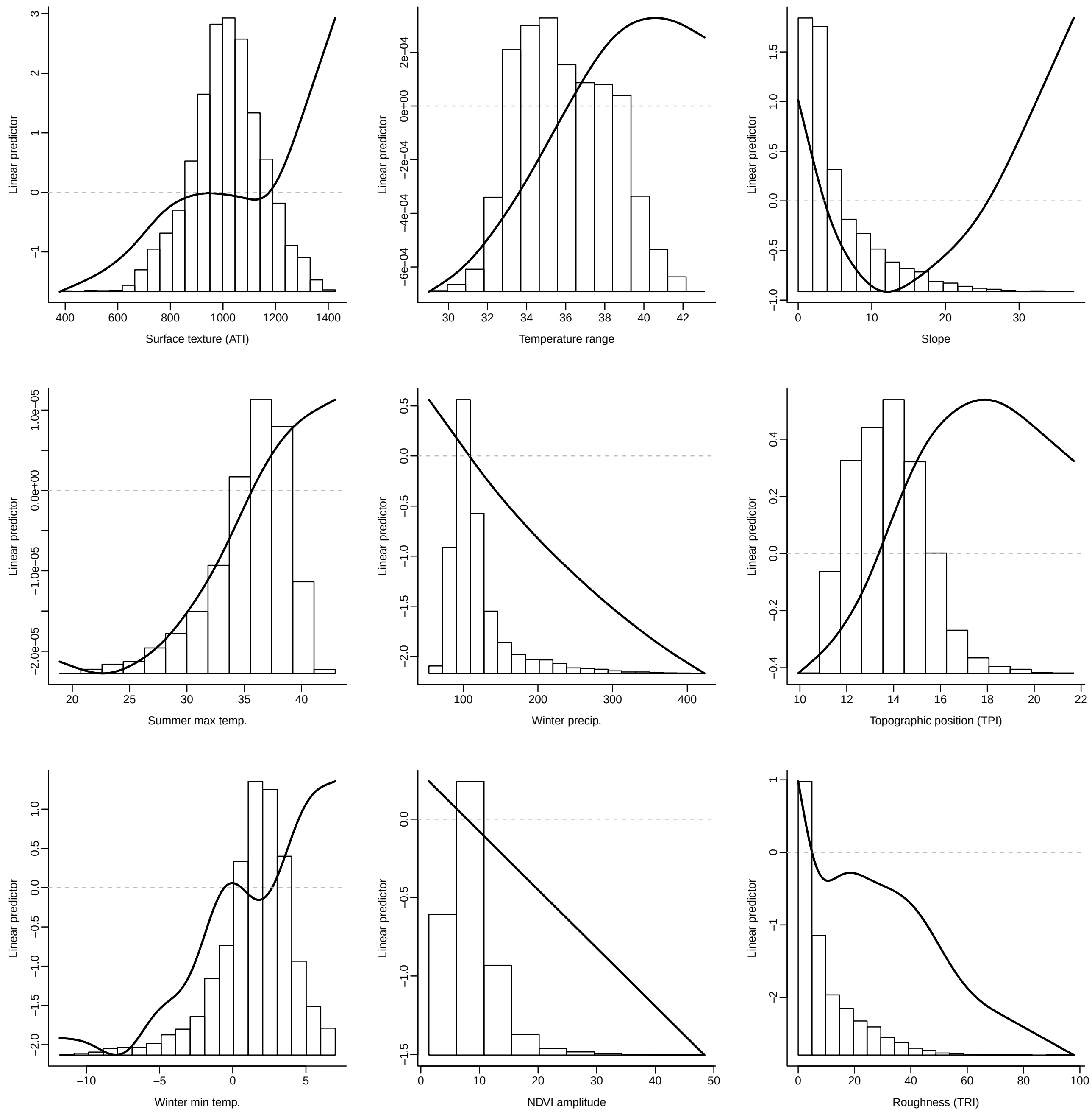


Figure 99. GAM partial response curves for the *Crotalus cerastes* model overlaid over distribution of environmental variable inputs in the study area.

MaxEnt Model

The MaxEnt model differed from the GAM models, dropping Surface Texture and NDVI Amplitude as habitat predictors and gaining Sandy Soils, and Washes. Winter Minimum Temperature had the largest contribution at 30%, followed by surface Roughness and Slope which had slightly less precise surfaces than for the GAM model (Figure 100, Figure 99). Annual Temperature Range, NDVI Maximum, Summer Maximum Temperature, Terrain Position Index, and Winter Precipitation each provided moderate influence, followed by Winter Precipitation, Washes, and Sandy Soils. Topographic index also appeared less precise in the MaxEnt response surface.

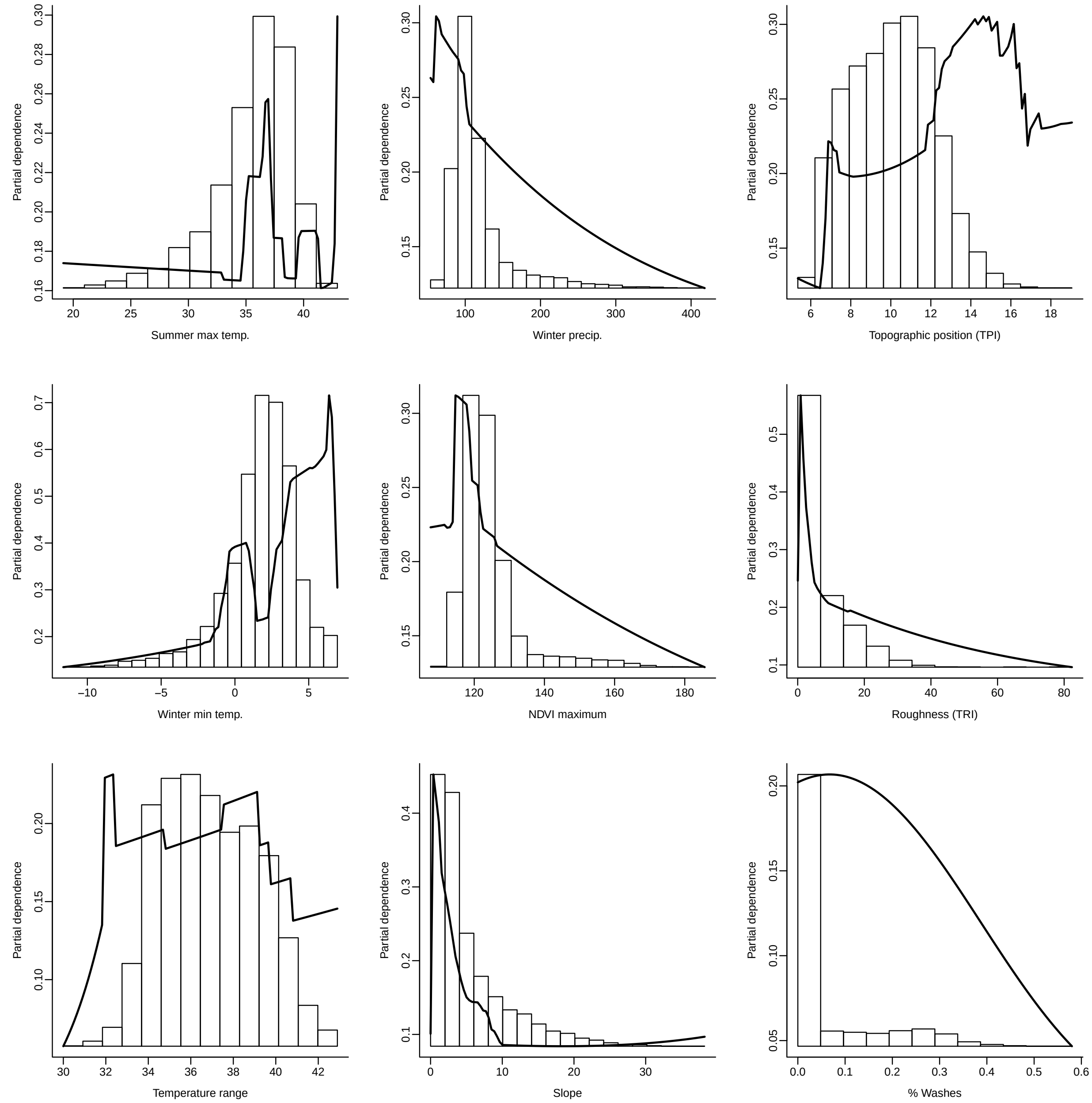


Figure 100. Response surfaces for the top environmental variables included in the MaxEnt ensemble model for *Crotalus cerastes*.

Random Forest Model

RF models showed highest contributions from Winter Minimum Temperature, Surface Roughness, Surface Texture, and Slope. Summer Maximum Temperature, Winter Precipitation, NDVI Maximum, Terrain Position Index, and NDVI Amplitude each provided moderate contributions, and Sandy Soils was the lowest contributor (Table 62). Model responses were similar to the MaxEnt model responses (Figure 101, Figure 100).

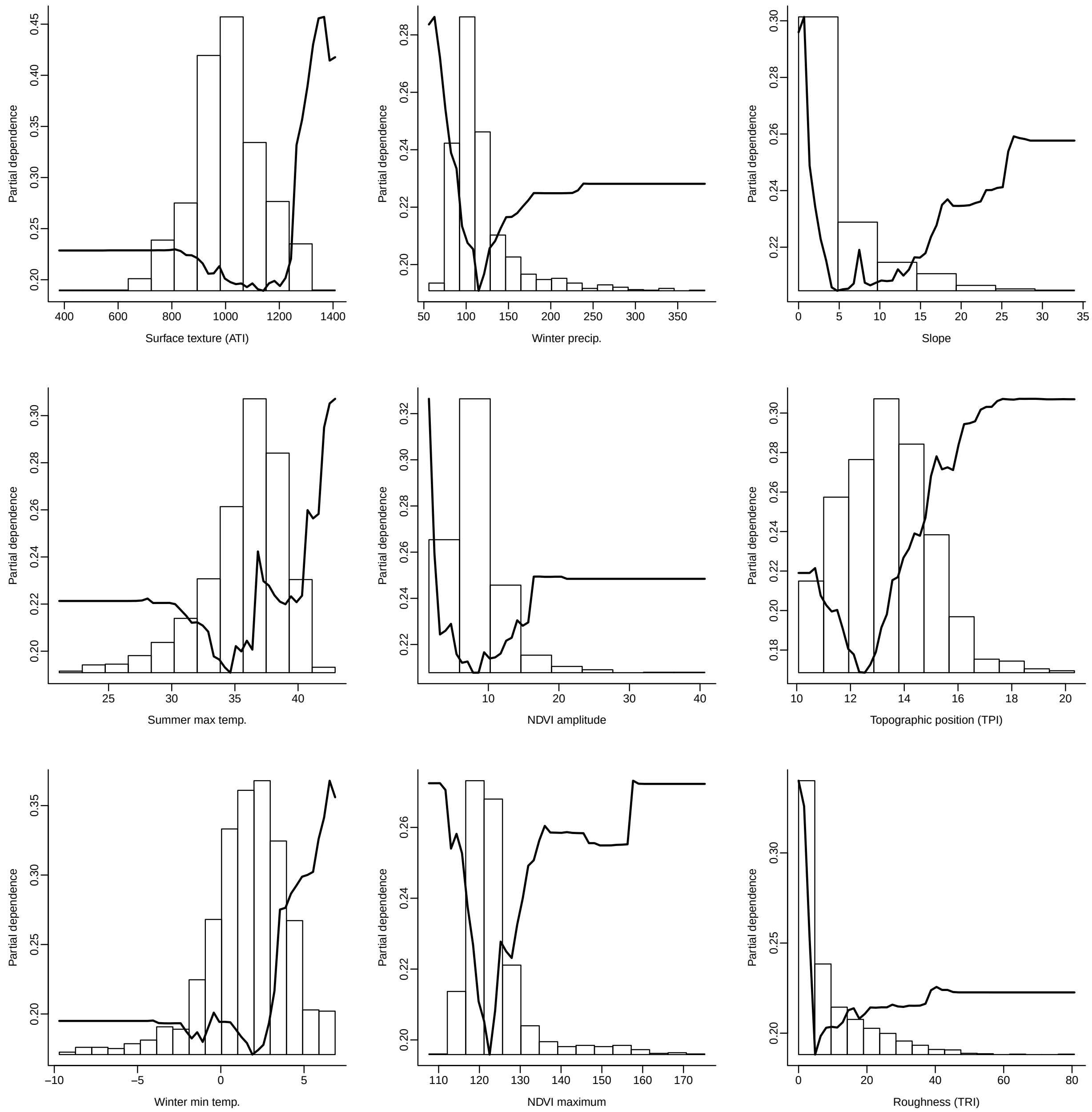


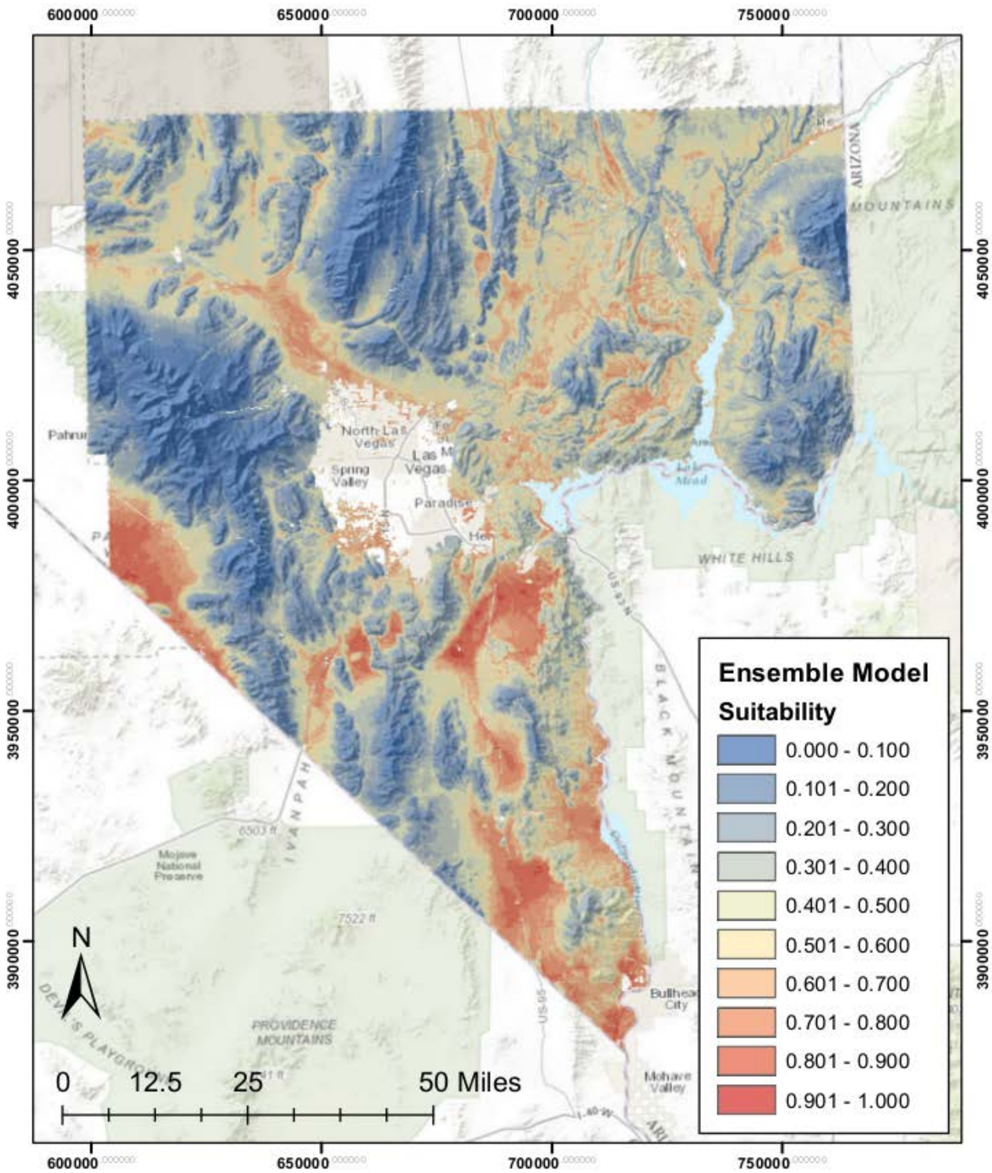
Figure 101. Partial response surfaces for the environmental variables included in the RF ensemble model for *Crotalus cerastes*. Histograms represent the range of each environmental variable across the x-axis, and predicted dependence relative to habitat

Locality Distribution

Mojave Desert Sidewinders inhabit lower bajada, valley bottoms, and mesa tops with surface sand components (Figure 102). Localities for this species were distributed in the Pahrump, Eldorado, and Paiute Valleys, along the I-15 corridor southwest, and in the US-95 corridor to the northwest of Las Vegas (Figure 96). There are also localities broadly distributed in the northeastern extent of the county. The Mojave Desert Sidewinder SDM indicates a high probability of occurrence in the low elevation valley from Cottonwood Cove southward along the Colorado River to the north side of the Newberry Mountains, and along the Colorado River near Laughlin, Nevada. In the region of Clark County east of the Overton Arm of Lake Mead and the Muddy River, including Mormon Mesa, there are several confirmed locality records for Mojave Desert Sidewinders, and they are known to occur continuously at least as far northeast as Washington, Utah in Mojave Desert habitats (Stebbins 2003). Some of the higher error values associated with the Mojave Desert Sidewinder model were also similar to the Shovel-nosed Snake model. On the upper and lower bajada on the north side of the Virgin Mountains, and south of Mesquite, Nevada, there are large, relative gently sloping areas where the probability of presence for Mojave Desert Sidewinders was predicted to be only about 50%. We suggest that while there are large sandy washes in that area, the intervening uplands may be too rocky for this species to occur there.

Standard Error

Areas of high error included two valleys: one north of Indian Springs; and the other northeast of Indian Springs on the Nellis Bombing Range. Similar to Shovel-nosed Snakes, the error in that region is likely due to the lack of verified sightings north of that area within Clark County (Figure 103). That region approaches the northern extent of the range for this species (Stebbins 2003). Other small areas where error was elevated occur near the confluence of the Muddy and Virgin rivers, and another somewhat large area of discrepancy is east of Jean, Nevada and south of Interstate 15. However, that area encompasses the Roach Dry Lake where Mojave Desert Sidewinders would not be found, and the area immediately surrounding that basin that is nearly devoid of vegetation. Mojave Desert Sidewinders occupy the sand sheets immediately east of that area and south of Jean on and around the Sheep Mountain Permanent Mojave Desert Tortoise Study plot (Esque and Duncan 1986).



Crotalus cerastes

Habitat Suitability Map

Projection:
NAD 1983
UTM Zone 11N

Ensemble habitat suitability models were derived by averaging predictions from Generalized Additive Models, Random Forest, and Maxent.

Figure 102. SDM map for the *Crotalus cerastes* Ensemble model.

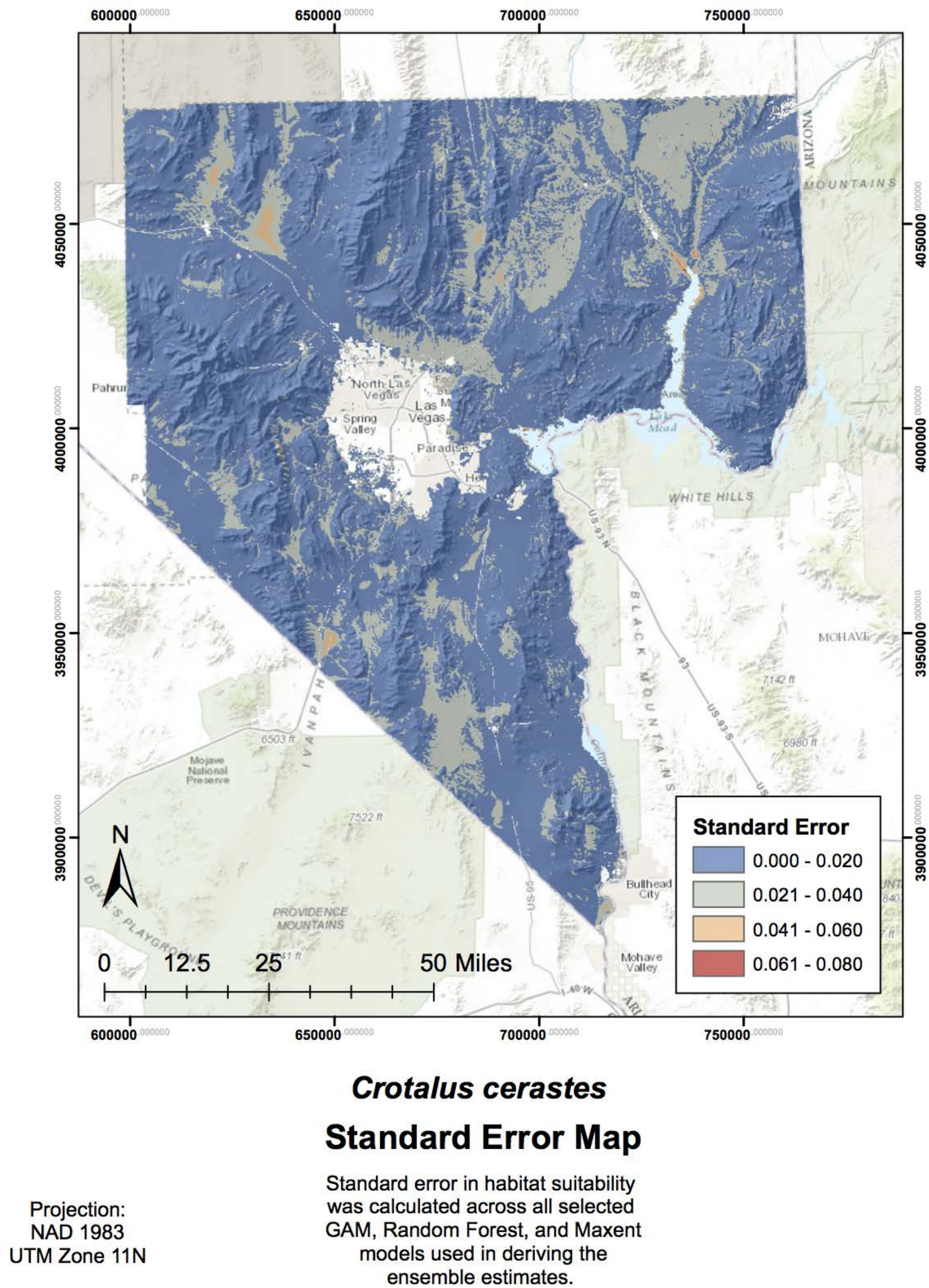


Figure 103. Standard Error map for the *Crotalus cerastes* ensemble model for Clark County, NV.

Distribution and Habitat Use within Clark County

Sidewinders are widespread in Clark County, Nevada wherever the habitat is appropriate and are among the most abundant rattlesnakes in hot deserts (Lowe et al. 1989). Sidewinders usually inhabiting areas of loose windblown sand and are frequently associated with areas of sparse creosote bush vegetation with hummocks built up around them. Within southern Nevada, such areas are typical throughout the Piute Valley surrounding Cal-Nev-Ari, the reds sands near St. Thomas Gap and Valley of Fire, across the top of the Mormon Mesa, the Boulder City Conservation Easement, between Jean and Goodsprings, the valley between the Desert Range and the Spring Mountains, and extreme eastern Ivanpah Valley on the west side of the Lucy Grey Mountains. They may also occur on open sand dunes, hardpan areas, and occasionally on rocky slopes – especially when there are expansive areas of loose windblown soils nearby (e.g. Bootleg Canyon in Boulder City, NV). They typically hibernate in burrows at the boarder of sand and alluvial soils within their ranges, which offers temperature stability and protection from predators (Secor 1994). Modeled habitat within Clark County indicated the most area of suitable habitat in the Mojave Desert Scrub and Salt Desert Scrub ecosystems, with moderate habitat also in those ecosystems, and in the blackbrush ecosystem (Table 63).

Table 63. Ecosystems within Clark County, and the area (Ha) of Low Medium and High predicted suitability within each ecosystem.

Ecosystem	Low	Medium	High
Alpine	124	0	0
Blackbrush	336355	77375	1080
Bristlecone Pine	7565	0	0
Desert Riparian	256	4633	5749
Mesquite Acacia	1671	9150	8811
Mixed Conifer	27339	0	0
Mojave Desert Scrub	234059	742407	301450
Pinyon Juniper	115557	290	0
Sagebrush	4326	373	0
Salt Desert Scrub	25547	38502	14591

Ecosystem Level Threats

Because of their broad distributions and habitat use sidewinders are not as vulnerable to ecosystem level threats as many of the other regionally endemic species. Like all other species, however, large-scale disturbances by recreationists, urbanization, highway and utility infrastructure, or renewable energy development do destroy habitat every time their footprint is enlarged. The dependence on the flattest available landscapes, and sandy soils puts renewable energy development in the greatest conflict with the distribution of the Mojave Desert Sidewinder at this time (Wildlife Action Plan Team 2012).

Population Trends

Population studies of Mojave Desert Sidewinders are rare and have not been conducted to sufficiently evaluate trends in this species (Wildlife Action Plan Team. 2012). IUCN currently lists the global population as Stable. Commercial collections have likely caused declines in this species. They are particularly vulnerable to illegal pitfall trapping and can be collected readily on roads.

Threats to Species

Large-scale, surface-disturbing activities such as urbanization, renewable energy development, military training, off-highway vehicle recreation, and utility and transportation infrastructure all pose threats to Mojave Desert Sidewinder rattlesnake populations. Commercial collecting also poses a threat to this species, although this practice has been recently prohibited in Nevada.

Summary of Direct Impacts

Anthropogenic development that occurs in sandy areas of valley bottoms and low to upper bajadas is likely to impact sidewinders. Impacted areas are likely to encompass higher amounts of High and Medium habitat (495, and 597 km^2 respectively), although far more habitat for this species is located in conserved areas (1056 km^2 high, and 2547 km^2 moderate; Table 64)

Table 64. Categorized modeled habitat values (High, Medium, and Low) and the average area (Hectares) predicted in the potential impact areas, conservation areas, already disturbed areas, and overall area

Habitat Level	Impact	Conserved	Disturbed	Area (Hectares)
High	49596	105624	21502	334835
Med	59699	254730	16844	883520
Low	13067	152166	1581	755639

Existing Conservation Areas/Management Actions

Existing conservation in Clark County, Nevada include Desert National Wildlife Refuge, Lake Mead National Recreation Area, Red Rocks National Conservation Area, BLM Areas of Critical Environment Concern in appropriate habitat, Gold Butte National Monument, and Valley of Fire State Park,

The Nevada Wildlife Action Plan considers the sidewinder a Species of Conservation Priority, and recommends the following actions: determine the impact of solar development projects on population and habitat connectivity; conduct surveillance surveys in prioritized habitats; and implement monitoring to gather information on home ranges, winter hibernacula, habitat preferences, and responses to vegetative community transitions (Wildlife Action Plan Team 2012).

The conceptual management plan for the Overton Wildlife Management Area (OWMA) calls for determining the occurrence and habitat use of sidewinders within OWMA boundaries, and for restoring, maintaining, and protecting sidewinder habitat (NDOW 2014).

CYMU - Blue Diamond Cholla (Cylindropuntia multigeniculata)

Blue Diamond Cholla, once thought to be precinctive to Clark County Nevada, is considered by the State of Nevada to be critically endangered. Despite concern for this species, little information exists on its habitat affinities or environmental requirements. It was formerly considered a hybrid subspecies (Hunt et al. 2006). They are sometimes hard to distinguish from other closely related species as they hybridize with *C. acanthocarpa* (Baker 2005), and many of the others are closely related polyploids of similar ancestral origin, but have since been recognized as a full species (Baker and Cloud-Hughes 2014).

Species Status

This species was once considered for federal listing due to its rarity (Baker 2005), but was removed from the candidate list due to a conservation agreement designed to reduce threats to this species and its habitat (USFWS 2001). This agreement apparently consists of provisions within the BLM Red Rock Canyon NCA conservation plan, and is designed to protect 83% of its known habitat (Clark County 2000, BLM 2005). Recent legislation has supported land exchanges to protect habitat for this species near the type locality with the BLM Red Rock Canyon NCA (S.B. 159, 2013).

US Fish and Wildlife Service Endangered Species Act: Not listed
US Bureau of Land Management (Nevada): Sensitive
US Forest Service (Region 4): No Status
State of Nevada (NAC 527): Critically endangered
NV Natural Heritage Program: Global Rank G2 State Rank S2
IUCN Red List (v 3.1): Least Concern
CITES: Appendix ii

Range

Blue Diamond Cholla is found in several sparsely distributed locations, most of them in Clark County, Nevada. They range from Gass Peak in North Las Vegas south to just north of Blue Diamond, Nevada (the type locality) and southeast into the McCullough range including the Sloan Canyon National Conservation Area [NCA] (Baker 2005, Baker and Cloud-Hughes 2014). They also inhabit Gold Butte near Bonelli Peak and along the southern margin of Gold Butte just north of Lake Mead (Baker 2005, Nussear et al. 2011), and in Mohave County Arizona in the Black Mountains and White Hills near Willow Springs Ranch (Baker 2005, Baker and Cloud-Hughes 2014, Beckstrom et al. 2014).

Population Trends

While formerly a candidate for federal listing, consideration was removed in 2001 due to a conservation agreement that satisfied the perceived need for protection by the USFWS (USFWS 2001). This conservation agreement included the type locality and was within the conservation plan for the Red Rock Canyon NCA (BLM 2005). The IUCN lists this species as one of least concern, citing that while this species does have a restricted range the species is known from ten subpopulations, most of which occur in protected areas, with no significant threats to its persistence identified, and listing the current population trend as stable (IUCN 2013).

Habitat Model

Cylindropuntia multigeniculata was modeled using 162 localities and was predicted to be in similar areas throughout Clark County by the three modeling algorithms and the subsequent ensemble model, with differences apparent in the magnitude of the suitability scores, but similar in most other aspects (Figure 104). Performance was highest for the Ensemble Model, followed by the RF model, which had higher AUC and TSS than the other models. The MaxEnt model ranked third and the GAM model had the lowest performance, although it should be noted that all four of the models had very good performance among all performance measures (Table 65). Standard error maps for the models indicated that the GAM model had the highest level of SE with more patches of higher values (SE 0.06 – 0.08) and moderate values (0.04 – 0.06) throughout the county, but most prominently in mountainous areas in the Spring, Sheep, and McCullough ranges, and in the Virgin Mountains. The MaxEnt model had a similar pattern of SE, but with moderate levels of error, while the RF model tended to have more error in lower slopes than the other two algorithms (Figure 105).

The CBI for the Ensemble mode indicated good model performance (Figure 106), and was the second highest reported BI compared to the three algorithms. Approximated bins for the ensemble model based on the CBI were 0-0.42 unsuitable, 0.43-0.65 marginal, 0.65 to 0.7 suitable, and 0.7 -1 optimal habitat; with a suggested cutoff threshold of ~ 0.6 (Figure 106) while the threshold value calculated from ROC statistics for the ensemble model was 0.64 (Table 65).

Table 65. Model performance values for *Cylindropuntia multigeniculata* models

Performance	GAM	RF	MaxEnt	Ensemble
AUC	0.934	0.986	0.953	0.963
BI	0.699	0.551	0.587	0.61
TSS	0.852	0.94	0.857	0.887
Correlation	0.511	0.604	0.694	0.84
Cut-off*	0.638	0.753	0.46	0.643

*threshold at which sum of sensitivity (true positive rate) and specificity (true negative rate) is highest

Table 66. Percent contributions for input variables for *Cylindropuntia multigeniculata* for ensemble models using GAM, MaxEnt and RF algorithms

Term	GAM	RF	Max	Avg
Summer Heat/Moisture Index	34.9	12.0	29.8	27.2
Summer Max Temp	4.0	8.1	15.1	10.2
Summer Precipitation	0.0	10.8	12.9	9.4
Winter Precipitation	0.0	9.5	11.4	8.3
Topographic Position (TPI)	0.0	11.8	8.0	8.3
NDVI Maximum	17.8	10.6	7.4	13.4
Roughness (TRI)	32.4	15.0	7.4	20.4
Surface Texture (ATI)	5.1	10.6	5.8	8.7
Winter Min Temp	5.8	6.9	1.3	5.6
Temperature Range	0.0	4.6	0.5	2.4
Slope	0.0	0.0	0.4	0.1

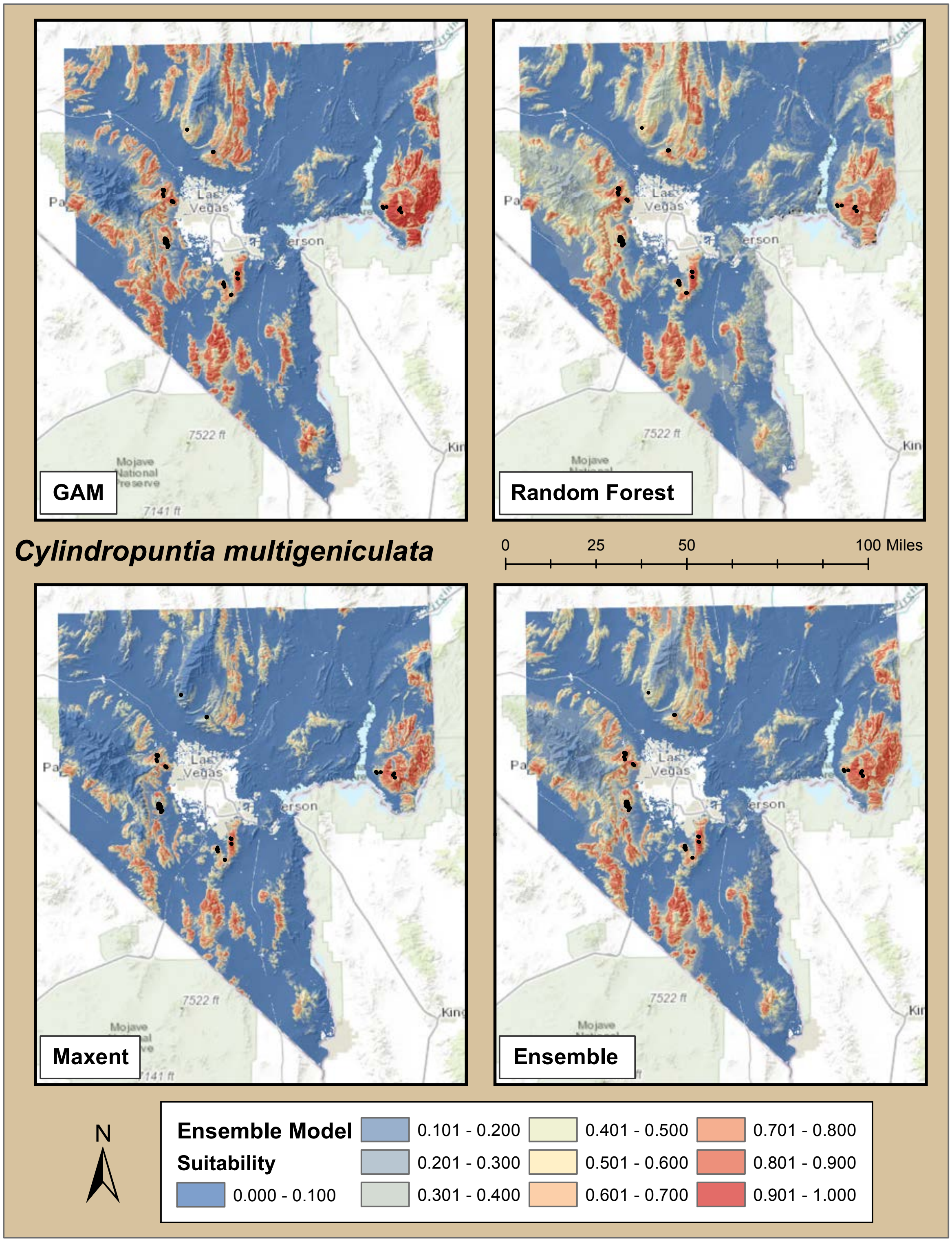


Figure 104. SDM maps for *Cylindropuntia multigeniculata* for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

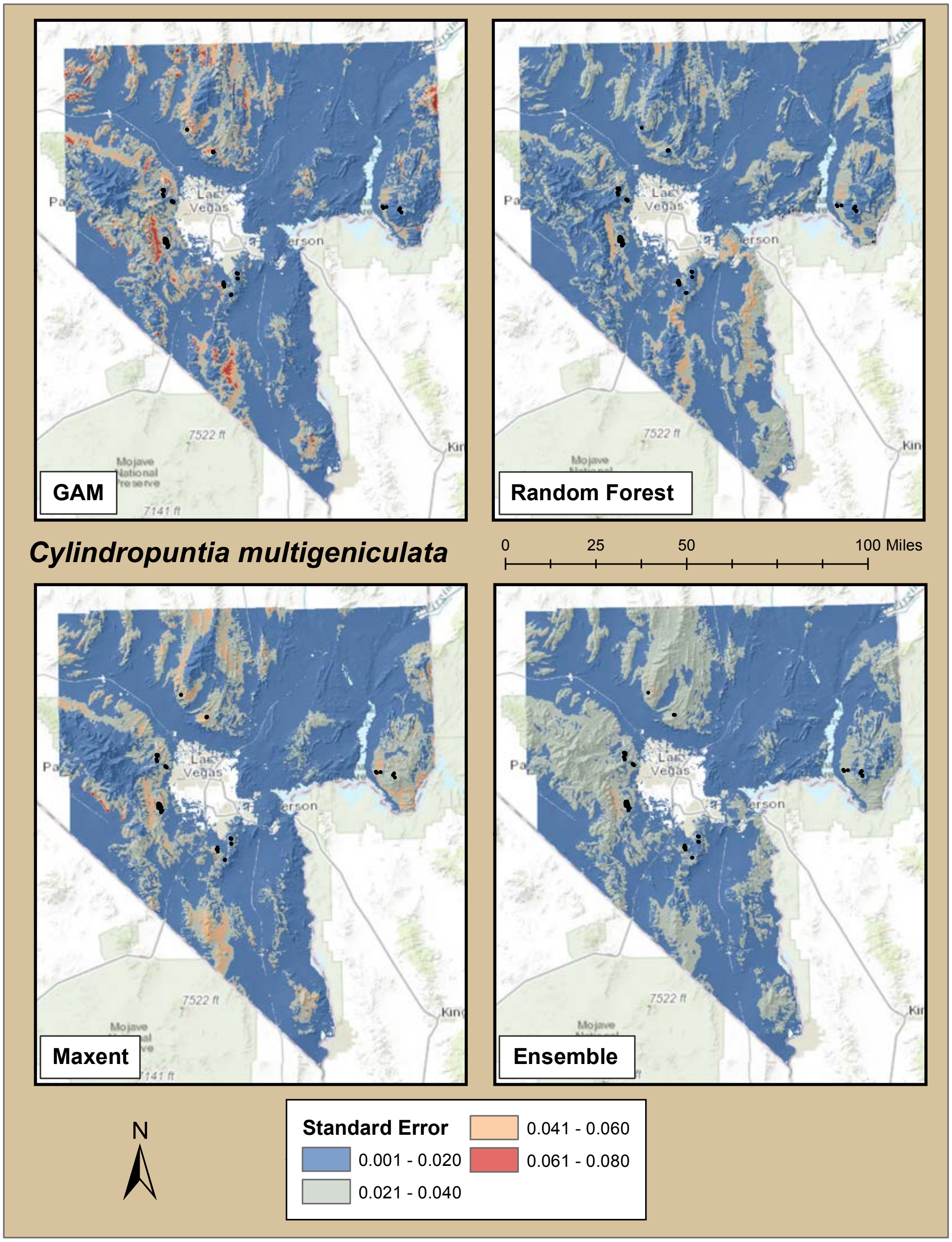


Figure 105. Standard error maps for *Cylindropuntia multigeniculata* models for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

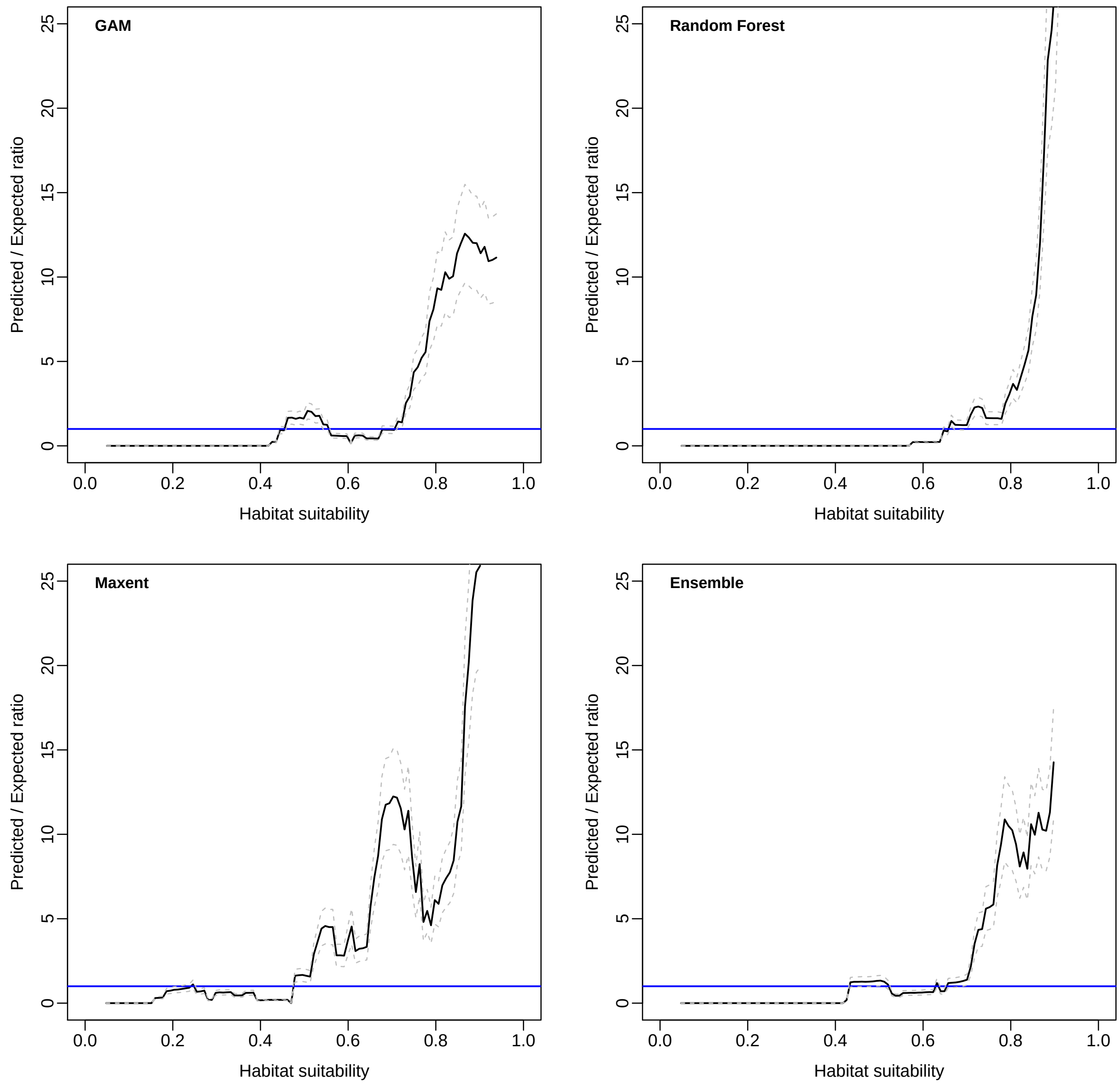


Figure 106. Continuous Boyce Indices for *Cylindropuntia multigeniculata* models for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

GAM model

The GAM model ensemble identified 3 contributing variables with more than 10% contribution toward the model representing 85% of the model contribution (Table 66). The summer heat/moisture index had 35% contribution and was negatively related to predicted habitat suitability. Surface Roughness was the second highest contributor with 32% influence with a partial response curve indicating higher habitat values at intermediated levels of Roughness. NDVI Maximum also predicted higher values at lower levels that were near the most common values for this indicator in the study area, as the response curve matched the peak histogram most closely (Figure 107). Lower contributions were from Winter Minimum Temperature, Surface Texture, and Summer Maximum Temperature, with higher predictions of suitability positively related to both temperature measures, and at moderate levels of surface temperatures, indicating rockier slopes at lower elevations (Figure 107). None of the remaining variables Summer Precipitation, Winter Precipitation, Topographic Position (TPI), NDVI Maximum, Roughness (TRI), Surface Texture (ATI), Winter Min Temp, Temperature Range, Slope provided input to the model (Table 66).

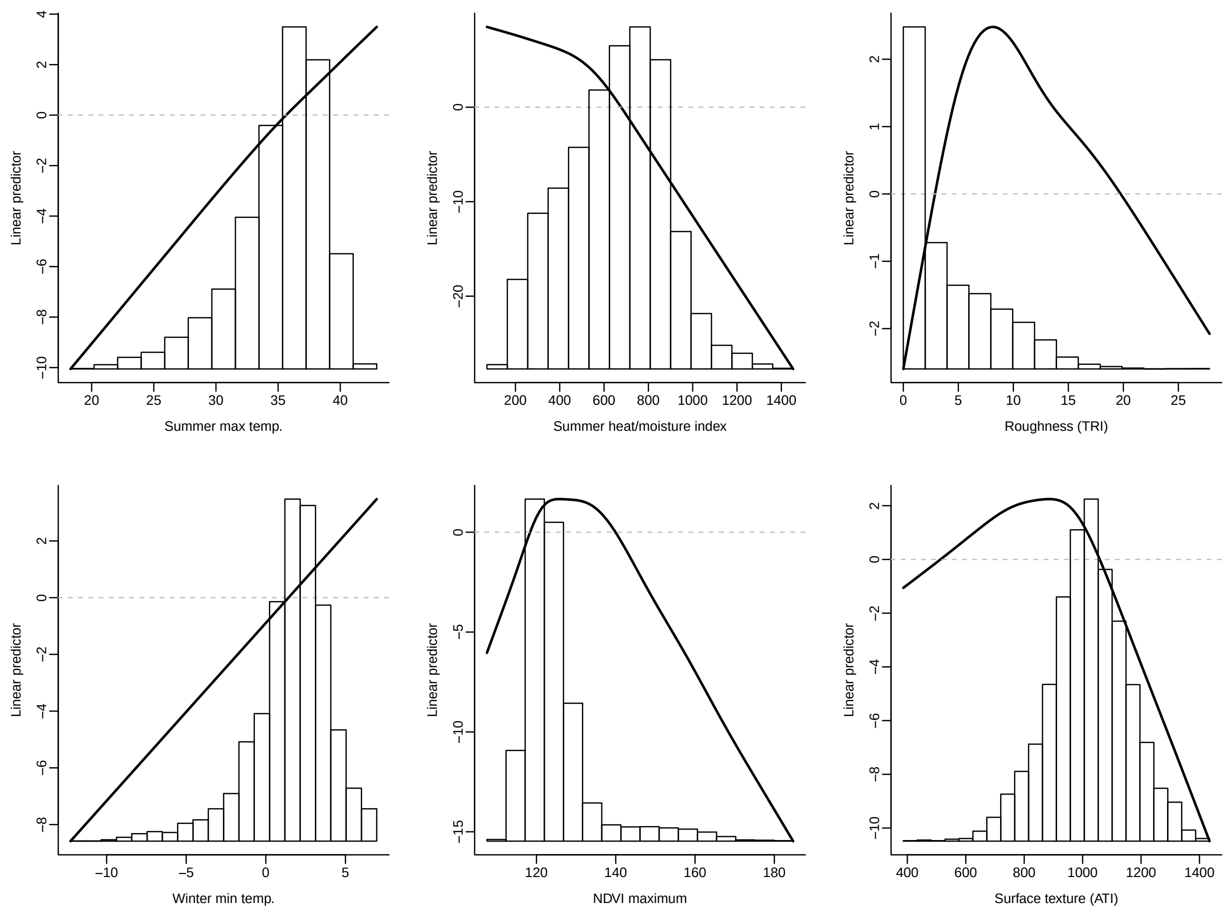


Figure 107. GAM partial response curves for the *Cylindropuntia multigeniculata* model overlaid over distribution of environmental variable inputs in the study area.

MaxEnt Model

The MaxEnt model had four variables contributing 10% or more each, accounting for 70% of model contribution, with an additional four contributing 5-7% (Table 66). The Summer Heat/Moisture index was the highest contributing covariate (30%) with higher suitability in areas with a lower index falling sharply above values of 400. This corresponds to high suitability in areas that tended to have higher temperatures and lower amounts of summer rains. Summer Maximum Temperature and Summer and Winter Precipitation were also strong contributors, with higher habitat suitability in areas of lower Summer Precipitation, higher Summer Maximum temperatures, and higher Winter Precipitation (Figure 108).

The standard error map for this algorithm showed areas of moderate uncertainty among the models (SE of 0.04 to 0.06) in what appear to be lower slopes and bajadas throughout the county (Figure 105). Of particular note regarding high standard error among the four models, are the bajada habitats in Red Rock Canyon NCA, and south-facing slopes at the southern end of Sheep Peak, in the Sheep Range. MaxEnt model performed third among the four models, with strong performance overall and a Continuous Boyce Index indicating strong performance (Table 65, Figure 106).

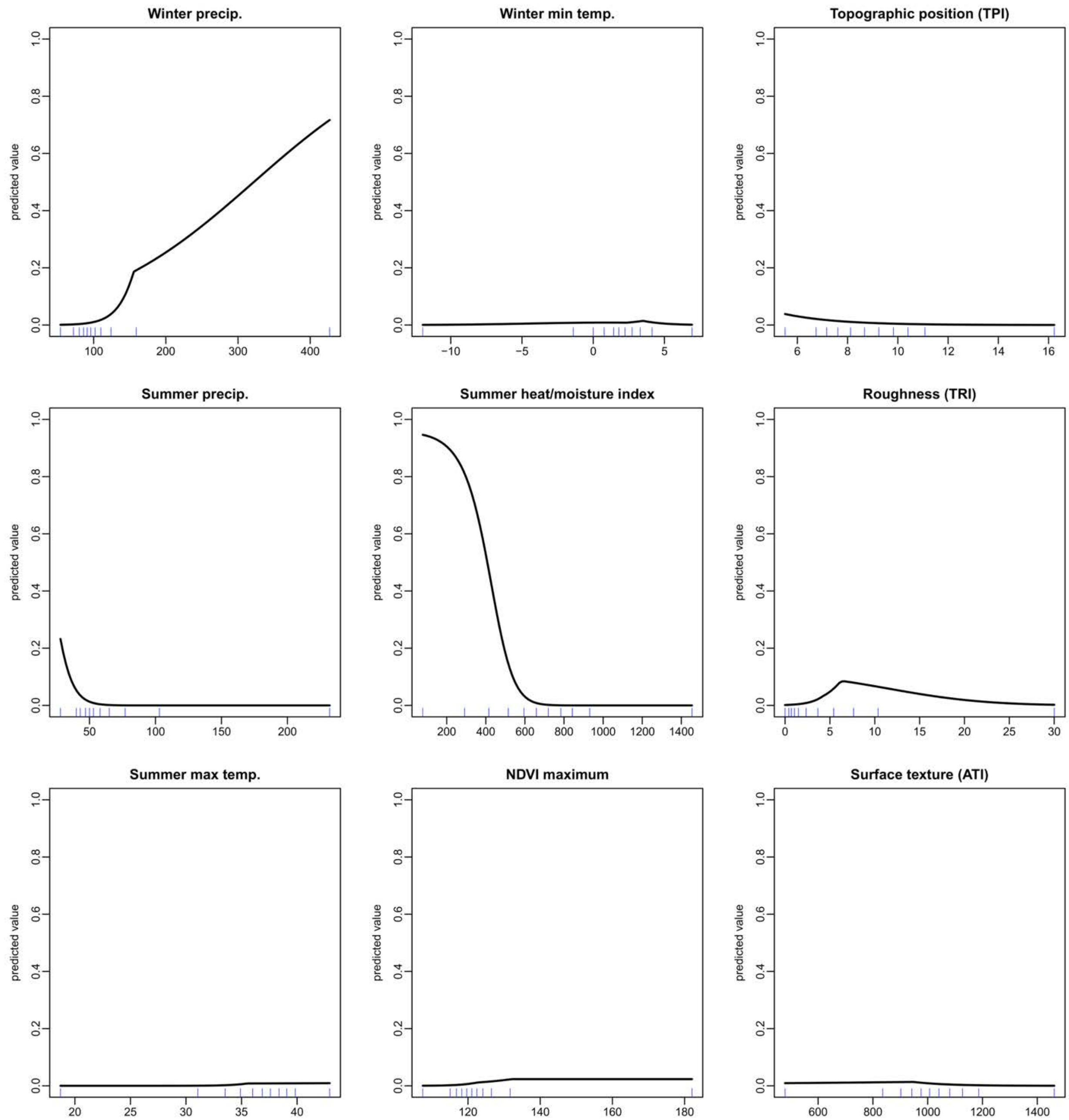


Figure 108. Response surfaces for the top 9 environmental variables included in the MaxEnt ensemble model for *Cylindropuntia multigeniculata*.

Random Forest Model

The RF models had seven environmental variables contributing 9% or more totaling 80% of total model influence, but had relatively even contribution across all variables. The seven highest contributing variables were: Roughness (TRI), Summer Heat/Moisture Index, Topographic Position (TPI), Summer Precipitation, Surface Texture (ATI), NDVI Maximum, and Winter Precipitation (Table 66). Habitat suitability was predicted by the RF model to be greatest in areas of higher surface roughness, with a lower Summer Heat/Moisture Index, with somewhat elevated levels of summer precipitation (Figure 109) – in contrast to the results of the MaxEnt partial response (Figure 108). Predicted habitat tended to be higher in the local watershed, with a peak in Surface Texture, possibly indicating an affinity for the surficial geology corresponding with that value, tending toward rockier habitats likely moderate sized rocky surfaces, with a lack of habitat predicted on sandier surfaces. Standard error maps for this model were similar to those for the GAM model with low levels of error spread throughout the county largely in lowland areas, but with moderate levels of uncertainty near the type location, in the Newberry Mountains, on the eastern slopes of the Highland range, and in lower elevation slopes throughout Gold Butte (Figure 105). This was the second best performing model overall among all models, with the exception of the Boyce Index which was the lowest among the four (Table 65), and the CBI which had little response below values of 0.6 (Figure 105).

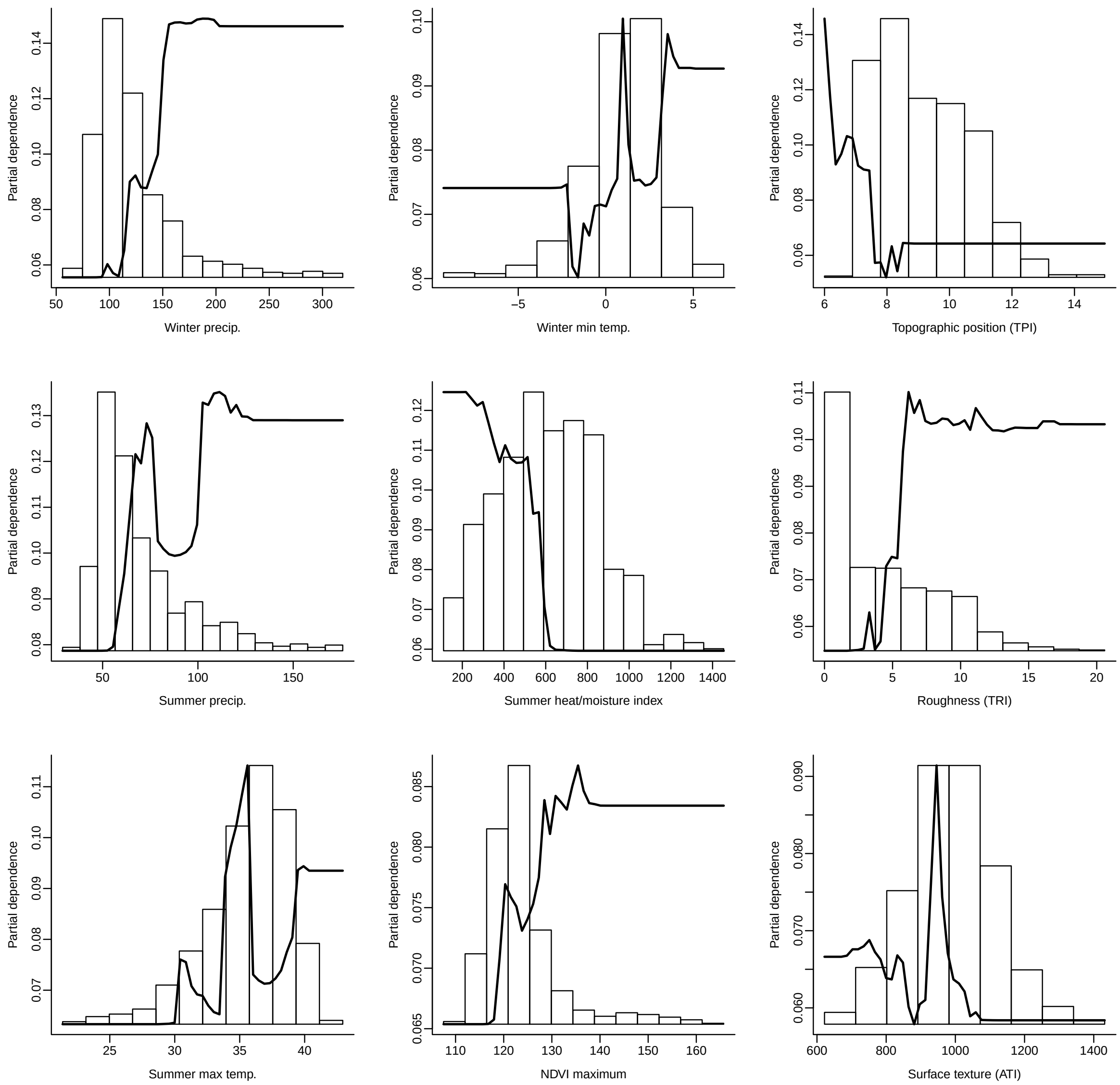
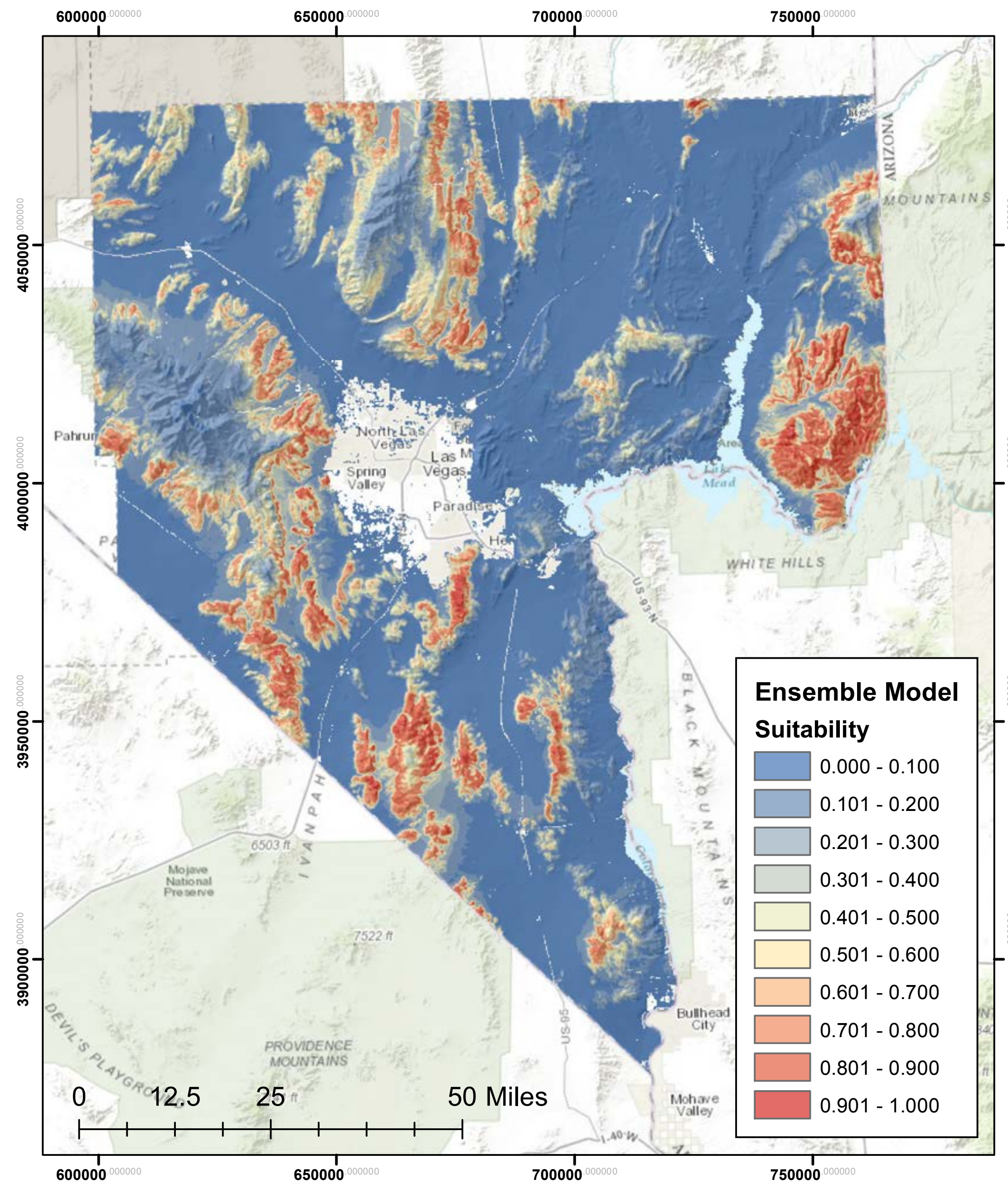


Figure 109. Response surfaces for the environmental variables included in the RF ensemble model for *Cylindropuntia multigeniculata*. Histograms represent the range of each environmental variable across the x-axis, and predicted dependence relative to habitat suitability values are on the y-axis



N

Cylindropuntia multigeniculata

Habitat Suitability Map

Projection:
NAD 1983
UTM Zone 11N

Ensemble habitat suitability models were derived by averaging predictions from Generalized Additive Models, Random Forest, and MaxEnt.

Figure 110. SDM map for the *Cylindropuntia multigeniculata* ensemble model.

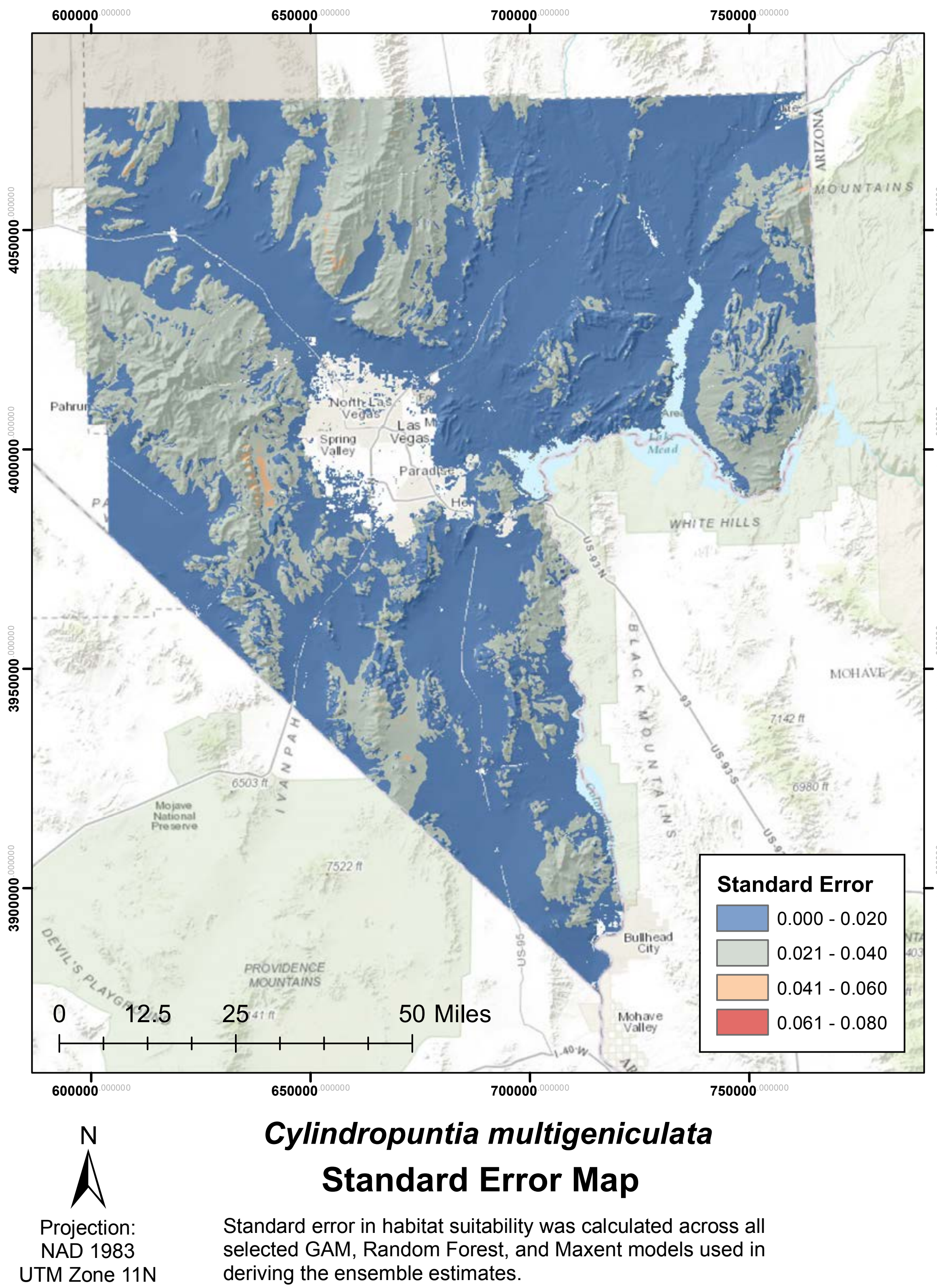


Figure 111. Standard Error map for the *Cylindropuntia multigeniculata* ensemble model.

Distribution of Localities

Localities for Blue Diamond Cholla are locally distributed in Clark County with only 162 observations. Most of the localities are distributed in clusters surrounding the Las Vegas valley with the exception of the northeast corridor (southern end of the Sheep Range). Two additional clusters occur in the mountains near the Gold Butte town site. (Figure 104).

Standard Error

The standard error for the habitat suitability model for Blue Diamond Cholla indicates low to generally low error throughout the majority of the mountainous areas in Clark County, with a SE of 0.02 – 0.04. One patch of moderate error (SE 0.04 to 0.06) occurs in the valley just east of the Spring Mountains on the bajadas in Red Rock NCA north of Blue Diamond – where the species was first described (Figure 111).

Distribution and Habitat Use within Clark County

Within Clark County this species has been reported north of Blue Diamond, Nevada (type locality), in Sloan Canyon, near Gass Peak, and in Gold Butte near Bonelli Peak (Baker 2005, Nussear et al. 2011, Baker and Cloud-Hughes 2014).

Individuals of this cactus occur on limestone soils near the type locality west of Las Vegas as well as volcanic soils derived from basalt and granite for other populations. Aspect varies across known sites, and plants are typically associated with steep, dry, rocky slopes or washes with large rocks or boulders and with minimal vegetation cover (Baker 2005). Individuals of this species may be associated with overlying gypsum beds located up-slope, and typically co-occur with succulents and shrubs associated with vegetation dominated by creosote bush or blackbrush (NNHP 2001). Nussear et al. (2011) modeled this species in the Gold Butte area and found positive associations with proximity to volcanic and metamorphic, carbonate and sedimentary rock deposits, and in areas of moderate surface roughness with low flow accumulation. A broad elevational range for Blue Diamond Cholla has been noted as 610 – 915 m (Baker 2005) and 1093-1295 m (NNHP 2001b), while Nussear et al. (2011) reported a range of 790 – 1420 m in their habitat suitability modeling. Habitat for this species is predominantly in Mojave Desert Scrub, Blackbrush and Pinyon Juniper ecosystems, with moderate habitat similarly distributed, but potentially including Salt Desert Scrub (Table 67).

Modeled Habitat in the county is predicted to be high in middle elevation ranges surrounding Las Vegas, especially so in the southern extent of the Spring Range, Jean, and Goodsprings. The rockier portions of the McCullough range near Sloan Canyon, the slopes surrounding the Lucy Gray mountains, the low portions of the Virgin Mountains and in the middle elevation mountains in the southern portion of Gold Butte also are predicted to be good habitat (Figure 110).

Among predictors for the Blue Diamond Cholla habitat suitability model areas of high temperatures and low precipitation were identified. This is consistent with habitat descriptions discussed by Baker (2005). While previous work considered low winter temperatures to be a likely habitat-limiting factor for the distribution of the Blue Diamond Cholla (Baker 2005), habitat suitability models found minimum winter temperatures to be of relatively low value among predictors, although it was quantifiable.

Table 67. Ecosystems within Clark County, and the area (Ha) of Low Medium and High predicted suitability within each ecosystem.

Ecosystem	Low	Medium	High
Alpine	124	0	0
Blackbrush	129312	137234	147979
Bristlecone Pine	7564	0	0
Desert Riparian	10468	162	0
Mesquite Acacia	17660	1290	751
Mixed Conifer	27262	73	0
Mojave Desert Scrub	1119667	102011	58028
Pinyon Juniper	72702	32753	10161
Sagebrush	3608	942	152
Salt Desert Scrub	63636	13693	1437

Ecosystem Level Threats

Desert fires have previously influenced the Blue Diamond Cholla, and will continue to be an ecosystem threat. However, the steep, rocky terrain occupied by this species also provides some inherent level of protection due to the sparseness of vegetation. The lack of fuel continuity makes fires patchier in such habitats, and thus less prone to widespread damage.

Threats to Species

This species has been threatened directly by wildfire, and habitat loss (e.g. due to gypsum mining and road building, Baker 2005). Due to the rocky and steep terrain, this species is unlikely to be impacted significantly by OHV activity.

Existing Conservation Areas/Management Actions

Within the Red Rock Canyon NCA, multi-agency and stakeholder agreements have been put in place to protect habitat for this species by limiting mining development, and by implementing fire prevention and suppression plans (BLM 2005). This species also inhabits the Sloan Canyon NCA and wilderness, and would be similarly protected (BLM 2009).

Summary of Direct Impacts

Blue Diamond Cholla habitat potential was assessed with respect to the proposed Impacted Areas by calculating the number of acres in each parcel that intercepted Low (0 – 30), Medium (30-60), and High (30-100) potential habitat levels using the ensemble model from the habitat modeling conducted for this species. Proposed impact areas were predominantly located in areas considered to be low habitat probability, with little projected impact in areas projected to be Medium or High for this species (Table 68). Far more habitat for this species is identified to be in conserved areas (Table 68).

Table 68. Categorized modeled habitat values (High, Medium, and Low) and the average area (Hectares) predicted in the potential impact areas, conservation areas, already disturbed areas, and overall area

Habitat Level	Impact	Conserved	Disturbed	Area (Hectares)
High	870	66916	77	219603
Med	3613	58820	867	289323
Low	118218	387784	39130	1466075

DIDE - Desert Kangaroo Rat (Dipodomys deserti)

The Desert Kangaroo Rat is a widespread species throughout the Mojave Desert and Clark County. Although this species has no federal or state status, rapid growth and natural habitat loss in Clark County has led to local extirpations within the Las Vegas city limits. The species is sensitive to local isolation and disturbance and may not occur in areas where suitable habitat is present. Other species of kangaroo rat that have become isolated because of agricultural and urban development have declined and become listed (e.g., Tipton kangaroo rat and Fresno kangaroo rat) (Williams and Germano 1992).

Species Status

US Fish and Wildlife Service Endangered Species Act: No Status
US Bureau of Land Management (Nevada): Sensitive
US Forest Service (Region 4): No Status
State of Nevada: No Status
NV Natural Heritage Program: Global Rank G5, State Rank S2S3
NV Wildlife Action Plan: Species of Conservation Priority
IUCN Redlist (v 3.1): Least Concern
CITES: No Status

Range

The Desert Kangaroo Rat is found in the Great Basin, Mojave Desert and Sonoran Desert ecoregions and it occupies the most arid region of the southwestern United States (Best et al. 1989). It occurs from near the northern boundary to the southern tip in west-central Nevada and a small part of northern California. It occurs throughout Mojave Desert habitats in southern California, southern Nevada, southwest Utah, and northwest Arizona. It also occurs in Sonoran Desert habitats of northeastern Baja del Norte and much of Sonora, Mexico. Large portions of the Sonoran Desert in southern and western Arizona are also provide habitat for this widespread species. The elevational range for this species is -60 m mean sea level at Salt Creek, Death Valley National Monument, Inyo County, California to 1,710 meters in the Huntoon Valley, Mineral County, Nevada (Nader 1978).

Habitat Model Review

Desert Kangaroo Rat habitat was modeled by Boykin et al. (2008) as one of four species for which MaxEnt models were applied in modification from the SWReGAP modeling efforts (Figure 112). Eight environmental variables were used for modeling, including: elevation, SWReGAP land cover and landform, percent sand and rock outcrop both derived from the Soil Survey Geographic (SSURGO) database, distance to mesquite/acacia Bosque habitat inclusive of Clark County derived from the US Bureau of Land Management, distance to perennial streams, and slope. Model building was conducted using iterative methods including variables based on hypothesized relevance to the biology of the species. Comparisons using AUC values, omission error, parsimony, biological knowledge, and variable contributions, response curves, and jack-knife variable response were also used in model selection.

Technical Considerations - Sample sizes were relatively low (50 presences and only 13 withheld for testing. There was no mention of iterated cross validation being used leaving the reader with the assumption that only 1 model run was conducted. Presence points used in modeling are shown relative to model predictions. While AIC is reported to be high there appear to be many points outside the predicted habitat, suggesting that accuracy may be lower than suggested. For example, there are many points outside the modeled area that are near the periphery of the predicted range for the species (e.g. near Pahrump, Muddy River, and Beaver Dam Wash, UT). Furthermore, a relatively large area was withheld from modeling because of the missing soils layer for the Nevada National Security Site (formerly Nevada Test Site) and Nellis Bombing Range areas due to the use of SSURGO, although STATSGO may have relevant layers that could have allowed a more complete model. The final model contained 3 variables with land cover (45.1%), elevation (41.8%), with sand (13.1%) a smaller proportion of model contribution. Given the model resolution it is likely that the SSURGO data are coarser than the model resolution, which may lead to some inaccuracies.

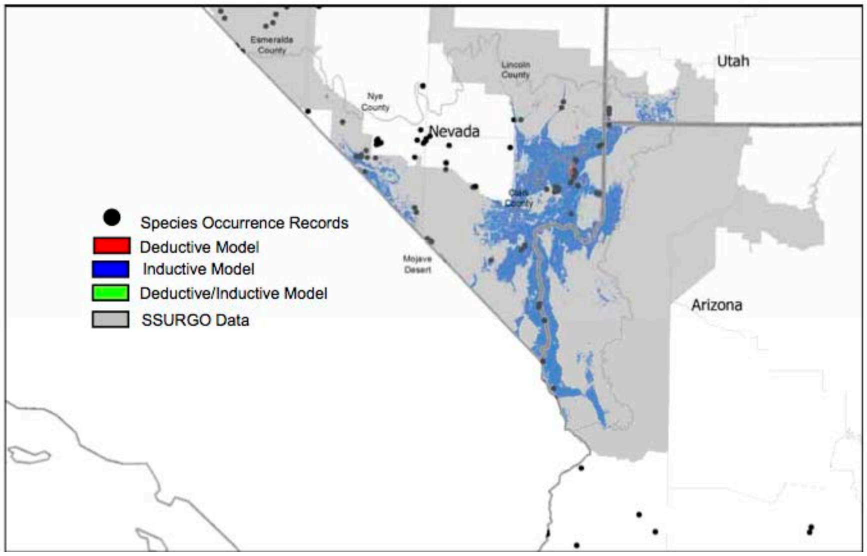


Figure 112. Model of *Dipodomys deserti* habitat from Boykin et al. 2008.

The model was thresholded using PRBE for calculations of habitat within the areas of interest. While not included in Boykin et al. (2008), we were provided the original rasters so that the effects of different thresholding levels could be examined. However, URL links for supporting website for other materials appear to be inoperative.

Future Modeling Considerations - As presented in the report (Figures 14 and 15 in Boykin et al. 2008) the models did not appear to delete areas that are so heavily developed as to be of little use for native animal habitat (e.g., Las Vegas proper). Thus, the model overestimates habitat available to Desert Kangaroo Rats in such areas that were likely formerly habitat. There are now layers available (e.g., Impermeable Surfaces) that can be used to render GIS models more relevant to actual animal distributions by masking areas that once were, but are no long habitat for certain species. Examining the raster layer provided these areas appear to have been masked out of the prediction. Because of their relatively broad occurrence, modeling habitat for this species would be enhanced by increasing the sample size of known occurrences. Considering the variables used in the model in relation to the predicted description, we question the use of the distance to perennial stream as a relevant variable for this desert upland species. Therefore, it appears that some large areas of likely suitable habitat (e.g. lower Piute Valley) are overlooked by the model, when in fact that area may support Desert Kangaroo Rats (Nussear and Esque, pers. obs).

Distribution and Habitat Use within Clark County

Within Clark County, the Desert Kangaroo Rat has been recorded recently in the following localities: Boulder City, Mesquite, St Thomas Gap and surrounding areas in Gold Butte, Corn Creek, Nellis Sand Dunes, and just across the California boarder in Tecopa, California.

Desert Kangaroo Rats live in the hottest, lowest, and most arid regions of North American deserts (Nader 1978), and are among the most highly specialized species of *Dipodomys* (Best et al. 1989). They occupy all of the dune habitats within their geographic and elevational ranges (Best et al. 1989), where deep, loose, windblown sands are dominant (Beatley 1976). They are less abundant in areas near the edges of dunes where sand becomes shallower and plants are more dense (Johnson et al. 1948). Mean (and range) values for environmental attributes associated with Desert Kangaroo Rats are: precipitation: 124.3 mm (range 117.0 to 130.3 mm); maximum temperature: 29.0 ºC (range 28.0 to 29.9 ºC); minimum temperature: 0.3 ºC (range -3.2 to 2.3 ºC); Mean temperature: 14.6 ºC (13.2 to 16.2 ºC); shrub cover: 17.2% (range 10.7 to 22.1%); grasses cover: 1.5% (range 0 to 2.5%); seasonal cover of winter annuals: 5.95% (range 0.8 to 11.5%); and seasonal cover of summer annuals: 0.3% (0 to 1.3%) (Beatley 1976).

Desert Kangaroo Rat habitats are normally very open areas, and the entrances to burrows often are associated with the coppice mounds around perennial vegetation (Johnson et al. 1948). The mounds have increased soil stability because of the plant root structure and additions of organic matter to the soil surface. Distinct trails may emanate from recently used burrow entrances. These are some of the very straight lines that are frequently observed in desert habitats. The burrows are often found as complexes with many aboveground entrances and a labyrinth of underground tunnels as deep as 1.2 meters (Ketcham 1940). The burrow complexes have many chambers, known as larder hoards, where large quantities of seeds may be cached (Elliot 1904). Smaller temporary caches with fewer seeds on the surface in a behavior known as scatter hoarding (VanderWall 1990). Desert Kangaroo Rats are a solitary species, and will exclude other species from their territories (Butterworth 1964). Thus, every burrow complex has but one individual occupying it, except for females with young (Ketcham 1940). Desert Kangaroo Rats primarily forage under shrubs where seeds are more abundant, but unlike other kangaroo rats they are also found regularly using open areas in the interstitial space between shrubs (Thompson 1982). Primary perennial vegetation in areas where Desert Kangaroo Rats occupy Clark County include creosotebush (*Larrea tridentata*), galleta grass (*Hilaria rigida*), Indian ricegrass (*Achnatherum hymenoides*), ocotillo (*Fouquieria splendens*), *Yucca* spp., brittlebush (*Encelia* spp.), greasewood (*Sarcobatus vermiculatus*), quail bush (*Atriplex canescens*), sand sage (*Artemisia filifolia*), and mesquite (*Prosopis velutina*). Modeled habitat for this species indicates higher and moderate categories of suitable habitat in Mojave Desert Scrub, Desert Riparian, Mesquite Acacia, and Salt Desert Scrub ecosystems, with only low quality habitat in any other ecosystems (Table 69).

Desert Kangaroo Rats are extremely efficient at gathering seeds and sorting them when seeds are abundant and can store prodigious amounts of seed. Desert Kangaroo Rats gather seeds that are from 1.4 to >4.7 mm in diameter (Brown 1975 and feed on seeds including mesquite (*Prosopis* sp.), beardtongue (*Penstemmon* sp.), desert chicory (*Glyptopleura marginata*), lupine (*Lupinus* spp.), and (*Gilia leptomeria*). Food caches that the rodents do not recover serve as a means for dispersal of many important desert plants and can be important for renewal and restoration of disturbed desert habitats (Waitman et al. 2012, DeFalco et al. 2010).

The Desert Kangaroo Rat does not hibernate and torpor is only weakly developed (MacMillen 1983). Desert Kangaroo Ratsdo not require “drinking water” because they acquire all of the fluid they need from metabolic water through eating seeds (Schmidt-Nielsen 1964), although, if offered water they will drink it readily (Butterworth 1964). The timing and success of spring breeding in these and other desert rodents is influenced by winter annuals, which depend on winter rains (Beatley 1969).

Table 69. Ecosystems within Clark County, and the area (Ha) of Low Medium and High predicted suitability within each ecosystem.

Ecosystem	Low	Medium	High
Alpine	124	0	0
Blackbrush	282486	29	0
Bristlecone Pine	6809	0	0
Desert Riparian	443	1693	7457
Mesquite Acacia	10882	4192	3281
Mixed Conifer	20243	0	0
Mojave Desert Scrub	725015	341277	161188
Pinyon Juniper	82023	0	0
Sagebrush	2442	0	0
Salt Desert Scrub	11088	3773	1119

Ecosystem Level Threats

Threats to Desert Kangaroo Rat habitats include conversion of habitat through urban and suburban development, renewable energy development, and recreational activities (Wildlife Action Plan Team 2006). Other concerns to this species’ habitats include invasive species such as mustards and grasses that can become dense and reduce the suitability for Desert Kangaroo Rat, which prefer lower density vegetation (Beatley 1976), and promote desert wildfires that reduce diversity of plant species. Effects on suitable habitat from off-highway vehicle use on sand dunes and badlands are not well understood, but these areas are popular for this type of recreational use (Wildlife Action Plan Team 2012).

Population Trends

The population trend of this species is considered stable to declining (Nevada Wildlife Action Plan 2012).

Threats to Species

Subsidized predators (e.g. common raven - *Corvus corax*, coyote – *Canis latrans*, and possibly others) that prey on kangaroo rats may increase in proximity to human concentration centers (Kristan and Boarman 2003, Esque et al. 2010). Habitat fragmentation is also a threat to the species. High incidence of highway mortalities were documented long ago and described local extirpation in wide areas to either side of highways (Huey 1941). Experimental exposure of Desert Kangaroo Rats to playbacks of off-highway vehicle sounds (lower than they would actually have experienced) resulted in impaired hearing for up to 10 days and the inability for the kangaroo rats to detect predator calls during that time (Brattstrom and Bondello 1983). Areas used for off-highway vehicle recreation had 25 percent fewer rodents than nearby control areas, and off-highway vehicle activity areas had fewer reptiles and birds as well (Bury et al. 1977, Luckenbach and Bury 1983). Desert Kangaroo Ratshave the largest occipital bullae of any *Dipodomys*, thus their hearing is extremely sensitive and may be damaged by off-highway vehicle activities. Desert Kangaroo Ratsuse foot-drumming, a non-vocal form of communication (Eisenberg 1963), thus hearing loss resulting from off-highway vehicular may pose an additional threat to the species.

Existing Conservation Areas/Management Actions

Recommended conservation actions specific to this species and species habitat are included in the Nevada Wildlife Action Plan (2012). The Nevada Wildlife Action Plan recommended approach is to determine population distinctness and analyze landscape-scale soils to indicate degree or potential for inter-population connectivity. Resolving these issues may require local and regional Desert Kangaroo Rat surveys, genetic analyses and spatial statistical modeling to be successful. Further, the recommended conservation strategies to conserve the habitat that this species occurs in include: maintaining this species habitat at its current distribution in stable or increasing condition trend; maintaining sand dune and badland habitats without compromising the sustainability of vegetation and wildlife communities; and sustaining stable or increasing populations of wildlife in key habitats (Nevada Wildlife Action Plan 2012). Careful consideration to the use of off-highway vehicle activities should be made when considering the future of this species in Clark County.

Summary of Direct Impacts

The Desert Kangaroo Rat is a year-round resident of Clark County, found in widely scattered populations throughout the county. It is known to occur in the plan area. Suitable habitat for this species was modeled by Boykin et al. (2008), indicating 7469 km^2 of high and moderate habitat for the species within the county (Table 70). It is estimated that approximately 8 percent of Desert Kangaroo Rat modeled high and medium habitat within Clark County could be impacted by activities covered under the Amendment, while only 4% is already disturbed. Conservation areas include 16% of modeled habitat throughout the County (Table 70).

Table 70. Categorized modeled habitat values (High, Medium, and Low) and the average area (Hectares) predicted in the potential impact areas, conservation areas, already disturbed areas, and overall area.

Habitat Level	Impact	Conserved	Disturbed	Area (Hectares)
High	26740	30176	8582	251833
Med	32964	85563	19617	495097
Low	68673	374437	86323	1627473

DIDO - Desert Iguana (Dipsosaurus dorsalis)

The Desert Iguana (*Dipsosaurus dorsalis*) is a broad-ranging, herbivorous lizard that occurs throughout the Mojave and Sonoran deserts. This robust lizard is generally dark brown to tan above, and very light colored below. The Desert Iguana occupies low elevation desert sites that are extremely hot and dry. Desert Iguanas are known to thrive in these extreme conditions and may be quite numerous in appropriate habitat.

Species Status

US Fish and Wildlife Service Endangered Species Act: No Status
US Bureau of Land Management (Nevada): No Status
US Forest Service (Region 4): No Status
State of Nevada: No Status
NV Natural Heritage Program: Global Rank G5, State Rank S3
NV Wildlife Action Plan: Species of Conservation Priority
IUCN Redlist (v 3.1): Least Concern
CITES: No Status

Range

The Desert Iguana occurs throughout the Mojave and Sonoran deserts in appropriate habitats. There are five subspecies of Desert Iguana. Two are endemic to islands in the Sea of Cortez, one occupies the cape region of Baja del Sur, Mexico and the fourth occurs in southern Sonoran and northwest Sinaloa. *Dipsosaurus dorsalis dorsalis* is the only subspecies found in the US The Desert Iguana is known from southwestern Utah (west of the Beaver Dam Mountains); southern Nevada (Clark and Nye counties); northwest to southwest Arizona; and from Death Valley southward through the hot deserts of California, with the western most point in western Kern County (Norris 1953). South of California, they occur in Baja del Norte and Baja del Sur, Mexico (mostly to the east of the central mountains, except in the far south. They are also sometimes abundant in the dune habitats of northern Sonora and southward to northwest Sinaloa. Desert Iguanas occur in an elevational range from below sea level in desert sinks to 1,524 meters (5,000 feet).

Habitat Model

The GAM models for Desert Iguana generally predict more habitat than either the MaxEnt or RF models, where the latter two were similar in prediction (Figure 113). Important differences for this species are along the southern most portion of the Colorado River in Clark County, and along the northeastern extent of Highway 95 both of which are predicted in GAM models, but less so using the other algorithms. RF had the highest performance scores for AUC and TSS, while the Ensemble model had a higher BI (Table 71). None of the model algorithms included Elevation, NDVI Start of Season, or total integrated NDVI. None of the models selected Elevation, NDVI Start of Season, total integrated NDVI, or Percent Washes (Table 72). All models had relatively low standard errors throughout the county (Figure 114). The Continuous Boyce indices showed strong predictive power for all but the GAM ensemble model (Figure 115).

Table 71. Model performance values for *Dipsosaurus dorsalis* models.

Model	Presences	AUC	BI	TSS
Ensemble	440	0.907	0.98	0.686
GAM		0.824	0.934	0.553
RF		0.971	0.942	0.846
MaxEnt		0.854	0.968	0.578

Table 72. Percent contributions for input variables for *Dipsosaurus dorsalis* for ensemble models using GAM, MaxEnt and RF algorithms.

Variable	GAM	MaxEnt	RF
Elevation			
NDVI Amplitude	0.893	5.359	17.266
NDVI Maximum	0.893	4.699	18.716
NDVI Start of Season			
NDVI Total Integrated			
Sandy Soils (TerraSpectra)	0.892	0.64	
Slope	1.785	2.236	20.506
Summer Maximum Temperature	0.893	7.85	28.74
Surface Roughness	5.821	0.875	15.89
Temperature Range (Annual Max - Min)	19.642	7.081	20.072
Terrain Position Index	0.893	3.537	14.822
Texture (ATI)	22.095	15.711	23.657
Washes			
Winter Minimum Temperature	31.027	40.797	38.029
Winter Precipitation	15.167	11.21	29.331

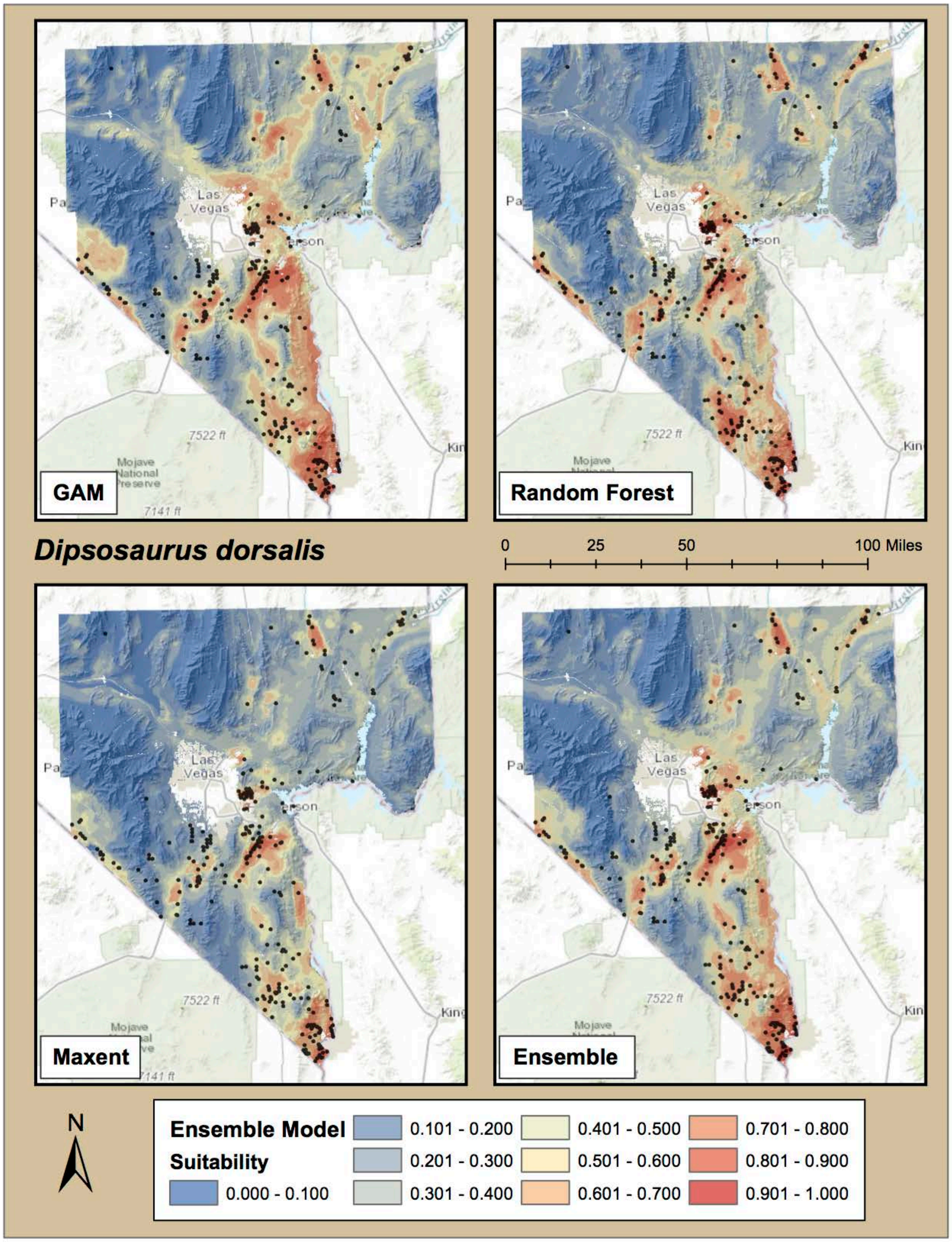


Figure 113. SDM maps for *Dipsosaurus dorsalis* model ensembles for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and ensemble model averaging the three (Lower Right).

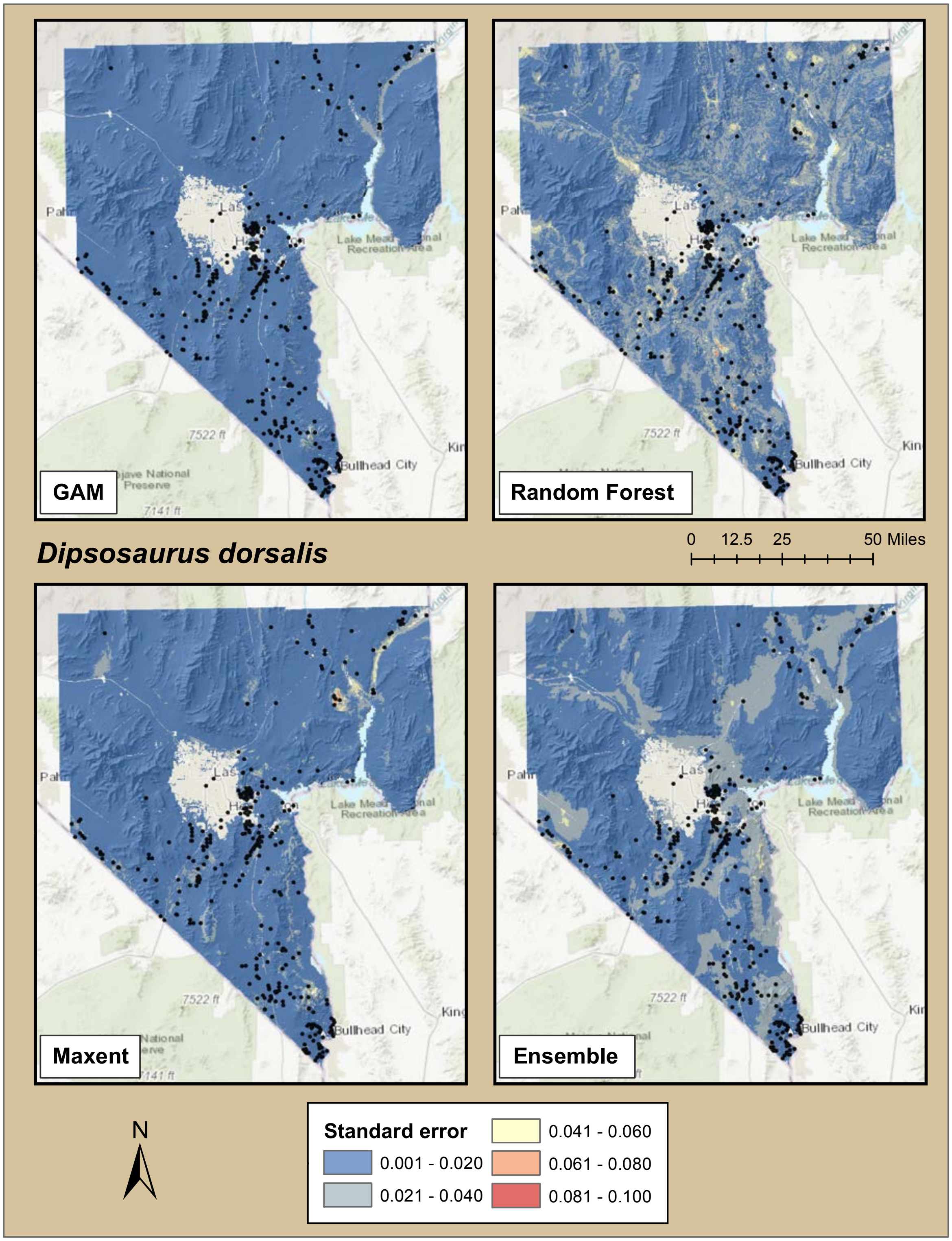


Figure 114. Standard error maps for *Dipsosaurus dorsalis* models for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

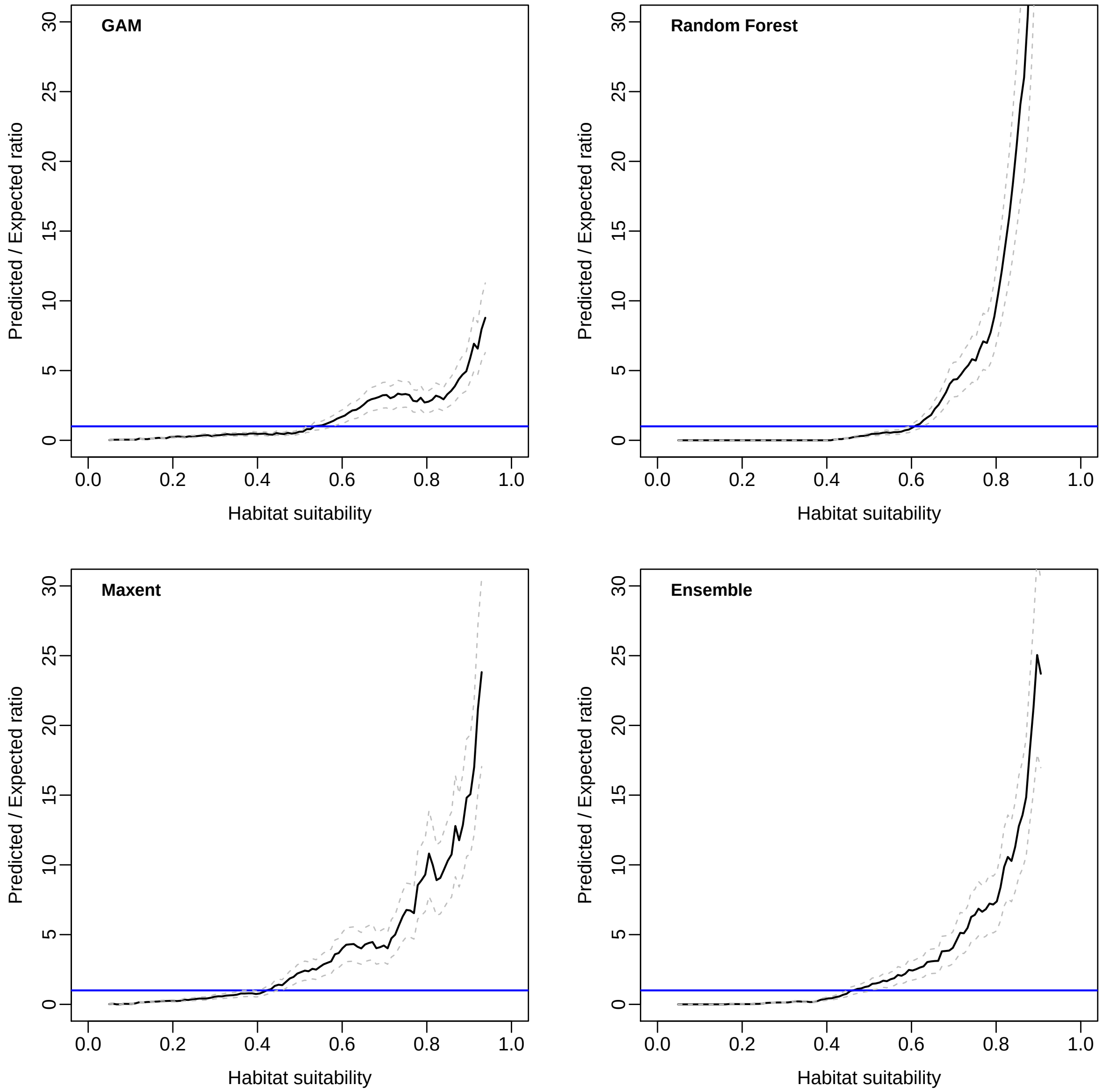


Figure 115. Graphs of Continuous Boyce Indices [CBI] for *Chionactis occipitalis* models for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

General Additive Model

The top 4 contributing environmental layers were Winter Minimum Temperature Surface Texture, Annual Temperature Range, and Winter Precipitation – where predicted habitat increased with warmer winter temperatures (above -2 ºC), and sandier substrates (i.e. higher Surface Texture values), and decreased with moderate Winter Precipitation, and was lowest but variable at moderate levels of annual temperature ranges (Figure 116). Surface Roughness showed a positive relationship with predicted habitat (Figure 116). The remaining input variables each contributed similarly where increased habitat was predicted for areas with lower Slopes, in lower areas (High Position Index) typical of valley bottoms and landscape scale drainages, with sandier soils and high summer temperatures (Figure 116).

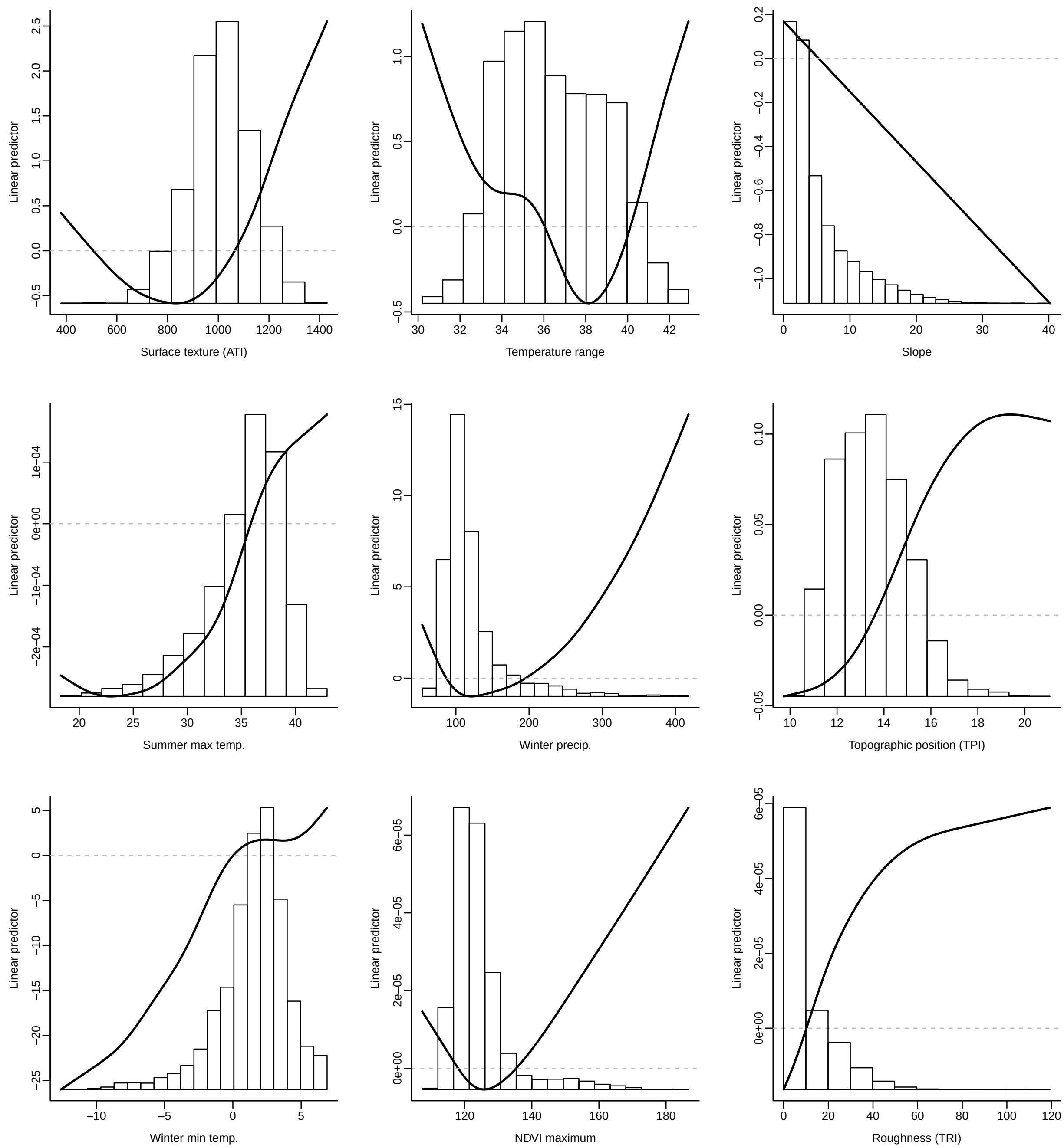


Figure 116. GAM partial response curves for the *Dipsosaurus dorsalis* model overlaid over distribution of environmental variable inputs in the study area.

MaxEnt Model

The MaxEnt models captured the same variables as those shown in the GAM models, and with similar rankings of relative contribution, and response surfaces among algorithms indicating relatively robust model selection (Table 72, Figure 116, Figure 117).

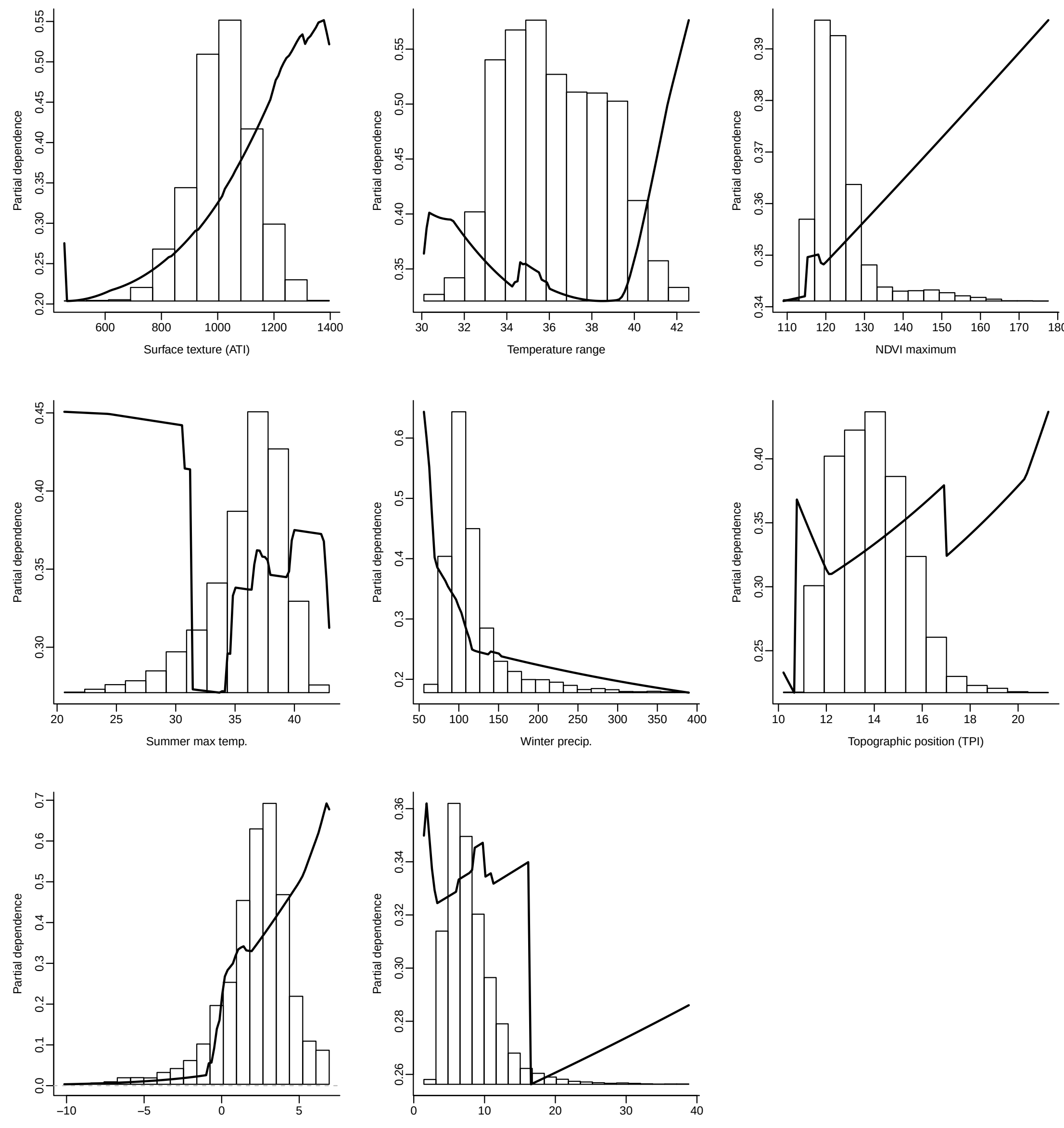


Figure 117. Response surfaces for the top environmental variables included in the MaxEnt ensemble model for *Dipsosaurus dorsalis*.

Random Forest Model

The RF model for Desert Iguana selected the same input variables as the GAM and MaxEnt models, dropping only the modeled sand layer (Table 72). The top 4 contributing covariates (Winter Minimum Temperature, Winter Precipitation, Summer Maximum Temperature, and Surface Texture) were the same as those selected in the MaxEnt model selection, with similar ranking among algorithms for the remaining variables. All model response surfaces are similar to those in the GAM and MaxEnt models for this species (Figure 116, Figure 117, Figure 118).

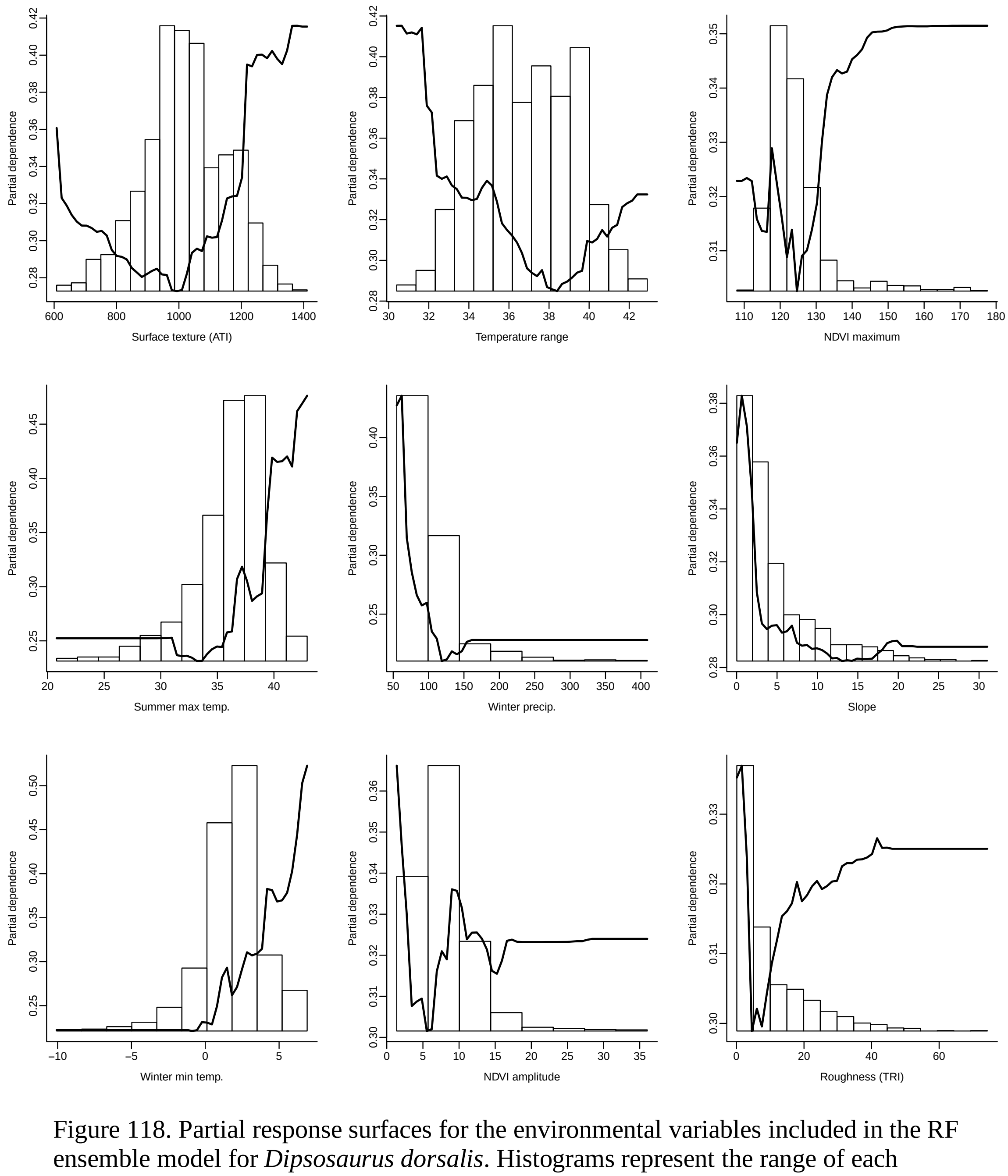


Figure 118. Partial response surfaces for the environmental variables included in the RF ensemble model for *Dipsosaurus dorsalis*. Histograms represent the range of each environmental variable across the x-axis, and predicted dependence relative to habit

Model Discussion

Desert Iguanas occupy the hottest, driest habitats in Clark County, Nevada (Figure 119). These areas occur in valley bottoms, around the edges of playas, and near all the major river drainages including the Colorado, Virgin, Muddy, and Amargosa rivers. Areas occupied by Desert Iguanas coincide with the lowest elevation areas and the finest soil particle sizes throughout the county. While the database for this species is represented by the largest data set among the four reptile species modeled here (N = 440), Desert Iguanas have the most restricted range among *Chionactis occipitalis*, *Crotalus cerastes*, and *Heloderma suspectum*. One area that we feel would benefit from additional species surveys is the Las Vegas Wash northwest of Las Vegas, and running northwesterly into the Three Lakes Valley (on the Nellis Air Force Range), further west through Indian Springs, and to the western margin of Clark County. While there is only one locality record currently available in the area just described, there are known records for Nye County, near Mercury, Nevada (Tanner 1969). The question is, are *Dipsosaurus* in the region previously described and if so, do they occur continuously from the Las Vegas Valley through to the Amargosa Valley (because there are locality records in both of these sites), or if not, how far into this unknown region do they occur from either side? In contrast to the *Chionactis occipitalis* and *Crotalus cerastes* SDMs, the *Dipsosaurus* contains some clusters of locality points that are not strongly associated with a high probability of occurrence in the SDMs. These records tend to be toward the western side of the county. The first aberrant site is between the McCollough Mountains and the Lucy Grey Mountains - just north of Nipton, California, and the second site surrounds the southernmost portion of the Spring Mountains south of State Highway 160.

Standard Error

There are two small regions of the SDM where the standard error is somewhat high (Figure 120). One area near Sandy Valley on the western margin of the county, and the other nearby, south of State Highway 160 in the Pahrump Valley. Another area of elevated error in the SDM is in several small isolated patches in the Eldorado Mountains east and southeast of Boulder City. While there are also some locality records nearby, this area is highly heterogeneous with intermittent steep and rocky mountain slopes, talus, and sandy valley bottoms.

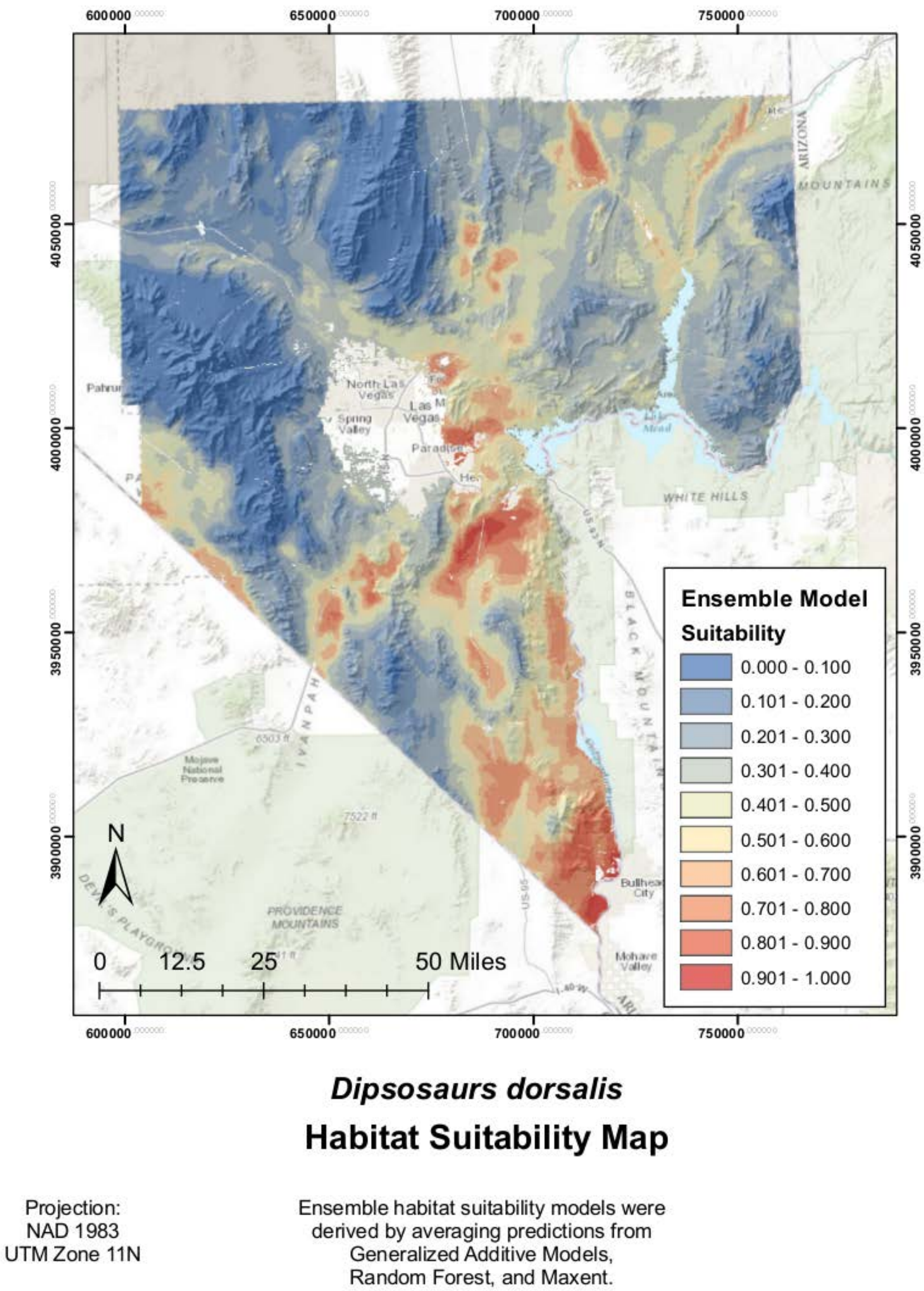
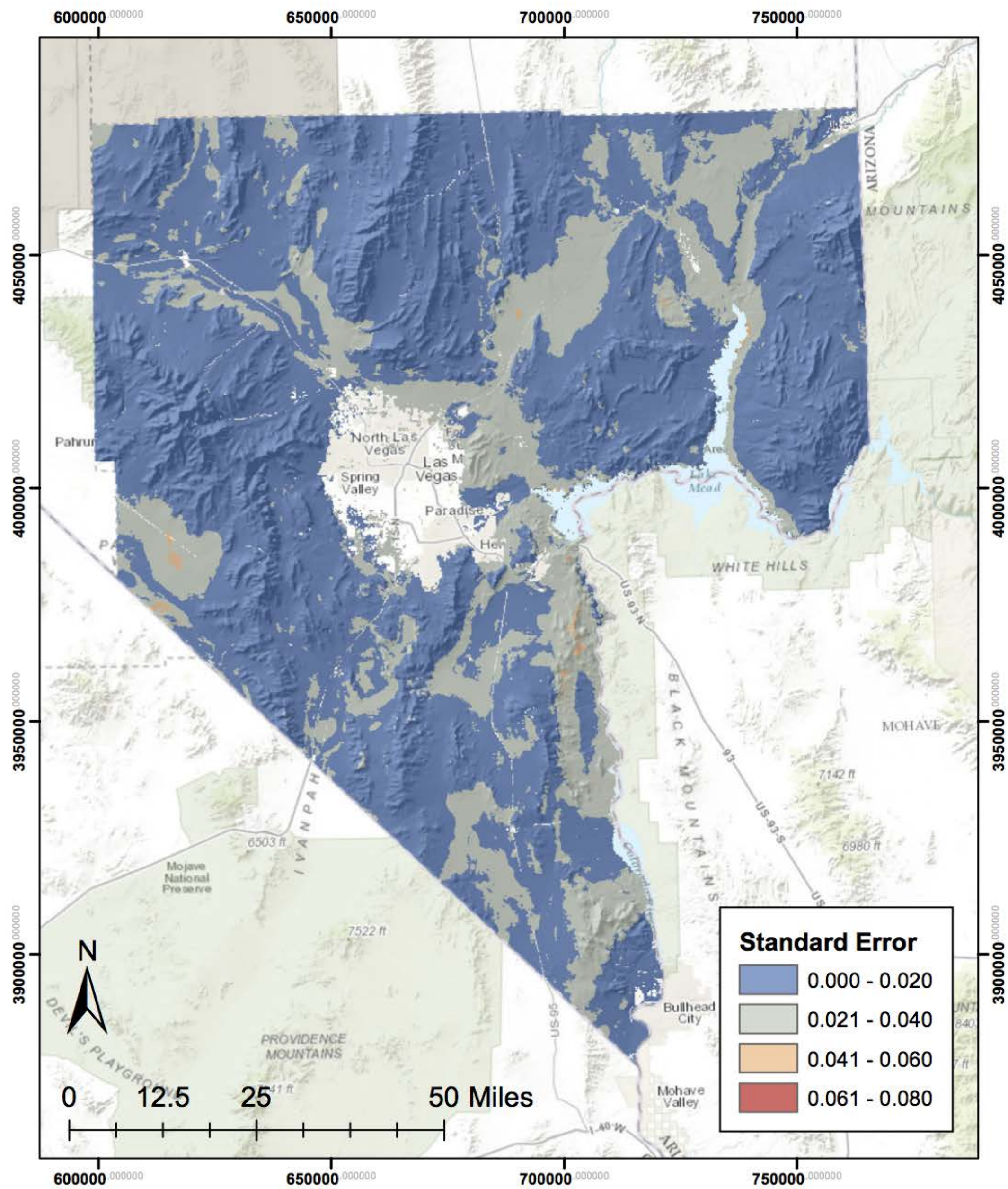


Figure 119. SDM map for the *Dipsosaurus dorsalis* Ensemble model.



Dipsosaurs dorsalis

Standard Error Map

Projection:
NAD 1983
UTM Zone 11N

Standard error in habitat suitability was calculated across all selected GAM, Random Forest, and Maxent models used in deriving the ensemble estimates.

Figure 120. Standard Error map for the ensemble *Dipsosaurus dorsalis* ensemble model for Clark County, NV.

Distribution and Habitat Use within Clark County

Desert Iguanas occupy low elevation sites and are among the most heat tolerant of desert lizards in North America (Norris 1953, Hulse 1992). Desert Iguanas occupy lower bajadas and valley bottoms where the soils are mostly deep, fine, sandy gravel, loam, or clay with some firm areas and rocks interspersed (Stebbins 2003), and like many reptiles they occupy only a small segment of available habitat (Norris 1953). Populations can be particularly dense in sandy washes and in areas of windblown sand with vegetation, and tend to be less dense, but still present on other soil types (Norris 1953). Vegetation in these areas is frequently dominated by creosotebush (*Larrea tridentata*) a desert shrub that forms hummocky areas that are commonly occupied by rodent burrows, often used for cover by Desert Iguanas. Upland areas within their range are frequently interrupted by dry washes lined by small desert trees (catclaw acacia [*Acacia greggii*], smoketree [*Psorathamnus spinosus*], and mesquite [*Prosopis* spp.]). Their modeled habitat was predominantly in Mojave Desert Scrub ecosystems, with inclusion in Mesquite Acacia, Desert Riparian, and Salt Desert Scrub (Table 73). Some moderate habitat may also include Blackbrush ecosystems, likely only at lower elevations (Table1). Desert Iguanas feed primarily on annual plants in the spring and shift to the leaves of desert perennials during the summer (Minnich and Shoemaker 1970). Insects and their own fecal material are frequently present in the diets (albeit in small amounts). Creosotebush flowers and leaves are a favorite food of the Desert Iguana and are consumed when available. They also feed on ocotillo (*Fouquieria splendens*).

Soil temperature and soil moisture may limit the geographic range of Desert Iguanas based on constraints these factors have on the successful development of eggs place in below ground nests (Muth 1980). Eggs are generally laid in mid-May and hatch about 100 days later. Temperature is also important for digestions, and this may also limit their distributions in cooler environments (Zimmerman and Tracy 1989).

Table 73. Ecosystems within Clark County, and the area (Ha) of Low Medium and High predicted suitability within each ecosystem.

Ecosystem	Low	Medium	High
Alpine	124	0	0
Blackbrush	389021	25789	429
Bristlecone Pine	7565	0	0
Desert Riparian	288	6629	3689
Mesquite Acacia	3482	8502	7657
Mixed Conifer	27339	0	0
Mojave Desert Scrub	350635	716091	209344
Pinyon Juniper	115667	188	0

Ecosystem	Low	Medium	High
Sagebrush	4706	1	0
Salt Desert Scrub	66263	6946	5527

Ecosystem Level Threats

The lower slopes and valley bottoms that are habitat to Desert Iguanas are prime areas for urban and suburban development, commercial agriculture, transportation and utility infrastructure, and most recently renewable energy development more recently.

Population Trends

There are no long-term population trend data on Desert Iguanas. Desert Iguanas may live at least 7.5 y, and survivorship was high in all size classes. Mean survivorship was 57% for males and 66% for females, which was not significantly different (Krekorian 1984). Density estimates at one site in southern California were 332 to 425 per hectare (Krekorian 1984).

Threats to Species

Given that Desert Iguanas inhabit sandy areas that tend to have low slope and found in valley bottoms, widespread development of these areas (e.g. urbanization, and utility scale solar) may remove large portions of habitat. Commercial collection may also impart pressure on localized populations. Recent analyses of the amount of time and space (two separate analyses) required to sustain commercial collecting activities indicated that it is harder to make the same collections without spending more time or covering more space (State Wildlife Commission, Board of Trustees Meeting, 23 Sept 2017). This illustrates an index of population declines. The species is closely tied to creosote bush, which are often surrounded by invasive grasses. The loss of shrub cover from altered fire regimes and conversion to annual plants is expected to reduce Desert Iguana’s ability to thermoregulate using natural features of the landscape (shade of shrubs; Wildlife Action Plan Team 2012).

Summary of Direct Impacts

The effects of habitat loss and fragmentation due to habitat conversion, and fragmentation are unknown. Commercial collection is reported annually, but population trends are not discernable using the reporting data alone, and no density or demographic surveys have been conducted to ascertain the level of impact that collection may have on the species. Impacted areas are likely to coincide with 424 km^2 of high quality habitat and 688 km^2 of moderate habitat, while 647 km^2, and 2535 km^2 of high and moderate habitat are contained within conserved areas respectively (Table 74)

Table 74. Categorized modeled habitat values (High, Medium, and Low) and the average area (Hectares) predicted in the potential impact areas, conservation areas, already disturbed areas, and overall area

Habitat Level	Impact	Conserved	Disturbed	Area (Hectares)
High	42421	64672	10037	228626
Med	68770	253574	25794	768982
Low	11195	193777	4107	974591

Existing Conservation Areas/Management Actions

The Desert Iguana is listed as a Species of Conservation Priority in the Nevada Wildlife Action Plan. One recommended conservation action includes protection of washes in Desert Iguana habitats. Conservation areas (DWMA's) and Management Actions for Mojave Desert Tortoise will likely benefit Desert Iguanas. It is also recognized that adjustments to commercial collection regulations may be needed to maintain population viability (Wildlife Action Plan Team 2012), and commercial collection was recently banned in Nevada.

DINE - Gold Butte Moss (Didymodon nevadensis)

Gold Butte Moss was inadvertently discovered in 1994 during a survey for California bearpoppy (*Arctomecon californica*) in the northern foothills of Lime Ridge on a gypsiferous outcrop at 487 m elevation, 16 km north of Gold Butte. Further investigation of similar gypsum formations led to the observation that the new species is locally abundant and restricted to gypsum substrates, a habitat which is unique compared to other moss species. Microhabitats on which it grows include gypsiferous outcrops, limestone boulders, and sandy soil from 500-1700 m (Zander et al. 1995). The gypsum soils this species has been found on are Triassic in origin and belong to the Chinle and Moenkopi formation (Longwell et al. 1965). The species is noticeably absent from adjacent areas just meters past gypsum soils. Gold Butte Moss is particularly abundant on loose un-compacted gypsum soil on east and north-facing slopes. Bryophyte collectors rarely venture onto gypsum deposits however, as bryophyte species don't generally inhabit them (Zander et al. 1995), which could account partially for gaps in data.

The moss forms dense, relatively deep mats in monospecific populations that are blackish green above and reddish brown below. The species does not often occur in multispecies populations, however, commonly associated plants include *Arctomecon californica*, *Enceliopsis argophylla*, *Petalonyx parryi*, *Anulocaulis leiosolenus*, *Psorothamnus fremontii*, *Atriplex confertifolia*, and *Eriogonum spp*. Surrounding vegetation often includes plants typical of lowlands including *Larrea tridentata*, *Ambrosia dumosa*, *Sphaeralcea ambigua*, *Atriplex hymenelytra*, *Ephedra nevadensis*, *Ephedra torreyana*, and *Krameria erecta*. Mosses that are commonly associated with *D. nevadensis* on gypsum soils include *Syntrichia caninervis*, *Grimmia orbicularis*, *Didymodon australasiae*, and *Crossidium crassinerve*. Less commonly associated moss species include *Aloina bifrons*, *Crossidium seriatum*, *Crossidium aberrans*, and *C. squamiferum*. Lichens associated with Gold Butte Moss include *Fulgensia bracteata*, *Psora decipiens*, *Peltula richarsii*, and *Catapyridium lacheum*. Calcareous cyanobacteria in small amounts are also present in soils on which it grows (Zander et al. 1995).

Gold Butte Moss is in the Pottiaceae family and can be distinguished from its closest relative, *D. brachyphyllus* by a few characters including variations in the costa and leaf margins. Another distinguishing feature of the moss is its spirally twisted leaves when dry. The population has been reported thus far to be solely represented by female plants (Zander et al. 1995). Male plants are thought to be extinct, which may have led to a more restricted range. The populations reproduce asexually through vegetative structures (Stark 2007). Bryophytes and lichens are the dominant vegetation on Nevada gypsum formations, and Gold Butte Moss is the most common bryophyte species within those communities (Zander et al. 1995).

Gold Butte Moss has been shown to have an extremely slow rate of growth compared to other moss species (Vitt 1989), likely a result of low annual precipitation (Zander et al. 1995). The plants are fertile late-winter to spring and grow vegetatively beginning in autumn (NNHP 2001).

Species Status

US Fish and Wildlife Service Endangered Species Act: No status
US Bureau of Land Management (Nevada): Sensitive
US Forest Service (Region 4): No status
State of Nevada (NAC-527): No status
NV Natural Heritage Program: Global Rank G4 State Rank S1
IUCN Red List (v 3.1): No status
CITES: No status

Range

According to Zander in Flora of North America (Zander 1995), this species ranges from British Columbia to Nebraska, Colorado, New Mexico, Texas, and Nevada. The only location for this species recorded on NatureServe under US distribution is in Clark County and lists 15 locations in Lake Mead. Reports from southern British Columbia suggest that the species range is limited but is abundant and mostly protected from disturbances in its habitat there, which is glacio-lacustrine banks. The total number of occurrences according to the site are 6-20 (NatureServe 2017). Nevada Natural Heritage Program lists the species as “confident or certain” in Clark County with 12 occurrences (NNHP). NNHP estimates the maximum range of the plant in Nevada to be 51.5 km (NNHP 2001).

Population Trends

Nevada Natural Heritage Program listed the species trend as stable based on the little known from population census in Nevada (NNHP 2001). Stark judged Gold Butte

Moss to be not under immediate threat of extinction as of 2007 due to the expanded number of previously existing populations (Stark 2007).

Qualitative Habitat Model

Only 17 localities were available for Gold Butte Moss – thus there were insufficient data to model this species using the quantitative methods employed for most of the other species as part of this project.

Methods

Based on the available literature and an examination of all known occurrences within Clark County, the only consistent indicator of suitable habitat for Gold Butte Moss appears to be the presence of (or, in some cases, direct proximity to) gypsum soils. Accordingly, we consider all areas within Clark County containing gypsum soils to be potentially suitable habitat for this species. However, additional landscape features such as exposed outcrops and northerly aspects are likely to increase habitat suitability (Zander et al. 1995). The elevation of known occurrences ranges from approximately 400 – 900 m. While the range of tolerance for southern populations of Gold Butte Moss in terms of climatic and / or elevational limits are unknown, relatively low-lying, arid areas appear to be favored (Zander et al. 1995). Finally, as bryophytes are particularly susceptible to surface disturbances, Gold Butte Moss is unlikely to occupy disturbed areas, such as those with a high degree of urban development or recreational activities. The relative lack of vegetation on most gypsum-rich soils makes them highly sought after for certain recreational activities such as off-road motoring – including motorized dirt bikes. Thus, some potential areas of habitat are currently in a highly disturbed conditions – such as parts of North Las Vegas.

Given these considerations, we developed an ordinal scale to rank habitat suitability for Gold Butte Moss, ranging from 1 - 4, based on four different habitat variables (Table 75). First, all areas with gypsum soils were assigned a score of 1, and all areas not assigned as gypsum soils were assigned a value of 0 regardless of other habitat features. Our representation of gypsum was based on the model developed by TerraSpectra (2011). However, an examination of occurrence records suggested that Gold Butte Moss sometimes occurs at the periphery of cells identified as gypsum by the TerraSpectra model. For this reason, we buffered gypsum cells by an additional 500 m to represent all potentially suitable soils. Outcrops, ridge-like features, and / or fissures that may contain exposed areas of gypsum favored by Gold Butte Moss were represented by a topographic roughness index (TRI; Wilson 2007) layer that was de-trended for the effect of larger-scale slope. To do so, we first calculated TRI at 30m spatial scale. Next, we regressed this layer against slope calculated at 250m. Finally, we took the residuals of this regression as the de-trended TRI layer. A cutoff value of 0.2 on this layer was selected to represent suitable habitat features based on visual examination of satellite imagery. To represent suitable aspects, we first transformed aspect values into northness and eastness indices (ranging from 0 to 1). Areas with values above 0.5 on either the northness or eastness scales were considered potentially favorable aspects for Gold Butte Moss. Finally, we considered areas within the species' known elevation range for Clark County ± 100 m as likely to represent favorable climatic conditions.

Areas above the selected cutoff values for each of the four variables were given a value of 1 (Table 75)). Final habitat suitability for each grid cell was calculated as the sum of these values, conditional on the gypsum value (all cells with gypsum = 0 were excluded).

Model Discussion

The resulting model predicts habitat to be located almost exclusively in the northern half of the County. This includes habitat patches in the periphery of the Las Vegas Valley, throughout the BLM and NPS lands on the northern shore of Lake Mead, and in the Moapa Valley, Mormon Mesa, and Gold butte areas. There is also a strip of suitable habitat predicted north of the US95 highway corridor on the northwest side of Las Vegas (Figure 121).

Table 75. Topographic features used to rank habitat for *Didymodon nevadensis*.

Topographic Feature	Description	Value
Gypsum Soils	Gypsum soils layer provided by TerraSpectra, buffered by 500m	1
Outcrops	Surface Roughness (TRI) de-trended for larger-scale slope; cutoff value of 0.2	1
Aspect Northness / Eastness	Aspect northness: cos(aspect * pi / 180). Aspect eastness: sin(aspect * pi / 180). Cutoff value of 0.5 (on a scale of 0 – 1) for either measure.	1
Elevation	Areas with elevation from 300 – 1000 meters	1
	Total:	**4**

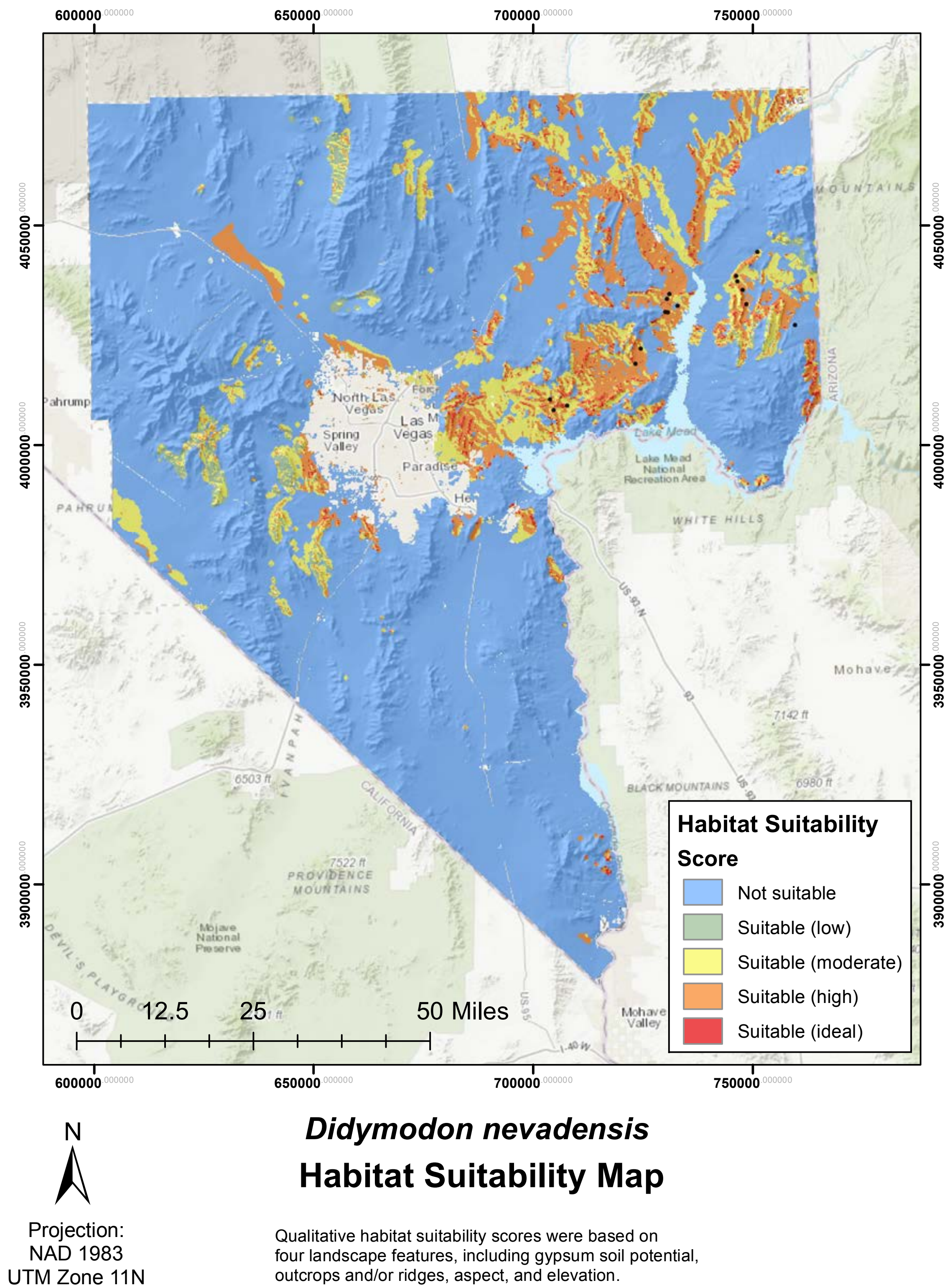


Figure 121. Estimated habitat for *Didymodon nevadensis* from the qualitative model developed from gypsum, outcrops, aspect and elevation layers (Table 75))

Distribution and Habitat Use within Clark County

On a range map provided through the Global Biodiversity Information Facility Backbone Taxonomy (GBIF) network, there are four locations within Lake Mead with two between Washington Road North and Anniversary Mine Road, north of the Northshore road, and two on either side of the Northshore road west of Stewart's point. This map also shows five occurrences east of Reno in Clark, Nevada, south of the Truckee River, one occurrence near Paria, Utah, and 23 in British Columbia (GBIF 2016). Collection records from SEINet paint a different picture of range for this species with three distinct points throughout Grand Canyon National Park in Arizona (SEINet). It is clear that data available on distribution is insufficient based on the conflicting records among different sources and low number of total reliable data points. It is likely that the Gold Butte population of the moss is the only "significant" population and is most likely where the species evolved. The following locations as of 2007 are grouped into three distinct regions (Stark 2007);

- North Shore of Lake Mead
  - Bitter Springs (Marrs-Smith 1998)
  - Blue Point Springs (Stark)
  - Boathouse Cove Road (Stark and Bonine)
  - Echo Wash (Stark)
  - Fire Bay (Fire Cove) (Stark)
  - Gale Hills south (Stark)
  - Overton arm of Lake Mead (Stark)
  - Piute Point (Stark and Bonine)
  - Westend Wash north (Stark)
- Muddy Mountains
  - White Basin (Stark and Bonine)
- Gold Butte region
  - Bitter Ridge (Stark)
  - Gold Butte (Marrs-Smith 1994
  - Lime Ridge (stark)
  - Red Bluff Spring (Stark)

The qualitative habitat model produced in conjunction with this report identified areas potentially high habitat within several of the County ecosystems (Table2). The largest area was within Mojave Desert Scrub (98 km^2), while other ecosystems had much smaller areas of high habitat (e.g. Blackbrush, Desert Riparian and Mesquite Acacia – which are generally nested within Mojave Desert Scrub, and Salt Desert Scrub, among others). Moderate habitat increases especially in the Blackbrush, Salt Desert Scrub and Mojave Desert Scrub ecosystems, while the others tend to stay limited in scope (Table 76).

Table 76. Ecosystems within Clark County, and the area (Ha) of Low Medium and High predicted suitability within each ecosystem.

Ecosystem	Low	Medium	High

Alpine	0	0	0
Blackbrush	22129	3447	17
Bristlecone Pine	0	0	0
Desert Riparian	2182	1559	17
Mesquite Acacia	1775	1980	10
Mixed Conifer	80	8	0
Mojave Desert Scrub	121306	133605	9885
Pinyon Juniper	4345	858	0
Sagebrush	40	5	0
Salt Desert Scrub	2044	5774	1

Ecosystem Level Threats

Because Gold Butte Moss grows on gypsum soil, we can assume the threats would be similar to other more well-known species that are gypsophiles including Las Vegas Bearpoppy (Meyer 1986) and Sticky Ringstem (Spellenberg and Wootten 1999). Threats specific to Sticky Ringstem (*Anulocaulis leiosolenus*) and Las Vegas Bearpoppy (*Arctomecon californica*) that may be applicable to Gold Butte Moss in Clark County include gypsum mining, off-highway vehicle use and trail development, flood-control projects, dumping, feral horse and burro trampling, rural and urban development, utility corridor construction and maintenance, related sprawl, federal land disposal, invasive plant species, legal recreation use, habitat inundation and shoreline fluctuation, and trespass grazing (TNC 2007).

Threats to Species

Off highway vehicle use, and wild horses and burros pose a threat to gypsum communities as they can easily damage gypsum and cryptobiotic surface crusts. Once damaged, these areas are susceptible to erosion and plant invasion (Niles et al. 1999 in TNC 2007). Enforcement of the laws that protect these habitats is important. For example, the Lava Butte area has regulations in place for OHV use, but it is not effectively enforced (TNC 2007). The threats listed above have resulted in population losses by direct mortality, and further loss or fragmentation of habitat (TNC 2007).

Existing Conservation Areas/Management Actions

As of 2001, Surveys for Gold Butte Moss were ongoing and mostly complete in Nevada and additional searching on gypsum deposits in Clark County for additional inventory was suggested. Gold Butte Moss occurs on the following land in order of decreasing predominance; Bureau of Land Management, National Park Service, Nevada State Lands, and possibly private lands (NNHP 2001).

The BLM ruled in March of 2005 that more research needs to be done to determine if two rare flowering plant species (*Eriogonum sp*. and *Arctomecon californica*) occur in the buffer zone of a prospected land sale in the Sheep Range. Because Gold Butte Moss often occurs with these rare species, a search was conducted to find new populations of the moss by looking for suitable habitat on gypsum mounds. No new viable populations were discovered (Stark 2007).

It has been suggested that the populations near Blue Point Spring and the White Basin region along the north Shore Road of Lake Mead should be revisited and have population health assessed adequately considering recent droughts (Stark 2007).

Summary of Direct Impacts

Total modeled habitat for this species in the high and medium categories in the qualitative model developed was 157 km^2, which is more than that estimated by NNHP. Given that this model is of a qualitative nature these figures may overestimate habitat area, or in contrast, there may be more potential area than is occupied, or known to host this species. Modeled habitat expected to be impacted in the high and medium classes in 185 km^2, and 63 km^2 is in habitat that is already disturbed (Table 77). In contrast, by this model 544 km^2 is in designated conservation areas.

Table 77. Categorized modeled habitat values (High, Medium, and Low) and the average area (Hectares) predicted in the potential impact areas, conservation areas, already disturbed areas, and overall area

Habitat Level	Impact	Conserved	Disturbed	Area (Hectares)
High	929	4086	182	9933
Med	17635	50349	6211	147298
Low	15961	54061	4533	153985

DIPU - Ring-necked Snake (Diadophis punctatus)

The Ring-necked Snake (*Diadophis punctatus*) is a relatively small and reported to be 0.762 meters (e.g. 30 inches) long. The slender snake is slate grey, olive, brown to black on the dorsal side. Its head is distinguished from the body by a narrow cream to bright orange ring that may be only a partial ring. The ventral side of the snake is mostly yellow, orange or red and intensifies toward the tail. The ventral side normally has small black spots. Ring-necked Snakes are secretive and slow-moving usually foraging in early morning and late evening (Lowe et al. 1989). When disturbed this snake recoils its tail, revealing the bright red underside – a diversion or warning tactic. They also may emit a foul smell from the vent that is thought to discourage predators (Lowe et al. 1989).

Species Status

The Ring-necked Snake is not protected at the federal level, but it is considered a species of conservation priority by the Nevada Wildlife Action Plan (Wildlife Action Plan Team 2012). It is restricted to mesic microhabitats in its Nevada distribution, which are vulnerable to climate change and habitat fragmentation.

US Fish and Wildlife Service Endangered Species Act: No Status
US Bureau of Land Management (Nevada): No Status
US Forest Service (Region 4): No Status
State of Nevada: No Status
NV Natural Heritage Program: Global Rank G5, State Rank S3
NV Wildlife Action Plan: Species of Conservation Priority
IUCN Red list (v 3.1): Least Concern
CITES: No Status

Range

The Ring-necked Snake is trans-continental, ranging almost continuously across most of the eastern half of the United States from Maine, through the upper Midwest, and then dropping down through Kansas, Nebraska, Oklahoma, New Mexico and Arizona (Stebbins 2003). In Canada they are found only in the southeast and near the borders with Michigan and New York. They also range southward into central and eastern Mexico. Ring-necked Snakes are patchy in the intermountain west, where habitat allows, including southern Nevada. Along the west coast Ring-necked Snakes have a nearly continuous distribution from northern Baja del Norte, Mexico, to southern Washington. Their elevational range spans from near sea level to 2200 meter (7200 feet).

Qualitative Habitat Model

Methods

Little is known of the distribution of Ring-necked Snakes in Nevada. Within Clark County, our search revealed only 4 occurrences, although more may be available from NDOW, we could not obtain those data at the time needed for modeling. We found an additional 11 occurrences within the greater Mojave Desert. Of these, all were located on mid-to-upper elevation slopes above the valley floor. Within Clark County, the four recorded observations all occurred near washes within blackbrush (*Coleogyne ramosissima*) vegetation associations. Based on our review of the literature, it appears likely that Ring-necked Snakes are restricted to higher elevation sites within Clark County, including vegetation from the blackbrush zone and above (Stebbins 2003; Fontanella et al 2008). Additionally, Ring-necked Snakes likely favor moist sites within suitable vegetation types, including washes, riparian channels, and springs. Areas of moist soil with accumulated plant litter, loose rocks and / or stable talus may constitute important microhabitats (Fowlie 1965). Within Clark County, such habitat occurs within the Spring Mountains National Recreation Area, the Desert National Wildlife Refuge, and the McCullough Range. The species apparently has limited dispersal ability, with home range sizes of only 100 m^2 or less (Fontanella et al. 2008). However, home range size has not been estimated for Mojave Desert populations.

Based on the above criteria, we delineated potential habitat for Ring-necked Snakes using a qualitative ranking procedure. Our analysis was conducted at a spatial resolution of 250 m^2 in order to account for hydrographic features of importance to the species. First, all vegetation within or above the blackbrush zone, including pinyon-juniper and mixed conifer associations, was considered potential habitat (Heaton et al. 2011). Vegetation associations below the blackbrush zone were considered unsuitable. Next, we assigned higher scores to grid cells that contained both suitable vegetation and wash-like features, which were delineated using a high-resolution digital elevation model (Table 78). Finally, we assigned the highest rank to grid cells containing riparian vegetation and springs, which are assumed to constitute ideal habitat for Ring-necked Snakes (Table 78).

Riparian vegetation was previously modelled for *Sisyrinchium radicatum* at a 90 m^2 resolution through a random forest model incorporating seven covariates: the normalized difference vegetation index (Landsat NDVI), normalized difference moisture index (Landsat NDMI), normalized difference water index (Landsat NDWI), tasseled cap greenness (coefficients in Baig et al. 2014), the maximum NDVI from MODIS scenes averaged across 2001-2010 (https://phenology.cr.usgs.gov), elevation, and topographic position (TPI). Riparian vegetation from the Heaton et al. 2011 map, along spring locations from the National Hydrography Dataset, were also incorporated into the final riparian vegetation layer.

Model Discussion

Our qualitative model for this species predicts habitat largely restricted to canons and washes within all of the major mountain ranges within the county, with no interstitial habitat predicted. From this model habitat appears to be most dense within the Spring Range (Figure 122).

Table 78. Landscape features used to identify potential Diadophis punctatus habitat at a spatial resolution of 250 m^2.

Variable	Description	Score
Vegetation Type	Blackbrush, sagebrush, pinyon-juniper, and mixed conifer vegetation types extracted from the Heaton et al. (2011) vegetation model of Clark County.	1
Washes	Washes were identified by applying a cutoff of 15 to a compound topographic index layer (i.e., topographic wetness index) derived from a 30 m^2 DEM. This layer was upscaled to 250 m^2 such that all of the larger grid cells containing washes were included.	2
Riparian / Springs	Riparian vegetation was modelled based on remote sensing metrics, topographic position, and elevation at a 90 m^2	3

Variable	Description	Score
	spatial scale. This layer was subsequently upscaled to 250 m^2 such that all of the larger cells containing riparian vegetation were included. Spring locations were derived from the National Hydrography Dataset (https://nhd.usgs.gov/) high-resolution layer for Nevada.	

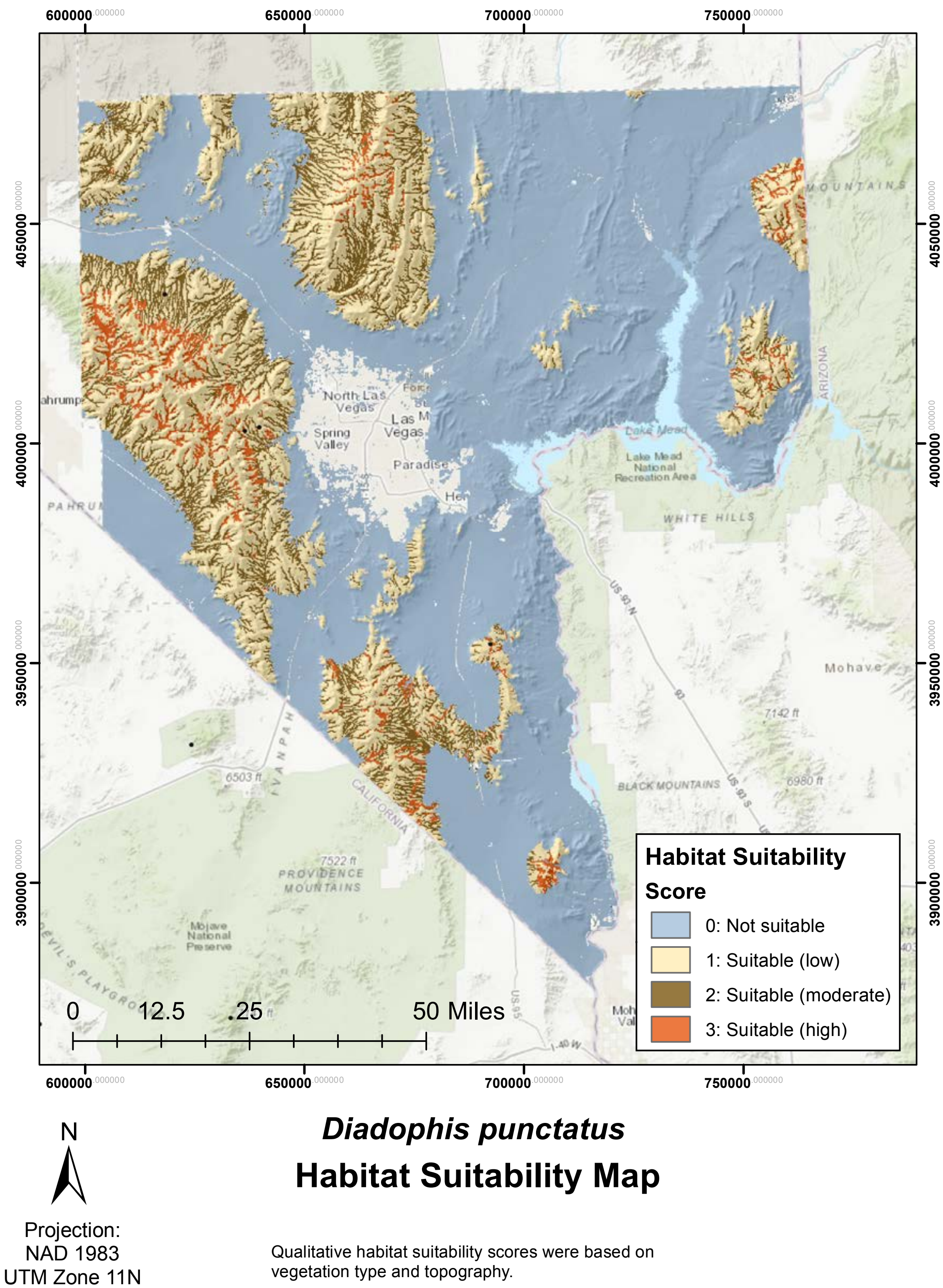


Figure 122. Estimated habitat for *Diadophis punctatus* from the qualitative model developed from vegetation, washes and riparian spring habitats (Table 78).

Distribution and Habitat Use within Clark County

The first specimen of a Ring-necked Snake documented for Nevada was collected near Caliente, at Beaver Dam State Park in 1947 (Tanner 1947). They are known from the Newberry, Spring, and McCollough mountain ranges, and may occur in some of the smaller ranges in the county, but have not yet been reported. Ring-necked Snakes also have been documented at Hiko Springs in nearby Lincoln County, Nevada; the Clark and Providence mountains in California; and the Virgin Mountains in northwest Mohave County, Arizona. Modeled habitat within Clark County included a broad spectrum of ecosystems, with higher categories of habitat occurring in Pinyon Juniper, Blackbrush, and Mixed Conifer ecosystems, with less area in Mojave Desert Scrub and Mesquite Acacia and other lower areas (Table 79). Moderate habitat had a larger inclusion in the Blackbrush and Mojave Desert scrub ecosystems, and moderate increases in others. Only low quality habitat was predicted for Alpine and Desert Riparian ecosystems (Table 79).

In the Mojave Desert Ring-necked Snakes are restricted to cooler higher elevation sites (Fontanella et al. 2008). Ring-necked Snakes occupy mesic mountain islands of Clark County and vicinity (Stebbins 2003). evening (Lowe et al. 1989). They have limited dispersal ability and tend to live in isolated populations in the Mojave Desert (Fontanella et al 2008). In Clark County these small snakes are often found in moist or wet areas, but may venture into drier areas as well. They have been found in aspen and fir groves all the way down to desert scrub areas, especially when associated with riparian habitats (Stebbins 2003). Ring-necked Snakes crawl through leaf layers and may be found under loose stones or flat pieces of bark in moist areas (Fowlie 1965). Ring-necked Snakes in the southwest envenomate their prey using enlarged, un-grooved upper rear teeth, and this distinguishes them from eastern ecotypes (Gehlbach 1974). These small rear-fanged snakes are not dangerous to humans. Ring-necked Snakes lay their small clutches of eggs in rotting wood, and the nests may be communal. Females have been found attending their eggs (Fowlie 1965).

Table 79. Ecosystems within Clark County, and the area (Ha) of Low Medium and High predicted suitability within each ecosystem.

Ecosystem	Low	Medium	High
Alpine	124	0	0
Blackbrush	185557	210145	19494
Bristlecone Pine	6378	859	327
Desert Riparian	10452	0	0
Mesquite Acacia	17109	363	2050
Mixed Conifer	14001	6249	7089
Mojave Desert Scrub	1232749	38862	2727

Ecosystem	Low	Medium	High
Pinyon Juniper	58707	33543	23590
Sagebrush	1604	2379	722
Salt Desert Scrub	70561	7550	11

Ecosystem Level Threats

Wildfire, development projects (e.g., roadways), and climate change represent the most relevant ecosystem threats for this species. While wildfires are part of the natural range of disturbance factors these snakes experience, a change toward sweeping, large-scale fires that threaten entire mountain systems would change the environmental conditions so dramatically that they could impact this species. Environmental forecasting related to some climate models indicate that western forests could be at risk of such changes (IPCC 2014). Ring-necked Snakes may also be vulnerable to the drying effects climate change may have on mesic microhabitats, including the desertification of riparian habitats (Nevada Wildlife Action Plan Team 2012).

Population Trends

There are no population level data available for this species (Wildlife Action Plan Team 2012). Population and community ecology studies are rarely conducted on small, fossorial snakes such as the Ring-necked Snake because of low recapture rates during surveys leading to high variability in density and survival estimates (Turner 1977; Parker and Plummer 1987; Vitt 1987, Riedle 2014).

Threats to Species

Because this species inhabits mountain island habitats, their populations are already fragmented, thus many of the surface-disturbing activities that threaten shrubland desert species are not relevant to this species. One study in eastern forests found that clear-cutting in pine forests reduced the relative abundance of Ring-necked Snakes and 5 other small snake species (Todd and Andrews 2008). Threats do exist from subsidized natural predators such as ravens and coyotes, and also feral, or free-ranging domestic species such as dogs and house cats.

Summary of Direct Impacts

The Ring-necked Snake is widely distributed on isolated mountain sky islands and riparian habitats, but uncommon, throughout Clark County. Ring-necked Snakes are known to occur in the MSHCP area, but most of their range is on mountain slopes and valleys above most development alternative energy development. There are approximately 3563 km^2 of high and moderate suitable habitat estimated by the qualitative model. Most of this habitat is located outside of the planning areas, however the greatest proportion is located within Conserved areas, with 19% of high and moderate habitat (Table 80). Very little habitat (0.1%) has already been disturbed, and only an additional 0.7% is in proposed Impact areas (Table 80).

Table 80. Categorized modeled habitat values (High, Medium, and Low) and the average area (Hectares) predicted in the potential impact areas, conservation areas, already disturbed areas, and overall area

Habitat Level	Impact	Conserved	Disturbed	Area (Hectares)
High	332	12345	174	56136
Med	2302	53742	230	300204
Low	115556	420904	36571	1608613

Existing Conservation Areas/Management Actions

The Nevada Wildlife Action Plan (Wildlife Action Plan Team 2012) considers the Ring-necked Snake to be a Species of Conservation Priority, and recommends developing monitoring protocols, determining occurrence and habitat functionality, and maintaining habitat and population connectivity. Ring-necked Snakes are also a species of Management Concern in Great Basin National Park. Although it has not yet been documented there, it is thought that suitable habitat exists within park boundaries (NPS 2014). The Clark County MSHCP considers this snake to be an Evaluation species of medium priority.

The Ring-necked Snake is not covered under the Spring Mountain Conservation Agreement. This agreement has been developed between various agencies to provide long-term protection for the rare and sensitive flora and fauna of the Spring Mountains National Recreation Area (USFS et al. 1998.)

EMTR - Southwestern Willow Flycatcher (Empidonax traillii extimus)

The Southwestern Willow Flycatcher is one of four recognized subspecies of *Empidonax trailii*. The *E.t. extimus* subspecies is a small (< 6 in total length) migratory generalist insectivore inhabiting riparian habitat in the southwestern United States (Kus et al. 2017). It is gray/green dorsally with a white throat, and olive-colored breast with the belly becoming yellow. The bill is dark on top, with a lighter-colored lower mandible. It breeds in May to June, primarily in riparian woodlands comprised of cottonwood (*Populous* spp.) and willow (*Salix* spp.), but also breeds in areas inundated with introduced salt cedar (*Tamarix* spp.) (Durst et al. 2008b). As with many species, there continues to be contention over the genetic justification for the distinction of the Southwestern Willow Flycatcher as a distinct “subspecies” (Paxton et al. 2008, Zink 2015, Theimer et al. 2016).

Species Status

In 1995, the Southwestern Willow Flycatcher was listed as endangered under the Endangered Species Act of 1973, three years after conservation organizations originally petitioned US Fish and Wildlife Service (USFWS) for the listing (USFWS 1995). In 2015, USFWS received a petition from the Pacific Legal Foundation requesting that the Southwestern Willow Flycatcher be delisted (USFWS 2016). In 2016, USFWS found that delisting may be warranted, based on information related to taxonomic status, but that a status review thoroughly evaluating all potential threats would need to be undertaken (USFWS 2016). The Southwestern Willow Flycatcher is also protected under the Migratory Bird Treaty Act (USFWS 2003).

US Fish and Wildlife Service Endangered Species Act: Endangered
US Bureau of Land Management (Nevada): Sensitive
US Forest Service (Region 4): Endangered
State of Nevada (NAC 503): Endangered
NV Natural Heritage Program: Global Rank G5T2 State Rank S1B
NV Wildlife Action Plan: SOCP
IUCN Red List (v 3.1): No status
CITES: No status

Range

The breeding range of the Southwestern Willow Flycatcher (subspecies *E. t. extimus*) includes southern California, Arizona, New Mexico, extreme southern portions of Nevada and Utah, far western Texas, perhaps southwestern Colorado, and extreme northwestern Mexico. This species winters from Mexico south to northwestern Colombia (USFWS 1995).

Population Trends

Populations of the Southwestern Willow Flycatcher have declined an estimated 75 to 90 percent over the last century (NatureServe 2009). Recent efforts to recover the subspecies are believed to be lessening the rate of decline, however, range-wide population trends are obscured by variations in annual survey effort and locations, making it difficult to determine if the population is increasing, decreasing, or stable (Sogge et al. 2003). The Southwestern Willow Flycatcher Breeding Site and Territory Summary documents all known Southwestern Willow Flycatcher breeding sites, and assembles data on population size, location, habitat, and other information for all breeding sites from 1993 through 2007 (Durst et al. 2008). These summaries show an increase in the number of known breeding locations over the survey period; however, this result is skewed by a recent increase in intensive survey efforts. Arizona, New Mexico, and California account for the greatest number of known Southwestern Willow Flycatcher breeding sites and territories. Nevada, Colorado, and Utah, combined, account for approximately 12 percent of territories, primarily because these states have few areas with breeding appropriate habitat occurring far enough south to fall within the willow flycatcher's range. In 2007, there were 13 known breeding sites and 76 known territories recorded in Nevada (Durst et al. 2008). The Nevada Department of Wildlife estimates there are 90 Southwestern Willow Flycatchers in the state, and assumes the trend is stable (Wildlife Action Plan Team 2012).

Habitat Model Review

There were four habitat models produced for the Southwestern Willow Flycatcher that are reviewed her; Boykin et al. 2008 (EPA), Crowe and Jaeger (NPS) 2010, SWCA (2010), and GBBO (2013).

The EPA model was part of a large modeling effort for 37 vertebrate species that was first produced in 2004 as a part of the SWReGAP analysis that modeled habitat for many species and was updated in 2008 (Boykin et al. 2008). The habitat modeling methods included a literature review to establish associations with habitat characteristics and plant alliances. Relevant environmental modeling layers were overlain and intersected sequentially resulting in habitat models (termed "deductive modeling" by Boykin et al. 2008). Models were then rendered at 30m and 250 m resolutions. These models were not based on occurrence points, and statistical estimations were not produced, therefore, they are not recommended for use in the upcoming Covered Species Assessments.

The NPS model focused on breeding habitat using data from surveys conducted on the Lower Colorado River within Nevada by the Bureau of Reclamation between 2006 and 2009 (Crowe and Jaeger 2010). MaxEnt Species distribution modeling software was used (Phillips et al. 2006) with model outputs predicted at 30 m resolution. The model was constructed using 201 flycatcher locations, that were thinned to 100 cells with observations at that resolution. Environmental layers included a riparian vegetation layer constructed from NDVI data from LANDSAT 5 imagery. Within this riparian habitat type, layers were also developed modeling vegetation density and biomass (and the variation in these), and distance to water. The number of environmental variables that were included was fairly limited and may not reflect the full complement of relevant ecological/environmental parameters for the species. The model is presented as continuous output and can be binned or scaled to desired classifications for later analysis as needed.

SWCA (2010) also created a habitat model for this species, but the model extent was limited to the Virgin river corridor between Lake Mead and the Border between Nevada and Utah (SWCA 2010). Approximately 50 flycatcher nests/territories were identified in the area and have been located across multiple years. Methods for modeling were similar to those illustrated for other species in this report, where remote sensing products were used to classify vegetation. Vegetation classification was conducted using a series of remote sensing datasets, and ISDODATA classification techniques to bin vegetation into 24 cover type classes. Samples from another survey were used to combine some of the cover classes. This reduced the number to 17 classes. Structure types were added with multiple field surveys and assessments to yield a final combination of 35 vegetation community/structure type combinations with 81% accuracy. Habitat designations were assigned into three categories (breeding habitat, potential breeding habitat, marginally suitable habitat) by determining which vegetation classes constituted these assignments via an expert opinion assignment method. The expert opinion was based on information from reported literature, much as the EPA modeling method. The resulting model is a polygon-based shapefile output that is binned as one of the three habitat types for this species.

GBBO (2013). The Great Basin Bird Observatory used 10-minute point counts at 316 transect sites, with 10 points on each transect. 1045 individual visits were conducted between 2008 and 2013, and presence was recorded for nine focal bird species. Flycatchers were detected within the lowland riparian stratum, where a total of 47 of the 317 transects were located. Further surveys were conducted in 2012 at 32 additional sites. A total of 4 Southwest Willow Flycatchers were observed. For each transect the density was calculated by calculating detection rate over the area surveyed. Of these sites only four yielded Flycatchers. Density estimates were calculated at 0.1 birds per 40 ha, and this density too low to provide a meaningful distribution map/prediction.

Among all four studies the NPS model is likely the most useful as it relied on occurrence data and statistical estimation of habitat, without the potential of bias due to expert opinion delineation. This model covers the full extent of potential habitat in the County at a fine resolution. However, the number of environmental layers used in the model construction may be a limiting factor, for example, measures of temperature, or nesting specific structural needs were not explicitly included. In addition, none of the models report accuracy using withheld datasets, and it would be useful to evaluate this on a larger combined dataset from all localities available.

Distribution and Habitat Use within Clark County

In Clark County, the Southwestern Willow Flycatcher can be found in isolated pockets of the Colorado River drainage, the Las Vegas Wash, the Virgin River above Lake Mead, and the Muddy River (Nevada Partners in Flight 1999). They are reported from four of the seven Important Bird Areas of Clark County; Lake Mead, Moapa Valley, Spring Mountains, and Virgin River (McIvor 2005). However, breeding has only been confirmed in riparian habitat along the Virgin River and along the upper and lower Muddy River (Krueger 2007). Preferred breeding habitat includes dense vegetation near watercourses or wetlands, and in southern Nevada, preferred vegetation includes willow (*Salix* spp.), cottonwood (*Populus* spp.), salt cedar or tamarisk (*Tamarix* spp.), and Russian olive (*Eleagnus angustifolia*) (Krueger 2007). Modeled habitat for this species is limited in area within Clark County, and occurs exclusively within the Desert Riparian ecosystem (Table 81)

Table 81. Ecosystems within Clark County, and the area (Ha) of Low Medium and High predicted suitability within each ecosystem

Ecosystem	Low	Medium	High
Alpine	0	0	0
Blackbrush	0	0	0
Bristlecone Pine	0	0	0
Desert Riparian	518	193	30
Mesquite Acacia	12	0	0
Mixed Conifer	0	0	0
Mojave Desert Scrub	18	2	0
Pinyon Juniper	0	0	0

Ecosystem	Low	Medium	High
Sagebrush	0	0	0
Salt Desert Scrub	0	0	0

Ecosystem Level Threats

Threats to Southwestern Willow Flycatcher habitat include removing, thinning, or destroying riparian vegetation (USFWS 2002). Riparian ecosystems have declined throughout the southwest from reductions in water flow, interruptions in natural hydrological events and cycles, physical modifications to streams, modification of native plant communities by invasion of exotic species and grazing of livestock, and direct removal of riparian vegetation, including habitat modifications resulting from water diversions and groundwater pumping, which can alter the structure of riparian vegetation and flood plains (USFWS 2002, Brodhead et al. 2007). While salt cedar appears to have lower preference by breeding birds (Brodhead et al. 2007), there appears to be no effect on nutritional condition of birds breeding in habitat invaded by salt cedar (Owen et al. 2005).

Fire is also a threat to riparian ecosystems. Many native riparian plants are not fire-adapted and recover poorly following fire events (USFWS 2002). Fires in riparian habitats are typically catastrophic, causing immediate and drastic changes in riparian plant density and species composition.

Development of land for agriculture can also pose a significant threat to riparian ecosystems. Agricultural development not only impacts this ecosystem through direct clearing of riparian vegetation, but additional impacts may result when floodplains are re-engineered (e.g., draining, protecting with levees) to divert water for irrigation, and through groundwater pumping. The use of herbicides and pesticides on these lands may also affect the ecosystem (USFWS 2002, Brodhead et al. 2007).

Threats to Species

This subspecies has declined because of overstocking or other mismanagement of livestock, habitat loss, and recreational development. In addition to the above threats, the Southwestern Willow Flycatcher is also subject to cowbird parasitism (USFWS 1995, Brodhead et al. 2007). Brood parasitism has been cited as a significant threat to this species, with 20-30% of nests being parasitized (Brodhead et al. 2007). Brood parasitism by brown-headed cowbirds (*Molothrus ater*) negatively affects the flycatcher by reducing reproductive performance. Parasitism typically results in reductions in number of flycatcher young fledged per female per year (USFWS 2002). Cowbirds are increasingly abundant in floodplains and areas of increased grazing, and modified habitats with increased edge-of-habitat patches are also associated with increased nest parasitism (Brodhead et al. 2007), Additionally, since Southwestern Willow Flycatcher population numbers are small in any given area (largely due to the infrequency of large patches of suitable habitat), they are highly susceptible to stochastic environmental factors. A single severe weather event can reduce a small population below a threshold level from which it cannot recover (USFWS 2002). Sex biases have also been reported in small declining populations, where they are in some cases male biased, and in others female biased, and these severe biases may have conservation and management implications as different management techniques may be required for recovery (Kus et al. 2017).

Existing Conservation Areas/Management Actions

USFWS' Southwestern Willow Flycatcher Recovery Team Technical Subgroup prepared a final recovery plan for the Southwestern Willow Flycatcher. The Southwestern Willow Flycatcher Recovery Plan's main objectives are to increase and improve occupied, suitable, and potential breeding habitat; increase metapopulation stability; improve demographic parameters; minimize threats to wintering and migration habitat; survey and monitor; conduct research; provide public education and outreach; assure implementation of laws, policies, and agreements that benefit the flycatcher; and rank recovery progress (USFWS 2002).

In 2013, as required by the Endangered Species Act of 1973, USFWS designated approximately 1,975 stream kilometers (1,227 stream miles) in Arizona, California, New Mexico, Nevada, and Utah as critical habitat for the Southwestern Willow Flycatcher. This included the lateral extent of each stream segment (the riparian areas and streams that occur within the 100-year floodplain), for a total area of approximately 84,569 hectares (208,973 acres) of critical habitat. Critical habitat within Clark County, Nevada is limited to a 48.4 km (30.0 mi) segment of the Virgin River running from the Arizona border to Colorado River Mile 280 at the upper end of Lake Mead. The 3.1 km (1.9 mi) segment of the Muddy River within the Overton State Wildlife Area in Clark County was also identified as essential to flycatcher conservation, but was excluded from the critical habitat designation because the State of Nevada is already managing riparian habitat within the wildlife area for the flycatcher. This 2013 critical habitat designation was a revision of earlier critical habitat rules from 2005 and 1999 (USFWS 2013).

The Nevada Wildlife Action Plan (NWAP) identifies the Southwestern Willow Flycatcher as a Species of Conservation Priority, and recommends: protecting nesting habitat from disturbances, degradation, and conversion; restoring lost or degraded riparian habitat to a willow-dominated condition; phasing restoration projects to avoid the removal of large amounts of tamarisk before suitable replacement habitat is created; and continuing intensive monitoring efforts to track population trends (Wildlife Action Plan Team 2012). The plan notes that USFWS, BLM, NPS, Forest Service, Nevada Department of Wildlife (NDOW 2008), and other entities have already conducted extensive surveys for the flycatcher (2012).

The Nevada Comprehensive Bird Conservation Plan, prepared by the Great Basin Bird Observatory (GBBO 2010) also recommends the approach described by NWAP summarized above (2012). In addition, GBBO's plan recommends: developing strategies to address the potential loss of current tamarisk breeding habitat to biocontrol agents, and developing comprehensive fire management strategies to protect important breeding habitat (GBBO 2010). The NV Comprehensive Bird Conservation Plan is a revision of the Nevada Partners in Flight Bird Conservation Plan (1999). The original plan stated an objective of establishing between 40 and 50 successful breeding pairs in suitable habitat in Nevada by 2010, but the revised plan does not have specific population objectives.

One of the goals of the conceptual management plan for the Overton Wildlife Management Area (OWMA) is to protect and enhance habitats and populations of endangered species, including the Southwestern Willow Flycatcher (NDOW 2014). Specific objectives within the plan related to this subspecies include: monitoring changes in population; protecting, enhancing, and/or restoring habitat, emphasizing diverse, healthy, and naturally-functioning habitats; and coordinating and collaborating with NDOW's conservation partners. Actions listed in the plan related to the Southwestern Willow Flycatcher include: planting new cottonwoods and willows on the lower reaches of the Muddy River and in habitat where biological vegetation control has taken place; conducting surveys and inventorying existing and potential habitat and assessing for habitat suitability; maintaining wet soils and/or inundated area from May 1 through August 1 within breeding sites; and increasing the removal of tamarisk and replacing with plantings of cottonwood and willows (NDOW 2014).

This subspecies is also covered under the Lower Colorado River Multi-Species Conservation Program. The goal of this program is to conserve habitat of threatened and endangered species and reduce any additional species being listed; accommodate present water diversions and power production; and provide the basis for incidental take authorizations (Lower Colorado River Multi-Species Conservation Program 2004).

In addition, the Southwestern Willow Flycatcher is covered under the Spring Mountain Conservation Agreement USFS 1998). This agreement has been developed between various agencies to provide long-term protection for the rare and sensitive flora and fauna of the Spring Mountains National Recreation Area.

Summary of Direct Impacts

The Southwestern Willow Flycatcher is a rare summer resident of Clark County. Approximately 20 km^2 of modeled habitat (Crowe and Jaeger 2010) exists within the County (Table 82), although the proportion of this that is suitable for willow flycatcher nesting is estimated to be less. Because of the limited amount of potential habitat, covered activities have the potential to adversely affect this species in Clark County. It is estimated that approximately 34% of high and moderate suitability within the county could be could be impacted by activities covered under the Amendment, while 13% is already disturbed, and only 14% of the combined habitat is located within conservation areas (Table 82).

Table 82. Categorized modeled habitat values (High, Medium, and Low) and the average area (Hectares) predicted in the potential impact areas, conservation areas, already disturbed areas, and overall area

Habitat Level	Impact	Conserved	Disturbed	Area (Hectares)
High	10	4	6	30
Med	68	28	23	197

Habitat Level	Impact	Conserved	Disturbed	Area (Hectares)
Low	179	67	40	550

ENAR - Silverleaf Sunray (Enceliopsis argophylla)

Silverleaf Sunray (*Enceliopsis argophylla*) is a silvery gray plant that grows in sparsely vegetated, low elevation country on soils where few other plants grow. They have relatively large leaves, a thick tap root, and the flowers rise on leafless stalks with a large yellow sunflower-like inflorescence. They are spectacular to see thriving in such a hot environment. The silvery leaf surfaces of *E. argophylla* stems result from small plant hairs known as trichomes that occur on the surface of the leaves (Ehleringer 1984) and protect the plants from over-exposure to the strong desert sunlight in the very sparse environments they inhabit. The dense, straight-haired trichomes (Cronquist et al. 1994) reduce incidental solar radiation and are known to reduce temperature, thus influencing photosynthetic and transpiration rates (Ehleringer 1984). This species was formerly known as *Tithonia argophylla* (Cronquist 1994). The type locality for this species is reportedly near St. Thomas, Nevada and has been mostly under the surface of Lake Mead for almost 80 years (Cronquist 1994). This species has been found on gypsum deposits and sandy soils, and even in roadsides where the correct soils exist (i.e. along a roadside in Lake Mead National Park).

Researchers sampled pollinators of Silverleaf Sunray on either side of Lake Mead in Mohave County, California and Clark County, Nevada. One bee species that visited the plants included an obligate specialist *Andrena balsamorhizae* to this *Enceliopsis* (Griswold et al. 2006). Other bees that visited *Enceliopsis argophylla* but do not specialize on it included: *Xeralictus bicuspiadariae, Perdita meconis, P. mohavensis, Lasioglossum sisymbrii,* and an undetermined species of *Lasioglossum.* (Griswold et al. 2006).

As with some other ground-nesting bees (Cane 1992), the Mojave Gypsum Bee (*Andrena balsamorhizae)* has a restricted distribution by its need for gypsum soils, and also limited by its dependence on *Enceliopsis argophylla* as a floral host. The young of *Andrena* are provisioned with pollen only from *Enceliopsis argophylla* (Griswold et al. 2006). While nurturing the young requires *Enceliopsis* pollen, the adults may nectar on a variety of other flower species. *Andrena* is a MSHCP listed Species of Concern. *Andrena* go through one generation during the active season and adults have been collected from 12 March to 7 May (Griswold et al. 2006).

The Mohave Poppy Bee (*Perdita meconis*) also uses *Enceliopsis argophylla*. It is a Species of Concern in the MSHCP, and limited in distribution by its floral host (Griswold et al. 2006). This endemic species to the eastern Mojave Desert is known primarily from Clark County, Nevada, but also known at several sites within five miles of Kelso, in San Bernardino County, California, and a single site southeast of St. George, Utah (Griswold et al. 2006). The Mojave Poppy Bee occupies creosote bush/mixed shrub communities (Griswold et al. 2006). This species' activity period is limited to a single annual generation whose adult phase is active from mid-April to early June. It is presumed that this species is a ground nester as all other congeners are (Griswold et al. 2006). As their name implies, these rare bees are specialists on large poppy species including *Arctomecon californica* (endemic to Clark County, Nevada), *A. humilis* (endemic to southwest Utah, near St. George), and a widespread *Argemone* sp. (prickly poppy) found extensively in roadsides across the desert – well beyond the range of this bee. *Perdita meconis* has not yet been found on *Arctomecon merriami* in Death Valley or elsewhere. Much is still not known about this bee species. For example, the nesting substrate is unknown. More work is required to understand the ecology of this bee and how important it is to the *Enceliopsis argophylla*.

Perdita mohavensis was found on Silverleaf Sunrays, but is generally known as a floral specialist on *Arctomecon* (Griswold et al. 2006). Thus it uses *Enceliopsis* (e.g. for nectar), but requires *Arctomecon* for some aspect of its life history for survival.

Species Status

US Fish and Wildlife Service Endangered Species Act: Not listed
US Bureau of Land Management (Nevada): No Status
US Forest Service (Region 4): No Status
State of Nevada (NAC 527): No Status
NV Natural Heritage Program: Global Rank G2G3 State Rank S1?
IUCN Red List (v 3.1): No status
CITES: No status

Range

Silverleaf Sunray is a rare plant reportedly found in Clark County, Nevada; Washington County, Utah (Cronquist 1994); and Mohave County, Arizona (McDougall 1973, Morefield 2001, Griswold 2006). McDougall (1973) erroneously reported *Enceliopsis argophylla* for San Bernardino Co., California (explorer.natureserve.org accessed on internet 19Nov2016).

Population Trends

No information on population trends is available for this species.

Habitat Model

Silverleaf Sunray localities used for modeling (N=230) were generally distributed within the Lake Mead National Park and surrounding BLM lands to the east of the Las Vegas Valley. Habitat predictions for this species from the three modeling algorithms differ somewhat in their extent, with both the GAM and RF models including some predicted habitat outside the general perimeter of the known localities. Suitable habitat is predicted along the eastern Lake Mead shore lines in Gold Butte National Monument, and the Eldorado Valley area south of Boulder City, with additional patches predicted along the Colorado River (Figure 123). The MaxEnt model predicted a very restricted habitat, with only a few sparse areas of moderate habitat suitability predicted outside the extent of the known localities (Figure 123). Model performance was highest for the RF models, with the exception of the fixed Boyce Index, which was highest in the Ensemble Model (Table 83). The Ensemble model was the second highest ranked model, with the GAM and MaxEnt models ranking similarly. Relative to the MaxEnt model, the GAM had higher correlation and BI scores, while MaxEnt had the higher AUC and TSS (Table 83). Continuous Boyce Indices (CBI) for the GAM and RF models indicated good predictive performance, however the MaxEnt model had a much earlier peak, with erratic performance at habitat suitability values from ~ 0.4 to 0.6 (Figure 125). The Ensemble CBI indicated good performance with a couple fluctuations, and a threshold value near 0.43, which was similar to the PRBE Cutoff score (Table 83). Standard errors for the GAM model was largely limited to moderate levels (SE 0.04 - 0.06) in the Eldorado Valley and the southern boundary of Gold Butte (Figure 124). The MaxEnt model had low error along the eastern Overton Arm of the Lake Mead shoreline in Gold Butte, with few other areas indicated. The RF model had moderately higher error near Echo Bay, and the southernmost boundary of Gold Butte. The Ensemble model had broader expanses of low/moderate error throughout the predicted habitat area (Standard Error map for the Enceliopsis argophylla ensemble model.).

These patterns may indicate true error in the models, however, they may also indicate habitat that could be, but has not yet been exploited by this species. Alternatively, the absence of Silverleaf Sunray in the habitats where the models indicate suitability may indicate that the species once existed in some of the areas, but has since been extirpated by incompatible land uses. It is also likely that the species once occupied some of the areas that were inundated by the creation of Lake Mead. However, this does not explain the predicted suitable habitat further downriver and below the dam. And it is seems unlikely that Silverleaf Sunray occur in the Eldorado Valley at present given the extensive biological surveys that have been completed in relation to the Clark County MSHCP and recent construction projects in that area. Similarly, it appears likely that this species' former habitat potentially extended further west from current known localities – an area now occupied by mostly impermeable surfaces of the municipalities within the Las Vegas Valley.

Table 83. Model performance values for *Enceliopsis argophylla* models

Performance	GAM	RF	MaxEnt	Ensemble
AUC	0.973	0.987	0.98	0.987
BI	0.698	0.74	0.596	0.766
TSS	0.89	0.948	0.911	0.935
Correlation*	0.877	0.921	0.824	0.906
Cut-off**	0.6	0.56	0.165	0.45

*point bi-serial correlation
**threshold at which sum of sensitivity (true positive rate) and specificity (true negative rate) is highest

Table 84. Percent contributions for input variables for *Enceliopsis argophylla* for ensemble models using GAM, MaxEnt, and RF algorithms

Term	GAM	RF	Max	Avg
Winter Min Temperature	44.2	21.2	37.4	45.3
Summer Max Temperature	13.2	16.6	44.8	33.5
Gypsum potential	27.9	13.7	7.0	23.3
NDVI Maximum	6.6	11.0	3.0	12.6
Temperature Range	8.0	8.9	3.1	11.3
Annual Heat/Moisture Index	0	9.1	1.0	8.1
Surface Texture (ATI)	0	6.6	3.6	6.8
Winter Precipitation	0	6.2	0.1	5.4
Slope	0	4.5	0	3.9
Heat Load Index (HLI)	0	2.2	0.1	2.0
Roughness (TRI)	0	0.0	0	0

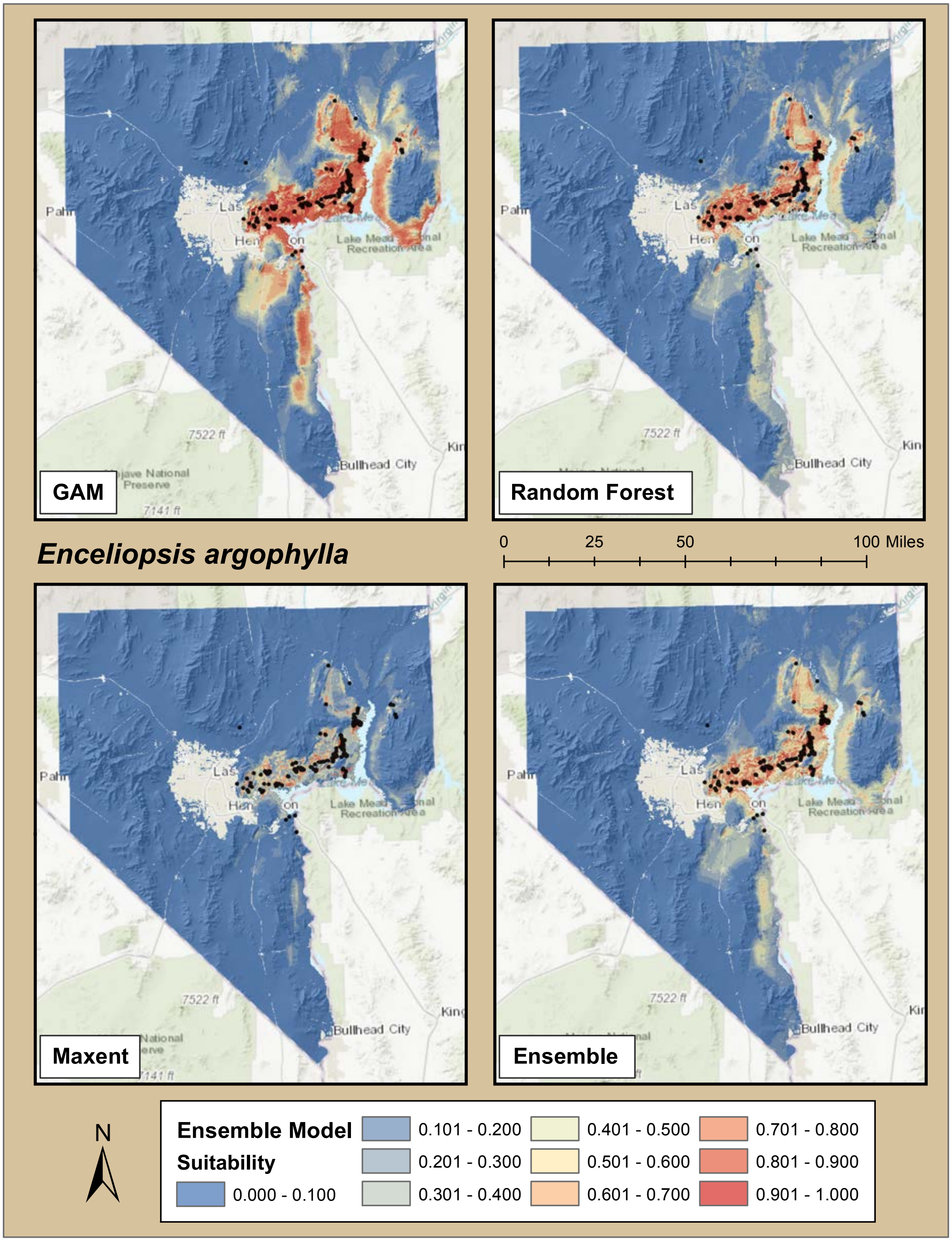


Figure 123. SDM maps for *Enceliopsis argophylla* for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right). Black dots indicate presence points.

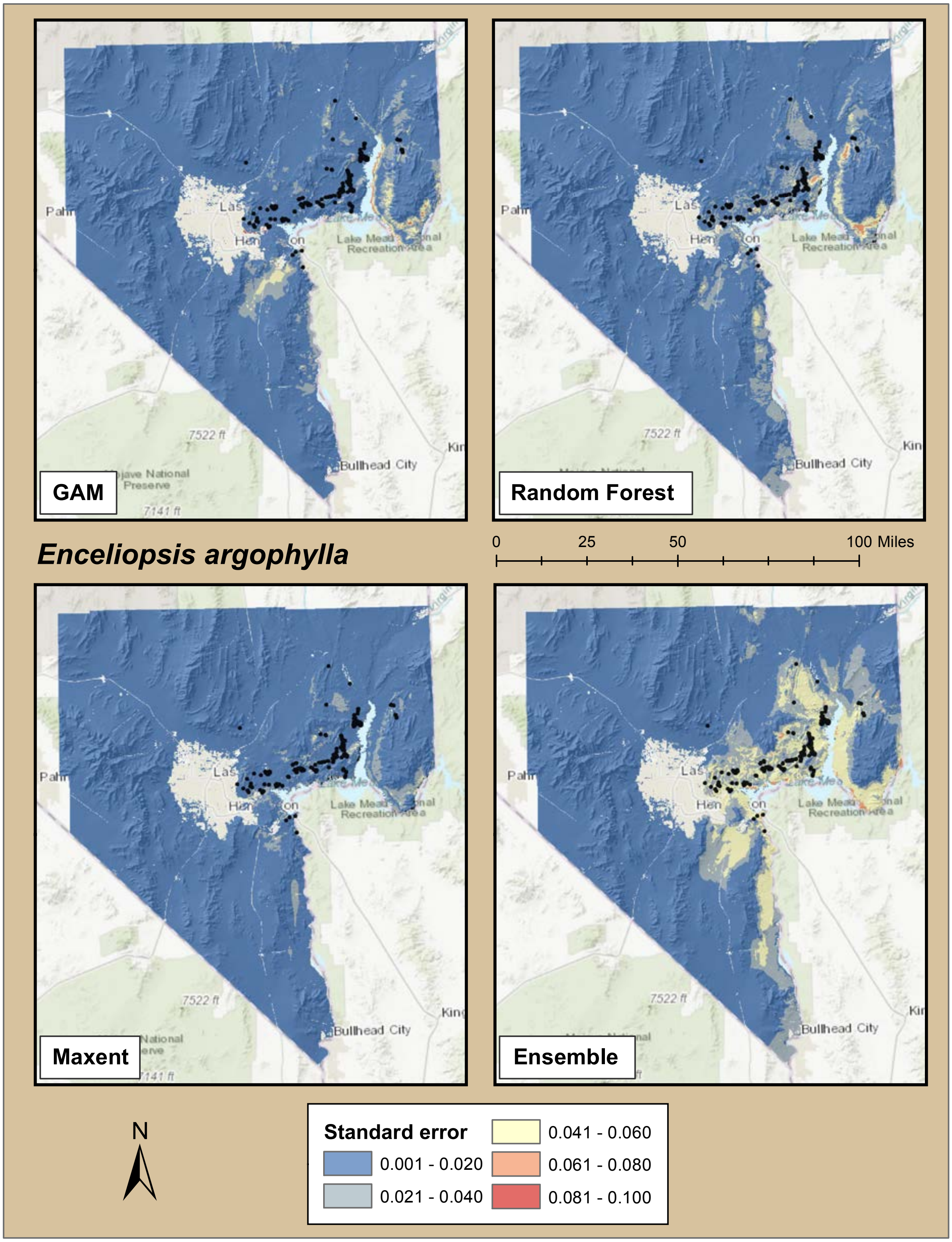


Figure 124. Standard error maps for *Enceliopsis argophylla* models for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an Ensemble model averaging the three (Lower Right).

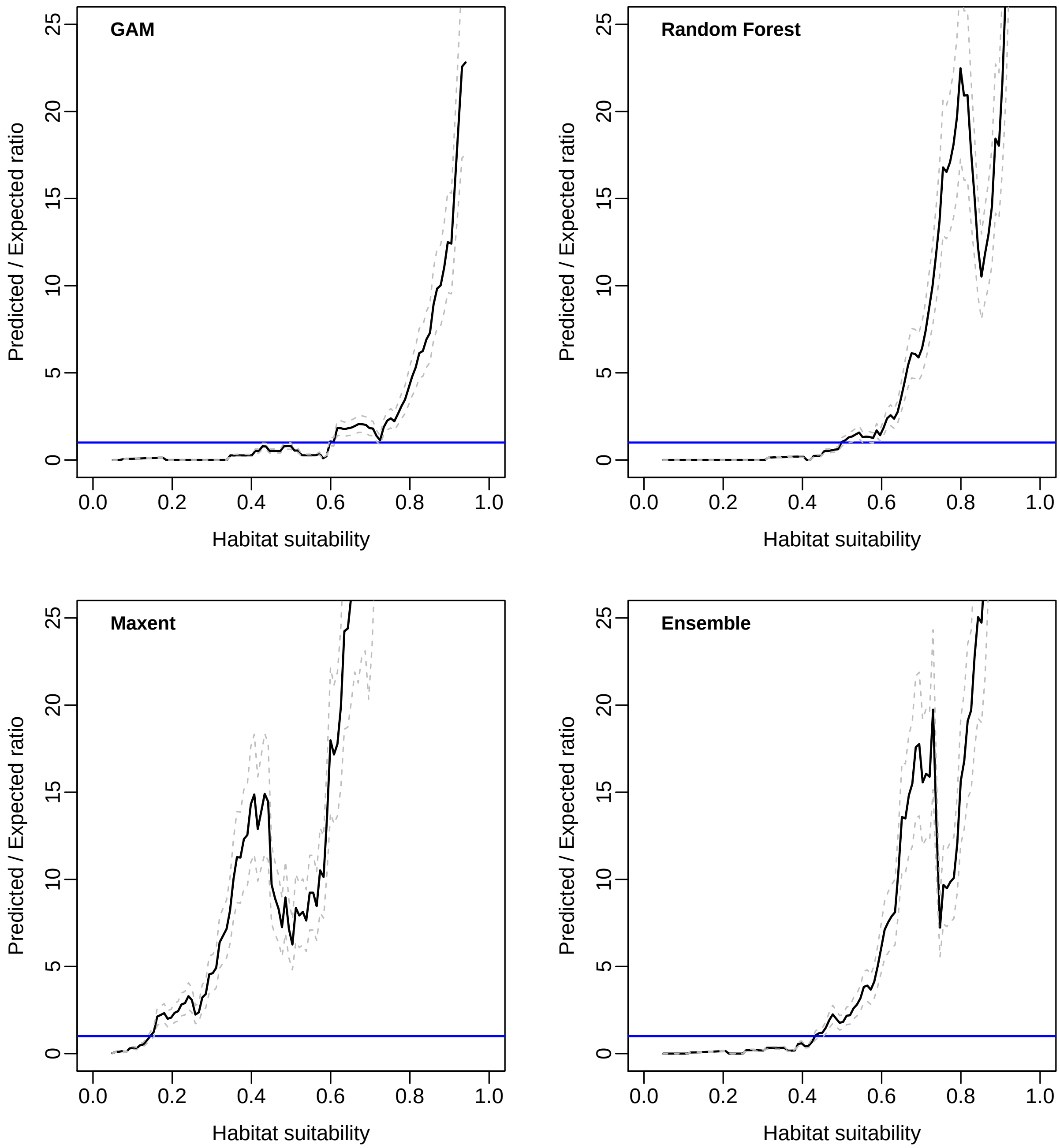


Figure 125. Continuous Boyce Indices for *Enceliopsis argophylla* models for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an Ensemble model averaging the three (Lower Right).

GAM Model

Five of the 11 environmental layers contributed ~ 8% or more to the model, collectively accounting for 99% of model contributions (Table 84. Winter Minimum

Temperature was by far the largest contributor to the model, with 44% explained variance. Winter Minimum Temperature was positively related to predicted habitat suitability, with the association becoming positive in areas where temperatures were above ~1ºC. Gypsum Potential contributed 27%, and was positively associated with suitability at all levels (Figure 126). Summer Maximum Temperature accounted for 13% of the model, predicting positive habitat with a peaked response above 35 ºC and peaking near 39 ºC. Temperature Range was also positively associated with predicted habitat suitability, while increases in NDVI Maximum were negatively associated with habitat suitability (Figure 125).

Habitat for the species as predicted in the GAM models was high (> 0.8) and contiguous through the northern shoreline of Lake Mead and in the adjoining BLM lands, and throughout Valley of Fire State Park up to Logandale and Glendale. Moderately high values (> 0.7) were predicted along the eastern shoreline of the Overton Arm of Lake Mead in the Gold Butte National Monument. Moderate habitat (~ 0.5) was also predicted in Eldorado Valley, and along the western shoreline of the Colorado River southward through Cottonwood Cove and Lake Mohave (Figure 123). The GAM model SE was moderate (0.04 - 0.06) in a patch in the Valley of Fire State Park area, and on the southern border of Gold Butte National Monument, with a few patches of lower habitat suitability in Eldorado Valley (0.02 - 0.04), and the northern Lake Mojave shoreline (Figure 124).

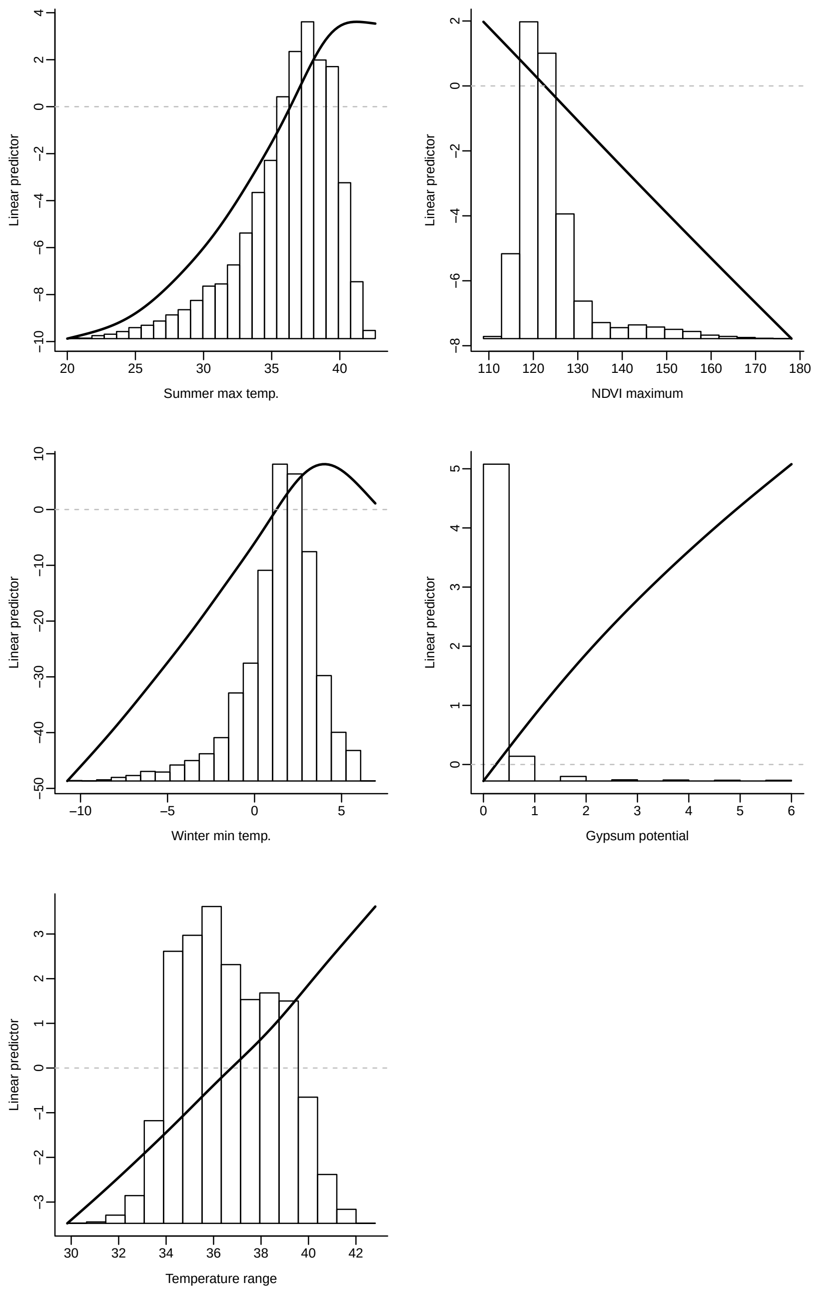


Figure 126. GAM partial response curves for the *Enceliopsis argophylla* model illustrated over the distribution of environmental variable inputs in the study area.

MaxEnt Model

There were only two variables contributing 10% or more to the model, accounting for 82% of total model contribution (Table 84). Winter Minimum Temperature (37%) and Summer Maximum Temperature (44%) were by far the largest drivers in the model, and both had nearly the same relative response with habitat showing a peaked response relative to Maximum Winter Temperature at 5 ºC, and for Maximum Summer Temperature at 40 ºC. Each had low probabilities of habitat suitability below peak values. NDVI Maximum (9% contribution) was negatively associated with predicted habitat suitability (Figure 127).

Predicted habitat suitability area for the MaxEnt model was extremely limited, with higher levels of habitat suitability predicted only near the modeling localities, and with little continuity of habitat within the habitat area (Figure 127). The standard error map for this algorithm indicated minimal error near Valley of Fire, southern Gold Butte, near Eldorado Valley and one area near the Colorado River corridor (Figure 124).

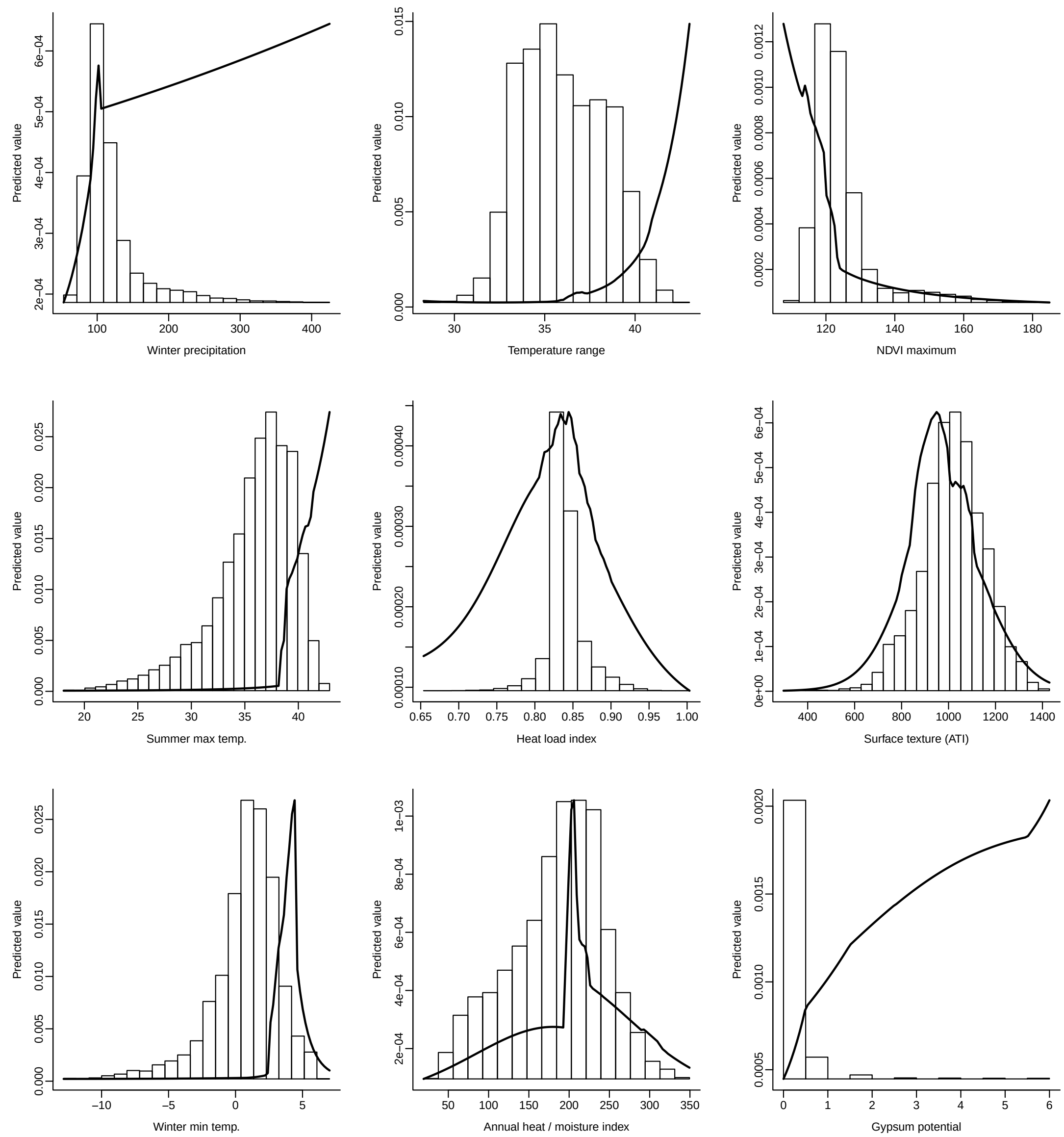


Figure 127. Response surfaces for the top 9 environmental variables included in the MaxEnt ensemble model for *Enceliopsis argophylla*.

Random Forest Model

The RF models had six environmental variables contributing ~ 9% or more totaling 80% of total model influence. Winter Minimum Temperature and Summer Maximum Temperature had similar partial curves to that seen in the MaxEnt model, with a sharp peaked response at higher values of both Winter Minimum and Summer Maximum temperatures reflecting the apparent preference for warmer habitats for this species (Figure 128), NDVI Maximum was negatively associated with predicted habitat occurring only at the lowest NDVI levels, indicating low vegetation density where habitat for this species was predicted. Gypsum Potential was strongly and positively associated with predicted habitat suitability as was the Annual Heat/Moisture Index (Figure 128).

Standard error had low (0.02 – 0.04) to moderate (0.04 – 0.06) values broadly in Eldorado Valley, along the shoreline on the east side of the Overton Arm of Lake Mead, southern Gold Butte, and the lower Colorado River (Figure 124). There were patches of higher error values (0.06 – 0.08) near Echo Bay, and Southern Gold Butte.

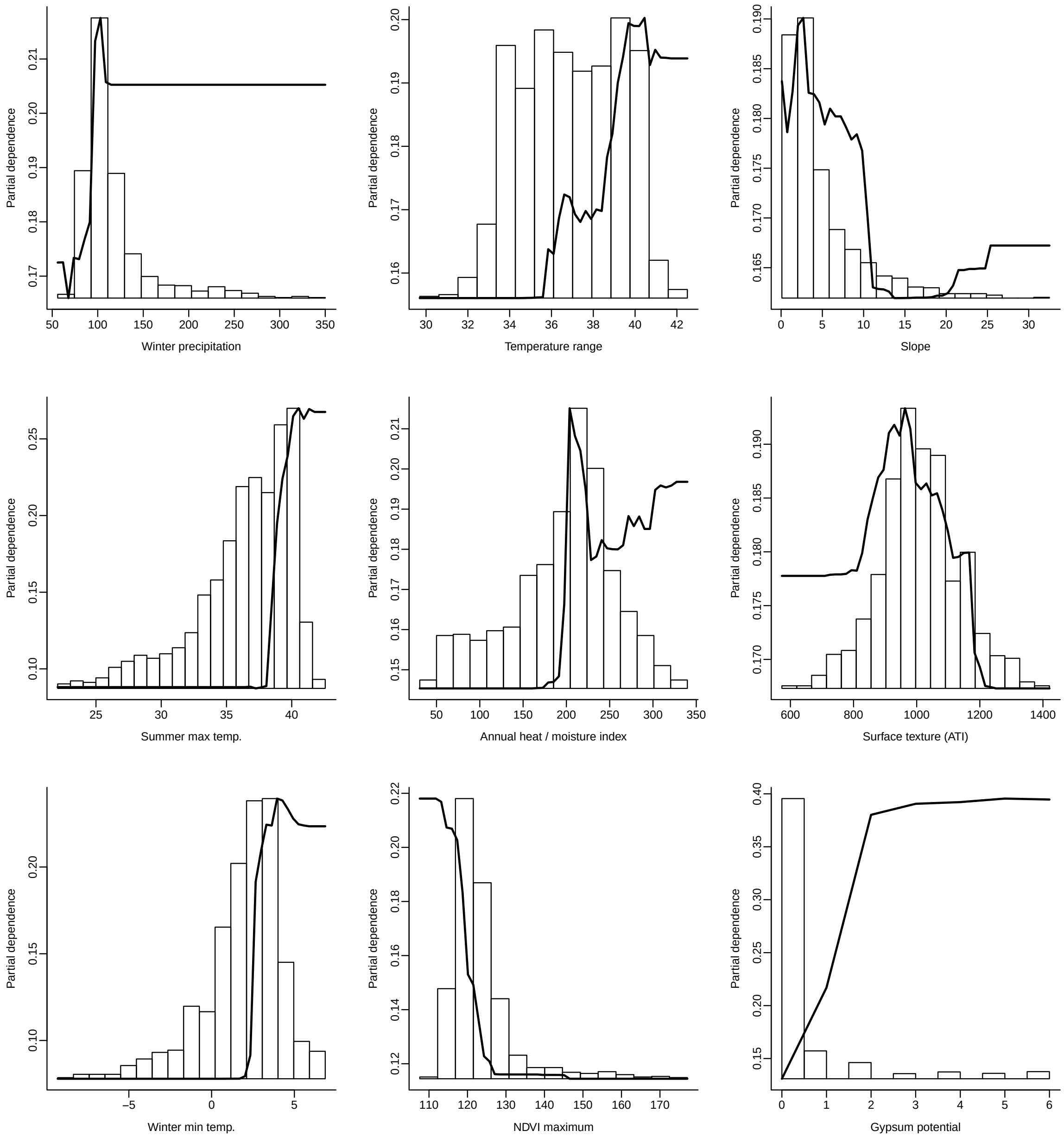


Figure 128. Response surfaces for the environmental variables included in the RF ensemble model for *Enceliopsis argophylla.* Histograms represent the range of each environmental variable across the x-axis, and predicted dependence relative to habitat suitability values are on the y-axis.

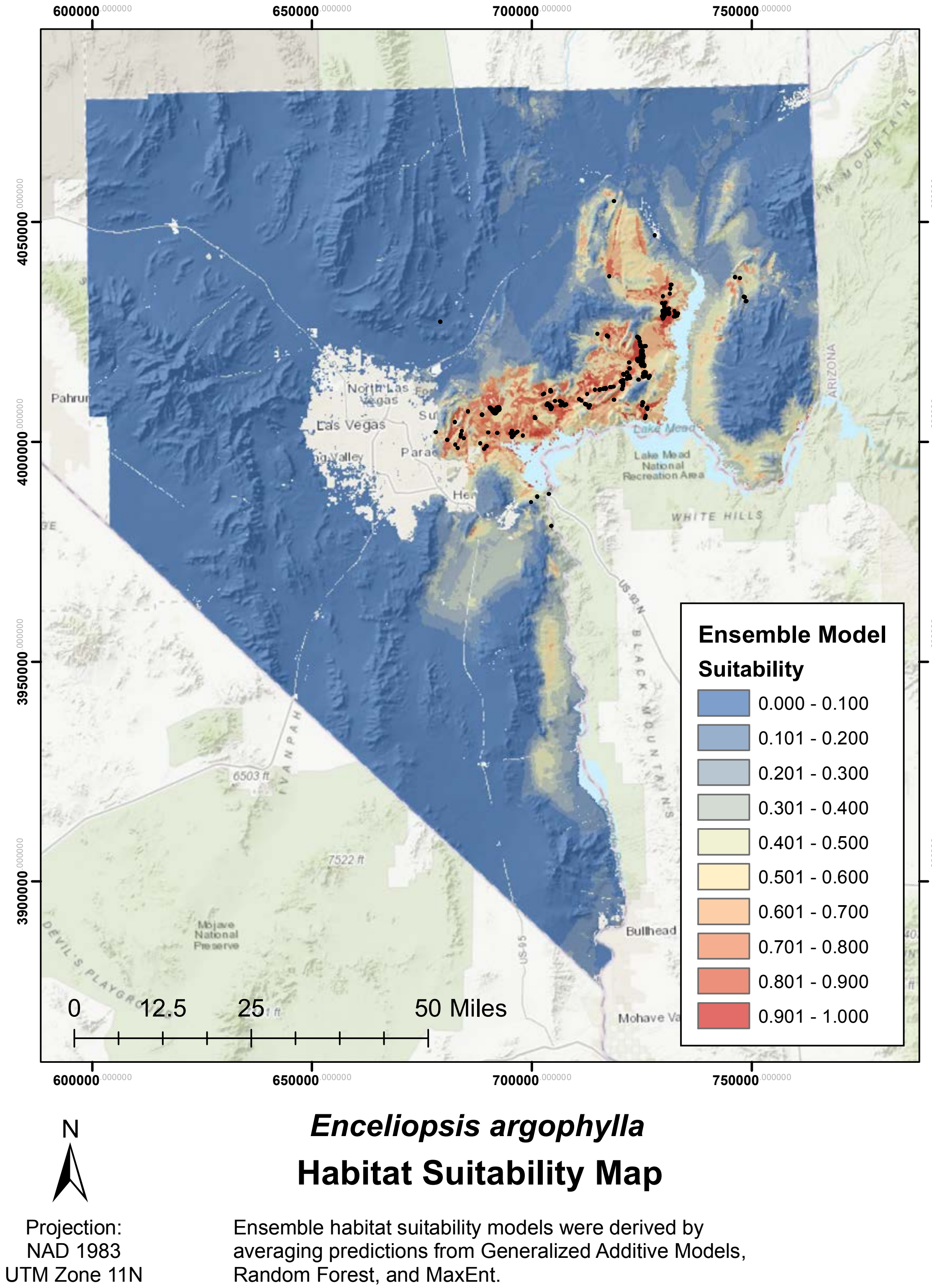


Figure 129. SDM map for the *Enceliopsis argophylla* ensemble model.

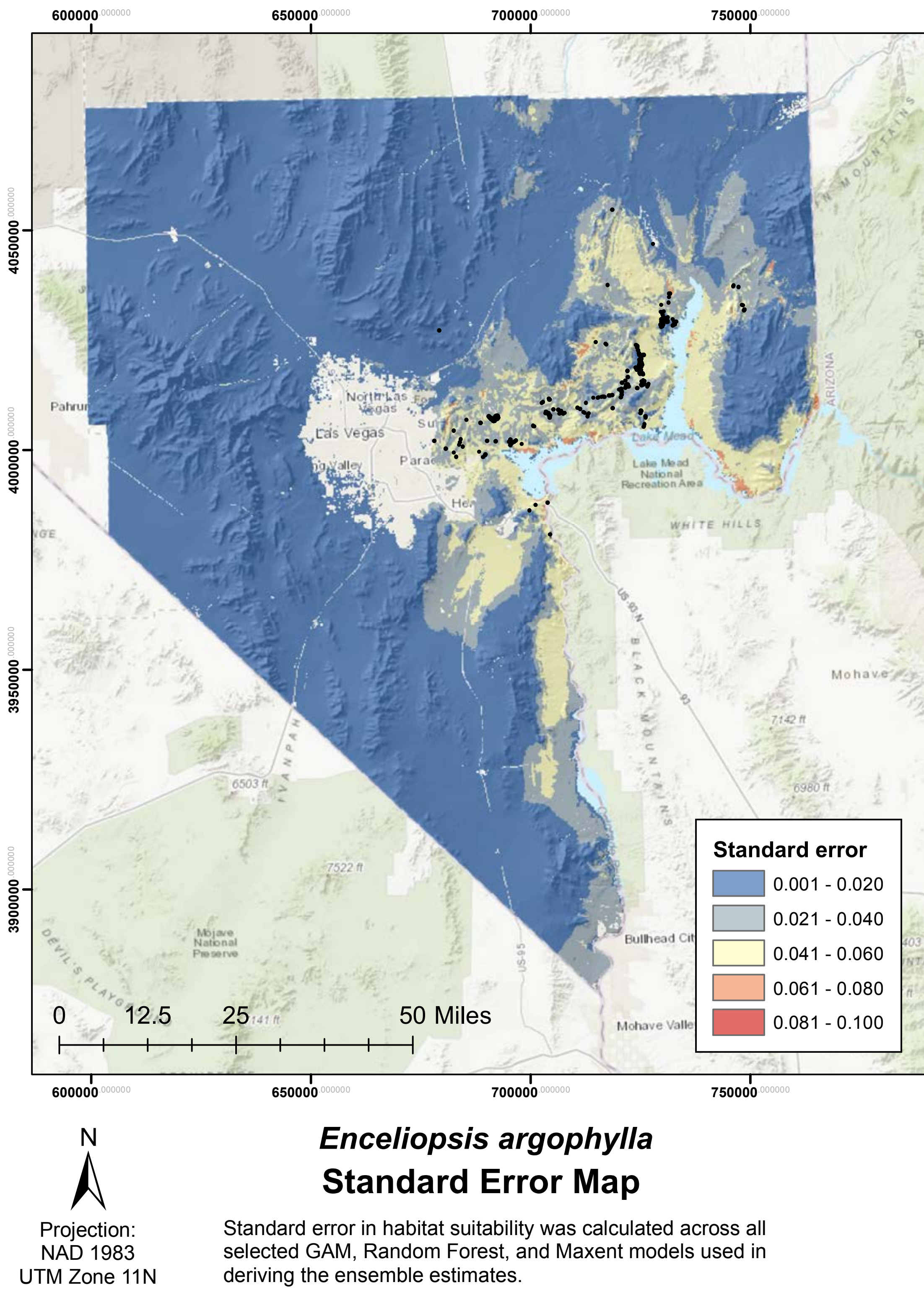


Figure 130. Standard Error map for the *Enceliopsis argophylla* ensemble model.

Distribution of Localities

Silverleaf Sunray habitat was modeled using 230 localities within the county, which were clustered within the North Shore and Overton areas of Lake Mead (Figure 129). There were few points outside this area, including northern Gold Butte National Monument, and in the upper extents of the Muddy River valley (Figure 129). Geographic thinning to reduce influences of spatial bias reduced this to 148 localities for modeling runs.

Standard Error

Moderate levels of SE (0.04 – 0.06) are in larger expanses in Eldorado Valley, Valley of Fire, the Gold Butte and Lake Mead shore lines, and in the predicted habitat areas immediately north of the bulk of the localities (Figure 130).

Distribution and Habitat Use within Clark County

The species is rare and known only to occur in Clark County in southern Nevada, from the River Mountains east of Henderson to Echo Bay and the Las Vegas Wash within the Lake Mead National Recreation Area (Kartesz 1988). It occurs on clay and gypsum cliffs and on gravelly slopes. It is very similar in appearance to *Enceliopsis covillei*, which occurs west of Boulder Dam, and extends up to Valley of Fire State Park within Clark County, but lives on gravel and clay banks and cliffs and has longer flowers (Kartesz 1988). The highest suitability habitat for this species is predicted to be within the Mojave Desert Scrub ecosystem, with very little habitat in any other ecosystem, even for moderate habitat (Table 85). Some, but limited moderate habitat is also predicted for areas in lower Salt Desert Scrub ecosystems.

Modeled Habitat in the county is predicted to be high in the areas generally surrounding the localities, with extensions of predicted habitat (without confirmed localities) in the area around Valley of Fire, extending to Glendale. and up to the Logandale area. Pockets of lower level habitat (0.5 – 0.6) are predicted in other areas in the county (e.g., Eldorado Valley, the Gold Butte shoreline, and lower valleys in the Colorado River corridor near Nelson’s Landing and Lake Mojave) (Figure 129).

Table 85. Ecosystems within Clark County, and the area (Ha) of Low Medium and High predicted suitability within each ecosystem.

Ecosystem	Low	Medium	High
Alpine	124	0	0
Blackbrush	415465	0	0
Bristlecone Pine	7565	0	0
Desert Riparian	9775	591	158
Mesquite Acacia	17887	892	932

Ecosystem	Low	Medium	High
Mixed Conifer	27339	0	0
Mojave Desert Scrub	1025131	184137	72109
Pinyon Juniper	115902	0	0
Sagebrush	4705	0	0
Salt Desert Scrub	77055	1547	100

Ecosystem Level Threats

Silverleaf Sunray only occur in the Mojave Desert Scrub ecosystem of Clark County (Cronquist 1994). Some of the land occupied by this species occurs within Lake Mead National Recreation Area and is therefore protected from development concerns. Interestingly, at least some of the habitat was lost due to inundation with the filling of Lake Mead (Cronquist 1994).

Threats to Species

Threats to the species include off-highway vehicle traffic in less-protected areas of Clark County such as Gold Butte. Urban development has also occurred within habitat for this species. Several of the known pollinators for this species are rare, local endemics and loss of pollinator diversity may threaten the long-term persistence of Silverleaf Sunray.

Existing Conservation Areas/Management Actions

Lake Mead National Recreation Area provides protection for some populations of Silverleaf Sunray. The Gold Butte area was designated a National Monument in December of 2016, and thus now offers similar protection. Some new areas of habitat for this species have recently been protected by private conservation efforts in Washington County, Utah (Endangered plant species workshop, St. George, Utah 2016).

Summary of Direct Impacts

Most of the predicted higher suitability habitat for this species is projected to be within Conserved areas, and comprises approximately 1/3 of the highest quality habitat that occurs in the county (Table 86). While 5.7 km^2 is already developed, an additional 21 km^2 will be potentially impacted, 227 km^2 is to be conserved. A higher proportion of moderate habitat will be potentially impacted relative to conserved areas, although a larger area of moderate habitat will be included in conservation areas (Table 86).

Table 86. Categorized modeled habitat values (High, Medium, and Low) and the average area (Hectares) predicted in the potential impact areas, conservation areas, already disturbed areas, and overall area

Habitat Level	Impact	Conserved	Disturbed	Area (Hectares)
High	2134	22703	573	74152
Med	10874	38328	3340	189950
Low	109510	452528	35924	1713275

ERBI - Pahrump Valley Buckwheat (Eriogonum bifurcatum)

The forked buckwheat was first described in Pahrump Valley in Nye County, NV near the California-Nevada state line. It is described as a low spreading annual plant that forms a flat-topped crown that can be more than a meter across (Reveal 1971, Mozingo and Williams 1980). Pahrump Valley Buckwheat is a winter annual in the buckwheat family (Polygonaceae) that blooms from late May to late June.

Species Status

This buckwheat is a former Category 2 candidate for threatened or endangered status under the ESA. The last ruling on the status of this species was published in the Federal Register on September 30, 1993 where it was determined that the forked buckwheat proposal for listing may be appropriate, but that insufficient data on biological vulnerability and threats were available to support the listing at that time (USFWS 1993).

US Fish and Wildlife Service Endangered Species Act: No status
US Bureau of Land Management (Nevada): Sensitive
US Forest Service (Region 4): No status
State of Nevada (NAC-527): No status
NV Natural Heritage Program: Global Rank G3, State Rank S2
IUCN Red List (v 3.1): No status
CITES: No status

Range

Pahrump Valley Buckwheat was originally found at 2525 ft., near the Charles Brown Highway - NV 372- CA 178) in Nye County, NV. Forked (Pahrump Valley) buckwheat is a highly range-restricted plant, known only from the California-Nevada border area in the Mesquite and Pahrump valleys in NV, and Stewart Valley in California (Reveal 1971, Crampton et al. 2006). The border region is within Clark and Nye counties in Nevada, and Inyo and San Bernardino counties in California. The elevational range for this species is from 2297 – 2800 ft. (700 – 853 m, NNHP 2001).

There are at least 19 extant occurrences in Clark and Nye counties in Nevada, with most occurring within Nye County (NNHP 2001, NatureServe 2010), and four occurrences in Inyo and San Bernardino Counties in California (California Natural Diversity Database 2009), which can be grouped into four population groups (TNC

2007). Pahrump Valley Buckwheat has also been found on Las Vegas Resource Management Plan lands near the town of Sandy Valley on the edge of the Mesquite dry lake (Crampton et al. 2006).

Population Trends

Germination of forked (Pahrump Valley) buckwheat is largely dependent on winter precipitation, and as a result, population size fluctuates greatly from year-to-year: very few or no plants may be present in a dry year and thousands may be counted in a wet year. This makes estimating population trends difficult (TNC 2007), and the trend of forked (Pahrump Valley) buckwheat is described as unknown by Nevada Natural Heritage Program (2001). However, the USFWS described the range-wide status as declining (USFWS 2000) based on recent occurrence records, and extirpations of populations have been reported on private lands near Sandy NV. Populations on public lands in Pahrump and Stewart valleys have remained intact (Crampton et al. 2006).

Based on the difficulty of quantifying the population trends for a species such as this, with highly fluctuating expression of adult plants, we suggest that seed bank assays may provide better insights into population status – if such methods are successful (Mayer and Poljakoff-Mayber 1982). Such assays have been widely used in the Great Basin (Young et al. 1976) and in other systems and also in the Mojave Desert (Esque 2004).

Habitat Model Review

Models for *"sand loving species"* were produced by Hamilton and Kokos (2011) using the same general methods. First, a soils-based model was created from SSURGO data from NRCS. The suite of sand loving species was observed over a wide range of percent sand and thus the initial model was not specific enough to accurately use it for modeling the potential for this group of plants. ASTER imagery was analyzed using principal component analyses to create a binary threshold of the Thermal Infrared band (identifying quartz), and supplementing this remote mapping effort with maps of surficial geology and SSURGO soil coverages. With this information SSURGO units were recoded using a 75% cutoff in the average percent in the top 1 foot of soil and this resulted in 28 sand categories that could be used for plant model classification.

The initial models were used as a basis to construct further sampling for these species by stratifying sampling into high (70% of sample locations), medium (20%) and low (10%) potential of occurrence for each species, and based the number of samples taken on the size of the potential habitat unit. Field surveys using this method resulted in 3 observations for *Eriogonum bifurcatum*.

The soils based models were considered to be over-predictive and MaxEnt models were explored. Environmental data used in the models were based solely on the Bioclim dataset, and no other soils or topography based layers were used. The MaxEnt for these species was deemed by Hamilton and Kokos (2011) to not be useful for refining their soil based habitat models (although no soils were included in their MaxEnt modeling effort). The SSURGO based soils model was further refined using remotely sensed imagery and the resulting soils model was then manually refined to better suit the species by “selecting suitable polygons” that were included in the elevational range for each species – and then eliminating ASTER and SSURGO scores that had no presences within them. Other SSURGO attributes were used to further refine models but specific methods or criteria were not given. The Pahrump Valley Buckwheat model was further refined from this soil based model by restricting elevation to between 700 m and 860 m, and by eliminating non-eolian areas, areas with a sand content above 80% as indicated by the SSURGO layer, and 23% surface fragment cover (Figure 131, Hamilton and Kokos 2011).

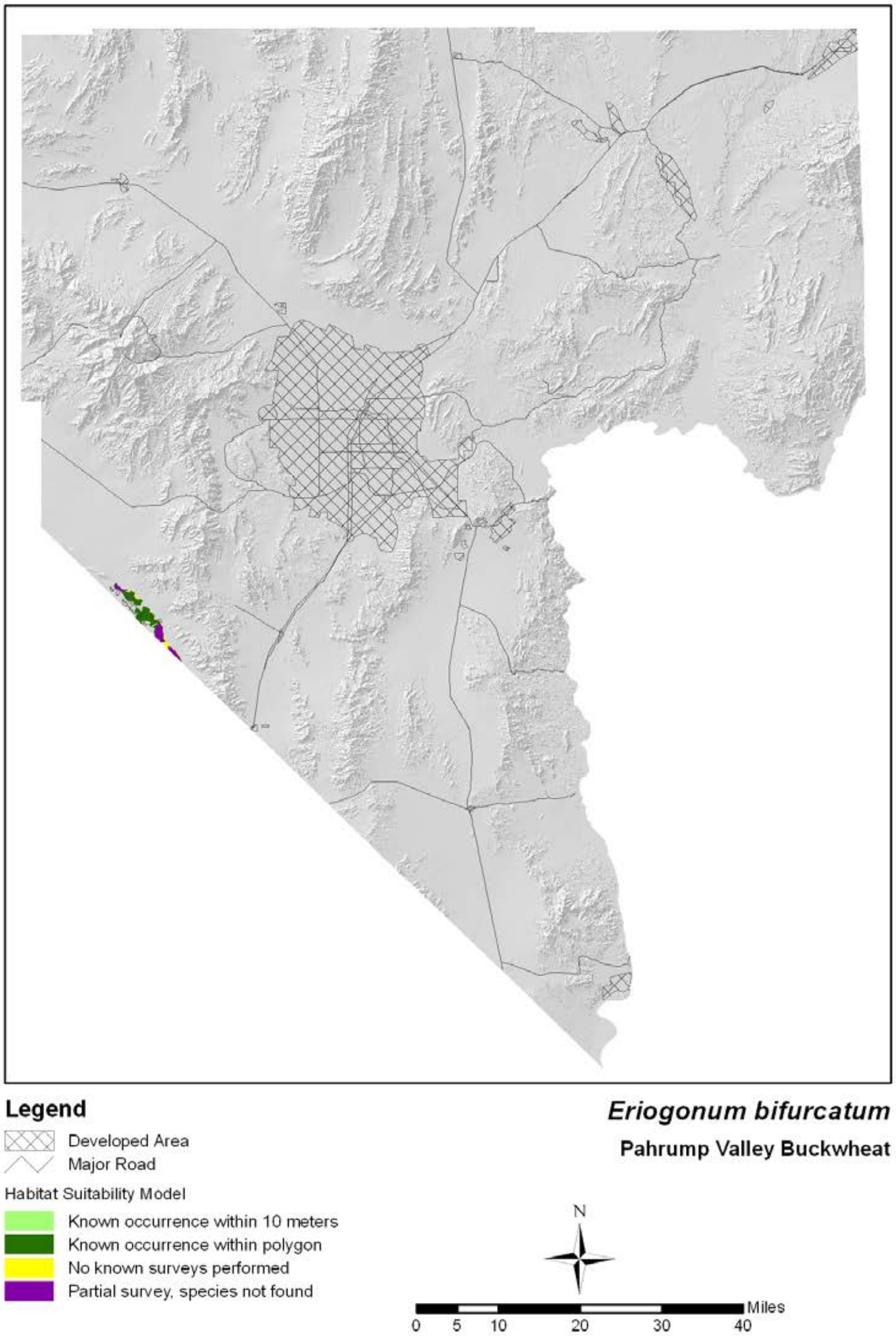


Figure 131. Modeled habitat for *Eriogonum bifurcatum* from Hamilton and Kokos (2011).

Distribution and Habitat Use within Clark County

In Clark County, forked (Pahrump Valley) buckwheat occurs only in Mesquite Valley in and around the town of Sandy Valley in the southwest region of the County, immediately adjacent to the Nye County border (Reveal 1971, Crampton et al. 2006, TNC 2007). This species occurs in valley bottoms, dry playa margins and adjacent shore terraces (Crampton et al. 2006) on barren heavy clays, silty hardpan soils, saline flats, and sandy hills (Reveal 1988, Nevada Natural Heritage Program 2001). Pahrump Valley Buckwheat occurs on rolling hills, stabilized dunes, and alkaline flats around dry lake beds in association with *Atriplex* spp. Soil types where it occurs include clay soil soils (Reveal 1971, Mozingo and Williams 1980, Crampton et al. 2006). Major plant associates are mesquite (*Prosopis* spp.), shadscale (*Atriplex confertifolia, Mozingo and Williams 1980).* These habitats are characteristic of the areas around the Mesquite Dry Lake, and others in the region.

Habitat modeling for sand dependent species were conducted and provide estimates of the amount of area for species habitat categories within Clark County ecosystems. Estimated high suitability habitat was identified in Mojave Desert Scrub, and to a lesser extent Salt Desert Scrub, Mesquite Acacia, and Blackbrush (Table 87). Moderate habitat includes some Desert Riparian areas as well (Table 88).

Table 87. Ecosystems within Clark County, and the area (Ha) of Low Medium and High predicted suitability within each ecosystem.

Ecosystem	Low	Medium	High
Alpine	0	0	0
Blackbrush	97	693	255
Bristlecone Pine	0	0	0
Desert Riparian	1287	1299	1
Mesquite Acacia	1857	880	494
Mixed Conifer	0	0	0
Mojave Desert Scrub	113208	57312	20895
Pinyon Juniper	0	0	0
Sagebrush	0	0	0
Salt Desert Scrub	661	1459	1804

Ecosystem Level Threats

This species occurs in Salt Desert Scrub, and Mesquite/Acacia ecosystems. Threats include encroaching commercial or residential development, land conversion for agriculture, off-highway vehicles, development of trails, and dumping (Mozingo and Williams 1980, Nevada Natural Heritage Program 2001). USFWS (2009) list as threats: a proposed airport, urban/industrial development, public land disposal, utility corridors, and off-highway vehicles. This species can tolerate moderate transient disturbance (Nevada Natural Heritage Program 2001). These types of disturbance increase the risk of invasive plants and may alter surface and groundwater flows (TNC 2007).

Threats to Species

Specific threats to this species have not been identified (Reveal 1988, TNC 2007, USFWS 2009).

Existing Conservation Areas/Management Actions

A conservation strategy specific to this species was developed by TNC for the Clark County Desert Conservation Program. The recommended conservation actions for this species included the following:

- proactively protect and manage for long-term viability of all populations on federal lands;
- ensure that disposal of federal lands in Clark County will not significantly impact conservation of rare plant populations;
- ensure that long term viability of low elevation rare plants is not significantly impacted by rural development and sprawl;
- investigate opportunities to acquire land or conservation easements for Pahrump Valley Buckwheat habitats in Clark County; and
- designate two population groups for proactive protection (TNC 2007).

The USFWS Spotlight Species Action Plan for the Pahrump Valley Buckwheat (USFWS 2009) recommends acquiring precise acreage figures for occupied and potential habitats and developing a conservation strategy that avoids, minimizes, or mitigates loss of both occupied and potential habitat. Crampton et al. 2006 suggest that conservation measures targeting mesquite woodlands in southern Nevada will provide indirect protection for the Pahrump Valley Buckwheat.

Summary of Direct Impacts

Pahrump Valley Buckwheat is a very rare species throughout its range. Suitable habitat for this species was modeled for the Amendment based largely on geology and soil mapping. This species has a low likelihood of occurrence within the plan area.

Direct impacts to sand species are relatively limited relative to the total amount of habitat projected to be within the county (Table 88). There are similar amounts of Conserved and Impacted habitat in the high suitability category for sand species, and twice the area conserved for conserved relative to impacted areas for moderate habitat (Table 88). Relatively little area was identified as already disturbed.

Table 88. Categorized modeled habitat values (High, Medium, and Low) and the average area (Hectares) predicted in the potential impact areas, conservation areas, already disturbed areas, and overall area

Habitat Level	Impact	Conserved	Disturbed	Area (Hectares)
High	543	592	93	23538
Med	610	1176	185	61679
Low	1307	2258	978	117118

ERCO - Las Vegas Buckwheat (Eriogonum corymbosum var. nilesii)

The Las Vegas Buckwheat is a recently identified, genetically unique subspecies of crispleaf buckwheat in the Polygonaceae (*Eriogonum corymbosum* - Reveal 2004). This buckwheat is a woody shrub with yellow to pale yellow or, rarely, white flowers, blooming in August to November. The species is distinguished by dense hairs on the leaves and stems that are at least twice as long as they are wide (USFWS 2014a).

Species Status

A petition to list the Las Vegas Buckwheat for Endangered Species Act (ESA) protection was filed with the Secretary of the Interior on April 22, 2008 (Center for Biological Diversity 2008). In the 12 month review finding, the USFWS determined that listing of this species as threatened or endangered under the ESA was warranted, but is precluded by other, higher priority actions (USFWS 2008). The species remained in that status until September 24, 2014. That finding determined that listing the Las Vegas Buckwheat for protection under the Endangered Species Act was unwarranted. New petitions for listing have not been submitted since that time.

US Fish and Wildlife Service Endangered Species Act: Sensitive
US Bureau of Land Management (Nevada): No status
US Forest Service (Region 4): No status
State of Nevada (NAC-527): No status
NV Natural Heritage Program: Global Rank G5T2, State Rank S1S2 (NNHP 2004)
IUCN Red List (v 3.1): No status
CITES: No status

Range

Initially Las Vegas Buckwheat was believed to occur only in the Las Vegas Valley of Clark County, Nevada. Early examination of herbarium specimens suggested that Las Vegas Buckwheat not only occurred in the Las Vegas Valley, but could be present in two additional locations outside of Nevada: Paria River in southern Kane County, Utah; and Pierce Wash near St. George Utah, in northern Mohave County, Arizona (Reveal 2004). However, further genetic investigations indicated that the extralimital locations are taxonomically distinct from those described in southern Nevada (Ellis et al. 2009). Populations of this species occur: north of Lake Mead in the Muddy Mountains of Lake Mead National Recreation Area of east Clark County; the north end of the Las Vegas Valley, Toquop Wash of Lincoln County and in the north and south of Coyote Springs Valley in both Clark and Lincoln counties. While somewhat widespread across the two counties, Las Vegas Buckwheat habitat occupies only ~ 320 ha (~790 ac).

Population Trends

Caution must be used in the interpretation of population trend data for this species for a variety of reasons including: confusion about the use of terms such as site, location, subpopulation and population in the source materials; the wide variety of census and 'estimation' methods that have been employed by various groups tasked with measuring abundance of the species, and error involved in identifying polygons to define stand boundaries. These factors render the data for this species too variable for the data to be of technical use (USFWS 2014). These factors preclude population trend analysis in terms of a demographic analysis.

A broader interpretation including a spatial analysis was provided by USFWS (2014). Of the original 12 populations recognized by USFWS, three have already been extirpated by urban development and highways construction. Of the nine remaining extant populations, impacts to two more seems imminent (USFWS 2014a). Looking at it a different way, it is known to have been extirpated from ~527 ha (~1305 ac), Las Vegas Buckwheat has lost nearly 62 % of its range (USFWS 2014a). Most of the lands from which the species has been extirpated are in private ownership (94.9 percent); the remaining lands where it was extirpated are owned or managed by the City of Las Vegas (1.95 percent), Clark County (2.24 percent), or the DOD (0.9 percent).

Habitat Model Review

Two SSURGO-based soils models (*i.e.* gypsum and sand) were used to create preliminary species-specific habitat models for rare plants covered under the MSHCP by Hamilton and Kokos (2011). The preliminary models used the soils layers in combination with presence and absence data for the species' localities to delineate potential habitat. These initial models were used to design survey efforts to obtain more presence and absence data to improve previously developed habitat models. In addition to these surveys the soils models were refined using SSURGO combined with remote sensing data from the ASTER platform for use in future modeling. MaxEnt was explored for further modeling, but was generally discounted for reasons that appear to be due to lack of experience in using this modeling algorithm. For example, the environmental variables that the modelers used were limited to available BioClim layers somewhat arbitrarily (i.e. without regard to their potential influence on the species). Furthermore, no substrate relevant layers, or other biophysical layers were explored – despite the apparent importance of soils on the distribution of these species (e.g. gypsum and sand content among other constituents). No precision or performance estimates are given for the refined models based on soils and elevation and other adjustments that were applied. MaxEnt Models were not compared with the soil based models, nor were outputs provided to calculate other performance scores.

Technical Considerations – The MaxEnt models were all run using 500 iterations with 10 % of points withheld for testing. The data layers used encompassed only the BioClim dataset despite their assertion that soils likely play an important role in defining the distribution of this species, and no other topographic layers were considered. Model performance scores for each MaxEnt model were indicated as VERY high relative to AUC (and models appeared to be over fit), no other test statistics are provided. There were also no performance metrics produced for the soil based models, and thus their accuracy cannot be assessed beyond the reported AUC scores. Models from the soils based models do not have a continuous scale output and thus exploring the potential proposed development scenarios on different predicted habitat values (e.g. High, Medium, Low) will be difficult.

Modeled habitat for the Las Vegas Buckwheat (LVB) was classified as high for Spring Deposits (classified both with and without ASTER, and medium for Gypsiferous Units as well as non-Gypsiferous Units, but because models for all 3 Gypsiferous species were similar only 1 model was produced for this class. Field surveys conducted using the initial models yielded 3 additional data points for Las Vegas Buckwheat. The model was further refined from the soils layer model by restricting elevation between 570 and 1180 meters, and by removing some lower class gypsiferous polygons (with respect to soils classifications) from the models (Figure 132).

In a separate modeling effort, Robbins et al. (2014) conducted a detailed case study at three focal study sites within Clark County, looking at the potential for classification of habitat for this species using more detailed soil profile data breaking gypsiferous soils into different age and composition strata. Their conclusions were that habitat occurred on "(1) fine-grained gypsum-rich substrates that lack strong physical crusts, (2) fine-grained carbonate rich, low gypsum parent materials formed from springs and paleo-wetlands, and (3) young, inactive, alluvial or mixed alluvial and eolian siliciclastic deposits with variable secondary gypsum and/or carbonate. Additionally, Las Vegas Buckwheat habitat is strongly negatively affected by the degree of desert pavement development and the thickness and grain size of siliciclastic sediments: areas with tightly interlocking desert pavement or deep coarse-grained alluvium are not suitable for LVB [Las Vegas Buckwheat]." (Robbins et al. 2014). This study did not provide species wide habitat mapping, and demonstrated that soil based methods, especially simple mapping of gypsum soils as a binary response, is unlikely to accurately represent or adequately predict habitat for Las Vegas Buckwheat.

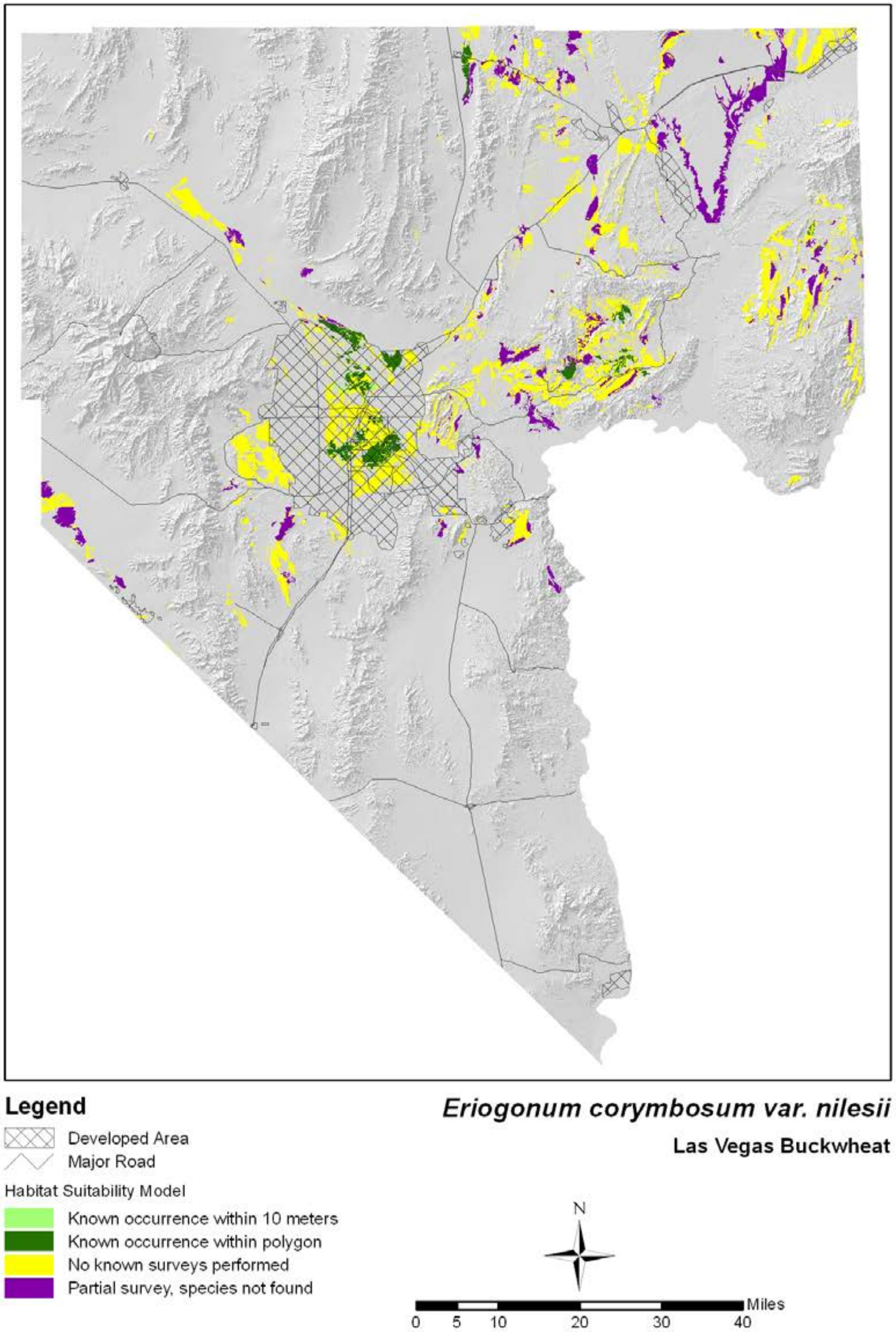


Figure 132. Modeled habitat for *Arctomecon merriamii* from Hamilton and Kokos (2011).

Distribution and Habitat Use within Clark County

Some of the largest populations of Las Vegas Buckwheat are found in the upper Las Vegas Wash ecosystem, Nellis Air Force Base, and smaller populations in the Las

Vegas Valley, Gold Butte, and Muddy Mountains (Morefield 2007). Historically, the largest concentration of this plant species and discrete localities has been in the Las Vegas Valley (USFWS 2008).

The elevational range of Las Vegas Buckwheat is 200 to 850 m (656 to 2,789 feet ft). This species is strongly associated with soils with high gypsum content, claybeds, or high-boron content shales. Las Vegas Buckwheat typically occurs with other gypsophylic species on sparsely-vegetated sites with cryptogamic soil crusts (Meyer 1986, Drohan and Merkler 2009, USFWS 2014a). Pollinators of Las Vegas Buckwheat have not been technically identified, however there have been 20 invertebrates observed on the flowers (Glenne 1999).

Estimated high and medium suitability habitat for this species is predicted to be nearly exclusive to the Mojave Desert Scrub ecosystem (Table 89).

Table 89. Ecosystems within Clark County, and the area (Ha) of Low Medium and High predicted suitability within each ecosystem.

Ecosystem	Low	Medium	High
Alpine	0	0	0
Blackbrush	5129	73	12
Bristlecone Pine	0	0	0
Desert Riparian	1177	8	1
Mesquite Acacia	1125	201	60
Mixed Conifer	0	0	0
Mojave Desert Scrub	124873	27949	9677
Pinyon Juniper	0	0	0
Sagebrush	0	0	0
Salt Desert Scrub	5729	556	56

Ecosystem Level Threats

This species occupies Mojave Desert Scrub and Salt Desert Scrub ecosystem types, and frequently on a subset of soils that support other sparse vegetation. Urbanization or infrastructure development (utility corridors and highways) of habitat is the primary threat to Las Vegas Buckwheat (Center for Biological Diversity 2008, USFWS 2009). Other major threats that have been identified include off-highway vehicle use (including dirt-bikes), illegal dumping activities, transient migrant habitation, flood control development, plant invasions (*Halogeton glomeratus*, *Salsola tragus* L., and *Strigosella africana* (L.) Botsch (syn. *Malcolmia africana*; African mustard), recreational activities (equestrian, and pedestrians), and surface mining and mineral claims (particularly of gypsum) (Edwards 2007, USFWS 2009, BLM 2011, USFWS 2014b). Another potential threat that has been named (USFWS 2014b) includes fire that is dependent on nonnative invasive grasses. However, the most prevalent invasive grasses in this region (*Bromus madritensis* var. *rubens* and *Schismus* spp.) do not thrive on the gypsum soils, thus do not provide fuel sufficient to burn in most cases (T. Esque, Pers. Obs).

Threats to Species

Urbanization, utility and transportation corridor development, and OHV activity can cause wholesale losses of Las Vegas Buckwheat populations. Other disturbance sources such as dumping and recreation can damage or kill individual plants in addition to damaging habitat. Several remaining populations are at risk due to land ownership and the potential for urban development.

Existing Conservation Areas/Management Actions

Seven conservation measures have been completed that benefit the Las Vegas Buckwheat (USFWS 2009):

- A conservation agreement with the City of North Las Vegas to establish the Eglington Preserve;
- Fencing installed by BLM to protect the Eglington Preserve and limit unauthorized off-highway vehicle impacts;
- Fencing installed by Nellis AFB to protect habitat within Nellis Area III;
- BLM purchase of 30 acres of the White Basin subpopulation; and
- BLM withdrawal of public minerals within some Las Vegas Buckwheat habitat.
- Designation of the Muddy Mountains Wilderness
- Establishment of Tropicana and Decatur Buckwheat Conservation Area
- During restoration efforts at Las Vegas Springs Preserve several Las Vegas Valley buckwheat plants were put in. While not significant for the population size it is important to note that they were placed there to educate the public on the Las Vegas Buckwheat.

Summary of Direct Impacts

The Las Vegas Buckwheat is a very rare species within Clark County, although it may be locally abundant. Suitable habitat for this species was modeled for the MSHCP Amendment based largely on geology and soil mapping (Hamilton and Kokos 2011). Approximately 38578 hectares of high and medium category modeled habitat exists within Clark County. The habitat and extent for this species is relatively low, with only 384 km^2 of high and moderate habitat combined projected within the county. Of this 100 km^2 are estimated to have already been disturbed, and another 28 km^2 are estimated to be impacted. A combined 108 km^2 of high and moderate habitat are estimated to be within the conservation areas (Table 90).

Table 90. Categorized modeled habitat values (High, Medium, and Low) and the average area (Hectares) predicted in the potential impact areas, conservation areas, already disturbed areas, and overall area

Habitat Level	Impact	Conserved	Disturbed	Area (Hectares)
High	1279	3606	439	9789
Med	1616	7216	9605	28789
Low	16993	47744	20098	138048

ERVI - Sticky Buckwheat (Eriogonum viscidulum)

Sticky Buckwheat is a small, rare winter annual in the buckwheat family (Polygonaceae) (Holland et al. 1979). The elevational range for this species is 1200 to 2200 ft. (Swearingen 1981, NNHP 2001). The Sticky Buckwheat inhabits sandy soils and grows up to 40 cm tall with diffusely branched, thready stems rising from a basal rosette of leaves (NNHP 2001, ARPC – No Date). The tiny yellow flowers bloom in April and May (NNHP 2001).

This species exhibits the characteristic of entrapping sand particles onto its surfaces from the surrounding environment thus rendering it less palatable to herbivores. This adaptation in plants is known as psammophory meaning “sand armor” (Lopresti and Karban 2016).

Some native plants associated with Sticky Buckwheat include *Larrea tridentata*, *Ambrosia dumosa*, *Pleuraphis rigida*, *Krameria parvifolia*, *Dicoria canescens*, *Pediomelum sp.*, *Croton californicus*, *Tiquilia sp.*, and *Abronia sp*. (NNHP 2001). The microhabitat of Sticky Buckwheat overlaps with another rare plant that is of concern in Clark County - *Astragalus geyeri var. triquetrus* (NNHP 2001).

Species Status

The Sticky Buckwheat is a former Category 2 candidate for threatened or endangered status under the Endangered Species Act of 1973. The last ruling on the status of this species was published in the Federal Register on September 30, 1993 where it was determined that the Sticky Buckwheat proposal for listing may be appropriate, but that insufficient data on biological vulnerability and threats were available to support the listing at that time (USFWS 1993).

US Fish and Wildlife Service Endangered Species Act: Not listed
US Bureau of Land Management (Nevada): Sensitive
US Forest Service (Region 4): No status
State of Nevada (NAC-527): Critically endangered
NV Natural Heritage Program: Global Rank G2, State Rank S2
IUCN Red List (v 3.1): No Status

CITES: No Status

Range

The first specimen of Sticky Buckwheat was found near the bridge over the Virgin River at Riverside, Clark County, Nevada (Howell, J.T., *in* Reveal 1985). Sticky Buckwheat is nearly confined to Clark County, Nevada but some populations also occur in adjacent Lincoln County, Nevada and the extreme northwest corner of Mohave County, Arizona (TNC 2007). Eleven of the 13 known populations occur in northeast Clark County (TNC 2007). Three populations found on lands managed by BLM occur at least partly within designated ACECs.

Population Trends

Sticky Buckwheat only appears sporadically due to the seasonal and inter-annual variability of available precipitation and appropriate temperatures. This must be considered in the evaluation of population trend data from monitoring plots. It will require several years of such data to understand population trends. The expression of this winter annual plant (i.e. germinating, growing, flower, going to seed and senescing between September and May) is dependent on seasonal precipitation with appropriate temperatures. However, if required germination conditions are met, several generations may germinate from the seed bank in a single season, or during droughts may not germinate at all. Niles et al. (1995) reported finding 20020 individual plants in an inventory of 22 localities where Sticky Buckwheat is known to occur. In 1997, an estimated 1500 plants were found at Lime Cove site, and 500 plants were found at the Glory Hole site in Lake Mead National Recreation Area (Powell 1999). In 2008, Bangle (2012) reported finding 4708 and 126 individuals at the Lime Cove and Glory Hole study plots; respectively, at the Overton Arm of Lake Mead. There are no systematic population assessments across the range of Sticky Buckwheat since the Niles' surveys (Bangle 2012). Extensive surveys have been conducted (Nevada Natural Heritage Program 2001), but populations fluctuate in response to variable rainfall, making long-term trends difficult to determine.

Habitat Model Review

Models for "sand loving species" were produced by Hamilton and Kokos (2011) using the same general methods. First, a soils-based model was created (for all sand species) from the SSURGO data from NRCS. The suite of sand loving species was observed over a wide range of percent sand and thus the initial model was not specific enough to accurately use it for modeling the potential for this group of plants. ASTER imagery was analyzed using principal component analyses to create a binary threshold of the Thermal Infrared band (identifying quartz), and supplementing this remote mapping effort with maps of surficial geology and SSURGO soil coverages. With this information SSURGO units were recoded using a 75% cutoff in the average percent in the top 1 foot of soil and this resulted in 28 sand categories that could be used for plant model classification.

The initial models were used as a basis to construct further sampling for these species by stratifying sampling into high (70% of sample locations), medium (20%) and low (10%) potential of occurrence for each species, and based the number of samples taken on the size of the potential habitat unit. Field surveys using this method resulted in 5 additional observations of Sticky Buckwheat on survey plots. As these models were considered to be over-predictive, MaxEnt models were explored using the combined point set of all occurrences where each species was modeled separately. Environmental data used in the models were based solely on the Bioclim dataset, and no other soils or topography based layers were used.

The MaxEnt for these species was deemed by Hamilton and Kokos (2011) to not be useful for refining their soil based habitat models (although no soils were included in their MaxEnt modeling effort). The SSURGO based soils model was yet further refined using remotely sensed imagery and the resulting soils model was then manually refined to better suit the species by “selecting suitable polygons” that were included in the elevational range for each species – and then eliminating ASTER and SSURGO scores that had no presences within them. Other SSURGO attributes were used to further refine models but specific methods or criteria were not given. Particular species elevation ranges retained were

The Sticky Buckwheat predictive habitat model was initially refined using an elevation range of 360 to 715 meters. The model was then further refined by removing areas with sand between 80-90% with ASTER values below 2 and eolian areas without an ASTER signature. Finally, areas with a geologic type of Avxk (as defined in House et al., 2010) or sand sheets over calcrete, were removed to produce the final model (Figure 133).

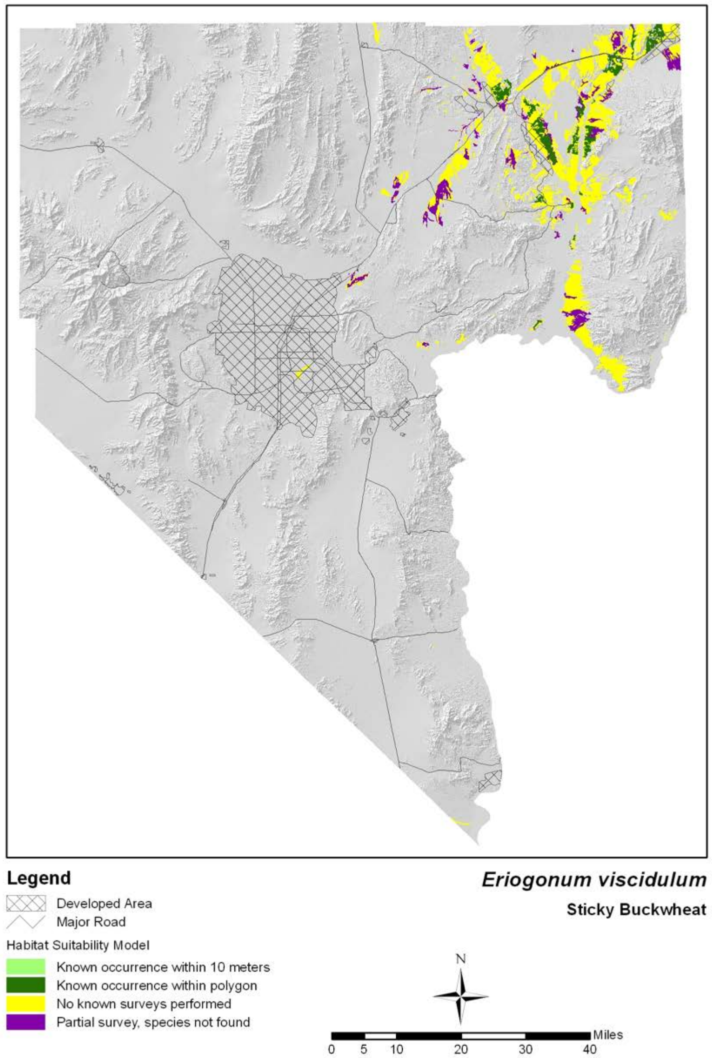


Figure 133. The refined soils based model for *Eriogonum viscidulum* from Appendix A of Hamilton and Kokos 2011.

Distribution and Habitat Use within Clark County

In Clark County, Sticky Buckwheat is confined to the eastern portion of the county, where it is centered on the confluence of the Muddy and Virgin rivers and ranges along the Muddy and Virgin rivers and the Overton Arm of Lake Mead (TNC 2007). Sticky Buckwheat is associated with deep loose sandy soils, and occurs on dunes, open beach sand, and sandy slopes along the Lake Mead shoreline, sandy dry washes, roadsides, and sandy flats and slopes within shrub communities (Nevada Natural Heritage Program 2001, TNC 2007). The occurrence of Sticky Buckwheat is associated with a sedimentary deposit known as the Muddy Creek Formation (Niles et al. 1995). As this formation surfaces among hills around the Overton Arm, Virgin Basin, and Boulder Basin of Lake Mead National Recreation Area extending along the Virgin River Valley and Muddy River Valley and Meadow Valley Wash. As sand weathers from the Muddy Creek Formation, it is redistributed as aeolian or fluvial material providing habitat for Sticky Buckwheat (Niles et al. 1995). Ecosystems within Clark County that contain modeled habitat for this species (Hamilton and Kokos 2011) in the high category include Mojave Desert Scrub and to a much lesser extent Salt Desert Scrub and Mesquite Acacia (Table 91). Moderate habitat for this species is also found in Mesquite Acacia, and Desert Riparian ecosystems (Table 91).

Table 91. Ecosystems within Clark County, and the area (Ha) of Low Medium and High predicted suitability within each ecosystem.

Ecosystem	Low	Medium	High
Alpine	0	0	0
Blackbrush	0	0	0
Bristlecone Pine	0	0	0
Desert Riparian	198	937	1
Mesquite Acacia	229	661	21
Mixed Conifer	0	0	0
Mojave Desert Scrub	50698	25844	13868
Pinyon Juniper	0	0	0
Sagebrush	0	0	0
Salt Desert Scrub	0	13	48

Ecosystem Level Threats

Sticky Buckwheat occupies a very small portion of the Mojave Desert Scrub ecosystem in Clark County, and would generally be associated with Desert Riparian habitat at a scale smaller than is used by the DCP ecosystem map. Historically, the largest loss of Sticky Buckwheat habitat was likely due to inundation by the impoundment of the Colorado River to create Lake Mead (Niles 1995, Powell 1999). During the high-stand of Lake Mead in 1998, several populations were temporarily inundated but apparently were not extirpated by short-term disturbance (Powell 1999). However, it is not known if the seeds survived short-term inundation or the area was re-populated by seed from nearby plants above the high water mark. It is possible that recent low water levels in Lake Mead have opened habitat where sandy shorelines exist, thus releasing previously unavailable potential habitat for use by this plant. Other identified threats to Sticky Buckwheat are habitat clearing for rural development, fire, energy development, invasive plant species, off-road vehicle use, surface water development, agriculture, utility corridor construction and maintenance, livestock grazing, sand and gravel mining, recreation use, and disturbance from wild burros and horses (TNC 2007). These factors can interact, resulting in changes in ecosystem functions that affect the sandy substrates that Sticky Buckwheat depends on, for example by increasing erosion or reducing fluvial sand deposition (TNC

2007). Invasive plant species such as Sahara mustard alter the fire regime, which can lead to increasing erosion and changes in habitat type. Other potentially important invaders include: *Tamarix* spp. (Saltcedar), *Salsola* spp. (Russian Thistle), and *Schismus* spp. (Mediterranean Grass; Bangle 2012).

Threats to Species

Sticky Buckwheat may be trampled and grazed by cattle and feral burros (Bangle 2012). Natural predators of Sticky Buckwheat include the caterpillars of the white-lined sphinx moth (*Celerio lineata*) that are known to eat the plants (Bangle 2012).

Energy infrastructure – In 1989/90 *E. viscidulum* plants were observed in the right-of-way of the Kern River Pipeline project, but project avoidance of the sensitive plants was preferred over disturbance thus, no further actions (e.g., re-seeding) were taken (Hiatt et al. 1995).

Existing Conservation Areas/Management Actions

The USFWS Spotlight Species Action Plan for the Sticky Buckwheat (2009) recommends conducting surveys and habitat modeling to acquire precise acreage figures for occupied and potential habitats and developing a conservation strategy that avoids, minimizes, or mitigates loss of both occupied and potential habitat.

A conservation strategy specific to this species was developed by The Nature Conservancy for the Clark County Desert Conservation Program (2007). The recommended conservation actions for this species include:

- proactively protect and manage for long-term viability of all populations on federal lands;
- manage viable populations by removing significant casual off-road vehicle use; control weeds in low elevation rare plant habitats;
- ensure that long term viability of low elevation rare plants is not significantly impacted by rural development and sprawl;
- ensure that disposal of federal lands in Clark County will not significantly impact conservation of rare plant populations;
- manage rare plants in sandy habitats for long term viability by addressing altered fire regimes (increased fire frequency and intensity) over the next century;
- manage viable populations of all covered rare plants in utility corridors and potential rights-of-way corridors; and management of viable populations on federal lands;
- protect Sticky Buckwheat populations along Muddy and Virgin rivers from significant agricultural impacts over the next fifty year;
- ensure conservation management for Sticky Buckwheat populations at LMNRA above high water line and manage populations below high water line during Lake Mead low water years;
- ensure construction of the Mesquite Airport does not significantly impact viability sticky wild buckwheat on public lands; and
- protect viable populations of Sticky Buckwheat in Gold Butte area (Lime Wash populations) and Virgin River Dunes from trespass grazing and exotic plant impacts (TNC 2007).

In addition, this species' habitat is included in the Nevada's Wildlife Action Plan within the Sand Dunes and Badlands Key Habitat type. The recommended conservation strategy for this habitat includes the objective of maintaining disturbance in sand dune and badland habitats within levels that do not compromise the sustainability of the vegetation and wildlife communities; conservation actions are focused on OHV use, minimizing disturbance, and developing conservation agreements that maintain biodiversity and multiple uses (Wildlife Action Plan Team 2012).

In addition to its inclusion in the Clark County MSHCP, Sticky Buckwheat is considered in the Lower Colorado River Multi-Species Conservation Plan (LCR MSCP) for the conservation of the species in and adjacent to the LCR- MSCP planning area and populations are maintained or increased (Bangle 2012).

It is clear that actively managing landscapes for such rare species as the Sticky Buckwheat has high priority and many useful management recommendations are provided. However, in the absence of population monitoring there is no way of accurately determining the population status of these species. Furthermore, it is clear that monitoring plants as they are expressed in sample populations can yield volumes of highly variable data. Quantifying propagules in the seed bank is a relatively straightforward endeavor in very sandy soils – such as those where the Sticky Buckwheat occurs. While seedbank estimates are also notoriously variable it is possible that they may provide a more reliable and cost effective estimate of population status than monitoring plants on an annuals basis. Furthermore, a seed bank investigation could also be used to determine the efficacy of invasive species control programs in these high-value habitats.

Summary of Direct Impacts

A total of 415 km^2 of high and moderate habitat is estimated within the County (Hamilton and Kokos 2011). Projected impacts by this plan amendment may affect 14% of the total area for high and moderate habitat, while 27% of the area is located within conserved areas (Table 92). Very little habitat is estimated to be already disturbed.

Table 92. Categorized modeled habitat values (High, Medium, and Low) and the average area (Hectares) predicted in the potential impact areas, conservation areas, already disturbed areas, and overall area

Habitat Level	Impact	Conserved	Disturbed	Area (Hectares)
High	2358	4138	297	14028
Med	3620	6859	1447	27488
Low	5591	11633	1361	51125

EUEX - Catchfly Gentian (Eustoma exaltatum)

Catchfly Gentian *Eustoma exaltatum* (syn. *Gentiana exaltata*) is a small-flowered biennial in the gentian (Gentianaceae) family native to the southern United States, Mexico, Central America, and the West Indies. It is a perennial, producing additional shoots each season. It has purple, funnel-shaped to campanulate flowers with corolla lobes up to 2.5 cm in length (Turner 2014). The flowers are whitish or very pale blue (Pinkava et al. 1992). The species has a strong association with heavy alkaline, saline, or clay soils, and those soils are frequently at seeps or otherwise water-logged soils (Shinners 1957, Turner 2014). *E. exaltatum* flower June through November (Shinners 1957). Minimum known elevation of the species is 149 meters (NNHP 2011). Another source lists the elevation range as 100-600 m and occurring on roadsides, alkaline marshes, and other open, wet places (Jepson Flora Project 2017).

Species Status

US Fish and Wildlife Service Endangered Species Act: No status
US Bureau of Land Management (Nevada): No status
US Forest Service (Region 4): No status
State of Nevada (NAC 527): No status
NV Natural Heritage Program: Global Rank G5 State Rank S1
IUCN Red List (v 3.1): No status
CITES: No status

Range

Catchfly Gentian is native to the southern United States, Mexico, Central America, and the West Indies (Turner 2014). Plants have been reported in the Organ Pipe National Monument in Arizona (Pinkava et al. 1992)

Population Trends

Very little quantitative data on population numbers appear to exist for this species in Nevada, and population trends are unavailable.

Habitat Model

Available data for this species yielded only 4 localities in Clark County, thus precluding County specific models for this species. However, an additional 41 points were available outside the County. To facilitate statistical modeling for habitat suitability we expanded our modeling extent to include the broader distribution of localities in areas of both the Mojave and western Sonoran Deserts in California and Arizona (see Model Discussion – below).

The GAM, RF, and MaxEnt modeling algorithms had generally similar predictions, with most showing likely habitat in the extreme southern extent of the County in the Colorado River drainage. The GAM and RF models also predicted thin strips of habitat in the Muddy and Virgin rivers and Lake Mead shorelines (Figure 134). Performance was highest in 2 of the four overall metrics for the RF model followed while the Ensemble model was consistently second among all metrics. The GAM and MaxEnt models performed poorest overall (Table 93). Standard errors were greatest for the GAM model, with elevated error relative to the other algorithms in the mid to high-range in habitat predicted in the drainages near the Virgin and Muddy rivers and Lake Mead, While MaxEnt showed areas of higher error directly in the drainage areas where higher habitat values were predicted (Figure 135, Figure 134).

Percent contributions among input variables to the models were consistently high among the three competing models for Elevation, NDVI Maximum, and Winter Precipitation (Table 94). Contributions from NDVI Amplitude, Slope, Topographic Position, Mean Annual Precipitation, Summer Precipitation, Summer Maximum Temperature, Winter Minimum Temperature, and Temperature Range were highly variable among algorithms or represented by zero-values in the output (Table 94).

The CBI for the Ensemble mode indicated good model performance (Figure 136) but was best for the GAM and RF models (Figure 136), while the fixed Boyce Index was highest for the GAM and Ensemble (Table 93). Approximated bins for the ensemble model based on the CBI were 0-0.4 unsuitable, 0.4-0.5 marginal, 0.5 to 0.6 suitable, and > 0.6 optimal habitat; with a suggested cutoff threshold of ~ 0.5 (Figure 136) and the threshold value calculated from ROC statistics for the ensemble model was 0.48 (Table 93).

Table 93. Model performance values for Catchfly Gentian (*Eustoma exaltatum*) models.

Performance	GAM	RF	MaxEnt	Ensemble
AUC	0.94	0.98	0.93	0.97
BI	0.96	0.90	0.80	0.94
TSS	0.80	0.92	0.81	0.87
Correlation	0.58	0.65	0.69	0.66
Cut-off*	0.48	0.62	0.20	0.48

*threshold at which sum of sensitivity (true positive rate) and specificity (true negative rate) is highest

Table 94. Percent contributions for input variables for Catchfly Gentian (*Eustoma exaltatum*) for ensemble models using GAM, MaxEnt, and RF algorithms.

Term	GAM	RF	Max	Avg
NDVI Amplitude	21.698	11.6	1.391	11.719
NDVI Maximum	30.791	21.5	24.76	25.939
Elevation (m)	27.119	22.7	45.045	31.917
Slope	0	0	0	0
Topographic Position (TPI)	7.644	0	0	2.548
Mean Annual Precipitation	0	0	3.691	1.23
Winter Precipitation	12.749	10.0	7.238	10.126
Summer Precipitation	0	8.0	7.596	5.299
Summer Maximum Temperature	0	0	5.645	1.882
Winter Minimum Temperature	0	20.8	4.059	8.539
Temperature Range	0	5.3	0.576	2.033

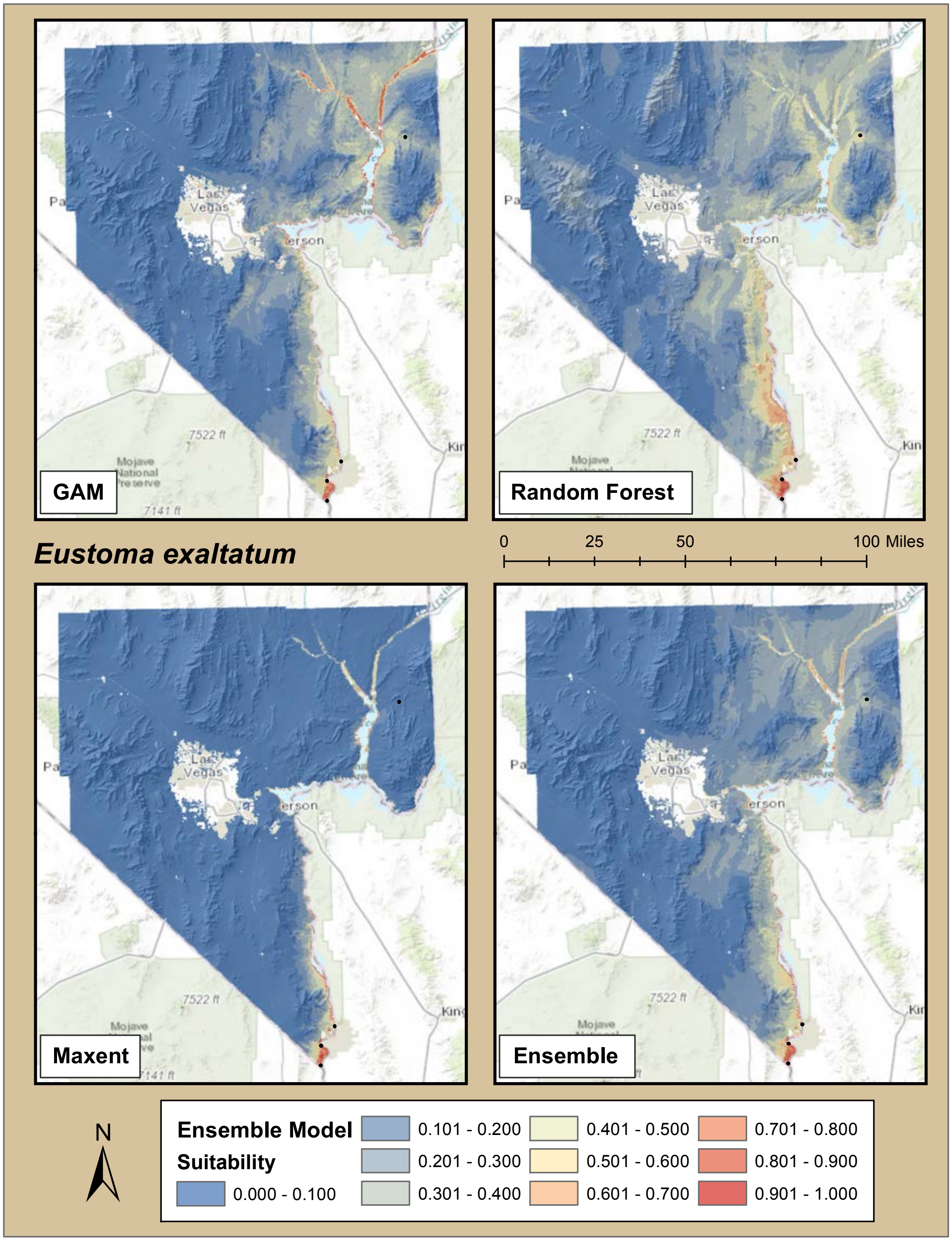


Figure 134. SDM maps for Catchfly Gentian (*Eustoma exaltatum*) for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

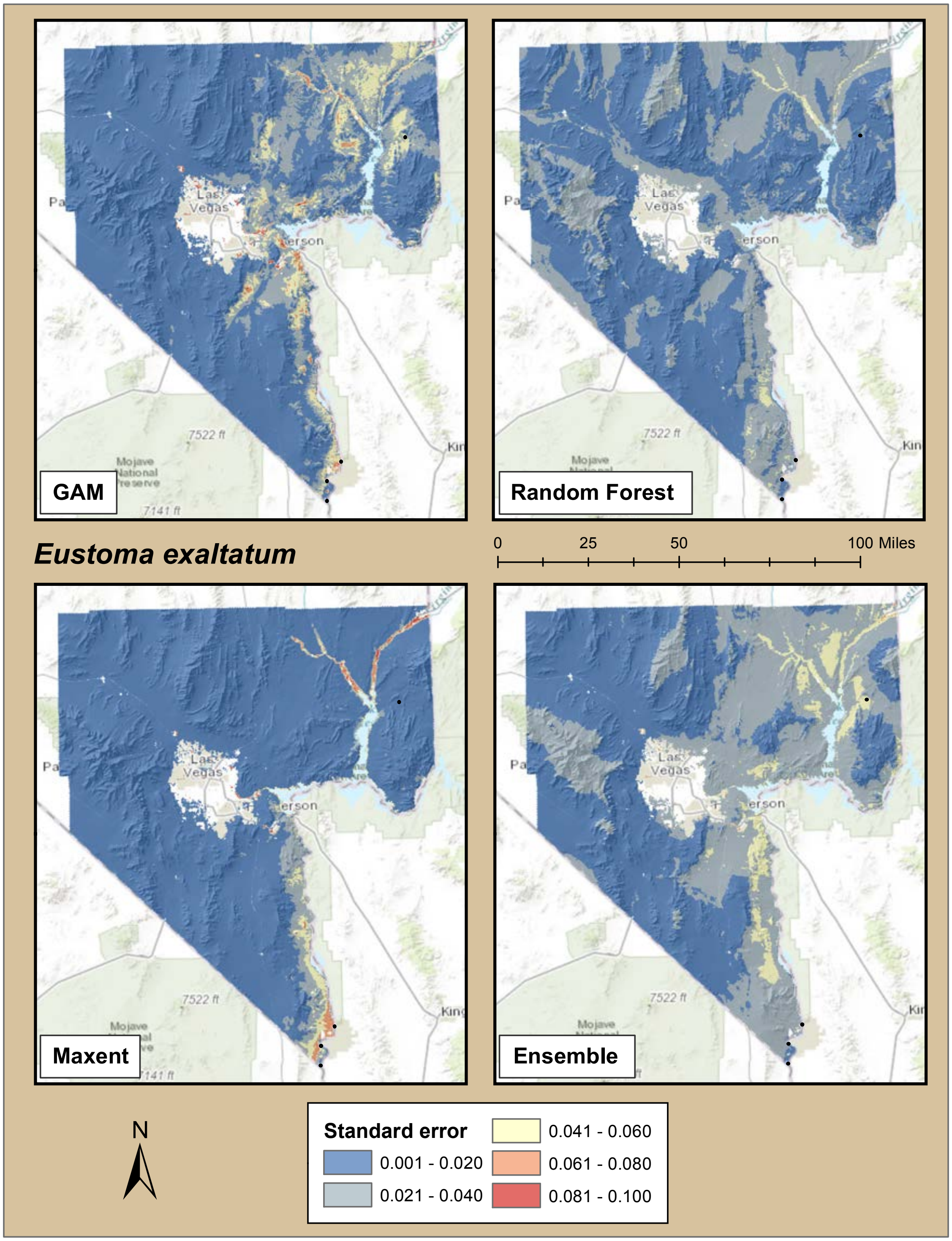


Figure 135. Standard error maps for Catchfly Gentian (*Eustoma exaltatum*) models for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

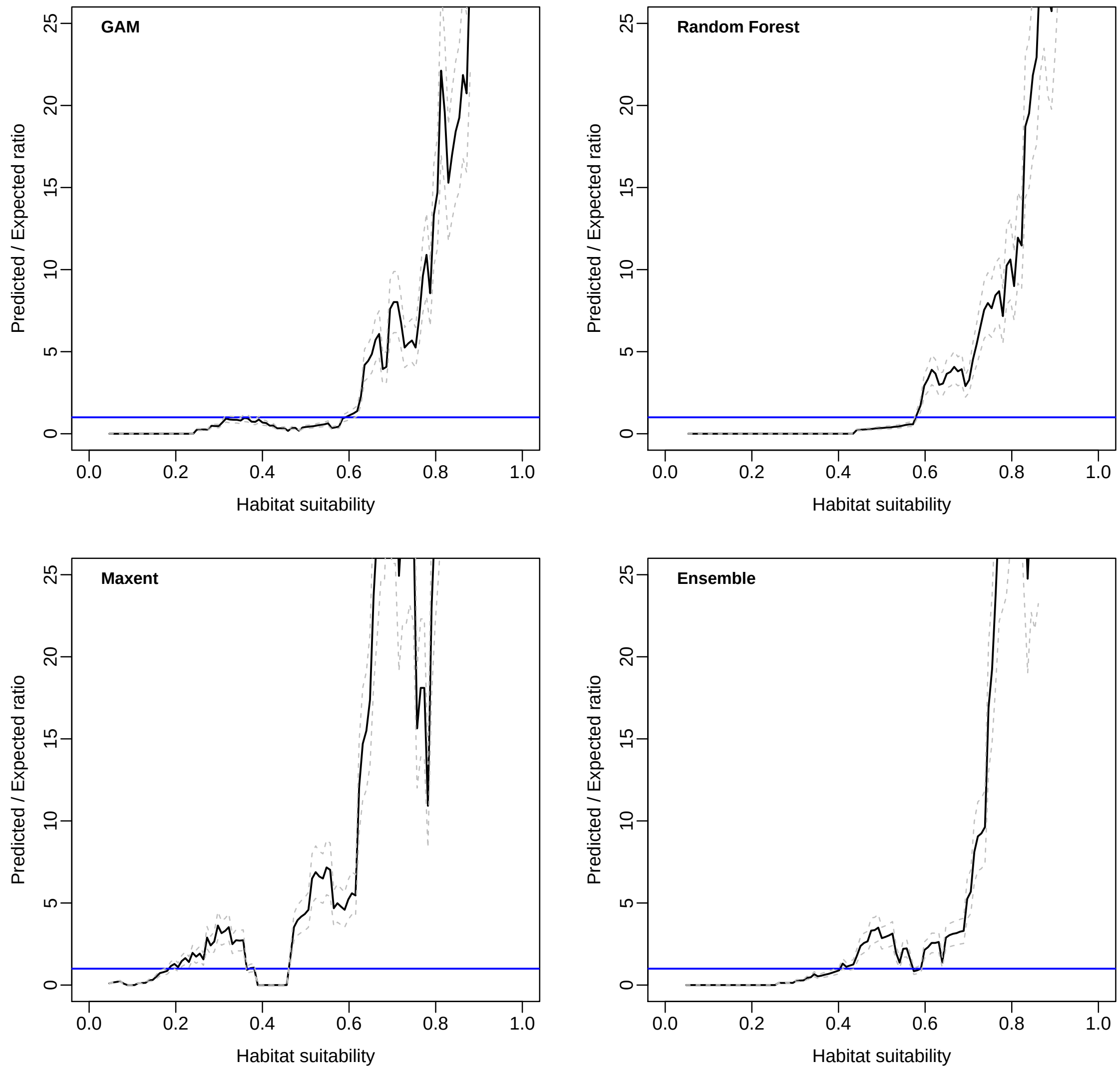


Figure 136. Continuous Boyce Indices for Catchfly Gentian (*Eustoma exaltatum*) models for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

GAM Model

The GAM model ensemble identified four contributing variables with more than 10% contribution toward the model (NDVI Maximum, Elevation, NDVI Amplitude, and Winter Precipitation). Collectively these four variables represent 92% of the total model contribution (Table 94). NDVI Maximum had a 31% contribution and a strongly positive influence on habitat suitability, with positive model prediction above values of 125, and well above the average value for this measure in the County (Figure 137).

Increased Elevation had a negative relationship with predicted suitability, with positive predicted values for habitat below 1000 m, and declining sharply thereafter. Catchfly Gentian had a largely negative response to NDVI Amplitude within the county, with the highest habitat suitability values predicted only at the lowest NDVI

Amplitude values (Figure 137). This indicated a correlation for presence in areas with relatively constant NDVI (e.g. Riparian areas). Winter Precipitation had a peaked response, increasing habitat suitability at values between 100 and 300 mm, and peaking at 225 mm (Figure 137). The Topographic Position Index had a lower contribution (8%), which also showed a peaked response for habitat suitability at relatively high values, indicating habitat was in the lower reaches of watersheds (Table 94).

The GAM model strongly predicted habitat for this species in the immediate areas of the Muddy and Virgin rivers, and in the extreme southern tip of the County were the river basin flattens near Needles, California. Lower habitat values were predicted in the areas proximal to these areas of higher values (Figure 134). This algorithm had higher standard error values (0.08 to 0.1) in only a few regions in and around the areas of the lowest predicted habitat suitability, especially near Boulder City, Valley of Fire State Park, and in the Logandale area. Broader areas of moderate error (0.04 to 0.06) occurred near Mormon Mesa, Mesquite, Eldorado Valley, and Coyote Springs Valley (Figure 135).

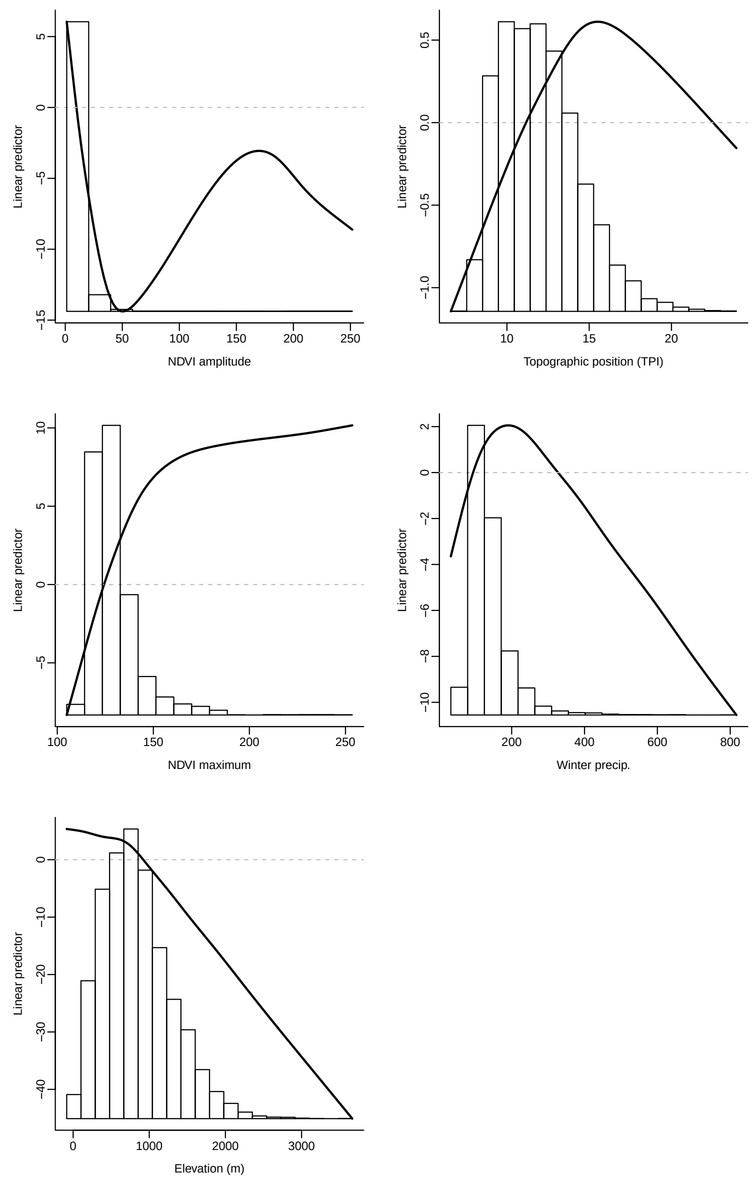


Figure 137. GAM partial response curves for the Catchfly Gentian (*Eustoma exaltatum*) model overlaid over distribution of environmental variable inputs in the study area.

MaxEnt Model

The MaxEnt model had two variables (Elevation, and NDVI Maximum) that were the strongest performers contributing 20% or more each, accounting for 70% of all model contributions. Three other variables (Summer Precipitation, Winter Precipitation, Summer Maximum Temperature) contributed 5% or more and the other variables contributed minimally (Table 94). Elevation had the strongest predictive value with 45% contribution. Highest suitability was predicted for areas of the lowest elevation, with no habitat predicted for areas higher than 1500 m (Figure 138). NDVI Maximum was positively associated with habitat suitability, with a sharply positive response, favoring areas well above the average for the County. Summer Precipitation and

Winter Precipitation were both favored at values above the average. Winter Precipitation had a peaked response, and Summer Precipitation had a positive trending response, favoring areas of higher winter accumulations (~200 mm), and the highest summer precipitation (Figure 138).

The standard error map for this algorithm showed few areas of relatively high uncertainty among the models (SE of 0.08 to 0.1) were in the immediate drainages of the Virgin and Muddy Rivers, and the Colorado River south of Laughlin (Figure 135).

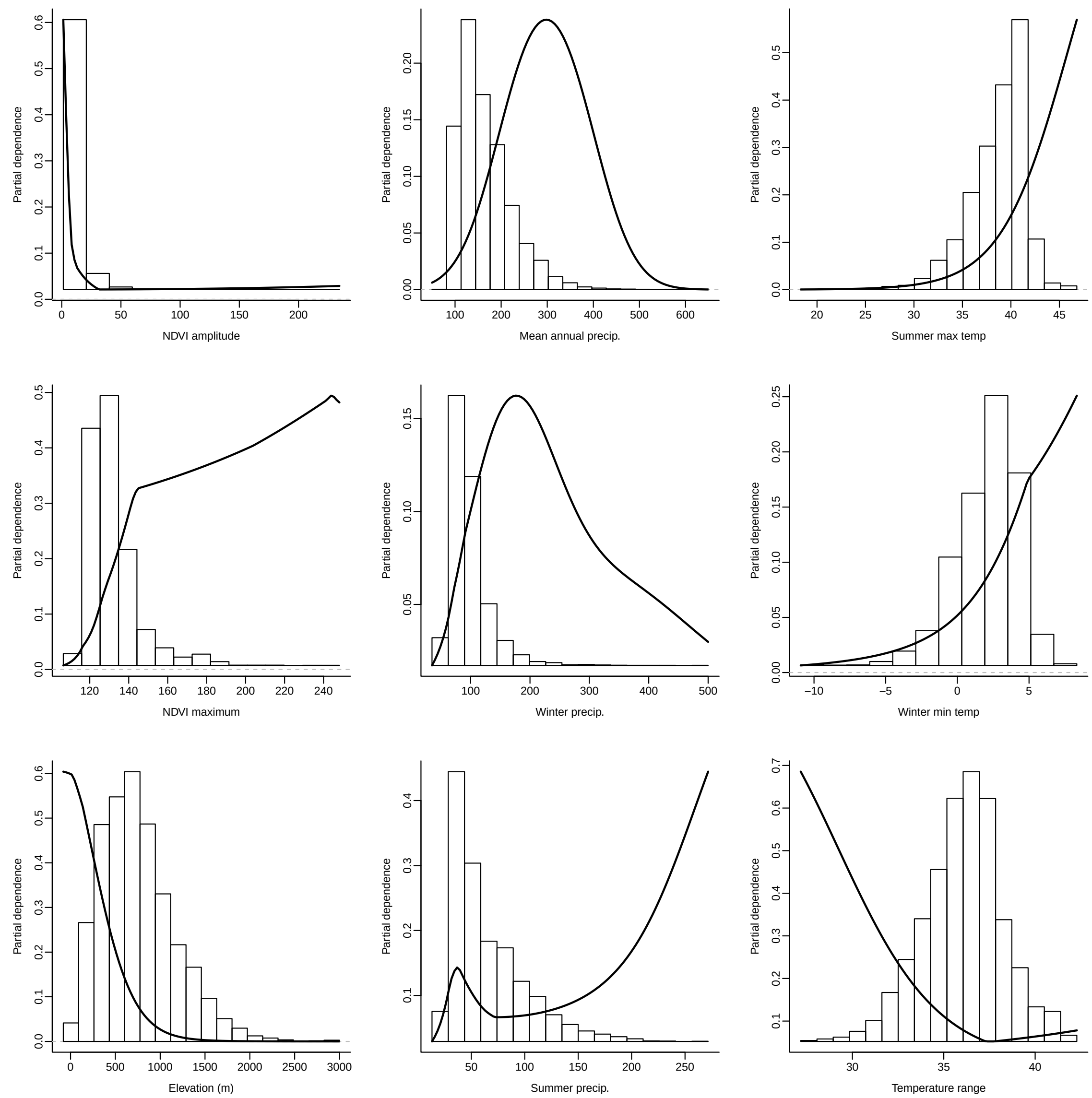


Figure 138. Response surfaces for the top 9 environmental variables included in the MaxEnt ensemble model for Catchfly Gentian (*Eustoma exaltatum*).

Random Forest Model

The RF models had five environmental variables contributing 10% or more totaling 90% of total model influence (Table 94). The highest contributing variable was Elevation (23%), with low elevation areas predicted to be more suitable as in the other models, with no habitat predicted above 1000 m (Figure 139). NDVI Maximum (22%) had a positive, thresholded response, with increasing suitability predicted at higher values for this metric, rising sharply to peak values at ~ 200. NDVI Amplitude (12%) was also positively associated with highest habitat above 100, which was different than indicated in the MaxEnt model (Figure 139, Figure 138). Winter Minimum Temperature (21%) indicated higher habitat suitability predictions for areas of higher temperatures, rising sharply above 4 ºC.

Standard error maps for this model indicated relatively low SE levels (0.02 to 0.04) in valley bottoms and lower bajadas throughout the County. Moderately low error was predicted in the Virgin and Muddy River, and near Laughlin (Figure 135).

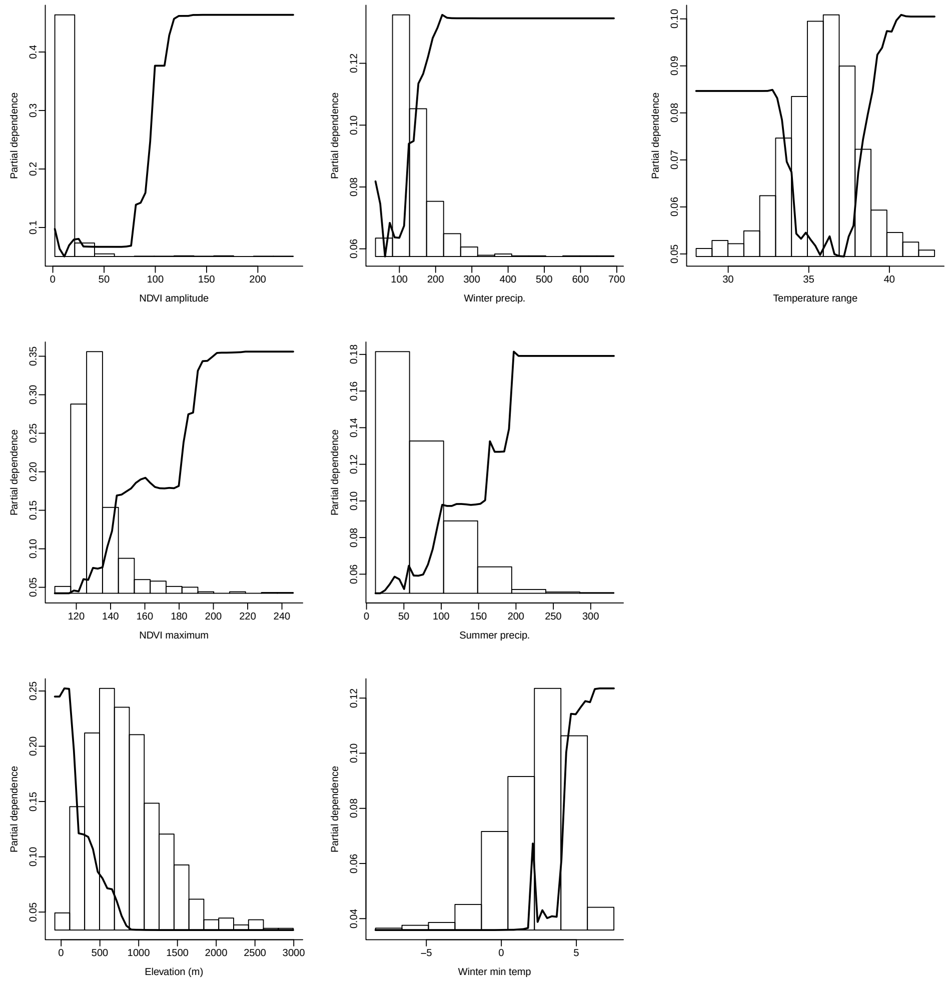


Figure 139. Partial response surfaces for the environmental variables included in the RF ensemble model for *Eustoma exaltatum.* Histograms represent the range of each environmental variable across the x-axis, and predicted dependence relative to habitat suitability values are on the y-axis.

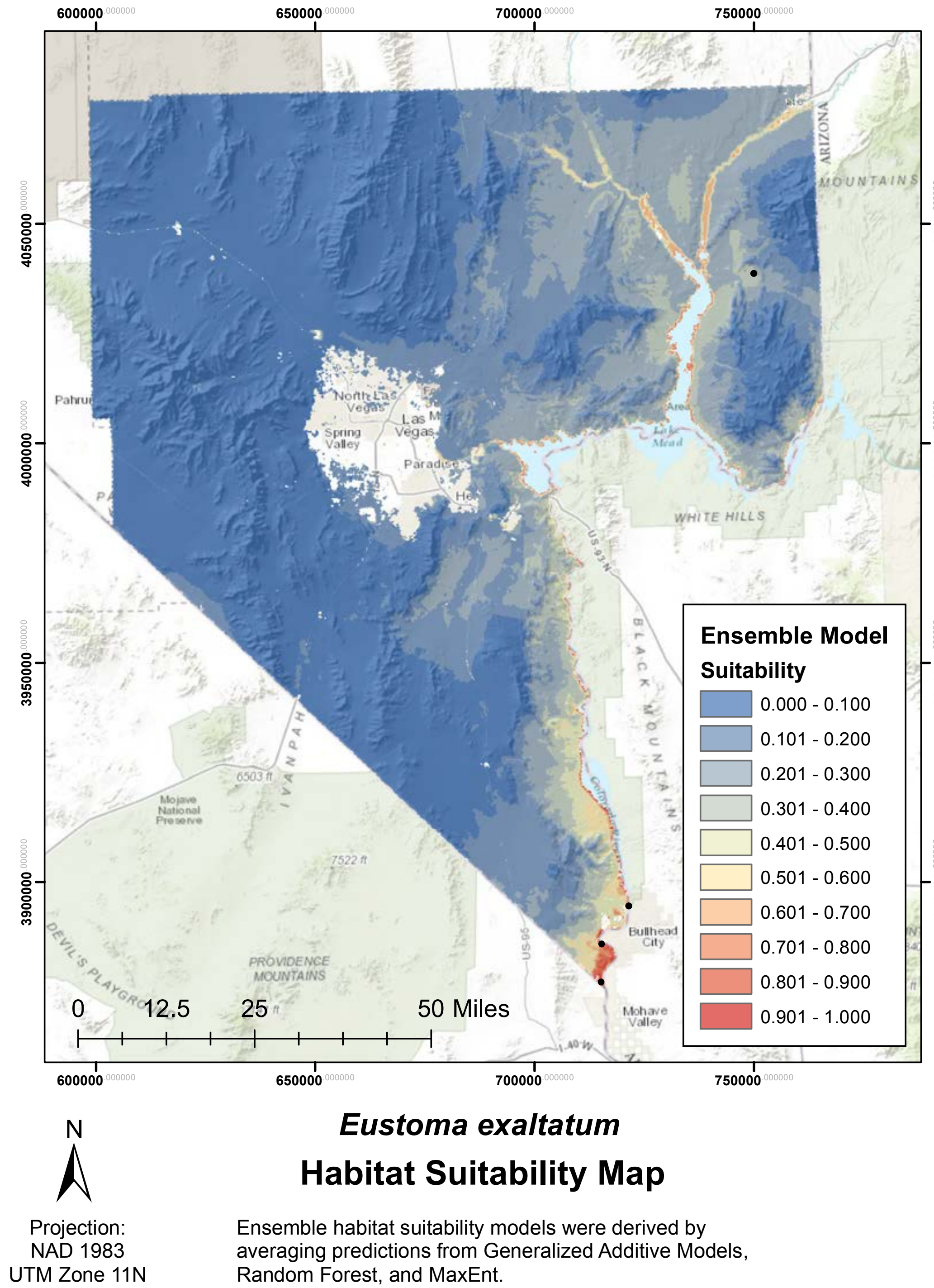


Figure 140. SDM map for the Catchfly Gentian (*Eustoma exaltatum*) Ensemble model.

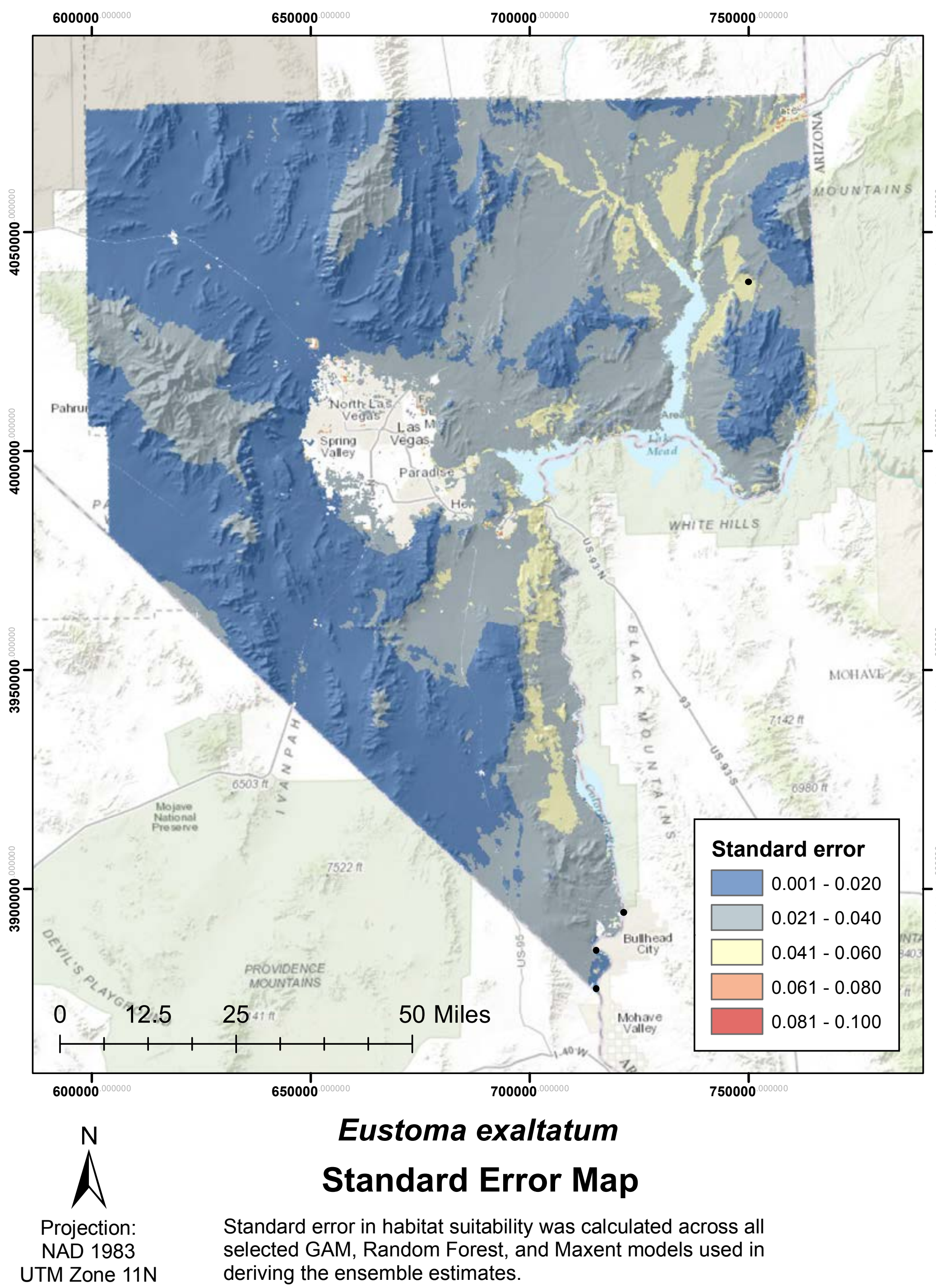


Figure 141. Standard Error map for the *Eustoma exaltatum* Ensemble model.

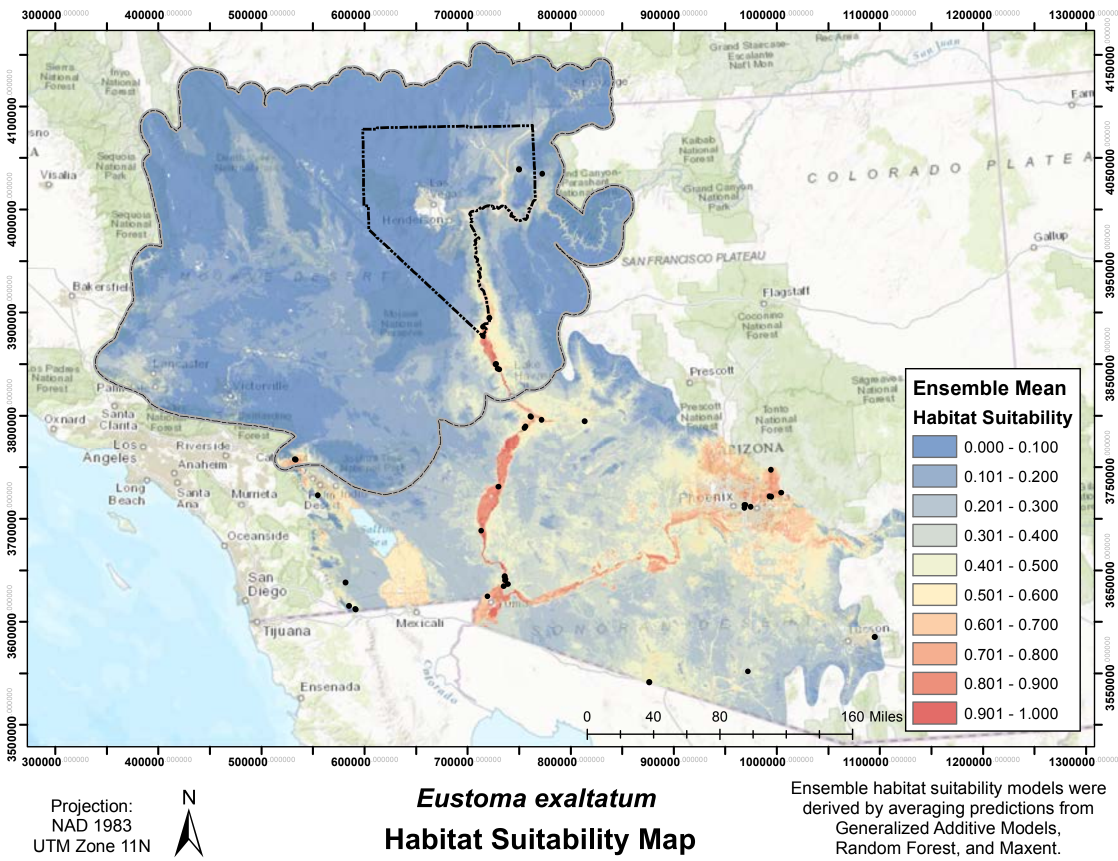


Figure 142. Habitat suitability map for the *Eustoma exaltatum* ensemble model for the Mojave and western Sonoran Desert.

Distribution of Localities

Localities (N=45) for Catchfly Gentian are found largely in the extreme southern portion of the Colorado River drainage in the southern-most tip of Clark County, with the exception of 2 points near the center of Gold Butte (Figure 140). This species is more broadly distributed outside Clark County in the lower Colorado, and in the Gila River system in Arizona east of Phoenix, with a few reported localities in Palm Desert California and southward (Figure 142).

Standard Error – The standard error for the ensemble habitat suitability model for Catchfly Gentian indicates widespread low values for error (SE 0.02 – 0.04) throughout the lower elevation regions of Clark County. Areas of moderate error (SE 0.04 – 0.06) occur in Mormon Mesa, Central Gold Butte, the Virgin and Muddy river drainages, and in the mountains on the west side of the Colorado river (Figure 141).

Distribution and Habitat Use within Clark County

Few sources list Catchfly Gentian as occuring in Nevada. Neither Shinners (1957) nor Turner (2014) recorded them occurring in Nevada. However, the Nevada Natural Heritage Program (2011) listed the species as “confident or certain” occurrence in Clark County (with an occurrence count of two). USDA plants also indicates Catchfly

Gentian occurrence in Clark County, Nevada (USDA, NRCS 2016). *E. exaltatum* ssp. *exaltatum* is the only subspecies occurring in Nevada (USDA, NRCS 2016). Modeled habitat within the county is predicted to be most prevalent in the Mojave Desert Scrub ecosystem, with habitat occurring also in Desert Riparian and Mesquite Acacia ecosystems in the bottom of the drainages (Table 95). Moderate habitat indicates a similar affinity for these ecosystems.

The species is listed as "critically imperiled" in Nevada (NatureServe 2015). The species is listed as occurring around Lake Mead, Lake Havasu, and Lake Mohave of the lower Colorado River watershed, but may be extirpated in the vicinity of Lake Havasu, and Lake Mohave (NatureServe 2015).

Modeled Habitat in the County is predicted to be highest in the southern most portion of the river drainage near Laughlin/Bullhead City and Cal-Nev-Avi (Figure 140). Linear areas of higher habitat suitability are also predicted along the lower river drainages of the Muddy and Virgin rivers, however these may be driven largely by one point reported in Gold Butte Wash (Figure 140).

Table 95. Ecosystems within Clark County, and the area (Ha) of Low Medium and High predicted suitability within each ecosystem.

Ecosystem	Low	Medium	High
Alpine	124	0	0
Blackbrush	415587	0	0
Bristlecone Pine	7565	0	0
Desert Riparian	224	4462	5383
Mesquite Acacia	14538	4264	997
Mixed Conifer	27339	0	0
Mojave Desert Scrub	1141251	129423	12007
Pinyon Juniper	115876	0	0
Sagebrush	4707	0	0
Salt Desert Scrub	79063	111	38

Ecosystem Level Threats

Because Catchfly Gentian has a high association with water-logged soils (Shinners 1957, Turner 2014), the only Clark County ecosystem where this species would likely be is Desert Riparian habitat. Therefore, we can presume that threats to riparian areas could also pose a threat to potential Catchfly Gentian habitat.

Threats to Species

Not much information is known of the status of populations within Clark County, thus consideration of threats is relegated to speculation. It is presumed that livestock or feral horse grazing, Off-Highway Vehicle use, inundation along watersheds, and wildfire would present the most serious manageable threats.

Existing Conservation Areas/Management Actions

It is thought that at least some of the Clark County population of Catchfly Gentian occurs in Lake Mead NRA (NatureServe 2015), so those supposed populations are under the protection and regulations of greater Lake Mead NRA. Species-specific management actions or plans do not appear to exist.

Summary of Direct Impacts

Of the 202 km^2 of predicted high suitability habitat in the county for this species, only 1.7 km^2 are within conservation areas. Fifteen km^2 are already disturbed and another 24 km^2 are likely to be impacted (Table 96). Moderate habitat is far more prevalent – which may indicate scant distribution in the county, given the low incidence of typical habitat for this species. 109 km^2 of moderate habitat is to be conserved, while ~ 15k km^2 of habitat is already disturbed or will be impacted in the future (Table 96).

Table 96. Categorized modeled habitat values (High, Medium, and Low) and the average area (Hectares) predicted in the potential impact areas, conservation areas, already disturbed areas, and overall area

Habitat Level	Impact	Conserved	Disturbed	Area (Hectares)
High	2349	172	1533	20283
Med	10203	10978	7269	139393
Low	110860	502728	35411	1823227

EUMA - Spotted Bat (Euderma maculatum)

Spotted Bats (*Euderma maculatum*) are solitary and widely distributed in western North America. Spotted Bats, though rarely observed by the public, have a striking coloration pattern, with a pair of white spots on their dorsal sides, against a dark background. They are one of the largest bats in North America, and they roost either singly, or in small groups where there are suitable cliffs and nearby foraging areas and water resources (Chambers et al. 2011).

Species Status

The IUCN Redlist categorizes this species as one of Least Concern because of its wide distribution, presumably large population, occurrence in protected areas, and absence of evidence of declining populations (Arroyo-Cabrales and Álvarez-Castañeda 2008). However, both Great Basin National Park and Lake Mead National Recreation Area list them as Species of Concern.

US Fish and Wildlife Service Endangered Species Act: No Status

US Bureau of Land Management (Nevada): Sensitive
US Forest Service (Region 4): Sensitive
State of Nevada: Threatened
NV Natural Heritage Program: Global Rank G4, State Rank S2
NV Wildlife Action Plan: Species of Conservation Priority
IUCN Red List (v 3.1): Least Concern
CITES: No Status

Range

The Spotted Bat is a solitary species found in northern Mexico, throughout the western United States, and in British Columbia, Canada (NatureServe 2009). They occur in 11 western states in the United States, and occur throughout Nevada. Thirty-three percent of the known localities in the state occur in the metropolitan areas of Reno and Las Vegas (Geluso 2000). Most Spotted Bat sightings are in the southwestern part of the state. Spotted Bats inhabit cliffs in their natural habitat, and are frequently found in dry rough desert terrain (Watkins 2007), but have also been observed roosting in buildings within cities (Geluso 2000, Sherwin and Gannon 2005).

Population Trends

Abundance and population trends are essentially unknown (Arroyo-Cabrales and Álvarez-Castañeda 2008). In Clark County, the species is considered a medium priority by the Western Bat Species Working Group regional priority matrix (Western Bat Species Working Group 2007).

Qualitative Habitat Model

Methods

According to our search, the Spotted Bat has been observed within Clark County only in the Las Vegas urban area and in the Muddy River drainage (Williams et al. 2006). The total number of occurrences (n = 13) were insufficient to pursue a quantitative habitat suitability model. However, the species' broad distribution within North America, along with research finding that Spotted Bats are a late flyer and roosts singly in isolated locations (Chambers et al. 2011), suggests that this species may occupy a broader range of habitat within Clark County than has previously been observed (Bradley et al. 2006). In particular, the county contains a large area of potential cliff roosting habitat, which appears to be the favored roosting habitat type for Spotted Bats (Chambers et al. 2011). The species has also been observed foraging in riparian habitat along the Muddy River (Williams et al. 2006), suggesting that similar habitat types within the county (i.e., along the Lake Mead riparian corridor) may also be used. Additionally, radio telemetry tracking in arid portions of Northern Arizona discovered Spotted Bats foraging in forested habitat as well as desert scrub (Chambers at al. 2011).

Based on the available information, we delineated potentially suitable habitat for Spotted Bats within Clark County through a GIS overlay of suitable habitat features (Table 97) at a 1 km^2 spatial resolution. Potential cliff roosting habitat was identified as rocky surfaces with a slope > 25 degrees (Inman et al. 2014). Forested and riparian foraging areas, including springs, were identified based on the vegetation classification of Clark County (Heaton et al. 2011) and the National Hydrography Dataset (NHD). Potential watering sites were identified as high resolution NHD waterbodies ((https://nhd.usgs.gov/) along with guzzler locations from the Nevada Department of Wildlife.

Given the large home range size and nightly flight patterns (distances up to 30 km) observed for Spotted Bats (Chambers et al. 2011), much or all of Clark County is likely within the species' potential flight path, including the urban Las Vegas area where Spotted Bats reportedly roost. Through distance overlays, we determined that the entire county was indeed within a typical flight distance (20 km) of potentially suitable roosting habitat and / or watering sites, particularly given the species known occurrences within the Las Vegas urban area. For this reason, we considered the entirety of Clark County to be a potential flight area for Spotted Bats. A base value of "1" was therefore assigned to all grid cells within our qualitative habitat suitability map (extent of Clark County). Other grid cells were assigned values according to the highest priority habitat type that occurred in each cell (Table 97), with roosting habitat given the highest value (e.g., Roosting > Foraging > Watering). We did not mask urban areas from the final layer because urban development is not thought to be a deterrent for Spotted Bats within Clark County.

Model Discussion

The qualitative habitat model predicts habitat for roosting sites in mountainous areas located throughout the county. Foraging areas are typically located nearby (e.g. the Sheep and Spring ranges and McCullough Mountains, and the north and south Virgin Mountains in Gold butte). Additional foraging areas are located in the more highly vegetated regions of the greater Lake Mead area, including Las Vegas Bay, the Virgin River, the Muddy River, and Moapa Valley (Figure 143).

Table 97. Landscape features used to identify potential *Euderma maculatum* habitat at a spatial resolution of 1 km^2.

Habitat type	Description	Value
Flight Area	Areas within a distance of 20 km from potential roosting sites and water sources.	1
Water sources	Water bodies and springs were identified from the National Hydrography Dataset (https://nhd.usgs.gov/) high-resolution layer for Nevada. Guzzler locations were provided by the Nevada Department of Wildlife. Point features were rasterized to 1 km^2 grid cells.	2

Habitat type	Description	Value
Foraging	Forested and riparian vegetation cover classes extracted from Heaton et al. (2011) vegetation classes.	3
Roosting	Cliffs were identified from a 30 m^2 DEM as cells with a slope > 25 degrees. This layer was aggregated to 1 km^2 such that all 1 km grid cells with at least 10 % cliff habitat were included. This binary slope layer was then clipped to rocky surfaces identified by Inman et al. (2014).	4

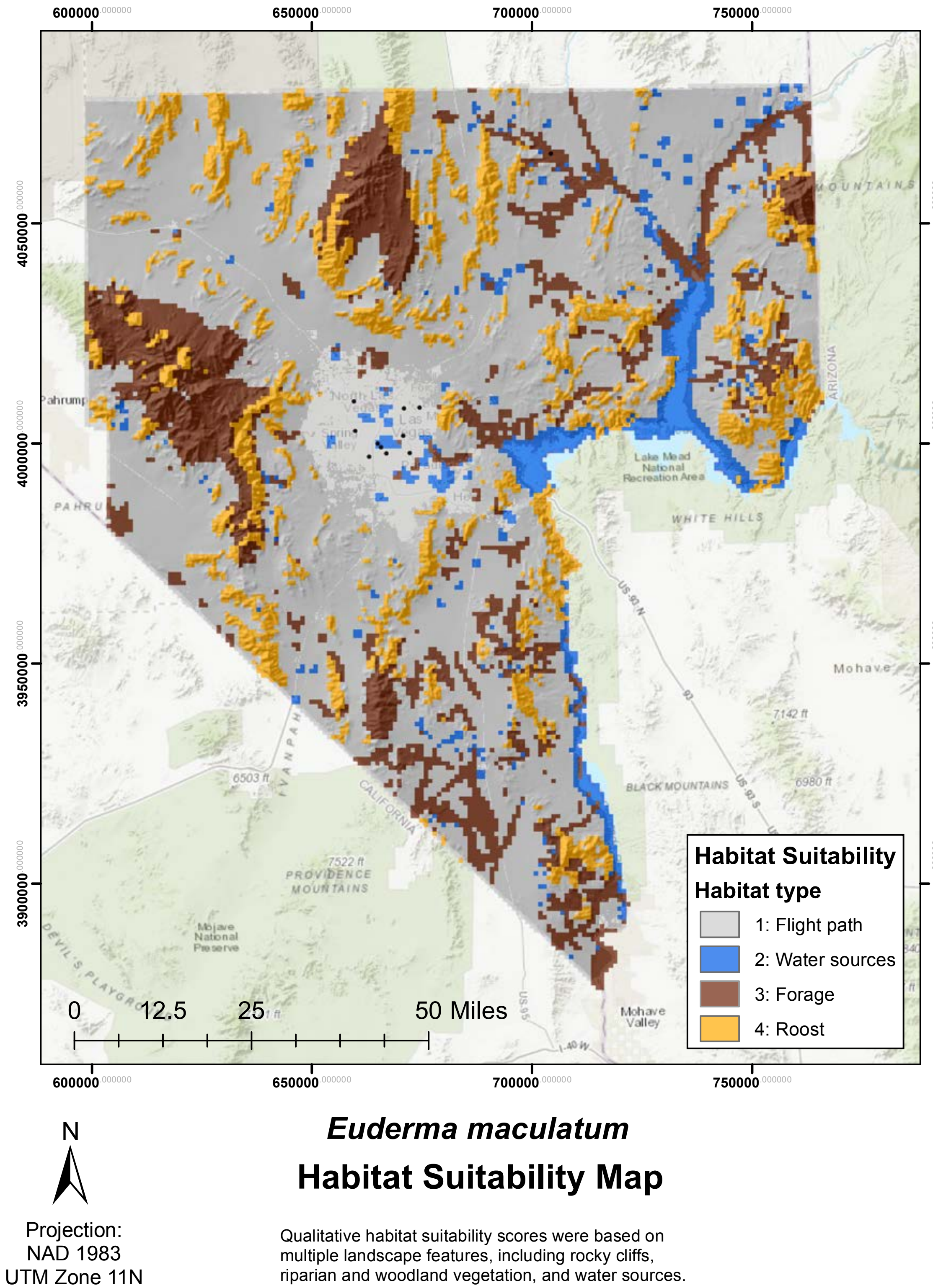


Figure 143. Estimated habitat for *Euderma maculatum* from the qualitative model developed from water sources, potential forage areas, and potential roosting sites (Table 97).

Distribution and Habitat Use within Clark County

The Nevada Natural Heritage database contains six records for Spotted Bat: five in the Las Vegas area and one in the upper Moapa Valley. This species has been studied in the Upper Moapa Valley (Willams et al. 2006). Geluso (2000) reported six records from urban areas in Las Vegas.

Spotted Bats occur within a wide variety of habitats including desert scrub, pinyon-juniper woodland, conifer and mixed conifer forests, riparian forests, and sub-alpine meadows (Chambers and Herder 2005). This species is closely associated with dry, rough desert country (Watkins 1977) and will use rocky cliffs, caves and cave-like structures as well as houses and/or urban high-rise buildings that mimic natural cliffs (Geluso 2000, Sherwin and Gannon 2005, Bradley et al. 2006). Along the Muddy River in Upper Moapa Valley, Spotted Bats were primarily observed foraging over mesquite habitat, and secondarily over riparian marsh (Williams 2001, Williams et al. 2006), and springs and areas of open water also provide important foraging habitat. They have also been observed foraging in the canyons of the Colorado River drainage system (Chambers et al. 2011). Modeled habitat for High and Moderate habitat classifications was most prominent in Mojave Desert Scrub, Salt Desert Scrub, and Blackbrush, and Pinyon Juniper ecosystems, but this species is also predicted to use higher elevation ecosystems, with high or moderate habitat overlapping much of the available Bristlecone Pine, and the Alpine ecosystems in the county (Table 98).

Table 98. Ecosystems within Clark County, and the area (Ha) of Low Medium and High predicted suitability within each ecosystem.

Ecosystem	Low	Medium	High
Alpine	0	0	124
Blackbrush	199308	124488	91877
Bristlecone Pine	70	4679	2816
Desert Riparian	96	10785	336
Mesquite Acacia	1209	18270	760
Mixed Conifer	0	23699	3640
Mojave Desert Scrub	934049	329738	103221
Pinyon Juniper	20	89359	26523
Sagebrush	542	3429	736
Salt Desert Scrub	60502	12476	9712

Ecosystem Level Threats

Spotted Bats likely occur in habitats such as Blackbrush, Desert Riparian, Mesquite/Acacia, Mixed Conifer, Mojave Desert Scrub, Pinyon-Juniper, Sagebrush, and Salt Desert Scrub. Threats to Spotted Bat habitats include loss of habitat due to development in areas where cliffs occur, recreational climbing, and mining and quarry operations (Bradley et al. 2006). Spotted Bats likely also have had a loss of foraging areas to large developments such as urbanization and large-scale renewable energy. Wind energy development can also be detrimental to Spotted Bats from being stuck by propellers, or due to extreme low pressure gradients that occur near the moving propellers and kill bats. Spotted Bats are not on the list of bat species known to be affected by white-nose syndrome (whitenosesyndrome.org 2017), and they may be less susceptible to it, due to their solitary behavior, but this should always be considered a potent risk for bat species.

Threats to Species

Little is known about possible threats to Spotted Bats because there are so few observations of them in the wild. Spotted Bats roost in remote locations making threats to roosts unlikely. However, recreational rock climbing may cause impacts in some areas due to disturbances and damage to habitats. Urbanization in some areas may remove roost sites, although they are known to roost in urban areas. Collection of Spotted Bats by humans and use of pesticides that may bio-accumulate in bats or kill prey may also be threats. In desert habitats, loss of accessible open water that was previously available in many areas for grazing livestock, but has been eliminated in many areas may impact bats because of their high rates of evaporative water loss. As with most bat species, threats include habitat destruction or alteration, disturbance, sensitivity to pesticides and other pollutants, and overexploitation (Chambers and Herder 1995, Wildlife Action Plan Team 2006). Renewable energy development can threaten bat habitat. First there is the direct habitat disturbance. In this regard, solar arrays may be the most destructive to foraging areas for desert bats in Clark County, while wind farms have a smaller surface area disturbance. In contrast, wind turbines can have direct impacts to bats through collisions or barotrauma (barotrauma results from exposure to extremely low pressure areas around moving propellers that cause severe trauma to the delicate bats; Cryan and Barclay 2009, Cryan 2011). White-nose fungus (*Pseudogymnoascus destructans*) has the potential to impact bat species, but has not been found in Spotted Bats, or any bats in the desert southwest, to date. Although incidence of white-nosed fungus – a cold-loving fungus that affects hibernating bat species (whitenosesyndrome.org 2017) -- has not been reported in Nevada, this disease has the potential to affect all hibernating bats, including Spotted Bats. Possible impacts from white-nosed fungus may be lower than with Townsend's Big-eared Bat (on which the fungus has been found, yet infected individuals have not been found), because Spotted Bat roosts alone or in small groups, which is less conducive to the spread of disease than large hibernacula.

Existing Conservation Areas/Management Actions

The Nevada Wildlife Action Plan sets a strategic vision for wildlife conservation at the landscape level in Nevada, and identifies the species of greatest conservation need within the state (2012). The plan designates the Spotted Bat as a Species of Conservation Priority because of its rare and patchy occurrences and because it is listed as threatened in the Nevada Administrative Code (Wildlife Action Plan Team 2012). The objective for this species is maintaining populations at detectable levels. Recommended research and conservation actions include: developing random-plot networks where bats are listened for using high performance microphones and recording devices to establish status, population trends, and distribution; promoting snag retention for potential roosting locations; supporting and advocating technological research to develop non-lethal wind turbine designs to minimize collision mortality; and monitoring for white-nose syndrome (Wildlife Action Plan Team 2012).

The Nevada Bat Conservation Plan assesses the state of bat conservation in Nevada and suggests strategies, actions, and research needed to promote healthy bat populations and habitats (Bradley et al. 2006). The plan considers Spotted Bat populations and habitats a medium priority for funding, planning, and conservation actions, though it states a lack of information about this species is a concern, and prevents an adequate assessment of its status (Bradley et al. 2006). Suggested research priorities are the identification and description of roost sites and breeding range within Nevada.

The Spotted Bat is covered under the Spring Mountain Conservation Agreement. This agreement has been developed between various agencies to provide long-term protection for the rare and sensitive flora and fauna of the Spring Mountains National Recreation Area (USFS et al. 1998). Conservation actions listed in the plan include: developing a bat monitoring plan, emphasizing roost site and water source monitoring; developing and implementing a plan to protect bat roosts in mines and caves; working with volunteers to provide nest boxes for roosting bats to replace lost habitat; and developing and implementing a monitoring program for assessing effects of recreational use on bats and their habitats (USFS et al. 1998).

The Overton Wildlife Management Area (OWMA) consists of 17229 acres in the Moapa Valley managed by the Nevada Department of Wildlife. The conceptual management plan for OWMA calls for protecting and enhancing mammal habitats and populations. Recommended management actions are to determine the occurrence and habitat functionality on the OVWMA for warm desert riparian bats, including Spotted Bats (NDOW 2014).

Summary of Direct Impacts

There are few Spotted Bat occurrences in Clark County; however, Spotted Bats are difficult to detect: they are “late-flyers” and “high-flyers” (Rodhouse et al. 2005) that are often missed in netting activities that typically operate for a few hours after sunset. They are infrequently caught using netting, and may be more accurately surveyed using acoustic methods. Suitable habitat for this species was modeled for the MSHCP Amendment based on the mapping of the American Warm Desert Bedrock Cliff and Outcrop map type from the *Synthesis of Vegetation Maps for Nevada* (Peterson 2008).

Approximately 9144 km^2 of high and moderate suitability modeled habitat exists within Clark County, however this species is rare throughout its range. Impacts to its habitat are likely to be low, since it roosts in high cliff faces unsuitable for development. It is estimated that approximately 3 percent of Spotted Bat modeled habitat in Clark County could be impacted by activities covered under the Amendment, although this number likely overestimates impacts due to the unsuitability for development of preferred roosting sites. Most of the habitat is outside the planning area, however that within the planning area is largely located within the conservation areas, with very little disturbed or likely to be impacted (Table 99).

Table 99. Categorized modeled habitat values (High, Medium, and Low) and the average area (Hectares) predicted in the potential impact areas, conservation areas, already disturbed areas, and overall area

Habitat Level	Impact	Conserved	Disturbed	Area (Hectares)
High	2099	51806	88	247216
Med	28020	144633	19268	667194
Low	95558	299819	104421	1230546

GOAG - Mojave Desert Tortoise (Gopherus agassizii)

On April 2, 1990, the Mojave Desert population of Mojave Desert Tortoise was placed on the federal list of Threatened species afforded protection under the Endangered Species Act. The protected Mojave population includes Mojave Desert Tortoises occurring north and west of the Colorado River in Arizona, California, Nevada, and Utah (55 FR 12178). In 2011, Mojave Desert Tortoises were re-defined taxonomically as two species: Mojave Desert Tortoise (*Gopherus agassizii*), and Sonoran Desert Tortoise (*Gopherus morafkai*) (Murphy et al. 2011). Further research has identified some tortoises east and south of the Colorado River as *G. agassizii* thus reducing the utility of the riverine boundary line and introducing ambiguity to the distribution of which tortoises should be protected in Arizona. Further analyses of tortoises on either side of the river will no doubt occur and perhaps clarify or obfuscate distributional limits for these species. The current ruling on the protections for the Mojave Desert Tortoise have not changed. In Clark County, Nevada all the wild tortoises are considered to be Mojave Desert Tortoises with full protection under the Endangered Species Act and there is no confusion on that point. The remainder of this species account will focus on the Mojave Desert Tortoise.

Species Status

US Fish and Wildlife Service Endangered Species Act: Threatened
US Bureau of Land Management (Nevada): Protected
US Forest Service (Region 4): Threatened
State of Nevada: Threatened
NV Natural Heritage Program: Global Rank G3, State Rank S2S3

NV Wildlife Action Plan: Species of Conservation Priority
IUCN Red list (v 2.3): Vulnerable
CITES: Appendix ii

Range

The Mojave Desert Tortoise occurs in the Mojave and Sonoran deserts in southern California, southern Nevada, Arizona, and the southwestern corner of Utah in the US (Germano et al. 1994, Nussear et al. 2009, Bramble and Hutchison 2014). The listed Mojave population of the Mojave Desert Tortoise includes those animals living north and west of the Colorado River in the Mojave Desert of California, Nevada, Arizona, and southwestern Utah, and in the Sonoran (Colorado) Desert in California (USFWS 1994, USFWS 2011). The northern range limit for confirmed wild Mojave Desert Tortoise sightings was verified by a photograph taken by a BLM employee near Hiko in Lincoln County, Nevada (BLM *unpublished data* 2015). The easternmost Mojave Desert Tortoises live near the entrance to Zion National park in Iron County, Utah, the westernmost sighting for Mojave Desert Tortoise is in the wind farms in Banner Pass, just northwest of Palm Springs, California, and the southernmost Mojave Desert Tortoises are found in the Cargo Muchacho Mountains, California north of Felicity in Imperial County, California (*data used in* Nussear et al. 2009). Elevational ranges for the species in the current climate are from below sea level to an elevation of 2,225 meters (7,300 feet), although they are more typically found below 1,677 meters (5,500 feet) (USFWS 2011).

Habitat Model Review

Two Mojave Desert Tortoise models were found with the potential for use/analysis with respect development and conservation in Clark County, NV. The first by Boykin et al. (2008, Figure 144), and a second by Nussear et al. (2009, Figure 144).

Technical Considerations - The Model by Boykin et al. 2008 was essentially the same as that presented in the SWReGAP. This was a literature-based model of intersecting habitat associations, and rendered as a 30m raster layer. The model is pre-thresholded and as a binary layer will not allow other cutoff levels to be explored. This modeling effort recommended inclusion of USGS products that were used in the other habitat model reviewed here, stating "Consider additional datasets, such as the climate datasets under development for use in Mojave Desert Tortoise habitat modeling by USGS (USGS-BRD Western Ecological Research Center, Henderson, Nevada). (d) As new information is obtained for species occurrence and distribution of habitat characteristics, re-do inductive modeling and accuracy assessment as an iterative process". The website cited as hosting the base layers for this model is no longer publicly accessible.

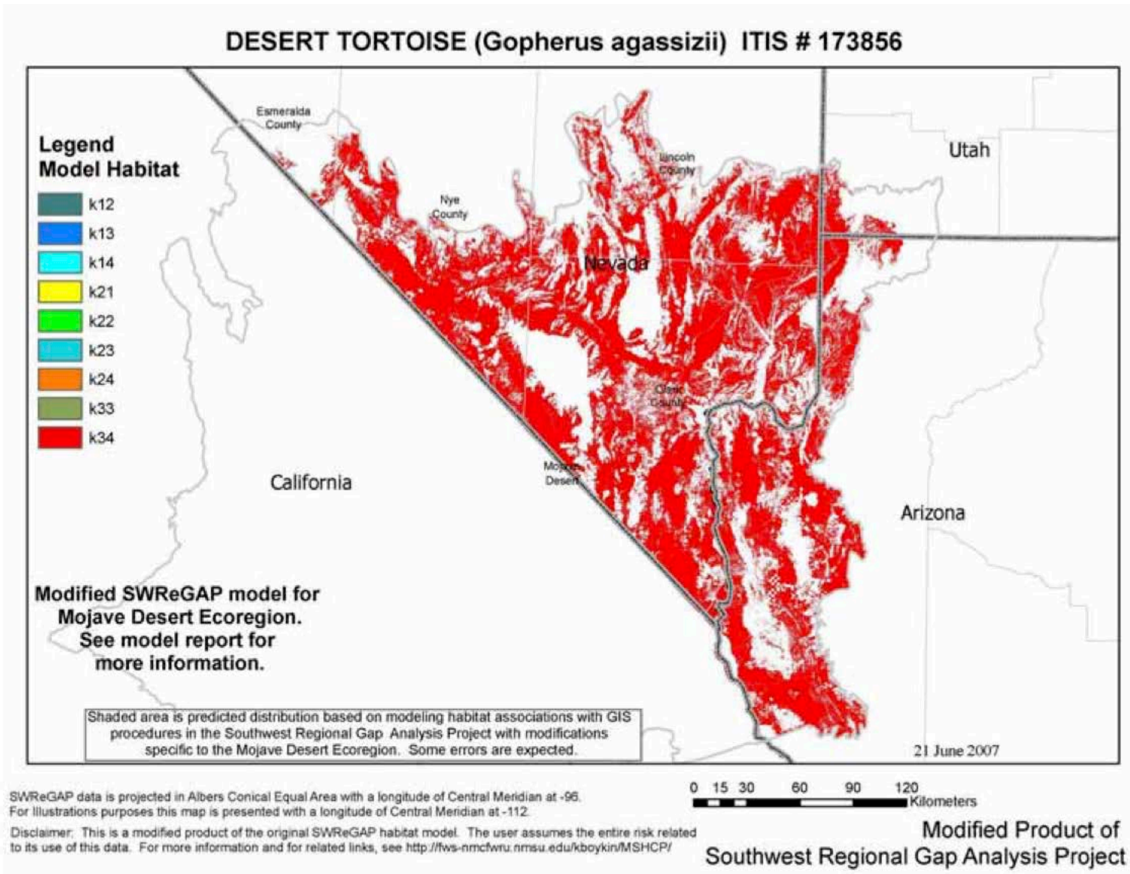


Figure 144. Mojave Desert Tortoise model presented in Boykin et al. 2008

The Nussear et al. (2009) model is MaxEnt-based using 15,311 tortoise occurrences and was reduced to 6,350 occurrences by data-thinning processes to reduce spatial and temporal sampling biases. The scale of this model was 1km^2 grid cells, and geographic layers represent climate (Winter and Summer Precipitation and variances for each), topography (Surface Roughness, Slope, Aspect and Elevation), vegetation (Annual Plant Green-up Potential and Perennial Plant cover), and geology (Soil Depth, Rockiness, and Bulk Density). Modeling was conducted iteratively with replacement (N=500) by withholding 80% of the presence points for training and 20% for testing randomly with each iteration. Points were not spatially re-sampled other than that inherent in the iterative re-sampling, and thus there is potential for spatial bias in the areas with more sampling (i.e. DWMAS), and in areas that are known to contain tortoises, but for which there were not available presence data at the time the model was conducted (e.g. Trout canyon/Sandy Valley, and Pahrump areas). Model selection was conducted by comparing the Jackknife and inclusion scores, the % Model contributions, and the precision and accuracy, AUC values, and Kohen's kappa scores among models including different combinations of environmental covariates. The final model included 10 of the 16 initial habitat variables including: Elevation, Surface Roughness, Percent Smoothness, Soil Bulk Density, Depth to Bedrock, % Rocks, Perennial Cover, Annual Growth Potential, and Summer and Winter Precipitation. The model was produced at a 1km^2 resolution, and was left un-thresholded, such that different values could be used for habitat inclusion as desired.

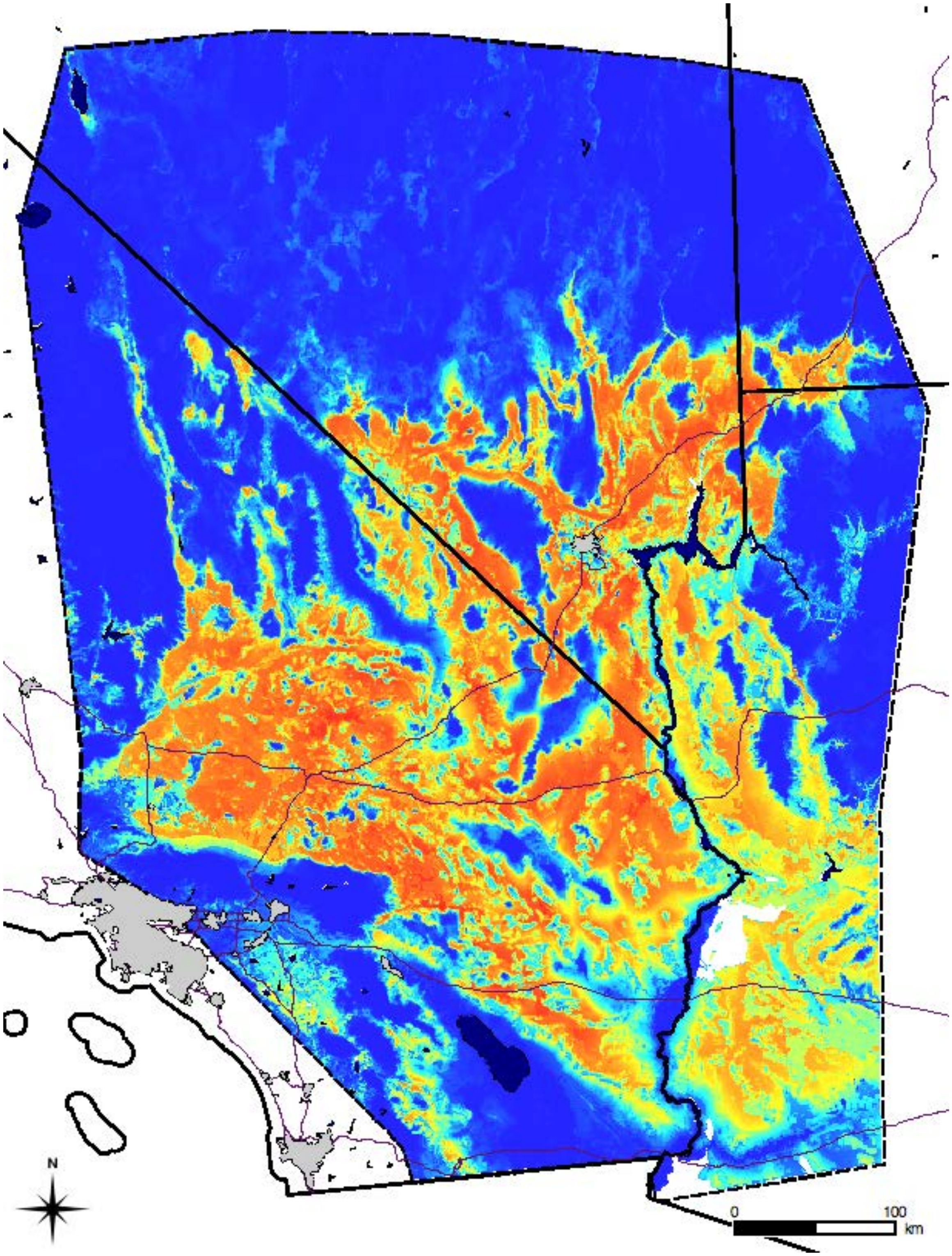


Figure 145. Mojave Desert Tortoise (*Gopherus agassizii*) habitat model from Nussear et al. 2009

Model Comparisons - The two models differ significantly in their predicted habitat, although the general extent of the predicted distributions are similar in nature. The Nussear model is statistical in nature and has a broad point base used for development. The Boykin model is based on habitat associations found in the literature. The Nussear et al. model is likely a more refined product for habitat development/conservation planning.

Considerations for Future Modeling - A new habitat layer is under development by Nussear et al. that included potential influences of climate change. This future product is at 1 km^2 resolution, and it is understood that Clark County may require a finer scale resolution model for future planning consideration. Spatial thinning might help reduce model biases from concentrated sampling efforts that provided points used to develop the 2009 model.

Distribution and Habitat Use within Clark County

Mojave Desert Tortoise habitat occurs widely throughout Clark County. The types of habitats that Mojave Desert Tortoises occupy in Clark County are diverse and can be characterized as valley bottoms, lower slopes, upper slopes, mountain slopes and mountain passes. Within the 10 terrestrial ecosystems defined for the county (Heaton et al. 2011) the highest categories of predicted suitable habitat for Mojave Desert Tortoises are Mojave Desert Scrub, Salt Desert Scrub, Mesquite Acacia, and Blackbrush, with a smaller amount of habitat in Desert Riparian ecosystems (Table 100). Moderate habitat incudes an expansion of habitat in these ecosystems, with an increase of area in the Blackbrush ecosystem and the inclusion of a small area of the Pinyon Juniper ecosystem, where tortoises are found, but not typically in high densities (Nussear and Tuberville 2014).

Table 100. Ecosystems within Clark County, and the area (Ha) of Low Medium and High predicted suitability within each ecosystem.

Ecosystem	Low	Medium	High
Alpine	124	0	0
Blackbrush	271404	127498	16770
Bristlecone Pine	7565	0	0
Desert Riparian	2336	5352	2260
Mesquite Acacia	455	6068	13715
Mixed Conifer	27339	0	0
Mojave Desert Scrub	28163	455963	872745
Pinyon Juniper	115339	563	0
Sagebrush	4707	0	0
Salt Desert Scrub	22195	35894	24602

Optimal habitat has been characterized as creosote bush scrub in which precipitation ranges from 50 to 203 mm (2 to 8 inches), where a diversity of perennial plants is relatively high, and production of annual plants is high (Luckenbach 1982; Turner 1994; Turner and Brown 1994). Mojave Desert Tortoises occupy habitat with a wide variety of geomorphic features from flat valley floors, and rolling hills of lower and upper outwash plains (i.e. bajadas), to rugged mountain slopes and passes (Nussear et al. 2009, Nussear and Tuberville 2014). Mojave Desert Tortoises are found in a variety of Mojave Desert scrub vegetation types (Turner 1994, Turner and Brown 1994, Keeler-Wolf 2007) variously dominated by perennial plants such as creosotebush (*Larrea tridentata*), white bursage (*Ambrosia dumosa*), saltbush (*Atriplex* spp.), galleta grass (*Hilaria rigida*), bush muhly (*Muhlenbergia porteri*), beavertail prickly pear cactus (*Opuntia basilaris*), cottontop cactus (*Echinocactus polycephalu*s), cholla cactus (*Cylindropuntia* spp.) Joshua tree and Mojave Yucca (*Yucca brevifolia* and *Y. schidigera*; respectively), Mormon tea (*Ephedra* spp.), and blackbrush (*Coleogyne ramosissima*). The lower elevational limits to Mojave Desert Tortoise range are dominated by saltbush species, and perennial grasses discussed above. The upper distributional limits of Mojave Desert Tortoise habitat are characterized by pinyon-juniper (*Pinus-Juniperus*) woodlands interspersed by patches of blackbrush, banana yucca (*Yucca baccata*), sagebrush (*Artemisia* spp.), rabbitbrush (*Ericameria nauseosus*) and a variety of the Mojave Desert scrub species already discussed (Luckenbach 1982, Germano et al. 1994, Nussear and Tuberville 2014).

<u>Valley bottoms</u> – Mojave Desert Tortoises do not occupy the seasonally submerged playas such as the Jean, or Eldorado dry lakes. However, they are abundant in the broad valleys like those around Cal-Nev-Ari, Goodsprings, and Coyote Springs. Those areas have deep soils of fine sandy-loam and gravels where tortoises dig their burrows. Vegetation is creosotebush and white bursage shrublands where many other species of shrubs, grasses, cactus and a few trees occur. The open shrublands have approximately 10 to 25 percent plant cover. The shrubby flats are often interspersed by large patches of desert pavement characterized by interlocking gravel surfaces on top of thin layers of clay and very sparse (i.e. less than five percent cover) shrubs, cactus and yuccas. These surfaces can be very ancient, taking millions of years to develop as we see them today. Desert pavements are important places for Mojave Desert Tortoises to get a drink during brief rains (Medica et al. 1980), and with adequate rainfall the pavements are thickly covered by desert annual plants that are important food for tortoises.

<u>Lower and upper outwash plains (lower and upper bajadas, respectively)</u> are gentle slopes resulting from the alluvial rocks, gravels and sands that erode from mountains. Outwash plains are characteristic of tortoise habitats at Red Rock Canyon National Conservation Area (BLM) and Lake Mead National Recreation Area (NPS), the slopes around the base of the Spring Mountains, and the Desert National Wildlife Refuge. These large geomorphic features are also known regionally as bajadas. The lower outwash plains arise from the edges of valley bottoms and playas. The soils are usually very fine with a lot of sand and clay and they are dominated by plants like saltbush (e.g. shadscale - *Atriplex confertifolia*, quailbush - *A. canescens*), and in sandy areas galleta grass. Normally these areas do not support high densities of

tortoises, but there are some areas in the Mojave Desert where robust populations inhabit these areas. Upper outwash plains are comprised of gravels, and larger cobbles and stones. These flat upland benches are incised by shallow washes and deeper arroyos that are also important to tortoises. The washes may expose layers of calcium carbonate deposits also known as caliche, or calcrete. Wherever caliche layers are exposed in washes, tortoises either dig caves between the layers in the walls of the arroyos or opportunistically use those that erode on their own. The caliche caves are often used as winter dens by tortoises when they can find them and also by many other desert animals like kit fox (*Vulpes macrotis*), Burrowing Owls (*Athene cunicularia*), Gila Monsters (*Heloderma suspectum*), and many snakes and invertebrates. The vegetation is frequently dominated by creosotebush and white bursage with many other associated shrubs, succulents, grasses, and a few trees such as catclaw acacia (*Acacia greggii*). A diversity of annual plants is also found on the benches. While caliche layers can be beneficial for Mojave Desert Tortoises and other wildlife, large flat areas where unbroken caliche layers occur just inches below the soil surface create an impediment to plant growth and to tortoises digging. These areas are frequently dominated by cactus gardens and other shallow rooted plants. Creosote bushes growing on these layers are frequently much smaller than in surrounding areas with deeper soil – thus an indicator of this important habitat feature.

<u>Mesa tops and slopes</u> – mesas are flat-topped geomorphic features with steep sides. Some are derived from sedimentary layers, while others are derived from volcanic layers. The sedimentary derived mesas often harbor tortoise populations. The volcanic mesas are often so stony on top as to provide few opportunities for tortoise cover, thus while tortoises may be found there, they are frequently sparser than other areas described here. Talus slopes, comprised of large unstable boulder piles on steep slopes are great habitat for rattlesnakes, but dangerous for tortoises, because it is difficult for them to move among the boulders, except around the edges where the large rocks can provide good cover. Mesas occur over less area than the valleys and outwash plains, yet they provide some important Mojave Desert Tortoise habitat. Some of the best representative mesa habitat is on Mormon Mesa near Overton. Once considered too low and harsh for tortoises, after a tortoise research project was conducted there it was found to support a healthy population of tortoises at the confluence of the Virgin and Muddy rivers (Nussear 2004, Nussear et al. 2012). The northern section of Mormon Mesa, near the Mormon Mountains is also challenging to tortoises because of extremely deep caliche layers; however, where arroyos have cut into the caliche there are caves that provide good cover for tortoises inhabiting the area.

<u>Mountain slopes and passes</u> - Low elevation mountain slopes and passes between valleys have recently been shown to provide good habitat for Mojave Desert Tortoises (Nussear et al. 2009). The mountain slopes and passes have expansive areas of exposed bedrock with caves, and boulder piles that provide tortoise cover around the edges, and a few areas of deep soil pockets that are probably important for reproduction. Examples of areas where tortoises occupy such areas occur throughout the McCullough Range, Spring Mountains, and the Arrow Canyon Range in north

central Clark County. While most of the previously mentioned desert scrub species are found in these habitats, additional shrubby species include: buckwheats (*Eriogonum* spp.), barrel cactus (*Ferocactus* spp.), teddy bear cholla cactus (*Opuntia bigelovii*), catclaw acacia (*Acacia greggii*), and many others.

Life history and ecology – Mojave Desert Tortoises hatch from eggs that are buried by the females in April through June (Rostal 2014). Clutch sizes are 3 to 5 eggs and in the northeast Mojave Desert a female may lay up to three clutches in a season (Turner et al. 1986). The eggs take 70 to 90 days to hatch (Rostal and Wibbels 2015). In most cases, after depositing her eggs, the female goes on about her business and leaves her eggs, and the young to hatch and disperse on their own. Neonatal tortoises are less than 1 year old and approximately 45 mm maximum carapace length when they hatch. Either before they hatch or within 24 to 48 hours of hatching the tiny tortoises absorb a remaining portion of egg yolk through a gap in the shell near their abdomen (Ewert 1979, Mushinsky 2014). The yolk is attached to the small intestine and provisions the small tortoise that may not find edible vegetation to eat until the following spring (if they are fortunate). Very little is known about tortoises from when they hatch until they are subadults at about 180 mm maximum carapace length. Juvenile Mojave Desert Tortoises that use rodent burrows or large rocks for cover from predators and harsh cold and hot environmental conditions (Esque and Duncan 1985, Nafus et al. 2015). The availability of abundant rodent burrows and small desert washes has been correlated with higher growth and survival of small tortoises (Nafus et al. 2017). As tortoises increase body size their ability to dig burrows increases substantially. Adult Mojave Desert Tortoises can increase burrow length more than a foot a day in friable soil. Soil that is too sandy (i.e., <8% clay) does not maintain the integrity for burrows to last very long. The shells of Mojave Desert Tortoises are not completely ossified until they are several years old. Mortality of tortoises smaller than adults is thought to be very high. Once they reach adult size, wild Mojave Desert Tortoise life expectancy is 30 to 50 years (Germano 1992, Medica et al. 2012).

Home range – Tortoise activities are concentrated in potentially overlapping core areas known as home ranges. Home ranges supply tortoises with shelter, food and water, and tortoises travel in these areas to find mates and lay eggs. The home range must provide for all the tortoises’ needs throughout all life stages. Because tortoises do not defend a specific, exclusive area, they do not maintain territories. The size of Mojave Desert Tortoise home ranges varies with respect to climatic factors, topographical features, burrowing substrate, forage availability, social interactions, anthropogenic disturbances, the physical structure of vegetation (Berish and Medica 2014), and the health of the individual tortoise. Annual home range sizes vary from 1 to 125 ha (Berish and Medica 2014). Female home ranges are approximately half that of the average male (Berry 1986). Over its lifetime, each Mojave Desert Tortoise may require more than approximate 4 km^2 (1.5 square miles) of habitat and make forays of more than Approximately 11 km (7 miles, Berry 1986) at a time.

Diet and drinking –If watched long enough, Mojave Desert Tortoises sample everything that is in their environment (Esque 1994). Tortoises in Clark County are no different, but they mostly eat desert annual plants. Annual plants remain dormant, as seeds, for much of the year. There are winter/spring annual plant species and there are summer/fall annual species as well. Some studies on tortoise diets have been conducted in the Mojave Desert (Esque 1994, Oftedal 2002, Jennings and Berry 2015), but summer diets are mostly unknown. Tortoise diets are more diverse when lots variety of species are available. Individual tortoises have dietary preferences but the mechanism driving this selection has not been determined (Esque et al 2014). Mojave Desert Tortoises eat fewer species of perennial plants than annual plant species. One of the shrubs they prefer is range ratany (*Krameria* spp.), and they particularly consume the flowers. Occasionally they will eat perennial grasses such as bush muhly or galletta grass. During years when there is very little to eat tortoises will consume beaver tail prickly pear cactus (Esque 1986). It is currently believed that sites having a diversity of plant species available represent good tortoise habitat. Diets of tortoises smaller than adults are mostly undocumented, but the small tortoises probably eat many of the same species as adults. They may be more selective in their diets to increase the value of their nutrition. Tortoises appear to benefit from acquiring mineral nutrition by sometimes consuming bones and stones. It is assumed that these materials provide calcium, phosphorus, and magnesium (Esque and Peters 1994, Walde et al. 2007).

Tortoises need to drink water, and they will drink whenever it rains. Tortoises have locations within their home ranges that they know water will pool and when storms are approaching they travel to those places in anticipation of getting a drink (Medica et al. 1980). As water pools or runs off of rocks, the tortoise positions itself so that the front of its face where it breathes (the nares) are in contact with the water or wet substrate and draw the water in through the nares. If the puddle is deep enough they may put their entire face into the water. Tortoises also wallow in mud, but it is not known whether this contributes to their water balance. Water intake is so important to tortoises that they will leave their winter dens to go and get a drink during winter storms.

Ecosystem Level Threats

Ecosystem level threats to tortoises and their habitats can be widespread in the environment and may be direct or indirect (Esque et al. 2003). Activities that create surface disturbances can damage vegetation, disturb seed banks, and increase surface erosion by water and wind (Sankey et al. 2011, Soulard et al. 2013,), which leads to further desertification by altering soil surfaces and the ability for water to infiltrate. Surface disturbances can be caused by urban and suburban development, renewable energy and infrastructure development, military training activities, transportation and communication corridors, and recreational activities (Tracy et al. 2004, USFWS 2011). Invasive species and related desert wildfires are other sources of disturbance that have been of concern by resource managers for the past 30 years (Brooks and Esque 2002, Brooks and Matchett 2006, Drake et al. 2015). Climate change has recently been acknowledged as an important consideration for the conservation of many species including Mojave Desert Tortoise (Rostal and Wibbels 2014). Invasive grasses have recently been shown to be a direct threat to tortoises for their negative influence on the health of tortoises that eat the harmful grasses (Drake et al. *In Review*). The largest threat to this species' habitat is the loss and degradation of habitat through urban and suburban development, although the widespread effects of fire and climate change have yet to be ascertained. Additionally, development results in the fragmentation of large expanses of habitat and can reduce genetic flow between subpopulations (USFWS 2011). Off-road vehicular activity and the invasion of non-native plants contribute to the degradation of suitable habitat (Bury and Luckenbach 2002). Non-native plant invasions can cause increased incidence of wildfires, from which desert vegetation is very slow to recover (Brooks 1999, Brooks and Esque 2002, Webb et al. 2003, Drake et al. 2015). Often, native vegetation is replaced with invasive non-natives and habitat is at risk to permanent conversion through a series of wildfires and re-invasion of non-natives (Wildlife Action Plan Team 2006, USFWS 2011). Historically, livestock grazing has induced changes to Mojave Desert Tortoise habitats through pressure on vegetation, soil disturbances, and changes in nutrient distributions (USFWS 2011).

Population Trends

Population trends for Mojave Desert Tortoises can be monitored in a variety of ways. In Clark County, there is a rich history of demographic and population trend monitoring. Beginning in 1976, a network of permanent population monitoring study plots that were sponsored by USDI-BLM and Nevada Department of Wildlife were established in southern Nevada. These plots were typically 1 sq. mile in area, were selected to be representative of the range of local habitat types, and were re-sampled on a roughly 5-year rotation (Tracy et al. 2004). Annual range-wide population monitoring of the Mojave Desert Tortoise using line distance transects began in 2001, and the study plots were temporarily abandoned in about 2000 in favor of a new sampling framework.

Following the federal listing of the Mojave Desert Tortoise there was a debate about the relative value of these demographic plots in comparison with transects randomly distributed throughout habitat areas. The benefit of the random transects is a stratified random sampling design could be used to select habitat types representative of a larger subset of all habitat available, and that they could statistically derive population estimates for large areas. While that is true, the random transects also had a very large error associated with the estimates and they required very large sample sizes over many years to yield statistically relevant results (Nussear and Tracy 2005). Fortunately, enough time has passed for the random transects to begin yielding relevant results. Population density estimates of adult tortoises resulting from these surveys varied among recovery units and years. These surveys show appreciable population declines at the local level in many areas without corresponding increases to offset declines in other areas (USFWS 2008). However, recent reports from the Mojave Desert Tortoise Recovery Office indicate increasing trends in the Northeast Mojave DWMA, which is largely composed of Clark County (USFWS 2015).

While the debate about demographic plots versus random transects has gone back and forth for an intervening 15 years, new opportunities provided the ability of resource agencies to adopt both types of surveys. The random transects allow for broad inference about population trends, while a return to intensively sampled demographic plots provide detailed information about changes in the demographic profile of local tortoise populations. The demographic profiles provide detailed information about reproduction and survival of tortoises at all of their life stages (e.g. juveniles, subadults, adults). While the plots have only recently been re-established, they are expected to provide new and rapid insights into the dynamics of population change in relation to habitat qualities for Mojave Desert Tortoises in Clark County.

Threats to Species

The vast majority of threats to the Mojave Desert Tortoise and its habitat are associated with human land uses. The threats identified in the 1994 *Mojave Desert Tortoise (Mojave Population) Recovery Plan (*USFWS 2011*)*, the basis for listing the tortoise as a Threatened species, continue to affect the species (Tracy et al. 2004, USFWS 2011). Habitat loss, degradation, and fragmentation from urbanization, off-road vehicular activity, linear features such as roads and utility corridors, livestock grazing, mining, and military activities were cited as some of the primary reasons for the decline in Mojave Desert Tortoise populations (Tracy et al. 2004, USFWS 2011). Disease and increased frequency of wildfire resulting from non-native invasive plant species proliferation in the Mojave Desert have also been implicated in Mojave Desert Tortoise population declines (Wildlife Action Plan Team 2006, USFWS 2008).

Atmospheric nitrogen is a by-product of internal combustion engines and other urban activities. This nitrogen can settle on plants and soils, which can then increase the abundance of certain invasive species (e.g., *Schismus barbatus, Erodium cicutarium, Bromus madritensis*), particularly non-native annual grasses and forbs (Allen et al. 2009), and cause a concomitant reduction in native forbs (Allen et al. 2009). The reduction in native annual plants can have a negative impact on Mojave Desert Tortoise (Brooks and Esque 2002, Drake et al. *in Review*).

Increases in Mediterranean grasses have led to extensive wildfires throughout the range of the tortoise (Brooks and Matchett 2003). Desert wildfires are known to kill >10% of adult populations of Mojave Desert Tortoise in a single event (Esque et al. 2002). While it is known that adult tortoises used burned habitat, and it has been found that their growth, behavior, reproduction and health in burned areas is not different from unburned areas (Drake et al. 2015), it is also known that diets high in brome grass result in slow growth, reduce survival, and present other health hazards for juvenile Mojave Desert Tortoises (Drake et al. 2017).

The presence of high levels of sand in soils can be detrimental to Mojave Desert Tortoises in a mostly indirect manner. Tortoises find it difficult to maintain burrows in sandy soils because they collapse easily (Esque et al. 1993), and areas of pure sand soils were found to support very little tortoise activity (Baxter 1987). Increases in sand can result from OHV disturbance of cryptobiotic crusts as the underlying soils become exposed and subject to wind effects blowing the sand into new areas downwind. This, in turn, results in a reduction of soils appropriate for burrowing.

Deliberate harassment by humans and over collection for commercial, recreational, scientific, educational, or dietary purposes, are threats to the species (USFWS 2011). Injury and death as a result of collisions with motor vehicles is perhaps the greatest known threat in this category. Areas near highways that previously did not have tortoise fencing usually have reduced tortoise population densities near roads (von Seckendorff Hoff and Marlow, 2002, Boarman and Sazaki 2006, USFWS 2011, Nafus et al. 2013, Hughson and Darby 2013).

Two bacterial organisms are known to infect wild Mojave Desert Tortoises in Clark County: Mycoplasma agassizii, and M. testudineum. The mycoplasmosis resulting from these infections can result in the signs of Upper Respiratory Tract Disease (URTD) that was important in the federal listing of the species (USFWS 2011). Other organisms known or suspected to infect Mojave Desert Tortoises in Clark County include herpesvirus, shell and skin fungi, pneumonia, Cryptosporidium, and Chlamydia (Jacobson 2014). Diseases known to affect tortoises include, gout, urolithiasis, and oxalosis (Jacobson 2014). A noninfectious disease known as cutaneous dyskeratosis also has been found in *G. agassizii* (Jacobson 2014). Disease-related mortality may be a result of multiple factors including drought, poor nutrition, environmental toxicants, or habitat degradation (Mojave Desert Tortoise Recovery Office 2009, Jacobson 2014).

Hatchling and juvenile tortoises are naturally preyed upon by several species of native mammals, reptiles, and birds (Grover and DeFalco 1995, Bjurlin and Bissonette 2004). However, in areas where human development and activity increase, human-derived food subsidies (e.g., open trash bins, pet food left outdoors, leaky watering systems) have allowed subsidized predators (common raven - *Corvus corax*, and coyote - *Canis latrans*) to colonize previously less suitable areas with unnaturally high population levels, which in turn have allowed them to opportunistically prey on juvenile Mojave Desert Tortoises (Kristan and Boarman 2003, Esque et al, 2010). Thus, urban and suburban development pose both a direct (i.e., loss of habitat) and indirect (i.e., increase in predation) threat to some Mojave Desert Tortoise populations. Common ravens (Ft Irwin Translocation Project – unpublished data), coyotes (Esque et al. 2010), and American badgers (*Taxidea taxus*; Emblidge et al. 2015), are now known to prey on Mojave Desert Tortoises of all sizes. Mountain lions (*Felis concolor*) are known to prey on adult Mojave Desert Tortoise (Medica et al. 2012 With increasing sizes of the wildland/urban interface, feral and free roaming pets (e.g., canines and felines) pose an increased risk of predation to the Mojave Desert Tortoise (USFWS 2011).

Captive or pet tortoises released into the wild can introduce diseases into the wild population potentially result in genetic contamination (USFWS 2008).

A more detailed discussion of threats to the Mojave Desert Tortoise and its habitat, including global climate change and regulatory mechanism inadequacies, is available in the *revised recovery plan for the Mojave population of the Mojave Desert Tortoise (Gopherus agassizii)* (USFWS 2011).

Summary of Direct Impacts

Modeled habitat for Mojave Desert Tortoise occurs throughout the plan area. Suitable habitat for this species was based on the model developed by Nussear et al. (2009). Approximately 2,656,786 hectares (26567 km^2) of high and moderate category habitat for this species exists within the county (Table 101). Of this 5075 $km^2$are located within conserved habitats (ACEC's, National and State Parks, etc). Areas already disturbed (but not masked from models due to heavy disturbance) include ~ 1204 km^2 of high and moderate category habitat (Table 101), and an additional 930 $km^2$of high, and 430 km^2 of moderate habitat will be potentially lost to development under the plan (Table 101).

Table 101. Categorized modeled habitat values (High, Medium, and Low) and the average area (Hectares) predicted in the potential impact areas, conservation areas, already disturbed areas, and overall area.

Habitat Level	Impact	Conserved	Disturbed	Area (Hectares)
High	93039	355371	56196	1375027
Med	42985	152149	64235	1281759
Low	5093	49857	21911	742315

Existing Conservation Areas/Management Actions

The 1994 Mojave Desert Tortoise (Mojave Population) Recovery Plan describes a strategy for recovering the Mojave population of the Mojave Desert Tortoise. The recovery plan includes the identification of six recovery units, recommendations for a system of Desert Wildlife Management Areas (DWMAs) within the recovery units, and development and implementation of specific recovery actions, especially within DWMAs. Establishment of recovery units and DWMAs was intended, in part, to facilitate an ecosystem approach to land management and Mojave Desert Tortoise recovery, as stipulated by section 2(b) of the Endangered Species Act (USFWS 1994). Critical habitat is legally defined under the ESA as areas that are essential for the conservation of the Mojave Desert Tortoise, that support physical and biological features essential for Mojave Desert Tortoise survival, and that may require special management considerations or protection. Critical habitat for the Mojave Desert Tortoise was designated in 1994, largely based on proposed DWMAs in the draft Recovery Plan.

The BLM formalized the DWMAs from the 1994 Recovery Plan through its planning process and administers them as Areas of Critical Environmental Concern (ACEC). The BLM designates ACECs where special management is needed to protect and prevent irreparable damage to important historical, cultural, scenic values, fish and wildlife, and natural resources (in this case, the Mojave Desert Tortoise) or to protect life and safety from natural hazards. In Nevada, the BLM Las Vegas, Ely, and Battle Mountain field offices manage more than 940,000 acres of Mojave Desert Tortoise habitat designated as ACECs by the Las Vegas and Ely field offices (Bureau of Land Management 2009).

The Mojave Desert Tortoise Management Oversight Group was established in 1988 to coordinate agency planning and management activities affecting the Mojave Desert Tortoise and to implement the management actions in the BLM's Mojave Desert Tortoise Range-wide Plan. Charter members of the Management Oversight Group included the four BLM State Directors from Arizona, California, Nevada, and Utah;

the four State Fish and Game Directors from these States; the three Fish and Wildlife Service Regional Directors that share tortoise management responsibilities; and, a BLM Washington Office representative. Membership was subsequently expanded to include representatives of the National Park Service, the US Geological Survey, and officials of the four branches of the military (Army, Air Force, Navy, and Marine Corps) that administers portions of Mojave tortoise habitat (USFWS 2008). County governments within the range of the Mojave Desert Tortoise were also included in 2007. Subsequent to the listing of the Mojave population as Threatened and following the publication of the recovery plan in 1994, the Mojave Desert Tortoise Management Oversight Group assumed a leadership role in coordinating agency activities directed toward recovery plan implementation.

The Mojave Desert Tortoise Recovery Office (DTRO) was established by the USFWS in 2004. The DTRO's staff focuses solely on the Mojave Desert Tortoise and its recovery. The DTRO coordinates recovery planning and implementation, research, monitoring, and recovery permitting, while working closely with those Service biologists focusing on regulatory issues. The DTRO assists in the coordination among land managers, research scientists, the interagency Mojave Desert Tortoise Management Oversight Group, the Desert Managers Group (DMG), and other local, state, or regional working groups. To complement the DTRO, the USFWS assembled a Mojave Desert Tortoise Science Advisory Committee (SAC) in 2005. This committee is presently composed of five scientists from diverse and experienced backgrounds charged with providing recommendations relative to Mojave Desert Tortoise recovery implementation and approach and ensuring rigorous scientific standards are met (USFWS 2008).

In Nevada, the Mojave Desert Tortoise is protected under the Nevada Administrative Code 503.080, wherein the species is listed as a state protected reptile further classified as Threatened, and collection is controlled under section 503.093. An appropriate license, permit, or authorization must be obtained from NDOW to possess an individual animal. The Mojave Desert Tortoise is also considered a Species of Conservation Priority under the Nevada Wildlife Action Plan (NWAP), which is implemented by NDOW (Wildlife Action Plan Team 2012).

The Mojave Desert Tortoise is also considered a Species of Conservation Priority under the Nevada Wildlife Action Plan (NWAP), which is implemented by NDOW (Wildlife Action Plan Team 2012). Recommended conservation actions particular to this species and its suitable habitat are included in the NWAP. The NWAP recommended approach is to protect large tracts of suitable tortoise habitat, well dispersed throughout their range. Furthermore, the recommended conservation strategies to conserve this habitat that this species occurs in include: maintaining this species habitat at its current distribution in stable or increasing trend; sustaining stable or increasing populations of wildlife in key habitats; and, obtain no net unmitigated loss or fragmentation of habitat in areas designated by the 2000 MSHCP as "Intensive Management Areas" or "Less Intensive Management Areas," or in areas designated as "Multiple Use Management Areas" that represent the majority of habitat for a species (Wildlife Action Plan Team 2012).

The Nevada Department of Transportation (NDOT), and Clark County, Nevada have taken action to protect Mojave Desert Tortoise on Nevada highways by installing exclusion fencing along many roadways that traverse Mojave Desert Tortoise habitat. Fencing impedes tortoise access to roadways, thus minimizing or avoiding tortoise injury and mortality from collisions with vehicles. Annual road mortality of Mojave Desert Tortoises has decreased by 75 percent or greater since NDOT began installing exclusion fencing (Mojave Desert Tortoise Recovery Office 2009).

In Clark County, the Mojave population of Mojave Desert Tortoise is also covered under the Lower Colorado River Multi-Species Conservation Program and the Coyote Springs Investment Multiple-Species Habitat Conservation Plan. The intended goals of each are to conserve habitat of federally listed species and minimize the potential for federal listing of additional species; to accommodate covered activities; and to provide incidental take authorizations (Lower Colorado River Multi-Species Conservation Program 2004, Coyote Springs Investment Multiple-Species Habitat Conservation Plan 2008).

In southern Nevada, the Mojave population of Mojave Desert Tortoise is addressed in the Southeastern Lincoln County HCP, which was issued in May 5, 2010. The focus of this plan is to permit growth and development in portions of tortoise habitat north of Mesquite and urban expansion in the Alamo area in Lincoln County (Southeastern Lincoln County Habitat Conservation Plan 2008.

HEGR - MacNeill's Saltbush Sootywing (Hesperopsis gracielae)

MacNeill's Sootywing is a small, dark brown skipper (Pratt and Wiesenborn 2011) with a wingspread of 23 mm (Wiesenborn 2012). They live on the floodplains of the main stem and primary tributaries of the Lower Colorado River drainage (Pratt and Wiesenborn 2011). Adult MacNeill's Sootywings fly from April through October with three flights per year in Nevada (Austin and Austin 1980) and two flights in southeastern California (Emmel and Emmel 1973). The MacNeill's Sootywing is dependent on quail brush (*Atriplex lentiformis*) as an oviposition, larval growth, and pupation substrate (citations in Pratt and Wiesenborn 2011), but the host plant does not provide nectar for adults (Wiesenborn and Pratt 2010). Two important nectaring plants include *Heliotropium currasavicum* and *Sesuvium verrucosum* and others include *Pluchea sericea*, *Malvella leprosa*, *Prosopis pubescens*, *P. glandulosum*, *Tamarix ramosissima*, *Portulaca oleracea* (Pratt and Wiesenborn 2009). The sootywings are attracted to flowers by color over scent, and also are more readily attracted to flowers that are in sunlight over shaded individuals (Wiesenborn 2012). Distribution of nectaring plants can influence oviposition sites (Wiesenborn and Pratt 2010). The chorion of the skipper eggs, on *A. lentiformis* leaves, is distinctive, and persistent long after hatching thus providing the most reliable indication for the presence of this species (Pratt and Wiesenborn 2011). Where *A. lentiformis* are used by MacNeill's Sootywing, they are preferred in shaded areas, such as under cottonwood (*Populus fremontii*) or mesquite (*Prosopis spp.*) trees (Pratt and Wiesenborn 2011). MacNeill's Sootywing oviposit more frequently on *A. lentiformis* that occur in shaded locations than sunny locations (Pratt and Wiesenborn 2008).

Shaded areas also provide cover for adults from wind and thermal extremes (Pratt and Wiesenborn 2011). Oviposition was positively correlated with increased water content, nitrogen content, and host plant size (Wiesenborn and Pratt 2008). Larval growth rates were also increased with increases in water and nitrogen content. This species has also reportedly been found on *A. argentea ssp. expansa* and pigweed (*Chenopodium sp.*)(Scott 1986).

Species Status

Due to its rarity and relatively small distribution, NatureServe considers the MacNeill's to have a rank of S1 (critically imperiled) in Nevada and S2 (imperiled) or S3 (rare or uncommon but not imperiled) in California and Arizona (Pratt and Wiesenborn 2011). Recent genetic analyses support the recognition of *Hesperopsis gracielae* as a distinct species from *H. Alpheus* (Pratt et al. 2015). This species was formerly inluded on the USFWS Category 2 list for protection consideration under the ESA, however this list was eliminated in 1995 (USFWS 1996).

US Fish and Wildlife Service Endangered Species Act: Not listed
US Bureau of Land Management (Nevada): No status
US Forest Service (Region 4): No status
State of Nevada (NAC 503): No status
NV Natural Heritage Program: Global Rank G2G3 State Rank S1
IUCN Red List (v 3.1): No status
CITES: No status

Range

MacNeill's Sootywing occurs in floodplains of the main stem and tributaries of the Colorado River from extreme southwest Utah through Clark County, Nevada; the Bill Williams, Gila and Salt rivers of western Arizona; the Coachella Valley of California; and into northeastern Baja Norte, Mexico. (MacNeill 1970, Scott 1986, Opler and Bartlett Wright 1999).

Population Trends

No population trend data are available for this species. The distribution of MacNeill's Sootywing appears to be discontinuous, rather than continuous as previously speculated, and this skipper may not be able to disperse between populations (Pratt and Wiesenborn 2011).

Habitat Model

Available data for this species yielded only 15 localities in Clark County, but an additional 78 localities were available outside the County. Because there were too few locations to create county specific models for this species we expanded our modeling extent to include the broader distribution of localities in areas of both the Mojave and western Sonoran Deserts in California and Arizona.

The individual algorithm predictions were similar among the MaxEnt, GAM and RF models. Habitat is restricted to the riparian areas along the Muddy, Virgin, and Colorado River corridors, and the Lake Mead shoreline, with only moderate differences in suitability values among the models (Figure 146). While the predictive maps were similar, the performance among models was probably more disparate among these models than any of the other species models produced thus far. The RF model had the highest performance among all models, with the highest AIC, BI, TSS, but only the third highest correlation (Table 102). The largest discrepancy among performance scores were in the Boyce Indices, and Correlation, with the AUC and TSS very similar among models. Higher BI values were in the RF and Ensemble model, while the higher correlation scores were in the MaxEnt and Ensemble models (Table 102).

The Continuous Boyce Index indicated good performance for the GAM and RF models, with extremely erratic performance by the MaxEnt model, which subsequently influenced the Ensemble model in the upper values for habitat suitability (Figure 148). Standard errors were greatest for the RF model, which had only low (0.02 – 0.04) to moderate (0.04 – 0.06) error predicted, but included the areas in lower drainages, and with low topographic index values (e.g. the US 95 corridor, and I-15 corridor – both north of Las Vegas; Figure 147). Approximated bins for the ensemble model based on the CBI were 0-0.4 unsuitable, 0.4-0.5 marginal, 0.5 to 0.55 suitable, and > 0.55 optimal habitat; with a suggested cutoff threshold of ~ 0.5 (Figure 148) and the threshold value calculated from ROC (AUC) statistics for the ensemble model was 0.45 (Table 102).

Table 102. Model performance values for McNeill's Saltbush Sootywing (*Hesperopsis gracielae*) models.

Performance	GAM	RF	MaxEnt	Ensemble
AUC	0.989	0.995	0.991	0.995
BI	0.799	0.870	0.453	0.830
TSS	0.963	0.984	0.964	0.978
Correlation	0.640	0.670	0.801	0.740
Cut-off*	0.597	0.557	0.230	0.453

*threshold at which sum of sensitivity (true positive rate) and specificity (true negative rate) is highest

Table 103. Percent contributions for input variables for McNeill's Saltbush Sootywing (*Hesperopsis gracielae*) for ensemble models using GAM, MaxEnt, and RF algorithms.

Term	GAM	RF	Max	Avg
NDVI Maximum	36.942	21.3	25.683	30.592
Elevation (m)	10.584	18.6	17.489	17.871
Slope	0	0.0	0.062	0.021
Topographic Position (TPI)	2.328	3.8	0.133	2.553
Summer Maximum Temperature	7.519	18.9	7.144	13.512
Temperature Range	3.581	10.9	1.027	6.505
Summer Precipitation	39.046	12.6	48.23	34.847
Mean Annual Precipitation	0	13.9	0.231	6.415

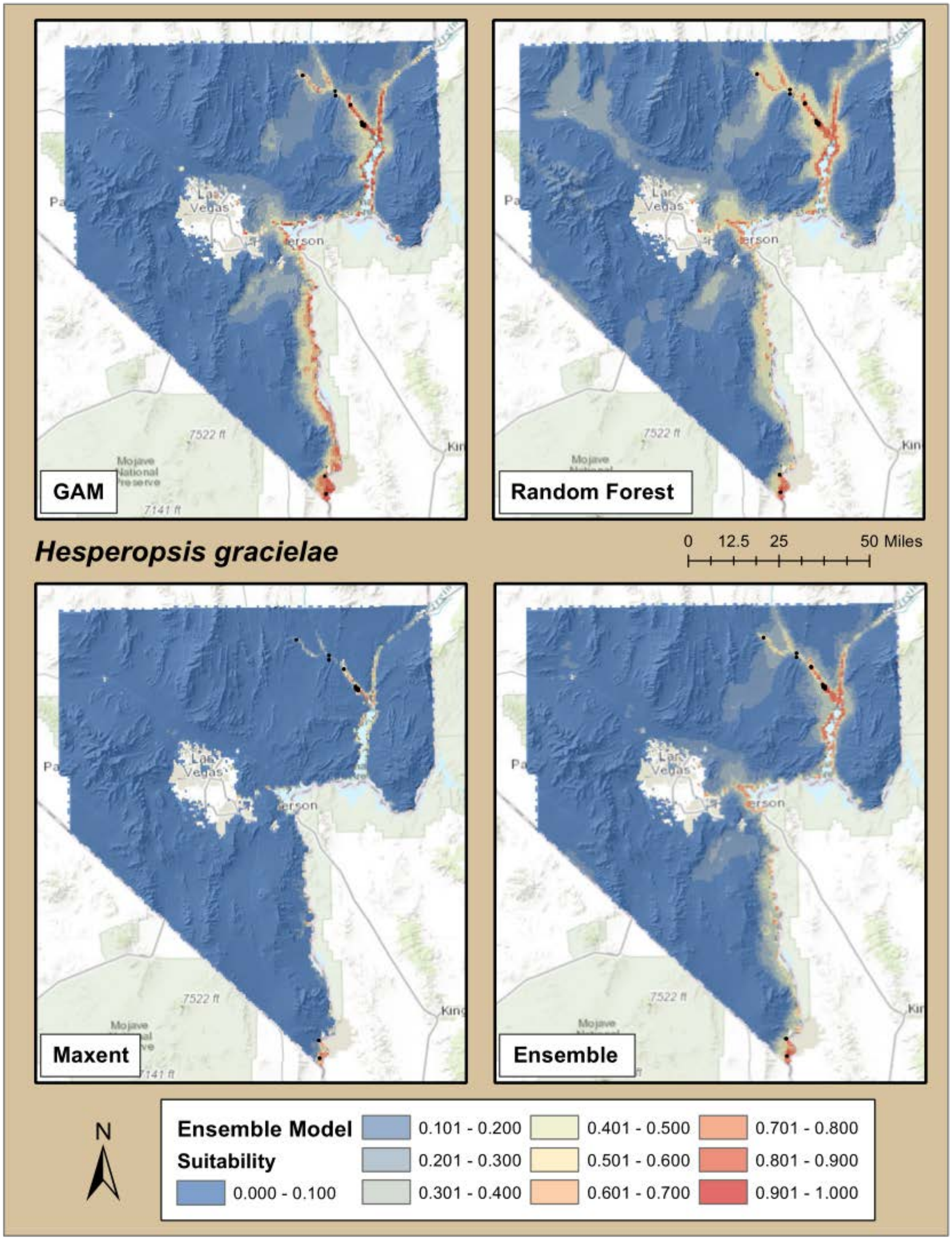


Figure 146. SDM maps for McNeill's Saltbush Sootywing (*Hesperopsis gracielae*) for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

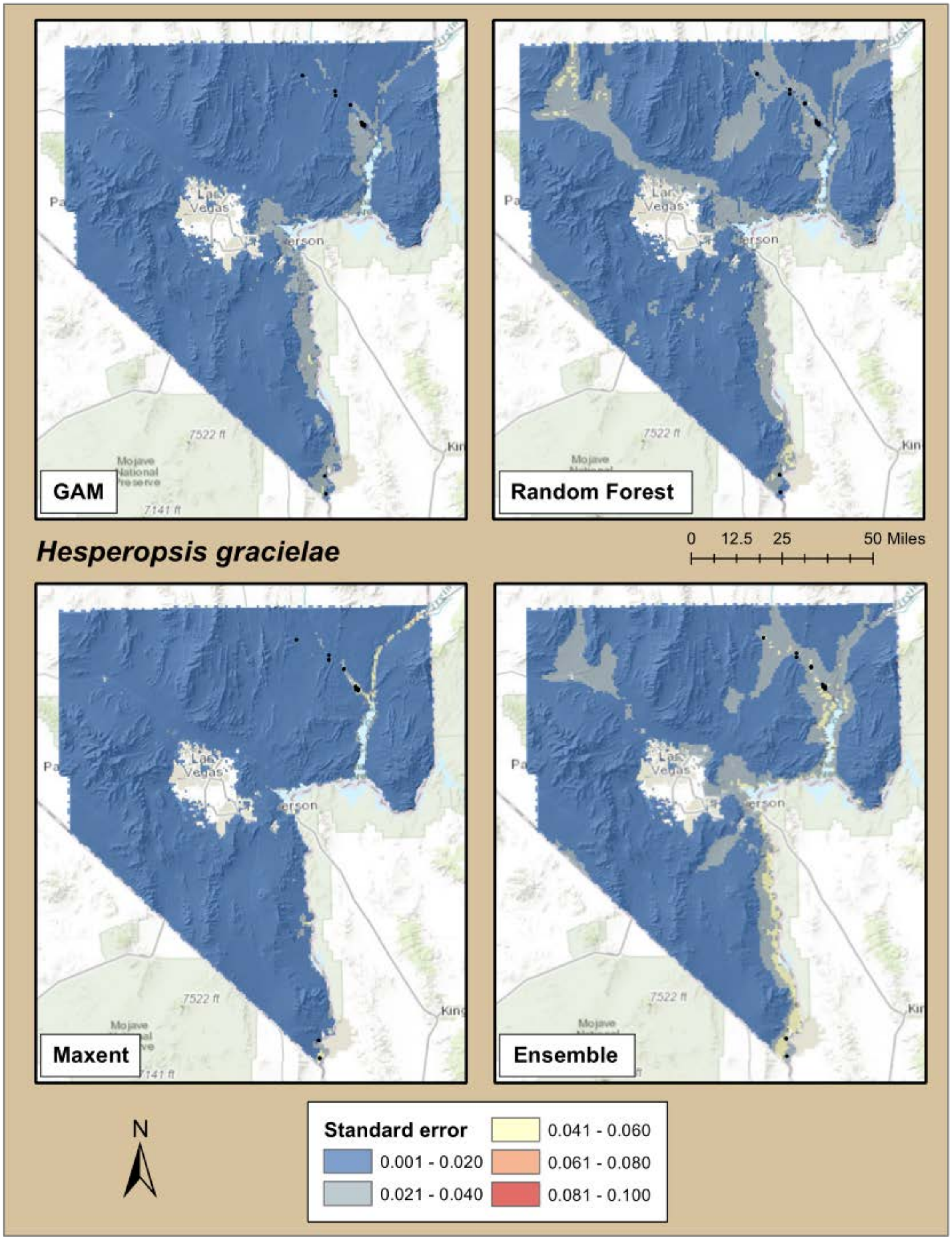


Figure 147. Standard error maps for McNeill's Saltbush Sootywing (*Hesperopsis gracielae*) models for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right)

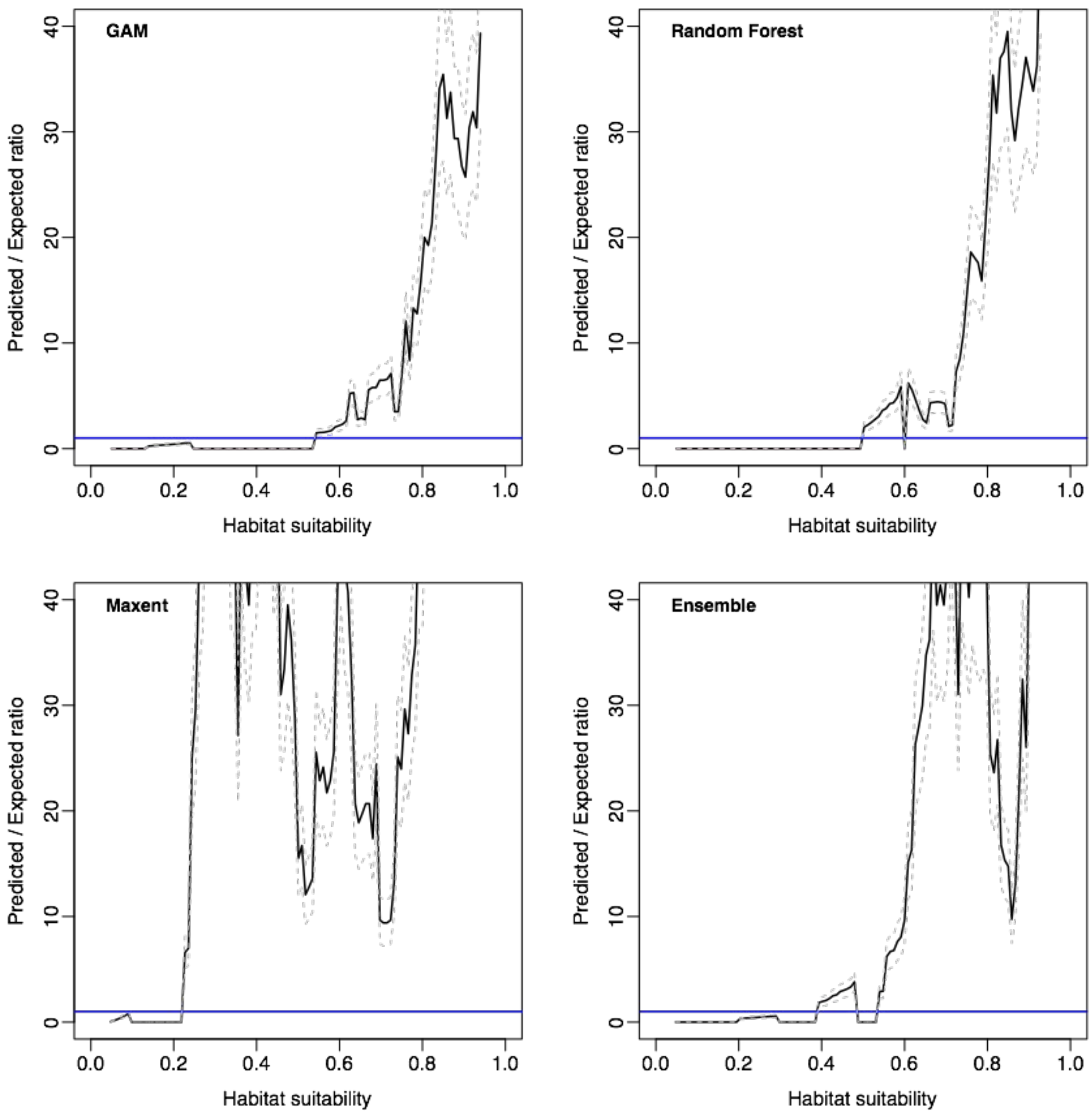


Figure 148. Continuous Boyce Indices for McNeill's Saltbush Sootywing (*Hesperopsis gracielae*) models for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower R

GAM Model

The GAM model ensemble identified four contributing variables with more than 7% contribution toward the model (Summer Precipitation, NDVI Maximum, Elevation, Summer Maximum Temperature), collectively accounting for 94% of the total model contribution (Table 103). Summer Precipitation (39%) had the highest contribution, with a negative relationship to habitat at levels above ~ 50 mm, and falling linearly thereafter (Figure 148). NDVI Maximum (37%) had the second highest contribution, and had an increasing relationship with habitat suitability, where low habitat values were predicted for areas with low maximum NDVI values, becoming a positive predictor at values above 125, and strongest at 200. Elevation was the third ranking contributor (11%), and had a negative influence on habitat, with positive habitat values below ~ 900 m, and an increasing negative effect above there (Figure 148).

The GAM model had the strongest predicted habitat among the three algorithms, with high suitability predicted continuously along the shorelines of the Virgin and Muddy rivers, Lake Mead, and Colorado River habitats within the county (Figure 146). Moderate habitat suitability was also predicted in a limited area near other riparian areas. This algorithm had low standard error values (0.02 to 0.4) in only a few regions in and around the region where moderate habitat was predicted (Figure 147).

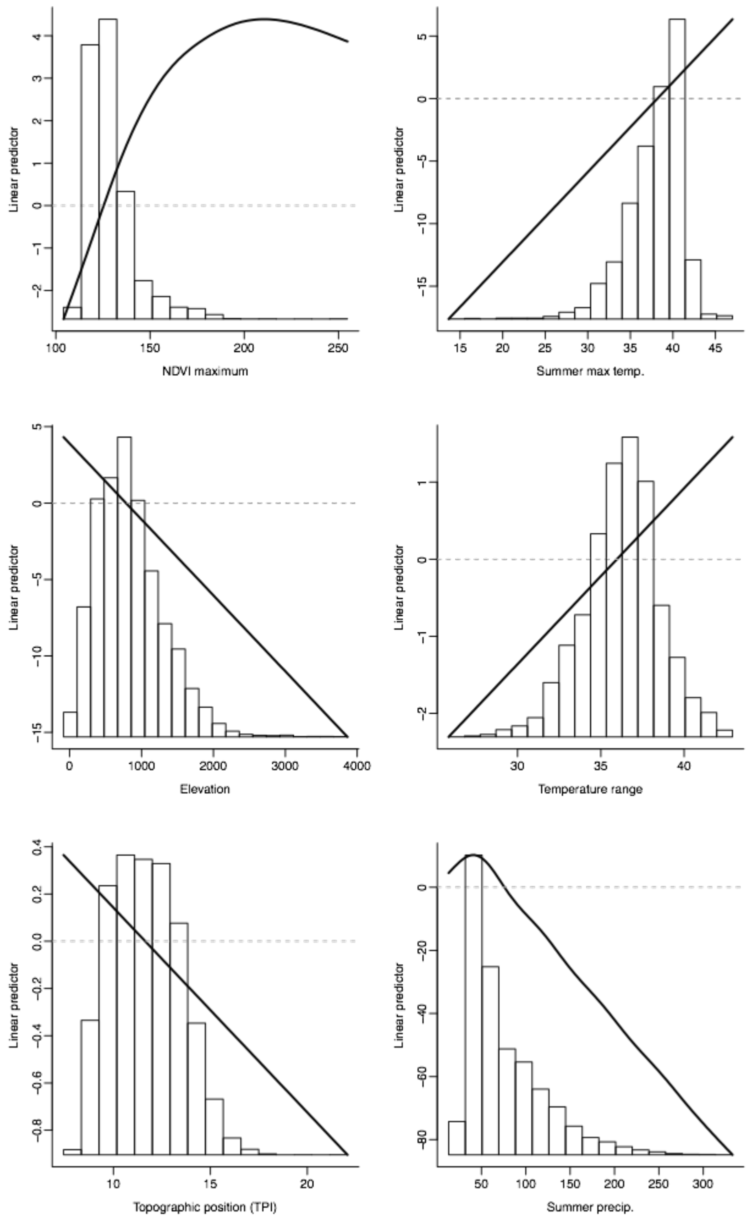


Figure 149. GAM partial response curves for the McNeill's Saltbush Sootywing (*Hesperopsis gracielae*) model overlaid over distribution of environmental variable inputs in the study area.

MaxEnt Model

The MaxEnt model had three variables (Summer Precipitation, NDVI Maximum, and Elevation) that were the strongest performers contributing 17% or more each, accounting for 91% of all model contributions (Table 103). Summer Maximum Temperature contributed 7%. Summer Precipitation had the strongest predictive value with 48% contribution, and a peaked response at ~ 25 - 30 mm, with lower habitat suitability predicted both above and below that level, and similar to the distribution of Summer Precipitation amounts in the county. NDVI Maximum (26%) had a thresholded response, where predicted suitability increased to a plateau from 110 - 135, predicting moderate suitability from 135 to 200, and increasing to higher predicted suitability at higher levels (Figure 150). Elevation (17%) showed a peak response at lower elevations, with decreased suitability above 500 m (Figure 150).

The standard error map for this algorithm showed the least relative error, with some moderate standard error in habitat predictions in the Muddy and Virgin River valleys (SE of 0.04 to 0.6) in the immediate drainages (Figure 147).

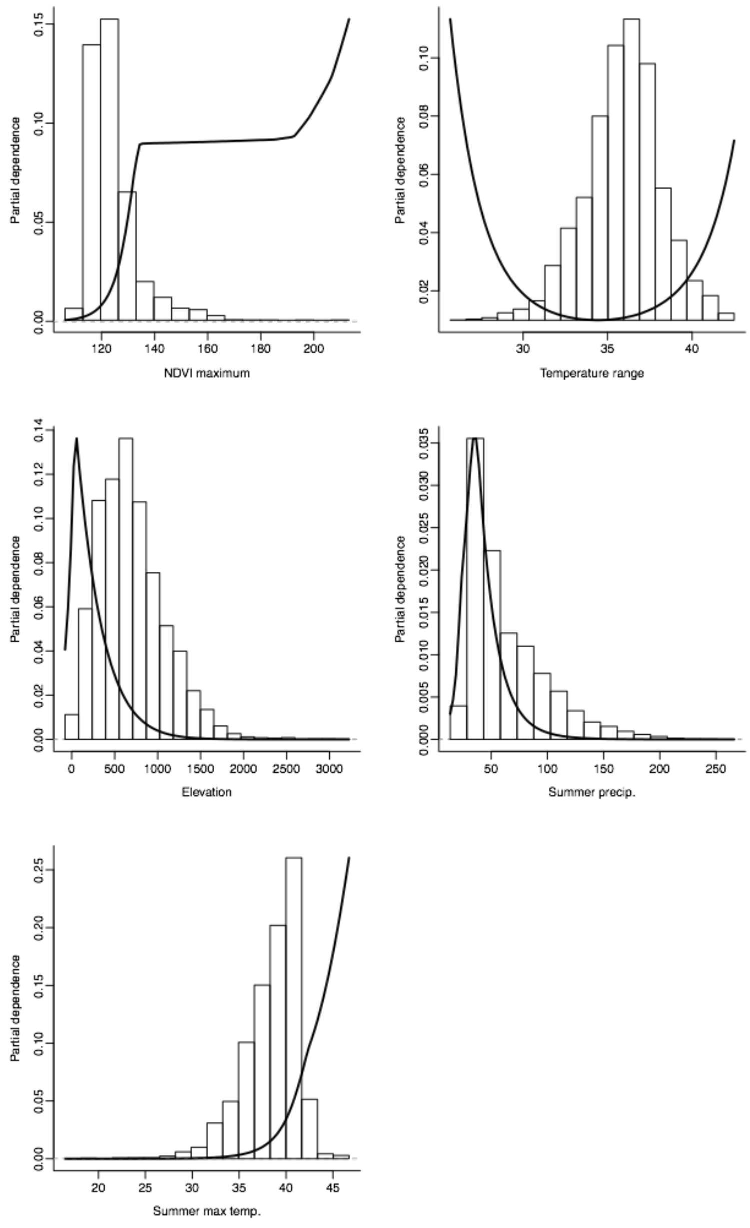


Figure 150. Response surfaces for the top 9 environmental variables included in the MaxEnt ensemble model for McNeill’s Saltbush Sootywing (*Hesperopsis gracielae*).

Random Forest Model

The RF models had six environmental variables contributing 14% or more totaling 96% of total model influence (NDVI Maximum, Summer Maximum Temperature, Elevation, Mean Annual Precipitation, Summer Precipitation, Temperature Range; Table 103). The highest contributing variable was NDVI Maximum (21%), which has a positive relationship with habitat suitability, with a strongly increasing relationship above 120 where this environment variable decreases in the county (Figure 151). Summer Maximum Temperature contributed 19%, which had a threshold type response increasing sharply above 40 ºC leveling off at ~ 45 ºC. Elevation (19%) had a sharp negative response, where habitat suitability was high below 250 m, and dropped to zero thereafter. Mean Annual Precipitation (14%) also had a negative relationship, with higher habitat suitability in areas with low mean annual precipitation (0-100 mm) and falling to low predicted habitat suitability at annual precipitation levels above 150 mm. Summer Precipitation (13%) had a peaked response at ~ 25 mm, with lower habitat suitability values both above and below this level. Finally, Temperature Range (11%) indicated lower habitat suitability in areas with annual temperature ranges of up to 40 ºC, increasing sharply above that level (Figure 151).

Standard error maps for this model indicated relatively low SE levels (0.02 to 0.04) along the Muddy and Virgin River lowlands, parts of the I-15 corridor, in the valleys of the Nevada National Security Site in the northwest portion of the county, and in the Eldorado Valley, and Las Vegas Wash areas. Moderate error (0.04 to 0.06) was predicted along Lake Mead shorelines and along the Colorado River from Willow Beach to the county southern border near Avi (Figure 147).

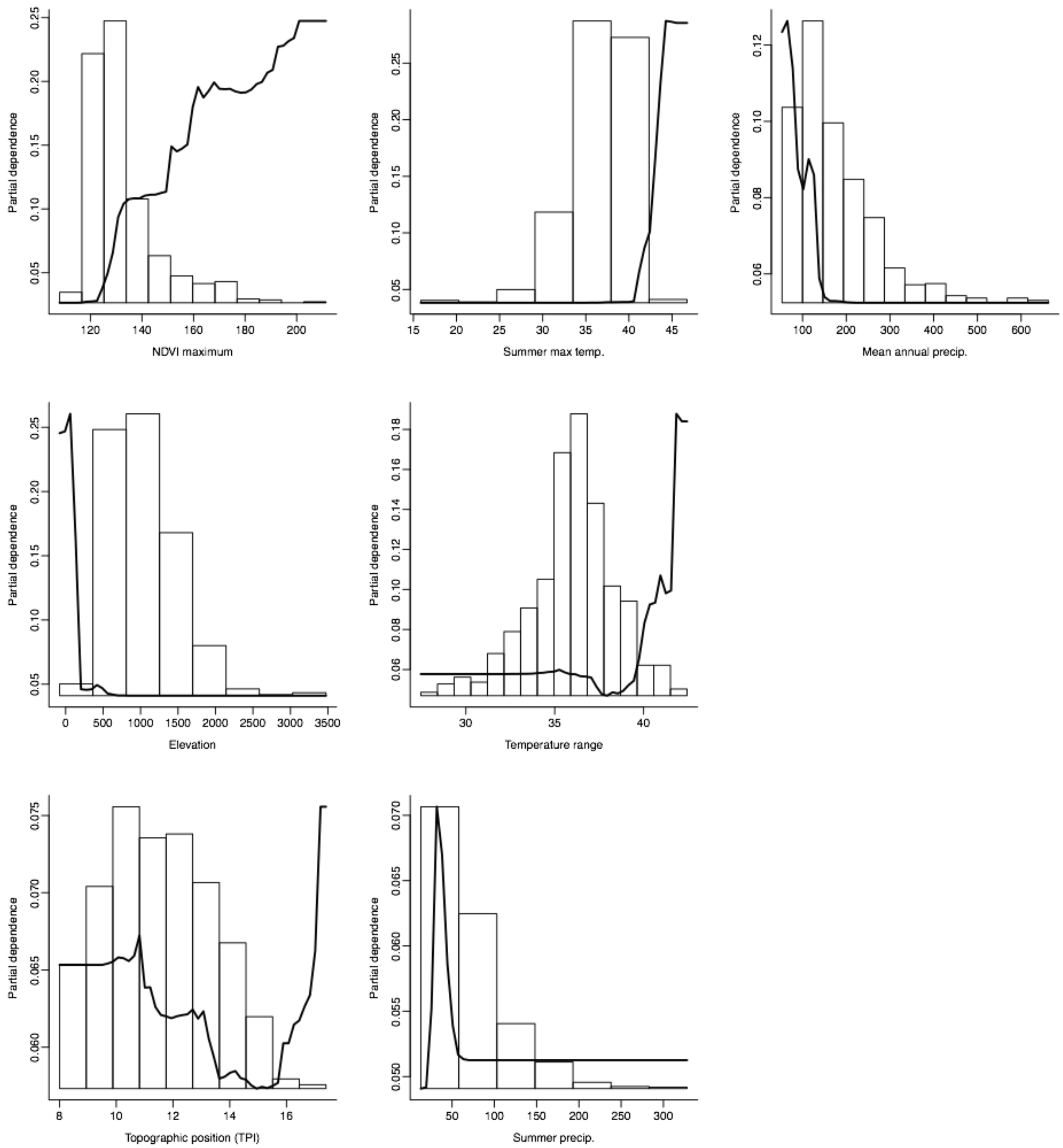


Figure 151. Partial response surfaces for the environmental variables included in the RF ensemble model for McNeill's Saltbush Sootywing (*Hesperopsis gracielae*). Histograms represent the range of each environmental variable across the x-axis, and predicted dependence relative to habitat suitability values are on the y-axis

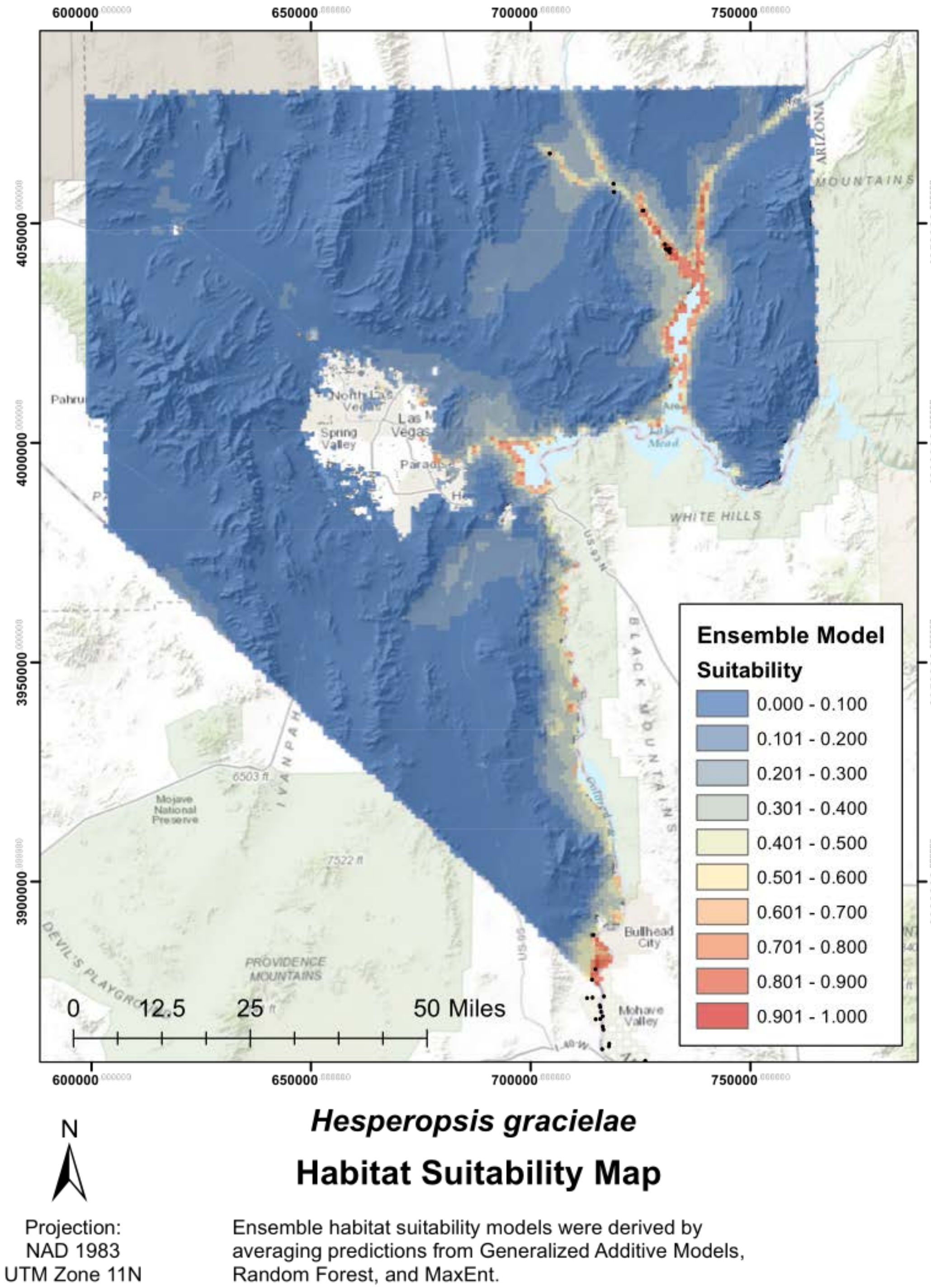


Figure 152. SDM map for the McNeill's Saltbush Sootywing (*Hesperopsis gracielae*) Ensemble model.

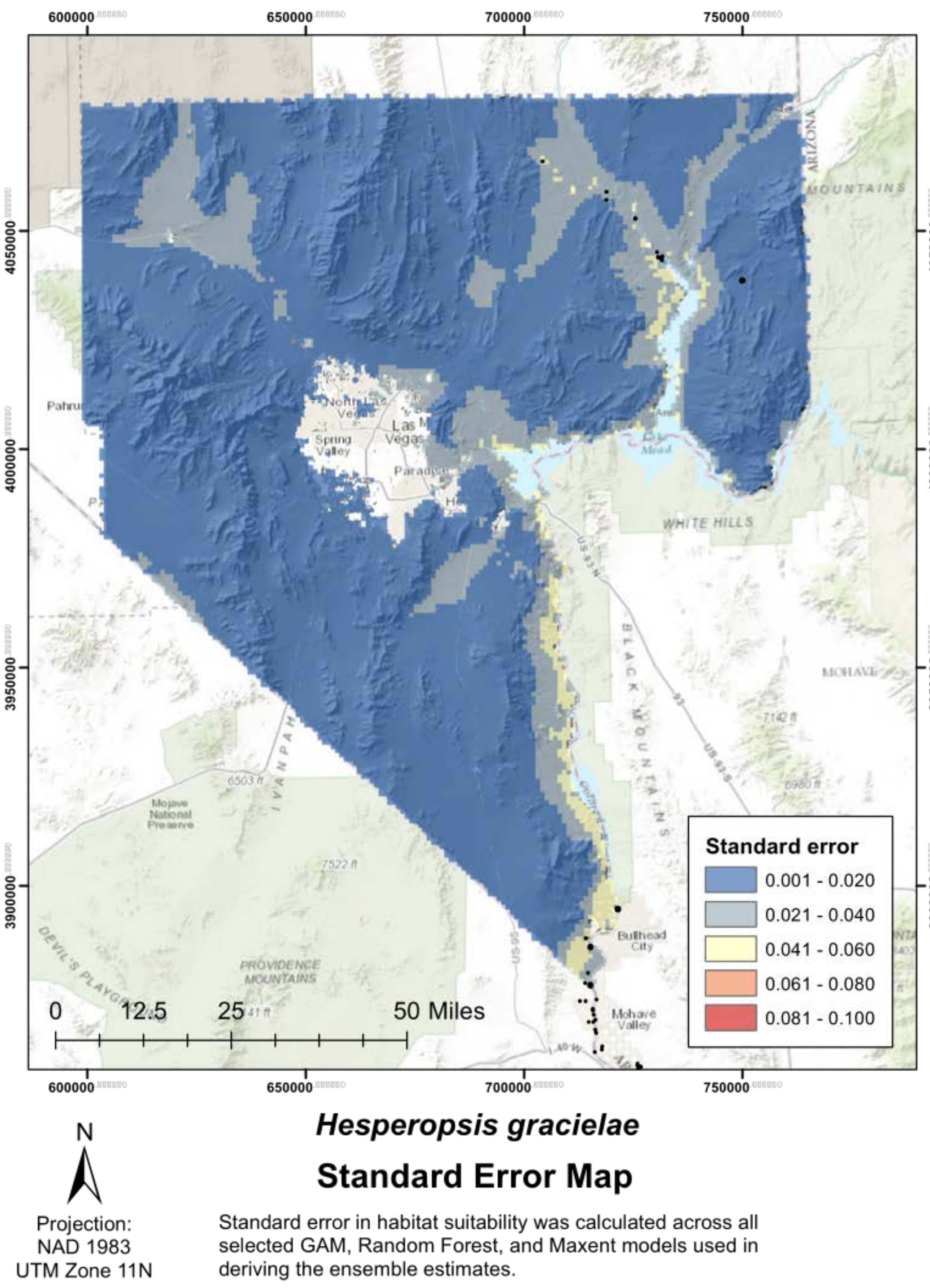


Figure 153. Standard Error map for the McNeill's Saltbush Sootywing (*Hesperopsis gracielae*) Ensemble model.

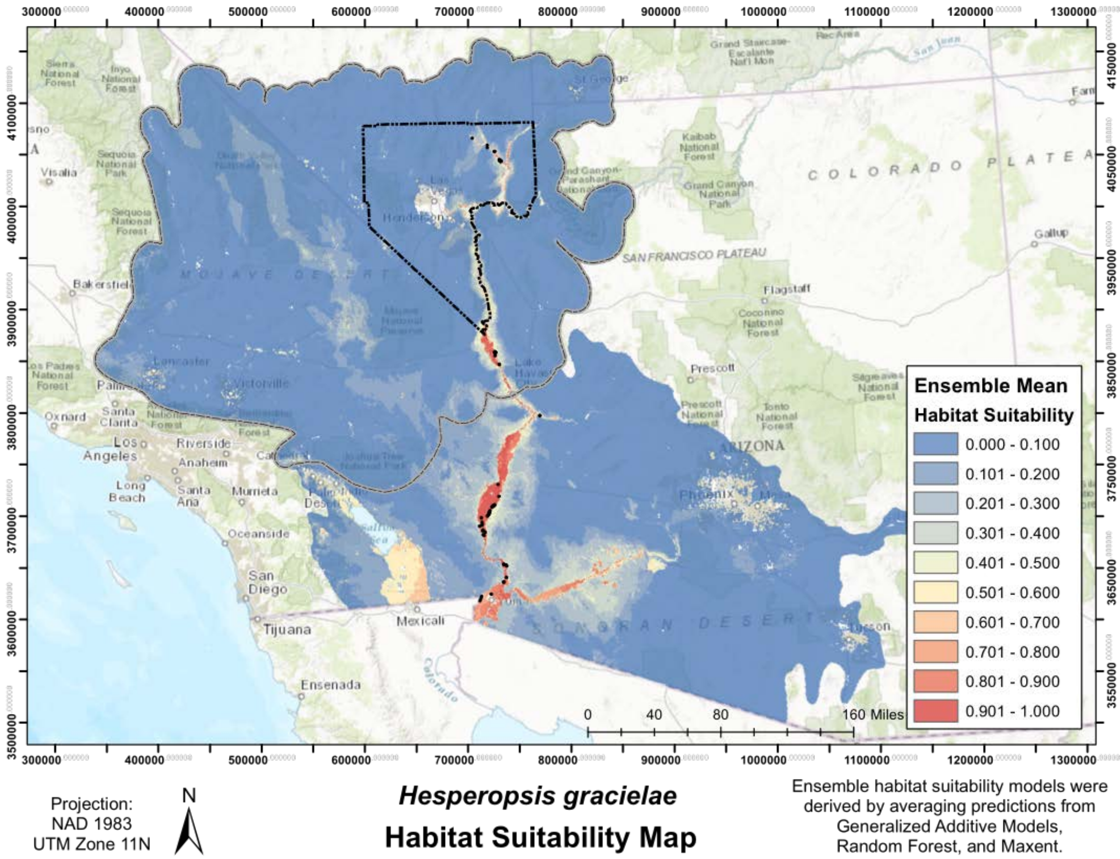


Figure 154. Habitat suitability map for the McNeill's Saltbush Sootywing (*Hesperopsis gracielae*) ensemble model for the Mojave and western Sonoran Desert.

Distribution of Localities

Localities (N=93) for MacNeill's Sootywing are found largely along the extreme southern portion of the main stem of the Colorado River. In Clark County several points also occur along the Muddy River (Figure 152). This species is more broadly distributed outside Clark County in the lower Colorado River extending all the way to Mexico (Figure 154).

Standard Error

The standard error for the Ensemble habitat suitability model for MacNeill's Sootywing indicates low level error (SE 0.02 – 0.04) throughout the lowest elevation areas within the county, mostly including the river drainages, and a few of the larger valleys (e.g. Eldorado, Las Vegas Wash, Nevada National Security Site near Mercury. Areas of moderate error (SE 0.04 – 0.06) are on the shorelines of Lake Mead in the Overton Arm, and the shoreline of the Colorado River from Hoover Dam to Avi (Figure 153).

Distribution and Habitat Use within Clark County

The MacNeill's Sootywing occurs in Clark County, Nevada below the town of Overton, along the Muddy River where the river delta intersects with Lake Mead, and below Laughlin on the main stem of the Colorado River (Pratt and Wiesenborn 2011). It appears to be dependent on *Atriplex lentiformis* as a food/host plant (Pratt et al. 2015), although it has been reported to feed on the nectar of several other species (see above, Pratt and Wiesenborn 2011). The habitat is contained largely within the Mojave Desert Scrub ecosystem, as this abuts most of the wetland areas within the county. The Desert Riparian and Mesquite Acacia ecosystems also contain areas of high predicted habitat suitability for this species. Moderate habitat for this species is also within the same ecosystems, with a very small portion of Salt Desert Scrub ecosystem showing as potential moderate habitat (Table 104).

Modeled habitat in the county is predicted to be highest in the southern most portion of the river drainage near Laughlin/Bullhead City near Avi (Figure 152). Linear strips of high habitat suitability are also predicted near the confluences of the Muddy and Virgin rivers, however these may be driven largely by one point reported in Gold Butte Wash (Figure 152).

Table 104. Ecosystems within Clark County, and the area (Ha) of Low Medium and High predicted suitability within each ecosystem.

Ecosystem	Low	Medium	High
Alpine	124	0	0
Blackbrush	415613	0	0
Bristlecone Pine	7565	0	0
Desert Riparian	1776	3134	6131
Mesquite Acacia	15545	2864	1544
Mixed Conifer	27339	0	0
Mojave Desert Scrub	1203353	83187	15279
Pinyon Juniper	115900	0	0
Sagebrush	4707	0	0
Salt Desert Scrub	79953	272	19

Ecosystem Level Threats

This species occurs only in the Desert Riparian ecosystem. Because this species inhabits floodplains of primary rivers, it is likely that much of the natural habitat was destroyed by the damming, inundation, and channelization of the main stem of the

Colorado River. Certainly there is much less floodplain habitat remaining today. The embayment of large bodies of water that once fluctuated seasonally also change the depth and dynamics of the water table that can provide opportunities for different types of plants to dominate large areas that were formerly more open and shrubby. Recently, large stands of the host plant that previously supported MacNeill's Sootywing were cleared along irrigation canals in some locations (Wiesenborn 2012). Many other sites that were formerly occupied by the MacNeill's Sootywing have become dominated by alien (e.g., *Tamarix ramosissima*) and native plant species (e.g. *Pluchea sericea*) that can choke out important species such as *Atriplex lentiformis*. Fires have also been reported as a threat (Pratt et al. 2015), which resulted in the loss of at least one known site for this species (Pratt and Wiesenborn 2011). Other factors that can cause habitat degradation include heavy livestock and feral horse grazing, and OHV activity.

Threats to Species

Tamarix ramosissima infestations are incompatible with MacNeill's Sootywing because it competes with their favored plant species (Pratt and Wiesenborn 2011, Pratt et al. 2015). This species may have been extirpated in parts of its range in Clark County due to river channelization, inundation, introduction of invasive species, livestock and feral horse grazing, OHV use, and other factors that modify habitats (Pratt and Wiesenborn 2011).

There seem to be few direct impacts to MacNeill's Sootywing, aside from habitat degradation, which is most important concerning the loss of the host plants species *Atriplex lentiformis* and changes in the availability of larger tree and shrub species that provide cover from extreme temperatures, and loss of nectaring plants. Losses of *A. lentiformis*, shade trees, and the key nectaring plants may be tied to changes in the water table, surface water levels (although, the species likely evolved within the disturbance regime of major rivers) and the geomorphology of the riverbed, OHV use within the habitats, and livestock and feral horse grazing in the river channel.

Existing Conservation Areas/Management Actions

Potential opportunities to restore MacNeill's Sootywing habitat were described by Pratt and Wiesenborn (2011). They state that appropriate sites should be areas within the floodplain of low elevation desert riverine that either has or has had sootywings present. The plant community at the sites should provide ample shade by large trees and shrubs to accommodate an understory of appropriate food plants, and *Tamarix* spp. should be removed. Planted quail brush should have access to water either through the water table or with supplemental irrigation until established to grow lush vigorous plants. Nectar species should also be added to the community including *H. curassavicum* or *S. verrucosum* and other species previously listed in this species account.

Habitat may be improved by the removal of *Tamarix* and other invasive plant species (Pratt and Wiesenborn 2011). Restoration of river channels that provide habitat closer to the water table may also be useful in promoting appropriate plant communities to support sootywings (Pratt and Wiesenborn 2011). Removal of trespassing livestock and feral horses would likely be beneficial to the key plants supporting the MacNeill's Sootywing. Consideration of the routes used by OHV recreationists might also reveal areas that could be reclaimed through minor changes in recreational trails.

Summary of Direct Impacts

Only 323 km^2 of high suitability habitat for this species is located within the county. Twenty-six km^2 of this is already disturbed and the proposed impacts will potentially impact and additional 21 km^2, while only 2 km^2 are located within conserved areas. Moderate suitability habitat totals 976 km^2 in the county, and a total of 185 km^2 will be disturbed if all proposed impact lands are developed (Table 105). Moderate suitability habitat to be conserved totals 22 km^2.

Table 105. Categorized modeled habitat values (High, Medium, and Low) and the average area (Hectares) predicted in the potential impact areas, conservation areas, already disturbed areas, and overall area

Habitat Level	Impact	Conserved	Disturbed	Area (Hectares)
High	2108	208	2643	32326
Med	12271	2203	6273	97568
Low	109329	511942	49008	1921820

HESU - Gila Monster (Heloderma suspectum)

Gila Monsters are large (350–500 millimeters total length), venomous lizards that range across portions of the Sonoran, Mojave, and Chihuahuan deserts in the US and Mexico. In the US, they are distributed in Arizona, southern Nevada, portions of southeastern California near the Nevada border, and southwest Utah. Gila Monsters are brightly colored, yet cryptic. They may have a short activity period (e.g. approximately 90 days from April to mid-June), with limited activity (i.e. only 1/3 of days during their activity season; Beck 1990). However, nocturnal activity may be much greater than expected from June - August (Beck 1990), and there is also commonly an increase in activity in the fall. They are strongly associated with burrows and deep caves and are frequently found in rocky (e.g. sandstone) or mountainous terrain. They are a secretive, diurnal predators and feed largely on the eggs and young of desert vertebrates, and feed by widely searching sandy areas and bajadas in the desert scrub habitats surrounding their shelter sites.

Species Status

In 2010, the Gila Monster was petitioned for listing under the federal Endangered Species Act (ESA) by WildEarth Guardians and Daniel Beck as a distinct population segment (DPS) in Utah. The petition cited the loss of habitat and associated habitat degradation as a result of urban development. Numbers there were estimated to be as many as 20 per square mile; however, like other secretive, ground dwelling species, Gila Monster population estimates are notoriously difficult to establish. The DPS was considered to have sustained substantial losses of individuals based on reduction of habitat from landscape development because census data were not available (WildEarth and Beck 2010). The USFWS denied review and consideration for listing as they determined that there was insufficient scientific evidence presented in the petition to distinguish the Utah population as a DPS (USFWS 2011). In 1982 the USFWS considered the Gila Monster as a Category 2 candidate. However, the Gila Monster was later removed from this categorization because there was insufficient information to justify listing (USFWS 1996). The Gila Monster has state protected status in Utah, Arizona, and Nevada. Nevada also prohibits collection for personal or commercial purposes (Nevada Department of Wildlife [NDOW] 2009). The Gila Monster is evaluated by the IUCN Red List as a species "Near Threatened" (Hammerson et al. 2007).

US Fish and Wildlife Service Endangered Species Act: No Status
US Bureau of Land Management (Nevada): Sensitive
US Forest Service (Region 4): No Status
State of Nevada: Protected
NV Natural Heritage Program: Global Rank G4T4, State Rank S2 - Imperiled
NV Wildlife Action Plan: Species of Conservation Priority
IUCN Red List (v 3.1): Near Threatened
CITES: Appendix ii

Range

Within the United States the Gila Monster inhabits isolated locales within extreme southwestern Utah, southern Nevada (Clark, Lincoln, and Nye counties), southeastern California (San Bernardino County), southern and western Arizona (Stebbins 2003), and southwestern New Mexico (Degenhardt et al. 1996). Gila Monsters can be found in many habitats between 2500 and 5000 feet, but most commonly frequent the lower slopes of mountains and adjoining canyon bottoms and arroyos, and are frequently associated with rocky terrain (Bogert and del Campo 1956, Funk 1966) in areas with natural shelters and caves (Beck and Jennings 2003, Gienger 2003). Common habitat for the Gila Monster is characterized by complex rocky landscapes of upland desert scrub adjacent to suitable foraging sites harboring appropriate prey and nest sites (Beck 1990, Gienger 2003). Most localities are also associated with desert wash, spring, and riparian areas, including those along the lower Colorado River drainage (Funk 1966, Lovich and Beaman 2007, NDOW 2007). Gila Monsters winter at more elevated locations (i.e., on rocky slopes, in rocky outcrops, or below cliffs) often with other reptiles such as rattlesnakes and Mojave Desert Tortoises. Summer ranges, however, are located in adjacent lower valleys or alluvial fans (Jennings and Hayes 1994) where the prey base is larger. Data are lacking on reproduction and nest sites for this species (Beck 2005, Jennings and Hayes 1994, WildEarth and Beck 2010). Home ranges in one population studied in Nevada are larger than those of lizards studied in a geologically similar habitat in southwest Utah (Gienger 2003) although both studies were of limited sample size and geographic areas. WildEarth and Beck (2010) argued for recognition of a unique DPS in southwestern Utah, citing isolation and ecological distinction. However, recent genetic analysis did not support the division of the species into subspecies (Davidson Douglas et al. 2010), although the sample sizes were small in that analysis.

Population Trends

Gila Monsters are rarely observed in nature which makes it difficult to determine population trends. Their populations are thought to be in decline throughout their range (Campbell and Lamar 2004). The Gila Monster is described as having decreasing population trends in the IUCN Red List (Hammerson et al. 2017). Populations have declined from thousands to hundreds in Washington County, Utah; however, these estimates are not based on quantitative field surveys (WildEarth and Beck 2010).

Habitat Model

Models created for Gila Monsters appear to be similar for the GAM and MaxEnt algorithms, with the RF predicting a tighter distribution (Figure 155). The RF model had the highest AUC and TSS scores, while the GAM model and the highest BI, although all models were similar in that metric (Table 106). The variables NDVI Start of Season, Sandy Soils, Summer Maximum Temperature, Washes were not selected in any of the models, and Surface Texture was chosen only in the RF model, ranking highest (Table 107). The GAM and MaxEnt models were comprised of the same covariates, while the RF models did not include Surface Roughness or Terrain Position. Standard error (SE) maps for each model yielded thin areas of elevated SE in the Muddy and Virgin River bottoms for the GAM model, and some areas of low to moderate SE in the Mormon Mesa area for the Ensemble model (Figure 156). Continuous Boyce Indices indicated good predictive abilities for each of the models (Figure 157).

Table 106. Model performance values for *Heloderma suspectum* models.

Model	Presences	AUC	BI	TSS
Ensemble	262	0.898	0.95	0.68
GAM		0.798	0.957	0.473
RF		0.959	0.942	0.79
MaxEnt		0.834	0.953	0.562

Table 107. Percent contributions for input variables for *Heloderma suspectum* for ensemble models using GAM, MaxEnt and RF algorithms

Variable	GAM	MaxEnt	RF
Elevation	29.378	34.387	26.657
NDVI Amplitude	7.703	14.014	14.109
NDVI Maximum	22.062	9.407	10.408
NDVI Start of Season			
NDVI Total Integrated	3.838	3.686	13.633
Sandy Soils (TerraSpectra)			
Slope	13.209	3.621	14.725
Summer Maximum Temperature			

Variable	GAM	MaxEnt	RF
Surface Roughness	5.189	10.211	
Temperature Range (Annual Max - Min)	6.733	7.443	14.843
Terrain Position Index	4.708	4.031	
Texture (ATI)			41.268
Washes			
Winter Minimum Temperature	5.9	8.986	27.774
Winter Precipitation	1.28	4.213	16.466

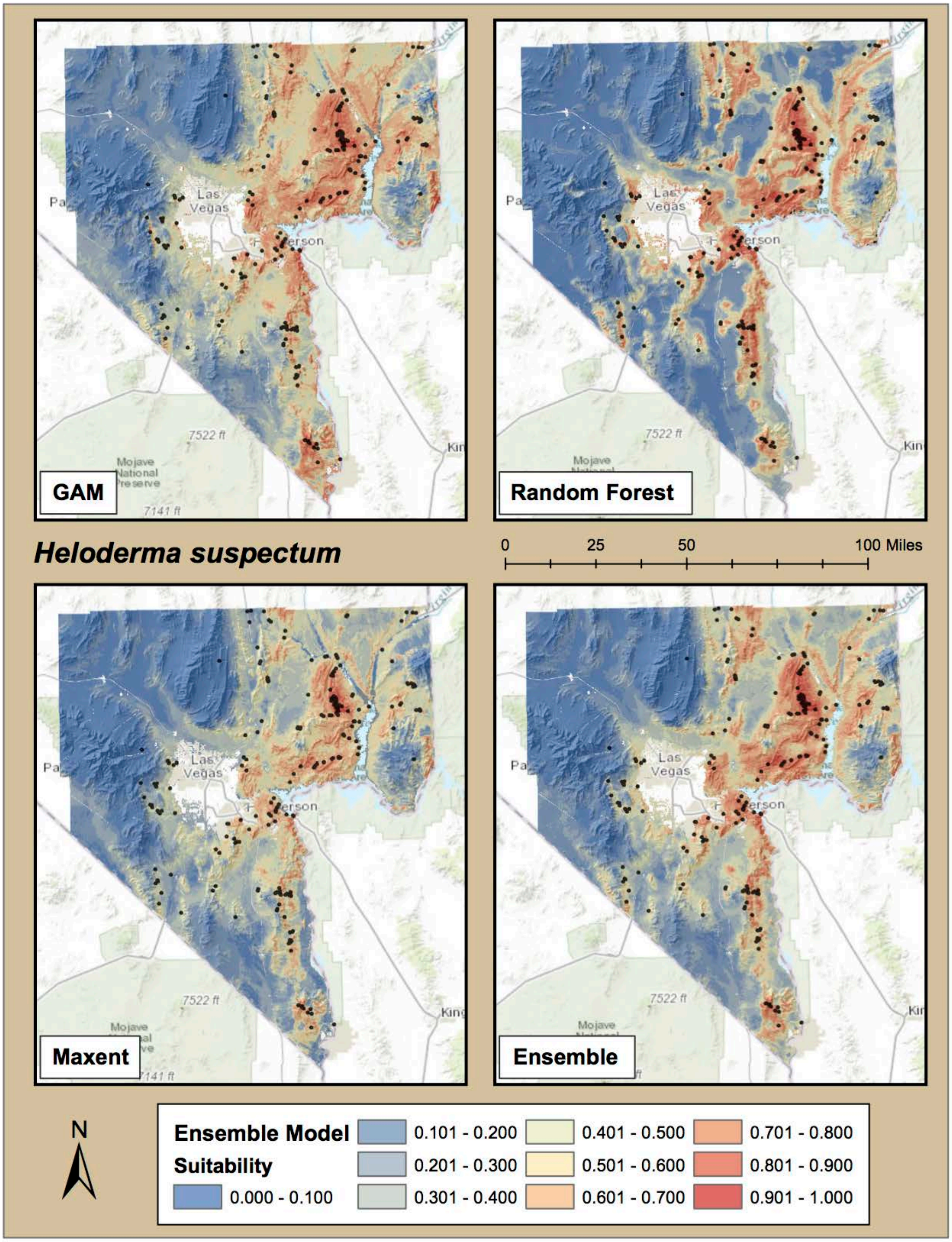


Figure 155. SDM maps for *Heloderma suspectum* model ensembles for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and ensemble model averaging the three (Lower Right).

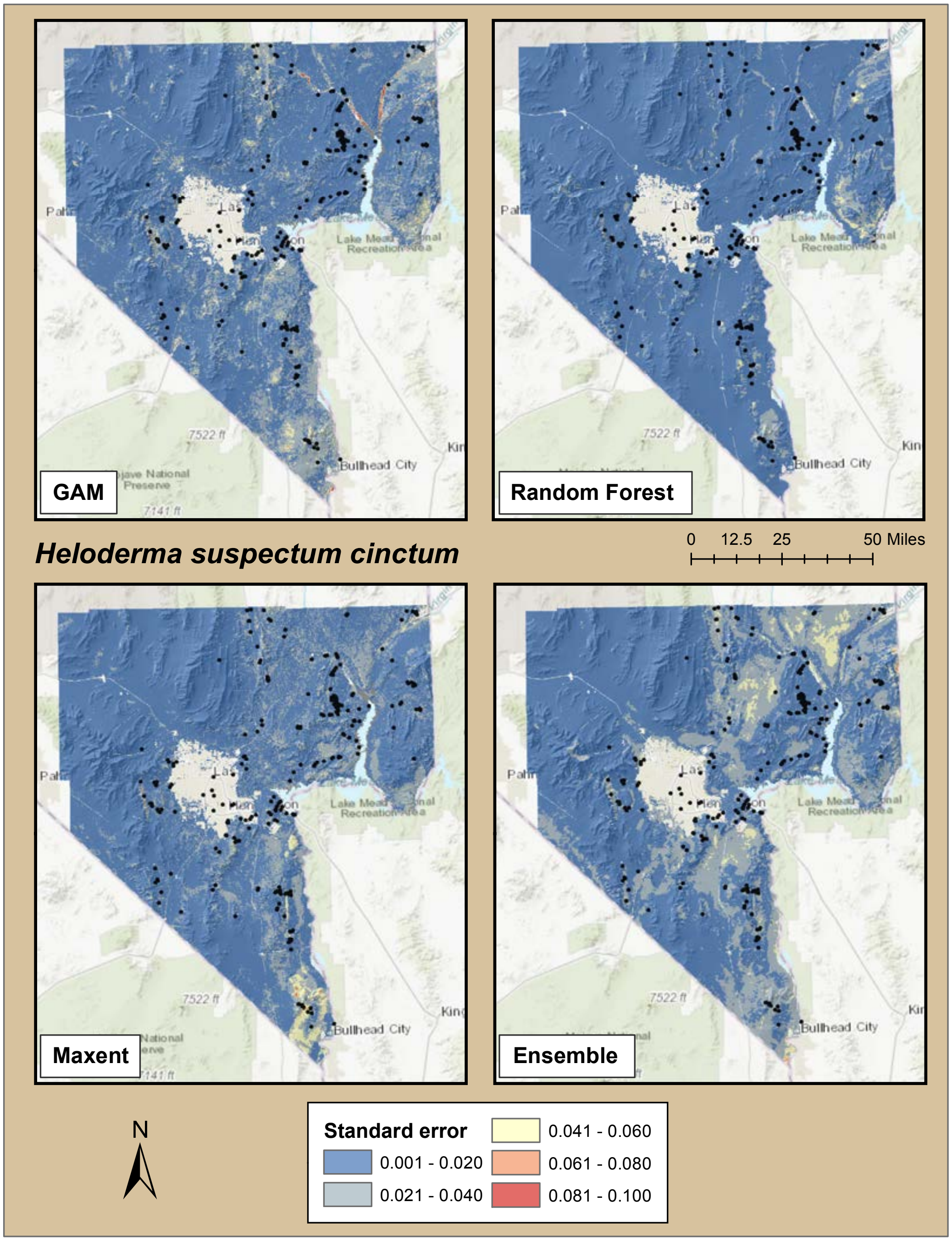


Figure 156. Standard error maps for *Heloderma suspectum* models for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

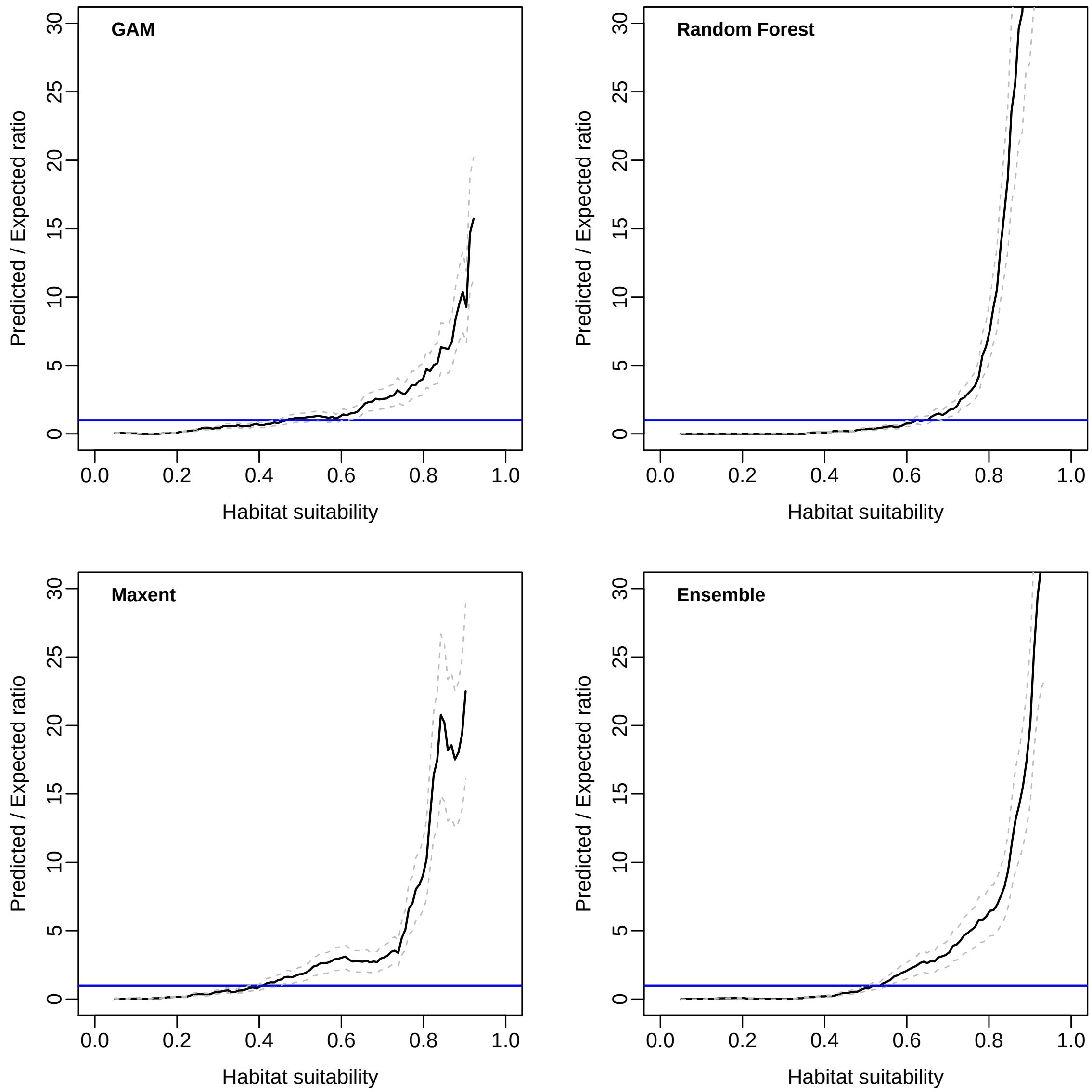


Figure 157. Graphs of Continuous Boyce Indices [CBI] for *Heloderma suspectum* models for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

General Additive Model

Elevation, NDVI Maximum, and Slope were the highest contributing covariates in the GAM model, where Gila Monster habitat was generally predicted at lower elevation and slope, and in areas with lower NDVI Maximum values, corresponding with lower vegetation found in the typically arid and rocky habitats (Table 107, Figure 158). NDVI Amplitude, Annual Temperature Range, Winter Minimum Temperature, Surface Roughness, Terrain Position Index, total integrated NDVI, and Winter Precipitation provided moderate contributions, were higher habitat was predicted for areas with warmer winter minimum temperatures with little greenup, and at a higher position relative to drainages, and decreased with surface roughness. These are characteristic responses that reflect the affinity of the species for rough, rocky terrain at lower elevations.

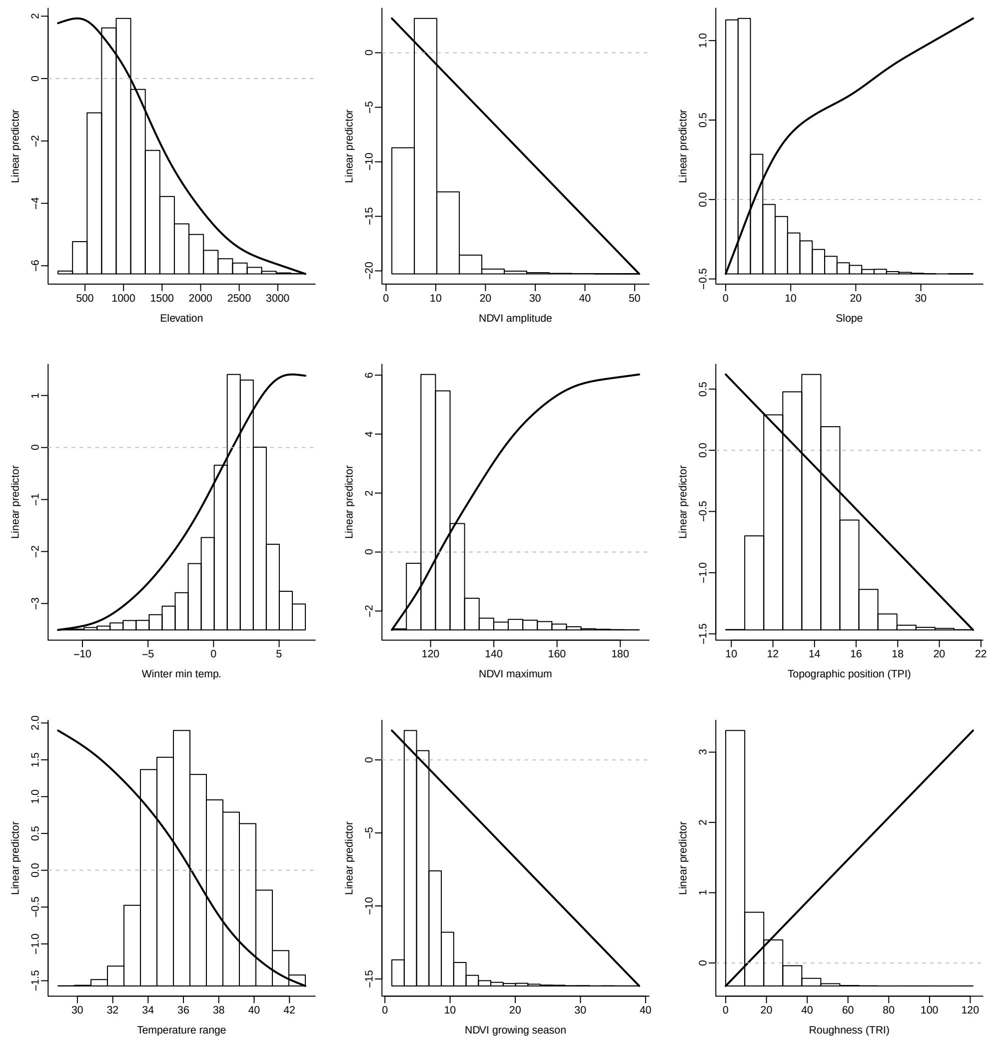


Figure 158. GAM partial response curves for the *Heloderma suspectum* model overlaid over distribution of environmental variable inputs in the study area.

MaxEnt Model

The MaxEnt ensemble was most influenced by Elevation, followed by NDVI Amplitude, Surface Roughness. NDVI Maximum, Winter Minimum Temperature, Annual Temperature Range, Winter Precipitation, Terrain Position Index, Total Integrated NDVI, and Slope each contributed moderately, gently decreasing in contribution (Figure 159). The predicted surfaces are qualitatively similar to those for the GAM model (Figure 158, Figure 159).

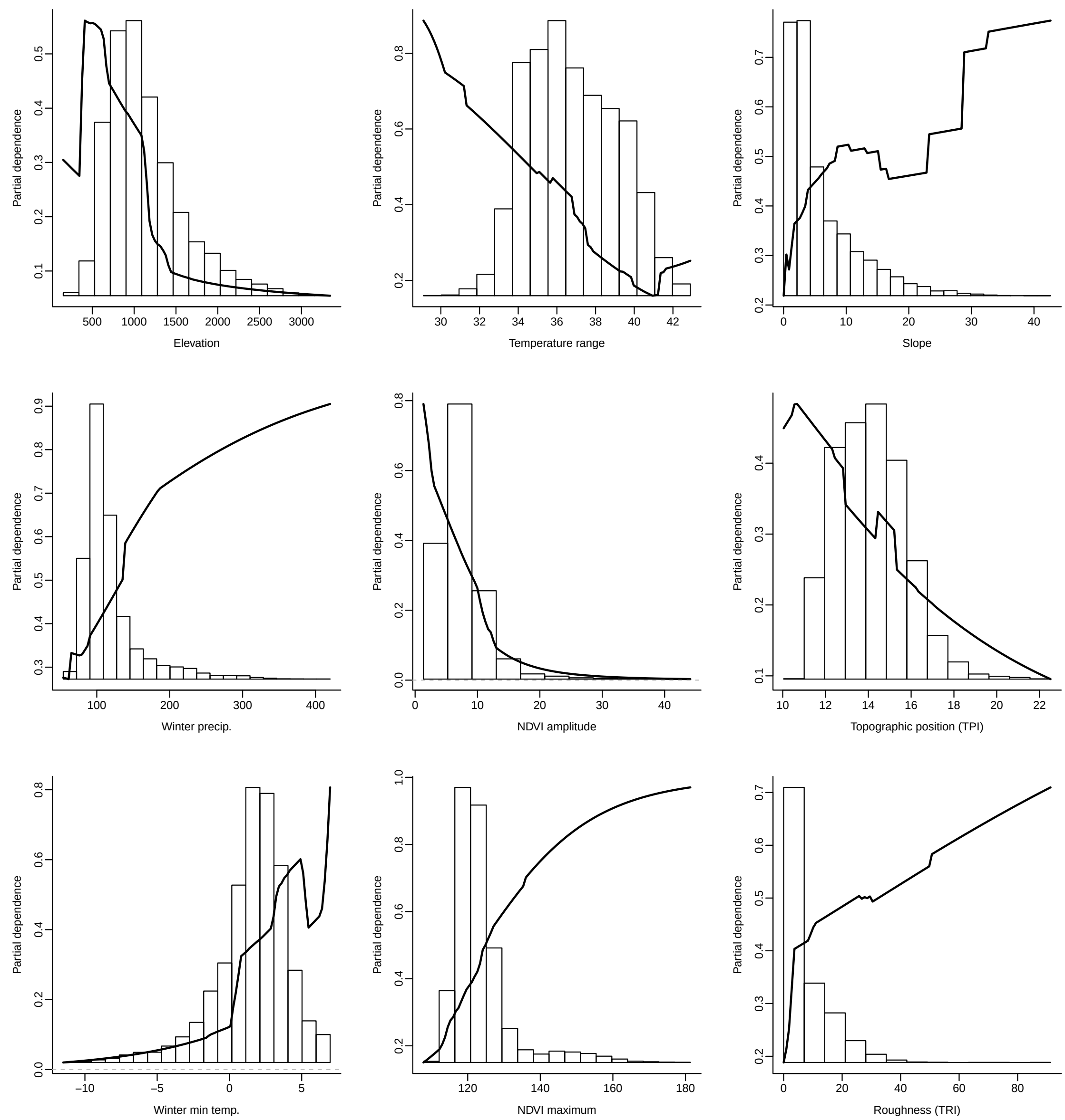


Figure 159. Response surfaces for the top environmental variables included in the MaxEnt ensemble model for *Heloderma suspectum.*

Random Forest Model

RF models had quite different variable selection and contribution rankings. Surface Texture was by far the highest contributing covariate, replacing Elevation as the top contributor in the other two models. Winter Minimum Temperature, and Elevation were the next highest ranking, with lower but similarly ranked contributions from Winter Precipitation, Annual Temperature Range, Slope, NDVI Amplitude, total integrated NDVI, and NDVI Maximum (Table 107). As for the MaxEnt models, the general trends indicated in the model response surfaces are conserved across algorithms for this species, although some additional complexity in the fitting functions is apparent in the RF surfaces relative to the others (Figure 160, Figure 158, Figure 159).

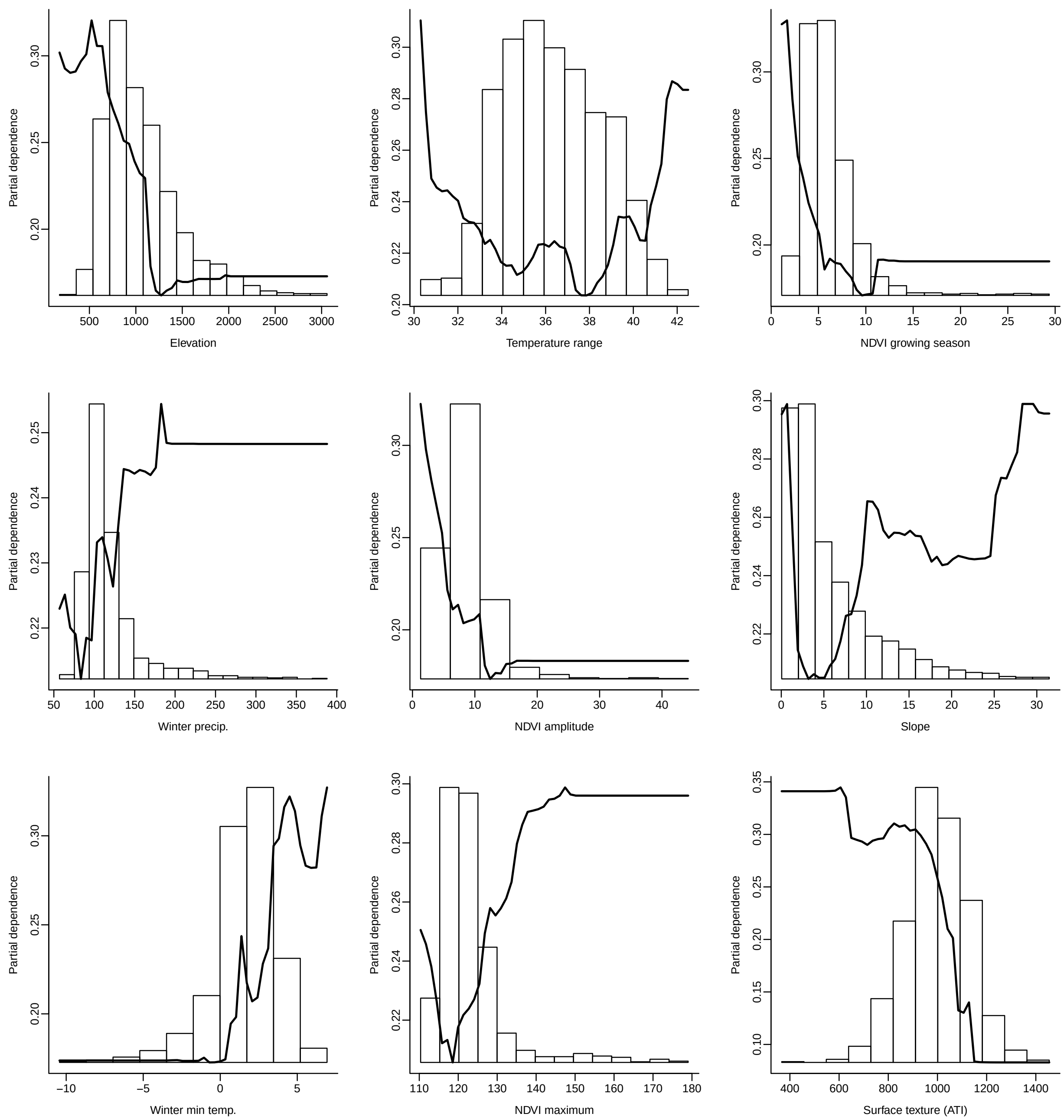


Figure 160. Partial response surfaces for the environmental variables included in the RF ensemble model for *Heloderma suspectum.* Histograms represent the range of each environmental variable across the x-axis, and predicted dependence relative to habitat suitability values are on the y-axis.

Model Discussion

The Gila Monster SDM predicts a range in Clark County where most locality points are concentrated along the main stem and primary tributaries of the Colorado River, although Gila Monsters are found across the western and southern extent of Clark County. Gila Monsters are also known to occur in Lincoln County, as well as southwest Utah, northwest Arizona (including on the north of the Colorado River in the Pakoon Basin), and in southern California just west of the Nevada border Figure 161). The distribution of *Heloderma* in Clark County is geographically most similar to *Dipsosaurus*, however, *Heloderma* are found in substantially more heterogeneous sites with respect to soil substrate, frequenting areas of boulder piles and rocky outcrops surrounded by sand or loamy sands, where they travel to forage, mate, and seek cover sites. *Heloderma* are not frequently seen in broad open valleys unless there are abundant caliche caves to provide cover - which is why one of the areas of high modeling error in Eldorado Valley may occur (see below). There are five primary areas of elevated standard error in the model (Figure 162). The first is a cluster of high error mostly concentrated along the Interstate Highway 15 corridor northeast of Las Vegas in the vicinity of California Wash, and the Moapa Indian Reservation. The second is mostly on top of the Mormon Mesa and west of there in the Muddy River Valley. The third area of increased modeling error is in the Eldorado Valley immediately southeast of Boulder City. A fourth area indicated to have somewhat higher error values is around the base of the Virgin Mountains and near St. Thomas Gap south of the Virgin Mountains. However, *Heloderma* have been observed just across the border from St. Thomas Gap in Arizona (T. Esque, *personal observation*), as well as the sightings in St. Thomas Gap. The final area of interest with respect to modeling error is at the extreme southern tip of Clark County, near Laughlin, which is another area of fairly high error. There are a few other isolated spots of error throughout the range. Most of the regions of high modeling error tend to be near sites where locality records exist, but do not have any locality records within their perimeters.

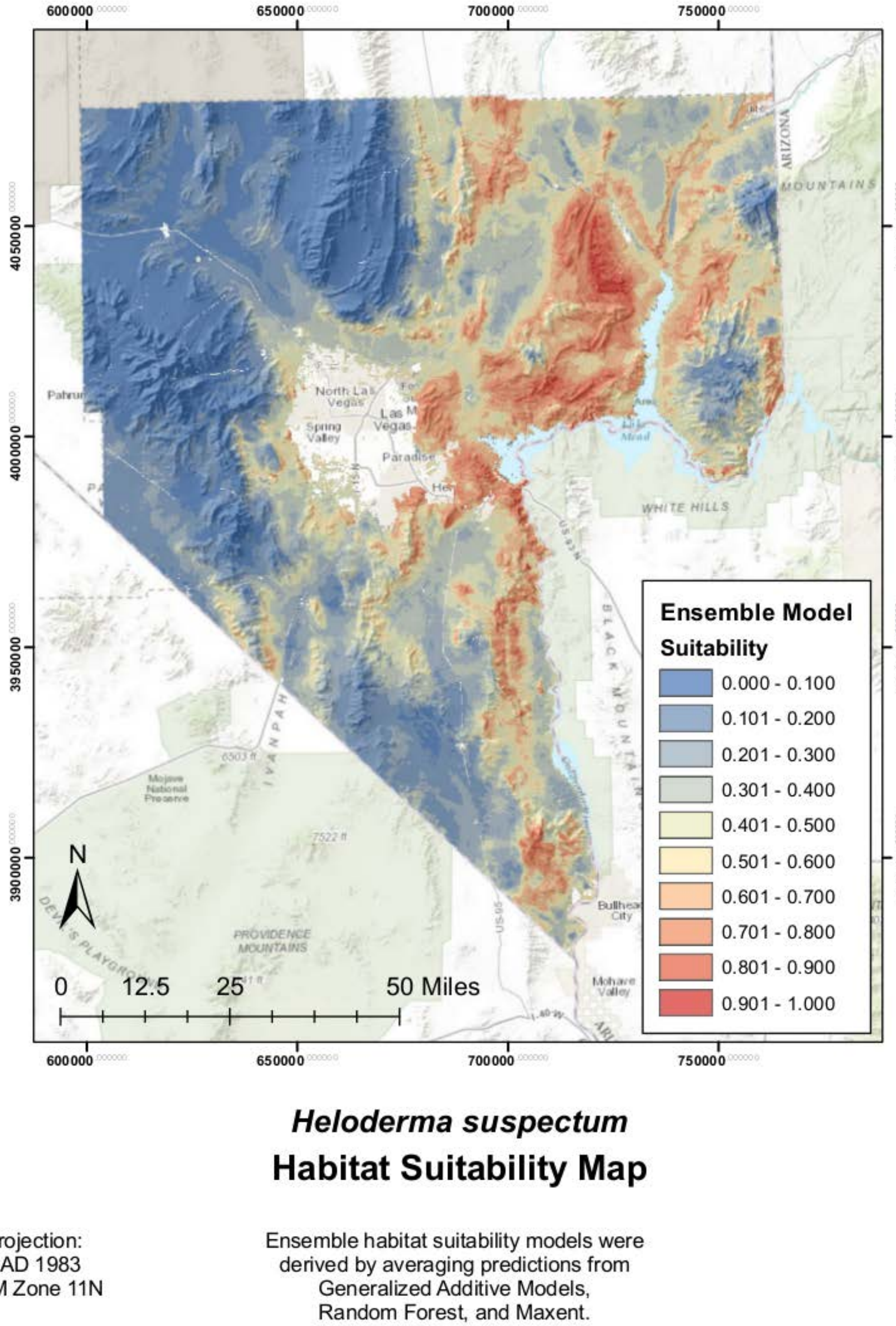


Figure 161. SDM map for *Heloderma suspectum* Ensemble model.

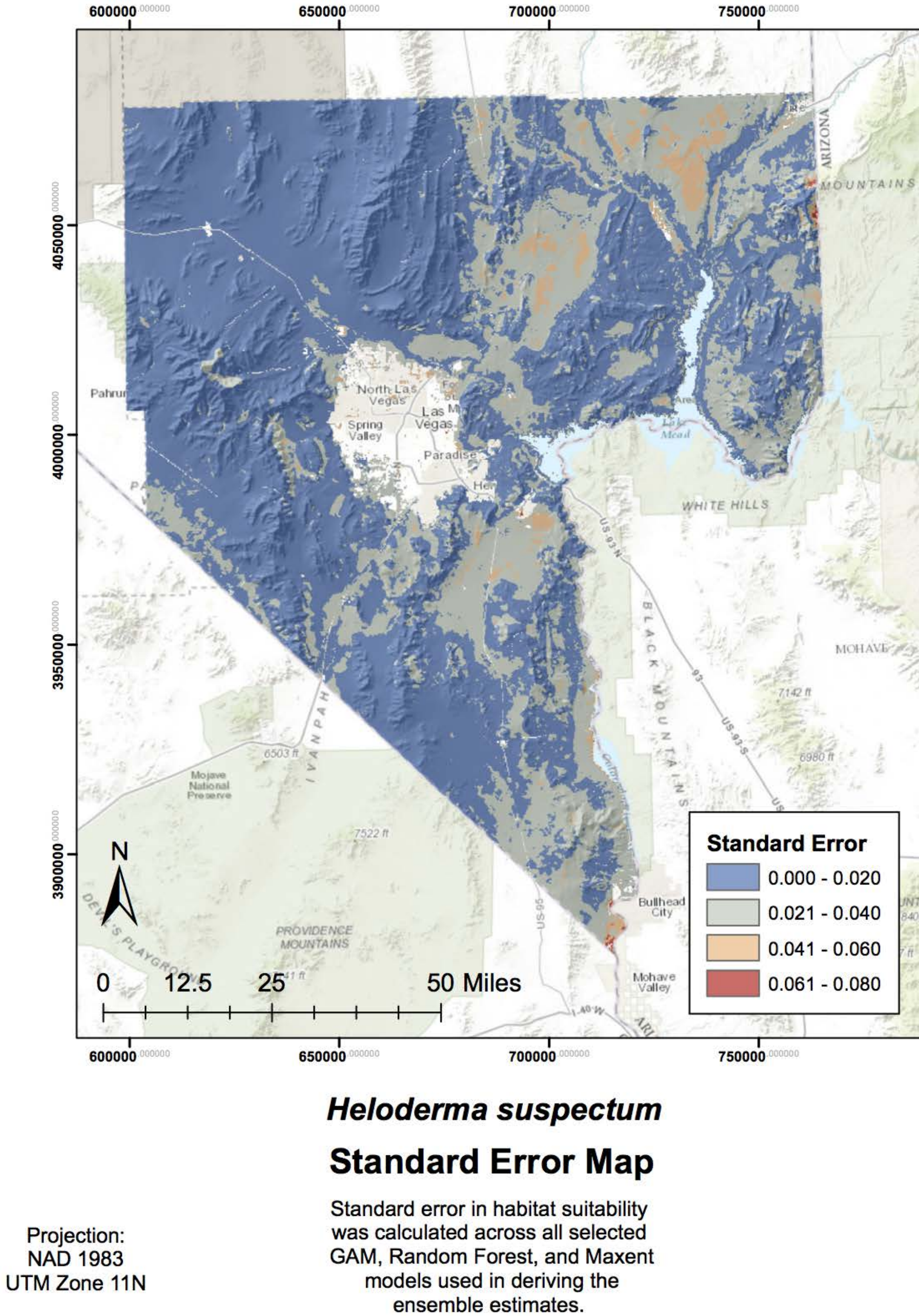


Figure 162. Standard Error map for the ensemble *Heloderma suspectum* ensemble model for Clark County, Nevada.

Distribution and Habitat Use within Clark County

Distribution of the Gila Monster within Clark County generally coincides with the distribution of Mojave Desert Tortoise and common chuckwalla (*Sauromalus ater*), however, little information exists on detailed distribution and relative abundance in Nevada (NDOW 2007). Recent research conducted by NDOW indicates that Gila Monsters may be more common than previously expected in the McCullough Mountains. Predicted habitat for the Gila Monster is nearly entirely contained within the Mojave Desert scrub ecosystem within Clark County.

Modeled habitat of additional habitat categories also predict limited high suitability habitat in Blackbrush, and Mesquite Acacia ecosystems, while moderate habitat is predicted in greater abundance among those three ecosystems (Table 108).

Table 108. Ecosystems within Clark County, and the area (Ha) of Low Medium and High predicted suitability within each ecosystem.

Ecosystem	Low	Medium	High
Alpine	124	0	0
Blackbrush	339104	70156	5725
Bristlecone Pine	7565	0	0
Desert Riparian	1841	8272	484
Mesquite Acacia	6462	10179	3024
Mixed Conifer	27339	0	0
Mojave Desert Scrub	305583	645853	325393
Pinyon Juniper	113758	1895	180
Sagebrush	4707	0	0
Salt Desert Scrub	74986	3607	203

Ecosystem Level Threats

Threats to Gila Monster habitat include loss and degradation of habitat associated, directly (e.g. bull-dozing landscapes, agriculture) and indirectly (e.g. feral pets, disturbances from increased recreation), with urban and suburban development. Large-scale solar development, associated infrastructure, and the proliferation of power lines contribute to recent losses of habitat. Utility, transportation and water distribution infrastructure also contribute to habitat fragmentation (Brown and Carmony 1999). Off-road vehicular activity and the invasion of non-native plants contribute to the degradation of suitable habitat by fragmenting habitat, reducing vegetative cover used by prey species, and eliminating shelter used by Gila Monsters. Illegal commercial collections are a source of population level losses throughout their range, because the species is highly valued by collectors globally (New Mexico Department of Fish and Game 1985). Native predator densities may increase in proximity to urban or suburban areas due to the increased availability of resources that are usually limiting in desert environments. These resources include food and water. Native predators gain access to increased refuse around human habitations, and prey species (rodents and cottontail rabbits) increase around parks and golf courses. More water is available around human habitations from run-off, and water features throughout these areas. These subsidized predators continue to prey on native wildlife during drought years that would normally cause decreases of predators (Esque et al. 2010). Increased presence of feral predators (i.e. dogs and cats) also impact Gila Monsters and their prey. Non-native plant invasions can cause increased frequency and intensity of wildfires, and desert vegetation is very slow to recover. Often native vegetation is replaced with invasive, non-natives and habitat is permanently converted through a series of wildfires and re-invasion of non-natives (Wildlife Action Plan Team 20012 USFWS 2008).

Threats to Species

Direct threats to the Gila Monster, including those in Clark County, include mortality from habitat destruction, illegal collection for commercial and recreational purposes, and injury and mortality resulting from collisions with vehicles on paved and unpaved roads (AGFD 2002). Predation is also a threat to this species. As urbanization becomes more prevalent in previously uninhabited deserts, human and pet densities increase, as well as densities of subsidized predators (Esque et al. 2010). Pet encounters with wildlife are presumed to be a contributing factor in Gila Monster declines (Jennings and Hayes 1994, WildEarth and Beck 2010). Additionally, the Gila Monster has a poisonous bite and has therefore been the target of unwarranted destruction by humans (NDOW 2009, WildEarth and Beck 2010). Mitigation of these threats may be possible through enforcement of off road vehicle regulations, and public education programs to reduce direct persecution and subsidized and feral predators.

Existing Conservation Areas/Management Actions

The Gila Monster is covered under the 1998 Conservation Agreement for the Spring Mountain Range. The goal of this conservation agreement is to provide long-term protection to the covered species and to preclude future listing of additional species under the ESA (USDA Forest Service, USFWS, and Department of Conservation and Natural Resources 1998).

In Nevada, the Gila Monster is protected under the Nevada Administrative Code 503.080, wherein the species is listed as a State protected reptile and collection is controlled under section 503.093. An appropriate license, permit, or authorization must be obtained from NDOW to kill or possess an animal.

The Gila Monster is considered a Species of Conservation Priority under the Nevada Wildlife Action Plan implemented by the NDOW. The banded Gila Monster was identified in the conservation strategy as one of the highest priority reptilian species on which to conduct research studies (Wildlife Action Plan Team 2012).

Recommended conservation actions specific to this species and species habitat are also included in the Nevada Wildlife Action Plan. The Wildlife Action Plan recommended approach is to identify and describe suitable habitat for this species in Nevada, develop management guidelines based on suitable habitat parameters, and to maintain prohibitions against indiscriminate collection and unnecessary killing. Further, the recommended conservation strategies to conserve habitat for this species include: maintaining this species habitat at its current distribution in stable or increasing trend; sustaining stable or increasing populations of wildlife in key habitats; and, obtain no net unmitigated loss or fragmentation of habitat in areas designated by the 2000 MSHCP as “Intensive Management Areas” or “Less Intensive Management Areas,” or in areas designated as “Multiple Use Management Areas” that represent the majority of habitat for a species (Wildlife Action Plan Team 2012).

The Gila Monster is on the Nevada Natural Heritage Program (NNHP) Animal and Plant At-risk Tracking List, which directs the data acquisition priorities of the NNHP and provides current information on the status of these taxa. Taxa considered at risk and actively inventoried by NNHP typically include those with federal or other Nevada agency protection status and those with Global and/or State ranks 1 through 3 (NNHP 2012).

The banded Gila Monster is included as a Covered Species in the Coyote Springs Investment Multiple-Species Habitat Conservation Plan published in July 2008 and the corresponding Endangered Species Act section 10(a)(1)(B) incidental take permit issued by the USFWS in October 2008 (Coyote Springs Investment Multiple-Species Habitat Conservation Plan 2008). The Coyote Springs Investment Multiple-Species Habitat Conservation Plan area covers portions of Clark and Lincoln counties, north of the Clark County MSHCP area.

Summary of Direct Impacts

When considered throughout the entire year, Gila Monsters spend up to 98 percent of their lives underground (Beck 2005, Beck and Jennings 2003), which makes them difficult to observe and survey. However, when tracking them during their active season, they are found on the ground surface as much as 25 percent of the time (Jason Jones – NDOW, *Personal Communication*). Infrequent observations should not be confused with low likelihood of occurrence, as they are known to occur throughout Clark County. Of the 3358 km^2 of high quality habitat modeled in Clark County, 1046 km^2 is identified in conservation areas, while 58 km^2 are already disturbed and an addition al 170 km^2 likely to be impacted. Moderate habitat is far more expansive, with and additional 797 km^2 likely to be impacted, and 298 km^2 already disturbed, but with 2274 km^2 of potential habitat in conservation areas (Table 109).

Table 109. Categorized modeled habitat values (High, Medium, and Low) and the average area (Hectares) predicted in the potential impact areas, conservation areas, already disturbed areas, and overall area

Habitat Level	Impact	Conserved	Disturbed	Area (Hectares)
High	16964	104610	5833	335836

Habitat Level	Impact	Conserved	Disturbed	Area (Hectares)
Med	79668	227464	29776	744157
Low	25802	180299	4375	892781

LABL - Western Red Bat (Lasiurus blossevillii)

Until recently, Western Red Bats (*Lasiurus blossevillii*) were rarely observed in Nevada and particularly Clark County (Bradley et al. 2006). This may be mostly due to predominantly solitary roosting habits (Carter et al. 2003). Recently developed acoustic sampling devices have proven to be much better at providing occurrence data than the use of mist nets for these solitary bats (Williams et al. 2001). Western Red Bats are considered to be foliage-dependent for roosting (Cryan 2003). Among their favored roosting habitats are riparian gallery forests, orchards, and even urban areas (Carter et al. 2003, Ellison et al. 2003, LCR MSCP 2004, Pierson et al. 2006). Foraging may occur along sand bars or other open country and along habitat edges such as between forest and meadow edges.

Species Status

No petitions have been received for this species at the federal level, but it is designated a Species of Special Concern in California (CDFG 2011).

US Fish and Wildlife Service Endangered Species Act: Not listed
US Bureau of Land Management (Nevada): Sensitive
US Forest Service (Region 4): No status
State of Nevada (NAC 503): Sensitive
NV Natural Heritage Program: Global Rank G5, State Rank S1M
NV Wildlife Action Plan: Species of Conservation Priority
IUCN Red List (v 3.1): Least Concern (Gonzalez et al. 2016)
CITES: No Status

Range

The Western Red Bat generally occurs along the west coast of North America, from British Columbia to California. Occurrences are uncommon in the Great Basin, and moderately frequent through the hot desert regions of southern California, southern Nevada, Arizona, and New Mexico, and extending eastward to west Texas (Cryan 2003, Carter and Menzel 2007). In California, Western Red Bats stay year round where males segregate from females at higher elevations and latitudes in the summer months (Cryan 2003). They winter in lower elevations in southern California, and are widespread across Mexico where both sexes are found together. Females have been observed giving birth in southeastern Arizona/southwestern New Mexico in early spring, but were thought to have migrated there from elsewhere (Cryan 2003).

Population Trends

In a survey of habitat and species conservation issues in southern California, population trends for Western Red Bats were classified as ‘unknown’ (Stephenson and Calcarone 1999). In a study on population trends of solitary foliage-roosting bats, it was determined that there was a paucity of data on historical or recent population trends and thus the trend is unknown (Carter et al. 2003). A search for population and trend data across the US found 21 observations of Western Red Bats, and 16 roosts, but there were no time series data with which to analyze population trends (Ellison et al. 2003). The primary cause for the lack of data stems from low detection probabilities for this bat as it is primarily a solitary roosting species (Carter et al. 2003). Without the accumulations of large numbers of these small and inconspicuous animals, they are frequently present, but overlooked. Thus, improved methods for detection, such as acoustic sensing, must be used.

While population trends for Western Red Bats cannot be quantified due to lack of data, many authors discussed the potential loss of bat habitat because of the thinning of mature forests as potentially contributing to a loss of bat populations (Stephenson and Calcarone 1999, Carter et al. 2003, Ellison et al. 2003). In particular, loss of mature riparian gallery forests along the Sacramento River and other major rivers in central California were cited as potential areas for reductions in bat habitat (Pierson et al. 2006). That being said, it was also stated that Western Red Bats probably benefited from the conservation measures provided in both commercial and public forests of the western US compared to the reductions of forested areas and human incursions in those regions of the eastern US (Carter et al. 2003). It has also been noted that Western Red Bats have shown some ability to adapt to new roosting opportunities such as ornamental trees, and this is likely to their advantage (Carter et al. 2003).

Historical observations of great migrating numbers of congeners to the Western Red Bat are also offered as evidence to the likely historical declines of Lasiurid bat species (Carter et al. 2003, Ellison et al. 2003).

Habitat Model

Model Results

Western Red Bat habitat was modeled at the extent of the Mojave Desert at a resolution of 1 km and trimmed to the Clark County boundary for presentation. The three modeling algorithms for Western Red Bat habitat predicted rather dissimilar areas within Clark County with the GAM and RF models predicting more broadly, the GAM model strongly so, while the MaxEnt model predicted habitat much more conservatively (Figure 163). The RF model generally had the highest performance scores among the four performance measures reported, closely followed by the Ensemble model, MaxEnt and GAM (Table 110). The Continuous Boyce Indices (CBI) indicated somewhat variable model performance, with some inconsistencies in performance for occurrences in the 0.7 to 0.8 range for the RF and MaxEnt Models, and generally low performance at values below 0.8 in the GAM. Standard error maps for each model indicated similar error for the GAM and RF models (Figure 164), with large patches of uncertainty for the MaxEnt model. The Ensemble model by design had more widespread areas of lower SE values (Figure 164).

The CBI for the Ensemble mode indicated good model performance (Figure 165), and this model also had the highest fixed BI among the group. Approximated bins for the ensemble model based on the CBI were 0-0.45 unsuitable, 0.45-0.65 marginal, 0.65 to 0.7 suitable, and 0.7 -1 optimal habitat; with a suggested cutoff threshold of 0.5 to 0.6 (Figure 165) while the threshold value calculated from ROC statistics for the ensemble model was 0.56 (Table 111).

Table 110. Model performance values for *Lasiurus blossevillii* models

Performance	GAM	RF	MaxEnt	Ensemble
AUC	0.908	0.975	0.942	0.962
BI	0.535	0.515	0.404	0.612
TSS	0.837	0.935	0.87	0.903
Correlation	0.732	0.779	0.754	0.739
Cut-off*	0.617	0.644	0.426	0.561

*threshold at which sum of sensitivity (true positive rate) and specificity (true negative rate) is highest

Table 111. Percent contributions for input variables for *Lasiurus blossevillii* for ensemble models using GAM, MaxEnt and RF algorithms

Term	GAM	RF	Max	Avg
Surface Texture (ATI)	39.99	12.425	14.279	22.231
Roughness (TRI)	39.235	5.348	19.047	21.21
Winter Precipitation	2.425	12.133	28.093	14.217
NDVI Maximum	18.349	10.208	10.191	12.916
Winter Min Temp	0	6.453	10.8	5.751
Topographic Position (TPI)	0	3.639	13.488	5.709
Summer Max Temp	0	9.1	1.401	3.5
Annual Temp. Range	0	6.098	1.419	2.506
NDVI Amplitude	0	0	1.092	0.364
Diurnal Temp. Range	0	0	0.186	0.062
Soil Water Stress	0	0	0	0

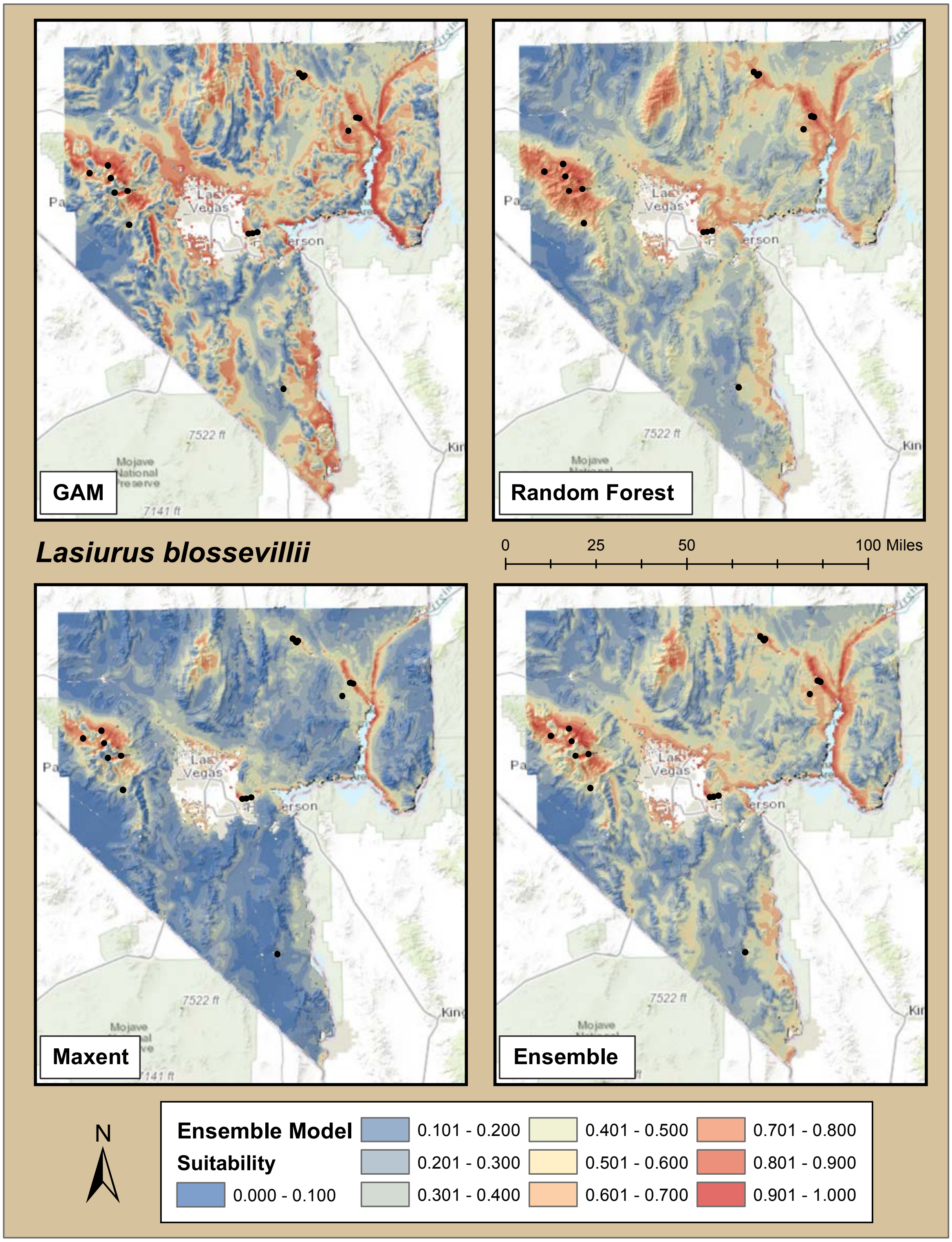


Figure 163. SDM maps for *Lasiurus blossevillii* for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

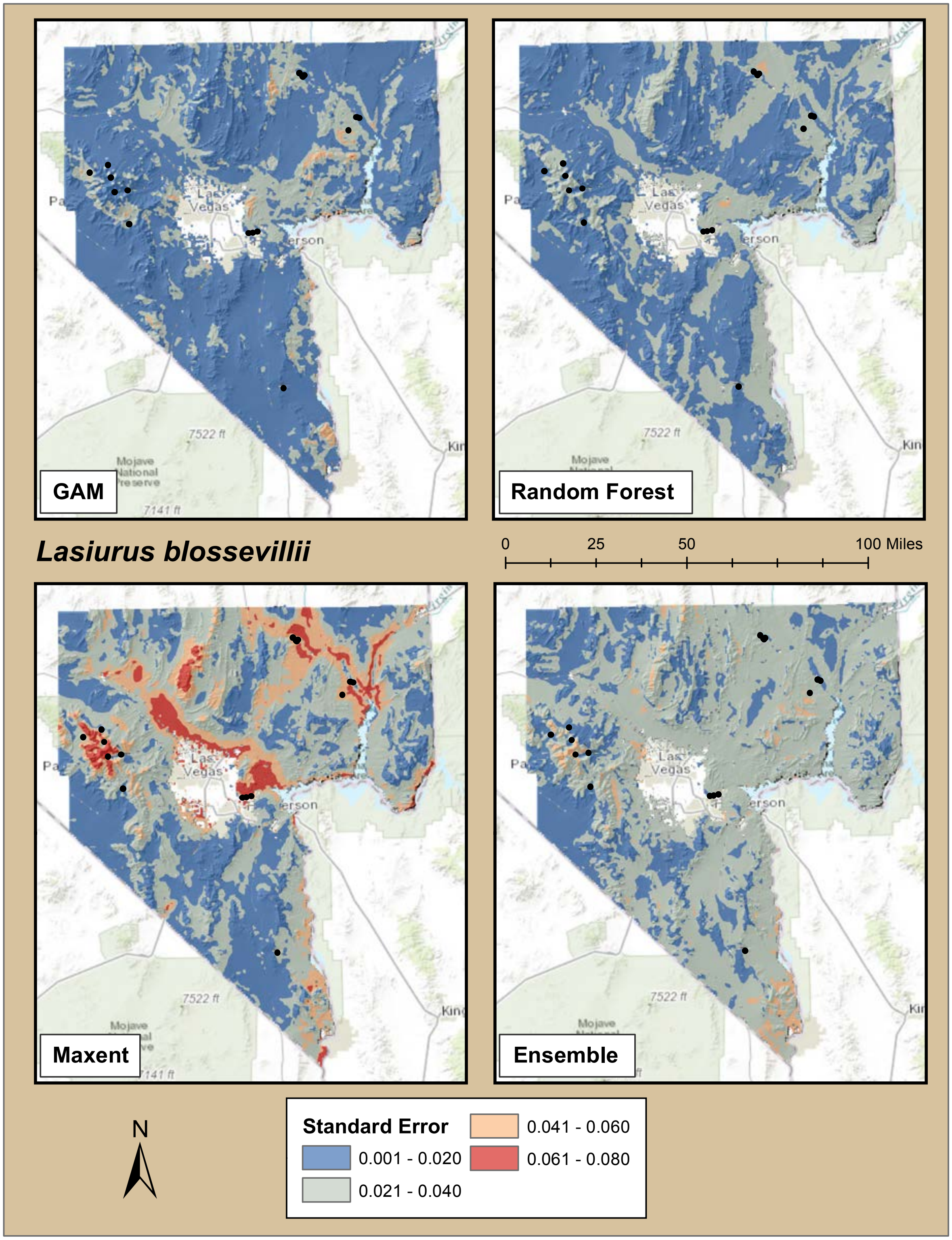


Figure 164. Standard error maps for *Lasiurus blossevillii* models for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

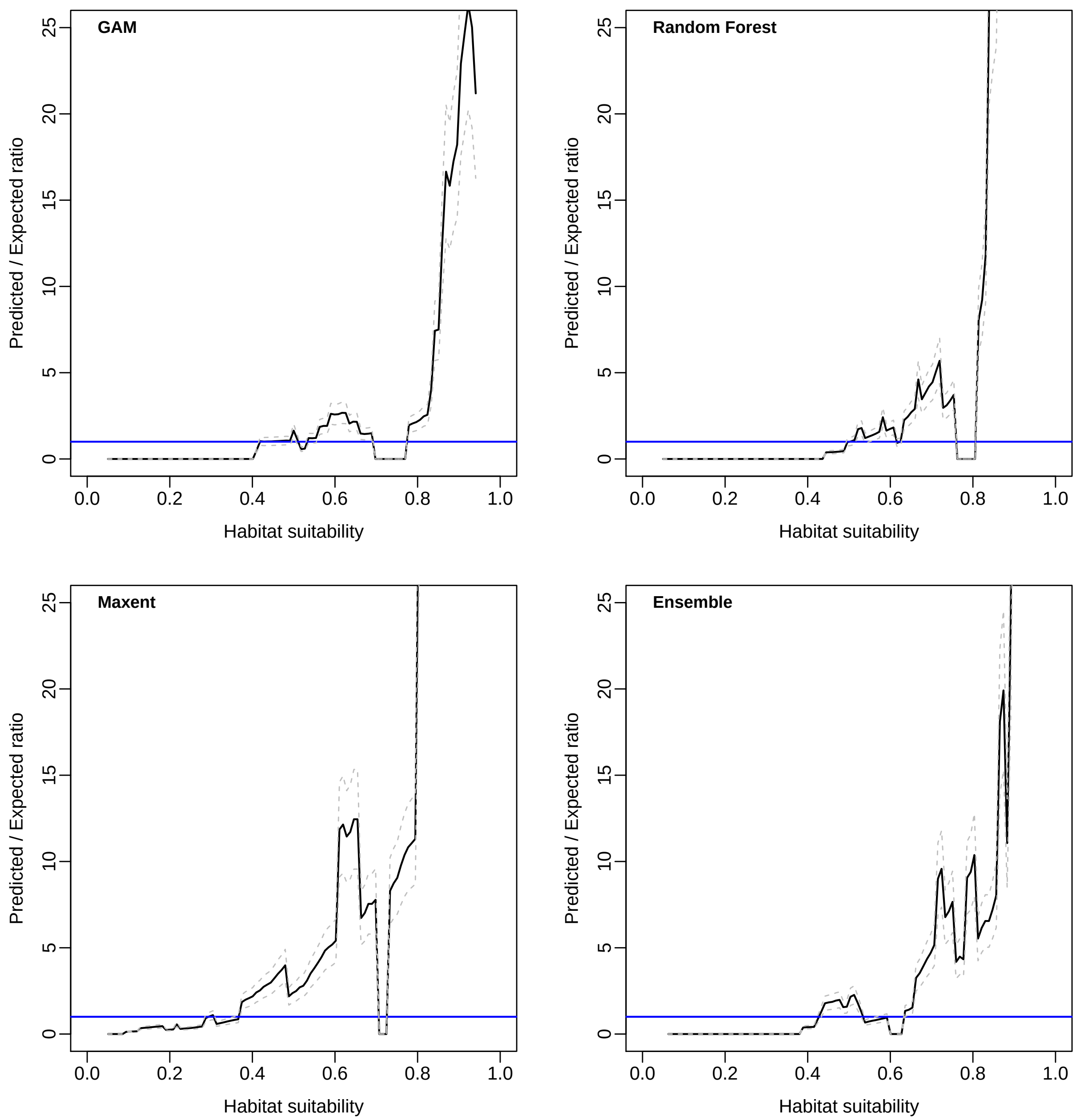


Figure 165. Continuous Boyce Indices for *Lasiurus blossevillii* models for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

GAM Model

The GAM model ensemble identified only 4 contributing variables of the 11 that were evaluated. These were: Surface Texture, Roughness, Winter Precipitation and NDVI Maximum (Table 112), all of which were predicted to have linear responses (Figure 166). Habitat suitability was predicted to be highest in areas with lower roughness, lower winter precipitation (i.e., largely corresponding with lowland areas where this species is known to forage), and increasing maximum NDVI which can be influenced by both riparian vegetation and higher elevation areas with increased vegetative cover (Figure 166). Rockier areas were also predicted to provide higher suitability habitat. The GAM standard error map indicated the most areas with higher standard error values largely in the eastern portion of the county in lowland areas predicted to be of high suitability (Figure 164, Figure 163), yet this algorithm performed the poorest overall among the models (Table 111).

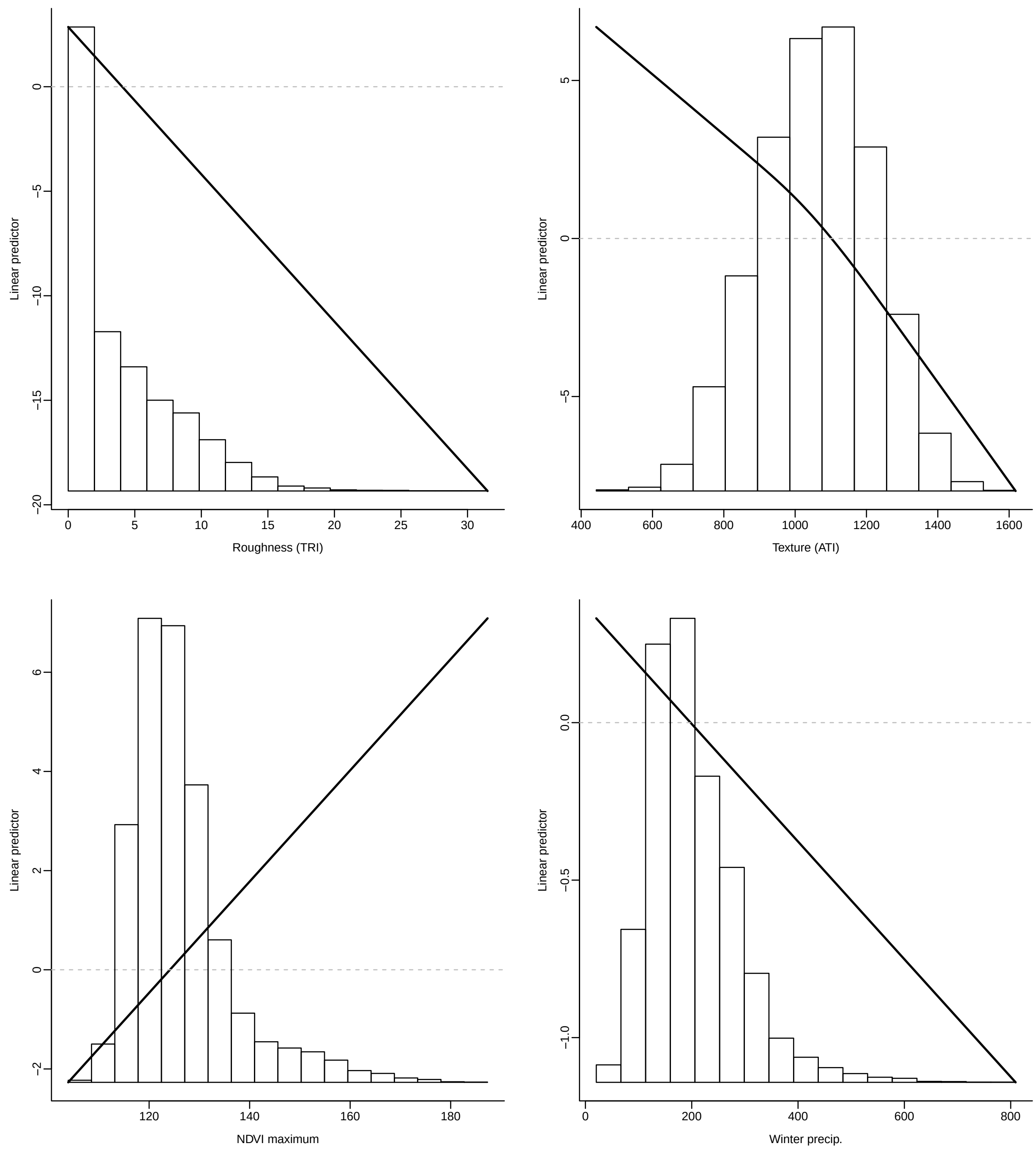


Figure 166. GAM partial response curves for the *Lasiurus blossevillii* model overlaid over distribution of environmental variable inputs in the study area.

MaxEnt Model

The MaxEnt model had six variables contributing 10% or more each, accounting for 96% of model contribution in total (Table 112). Modeled habitat indicated higher suitability in areas with lower Winter Minimum Temperature and Precipitation, lower Surface Roughness, and Rockier Substrates (corresponding to lower values of ATI).

Highest habitat suitability was predicted for areas of lower Topographic Position with low Winter Minimum Temperatures, which corresponds with mountainous areas at the top of the local watershed (Figure 167). The standard error for this algorithm showed areas of the highest uncertainty among the models (SE of 0.06 to 0.08) in both lowland and higher elevation locations throughout the county (Figure 164). The MaxEnt model performed third among the four models explored, and while it had a relatively weaker BI, the other performance measures were not indicative of poor performance overall (Table 111., Figure 165).

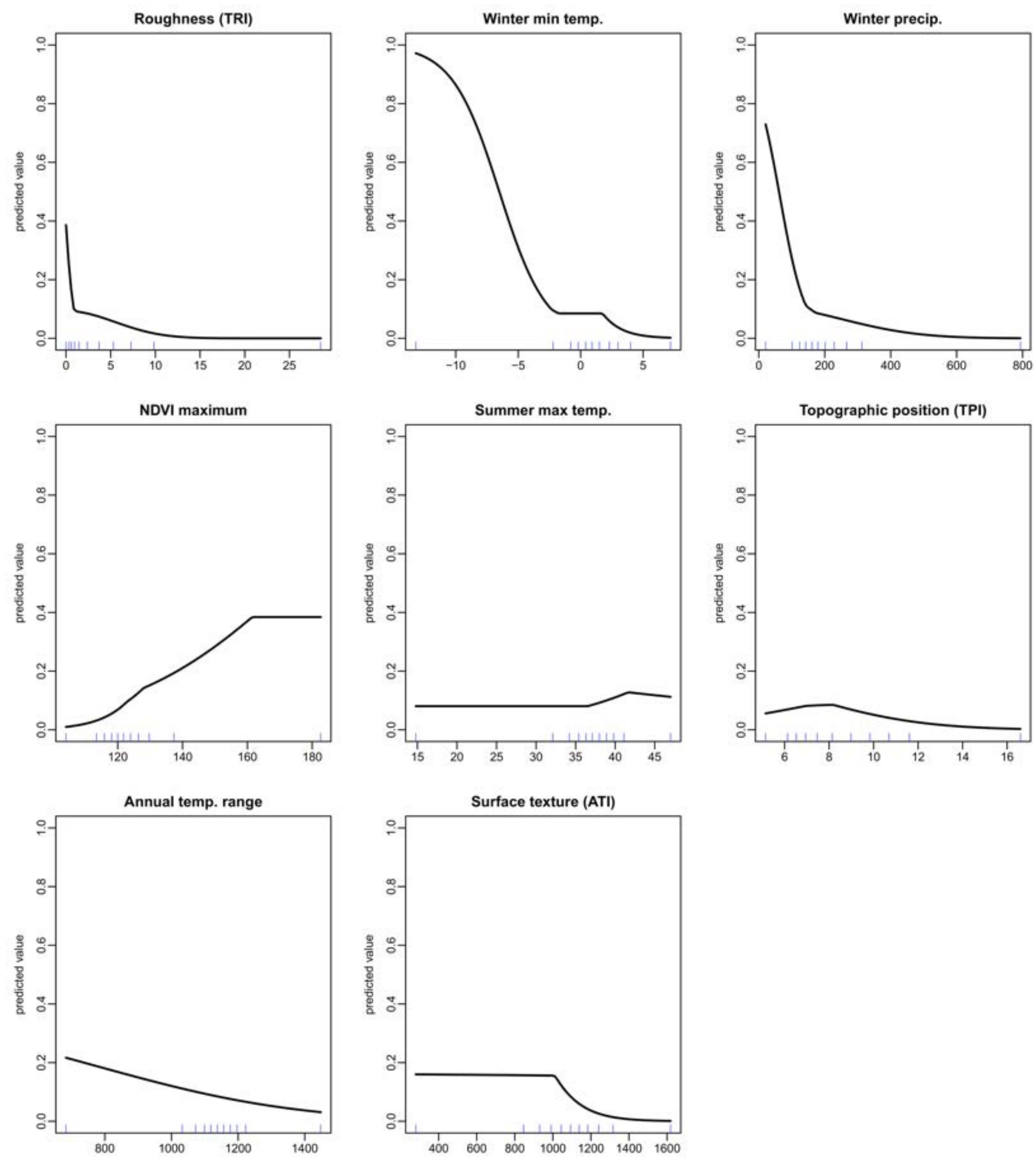


Figure 167. Response surfaces for the top 9 environmental variables included in the MaxEnt ensemble model for *Lasiurus blossevillii.*

Random Forest Model

The RF models had three environmental variables contributing 9% or more totaling 44% of total model influence. Surface Texture and Winter Precipitation were the highest contributors with highest predicted habitat values in areas with lower winter precipitation and lower values of ATI – corresponding with rockier areas (Figure 168). Higher habitat values were also predicted for areas of higher max values of NDVI and for areas of both higher and lower (excluding moderate) Summer Max Temperatures, likely reflecting the dichotomy of roost sites in mountainous areas, and foraging sites in lowland areas (Figure 168). Decreasing contributions were also noted for Winter Minimum Temperature, Annual Temperature Range, and Terrain Roughness with higher habitat values predicted for areas with low temperatures and higher roughness (Figure 168). Standard error maps for this model were similar to those for the GAM model with low levels of error spread throughout the county largely in lowland areas, but with uncertainty in the spring range as well (Figure 164). This was the highest performing model overall among all models, with the exception of the Boyce Index (Table 111).

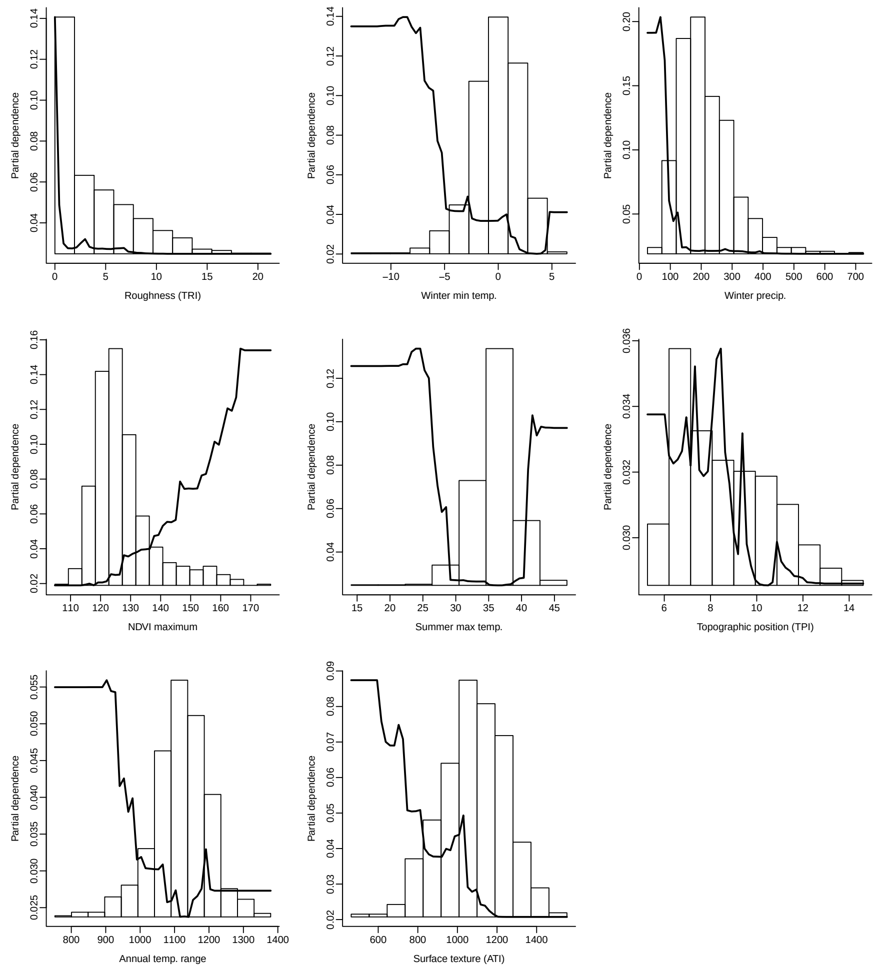


Figure 168. Response surfaces for the environmental variables included in the RF ensemble model for *Lasiurus blossevillii*. Histograms represent the range of each environmental variable across the x-axis, and predicted dependence relative to habitat suit

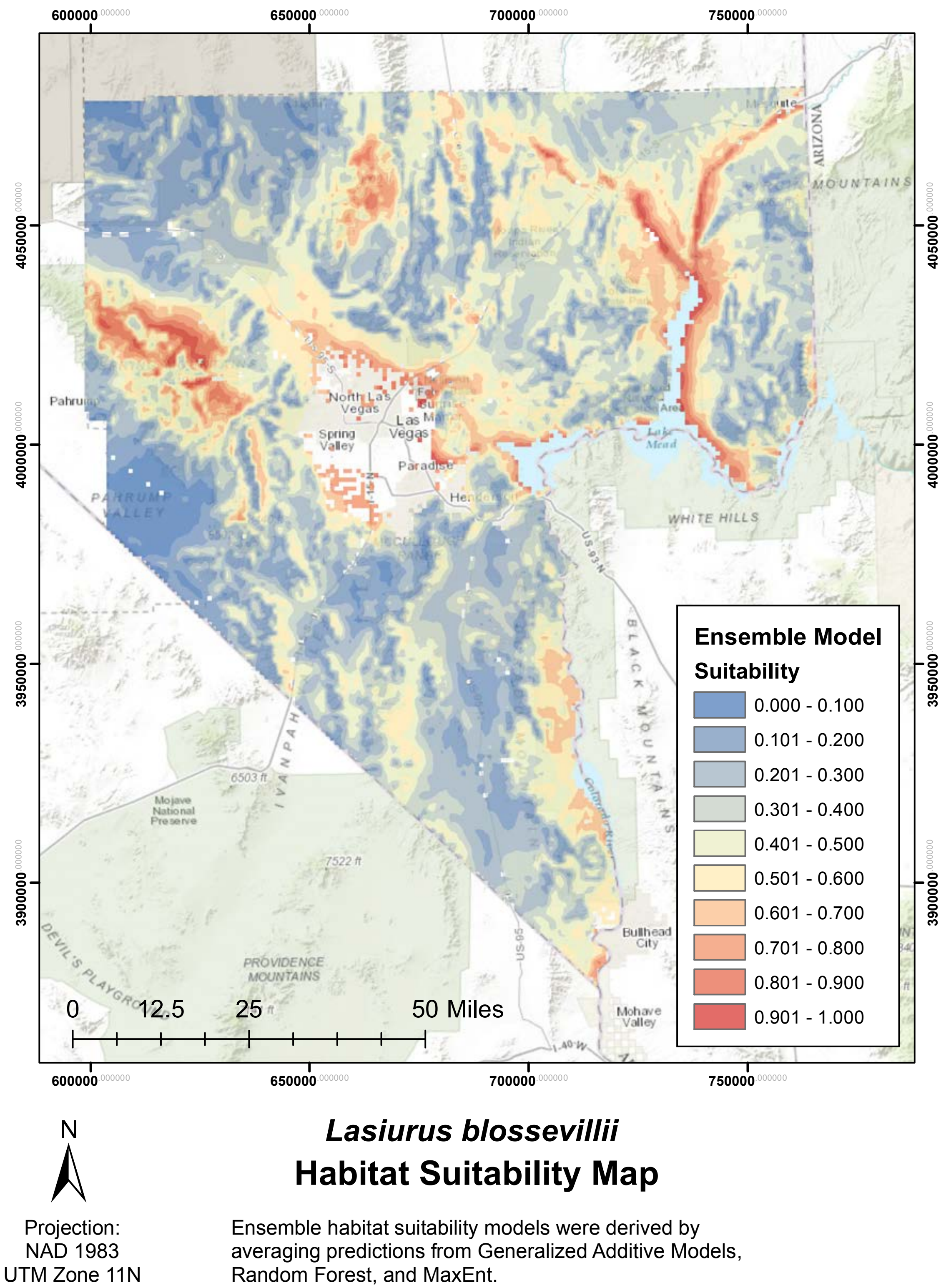


Figure 169. SDM map for the *Lasiurus blossevillii* ensemble model.

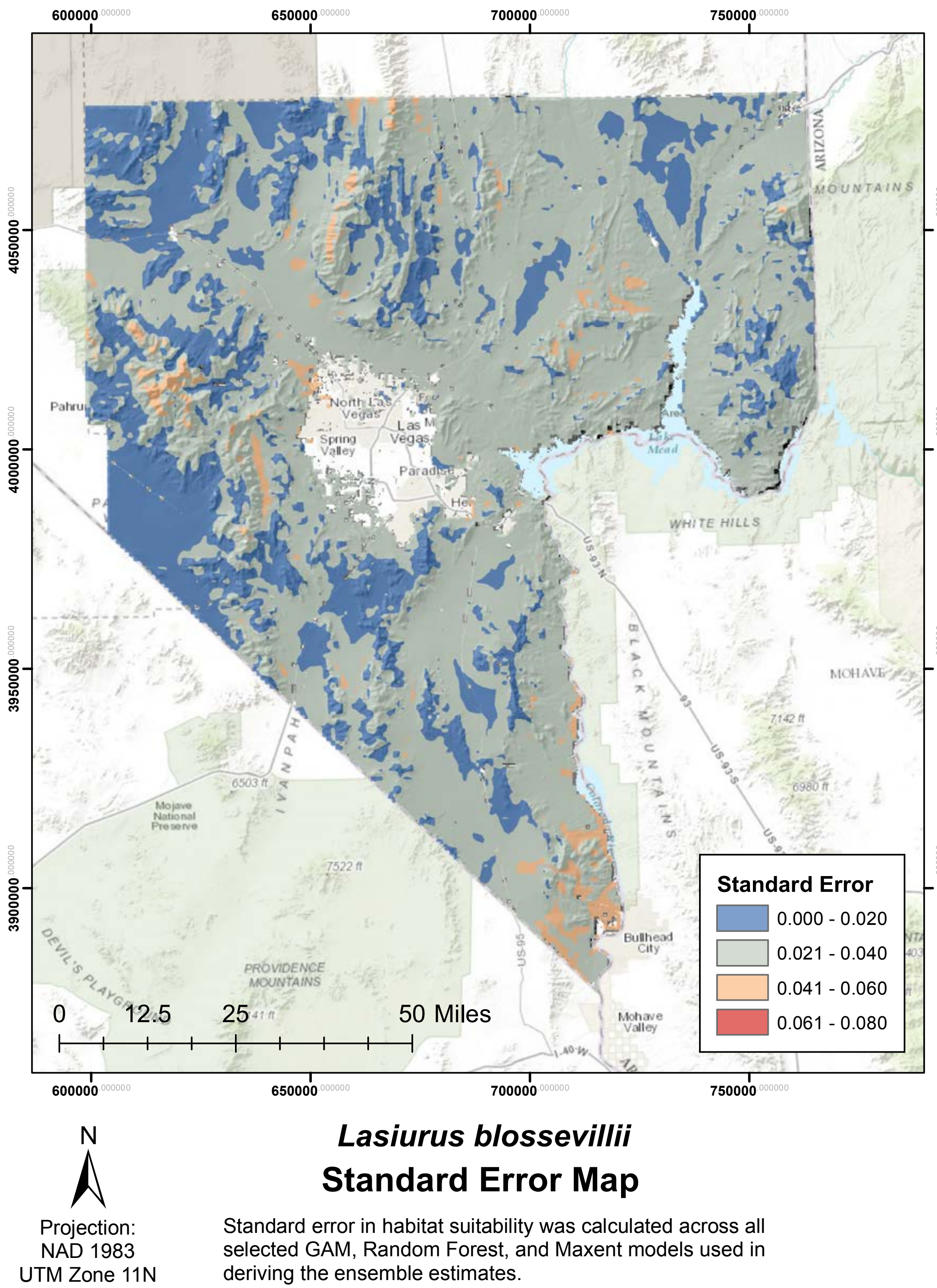


Figure 170. Standard Error map for the *Lasiurus blossevillii* ensemble model.

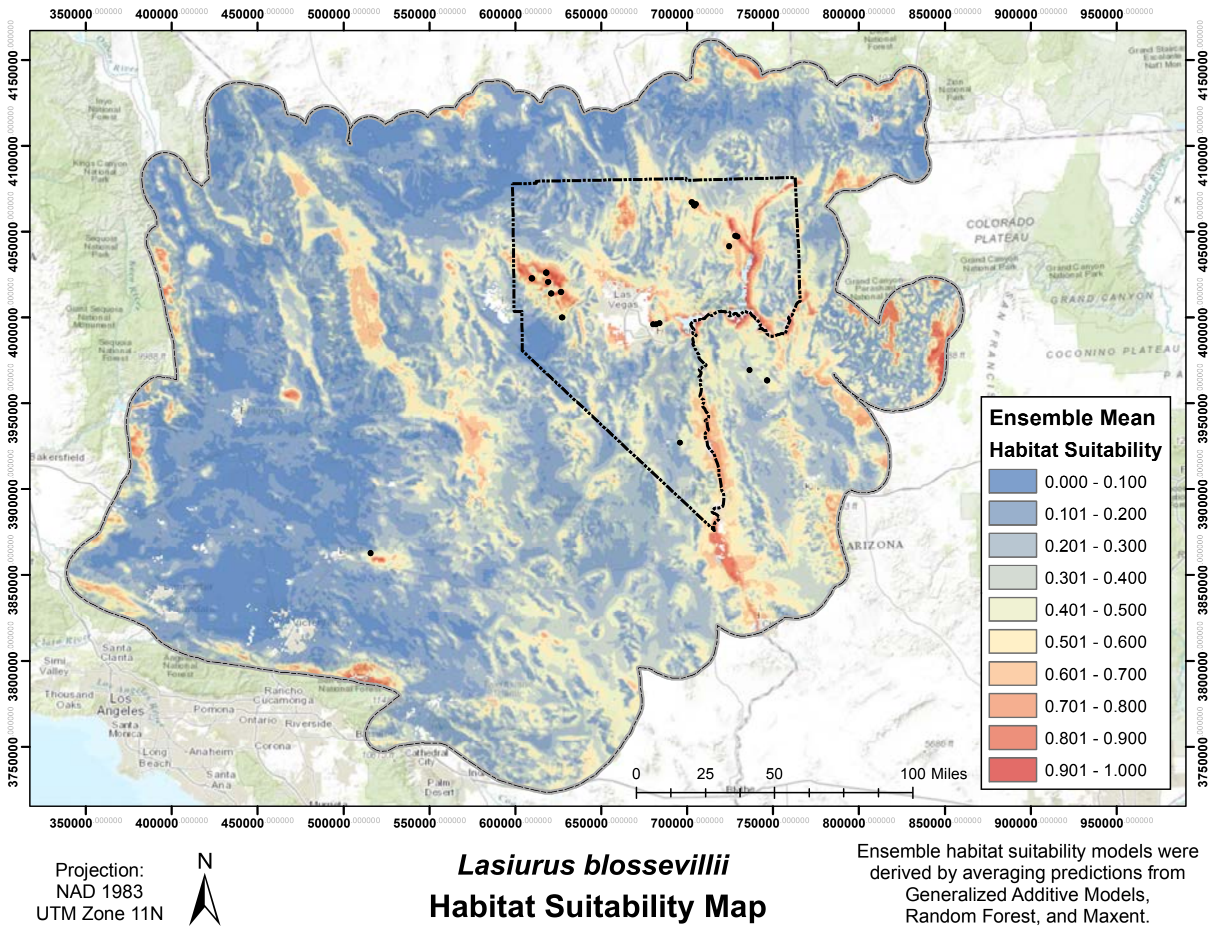


Figure 171. Habitat suitability map for the *Lasiurus blossevillii* ensemble model for the entire Mojave Desert.

Distribution of Localities –

Localities for Western Red Bats are sparsely distributed in Clark County with only 27 localities distributed in clusters in the Spring Mountains west of Las Vegas, in the River Mountains east of Henderson, and with several observations during foraging in the lowlands along the Muddy River and the Moapa Valley northwest of Overton, and with a single observation near Searchlight NV (Figure 163).

Standard Error

The standard error for the habitat suitability model for Western Red Bats is generally low over the majority of Clark County, with a SE of 0.02 – 0.04 predicted for most of the area. Small patches of moderate error (SE 0.04 - 0.06) are shown in parts of the Spring Mountains Sheep Mountains, Muddy Mountains and in the Newberry Mountains and surrounding area in the southern portion of the County (Figure 164).

Distribution and Habitat Use within Clark County

There are few records of Western Red Bats in Clark County, Nevada, or desert regions in general (Cryan 2003, Pierson et al. 2006). In a survey of the records for bat occurrences in the California deserts there were no records found since 1990 (ICF/Dudek 2012). Similarly, a review of Western Red Bat occurrences in regard to the Lower Colorado River Multi-Species Conservation Program found no occurrences on record for this species (LCR MSCP 2004). In a national survey of Western Red Bat roosting behavior, 71.4 % of roosts were in broad-leaved trees (i.e., none in conifers), and individual roosts were observed in a mine, a cave, a log cabin, and a house (Ellison et al. 2003). Trees that Western Red Bats were documented as using in California and that are present and available in Clark County, Nevada, include mostly mature deciduous trees of tall stature and large basal circumference such as Fremont cottonwood (*Populus fremontii*), willow (*Salix* spp.), Chinaberry (*Melia azedarach*), mulberry (*Morus rubra*), and mesquite (*Prosopis* spp.), (Carter et al. 2003, LCR MSCP 2004, Pierson et al. 2006). Western Red Bats also roost in citrus and other fruit trees (Constantine 1959) providing a potential alternative to large gallery forests that are relatively rare in southern Nevada. A study of the bat community in a riparian habitat of Clark County, Nevada, found Western Red Bats to be present in all four habitat types that were surveyed including riparian marsh, mesquite bosque, riparian woodland, and riparian shrubland (Williams et al. 2001). Because Western Red Bats use primarily deciduous trees, they may be forced to migrate from any areas with seasonality that results in a loss of leaves (Cryan 2003). Within the county they are high habitat is predicted to broadly distributed in all but Alpine ecosystems, which is included in moderate habitat (Table 112). Blackbrush and portions of Mojave Desert Scrub and Salt Desert scrub ecosystems appear to be largely lower quality habitat for this species (Table 112).

Some of the modeled habitat in the county is predicted to occur high in the Spring and Sheep ranges. Other habitat occurs in the lowlands where animals forage surrounding the edges of Lake Mead, along the Virgin and Muddy river basins, and along the lower portion of the Colorado River within the State, although the prevalence of habitat here is questioned by NDOW (NDOW pers comm). Habitat is also predicted peripheral to the city of Las Vegas where the habitat is masked over. In those areas the abundance of large deciduous trees presents a lot of potential habitat depending on the tolerance these bats have for other urban factors. Urban sampling for bat detections would be useful to determine their use of parks, open areas, and neighborhoods in these areas. The combination of the dependence of this species on deciduous trees for roosting and its foraging behavior over wetlands likely contribute to the broadly predicted habitat produced by the model. The use of montane habitats in the Spring and Sheep ranges are likely dependent on the few large species of deciduous trees found in those areas including: Frémont cottonwood, (*Populus fremontii*), narrow-leaved cottonwood (*P. angustifolia*), aspen (*P. tremuloides*), Gooding Willow (*Salix gooddingii*), and velvet ash (*Fraxinus velutina*) (Ackerman 2003, and Niles and Leary 2007). The Spring Mountains have a greater diversity of deciduous trees and the following tree species are also potential roosting substrate for *L. blossevillii* there: (*S. lasiolepus*), coyote willow (*S. exigua*), water birch (*Betula occidentalis),* blue elderberry (*Sambucus mexicana*), and Gambel's oak (*Quercus gambelii*). While some of those species provide leafy cover, they do not all meet the large bole-size supposedly required by the bats. L blossevillii are also known to roost in caves and man-made structures which likely contributes to increased presence in the low elevation mountains within the county that do not support large trees or gallery forests (Figure 169). Based on the patterns of predicted suitable habitat in other parts of the county, it is unclear why Boulder City does not have higher potential habitat values due to the large, concentrated area of deciduous trees found there. Acoustic sampling would also be helpful in determining the relative importance of that area. Despite higher performance for the Ensemble model, NDOW officials commented that they agreed more with the MaxEnt models for this species (NDOW pers comm).

Table 112. Ecosystems within Clark County, and the area (Ha) of Low Medium and High predicted suitability within each ecosystem.

Ecosystem	Low	Medium	High
Alpine	0	117	6
Blackbrush	235135	170697	8591
Bristlecone Pine	7	5184	2357
Desert Riparian	7	1142	9603
Mesquite Acacia	4865	10745	4204
Mixed Conifer	210	10340	16734
Mojave Desert Scrub	442857	696122	145821
Pinyon Juniper	19482	57340	38740
Sagebrush	1083	2348	1264
Salt Desert Scrub	49232	27613	2774

Ecosystem Level Threats

Western Red Bats inhabit Desert Riparian and Water communities in Clark County, Nevada. Any activities that reduce the number of tall, mature, riparian gallery trees of the largest basal girth and mesquite bosques are considered a threat to Western Red Bats (Carter et al. 2003). Tree-roosting bats such as Western Red Bats must migrate in temperate regions because deciduous trees drop their leaves seasonally and the cover is lost for roosting bats. Due to the migratory behavior, tree-roosting bats, including the Western Red Bat have the greatest losses due to collisions with man-made structures such as wind turbines (Cryan 2011).

If this species uses alternate roosting sites, such as orchards, golf courses, or suburban areas, the potential for harmful exposure to pesticides must be considered (Geluso et al. 1976, O’Shea and Clark 2002).

Threats to Species

Anything contributing to the loss of riparian gallery forest, woodland, or upland forest would be considered a threat to Western Red Bats (Carter et al. 2003, Pierson et al. 2006) including fire, fuel management, overgrazing, or agricultural conversion. Agricultural spraying can be detrimental to bats (Bradley et al. 2006). Water impoundments have historically reduced cottonwood gallery forests. The addition of riparian natural reserves could be of significant value to Western Red Bat populations, as well as, allowing existing reserves to mature into large gallery forests. losses of orchards, due to conversion to housing developments could be detrimental to Western Red Bat habitat. Western Red Bats may be at risk to wind energy turbines or powerlines and other physical structures into which they may collide during migration – depending on how many of them migrate in this area (Cryan 2003). Loss and degradation of riparian habitats due to overgrazing agricultural conversion to upland habitat; agricultural spraying; water impoundments; fire; predation, particularly by jays; found by humans and pets in suburban areas. Need more information on seasonal movement patterns, habitat use, roosting locations and characteristics, and status and distribution within the state.

Existing Conservation Areas/Management Actions

In 2006, the Nevada Bat Working group published the Nevada Bat Conservation Plan (Plan). This Plan is a revision and update of the original Plan that was published in 2002. The Plan identifies the 23 bat species that occur within the State of Nevada as well their life histories and habitat requirements. The goal of the Plan is to reduce the threats to the bat species that occur within Nevada and within the habitats where they occur. Ultimately, the goal of the Plan is to diminish the likelihood that any of the bat species that occur within Nevada are listed under the federal Endangered Species Act (Bradley et al. 2006).

Increasing the amount of land reserved in Desert Riparian ecosystems is perhaps the best way to enhance habitat for Western Red Bats. Reducing conversion of agricultural lands, especially orchards may also contribute to the conservation of the Western Red Bat. Increasing acoustical sampling and monitoring such that we have a better understanding of the presence, activities, and movements of Western Red Bats may be the best way to understand how to conserve their populations.

Summary of Direct Impacts

Potential impacts for this species include 234 km^2 of high, and 647 km^2 of moderate habitat. Conserved areas are largely composed of moderate to low habitat, while areas considered to be already disturbed total 283 km^2 (Table 113).

Table 113. Categorized modeled habitat values (High, Medium, and Low) and the average area (Hectares) predicted in the potential impact areas, conservation areas, already disturbed areas, and overall area

Habitat Level	Impact	Conserved	Disturbed	Area (Hectares)
High	23472	11743	28344	236744
Med	64737	275170	18229	999478
Low	34345	225408	4843	776100

LACI - Hoary Bat (Lasiurus cinereus)

The Hoary Bat (*Lasiurus cinereus*) is brownish or greyish, with white highlights (thus its namesake “hoary”), a white shoulder patch, and yellowish throat patch (Shump and Shump 1982). It is a solitary bat that roosts in tree foliage (Carter et al. 2003). It forages after sunset, and is active at midnight and later in desert areas and juniper woodland habitats (Bell 1980). Copulation and fertilization likely occur during late fall and during the overwintering season, with young born in early June (Kohler at el. 2000). Young may fly as soon as 33 days after birth (Shump and Shump 1982). Temperature has been found to affect the growth rates of young. Cooler temperatures resulted in slower growth rates as female bats had to use available energy for other needs (e.g. thermoregulation vs. lactation) (Kohler et al. 2000).

Species Status

The IUCN lists this species as one of Least Concern due to its wide distribution, large population size, and tolerance to some degree of disturbance (Gonzalez et al. 2016). They do not have special federal or state status in the region, and are considered to have a large population size collectively throughout their range and thus unlikely to be declining significantly (Cryan 2011).

US Fish and Wildlife Service Endangered Species Act: Status undefined
US Bureau of Land Management (Nevada): Sensitive
US Forest Service (Region 4): No status
State of Nevada (NAC 503): No status
NV Natural Heritage Program: Global Rank G5, State Rank S3N
NV Wildlife Action Plan: Species of Conservation Priority
IUCN Red List (v 3.1): Least Concern
CITES: No Status

Range

The Hoary Bat is a large, migratory, tree-roosting bat found from northern Canada to Argentina and Chile in South America making them the most widespread of all American bats (Shump and Shump 1982). They are also found on several islands, including Hawaii, Iceland, and Bermuda, among others. In the US, they are most common in parts of the Midwest and Pacific Northwest, and they are known to winter in California and Mexico, but are also found in more northern locations in winter (Shump and Shump 1982, Cryan 2003). Males and females are geographically separated during the warm season with males found typically in the western US, and females in the east, and there is also evidence of separation in some regions during winter where more males are found in Mexico, with relatively even distributions of sexes wintering in California (Cryan 2003). It is thought that females exhibit more movement than males as they search for adequate conditions to give birth (Cryan 2003).

Population Trends

A review was conducted to determine the status of several species of solitary foliage-roosting bats in the US (Carter et al. 2003). That study concluded that: "No quantitative information concerning long-term population trends of solitary foliage-roosting bats can be drawn from existing data. Lack of standardized reporting and the inability to determine the proportion of total populations sampled (detection probabilities) for each of the observation and capture methods employed renders all capture data incomparable."

Habitat Model

Model Results

The GAM and RF models for Hoary Bats generally predicted suitable habitat more broadly than the MaxEnt models. "Core" predicted habitat was similar among all three algorithms, centering on the Spring and Sheep Ranges, and the Virgin and Muddy River corridors (Figure 172). Standard error maps tended to differ among algorithms, with GAM models highlighting areas largely along the River corridors and mountain bases, MaxEnt predominantly highlighting areas north and west of the Las Vegas Valley, with lower standard error values for the RF model altogether, but in similar areas as highlighted in the MaxEnt model (Figure 173). Boyce indices indicated generally good model performance for the RF and MaxEnt models, as well as the Ensemble model (Table 114, Hirzel et al. 2006). The GAM model tended to peak at model values of ~ 0.8 and fell off thereafter. Bins for the ensemble model based on the CBI were 0-0.5 unsuitable, 0.5-0.6 marginal, 0.6-0.8 suitable, and 0.8 -1 optimal habitat; with a suggested cutoff threshold of 0.55 – 0.06 (Figure 174) which corresponded closely with Precision Recall Break Even Point (Cut-off, Table 115). RF had the highest performance scores across four of the performance metrics (Table 115), and the second best performing model was the Ensemble model of the three algorithms. The top two influential environmental variables were consistently Annual Temperature Range and NDVI Greenness Timing, while the others varied in importance from the third element down (Table 116).

Table 114. Model performance values for *Lasiurus cinereus* models

Performance	GAM	RF	MaxEnt	Ensemble
AUC	0.907	0.977	0.932	0.958
BI	0.535	0.649	0.334	0.635
TSS	0.8	0.919	0.83	0.883
Correlation	0.726	0.861	0.769	0.823
Cut-off*	0.501	0.644	0.35	0.592

*threshold at which sum of sensitivity (true positive rate) and specificity (true negative rate) is highest

Table 115. Percent contributions for input variables for *Lasiurus cinereus* for ensemble models using GAM, MaxEnt and RF algorithms

Term	GAM	RF	Max	Avg
Annual Temp. Range	24.084	17.866	26.128	22.693
NDVI Greenness Timing	27.227	16.188	16.295	19.903
Diurnal Temp. Range	17.417	7.223	11.296	11.979
Surface Texture (ATI)	11.771	12.488	4.866	9.708
NDVI Maximum	5.962	9.788	12.426	9.392
Winter Precipitation	4.803	13.951	9.197	9.317
Soil Water Stress	1.481	13.313	9.104	7.966
Roughness (TRI)	5.774	5.344	9.393	6.837
Winter Min Temp.	1.481	5.538	1.292	2.77
Annual Temp. Range	24.084	17.866	26.128	22.693

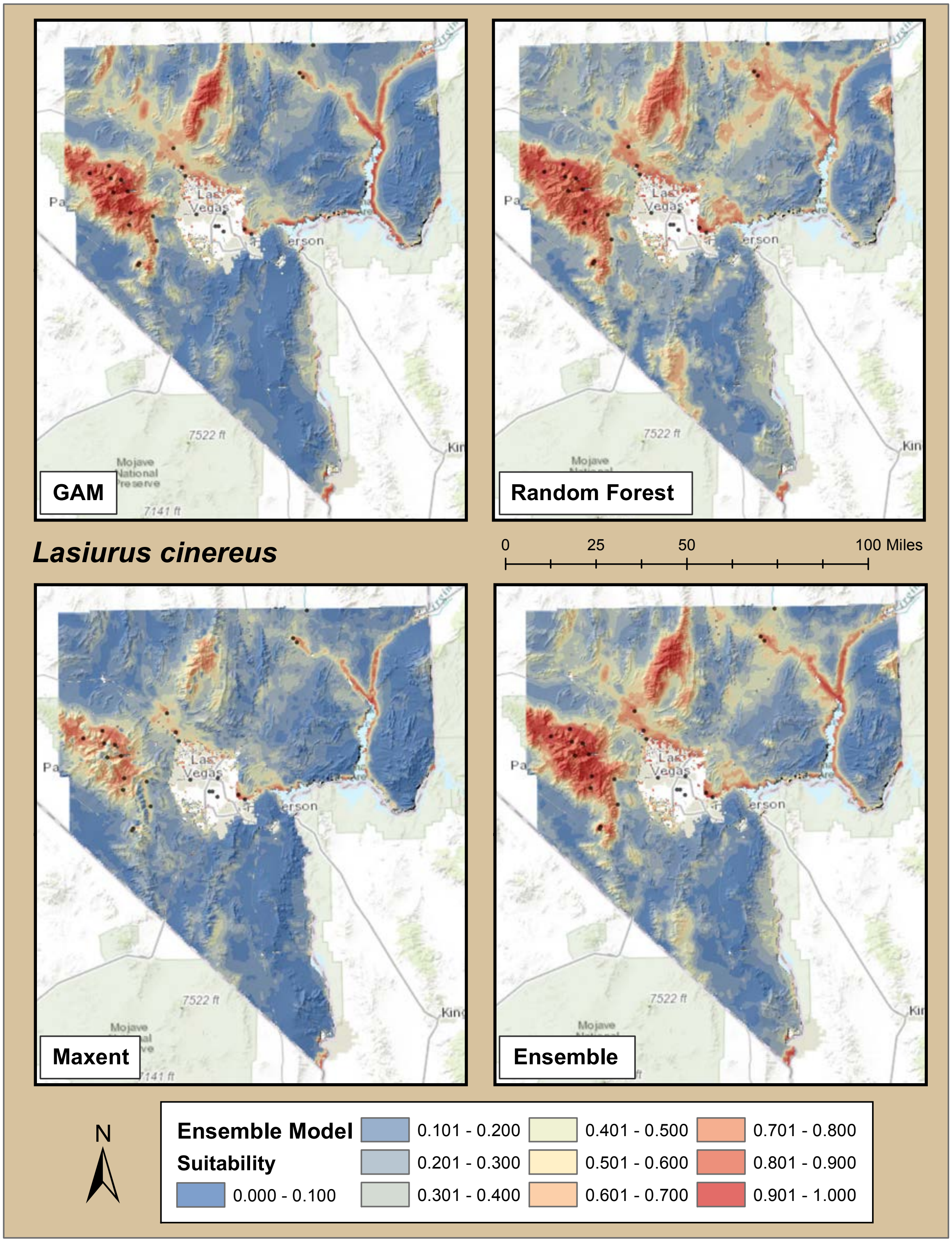


Figure 172. SDM maps for *Lasiurus cinereus* model ensembles for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an Ensemble model averaging the three (Lower Right).

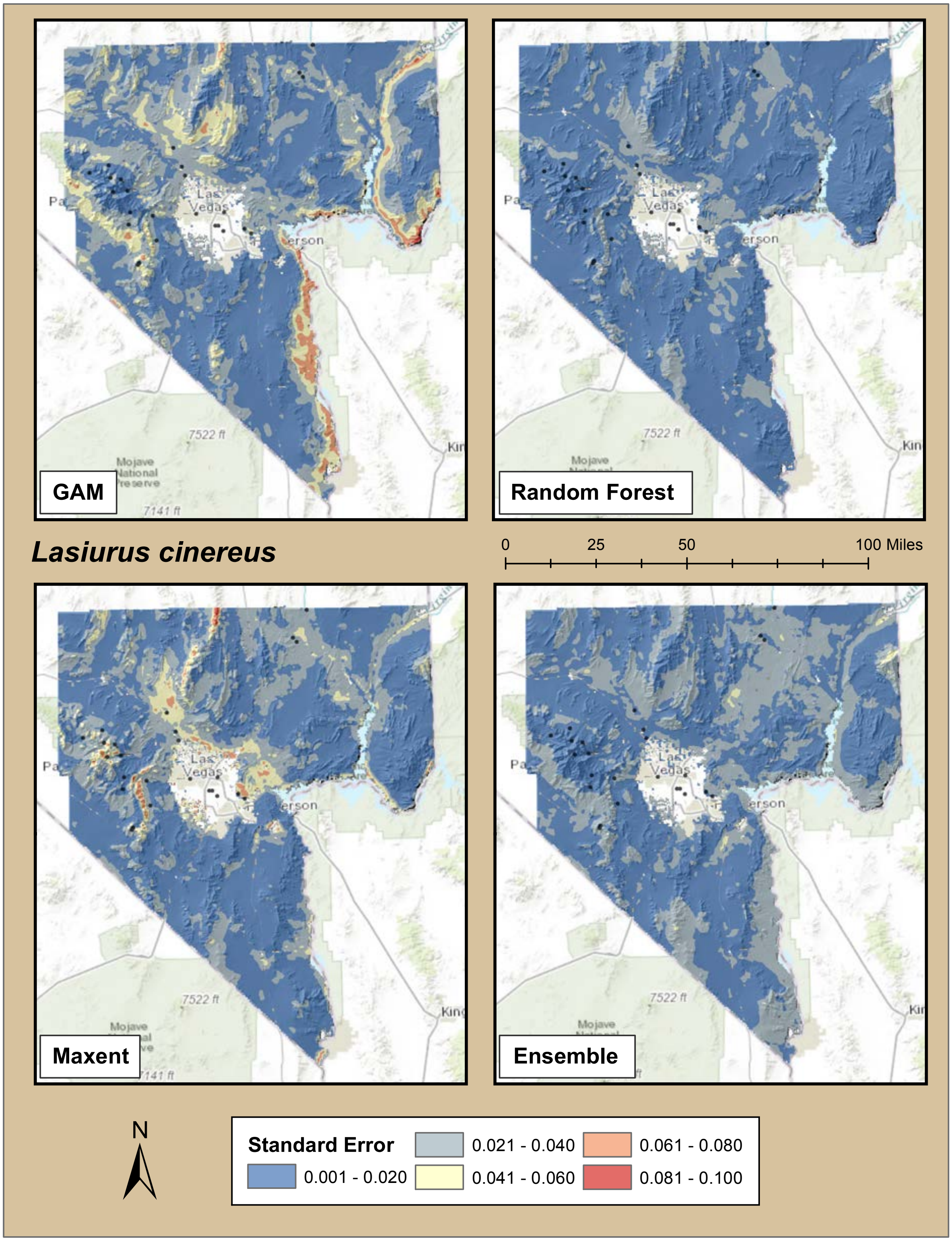


Figure 173. Standard error maps for *Lasiurus cinereus* models for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an Ensemble model averaging the three (Lower Right).

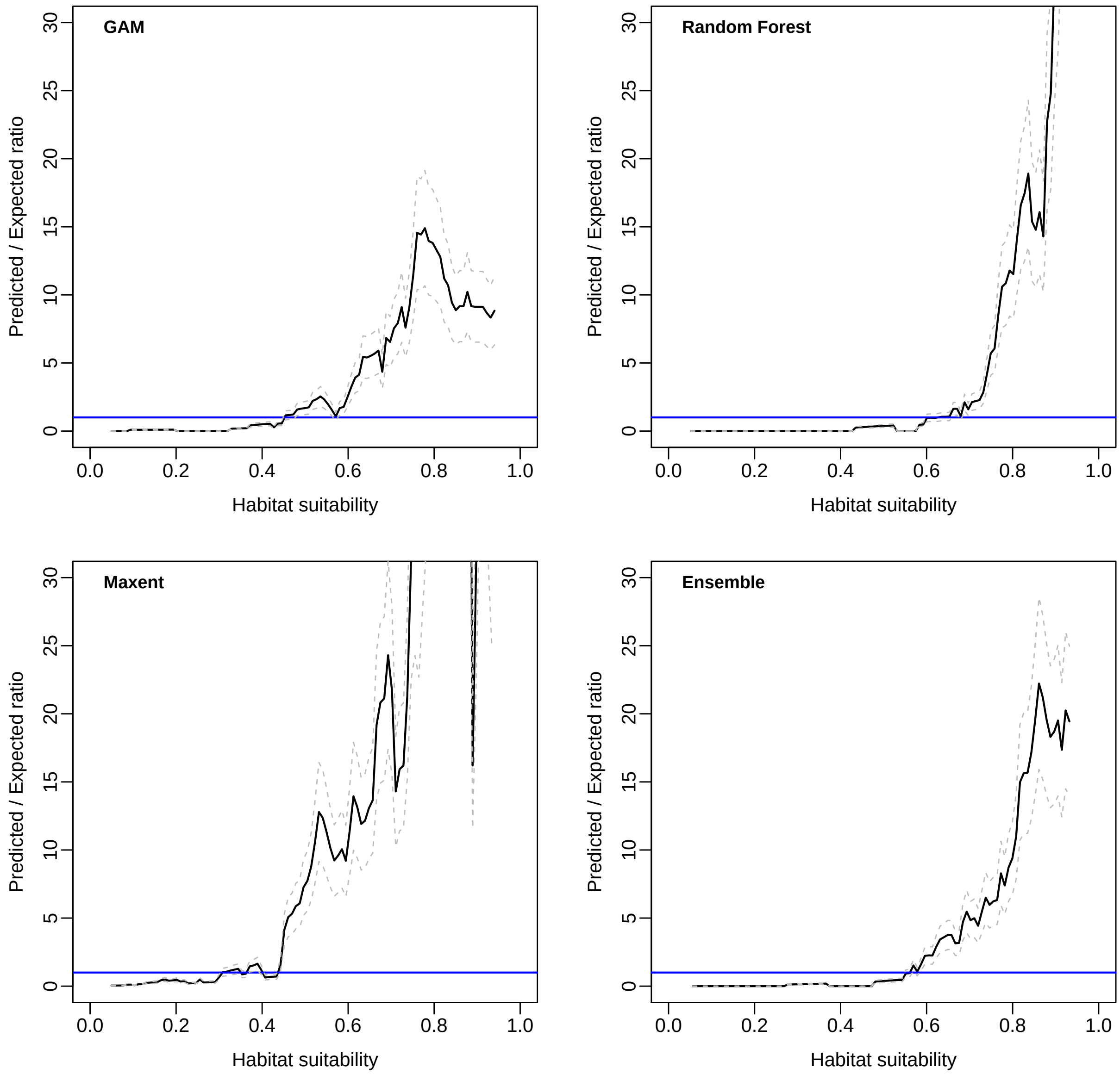


Figure 174. Continuous Boyce Indices for Lasiurus cinereus models for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

General Additive Model

NDVI Greenness Timing, Annual Temperature Range, Diurnal Temperature Range, and Surface Texture (ATI) at the top 4 contributing environmental variables, contributing 80% of the overall model influence (Table 116). GAM models predicted generally linear relationships with Surface Texture, Annual Temperature Range, and Diurnal Temperature Range, with higher habitat suitability predicted for rockier areas, with lower annual temperature ranges, but with higher diurnal temperature ranges (Figure 175). NDVI Greenness Timing had a threshold type response, where higher habitat suitability was predicted at moderate levels of NDVI timing, likely reflecting higher elevation areas where spring green up occurs later in the season (Figure 175).

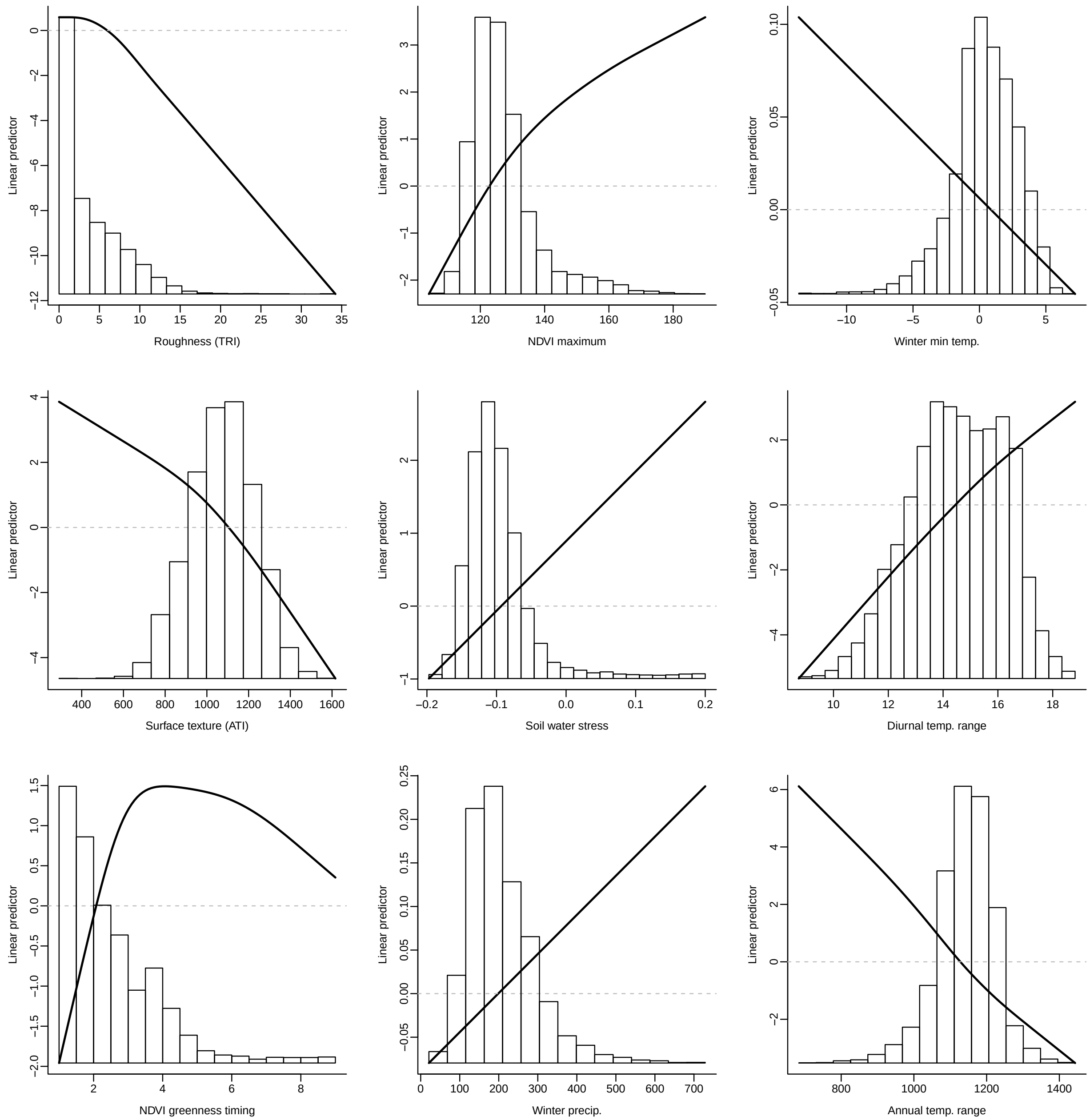


Figure 175. GAM partial response curves for the Lasiurus cinereus model - overlaid over distribution of environmental variable inputs in the study area.

MaxEnt Model

The top four contributing environmental variables for the MaxEnt model ensemble contained three of the top variables among all other models. Contributions of Annual

Temperature Range, NDVI Greenness Timing, and NDVI Maximum ranked highest, contributing to 66% of combined model contributions. Following the top four environmental variables, Roughness (TRI), Winter Precipitation, and Soil Water Stress each contributed ~ 10% (Table 116). The MaxEnt model ensemble predicted higher suitability of habitat in areas with Lower annual temperature ranges, moderate levels of NDVI Maximum values, and higher diurnal temperature ranges. Lower habitat was predicted in areas with earlier NVDI timing (e.g. non-riparian valley bottoms)(Figure 176). The lower contributing variables indicated slightly higher habitat suitability in areas of lower roughness, and increased rockiness with lower levels of winter precipitation. The continuous Boyce index indicated that while higher there were irregular patterns at higher habitat values (Figure 174), and the fixed BI placed this among the poorer performing models (Table 115).

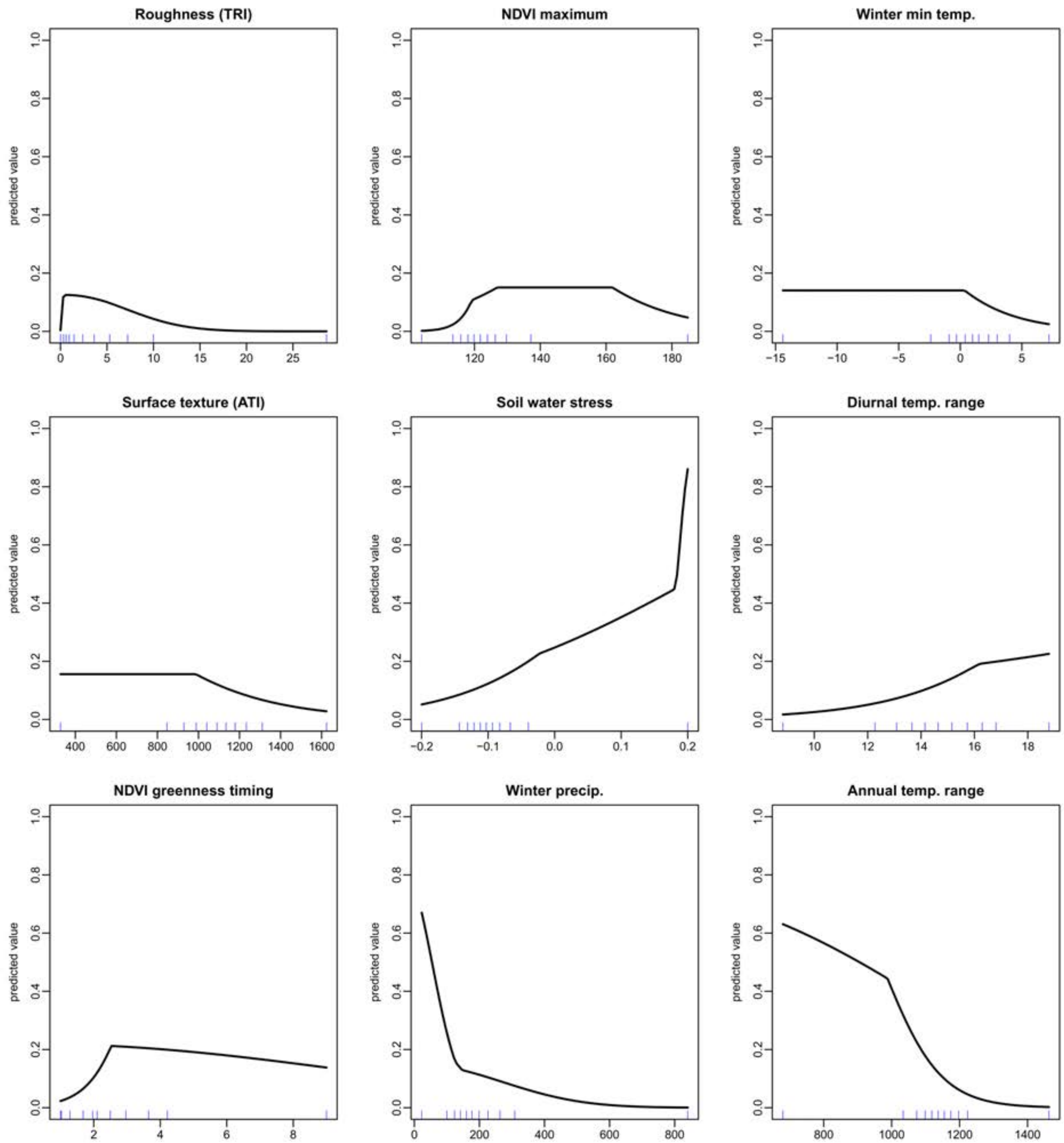


Figure 176. Response surfaces for the top 9 environmental variables included in the MaxEnt ensemble model for Lasiurus cinereus.

Random Forest Model

RF models showed highest contributions from Annual Temperature Range, NDVI Greenness Timing, Winter Precipitation, and Soil Water Stress, collectively comprising 73% of model influence (Table 116). Higher suitability predicted habitat coincided with lower annual temperature ranges, areas with later greenup, higher winter precipitation and higher Soil Water Stress (Figure 177). Annual Temperature

Range, and Winter Precipitation also had lesser peaks of elevated habitat prediction near the opposite extremes where Annual temperature is higher, and winter precipitation lower, which likely reflects the dichotomy of high suitability habitat being predicted both in the upper elevations of the mountainous areas as well as the lower elevation areas near the Muddy and Virgin river confluence at the northern tip of Lake Mead and the Moapa Valley (Figure 172).

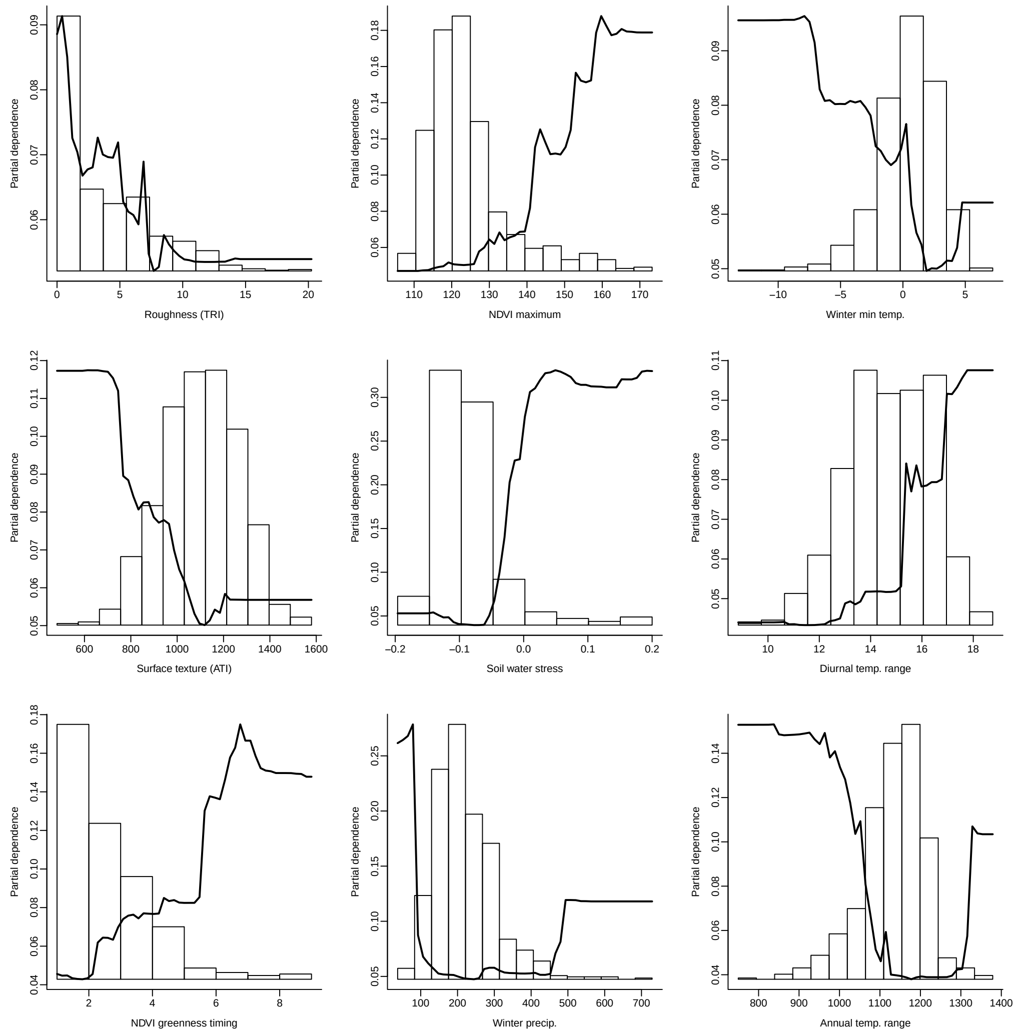


Figure 177. Response surfaces for the environmental variables included in the RF ensemble model for *Lasiurus cinereus*. Histograms represent the range of each environmental variable across the x-axis, and predicted dependence relative to habitat suitability values are on the y-axis.

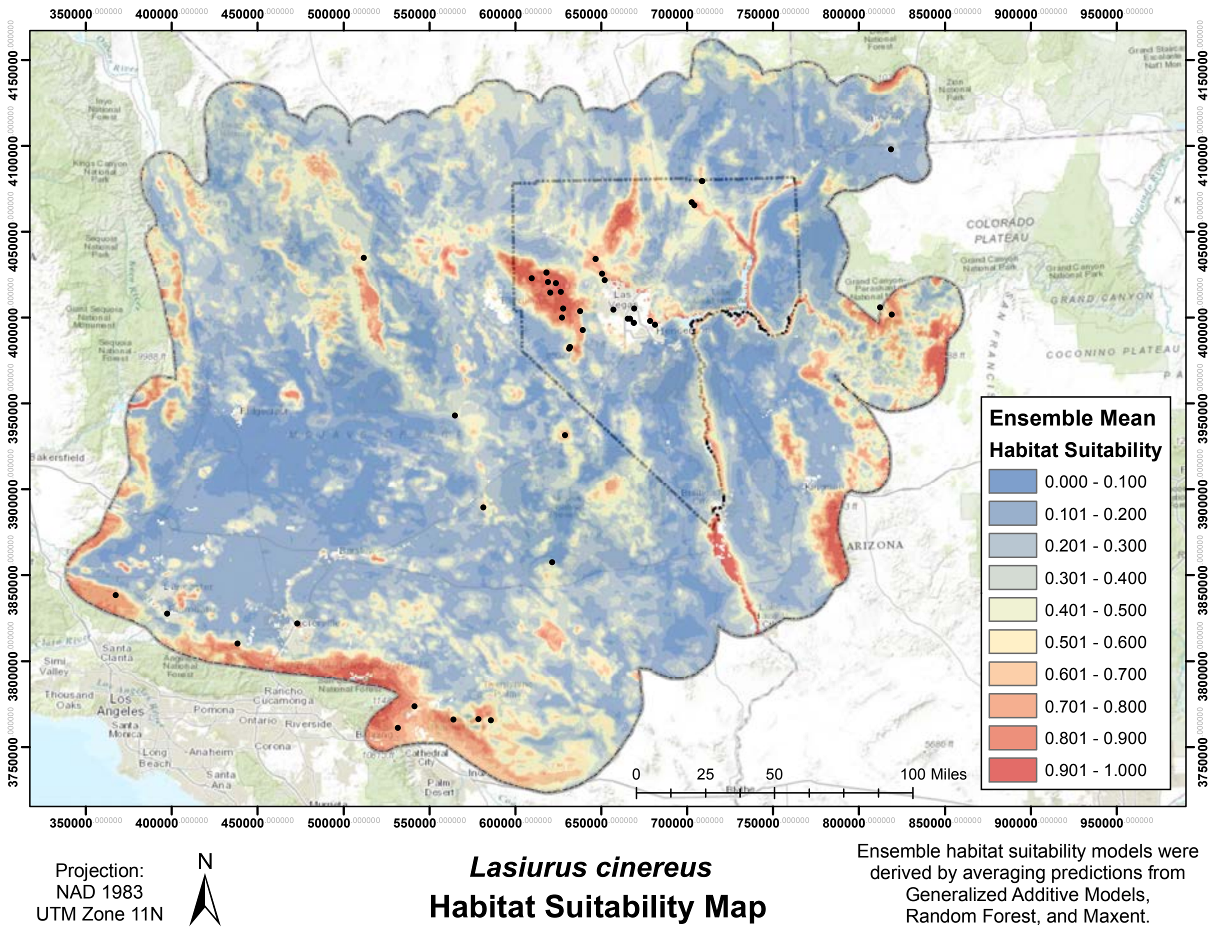


Figure 178. Mojave wide SDM map for the *Lasiurus cinereus* ensemble model

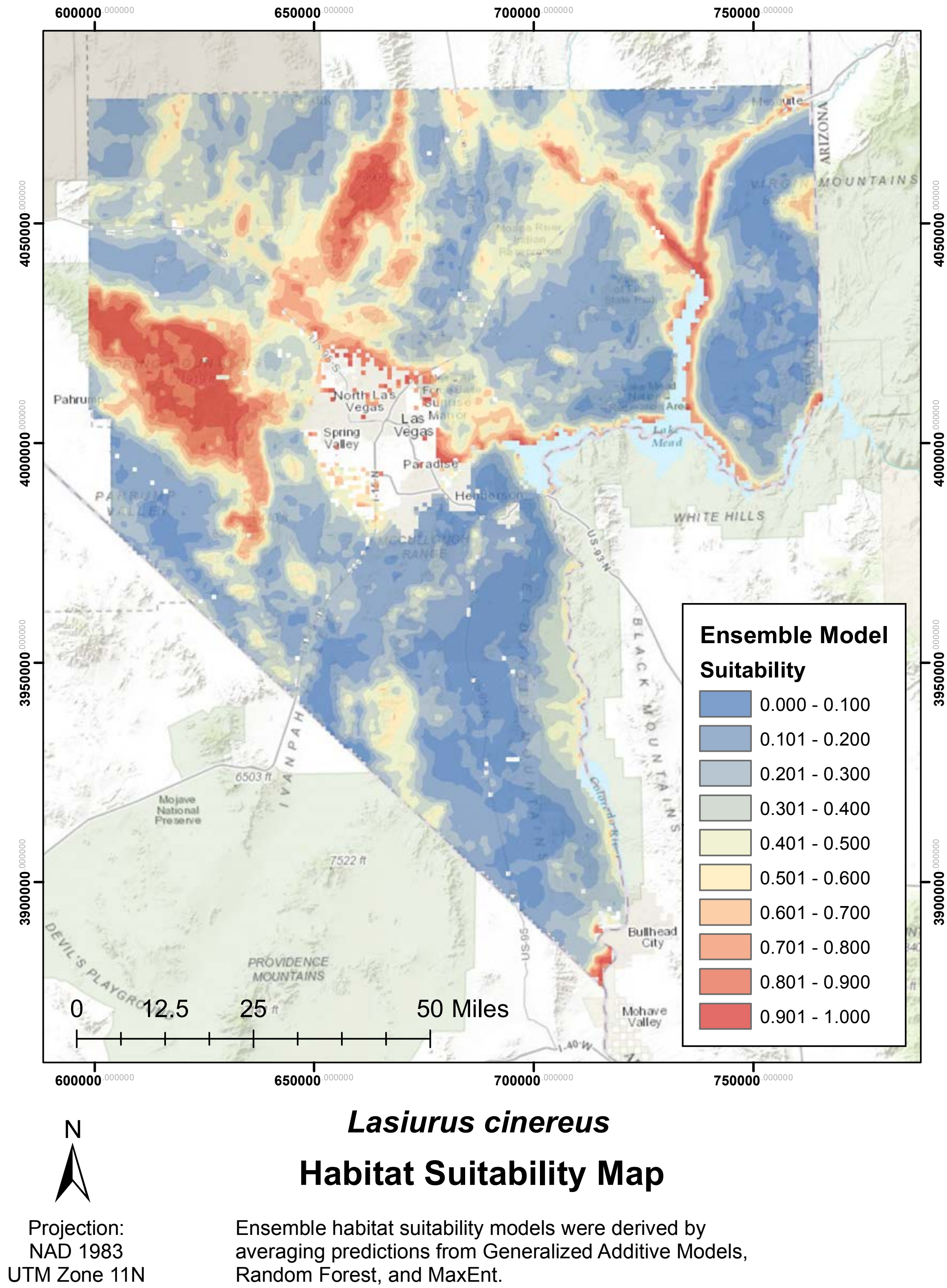


Figure 179. SDM map for the *Lasiurus cinereus* Ensemble model

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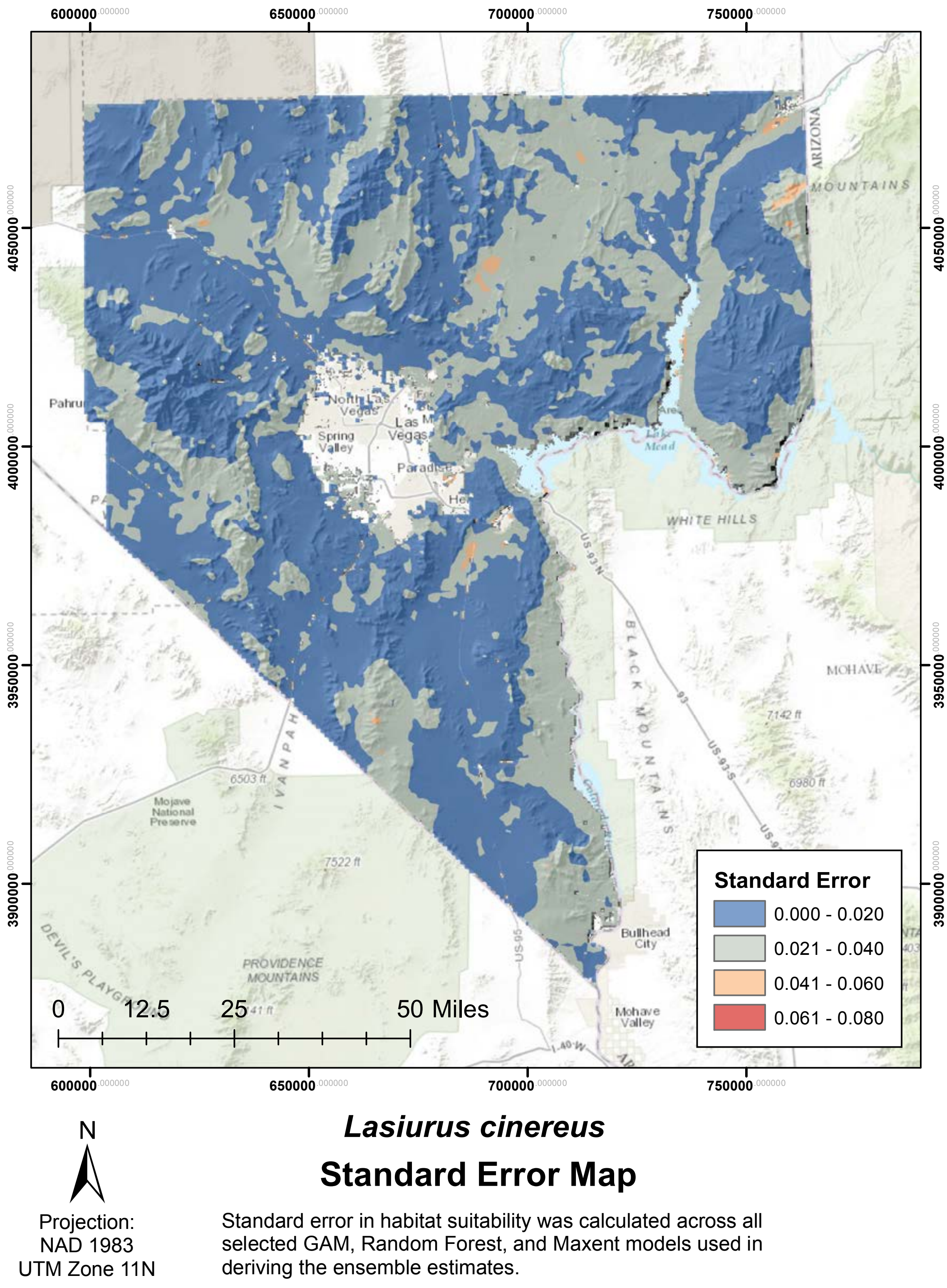

Figure 180. Standard Error map for the *Lasiurus cinereus* Ensemble model

Data Distribution

Hoary Bats had only 17 data points for Clark County, so the model was run including points within the Mojave Desert upping the number of localities to 42 after spatial thinning (Figure 178). Unlike many of the other bat species discussed here, these bats tend toward wooded areas and possibly only spend summers in the Mojave Desert, because in Arizona they are known to be migratory and fly to southern Arizona - where they may be found year round (Hoffmeister 1986). Their migratory patterns are not known for Nevada, but they are speculated to hibernate in some of their range here (Bradley et al. 2006). They are strong fliers that forage at higher altitudes than other bats, and this too may account for the low numbers of captures. The individual captures known for the state of Nevada include captures of single animals while foraging or during acoustic monitoring (Bradley et al. 2006).

Habitat Suitability in the Mojave Desert

This relatively large bat species is noted to occur broadly throughout the Mojave Desert in general field guides (Burt and Grossenheider 1976), but our Mojave Desert-wide habitat suitability model would suggest that their distribution may be much spottier than that (Figure 178). This likely reflects their primary habitat preference for wooded areas, which are somewhat rare in the Mojave Desert Ecoregion, but the bats occur in montane forests, woodlands, riparian areas, agricultural areas, and urban areas with trees (Bradley et al. 2006). Outside of Clark County, there are four primary areas of highly suitable habitat. First, occurs along the southwest boundary of the Mojave Desert in the San Bernardino and San Gabriel mountains. There are also large patches of highly suitable habitat in the Hualapai and Cerbat mountains of Mohave County, Arizona. The high elevation wooded plateaus north and south of the Grand Canyon are predicted to be highly suitable habitat, as well. These three previous locations all occur near the margins of the habitat model and should be considered carefully based on model behavior near the edges – however these habitats are all consistent with *Lasiurus* habitats, and the only layer likely to create edge effects (distance to Cliffs) was not selected for inclusion in any of the models. The fourth major area of high habitat suitability for *Lasiurus* outside Clark County is along the main stem of the Colorado River, below Needles, California. Isolated patches of moderately high habitat suitability extend along the western boundary of the Mojave Desert and are subject to the same cautions as previously mentioned. Elsewhere, isolated patches of moderate to high suitability are estimated to occur east of Ridgecrest, just east of Barstow, the Panamint Range in California. There is also a patch of highly suitable habitat at southern base of Pine Valley Mountain in Washington, County, Utah.

Standard Error for Habitat Suitability Modeling

Generally the habitat suitability model for Hoary Bats has greater error associated with it than other bat species modeled, with each algorithm producing higher error rates in different areas (Figure 173). Those patches of moderately high error in the model occur along the Virgin River, near Mesquite, Nevada, near the top of the Virgin Mountains, near Apex at Dry Lake, in Eldorado Valley southwest of Boulder City, and on top of the McCullough Mountains near Wee Thump (Figure 180). All of those patches are relatively small and are not associated with the major high-quality habitat patches.

Distribution and Habitat Use within Clark County

Hoary Bats are rare in southern Nevada, but have been observed migrating through lowland riparian woodlands frequented by other species when foraging (Williams et al. 2006). They also occur in southwestern Utah near desert areas around St. George (Hardy 1941). They roost in trees and can be found foraging over upland forested areas and riparian areas with nearby trees to provide roosts (Szewczak et al. 1998, Hagen and Sabo 2014, Bradley et al. 2006). Hoary Bats have been observed foraging in desert riparian, juniper woodlands, and Mojave Desert scrub habitats (Bradley et al. 2006). Habitat modeling for Clark County predicts the areas of highest habitat suitability to be in Mixed Conifer, Pinyon Juniper, Black Brush Mojave Desert Scrub habitats, although the species has high habitat predicted throughout the ecosystems within the county (Table 116).

While the modeled habitat suitability for Hoary Bats in Clark County, is qualitatively similar to most of the other bats discussed in this report (Figure 172). This species may be more tightly tied to their arboreal habitats because, at least during summer, they roost individually among trees where they use deep cover. The primary habitat patches are on the Spring Mountains, Sheep Range, confluence of the Muddy and Virgin rivers, and Las Vegas Wash (Figure 179). There is predicted habitat of moderate suitability interspersed throughout Clark County, and apparently only areas dominated by large expanses of creosotebush/burrobush (*Larrea tridentata*/*Ambrosia dumosa*) stands.

Table 116. Ecosystems within Clark County, and the area (Ha) of Low Medium and High predicted suitability within each ecosystem.

Ecosystem	Low	Medium	High
Alpine	0	0	124
Blackbrush	200469	170583	43318
Bristlecone Pine	0	0	7565
Desert Riparian	44	2191	8518
Mesquite Acacia	12307	3307	4225
Mixed Conifer	0	124	27213
Mojave Desert Scrub	831055	373488	82065
Pinyon Juniper	5621	18744	91404
Sagebrush	302	1709	2690
Salt Desert Scrub	23074	46350	10139

Ecosystem Level Threats

This species is apparently most likely to inhabit Desert Riparian Ecosystems and juniper woodlands when they are found (Hardy 1941, Szewczak et al. 1998, Williams et al. 2006, Hagen and Sabo 2014). Due to their habitat preferences, these bats are particularly susceptible to losses of roosting trees. Therefore, forest fires can reduce habitat availability. During migration, wind farms could be detrimental to Hoary Bats because of propeller strikes, and trauma from flying too close to the rapidly moving props that create an extreme low pressure zone around them as they move that is capable of killing bats (Cryan 2011).

Threats to Species

There are no known predators of importance to this species (Shump and Shump 1982). A high proportion of Hoary Bats are found to be rabid (Shump and Shump 1982). As tree roosters, loss of upland forests and riparian trees is detrimental to these bats. As relatively solitary bats, this species may be less susceptible to white-nose fungus (*Pseudogymnoascus destructans*). This species is not known to be infected by the fungus, or to carry it (whitenosesyndrome.org 2017).

Existing Conservation Areas/Management Actions

This species may use a variety of habitat types and therefore, potential conservation areas include: Lake Mead National Recreation Area; Desert National Wildlife Refuge, Key Pittman Wildlife Area, Overton National Wildlife Area, Valley of Fire State Park, Toiyabe National Forest, and Red Rocks National Conservation Area. In 2006, the Nevada Bat Working group published the Nevada Bat Conservation Plan (Plan). This plan is a revision and update of the original Plan that was published in 2002. The goal of the plan is to reduce the threats to the bat species that occur within Nevada and within the habitats where they occur. This species occurs infrequently in this area and appears to pass through during its annual migration.

Summary of Direct Impacts

Direct impacts are not known, but like other bats, this species may be impacted by energy development by collision with energy associated structures or by barotrauma resulting from exposure to extremely low pressure around propellers on turbines (Arnett et al. 2008, Baerwald et al. 2008). Within the county predicted habitat for this species of High and Moderate suitability combined is approximately 9166 km^2. Conserved areas contain 9% of total habitat, and it is estimated that a total of 7% is likely to be impacted, and only 4% is potentially already disturbed (Table 117).

Table 117. Categorized modeled habitat values (High, Medium, and Low) and the average area (Hectares) predicted in the potential impact areas, conservation areas, already disturbed areas, and overall area

Habitat Level	Impact	Conserved	Disturbed	Area (Hectares)
High	19355	7675	19970	284922
Med	47417	77606	19583	631657
Low	55759	428290	11839	1097765

LALU - Loggerhead Shrike (Lanius ludovicianus)

The Loggerhead Shrike (*Lanius ludovicianus*) is a medium-sized bird with a striking black mask across the eyes, on its wings, and tail, contrasting with the white breast and other highlights on the wings and tail, against a grey base color. This small hunter is the only raptorial songbird with a notch in its beak for trimming prey. Its beak is shaped similarly to that of the American kestrel (*Falco sparverius*). Also known as the butcherbird, Loggerhead Shrikes have a habit of impaling their small prey on sharp features such as yucca leaves, mesquite spines, creosotebush twigs, and barbed wire across the American southwest. The prey: scorpions, beetles, centipedes, Jerusalem crickets, house finches, adult and young horned larks, meadow mice and kangaroo rats, side-blotched lizards, horned lizards, coachwhip snakes, carrion, and others (Dawson 1923, Bent 1965, Kridelbaugh 1983, Yosef 1996, T. Esque – pers. Observation). Once impaled and stabilized, prey are stripped of flesh to feed their young. Vertebrate prey are killed by biting the neck and disarticulating cervical vertebrae (Pruitt 2000). The shrike must use these tools to assist in handling prey because they do not grasp the prey in their feet as do other raptorial birds (Dawson 1923). Like other raptorial birds and some Corvidae, the shrike regurgitates indigestible portions of their prey including exoskeletons and bones (Dawson 1923). Loggerhead Shrikes inhabit open to semi-open habitats where they perch on prominent plants, power wires and poles, and fence posts to watch for prey (Dawson 1923, Rotenberry and Wiens 1980, Dechant et al. 2002). Their nests are found at medium heights, often in thorny plants such as Joshua tree (*Yucca brevifolia*), mesquite (*Prosopis* spp.), or catclaw (*Acacia* spp.), but also in sagebrush (*Artemisia* spp.) or greasewood (*Sarcobatus* sp.) in some locations across the west (Dawson 1923, T. Esque – pers. Obs.). Eggs number from 5 to 7 and are pale bluish gray, or dull grayish-white for ground colors with nearly uniform yellow-brown to gray brown blotches (Dawson 1923). Loggerhead Shrikes may have two clutches in a season.

Species Status

Loggerhead Shrikes are the only member of the shrike family that occurs in North America. The Loggerhead Shrike is not protected by the Endangered Species Act of 1973, and no petitions have been filed for its listing. The USFWS designated the Loggerhead Shrike as a Migratory Nongame Bird of Management Concern in the United States in 1987 due to range-wide declines in populations, and the species is listed as sensitive or threatened at the state level in 14 states. In Canada, the eastern population of the Loggerhead Shrike is listed as endangered and the western population is listed as threatened (Pruitt 2000). While populations are declining, they are not at a sufficient rate to warrant concern (BirdLife International 2016).

US Fish and Wildlife Service Endangered Species Act: Not listed
US Bureau of Land Management (Nevada): No status
US Forest Service (Region 4): No status
State of Nevada (NAC 503): Sensitive
NV Natural Heritage Program: Global Rank G4 State Rank S4
NV Wildlife Action Plan: SOCP

IUCN Red List (v 3.1): Least Concern
CITES: No status

Range

Loggerhead Shrikes have a broad distribution across central and southern Canada, most of the United States and Mexico (Dawson 1923, Pruitt 2000, Dechant et al. 2002, Sibley 2003). They prefer open habitat with sufficient perching/prey handling resources for hunting (Brooks and Temple 1990). In the desert southwest they are known to in-habitat a variety of habitat types, including shadscale in east and central Nevada (Medin 1990), Sagebrush habitats in the Great Basin (McAdoo et al. 2004), Mojave Desert Creosote/Bursage in the West Mojave (Brooks 1999) and southwestern Clark County (Ironwood 2012), and Mixed Mojave Desert Scrub in Southern Nevada (Blake 1984).

Population Trends

Population declines for this species have been reported throughout the eastern US (Brooks and Temple 1990, Pruitt 2000). For example, the Breeding Bird Surveys have documented widespread declines of 3.7% per year from 1966-1998 (Pruitt 2000, Sauer et al. 2013). While exact causes of decline are unknown, habitat loss and degradation are suspected to be major contributing factors, but are not sufficient to explain the levels of documented decline (Pruitt 2000). Although some western populations have been reported as stable during the same time period (Peterjohn and Sauer 1995) there is still concern that the sources of declines are unknown, and a series of measures have been proposed to improve habitat conditions (Cade and Woods 1997) including restoring nesting habitat, habit diversity, and hunting perches in habitat (Yosef 1994, 1996).

Habitat Model Review

A habitat model for this species was produced by GBBO (Ammon 2015). The habitat suitability model for Loggerhead Shrikes used locality data generated from point-count transects (3 km in length) conducted over a six-year period using a combination or random and targeted survey locations (Ammon 2015). Bird detections on transects were used to create density estimates for each dominant vegetation type in the Landfire Database (Provencher and Anderson 2011). Habitat models were produced by mapping density estimates for each of the vegetation associations throughout the county (Ammon 2013). Conceptual models were created but not used for environmental layer selection, but rather for conservation planning efforts. Highest densities were found in desert riparian habitat, with disturbed areas, and Mesquite/Acacia habitat. Logistical ANOVA models were used to model shrike presence relative to habitat types. These statistical analyses indicated that shrikes select habitats that include cheesebush, cliffrose, and dry washes, with trees nearby (Ammon 2015). These models provide indications of site selection within habitat associations, but were not used to create county-wide suitability estimates as layers for the analyzed associations do not exist in a GIS at the scale of the county. Thus the statistical model is a good description of the local attributes of habitat preference by the species, but cannot in its current form be used for spatial mapping or modeling. The spatial model/map produced by this effort is an extrapolation of the densities per given habitat/vegetation types (Landfire) mapped across these attributes in the county (Figure 181)(Ammon 2015).

Technical Considerations – given that the map is created by extrapolation of density estimates to county- wide vegetation a few considerations are in order. First it cannot be determined if the error rates for the density estimates per habitat type were considered, there were not maps provided to show error estimates for these associations. Density estimates per habitat type were not provided in this report and we have no sense of the potential error rates that could be compounded by extrapolation. The extrapolation beyond sampled areas makes the assumption that density associations for habitat types are the same for each of the areas for which extrapolation occurred. Furthermore, because shrikes prefer the largest shrubs, or tree-like vegetation to nest, and the abundance of that resource is highly patchy and variable among habitat types, it introduces further error into the models. For example, Joshua trees are used commonly for nesting by Loggerhead Shrikes in the Mojave Desert. However, Joshua tree densities vary considerably across habitats that the tree-yucca occupies. Thus, the availability of quality nesting substrate varies substantially and might affect presence/absence of the birds.

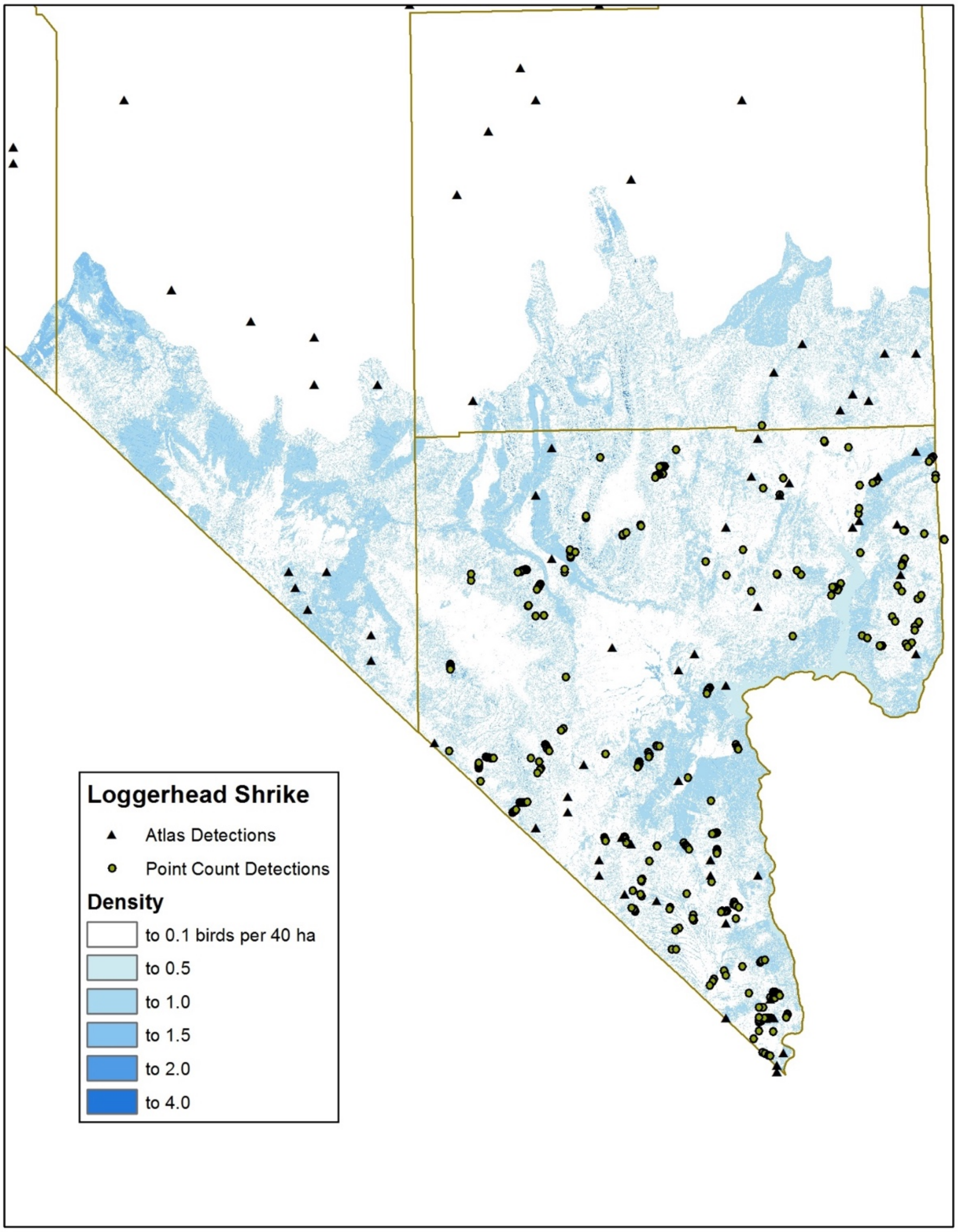

Figure 181. Loggerhead Shrike habitat suitability model from Ammon (2015).

Distribution and Habitat Use within Clark County

In Clark County, Nevada the Loggerhead Shrike is very widespread and fairly common. Loggerhead Shrikes are seasonal visitors to lower mountain slopes of semi-open woodlands, and year-round residents of desert shrub communities on lower bajadas and valley bottoms (Blake 1984). Suitable environments to support shrikes include open desert to woodlands, pastures, fencerows or shelterbelts of agricultural fields, orchards, riparian areas, ranches, suburban areas, roadsides, cemeteries, and golf courses (Prescott and Collister 1993, Dechant et al. 2002). Loggerhead Shrikes are found throughout desert shrub communities dominated by creosotebush (*Larrea tridentata*), burro brush (*Ambrosia dumosa*), sagebrush (*Artemisia* spp.) or saltbush (*Atriplex* spp.) interspersed by Joshua trees, catclaw, or mesquite. Shrikes inhabit areas of low slope and high horizontal and vertical structural diversity (Poole 1992 *in* Dechant et al. 2002). Ecosystems in Clark County that contain high densities of these birds (GBBO 2011) include all ecosystems except Alpine, Bristlecone Pine, and Mixed Conifer. Moderate densities are projected to be found in at least some areas of all ecosystems within the County (Table 118). In Idaho, impaling stations, where they cache food items on sharp objects, were 7 to 65 m from nests and were protected within shrubs (Woods 1995). Impaling stations in southern Nevada are frequently on exposed yucca leaves. Territory sizes of Loggerhead Shrikes throughout North America range from 2.7 to 25 ha (Dechant et al. 2002).

Table 118. Ecosystems within Clark County, and the area (Ha) of Low Medium and High predicted suitability within each ecosystem.

Ecosystem	Low	Medium	High
Alpine	61	63	0
Blackbrush	266886	125189	17517
Bristlecone Pine	7240	325	0
Desert Riparian	4963	5298	596
Mesquite Acacia	11516	6768	1899
Mixed Conifer	17687	9651	1
Mojave Desert Scrub	830235	501353	32336
Pinyon Juniper	44052	69884	1807
Sagebrush	2673	1665	150
Salt Desert Scrub	49812	29805	2697

Ecosystem Level Threats

Loggerhead Shrikes occupy, blackbrush, Desert Riparian, Mesquite/Acacia, Mojave Desert Scrub, Pinyon-Juniper, Sagebrush, Dry Lake, and Playa ecosystems, as well as rural and suburban parkland areas and near human habitations. Losses of open habitat and importantly perching and nesting sites may be a threat to Shrike populations (Yosef 1994).

Threats to Species

The most important manageable threats to Loggerhead Shrikes are activities or processes that reduce nesting and perching substrates or reduce primary production on which most prey species depend (GBBO 2015). Activities in this category are Off-Highway Vehicle use – especially when it occurs on closed roads and trails. Urbanization or development of energy development and supporting infrastructure also can reduce available habitat. Wildfire has negative impacts to Loggerhead Shrikes. In sagebrush steppe, wildfire reduced shrike densities and nest survivorship by 50%, and resulted in a switch in the tree species where nests occurred (Himple and Holmes 2006). However, in that study, shrikes persistently re-nested and fledged similar numbers of young before and after the fires (Himple and Holmes 2006). Urbanization has also been associated with reduction or loss of shrike population at some locations (Jones and Bock 2002), while in the east Mojave Desert of southern California Loggerhead Shrikes were most abundant in urban areas (Knight et al. 1999). However, qualitative comparisons cannot be made between the studies. Habitat conversions from unimproved pasture to croplands have been correlated with Loggerhead Shrike declines greater than 50% (Dechant et al. 2002), in comparison with more moderate habitat declines that had less dramatic losses of shrike populations. Grazing by livestock and feral horses in sagebrush areas is considered to be negative to shrike populations as well Wood 1995a). Some populations of shrikes have shown decreased reproductive success near roads (Yosef 1995). While brown-headed cowbird (*Molothrus ater*) nest parasitism has been recorded, it is relatively rare among Loggerhead Shrike nests (Dechant et al. 2002). Furthermore, shrikes may be able to discern parasitic eggs, and remove them from their nests (Rothstein 1982). Organochlorides have been associated with egg shell thinning in Loggerhead Shrikes in some areas (Pruitt 2000). These chemicals have been banned for use in the United States, however, wintering shrikes may bio-accumulate some organochlorides in Mexico.

Existing Conservation Areas/Management Actions

Protection of desert shrub communities may be increased by land management actions that reduce surface disturbances and increase vegetation cover. Fencing protected areas to reduce livestock grazing and OHV activities can result in greater cover of perennial plant species thus increasing food and cover for many species (Brooks 1999). Fewer disturbances and increases in food availability can increase densities and nesting in many species including the Loggerhead Shrike (Brooks 1999). Loggerhead Shrike habitat may be protected through incentive programs such as county reserves, easements, land trusts, leases, purchases or through the protection of natural areas that are set aside for other species such as the Mojave Desert Tortoise (Hands et al. 1989, Dechant et al. 2002).

The Nevada Wildlife Action Plan considers the Loggerhead Shrike a Species of Conservation Priority, and recommends the following: maintain suitable nesting and wintering habitat in areas of regular shrike activity; maintain thorny shrubs, barbed-wire fences, and other objects suitable for impaling prey; and restrict pesticide use to avoid decreasing the prey base (Wildlife Action Plan Team 2012).

Partners in Flight Landbird Conservation Plan's 2016 Revision for Canada and Continental United States considers the Loggerhead Shrike to be a "common bird in steep decline", with the population in the intermountain west region – which includes all of Nevada – declining by 48% over the long-term (1970-2014), and by 1.3% in the short-term (2004-2014). The plan recommends generic actions for conserving bird populations, including: reduce and prevent collisions with buildings and other structures; reduce the loss of habitats in nonbreeding areas; and implement conservation practices in agricultural and rangeland landscapes (Rosenberg et al. 2016).

Summary of Direct Impacts

High density Loggerhead Shrike densities are modeled to encompass 582 km^2 of habitat, of which 135 km^2 (23%) are expected to be in conserved areas (Table 119). Minimal areas of high density habitat are located in Disturbed or areas to be impacted by this amendment (27 km^2 each). Moderate density habitat is far more broadly predicted throughout the county and 11% combined may be disturbed or impacted, and 17% is expected to lie within conservation areas (Table 119).

Table 119. Categorized modeled habitat values (High, Medium, and Low) and the average area (Hectares) predicted in the potential impact areas, conservation areas, already disturbed areas, and overall area

Habitat Level	Impact	Conserved	Disturbed	Area (Hectares)
High	2692	13476	2714	58183
Med	37173	136152	55444	787910
Low	91142	344895	80067	1263655

LANO - Silver-haired Bat (Lasionycteris noctivagans)

Silver-haired Bats (*Lasionycteris noctivagans*) have dark brown fur with white tips, giving it a silver appearance (Kunz 1982) that resembles the Hoary Bat in coloration, but the Silver-haired Bat has a smaller body and wingspan. It is migratory, and like other migratory bat species, males and females have different migration patterns. Females have higher fat stores during migration and migrate more slowly during cooler periods with bad weather (Jonasson and Guglielmo 2016). Silver-haired Bats are a tree-roosting species (Kunz 1982), but are also known to use crevices, cavities, other rock shelters, or bridges during at least part of their annual cycle (Bogan et al. 2003, Kunz and Reynolds 2003). They live up to 12 years, and fledge an average of 1.7 young (Kunz 1982). Silver-haired Bats are insectivores with a broad diet. They forage in or near forests adjacent to ponds, rivers, or streams (Kunz 1982), and have been observed foraging at the same time and place as many other bat species.

Species Status

There are no petitions to protect this species at either the federal or state level. The International Union for Conservation of Nature and Natural Resources (IUCN) lists this species as one of Least Concern because of its wide distribution, large population size, and tolerance of habitat modification (Arroyo-Cabrales et al. 2016).

US Fish and Wildlife Service Endangered Species Act: Not listed
US Bureau of Land Management (Nevada): Sensitive
US Forest Service (Region 4): No status
State of Nevada (NAC 503): No status
NV Natural Heritage Program: Global Rank G5, State Rank S3B
NV Wildlife Action Plan: Species of Conservation Priority
IUCN Red List (v 3.1): Least Concern
CITES: No Status

Range

The Silver-haired Bat ranges throughout the continental United States, southern Canada, and into southwestern Alaska excluding southwestern California, southwestern Arizona, and Florida (Hoffmeister 1970, Kunz 1982). Its abundance throughout the distribution is somewhat unpredictable, but it has patches of high local abundance (Kunz 1982). Although this is considered a tree-roosting species, many observations of this bat roosting in caves, mines, hollow trees and man-made structures occur in the literature (Kunz 1982, Szewczak et al 1998). This species was observed occupying closed mine shafts at nine of 13 sites surveyed in central Nevada (Morrison and Fox 2009), and flying near Searchlight Nevada, where several active and abandoned mine sites occur (Tetra Tech 2009).

Population Trends

Although 68 observations of 61 localities in the US were compiled in a study of Silver-haired Bat roost sites, none of those data were useful for trend analyses (Ellison et al. 2003). Furthermore, no information was available for such analyses Clark County or in Nevada or the Mojave Desert in general. The lack of information is attributed to frequent switching among roosts in trees, their migratory movements, and lack of research effort on this species (Ellison et al. 2003).

Habitat Model

Silver-haired Bat habitat was modeled at a resolution of 1 km at the scale of the Mojave Desert due to low numbers of localities for this species within the county (N=25), as was the case for many of the bats modeled for this report. The number of localities Mojave wide was 32. Localities for this species were generally in the northern half of the county, with 2 observations near Searchlight. The three modeling algorithms generally predicted different amounts of area as habitat, but with several core areas of similarity (Figure 182). The GAM model was the most widely predicting model, with habitat predicted in both mountainous areas (e.g. the Spring and Sheep Ranges) as well as lowland areas along the boundary of Lake Mead the Moapa Valley, and along the US 95 north corridor. Random forest predicted similar areas with more restricted predictions, especially in the northwest portion of the County along the US 95 corridor. The MaxEnt model had a much more restricted prediction, focusing on the Spring and Sheep Ranges, Corn Creek and North Las Vegas, and along the Las Vegas wash to the edges of Lake Mead, and throughout the Muddy and Virgin River riparian areas. Model performance was highest for the RF model for each of the 4 performance measures, followed by the ensemble model, MaxEnt, and finally the GAM model (Table 120). Standard errors were highest for the GAM model in two areas: The largest area just southeast of Nelson, near Knob Hill, and the 2nd - a smaller area at Searchlight. Two other areas of moderately high error occur on the west side of the county: one along highway 160 where it crosses the McCollough Range, and the second on Mt. Potosi. The MaxEnt had similar areas of High SE (0.06 – 0.08), but also had moderate levels of SE along the US 95 corridor north of Corn Creek. The RF SE map had only sparse areas of moderately low error (Figure 183).

The CBIs for the models indicated good performance overall, although the fixed BI was much higher for the RF and Ensemble models than for MaxEnt or GAM models (Figure 184, Table 120). Approximated bins for the Ensemble model based on the CBI were 0-0.37 unsuitable, 0.37-0.55 marginal, 0.55 to 0.6 suitable, and 0.6 -1 optimal habitat; with a suggested cutoff threshold of ~ 0. 5 (Figure 184) while the threshold value calculated from ROC statistics for the ensemble model was 0.45 (Table 120).

Table 120. Model performance values for *Lasionycteris noctivagans* models

Performance	GAM	RF	MaxEnt	Ensemble
AUC	0.847	0.967	0.889	0.931
BI	0.375	0.766	0.359	0.58
TSS	0.682	0.913	0.757	0.813
Correlation	0.613	0.839	0.679	0.744
Cut-off*	0.585	0.57	0.344	0.453

*threshold at which sum of sensitivity (true positive rate) and specificity (true negative rate) is highest

Table 121. Percent contributions for input variables for *Lasionycteris noctivagans* for ensemble models using GAM, MaxEnt and RF algorithms

Term	GAM	RF	Max	Avg
Winter Precipitation	0	12.641	38.597	17.079
Winter Min Temp	27.765	9.282	32.069	23.039
Mine Density	7.493	1.371	6.844	5.236
Roughness (TRI)	0	2.226	5.445	2.557
NDVI Maximum	2.944	0	3.752	2.232
Cliff Distance	0	0.246	3.424	1.223
Annual Temp. Range	2.858	8.873	3.405	5.045
NDVI Amplitude	0	1.747	1.685	1.144
Topographic Position (TPI)	0	1.428	1.367	0.932
Summer Max Temp	53.452	7.3	1.241	20.664
Soil Water Stress	0	0	0.969	0.323

Term	GAM	RF	Max	Avg
Diurnal Temp. Range	0	3.473	0.859	1.444
Surface Texture (ATI)	5.488	0	0.341	1.943

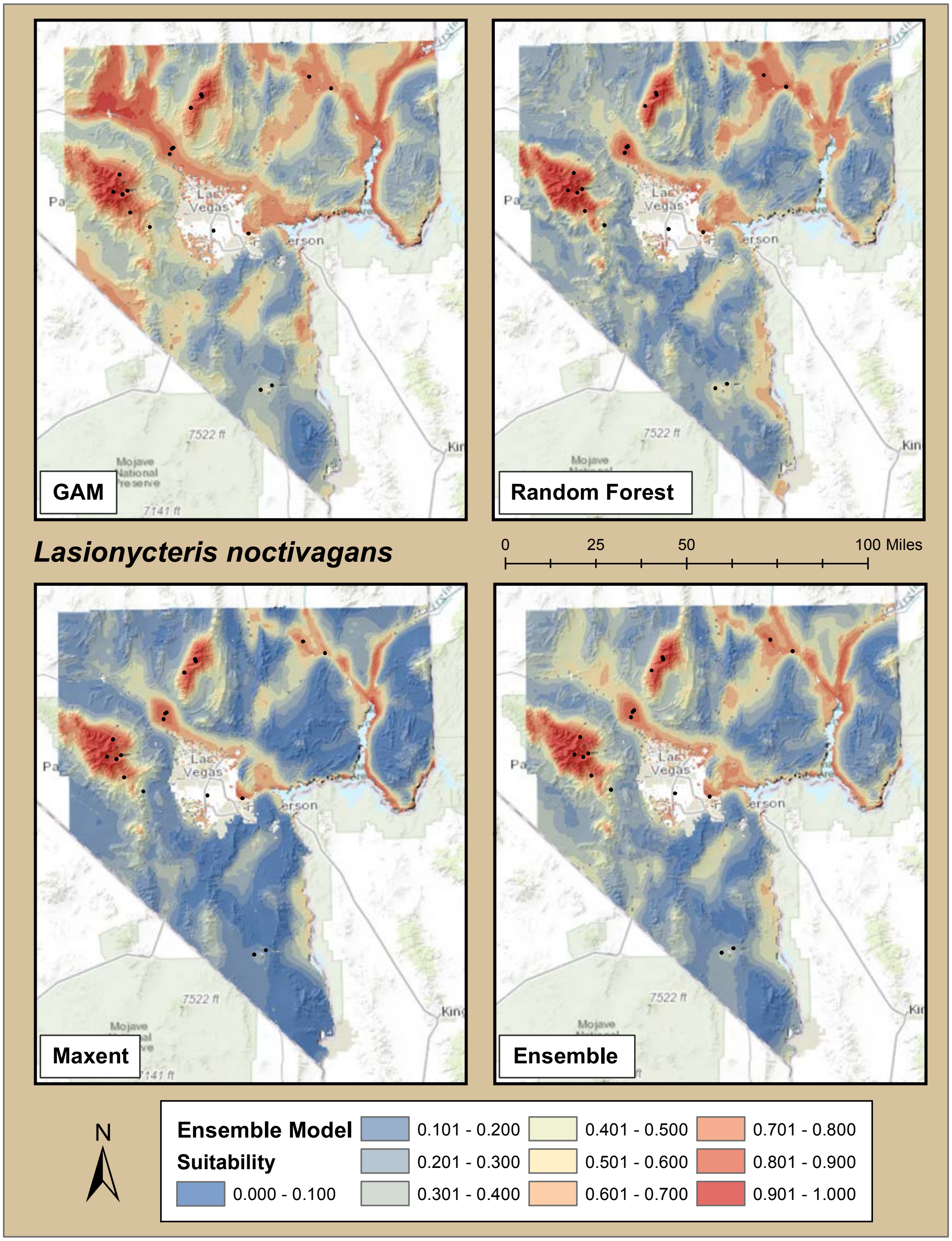

Figure 182. SDM maps for *Lasionycteris noctivagans* for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

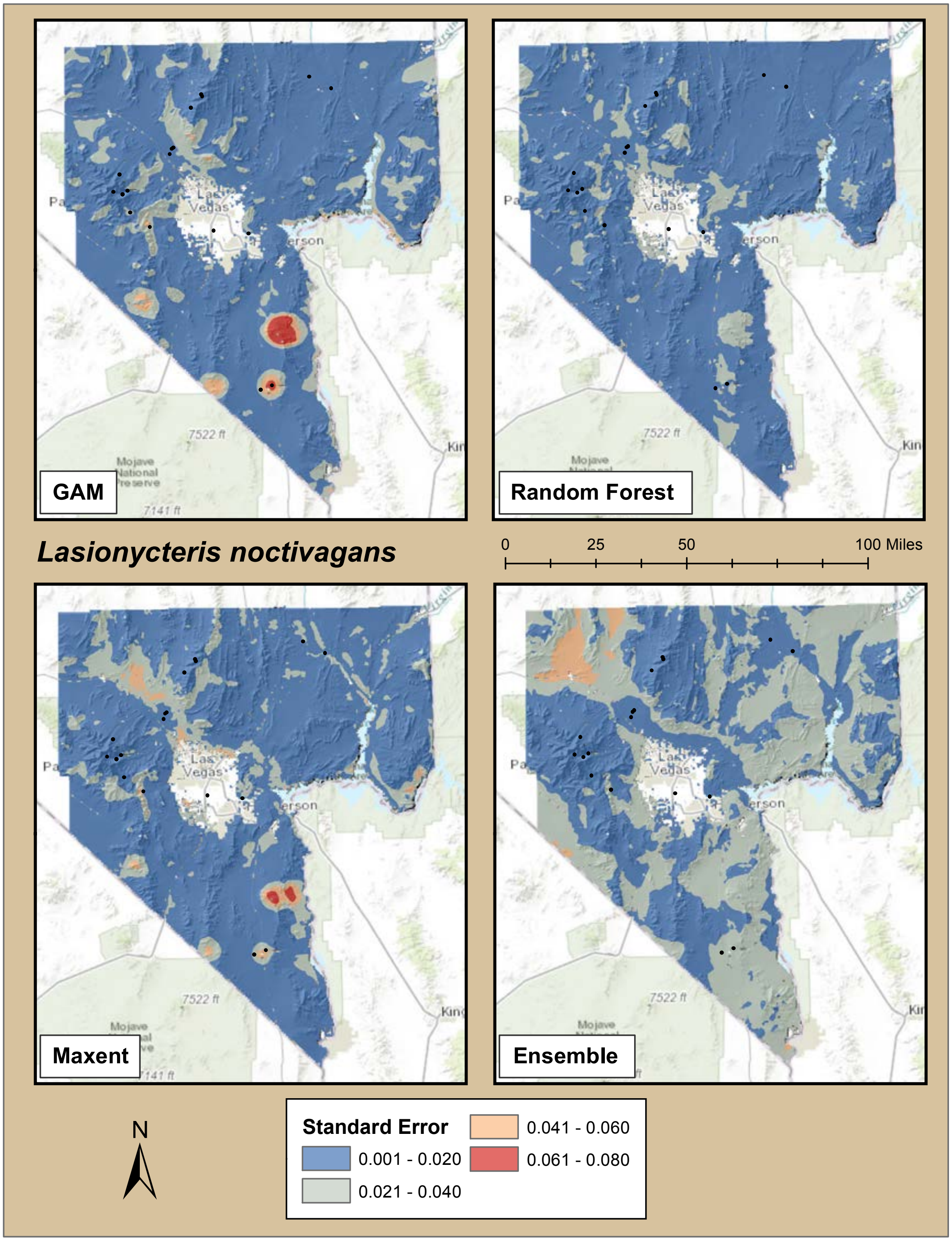

Figure 183. Standard error maps for *Lasionycteris noctivagans* models for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

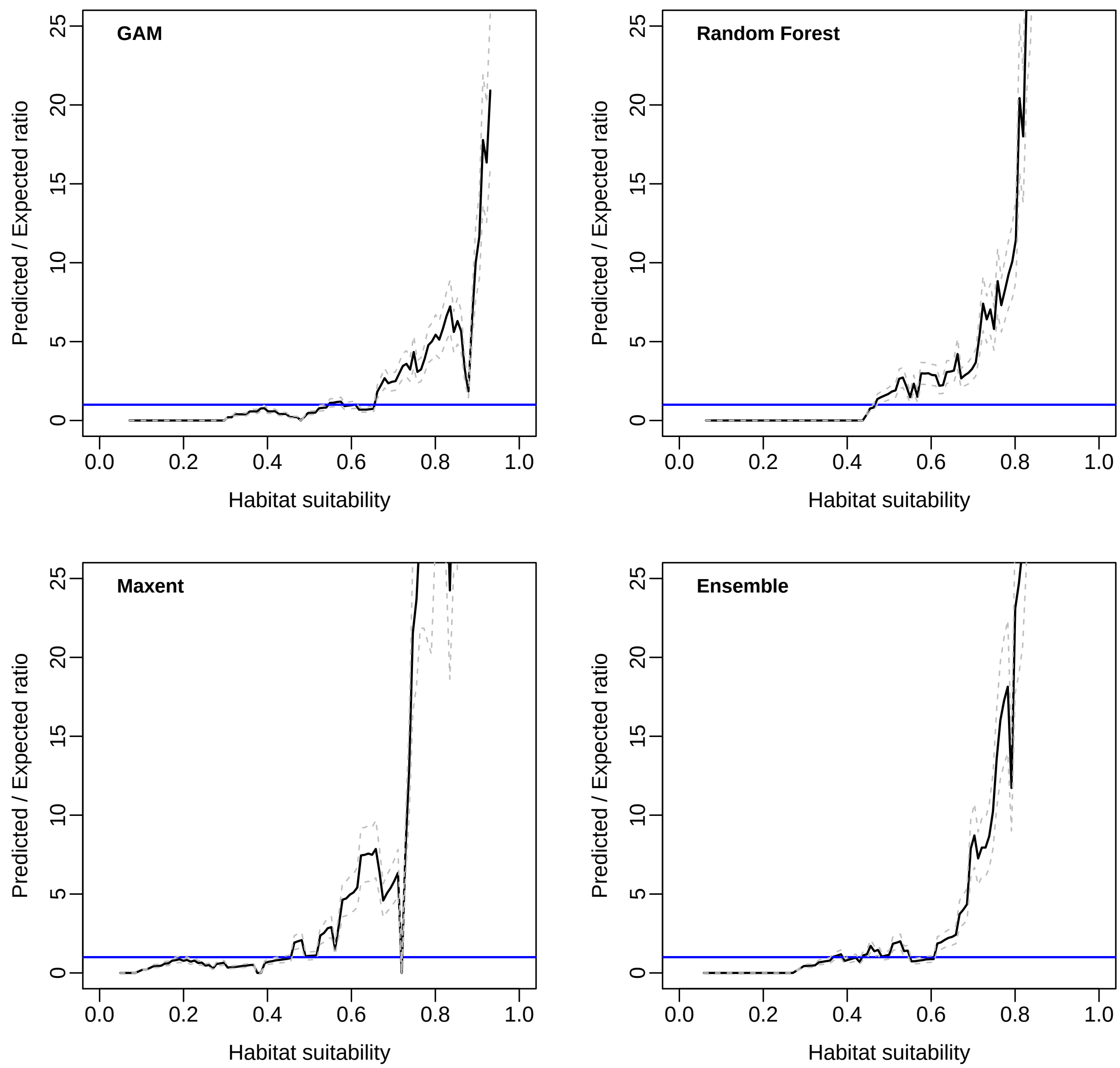

Figure 184. Continuous Boyce Indices for *Lasionycteris noctivagans* models for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

GAM Model

The GAM model ensemble identified only 2 contributing variables with more than 10% contribution toward the model representing 81% of the model contribution, with four other inputs contributing at lower levels (Table 121). Summer Maximum temperature was positively correlated with habitat suitability, and Winter Minimum temperatures were negatively correlated with predicted habitat suitability (Figure 185). All of the predicted response curves were linear, which is rather unusual for GAM models generally as they are typically better at curve fitting relationships. This could be a result of low sample size for this species. Performance measures were lowest for this algorithm, with the exception of the BI, which was slightly higher, but similar to the BI for the MaxEnt model (Table 120). While the BI indicated poor fit among the modeled points, the AUC for the model gave it a higher perceived performance level relative to the other metrics.

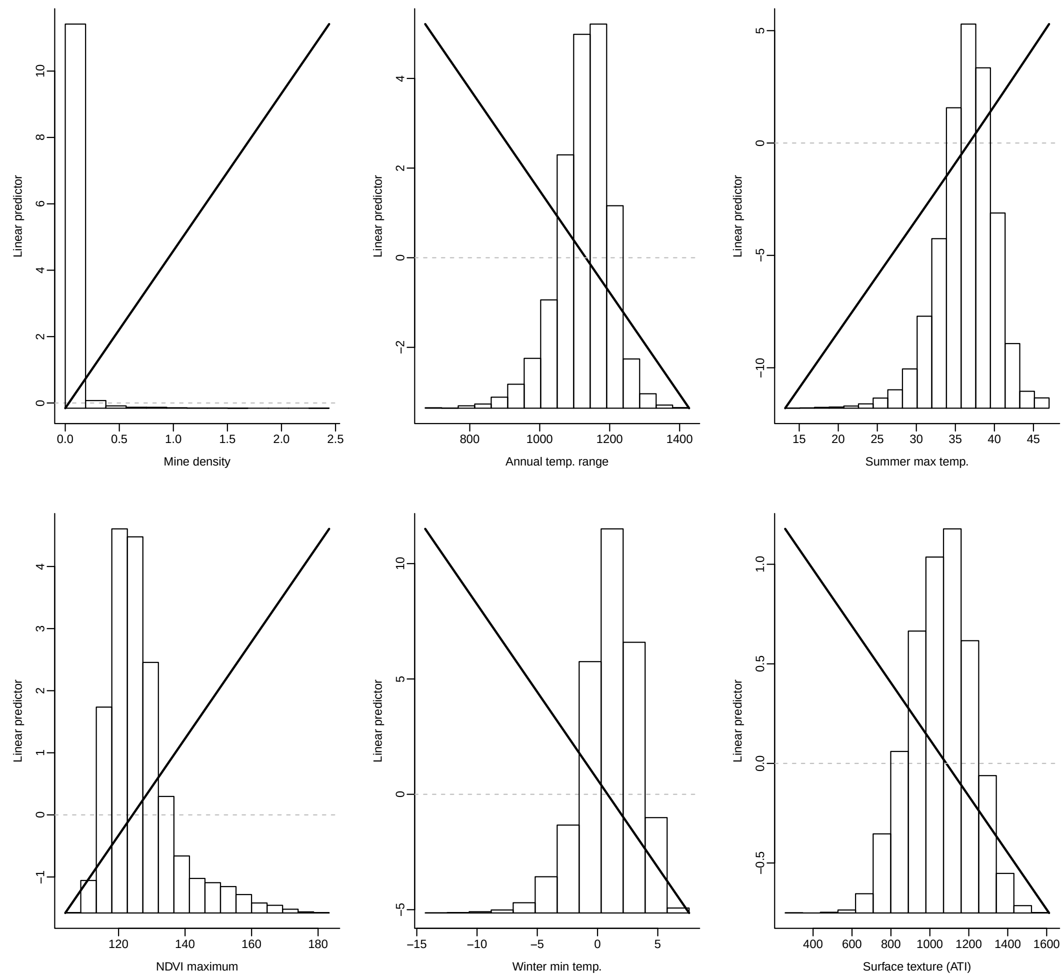

Figure 185. GAM partial response curves for the *Lasionycteris noctivagans* model overlaid over distribution of environmental variable inputs in the study area.

MaxEnt Model

The MaxEnt model also had only two variables contributing 10% or more each, accounting for 71% of model contribution, with an additional two contributing 5-7% (Table 121). Winter Precipitation was the highest contributing variable, with 39% contribution, and was strongly negatively associated with habitat suitability dropping sharply at values approaching 150 mm. Winter Minimum temperature was also negatively associated with habitat, with a nearly linear relationship (Figure 186). The MaxEnt model performed third among the four models, the lowest BI, and a somewhat erratic Continuous Boyce Index (Table 121, Figure 184).

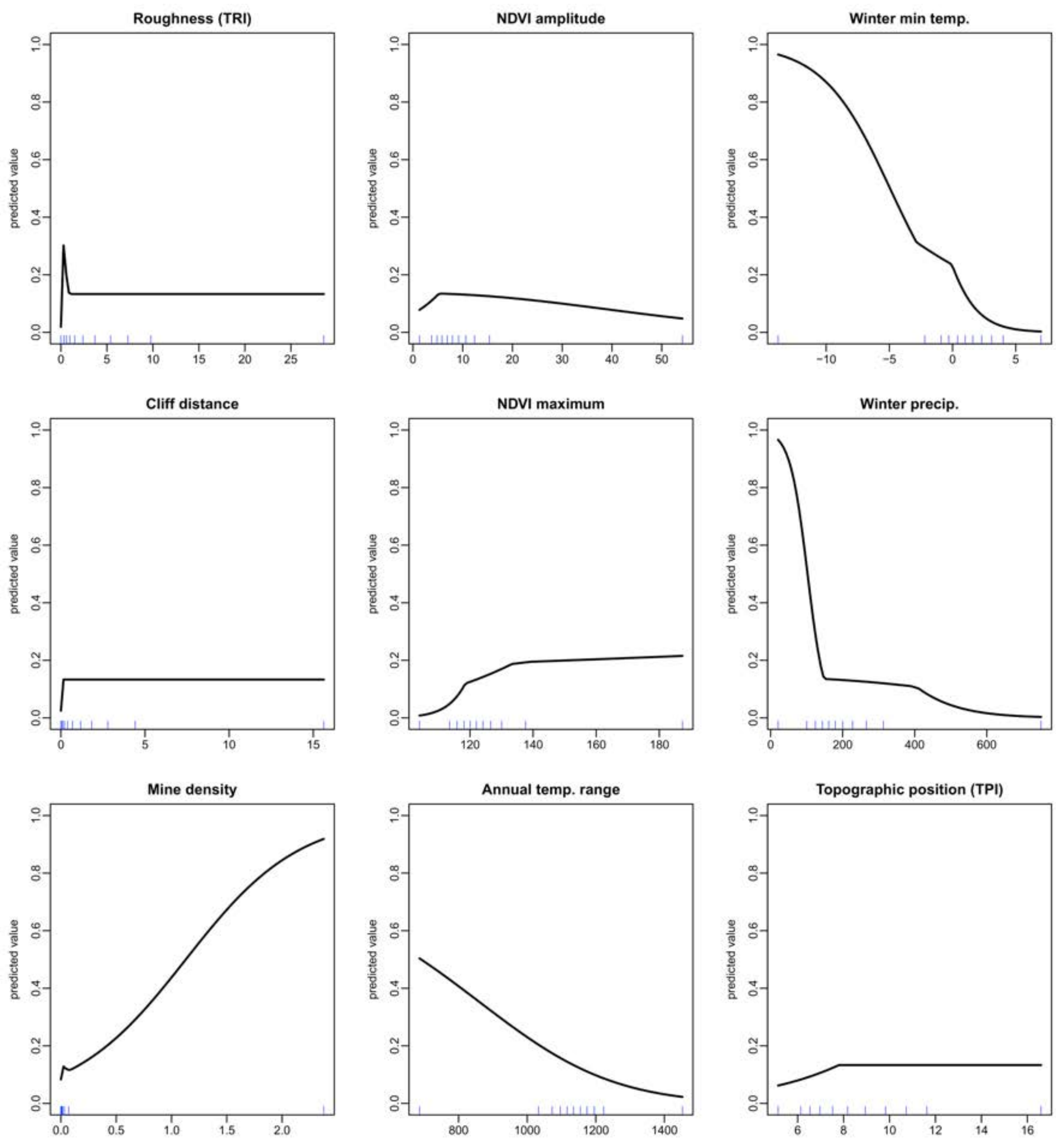

Figure 186. Response surfaces for the top 9 environmental variables included in the MaxEnt ensemble model for *Lasionycteris noctivagans*.

Random Forest Model

The RF models had three environmental variables contributing 7% or more totaling 38% of total model influence, with lower level contributions from 6 more variables (Table 121). Habitat suitability was predicted by the RF model to be greatest in areas of lower Winter Precipitation, and Winter Minimum Temperature. Predicted habitat was also higher in areas with lower Annual Temperature Ranges, and lower Summer Maximum temperatures, although there was a sharp increase in habitat prediction for areas of the highest summer temperature as well, likely associated with low elevation foraging sites typical of the riparian areas in the County (Figure 187). This model had the highest performance among all models, with strong performance measures, a CBI curve indicating good performance (Table 121, Figure 184), and relatively low error rates (Figure 183).

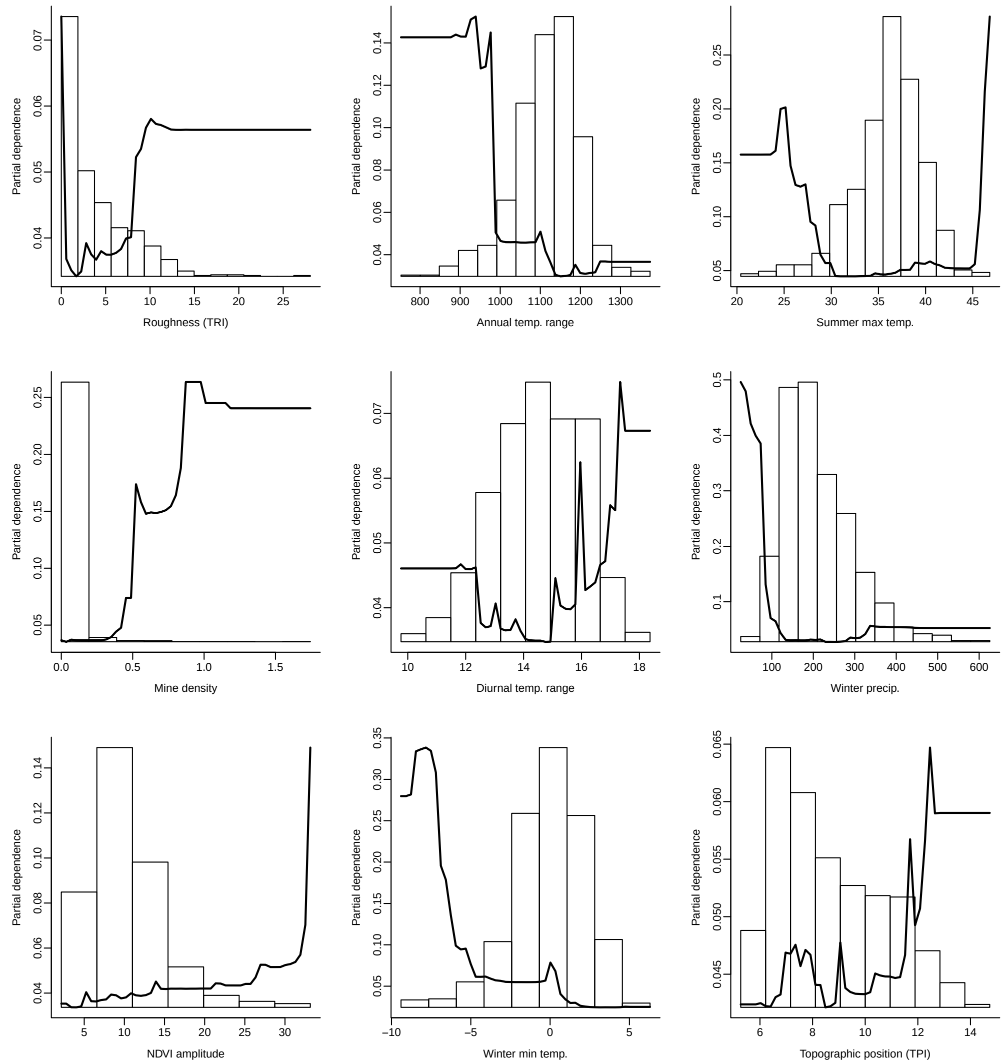

Figure 187. Response surfaces for the environmental variables included in the RF ensemble model for *Lasionycteris noctivagans.* Histograms represent the range of each environmental variable across the x-axis, and predicted dependence relative to habitat

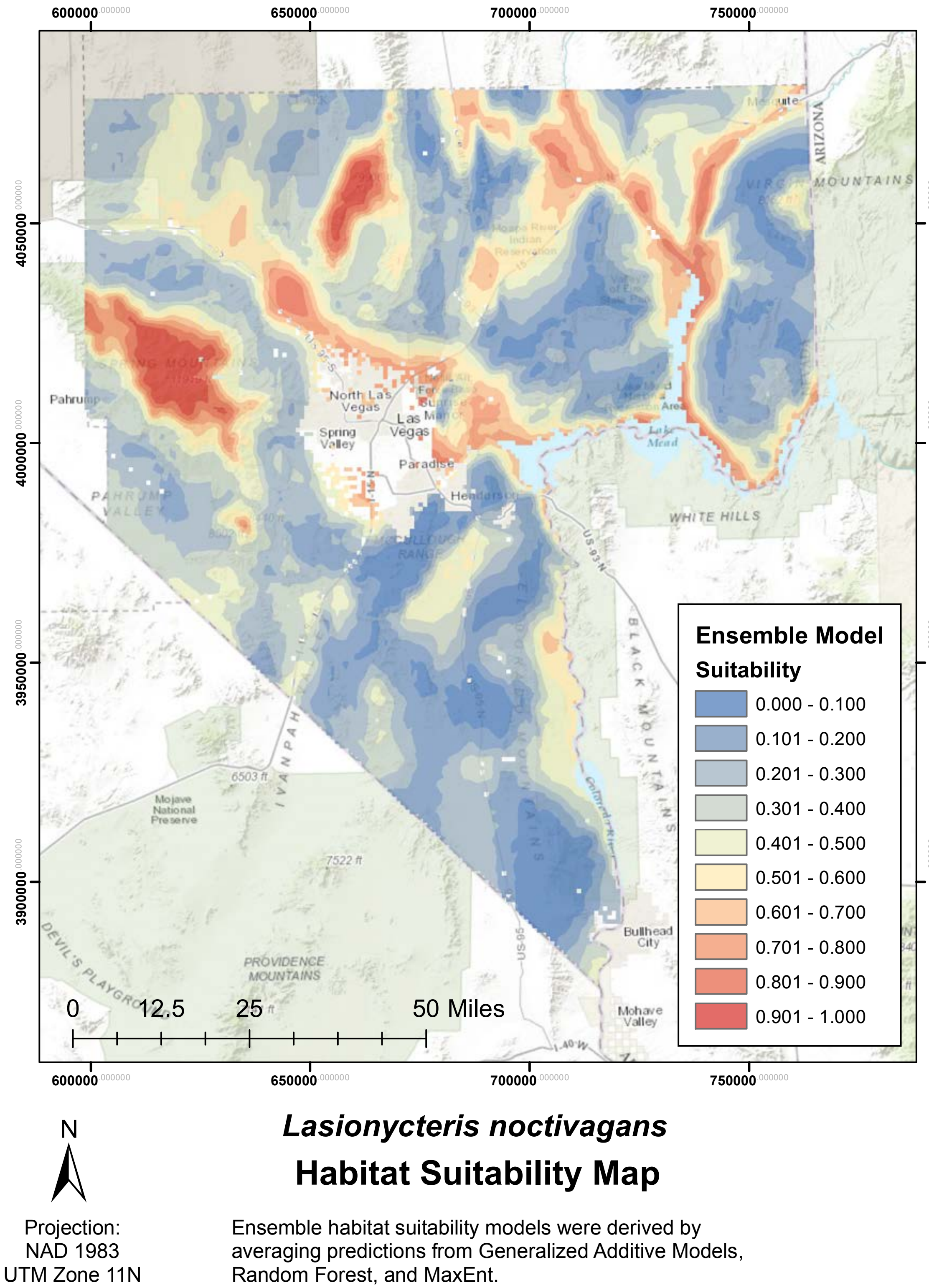

Figure 188. SDM map for the *Lasionycteris noctivagans* ensemble model.

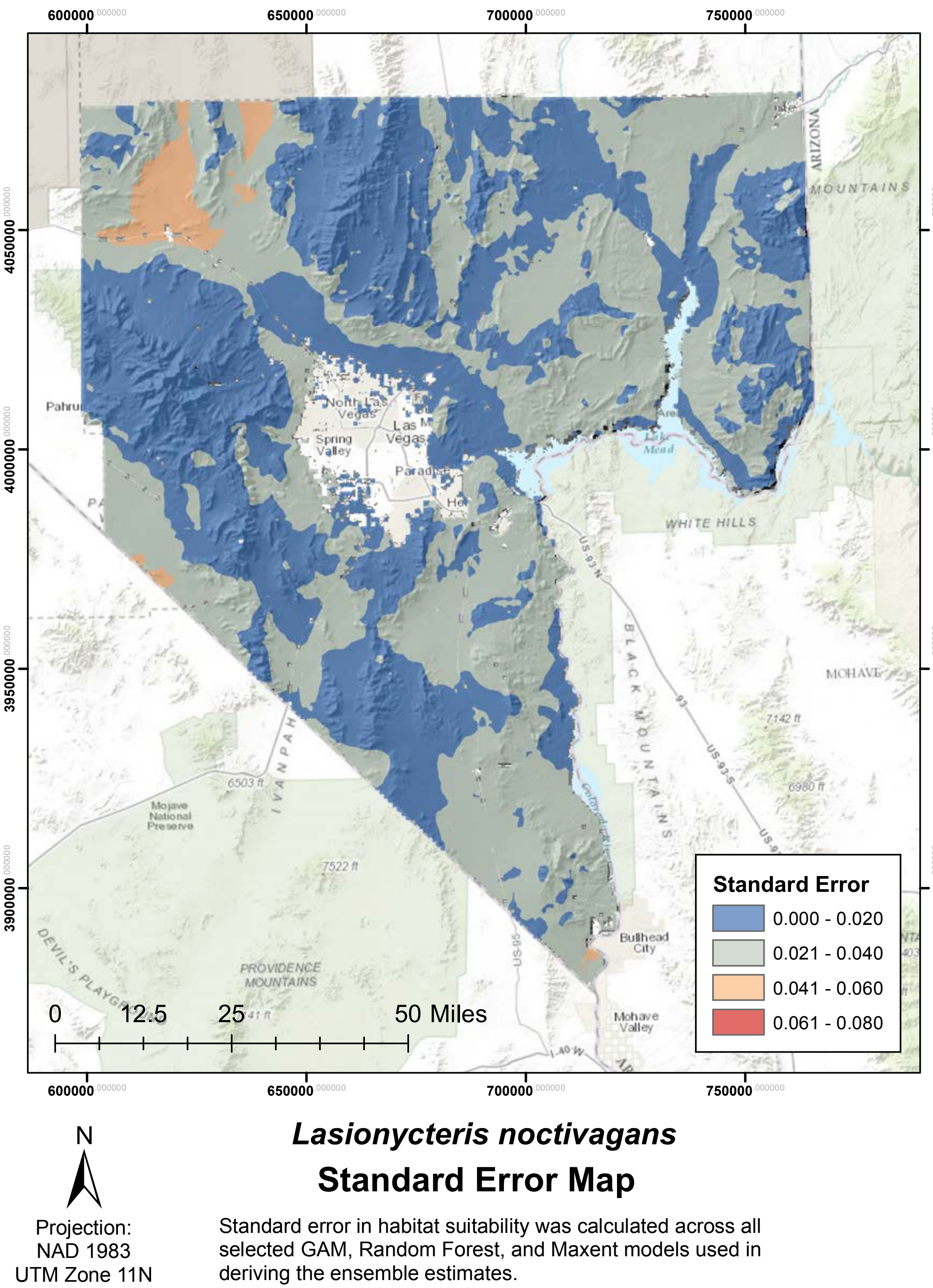

Figure 189. Standard Error map for the *Lasionycteris noctivagans* ensemble model.

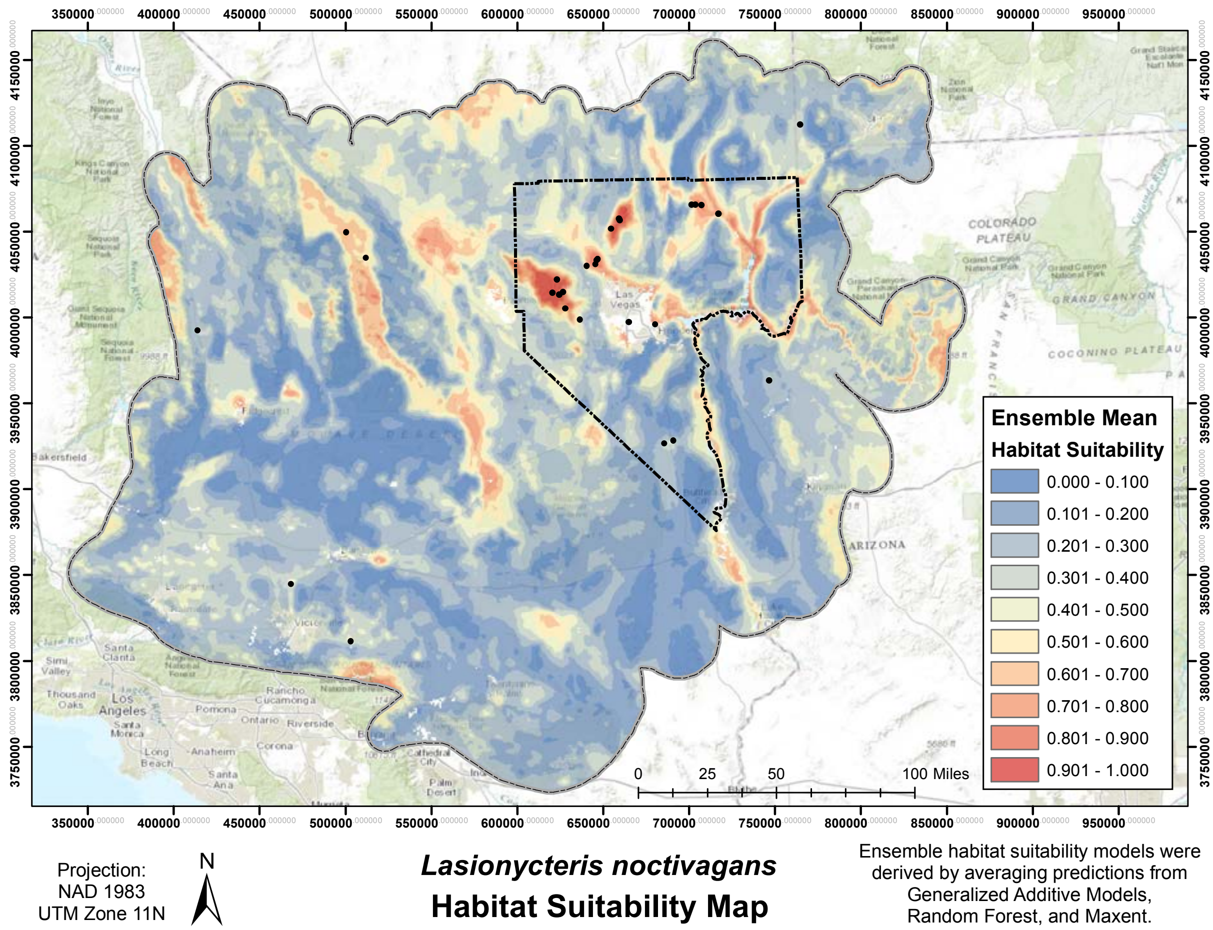

Figure 190. Predicted habitat map for the Lasionycteris noctivagans ensemble model at the scale of the Mojave Desert.

Distribution of Localities

Localities for Silver-haired Bats are sparsely distributed with only 25 of 32 observations for the Mojave within the County (Figure 182). Observations were associated with the Spring Mountains, Corn Creek, The Sheep Mountains, and Moapa Valley riparian areas, Searchlight with two observations within the Las Vegas metropolitan area. A handful of observations outside the county were widespread, but included Death Valley, St George, and one in Mojave County AZ (Figure 190).

Standard Error

The standard error for the habitat suitability model for Silver-haired Bats indicates low to generally low error throughout the majority of the areas in Clark County, with a SE of 0.02 – 0.04 (Figure 189). One patch of moderate error (SE 0.04 to 0.06) occurs in the valley just north of Indian Springs, along highway 95, which is within the Nellis Bombing Range – this error is likely due to the GAM model predicting higher habit potential there, while the MaxEnt and RF models did not (Figure 183).

Distribution and Habitat Use within Clark County

There are relatively few records in the scientific literature for this species in Clark County. Early records include observations in the Sheep Mountains at 8,500 feet, and Corn Creek Ranch (now the Desert National Wildlife Refuge) at 3,000 feet (Hall 1946), with later records from near Glendale, Nevada, at 964 feet and Pine Creek on Mount Charleston at 3,000 to 4,000 feet (Bradley et al 1965). This species was also detected using acoustic surveys along the Muddy River system in the Moapa Valley near Glendale, but was rarely encountered, and only encountered during the spring and autumn migration periods (Williams et al. 2006). Similar encounters over non-riparian areas were reported during surveys for a wind generation facility proposed for construction near Searchlight, Nevada (Tetra Tech 2009). Higher suitability modeled habitat for this habitat spanned all ecosystems, with more low to moderate habitat predicted for Blackbrush, Mojave Desert Scrub and Salt Desert Scrub ecosystems (Table 122).

Modeled Habitat in the county is predicted to be high in upper elevation ranges in the Spring and Sheep Mountains and in a band from Corn Creek across the northern Boundary of Las Vegas (Figure 188). Interestingly, while vegetation types were not part of the covariates used to model bat species, the habitat suitability model indicates more widespread high suitability areas on the montane habitats where conifers are the dominant tree type, compared to the habitat suitability models for the Western Red Bat. Silver-haired Bats use conifer forests, while Western Red Bats are tied much more closely to deciduous tree species, and the patterns of high suitability in the models support this pattern of habitat use. The Las Vegas Wash, Lake Mead Shorelines, and Colorado Muddy and Virgin River riparian areas were also predicted as habitat, and have been associated with foraging areas for many bat species. Several of the bats have also shown higher predicted habitat northeast of Las Vegas near Apex. (Figure 188).

Table 122. Ecosystems within Clark County, and the area (Ha) of Low Medium and High predicted suitability within each ecosystem.

Ecosystem	Low	Medium	High
Alpine	0	0	124
Blackbrush	261265	150608	2311
Bristlecone Pine	0	0	7565
Desert Riparian	0	3686	7132
Mesquite Acacia	11415	3023	5471
Mixed Conifer	0	316	27022
Mojave Desert Scrub	660022	471093	160133
Pinyon Juniper	6088	53800	55785

Ecosystem	Low	Medium	High
Sagebrush	366	2854	1476
Salt Desert Scrub	16727	52902	10073

Ecosystem Level Threats

The Silver-haired Bat has been observed in Desert Riparian and Mixed Conifer ecosystems (Bradley et al. 1965). As this species is reported to roost in trees and in caves, mines, and man-made structures, it is potentially influenced by changes in tree densities (e.g., by forest fires, urbanization, logging or other disturbances that reduce tree cover), as well as disturbances to caves, mines, and abandoned structures used for roosts. This species also forages in riparian areas in Clark County, and likely travels between roost sites and foraging areas, thus opening the potential susceptibility to mortality due to wind turbine blade collisions or barotrauma (trauma caused by lethally low pressure created by the movement of the blade through the air) should these facilities be constructed in Clark County (Baerwald et al. 2008, Cryan and Barclay 2009). The Revised Bat Conservation Plan states that riparian habitat is important and can be impacted by water diversions, improper grazing and altered flood regimes.

Threats to Species

As this species is reported to migrate, wind turbines are also likely to increase mortalities during migrations (Arnett et al. 2008). While rarely detected, this species has been shown to be active in caves and mine shafts, and thus may be disturbed by recreational use, mining activities, or mine abatement. In addition, this species is known to use trees for roosting, and thus will likely be affected by losses of wetlands.

Existing Conservation Areas/Management Actions

Important conservation areas range throughout the county due to the great elevational range this species is known to occupy. Lake Mead National Recreation Area, Desert National Wildlife Refuge, Overton National Wildlife Refuge, Toiyabe National Forest, federally designated Wilderness Areas, and Areas of Critical Environmental Concern also may provide this species protection.

In 2006, the Nevada Bat Working group published the Revised Nevada Bat Conservation Plan (‘Plan’, Bradley et al. 2006). The Plan identifies the 23 bat species that occur within the State of Nevada as well their life histories and habitat requirements. The Plan “assesses the current state of bat conservation in Nevada and suggests proactive strategies for improving and standardizing the conservation of Nevada’s bats.” Initiating standard surveys and ecological research for roost sites and bat distributions across the seasons and throughout the state are among the important advancements suggested for bat conservation. Other management actions in the plan that are relevant to the Silver-haired Bat include: limiting, monitoring, and coordinating any activities in caves, mine shafts, and adits (i.e. prospecting holes) that may be occupied by bats to avoid unnecessary disturbances to bat colonies including the Silver-haired Bat. Bat gates are suggested to reduce casual visits to the habitat features. While roosting, nursery, and hibernation sites are important, they must be supported by the availability of appropriate foraging areas for bat – e.g. for Silver-haired Bats this includes riparian areas, mixed conifer areas, and Mojave Desert scrub areas. Education about bats is a very important to creating understanding among the constituents of the state for all bats including the Silver-haired Bat that is one of the less well known species. While there is great emphasis on rocky substrate for bat habitats, the Plan emphasized that tree roosting habitat is very important to Silver-haired Bats. Primarily riparian woodlands, and upland woodland or forested areas are available for Silver-haired Bats. Besides inventory and monitoring of areas occupied by trees that Silver-haired Bats may occupy, the Plan suggests incorporating important roost sites in planning efforts for forest management, and initial attack planning during forest fires. Subsequent to disturbance, restoration is recommended in appropriate areas. Managing water sources is also identified as very important to bats both for providing in-flight drinking water, as well as, enriched areas to forage for insects. The Silver-haired Bat is a priority species in consideration of this management action.

Summary of Direct Impacts

Potential impacts for this species are spread across all habitat categories for this species. Conserved areas for higher quality habitat are lower than the projected impacts and already disturbed areas (225 km^2 vs 567 km^2, Table 123).

Table 123. Categorized modeled habitat values (High, Medium, and Low) and the average area (Hectares) predicted in the potential impact areas, conservation areas, already disturbed areas, and overall area

Habitat Level	Impact	Conserved	Disturbed	Area (Hectares)
High	33971	22751	22653	280569
Med	53909	101475	20171	755397
Low	34807	388975	8333	977345

MACA - California Leaf-nosed Bat (Macrotus californicus)

The California Leaf-nosed Bat (*Macrotus californicus*) is a cave roosting bat that forages on large insects in desert wash vegetation (Bradley et al. 2006). They will also use buildings and mine shafts, and regulate their temperature by selecting different depths to roost. Many structures near foraging areas are used for temporary resting/feeding roosts when processing large insect prey (Bradshaw 1961). They are colonial brooders (Bell et al. 1986), but roost individually. California Leaf-nosed Bats have been found co-inhabiting shelters with many other bat species (Bradshaw 1961). While almost any structure is used for nighttime resting/foraging roosts (Bradshaw 1961), deeper structures are used for daytime and winter roost sites as they have very stable temperatures (Bell et al. 1986). Longevity is greater than 10 years (Bradshaw 1961). Natural predators include raptors and carnivorous mammals. Conservation priority of desert washes near known roost sites.

California Leaf-nosed Bats have a mean body temperature of 37ºC (98.6 ºF), are not known to hibernate (Bell et al. 1986), and cannot sustain body temperatures below 26ºC (78.8 ºF) Bradshaw 1962), although their body temperatures do cycle daily (Bradshaw 1961). They have physiological adaptations such as a low basal metabolic rate, low evaporative water loss, no need for dietary water, and increased efficiency in foraging by visually locating prey items thus allowing them to live in desert environments (Bell 1985, Bell et al. 1986). California Leaf-nosed Bats feed mostly on insects during warmer periods, (Bradshaw 1961), but will take some fruits (e.g., organ pipe cactus) when available (Bradshaw 1961). They typically feed near roost sites, but will travel greater distances (e.g., 6-12 miles) to forage when foraging areas are not proximal to roost sites (Bradshaw 1961). In the Sonoran Desert, only males were present during the winter months, while females migrated to warmer areas (Bradshaw 1961).

Female California Leaf-nosed Bats are reproductive in their first year (Bradshaw 1962), while males are not sexually active until their second season (Bradshaw 1961). Fertilization occurs in the fall, and embryonic development is delayed until spring, resulting in the longest gestation period of any new world bat species (Bradshaw 1961). Young are born in June and weaned within about one month.

Species Status

The California Leaf-nosed Bat is not listed as threatened or endangered (LCR MSCP 2004). The IUCN lists this as a species of least concern, downgraded from a listing of Vulnerable in earlier assessments (1996) (Arroyo-Cabrales et al. 2008). The Arizona Department Game and Fish, however, has this species listed as a candidate species. State wildlife agencies in the region list it as a sensitive species (California), species of concern (Arizona), or Species of Conservation Priority (Nevada) (LCR MSCP 2004, Nevada Wildlife Action Plan 2012).

US Fish and Wildlife Service Endangered Species Act: Not listed
US Bureau of Land Management (Nevada): Sensitive
US Forest Service (Region 4): No status
State of Nevada (NAC 503): Sensitive
NV Natural Heritage Program: Global Rank G4, State Rank S2
NV Wildlife Action Plan: Species of Conservation Priority
IUCN Red List (v 3.1): Least Concern
CITES: No Status

Range

These bats are distributed throughout the Sonoran Desert of the United States and Mexico, and the southern portion of the Mojave Desert in California, southern Nevada and northeastern Arizona, and notably along the Colorado River system bordering Clark County and Arizona (Bradshaw 1961). This species has the northern-most distribution of this neo-tropical family (Bell et al. 1986). They are typically found in riparian areas below 3,500 feet (Bradshaw 1961) where rainfall is 12 to18 inches annually and daily temperatures are high, with high daily and seasonal ranges (Shreve 1951). They are thought to be excluded from areas higher than 5,000 feet and when found at higher elevations they are found in mountain valleys and canyons leading to the higher elevation sites (Bradshaw 1961).

Population Trends

IUCN lists the population status as stable, and considers the species to be of least concern because of its wide distribution, occurrence in a number of protected areas, and because it is unlikely to be declining at nearly the rate required to qualify for listing in a threatened category (IUCN 2016). Nevada Wildlife Action Plan (2012) states that the population trend is unknown, but that roosts have been lost due to mine closure and vandalism. The Revised Bat Conservation Plan states that California Leaf-nosed Bat populations in adjoining states are declining (Bradley et al. 2006).

Habitat Model

Model Results

California Leaf-nosed Bat habitat was modeled at a resolution of 1km at the scale of the Mojave Desert due to low numbers of localities for this species within the county (N=32), as was the case for many of the bats modeled for this report. The number of localities for the entire Mojave was 36, with 4 more (10%) localities added to the dataset by considering a broader model. Localities for this species were generally in the eastern third of the county along riparian areas of Moapa Valley, Las Vegas Wash, and throughout the Colorado River drainage and the mountains that boarder the river on the western banks. The three modeling algorithms generally identified similar areas of habitat, where the GAM and RF models were most similar, and the MaxEnt model had a more restricted prediction within the same core areas (Figure 191). The GAM model predicted slightly more moderate habitat in the Corn creek area and along the I-15 corridor. The MaxEnt model had a much more restricted prediction, focusing on valleys and mountainous area proximal to riparian habitat. Model performance was highest for the RF model for 3 of the 4 performance measures, with the exception of having the lowest Boyce Index (Table 124). The Ensemble model had the second highest performance, followed by the MaxEnt and GAM models. Standard errors were highest for the MaxEnt model, especially in the areas around Moapa Valley, Eldorado Valley, and the northern end of the Overton Arm of Lake Mead, which all had moderate levels of error (SE 0.04 – 0.06), and high SE (0.06 – 0.08) on the extreme southwestern edge of Gold Butte on the Lake Mead shoreline (Figure 192). Other models had fairly widespread errors considered to moderately low (SE 0.02 to 0.04).

The Continuous Boyce Indices for RF, MaxEnt and Ensemble models indicated good performance, while the GAM model had lower predictive ability at higher habitat suitability estimates than the others (Figure 193), yet its fixed BI was higher than that for MaxEnt (Table 124). Approximated bins for the ensemble model based on the CBI were 0-0.35 unsuitable, 0.35-0.5 marginal, 0.5 to 0.6 suitable, and 0.6 -1 optimal habitat; with a suggested cutoff threshold of ~ 0. 53 (Figure 193) while the threshold value calculated from ROC statistics for the ensemble model was 0.55 (Table 124).

Table 124. Model performance values for *Macrotus californicus* models

Performance	GAM	RF	MaxEnt	Ensemble
AUC	0.955	0.979	0.962	0.975
BI	0.654	0.602	0.721	0.704
TSS	0.904	0.94	0.908	0.92
Correlation	0.838	0.871	0.795	0.859
Cut-off*	0.581	0.718	0.334	0.551

*threshold at which sum of sensitivity (true positive rate) and specificity (true negative rate) is highest

Table 125. Percent contributions for input variables for *Macrotus californicus* for ensemble models using GAM, MaxEnt and RF algorithms

Term	GAM	RF	Max	Avg
Winter Precipitation	24.601	20.358	52.52	32.493
NDVI Maximum	11.481	6.504	24.009	13.998
Winter Min Temp	24.043	9.662	5.557	13.087
Summer Max Temp	9.637	16.538	8.342	11.506
Diurnal Temp. Range	15.476	0	0.302	5.259
Texture	4.92	3.652	0.662	3.078
Topographic Position (TPI)	4.92	1.84	1.377	2.712
Annual Temp. Range	1.64	2.092	3.415	2.382
Mine Density	1.64	0.286	2.872	1.599
Cliff Distance	1.64	2.738	0.362	1.58
Surface Roughness (TRI)	0	1.862	0.579	0.814
NDVI Amplitude	0	0	0	0

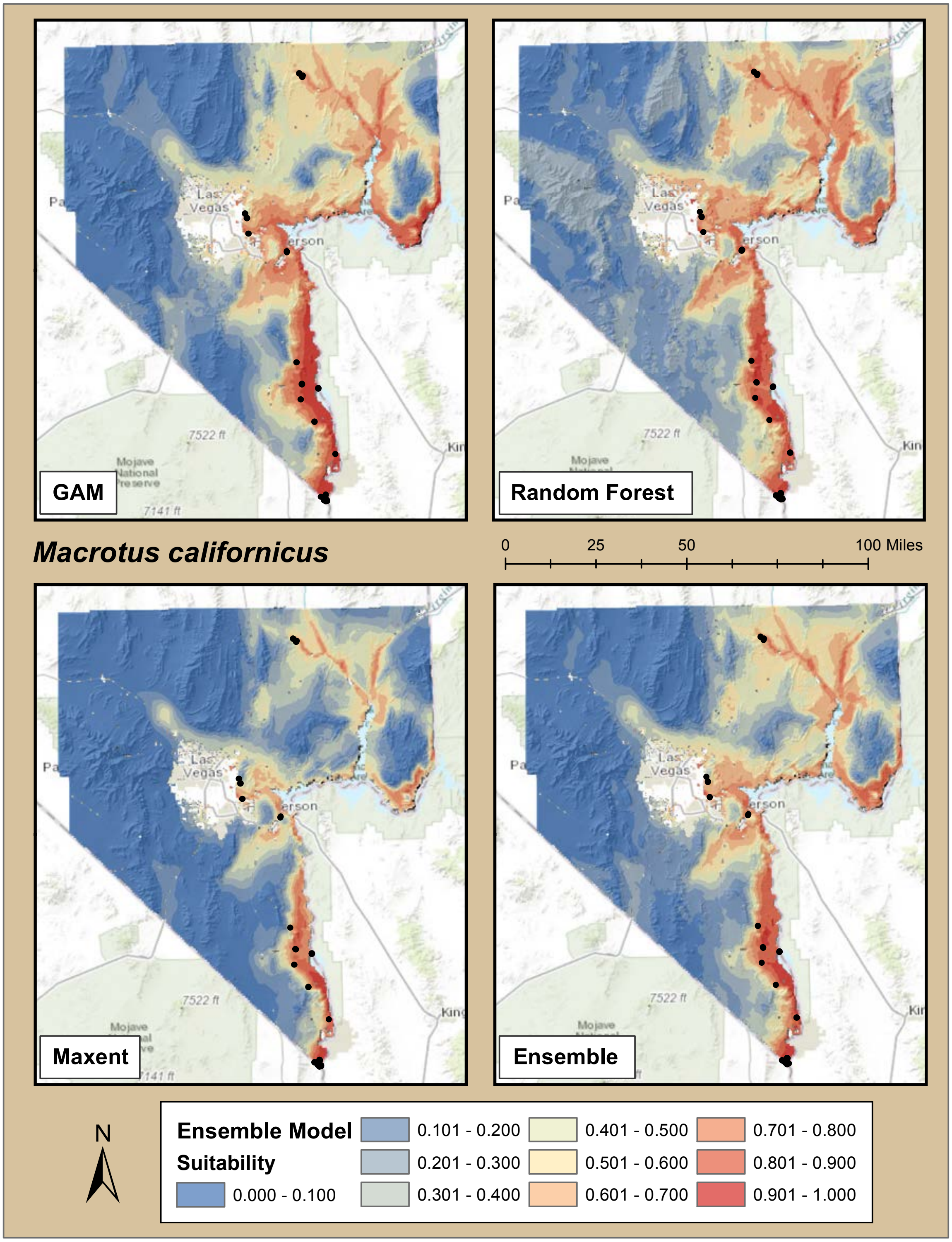

Figure 191. SDM maps for *Macrotus californicus* for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an Ensemble model averaging the three (Lower Right).

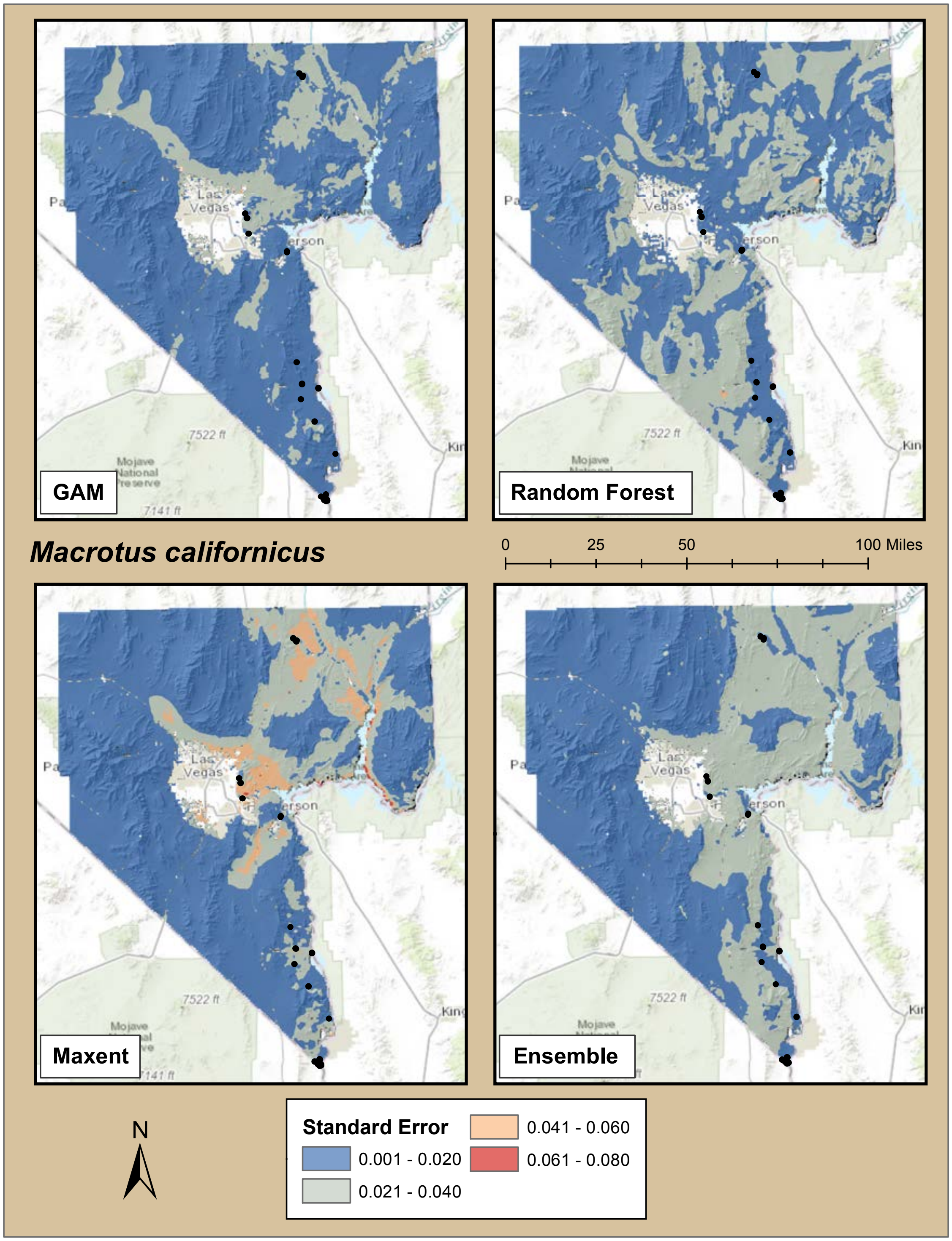

Figure 192. Standard error maps for *Macrotus californicus* models for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an Ensemble model averaging the three (Lower Right).

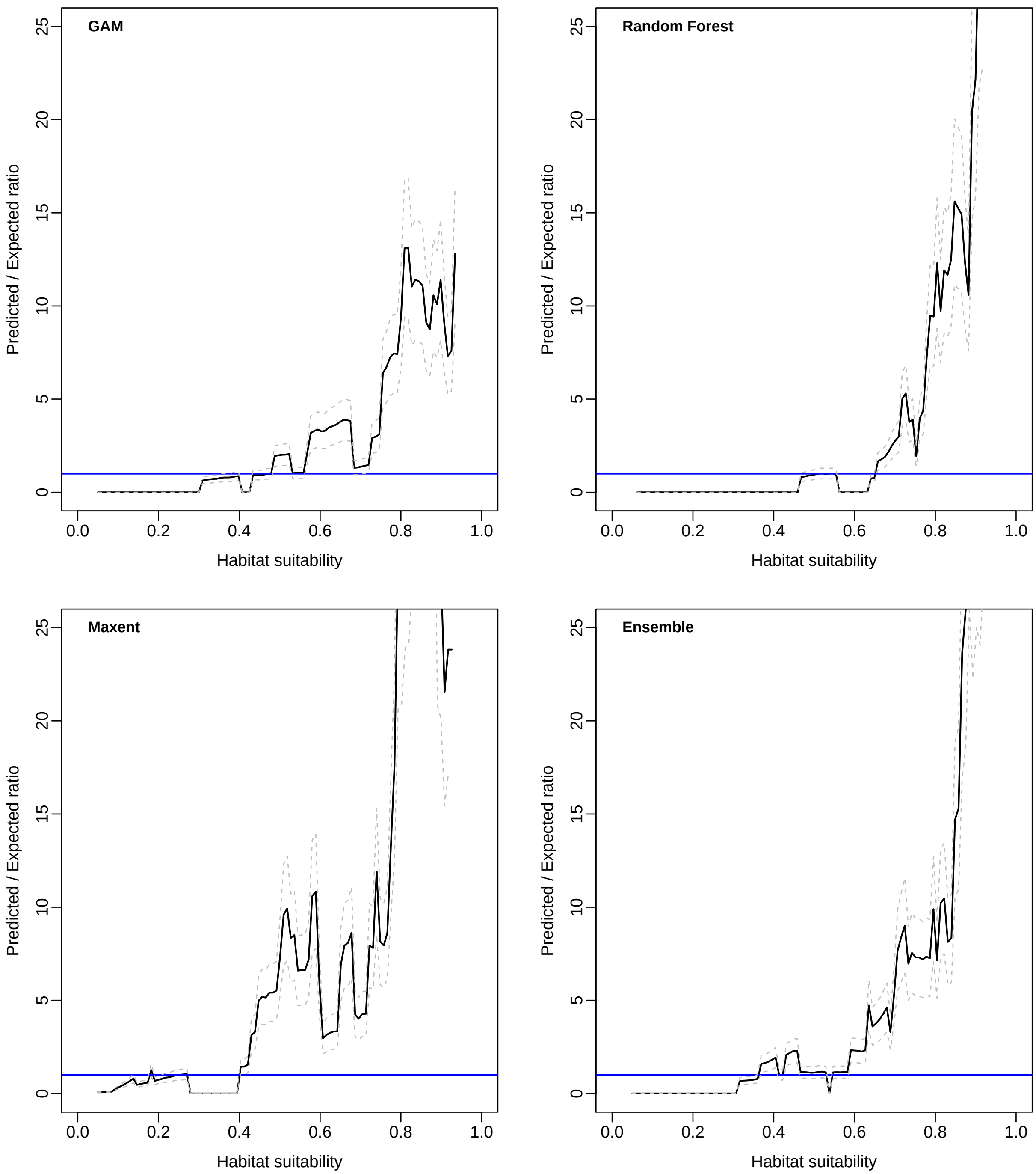

Figure 193. Continuous Boyce Indices for *Macrotus californicus* models for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

GAM Model

The GAM model ensemble identified five contributing variables with more than 9% contribution toward the model: Winter Precipitation, Winter Minimum Temperature, Diurnal Temperature Range, NDVI Maximum, and Summer Maximum Temperature - representing 85% of the model contribution (Table 125). Five other variables contributed to the model at lower levels, including Mine Density, and indices of topography and substrate (Table 125). Higher suitability was predicted for areas of both low and high Winter Precipitation, with the lowest values at moderate levels of precipitation (e.g. 200 – 400 mm) just above the average for the County. High Winter Minimum Temperatures were positively associated with predicted habitat suitability as was greater values for Diurnal Temperature Range. NDVI Maximum had a nonlinear positive response, with habitat of higher suitability predicted in areas above average for the county, peaking above 140, and tapering off slightly thereafter (Figure 194). Summer Maximum Temperature had a similar response, with higher habitat values predicted in areas of higher temperature, but not at the extreme of this metric.

Performance measures were lowest for this algorithm, although responses traded rank with MaxEnt performance, which had slightly better overall performance due to a higher Boyce Index (Table 124). Despite being the 4th best performing models it is notable that even with small sample size for this species model performance in general was surprisingly high.

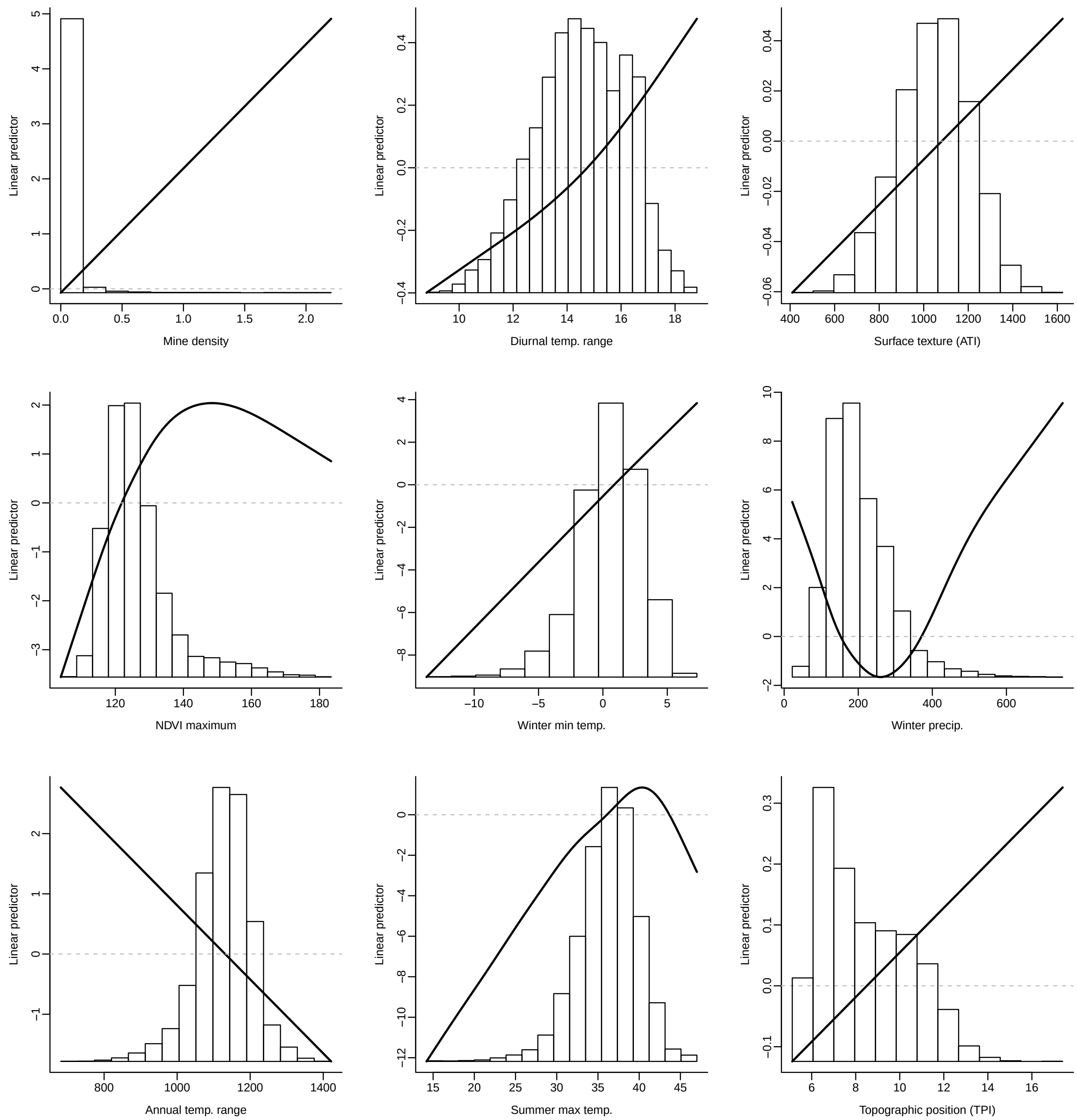

Figure 194. GAM partial response curves for the *Macrotus californicus* model overlaid over distribution of environmental variable inputs in the study area.

MaxEnt Model

The MaxEnt model also had only three variables contributing 8% or more each, accounting for 85% of model contribution. These were Winter Precipitation (52%), NDVI Maximum (24%) and Summer Maximum Temperature (8%) (Table 125). The partial response curves for this model show higher predicted habitat values in areas with lower than average Winter Precipitation, and higher than average Maximum

NDVI (Figure 195). Habitat with high Winter Minimum Temperatures and high Summer Maximum temperatures were also associated with increased habitat suitability as predicted by the MaxEnt ensemble. The MaxEnt model performed third among the four models, it had the highest BI, most restrictive habitat prediction, and a somewhat erratic Continuous Boyce Index (Table 124., Figure 193).

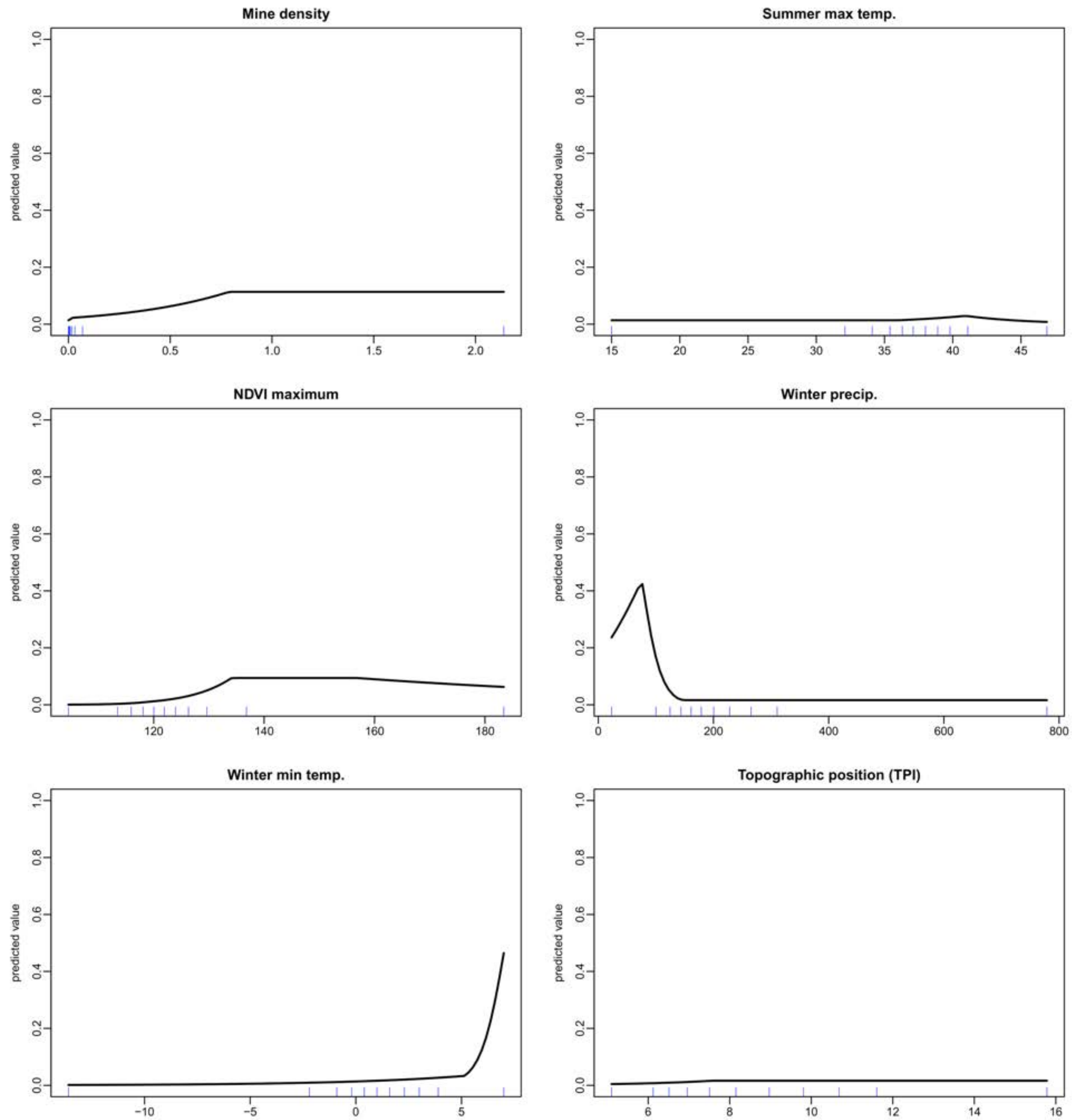

Figure 195. Response surfaces for the top 9 environmental variables included in the MaxEnt ensemble model for *Macrotus californicus*.

Random Forest Model

The RF models had three environmental variables contributing 9% or more totaling 47% of total model influence with a broad level of influence from 7 of the additional 10 environmental layers considered (Table 125). Greater habitat suitability was predicted in areas that received lower levels of Winter Precipitation, higher Summer Maximum Temperatures and higher Winter Minimum Temperatures – a pattern that was consistent among all models (Figure 196). Predicted habitat was also higher in areas of higher NDVI Maximum; likely corresponding with the mix of upper elevation vegetation, and lowland riparian vegetation in the areas of predicted habitat (Figure 196, Figure 191). This model had the highest performance among all models, with strong performance measures excepting the BI, although the CBI curve indicated good overall performance (Table 124, Figure 193). Standard error rates were relatively low, but broadly occurring throughout the eastern half of Clark County (Figure 192).

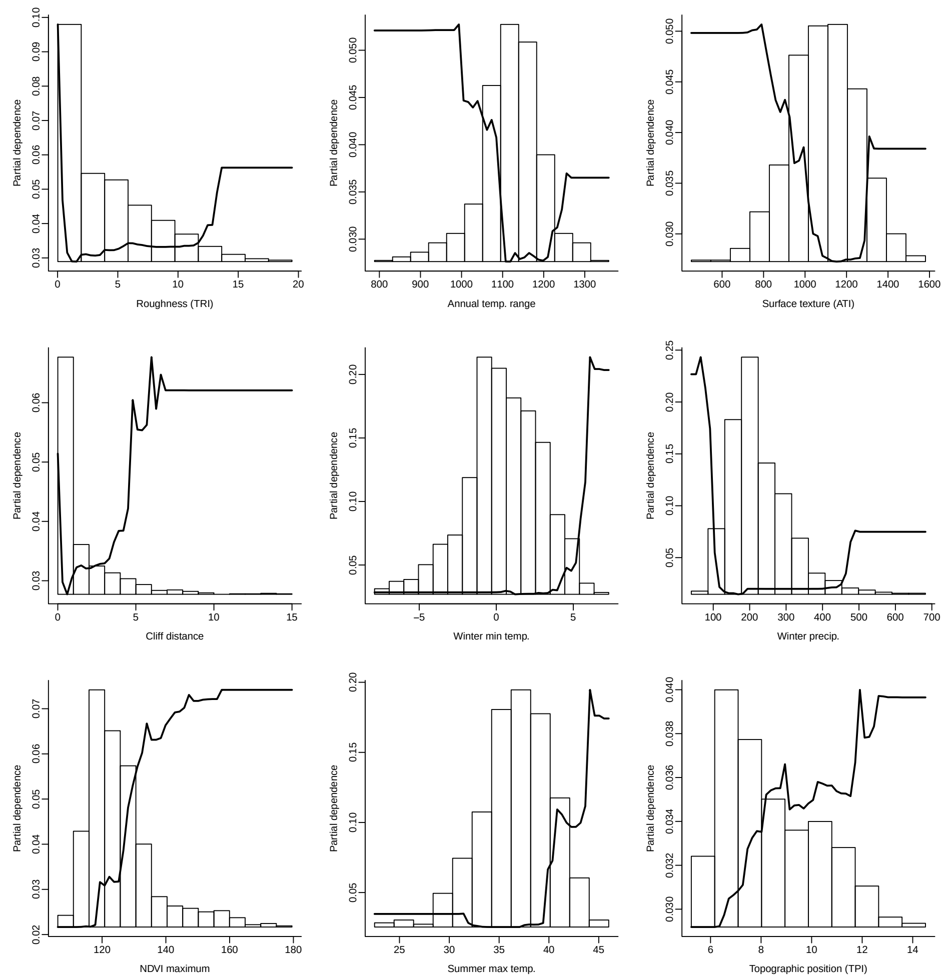

Figure 196. Response surfaces for the environmental variables included in the RF ensemble model for *Macrotus californicus*. Histograms represent the range of each environmental variable across the x-axis, and predicted dependence relative to habitat suitability values are on the y-axis.

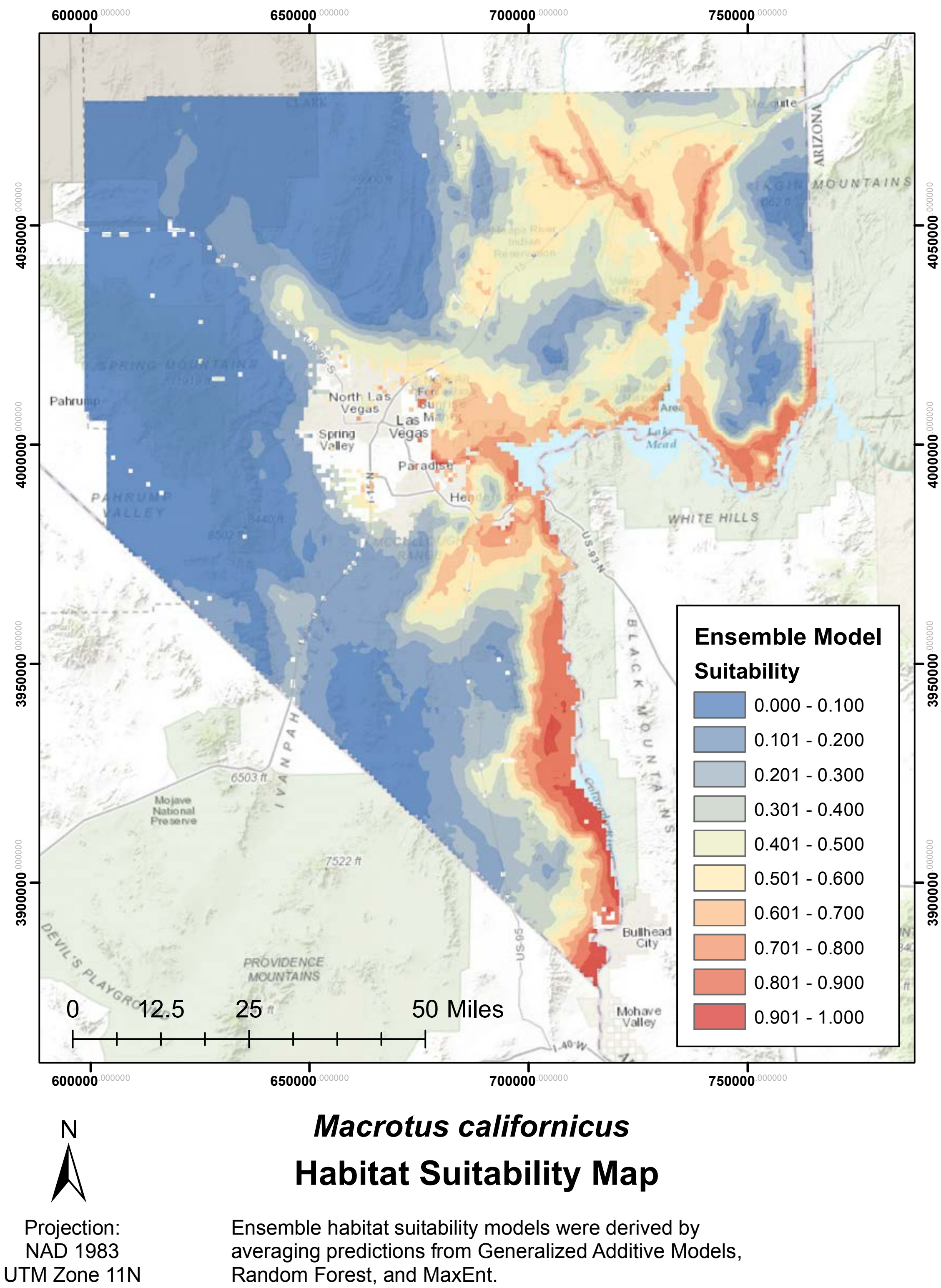

Figure 197. SDM map for the *Macrotus californicus* ensemble model.

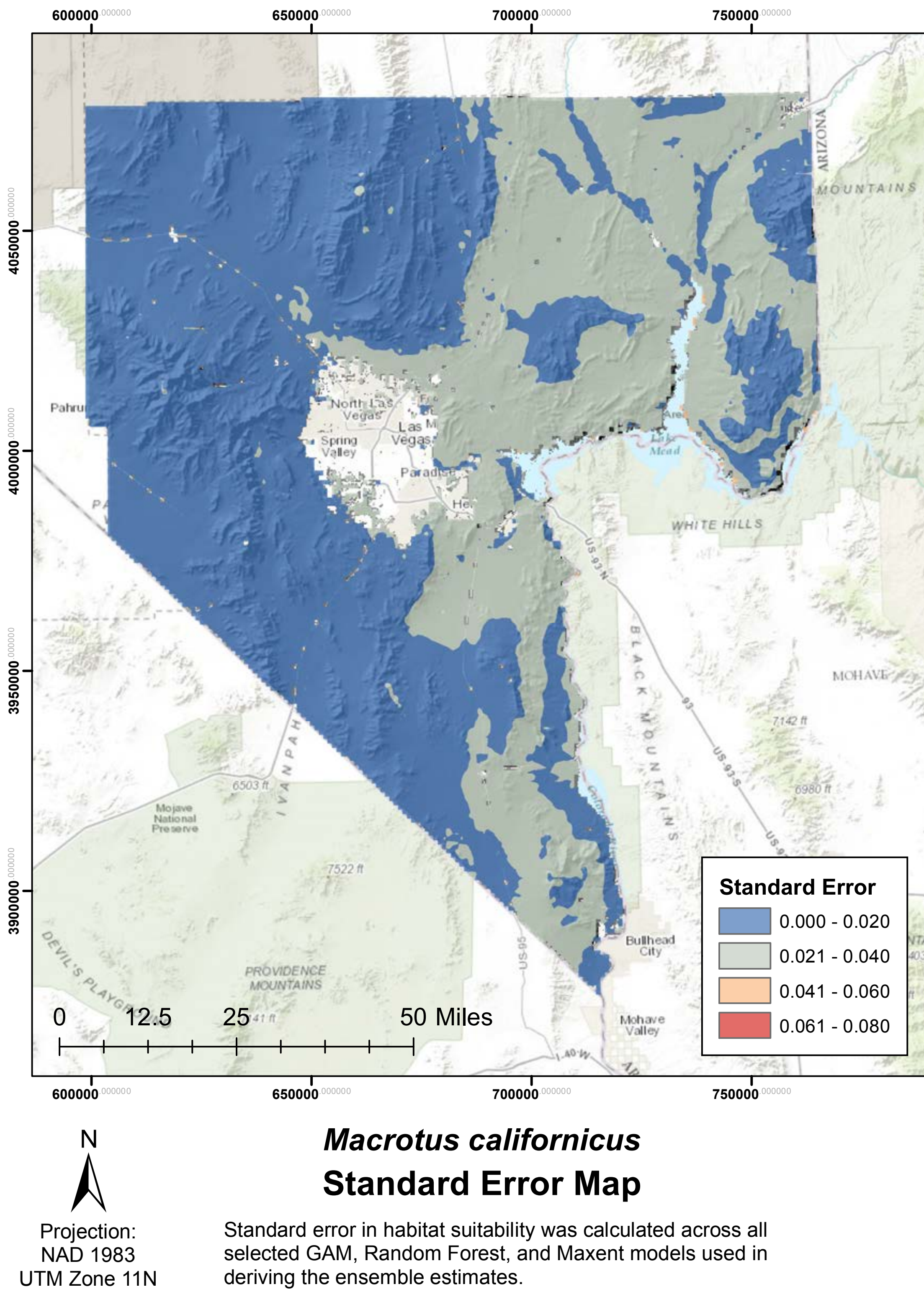

Figure 198. Standard Error map for the *Macrotus californicus* ensemble model.

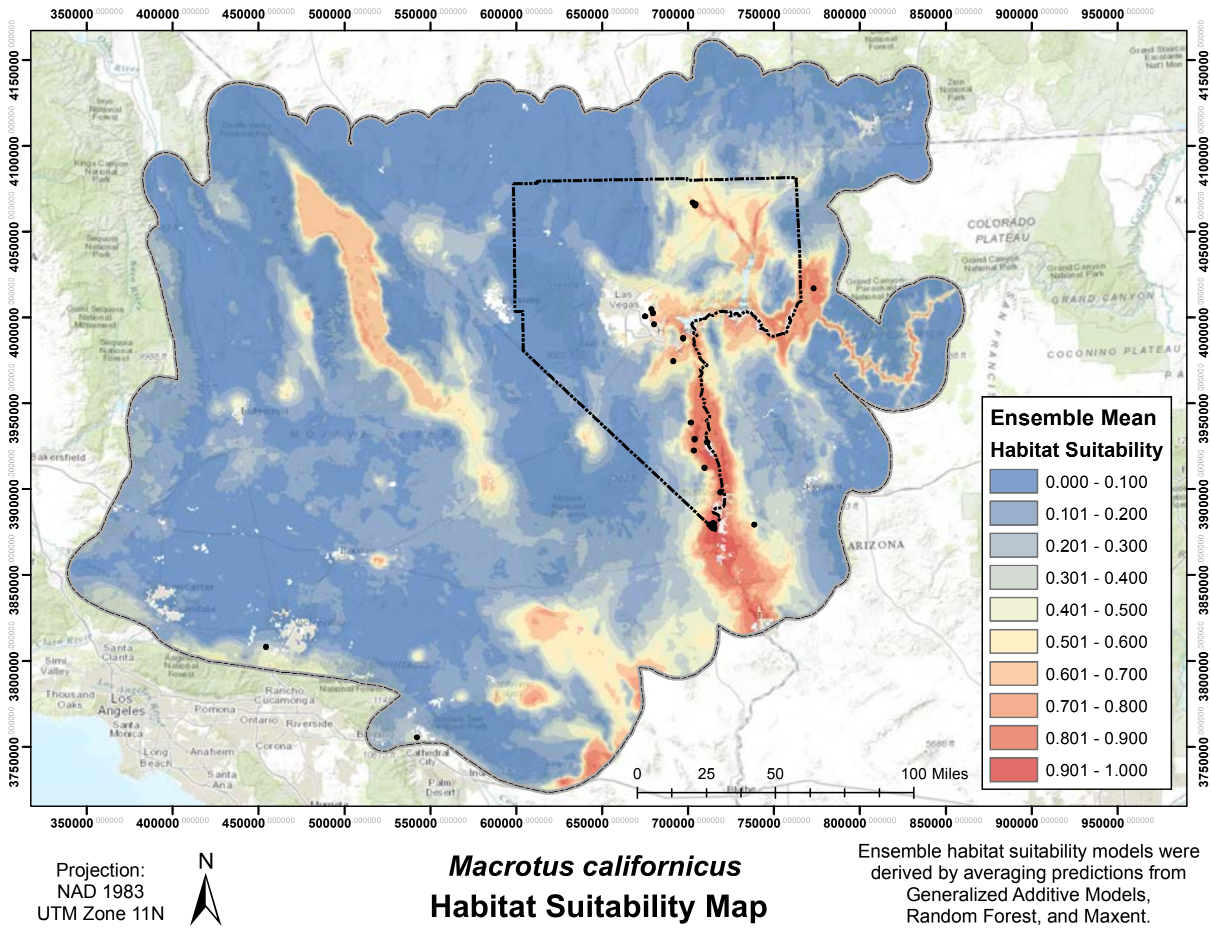

Figure 199. Predicted habitat map for the *Macrotus californicus* ensemble model at the scale of the Mojave Desert.

Distribution of Localities

Localities for California Leaf-nosed Bats are distributed along the eastern portion of the county largely along riparian areas. Thirty-two of 36 total observations for the Mojave were located within Clark County (Figure 191). Mojave Desert observations outside the county were either across the Colorado River in Arizona (N=2), or at the western fringe of the Mojave Desert near Palm Springs and Victorville, CA (Figure 199).

Standard Error

The standard error for the habitat suitability model for California Leaf-nosed Bats consisted of widespread pattern of moderately low values (SE 0.02 to 0.04) throughout the general predicted habitat area, with very low values in the western half of Clark County where the bats are presumed to be absent (Figure 192, Figure 198).

Distribution and Habitat Use within Clark County

Studies have identified California Leaf-nosed Bat in southeastern Clark County occupying caves and mines in mountains along the Colorado River. Locations include Frenchman's Mine east of Las Vegas, Hemenway Wash and near the Cottonwood Cove area, and on the cliffs west of Lake Mohave, and Cottonwood Valley, 31 miles north of Needles (Howell et al. 1937, Bradshaw 1961 *and literature therein*, Cockrum and Cross 1965,). Williams et al. (2006) detected this species among 15 other species in acoustic sampling conducted in four habitat types along the Muddy River in upper Moapa Valley, noting that they were found to be distributed equally in the four habitat types sampled (riparian marsh, mesquite bosque, riparian woodland, and riparian shrubland). Habitat for this species was predominantly in lower elevation ecosystems with higher suitability habitat predominantly in Mojave Desert Scrub, including Mesquite Acacia, and Desert Riparian areas (Table 126). Moderate habitat mirrored this pattern, while higher elevation ecosystems were largely classified as lower quality (e.g. Alpine, Bristlecone Pine, Pinyon Juniper, Mixed Conifer, and most of Blackbrush ecosystems; Table 126).

Modeled habitat in the county is predicted to be high nearest or in habitats adjacent to riparian ecosystems (Figure 197). These are most highly predicted along the southern Colorado River drainage along Lake Mojave, but also throughout the shorelines of Lake Mead, the Las Vegas wash and Lake Las Vegas area in the eastern Las Vegas Valley, and in the upper extent of the Overton Arm of Lake Mead, including the lowlands encompassing the Muddy and Virgin River drainages. Lower level habitat was predicted adjacent to these areas (Figure 197). The MaxEnt and Ensemble models had similar performance statistics, however NDOW commented that the MaxEnt model appeared to be more accurate for this species in their experience (NDOW *pers comm*). The habitat predictions, when considering the remainder of the Mojave, support the prediction of habitat continuing down the Colorado River drainage into Arizona. Moderate suitability habitat was also predicted within Death Valley National Park, near the Salton Sea in California, and a small patch just east of Barstow, but no *Macrotus* have been documented in any of those places (Figure Mojave Map). The patch described west of Barstow is also identified for other bat species that were modeled in this program, but for which there are no documented sightings (Figure 199).

Table 126. Ecosystems within Clark County, and the area (Ha) of Low Medium and High predicted suitability within each ecosystem.

Ecosystem	Low	Medium	High
Alpine	124	0	0
Blackbrush	413335	2213	0
Bristlecone Pine	7565	0	0
Desert Riparian	1	2045	8809

Ecosystem	Low	Medium	High
Mesquite Acacia	7756	6179	5973
Mixed Conifer	27339	0	0
Mojave Desert Scrub	517790	519703	253726
Pinyon Juniper	115902	0	0
Sagebrush	4707	0	0
Salt Desert Scrub	71005	7252	1646

Ecosystem Level Threats

Ecosystem level threats to this species include, mine-shaft abatement, and energy development projects that interfere with foraging flyways (IUCN 2016). Mine-shaft abatement is detrimental to bats if it excludes bats from former roost sites. As with other bat species renewable energy development can be detrimental to bat populations. Solar development can destroy habitat during buildout, while wind energy can be detrimental after it is installed due to propeller strikes or by trauma induced to bats by the extremely low pressure areas associated with the movement of the propeller through the air – known as barotrauma (Cryan and Barclay 2009, Cryan 2011).

Threats to Species

The Revised Nevada Bat Conservation Plan (Bradley et al. 2006) indicates that recreational caving; mine reclamation; renewed mining; water impoundments; availability of desert wash riparian vegetation are conservation concerns for the California Leaf-nosed Bats. They are also behaviorally sensitive to roost disturbance. Populations in adjoining states are declining. Wind turbines in proximity to caves and structures used by bats may impact bats directly by killing animals in turbine blade collisions or through barotrauma (Arnett et al. 2008, Baerwald et al. 2008). White-nose syndrome has not been documented to affect this species, although the spread of this disease throughout the United States is of concern to all bat species.

Existing Conservation Areas/Management Actions

Based on known localities, important areas of conservation concern are likely to be near riparian areas and protected areas near there. Existing conservation areas include Lake Mead National Recreation Area, Desert National Wildlife Refuge, several Bureau of Land Management or National Forest Service Wilderness Areas, Red Rock Canyon National Conservation Area, Areas of Critical Environmental Concern that are set aside for the Mojave Desert Tortoise and other sensitive species, and Valley of Fire State Park.

To assess the conservation status and to identify appropriate management actions for this species it is considered in the Revised Bat Conservation Plan (Bradley et al. 2006). However, few actions particular to this species are identified. General items include preserving roosts in abandoned mines, reducing disturbances near occupied roosts, and protecting desert feeding areas.

Summary of Direct Impacts

Higher quality habitat for this species are relatively evenly spread across Impacted and Conserved areas, while about 43% of the higher suitability habitat is likely already disturbed, although the degree to which that effects this species is unknown (Table 127). Far more moderate habitat is slated to be conserved, than that predicted to be impacted (Table 127).

Table 127. Categorized modeled habitat values (High, Medium, and Low) and the average area (Hectares) predicted in the potential impact areas, conservation areas, already disturbed areas, and overall area

Habitat Level	Impact	Conserved	Disturbed	Area (Hectares)
High	30870	33764	14863	274720
Med	48968	191045	23919	544463
Low	42683	288222	12619	1196037

MEPO - Polished Blazingstar (Mentzelia polita)

Polished Blazingstar *(Mentzelia polita)* is an herbaceous perennial first described in 1909. Specimens were collected by Leslie N. Goodding on a botany trip in 1905 through southern Nevada (Goodding 1905). Several years later, Aven Nelson described the species from the previous collections that had been stored at the University of Wyoming (Nelson 1909). Other than morphological descriptions found in manuals (Christy 1998, Brokaw 2017) and a phylogeny (Schenk 2011) comparing more recently discovered *Mentzelia* species with *M. polita,* little has been published about this plant since it was first described in 1909.

Species Status

US Fish and Wildlife Service Endangered Species Act: No status
US Bureau of Land Management (Nevada): Sensitive
US Forest Service (Region 4): No status
State of Nevada (NAC-527): No status
NV Natural Heritage Program: Global Rank G2 State Rank S1S2
IUCN Red List (v 3.1): No status
CITES: No status

Range

Little is known about the historic or current populations of Polished Blazingstar. Historical herbaria collections and more current occurrence records from NNHP and SEInet are the only known sources for range distributions. The Polished Blazingstar is limited to gypsum rich soils in the hills and washes of mountain ranges in California, Nevada, and Arizona. In California, its range is limited to the northeast part of the Clark Mountain Range just west of Primm, NV (Brokaw et al. 2017). In

Arizona, the only known location is in Northern Mohave County (the Arizona Strip), somewhere south of Colorado City, AZ (Christy 1998). In Nevada, it has been found in the foothills of mountain ranges surrounding the Las Vegas metropolitan area and its range in Nevada is described in more detail below.

Population Trends

There are no quantitative population trend data available for this species. Qualitatively, it seems likely that certain historical populations of Polished Blazingstar were extirpated due to urbanization of the Las Vegas metropolitan area. When first collected, Polished Blazingstar was found in the washes among hillsides of Las Vegas, Nevada (Nelson 1909). In the larger Las Vegas Valley, he collected from Mesquite Spring (now near the junction of Sunset Road and Green Valley Parkway), Las Vegas Wash, the "hills near the town of Las Vegas", and Tule Ranch (Tule Springs). His records show that he collected two other Mentzelia species from Tule Springs but the vouchers no longer exist, therefore the species remain unknown. Remnants of a historical population (based on three remaining plants) found in 1998 in the Las Vegas Springs Preserve are in the NNHP database. Two of the three plants found at the Preserve were located in an area that was restored in 2000. It seems likely that the plants were removed during the tilling process for soil restoration. It's unknown if the Polished Blazingstar plants survived, were replaced, or reseeded at the Preserve.

Habitat Model

Model Results

There were 19 localities for this species in Clark County, with an additional 19 localities outside the County. We expanded our modeling extent to include the broader distribution of localities in areas of the Mojave Desert in California as there were too few locations to create Clark County specific models for this species.

The individual algorithm predictions had a gradation where the GAM model produced the broadest area of predicted habitat, the RF models are intermediary, and the MaxEnt model predicted the least amount of habitat, and the Ensemble model by design represents an average of these (Figure 200). Generally speaking the models appear to predict higher habitat suitability in the mid to lower bajadas around the major mountain ranges in the county, especially in the western and northern extents (Figure 200).

Performance metrics indicate that the Ensemble model had the highest performance among all models, with the highest BI, and the second highest AUC, TSS and Correlation. The RF model had the highest AUC and TSS, but he second highest BI, and the third highest Correlation. The MaxEnt model had the third highest overall performance followed by the GAM model, which appears largely over-predictive and had the lowest in 3 of 4 performance metrics (Table 128).

The Continuous Boyce Index indicated good performance for each of the models, showing a strong increase in predictive agreement with presence values above 0.06 for most models (Figure 202). Standard errors were greatest for the GAM model, which had higher levels of error predicted (0.08 - 0.1) for many areas throughout the county, the RF model had limited higher SE values surrounding the Las Vegas Valley and in a few other locations (e.g. Pahrump, Mormon Mesa/Mountains), while the MaxEnt model had higher SE in limited areas (e.g. the eastern shore of Lake Mead at Gold Butte, and the southwestern extent of Las Vegas Valley. The ensemble model had relatively limited areas with high error, but with much broader areas of moderate SE (0.04 - 0.06) located throughout the county (Figure 201). Approximated bins for the ensemble model based on the CBI were 0-0.35 unsuitable, 0.35-0.4 marginal, 0.4 to 0.5 suitable, and > 0.55 optimal habitat; with a suggested cutoff threshold of ~ 0.55 (Figure 202) and the threshold value calculated from ROC (AUC) statistics for the ensemble model was 0.54 (Table 128).

Table 128. Model performance values for Polished Blazingstar (*Mentzelia polita*) models.

Performance	GAM	RF	MaxEnt	Ensemble
AUC	0.98	0.99	0.98	0.99
BI	0.67	0.72	0.58	0.77
TSS	0.92	0.96	0.93	0.95
Correlation	0.68	0.73	0.81	0.78
Cut-off*	0.54	0.63	0.18	0.46

*threshold at which sum of sensitivity (true positive rate) and specificity (true negative rate) is highest

Table 129. Percent contributions for input variables for Polished Blazingstar (*Mentzelia polita*) for ensemble models using GAM, MaxEnt, and RF algorithms.

Term	GAM	RF	MaxEnt	Average
NDVI Amplitude	12.45	17.54	4.41	11.74
NDVI Maximum	3.87	9.96	3.74	6.01
Summer Precipitation	47.75	19.59	41.80	36.68
Winter Precipitation	0	0	0.19	0.06
Summer Maximum Temperature	0	0	1.30	0.43
Winter Minimum Temperature	27.90	13.71	38.16	26.80
Slope	0	9.76	0.00	3.40
Topographic Position (TPI)	0	5.20	0.00	1.82
Surface Texture (ATI)	8.05	13.83	7.77	10.10
Surface Roughness (TRI)	0	10.40	2.63	4.51

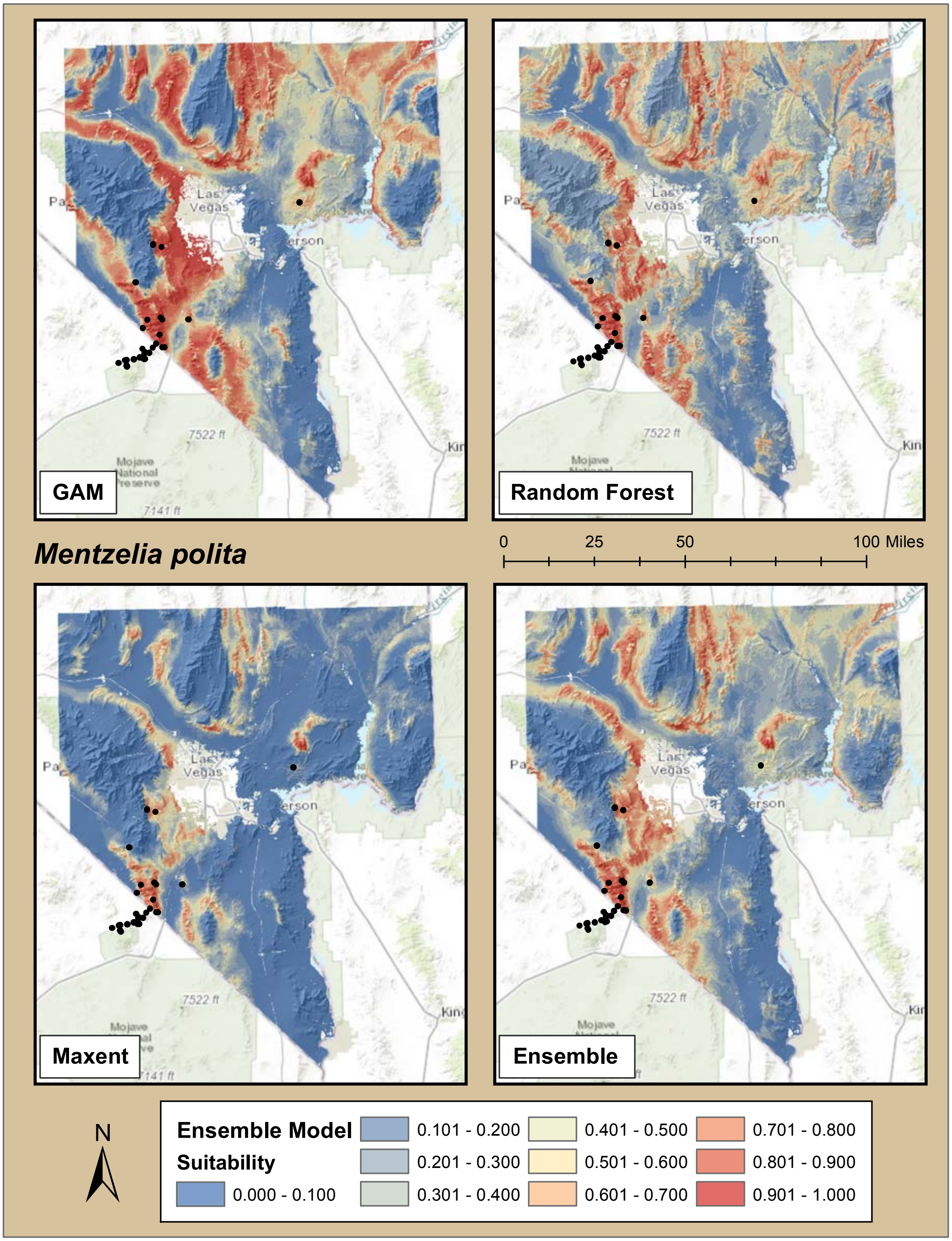

Figure 200. SDM maps for *Mentzelia polita* for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

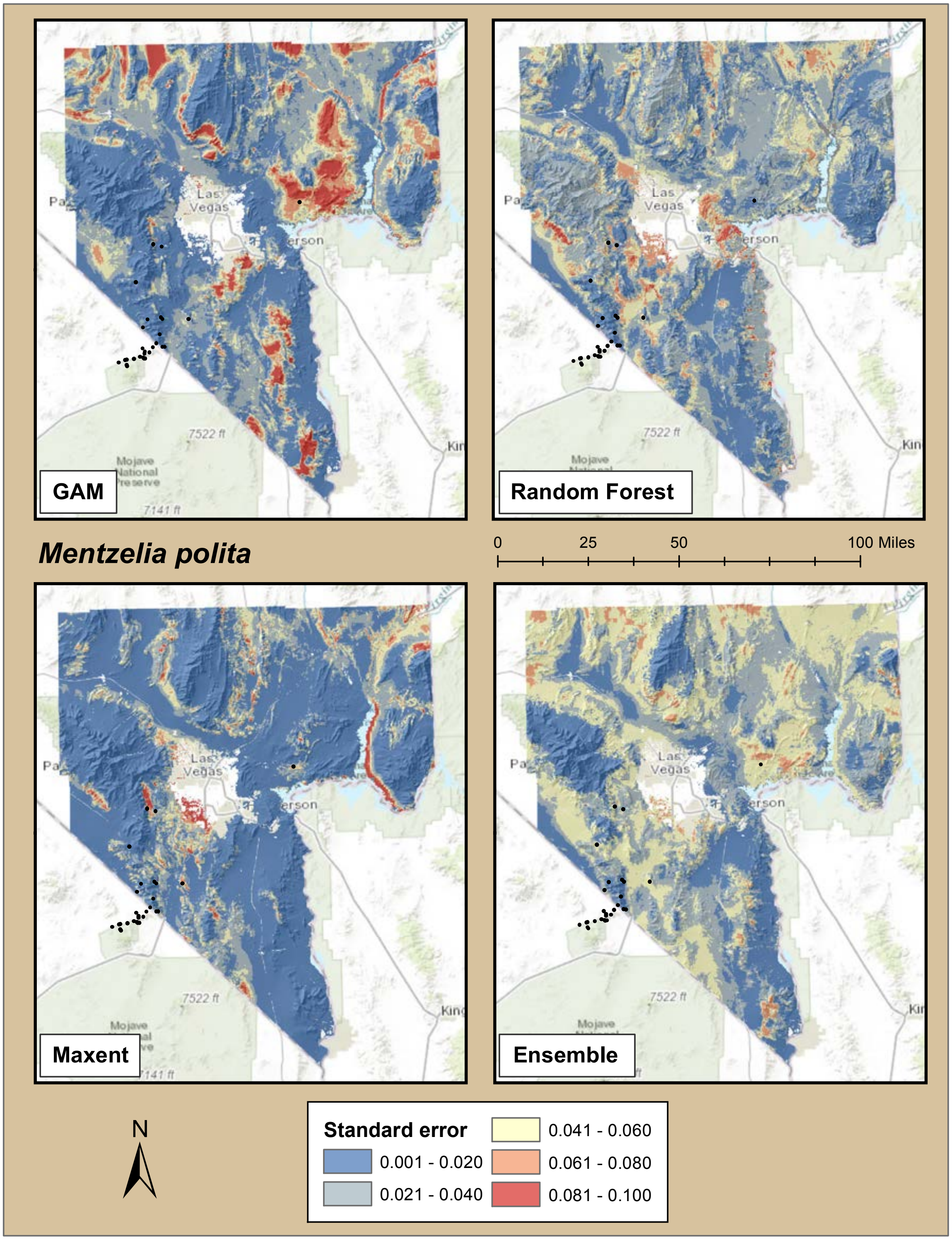

Figure 201. Standard error maps for *Mentzelia polita* models for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

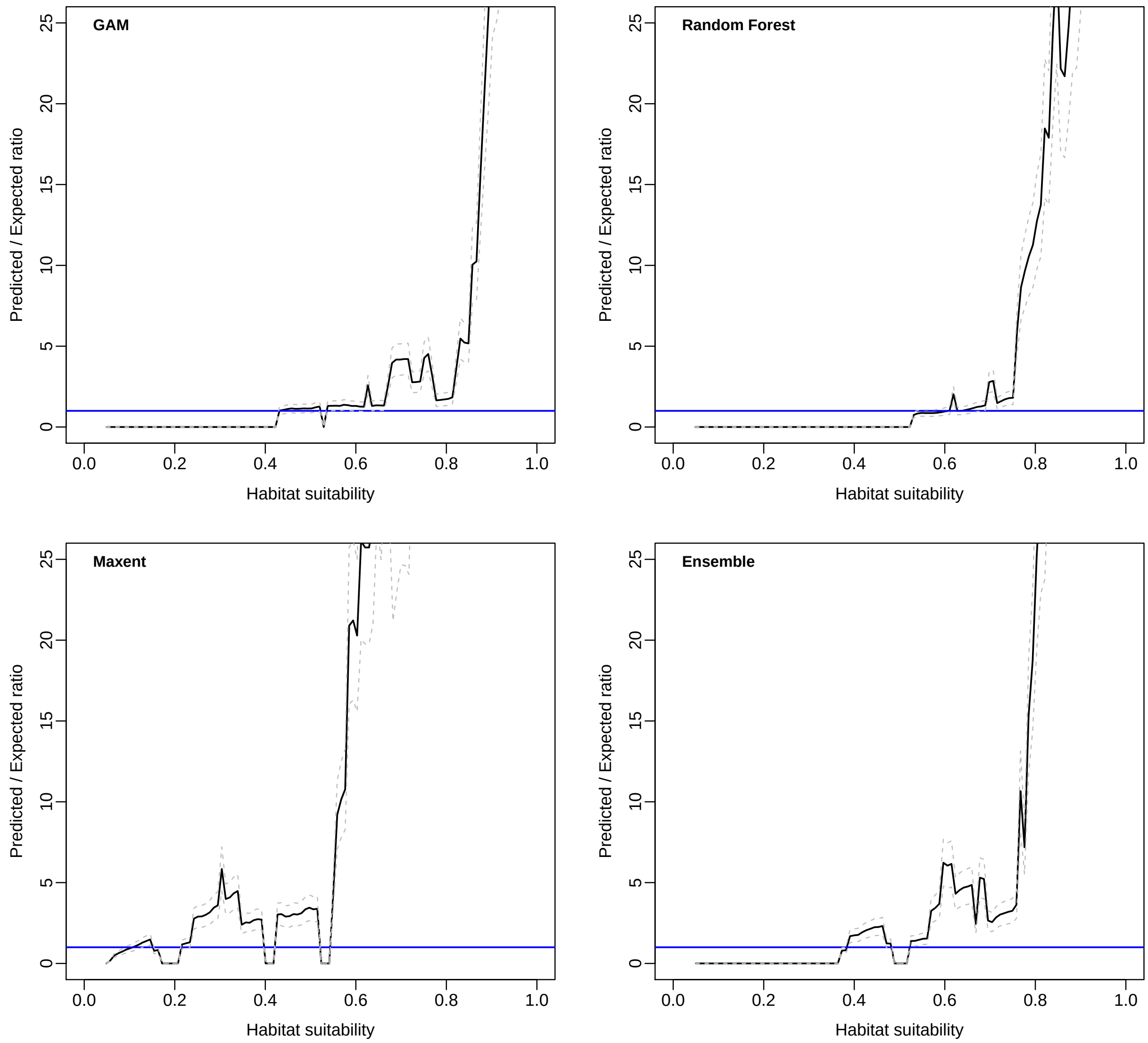

Figure 202. Continuous Boyce Indices for *Mentzelia polita* models for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

GAM Model

There were three contributing variables in the GAM model ensemble identified with more than 8% contribution toward the model (Summer Precipitation, Winter Minimum Temperature, NDVI Amplitude, Surface Texture), collectively accounting for 96% of the total model contribution (Table 129). Summer Precipitation (48%) had the highest contribution, with a peaked predictive response of habitat suitability, where habitat suitability was predicted to be highest at precipitation values between 40 and 100 mm. Winter Minimum Temperature (28%) also had a peaked response of habitat suitability, with the highest suitability matching the distribution of this variable in the habitat and positive influence between -1 and 2.5 ºC (Figure 203).

NDVI Amplitude indicated a negative relationship with habitat suitability, where it asserted a positive influence on predicted habitat suitability below 10, and progressively negative at higher values. Surface Texture exhibited a negative response, where highest habitat suitability was predicted in the lowest values, indicating a preference toward rockier substrates (Figure 203).

The GAM model had the broadest extent of predicted habitat among the three algorithms, with high suitability predicted in the lower and middle bajadas around the Spring Range, Sheep Range, Lucy Gray Mountains, and the upper Mormon Mesa (Figure 200). Moderate habitat was predicted in a limited area in the northeastern part of the County. This algorithm had high standard error values (0.08 to 0.1) in several areas throughout the County, notably in the Highland and McCullough mountains, and especially the Muddy Mountains near Lake Mead (Figure 201).

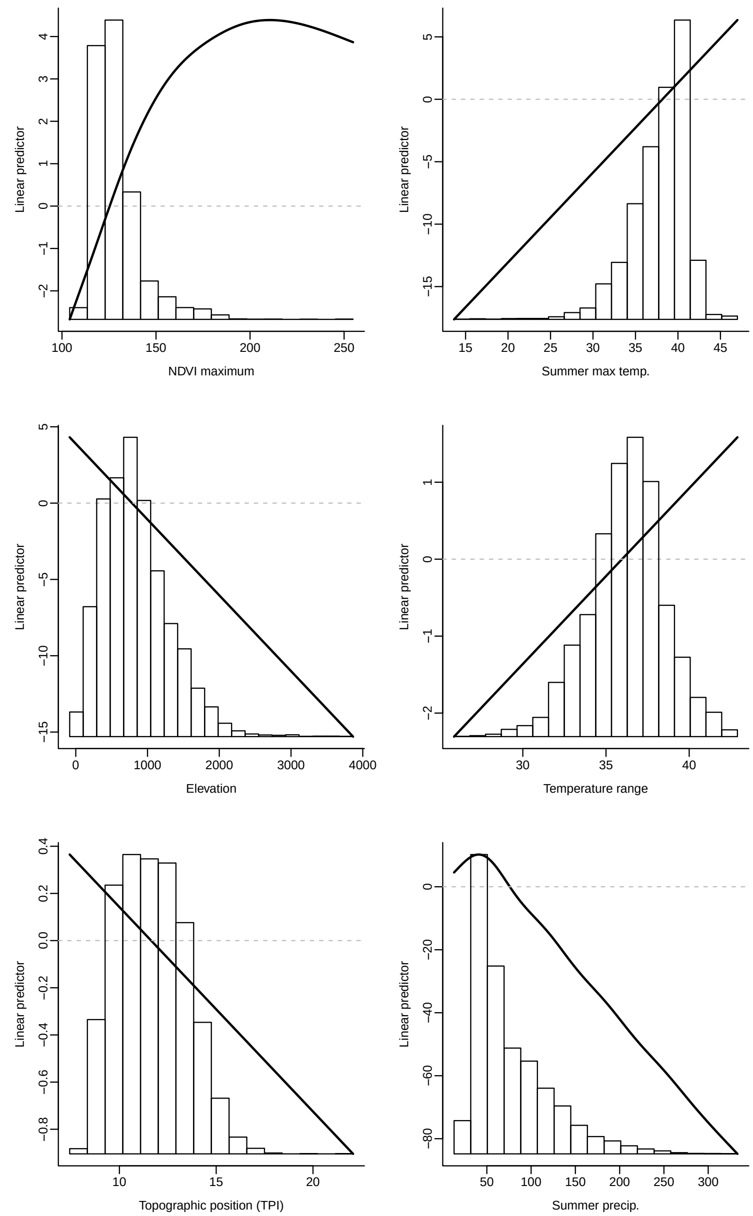

Figure 203. GAM partial response curves for the *Mentzelia polita* model overlaid over distribution of environmental variable inputs in the study area.

MaxEnt Model

The MaxEnt model had three variables (Summer Precipitation, Winter Minimum Temperature, Surface Texture) that contributed 7% or more to the model, accounting for 88% of all model contributions (Table 129). Summer Precipitation 42%, had a peaked response at ~ 70 mm, with lower habitat suitability predicted above 100 mm and below 25 mm. Winter Minimum Temperature (38%) was the second highest contributor, with a peaked response at lower levels of winter precipitation (150 mm), and with decreased suitability predicted above 200 mm. Surface Texture (8%) had a negative relationship with predicted habitat suitability, where predicted suitability was highest at lower values, indicating a preference for rockier habitats (Figure 204).

The standard error map for this algorithm showed the least relative error, with limited areas of higher standard error (0.08 - 0.1) near southwestern Las Vegas, and along the eastern shore of the Overton arm off Lake Mead near Gold Butte (Figure 201).

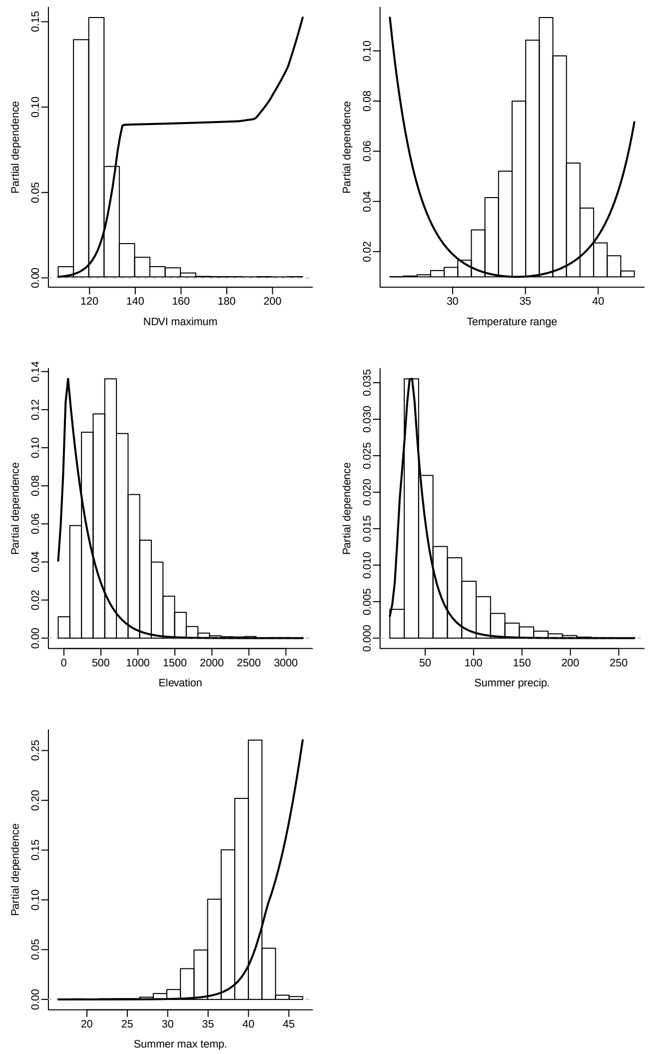

Figure 204. Response surfaces for the top 9 environmental variables included in the MaxEnt ensemble model for *Mentzelia polita*.

Random Forest Model

The RF models had seven environmental variables contributing 10% or more totaling 97% of total model influence (Summer Precipitation, NDVI Amplitude, Surface Texture, Winter Minimum Temperature, Surface Roughness, NDVI Maximum, Slope; Table 129). The highest contributing variable was Summer Precipitation

(20%), which has a peaked response predicting suitably at precipitation levels between 60 and 90 mm, with the lowest levels below, and moderate habitat above that window (Figure 201). NDVI Amplitude contributed 18%, predicting higher levels of habitat at lower amplitudes of NDVI. Surface Texture (14%) had a sharp negative response, where habitat suitability was high at lower values of texture, corresponding with rockier substrates. Winter Minimum Temperature (14%) had a peaked response, with higher habitat suitability in areas where the Winter Minimum Temperature was between -1 and 2.5 ºC. Surface Roughness (10%) had a thresholded response where tiger roughness generally indicated increased habitat suitability, peaking at values above 20. NDVI Maximum (10%) indicated higher suitability at lower values, indicating preference for areas of lower plant density (Figure 205). Finally, Slope (10%) indicated a preference for areas with steeper slopes, which corresponds with typical rockier substrates with increased roughness (Figure 205).

Standard error maps for this model had decreased areas of higher error values relative to the GAM model, with the highest SE (0.08 - 0.1) surrounding the Las Vegas Valley and near Pahrump (Figure 201).

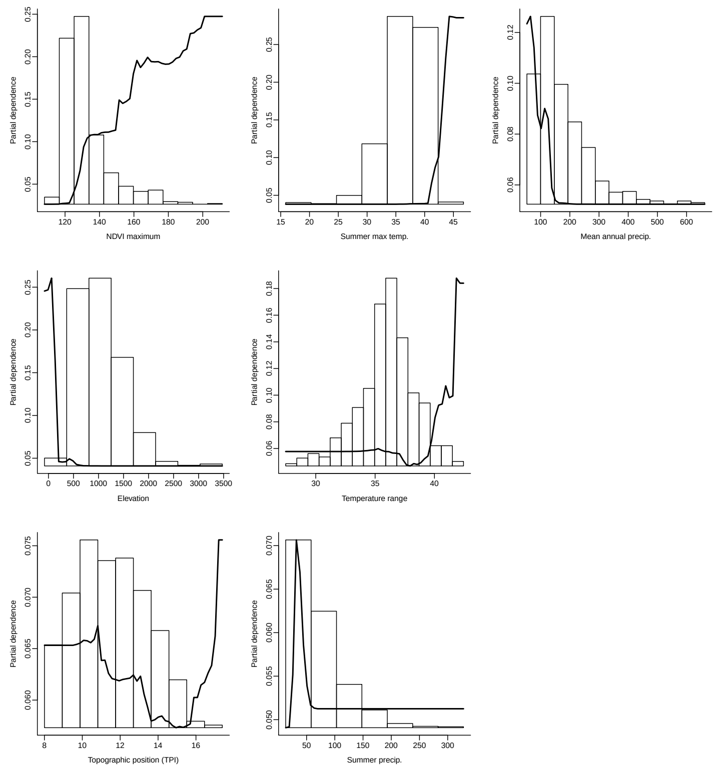

Figure 205. Partial response surfaces for the environmental variables included in the RF ensemble model for *Mentzelia polita*. Histograms represent the range of each environmental variable across the x-axis, and predicted dependence relative to habitat suitability values are on the y-axis.

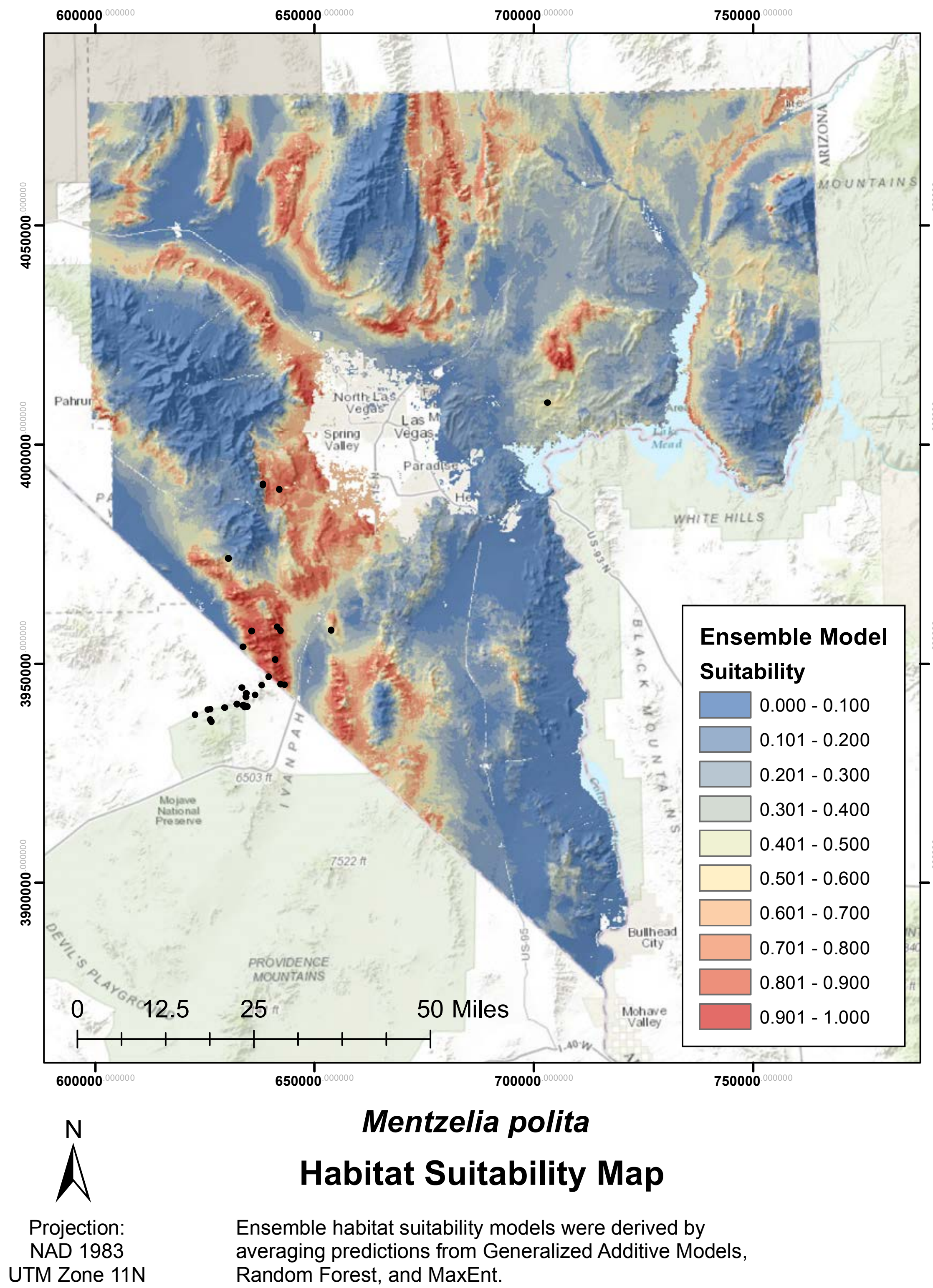

Figure 206. SDM map for the *Mentzelia polita* Ensemble model.

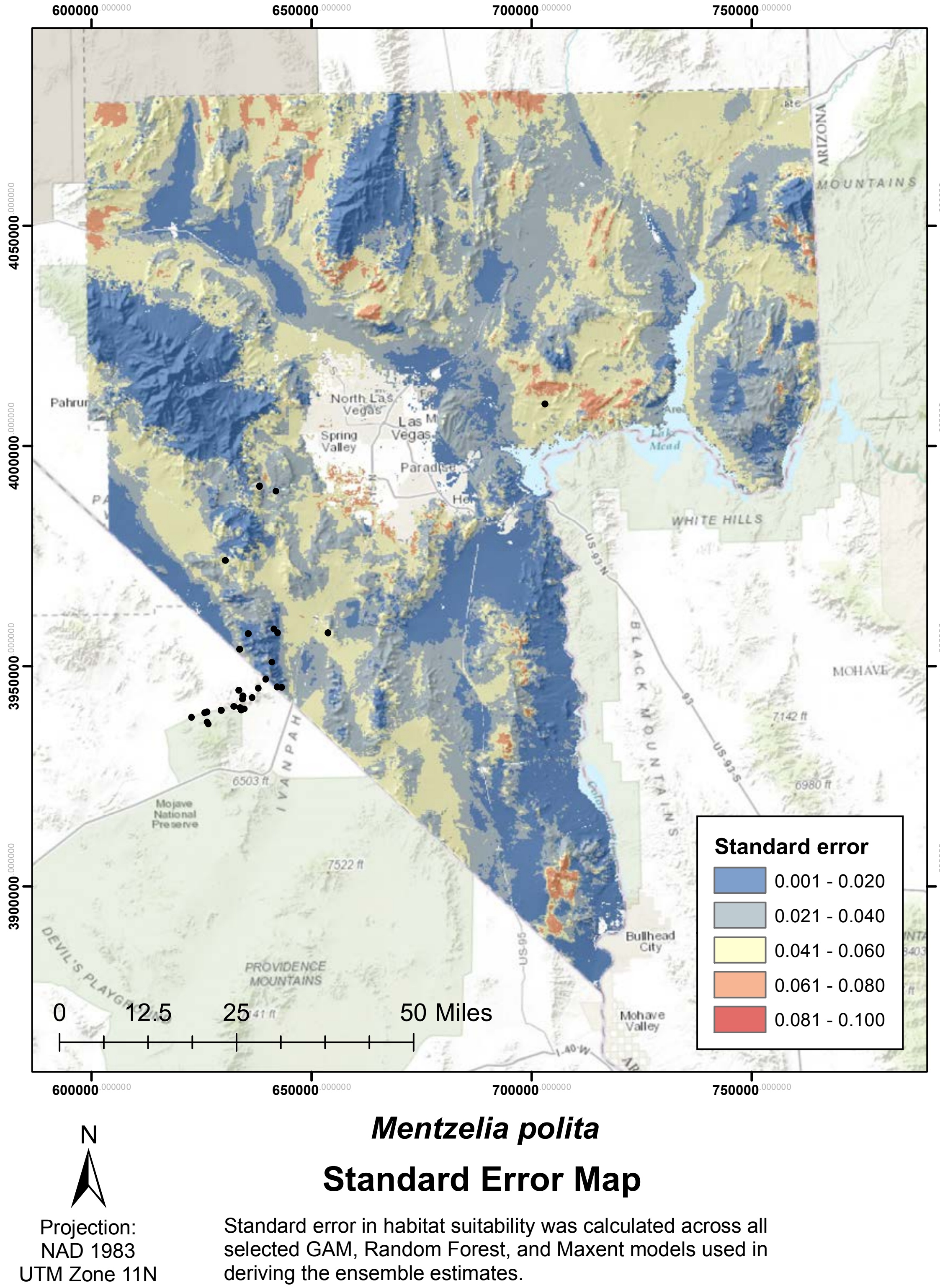

Figure 207. Standard Error map for the *Mentzelia polita* Ensemble model.

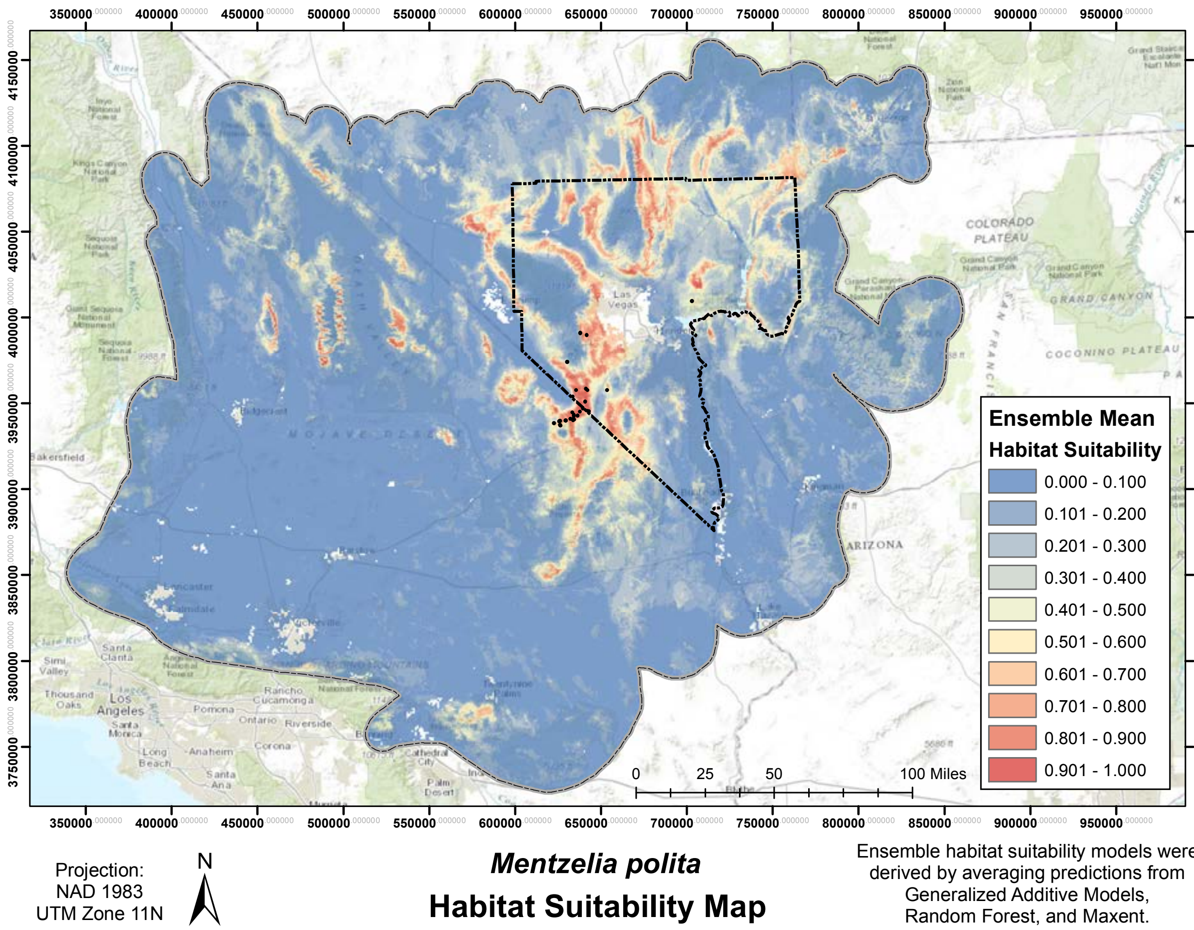

Figure 208. Habitat suitability map for the *Mentzelia polita* ensemble model for the Mojave and western Sonoran Desert.

Distribution of Localities

Localities (N=38) for Polished Blazingstar are found largely in the western portion of the county near the Bird Spring Range extending into California along the Clark Mountain Range in the State Line Wilderness Area (Figure 206). Other localities continue into the Stateline Wilderness area in California on the southern extent of Mesquite Valley (Figure 208).

Standard Error

The standard error for the ensemble habitat suitability model for Polished Blazingstar indicates largely moderate levels error (SE 0.04 – 0.06) throughout the county, especially in lower elevation (Figure 207).

Distribution and Habitat Use within Clark County

Polished Blazingstar is restricted to gypsum, limestone, or mixed gypsum in clay soils (Christy 1998, Brokaw 2017). It is usually found in washes among limestone hills. In Clark County, it has been found in the foothills of the Spring Mountains, south of Potosi Mountain; the hills south of Jean; West End Wash near the Muddy Mountains;

and in the Stateline Hills and the washes among those hills. Plant discoveries closest to development and human impact include those in the Las Vegas Springs Preserve, plants near the Spring Mountain Ranch Park, and two occurrences near the Sultan and Milford Mines. Ecosystems within the county that contain high and moderate suitability habitat include Mojave Desert Scrub, Blackbrush, and Salt Desert Scrub habitats, with smaller areas predicted for Mesquite Acacia ecosystems (Table 130). Moderate habitat for the species is predicted to be in similar ecosystems (Table 130).

Modeled Habitat in the county is predicted to be highest in the western portion of the county, from Las Vegas to the California border on the north side of I-15 (Figure 206). Other areas of predicted suitable habitat include the bajadas and foothills of the Spring Range, and Sheep Ranges, and the Muddy Mountains (Figure 206).

Table 130. Ecosystems within Clark County, and the area (Ha) of Low Medium and High predicted suitability within each ecosystem.

Ecosystem	Low	Medium	High
Alpine	124	0	0
Blackbrush	170873	134023	109669
Bristlecone Pine	7565	0	0
Desert Riparian	8584	1969	94
Mesquite Acacia	15223	3142	1319
Mixed Conifer	27339	0	0
Mojave Desert Scrub	717463	405740	154185
Pinyon Juniper	114776	958	112
Sagebrush	4493	129	83
Salt Desert Scrub	39392	19267	20011

Ecosystem Level Threats

This species occurs in the Mojave Desert scrub in gypsum rich soils usually in the washes among limestone hills (Nelson 1909, Brokaw 2017). Development in these areas likely threatens populations of this species.

Threats to Species

Based on known locations and the soil requirements for Polished Blazingstar, the largest threats to this species are urban development and gypsum mines.

Existing Conservation Areas/Management Actions

Likely due to the lack of knowledge on population size and ecology, there seem to be no regulatory protections designed specifically for Polished Blazingstar. This species benefits mostly from conservation actions designed to protect habitats in general, and other species. Two locations of Polished Blazingstar that are closest to urban Las Vegas and impact are in Red Rock Canyon National Conservation Area and the Las Vegas Springs Preserve.

The Las Vegas Springs Preserve has managed the restoration of several rare and sensitive plants on their land. In the early 2000's (2000-2004) the Preserve restored 90 acres of land. The restoration ecologist responsible for coordinating the project published a research paper focusing on the Las Vegas Buckwheat and Las Vegas Bearpoppy to inform management decisions. These two species along with the Blue Diamond Cholla were the three rare plants that the preserve coordinated its restoration efforts around. Restoration efforts began in 2002 and included scraping and filling of soil at two of the three previously discussed locations of Polished Blazingstar within the Preserve. The other location appears to be a couple meters outside the perimeter of the restoration site. It is unknown if Polished Blazingstar was one of the 70 native plant species that were replanted or reseeded within the restoration zone.

Red Rock Canyon National Conservation Area is required to analyze potential impacts, as mandated by the National Environmental Policy Act, prior to commencing any construction project. The most recent analysis of potential impacts is for the new improvements on the Scenic Loop Drive and its parking areas (BLM 2015). The two plants considered in this analysis were the Blue Diamond Cholla (*Cylindropuntia multigeniculata*) and the yellow two-toned beardtongue (*Penstemon bicolor ssp. bicolor*). The known locations of Polished Blazingstar within Red Rock Canyon are far from roads and therefore will not likely be affected by alterations on the Scenic Loop Drive. There seem to be no other management plans that might affect the polished blazing star. The plant is listed as a sensitive species and so it seems likely Red Rock Conservation Area will consider it during major construction.

Summary of Direct Impacts

Disturbed and Impact areas likely to impact habitat for this species comprise 285 km^2 of predicted higher suitability habitat. High suitability habitat in conservation areas totaled 505 km^2, with an additional 1910 km^2 of additional habitat. Moderate habitat in impact areas totals 326 km^2 of habitat, while relatively little is already disturbed (72 km^2; Table 131).

Table 131. Categorized modeled habitat values (High, Medium, and Low) and the average area (Hectares) predicted in the potential impact areas, conservation areas, already disturbed areas, and overall area

Habitat Level	Impact	Conserved	Disturbed	Area (Hectares)
High	17982	50536	10761	286633
Med	32639	191059	7235	568841
Low	71818	271254	21990	1117364

PEAL - White-margined Beardtongue (Penstemon albomarginatus)

White-margined Beardtongue is an herbaceous perennial in the figwort family (Plantaginaceae, formerly Scrophulariaceae). As the name suggests, the leaves have a fine white margin around the edges. The bright pink to lavender or white corolla also has a white margin and flowers in March to May (Munz 1974). The tap root (30 to 120 cm long) can be more than double the height of the stems (15-35 cm tall) on this rare plant (Holmgren 1993, MacKay 2006). White-margined Beardtongue is yet another psammophyte occurring in deep (>60 cm) stabilized sand deposits. Deep sandy soils accommodate the large taproot which stores resources such that growth and flowering may be less dependent on a given season's rainfall. Even so, the White-margined Beardtongue is dependent on rainfall for seedling establishment (Scogin 1989).

Some insect pollination occurs, but there is speculation that self-pollination may be possible, and it is also hypothesized that vegetative reproduction occurs (MacKay 2006). A study of White-margined Beardtongue pollinators found that pollinators visited this species infrequently, and this is considered unusual among *Penstemon* as a group (Griswold 2013). Furthermore, there are frequently specialist pollinators for *Penstemon* species, but this is not the case for the White-margined Beardtongue, and Griswold et al. (2013) hypothesized that it may be due to the atypically small diameter of the flowers. The pollinators observed visiting White-margined Beardtongue included *Anthidium paroselae, Ashmeadiealla gillettei, A. holtii, A. xenomastax,* and *Lasioglossum sisymbrii.* Visitation rates of pollinators have not been quantified for this flower species, nor have experiments to determine pollination success under various scenarios. Seed dispersal that was measured at Hidden Valley in Clark County, Nevada ranged from 1 to 15 cm. This is in contrast to measurements of blackbrush and Joshua tree seed dispersal that were moved up to 30 m as facilitated by rodent dispersal (Vander Wall et al. 2006). If growth rings can be used to age White-margined Beardtongue, then the range of ages for plants that were sampled is 5 to 35 years, but more work is required to validate those techniques (Etyemezian et al. 2010).

Species Status

The White-margined Beardtongue is a former Category 2 candidate for threatened or endangered status under the Endangered Species Act of 1973. The last ruling on the status of this species was published in the Federal Register on September 30, 1993 where it was determined that the proposal for listing may be appropriate, but that insufficient data on biological vulnerability and threats were available to support the listing at that time (USFWS 1993).

In 2007, the Nevada Native Plant Society's Rare Plant Committee recommended the White-margined Beardtongue be placed on Nevada's List of Fully Protected Species of Native Flora (Nevada Administrative Code 527.010). The Committee listed a number of threats including: potential changes in sand transport and accumulation from proposed Ivanpah Airport, BLM's 90-mile OHV high speed races, mining, and development (Rare Plant Committee 2007, 2008) This petition was denied and the plant was ultimately not listed by the state.

US Fish and Wildlife Service Endangered Species Act: Not listed
US Bureau of Land Management (Nevada): Sensitive
US Forest Service (Region 4): No status
State of Nevada (NAC-527): No status
NV Natural Heritage Program: Global Rank G2, State Rank S2
IUCN Red List (v 3.1): No Status
CITES: No Status

Range

The White-margined Beardtongue occurs in Clark and Nye counties, Nevada; San Bernardino County, California; and in Mohave County, Arizona. They are found at elevations between 300 to 900 m (~2000 and 3000 ft.- Scogin 1989).

Population Trends

The populations in California were surveyed and found to have in excess of 650 individuals. The population on the western slope of the Hualapai Mountains in Mohave County, Arizona is thought to be the largest single population, but the 15 known populations in Nevada are thought to include 1000's of individuals (MacKay 2006). Twelve populations were estimated in Clark County, Nevada and in 1997/98, Smith (2001) estimated 25,964 White-margined Beardtongue in Clark County, and 42,200 plants in Nye County. In 2008/09, estimates were nearly twice those of the previous decade with 125,825 White-margined Beardtongue in Clark County and 78,954 in Nye County, however, these estimates cannot be directly compared due to differences in methods (Etyemezian et al. 2010).

Genetic diversity among 12 populations of White-margined Beardtongue was evaluated and those studies indicated that most populations do not suffer from inbreeding (Wolfe et al. 2016). However, there was a geographic pattern of greater genetic diversity toward the south suggesting post-glacial dispersal of this species from north to south (Wolfe et al. 2016).

Range-wide, population trends are presumed stable, but may be declining in areas with intensive grazing (USFWS 2000). Trends in Nevada were described as unknown by Smith (2001), and Nevada Natural Heritage Program (2001). Populations in Clark County appear to be stable (TNC 2007).

Habitat Model Review

Models for "sand loving species" were produced by Hamilton and Kokos (2011) using the same general methods. First, a soils-based model was created (for all sand species) from the SSURGO data from NRCS. The suite of sand loving species was observed over a wide range of percent sand and thus the initial model was not specific enough to accurately use it for modeling the potential for this group of plants. ASTER imagery was analyzed using principal component analyses to create a binary threshold of the Thermal Infrared band (identifying quartz), and supplementing this remote mapping effort with maps of surficial geology and SSURGO soil coverages. With this information SSURGO units were recoded using a 75% cutoff in the average percent in the top 1 foot of soil and this resulted in 28 sand categories that could be used for plant model classification.

The initial models were used as a basis to construct further sampling for these species by stratifying sampling into high (70% of sample locations), medium (20%) and low (10%) potential of occurrence for each species, and based the number of samples taken on the size of the potential habitat unit. Field surveys using this method resulted in 1 additional observation of White-margined Beardtongue on the survey plots. As these models were considered to be over-predictive and thus MaxEnt models were explored using the combined point set of all occurrences where each species was modeled separately. Environmental data used in the models were based solely on the Bioclim dataset, and no other soils or topography based layers were used.

The MaxEnt for these species was deemed by Hamilton and Kokos (2011) to not be useful for refining their soil based habitat models (although no soils were included in their MaxEnt modeling effort). The SSURGO based soils model was yet further refined using remotely sensed imagery and the resulting soils model was then manually refined to better suit the species by "selecting suitable polygons" that were included in the elevational range for each species – and then eliminating ASTER and SSURGO scores that had no presences within them. Other SSURGO attributes were used to further refine models but specific methods or criteria were not given. The model for White-margined Beardtongue was further refined from the soils model by constraining predicted habitat from 800 to 1100 m in elevation, restricted by SSURGO Bluepoint, Birdspring, Commski or Prisonear soil units, areas with ASTER quartz but no corresponding sand geology removed (Figure 209).

No precision or performance estimates are given for the refined models based on soils and elevation and other adjustments that were applied. MaxEnt models were not compared with the soil based models, nor were outputs provided to calculate other performance scores.

Technical Considerations – The MaxEnt models were all run using 500 iterations with 10 % of points withheld for testing. The data layers used encompassed only the Bioclim dataset despite their assertion that soils likely play an important role in defining the distribution of this species, and no topographic layers were considered.

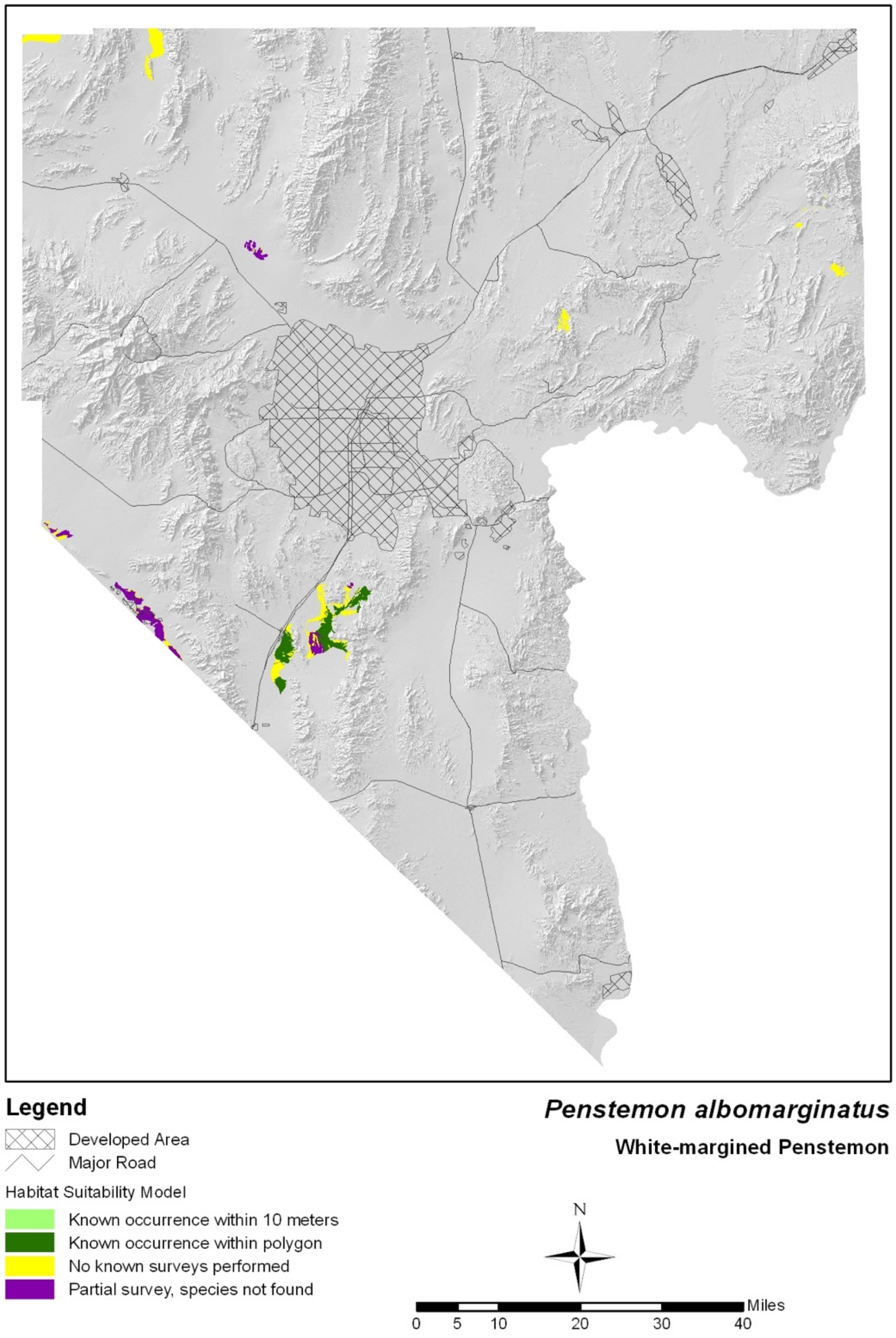

Figure 209. The refined soils based model for *Penstemon albomarginatus* from Appendix A of Hamilton and Kokos 2011.

Distribution and Habitat Use within Clark County

White-margined Beardtongue is found in southern Clark County in Hidden Valley, Jean Lake, Roach Lake, and Ivanpah Valley; these occurrences are centrally located within the global range for the species (TNC 2007). It grows on sand dunes and sand sheets at the base of mountain slopes, or deep sand (>60 cm) in washes and along roads, especially in washes, small dry drainages, foot-slopes, or alluvial terraces (Smith 2001). White-margined Beardtongue is found on the on west-facing slopes where sand has accumulated over geologic time-scales (TNC 2007; Etyemezian et al. 2010). Ecosystems within Clark County projected to contain this species from the sand species habitat model (Hamilton and Kokos 2011) include Mojave Desert Scrub, Salt Desert Scrub, Mesquite Acacia, and Blackbrush to a lesser extent (Table 132).

Comparison of White-margined Beardtongue inhabited sites versus sites without the beardtongue indicate a strong correlation with soils consisting of alluvium covered by eolian sand in both Clark and Nye counties (Etyemezian et al. 2010).

White-margined Beardtongue is found among *Larrea tridentata*, *Ambrosia dumosa*, and *Hilaria rigida* associations. While the beardtongue may be found beneath *A. dumosa* and *H. rigida*, it is never found within the dripline of *Larrea* (Etyemezian et al. 2010). Soil types possessing these characteristics in this region include Bluepoint and Arizo soil series (Etyemezian et al. 2010).

Table 132. Ecosystems within Clark County, and the area (Ha) of Low Medium and High predicted suitability within each ecosystem.

Ecosystem	Low	Medium	High
Alpine	0	0	0
Blackbrush	0	121	255
Bristlecone Pine	0	0	0
Desert Riparian	0	0	0
Mesquite Acacia	35	169	362
Mixed Conifer	0	0	0
Mojave Desert Scrub	4411	3677	5710
Pinyon Juniper	0	0	0
Sagebrush	0	0	0
Salt Desert Scrub	124	477	1501

Ecosystem Level Threats

White-margined Beardtongue occurs in Mojave Desert Scrub Ecosystems of Clark County, Nevada. The primary threats to White-margined Beardtongue in Clark County are urban development, mineral exploration, utility corridor construction and maintenance, invasive plant species, OHV use, livestock grazing, highway and road construction and maintenance, legal and illegal off-highway events, federal land disposal to private ownership which may increase the probability of development, sand and gravel mining, and construction of the planned Ivanpah Airport (TNC 2007). Historical cattle grazing at the Hidden Valley population has disturbed the native vegetation and introduced several species of invasive plants (Sheldon 1994 *in* TNC 2007)

Threats to Species

Some habitat for the White-margined Beardtongue has already been lost to pipelines, powerlines, transportation corridors, and their associated infrastructure (McKay 2006). These types of activities along with urban development and military training within habitats would also be detrimental to this species where it occurs. Heavy and persistent OHV use can damage or kill individual plants in addition to damaging habitat (McKay 2006). Increasing human population size in the Las Vegas metropolitan area will likely result in greater visitation and use to natural areas thus potentially increasing disturbances.

Existing Conservation Areas/Management Actions

A conservation strategy was developed particularly for this species by The Nature Conservancy for the Clark County Desert Conservation Program (TNC 2007). The nine recommended conservation actions for this species are:

- proactively protect and manage for long-term viability all populations on federal lands;
- manage viable populations by removing significant casual off-road vehicle use; control weeds in low elevation rare plant habitats;
- control weeds in low elevation rare plant habitats by 2020;
- ensure that long term viability of low elevation rare plants is not significantly impacted by rural development and sprawl;
- ensure that disposal of federal lands in Clark County will not significantly impact conservation of rare plant populations;
- manage rare plants in sandy habitats for long term viability by addressing altered fire regimes (increased fire frequency and intensity) over the next century;
- manage viable populations of all covered rare plants in utility corridors and potential rights-of-way corridors;
- manage viable populations of White-margined Beardtongue along Federal highways and county roads; and
- ensure construction and maintenance of the Ivanpah Airport does not significantly impact the viability of four White-margined Beardtongue populations on county land (TNC 2007).

In addition, this species' habitat is included in the Nevada's Wildlife Action Plan within the Sand Dunes and Badlands Key Habitat type. The recommended conservation strategy for this habitat includes the objective of maintaining disturbance in sand dune and badland habitats within levels that do not compromise the sustainability of the vegetation and wildlife communities; conservation actions are focused on OHV use, minimizing disturbance, and developing conservation agreements that maintain biodiversity and multiple uses (Wildlife Action Plan Team 2012).

Previous attempts to transplant White-margined Beardtongue have failed, potentially because of the large and sensitive tap root. However, successful cultivation may provide restoration alternatives (e.g. potentially smaller plants could be out-planted), as well as increasing appreciation for the plant as more people come to know it.

An area on the western slope of the Hualapai Mountains in Mohave County, Arizona having the highest White-margined Beardtongue densities was acquired by the Bureau of Land Management in a land exchange with the Santa Fe Pacific Railroad to benefit this species by expanding the lands in an ACEC (Anderson 2001).

Most of the White-margined Beardtongue populations in Clark County are managed for multiple uses by the BLM; however, 10% of the Hidden Valley population is within the Sloan Canyon NCA. BLM has posted signs and conducts enforcement patrols to reduce illegal OHV use and actively manages legal OHV use (TNC 2007).

Summary of Direct Impacts

Habitat for this species totals an estimated 123 km^2 of combined high and moderate modeled habitat (Hamilton and Kokos 2011), 40% of which is likely to be impacted by the proposed MSHCP Amendment, while 35% is located within Conserved areas. Very little habitat for this species is already disturbed (Table 133).

Table 133. Categorized modeled habitat values (High, Medium, and Low) and the average area (Hectares) predicted in the potential impact areas, conservation areas, already disturbed areas, and overall area.

Habitat Level	Impact	Conserved	Disturbed	Area (Hectares)
High	3058	2248	324	7828
Med	1790	2025	60	4446
Low	1720	1042	27	4575

PEBIBI - Yellow Two-tone Beardtongue (Penstemon bicolor ssp. bicolor)

Yellow Two-tone Beardtongue is a short-lived perennial herb in the figwort family (Plantaginaceae, formerly Scrophulariaceae) that flowers in spring. The species was first discovered and collected in 1915 by Katharine Brandegee near Goodsprings, Clark County, Nevada. The plant was named and published as *Penstemon palmeri* ssp. *bicolor* in 1916. Clokey and Keck elevated it to a species, *Penstemon bicolor*, in 1939, with subspecies *bicolor* and *roseus* based on the yellow and rose color forms of the flowers, respectively. Within the last decade, the validity of the subspecies has been questioned. Dr. Noel Holmgren did not recognize the subspecies in California for the Jepson Manual and Desert Jepson Manual (Holmgren 1993, 2002). In a status report submitted to Nevada Power Company and USFWS, Smith (2005) also recommends that the subspecies *roseus* and *bicolor* be lumped together and not be recognized as separate subspecies because recent data on pollination and genetics indicate that there are no significant differences between the subspecies.

Species Status

The Yellow Two-tone Beardtongue is a former Category 2 candidate for Threatened or Endangered Species status under the Endangered Species Act. The last ruling on the status of this species was published in the Federal Register on September 30, 1993 where it was determined that the Yellow Two-tone Beardtongue proposal for listing may be appropriate, but that insufficient data on biological vulnerability and threats were available to support the listing at that time (USFWS 1993).

US Fish and Wildlife Service Endangered Species Act: No status
US Bureau of Land Management (Nevada): No status
US Forest Service (Region 4): No status
State of Nevada (NAC-527): No status
NV Natural Heritage Program: Global Rank G3T2Q State Rank S2
IUCN Red List (v 3.1): No status
CITES: No status

Range

Yellow Two-tone Beardtongue is limited to the mountain ranges of the Mojave Desert. The yellow flowered subspecies *Penstemon bicolor ssp. bicolor* is believed to be endemic to Nevada and is concentrated in the Spring and Bird Spring mountains, with a few other populations in the McCullough and El Dorado mountains (Smith 2005). The range of all variants of *Penstemon bicolor* includes the New York and Castle mountains of California (CCNPS 2017), and the Black Mountains of Arizona, but most of the known populations occur in mountain ranges of Clark County, Nevada (Smith 2005). Besides the previously mentioned mountain ranges, the species has historically been found in the southern Las Vegas Range, and the Muddy Mountains (but they have not been surveyed recently) (Smith 2005).

Population Trends

Of the largest known populations for this species (count of 7000 individuals), about 1/3 of these are the Yellow Two-tone Beardtongue (*P. bicolor ssp. bicolor*) (Smith 2005). In 2005, Smith calculated about a 9% loss for the population of all subspecies of *Penstemon bicolor* based on extirpation of known historical populations. Five of these historical populations were of the Yellow Two-tone Beardtongue and two were of the rose colored *Penstemon bicolor.* These population losses occurred entirely in urban fringe areas of Las Vegas (Smith 2005) It is likely that additional undocumented population losses exist but the 9% loss is considered representatively accurate based on the possibility of finding previously undocumented populations (Smith 2005).

Habitat Model

Model Results

Point locations for Yellow Two-tone Beardtongue (N=288) were used to model this species. Points were generally distributed in the western to southwestern portion of the Las Vegas Valley, which is consistent with the current knowledge of this species in Clark County (see species account). The patterns of predicted habitat suitability produced by the three modeling algorithms showed similar patterns of suitability on the landscape, with decreasing extent predicted from the GAM to the RF, to the MaxEnt predictions (Figure 210). Habitat is predicted generally on the eastern slope of the Spring range, continuing west into the Trout Canyon area of the greater Pahrump Valley, and south into the Goodsprings and Jean area, and into the McCullough range – less strongly so in the MaxEnt model (Figure 210). All models also predict habitat in the south and east of the Sheep Range, and in southern Gold Butte. The RF Model was the highest performing among three of four performance measures, but with the lowest BI score (Table 134). The Ensemble model was the second highest performing, but also had a lower BI score. Most models had similar measures overall, while the GAM model had the lowest performance across 3 of 4 metrics (Table 134).

The CBI indicated strong performance among all models with a later increase in the RF models, which likely led to the lower fixed BI score (Figure 212). Standard errors were lowest for the GAM model (which again had the lowest performance), the RF model had low to moderately low error patches in several areas (SE 0.02 – 0.06), and especially in the extreme western portion of the County. The MaxEnt model had higher error in the Pahrump Valley (Figure 211). The Ensemble model (integrating among model error) had fairly widespread pockets of low to moderately low error around the Sheep Range, Pahrump Valley, Ivanpah corridor, Piute Valley and Gold Butte (Figure 211). Approximated bins for the ensemble model based on the CBI were 0-0.55 unsuitable, 0.55-0.6 marginal, 0.6 to 0.7 suitable, and > 0.7 optimal habitat; with a suggested cutoff threshold near 0.55 (Figure 212) and the threshold value calculated from the AUC analysis for the ensemble model was 0.56 (Table 134).

Table 134. Model performance values for *Penstemon bicolor ssp. bicolor* models.

Performance	GAM	RF	MaxEnt	Ensemble
AUC	0.94	0.99	0.96	0.97
BI	0.83	0.69	0.83	0.80
TSS	0.81	0.91	0.87	0.88
Correlation	0.81	0.89	0.84	0.86
Cut-off	0.58	0.59	0.34	0.56

*threshold at which sum of sensitivity (true positive rate) and specificity (true negative rate) is highest

Table 135. Percent contributions for input variables for *Penstemon bicolor ssp. bicolor* in an ensemble model combining GAM, MaxEnt, and RF algorithms.

Term	GAM	RF	Max	Average
Winter Precipitation	26.26	13.49	31.36	23.70
Summer Maximum Temperature	33.55	20.54	35.28	29.79
Winter Minimum Temperature	30.75	21.82	22.89	25.15
Temperature Range	0	16.57	6.97	7.84
NDVI Amplitude	3.28	8.51	0.28	4.02
NDVI Maximum	0	0	0	0
NDVI (Landsat 8)	0.76	12.36	1.20	4.78
Slope	0.74	0	0	0.25
Topographic Position (TPI)	2.39	0	0.32	0.90
Topographic Position (TPI) b	1.42	0	0.25	0.56
Roughness (TRI)	0.84	0	0	0.28
Surface Texture (ATI)	0	6.71	1.46	2.72

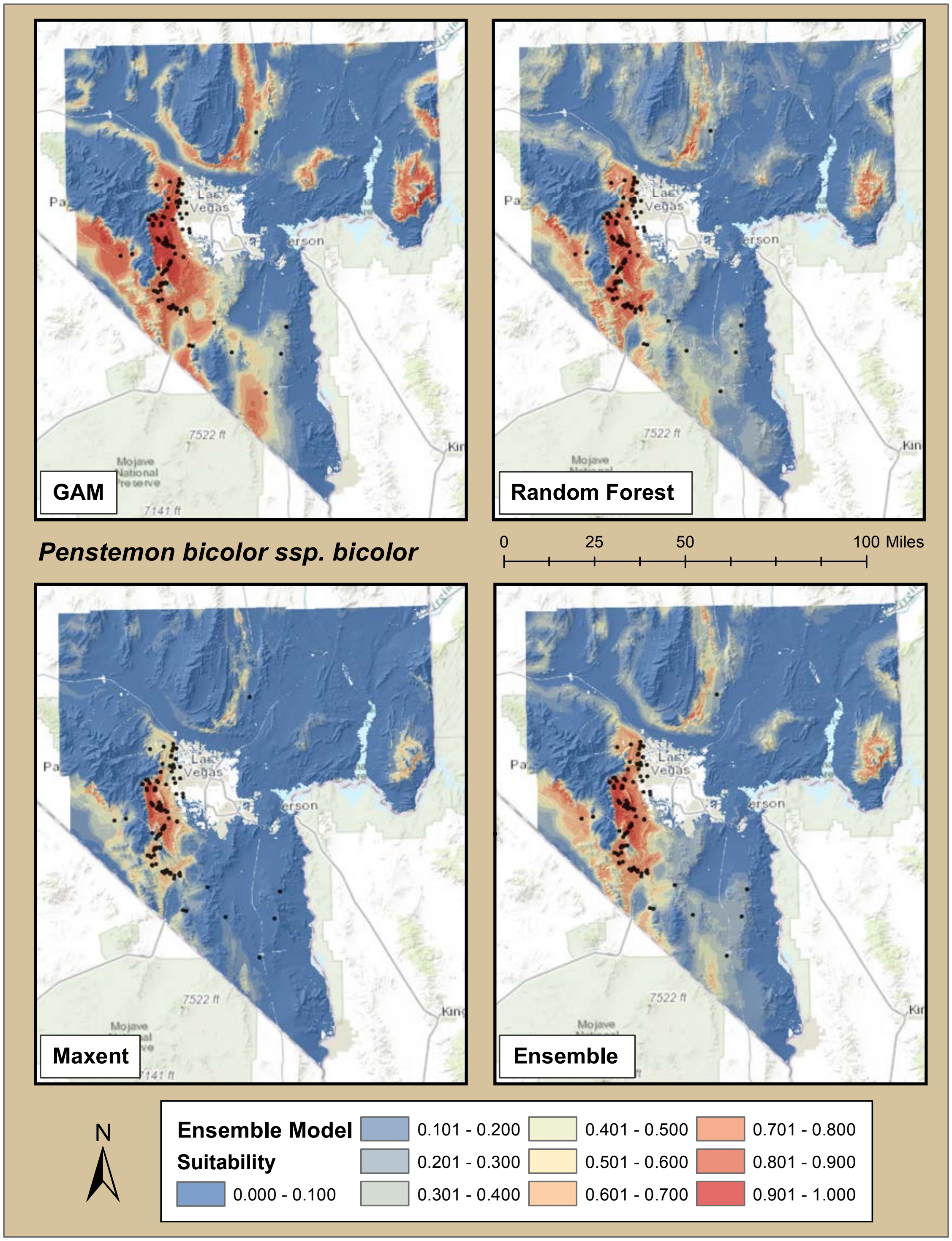

Figure 210. SDM maps for *Penstemon bicolor ssp. bicolor* for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

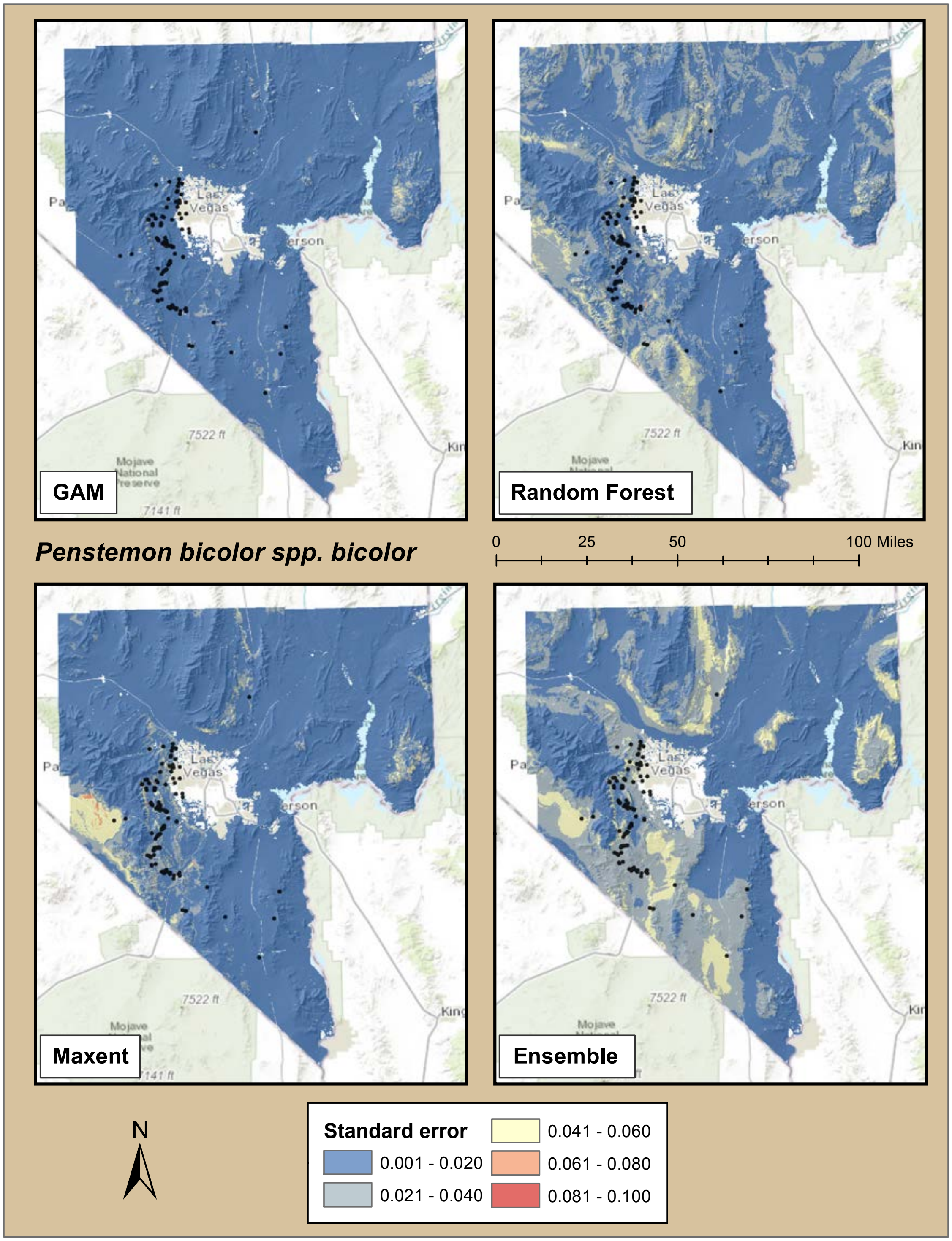

Figure 211. Standard error maps for *Penstemon bicolor ssp. bicolor* models for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

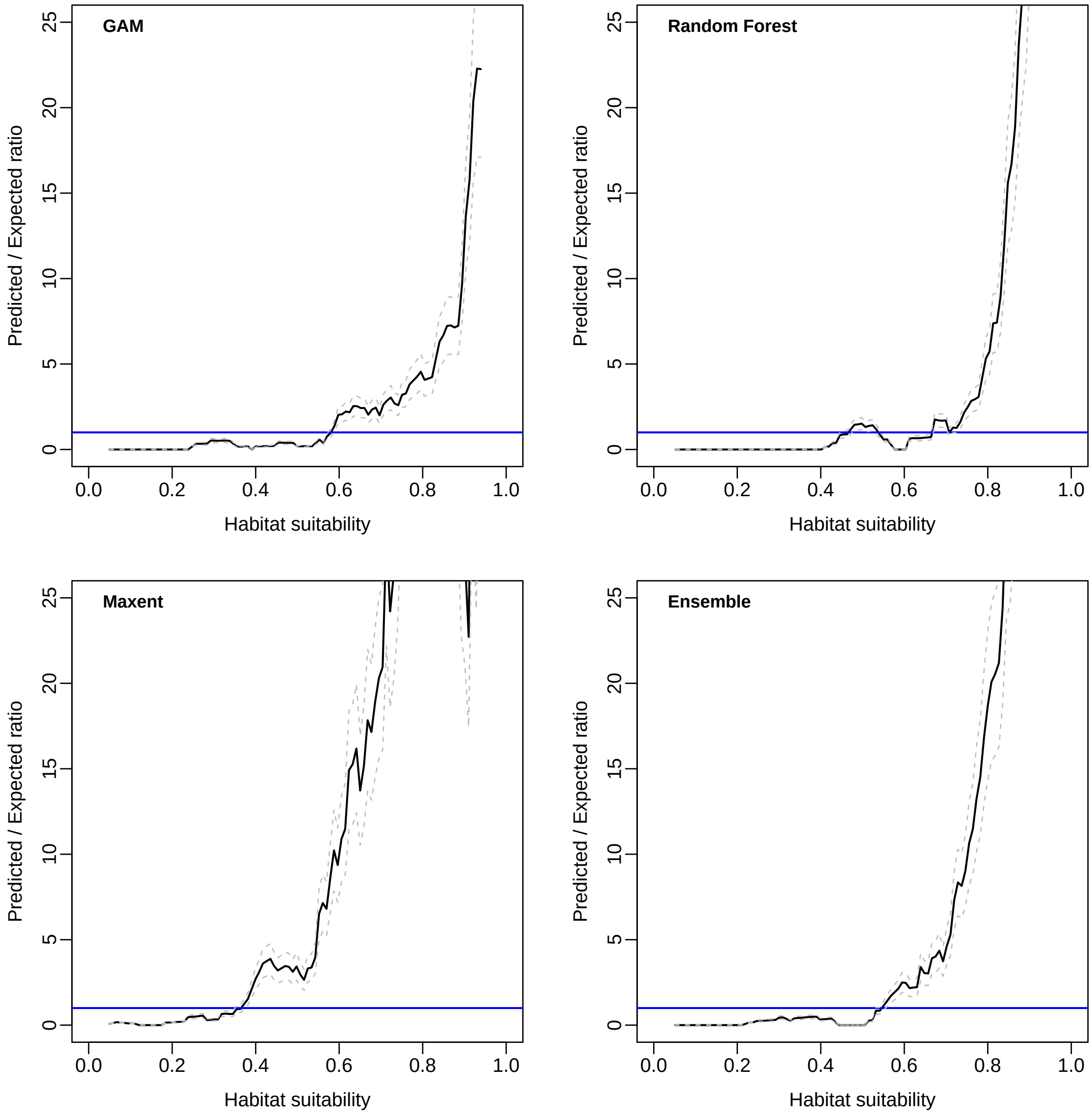

Figure 212. Graphs of Continuous Boyce Indices [CBI] for *Penstemon bicolor ssp. bicolor* models for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

GAM Model

The variables in the GAM ensemble contributed 20% or more to the models, collectively accounting for 91% of total model contribution (Table 135). These were Summer Maximum Temperature (34%), Winter Minimum Temperature (31%), and Winter Precipitation (26%). Summer Maximum Temperature had a peaked response, closely following the distribution of this variable within the County, with predicted suitability peaking at ~ 35 ºC and positive suitability predictions from ~ 31 ºC to 39 ºC (Figure 213). Winter Minimum Temperature also had a peaked response with a positive influence on habitat suitability at minim temperatures between 0 ºC and 5 ºC, with a peak at ~ 2 ºC. Winter Precipitation had a positive relationship with predicted habitat suitability with a positive influence on habitat suitability above 125 mm (Figure 213). Six other variables contributed minimally to the model (Table 135).

The GAM model predicted the largest extent of habitat for this species with large tracts of suitable habitat predicted on bajadas around the Spring, Sheep, McCullough, Virgin and Gold Butte mountains (Figure 210). The habitat predictions extended well beyond the locality data, and thus the model potentially over-predicts habitat. Standard error for the models within this algorithm were generally low throughout the County, indicating the consistency of models within this ensemble (Figure 211). Despite the seemingly lower SE of the model predictions, this model had the lowest performance among the four (Table 134).

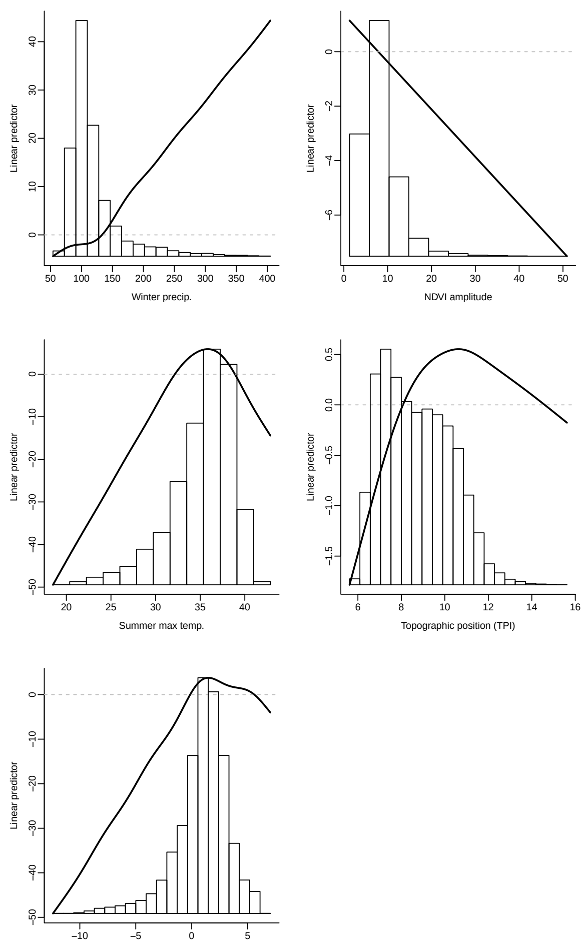

Figure 213. GAM partial response curves for the *Penstemon bicolor ssp. bicolor* model overlaid over distribution of environmental variable inputs in the study area.

MaxEnt Model

The MaxEnt model had three variables contributing 20% or more each, and an additional variable that contributed 7%, collectively accounting for 96% of total model contribution (Table 134). The three highest contributors were the same as those for the GAM model. Summer Maximum Temperature (35%) had a peaked response closely matching the distribution of this variable within the county, with the highest suitability predicted for areas with max temperatures of 37 ºC, and falling sharply above that (Figure 214). Winter Precipitation (31%) had a threshold response, with a sharp increase in suitability predicted for areas above 60 mm, peaking at ~ 225 mm. Winter Minimum Temperature contributed 23% and also had a peaked response at ~ 2 ºC, with habitat predicted in areas with minimum temperatures between 0 ºC and 3 ºC (Figure 214). Temperature Range contributed 7%, and indicated a peaked response at annuals ranges of 37 ºC. This model produced the most conservative habitat predictions among models, with the highest habitat predicted where the localities were most dense, and with some moderate habitat predicted for extreme eastern Pahrump Valley, eastern Sheep Range, and Gold Butte (Figure 210). No habitat was predicted in the McCullough range, despite three localities. Patches of moderate (SE 0.04 – 0.06), and moderately high Standard Error (0.08 – 1.0) were seen the Pahrump Valley, Stateline pass, and Gold Butte (Figure 211).

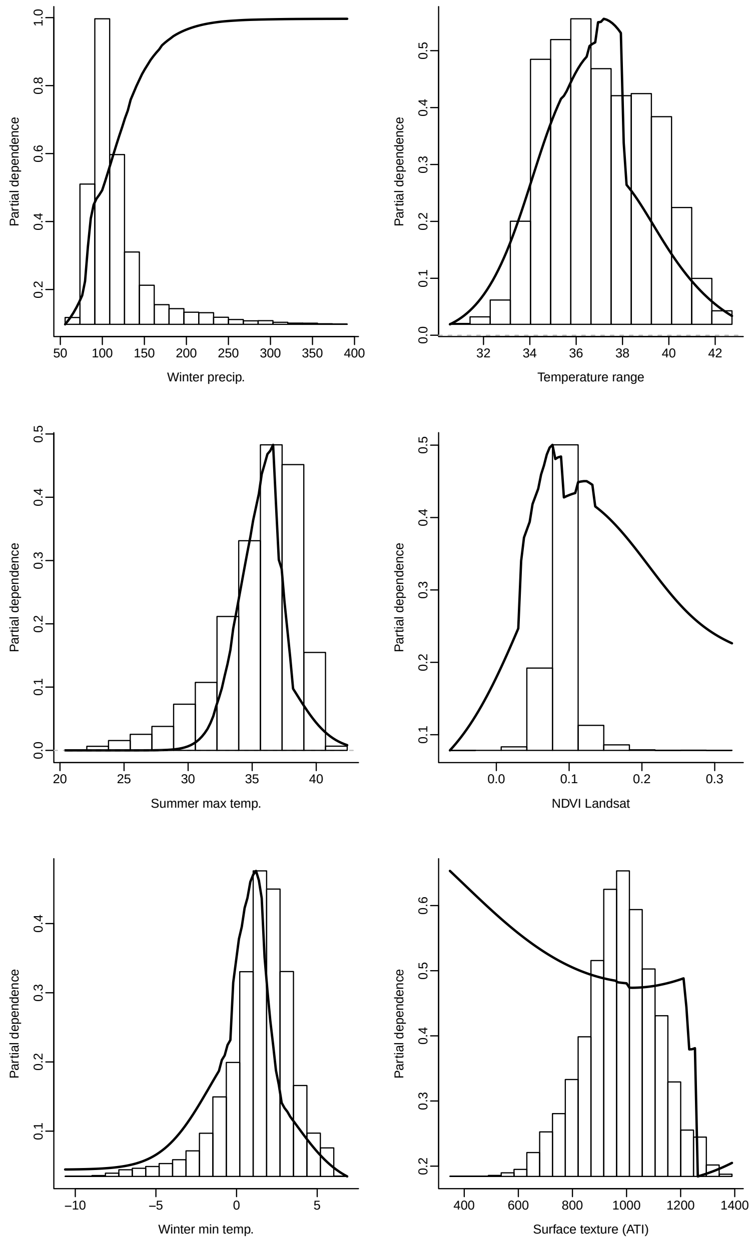

Figure 214. Response surfaces for the top environmental variables included in the MaxEnt ensemble model for *Penstemon bicolor ssp. bicolor*.

Random Forest Model

The RF models had five environmental variables (four in common with the previous models) that contributed ~ 10% or more collectively accounting for 85% of the total model influence. Two additional variables contributed moderately (Table 135).

Winter Minimum Temperature had the highest contribution at 22% and had a peaked response with habitat predicted in areas with minimums between 0 ºC and 3 ºC (Figure 215). Summer Maximum Temperature (21%) also had a peaked response with habitat predicted between 32 ºC and 37 ºC, peaking around 35 ºC. Temperature

Range had a 17% contribution with a peaked response between annual ranges of 34 ºC and 38 ºC, peaking at 37. Winter Precipitation (14%) had a threshold response similar to that of MaxEnt Model with habitat increasing sharply above 100 mm winter rainfall, and peaking above 150 mm (Figure 215). NDVI (Landsat 8) was also influential, with 13% model contribution and a sharp threshold response beginning at 0.07, and remaining high thereafter.

Standard error maps for this model indicated mostly low (0.02 to 0.04) error rates surrounding moderately low patches (0.04 – 0.06). Low areas are present throughout the county e.g. Pahrump Valley, Ivanpah Valley and the US95 corridor (Figure 211). High habitat suitability was predicted on the bajadas and slopes on the east side of the Spring Range, the eastern bajadas in the Pahrump valley, and smaller areas on the eastern side of the Sheep range and southern Gold Butte (Figure 210).

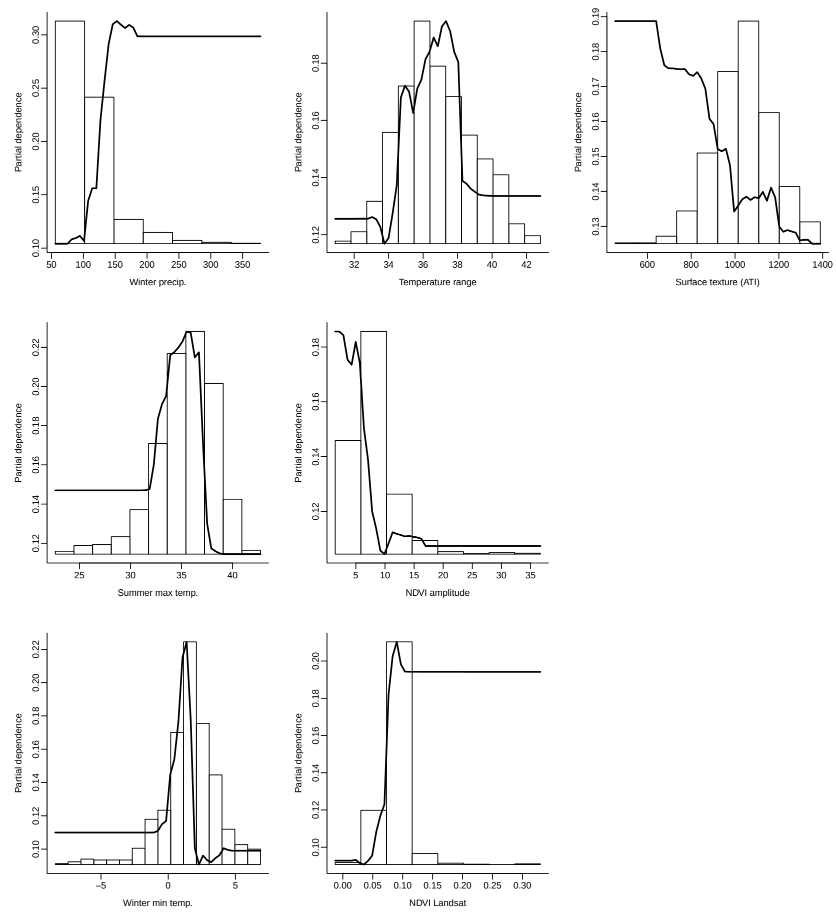

Figure 215. Partial response surfaces for the environmental variables included in the RF ensemble model for *Penstemon bicolor ssp. bicolor.* Histograms represent the range of each environmental variable across the x-axis, and predicted dependence relative to habitat suitability values are on the y-axis.

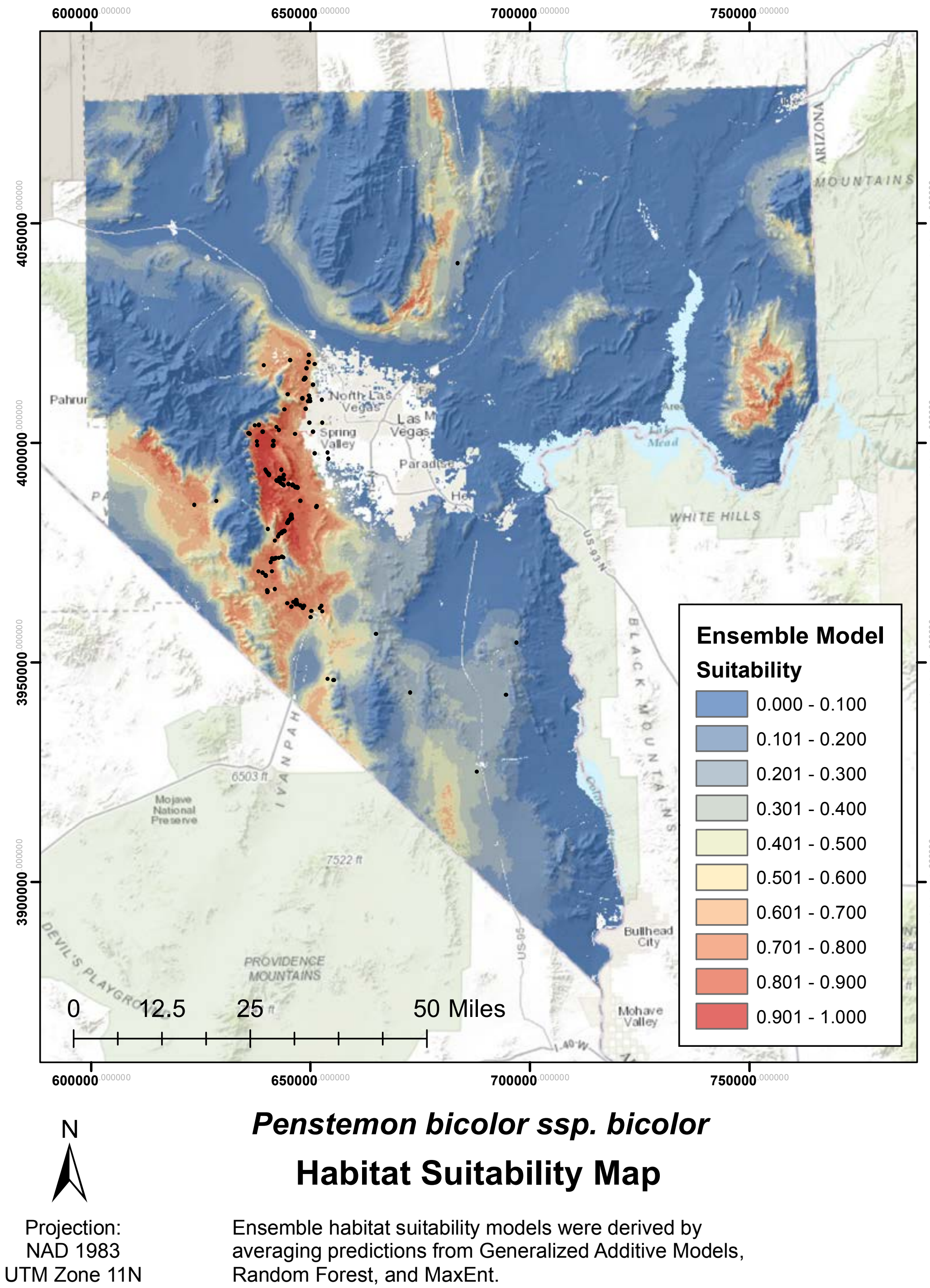

Figure 216. SDM map for the *Penstemon bicolor ssp. bicolor* Ensemble model.

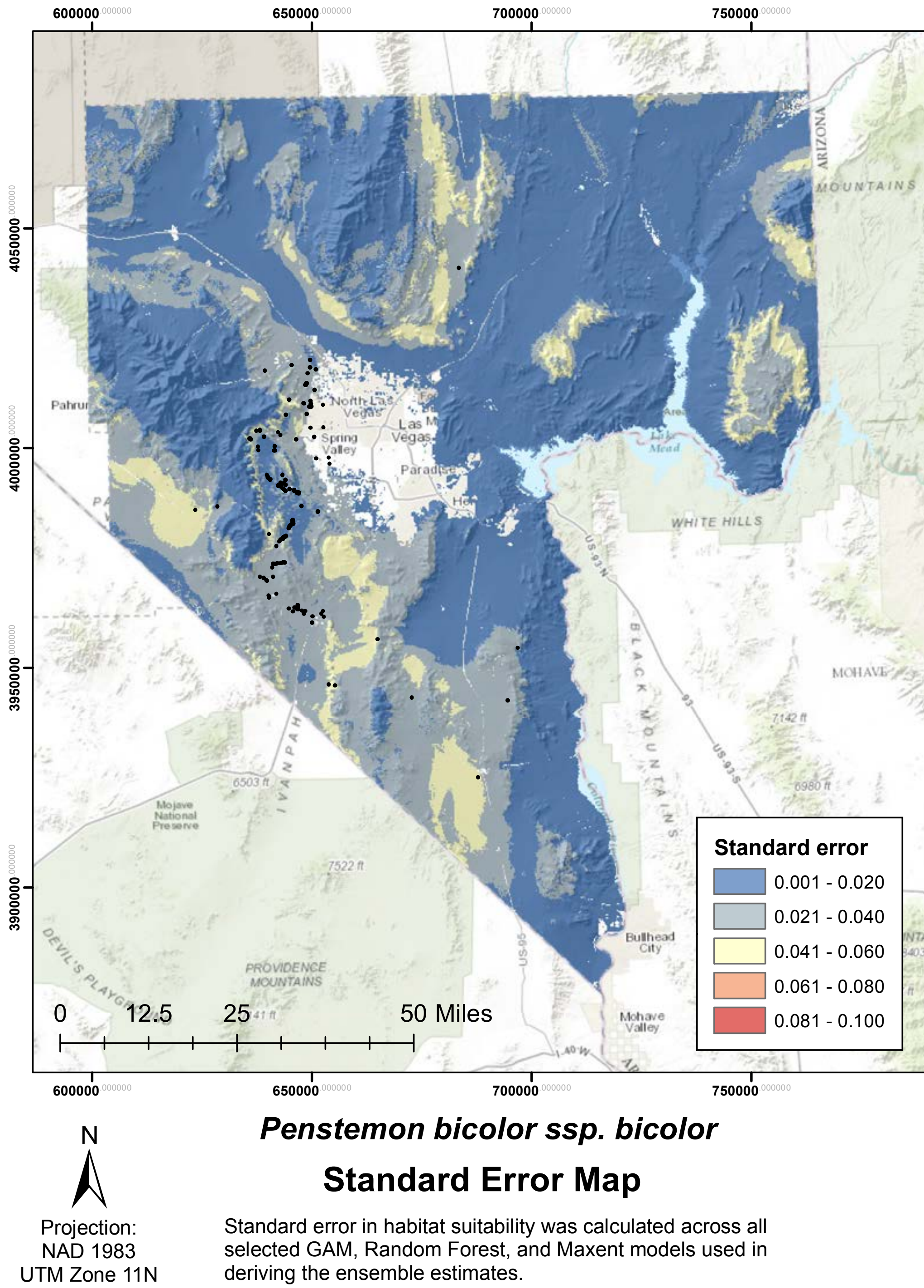

Figure 217. Standard Error map for the *Penstemon bicolor ssp. bicolor* Ensemble model.

Distribution of Localities

We collected 288 localities for Yellow Two-tone Beardtongue used for modeling, and are mostly distributed along the western edge of the Las Vegas Valley, with scattered points below Las Vegas in the McCullough range, in the eastern Pahrump Valley, and along Good Springs Road. A single lone locality is on the east side of the Sheep Range (Figure 216).

Standard Error

Moderate standard error (0.04 – 0.06) is predicted in Pahrump Valley, the eastern foothills of the Sheep range, the foothills of the mountains in Gold Butte, the Jean area, and Paiute Valley (Figure 217).

Distribution and Habitat Use within Clark County

Yellow Two-tone Beardtongue populations are concentrated on the eastern slopes of the Spring Mountains in Red Rock Canyon Conservation Area and on the Bird Springs Range near Goodsprings, Nevada. There are outlier populations in the higher elevations of the McCullough and El Dorado mountains but the rose-colored subspecies is much more common in these ranges (Smith 2005).

Yellow Two-tone Beardtongue occurs in naturally or artificially disturbed calcareous or carbonate soils in washes, roadsides, rock crevices, outcrops, or similar places receiving enhanced runoff, in creosote-bursage, blackbrush, or Joshua tree – mixed shrub vegetation (NNHP 2001, Smith 2005). Ecosystems within the county containing predicted high suitability habitat for this species include Mojave Desert Scrub, Blackbrush and to a lesser extent Pinyon Juniper and Mesquite Acacia (Table 136). Moderate suitably habitat are within the same ecosystems, and are more widespread (Table 136).

Modeled habitat suitability in the county is predicted to be highest in west side of Las Vegas, within the Pahrump Valley, and along the I-15 corridor to Ivanpah Valley. Habitat suitability is also predicted along the eastern foothills and bajada of the Sheep Range with two large patches surrounding the mountains in southern Gold Butte (Figure 216). Slightly lower suitability habitat is predicted in western Paiute Valley (Figure 216).

Table 136. Ecosystems within Clark County, and the area (Ha) of Low Medium and High predicted suitability within each ecosystem.

Ecosystem	Low	Medium	High
Alpine	124	0	0
Blackbrush	262768	92327	59628
Bristlecone Pine	7565	0	0
Desert Riparian	10676	0	0
Mesquite Acacia	16177	3050	457
Mixed Conifer	27339	0	0
Mojave Desert Scrub	1032488	166483	81674
Pinyon Juniper	111741	3106	991

Ecosystem	Low	Medium	High
Sagebrush	4707	0	0
Salt Desert Scrub	73948	4687	67

Ecosystem Level Threats

The primary ecosystems where this species may be found include Mixed Mojave Desert Scrub and Blackbrush. The primary threat to Yellow Two-tone Beardtongue populations is habitat loss due to housing and road development, mining activities, off-road vehicle use, utility corridor development and maintenance, and water development (Smith 2005).

Threats to Species

An emerging threat is hybridization with Palmer's Penstemon (*Penstemon palmeri*), a closely related species that is seeded into disturbed areas within the range of Yellow Two-tone Beardtongue for revegetation by land management agencies (Glenne 2003). The collection of plants and seeds for horticulture is also a potential threat to this taxon (AZGFD 2003).

Existing Conservation Areas/Management Actions

Most of the populations of Yellow Two-tone Beardtongue are within the Red Rock Canyon National Recreation Area and are managed for both recreation and resource protection. Yellow Two-tone Beardtongue was accounted for in the final Environmental Assessment for the proposed scenic loop drive and parking areas improvements (BLM 2015). This is likely the most recent management action for this subspecies.

Summary of Direct Impacts

The Yellow Two-tone Beardtongue is an uncommon species within Clark County. Approximately 4138 km^2 of habitat were modeled within Clark County, of this 417 km^2 of high suitability habitat are to be conserved, while 118 km^2 of high suitability habitat are likely to be impacted, in addition to the 34 km^2 already disturbed. Much more moderate habitat is to be conserved (1024 km^2), with similar levels of moderate habitat intersecting Impact and Disturbed areas (Table 137).

Table 137. Categorized modeled habitat values (High, Medium, and Low) and the average area (Hectares) predicted in the potential impact areas, conservation areas, already disturbed areas, and overall area

Habitat Level	Impact	Conserved	Disturbed	Area (Hectares)
High	11287	41725	3499	142924
Med	12062	102445	3214	270895
Low	99252	368784	33306	1562983

PEBIRO - Rosy Two-tone Beardtongue (Penstemon bicolor ssp. roseus)

Rosy Two-tone Beardtongue (*Penstemon bicolor* ssp. *Roseus*) is one of two bi-colored *Penstemon* that inhabit southern Nevada. *Roseus* is a two-toned red colored variant. The species is red to cream in color, and is a short-lived perennial that grows up to 0.5 m tall and (Smith 2005). This species was first discovered near Goodsprings in Clark County NV, and was elevated to full species status in 1939, although the subspecies distinction has been questioned recently, and is largely no longer recognized (Wolfe et al. 2000 cited in Smith 2005). In the southern Nevada area, roughly 2/3 are the rose colored phase, while 1/3 are of the yellow variant (Smith 2005). The plant is pollinated by at least two bee species in the *Osmia* genus (Glenne 2003).

Species Status

US Fish and Wildlife Service Endangered Species Act: Not listed
US Bureau of Land Management (Nevada): No Status
US Forest Service (Region 4): No Status
State of Nevada (NAC 527): No Status
NV Natural Heritage Program: Global Rank G3T3Q; State Rank S3
IUCN Red List (v 3.1): No status
CITES: No status

Smith (2005) recommended the addition of this species to the Nevada state list of fully protected species due to threats to populations in and around the Las Vegas area where development continues to encroach on habitat.

Range

This species is found in the Mojave Desert of southeastern California, southern Nevada and northwestern Arizona (Smith 2005). In southern Nevada it is known to occur at 70 or more sites with most of these occurring on federal lands managed by the BLM. They typically occur in mountainous areas including the Spring Range in NV, the Castle Mountains in California, and the Black Mountains in Arizona (Smith 2005).

Population Trends

Current population trends are unknown (NNHP 2001). The estimated number of total individuals of Rosy Two-tone Beardtongue is less than 7000, and numbers vary widely from year to year, making trends difficult to discern (Smith 2005).

Habitat Model

Model Results

Rosy Two-tone Beardtongue was modeled using 263 localities distributed most densely throughout the center of the county. Habitat for this species throughout valleys and upland slopes are characteristic of Mixed Mojave Desert Scrub habitats. Among all models, habitat was most broadly predicted by the Gam model, but with similar patterns of predicted habitat becoming more restrictive in the RF model, with less area and even fewer areas of high habitat suitability predicted by the MaxEnt modeling ensemble (Figure 218). Performance was highest for the RF Model across 3 of the 4 performance metrics, where the Ensemble model had a fractionally higher BI (Table 138). The Ensemble model was the second highest model in terms of performance and had consistently high measures across all performance metrics. The MaxEnt model ranked third and the GAM model had the lowest performance, although the metrics for all 4 models were relatively good (Table 138). Standard error maps for the models indicated that the RF model had a moderate level of SE with more patches of higher values (SE 0.06 – 0.08) near the Callville area of Lake Mead, and between the Nelson Road and the Newberry range southward along the Colorado River. The MaxEnt model had several small patches of moderately elevated SE throughout the county, with the largest patch around Cal-Nev-Ari, while the GAM model tended to have more areas of moderately low error in the northwest portion of the County, and in the lowlands along the Colorado River near AVI (Figure 219).

The CBI for most of the models indicated good model performance, while the GAM model showed some decrease in predictive power at higher habitat values (Figure 220) all of the algorithms tested had similar fixed BI valu5es (Table 138). Approximated bins for the ensemble model based on the CBI were 0-0.5 unsuitable, 0.5-0.6 marginal, 0.6 to 0.73 suitable, and 0.73 -1 optimal habitat; with a suggested cutoff threshold of ~ 0.6 (Figure 220) while the threshold value calculated from ROC statistics for the ensemble model was 0.58 (Table 138).

Table 138. Model performance values for *Penstemon bicolor ssp. roseus* models

Performance	GAM	RF	MaxEnt	Ensemble
AUC	0.842	0.96	0.889	0.913
BI	0.882	0.893	0.872	0.898
TSS	0.577	0.818	0.649	0.693
Correlation	0.593	0.805	0.68	0.72
Cut-off*	0.573	0.6403	0.437	0.58

*threshold at which sum of sensitivity (true positive rate) and specificity (true negative rate) is highest

Table 139. Percent contributions for input variables for *Penstemon bicolor ssp. roseus* for ensemble models using GAM, MaxEnt and RF algorithms

Term	GAM	RF	Max	Avg
Winter Min Temp	34.234	16.672	21.95	31.48
Summer Max Temp	30.639	15.912	24.805	30.651
Winter Precipitation	12.488	11.139	5.872	14.365
Annual Heat/Moisture Index	12.739	10.780	9.962	14.169
Temperature Range	1.823	9.713	5.327	10.903
Surface Texture (ATI)	3.102	8.854	7.89	10.436
Summer Precipitation	0	8.631	2.444	8.243
Rockiness	2.485	7.794	3.849	8.072
Surface Roughness (TRI)	0.535	5.498	3.355	5.502
Slope	0.435	5.006	2.089	4.67

Term	GAM	RF	Max	Avg
Topographic Position (TPI)	1.518	0	7.894	3.137
NDVI Maximum	0	0	4.562	1.521

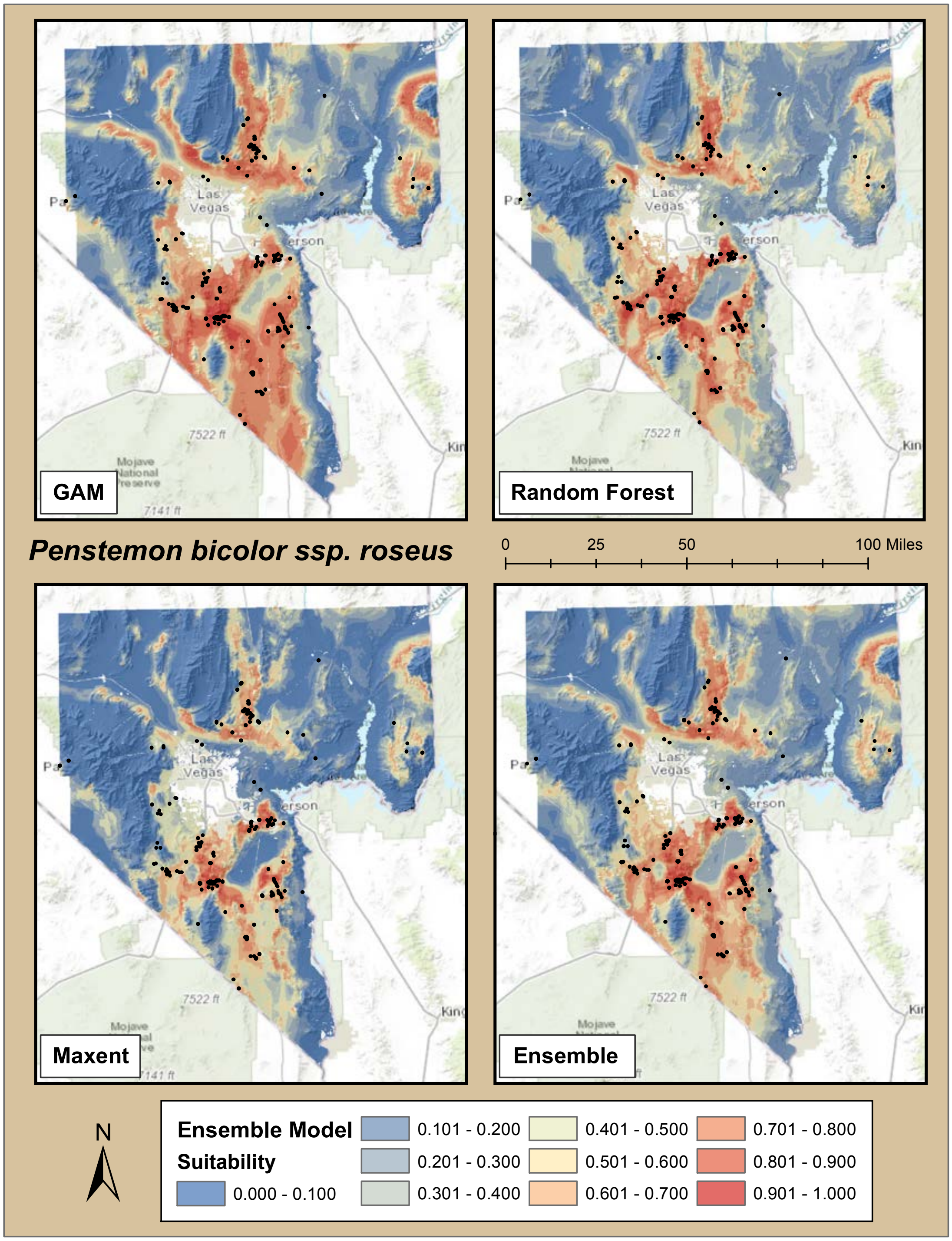

Figure 218. SDM maps for *Penstemon bicolor ssp. roseus* for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

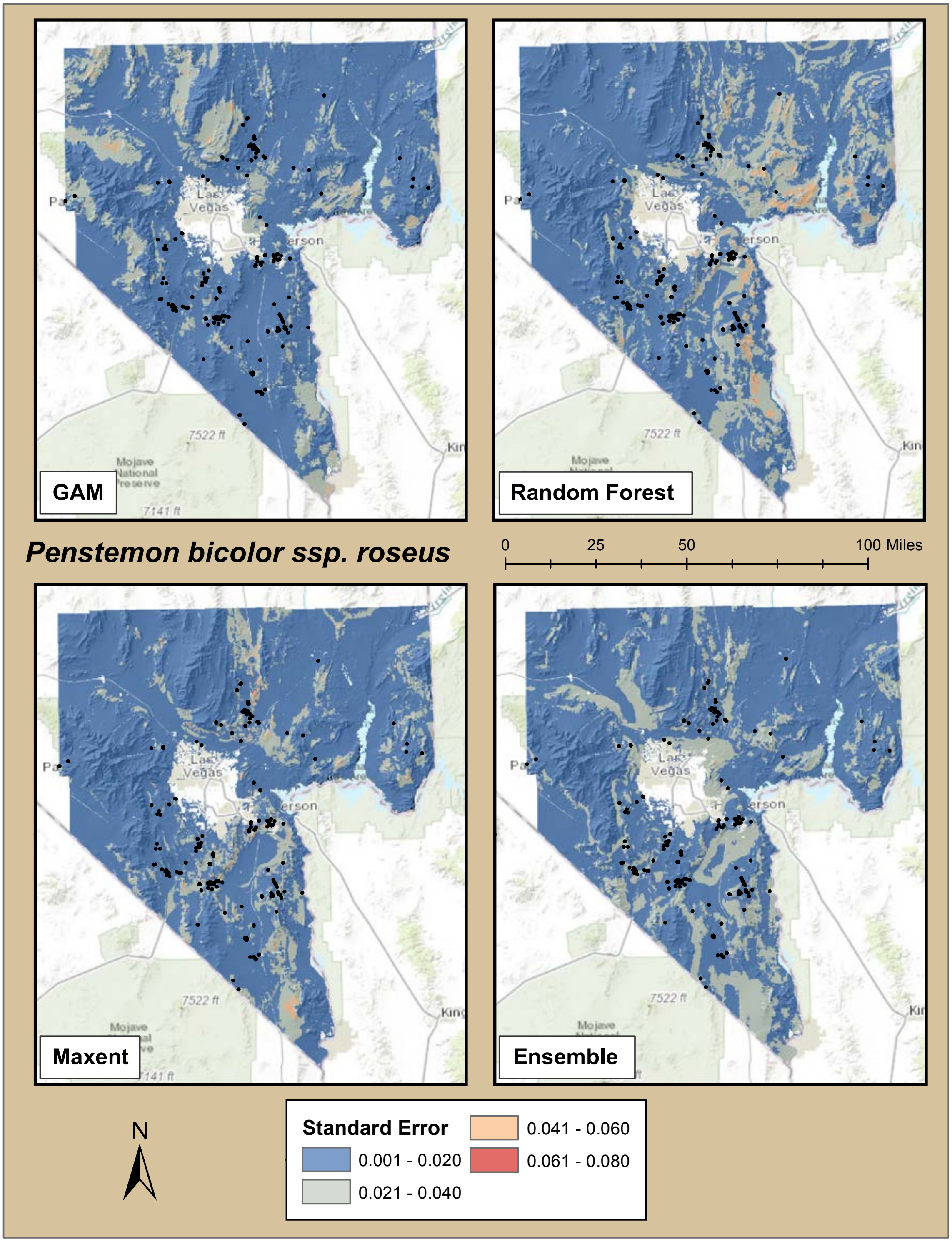

Figure 219. Standard error maps for *Penstemon bicolor ssp. roseus* models for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

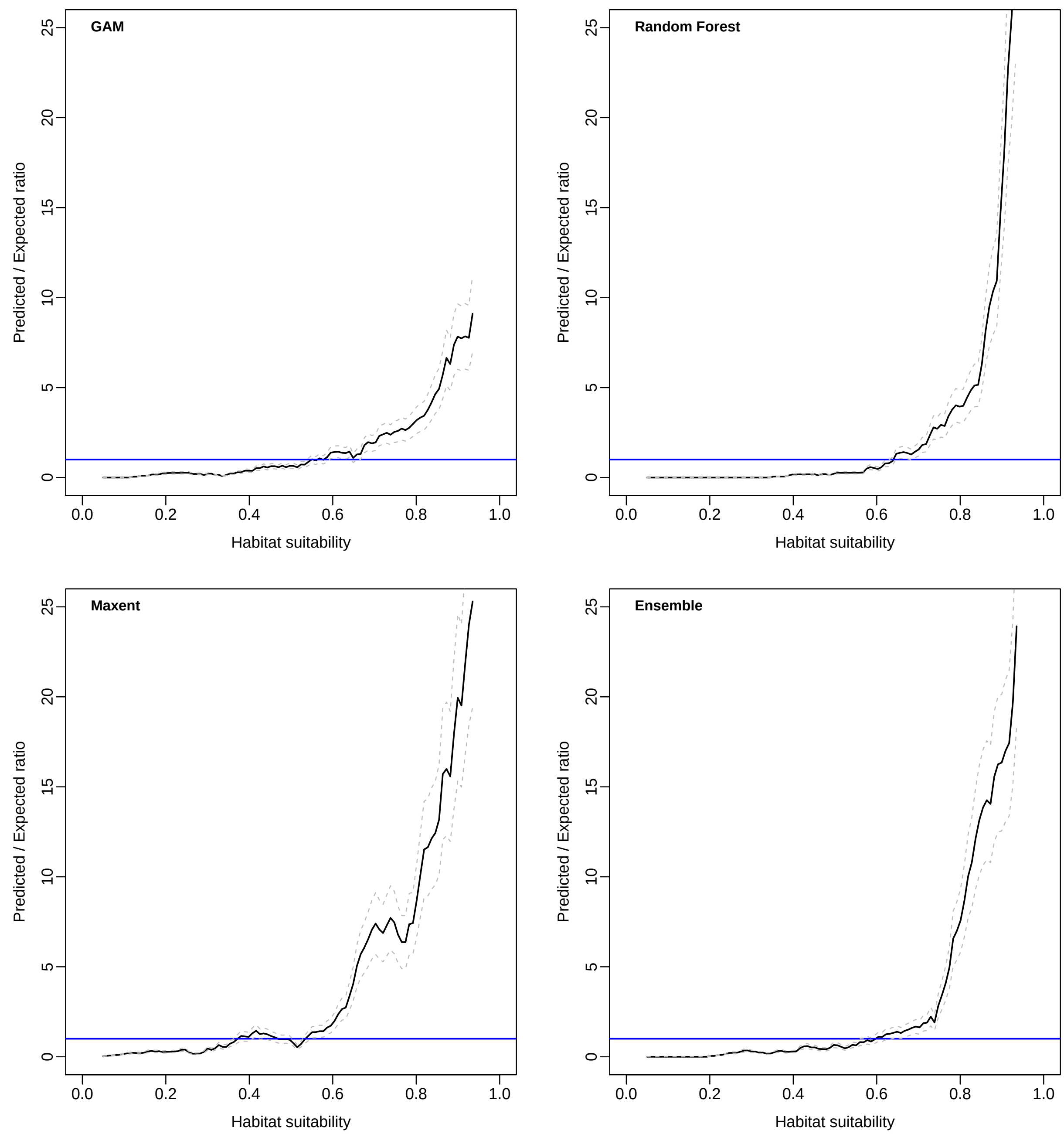

Figure 220. Continuous Boyce Indices for *Penstemon bicolor ssp. roseus* models for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

GAM Model

The GAM model ensemble identified 4 contributing variables with more than 10% toward the model with collectively accounting for 90% of all model contribution (Table 139). Winter Minimum Temperatures had the highest contribution (34%) with higher habitat suitability predicted in areas with higher winter temperatures, somewhat matching the relative distribution of this variable throughout the county (Figure 221). Summer Maximum Temperatures were the second highest contributing covariate (31%) where higher suitability was high and nearly constant in cooler areas, falling sharply in the areas with higher maximum temperatures. The Annual Heat/Moisture Index yielded peaks in areas both low and high on the Index, with reduced suitability near the center of the distribution – where more common combinations of temperature and precipitation were distributed (Figure 221). Winter Precipitation contributed to 12% of the model contributions, and had a non-linear but generally positive relationship with habitat suitability.

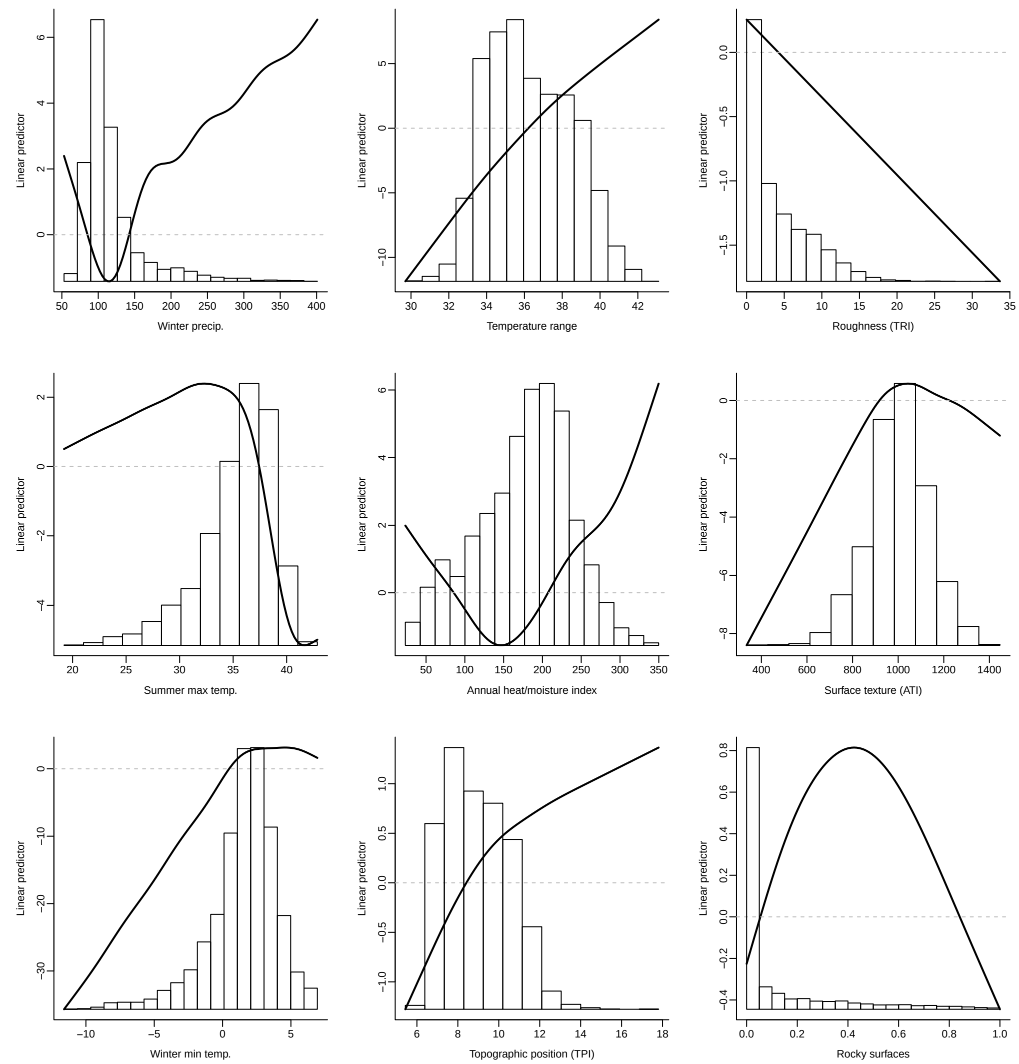

Figure 221. GAM partial response curves for the *Penstemon bicolor ssp. roseus* model overlaid over distribution of environmental variable inputs in the study area.

MaxEnt Model

The MaxEnt model had five variables contributing ~8% or more each, accounting for 73% of the total model contribution, with an additional seven environmental variables contributing to the overall model (Table 139). Summer Maximum Temperature was the highest contributing covariate (25%) and had a threshold response with higher suitability in areas with lower to moderate Summer Maximum Temperatures, and falling sharply in areas above ~ 36 ºC (Figure 222). Habitat suitability was higher in areas with warmer Winter Minimum Temperatures ranging from 0 to 5 ºC, and was predicted to be lower outside that range in both directions (Figure 222). The annual Heat/Moisture index contributed 10 % and habitat suitability was stable but variable at levels below 300, increasing afterward. Partial contribution curves for Topographic Index and Surface Texture collectively indicated higher habitat predictions in lower portions of watersheds and at areas with and ATI of 900-1300, corresponding with soils that have smaller particles, but not necessarily comprised of the sandiest substrate (Figure 222).

The standard error map for this algorithm showed very few areas of moderate uncertainty (SE of 0.04 to 0.06) with only small patches in Piute Valley, to the south and Hidden Valley north of Las Vegas near Coyote Springs. (Figure 219). The MaxEnt model performed third among the four models, with strong performance overall and a Continuous Boyce Index indicating strong performance (Table 138, Figure 220).

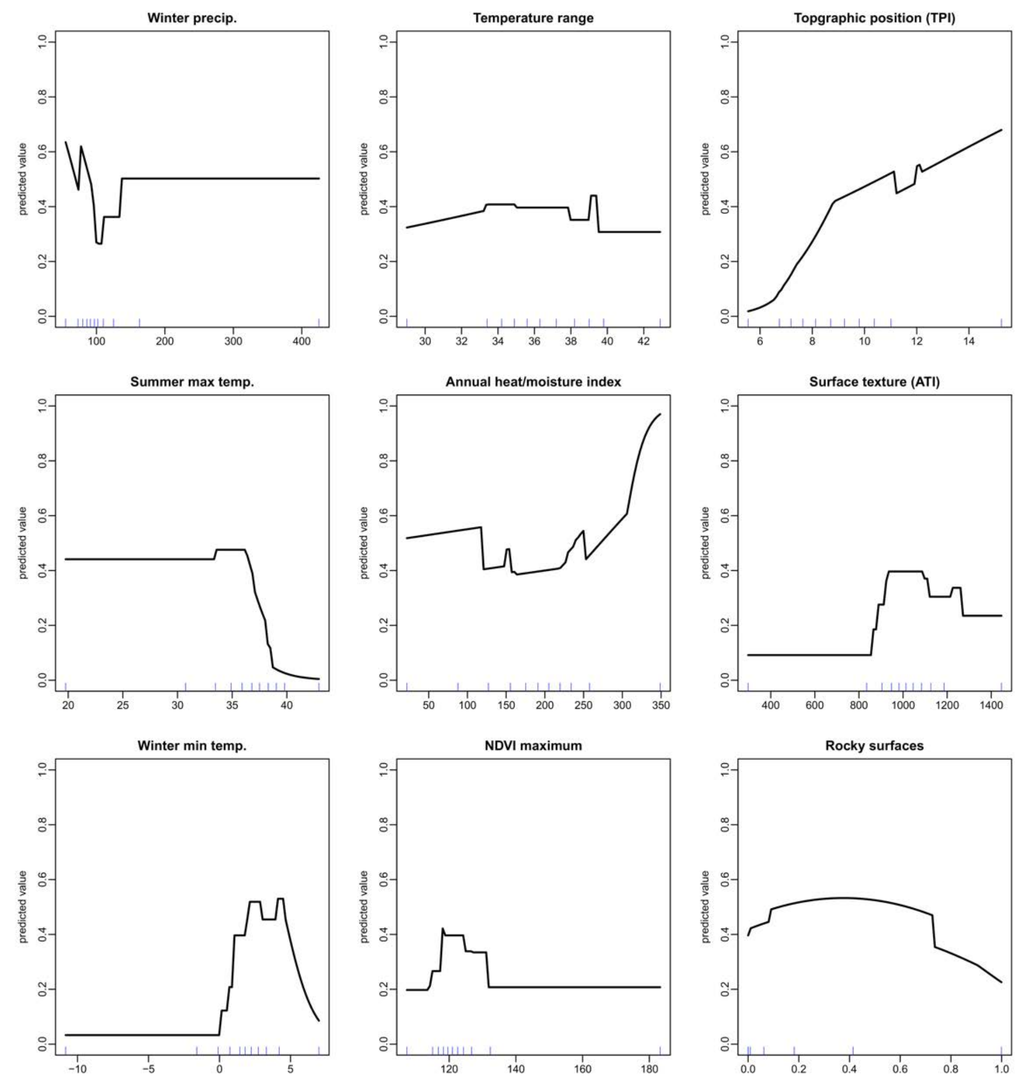

Figure 222. Response surfaces for the top 9 environmental variables included in the MaxEnt ensemble model for *Penstemon bicolor ssp. roseus.*

Random Forest Model

The RF models had five environmental variables contributing ~10% or more totaling 64% of total model influence, but high levels of support across five additional variables, with 10 of the 12 variables considered providing information toward the prediction of habitat. Winter Minimum Temperature was the strongest predictor with 17% contribution and higher suitability habitat predicted at higher temperatures, rising sharply at 0 and continuing through 5 ºC, which was a similar response to that of the MaxEnt mode for this predictor. Summer Maximum Temperature contributed also had a similarly shaped response curve relative to the MaxEnt Model with habitat predicted to be high and constant at low temperature levels with a slight peak at 35 ºC, and falling sharply thereafter (Figure 223). Habitat suitability was highest in areas with a low annual temperature range, and low Winter Precipitation, although the Winter Precipitation relationship was complex and difficult to interpret – as was the next highest contributor – Summer Precipitation, however peak habitat predictions for these two variables appeared to match the distribution of the variables throughout the study area (as indicated by the peaks in the histograms, Figure 223). Surface Textures corresponding with higher habitat tended to be finer textured soils (Figure 223). Standard error maps for this model were similar to those for the MaxEnt model but with slightly higher levels of error in some of the areas with increased elevational relief, perhaps reflecting the general preference toward rougher areas, while simultaneously preferring smaller Surface Textures (Figure 219, Figure 223). This was the best performing model among all models (Table 138).

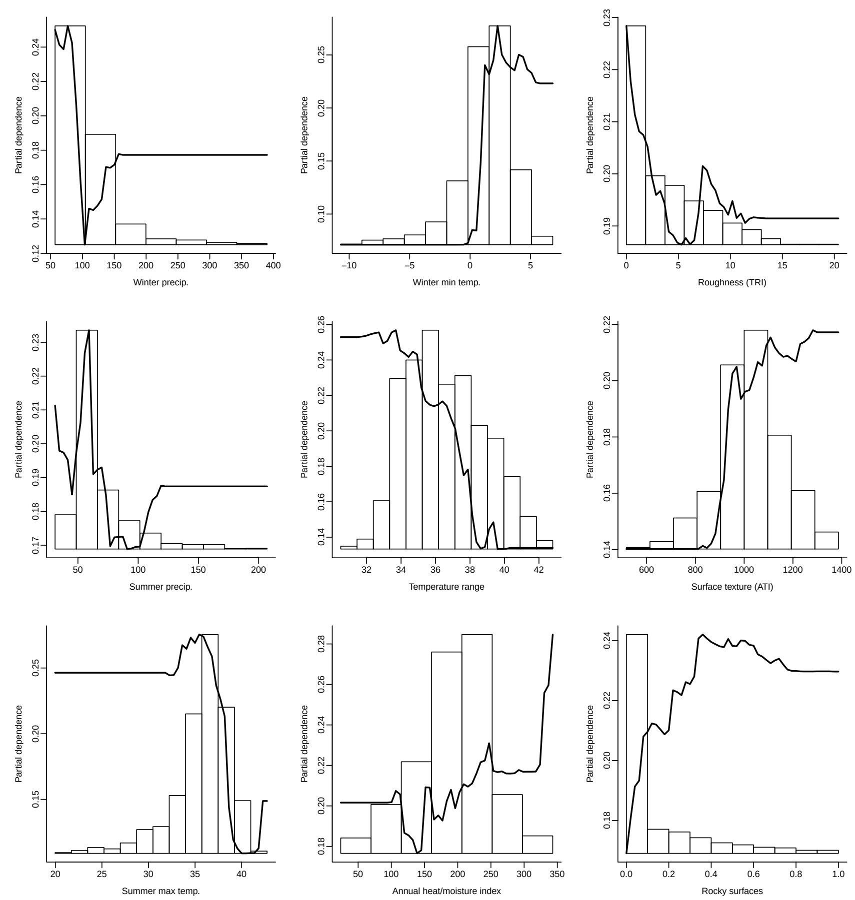

Figure 223. Response surfaces for the environmental variables included in the RF ensemble model for *Penstemon bicolor ssp. roseus*. Histograms represent the range of each environmental variable across the x-axis, and predicted dependence relative to habitat suitability values are on the y-axis.

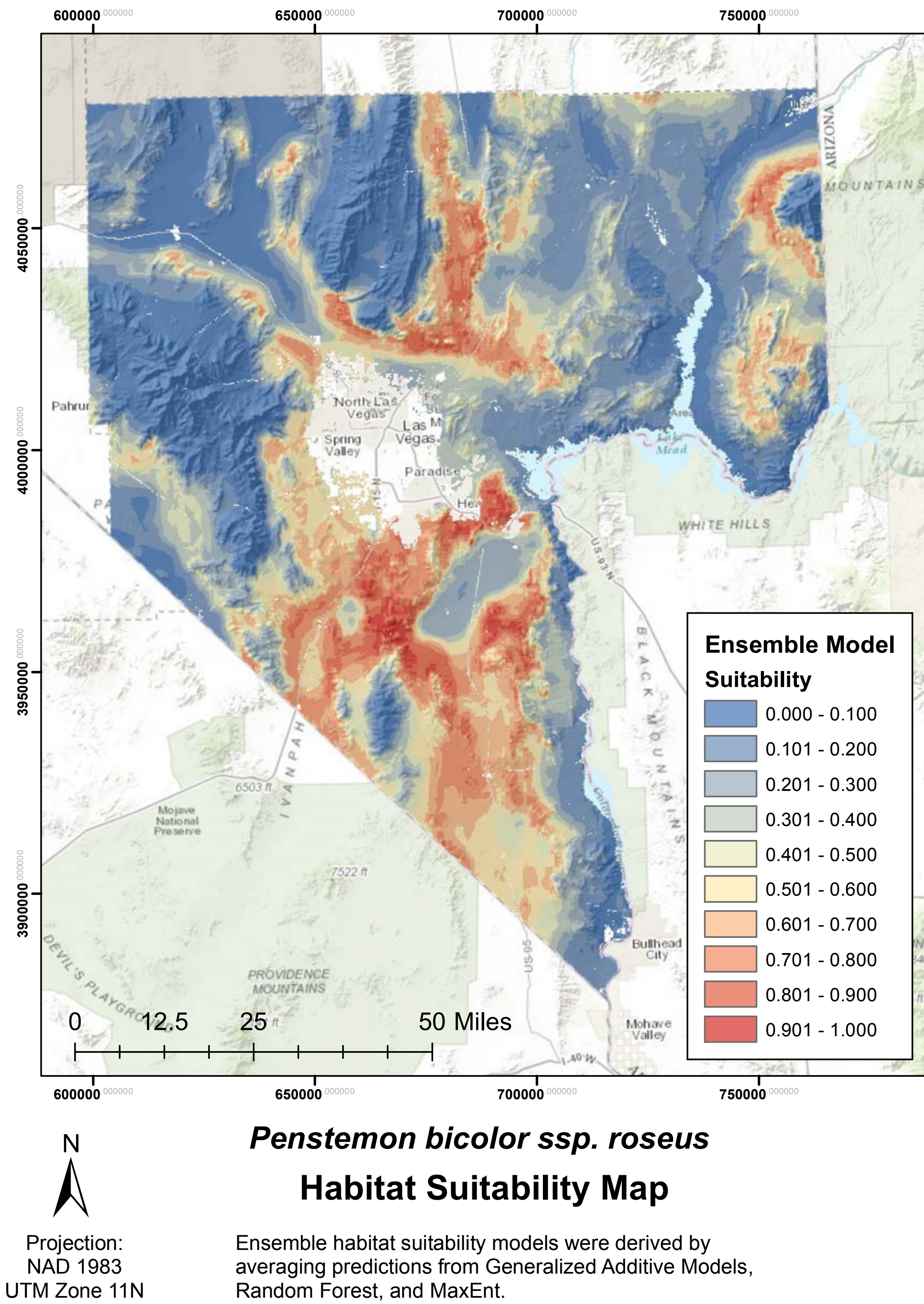

Figure 224. SDM map for the *Penstemon bicolor ssp. roseus* ensemble model.

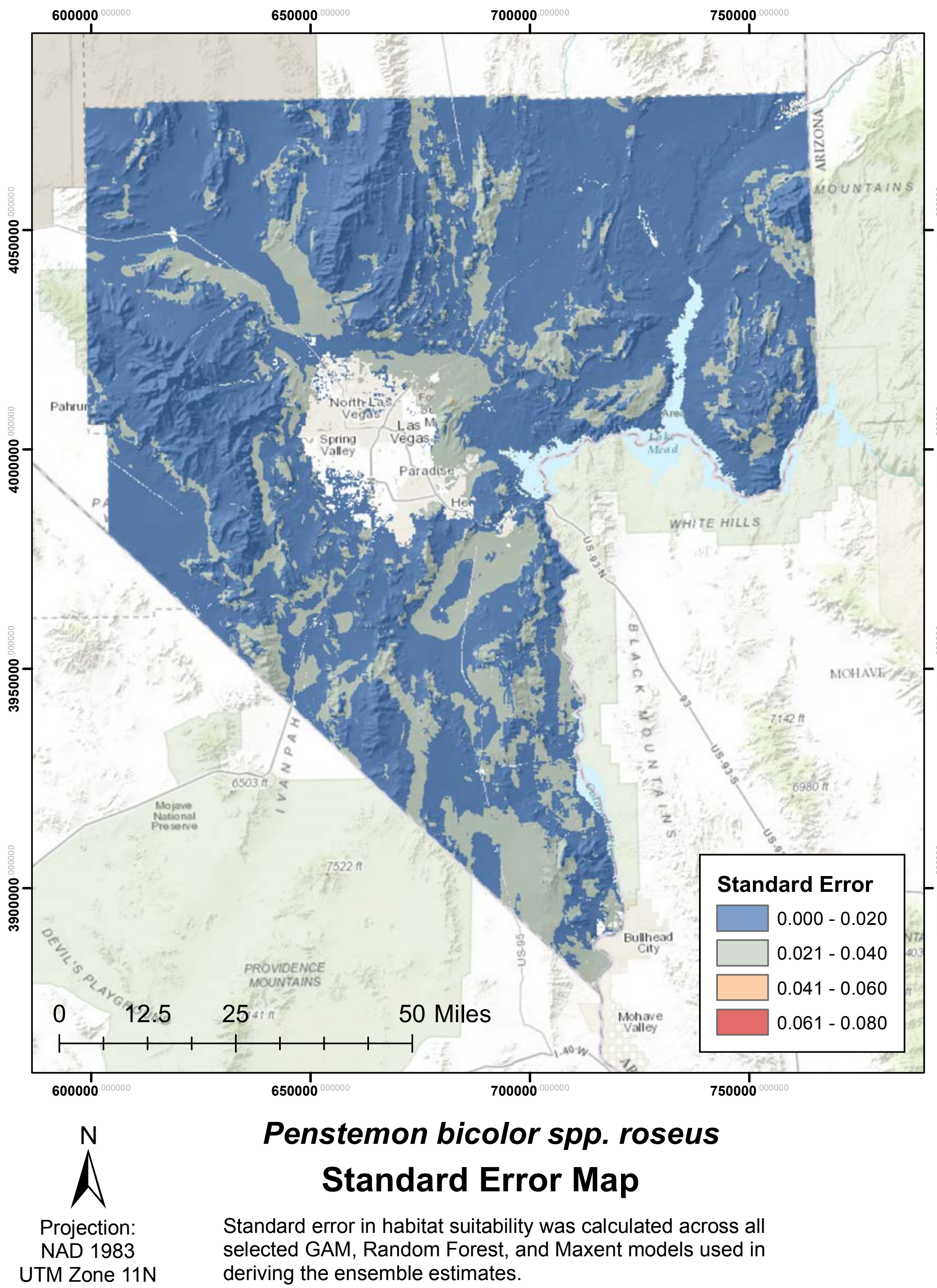

Figure 225. Standard Error map for the *Penstemon bicolor ssp. roseus* ensemble model.

Distribution of Localities

Localities for Rosy Two-tone Beardtongue (N=263) were sparsely distributed around the center of the county, with large concentrations of localities south of Las Vegas Valley, and fewer localities to the northeast of the metropolitan area with a hand full of sightings in Gold Butte and near Lake Mead (Figure 218).

Standard Error

The standard error for the Ensemble suitability model for this species indicates low to marginally low error throughout the majority of the lower valleys in Clark County, with a SE of 0.02 – 0.04. There were few large areas of higher SE (Figure 225).

Distribution and Habitat Use within Clark County

This species was first discovered near Goodsprings in Clark County, NV, and was elevated to full species status in 1939, although the subspecies status has been questioned (Smith 2005). The yellow variant occurs on the eastern slopes of the Spring Range and Bird Spring Mountains, south through Red Rock, Blue Diamond and Goodsprings. The red variant typically occurs in the areas south of Las Vegas, through the Eldorado and McCullough Mountains, and on the western slopes of the Spring Range near Pahrump (Smith 2005). The species grows in washes, disturbed areas, roadsides and rocky areas in the mountains (Kartesz 1988). Associated perennial species within its habitat include *Larrea*, *Yucca*, *Stephanomaria*, *Hymemoclea*, and *Coleogyne*, and ranges from 1900 – 5400 ft (Kartesz 1988). This species occurs largely in Mojave Desert Scrub and Blackbrush ecosystems, where it had the highest area of predicted high and moderate suitable habitat (Table 140). Moderate habitat is also predicted to be within Salt Desert Scrub ecosystems in some areas (Table 140). Both "species" are capable of self-fertilization, but out-crossings are more successful, and they are known to hybridize with the other variant of *P. bicolor* and with *P. palmeri* (Glenne 2003).

Modeled habitat in the county is predicted to be high at middle elevations surrounding Las Vegas, and especially so in the southern extent of the valleys along the I15 corridor toward Jean, Goodsprings, and Primm. Sloan Canyon and the Northern McCullough range were strongly predicted to be habitat, as was the southern portion of Eldorado Valley in the uplands approaching Searchlight, and extending southward throughout Piute Valley. North of Las Vegas habitat is predicted along the I-15 Corridor to Apex and throughout Hidden Valley along highway 93. Habitat is also predicted along mid elevation slopes in Gold Butte, and the bajadas on the north side of the Virgin Mountains. However, north of the Virgin Mountains the species has not been documented, yet. Localities are also found along the US 95 corridor to the northwest, and in Trout canyon along highway 160 – on the west side of the county (Figure 224).

Table 140. Ecosystems within Clark County, and the area (Ha) of Low Medium and High predicted suitability within each ecosystem.

Ecosystem	Low	Medium	High
Alpine	124	0	0
Blackbrush	238909	123456	52162
Bristlecone Pine	7565	0	0
Desert Riparian	10259	372	0
Mesquite Acacia	9584	5376	4683
Mixed Conifer	27339	0	0
Mojave Desert Scrub	600244	381570	295428
Pinyon Juniper	113859	1948	32
Sagebrush	4702	4	0
Salt Desert Scrub	61160	15575	1958

Ecosystem Level Threats

This species is threatened by habitat loss due to development, and is thought to be threatened throughout the Las Vegas Valley area due to continued urbanization.

Threats to Species

Populations of this species are threatened by urbanization, and other anthropogenic activities that disturb habitat (e.g. mining, Smith 2005). Restoration efforts using *P. palmeri* may pose a threat of hybridization if populations are close enough to be visited by the same pollinators, and re-seeding of linear disturbances increases the probability of crossing through or near *P. bicolor* populations (Glenne 2003).

Existing Conservation Areas/Management Actions

No existing conservation areas or management actions exist beyond those which would be inclusive of all plants with a protected area (e.g. Red Rock Canyon NCA, Sloan canyon NCA etc.).

Summary of Direct Impacts

Nearly half of the high-quality habitat predicted for this species is located within designated conservation areas (Table 141). An area of high quality habitat 58 km^2 has already been disturbed, and additional 331 km^2 of habitat will be potentially impacted. Large areas of moderate habitat will also be conserved (2039 km^2), while additional lands (349 km^2) will be impacted in the moderate category.

Table 141. Categorized modeled habitat values (High, Medium, and Low) and the average area (Hectares) predicted in the potential impact areas, conservation areas, already disturbed areas, and overall area

Habitat Level	Impact	Conserved	Disturbed	Area (Hectares)
High	33171	143715	5888	354845
Med	34863	203987	18543	531746
Low	54360	164650	15499	1086037

PECA - Beaver Dam Breadroot (Pediomelum castoreum)

Beaver Dam Breadroot is considered to be a rare species, and is vulnerable to decline because of its very restricted range. It has a deep taproot, 4-5 palmate leaves, with purple flowers in April – May (MacKay 2013). The root was used by Native Americans and early European settlers for food (Dayton et al. 1937).

Species Status

The Beaver Dam Breadroot is not state or federally listed, although it is listed as a California Native Plant Society 1B2 Species (rare, threatened or endangered in CA, Calflora 2017).
US Fish and Wildlife Service Endangered Species Act: No status
US Bureau of Land Management (Nevada): Sensitive
US Forest Service (Region 4): No status
State of Nevada (NAC 503): No status
NV Natural Heritage Program: Global Rank G3 State Rank S3
IUCN Red List (v 3.1): No status
CITES: No status

Range

The Beaver Dam Breadroot reportedly occurs from the Mojave Desert of southern California near Victorville and Barstow, and extends eastward through Death Valley, into Nevada, Northern Arizona (AZGFD 2005, MacKay 2013), although there reports of the species in California and Utah they are suspected to be inaccurate (AZGFD 2005, NatureServe 2017, but see Calflora 2017). The species exists on sandy surfaces or sandy gravel, including washes and roadcuts (MacKay 2013). Arizona elevation ranges are 534-1196 m, but may be 390 – 1524 m in Nevada, with a broader range of habitats including areas up to Piñon-Juniper woodlands (AZGFD 2005).

Population Trends

The Beaver Dam Breadroot is thought to be vulnerable to population declines due to its small population sizes, the potential to be influenced by OHV use, and expansion of urban areas and infrastructure (MacKay 2013). There have been “extensive” distribution surveys (NNHP 2017), but information on population trends is lacking.

Habitat Model Review

Models for “sand loving species” were produced by Hamilton and Kokos (2011) using the same general methods. First, a soils-based model was created (for all sand species) from the SSURGO data from NRCS. The suite of sand loving species was observed over a wide range of percent sand and thus the initial model was not specific enough to accurately use it for modeling the potential for this group of plants. ASTER imagery was analyzed using principal component analyses to create a binary threshold of the Thermal Infrared band (identifying quartz), and supplementing this remote mapping effort with maps of surficial geology and SSURGO soil coverages. With this information SSURGO units were recoded using a 75% cutoff in the average percent in the top 1 foot of soil and this resulted in 28 sand categories that could be used for plant model classification.

The initial models were used as a basis to construct further sampling for these species by stratifying sampling into high (70% of sample locations), medium (20%) and low (10%) potential of occurrence for each species, and based the number of samples taken on the size of the potential habitat unit. Field surveys using this method resulted in 25 additional data points for Beaver Dam Breadroot on survey plots. As these models were considered to be over-predictive and thus MaxEnt models were explored using the combined point set of all occurrences where each species was modeled separately. Environmental data used in the models were based solely on the Bioclim dataset, and no other soils or topography based layers were used.

The MaxEnt for these species was deemed by Hamilton and Kokos (2011) to not be useful for refining their soil based habitat models (although no soils were included in their MaxEnt modeling effort). The SSURGO based soils model was yet further refined using remotely sensed imagery and the resulting soils model was then manually refined to better suit the species by “selecting suitable polygons” that were included in the elevational range for each species – and then eliminating ASTER and SSURGO scores that had no presences within them. Other SSURGO attributes were used to further refine models but specific methods or criteria were not given.
The model for Beaver Dam Breadroot was further refined from the sandy soil model by restricting elevation to a range of 390 m to 750 m, and removing non-eolian areas with a high sand content (80-90%) (Hamilton and Kokos 2011, Figure 226).

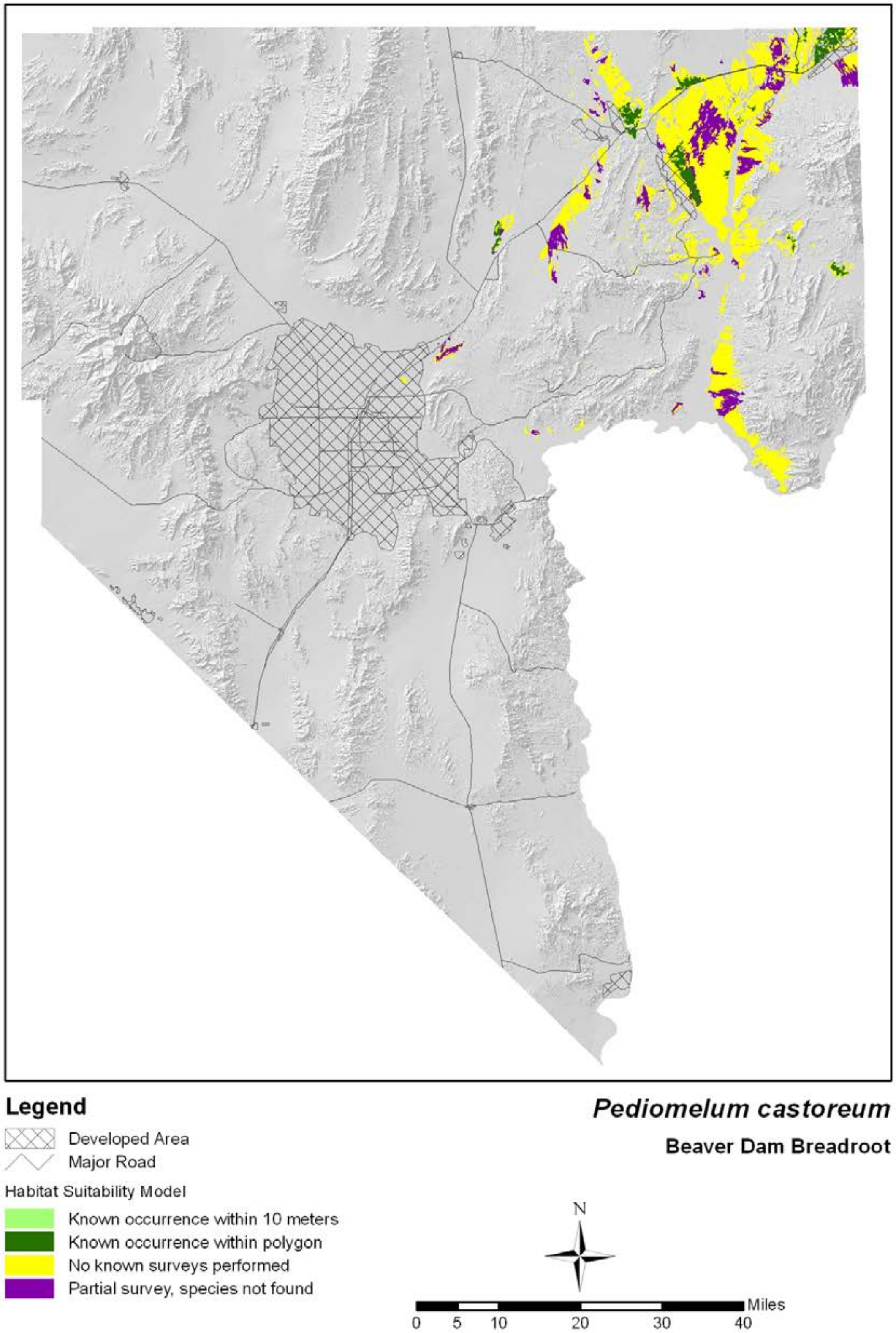

Figure 226. The refined soils based model for *Pediomelum castoreum* from Appendix A of Hamilton and Kokos 2011.

Distribution and Habitat Use within Clark County

This herbaceous perennial occurs in deep sand deposits at an elevational range of 610 m – 1220 m (Kearney and Peebles 1960; McDougall 1973). The breadroot is associated with creosote bush scrub and Joshua tree, or pinyon-juniper woodland habitats in washes or where sandy substrates are present (Munz 1974). Parent materials in the habitats may be limestone or sandstone.

Known in Lincoln and Clark Counties in Nevada (Kartesz 1988). There are ~ 17 localities of this species in NV (NNHP 2017) with most observations occurring within the Moapa Valley area, and the Virgin River from Lake Mead to Mesquite, and other Localities are mentioned nearby in the Beaver Dam Wash area (AZGFD 2005), and Riverside, Gold Butte, and along the Virgin river to the confluence with the Muddy River (Kartesz 1988, Nussear et al. 2011). Present in desert area with dry sandy soils. Occasionally confused with *Psoralidium lanceolatum* (Kartesz 1988). Other locations include Bonnie Springs and Lovell Canyon near the southern Spring Mountains (iNaturalist 2017). Habitat modeling for sand dependent species were conducted and provide estimates of the amount of area for species habitat categories within Clark County ecosystems. Estimated high suitability habitat for the Beaver Dam Breadroot was identified in Mojave Desert Scrub, and to a lesser extent Mesquite Acacia (Table 142). Moderate habitat includes some Desert Riparian areas as well (Table 142).

Table 142. Ecosystems within Clark County, and the area (Ha) of Low Medium and High predicted suitability within each ecosystem.

Ecosystem	Low	Medium	High
Alpine	0	0	0
Blackbrush	0	0	0
Bristlecone Pine	0	0	0
Desert Riparian	143	114	1
Mesquite Acacia	225	171	16
Mixed Conifer	0	0	0
Mojave Desert Scrub	57975	27988	13460
Pinyon Juniper	0	0	0
Sagebrush	0	0	0
Salt Desert Scrub	0	0	0

Ecosystem Level Threats

Beaver Dam Breadroot is found in Mojave Desert Scrub through Pinyon-Juniper Woodland Ecosystems. Mojave Desert Scrub habitats are often susceptible to fire due to invasive species. While this is true, the geophytic growth form – having large subsurface tubers, would likely protect the breadroot from fire. Invasive grasses may compete with seedlings. Livestock or feral horses and cattle are likely to be detrimental to the species through herbivory and soil surface disturbances. It is likely that some breadroot habitat areas were inundated by the creation of Lake Mead.

Threats to Species

The primary threats currently facing the Beaver Dam Breadroot include: livestock and feral animal disturbances, invasive plant species, urbanization, or energy and utility/transportation corridor development.

Existing Conservation Areas/Management Actions

While no specific conservation measures have been developed for this species, it can benefit from over-arching landscape protections such as State Parks and Wildlife Management Areas, National Parks, National Wildlife Refuges, National Conservation Areas, or Areas of Critical Environmental Concern.

The recently established Gold Butte National Monument has populations within its boundary, but as yet there is not conservation plan for that new entity. Note – we can fill this in when once the model is completed to determine if breadroot occurs in any other ACEC, NCAs, NWRs, etc.

Summary of Direct Impacts

Direct impacts to this species are projected to impact 17% of predicted high suitability habitat, and 12% of moderate suitability habitat (Hamilton and Lolos 2011, Table 143). Conserved habitat consists of 32 and 20% of total habitat for the High and Moderate suitable habitat respectively. Conserved habitat contains 1.75 times more area than the combined Disturbed and Impacted habitat in the high suitability category, and 1.4 times the combined Disturbed and Impacted areas for moderate habitat (Table 143). Relatively little area was identified as already disturbed.

Table 143. Categorized modeled habitat values (High, Medium, and Low) and the average area (Hectares) predicted in the potential impact areas, conservation areas, already disturbed areas, and overall area.

Habitat Level	Impact	Conserved	Disturbed	Area (Hectares)
High	2278	4379	218	13478
Med	3317	5688	774	28281
Low	5617	14077	1359	58343

PHDE - Spotted Leaf-nosed Snake (Phyllorhynchus decurtatus)

The Spotted Leaf-nosed Snake (*Phyllorhynchus decurtatus*), named for the enlarged scale at the tip of its snout, is a broadly occurring species found throughout the Mojave and Sonoran deserts. It is a small snake, typically less than 510 millimeters total length. It burrows underground, but can also be found hiding in surface debris (Frost et al. 2007). Due to its nocturnal activity and secretive nature, little is known about its biology. It is active April through July, lays three to five eggs per clutch, and typically inhabits sandy or gravelly habitats, and has been associated with creosote bush habitats typical of Mojave Desert scrub, and mixed Mojave Desert scrub (Brattstrom 1953, Goldberg 1996, Stebbins 2003). It is usually found in bajadas and valley bottoms and is rare in sandy flats, although in some areas it occupies sand dunes (Cowles 1941). They are not found in mountainous areas. Their diets consist predominantly of the eggs of lizards (Gardner and Mendelson 2003).

Species Status

Leaf-nosed Snakes have not been petitioned for listing at the federal or state level, and are on the lower tier of consideration and or conservation concern in most cases (e.g. UDWR 2005).

US Fish and Wildlife Service Endangered Species Act: No Status
US Bureau of Land Management (Nevada): No Status
US Forest Service (Region 4): No Status
State of Nevada: No Status
NV Natural Heritage Program: Global Rank G5, State Rank S4
NV Wildlife Action Plan: Species of Conservation Priority
IUCN Red List (v 3.1): Least Concern
CITES: No Status

Range

The range of the spotted leaf-nose snake in the United States extends from Inyo County, California, and southward though the western Mojave Desert north of San Diego and throughout San Bernardino County, California. They occupy the Mojave Desert of southern Nevada and extreme southwestern Utah, and the Sonoran Desert of central Arizona. In Mexico they extend to southern Baja California and southern Sonora along the interior lands surrounding the Sea of Cortez including some islands in the Gulf of California (McCleary and McDiarmid 1993, Stebbins 2003, Gardner and Mendelson 2004, Frost et al. 2007). They can be encountered across a broad range of elevations from below sea level (Turner and Wauer 1963) to 1220 m (Stebbins 2003).

Population Trends

Spotted Leaf-nosed Snakes are common in most of their range, and populations are thought to be relatively stable (Frost et al. 2007). No specific research has been conducted on trends for this species in Clark County, Nevada. Surveys are difficult as this snake is both nocturnal, and usually burrowing. Night driving along roadways is reportedly the easiest way to encounter this species (McCleary and McDiarmid 1993).

Habitat Model

The three modeling algorithms for Spotted Leaf-nosed Snake habitat predicted similar areas within Clark County largely differing in the intensity of prediction throughout suitable habitat areas in the county. The GAM model tended to predict more area of higher suitability than either the RF or the MaxEnt models (Figure 227). The RF model had the highest performance scores among the four performance measures reported, followed by the Ensemble model, MaxEnt and GAM (Table 144). The Continuous Boyce indices indicated good model performance for the RF models, with relatively poorly performing profiles for the MaxEnt and GAM models (Figure 229). The CBI for the ensemble model had a good model profile, but lacked a strong positive peak at higher values of suitability (Hirzel et al. 2006)(Figure 229), and its fixed Boyce index was the same as that of the RF model. Approximated bins for the ensemble model based on the CBI were 0-0.64 unsuitable, 0.64-0.7 marginal, 0.7 to 0.8 suitable, and 0.8 -1 optimal habitat; with a suggested cutoff threshold of 0.65 to 0.7 (Figure 229) while the threshold value calculated from ROC statistics for the ensemble model was 0.7 (Table 144).

Table 144. Model performance values for *Phyllorhynchus decurtatus* models

Performance	GAM	RF	MaxEnt	Ensemble
AUC	0.78	0.96	0.88	0.91
BI	0.72	0.76	0.73	0.76
TSS	0.53	0.76	0.70	0.73
Correlation	0.51	0.79	0.66	0.70
Cut-off*	0.54	0.65	0.51	0.70

*threshold at which sum of sensitivity (true positive rate) and specificity (true negative rate) is highest

Table 145. Percent contributions for input variables for *Phyllorhynchus decurtatus* for ensemble models using GAM, MaxEnt and RF algorithms

Term	GAM	RF	Max	Avg
Slope	34.93	20.24	22.84	25.38
Diurnal Temp. Range	15.21	10.53	20.59	14.91
Winter Precip	15.21	13.35	9.50	12.76
Summer Max Temp.	6.52	12.74	13.29	11.06
Roughness (TRI)	6.52	12.55	2.13	7.66
Winter Min Temp.	0.00	12.91	6.42	7.15
Topographic Position (TPI)	10.44	0.00	12.25	6.74
Surface Texture (ATI)	3.71	6.23	7.45	5.84
NDVI Maximum	5.71	6.07	1.86	4.71
NDVI Amplitude	1.76	5.37	3.67	3.79

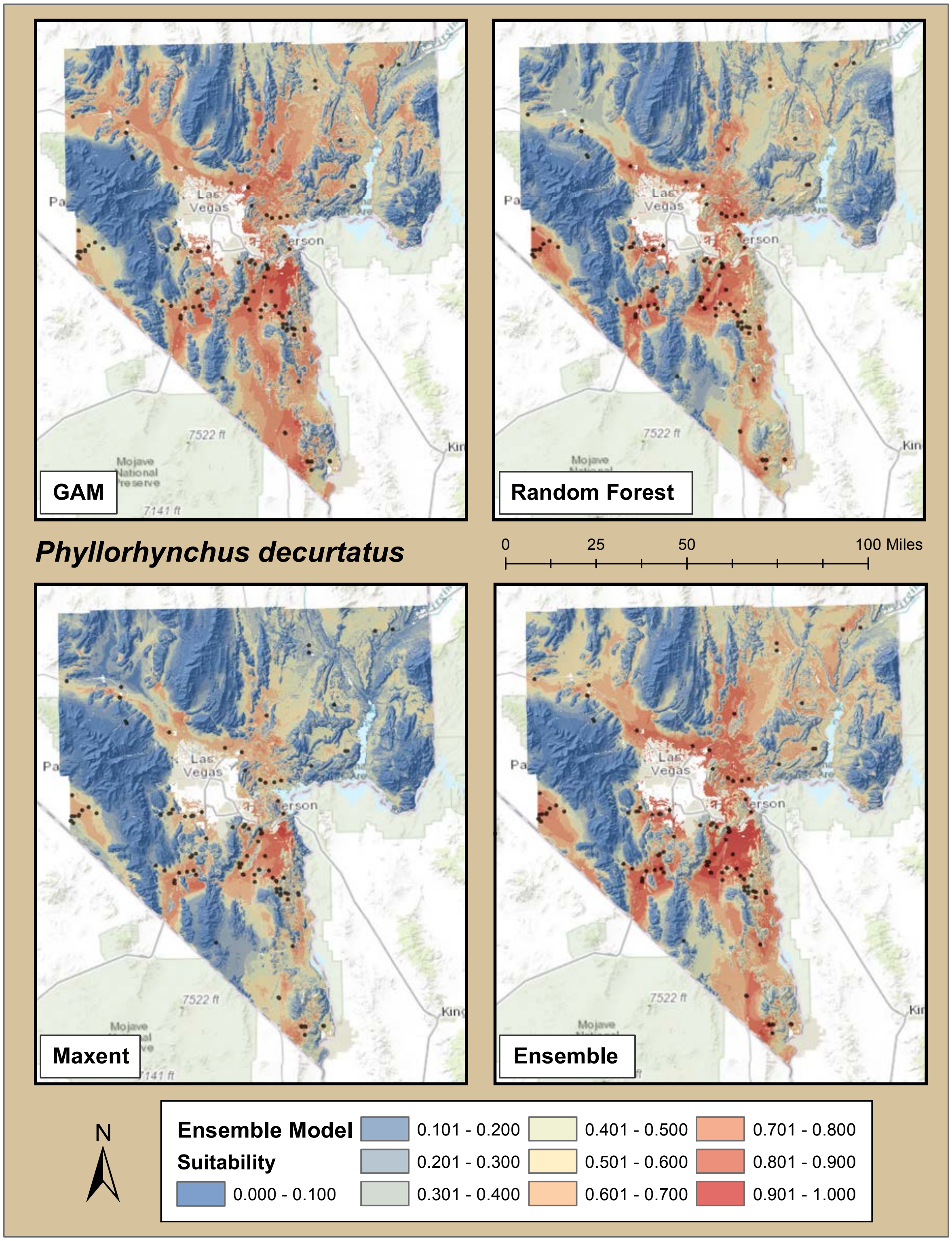

Figure 227. SDM maps for *Phyllorhynchus decurtatus* model ensembles for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

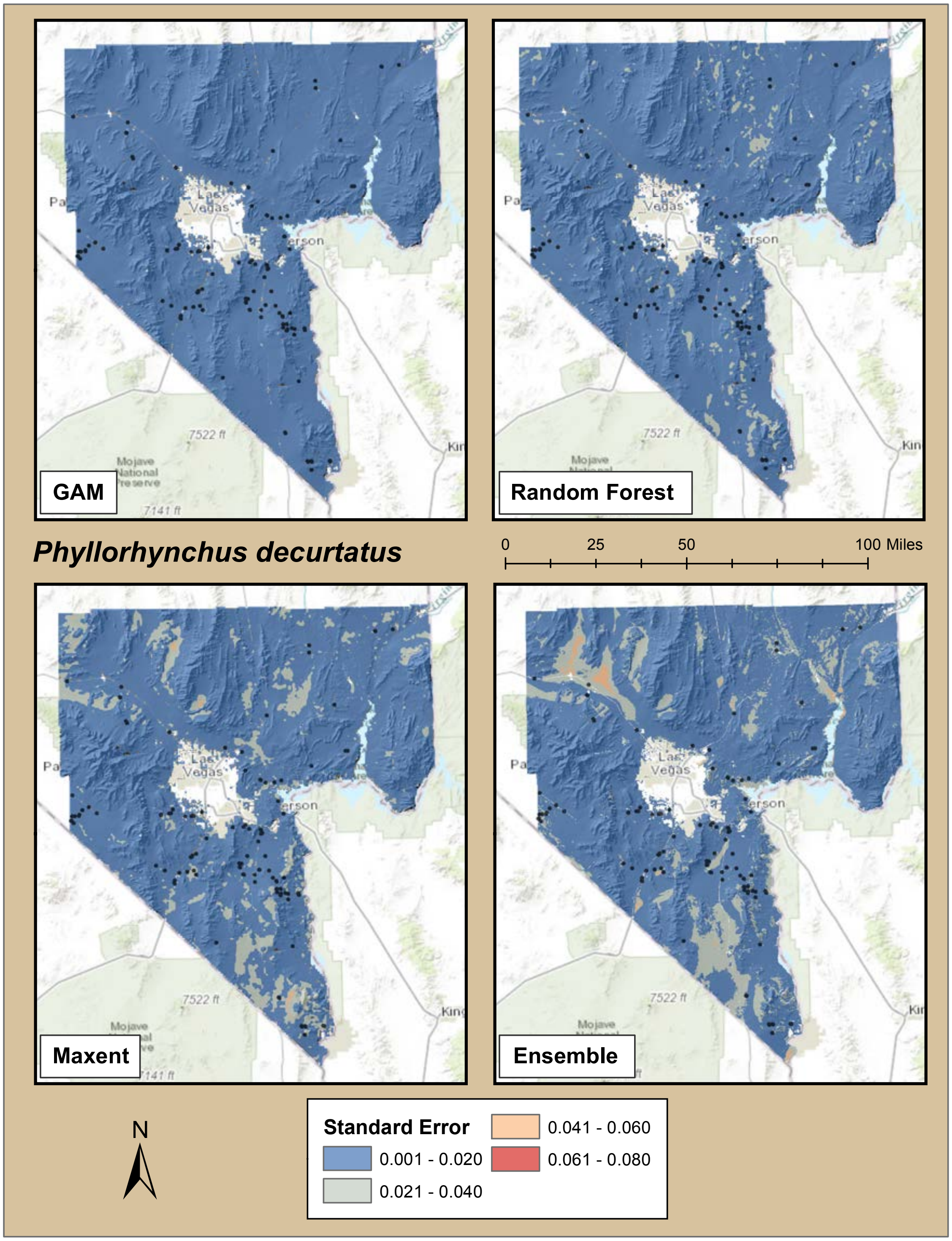

Figure 228. Standard error maps for *Phyllorhynchus decurtatus* models for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

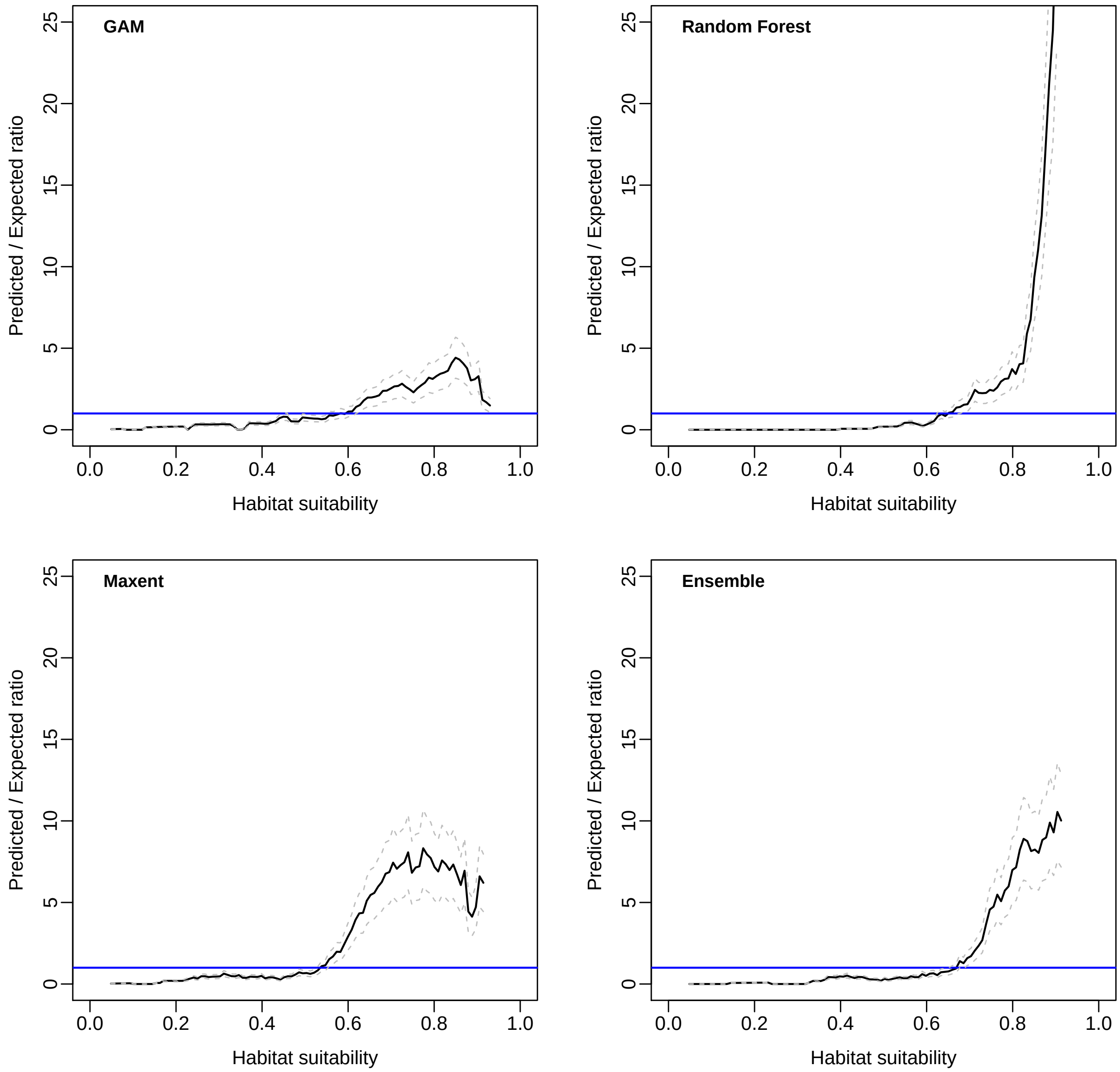

Figure 229. Continuous Boyce Indices for *Phyllorhynchus decurtatus* models for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

GAM Model

The top 4 contributing variables to the GAM model were: Slope, Diurnal Temperature Range, Winter Precipitation, and Topographic Position (TPI), which accounted for 76% of the influence to the model by environmental variables (Table 145). Habitat suitability was predicted to be highest in flatter areas, with suitability decreasing sharply to areas with slopes of 5%, and with slope depreciating predictions strongly thereafter (Figure 230). Areas of with lower differences between night and daytime temperatures were also predicted to be more suitable. Habitat suitability was highest in areas with lower winter precipitation, becoming strongly negative as precipitation exceeded 10 cm per year. The partial response curve for Topographic

Position indicated increased habitat predictions in areas in the middle values, corresponding with areas tending to be in the middle lf their local watersheds. (e.g. Bajada's rather than either peaks, or low drainages (Figure 230). The GAM standard error map indicated little or no areas with high standard error among the model runs (Figure 228), but was the poorest performing of the three modeling algorithms we employed (Table 144).

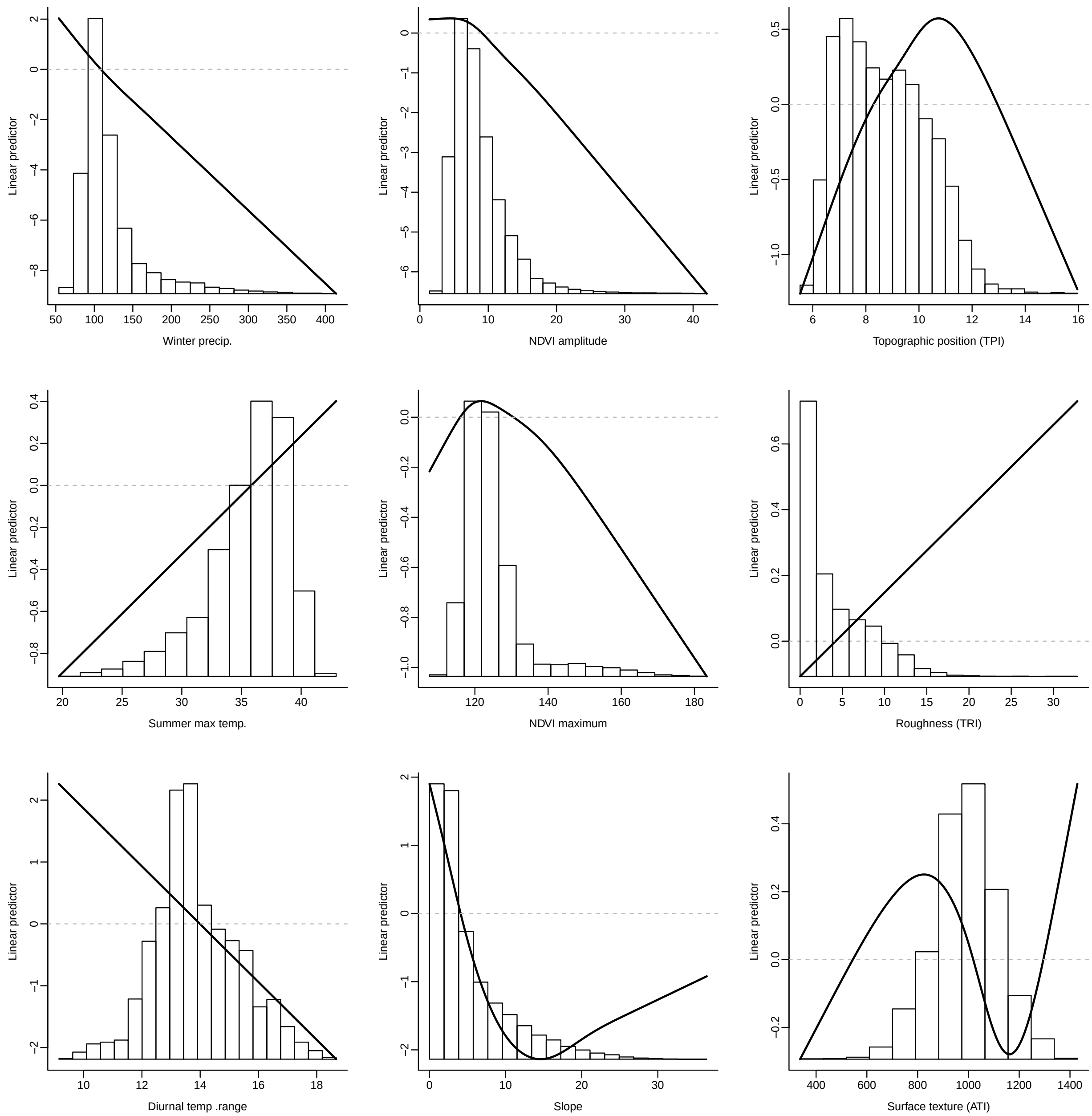

Figure 230. GAM partial response curves for the *Phyllorhynchus decurtatus* model overlaid over distribution of environmental variable inputs in the study area.

MaxEnt Model

The MaxEnt model had five variables contributing nearly 10% or more each, accounting for 78% of model contribution in total (Table 145). Partial responses indicating the behavior of each of the environmental variables relative to modeled habitat suitability were similar to those for the GAM modeling approach, where modeled habitat indicated higher suitability in areas with lower slope, lower range of temperatures across the day (Figure 231). Predicted modeling responses for Summer Maximum Temperatures were all positive, but tended to decline with increasing temperatures. Unlike the GAM MaxEnt predicted increasing suitability with increases in Topographic Position, and Winter Precipitation followed the prediction for more suitable habitat in areas of lower precipitation. The MaxEnt model performed third among the four models explored, and while it had a relatively weaker CBI, the other performance measures were not indicative of poor performance overall (Table 144).

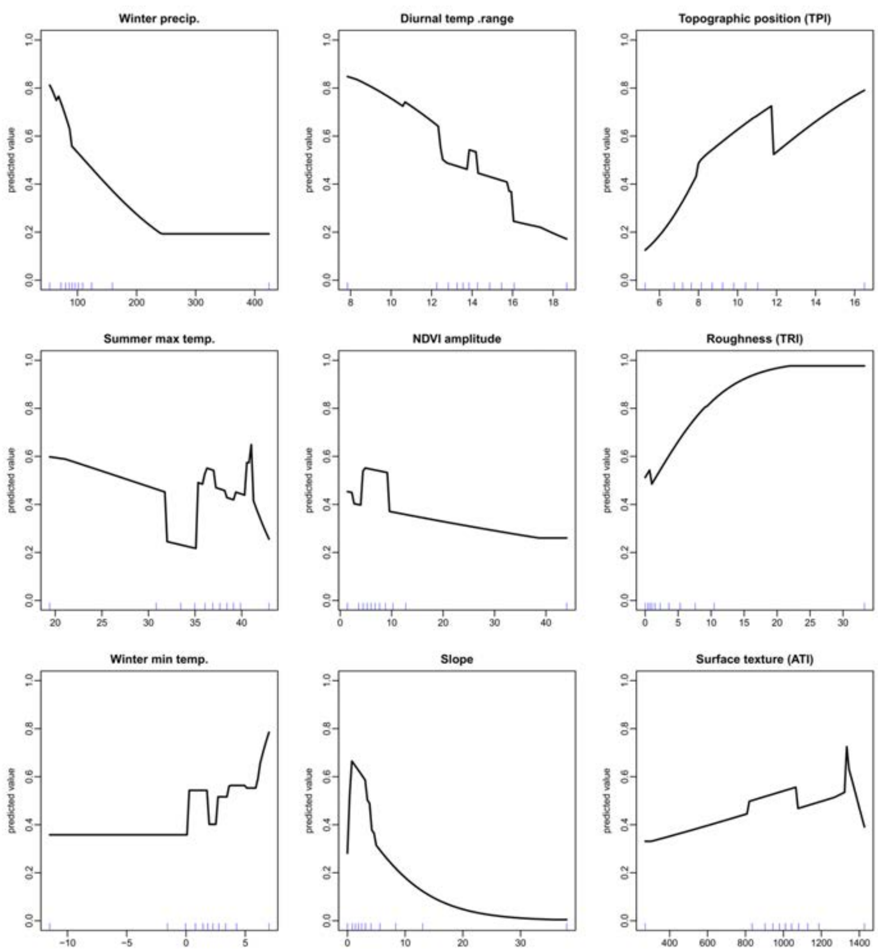

Figure 231. Response surfaces for the top 9 environmental variables included in the MaxEnt ensemble model for *Phyllorhynchus decurtatus.*

Random Forest Model

The RF models had six environmental variables contributing 10% or more totaling 82% of total model influence (Table 145). Slope was the highest contributor – with predicted habitat declining sharply from slopes of 0 to 5%, and suitability remaining low above that level (Figure 232). Winter Precipitation displayed a similar pattern, with suitable habitat declining sharply as precipitation approached 19 cm. Winter Minimum Temperatures were included in the top-ranking influences for the RF models, but not the others, and higher temperatures were associated with higher predicted suitability, increasing strongly in areas above 3ºC. Surface Roughness was included in the models (likely substituting for the TPI included in the others) which resulted in predictions for increased suitability in flatter areas without much local topographic relief. Habitat was again predicted to be higher in areas with a narrower Diurnal Temperature Range (Figure 232). The random forest model had a strong CBI curve (Figure 229), and was the highest performing model across all reported measures (Table 144).

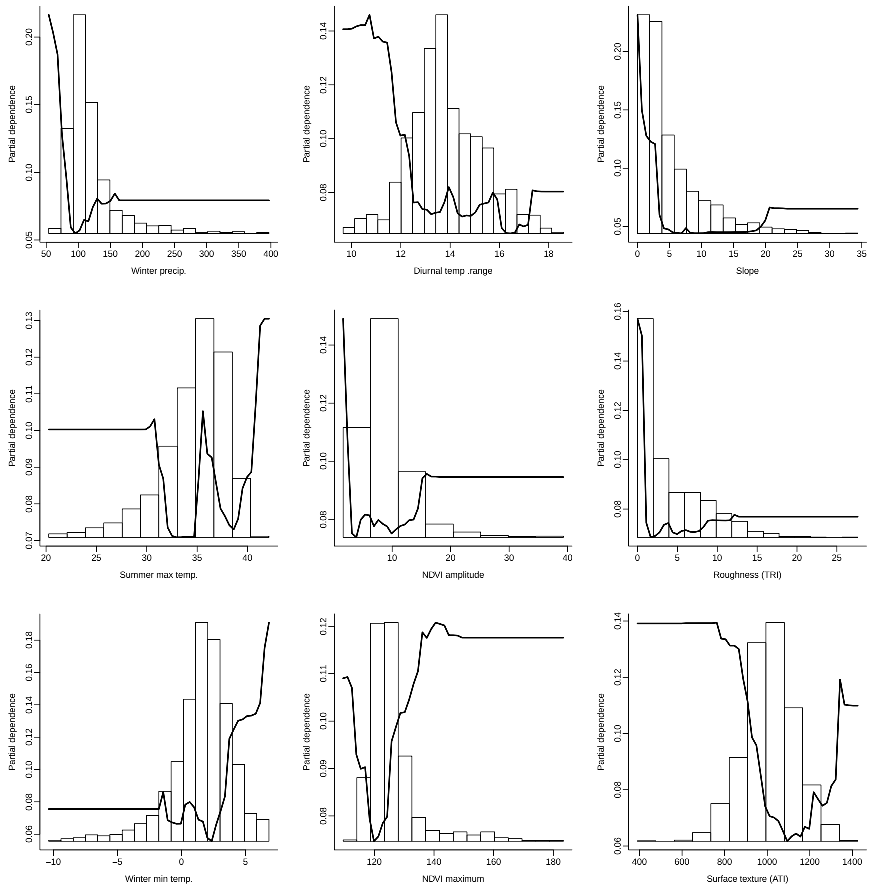

Figure 232. Response surfaces for the environmental variables included in the RF ensemble model for *Phyllorhynchus decurtatus*. Histograms represent the range of each environmental variable across the x-axis, and predicted dependence relative to habitat suitability values are on the y-axis.

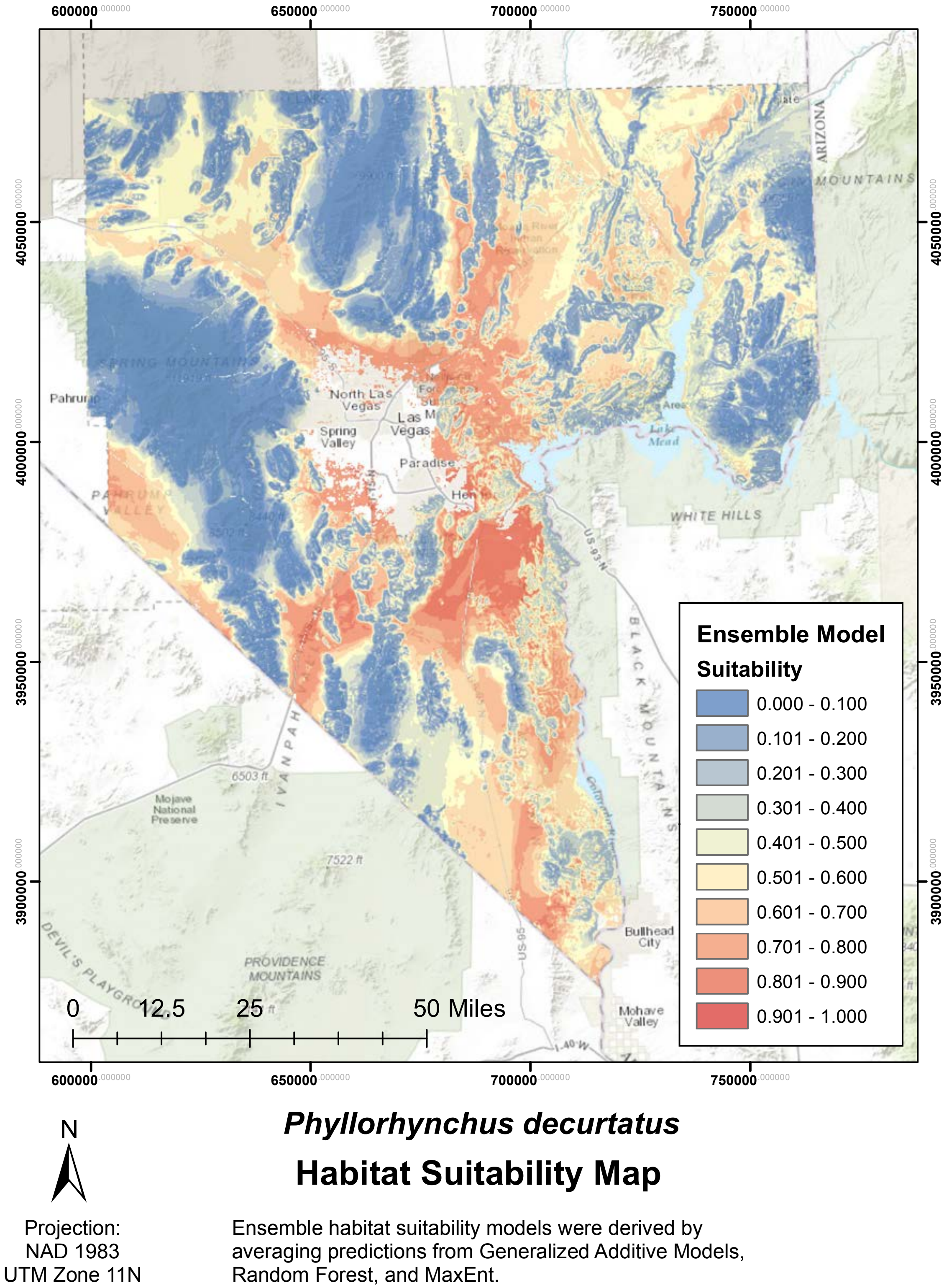

Figure 233. SDM map for the *Phyllorhynchus decurtatus* ensemble model

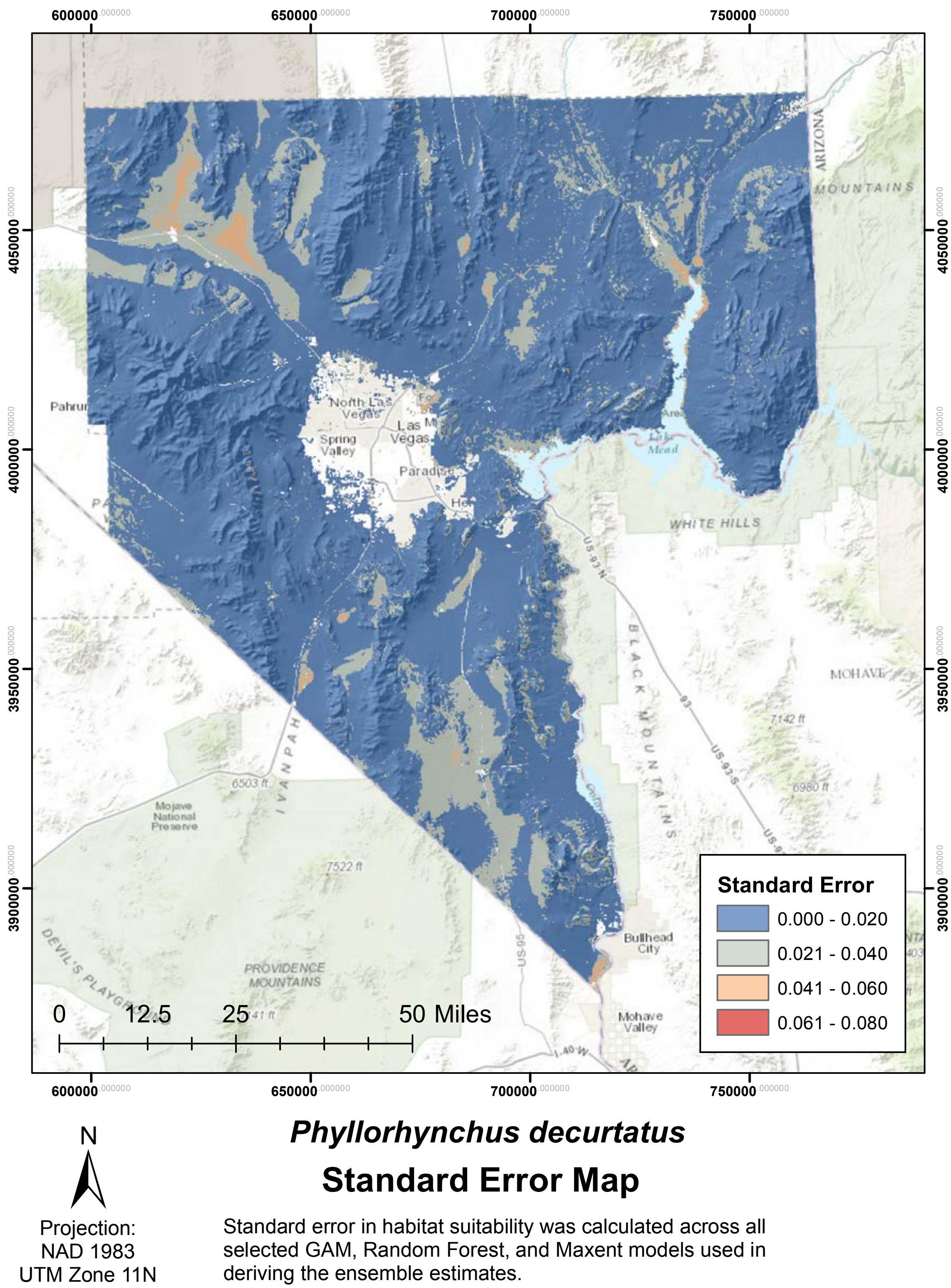

Figure 234. Standard Error map for the *Phyllorhynchus decurtatus* ensemble model

Distribution of Localities

Known locations for Spotted Leaf-nosed Snakes are fairly well distributed throughout Clark County. The northern limit of the range for this snake is near the northern boundary of Clark County, however, they are known to occur into Lincoln County (TCE personal observation). There are substantially more locality points in the southern one-half of the county, particularly so in the greater Eldorado Valley, westward near Jean in the I15 corridor, and in Lovell and Trout canyons (Figure 227).

Standard Error

The standard error for the habitat suitability model on Spotted Leaf-nosed Snake habitat is generally low over the majority of Clark County (Figure 234). Small patches of moderately high error occur at the extreme southern tip of Clark County, Eldorado Valley, Ivanpah Valley, near Jean, the northeast of the Las Vegas Valley near the OHV open area, and on the Nellis Air Force Base properties up the US 95 corridor toward Indian Springs. These relatively small patches occur within moderate to high habitat suitability areas. One additional location of moderately high standard error occurs at the confluence of the Muddy and Virgin Rivers and either side of the Overton Arm of Lake Mead.

Distribution and Habitat Use within Clark County

Spotted Leaf-nosed Snakes are found throughout Clark County in appropriate habitats. Like the Mojave sidewinder rattlesnake, this species prefers valley bottoms, especially where fine sandy soils are prevalent. Searchers found during road-cruising surveys that Spotted Leaf-nosed Snakes and sidewinders were nearly sympatric and found in similar habitats and geological types along the Colorado River road networks (e.g., Northshore, Cottonwood, and Nelson—in and around LMNRA). Modeled habitat for Spotted Leaf-nosed Snakes in high and moderate categories is found predominantly in Mojave Desert Scrub, Mesquite Acacia, Salt Desert Scrub, Desert Riparian, and Blackbrush ecosystems within Clark County (Table 146).

Modeled habitat suitability for Spotted Leaf-nosed Snakes is moderate to high in most of the valley bottoms across Clark County (Figure 233). This coincides with the sandy to gravelly soils preferred by this secretive snake (Stebbins 2003). Very high suitability habitat occurs in Eldorado, Ivanpah, and [Pahrump] valleys, as well as Ivanpah Valley and Hidden Valley north of the Lucy Gray Mountains. Moderately high suitability exists surrounding those areas, and extending northward from Las Vegas up the I15 corridor up to the state line, and the US 95 corridor near Indian Springs.

Table 146. Ecosystems within Clark County, and the area (Ha) of Low Medium and High predicted suitability within each ecosystem.

Ecosystem	Low	Medium	High
Alpine	124	0	0
Blackbrush	331560	80414	3020
Bristlecone Pine	7565	0	0
Desert Riparian	592	3505	6598
Mesquite Acacia	1333	6345	11994
Mixed Conifer	27339	0	0
Mojave Desert Scrub	223223	493074	562756
Pinyon Juniper	115377	513	0
Sagebrush	4294	403	0
Salt Desert Scrub	22954	32278	23291

Ecosystem Level Threats

This species can be found in Mojave Desert Scrub habitats. This species is likely to suffer most from habitat loss and degradation.

Threats to Species

The species is threatened by urban and agricultural development. Energy development, especially solar, results in widespread habitat destruction, and populations may be fragmented by utility and transportation infrastructure such as roadways. Like other species it is likely impacted by pets in and around development, and where feral cats and dogs are common. Due to its small size, the Spotted Leaf-nosed Snakes are attractive in the pet industry. Recent analyses on collection records indicate that commercial collections have reduced populations for this species (NDOW – unpublished data). Spotted Leaf-nosed Snakes are sold on the internet. Collections of native reptiles for export are currently legal in Clark County, Nevada. Commercial collections of reptiles in Nevada ceased in January 2018.

Existing Conservation Areas/Management Actions

The Spotted Leaf-nosed Snake is considered a Species of Conservation Priority by the Nevada Wildlife Action Plan due to increasing habitat fragmentation, especially from alternative energy developments such as large-scale solar power plants (Wildlife Action Plan Team 2012). This plan sets a strategic vision for wildlife conservation at the landscape level in Nevada, and identifies the species of greatest conservation need within the state. Plan objectives for this snake are to maintain healthy viable populations. Research and conservation actions recommended specifically for this species include: developing a regionally targeted night drive/pit trap survey network to determine status and distribution of the species; analyzing habitat integrity and connectivity and developing a habitat connectivity monitoring program; and developing goals, objectives, and contingency strategies for maintaining habitat and population connectivity at regional and local scales (Wildlife Action Plan Team 2012).

The Overton Wildlife Management Area (OWMA) consists of 17,229 acres in the Moapa Valley managed by the Nevada Department of Wildlife. The conceptual management plan for OWMA calls for determining the occurrence and habitat use of Spotted Leaf-nosed Snake, as well as for the restoration, maintenance, and protection of habitats that will benefit species considered to be a conservation priority by the NV Wildlife Action Plan, such as this snake (NDOW 2014).

Summary of Direct Impacts

High predicted habitat for this species is predicted to be largely conserved (1685 km^2), and much of this category is outside of the planning area. Collectively 1129 km^2 of high suitability habitat will be altered in the future (Table 147). Moderate habitat is similarly predicted throughout the county, however 1/3 is in conserved areas, while much less moderate habitat is to be impacted.

Table 147. Categorized modeled habitat values (High, Medium, and Low) and the average area (Hectares) predicted in the potential impact areas, conservation areas, already disturbed areas, and overall area

Habitat Level	Impact	Conserved	Disturbed	Area (Hectares)
High	80127	168589	31920	614272
Med	32595	206213	6871	623520
Low	9721	137700	1247	736679

PHFI - Clarke Phacelia (Phacelia filiae)

Clarke Phacelia is a small annual forb (2.3-6.0 cm high) in the Hydrophyllaceae family (occasionally grouped into the Boraginaceae family) most closely related to *P. crenulata* which is more widely distributed and abundant. The species name *filiae* was chosen to honor the daughter of the third author in Atwood et al. (2002). The most prominent physical distinctions in *Phacelia filiae* compared to other *Phacelia* are the shape of the seeds and the appearance of the seed coats. Other morphological characteristics that can help in distinguishing the species from others are: leaf size, shape, and pubescence; size, shape, and color of flowers; stamen and style length compared to corolla length; duration; and geographical distribution (Atwood et al. 2002).

Species Status

US Fish and Wildlife Service Endangered Species Act: Not listed
US Bureau of Land Management (Nevada): No Status
US Forest Service (Region 4): No Status
State of Nevada (NAC 527): No Status
NV Natural Heritage Program: Global Rank G2; State Rank S2

IUCN Red List (v 3.1): No status
CITES: No status

Range

Known populations of Clarke Phacelia are limited to a very small region only within southern Nevada (Atwood et al. 2002). Besides populations known in Clark County, it has also been found on the Nevada National Security Site in Nye County.

Population Trends

It is estimated that 30 populations of Clarke Phacelia occupy the current known range of the species, however, no population trend data are available at this time

Habitat Model

Model Results

Habitat for Clarke Phacelia was modeled from a very low number of available localities (N= 26), restricted to the northwestern extent of the county. Despite the smaller sample sizes all of the habitat modeling algorithms produced similar prediction maps with the exception of the RF models with low and moderately low habitat suitability (0.2 – 0.4) predicted extensively in the eastern portion of the county (Figure 235). Performance was highest overall for the Ensemble model, followed by the RF model, MaxEnt Model, and GAM model (Table 148). While performance measures were high overall there was a higher drop in CBI between GAM models to the lower performing RF and MaxEnt models for this metric (Figure 237). Continuous Boyce Indices for the models indicated good performance for the GAM, RF and Ensemble Models, with erratic performance for the MaxEnt model, which had several areas of large fluctuation on the curve (Figure 237). Curve thresholds for the Ensemble model indicated habitat at suitability levels above 0.6, while the PRBE cutoff was higher at 0.7, which is higher than typical in species distribution models generally (Figure 237, Table 148).

There was a broad range of error values among the model with the most and highest predicted values for GAM, followed by MaxEnt, Ensemble, and RF models. Standard errors were highest and most extensive for the GAM model with large areas > 0.08 throughout much of the county, especially in low lying areas (Figure 236).

Table 148 . Model performance values for *Phacelia filiae* models

Performance	GAM	RF	MaxEnt	Ensemble
AUC	0.983	0.985	0.982	0.989
BI	0.725	0.668	0.638	0.782
TSS	0.966	0.989	0.975	0.981
Correlation*	0.715	0.773	0.8	0.771
Cut-off**	0.744	0.749	0.412	0.661

*point bi-serial correlation

**threshold at which sum of sensitivity (true positive rate) and specificity (true negative rate) is highest

Table 149 . Percent contributions for input variables for *Phacelia filiae* for ensemble models using GAM, MaxEnt and RF algorithms

Term	GAM	RF	Max	Avg
Winter Min Temp	46.87	18.58	35.17	33.28
Summer Precipitation	27.56	14.36	21.97	21.10
Winter Precipitation	13.76	16.18	34.11	21.13
NDVI Maximum	6.05	10.23	1.43	5.76
Summer Max Temp	3.41	9.04	6.45	6.18
Annual Temp. Range	2.36	11.54	0.00	4.48
Topographic Position (TPI)	0.00	2.68	0.30	0.96
Greenness Timing	0.00	14.50	0.58	4.83
Surface Texture (ATI)	0.00	2.90	0.00	0.93
Slope	0.00	0.00	0.00	0.00

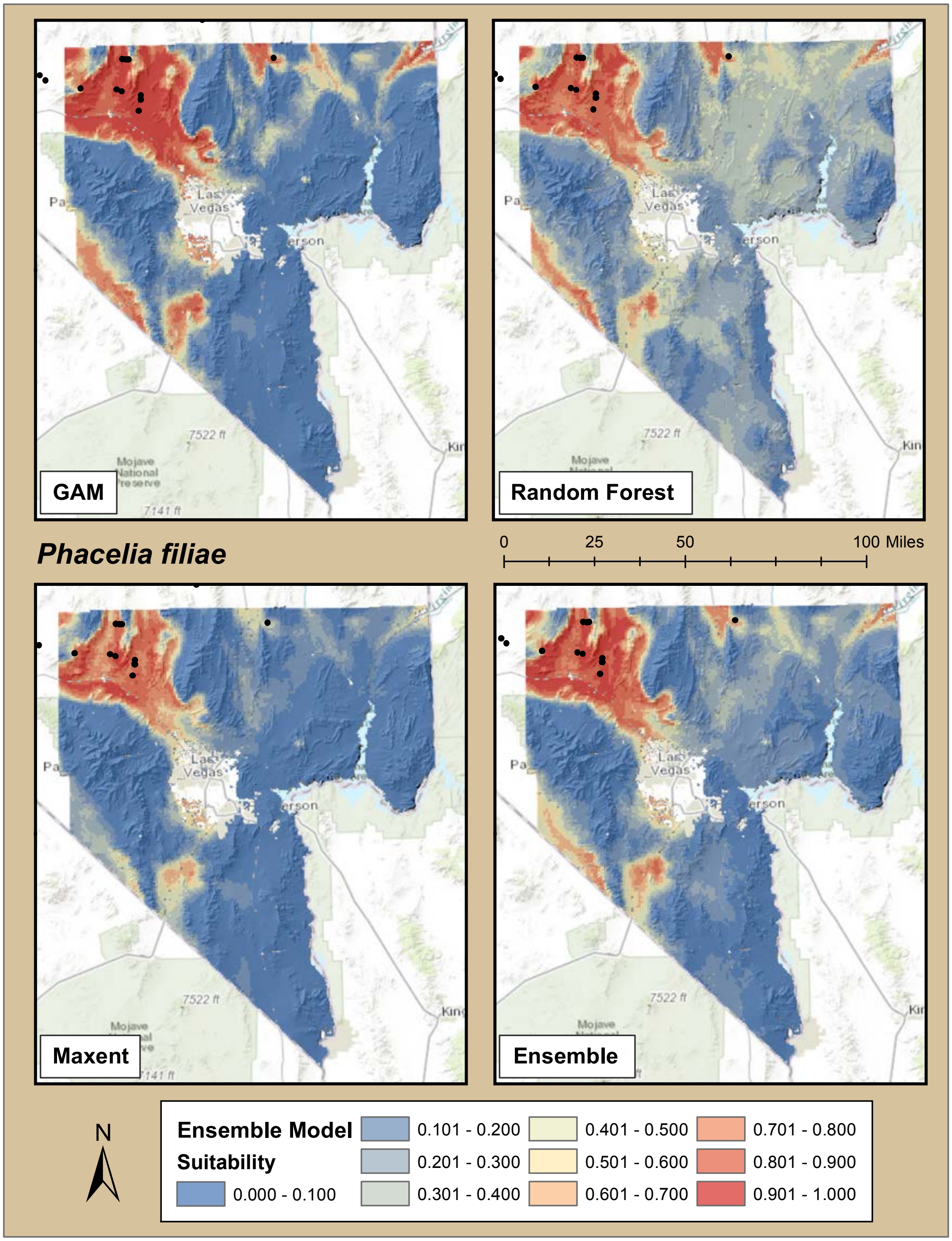

Figure 235 . SDM maps for *Phacelia filiae* for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right). Black dots indicate presence points for the Phacelia

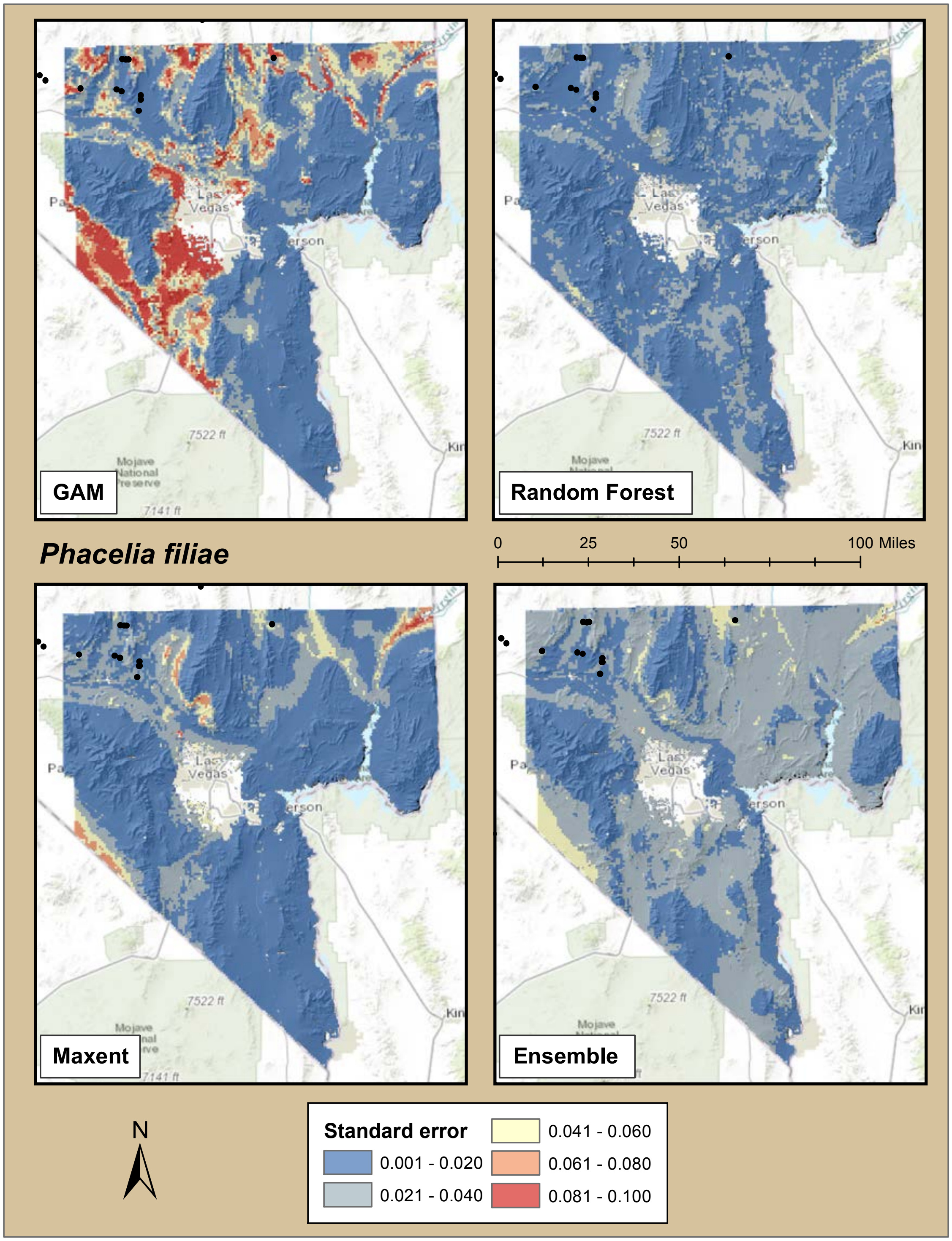

Figure 236 . Standard error maps for *Phacelia filiae* models for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

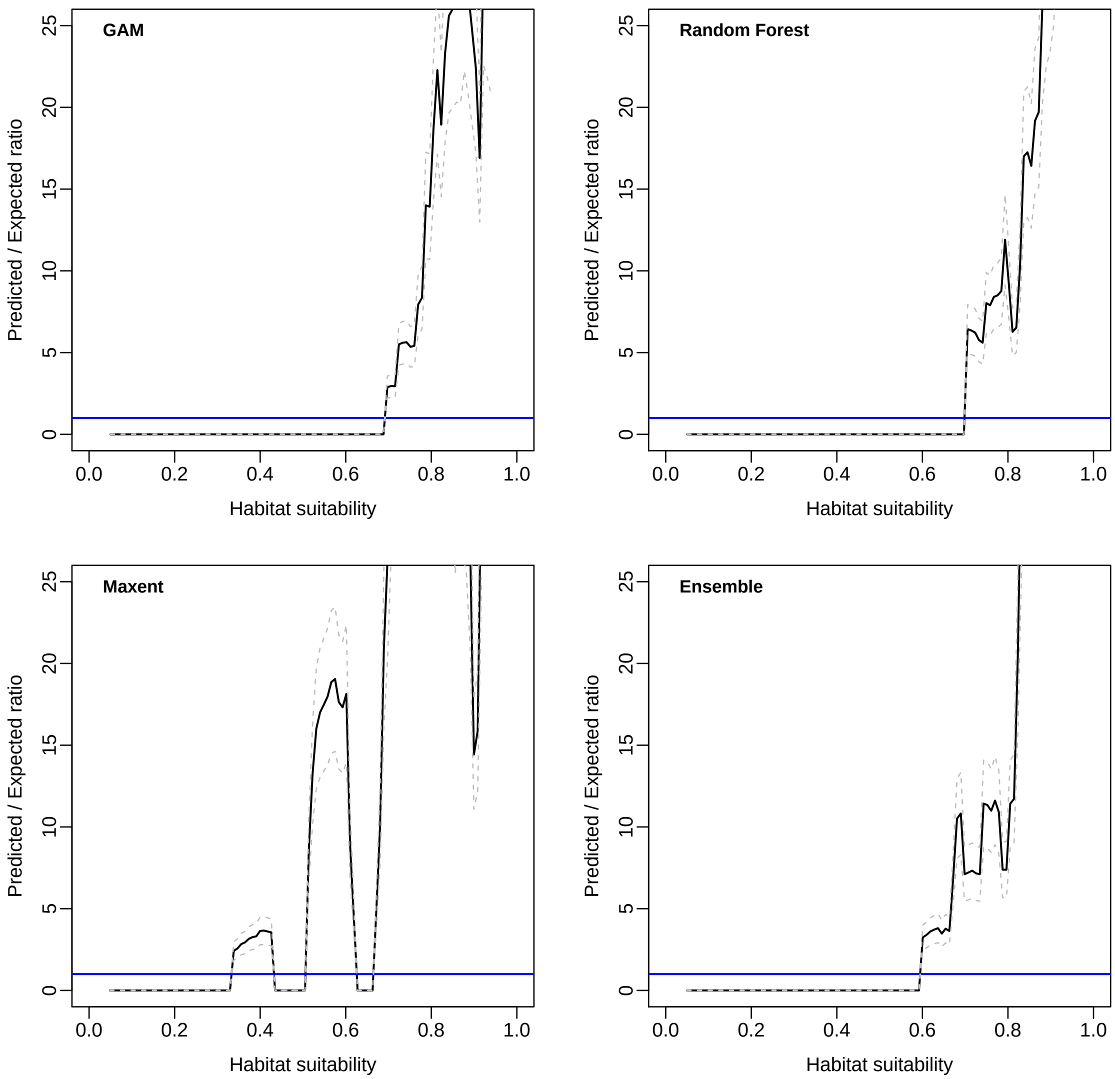

Figure 237 . Continuous Boyce Indices for *Phacelia filiae* models for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

GAM Model

Only three (Winter Minimum Temperature, Summer Precipitation, and Winter Precipitation) of the 10 environmental layers contributed 10% or more to the model, collectively accounting for 88% of model contributions (Table 149). Four of the environmental covariates had zero contribution. Winter Minimum Temperature was the highest contributing with 47% of total contribution, predicting positive habitat for areas with minimums between -6 ºC and 2 ºC, peaking at ~ -1 ºC (Figure 237). Summer Precipitation (28% contribution) had a peaked positive response above 25mm, with highest habitat suitability values predicted at 60mm and becoming negative above 100 mm. Winter Precipitation was negatively associated with predicted habitat for this species. Positive influences for Winter Precipitation were predicted at values below 175 mm, and above which there was a strong negative influence (Figure 237).

Habitat for the species as predicted in the GAM models was high (> 0.8) and contiguous throughout the northwestern corner of the county, with a broad band of habitat predicted along the US 95 corridor, extending well north of the highway into the Nevada National Security Site, and the Nellis Bombing Range and right to the northern county border. Habitat was also predicted in much of the Coyote Springs Valley and extending toward the Moapa Valley to the east. After a break in predicted habitat there is more predicted habitat of moderate values (i.e., 0.4 to 0.6) in the southern Moapa Valley north of Highway I-15. The mesas along the Virgin River have high values for habitat suitability. Much of the greater Pahrump Valley has predicted habitat suitability values > 0.6 and higher. The I-15 Corridor in the Ivanpah Valley, around Goodsprings, Jean, and the Lucy Grey Mountains also support habitat of moderate to high suitability (Figure 235). As stated above, standard errors for this algorithm were the greatest among all four models, with extensive patches of high (0.08 – 0.1 error) (Figure 236).

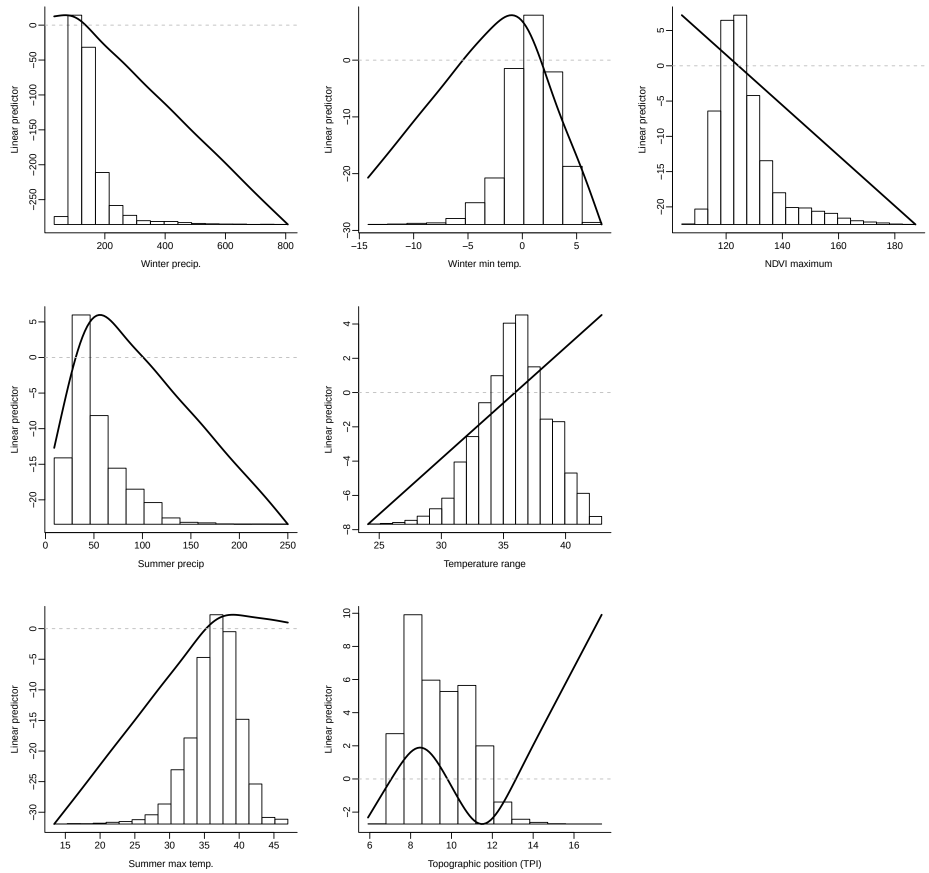

Figure 238 . GAM partial response curves for the *Phacelia filiae* model illustrated over the distribution of environmental variable inputs in the study area.

MaxEnt Model

The MaxEnt model was influenced primarily by the same three environmental variables as in the GAM model (Winter Minimum Temperature, Summer Precipitation, and Winter Precipitation), with a combined contribution of 91% (Table 149). Winter Minimum Temperature and Winter Precipitation contributed the greatest amounts (~ 35% each), with habitat prediction favored in areas receiving < 100 mm of winter precipitation, and with low Winter Minimum Temperatures relative to the county average, with a peaked response at -1 ºC (Figure 238). Summer Precipitation also had a sharp peaked response at ~ 60mm, which was higher than the average value for the county, generally (i.e., 30 mm)(Figure 238). Predicted habitat suitability was similar to that of the GAM model, although with slightly reduced habitat suitability values throughout (Figure 235). In addition to the large polygon of moderately high habitat suitability in the northwestern extent of the county, a small area is predicted south of Pahrump. Elsewhere the habitat suitability values are moderately low. (Figure 235). Standard errors for this habitat were highest near Pahrump, North Las Vegas, and in the Virgin River Valley, near Mesquite (Figure 236).

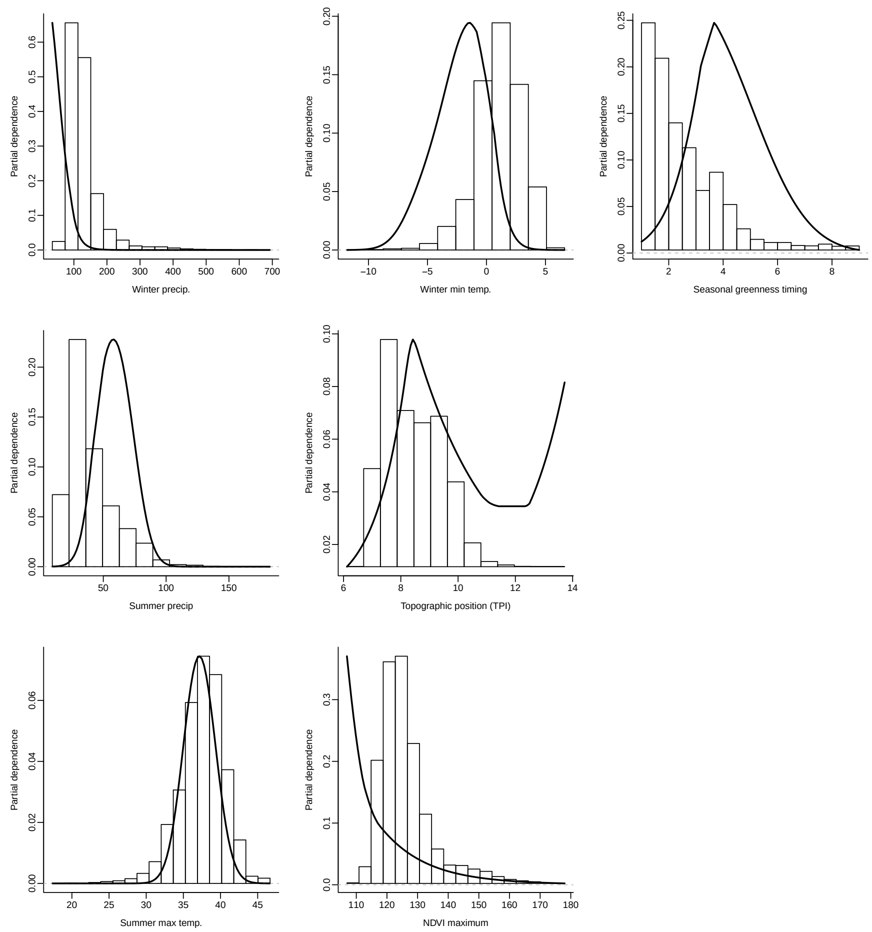

Figure 239 . Response surfaces for the top 9 environmental variables included in the MaxEnt ensemble model for *Phacelia filiae.*

Random Forest Model

The RF models had seven environmental variables contributing 9% or more totaling 94% of total model influence (Table 149). The highest contributors were Winter Minimum Temperature, Winter Precipitation, Summer Max Temperature and Greenness Timing, each with 14% – 18% contribution (3 of which were also the highest contributors to the GAM and MaxEnt models). Winter Minimum Temperature and Winter Precipitation had similar partial curves to that seen in the other models – where lower precipitation levels and cooler Winter Minimum Temperatures were associated with higher predicted habitat suitability (Figure 239). Summer Maximum Temperatures above 35 ºC were favored, and areas with later Seasonal Greenness Timing than the average for the county were preferred (Figure 239). Higher habitat suitability values were also predicted for areas with higher Annual Temperature Ranges, and lower Maximum NDVI values than average (Figure 239).

Standard errors for this habitat suitability prediction were less extensive and generally of lower values than the other models (SE 0.02 to 0.04), with patches throughout the county (Figure 236).

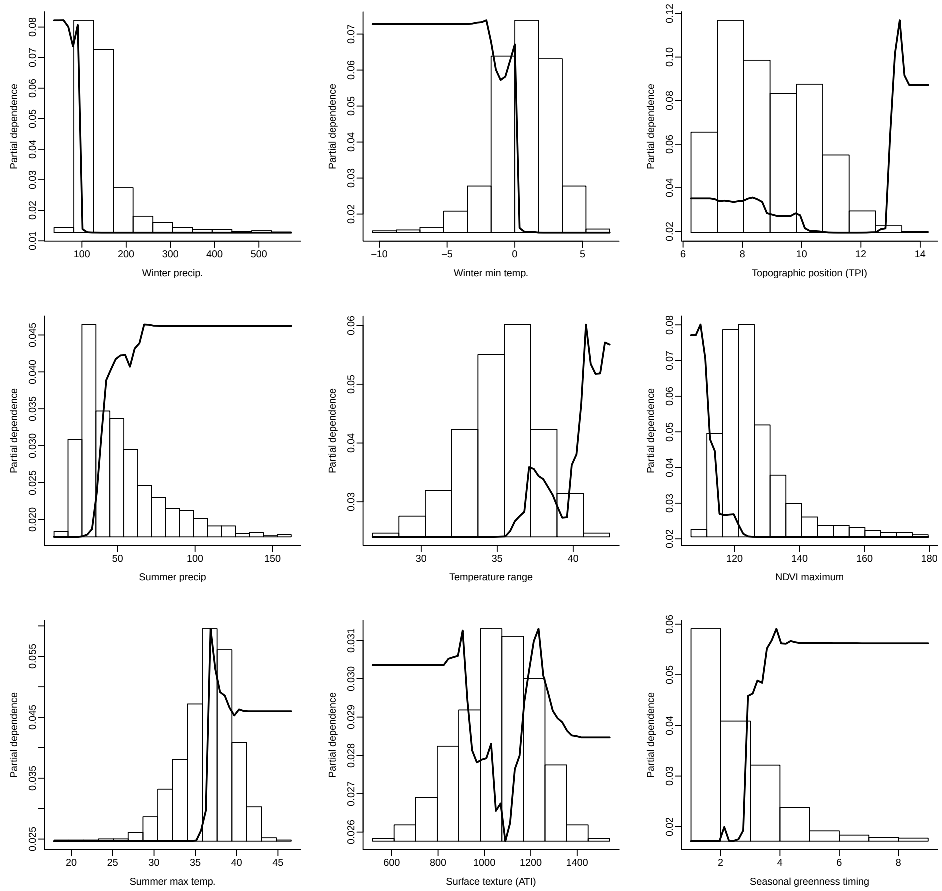

Figure 240 . Response surfaces for the environmental variables included in the RF ensemble model for *Phacelia filiae*. Histograms represent the range of each environmental variables across the x-axis, and predicted dependence relative to habitat suitability values are on the y-axis.

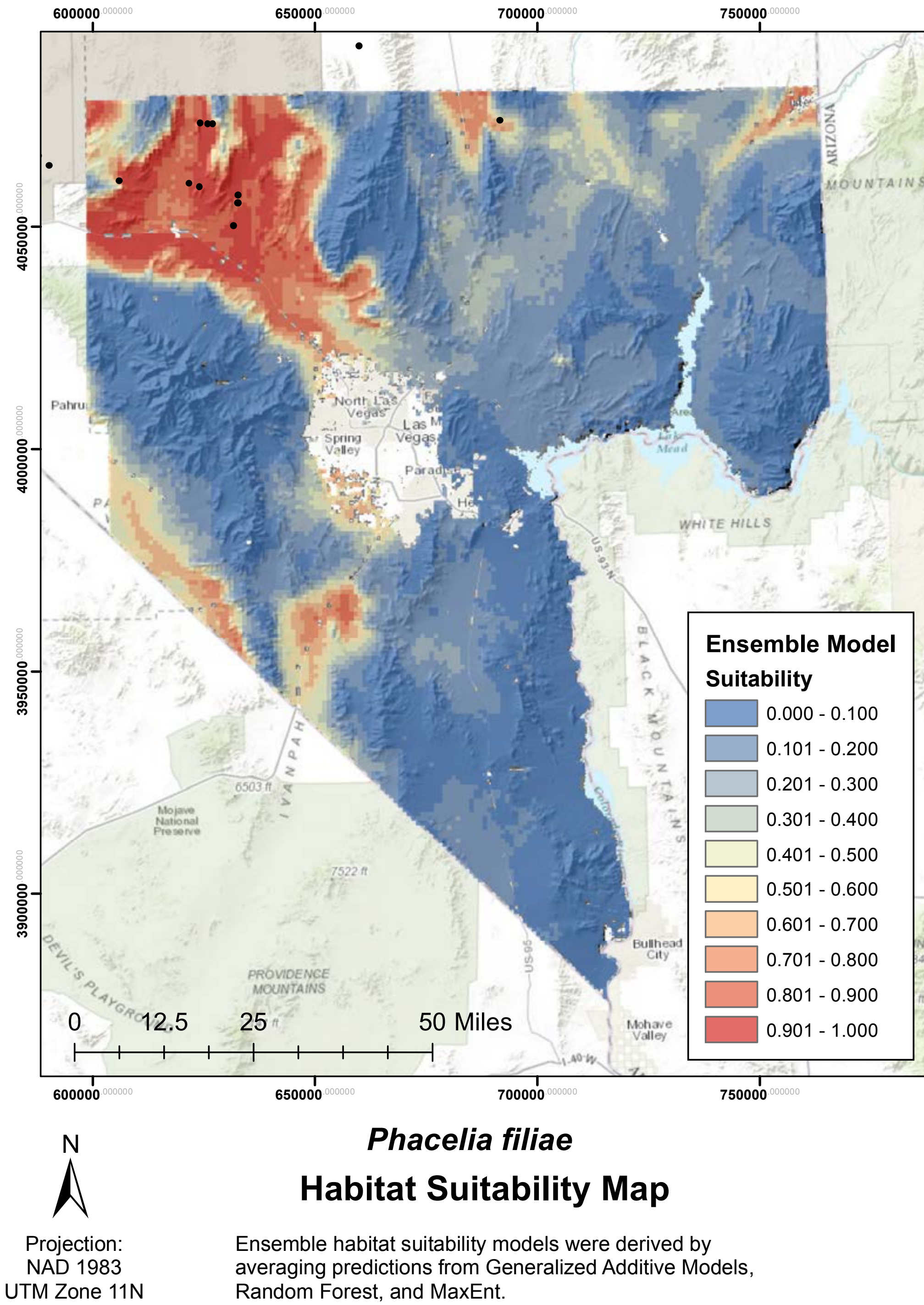

Figure 241 . SDM map for the *Phacelia filiae* ensemble model

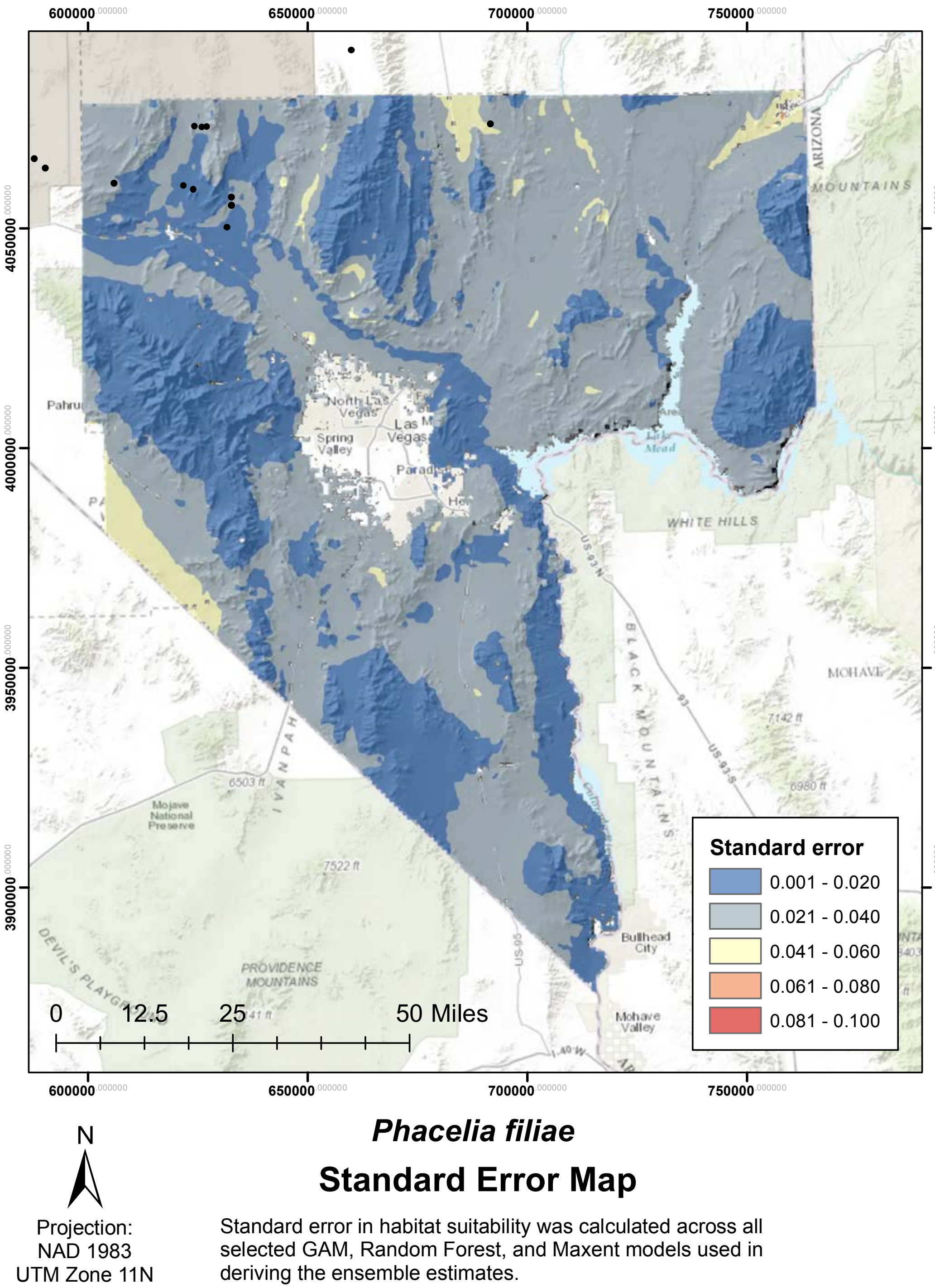

Figure 242 . Standard Error map for the *Phacelia filiae* ensemble model.

Distribution of Localities

Localities were restricted to the northwest corner of Clark County and north of US 95, with one location in the pass between the Coyote Springs Valley and the Moapa

Valley (Figure 240). Despite the very low number of points (26) used for modeling performance of the models was generally high (Table 148).

Standard Error

Error in habitat suitability predictions was broadly very low (i.e., <0.041) throughout the county, and moderate (i.e., > 0.041) in the Pahrump Valley, the Virgin River Valley, and the Coyote Springs Valley (Figure 242).

Distribution and Habitat Use within Clark County

Clarke Phacelia is endemic to the transition between Mojave Desert and Mojave/Great Basin zone and has been found in Clark County on Nellis Small Arms Range, in Desert National Wildlife Refuge, and in the city of Las Vegas (Atwood et al. 2002). Clarke Phacelia are found mostly in the foothills of Mojave mountain ranges, above the playas on relatively flat areas or low knolls on valley floors within an elevation range of 610 to 1220 m (2000 to 4000 ft.). The local habitat consists of calcareous sandstone, siltstone, tuffaceous claystone, and limestone substrates in blackbrush, shadscale, and creosote bush dominated communities (Atwood et al. 2002). Its distribution within the 10 major ecosystems within the county is spread between Blackbrush, Mojave Desert Scrub, and Salt Desert Scrub ecosystems. Moderate habitat mirrors this pattern, with the largest proportion of habitat being in the Mojave Desert Scrub and Blackbrush ecosystems, which are typically higher in elevation (Table 150).

Broad areas of modeled high habitat suitability were predicted surrounding the known locality points in the north of Indian Spring and within the Nellis Bombing Range and other areas that are generally off-limits to the public. Another broad patch of predicted habitat exists in the Coyote Springs Valley where only 1 previously known locality point exists in the far west margin of that valley in a relatively low pass. Elsewhere, large patches of high habitat suitability occur in the Virgin River Basin at the northeast terminus of the county, in the Pahrump Valley, and in the greater Ivanpah Valley from Stateline along the Interstate-15 corridor toward Jean/Roach Dry Lake (Figure 240).

Table 150 . Ecosystems within Clark County, and the area (Ha) of Low Medium and High predicted suitability within each ecosystem.

Ecosystem	Low	Medium	High
Alpine	124	0	0
Blackbrush	343892	41363	29972
Bristlecone Pine	7565	0	0
Desert Riparian	7718	2281	749
Mesquite Acacia	16564	2456	827
Mixed Conifer	27339	0	0
Mojave Desert Scrub	933252	188779	165540

Ecosystem	Low	Medium	High
Pinyon Juniper	115850	45	0
Sagebrush	4447	177	82
Salt Desert Scrub	3938	10557	65232

Ecosystem Level Threats

This species is found primarily in Blackbrush, Mojave Desert Scrub, and Salt Desert Scrub ecosystems. Threats within these ecosystems potentially include wildfire, livestock grazing, and various types of development. Wildfire is a well-known threat in the two higher elevation ecosystems of Blackbrush and Mojave Desert Scrub (Van Linn et al. 2013), while it has not been as big of a problem in Salt Desert Scrub. However, because Salt Desert Scrub primarily occurs at lower elevations on outwash plains and thus are flatter, they are pre-disposed to renewable energy development and other forms of development such as road-building (Tracy et al. 2004). Livestock grazing occurs on public lands within the range of this species and must be considered.

Threats to Species

The populations of this species are under a variety of ownerships and land managements and each population faces a different set of threats. Existing populations within urban areas of Las Vegas face direct losses from development as well as losses related to habitat fragmentation, and some have already been extirpated. Populations on land managed by the Department of Defense and the Department of Energy are at lower risk due to their remote location and restricted access. However, populations such as those on Nellis Air Force Base may be at risk from exposure to defense-related activities or expansion (Nellis Air Force Base 2010, Atwood et al. 2002)

Existing Conservation Areas/Management Actions

Full consideration of this topic will be evaluated in concert with the development plan when available. Note - Look at 2010 version of Nellis AFB management plan - Conservation of areas on Nellis Airforce Base that contain the species was under consideration as of 1998 (Keystone Dialogue 1998). Desert National Wildlife Refuge: Moapa Valley Unit is the only one within Clark Co. (USFWS 2009 a, b, c).

Summary of Direct Impacts

Impacted area (219 km^2) for this species in the higher predicted habitat quality is higher than for either conserved or disturbed habitats, although this accounts for less than 10% of total higher quality habitat for the species (Table 151). Moderate habitat has a larger area within conservation lands than the Impacted and Disturbed Combined.

Table 151 . Categorized modeled habitat values (High, Medium, and Low) and the average area (Hectares) predicted in the potential impact areas, conservation areas, already disturbed areas, and overall area

Habitat Level	Impact	Conserved	Disturbed	Area (Hectares)
High	21895	13204	9017	273834
Med	36663	62378	17036	254944
Low	64025	438024	25314	1487740

PHNI - Phainopepla (Phainopepla nitens)

Phainopepla (*Phainopepla nitens*) are medium-sized songbirds with long tails and deep red eyes. Both sexes have a ragged crest. The adult female is mostly dull gray and the male is glossy black. Phainopepla are also known as silky flycatchers (Sibley 2000), or mistletoe-birds because of their close relationship with that parasitic plant. Phainopepla spend a great deal of time perched near the top of desert trees, usually near mistletoe. The density of breeding Phainopepla pairs and clutch sizes are positively correlated with mistletoe berry abundance (Walsberg 1977, Chu and Walsberg 1999). If mistletoe is not found nearby, then other plants that bear small fruits likely will be, such as elderberry (*Sambucus* sp.), boxthorn/wolfberry (*Lycium* spp.), or Brazilian pepper trees (*Schinus terebinthifolius*).

Species Status

Phainopepla have no Federal or State special status listing at this time, and have no history of petitions for listing.

US Fish and Wildlife Service Endangered Species Act: No Status
Migratory Bird Treaty Act: Protected
US Bureau of Land Management (Nevada): No Status
US Forest Service (Region 4): No Status
State of Nevada: No Status
NV Natural Heritage Program: Global Rank G5, State Rank S2B
NV Wildlife Action Plan: No Status
IUCN Red List (v 3.1): Least Concern
CITES: No Status

Range

Phainopepla occur throughout most of northwestern Mexico with 63% of their breeding range there (Sauer et al. 2013). Their range within the US is within the lower 2/3 of California (except the higher Sierra and Coastal ranges), southern Nevada, Washington and Iron Counties, Utah, most of southwest Arizona, a small portion of southwest New Mexico, and the Big Bend area of Texas (Sibley 2000).

Population Trends

Based on the North American Breeding Bird Survey data, population trends for Phainopepla are considered to be stable (Sauer et al. 2013). An observational study along the middle Gila River south of Phoenix noted that there has been no change in Phainopepla occurrences between the early twentieth century and 1980 (Rea 1983). One study, in Clark County, documented that Phainopepla were observed at 25 of 53 historical locations (Fletcher et al. 2010), indicating a loss of occupied sites. While climatic variables, and short-term population fluctuations may account for some of the documented absences, it should be noted that many of the current absences are located on sites that are now in disturbed sites within the urban or suburban footprints of municipalities (Fletcher 2010), and Phainopepla habitat was likely disturbed or destroyed in those areas.

Habitat Model Review

Models – Densities of Phainopepla were modeled County wide by the GBBO (Figure 243), reported in Developing Habitat Models and Monitoring Techniques for Nine Bird Species of Clark County. Draft final report (D19) to Clark County DCP. Project ID 2005-GBBO-581-P.

Technical Considerations – GBBO modeled Phainopepla by using point count surveys at two scales (Clark County, and the Mojave Desert of southern Nevada) using models generated by mapping densities across different cover associations estimated for point count sampling sites. Dominant vegetation was assessed at each sampling site within 100 meters of the survey point, which was then mapped to its corresponding vegetation type for each of 2 vegetation layers used to model bird density at two scales. 1) The Clark County - using the specific vegetation layer by Heaton et al. (2011), and 2) a LandFire classification for the state that was used to model projections within the Mojave Desert in Nevada by Provencher and Anderson (2011).

Statistical models of densities for this species were conducted to calculate densities per vegetation stratum (e.g. Joshua tree woodlands, Mesquite-catclaw, etc.). Densities given in the report, however confidence limits for the density calculations within each stratum were not found. As with the other bird models by GBBO resolution of the models is limited to the size of the polygons containing vegetation projections, as they are effectively provided as a classified layer. Thus, there are 8 habitat classes for the County-wide model, which cover broad areas without finer resolution or habitat gradations. In addition, other factors that could contribute to Phainopepla densities aside from vegetation type are not considered in this type of model. The Mojave level model within Nevada is presented at 16 predicted bird density levels as there were more vegetative strata mapped in the LandFire vegetation layer.

Localities used for modeling are located throughout Clark County, encompassing most areas. The US 95 corridor northwest of Las Vegas, and the River mountains North of Boulder City, Trout Canyon, and the Eldorado Valley are areas that appear to be devoid of points, and it is unknown if sampling occurred there, although this species has been observed in many of those locations in association with Mesquite/Catclaw Acacia stands.

A statistical model was also produced that recorded presence/absence relative to specific site features such as vegetation height and presence of key species. While these models may be useful for site assessments, the predictors used are not amenable to County or Range wide predictions as GIS layers for this level of detail do not yet exist, and are unlikely to be available with current sensing and mapping technologies.

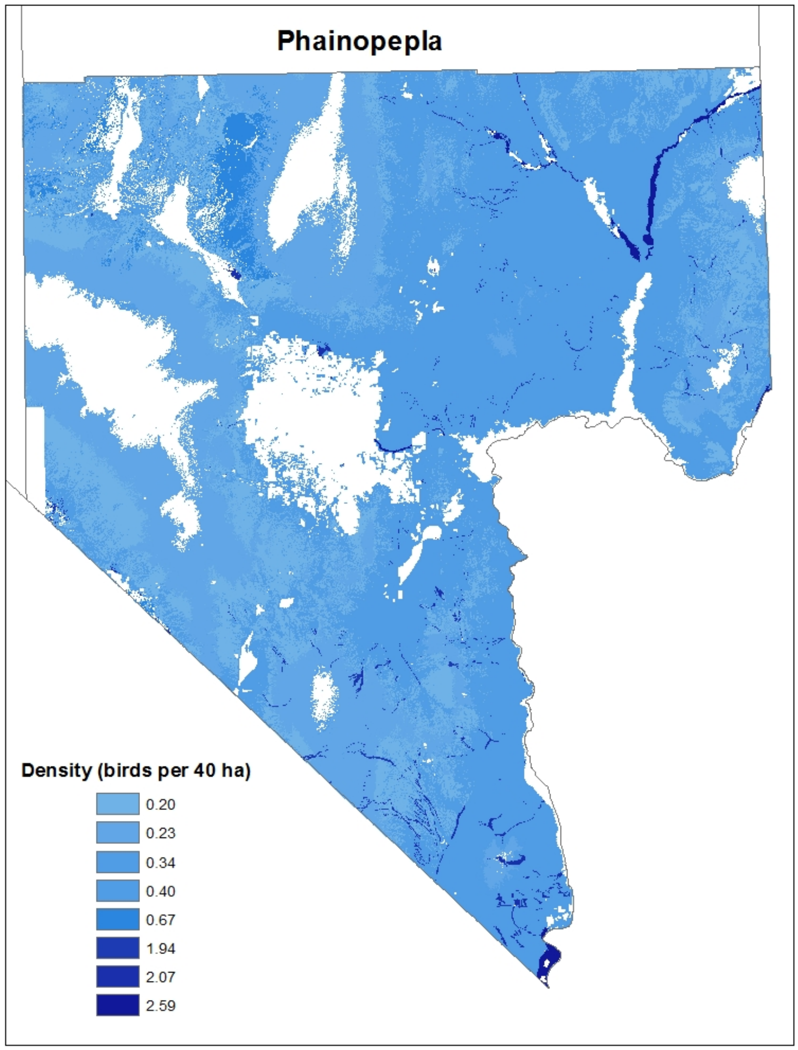

Figure 243. Habitat model from GBBO 2013. Predicted distribution of Phainopepla in Clark County. Mapped values represent the predicted density of Phainopepla in each GIS habitat category from the Clark County habitat map (Heaton et al. 2011).

Distribution and Habitat Use within Clark County

Trees must be present for Phainopepla to perch and more importantly to nest. They place their relatively small cup nests on a branch or fork of small trees (Merriam 1986), or tightly enmeshed within a mistletoe plant. In open deserts of Clark County, Phainopepla depend on sporadic catclaw acacia (*Acacia greggii*), velvet mesquite (*Prosopis velutina*), or screwbean mesquite (*P. pubescens*) for nesting platforms. The trees usually occur along xeririparian habitat (dry washes). One study compared the nest site characteristics between acacia tree stands and mesquite tree stands, and concluded that Phainopepla preferred to nest in trees that were taller and wider, and had more mistletoe berries available than surrounding non-nest trees (Crampton and Sedinger 2011). Also, vegetation patches where Phainopepla nested had taller trees, higher densities of mistletoe-host tree species, and more mistletoe berries than non-nesting vegetation patches (Crampton and Sedinger 2011). Both of these important trees and the parasitic mistletoe have a wide, but patchy distribution in Clark County. Phainopepla are listed as a 'preferential riparian' species in one account (Johnson et al. 1977) but the rarity of riparian gallery woodlands make this a moot point in Clark County, where small dry washes, or the edges of playas, and wetlands provide the greatest proportion of habitat for Phainopepla. Ecosystems within Clark County estimated to contain higher suitability habitat for this species (Jaeger et al. 1010) include: Desert Riparian, Mesquite Acacia, and Blackbrush ecosystems, while moderate suitability habitat is located within Blackbrush and Mojave Desert scrub habitat for the most part (

Table 152). This may be an indication of either a lack of specificity in these ecosystem delineations, or of the species habitat model.

Phainopepla arrive on the breeding ground and begin to set up territories in about October, and are classified as territorial birds (i.e. defending the nesting areas from conspecifics), or loosely colonial (i.e. allowing others to nest nearby – Chu et al. 2002). By February the first nests are be built and eggs laid. This timing is beneficial because many mistletoe are in flower during this time and the sweet scent attracts many small insects that are excellent for feeding the rapidly growing young. Most young are fledged by May, and by June Phainopepla may be rare on the breeding range. It is surmised that they travel to nearby montane habitats (Rea 1983) at higher elevation where it is cooler during the heat of summer (e.g. the Spring, Sheep, McCullough, or Virgin Mountains of Clark County). Therefore, Phainopepla may occupy many different habitats to meet their annual requirements (Rea 1983).

Phainopepla are involved in a symbiotic relationship with species of mistletoe where the two co-exist, meaning that the bird and the plant both benefit from their relationship. Phainopepla eat mistletoe berries and the availability of the berries affects nest site selection (Crampton and Sedinger 2011) and reproductive success of these birds (Walsberg 1977). The mistletoe plants produce berries with very viscous and sticky juice. As the birds eat the berries the seeds may become stuck on the beaks, feathers, or feet of the bird only to be brushed off on a branch of another host tree somewhere – potentially far away. The sticky seeds adhere to the branch and may grow there as a parasite on their new hosts. Seeds that are consumed by the birds pass through the digestive system unharmed and when defecated are still quite sticky. As such they may adhere to a branch below the bird and infect a new host tree – wherever the birds might go. Interestingly, mistletoe have another mode of seed dispersal: as the fruits ripen, they may explode and distribute the seeds some distance from the parent plant.

There are at least five species of mistletoe that grow in Clark County. All are important to Phainopepla and other birds and many insects. The dwarf desert mistletoe (*Phoradendron californicum*) is found on many desert leguminous trees like cactlaw acacia and mesquite. Oak mistletoe (*Phoradendron villosum*) grow well on scrub oak (*Quercus turbinella*, et al. spp.) and Gambel's oaks (*Q. gambelii*) in the mountains of Clark County, and are the plant harvested to bring into homes during the holiday season. Big leaf mistletoe (*Phoradendron macrophyllum*) grow in the willows (*Salix* spp.), cottonwoods (*Populus fremontii*) and ash (*Fraxinus* spp.) trees of riparian areas such as the Muddy River, Virgin River, and possibly Las Vegas Wash drainages, or suburban areas of Clark County. Dwarf pinyon mistletoe grows on pinyon pines. Juniper mistletoe (*Phoradendron juniperinum*) grows on junipers (*Juniperus* spp.).

Table 152. Ecosystems within Clark County, and the area (Ha) of Low Medium and High predicted suitability within each ecosystem.

Ecosystem	Low	Medium	High
Alpine	124	0	0
Blackbrush	374059	33838	3459
Bristlecone Pine	7565	0	0
Desert Riparian	5520	2784	1023
Mesquite Acacia	11757	3027	1827
Mixed Conifer	26768	0	0
Mojave Desert Scrub	1200373	20001	3706
Pinyon Juniper	113140	1918	154
Sagebrush	4322	231	44
Salt Desert Scrub	74914	1020	93

Ecosystem Level Threats

Phainopepla occupy most of the ecosystems available in Clark County including Mojave Desert Scrub, Mesquite/Acacia, Mixed Conifer, Pinyon-Juniper, Saltbrush, Salt Desert Scrub, Desert Riparian, and Blackbrush habitats, as long as there are trees present and especially with mistletoe.

In Clark County, the invasion of annual grasses that carry fire are an ecosystem threat that is particularly damaging to Phainopepla habitat. Wildfires kill trees and other large plants, reducing important habitat structure in desert habitats (Brooks and Esque 2002, Shryock et al. 2015). Those trees provide nesting substrate and host the Phainopepla's primary food plant (Crampton and Sedinger 2011).

Most surface-disturbing development activities can contribute to habitat disturbance for Phainopepla by loss of trees. The sum total of disturbance in Clark County is sufficient to be considered an ecosystem level threat. The past 20 years of urban growth have consumed considerable amounts of former Phainopepla habitat. Any activity (e.g. ground-water draw down) that results in the loss of native trees in desert uplands, riparian habitat, or playas would be detrimental to Phainopepla.

Threats to Species

Cowbirds (*Molothrus ater*) are known to parasitize the nests of Phainopepla and many other songbirds (Friedman 1931) however, such incidents are variable (Powell and Steidl 2000) and may be lower than other birds among Phainopepla.

Existing Conservation Areas/Management Actions

Phainopepla are federally protected by the Migratory Bird Treaty Act. The Nevada Comprehensive Bird Conservation Plan designates Phainopepla as an Indicator species. Indicator species are those that are studied such that by knowing about how they are responding to changes in their environments, the likely status of lesser studied species can be inferred, in the absence of empirical data. While indicator species are not considered a conservation priority, they are a way to evaluate the integrity of habitats that only have few, rare, or geographically restricted Priority species (GBBO 2010). The plan's recommended conservation strategies include: preventing habitat conversion in mesquite-acacia stands; managing habitat at the scale of a whole stand with the goal of maintaining healthy trees, mistletoe infections, and intact understory plants; evaluating effects of local groundwater pumping on mesquite-acacia viability; discouraging feral cat colonies in mesquite-acacia areas; managing invasive plants to reduce fire risk; minimizing disturbance during the nesting period; promoting responsible OHV use and low-impact recreation; and continuing long-term monitoring of Phainopepla populations statewide (GBBO 2012).

Partners in Flight's (PIF) North American Landbird Conservation Plan identified the Phainopepla as a Species of Continental Importance for the US and Canada (Rosenburg et al. 2016). Though not considered a Watch List species (birds most in need of conservation attention), it is designated a Stewardship species (species that are characteristic of specific habitats and require… high stewardship responsibility for that species within that regional boundary with a high percent of its global population in a single biome (Rosenburg et al. 2016). At the state level, PIF identified Phainopepla as a priority species, and set an objective of maintaining the current Nevada population at 3,900 individuals (Rosenberg 2004). In order to meet continental population objectives, the statewide population target was set to 3,929 individuals (Rosenberg 2004).

Summary of Direct Impacts

Approximately 104 km^2 of highly suitable habitat exists within the county, of which 23% is located within conservation areas, while only 9% will likely be impacted by the proposed amendment and only 3% is currently disturbed (Table 153). There is approximately 632 km^2 of moderate habitat, and 25% of this is located within conserved areas, while very little is expected to be impacted (3%).

Table 153. Categorized modeled habitat values (High, Medium, and Low) and the average area (Hectares) predicted in the potential impact areas, conservation areas, already disturbed areas, and overall area.

Habitat Level	Impact	Conserved	Disturbed	Area (Hectares)
High	927	2425	351	10361
Med	2017	15770	2923	63164
Low	100678	464267	64273	1835978

RAOB - Yuma Ridgway's Rail (Rallus obsoletus yumanensis)

Yuma Ridgway's Rail (*Rallus obsoletus yumanensis*), formerly known as the Yuma Clapper rail (*R. longirostris yumanensis*, Chesser et al. 2014, Dickey 1923, Maley and Brumfield 2013, Pranty et al. 2014), is listed as an endangered species at both the federal and state level. It is a relatively small species of *Rallus*, 20-23 cm in height and weighing an average of ~250 g (males slightly larger than females), with brown dorsal (back) feathers edged grayish and bright rufous breast (Maley and Brumfield 2013, Rush et al. 2012). It is a secretive bird and is seldom seen, with its dense marsh habitat providing camouflage and cover. A typical marsh bird, it has long legs and a short tail and eats primarily crayfish, clams, isopods, freshwater shrimp, fish beetles, and various insects (Ohmart and Tomlinson 1977). These rails are monogamous and both sexes assist in incubation and brood-rearing in the spring, usually laying 7 to 11 eggs in a cup nest of grasses or sedges. Young are precocial and can fly in about 9 to 10 weeks.

Species Status

The Yuma Clapper Rail was listed as an endangered species under Section 1(c) of the Endangered Species Preservation Act of 1966 (80 Statute 926; 16 USC 668aa(c)) on March 11, 1967 (DOI FWS 1967). This species was subsequently included on the list of endangered species under the ESA when the act was enacted in 1973. A down-listing package was prepared for the Federal Register in 1983; however, flooding of important clapper rail habitat on the lower Colorado River in that year resulted in the proposal not being published (USFWS). Instability of population numbers after 1983 precluded reconsideration of the proposal (USFWS 2006). The species is also protected under the Migratory Bird Treaty Act of 1918, as amended (16 USC 703-712), and listed as endangered in Arizona, California, and Nevada. IUCN Lists the Ridgway's Rail at the species level as Near Threatened, since the moderately small population is thought to be declining due to habitat losses from agriculture and other development.

US Fish and Wildlife Service Endangered Species Act: Endangered
US Bureau of Land Management (Nevada): Sensitive
US Forest Service (Region 4): Endangered
State of Nevada (NAC 503): Endangered

NV Natural Heritage Program: Global Rank G1 State Rank S1
NV Wildlife Action Plan: Species of Conservation Priority
IUCN Red List (v 3.1): Near Threatened
CITES: No status

Range

There are three subspecies of Ridgway's Rail in the US (Maley and Brumfield 2013): California Ridgway's Rail (*R. o. obsoletus)* in the San Francisco Bay area (Wood et al. 2017), light-footed Ridgway's Rail (*R. o. levipes*) in costal southern California, and Yuma Ridgway's Rail (*R.o. yumanensis*), found along the lower Colorado River and its tributaries and around the Salton Sea in California (Tomlinson and Todd 1973, Hinojosa-Huerta et al. 2001, Pranty et al. 2014, USFWS 2006). Additional subspecies of Ridgway's Rail are found only in Mexico (Pranty et al. 2014). The Yuma Ridgway's Rail is the only subspecies present in Clark County, NV.

Population Trends

Variable survey methods and locations have made it difficult to accurately estimate population trends for the Yuma Ridgway's Rail (USFWS 2006). Expert sources estimate that populations are likely declining due to widespread loss of breeding habitat (NatureServe 2009). Few population estimates exist, although early estimates for the US population were in the 400 - 1000 range in the 1960's to mid-1970s, and 500 – 1000 birds from 1990 - 2005 (AGZFD 2006). Ehrlich et al. (1992) estimated 1,700-2,000 individuals. Hinojosa-Huerta et al. (2001) surveyed for the Yuma Ridgway's Rail in 1999 and 2000 in the Ciénega de Santa Clara, the largest marsh wetland (5800 ha) in the Colorado River delta in Mexico, finding an estimated average of 6040 individuals (S.E. = 313) over four surveys (2001). Garnett et al. (2004) performed surveys within Clark County from 1999 through 2003, finding between 2 and 32 individuals in any given year (average of 13.6), with the majority of occurrences along the Virgin River. No population estimates were generated from the counts (Garnett et al. 2004).

Habitat Model Review

SWCA (2010) created a habitat model for Ridgeway's Rail for the area bounding the Virgin River in Clark County NV from the NV boarder near Mesquite to the confluence of the Virgin and Muddy River in Lake Mead National Recreation Area. Habitat suitability was estimated using modeled vegetation classifications reviews of the bird's habitat affinities from several previous surveys.

Vegetation classification was conducted using a series of remote sensing datasets, and ISDODATA classification technique to classify vegetation into 24 cover type classes. Samples from another survey were used to combine some cover classes, reducing the number to 17, and structure types were added with multiple field surveys and assessments to yield a final combination of 35 vegetation community/structure type combinations with 81% accuracy.

Habitat for the Rail was classified into three categories (breeding habitat, potential breeding habitat, marginally suitable habitat) for different marsh structure types from those identified in Anderson and Ohmart (1984), see Table 3 in SWCA 2010, which were classified by the percentage of cattail/bulrush composition (Table 4, SWCA 2010). "Marsh structure type I", which consisted of 100% cattail/bulrush with small amounts of *Phragmites* and open water was deemed the most suitable habitat type for Rails. Only 6.2 acres of this habitat type was located within the project area (Table 8, SWCA 2010). The project area was largely composed of MA-V (52%), which was classified as potential breeding habitat under the right conditions, and MA-III (67%) which was classified as marginally suitable.

There were no detections of Ridgeway's Rails located within the study area. Therefore, no accuracy assessments were possible, although prior USFWS reports lists the species within the study area. The extent of this model excludes the Muddy river, which may also be habitat for this species.

Distribution and Habitat Use within Clark County

The Yuma Ridgway's Rail is found in marshes along rivers, backwaters, and in drains or sumps supported by irrigation water (USFWS 2006). This species generally requires a wet substrate, such as mudflats, and drainage bottoms that are densely vegetated. Vegetation density is the critical element for suitable nesting habitat (Rush et al. 2012). This subspecies breeds in heavily vegetated fresh-water marshes with vegetation cover of moderately dense stands of cattail (*Typha* spp.) and bulrushes (Scirpus spp.) along the Colorado River and its tributaries (Tomlinson and Todd 1973).

The Yuma Ridgway's Rail is the only subspecies present in Clark County, NV, where it occurs in freshwater marsh habitat along the Virgin, Muddy, and lower Colorado Rivers, and has been sighted in the Las Vegas Wash (Garnett 2004, Van Dooremolen 2015). It is the only subspecies known to occupy freshwater marshes during the breeding season, and is known to visit brackish and saltwater marshes south of the US in the non-breeding season (Tomlinson and Todd 1973). It is found in elevations ranging from below sea level to around 1,300 feet (AZGFD 2006).

Nesting of multiple pairs in 2001 was confirmed at Big Marsh along the western portion of the Virgin River - one of the seven Important Bird Areas of Clark County (Floyd et al. 2007). Despite yearly surveys, Yuma Ridgway's Rail detections in the Las Vegas Wash vary from year-to-year (Van Dooremolen 2015). A single Yuma Ridgway's Rail was detected in the Wash, within Clark County Wetlands Park, in 1998, 2005, 2006, and 2015 (SWCA 2006, SWCA 2007, Van Dooremolen 2015). The Lower Virgin River and Muddy River areas are likely more important areas for Ridgway's Rail in Clark County, with regular (albeit decreasing) occurrences (Garnett et al. 2004), and an existing habitat conservation and recovery program (USFWS 2006).

Ecosystem Level Threats

This subspecies occurs exclusively in the Desert Riparian habitats of Clark County, NV. Threats to this ecosystem include loss and degradation of fresh water marsh habitat, through irregular water availability due to manipulation of stream banks and water flow, and invasive species (Wildlife Action Plan Team 2012). Ecosystem threats due to conversion of lands to agriculture, and agricultural practices (e.g. maintenance of drainages and chemical/pesticide use should also be considered (Hinojosa-Huerta et al. 2001)

Threats to Species

Selenium is a potential threat to the Yuma Ridgway's Rail. High levels of selenium can result in acute toxicity, chronic poisoning and tissue damage, and reproductive impairment in birds. The birds accumulate selenium from the invertebrates and fish they eat (USFWS 2006). Another significant threat to this species is the inadequacy of existing regulatory mechanisms for the Ciénega de Santa Clara population in Mexico. The Ciénega, a 6,000-hectare wetland in the Colorado River Delta, contains the largest known population of Yuma Ridgway's Rail and is believed to be the source population for this subspecies throughout the remainder of their range. A population decline of 23 percent was observed between 1999 and 2002 at this site. Habitat loss for the Ciénega de Santa Clara remains a significant threat to the Yuma Ridgway's Rail because the Ciénega's water supply is entirely dependent on drain flows from the US which could be cut at any time (USFWS 2006).

Within Clark County, most of the rail habitat is reportedly within the Virgin and Muddy river 100-year flood plains (Garnett et al. 2014). This area has some agricultural areas, as well as potential contaminants form the cities of Mesquite, and runoff from cities in Washington County, Utah that are potential sources of water contamination. Threats to species are largely due to losses of habitat due to water management, altering marsh habitats or conversion for other anthropogenic purposes.

Existing Conservation Areas/Management Actions

Conservation measures for the Yuma Ridgway's Rail are addressed in the *Yuma Clapper Rail Recovery Plan* of 1983 (USFWS). This plan's goals are to: have a stable population of 700 to 1,000 individuals; preserve habitat; and carry out a program of public education (USFWS 1983). The plan recommends: maintaining consistent water levels in marshes in the Virgin and Muddy River valleys; controlling invasive plants in marshes; controlling nest predators when unusual predation levels are documented; and continuing surveys and research to better determine population trends, threats, and habitat requirements (USFWS 1983). In 2010, USFWS released a draft revision to the recovery plan, but no further actions regarding the revision have been taken. The revision includes additional scientific information about the species and provides the criteria and actions needed to delist the species (USFWS 2010). Critical habitat, as required by the Endangered Species Act of 1973, has not been designated yet (USFWS 2010).

Yuma Ridgway's Rail is listed as a covered species under the Lower Colorado River Multi-Species Conservation Plan (LCR MSCP 2004). The LCR MSCP is a 50-year, comprehensive habitat conservation plan that addresses the effects of water use and hydropower generation along the Lower Colorado River on 26 species, including the Ridgway's Rail. Conservation measures outlined in this plan include the creation of 512 acres of habitat, and the maintenance of existing habitat (Lower Colorado River MSCP 2004).

This subspecies of rail is considered a Species of Conservation Priority by the Nevada Wildlife Action Plan (2012). The plan considers the main threat to the subspecies to be the loss or degradation of marshes due to water diversions, decline in water quality, and development, and recommends implementing the conservation strategies outlined in the Recovery Plan released by USFWS (Wildlife Action Plan Team 2012).

The Nevada Comprehensive Bird Conservation Plan recommends creating artificial wetlands if habitat parameters are suitable, using prescribed fires in overgrown marshes, and conducting studies to determine whether seasonal movements occur (GBBO 2010).

Summary of Direct Impacts

The Yuma Ridgway’s Rail is a very rare breeding bird and summer resident in Clark County. Approximately 22,623 acres of modeled habitat exists within Clark County, although the proportion of this that is suitable for Yuma Ridgway’s Rail nesting (i.e., open marsh habitat) is estimated to be much less. This species rarely occurs in the plan area; however, due to the limited amount of potential habitat, covered activities have the potential to adversely affect this species within Clark County. It is estimated that approximately 6.6 percent of Yuma Ridgway’s Rail modeled habitat within Clark County could be impacted by activities covered under the Amendment.

SIRA - St. George Blue-eyed Grass (Sisyrinchium radicatum)

St. George Blue-eyed Grass (*Sisyrinchium radicatum*) is a perennial forb in the Iridaceae family. The flowers consist of bluish violet tepals with yellow bases. The St. George Blue-eyed Grass flowers late spring to mid-summer. This species is predominately self-pollinating, which is a unique trait of the genus. The plant is able to achieve this because the anthers and stigmata mature concurrently. Self-pollination could also be a possibility by bees if the stigma maturation and anther dehiscence occur simultaneously, and if the elongation of the style results in the stigmata being close to the same height as the anthers, as is also believed to occur in St. George Blue-eyed Grass (Cholewa and Henderson 1984).

S. radicatum looks much like, and is closely related to *S. demissum,* but can be distinguished by the white or cartilaginous margins on the stem and a broad apex to the hyaline margin of the inner spathe of *S. radicatum* (Bicknell 1901a; Bicknell 1901b). Another distinguishing feature of *S. radicatum* is branching stems (Ingram 1967; Henderson 1976).

As of 1977, Intermountain Flora classified *Sisyrinchium radicatum* and *S. demissum* as the same species (Cronquist et al. 1977). Utah Flora (Welsh et al. 1987) also classifies the two as the same species. This species has been confused with *S. demissum* as a result of these publications (Goodrich and Neese 1986). This should be considered when investigating distribution for management purposes.

Species Status

US Fish and Wildlife Service Endangered Species Act: No status

US Bureau of Land Management (Nevada): Sensitive
US Forest Service (Region 4): No status
State of Nevada (NAC-527): No status
NV Natural Heritage Program: Global Rank G2?Q State Rank S1S2
IUCN Red List (v 3.1): No status
CITES: No status

Range

St. George Blue-eyed Grass is thought to be restricted to the northeast Mojave Desert between St. George Utah and Las Vegas, Nevada. The species is also expected to be in the adjacent northwest corner of Arizona (Bicknell 1901a). It has been reported in Duchesne, Kane, and Washington counties in Utah. Plants commonly associated with the species include *Poa pratensis*, *Juncus* spp., and *Glaux maritima*. In southern Utah it is thought to be sympatric with *S. demissum* (Cholewa and Henderson 1984).

All SEINet occurrences recorded of the species are in southern Nevada with one occurrence in Lincoln County (Ash Springs), one in Nye County (Ash Meadows), and four in Clark County. The Clark County occurrences are in the Spring Mountains (one at Pine Creek and one at a seep in juniper habitat north of Mountain Springs), Warm Springs in Moapa (alkali meadow), and southeast of Riverside (alkali meadow). Three of these occurrences listed *Distichlis spicata* as an associated species. Other associated species included *Scirpus sp*. and *Muhlenbergia asperifolia* in Clark County occurrences. Other southern Nevada occurrences listed *Juncus balticus*, *Grindelia fraxinopratensis*, and *Spiranthes infernalis* as associated species (SEINet).

St. George Blue-eyed Grass has an occurrence count of six according to one source and has a distribution status of confident or certain within Nevada in Clark, Lincoln, and Nye counties (NNHP).

Population Trends

There are insufficient data on St. George Blue-eyed Grass to suggest any trends across populations. Historical discrepancies in accurate identification also obfuscate population information over time.

Qualitative Habitat Model

There were 14 localities for this species in Nevada, only 11 of which were within Clark County. Although few occurrence records exist for this species, it is clear that St. George Blue-eyed Grass requires moist or wetland soils for population establishment and persistence. The majority of known populations occur at desert springs (e.g., the Calico Basin in Red Rock Canyon National Conservation Area), alkaline meadows (e.g., Ash Meadows National Wildlife Refuge), or along riparian corridors (e.g., the Muddy River). However, the sample size (n = 14) of known occurrences is not sufficient to support development of a quantitative habitat model at this time. High variability in habitat characteristics of known occurrences also hamper such an effort: populations span an elevation range from 1760 to over 6000 ft. and include several different types of wetlands. For these reasons, and without further knowledge of the species distribution, we considered any riparian vegetation within Clark County to be potential habitat for St. George Blue-eyed Grass, including moist soils surrounding desert springs and their outflows, riparian vegetation along perennial or intermittent streams, and alkaline meadows.

To represent these riparian habitat types, we merged several existing sources of information. First, we selected the Desert Riparian and Mesquite / acacia vegetation classes from the Clark County vegetation map developed by Heaton et al. (2011). This mapping project incorporated a broad range of remotely sensed data as well as a large sample size of field validation sites, and appears to be the most accurate vegetation map available for Clark County. Second, we compiled the locations of spring features from the National Hydrography dataset (https://nhd.usgs.gov/) as well as waypoints for springs from existing MSHCP project data. These point features were converted to a raster grid and merged with the Heaton et al. (2011) riparian vegetation classes at a unified spatial resolution of 90 m^2, representing an initial model of riparian vegetation types that may be suitable for St. George Blue-eyed Grass.

Third, we developed a refined model of riparian vegetation within Clark County to supplement the riparian vegetation classes identified in Heaton et al. (2011). Visual examination of satellite imagery made it apparent that the Heaton et al. (2011) vegetation map underestimates riparian vegetation within Clark County, particularly where this type of vegetation occurs as narrow corridors within broader vegetation classes. For example, the Heaton et al. map does not include riparian vegetation within several creek channels where St. George Blue-eyed Grass occurs within the Red Rock Canyon National Conservation Area. In part, this may be because the vegetation map did not include ephemeral riparian vegetation within the riparian vegetation class, but rather dissolved such areas into the surrounding vegetation classes (Heaton et al. 2011). Therefore, we broadened the riparian vegetation classes from Heaton et al. (2011) to include a wider range of potential St. George Blue-eyed Grass habitat through a RF classification of riparian vegetation. The locations of known springs and riparian channels were treated as training points for the model, while background points were drawn randomly from non-riparian vegetation classes. The model was subjected to the same thinning and cross validation procedures described above (see *Quantitative statistical models*). Covariates for this model included various vegetation indices calculated from a Landsat 8 mosaic (NOV 2016) of Clark County: Normalized Difference Vegetation Index (NDVI); Normalized Difference Moisture Index (NDMI); Normalized Difference Water Index (NDWI); and Tasseled Cap Greenness (coefficients in Baig et al. 2014). Additionally, we included the Maximum NDVI from the MODIS satellite averaged across 2001-2010 (https://phenology.cr.usgs.gov), along with Elevation and Topographic Position (TPI).

The final RF model (Figure 244) had an R^2 of 0.72, with an average AUC of 0.91 and True Skill Statistic (TSS) of 0.84 across cross-validation runs. The Landsat-derived NDVI was the most influential term in the model, followed by TPI, Elevation, and NDMI, respectively. The Continuous Boyce Index also indicated strong performance (Figure 245) with wetland delineation use as a proxy for habit in this species indicated above 0.5 to 0.6 range. From this model, we defined grid cells as riparian vegetation that had a probability score of at least 0.61 (the model's precision-recall break-even point) in addition to having an NDVI value of at least 0.1 in the Landsat 8 imagery. This latter criterion reduced the potential for commission error in our riparian vegetation designations. For our final qualitative model of potential riparian habitat for St. George Blue-eyed Grass, we then merged riparian grid cells identified through the RF model with the Heaton et al. (2011) riparian vegetation classes and the mapped spring locations.

The 11 localities within Clark County are distributed in two general areas. A single observation was made in the Moapa Valley area (Figure 246), while the remaining 10 were west of Las Vegas in the general area of Red Rock National Conservation Area - in Calico basin and Pine Creek Canyon, and others. The resulting qualitative model shows habitat predictions along the Virgin and Muddy Rivers, in the lowland habitat of the Colorado River near Avi, and in various spring and ephemeral washes throughout the County, with most patches in and around the Spring Range, west of Las Vegas (Figure 246).

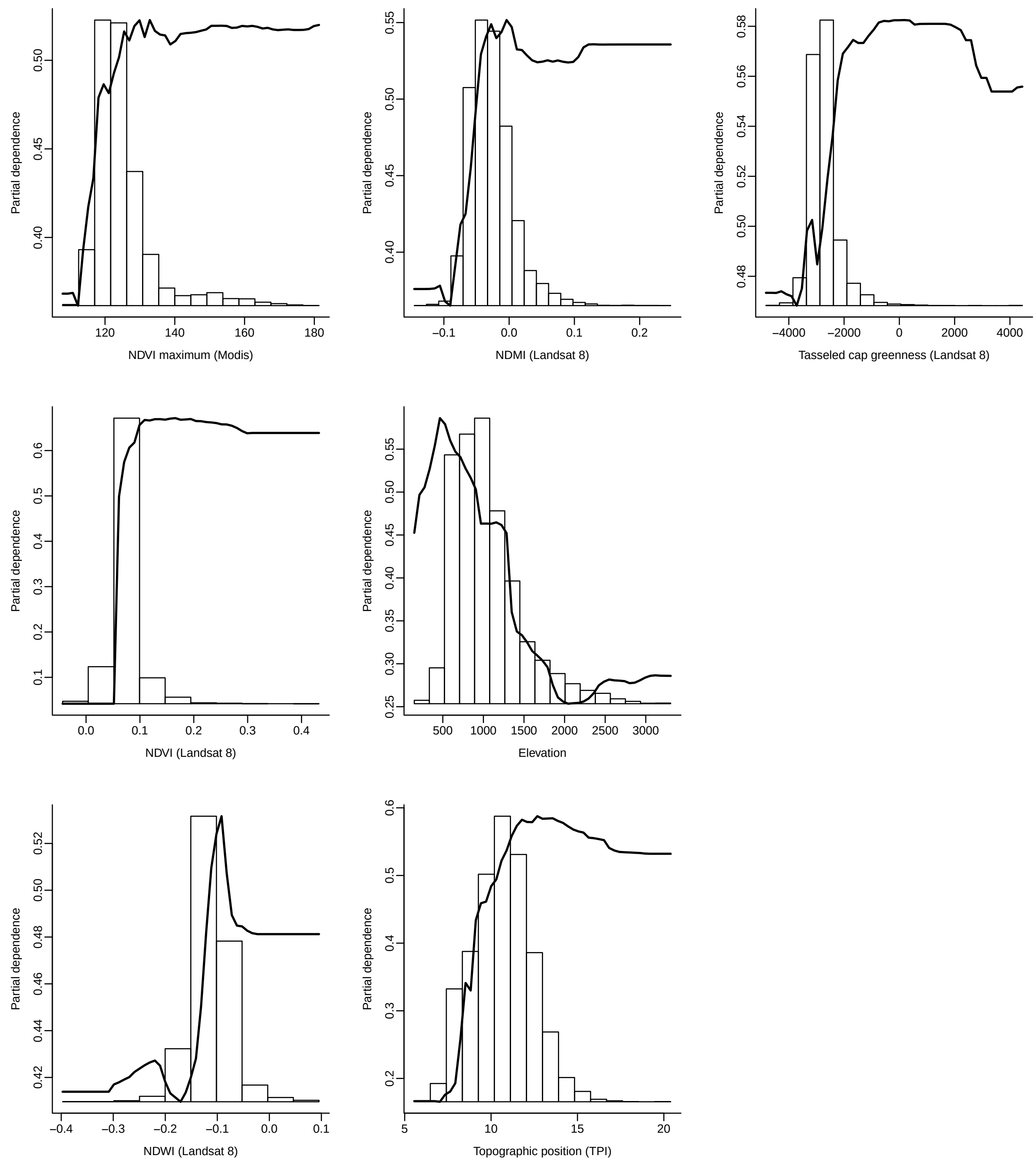

Figure 244. RF partial response curves for the wetland soils and vegetation model to define qualitative habitat for *Sisyrinchium radicatum* (St. George Blue-eyed Grass) overlaid over distribution of environmental variable inputs in the study area.

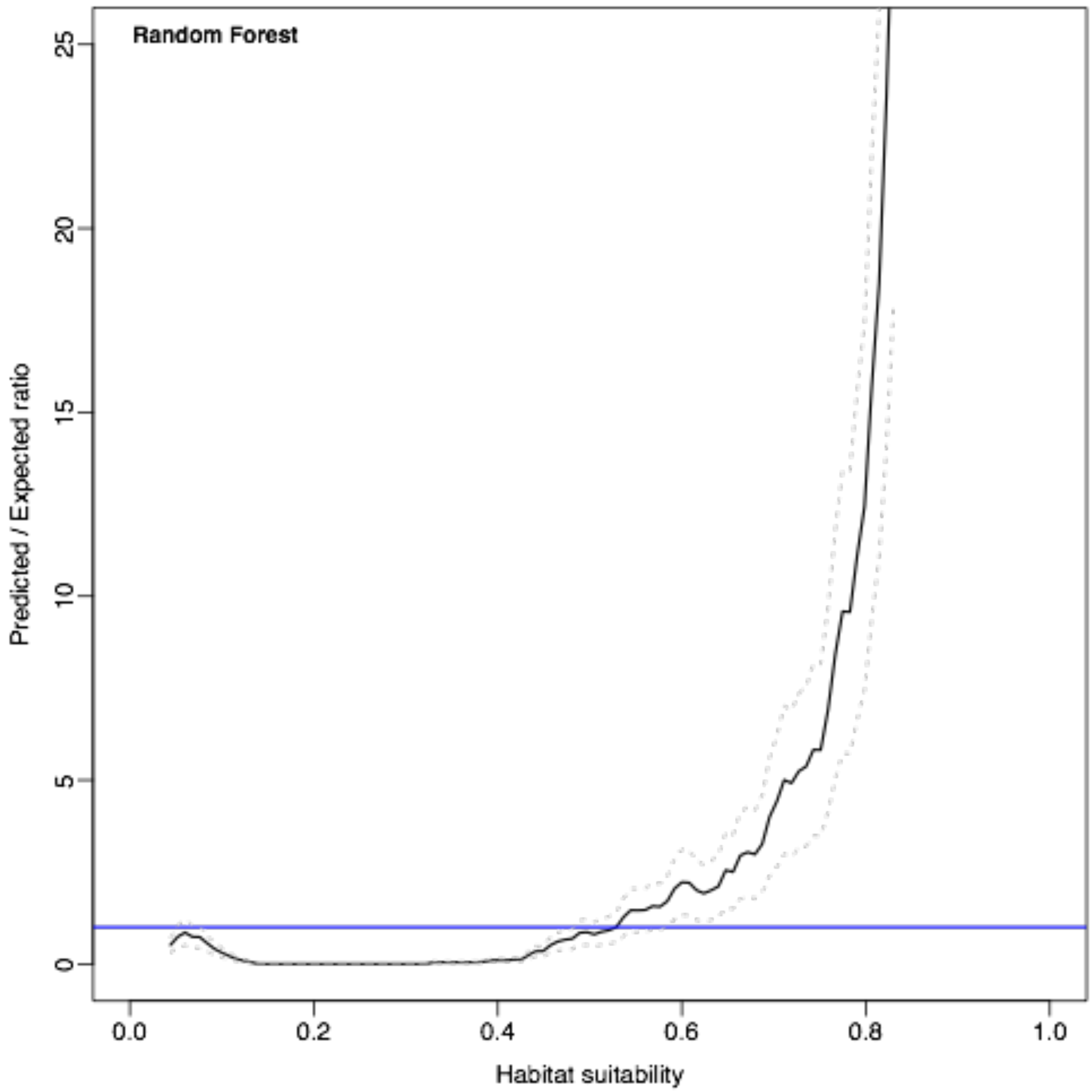

Figure 245. Continuous Boyce Index plot for the GAM model defining wetland and riparian soils and vegetation for the qualitative *Sisyrinchium radicatum* (St. George Blue-eyed Grass) model.

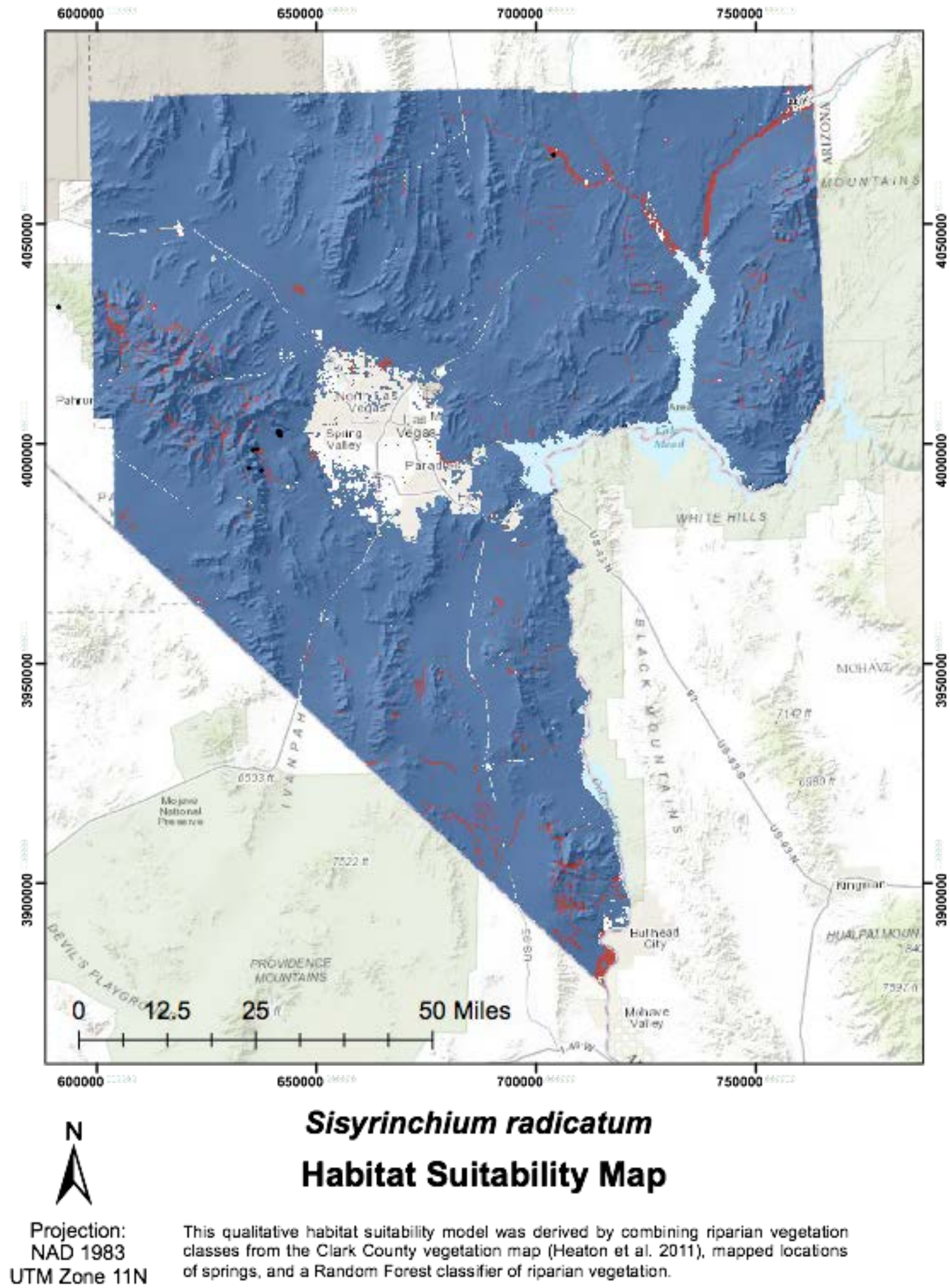

Figure 246. Qualitative habitat suitability map for *Sisyrinchium radicatum* (St. George Blue-eyed Grass).

Distribution and Habitat Use within Clark County

There may be only four SEINet locations that exist for this species in Clark County. This plant grows on moist, sometimes alkaline meadows, borders of springs, and on stream banks at 600 to 1300 m in Nevada and Utah (Bicknell 1901a). It is classified as a "wetland" species according to Nevada Natural Heritage Program (NNHP). The qualitative model for this species indicated limited areas of habitat among several ecosystems as the riparian and spring systems are widely dispersed throughout the county. The Mesquite Acacia had the largest area of habitat, while the areas within Desert Riparian ecosystems were nearly all considered habitat (Table 154).

Table 154. Ecosystems within Clark County, and the area (Ha) of Low and High predicted suitability within each ecosystem.

Ecosystem	Low	High
Alpine	124	0
Blackbrush	411497	2875
Bristlecone Pine	7533	32
Desert Riparian	767	7803
Mesquite Acacia	3997	15271
Mixed Conifer	25354	1968
Mojave Desert Scrub	1248522	9319
Pinyon Juniper	109456	6175
Sagebrush	4524	160
Salt Desert Scrub	77362	405

Ecosystem Level Threats

Alkaline meadow, springs, stream banks, and other wetland areas that are under threat could potentially inhabit St. George Blue-eyed Grass (Bicknell 1901a). Because the species flowers late spring to mid-summer (Bicknell 1901a), disturbances happening during those times could be especially harmful.

The two possible occurrences in the Spring Mountains (SEINet) are near Pinyon-Juniper woodlands and could be vulnerable to wildfire as a result. The two other occurrences from SEINet are located on alkali meadows. One of these is located on BLM land and one is located on private land.

Alkali Mariposa Lily occupies alkaline meadows, similar to St. George Blue-eyed Grass, presumably. Known threats to the lily may therefore be applicable to St. George Blue-eyed Grass. Threats of Alkali Mariposa Lily (*Calochortus striatus*) that could be applicable to St. George Blue-eyed Grass include; lowering water tables, grazing, competition with weedy species, and land development (Green and Sanders 2006). Other threats to alkaline meadows include trampling and hydrological alterations such as water diversions that result in lowering the water table (Baldwin 2002; CNPS 2016).

Threats to Species

Direct threats to the St. George Blue-eyed Grass may include threats common to other rare plants including: illegal harvesting; livestock grazing; feral equids, and OHV impacts.

Existing Conservation Areas/Management Actions

St. George Blue-eyed Grass was listed as a sensitive species occurring in Ash Meadows in 2009 (USFWS 2009) and is thought to have hybridized with the other species on the Refuge, *S. funereum* (USFWS 2012).

Of the four locations listed within Clark County on SEINet, two occur in Red Rock National Recreation Area, managed by the Bureau of Land Management, one occurs on BLM land southeast of Riverside, and one occurs on private land outside of Moapa Valley National Wildlife Refuge (SEINet).

Summary of Direct Impacts

The qualitative habitat model for this species produced for this report identified 440 km^2 of potential habitat for this species, and considered most of the County to be non-habitat (Table 155). Collectively 20% of habitat will potentially be impacted, 10% of which is already disturbed. Conserved areas in the county will protect 29% of predicted habitat (Table 155).. This assessment could benefit from a more accurate species model, but more localities are needed to make this possible.

Table 155. Categorized modeled habitat values (High, and Low) and the average area (Hectares) predicted in the potential impact areas, conservation areas, already disturbed areas, and overall area.

Habitat Level	Impact	Conserved	Disturbed	Area (Hectares)
High	4570	12667	4709	44052
Low	111714	471245	29636	1897787

TABR - Mexican Free-tailed Bat (Tadarida brasiliensis)

Mexican Free-tailed Bat (*Tadarida brasiliensis*) is a relatively small bat with the end of the tail extending freely beyond the uropatagium (webbing between the hind legs) (Wilkins 1989). This species is brown in color, and is darker dorsally than ventrally (Wilkins 1989). It is a migratory species and moves southward in winter in North America (Herreid 1967). Males and females typically roost separately, with large maternal colonies comprising up to millions of individuals in some large caves. Males may migrate further north than females, and these bats are also known to roost in man-made structures (Wilkins 1989. It is an insectivorous species eating primarily moths, beetles, flying ants, midges, and mosquitos (Kunz et al 1995).

Species Status

This species is commonly accepted as among the most common bats in North America (Kunz and Reynolds 2003). IUCN considers this species as one of Least Concern due to its wide distribution, large overall population size, and lack of evidence for widespread decline (Barquez 2016). Recent genetic analyses of migrating populations indicated that earlier hypotheses of distinctions among migratory populations (see Wilkins 1986) were not supported by genetic structure, and that like many migratory and widely dispersing species, only one genetic population was supported (Russel et al. 2006). An effective population size for the species was estimated at 28.4 million females (Russel 2003).

USFWS: No Status
State of Nevada: Protected Mammal NAC 503.030.1, and a Species of Conservation Priority as per the Nevada Wildlife Action Plan - 2012
US Bureau of Land Management (BLM) - Sensitive
US Forest Service (USFS) – No Status
Natural Heritage Program: S3S4B - Watch List
IUCN: Least Concern ver 3.1 (Barquez et al. 2016)

Range

Mexican Free-tailed Bats are among the most widely distributed species of mammals in the western Hemisphere, occurring generally from southern Oregon to North Carolina in its northern extent, and continuously through Mexico and Central America, through western South America to a wider distribution again in the temperate regions of central South America (Wilkins 1989). It selects areas with upper ambient temperatures of 35ºC (95ºF) in laboratory conditions (Herreid 1967), but can be found roosting in structures and caves with warmer temperatures up to 40ºC (104ºF Wilkins 1989). Individuals aggregate in large numbers while roosting, and are frequently seen exiting roosts simultaneously – a phenomenon that may require up to four hours (Wilkins 1989).

Population Trends

Eight Tadarida brasiliensis colonies for which there were at least four years of data were analyzed for their population trends in the United States, and two of them showed positive population trends, six of them had no trend, and zero had a negative trend. In Nevada, one of the largest Mexican Free-tailed Bat colonies near Ely had at least a temporary negative population trend due to a disturbance that involved an artificial cave entrance (Bradley et al. 2006). Mexican Free-tailed Bats in Nevada are stated to potentially be below historical levels (Bradley et al. 2006), but no quantitative data were provided to support this suggestion.

Habitat Model

Model Results

The three modeling algorithms for Mexican Free-tailed Bat habitat predicted similar areas around three mountain ranges in Clark County, including the Spring Range, Sheep Range, and the Newberry mountains at the southern tip of the state. The intensity of the prediction for suitability in the lowlands differed slightly among models, with MaxEnt being the most pessimistic (predicting lower suitability overall) among models (Figure 247). The GAM had generally more and higher standard error values than the other models (Figure 248). The RF model had the highest performance scores among the four performance measures reported, followed by the Ensemble model (Table 156). Continuous Boyce indices indicated good model performance each of the modeling approaches, as well as the ensemble model (Hirzel et al. 2006)(Figure 249). Bins for the ensemble model based on the CBI were 0-0.4 unsuitable, 0.4-0.5 marginal, 0.6-0.8 suitable, and 0.8 -1 optimal habitat; with a suggested cutoff threshold of 0.5 (Figure 249) which corresponded closely with that calculated from ROC statistics for the ensemble model (Table 156).

Table 156. Model performance values for *Tadarida brasiliensis* models

Performance	GAM	RF	MaxEnt	Ensemble
AUC	0.90	0.98	0.91	0.95
BI	0.56	0.73	0.51	0.66
TSS	0.73	0.90	0.75	0.82
Correlation	0.71	0.86	0.71	0.78
Cut-off*	0.48	0.57	0.28	0.51

*threshold at which sum of sensitivity (true positive rate) and specificity (true negative rate) is highest

Table 157. Percent contributions for input variables for *Tadarida brasiliensis* ensemble models using GAM, MaxEnt and RF algorithms

Term	GAM	RF	Max	Avg
NDVI Start-of-Season	22.01	16.48	23.29	19.99
NDVI Greenness Timing	20.52	15.48	18.41	11.80
Diurnal Temp. Range	18.64	13.75	18.74	17.00
Surface Texture (ATI)	21.04	11.88	15.01	15.75
Winter Precipitation	7.07	11.25	10.93	15.10
Roughness (TRI)	5.36	10.39	7.76	6.16
Soil Water Stress	1.07	7.63	4.83	4.12
Winter Min Temp.	2.14	6.95	0.77	3.68
Annual Temp. Range	2.14	6.20	0.26	6.41

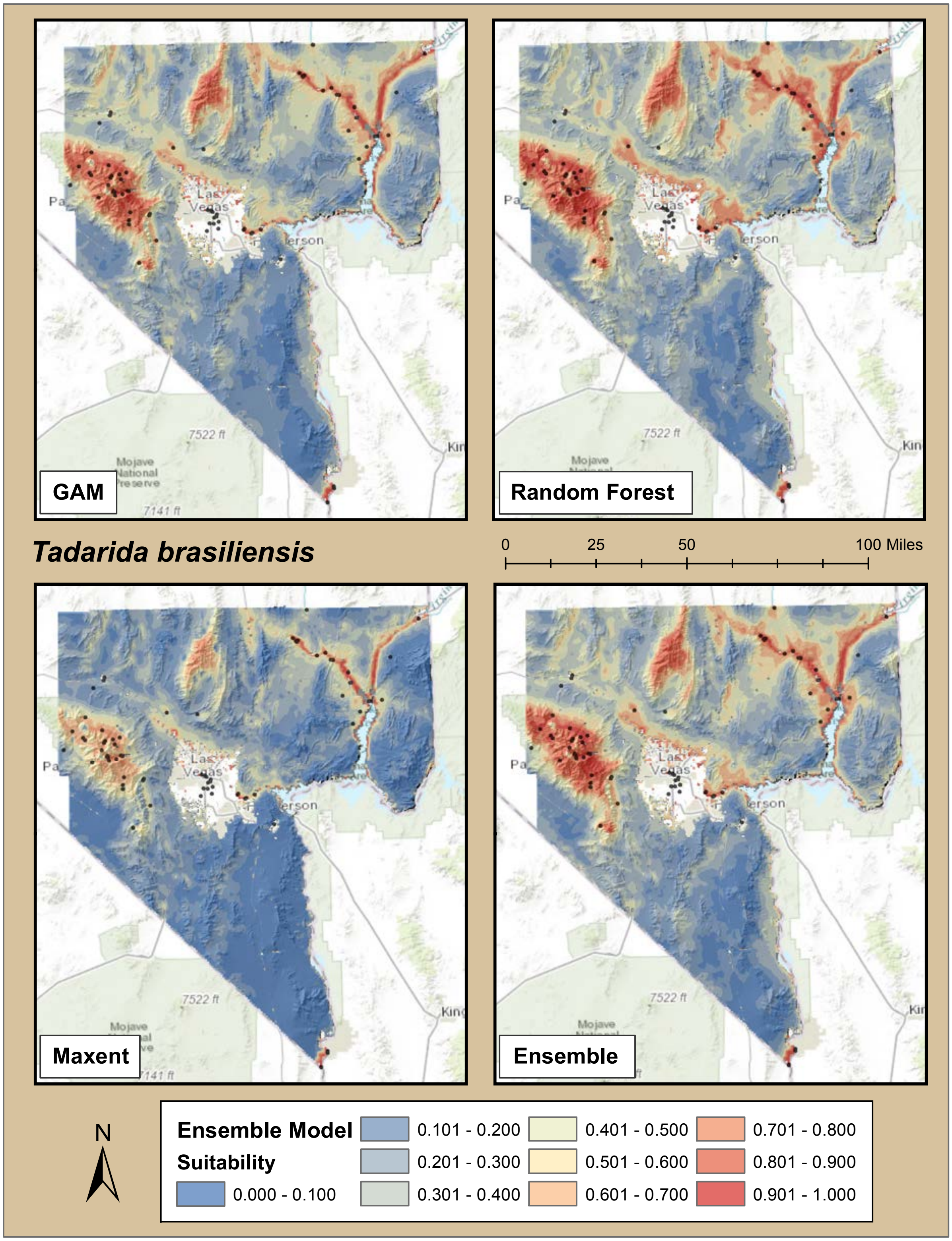

Figure 247. SDM maps for *Tadarida brasiliensis* model ensembles for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

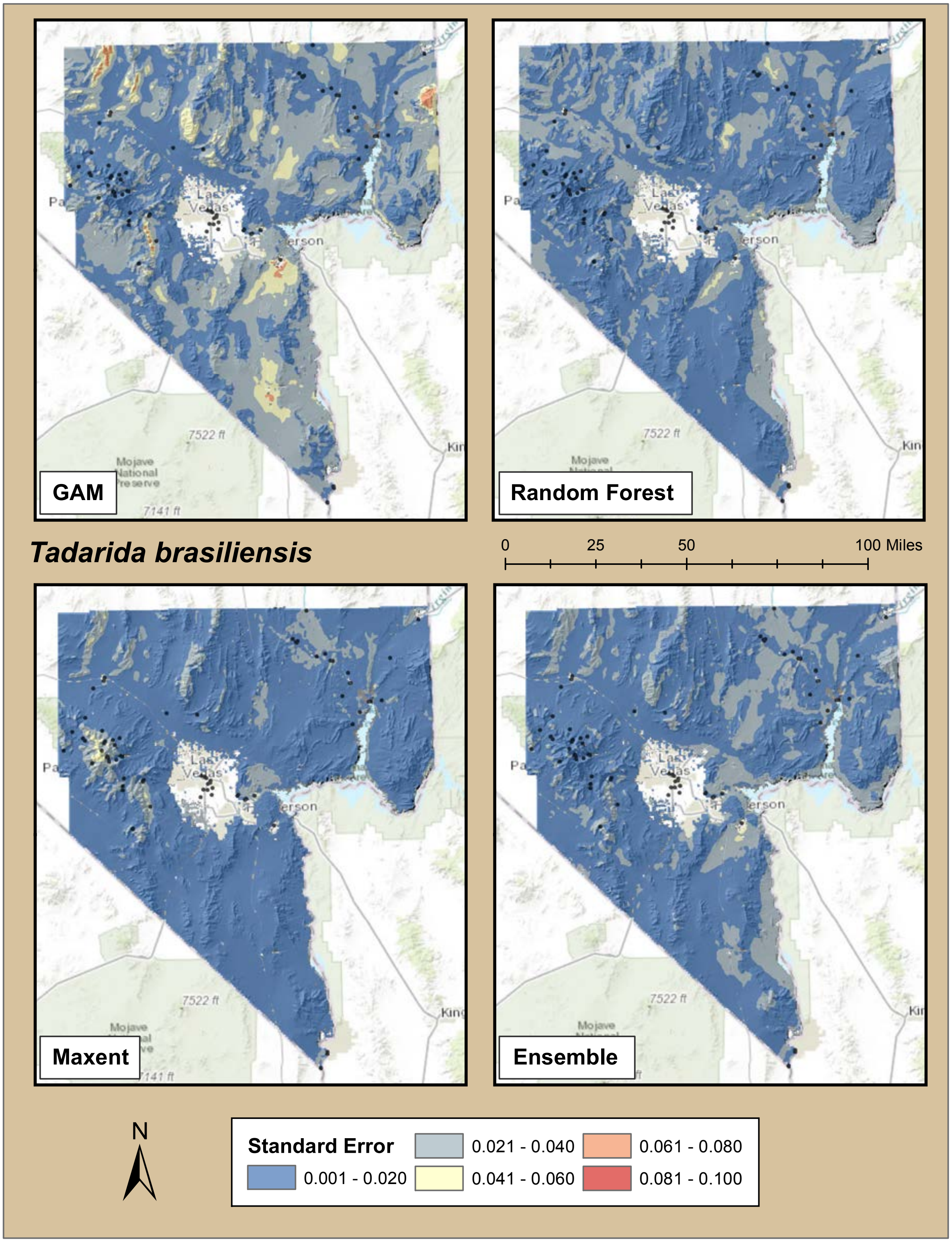

Figure 248. Standard error maps for *Tadarida brasiliensis* models for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

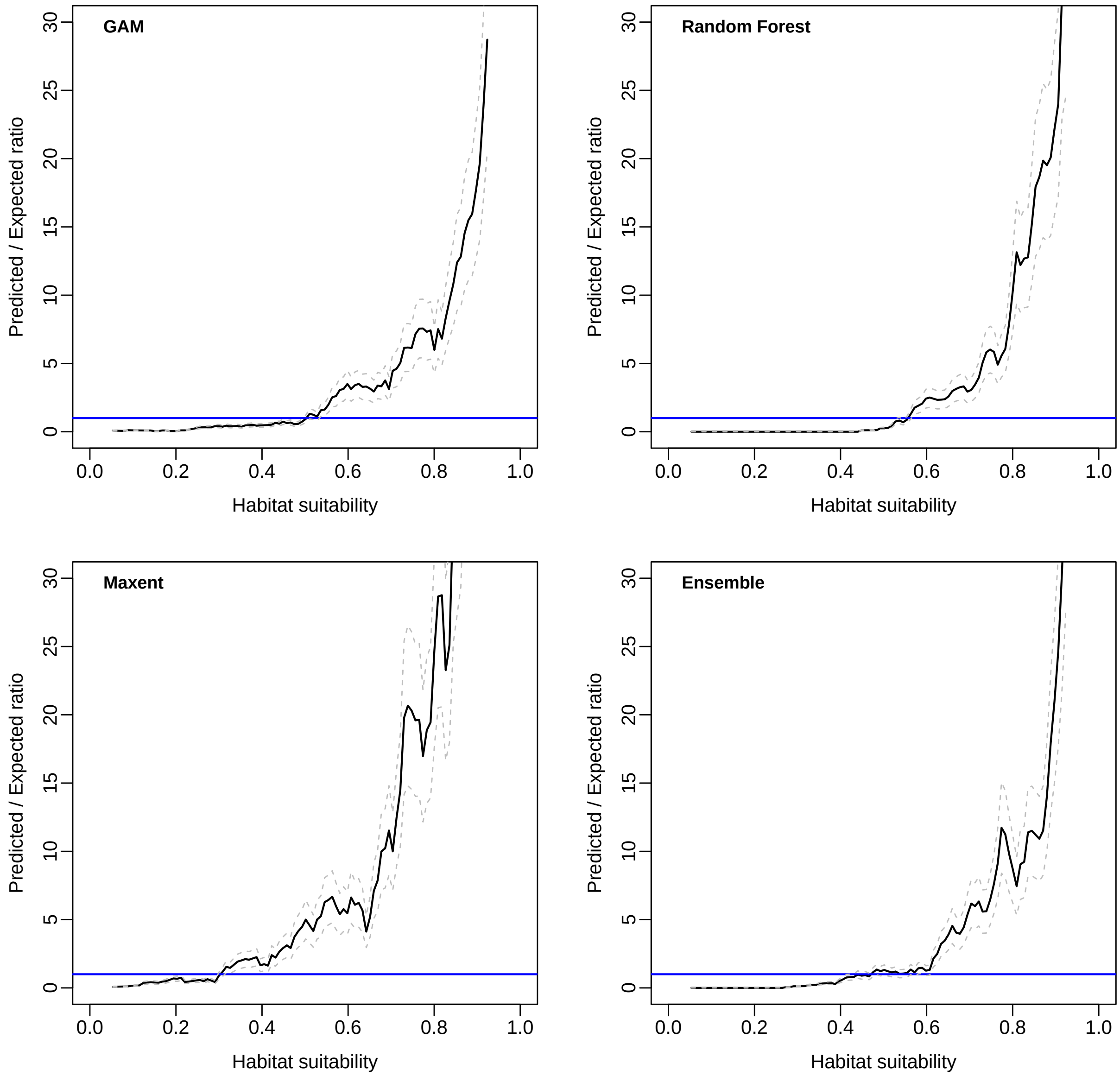

Figure 249. Continuous Boyce Indices for *Tadarida brasiliensis* models for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

GAM Model

The top 4 contributing variables to the GAM model were: NDVI Start-of-Season, Surface Texture, NDVI Greenness Timing, and Diurnal Temperature Range, collectively contributing 82% of the overall environmental influence to the model (Table 157). Habitat suitability peaked with areas that had intermediate start dates for the spring greenup, and increased in areas where NDVI peaked at later dates (i.e. higher elevation areas). As with the other bat species for which Surface Texture was selected, higher habitat suitability corresponded with lower values – characteristic of rockier substrates. Suitability for the Free-tailed Bat increased semi-linearly in areas that had a broader spread of diurnal temperature range (Figure 250). The continuous BI curve for the GAM model indicated good performance, but the other performance variables were not among the higher performing models (Table 156). The GAM model had the most widespread uncertainty in model agreement (Figure 248), with several areas of higher model standard error.

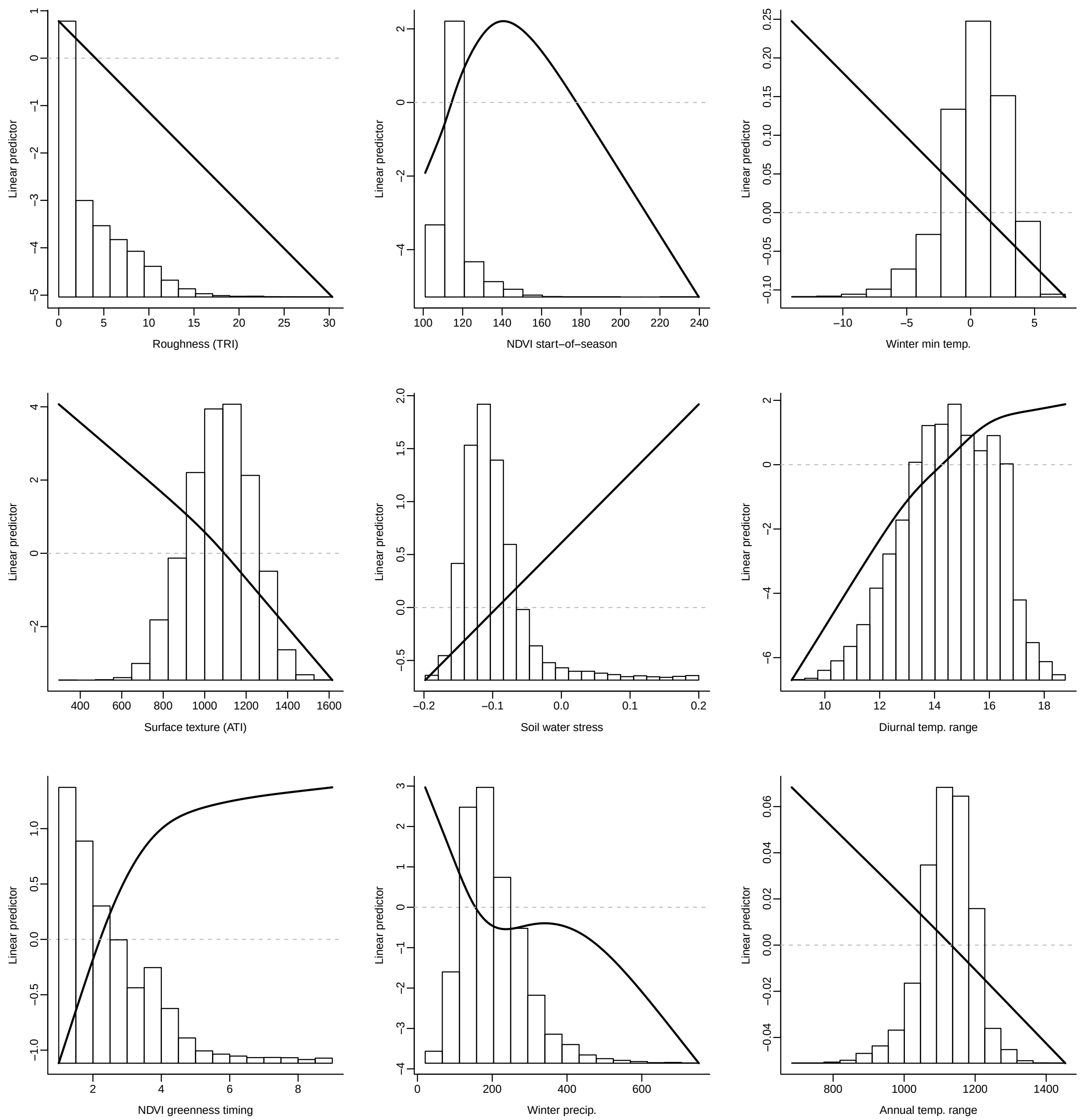

Figure 250. GAM partial response curves for the *Tadarida brasiliensis* model overlaid over distribution of environmental variable inputs in the study area.

MaxEnt Model

The MaxEnt model had five variables contributing more than 10% each, accounting for 86% of model contribution in total (Table 157). NDVI Start-of-Season was modeled as a threshold influenced variable, with suitability increasing sharply at day 120 (corresponding with April 29), and leveling off relatively quickly at day 140 (May 19), after which habitat suitability was predicted to be highest. Diurnal Temperature Range also modeled as a threshold response remaining low until areas with an 18º difference, after which suitability was predicted to increase sharply. NDVI Greenness Timing had a peaked response relative to predicted suitability at 3 (~ April 7), gently falling off thereafter (Figure 251). As for the other bat species models for which Surface Texture was selected, lower values (rockier areas) corresponded with more suitable habitat, declining as surfaces became smoother and composed of smaller materials. Habitat suitability was highest at low levels of Winter Precipitation, falling sharply and leveling off at 180mm (Figure 251). The MaxEnt model performed third among the four, models explored, and while it had a strong CBI, the fixed BI, and TSS values were among the lowest, interchanging with those of the GAM model (Table 156.). The cutoff value (habitat threshold) for this model was relatively low, which reflects the lower overall suitability scores produced by MaxEnt (Figure 247).

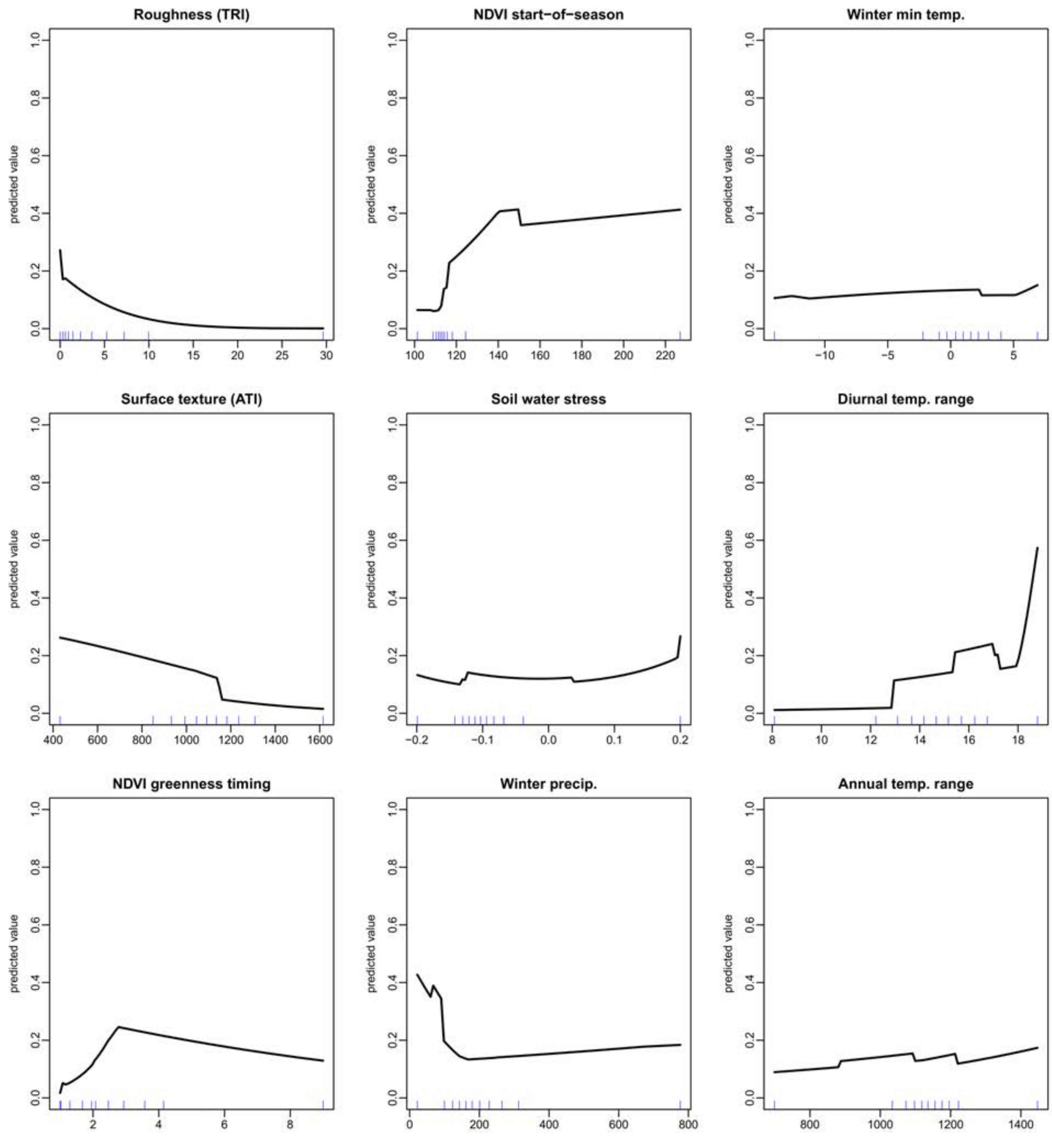

Figure 251. Response surfaces for the top 9 environmental variables included in the MaxEnt ensemble model for *Tadarida brasiliensis.*

Random Forest Model

The RF models had six environmental variables contributing 10% or more totaling 79% of total model influence. The highest contributor – NDVI Start-of-Season – had a sharp negative response at 110 (mid-April), predicting higher suitability for areas with plant production starting later (but with a potential artifact in earlier dates).

Habitat suitability was predicted to be higher in areas with low Winter Precipitation, sharply declining at areas receiving 200 mm or more during the winter (which is 4x the annual average for Las Vegas)(Figure 252). Predicted habitat suitability increased with later NDVI Greenness Timing, and with increasing diurnal temperature range (NDVI Greenness Timing). Rockier areas (low Surface Texture) also had higher predicted habitat suitability. The Continuous Boyce Index had the best relationship for this algorithm (Figure 249). The RF model had a strong CBI curve (Figure 249), and was the highest performing model across all reported measures (Table 156).

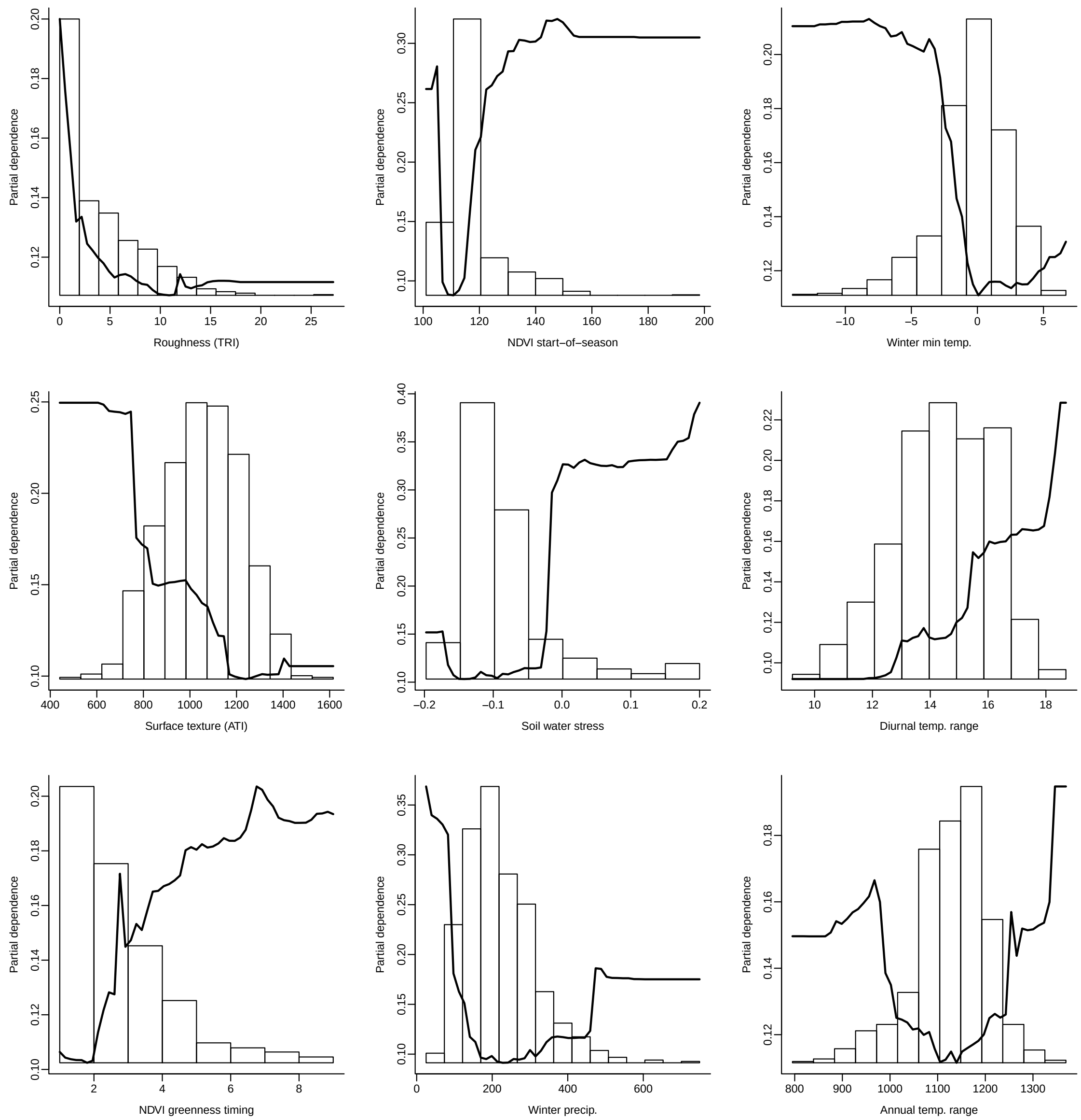

Figure 252. Response surfaces for the environmental variables included in the RF ensemble model for *Tadarida brasiliensis*. Histograms represent the range of each environmental variable across the x-axis, and predicted dependence relative to habitat suitability values are on the y-axis.

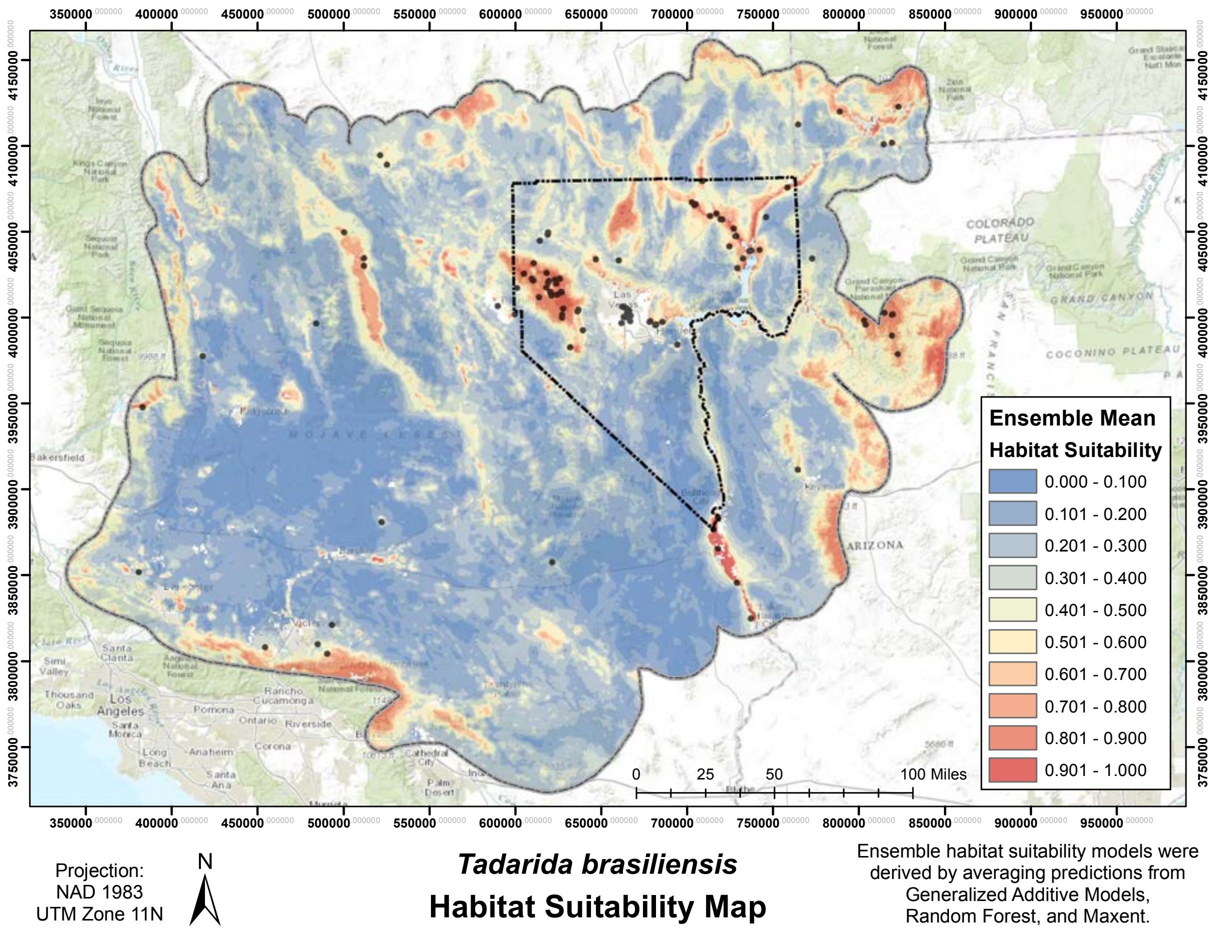

Figure 253. Mojave wide SDM map for the *Tadarida brasiliensis* ensemble model

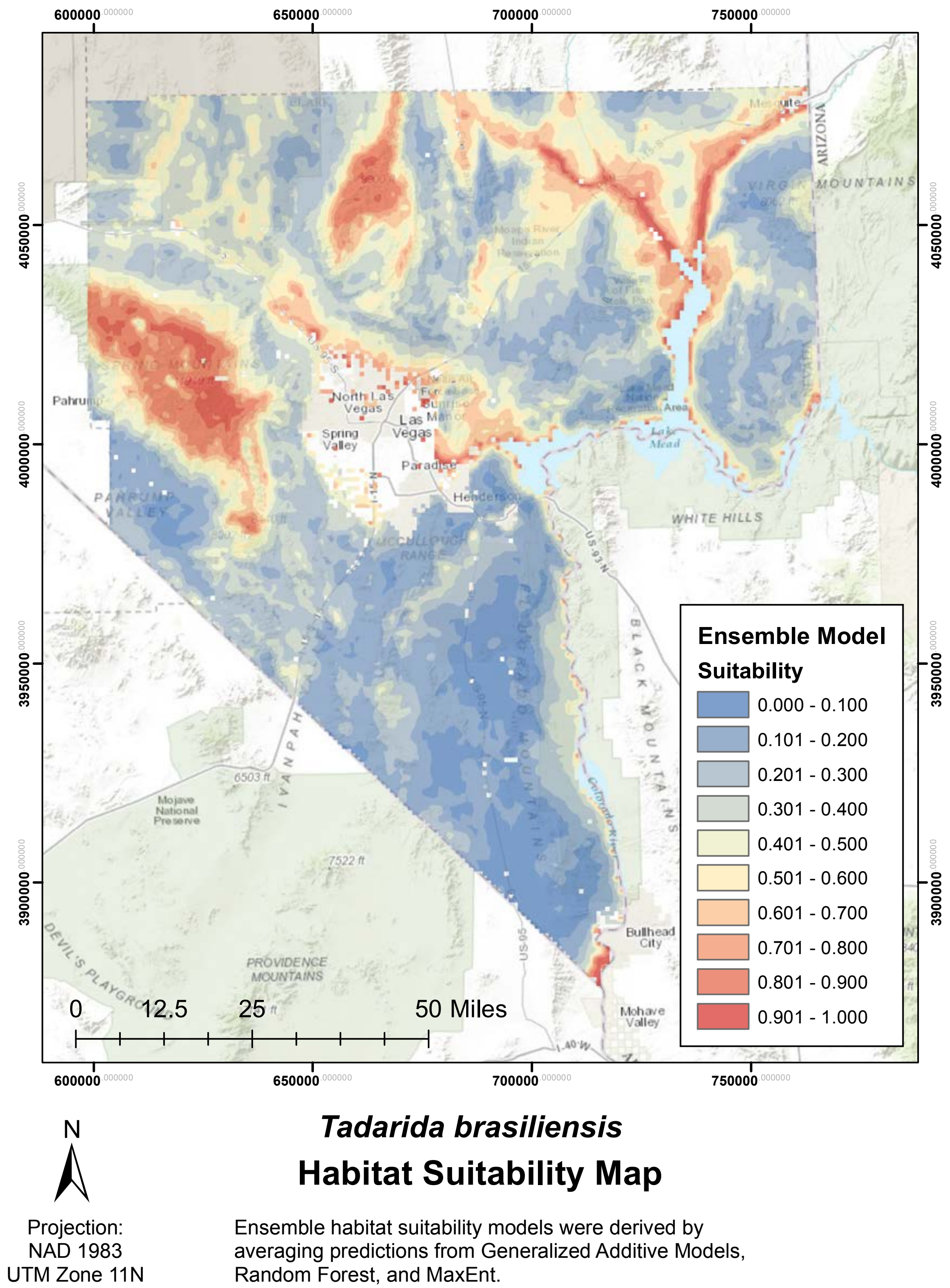

Figure 254. SDM map for the *Tadarida brasiliensis* ensemble model

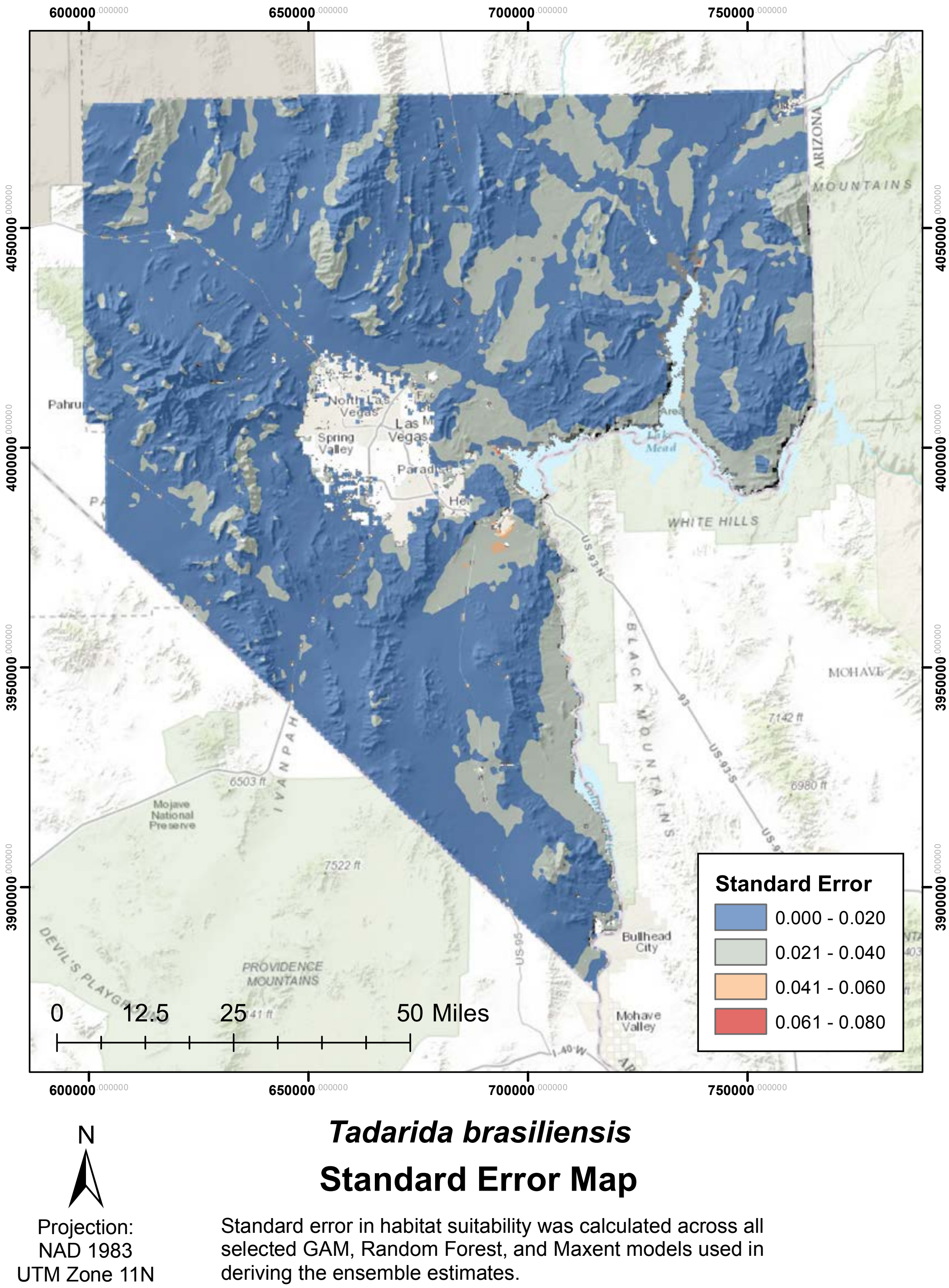

Figure 255. Standard Error map for the *Tadarida brasiliensis* ensemble model

Data Distribution

Localities for Mexican Free-tailed Bat in the Mojave Desert Ecoregion are very sparse ad widespread (Figure 253). Clark County, NV has the greatest concentrations of locality data across the entire Mojave Desert. Outside of that, the Arizona Strip in Mojave Co., Arizona, and the main stem of the Colorado River south of Needles, in San Bernardino Co., CA, there are few concentrations of captures in the Mojave Desert.

Mojave Desert suitability model

The Mojave Desert Ecoregion habitat suitability map indicates a pattern that is qualitatively similar to that of the Pallid Bat. In the southwest the suitability seems to be more extensive along the San Gabriel Mountains of California, and on the north and south rims of the Grand Canyon on the central eastern boundary of the map the suitability is also similar to Pallid Bats likely because of collections on the Arizona Strip (north rim of Grand Canyon) for both species. Mojave-wide Mexican Free-tailed Bats have a large linear patch of moderately high suitability in the Panamint range on the west side of Death Valley (Figure 253).

Model Standard Error

The Clark County, Nevada model standard error map indicates no large areas of concern for the Mexican Free-tailed Bat habitat model (Figure 255). There is a small area of moderately high error around the Boulder City, and another in Eldorado Valley that are really quite small. There are pixel-sized error points that generally occur along the I15 south of Las Vegas, and US Highway 95 corridors north of Las Vegas, that cannot be explained at this time.

Mexican Free-tailed Bats are found in summer residence and breeding (confirmed by the collection of lactating females) occurred in the vicinity of at a cattle tank in ponderosa pine forests on Black Rock Mountain, Mohave Co., Arizona just east of Clark County in association with its congener *Tadrida macrotis* and *Eptesicus fuscus*. Summer residents were also collected in pinyon-juniper woodland near Mt. Trumbull on the Arizona Strip in association with *T. macrotis*, *Myotis thysanodes*, and *M. volans* (Hoffmeister and Durham 1971). Even further south than these residents, *T. brasiliensis* are documented to be winter migrants at least as far as southern Arizona and definitely into the states of Sonora and Sinaloa, Mexico (Hoffmeister 1986).

Distribution and Habitat Use within Clark County

In a study along the Muddy River drainage near Moapa in Clark county Nevada, Mexican Free-tailed Bats were equally common in each of the four habitat types surveyed and was the most frequently detected species using acoustic surveys (Williams et al. 2006). This species was observed foraging at altitudes of as high as 300 m above ground surface in Clark County, Nevada (Griffin and Thompson 1982). Point distributions and predicted habitat provided in the Species Distribution Model indicate distributions in mountainous areas in the Spring and Sheep ranges, as well as likely foraging areas occurring along the Las Vegas Wash, the Muddy and Virgin river systems in Moapa Valley, throughout the Overton arm of Lake Mead National

Recreation Area (NRA), and in the Colorado River drainage in the southernmost extent of the county near the community of Avi. High and moderate modeled habitat for this species occurs in all ecosystems within the county, with the majority of the area within Mojave Desert Scrub, Pinyon Juniper, Mixed Conifer and Blackbrush ecosystems (Table 158).

In Clark County, modeled highly suitable habitat occurs in a similar pattern to that described for Pallid Bats. However, suitability appears to be slightly more concentrated around the primarily suitable areas indicated by generally lower suitability values in the southern one-half of the county (Figure 254). This is especially apparent in comparison to Pallid Bat habitat suitability in the McCollough Mountains, which remains of lower habitat suitability for Mexican Free-tailed Bats according to the habitat model. The Spring Mountains, upper Overton Arm/Muddy and Virgin River, Sheep Range, and habitat patches north of Las Vegas are very similar to those described for Pallid Bats as well. In those areas moderate to highly suitable habitat occurs in desert scrub, to forested habitat areas (Spring Mountains, and Sheep Range). Primarily riparian habitat occurs in the upper Overton Arm/Muddy and Virgin Rivers, lower Colorado River (below Bullhead City, Mohave Co., AZ, and habitat areas north of Las Vegas (as well as some pseudo-riparian/ urban areas). The urban areas of Las Vegas have many more localities than observed for *Antrozous*. This may be attributed to the large colonies of these bats that commonly roost structures such as bridges and buildings. It appears that Mexican Free-tailed Bats have a greater tolerance for human activities than Antrozous based on the number of large urban colonies. For example, there has been a large colony of bats roosting over the passenger pickup parking lots at McCarran International Airport for a number of years. Some moderately high habitat values occur in the Apex Industrial area north of the Jct. of I15 and Hwy 93, as well as on the Moapa River Indian Reservation.

Table 158. Ecosystems within Clark County, and the area (Ha) of Low Medium and High predicted suitability within each ecosystem.

Ecosystem	Low	Medium	High
Alpine	0	110	13
Blackbrush	220031	177862	16254
Bristlecone Pine	0	358	7205
Desert Riparian	0	182	9734
Mesquite Acacia	12109	2490	5248
Mixed Conifer	0	374	26963
Mojave Desert Scrub	673979	473272	134302
Pinyon Juniper	8744	21722	85239
Sagebrush	295	1980	2423
Salt Desert Scrub	29808	44647	4986

Ecosystem Level Threats

Ecosystem level threats include disturbances to and closures of roosting habitat. As they may fly long distances to foraging areas it is likely that structures interfering with flyways, and loss of foraging habitat would also negatively affect this species.

Threats to Species

The Mexican Free-tailed Bat faces threats from disturbance at roosts, pollution, development, and vandalism. Declines in some populations have been attributed to the use of DDT and disturbance due to guano mining in Mexico (Wiederholt et al. 2013).

Wind turbines are also likely to affect survival during migrations (Arnett et al. 2008) as Mexican Free-tailed Bats are among the most frequently observed bat species at energy development facilities in the southern US (Cryan and Barclay 2009). The bats are susceptible to structural collisions during flight, propeller strikes, and barotrauma from exposure to lethally low pressures created by the speed of the propellers in the atmosphere.

The white-nose fungus (*Pseudogymnoascus destructans*) is not known to affect this species, at this time (Whitenosesyndrome.org 2017).

Existing Conservation Areas/Management Actions

Protection of mines and caves and structures that support large colonies would also be appropriate here to protect roosting habitat. Preservation of existing riparian areas by the addition of reserve areas for Desert Riparian Ecosystem habitat in Clark County, Nevada, would be beneficial to this and other species of bats using riparian areas for foraging habitat.

Summary of Direct Impacts

Of the estimated 10,407 km^2 of high and moderate habitat for this species located within the county, 45% is located within conservation areas. Impacted areas are likely to affect 25% of high and moderate habitat area, while 14% is already disturbed (Table 159).

Table 159. Categorized modeled habitat values (High, Medium, and Low) and the average area (Hectares) predicted in the potential impact areas, conservation areas, already disturbed areas, and overall area

Habitat Level	Impact	Conserved	Disturbed	Area (Hectares)
High	28259	25032	21070	297879
Med	45608	108814	19762	742867
Low	48589	379053	10516	964423

THBO - Botta's Pocket Gopher (Thomomys bottae)

Botta's Pocket Gopher is one species among a broadly occurring Genus of rodents that has been recognized at the subspecies level for protection of different degrees. Endemic subspecies have been considered as rare and sensitive to extirpation and have been recommended for Conservation Priority in the recent Nevada Wildlife Action Plan (Wildlife Action Plan Team. 2012), although recent taxonomic analyses would suggest that these subspecies are likely a part of a larger and locally variable group existing throughout the Mojave and into California (Alvarez-Castañeda, 2010).

Species Status

US Fish and Wildlife Service Endangered Species Act: No Status
US Bureau of Land Management (Nevada): Sensitive (applies only to *T.b. abstrusus* and *T.b curtatus*, no status for full species; see text for details)
US Forest Service (Region 4): No Status
State of Nevada: No Status
NV Natural Heritage Program: Global Rank G5, State Rank SH
NV Wildlife Action Plan: Species of Conservation Priority
IUCN Redlist (v 3.1): Least Concern
CITES: No Status

Range

Thomomys bottae (consisting of several subspecies) range from southern Oregon through California to Mexico including the Baja peninsula, and east across central and southern Nevada and Utah to southwestern Colorado. On the easternmost extent of their range they occur in most of New Mexico west of the Pecos River, and southward range into west Texas, Coahuila, Chihuahua, Nuevo Leon, Sinaloa, and Sonora, Mexico (Jones and Baxter 2004). Elevation ranges for the species have been reported from sea level up to 4,200 m (Howard and Childs 1959, Jones and Baxter 2004).

Habitat Model

Botta's Pocket Gopher habitat models were similar among algorithms with important distinctions. The RF and MaxEnt predicted habitat models appear to have tighter predictions, with concentrated habitat islands predicted that are not as pronounced in the GAM habitat predictions. The RF Models had the highest AUC and TSS values, while the Ensemble model had the highest BI (Table 160). The GAM model had 8 predictive variables, the MaxEnt, and RF models 10 each. RF and MaxEnt shared those 8 and added the same 2 variables, NDVI Amplitude, Summer Maximum Temperature. Error was highest in the MaxEnt models, with moderately high error throughout the study area (Figure 257). Continuous Boyce Indices indicated strong predictive performance for all but the GAM models (Figure 258).

Table 160. Model performance values for *Thomomys bottae* models

Model	Presences	AUC	BI	TSS
Ensemble	130	0.9	0.913	0.697
GAM		0.753	0.719	0.507

Model	Presences	AUC	BI	TSS
RF		0.961	0.891	0.838
MaxEnt		0.852	0.845	0.632

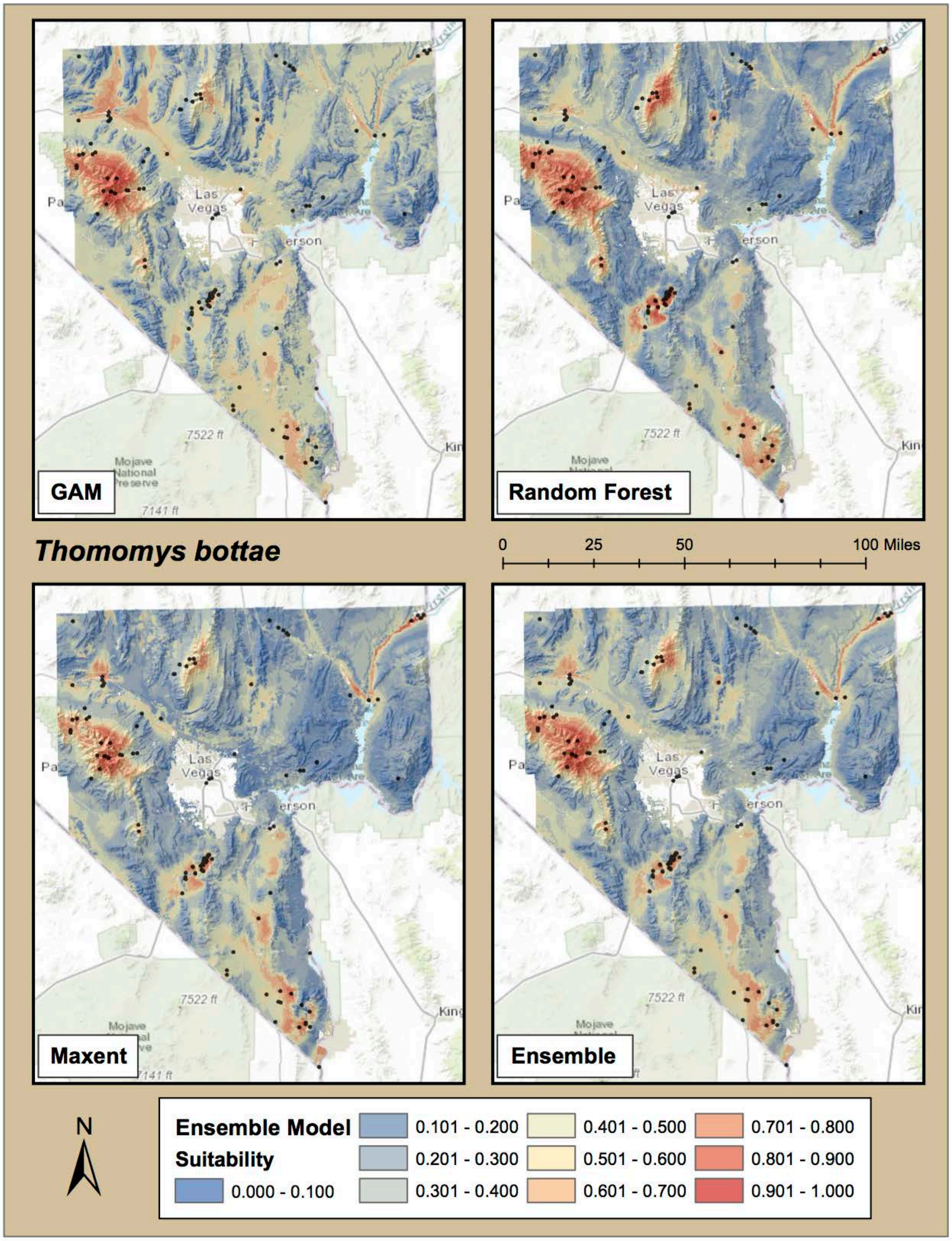

Figure 256 . SDM maps for *Thomomys bottae* model ensembles for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and ensemble model averaging the three (Lower Right).

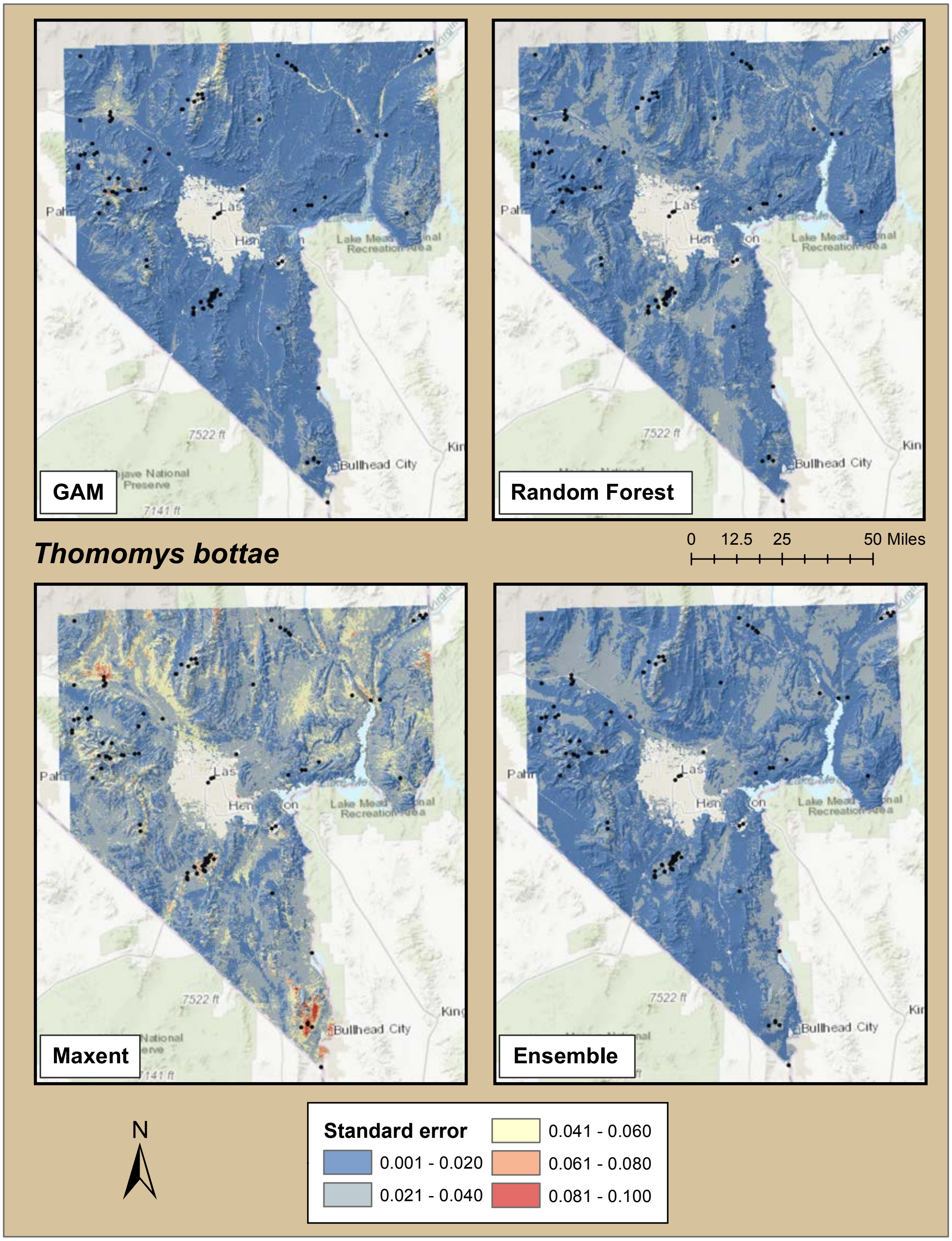

Figure 257 . Standard error maps for *Thomomys bottae* models for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

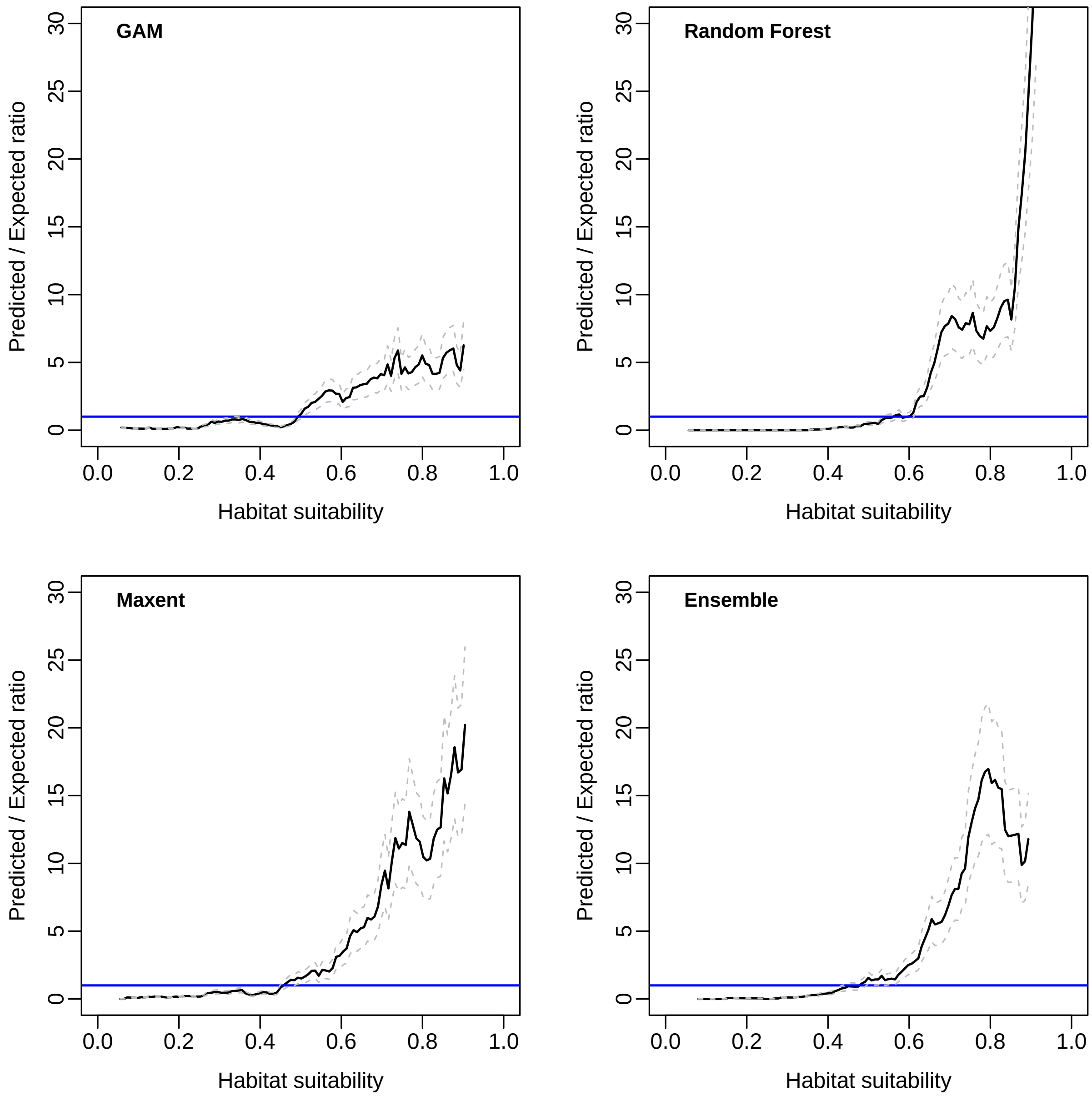

Figure 258 . Graphs of Continuous Boyce Indices [CBI] for *Thomomys bottae* models for each of three modeling algorithms used (GAM - upper left, RF - upper right, MaxEnt - lower left), and an ensemble model averaging the three (Lower Right).

General Additive Model

Winter Precipitation and Annual Temperature Range were the highest contributing covariates, with most habitat at low levels, but also increasing habitat predicted with increasing winter precipitation above 120 mm, and with some indication of decreasing habitat with broader seasonal temperature ranges (Figure 259). Slope was the next ranking in covariate contribution, with decreasing habitat values predicted for areas with increasing slopes. Surface Roughness and Surface Texture provided moderate contributions where rougher surfaces predicted lower habitat, and Sandy

Surfaces predicted elevated habitat (Table 161, Figure 259). Terrain Position Index and NDVI Maximum had positive correlations with predicted habitat, and habitat generally decreased with Winter Minimum Temperature, but not to extremely low levels (Figure 259).

Table 161 . Percent contributions for input variables for *Thomomys bottae* for ensemble models using GAM, MaxEnt and RF algorithms.

Variable	GAM	MaxEnt	RF
Elevation			
NDVI Amplitude		4.127	10.991
NDVI Maximum	2.409	9.326	13.996
NDVI Start of Season			
NDVI Total Integrated			
Sandy Soils (TerraSpectra)			
Slope	17.248	2.815	12.308
Summer Maximum Temperature		14.037	16.485
Surface Roughness	8.433	4.759	16.603
Temperature Range (Annual Max - Min)	26.813	15.992	16.414
Terrain Position Index	3.614	5.177	13.517
Texture (ATI)	6.692	17.604	14
Washes			
Winter Minimum Temperature	1.205	13.274	16.843
Winter Precipitation	33.585	12.888	15.629

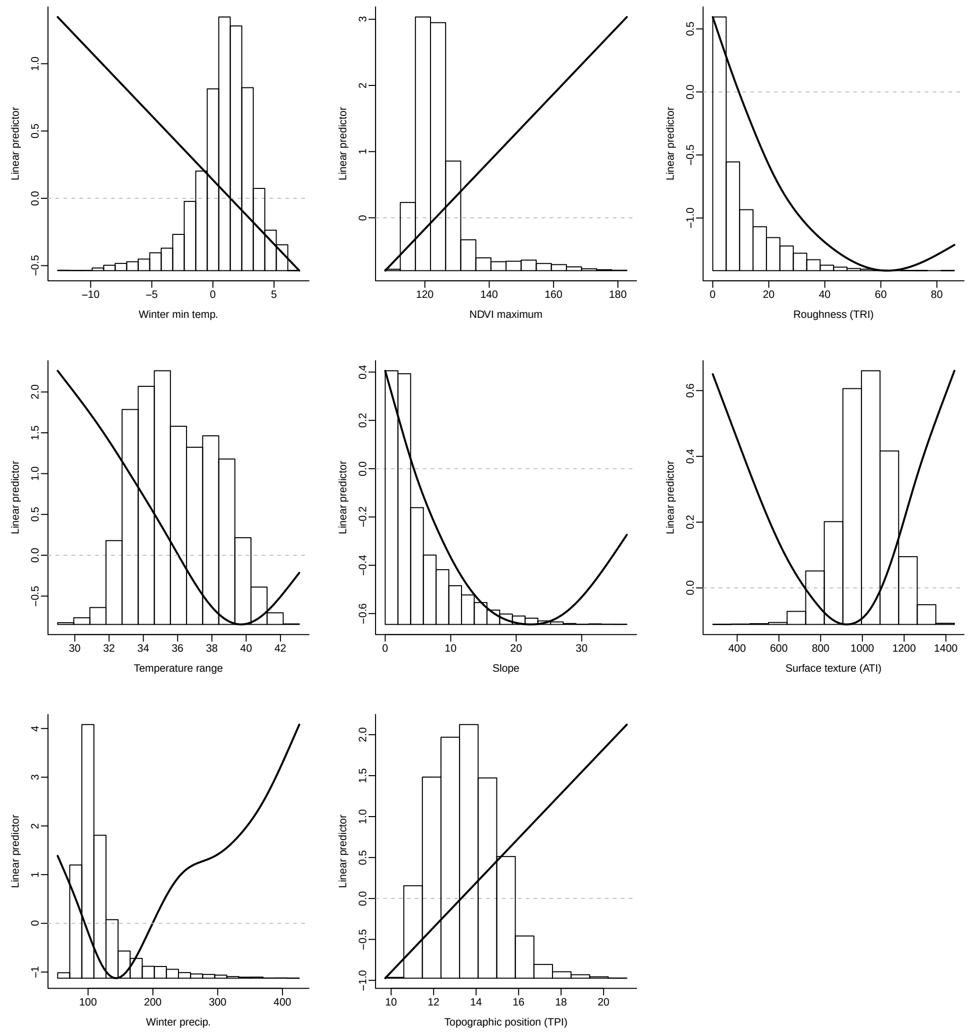

Figure 259 . GAM partial response curves for the *Thomomys bottae* model overlaid over distribution of environmental variable inputs in the study area.

MaxEnt Model

MaxEnt model contribution rankings for the covariates were highest for Surface Texture, Annual Temperature Range, Summer Maximum Temperature, Winter Minimum Temperature, and Winter Precipitation, followed by decreasing contributions of NDVI Maximum, Terrain Position Index, Surface Roughness, NDVI Amplitude, and Slope. The general response surfaces are similar to those for the GAM model (Figure 260), with increasing complexity in the relationships potentially caused by incomplete sampling of this species across all habitats (Figure 256).

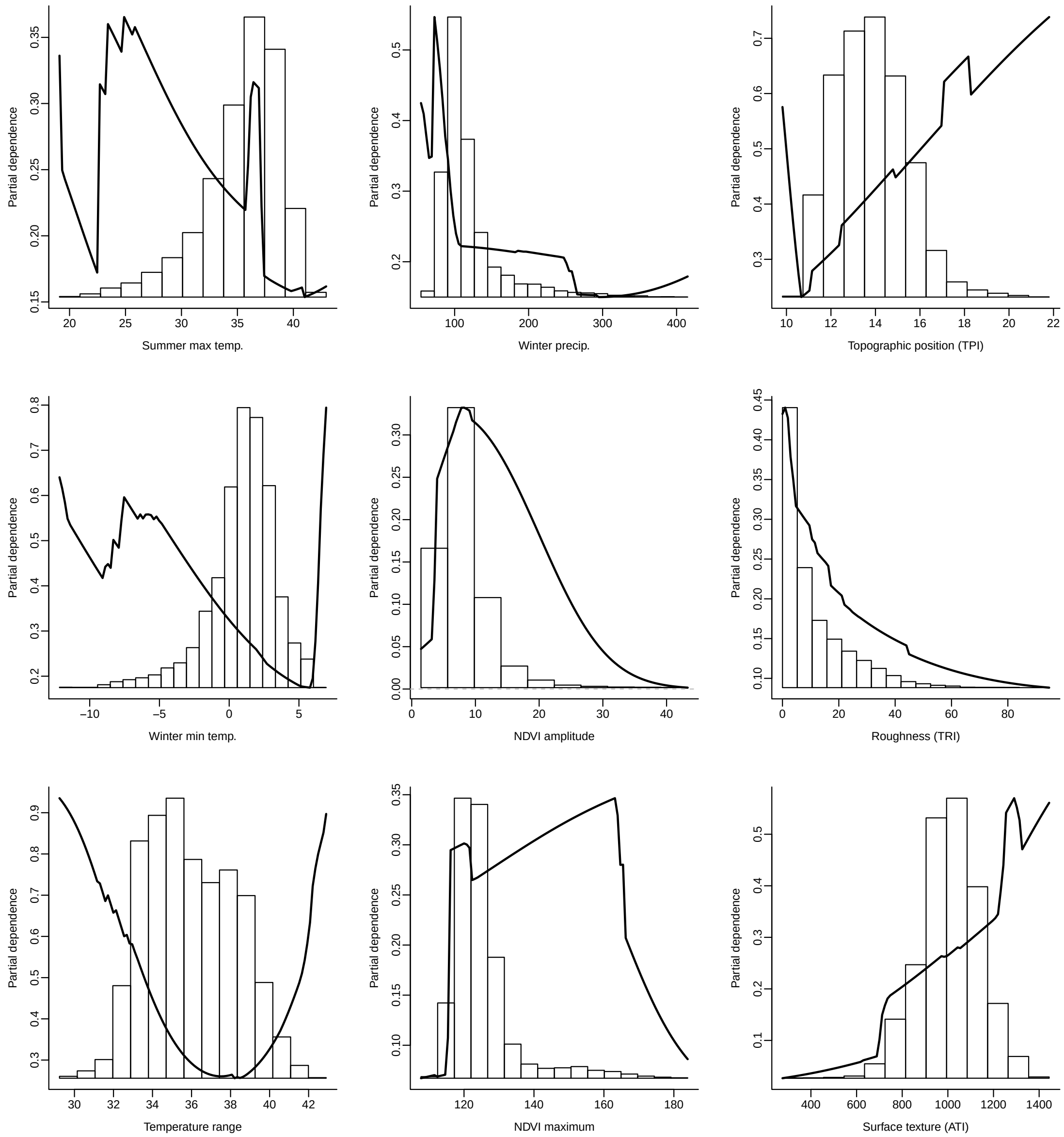

Figure 260 . Response surfaces for the top environmental variables included in the MaxEnt ensemble model for *Thomomys bottae.*

Random Forest Model

The RF model has similar levels of contribution from the first five covariates, Winter Minimum Temperature, Surface Roughness, Summer Maximum Temperature, Annual Temperature Range, Winter Precipitation, with decreasing contributions from Surface Texture, NDVI Maximum, Terrain Position Index, Slope, and NDVI Amplitude. Like the MaxEnt model, the response surfaces for RF showed more complex patterns than seen in the GAM predictions, indicating potential overfitting, or bias in sampling (Figure 261)

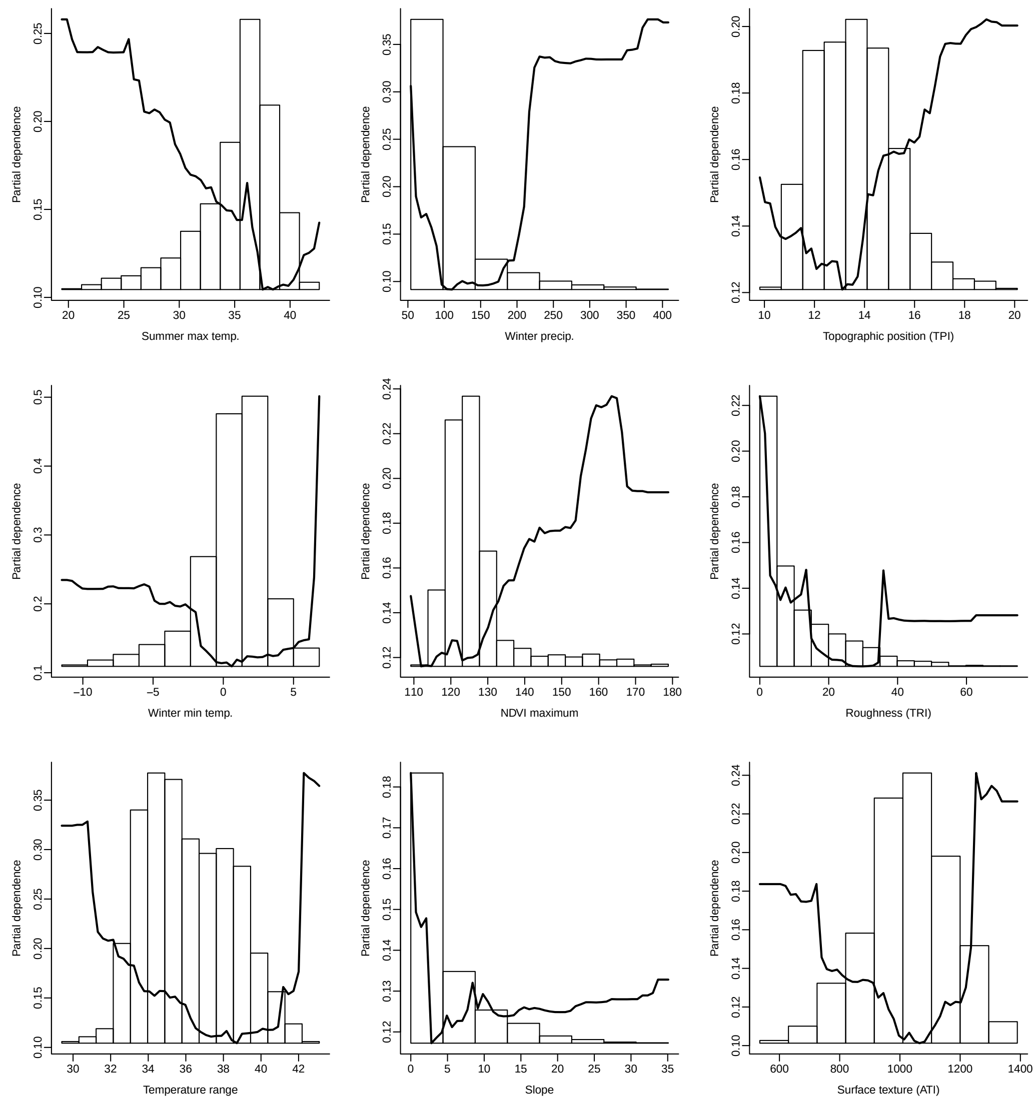

Figure 261 . Partial response surfaces for the environmental variables included in the RF ensemble model for *Thomomys bottae.* Histograms represent the range of each environmental variable across the x-axis, and predicted dependence relative to habitat suitability values are on the y-axis.

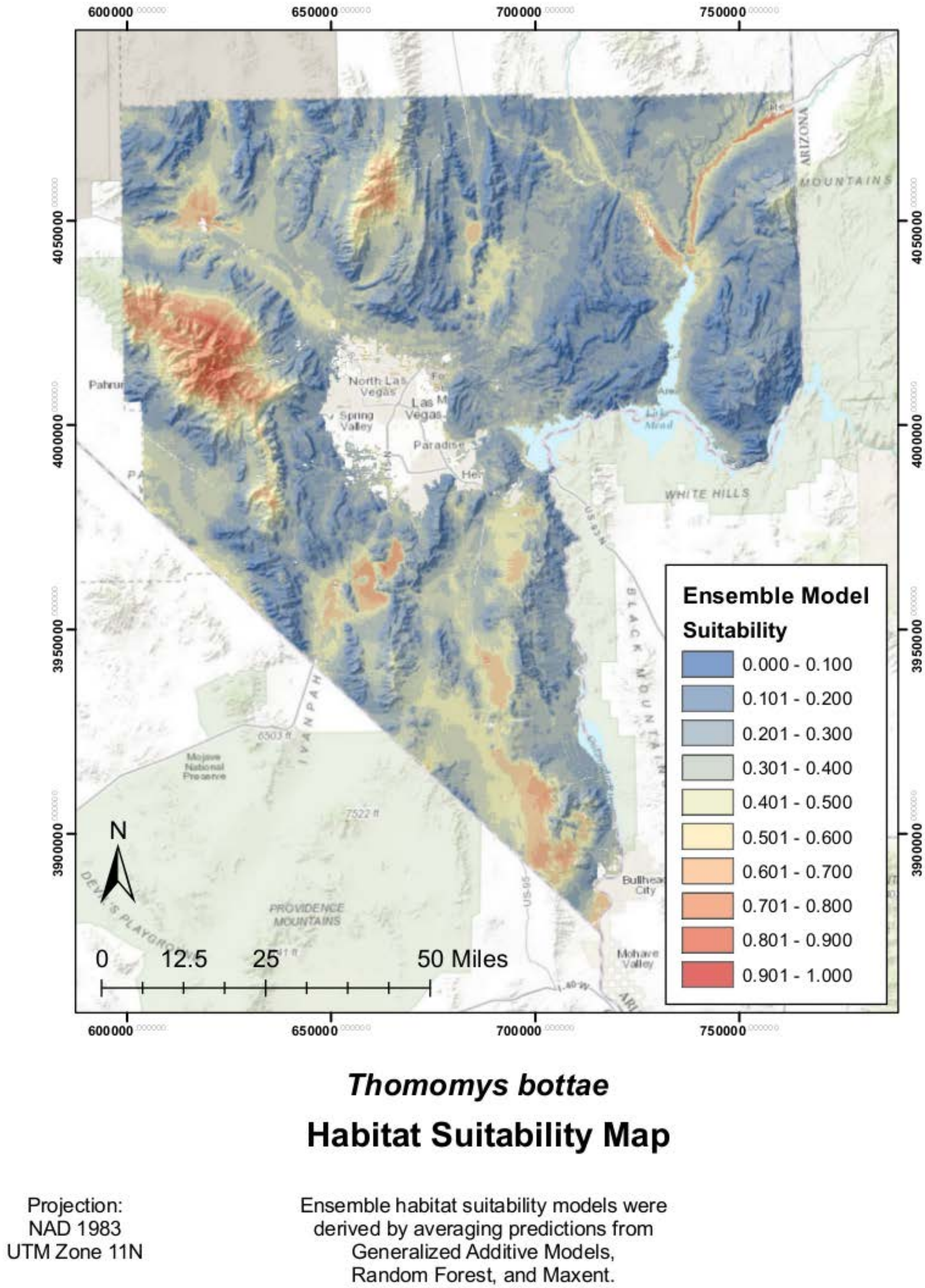

Figure 262 . SDM map for the *Thomomys bottae* Ensemble model.

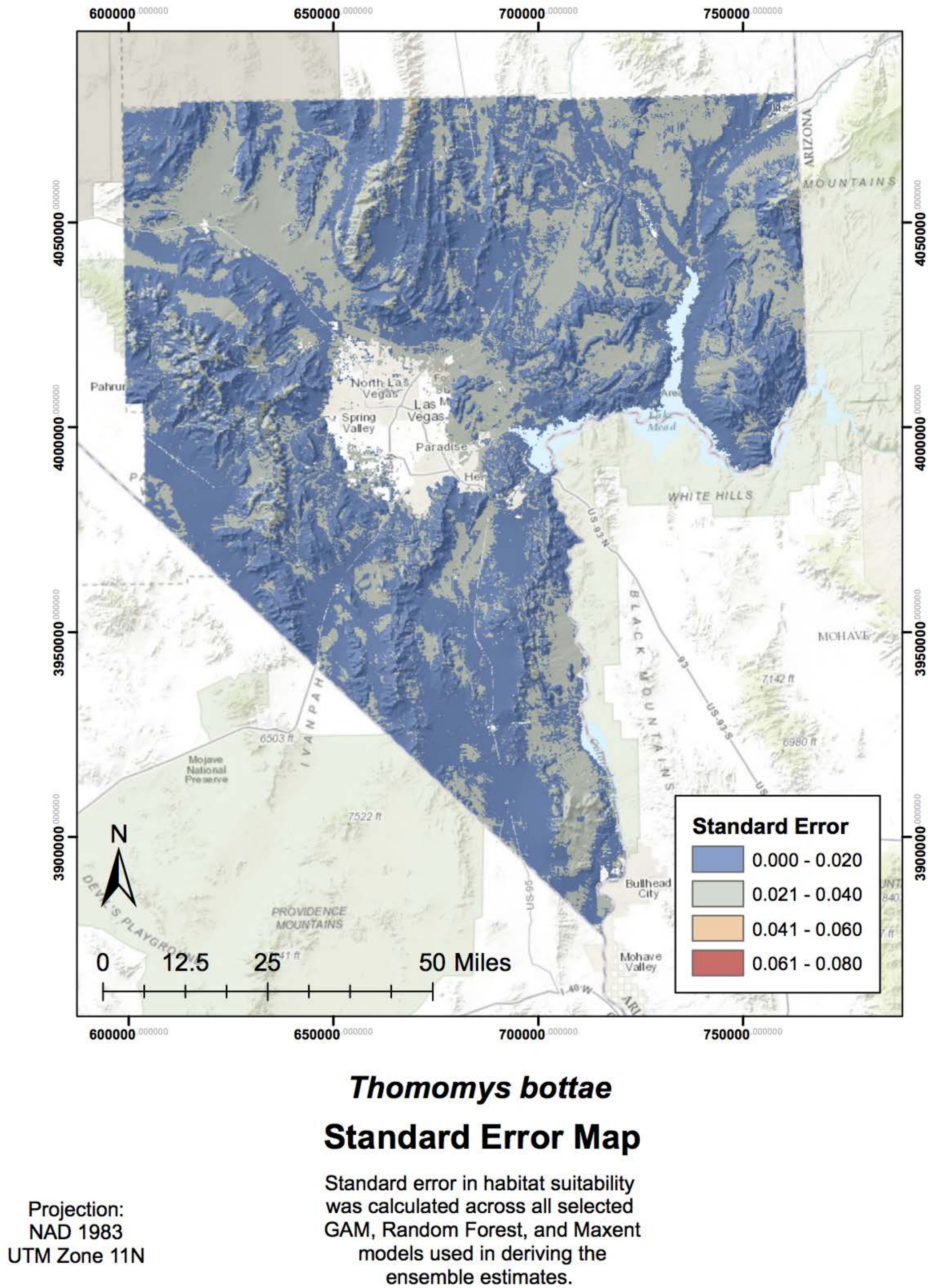

Figure 263 . Standard Error map for the *Thomomys bottae* ensemble model for Clark County, NV.

Model Discussion

The species distribution model for Botta's Pocket Gopher was predicted using a relatively small number of locality records (N = 130). Thus, the model prediction is expected to be somewhat less robust that some of the other species modeled in this report. Furthermore, the original data set was extremely spatially biased primarily concentrated on the slopes of the Spring Mountains and the Desert Range. The bias was so detrimental to the model that we gathered extra locality points by conducting road surveys and identifying Botta's Pocket Gopher burrow complexes across a broader geographic and habitat range in Clark County. While our search was not exhaustive, we found this to be a very good investment of time for the success of this model. By filling in data gaps in the northeast and southern portions of Clark County and focusing on different habitat types (e.g., valley bottoms, and bajadas), the SDM resulted in habitat predictions that we believe are much more representative of the distribution for Botta's Pocket Gopher (Figure 262). After all, the common name for this species is the Valley Pocket Gopher and not the "Mountain Pocket Gopher".

Not all artifacts resulting from the low number of locality records could be removed from the SDM for Botta's Pocket Gophers at this time. Most obvious among such artifacts is an elevational "ring" created by a hole in the distribution of Botta's Pocket Gopher encircling the Spring Mountains - this is a blue ring indicating low probability of finding Botta's Pocket Gopher at a certain elevation - which we consider to be incorrect (Figure 256). We suggest that this ring and some other mid-elevation absences on the SDM are due to a lack of sampling at that elevation, which is also reflected in some of the response surfaces (Figures 5 and 6). Another major hole in the distribution of Botta's Pocket Gopher occurs on either side of the Overton Arm of Lake Mead. West of the Overton Arm is the Muddy Mountains, White Valley, and the Black Mountains on the margin of Lake Mead. East of the Overton Arm is the Gold Butte and Virgin Mountains area rising to nearly 2500 m. Both areas have an elevational range as low as Lake Mead (~360 m). The current SDM does not predict these areas to support Botta's Pocket Gopher. A third area that the model predicts as nearly devoid of Botta's Pocket Gopher habitat is in the Arrow Canyon area, north of the junction of Interstate Highway 15 and State Highway 93. And finally, the expansive valley bottom and rolling gravelly hills that span from Cottonwood Cove to the Newberry Mountains along the Colorado River indicate that the model predicts very low probability of occurrence for Botta's Pocket Gopher at this time. This seems unlikely to us because some of the species of reptiles that we modeled for this report also require friable soil to exist, and we consider their SDMs to be robust - yet Botta's Pocket Gopher is not predicted to have a very high prevalence of occurrence in these areas, despite its prevalence in other areas with similar soils and environmental conditions. None of these additional areas where the SDM fails to predict Botta's Pocket Gopher habitat can be entirely explained by the lack of mid-elevation locality records described before. More likely it is simply due to the lack of enough locality records. We predict that once sufficient locality records are collected there will be few places in the county where gophers are not predicted to occur. It is likely that the only places actually devoid of Botta's Pocket Gophers are expansive areas of bedrock and a geomorphic surface known as stony ground. A good example of expansive stony ground is in the Black Mountains immediately south and adjacent to the city of Henderson, NV.

Standard Error

The standard error map (Figure 263) for Botta's Pocket Gopher habitat illustrates a large amount of low grade uncertainty in model prediction. Some of the areas are similar to areas where other modeled species in this report showed uncertainty - such as the Las Vegas Wash to Indian Springs areas northwest of the city of Las Vegas. However, the Botta's Pocket Gopher SDM standard error may illustrate the most uncertainty and we suggest that this is due to the low sample size for locality records in conjunction with the extremely broad ecological niche that this species is capable of occupying.

Friable soils, such as those found in valley bottoms, hillslopes, mountain meadows, and tundra habitats of Clark County are essential for Botta's Pocket Gophers to travel from plant to plant in order to "fill their capacious pockets" (Schaefer 1992). The range of soils and vegetation types they can inhabit indicates to us that once a robust locality record is completed for this species they will have among the broadest geographic occurrences and ecological amplitudes of any modeled species for Clark County.

Distribution and Habitat Use within Clark County

Botta's Pocket Gophers are strictly herbivorous with a broad diet, and their reproductive rates and body size are limited by the availability of forage (Smith and Patton 1988, Jones and Baxter 2004). Given their broad distribution, they occur in a wide range of habitats from valleys to desert ranges and above the timberline (Jones and Baxter 2004), but are primarily found in areas that support burrowing, such as sandy or gravelly soils (Zeveloff, 1988), and can be limited from or reduced in abundance in areas with shallow or unfriable soils (Grinnell 1926, Howard and Childs 1959, Jones and Baxter 2004). Botta's Pocket Gophers are also often found in areas with alluvial soils that can support grasses and forbs for forage (Linsdale 1938, Bond 1946, Fitch and Bentley, 1949, Smallwood and Morrison, 1999), and burrow production is related to forage availability and periods of heavy rainfall (Bandoli 1981). In the Mojave they occupy nearly all vegetation communities that have sufficient food and friable soils (Smith and Patton 1988), and thus they are broadly distributed across the ecosystems in the County (Table 162). Botta's Pocket Gophers are not often found in extremely rocky terrain, but can occur in meadows at high elevations (Zeveloff, 1988). They can also occur in increased densities in agricultural areas, thus potentially benefiting from some development – if not off-set by control measures in these same areas, and are documented to occupy alfalfa fields among others (Lay 1978, Smith and Patton 1980, Jones and Baxter 2004).

One of the earliest observations of Botta's Pocket Gophers in Clark County (then deemed a new species *Thomomys phelleoecus*) was in the Sheep Mountains at 2,590 m, near Hidden Forest (8,500 ft; Burt 1933). Other subspecies were described in Esmeralda County (Hall and Davis 1935)

Table 162 . Ecosystems within Clark County, and the area (Ha) of Low Medium and High predicted suitability within each ecosystem.

Ecosystem	Low	Medium	High
Alpine	0	0	124
Blackbrush	248983	158733	6464
Bristlecone Pine	0	227	7333
Desert Riparian	332	2453	7900
Mesquite Acacia	3035	13259	3365
Mixed Conifer	0	1778	25535
Mojave Desert Scrub	550775	674267	53235
Pinyon Juniper	12975	61266	41279
Sagebrush	800	2295	1600
Salt Desert Scrub	24927	48355	5249

Ecosystem Level Threats

Given the broad habitat preferences and distribution of this species, there are few known ecosystem level threats besides large scale urban development, utility infrastructure, and solar arrays.

Population Trends

We have little information on population trends in Pocket Gophers, especially in the Clark County area. Some studies show declining populations with OHV use (Vollmer et al. 1977), but increased density with changes in vegetation cover associated with cattle grazing in Sierra Nevada meadow systems (Powers et al. 2011). While Pocket Gopher populations have been reported to be of increased density in agricultural fields (e.g. alfalfa), this may depend on stand age, and other factors (Smallwood et al. 2001), and would depend on gains not being off-set by artificial control measures such as rodenticide distributions in these areas.

Threats to Species

While the NNHP lists Botta's Pocket Gophers in Nevada as potentially extirpated, most management plans list them as an expected species in the project area, and surveys conducted in the early 2000's show them in pitfall array sampling in Clark County in and around Hidden Valley/Jean Dry Lake (UNR BRRC 2002). NDOW lists two endemic subspecies as Nevada sensitive species (both are outside the county, i.e. Little Fish Lake Valley and Big Smoky Valley). These subspecies were described in early accounts, often with few or even single observations (Hall 1932, Hall and Davis 1935), and have undergone frequent taxonomic revision (Jones and Baxter 2004). The subspecies have recently undergone extensive genetic analyses, and have been grouped with a clade (the Pacific Group) spanning from the Central Valley in California extending east across the Mojave through Nevada terminating at the

Colorado River (Alvarez-Castañeda 2010). Thus, the species is likely less prone to local impacts that might threaten extirpation of a local subspecies.

Existing Conservation Areas/Management Actions

Botta's Pocket Gopher is a Species of Conservation Priority in the Nevada Wildlife Action Plan due to varieties of Pocket Gopher that occur in central Nevada, and not within Clark County (Wildlife Action Plan Team 2012). Recommended conservation actions are to conduct research to update distribution, genetic analysis, and population viability analyses. This species is not covered by the Clark County MSHCP.

Summary of Direct Impacts

Pocket Gophers appear to be mostly widespread such that direct impacts do not apparently pose a threat to populations in rural areas. Heavily urbanized areas may become depleted of gophers, however, parklands within those areas, such as Sunset Park in Henderson, NV have robust populations of Pocket Gophers.

Pocket Gophers may be prone to population fragmentation because they are reticent to leave the cover of their burrows to cross impermeable ground such as highways. However, gophers have evolved with close ties to soil conditions, so fragmentation is not new to them.

Pocket Gophers are considered a pest in agricultural areas and measure for control such as trapping and rodenticide are used in those areas. Rodenticides may contribute to non-target killing of mesopredators such as kit fox (*Vulpes macrotis*) and apex predators such as Golden Eagles (*Aquila chrysaetos*).

Projected impacts to habitat are 108 km^2 of high suitability habitat and 831 km^2 of moderate habitat, while 338 km^2 and 2271 km^2 are likely to be conserved (Table 163). Relative to the total predicted habitat for this species within the county, this represents 10% of High quality habitat that is already disturbed, or expected to be impacted in the near future (Table 163).

Table 163 . Categorized modeled habitat values (High, Medium, and Low) and the average area (Hectares) predicted in the potential impact areas, conservation areas, already disturbed areas, and overall area

Habitat Level	Impact	Conserved	Disturbed	Area (Hectares)
High	10868	33755	5122	152683
Med	83099	227143	28616	974095
Low	28332	251319	6193	845679

TOBE - Bendire's Thrasher (Toxostoma bendirei)

Bendire's Thrashers are medium-sized and long-tailed desert songbirds in the Mimidae family or "mimic Thrashers". Thrashers typically perch on vegetation to sing, and when disturbed drop to ground level to fly or run away from their pursuer. Thrashers can be difficult to survey for because of their wariness (Fisher 1903). The uncertainty of detections can increase false negatives during presence surveys, thus increasing the error in distribution and density surveys. While they are perfectly capable of robust song, the Bendire's Thrasher may be less vocal that other desert Thrashers (Brown 1901); however, they may be attracted by recordings of their vocalizations and those of other Thrashers (Fletcher 2009).

Bendire's Thrasher nests have been found in shrubs (e.g. *Lycium* spp.), cactus (e.g., cholla - *Cylindropuntia* spp.), desert trees (e.g. *Acacia greggii*, *Prosopis* spp.), and tree yuccas (*Yucca brevifolia* and *Y. schidigera* – Gullion et al. 1959), or mistletoe (*Phoradendron* sp.) (Brown 1901, Gilman 1909). Nests are typically placed about 1 meter above the ground, but may be placed as low as 0.15 m, or as high as 6 m above the surface. Bendire's Thrasher nests resemble other Thrasher nests. The rough outside includes many interwoven twigs (less than 1 centimeter), and the interior is lined with grasses, feathers, horse hair, and other fine threaded materials including materials from human habitations such as twine (Gilman 1909). The Bendire's Thrasher nest differs from others in that they use finer outer twigs and they are woven more tightly together for a more compact cupped shape. There are usually three eggs in the nest, sometimes four, and very rarely five. The ground coloration of the eggs ranges from clay to light green with fine specks or blotches of darker colors in highly variable patterns.

Species Status

No federal or state listing petitions have been filed for the Bendire's Thrasher, although it is a USFWS "Species of Concern", and also listed so by California Fish and Game (Shuford and Gardali 2008), a Species of Conservation Priority in Nevada (GBBO 2010, Nevada Action Plan Team 2012), and Arizona (AZGFD 2012). This species is thought to be rapidly declining as a result of negative impacts from urban and agricultural expansion (BirdLife International 2012).

Bendire's Thrashers are among a small number of North American bird species whose conservation concerns may have 'fallen through the cracks.' They are a species of global conservation concern by a number of authorities on this topic (Wells et al. 2010, BirdLife International 2012). Yet they are not listed at the federal level under the Endangered Species Act (ESA), and only special consideration in three of the six states they occupy.

US Fish and Wildlife Service Endangered Species Act: No Status
Migratory Bird Treaty Act: Protected
US Bureau of Land Management (Nevada): Sensitive
US Forest Service (Region 4): No Status
State of Nevada: Protected
NV Natural Heritage Program: Global Rank G4G5, State Rank S1
NV Wildlife Action Plan: Species of Conservation Priority
IUCN Red List (v 3.1): Vulnerable
CITES: No Status

Range

Bendire's Thrashers are resident in southern Utah and Colorado, western New Mexico, the northern half of Arizona, southern Nevada, and the eastern Mojave Desert of California. Scattered vagrants have been observed mostly in southern California, but also across the western US Bendire's Thrashers are migratory and spend part of the year in southern Arizona and Sonora, Mexico (Sibley 2000). In Nevada, the Thrasher is known from Lincoln (Austin and Bradley 1965), Nye and Clark counties, with most observations in southern Clark County in upland mixed Mojave Desert scrub habitat (GBBO 2010), and adjacent to this area in California in San Bernardino County (Shuford and Gardali 2008).

Bendire's Thrashers appear to occupy somewhat contiguous habitat in parts of Arizona's Sonoran Desert, but in the Mojave Desert, Colorado Desert, Colorado Plateau, and Chihuahuan Desert they occupy many small and scattered populations, which contributes to the concern for the species. Concern for the species stems from the risk of inbreeding or local extinctions for small, isolated populations (England and Laudenslayer, Jr. 1995). However, one source noted that the breeding range of Bendire's Thrasher is thought to have increased in Arizona and New Mexico during the period between 1890 and 1990 (Brown and Davis 1996). This is hard to imagine in the face of the declining population trend data that are available (please see Trends section of this document), and their rarity may be due in part to lack of survey effort (Shuford and Gardali 2008). However, yet another source used a habitat suitability model to project Bendire's Thrasher ranges into the future, and predicted that their ranges would increase substantially during the next 50 years into southeastern New Mexico (Menke and Bushway 2015).

Population Trends

Based on analyses of the most comprehensive data source that is available for population trends of North American birds, the mimic thrushes (Curve-billed Thrasher, Le Conte's Thrasher, and Bendire's Thrasher) are all significantly declining across their ranges (Sauer 2013). The Bendire's Thrasher, in particular, is declining precipitously in New Mexico since at least 1970 (Menke and Bushway 2015), and is thought to be declining rapidly throughout its range (BirdLife International 2012), but see Shuford and Gardali (2008). The species is thought to have a low population size (i.e. probably not historically very numerous) and is more vulnerable to habitat degradation (Wildlife Action Plan Team 2012). Also, GBBO (2010) notes Nevada's population may be less than 50 birds, compared to California's population of less than 400 birds (England and Laudenslayer 1993).

Habitat Model Review

Densities of Bendire's Thrashers were modeled by the GBBO and reported in Developing Habitat Models and Monitoring Techniques for Nine Bird Species of Clark County submitted to the DCP in 2013 under project number 2005-GBBO-581-P.

Technical Considerations – GBBO modeled Bendire's Thrashers by using point count surveys at two scales (Clark County – Figure 264, and the Mojave desert of southern Nevada) using models generated from cover associations collected at point count sampling sites. Dominant vegetation was assessed at each sampling site within 100 meters of the survey point, which was then mapped to its corresponding vegetation type for each of 2 vegetation layers used for modeling at two scales. 1) The Clark County specific vegetation layer by Heaton et al. (2011), and 2) a LandFire classification for the state that was used to model projections within the Mojave desert in Nevada by Provencher and Anderson (2011).

Statistical models of densities (Figure 265) for this species were conducted to calculate densities per vegetation stratum (e.g. Joshua tree woodlands, Mesquite-catclaw), however all density estimates overlapped with 0, and thus the precision of the resulting model should be considered with this in mind. Specific outputs/methods for the statistical models were not provided, although the confidence limits for the per stratum density estimates are provided in table 20 of the report (GBBO 2013). Resolution of the models is limited to the size of the polygons containing vegetation projections, thus there are only 5 habitat classes for the Clark County model, which cover broad areas without finer resolution.

Localities used for modeling (Figure 264) are largely located in the southern 1/3 of Clark County, while there is evidence that they may occur more broadly, they are thought to be rare in more northern habitats. A thorough random sampling schema was presented in the report, which would also support other types of statistical modeling (e.g. probability of occurrence, occupancy, etc.) that could provide other insights into the presence of this species in the county, and allow modeling at finer resolutions.

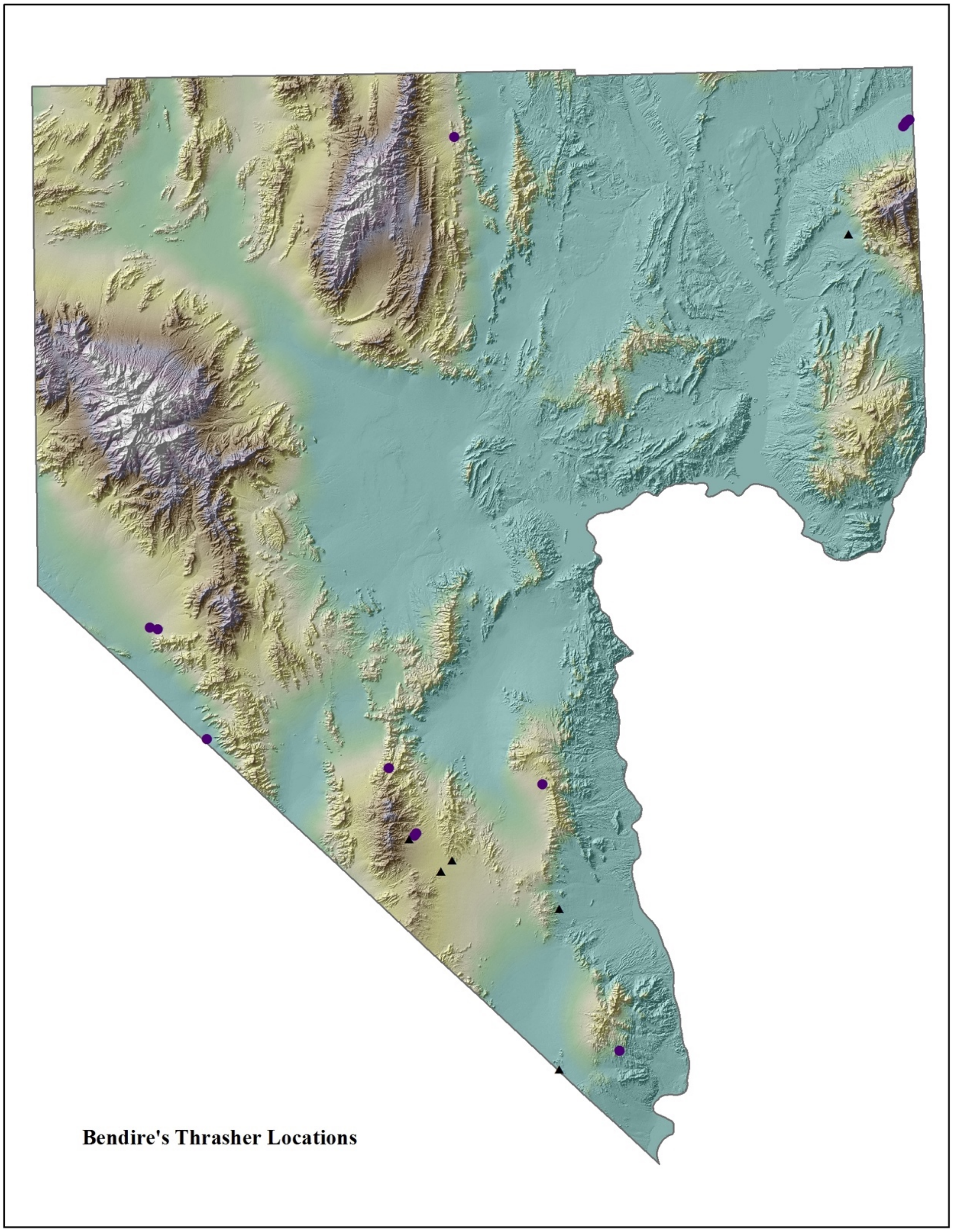

Figure 264. Bendire's Thrasher locations within Clark County. Circles indicate records at Nevada Bird Count transect points (2003-2013); triangles indicate Breeding Bird Atlas records (1998-2000).

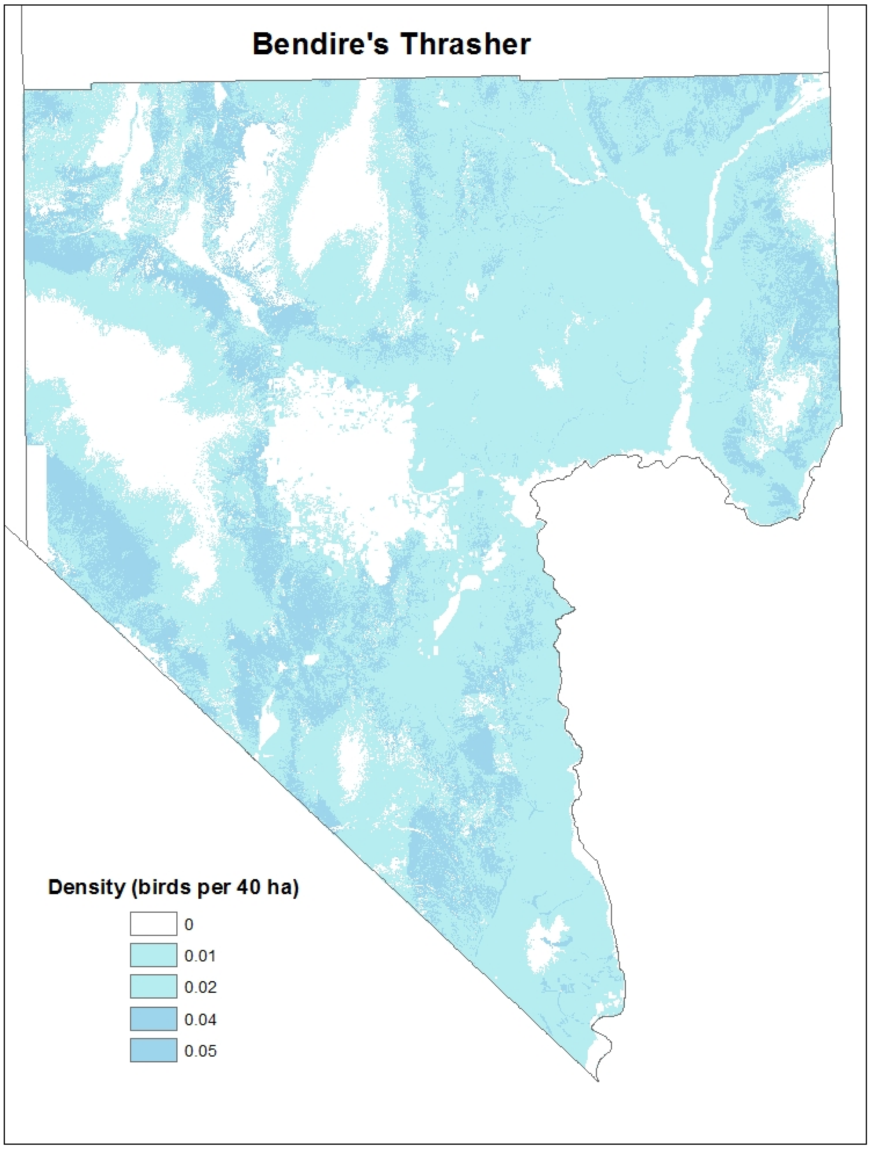

Figure 265. Clark County Habitat model projection for Bendire’s Thrasher. Units are densities of birds per 40 ha. - from GBBO 2013 Report.

Distribution and Habitat Use within Clark County

GBBO (2013) report that Bendire’s Thrashers were sparsely distributed and associated with stands of *Yucca* and *Cholla* indicative of Upland Mixed Mojave desert scrub habitats, and is likely restricted to those habitats. Modeled habitat for this species (Jaeger et al. 2010) included estimated high suitability habitat within the Mojave Desert Scrub, and Blackbrush ecosystems, with some habitat within Mesquite Acacia ecosystems (Table 164). Moderate habitat was similarly distributed.

Major habitat variables considered to be important to Bendire’s Thrashers in New Mexico and their respective contributions to the final models (%) were: Average

Annual Precipitation (36.5%), Average Annual Maximum Temperature (21.8%), Vegetation Type (18.4%), Elevation (10.6%). Minor habitat model components included: Average Annual Minimum Temperature (4.2%), Average Spring Minimum Temperature (2.8%), Topographic Position (2.8%), Slope (1.6%), Canopy Height (0.7%), and Canopy Height (0.5 %) (Menke and Bushway 2015).

The elevational range of locations where Bendire's Thrashers have been documented from 0 to 1800 m in Utah (Birdlife International 2012). However, at least one individual was observed as high as 2560 m (8400') in Clark Canyon in the Spring Mountains, of Clark County, NV. That juvenile bird was collected (killed for a scientific specimen) in a fir-pine forest with shrubby undergrowth. It was presumed that the bird may have wandered from its usual habitat type because it was young and inexperienced (Austin and Bradley 1965).

Table 164. Ecosystems within Clark County, and the area (Ha) of Low Medium and High predicted suitability within each ecosystem.

Ecosystem	Low	Medium	High
Alpine	124	0	0
Blackbrush	361300	45575	4480
Bristlecone Pine	7565	0	0
Desert Riparian	8968	288	72
Mesquite Acacia	12678	3390	543
Mixed Conifer	26768	0	0
Mojave Desert Scrub	1109785	100302	13993
Pinyon Juniper	114054	1134	24
Sagebrush	4118	474	6
Salt Desert Scrub	75174	841	12

Ecosystem Level Threats

It can be inferred from publications about the plants that Bendire's Thrashers nest in that they inhabit a range of ecosystem types native to Clark County, NV including: Blackbrush (e.g. in association with yuccas, Desert Riparian, Mesquite/Acacia, Mojave Desert Scrub, and Salt Desert Scrub (Brown 1901, Gilman 1909, Gullion et al. 1959). Disturbances to these habitats due to increasing wildland fire, or development are likely to result in the continued decline of this species.

Threats to Species

The first step to understanding the role potential threats play in regard to populations of native species involves understanding population trends. In other states, the status of species has been analyzed using the Breeding Bird Survey data. Trends in Clark

County are unknown, however the apparent restriction to mixed Mojave Desert scrub habitats and the conceptual model of threats found in the GBBO report (2013) can serve to provide a starting point for conservation planning regarding this species. Like all other species they are sensitive to destruction and degradation of their habitat, and because the nests are built relatively low in vegetation (e.g. often approximately 1meter above the ground surface – Brown 1901). Predators (esp. coyote and fox) that are subsidized from suburban and urban areas with food (e.g. from garbage, gardens, and abundant small animals), and water (golf courses, and overwatering) are capable of accessing the nests, and this may expand the influence of urban areas as has been documented for other species (Esque et al. 2010).

Wildfire has been increasing in the northeastern Mojave Desert as a result of increased fuels provided by invasive species (D'Antonia and Vitousek 1992, Brooks and Esque 2002). Fire and habitat loss are known to negatively affect bird populations (Bock and Block 2005) by destroying and degrading habitat and removing vegetation required for nesting. Bendire's Thrashers (along with many other desert dwelling species) were shown to respond positively to restoration of desert habitats (e.g. cessation of over-grazing, addition of water spreading features– Monson 1941).

Existing Conservation Areas/Management Actions

Bendire's Thrasher is protected at the federal and state level by the Migratory Bird Treaty Act, and is considered a Species of Conservation Priority by the Nevada Wildlife Action Plan (Wildlife Action Plan Team 2012). This plan establishes a strategic vision for wildlife conservation in Nevada at the landscape level, and identifies the species of greatest conservation need. Plan objectives for Bendire's Thrasher are to stabilize declining population trends and distribution. Recommended conservation actions for this species are as follows: conduct research investigating distribution, population demography, and ecology; establish targeted point count transects to supplement the Nevada Bird Count's ability to detect and monitor this species; develop predictive models and inventory occupied habitat for the purpose of developing reliable population estimates; habitat use, and restore and maintain associated habitats occupied by the Bendire's Thrasher (Wildlife Action Plan Team 2012).

The Nevada Comprehensive Bird Conservation Plan designates Bendire's Thrasher a Conservation Priority species. Population declines, significant threats, dependence on restricted or threatened habitats, or small population size can all contribute to this designation (GBBO 2010). This plan's recommendations include: protecting occupied habitat from habitat conversion, energy development, and fire; monitoring and possibly limiting off-highway vehicle use in occupied habitat; controlling invasive weeds to reduce fire risk; inventorying and mapping important habitat; developing an improved method for monitoring this species; and conducting studies to better estimate minimum patch size, home range, landscape mosaic use, vagrancy, and response to edge effects (GBBO 2010).

Partners in Flight's (PIF) North American Landbird Conservation Plan identified Bendire's Thrasher as a Species of Continental Importance for the US and Canada, further designating it as a Watch List species with restricted distribution or low population size (Rich et al 2004). At the state level, PIF identified Bendire's Thrasher as a priority species, and set an objective of doubling the Nevada population from 1,000 individuals to 2,000 individuals (Rosenberg 2004). In order to meet continental population objectives, statewide population targets were set at 2,046 individuals (Rosenberg 2004).

Summary of Direct Impacts

Approximately 193 km^2 of high suitability and 1525 km^2 of moderate suitability are located within Clark county as estimated by Jaeger et al. (2010). Most of this habitat is located within conserved areas (65 and 42% respectively), and very little is either disturbed (7% high and moderate combined) or likely to be impacted (3% high and moderate combined; Table 165).

Table 165. Categorized modeled habitat values (High, Medium, and Low) and the average area (Hectares) predicted in the potential impact areas, conservation areas, already disturbed areas, and overall area.

Habitat Level	Impact	Conserved	Disturbed	Area (Hectares)
High	190	12582	802	19330
Med	3695	63915	5775	152531
Low	99735	407138	60987	1737642

TOLE - Le Conte's Thrasher (Toxostoma lecontei)

Le Conte's Thrasher (*Toxostoma lecontei*) is among four species of desert Thrashers found in Clark County, Nevada; including: Bendire's (*T. bendirei*); Crissal (*T. crissale*); and Sage Thrashers (*Oreoscoptes montanus*). All of these Thrashers are roughly the same size and color – drab shades of brown to grey. They are also similar in size to the more frequently observed Mockingbird (*Mimus polyglottos*) which is abundant in urban areas of southern Nevada. Le Conte's Thrasher is generally grey and is the palest Thrasher except for the dark tail and pale buffy under-tail coverts (Sibley 2003). In good light, this Thrasher has dark red-brown eyes (Fisher 1893), and this characteristic distinguishes it from the other Thrasher species whose eyes are yellowish. The call of this secretive bird "resembles closely the whistle a man employs on calling a dog, short, and with rising inflection at the end" (Gilman 1904). The song is heard much less frequently than the call and is recognized as distinctive and melodious, and similar to the mockingbird but of higher pitch and richer (Gilman 1904). Although they are shy, a playback tape of the birds' song is said to elicit a call from the birds in any time of year (Sheppard 1970). It was noted that in many places throughout the Le Conte's Thrasher's range, the young, nearly ready to fledge, were captured by Native Americans and Anglos for the purpose of making them cage-birds to enjoy their song (Fisher 1893). At the Nevada National Security Site in Nye County, NV nesting was observed to occur in the middle of shrubs ~40 cm above the ground, almost exclusively in *Lycium andersonii*, or *L. pallidum.* At other sites, Le Conte's Thrashers nest in *Opuntia ramosissima*, *O. echinocarpa*, and *Atriplex* *polycarpa* (Dawson 1923, Jongsomjit et al. 2012). In Rock Valley, NV, Le Conte's Thrashers attempted two to three nests per breeding season, with one pair laying four clutches in the spring of 1973, following a wet winter (Hill 1980). Mean clutch size was 3.3 to 3.8 eggs/clutch, and was higher in a wetter year (Hill 1980). Le Conte's Thrashers are shy birds that prefer running away from intruders to flying (Fisher 1893).

Species Status

US Fish and Wildlife Service Endangered Species Act: Not listed, no petitions for listing.

US Bureau of Land Management (Nevada): No status
US Forest Service (Region 4): No status
State of Nevada (NAC 503): Protected
NV Natural Heritage Program: Global Rank G4 State Rank S2
NV Wildlife Action Plan: SOCP
IUCN Red List (v 3.1): Least Concern
CITES: No status

Range

Le Conte's Thrashers are a hot desert species. In the United States they inhabit the San Joaquin Valley, Colorado and Mojave deserts of California, extreme southern Nevada, western Arizona, and extreme southwestern Utah (Fisher 1893, Dawson 1923, Sibley 2003). In Nevada, Le Conte's Thrashers occur in Clark, Nye, Esmeralda, and Lincoln counties (Hayward et al. 1963, Sheppard 1996, Fletcher 2009, GBBO 2013). In Mexico they occur in Sonora, Baja Norte, and Baja Sur (Sheppard 1970, Riddle et al. 2000). They are permanent residents throughout their range (Sheppard 1970).

Population Trends

Le Conte's Thrashers respond to variability in precipitation by increasing nesting and production in wetter years with higher primary and secondary production (Gilman 1904). At Rock Valley, NV – on DOE's Nevada National Security Site (formerly Nuclear Test Site) – Le Conte's Thrasher had breeding densities of 3/100 ha, which stayed constant among years (Hill 1980). They were regular breeders in that habitat, and were found there year round in desert habitat, but not on the higher mesas (Hayward et al. 1963). At other locations throughout their range they are estimated to be found in densities of zero to five per square mile, and near Maricopa, California there were 10 pairs / square mile (Sheppard 1970).

The Death Valley Expedition (Fisher 1893) reported that Le Conte's Thrashers were "common at [nearby] Ash Meadows", and they collected specimens in the "Pahrump and Vegas valleys". This species was also said to be "tolerably common" in the Virgin and Muddy river valleys, and a nest was seen on the Mormon Mesa (Fisher 1893). Gilman (1904), however, noted that the birds are never abundant or even fairly common and found few at most locations, though he reported having seen as many as six pairs in one day at one site and six nests in one day at another site.

The Nevada Wildlife Action Plan estimates there are 100 individuals in the Nevada population, and states that the trend is inconclusive (Wildlife Action Plan Team 2012). While quantitative time-trend data are not available for this species in Clark County, large-scale habitat disturbances such as those in the Eldorado, Indian Springs, and Ivanpah valleys may have reduced populations in those key areas.

Habitat Model Review

There are three existing models for the Leconte's Thrasher that cover Clark County that were provided for review. From GBBO (2013), Fletcher (2009), and Jaeger et al.

GBBO

GBBO conducted 316 -10 minute point count transects, with 10 points on each transect throughout Clark County, Nevada. 1045 individual visits were conducted between 2008 and 2013. Presence was recorded for nine focal bird species. Thirty-five additional sites (transects) were added in 2012. For each transect the density was calculated by calculating detection rate over the area surveyed by species. Only four Le Conte's Thrashers were detected among these sites.

Fine scale logistic models were conducted to determine specific habitat preferences (within sites). However, this type of modeling is not applicable to broader scale modeling as the level of detail used in the local analysis (e.g. density of specific plant species at given heights per given site and proportional community composition of key plant species) is not available in landscape scale GIS coverages for the county.

For most birds, densities were estimated per 6 vegetative strata within Clark County, however because LC Thrasher detections were low they were pooled with Crissal Thrasher observations as these species had similar detectability. However, it should be noted that they typically occupy different habitat with some overlap (see Jaeger et al.) and detection was only estimated across all strata, but then parsed to create estimates in "appropriate habitats". The use of “appropriate habitats” relegates this modeling effort to expert opinion models. Density estimates were produced from the point counts for 2012 and 2013 for these habitat types and extrapolated across the different vegetation types and years to provide a “10-year estimate”. Habitat was predicted by mapping these densities across the vegetation strata produced in the Heaton et al. (2011) vegetation model for the county, and a second map was produced using the LandFire vegetation classifications (Provencher and Anderson 2011).

Fletcher 2009

Fletcher evaluated the distribution and habitat selection of both Crissal and Le Conte's Thrashers in Clark County. Auditory surveys were conducted using bird broadcast recordings of bird calls to enhance detections. Stratified random surveys were sampled at 432 sites. There were detections at 45 sites for Le Conte's and 41 sites for Crissal Thrashers. Site specific vegetation models were conducted for local habitat preference evaluation and logistic regressions were also used to provide a broader predictive distribution map using topographic variables (e.g. elevation, slope, latitude, longitude) and bioclimatic variables (e.g. potentially limiting temperatures and seasonal precipitation) in a Principle Components Analysis. Where presence of the birds was detected vegetation type was included (e.g. saltbush, wash vegetation, cholla, and Mojave mixed scrub). Road and Wash density were also included. The final model was a result of an AIC model averaged computation of the highest competing models (N = 27), none of which stood out as a better performing model by the AIC criterion. The highest contributing variables among the models were Landform, Plant Assemblage, Wash Presence and Number of Roads (which was likely confounded with the lower elevation sites, and not a result of habitat selection).

Jaeger et al. 2010

Jaeger et al. 2010 modeled habitat for nine bird species in Clark County in a collaborative effort with UNLV, NPS and USGS. For the Le Conte's Thrasher the data built upon the modeling efforts of Fletcher 2009 by expanding the number of occurrences to draw from 11 additional sources expanding the previously used 41 presence observations to 136. Models were conducted using the MaxEnt species modeling algorithm (Phillips et al 2006), which is a widely used method specifically for Species Distribution Modeling. Potential environmental variables for modeling were derived from conceptual habitat models using input layers from among 27 developed for the nine species modeled. Habitat variables selected in the final model for this species included 11 environmental variables, including information on Temperature, Vegetation Type, Landform and Topographic feature. The strongest contributing variables toward habitat prediction were Winter Days Below Freezing, Slope, and the presence of Mesquite-Catclaw, where LeConte's Thrashers were negatively associated with higher numbers on winter days below freezing, and higher slopes, and were positively associated with areas containing Mesquite/Catclaw vegetation. The models are presented as continuous outputs predicting the probability of presence at a 250 m scale. This output is in a format that lends itself easily toward the analysis of potential impacts of future development within the county, and is the best suited among the three reviewed here for this purpose.

Distribution and Habitat Use within Clark County

Le Conte’s Thrashers are found in open shrublands with sparse shrubs and seasonally little to no annual vegetation. Surface litter accumulations around the shrubs are important where they acquire invertebrates such as scorpions, beetles, grasshoppers, spiders, Lepidoptera, many larvae, and small lizards (e.g. *Uta stansburiana*, Sheppard 1970). Habitats are relatively flat with slope generally < 4 degrees throughout Clark County, NV (Sheppard 1970, Fletcher 2009). Soils in areas where the bird is found are silty or sandy and often alkaline. Areas inhabited by these shy Thrashers include saltbush (*Atriplex polycarpa*, and *A. canescens*), cholla (*Opuntia echinocarpa, O. ramosissima*), Mojave mixed-shrub communities, and wash vegetation including mesquite (*Prosopis* spp.), smoketree (*Psorathamnus spinescens*), and catclaw acacia (*Acacia greggii*) (Dawson 1923, Fletcher 2009). The association with *Prosopis*/*Acacia* vegetation was the strongest, with moderate association to Saltbush Playa (Jaeger et al. 2010). A weaker association was found with *Yucca brevifolia* and Mojave Mixed Scrub associations, however, mixed shrub encompasses many species that vary spatially and therefore the accuracy of this association in some cases is questionable (Jaeger et al. 2010). Le Conte’s Thrashers show a strong positive response to the presence of wash habitat and this may be due to the increased presence of large thorny tree, shrub and cactus species that provide both protection from predators, and ameliorate harsh desert conditions for young birds in the nest (Johnston and Ratti 2002, Fletcher 2009). Nest sites are usually between 1 to 2 m above the ground surface. Blackbrush and pinyon/juniper communities were found to have a negative relationship for the presence of Le Conte's Thrashers (Fletcher 2009). Both of those vegetation types are correlated with mountain slopes or hillslopes of > 4%, and steep hillslopes were also negatively associated with this Thrasher. Zonal analysis of the habitat model with the Clark County ecosystems developed by Heaton et al. 2011 indicated that most of the highest suitability habitat for this species is located in Mojave Desert Scrub, Mesquite Acacia, and Salt Desert Scrub ecosystems. Moderate habitat also followed this pattern, with an increase in the Blackbrush ecosystem as well (Table 166).

Valleys throughout Clark County were surveyed at 432 random sites for presence of Le Conte's Thrashers between 2005 and 2007, and positive detections were made at 41 of the random survey locations with 24 additional non-random incidental sites (Fletcher 2009). An occupied nest was observed on Mormon Mesa, but the Thrashers were not detected on Mormon Mesa during recent surveys (Fisher 1893, Fletcher 2009). While survey sites were extensive during the 2009 surveys, the Las Vegas Valley was not surveyed, and the Nevada National Security Site (most of which is in Nye County) was not surveyed. The largest contiguous area where Le Conte's Thrashers were not detected was most of Gold Butte and the Virgin River Valley. This is in contrast to observations during the late 1800's when LeConte's Thrashers were observed in the Virgin River Valley (Fisher 1893), although other surveys and a habitat model for this species in Gold Butte reported no sightings, and limited suitable habitat (Nussear et al. 2011),

A predictive model of habitat indicated widespread areas of moderate suitability in all low valley bottom areas of Clark County Nevada (Fletcher 2009). The models predicted 3998 km^2 of high to very high potential habitat suitability. However, these areas are disjunct and rare, and they are mostly confined to western Clark county. High quality habitat suitability areas occur in Nevada on the western border with California in the Pahrump and Sandy valleys, Ivanpah Valley, south of Jean Dry Lake, the valley south of Sloan Canyon, the northwestern bajada of Eldorado Valley, the vicinity of Corn Creek, and several highly suitable habitat patches near Indian Springs (Fletcher 2009). There were several small patches of highly suitable predicted habitat in the Muddy Mountains of Lake Mead National Recreation Area, along the Muddy River, on Mormon Mesa, and a few patches between Devil's Kitchen and St. Thomas Gap in Gold Butte. However, the highly suitable habitat that was modeled in eastern Clark County did not coincide with any observations of Le Conte's Thrashers.

Table 166. Ecosystems within Clark County, and the area (Ha) of Low Medium and High predicted suitability within each ecosystem.

Ecosystem	Low	Medium	High
Alpine	124	0	0
Blackbrush	398941	12285	129
Bristlecone Pine	7565	0	0
Desert Riparian	7188	1930	209
Mesquite Acacia	7875	6334	2401
Mixed Conifer	26768	0	0
Mojave Desert Scrub	1053180	159055	11845
Pinyon Juniper	115208	4	0
Sagebrush	4598	0	0
Salt Desert Scrub	69911	4200	1917

Ecosystem Level Threats

The Le Conte's Thrashers inhabit Desert Riparian, Mesquite/Acacia, Mojave Desert Scrub, Salt Bush Scrub, and Dry Lake Beds/Playa habitats (Fisher 1893, Dawson 1923, Fletcher 2009). Ecosystem level threats for this species are similar across the species' range in hot desert habitats. This includes any type of surface disturbance that destroys desert vegetation thus modifying or reducing cover, foraging sites, and nesting areas. Such disturbances include industrial or urban development, military training, and off-highway vehicle use – particularly that occurring along desert washes. Wildfire or prescribed fire, fueled by invasive non-native annual plants can also be detrimental to Le Conte's Thrashers (Germano et al. 2001).

Threats to Species

The greatest current threats to Le Conte's Thrasher habitat are land disposals for construction projects. Planned land disposals by BLM are documented on the largest single habitat patch of the highest predicted quality in Ivanpah Valley. Many of the other large areas of predicted highly suitable habitat are within or adjacent to other disposal areas including parts of Sandy Valley, Jean Dry Lake, and the upper Muddy River drainage. Large portions of the only large predicted habitat in Eldorado Valley are already covered by solar energy development.

Le Conte's Thrasher habitats are particularly vulnerable to solar energy farms because the Thrashers and the farms both require the flattest landscape available. Therefore, Le Conte's the highest quality Thrasher habitat and the most sought after solar development areas overlap nearly 100%.

Existing Conservation Areas/Management Actions

Most of the modeled habitat of high habitat suitability does not occur within protected areas. The Le Conte's Thrasher is not protected by the ESA, and therefore are no lands set aside specifically for them (Fletcher 2009). However, other low desert valley areas that are protected for a variety of other reasons can also be considered beneficial for a great deal of habitat that modeling indicated was of moderate quality.

Le Conte's Thrasher habitats are afforded some protections on lands administered by the National Park Service, US Bureau of Land Management, US Fish and Wildlife Service, and US National Forest. Specific parcels include Lake Mead National Recreation Area, Gold Butte National Monument, Desert National Wildlife Refuge, Red Rock National Conservation Area, the Weethump Wilderness and others, Toiyabe National Forest, and several Areas of Critical Environmental Concern throughout Clark County. Habitat restoration activities are currently widespread on public lands in Clark County including the reduction of invasive species that promote fire. Habitat restoration in low valley habitats is likely to be beneficial to Le Conte's Thrashers.

Le Conte's Thrasher is considered a Species of Conservation Priority by the Nevada Wildlife Action Plan (Wildlife Action Plan Team 2012). Conservation challenges listed by the plan include: sensitivity to habitat fragmentation, degradation, or conversion from disturbances such as urban/agricultural/industrial development, heavy OHV use, fire, and energy development; extended late-summer livestock grazing; and invasive plants. The plan recommends: protecting occupied habitat at the recommended patch size; maintaining corridors of suitable habitat between occupied areas; and minimizing habitat fragmentation (Wildlife Action Plan Team 2012).

The Nevada Comprehensive Bird Conservation Plan (GBBO 2010) Le Conte's Thrasher a priority species. Conservation strategies recommended by the plan include: inventory and map critical habitat; improve monitoring efforts and generate improved population size and trend estimates; control invasive weeds in and near occupied habitat to reduce fire risk; monitor and (if necessary) limit OHV use in occupied habitat (GBBO 2010).

Summary of Direct Impacts

The direct impacts to Le Conte's Thrashers and their habitats are any activity or process that reduces the availability of vegetation providing cover, foraging areas, and nesting substrate. Such activities include construction activities (especially urbanization, highways, and solar energy capture and distribution infrastructure), military training and infrastructure, and off-highway vehicle activities. The introduction of invasive species and fire also can be detrimental to the habitat of Le Conte's Thrashers. Habitat models produced by Jaeger et al. 2011 resulted in an estimated 2027 km^2 of high and moderate level habitat combined (Table 167), most of which is outside of the areas considered in this planning effort. Relatively little habitat is disturbed to date (~ 24 km^2). An additional 140 km^2 will be potentially impacted by this project, while 884 km^2 of habitat is located within conservation areas, although the majority of this is in the moderate category (Table 167).

Table 167. Categorized modeled habitat values (High, Medium, and Low) and the average area (Hectares) predicted in the potential impact areas, conservation areas, already disturbed areas, and overall area.

Habitat Level	Impact	Conserved	Disturbed	Area (Hectares)
High	1575	6752	79	16681
Med	12483	81620	2371	185974
Low	89566	395503	65094	1706849

VIBE - Arizona Bell's Vireo (Vireo bellii arizonae)

There are four subspecies of Bell's Vireo whose range occurs in North America. Population trends have been declining for this species and the Least Bell's Vireo is recognized as endangered under the Federal Endangered Species Act, as well as the California Endangered Species Act. The *V. arizonae* subspecies occurs in desert riparian areas along the Colorado River drainage and is known to use various types of desert riparian vegetation.

Species Status

US Fish and Wildlife Service Endangered Species Act: Not Listed
US Bureau of Land Management (Nevada): No Status
US Forest Service (Region 4): No Status
State of Nevada (NAC 503): Protected
NV Natural Heritage Program: Global Rank G5T4; State Rank S2B
NV Wildlife Action Plan: Species of Conservation Priority
IUCN Red List (v 3.1): No status for this subspecies, however *Vireo bellii* is listed as Near Threatened
CITES: No status

The Least Bell's Vireo subspecies (*Vireo bellii pusillus*) was listed as an endangered species under the ESA in 1986, but this subspecies is not known to occur in southern Nevada. The Arizona Bell's Vireo subspecies (*Vireo bellii arizonae*) occurs in southern Nevada, but has no federal designation as endangered or threatened, although it is listed as Endangered under the California Endangered Species Act (CDFW 2016). The Bell's Vireo is protected under the Migratory Bird Treaty Act of 1918 as amended (16 USC 703-712).

The IUCN Redlist lists the species as "Near Threatened" due to widespread population declines of approximately 2.7% per year, although subspecies trends are not reported (BirdLife International. 2012). This species is also listed as a Bird of Conservation Concern by the USFWS within the Mojave Desert BCR (USFWS 2008). It is also listed as a covered species under the Lower Colorado River Multi-Species Conservation Program.

Range

The breeding range of the Bell's Vireo occurs throughout central and southwestern US and south through northern Mexico. Breeding habitat generally consists of dense, low, shrubby vegetation, in riparian areas, brushy fields, young second-growth forest or woodland, scrub oak, coastal chaparral, and mesquite brushlands, often near water and in desert washes in arid regions (Hutto 1985, Brown 1993). The winter range of the Bell's Vireo extends from south Baja California along the west coast of Central America, through Mexico, El Salvador, Guatemala, Nicaragua and Honduras (Brown 1993). This species winters in habitat that contains thornscrub vegetation adjacent to watercourses or in riparian gallery forests along the west coast of northern and central Mexico. *V. b. arizonae* occur in Arizona, Utah, Nevada and California along the Colorado River and extends into Sonora Mexico where they winter (Franzreb 1989). They have been observed to use willow (*Salix goodingii)* and honey mesquite (*Prosopis glandulosa*) for nesting, and avoid salt cedar (*Tamarix chinensis*), arrow weed (*Pluchea sericea*) and giant reed (*Phragmites communis,* Serena 1986).

Population Trends

The current population of this species is estimated to be approximately 1,500,000. Bird Life International estimates that this species is declining at an average rate of 2.7 percent per year since 1966 (BirdLife International 2009), although no subspecies trends are identified. The North American Breeding Bird Survey data also indicates a significant survey wide decline that averages 3.2 percent per year (Sauer et al. 2008). Recent Great Basin Bird Observatory (GBBO 2009) data shows Bell's Vireo population declines in most regions, but that trend was not confirmed for Nevada. Some studies have shown recovery trends in this species as a result of the removal of stressors and subsequent vegetation recovery (e.g. grazing removal - Krueper et al. 2003).

Habitat Model Review

We found three models in the provided materials for *Vireo bellii*. Separate habitat models were conducted by EPA, UNLV/NPS, and GBBO.

EPA

The EPA model was first produced in 2004 as a part of the SWReGAP analysis that modeled habitat for many species (Boykin et al. 2008). The habitat methods included reviewing literature to establish habitat associations and plant alliance associations, and then modeling habitat as a series of GIS overlay and intersections of relevant environmental layers. They were then rendered as raster layers at 30 m and 250 m resolutions. As these models were not based on occurrence points, and statistical estimations were not produced this is likely the least useful model for the upcoming covered species assessments.

NPS/UNLV

The NPS/UNLV model (Figure 266) was conducted by researchers the Public Lands Institute, University of Nevada, Las Vegas (UNLV) in Collaboration with USGS, and NPS under a Clark County DCP project (Jaeger et al. 2010). Models were conducted using the MaxEnt Modeling algorithm at a resolution of 250 m for the county. Environmental layers used in this model were identified by first creating a conceptual model for the species. Suitable (and available) GPS layers were then identified to use for creating statistical models in MaxEnt. Developmentally altered lands were removed from the environmental layers prior to modeling. Localities were collected from a variety of sources and 116 localities within the county were identified and determined to be suitable for modeling (Figure 266). Eight environmental variables were retained in the final model including: Mesquite-Riparian, Major Surface Water, Select Riparian Vegetation Index, Washes, Geomorphology, Maximum Summer Temperature, Topography, and Landform. The first two layers were the largest contributors to the model, contributing 50 % and 30 %, respectively. There were strong associations of habitat suitability in relation to each (Jaeger et al. 2010).

Technical Considerations – Specifics of the MaxEnt modeling procedures were not presented in the final report, although these should be available if the original MaxEnt outputs were submitted. The sample size was likely sufficient given the strong riparian association for this species, and the limited extent of riparian habitat within the county. Similarly, performance measures, partial response curves, and error estimations were not presented in the report, and thus the accuracy/precision of the models cannot be evaluated without the original MaxEnt Output.

Bell's Vireo – Habitat Suitability Model

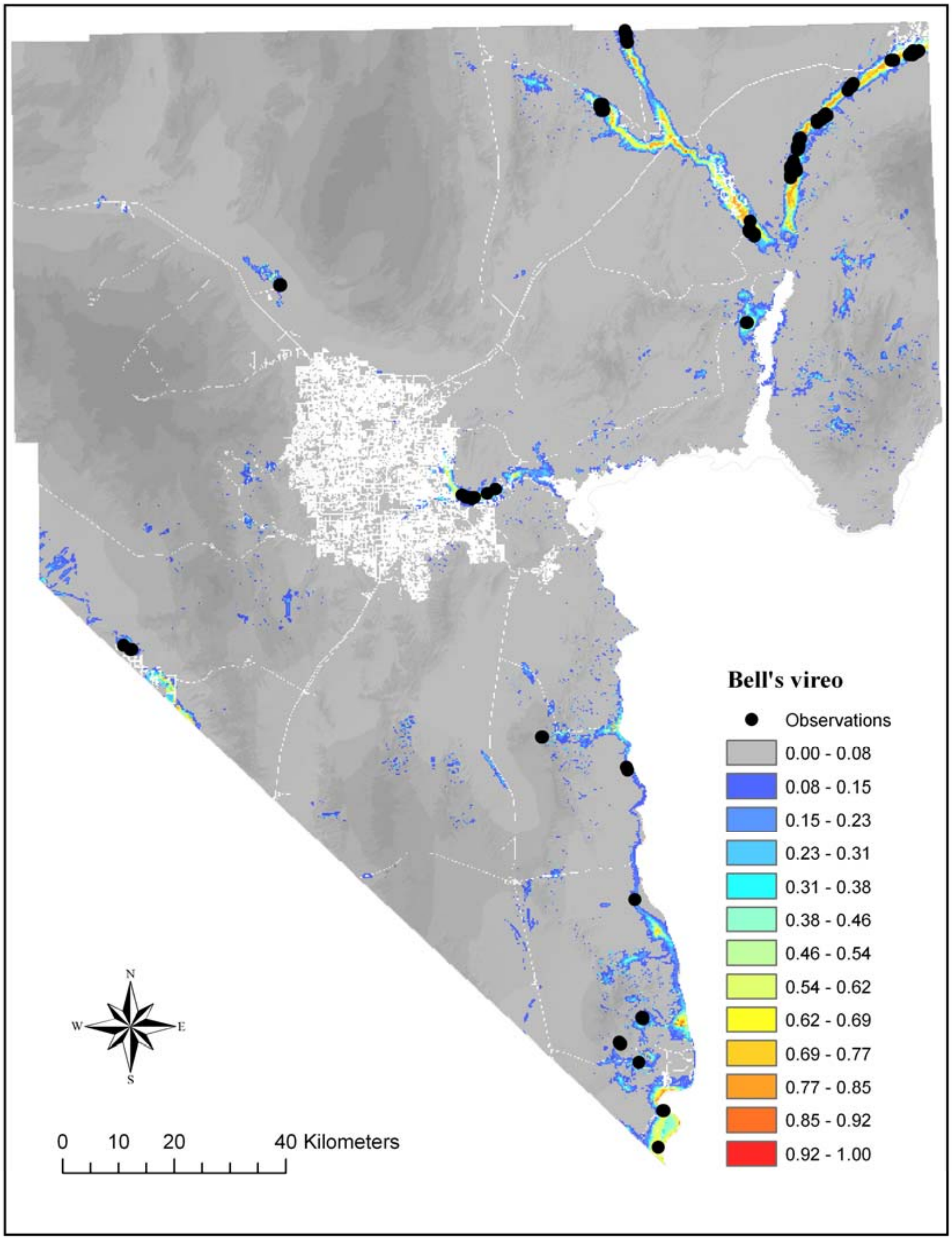

Figure 266. The NPS/UNLV MaxEnt model for Arizona Bell's Vireo produced by Jaeger et al. 2010.

GBBO

The GBBO model (Figure 267) used locality data generated from point-count transects conducted over a six-year period using a random and targeted survey approach and combinations of them (Ammon 2013). Bird detections on the point-count transects were used to create density estimates for each dominant vegetation type. Habitat models were produced by mapping density estimates for each of the vegetation associations throughout the county (Ammon 2013). Conceptual models were created but were not used to develop or select environmental layers, but rather to guide conservation planning efforts. Highest densities were found in desert riparian habitat, with disturbed areas, and Mesquite/Acacia habitat. Logistical ANOVA models were used to model Bell's Vireo densities relative to habitat types, and proximity to water, disturbance, and vegetative structural features, although these models were not used to create county-wide suitability estimates as layers - the analyzed associations do not exist in a GIS. Thus, the statistical model is a good description of the local attributes of habitat preference by the species, but cannot in its current form be used for spatial mapping or modeling. Therefore, spatial model produced by this effort is strictly an extrapolation of the densities per given habitat/vegetation types mapped across these attributes in the county (Figure 267; Ammon 2013).

Technical Considerations – given that the map is created by extrapolation of density estimates to county-wide vegetation classifications, a few considerations are in order. First it cannot be determined if the error rates for the density estimates per habitat type were considered, there were not maps provided to show error estimates for these associations, and thus we do not know if these were considered. Second the extrapolation beyond sampled areas makes the assumption that density associations for habitat types are the same for each of the areas for which extrapolation occurred. While this may be an accurate assumption we note fairly high error on the density estimates for lowland riparian and agricultural habitats provided in Table 7 of Ammon (2013) and these are to our knowledge not accounted for in the extrapolation of habitat for this species.

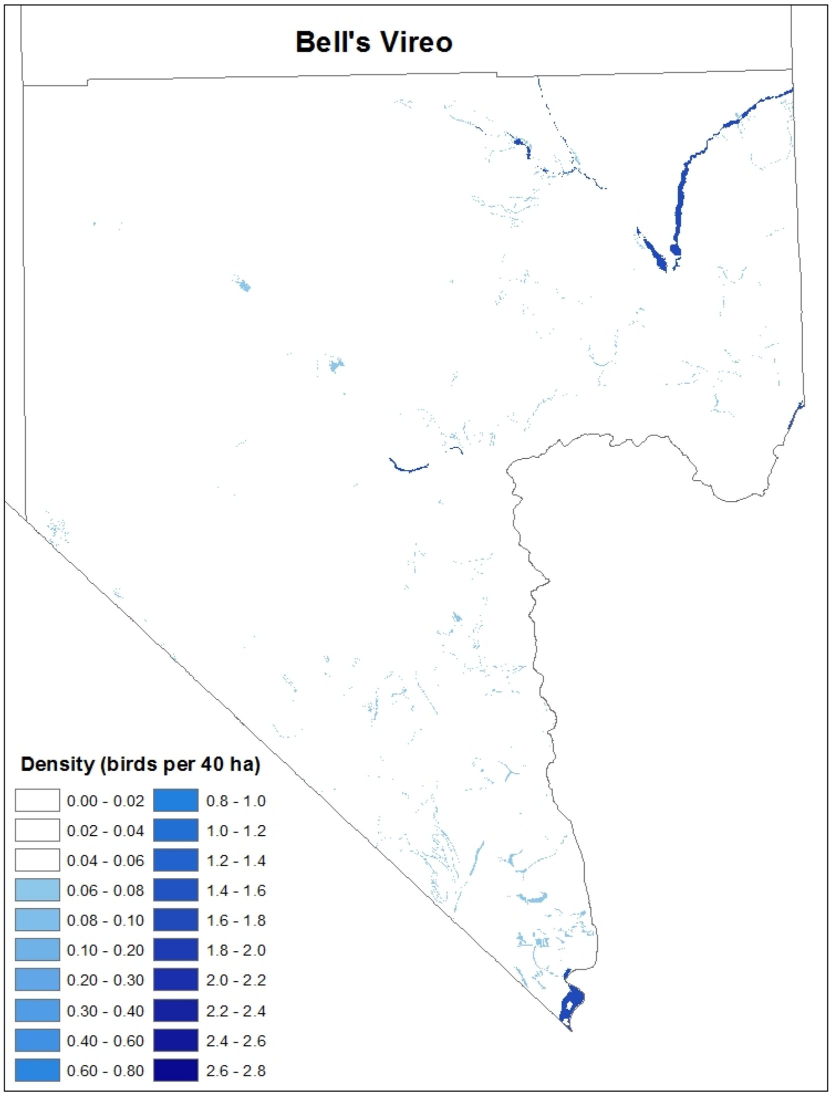

Figure 267. Predicted distribution of Bell's Vireo in Clark County from Ammon 2013.

Distribution and Habitat Use within Clark County

Distribution within Clark County is largely concentrated in the southern tip of the county, but recent surveys confirmed several breeding pairs in northern Clark County along the Virgin River (Floyd et al. 2007). It is a rare resident of Clark County, Nevada and is a declining resident along the Colorado, Virgin, and Muddy Rivers and isolated springs (AZGFD 2002). This species can be found within rivers and streams, mesquite bosques, and desert washes throughout Clark County (Wildlife Action Plan Team 2012). Modeled habitat within Clark County Ecosystems showed the most high suitability habitat in Desert Riparian, adjacent Mojave Desert Scrub and Mesquite Acacia ecosystems. Moderate habitat was also contained within these ecosystems, with an increased – but limited amount of habitat in Salt Desert Scrub ecosystems (Table

168).

Table 168. Ecosystems within Clark County, and the area (Ha) of Low Medium and High predicted suitability within each ecosystem.

Ecosystem	Low	Medium	High
Alpine	124	0	0
Blackbrush	415089	62	0
Bristlecone Pine	7565	0	0
Desert Riparian	1723	4688	4248
Mesquite Acacia	15863	2503	991
Mixed Conifer	27294	0	0
Mojave Desert Scrub	1293734	11312	2533
Pinyon Juniper	115837	0	0
Sagebrush	4700	0	0
Salt Desert Scrub	77928	655	115

Ecosystem Level Threats

Threats to this species' habitat include urban and suburban development on floodplains and riparian habitat, the presence of large areas of tamarisk, and off-road vehicular activity (DeSante and George 1994, Wildlife Action Plan Team 2012). Urban development, water diversion, flood control projects, grazing, and the spread of agriculture have destroyed much of the western nesting habitat (Dudley et al. 2000, Krueper et al. 2003, NatureServe 2009). Tamarisk has been shown to reduce insectivorous birds (and many other guilds, Dudley et al. 2000), and is associated with reduced or complete lack of nesting in this species, which preferred willow thickets, or stands of honey mesquite for nesting (Serena 1986).

Threats to Species

Brood parasitism by brown-headed cowbirds (*Molothrus ater*) is considered a significant threat to some populations of this species and has resulted in reductions in breeding populations in the southwestern US (Serena 1986, Brown 1993, DeSante and George 1994). While nest abandonment was once considered a compensating mechanism, research indicates that this behavior results in lower fitness relative to birds that raise parasitic cowbird chicks (Kus 2002).

Existing Conservation Areas/Management Actions

The Bell's Vireo is protected under the Migratory Bird Treaty Act. In addition, recommended conservation actions specific to this subspecies and subspecies habitat are included in the Nevada Wildlife Action Plan (NWAP)(Wildlife Action Plan Team

2012). The NWAP's recommended conservation actions are: to preserve mesquite bosques through private landowner consultation and responsive development planning for the Bell's Vireo; conserve the habitat that this species occurs in by expanding protected status for riparian habitat that this species occurs in; increasing the linear extent of multi-stored native riparian habitat on floodplains; maintaining this species habitat at its current distribution in stable or increasing condition trend; and sustaining stable or increasing populations of wildlife in key habitats (Wildlife Action Plan Team 2012).

In addition, this subspecies is also covered under the Lower Colorado River Multi-Species Conservation Program. The goal of this program is to conserve habitat of threatened and endangered species and reduce any additional species being listed; accommodate present water diversions and power production; and provide the basis for incidental take authorizations (Lower Colorado River Multi-Species Conservation Program 2004).

The species is also included in the Partners in Flight North American Landbird Conservation Plan (Rich et al. 2004), where it is designated as a Watch List species that warrants immediate action. Additionally, it has recently been included in the Great Basin Bird Observatory six-year inventory and monitoring program on landbirds of Clark County (initiated in 2008), and is on the USFWS list of Birds of Conservation Concern 2008 (USFWS 2008).

Summary of Direct Impacts

This section will be revised with updated analysis of the County Direct impacts layer and species distribution model.

The Bell's Vireo is a locally common breeding bird and summer resident in Clark County. Approximately 280 km^2 acres of modeled habitat (high and moderate categories combined) exists in Clark County (Table 169), although the proportion of this habitat that meets the criteria for nest suitability is estimated to be much less. This species is locally common in the plan area; and covered activities have the potential to affect modeled habitat for the species. The total disturbed High and Moderate habitat for this species is 46 km^2, and an additional 75 km^2 is likely to be impacted by development under this amendment (20% of total). Conservation areas will contain 46 km^2 of habitat (17% of total; Table 169).

Table 169. Categorized modeled habitat values (High, Medium, and Low) and the average area (Hectares) predicted in the potential impact areas, conservation areas, already disturbed areas, and overall area.

Habitat Level	Impact	Conserved	Disturbed	Area (Hectares)
High	2135	2086	1282	8038
Med	5396	2693	3269	19948
Low	112045	479695	60662	1977095

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