Predicting Desert Tortoise Habitat in the Mojave Desert

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Abstract

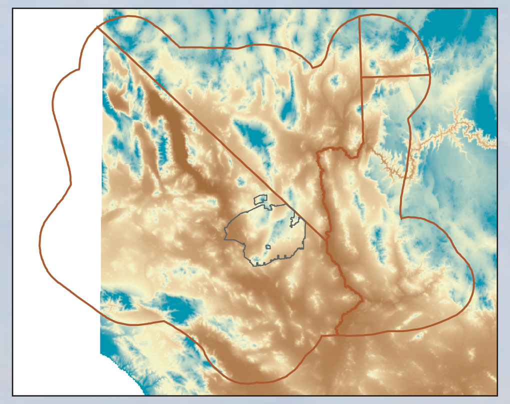
Quantifying the characteristics of suitable habitat, modeling its distribution, and prioritizing the value of habitat within that distribution are extremely important factors in management strategies for the federally protected Mojave Desert tortoise (*Gopherus agassizii*) population. Desert tortoises mainly occur on alluvial fans (bajadas) within the creosote bush or creosote bush-white bursage (*Larrea tridentata-Ambrosia dumosa*) alliances, although some desert tortoises occur at higher elevations and in other vegetation communities. This project's goal is to construct a statistically-based spatial model of desert tortoise habitat for large areas of the Mojave Desert on the basis of abiotic, biotic, and anthropogenic descriptors. Data describing desert tortoise occurrences are being compiled from existing U.S. Bureau of Land Management, National Park Service, California Department of Fish and Game, and U.S. Fish and Wildlife Service records. In addition, topographic, soil, climate, perennial vegetation community, and potential annual plant productivity maps are being produced and collected. These data are being incorporated into habitat-suitability models, which are extrapolated across various study areas. The habitat-suitability models are combined with maps of anthropogenic factors, including roads and land-management status, in a geographic information system to produce maps of predicted suitable habitat with possible land use and stewardship constraints. These predictive maps will aid in the management of desert landscapes for desert tortoise populations.

Desert tortoise habitat, St. George, Utah
Photo courtesy of US Fish and Wildlife Service

Data collection

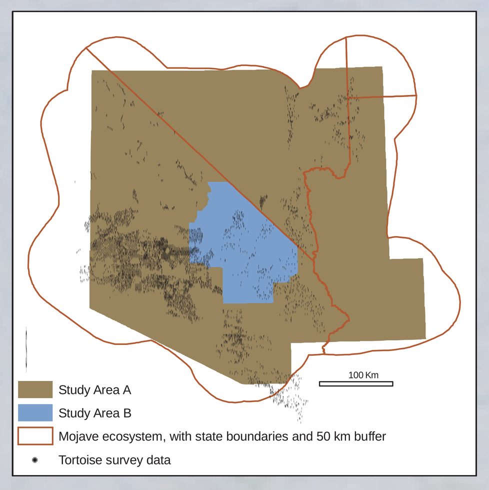
Habitat suitability models require species occurrence and environmental data. The geographic extent of data varies according to data sources. Data we have collected include:

Tortoise occurrence data
- line distance sampling
- belt transects
- survey plots



Mean temperature

Vegetation types

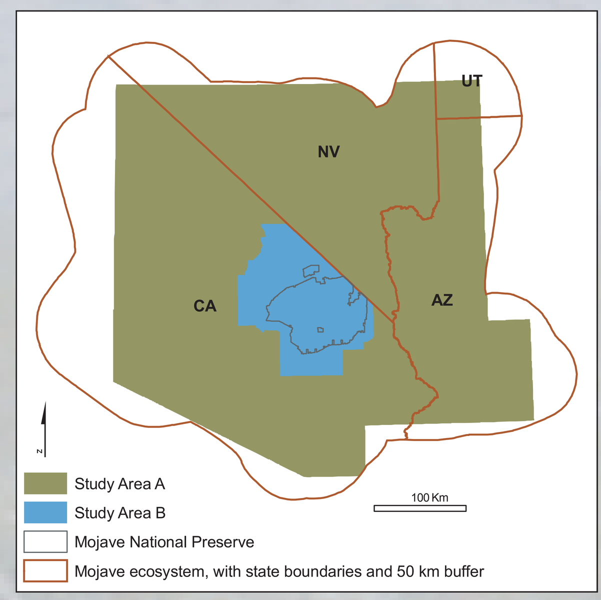


Environmental data
- soils
- surficial and bedrock geology
- climate (temperature, precipitation, etc.)
- elevation models and derivative data
- vegetation types and cover
- cultural features (roads, ownership, etc.)

Surficial geology

Study area definition

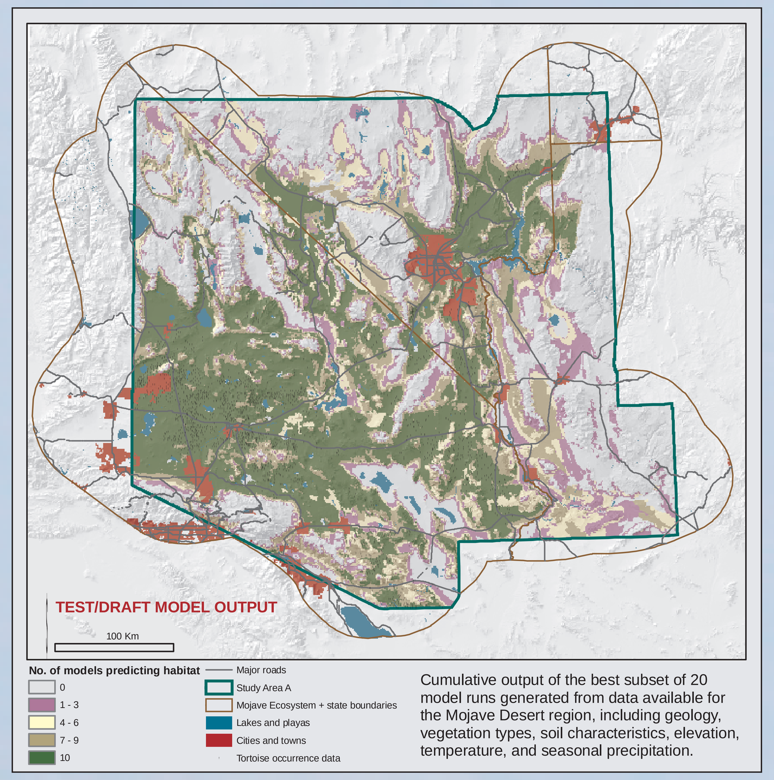
We are modelling tortoise habitat across geographic areas in which environmental data are available:
- across most of the Mojave Desert (Study Area A),
- and at focus study areas within the Mojave Desert (for example, Study Area B)



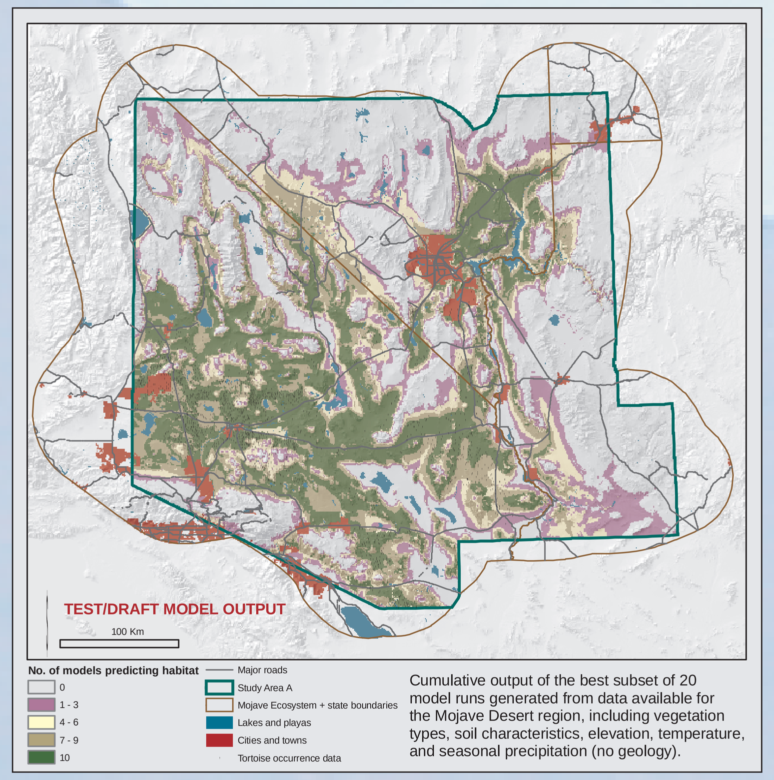
Test of GARP model

GARP (Genetic Algorithm for Rule-set Production; Scachetti-Pereira, 2002) produces models that describe environmental conditions under which species should be able to maintain populations. GARP uses point localities of species occurrence along with spatial data representing environmental parameters, and searches iteratively for non-random correlations between species presence and environmental attribute values using atomic, logistic regression, bioclimatic envelope, and negated bioclimatic envelope rules.

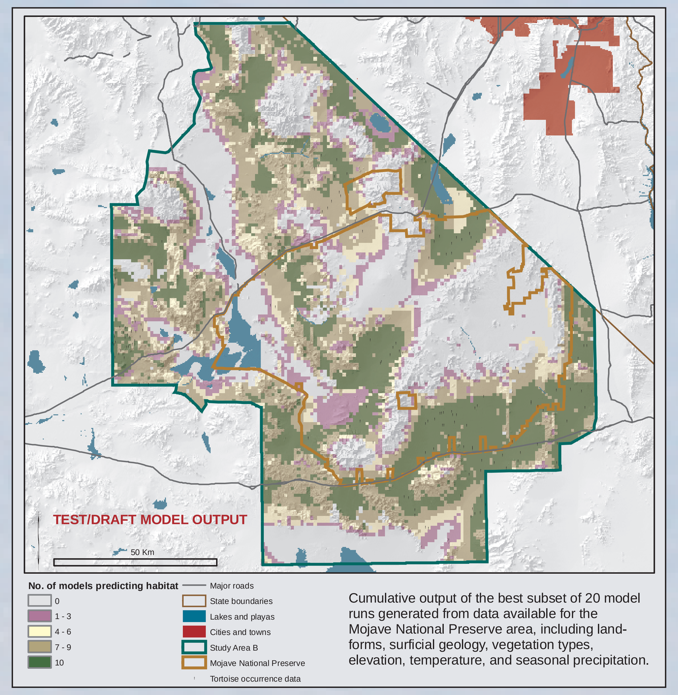
We used the tortoise occurrence and environmental data we currently have available for Study Areas A and B, to design our model and test the software and protocols.



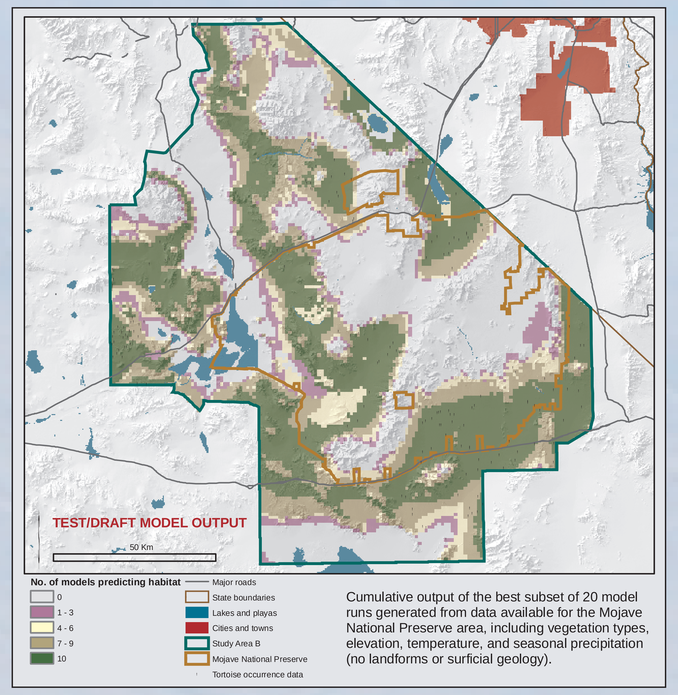
Study Area A



Study Area A, no geology input



Study Area B



Study Area B, no geology input

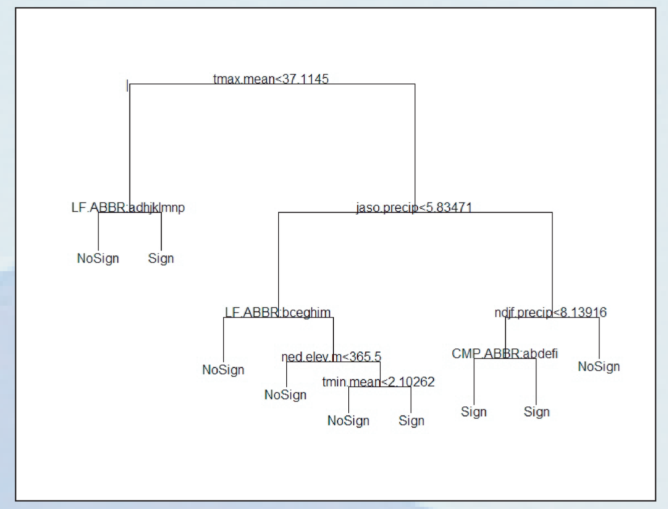
Task	Run	Species	Atomic Rules	Range Rules	Negated Rules	Logit Rules	Iter.	Conv.	Train Acc	Pr:Pr/Ac:Pr	Pr:Ab/Ac:Pr	Pr:Pr/Ac:Ab	Pr:Ab/Ac:Ab	Test Acc	Pr:Pr/Ac:Pr	Pr:Ab/Ac:Pr	Pr:Pr/Ac:Ab	Pr:Ab/Ac:Ab	Total Area	Presence Area	Absence Area
1	1	tort	1	1	1	1	96	0.009439	0.6756	1067	183	540	622	0.6428	976	254	550	631	15890	7318	7500
2	2	tort	1	1	1	1	90	0.00931	0.3492	0	429	0	873	0.3592	0	488	0	898	15890	0	11254
3	3	tort	1	1	1	1	106	0.009554	0.6396	1122	105	700	477	0.6424	1133	97	700	473	15890	8700	6206
4	4	tort	1	1	1	1	105	0.00981	0.7044	967	256	403	794	0.6904	971	260	449	755	15890	5346	9876
5	5	tort	1	1	1	1	93	0.009418	0.6888	1012	238	481	710	0.6116	828	422	500	701	15890	6392	8782
6	6	tort	1	1	1	1	80	0.009993	0.6836	1127	123	608	582	0.6432	1095	139	661	513	15890	8244	6658
7	7	tort	1	1	1	1	93	0.009499	0.6112	1237	13	744	291	0.6008	1202	33	726	300	15890	9150	3877
8	8	tort	1	1	1	1	106	0.009674	0.688	1165	78	620	555	0.594	936	296	650	549	15890	8151	6902
9	9	tort	1	1	1	1	94	0.008961	0.6972	961	289	457	782	0.6684	892	358	461	779	15890	5806	9938
10	10	tort	1	1	1	1	102	0.009287	0.7092	998	252	465	775	0.698	939	297	436	806	15890	5926	9841
11	11	tort	1	1	1	1	87	0.009996	0.6772	1082	168	635	611	0.6832	1107	143	641	601	15890	8162	7662
12	12	tort	1	1	1	1	90	0.00806	0.6752	1147	71	568	541	0.6224	1014	219	598	542	15890	7640	6625
13	13	tort	1	1	1	1	97	0.009513	0.6124	1244	6	757	287	0.568	1114	31	756	306	15890	9738	3619
14	14	tort	1	1	1	1	87	0.009726	0.6512	1227	0	678	401	0.6152	1125	89	684	413	15890	8729	5083
15	15	tort	1	1	1	1	107	0.009903	0.7032	1232	18	706	526	0.6672	1168	64	721	500	15890	9212	6326
16	16	tort	1	1	1	1	100	0.008788	0.7008	1027	223	508	725	0.6728	939	311	490	743	15890	6237	9453
17	17	tort	1	1	1	1	108	0.009989	0.6224	1208	26	742	348	0.592	1108	73	720	372	15890	9452	4622
18	18	tort	1	1	1	1	100	0.009783	0.6632	1014	236	582	644	0.6856	1073	177	589	641	15890	7497	8134
19	19	tort	1	1	1	1	95	0.009006	0.6348	1153	74	676	434	0.6036	1044	162	639	465	15890	8303	5730
20	20	tort	1	1	1	1	92	0.009228	0.6516	1167	66	636	462	0.6168	1096	125	665	446	15890	8192	5755

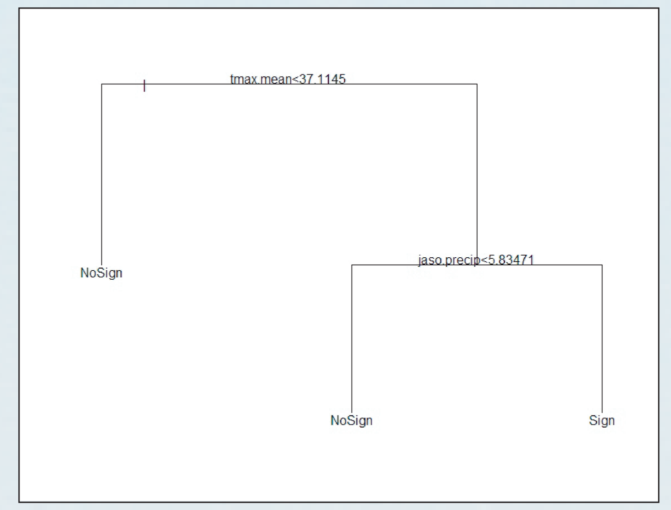
Non-predicted Area	Yes	No	ChiSq	p	Commission	Omission (int)	Omission (ext)	Status	Message	Layers (used for all runs)
1072	54	16	27.23186405	1.8046E-07	46.05412209	14.64	22.85714286	Processed	Success (104 unique points used)	comp03pt_ag_b
4636	0	70	0	1	0	34.32	100	Processed	Success (105 unique points used)	comp03pt_ma_b
984	64	6	38.00922226	7.0411E-10	54.75141598	8.4	8.571428571	Processed	Success (103 unique points used)	comp03pt_sh_b
668	54	16	59.3295627	1.33358E-14	33.64380113	20.48	22.85714286	Processed	Success (104 unique points used)	geocd_ab_b
716	47	23	21.09150688	4.37865E-06	40.22655758	19.04	32.85714286	Processed	Success (104 unique points used)	geocd_l1_b
988	62	8	37.74529924	8.06107E-10	51.8816866	9.84	11.42857143	Processed	Success (104 unique points used)	geocd_lft_b
2863	67	3	41.66956381	1.08078E-10	57.58338578	1.04	4.285714286	Processed	Success (104 unique points used)	geocd_mat_b
837	52	18	14.80817863	0.000119018	51.29641284	6.24	25.71428571	Processed	Success (104 unique points used)	geocd_ml_b
146	50	20	36.74807675	1.34423E-09	36.53870359	23.12	28.57142857	Processed	Success (104 unique points used)	jaso_u_b
123	53	17	44.18491365	2.98775E-11	37.29389553	20.16	24.28571429	Processed	Success (104 unique points used)	mamj_u_b
66	61	9	35.86701829	2.11255E-09	51.36563877	13.44	12.85714286	Processed	Success (104 unique points used)	mojveg_l1_b
1625	57	13	31.18448469	2.34634E-08	48.08055381	5.68	18.57142857	Processed	Success (104 unique points used)	mojveg_lc_b
2533	62	8	21.96799849	2.77235E-06	61.28382631	0.48	11.42857143	Processed	Success (103 unique points used)	mojveg_sys_b
2078	63	7	34.76819048	3.71392E-09	54.9339207	0	10	Processed	Success (104 unique points used)	moj_ned_b2
352	65	5	34.96129035	3.36326E-09	57.97356828	1.44	7.142857143	Processed	Success (104 unique points used)	ndjf_u_b
200	51	19	33.15450161	8.51191E-09	39.25110132	17.84	27.14285714	Processed	Success (105 unique points used)	tmax_u_b
1816	63	7	27.04753696	1.98513E-07	59.48395217	2.08	10	Processed	Success (105 unique points used)	tmin_u_b
259	60	10	41.70823626	1.05962E-10	47.18061674	18.88	14.28571429	Processed	Success (104 unique points used)	
1857	58	12	26.27855358	2.95553E-07	52.2529893	5.92	17.14285714	Processed	Success (102 unique points used)	
1943	61	9	35.49730713	2.55403E-09	51.55443675	5.28	12.85714286	Processed	Success (103 unique points used)	

Output table for a test of the GARP model, using environmental data for Study Area B (see map output above, left): landforms, surficial geology, vegetation types, elevation, temperature, and seasonal precipitation.

Test of decision tree model

We are using S-Plus (version 6.2.1, Insightful Corporation, Seattle, WA, 2003) for tree modeling, a non-parametric method of iteratively partitioning or splitting data representing the dependent variable into increasingly homogeneous subsets or nodes using decision rules based on critical values of independent variables. For our initial tests, we ran the decision tree model using the data we have for Study Area B.





The first iteration of the tree model resulted in a 67-node tree with 8 of the 9 independent variables used in the model. The misclassification rate of 0.157 implied that 84% of the occurrence observations were correctly classified. The tree was "pruned" to examine variables used, critical values of variables, and the relative decrease in misclassification with increase of node size (Table 2). The tree with 3 nodes resulted from a model that explains 67% of the sign/no sign observations.

Table 1. Environmental parameters examined for decision tree modeling in study area B.

Environmental Parameter	Input Code	Explanation
Precipitation	Jaso.precip	July-Oct. ave. (mm)
	Mamj.precip	March-June ave. (mm)
	Ndjf.precip	Nov.-Feb. ave. (mm)
Temperature	Tmax.mean	Ave. max Temp (˚C)
	Tmin.mean	Ave. min Temp (˚C)
Elevation	Ned.elev	Elevation (m)
Substrate	LF.ABBR	Landform
	CMP.ABBR	Geologic composition
	MAT.TYPE	Material type

Table 2. Inclusion of environmental parameters in various tree output*

Environmental Parameter	Input Code	Inclusion of parameters by tree node size and misclassification rate					
		3 (.331)	4 (.323)	6 (.312)	7 (.303)	9 (.267)	67 (.157)
Precipitation	Jaso.precip	x	x	x	x	x	x
	Mamj.precip						x
	Ndjf.precip	x		x	x	x	x
Temperature	Tmax.mean	x	x	x	x	x	x
	Tmin.mean					x	x
Elevation	Ned.elev						x
Substrate	LF.ABBR		x	x	x	x	x
	CMP.ABBR		x	x	x	x	x
	MAT.TYPE						

* Trees with 5 or 8 nodes could not be created as output as a result of how the splitting routine handled the data.

Next steps and future work

- continue to gather tortoise location data from various sources
- combine all tortoise location data into a comprehensive database for use in the habitat model
- create a climate model that predicts spatial and temporal precipitation patterns
- create map(s) of annual plant productivity
- continue to collect and incorporate into models new and additional enviromental data
- iteratively refine and test data input and model parameters for both the GARP and decision tree models
- test and validate model results, using occurrence data withheld from modeling
- compare results from comparable GARP and decision tree models, and results from models run with environmental data at different scales, extents, and geographic areas
- investigate other habitat model structures
- use maps of anthropogenic influences (roads, urban areas, etc.) to constrain areas of predicted suitable habitat
- expert review of model output

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Reference

Scachetti-Pereira, R. 2002. Desktop GARP. University of Kansas Natural History Museum, Lawrence. Available from http://www.lifemapper.org/desktopgarp/ (accessed July 2004).

Contact Information

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