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Regional Groups Serving Riverside and San Bernardino Counties: Big Bear, Los Serranos, Mojave, Moreno Valley, Mountains, Santa Margarita, Tahquitz.

June 22, 2009

DOCKET
07-AFC-5
DATE 06/22/09
RECD. 06/21/10

Via Electronic Mail

Tom Hurshman
BLM Project Manager
2465 South Townsend Ave.
Montrose, CO 81401
tom_hurshman@co.blm.gov

Re: Draft Environmental Impact Statement for the Ivanpah Solar Electric Generating System

Dear Mr. Hurshman:

We write to propose a project alternative for incorporation into the BLM's upcoming draft environmental impact statement for the proposed Ivanpah Solar Electric Generating System project ("Project"). We provide this NEPA-based alternative in the spirit of cooperation, and with the goal of achieving timely resolution of the dual-track Project approval processes for the BLM and California Energy Commission so that the project can be under construction by 2010.

We strongly support environmentally responsible renewable energy, including appropriately-sited, large-scale solar development. Specifically, it is the Sierra Club's policy that large-scale, renewable energy be developed, whenever possible, on previously disturbed, preferably privately-held, lands.[1] Unfortunately, the Project as proposed would be built on unspoiled public land presenting significant, unmitigated impacts on the state and federally listed desert tortoise and on sensitive plant communities, some of which are also listed. Concerning desert tortoise, the Energy Commission staff determined:

> The applicant's proposed mitigation, acquisition, and enhancement of approximately 4,065 acres would be insufficient to avoid significant direct, indirect, and cumulative impacts to biological resources of the Ivanpah Valley, and fails to meet the California Department of Fish and Game's full mitigation standard for desert tortoise. Staff also believes this proposed mitigation will be inadequate to compensate for cumulatively significant impacts to other special-status plant and animals inhabiting the project site…"[2]

---

[1] Testimony of Carl A. Zichella, Director of the Sierra Club's Western Renewables Program before the Subcommittee on Energy and Mineral Resources Committee on Natural Resources (May 11, 2009).

[2] Preliminary Staff Assessment at p. 5.2-2.

Many of the Project's negative effects occur because the proposed configuration was mapped out before anyone had conducted meaningful surveys of the site's biological resources and drainage issues. Indeed, the current footprint is situated on the best habitat for wildlife and special-status plant species, while the most disturbed lands, closest to existing development and Interstate 15 would serve as translocation lands for the listed desert tortoise. From a biological perspective, this is an utterly backward use of public land. Similarly, the Project would be built on lands with the most challenging drainage problems while the translocation lands are relatively flat and pose fewer drainage issues. In short, the lower elevation lands near Interstate 15 appear to be much more suitable for large-scale solar development than the current, upslope habitat where more than 20 desert tortoises and other imperiled species reside. The optimum lower elevation alternative in terms of protecting biological resources is the south end of the Ivanpah Dry Lake. If siting the Project on the dry lake is not feasible, we propose the following.

We request that the BLM include an EIS alternative that (1) relocates the Project's three power blocks closer to the areas adjacent to Interstate 15 currently mapped as translocation sites; (2) leaves the desert tortoise undisturbed and designates its habitat at Ivanpah as an area of permanent protection such as that provided by areas of critical environmental concern (ACEC); and (3) retires the Clark Mountain grazing allotment.

1. Biological Basis for the Sierra Club's Alternative

In a May 13, 2009, Energy Commission filing, the Western Watersheds Project presented evidence showing how the areas along Interstate 15, currently proposed as tortoise translocation areas 1 and 2, have historically supported few desert tortoises.[3] In that filing to the Energy Commission, Western Watersheds Project provided survey data from Kristin Berry estimating tortoise density in the Project footprint in the range 50-100 desert tortoises per square-mile; whereas the low lying areas along Interstate 15 supported approximately 20-50 desert tortoises per square-mile or less than half.

It is clear that the lands near Interstate 15 have served as a major sink for tortoises, depleting nearby populations, either as a result of cars colliding with tortoises, predation or possibly due to truck- and automobile-related pollutants in the soil, or all three factors. Translocating the listed tortoise to sites known not to support them simply makes no sense. Even a casual inspection of the Project site and the translocation areas shows that the native plant life at the Project site is much more extensive and varied than at the translocation lands. The areas currently designated as Ivanpah 2 and 3 provide the highest quality tortoise burrowing habitat and food sources. In contrast, due to the dirt road paralleling Interstate 15, and the grazing operations in and around the corral adjacent to the highway, the translocation lands are denuded and contain exotic plants. In short, completely avoiding habitat lands eliminates translocation, thereby, avoiding the Ft. Irwin pattern of desert tortoise mortalities. It is well established that desert tortoise translocation results in very high mortality.

Similarly, there are approximately 2,000 ephemeral washes that occur throughout the project site. The lower elevations adjacent to the highway present far fewer drainage challenges because of the reduced slope. Relocating the three power blocks to the lower elevations would reduce or eliminate drainage issues that arise with heavy rains.

---

[3] Letter to John Kessler, Commission staff project manager from Michael J. Connor, Western Watersheds Project (May 13, 2009) properly filed on or about June 17, 2009.

The Sierra Club's Project alternative stems from a deep concern for the remaining tortoises in the California portion of the Northeastern Mojave Desert Tortoise Recovery Unit. This particular unit is one of six recovery units designated in the U.S. Fish and Wildlife Service's recovery plan.[4] Because the Mojave Desert tortoise is listed as a threatened species under state and federal law, and because the entire California population of this particular unit is found within the Ivanpah area, protecting these individuals must be a high priority for all of the approving agencies, including the BLM. A simple reconfiguration of the Project along with an ACEC designation for the most densely populated portions of Ivanpah Valley would significantly protect this recovery unit, and stands to facilitate timely resolution of Project approval.

2. The BLM Should Consider Analyzing the Designate Portions of the Current Project Footprint as Areas of Critical Environmental Concern

The BLM should include in the EIS an analysis of designating the portions of Ivanpah Valley currently proposed for development as Ivanpah 2 and 3 as areas of critical environmental concern. The Sierra Club seeks permanent protection for these lands because a reconfiguration of the Project footprint only makes sense if the habitat protected by the change remains off limits to development permanently.

A critical factor for whether an ACEC designation is appropriate in terms of species protection is whether the area contains wildlife resources, including habitat for endangered or threatened species, or habitat essential for maintaining species diversity. The area bounded on the west by the eastern portion of the Clark Mountains, on the north by the Nevada State line and on the south and east by I-15 fulfills this criterion. Project surveys to date document the presence of wildlife resources, namely desert tortoise, other wildlife of concern, and special-status plant species. The PSA is clear that the Project area is excellent tortoise habitat, with a low level of disturbance and high plant species diversity.[5] In addition, the BLM designated portions of the valley as Category I desert tortoise habitat in its documentation for the Northern and Eastern Mojave Desert Management Plan (NEMO).[6] Although the NEMO boundary for the nearby Desert Wildlife Management Area excluded the Northern Ivanpah Valley Unit, an ACEC designation is necessary to protect the important biological resources throughout the higher elevation portions of the valley.

Permanent protection via an ACEC designation is further warranted because the desert tortoise population in Ivanpah Valley is unique given that the individuals residing there are at the highest elevation known anywhere in the state. The elevations range from approximately 3,150 to 2,850 feet above mean sea level. Given new impacts based on climate change affecting food availability and other vital factors, it has become increasingly important to protect higher elevation habitat.

3. The BLM Should Retire the Clark Mountain Grazing Allotment

Finally, the BLM should retire the Clark Mountain grazing allotment as a component of the ACEC designation. Grazing is simply not compatible with protecting wildlife and plant species in the Ivanpah Valley. This particular allotment is rarely used based on the records at the Needles Office. Those records reveal that no animal unit months were billed for the allotment

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[4] Desert Tortoise (Mojave Population) Recovery Plan.

[5] PSA, at 5.2-30.

[6] NEMO Appendix A.

from 2007 to 2009 (to the end of March). And it appears from the Moon's letter of September 4, 2008 to Sterling White of the Needles BLM Office that the permit holders are willing to accommodate a retirement of the allotment were the BLM to issue a right-of-way in connection with the Project.

4. Conclusion

NEPA requires the BLM to include a reasonable range of meaningful alternatives in its Project EIS. Specifically, BLM must "study, develop, and describe appropriate alternatives to recommend courses of action in any proposal which involves unresolved conflicts concerning alternative uses of available resources."[7] A full analysis of alternate siting scenarios is warranted for the Project given the potential conflict from developing renewable solar energy on intact desert public lands supporting imperiled plant and wildlife species. The Sierra Club believes such a conflict can be avoided in the Ivanpah Valley by situating the Project in a manner that completely avoids much of the highest quality desert tortoise habitat while keeping the Project at its proposed scale, thereby maximizing solar generation.

Respectfully Submitted
Sid Silliman
Sidney Silliman
Sierra Club San Gorgonio Chapter and Desert Committee

---

[7] 42 U.S.C. § 4332(2)(E).

BEFORE THE ENERGY RESOURCES CONSERVATION AND DEVELOPMENT COMMISSION OF THE STATE OF CALIFORNIA
1516 NINTH STREET, SACRAMENTO, CA 95814
1-800-822-6228 – WWW.ENERGY.CA.GOV

APPLICATION FOR CERTIFICATION
FOR THE *IVANPAH SOLAR ELECTRIC GENERATING SYSTEM*

DOCKET NO. 07-AFC-5

PROOF OF SERVICE
(Revised 5/27/09)

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Elena Miller

Public Adviser publicadviser@energy.state.ca.us

DECLARATION OF SERVICE

I, Violet Lehrer, declare that on June 22, 2009, I served and filed copies of the attached letter, dated June 22, 2009. The original document, filed with the Docket Unit, is accompanied by a copy of the most recent Proof of Service list, located on the web page for this project at: **[www.energy.ca.gov/sitingcases/ivanpah]**. The document has been sent to both the other parties in this proceeding (as shown on the Proof of Service list) and to the Commission's Docket Unit, in the following manner:

(***Check all that Apply***)

FOR SERVICE TO ALL OTHER PARTIES:

______ sent electronically to all email addresses on the Proof of Service list;

X by personal delivery or by depositing in the United States mail at Sierra Club 85 2nd St., 2nd Floor SF, CA 94105 with first-class postage thereon fully prepaid and addressed as provided on the Proof of Service list above to those addresses **NOT** marked "email preferred."

AND

FOR FILING WITH THE ENERGY COMMISSION:

X sending an original paper copy and one electronic copy, mailed and emailed respectively, to the address below (***preferred method***);

OR

______ depositing in the mail an original and 12 paper copies, as follows:

CALIFORNIA ENERGY COMMISSION
Attn: Docket No. 07-AFC-5
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docket@energy.state.ca.us

I declare under penalty of perjury that the foregoing is true and correct.

EXHIBIT 600

SIERRA CLUB
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Respectfully Submitted
Sid Silliman /B
Sidney Silliman
Sierra Club San Gorgonio Chapter and Desert Committee

---

[7] 42 U.S.C. § 4332(2)(E).

BEFORE THE ENERGY RESOURCES CONSERVATION AND DEVELOPMENT COMMISSION OF THE STATE OF CALIFORNIA

1516 NINTH STREET, SACRAMENTO, CA 95814
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PROOF OF SERVICE
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DECLARATION OF SERVICE

I, Violet Lehrer, declare that on June 22, 2009, I served and filed copies of the attached letter, dated June 22, 2009. The original document, filed with the Docket Unit, is accompanied by a copy of the most recent Proof of Service list, located on the web page for this project at: **[www.energy.ca.gov/sitingcases/ivanpah]**. The document has been sent to both the other parties in this proceeding (as shown on the Proof of Service list) and to the Commission's Docket Unit, in the following manner:

(***Check all that Apply***)

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______ sent electronically to all email addresses on the Proof of Service list;

X by personal delivery or by depositing in the United States mail at Sierra Club 85 2nd St., 2nd Floor SF, CA 94105 with first-class postage thereon fully prepaid and addressed as provided on the Proof of Service list above to those addresses **NOT** marked "email preferred."

AND

FOR FILING WITH THE ENERGY COMMISSION:

X sending an original paper copy and one electronic copy, mailed and emailed respectively, to the address below (***preferred method***);

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CALIFORNIA ENERGY COMMISSION
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I declare under penalty of perjury that the foregoing is true and correct.

EXHIBIT 601

Modeling Habitat of the Desert Tortoise (*Gopherus agassizii*) in the Mojave and Parts of the Sonoran Deserts of California, Nevada, Utah, and Arizona

Open-File Report 2009-1102

U.S. Department of the Interior
U.S. Geological Survey

COVER PHOTOGRAPH

(2005) Mojave Desert Tortoise found in Piute Valley in Clark County, Nevada (Kenneth E. Nussear)

Modeling Habitat of the Desert Tortoise (*Gopherus agassizii*) in the Mojave and Parts of the Sonoran Deserts of California, Nevada, Utah, and Arizona

By Kenneth E. Nussear, Todd C. Esque, Richard D. Inman, Leila Gass, Kathryn A. Thomas, Cynthia S. A. Wallace, Joan B. Blainey, David M. Miller, and Robert H. Webb

Prepared as a part of the
Department of the Interior on the Landscape – Mojave Project
for the Western Region, of the U.S. Geological Survey

Open-File Report 2009-1102

U.S. Department of the Interior
U.S. Geological Survey

U.S. Department of the Interior
KEN SALAZAR, Secretary

U.S. Geological Survey
Suzette M. Kimball, Acting Director

U.S. Geological Survey, Reston, Virginia: 2009

Suggested citation:
Nussear, K.E., Esque, T.C., Inman, R.D., Gass, Leila, Thomas, K.A., Wallace, C.S.A., Blainey, J.B., Miller, D.M., and Webb, R.H., 2009, Modeling habitat of the desert tortoise (*Gopherus agassizii*) in the Mojave and parts of the Sonoran Deserts of California, Nevada, Utah, and Arizona: U.S. Geological Survey Open-File Report 2009-1102, 18 p.

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Conversion Factors, Datums, and Abbreviations and Acronyms

Conversion Factors

Multiply	By	To obtain
	Length	
kilometer (km)	0.6214	mile (mi)
millimeter (mm)	0.03935	inch (in.)
	Area	
square kilometer (km^2)	0.3861	square mile (mi^2)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$°F+(1.8×°C)+32.$$

Datums

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88).
Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Abbreviations and Acronyms

AGP – Annual Growth Potential
AUC – Area Under the ROC Curve
CV – Coefficients of Variation
DEM – Digital Elevation Map
EVI - Enhanced Vegetation Index
MODIS –Moderate Resolution Imaging Spectroradiometer
NAD –North American Datum
NED – National Elevation Database
RBG – Random Background
ROC – Receiver Operating Characteristic
STATSGO - State Soil Geographic (STATSGO) Database
USGS – U.S. Geological Survey

Modeling Habitat of the Desert Tortoise (*Gopherus agassizii*) in the Mojave and Parts of the Sonoran Deserts of California, Nevada, Utah, and Arizona

By Kenneth E. Nussear, Todd C. Esque, Richard D. Inman, Leila Gass, Kathryn A. Thomas, Cynthia S. A. Wallace, Joan B. Blainey, David M. Miller, and Robert H. Webb

Abstract

Habitat modeling is an important tool used to simulate the potential distribution of a species for a variety of basic and applied questions. The desert tortoise (*Gopherus agassizii*) is a federally listed threatened species in the Mojave Desert and parts of the Sonoran Desert of California, Nevada, Utah, and Arizona. Land managers in this region require reliable information about the potential distribution of desert tortoise habitat to plan conservation efforts, guide monitoring activities, monitor changes in the amount and quality of habitat available, minimize and mitigate disturbances, and ultimately to assess the status of the tortoise and its habitat toward recovery of the species. By applying information from the literature and our knowledge or assumptions of environmental variables that could potentially explain variability in the quality of desert tortoise habitat, we developed a quantitative habitat model for the desert tortoise using an extensive set of field-collected presence data. Sixteen environmental data layers were converted into a grid covering the study area and merged with the desert tortoise presence data that we gathered for input into the Maxent habitat-modeling algorithm. This model provides output of the statistical probability of habitat potential that can be used to map potential areas of desert tortoise habitat. This type of analysis, while robust in its predictions of habitat, does not account for anthropogenic changes that may have altered habitat with relatively high potential into areas with lower potential.

Introduction

Spatial models that predict areas of potential habitat for plants and animals are extremely useful for evaluating management actions, particularly recovery plans for threatened or endangered species (Graham and others, 2004). Using spatially defined environmental variables, which may be either continuous numbers, integers, or categorical data, these habitat models can be very robust at detailed scales and are useful when designing of conservation programs and evaluating changes in species distributions owing to anthropogenic effects or global change. Data on species occurrence, combined with spatially explicit environmental data, can be used with recently developed statistical techniques and analytical tools without specific absence data (Elith and others, 2006; Phillips and others, 2006; Phillips and Dudik, 2008).

The desert tortoise (*Gopherus agassizii*, cover photograph) occupies a variety of habitat types in the Mojave Desert including creosotebush – white-bursage (*Larrea tridentata – Ambrosia dumosa*) communities (Fig. 1). The species is widely distributed in southwestern North America, ranging from the Sierra Nevada in California to southwestern Utah and southwards into Sonora and Sinaloa, Mexico (Fig. 2). North and west of the Colorado River, the desert tortoise is a federally listed threatened species owing to reductions in habitat quality and extent caused by human activities, land-use practices, increasing populations of subsidized predators, disease, and other factors (Luckenbach, 1982; Department of the Interior, 1990; Berry and others, 2002). Urbanized areas within Clark County, Nevada, typify several fast-growing urban areas within former tortoise habitat (*http://www.censusscope.org/us/m4120/chart_popl.html*) that have caused significant displacements of these animals. Land-use practices leading to habitat degradation or destruction include development (urban and rural), military training activities, habitat fragmentation from roads and utility corridors, recreational activities, livestock grazing, and previously uncommon fires fueled mostly by non-native species (Tracy and others, 2004). Extensive habitat changes and reduction in populations prompted wildlife managers to create a recovery plan (U.S. Fish and Wildlife Service, 1994) and a subsequent revision of the recovery plan (Tracy and others, 2004; U.S. Fish and Wildlife Service, 2008). The results of this modeling project will be a useful element of the Revised Recovery Plan.

Figure 1. Creosote scrub habitat (one type of preferred desert tortoise habitat) in the Mojave Desert.

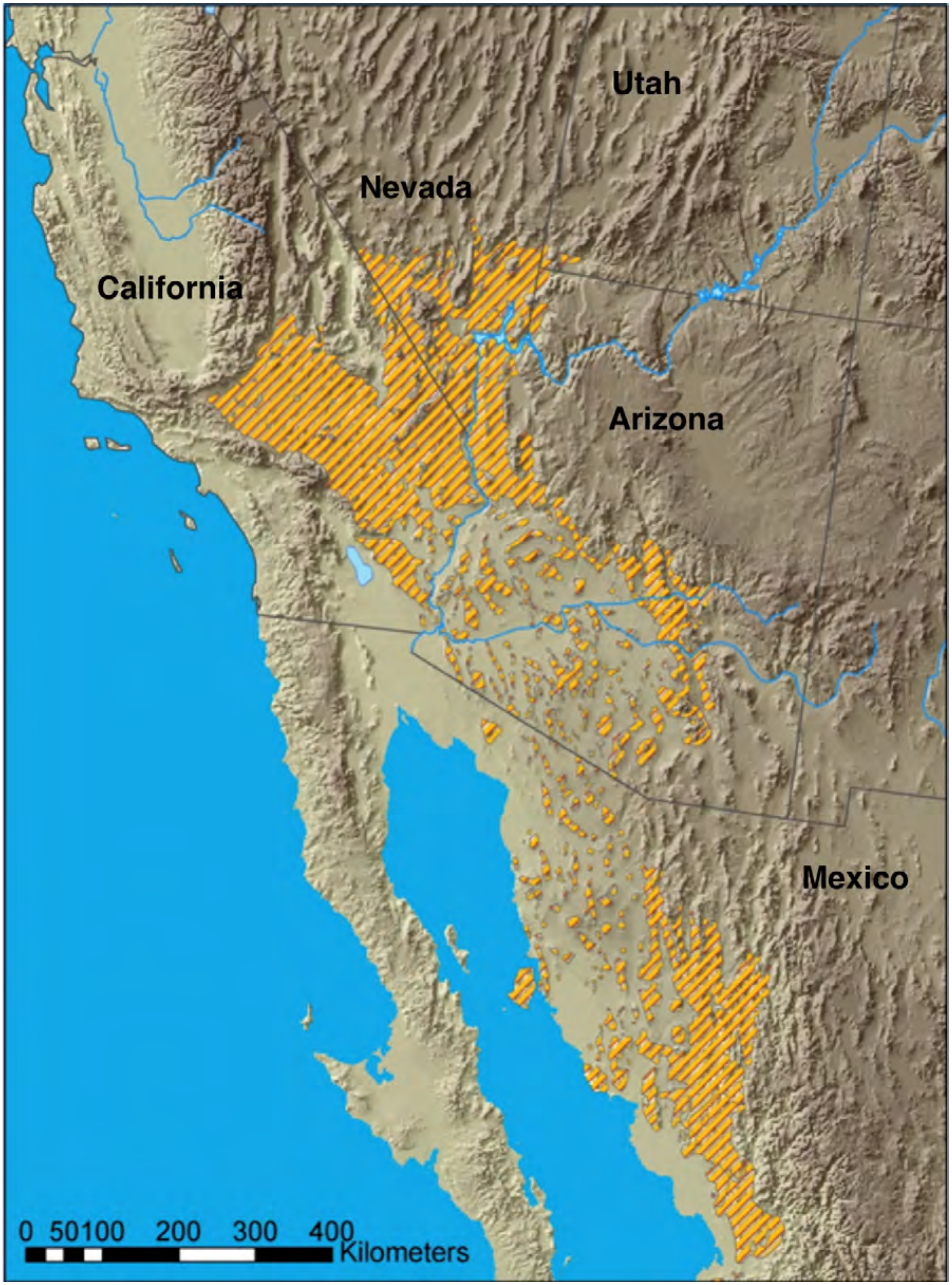

Figure 2. Map showing distribution of desert tortoise (*Gopherus agassizii*) in western North America (adapted from Germano and others, 1994).

We assembled an interdisciplinary team to create a model of potential habitat for the listed Mojave Desert populations of the desert tortoise. After assembling a unique set of presence data (Fig. 3) gleaned from the scientific literature, state and federal land-management agencies, scientists, and biologists, we used a series of innovative techniques (for example; remote sensing and spatial interpolation; Blainey and others, 2007; Wallace and Gass, 2008; Wallace and Thomas, 2008; Wallace and others, 2008) to develop environmental data layers at a common spatial scale of 1 km^2 to help define potential habitat. We used the Maxent algorithm (Phillips and others, 2006) to predict potential desert tortoise habitat in the Mojave Desert and parts of the Sonoran Desert.

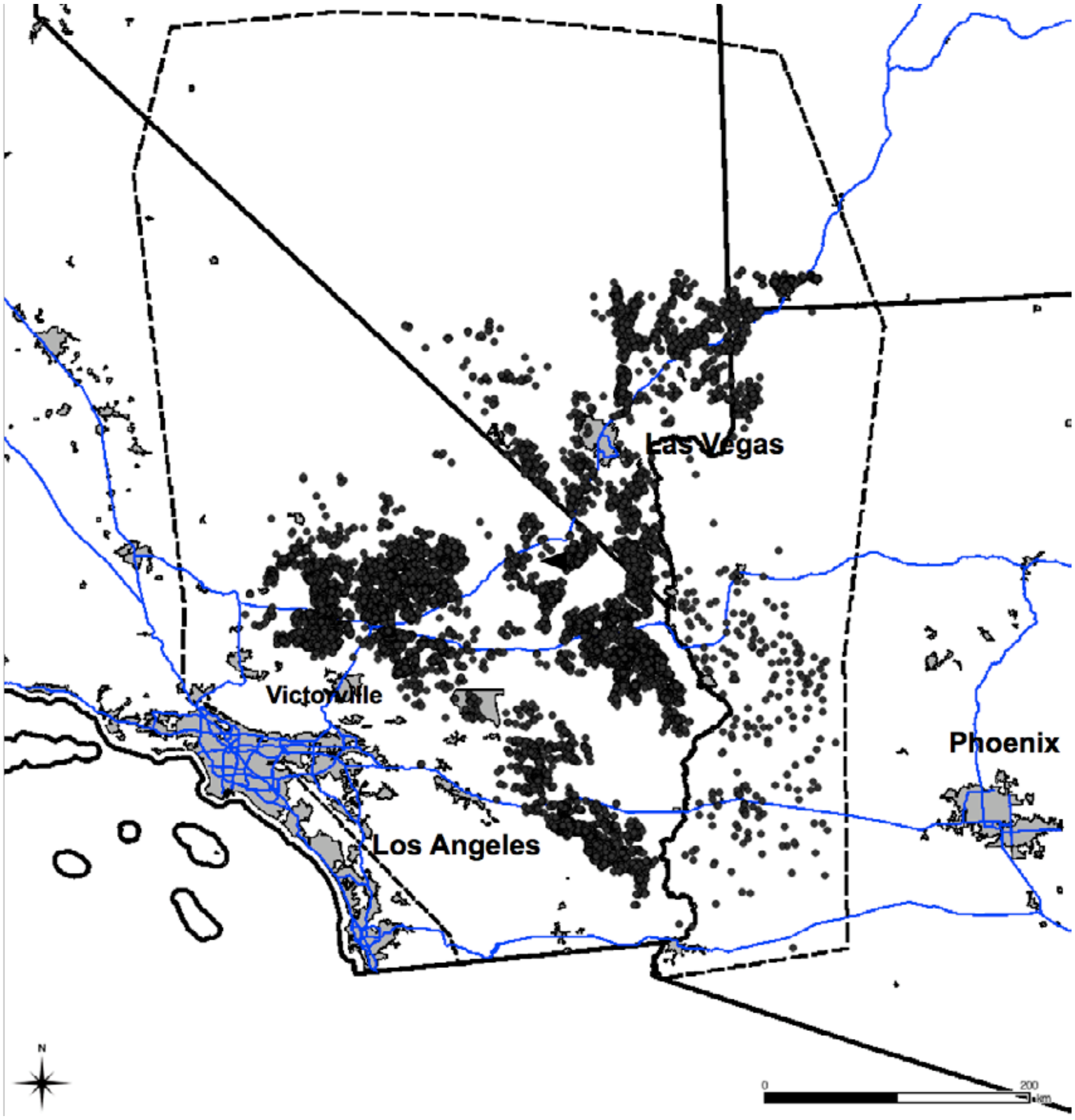

Figure 3. Distribution of desert tortoise (*Gopherus agassizii*) presence observations at sites in the Mojave Desert and parts of the Sonoran Desert of California, Nevada, Utah, and Arizona. *Solid circles* indicate records of one or more observations of live or dead tortoises. The dashed line indicates the study area boundary for the habitat model. Major highways are indicated by blue lines, and urban areas are indicated by gray shaded areas.

Purpose and Scope

The purpose of this report is to document the methods and data sources used to model the potential habitat of the desert tortoise in the Mojave and parts of the Sonoran Desert and to present a map showing this potential habitat. We discuss some of the limitations of our data and caution that our results do not account for other factors that affect habitat quality, notably significant changes brought about by land-use practices.

Background

Geography and Topography

Our study encompasses the range for the Mojave population of desert tortoises north and west of the Colorado River, as well as a small portion of the northwest Sonoran Desert, and comprises 336,594 km^2 of basin-and-range topography (Fig. 3). The study area was used to create spatially coincident environmental-data layers for environmental variables known from the literature and our experience for defining potential habitat. Within this area, we created a spatial grid of 1-km^2 cells for which we assessed habitat potential. Although the habitat for the desert tortoise is thought to occur primarily at elevations between 600 and 1,200 m above sea level (Germano and others, 1994, Fig. 2), we used the entire elevation range within the distributional limits of this species, which ranges from the rugged mountain ranges to the flat-lying playa systems that characterize the study area.

Climate

Owing to relatively sparse climatological data for the study area, the range in temperatures and precipitation within the current desert-tortoise habitat is only generally known. In the Mojave Desert, annual precipitation within known habitat ranges from 100 to 210 mm (Germano and others, 1994), mostly occurring during the winter months (> 50-75%) and infrequently as snow below 1,200 m. The temperature range of known habitat is extreme, with average daily low temperatures in January typically at or slightly below 0 ºC and average daily high temperatures in July ranging from 37 to 43 ºC (Germano and others, 1994). Both precipitation and temperature are strongly and complexly related to elevation, aspect, and position within this desert; the closed-basin playa systems that characterize the Mojave Desert tend to control air movement, leading to low-level temperature inversions in winter and thermal trapping of heat in some valleys during summer. Winter precipitation is usually dependent on frontal storms or the residual effects of gulf storms penetrating northward with increasing amounts of rain or snow at higher elevations. Summer precipitation is associated with the North American monsoon, which is more reliable in the easterly parts of the desert tortoise range. Precipitation events, especially the monsoon, may be highly local depending strongly on orographic effects.

The complex interactions between topography and climate are perhaps best illustrated by the differing results of studies of preferred aspect by the desert tortoise. Weinstein (1989) found a significantly greater abundance of desert tortoises on northwest to north-northwest facing slopes, a result that he attributed to ground heating and possibly illumination. However, Andersen and others (2000), working in a different part of the Mojave Desert, found a preference for southwestern facing slopes, again for possible effects of soil heating during winter. This apparent shift in habitat preference on the basis of aspect underscores the complexity of topography and climate interactions as they affect habitat preference for this species and illustrates the need for robust environmental data over the entire range of this species.

Other Environmental Constraints on Habitat

The characteristics of high-quality habitat for the desert tortoise have been proposed by numerous researchers, possibly beginning with Woodbury and Hardy (1948) and Miller (1932, 1955) and more recently including Luckenbach (1982), Weinstein (1989), Germano and others (1994), U.S. Fish and Wildlife Service (1994), and Andersen and others (2000). A conceptualized array of these environmental characteristics are related to the core variables of soils, landscape, climate, and biological characteristics (Fig. 4). As summarized most recently in U.S. Fish and Wildlife Service (2008), desert tortoise habitat typically consists of alluvial fans and plains and colluvial/bedrock slopes with vegetation alliances of creosote bush (*Larrea tridentata*) or, less commonly, blackbrush (*Coleogyne ramosissima*), Joshua tree (*Yucca brevifolia*), and even juniper (*Juniperus* sp.) at higher elevations and saltbush (*Atriplex* sp.) at lower elevations. In general, tortoises prefer *Larrea* habitat with high diversity and cover of perennial species and high production of ephemeral plants, which comprise their primary diet (Esque, 1994; Jennings, 1997; Avery, 1998).

Soils tend to be of sufficient strength to accommodate burrows without collapse but allow excavation by the animals (Andersen and others, 2000); in some cases, tortoises take advantage of natural shelters in rock formations or exposed calcic soil horizons. Both from constraints on mobility and their inability to easily construct shelters, tortoises tend not to use rocky or shallow bedrock habitat, particularly on very steep slopes, in the Mojave Desert. Home ranges of desert tortoises can cover 3.9 km^2 (Berry, 1986) or more over their long lifespans, suggesting that a spatial modeling unit of 1 km^2 is appropriate.

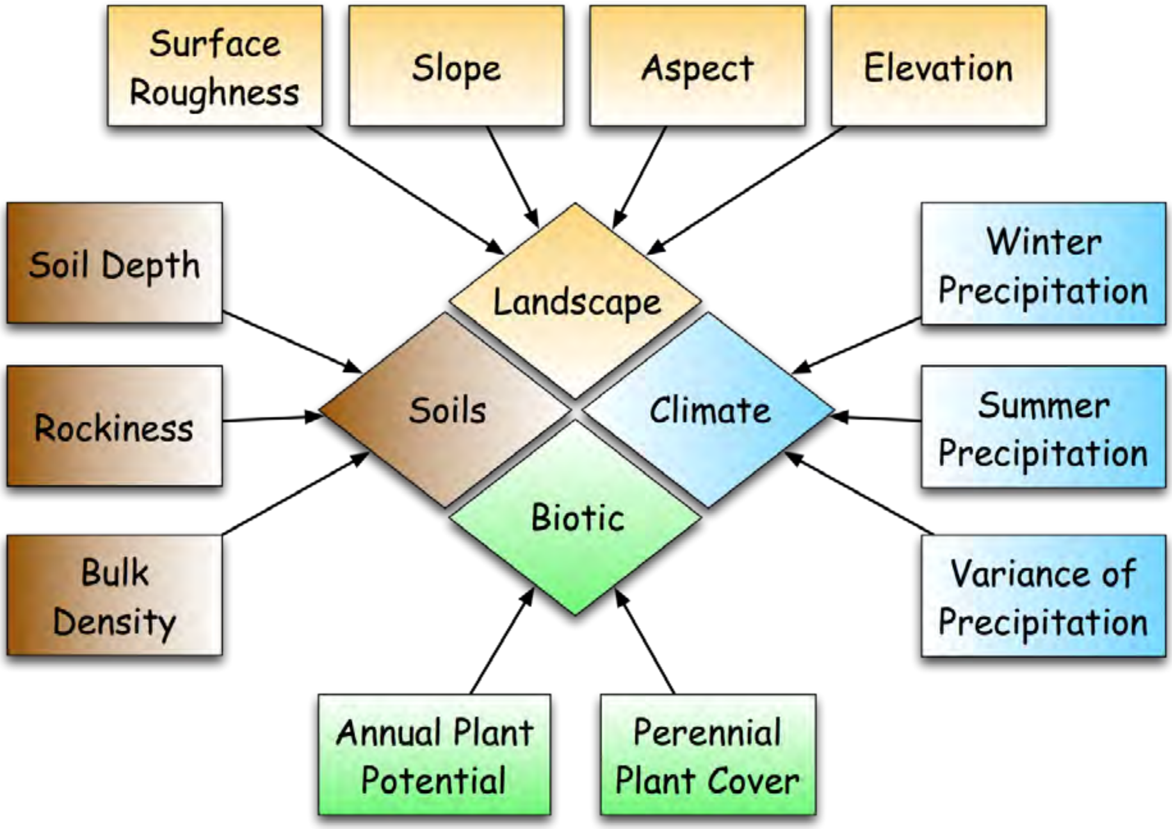

Figure 4. Array of variables used to predict desert tortoise habitat. Environmental variables were generally related to four categories of influence on the landscape and were hypothesized to influence tortoise ecology/habitat potential through a variety of mechanisms.

Methods

Tortoise Presence Data

We combined several datasets of desert tortoise occurrence collated from a variety of sources to assemble presence points in the Mojave and parts of the Sonoran Deserts (see Acknowledgments). Presence records included data from 1970 through 2008, although most of the data were collected after 1990. These data resulted from at least 23 different data-collection initiatives. Although methods of data collection varied among the primary sources, we were able to use the observations of tortoises (live or dead) as point sources of presence. We used only data involving evidence of live tortoises or carcasses, discarding locations reported on the basis of burrows, scat, or other sign, as these can be easily misidentified. The locations represent "potential" presence because carcasses may have been moved into unsuitable habitat by predators or humans. Our geospatial database includes 15,311 points representing presence (Fig. 3).

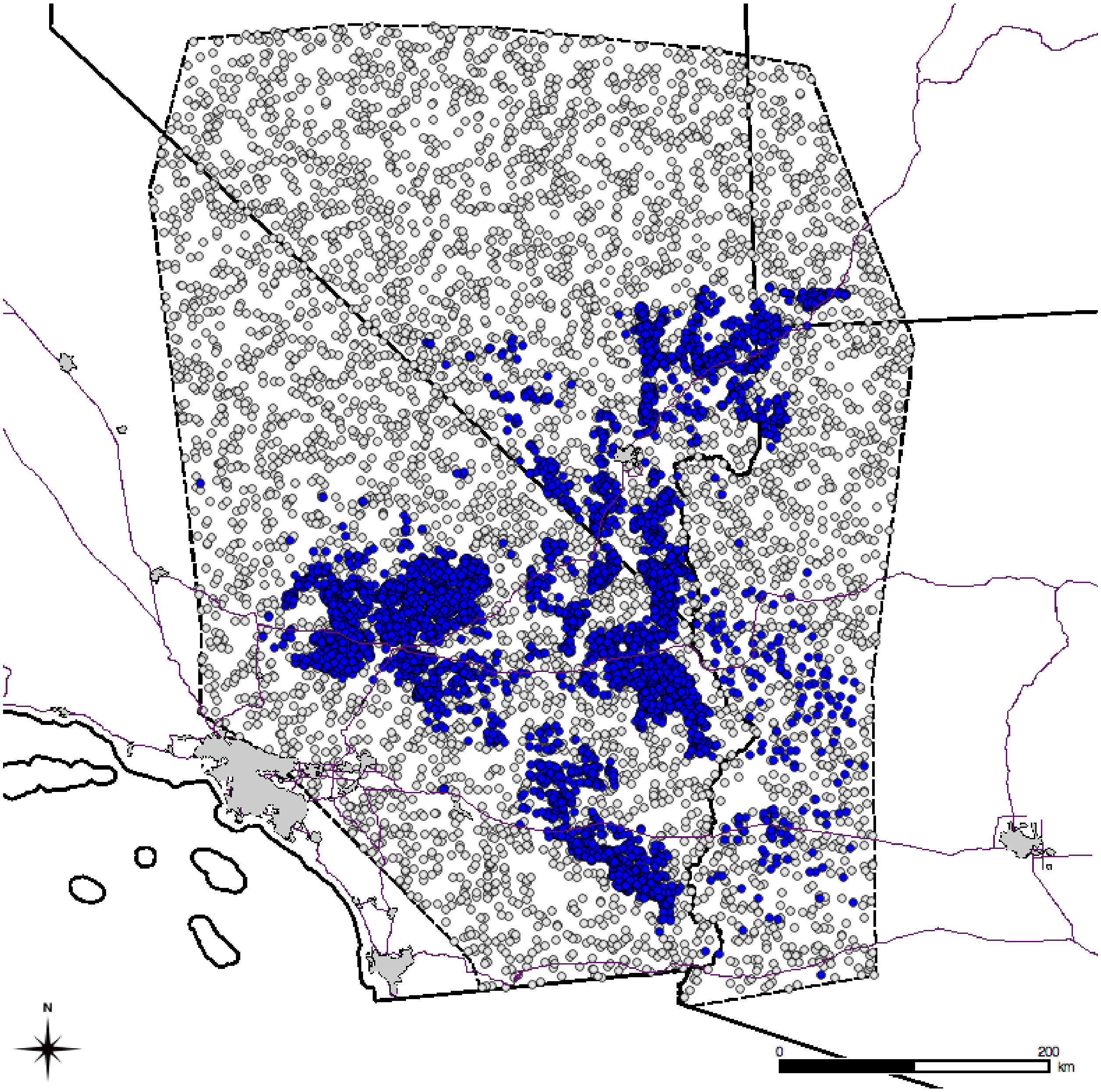

Figure 5. Distribution of presence data (blue circles) and random background data (gray circles) used in habitat modeling. Urban areas are defined by the gray shaded polygons.

We aggregated the presence observations to the 1-km^2 grid by merging all points within each grid cell to a single point at the grid-cell center. This reduced the 15,311 occurrences to 6,350 grid-cell points (Fig. 5). We randomly selected 20% of the presence points (1,270 points) for model testing; the remaining 80% (5,080 points) were used for model training.

Environmental Data Layers

Using the literature (e.g., Luckenbach 1982) and the experience of the authors of this report, we developed 16 environmental data layers that define or influence desert tortoise habitat. These data, assembled by an interdisciplinary team, include soil characteristics, perennial and annual vegetation, elevation and extracted topographic variables, and seasonality and variability of precipitation (Table 1). All environmental datasets were resampled to match our standard spatial grid using tools available in GRASS 6.4 (GRASS Development Team, 2008)

Table 1. Environmental data used in modeling potential habitat of the desert tortoise in the Mojave and parts of the Sonoran Deserts of California, Nevada, Utah, and Arizona.

[Dry season, May through October; wet season, November through April with statistics for 1961 to 1990 used as the climatic normal and coefficient of variation]

Description of Environmental Data Layer	Source of Environmental Data
CLIMATE	
Mean dry season precipitation for 30-year normal period	Blainey and others (2007)
Dry season precipitation, spatially distributed coefficient of variation *	Blainey and others (2007)
Mean wet season precipitation for 30-year normal period	Blainey and others (2007)
Wet season precipitation, spatially distributed coefficient of variation *	Blainey and others (2007)
TOPOGRAPHY	
Elevation	30 m NED DEM (USGS)
Slope *	derived from 30 m NED DEM (USGS)
Northness (aspect) *	derived from 30 m NED DEM (USGS)
Eastness (aspect) *	derived from 30 m NED DEM (USGS)
Average surface roughness	derived from 30 m NED DEM (USGS)
Percent smooth	derived from 30 m NED DEM (USGS)
Percent rough *	derived from 30 m NED DEM (USGS)
SOILS	
Average soil bulk density	STATSGO database
Depth to bedrock	STATSGO database
Average percentage of rocks > 254 mm B-axis diameter	STATSGO database
BIOLOGICAL CHARACTERISTICS	
Perennial plant cover	Wallace and others (2008)

* Environmental layers that were dropped from the final model after evaluation of the jackknife analyses.

Climate data consisted of two seasonal data layers representing average summer (May–October) and average winter (November–April) precipitation. Based on climatic normals calculated from conditions between 1961 and 1990, we used spatially distributed coefficients of variation (CV) for both seasons (Blainey and others, 2007). We did not use temperature as a variable, although some studies show a relation between temperature and tortoise physiological response (Naegle, 1976; Spotila and others, 1994; Rostal and others, 2002). In our experience, no data published to date definitively show direct temperature limitations on the extent of desert tortoise habitat. Temperature is likely to influence tortoises ecologically at several time periods and life history stages, which would require several complex hypothetical temperature interactions to be created as GIS layers of temperature, and was beyond the scope of this project. Despite this, temperatures indirectly were used in our model owing to their strong correlation with elevation and position, particularly in the northern parts of the study area.

We derived six topographic data layers from a 30-m DEM that, along with elevation, provided the suite of topographic variables that influence desert tortoise habitat at a 1-km^2 scale using methods similar to Wallace and Gass (2008). Surface roughness was calculated at a 30-m cell size using the method specified by Hobson (1972). Average surface roughness was calculated as the average value of surface roughness in each 1-km^2 grid cell. Separately, the percentage of each 1-km^2 cell that was “smooth” and “rough” was assessed by measuring the proportion of 30-m average roughness grid cells that were < 1.01 (threshold for smooth) or > 1.11 (threshold for rough), where the 25% and 75%quartiles of the 30-m surface roughness grid were used to define the thresholds, respectively.

The aspect of each 1-km^2 grid cell was represented by eastness and northness (Zar, 1999), which are variables that represent aspect by converting the 1 to 360º range of possible azimuths into a range of -1 to 1, where -1 = south or west and 1 = north or east for northness and eastness, respectively. This transformation avoids identical aspects (e.g., 0 and 360 degrees) and creates two data layers with unique numerical representation of aspect, and was calculated using

$$\mathrm{E} = \sin\left(\frac{A \times \pi}{180}\right) \text{ and} \qquad \text{eqn. (1)}$$

$$\mathrm{N} = \cos\left(\frac{A \times \pi}{180}\right), \qquad \text{eqn. (2)}$$

where E = eastness, N = northness, and A = aspect.

Spatial data for average soil bulk density, depth to bedrock, percent area with depth to bedrock greater than 1 m, and percent of soil mass with rocks greater than 254 mm B-axis (intermediate) diameter were previously created from the STATSGO database by the Natural Resource Conservation Service and modified by USGS (Bliss, 1998).

The total perennial plant cover data were modeled using Moderate Resolution Imaging Spectroradiometer (MODIS) Enhanced Vegetation Index (EVI) collected by the MODIS satellite and composited over 16-day intervals (Wallace and others, 2008), combined with field measurements of total perennial cover, estimated from line intercept transects at locations across the Mojave Desert (Webb and others, 2003, 2009; Thomas and others, *unpublished data*; Wallace and others, 2008). Total perennial cover was related to elevation and 2001 through 2004

MODIS-EVI data at the transect locations ($R^2 = 0.82$), and the resulting model was used to extrapolate cover estimates for the remaining study area. The resulting data used in our study represented the absolute cover of all perennials irrespective of species composition (Wallace and others, 2008).

Annual growth potential is an environmental data layer that is a proxy for annual plant biomass, which reflects potential forage for tortoises. This data layer was derived by calculating the difference in greenness (a measure of plant growth) between two highly contrasting years of annual plant production (Wallace and Thomas, 2008). The difference between MODIS-EVI images for 2002 (a very dry year) and 2005 (a very wet year) had high correlation with field measurements of annual plant cover collected on 36 plots in the Mojave National Preserve in 2005 ($R^2 = 0.63$, p=0.01). The proxy measure of annual growth potential, AGP, was calculated as

$$\mathrm{AGP} = \left(\frac{EVI(2005) - EVI(2002)}{EVI(2005) + EVI(2002) + 1} \right) * 100, \qquad \text{eqn. (3)}$$

where EVI (2005) and EVI (2002) are the average MODIS-EVI values for the years 2005 and 2002. This formula is analogous to the Normalized Difference Vegetation Index of Huete and others (2002). The resulting values represent the potential for site specific food availability for desert tortoise.

Background Data

If both presence and absence data are available, many statistical techniques exist to predict potential habitat (Guisan and Zimmermann, 2000). However, absence data are rarely available or reliable for animals that hibernate in shelters for part of the year, in part, because their absence from specific areas is difficult to confirm (Guisan and Thuiller, 2005; MacKenzie and others, 2005; Thompson, 2004). Moreover, current ranges for species that have been extirpated from a larger area are misleading when it comes to development of recovery plans. Models built with presence-only data do not incorporate information on the frequency of occurrence of a species in a region, and therefore, they cannot accurately predict probability of presence; these models only estimate a relative index of habitat potential (Elith and others, 2006). We used a random background set of data to serve as “absences.” Although these data do not reflect true absences, they do create comparable models for testing a variety of algorithms and models with different environmental data without embedding assumptions of pseudo-absence point generation models into the habitat model, and they perform similarly to models using pseudo-absence (Phillips and Dudik, 2008).

We created random background points, which we refer to as RBG, by selecting random cells throughout our study area in locations constrained only to cells where desert tortoises were not observed. A total of 6,350 RBG points were selected; 20% of the RBG points (1,270) were used for model testing, and 80% (5,080) points were used for model training.

The Maxent Model

We modeled potential habitat using the Maxent algorithm (version 3.2.19, Phillips and others, 2006). Maxent uses a maximum entropy probability distribution to compare samples of occurrence data with background environmental data. Each of the included predictor variables were assessed using a jackknife test of variable importance and percent contribution (Phillips and others 2006). We used the logistic model output to represent an index of the potential of the habitat in a cell given the training data (Phillips and Dudik, 2008).

To assess the performance of this model, we used area under the curve (AUC) of the receiver operating characteristic (ROC) as a threshold-independent measure of model performance (Elith and others, 2006). ROC is plotted for all possible thresholds, with sensitivity (true positive rate) on the y-axis and 1-specificity (false positive rate) on the x-axis (Fawcett, 2003). The AUC characterizes the performance of the model at all possible thresholds and is summarized by a single number ranging from 0 to 1, where 1 indicates perfect model performance, 0.5 indicates the equivalent of a random guess, and less than 0.5 indicates performance worse than random. Here AUC tests the model discrimination between presence and the random background points rather than presence and true absence; therefore, the maximum possible $AUC < 1$ and random chance is $AUC = 0.5$ (Phillips and others, 2006). We also calculated the correlation between the test presence and RBG points (1 or 0) and the predicted values as Pearson's correlation coefficient (Zheng and Agresti, 2000; Elith and others, 2006). This performance metric is similar to AUC, but provides a more direct measure of how the model predictions vary from observations (Elith and others, 2006). The predicted habitat values from Maxent were continuous numbers between 0 (no habitat) to 1 (habitat), which we then binned into 12 intervals to represent various levels of potential habitat. These results were mapped to graphically represent potential habitat.

Results

The Maxent model produced a map of potential desert tortoise habitat for parts of the Mojave and Sonoran Deserts (Fig. 6). This model had a high AUC test score (0.93) and had a significant Pearson's correlation coefficient of 0.74 ($p < 0.01$), indicating a substantial agreement between the predicted habitat and the observed localities of desert tortoises. The final selected model excluded 6 of 16 habitat variables including eastness, northness, winter precipitation CV, summer precipitation CV, percent roughness, and slope (Table 1). These variables were dropped due to their low overall contributions to the model performance in jackknife tests. The model produced output with habitat-potential scores ranging from 0 to 1 (Fig. 7), plus an area that was not estimable because environmental data were not available for one or more layers (Fig. 6). These scores were placed in 12 different bins to provide an index of habitat potential (Table 2). Tortoises were present in 1-km^2 cells that spanned the entire range of model outputs. The mean model score for all tortoise presence cells was 0.84, and 95% of the cells with known presence had a model score greater than 0.7 (Fig. 7). The total area occupied by each of the 12 bins used as an index for habitat potential is presented in Table 2.

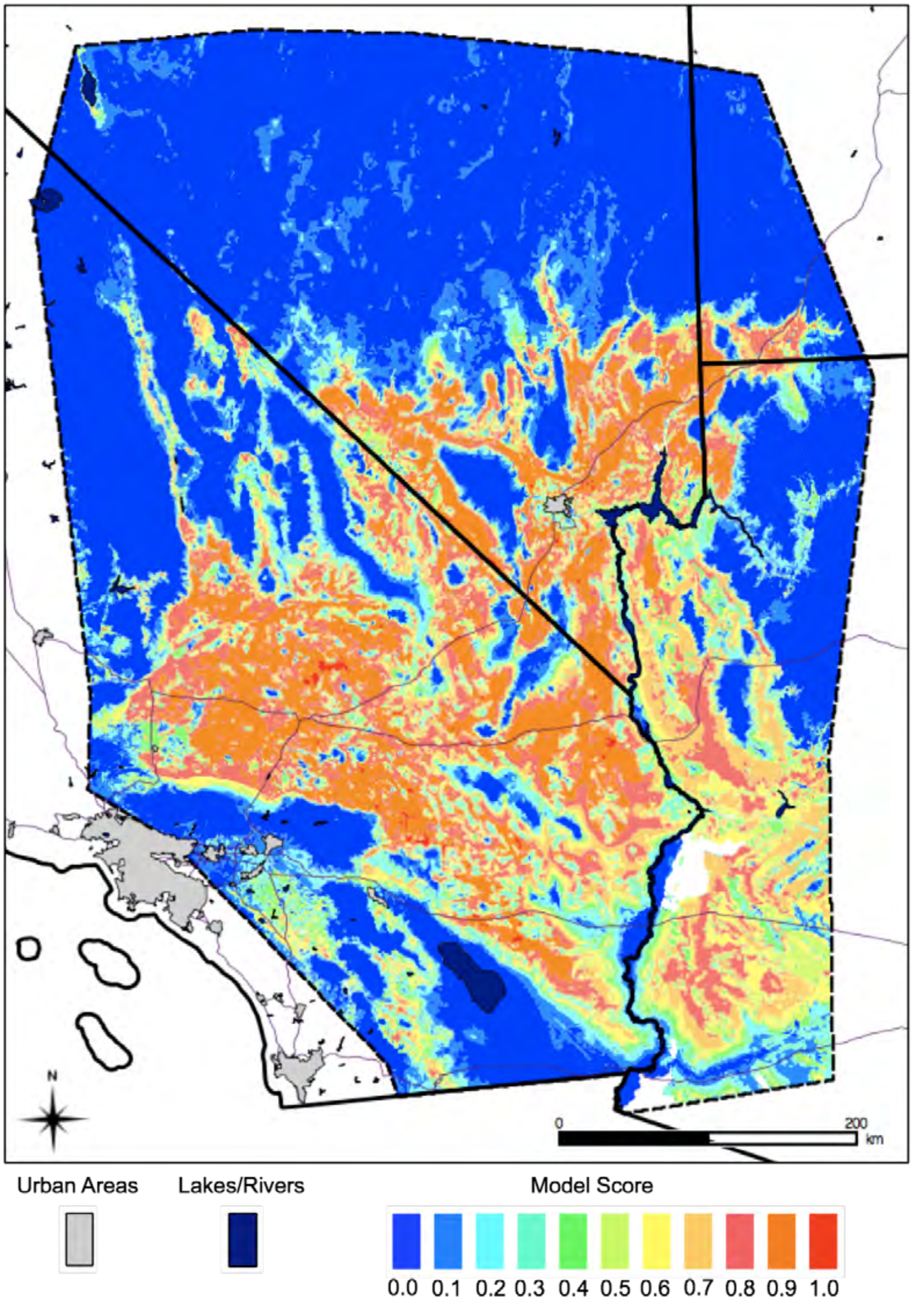

Figure 6. Spatial representation of the predicted habitat potential index values for desert tortoise (*Gopherus agassizii*) in the Mojave and parts of the Sonoran Deserts of Arizona, Nevada, Utah, and Arizona. White patches within the study area indicate areas where no environmental data were available for one or more layers. The Maxent model output used to develop this figure available as an ESRI ASCII GRID file at http://pubs.usgs.gov/of/2009/1102/.

Table 2. Total predicted area of desert tortoise habitat for each of 12 bins representing habitat potential values in the habitat potential model of the Mojave and parts of the Sonoran Deserts of California, Nevada, Utah, and Arizona.

[The item labeled as Not Estimable represents a relatively small area where supporting data layers were not available]

Habitat Potential Index Value	Area km^2
1	677
0.9	27,303
0.8	31,216
0.7	23,835
0.6	15,191
0.5	12,880
0.4	13,119
0.3	14,612
0.2	15,100
0.1	30,493
0	147,249
Not Estimable	4,919
Study Area Total	336,594

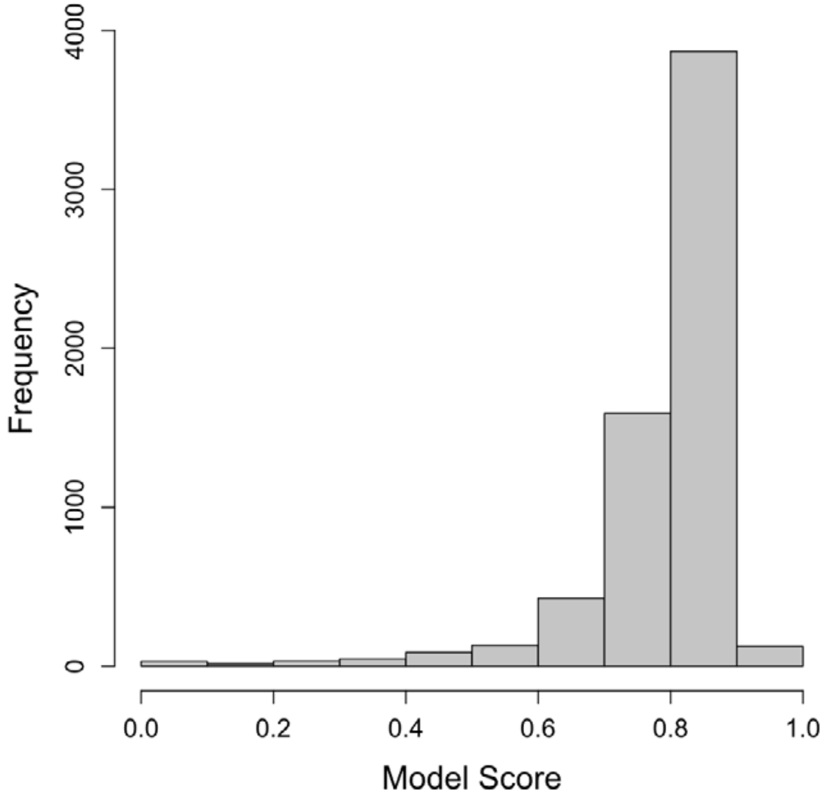

Figure 7. Frequency of the habitat potential index values for the 6,350 1-km^2 grid cells with known tortoise presence in the Mojave and parts of the Sonoran Deserts of California, Nevada, Utah, and Arizona.

Study Limitations

The quality of the spatial data used in this report is strongly dependent on the accuracy of previously reported presence points for desert tortoises and on the data used to calculate the environmental layers. Though all possible efforts were made to create a seamless and robust dataset, discrepancies are unavoidable since data were collected by different groups using different measurement techniques and sampling frequencies. Model scores reflect a hypothesized habitat potential given the range of environmental conditions where tortoise occurrence was documented. As such, there are likely areas of potential habitat for which habitat potential was not predicted to be high, and likewise, areas of low potential for which the model predicted higher potential. Finally, the map of desert tortoise potential habitat that we present does not account either for anthropogenic effects, such as urban development, habitat destruction, or fragmentation, or for natural disturbances, such as fire, which might have rendered potential habitat into habitat with much lower potential in recent years. Those topics are important foci for future analyses.

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to relatively high uptake from a contaminated substrate or, more commonly, to surface contaminated resulting from wind borne dust. Most high concentrations are thus not the result of natural accumulation in an uncontaminated area.

Two ill adult tortoises were salvaged from the Rand district and necropsied. One of the two contained the highest level of As (15 mg/kg wet weight) in keratin (scute) recorded to date in necropsied tortoises. The ingestion by tortoises of plants from these mineralized or contaminated areas may thus represent a potential threat to their health and longevity.

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PROXIMATE CONSTRAINTS AFFECTING THE REPRODUCTIVE OUTPUT AND MORTALITY OF DESERT TORTOISES

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Understanding the affects of resource availability on reproduction is critical to the study of life history and demography of animal populations. The desert tortoise (*Gopherus agassizii*), a long-lived species with delayed sexual maturity, is dependent on stored nutrients and water to minimize fluctuations in reproductive output. Tortoise populations are subject to lower fecundity and higher mortality in unpredictable desert ecosystems following extended periods of decreased resource availability. In an ongoing study, we measured the reproductive output of female tortoises from a population at Ivanpah Valley, California, located within the Mojave National Preserve, from 1997 - 1999. We measured egg and clutch size, and clutch frequency in 42 female tortoises using a portable x-ray unit. Eleven rain gauges were used to monitor monthly precipitation across three study sites within Ivanpah valley to measure variance in rainfall. Perennial plant cover and annual plant biomass were also measured. Precipitation was significantly greater at higher elevations across a 10 km distance characterized by a 400 m increase in elevation. Availability of food plants increased with higher elevation as well. Tortoise reproductive output was greater and recent mortality was lower, at the higher elevation along this short elevational and rainfall gradient. Resource variability is a defining feature of desert ecosystems, yet the importance of micro-geographic variation of these resources to desert tortoise populations has not been previously determined. Our study shows that micrographic differences in rainfall and primary productivity of annual vegetation can result in significant differences in survivorship and mortality of the threatened desert tortoise. These findings have important implications to designing reserves, managing public lands, and other conservation issues relevant to the desert tortoise.

THE DESERT TORTOISE PRESERVE COMMITTEE: A QUARTER CENTURY OF PROGRESS

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Since 1974, the nonprofit Desert Tortoise Preserve Committee has been driven by its mission to protect the welfare of the desert tortoise in its native wild state. Starting from a small group of volunteers working to build and protect a preserve in the Fremont Valley-Rand Mountain area, the Committee has developed into a highly effective force for the conservation of the tortoise and associated species throughout the West Mojave Desert. Examples of the Committee's many accomplishments from the last twenty-five years that have significantly benefited tortoise conservation include: development of creative strategies to acquire significant numbers of privately held small land parcels within the Desert Tortoise Research Natural Area, implementation of fencing mitigation commitments along Harper Lake Road, long-term protective management and recovery at the Pilot Knob grazing allotment, and the development and use of innovative educational programs. The Committee's success in meeting these challenges reflects its relative freedom from bureaucratic and political constraints, its flexibility to adaptively manage to make the most of opportunities that arise, and its ability to complement the work of state and federal government agencies to further its mission.