3. Existing Models Relevant to Habitat and Connectivity

29 October 2019
Mojave Desert Tortoise MOG Meeting
Desert Tortoise “Recovery Network” and Connectivity

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

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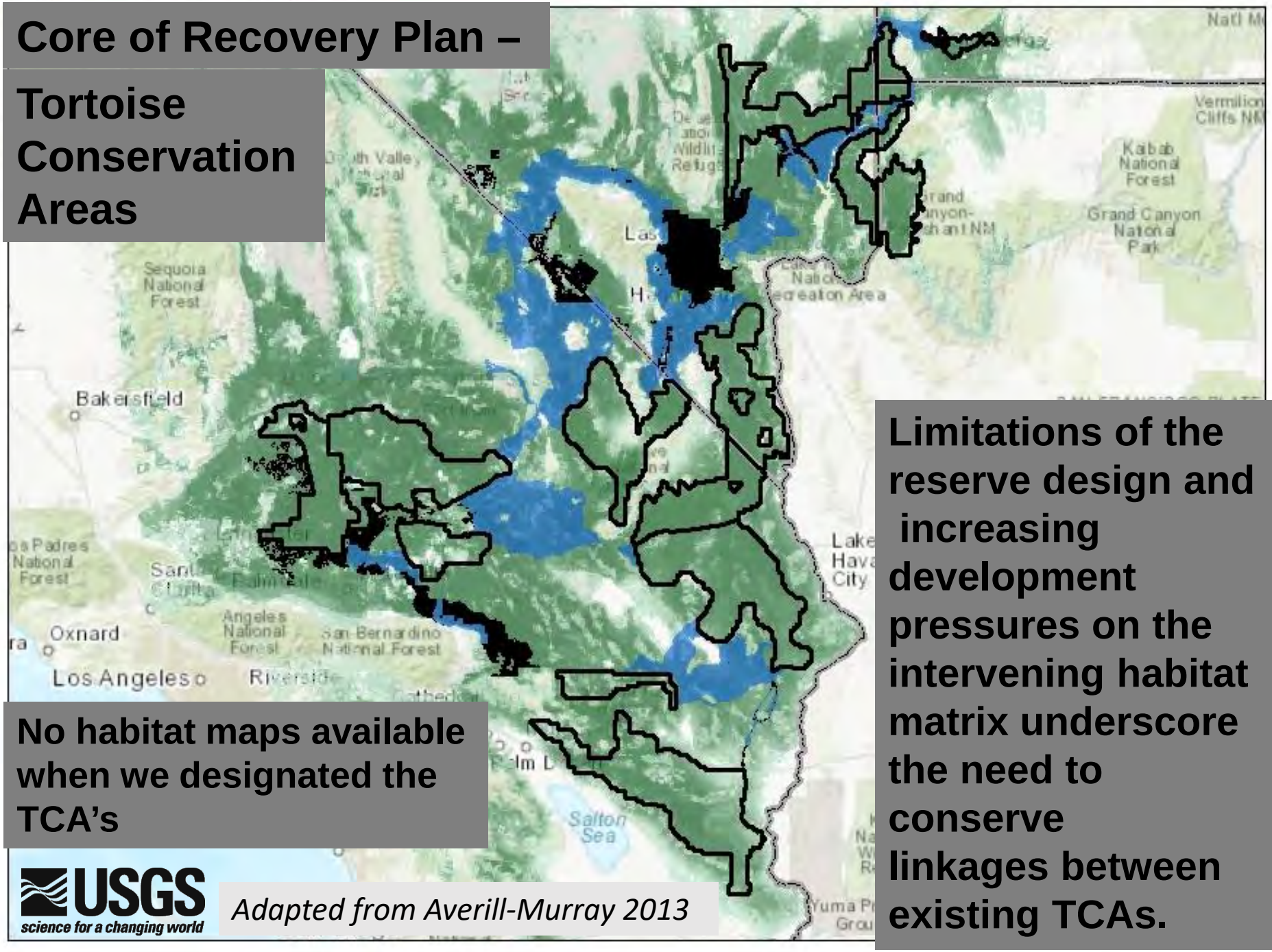
US Geological Survey
US Fish and Wildlife Service
US Bureau of Land Management
Utah Division of Wildlife Resources

Core of Recovery Plan – Tortoise Conservation Areas



No habitat maps available when we designated the TCA's

Limitations of the reserve design and increasing development pressures on the intervening habitat matrix underscore the need to conserve linkages between existing TCAs.

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Adapted from Averill-Murray 2013

5 Models Relevant to Mojave Desert Tortoise Habitat and Connectivity

3.1 USGS habitat model (Nussear et al. 2009)
(*basis for most current management*)

3.2 Gene flow model (Hagerty et al. 2010)

3.3 USFWS linkage model (Averill-Murray et al. 2013)
(*comparison with gene flow model*)

3.4 Omnidirectional connectivity model (Gray et al. 2019)

3.5 Intactness model (Carter et al. *Submitted*)

3.1 USGS Habitat Suitability Model (2009)

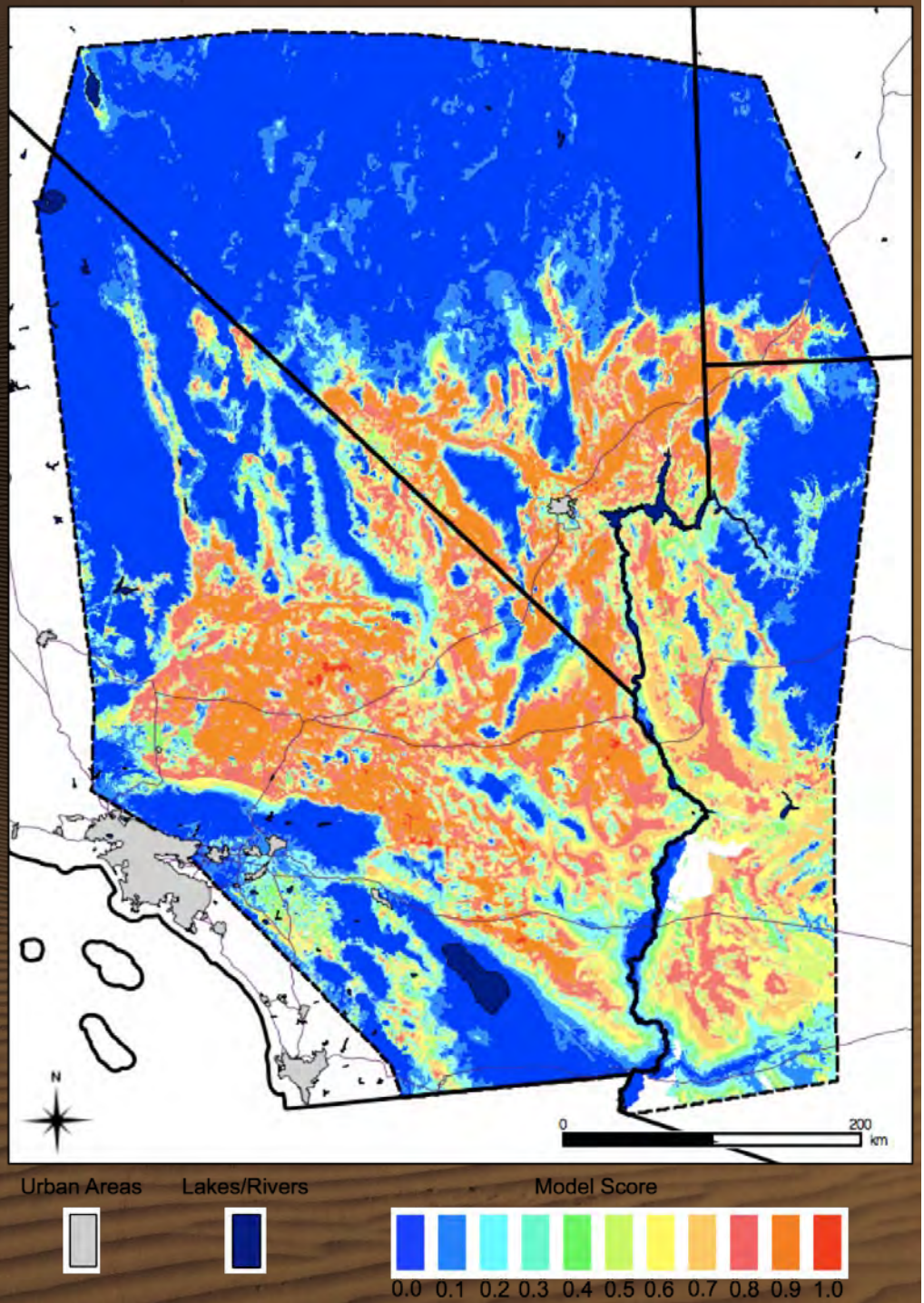
K.E. Nussear, T.C. Esque, R.D. Inman, L. Gass, K.A. Thomas, C.S.A. Wallace, J.B. Blainey, D.M. Miller, and R.H. Webb

What is the current spatial extent of habitats potentially suitable for occupation by tortoises?

Statistical probability of Mojave Desert Tortoise habitat potential

Based on correlation of:

1. tortoise presence points
2. statistically derived pseudo-absences (where we do not have presence data)
3. a variety of habitat variables



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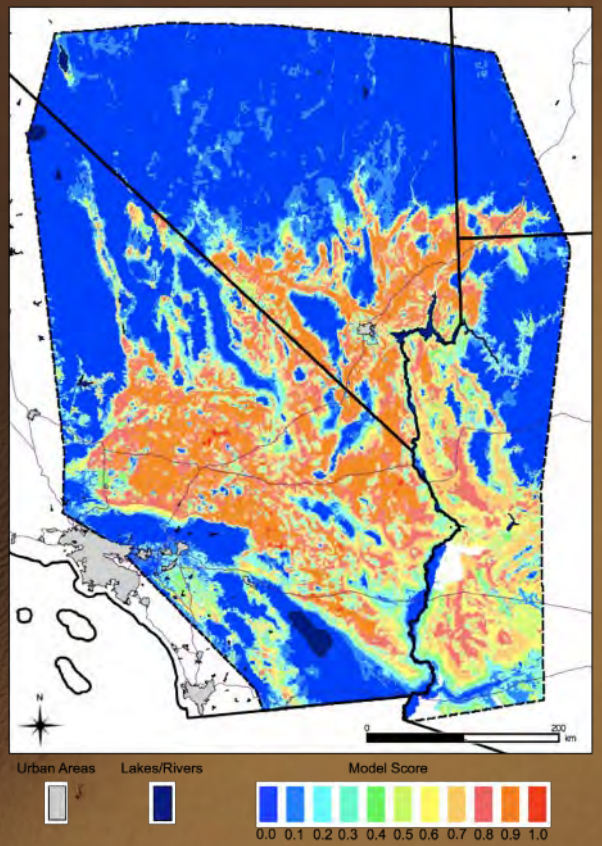
Habitat Variables

Mean dry season ppt for 30-y normal period
spatially distributed coefficient of variation
Mean wet season ppt for 30-y normal period
spatially distributed coefficient of variation
Elevation
Slope
Aspect (northness or eastness)
Surface Roughness (% smooth, % rough)
Avg Soil bulk density
Depth to bedrock
Avg % rocks >254 mm
Perennial Plant Cover



Maxent Model
Area - 336,594 km^2
15,311 desert tortoise presence points
6350 grid cell points
-1270 withheld for model testing
5080 points used for model training

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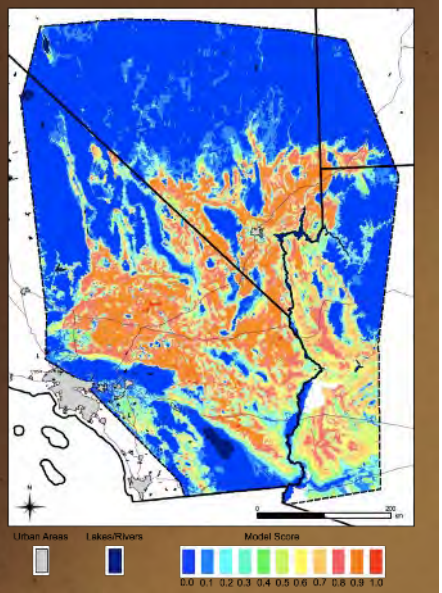
Applications

1. Project Proponent Planning
2. Establishing survey requirements
3. Evaluating reports on tortoises
4. Base for subsequent models
5. Modeling layers also applied to many other problems



Models must be updated as environmental layers & computational ability are always improving and increasing.

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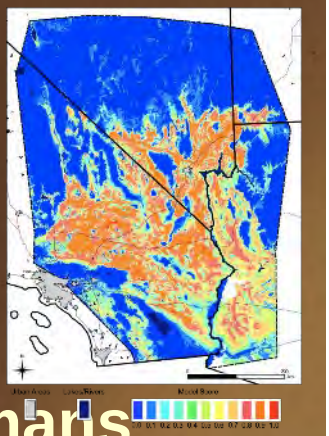
Assumptions, Limitations, Caveats for Habitat Model



1. This model assumes pristine habitat status.
   … it does not consider the influence of humans in the distribution.

   For Example:
   impermeable surfaces (roads, buildings, solar arrays)
   linear disturbances (power, digital, and pipe lines)
   invasive plants and fire …..
   ….. were not factored into the pattern

2. 1 km^2 resolution – relevant to tortoise movement
   Finer resolution desired for some applications.

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3.2 Gene flow model

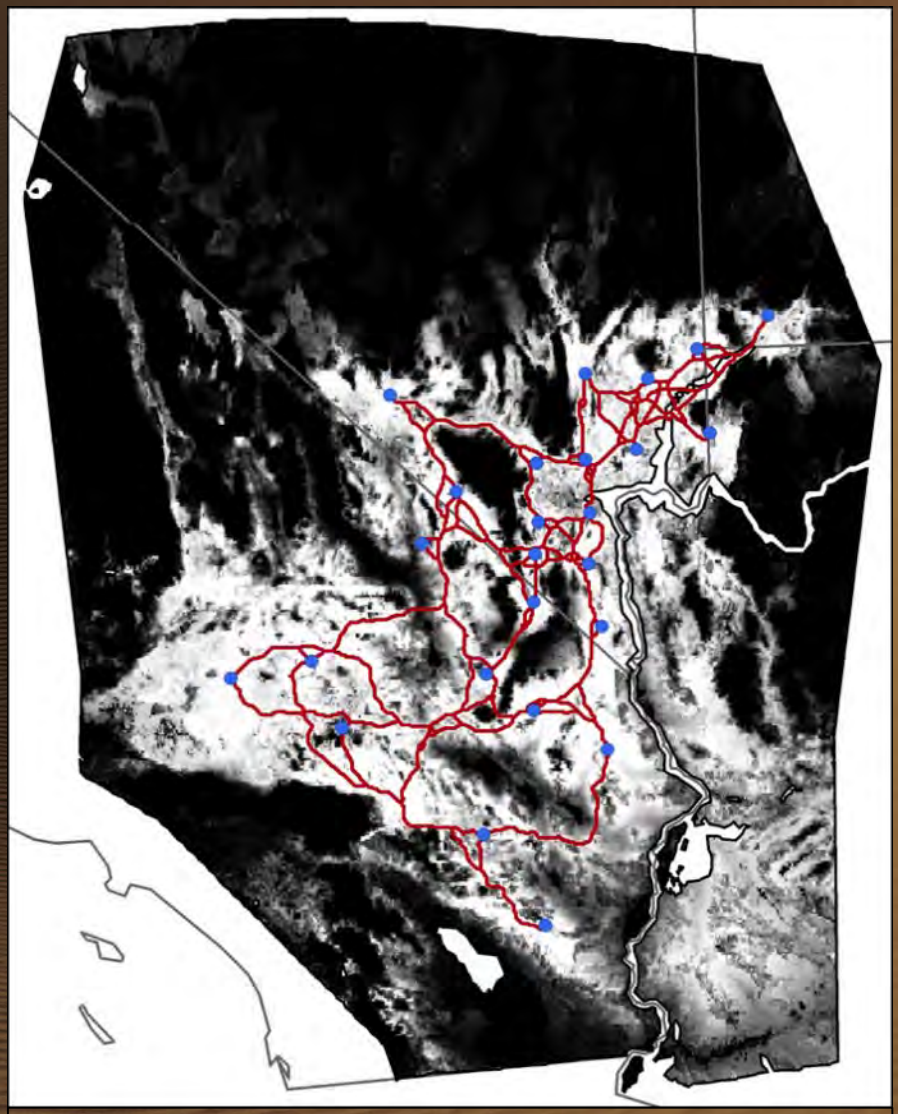
(2010)

B.E. Hagerty, K.E. Nussear, T.C. Esque, C.R. Tracy

What are the contributors to genetic isolation of desert tortoises across the Mojave Desert?

Investigated 3 factors that influence landscape connectivity

1. geographic distance – 68% (Murphy et al. 2007; Hagerty and Tracy 2010)
2. natural barriers to dispersal
3. landscape friction / permeability (a habitat's resistance to the flow of individuals through it)



Blue dots – 25 population centroids
Red lines - least cost paths between pairs of sampling locations.

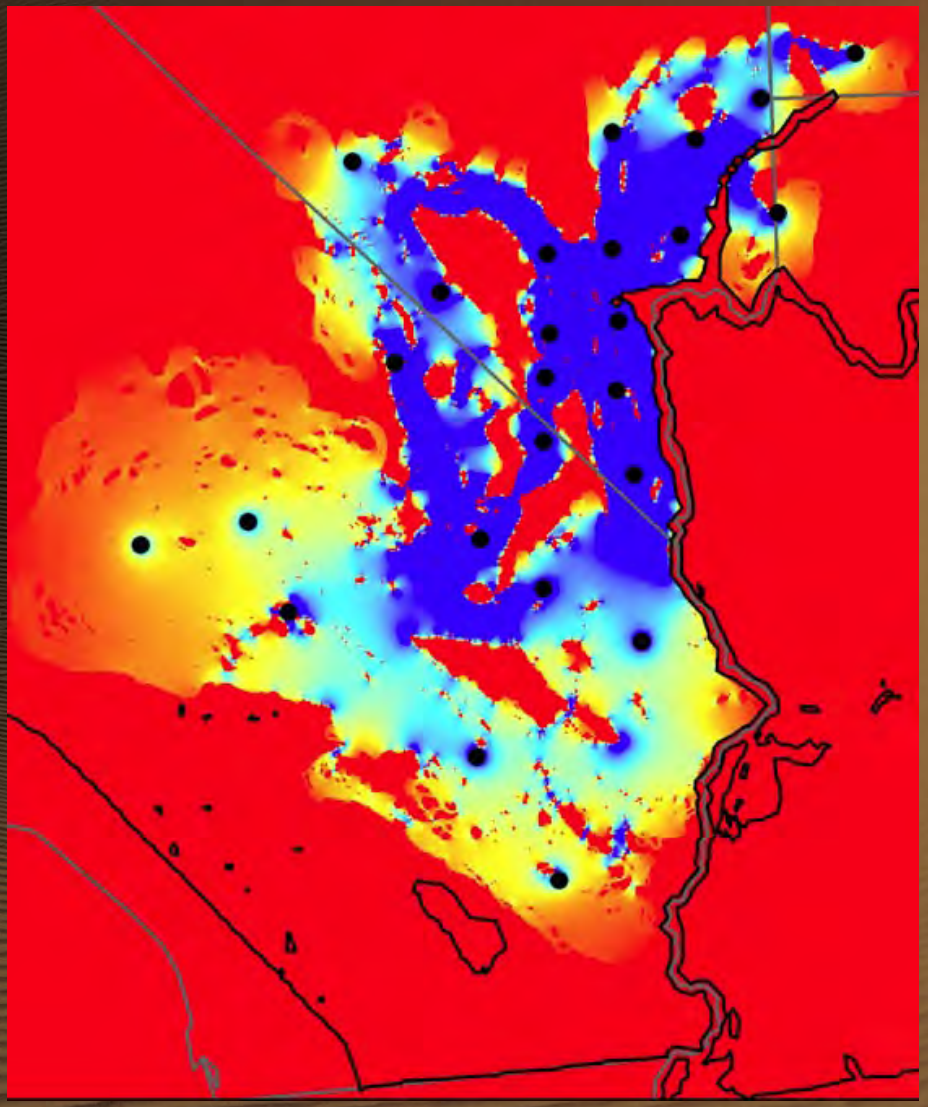
Assumptions, Limitations, Caveats for Genetic Connectivity

Habitat suitability is an appropriate estimate of habitat friction / permeability

Development was not factored in

Migrations rates per generation

Modeling does not address recent barriers to gene flow for the Mojave desert tortoise.



Cumulative current map between pairs of populations from the isolation-by-resistance models

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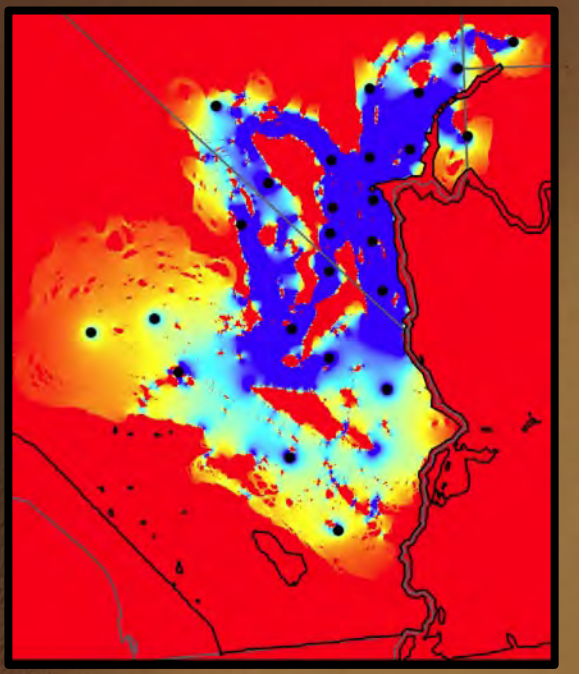
Geographic distance and dispersal barriers were dominant factors associated with genetic structure, while landscape friction had little to no influence.

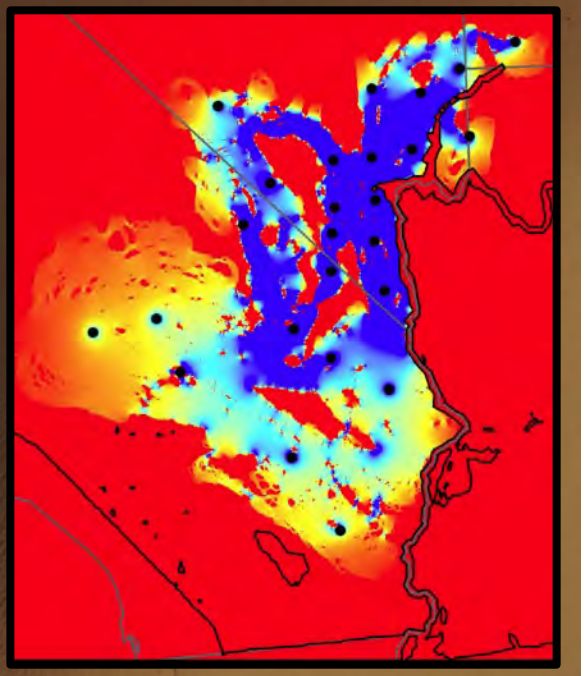


Perhaps habitat suitability values, in the original model, were not effective approximations of factors causing landscape friction.

Does this result de-couple habitat suitability from habitat permeability?

* When more than one pathway is available to traverse the landscape or the size of the path increases,

resistance to movement decreases



Habitat within the Mojave population of the desert tortoise ***was*** well connected.

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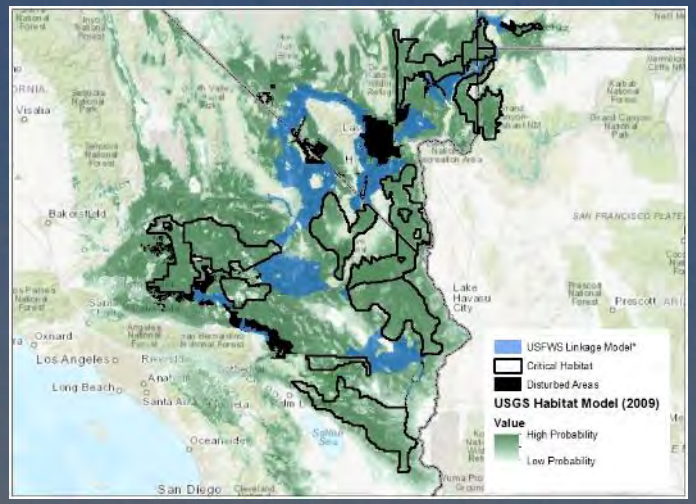
3.2 USFWS linkage model (2013)

R.C. Averill-Murray, C.R. Darst, N. Strout, and M. Wong

Main Question

Identify linkages between TCAs using **least-cost corridors** based on an underlying **habitat suitability model**, while accounting for highly disturbed areas such as military training areas and Off-highway vehicle open areas



Methods

1. Habitat Suitability Model base
2. National Landcover Dataset (Fry et al. 2011) developed-areas layer
3. The Nature Conservancy's "Highly Converted Areas" for the Mojave ecoregion (Randall et al. op. cit.) and
4. Conservation Category D areas for the Sonoran ecoregion (Conservation Biology Institute op. cit.)

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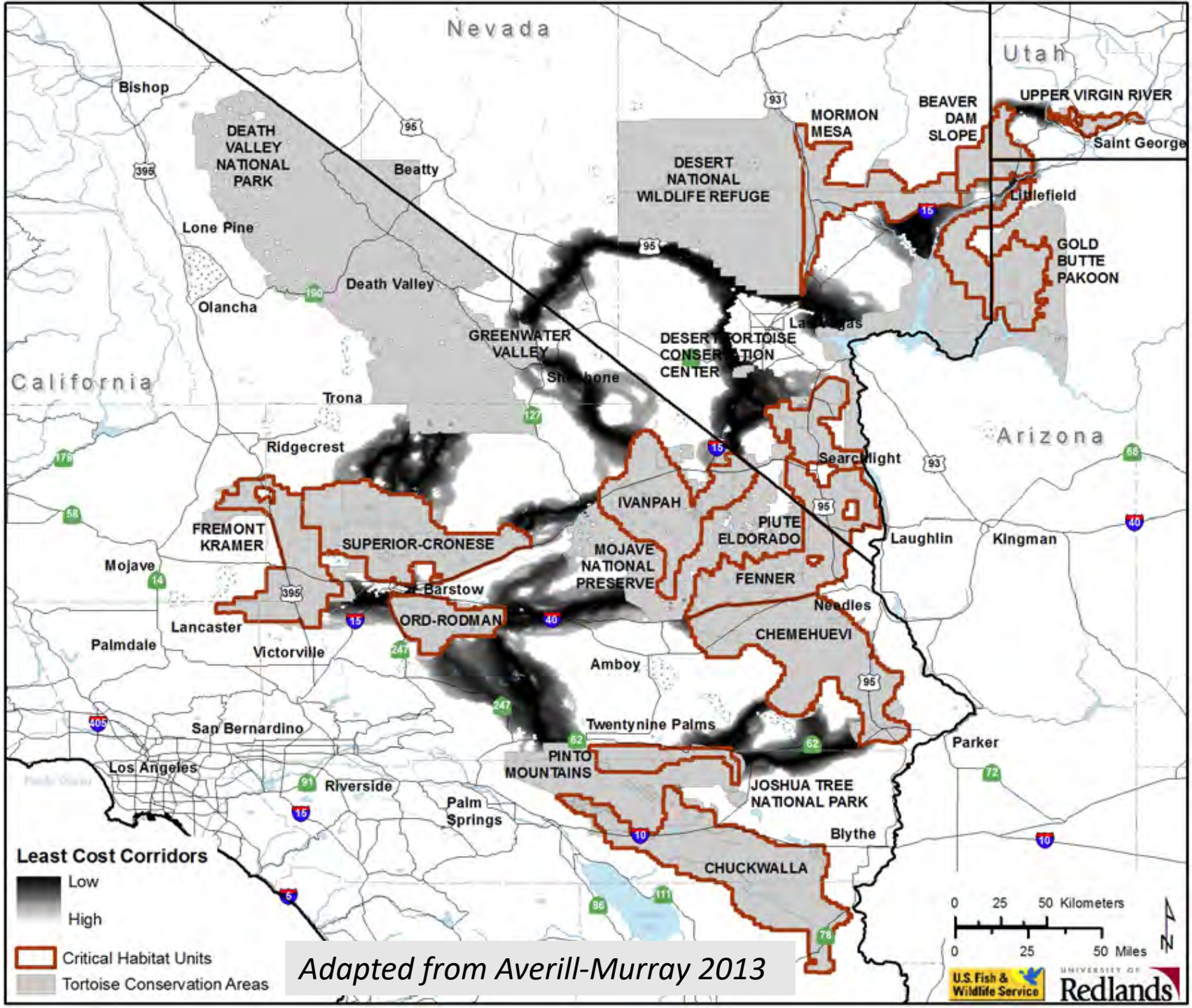
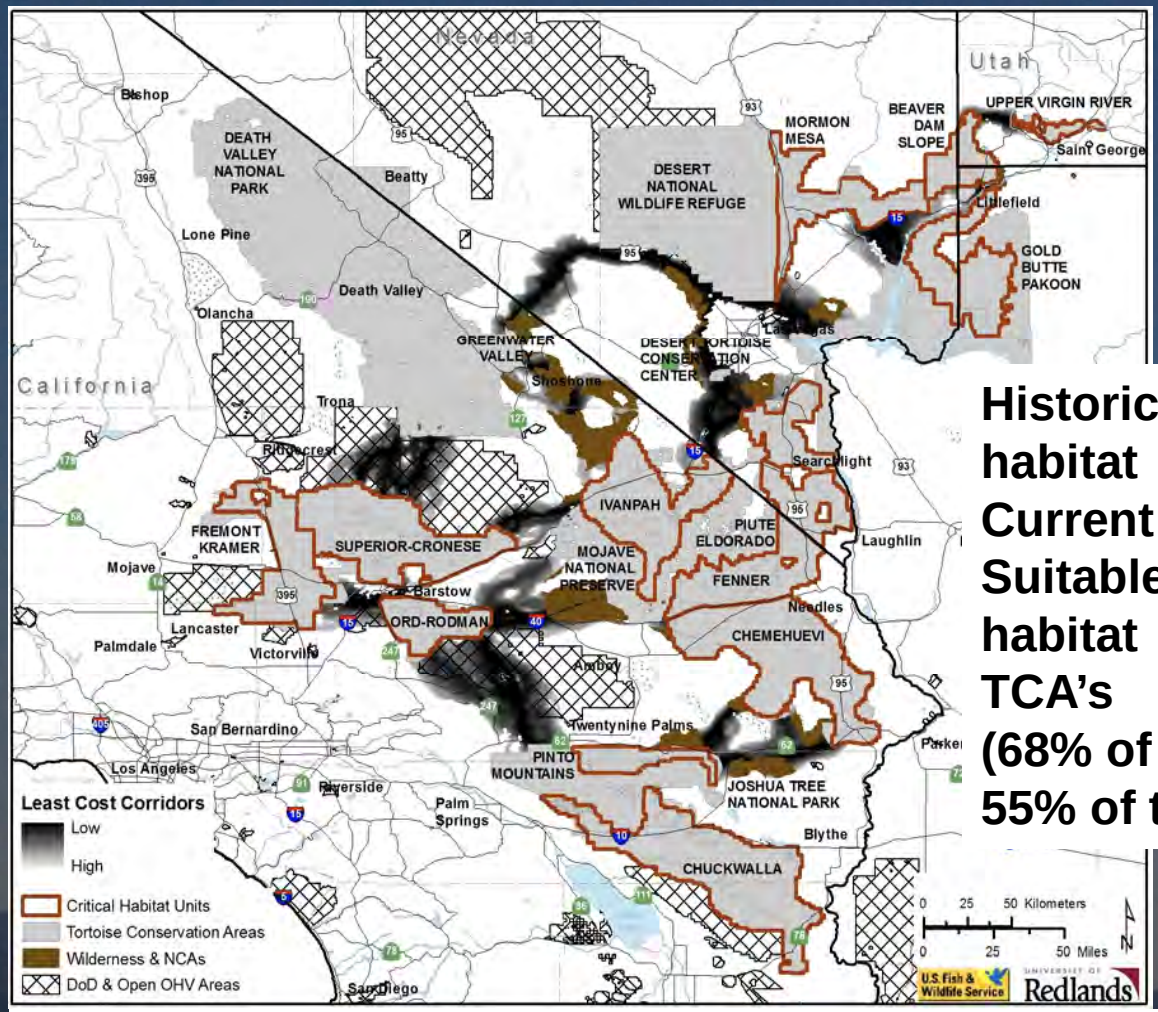


Adapted from Averill-Murray 2013



Historic MDT habitat 83,138 km^2

Current Suitable habitat 67,000 km^2 (81%)

TCA's 45,340 km^2

(68% of total current habitat, 55% of total historic habitat)

Suitable Habitat within linkages	**17,831 km^2**
DOD (loss)	**2,375 km^2 (13%)**
OHV (loss)	**875 km^2 (5%)**
Wilderness (protected)	**2,952 km^2 (17%)**

Application of linkage models…

…will require refinement at the local level, and questions remain about the ultimate ability of a conservation network based on these models to support viable tortoise populations *and* accommodate climate change.

Nevertheless, conservation decisions cannot be delayed while awaiting final answers to all relevant questions, [because] areas proposed for permanent habitat conversion, critical linkages may be severed before they are protected.

Averill-Murray et al. 2013

3.4 Omnidirectional connectivity model (2019)

M.E. Gray, B.G. Dickson, K.E. Nussear, T.C. Esque, and T. Chang

A range-wide model of contemporary, omnidirectional connectivity for the threatened Mojave desert tortoise

HABITAT MOVEMENT QUALITY

Objectives

(1) Leverage existing telemetry data to develop an empirically based, range-wide model and map of movement habitat potential (i.e., a map of landscape conductance) for the Mojave desert tortoise, and at a resolution relevant to the scale of movement

(2) use this model to derive a range-wide estimate and map of potential omnidirectional connectivity, and that did not rely on the delineation of discrete habitat or population cores.

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Methods

Acquire high resolution desert tortoise movement data
Brownian Bridge Movement Models

<u>Habitat covariates for movement habitat quality describing</u> :
presence of desert washes,
distance to minor roads,
amount of available vegetation,
30-yr average temperatures

Environmental and human-associated landscape filters were applied spatially using a variety of publicly available data sources

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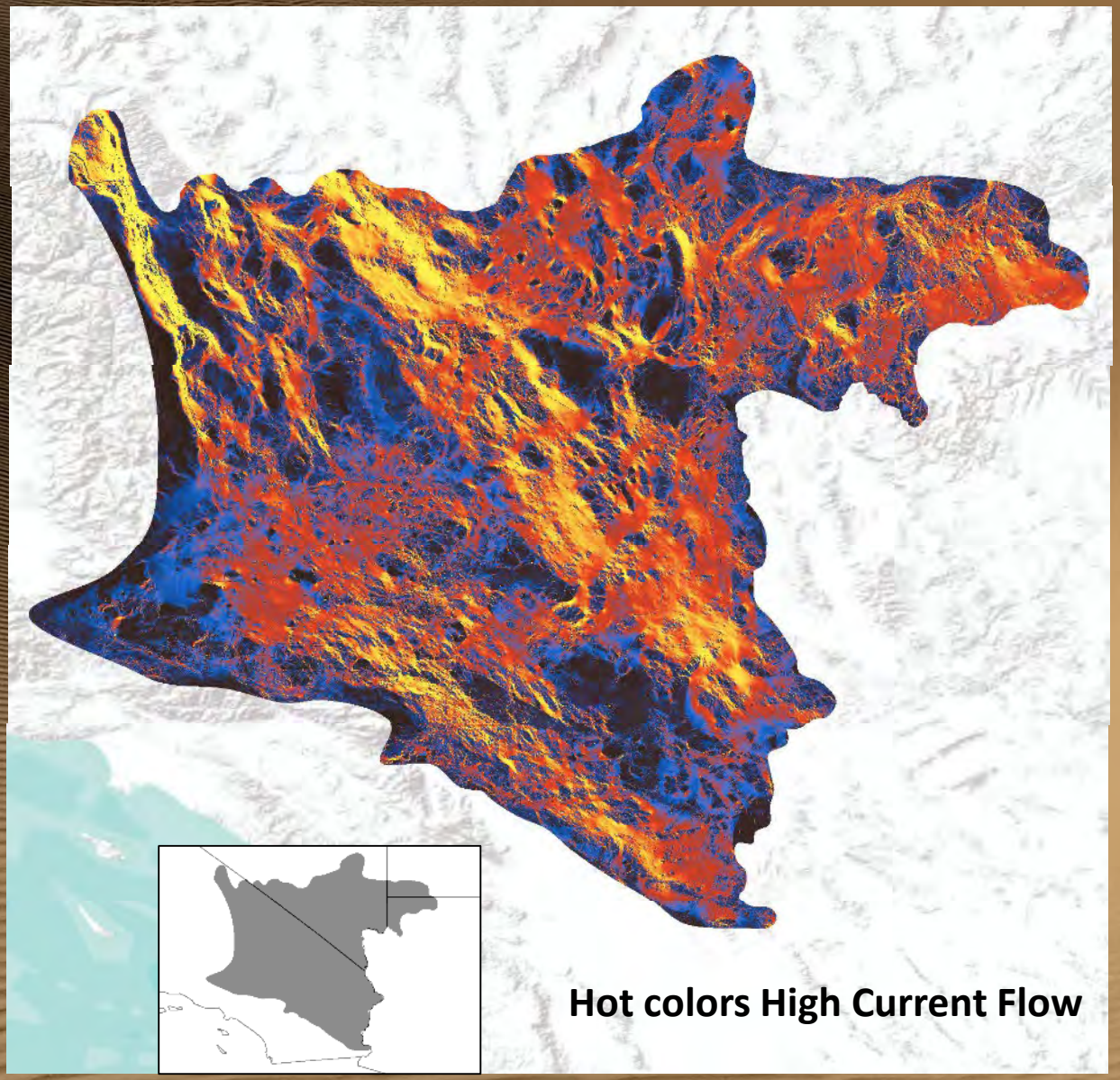

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Adapted from Gray et al. 2019

Results

These models differentiate habitat movement quality from other factors associated with other life history requirements (e.g. precipitation, food plant availability)

New spatial layers have application for many future analyses e.g. wash spatial layer

Non centralized approach identify areas previously overlooked for their value desert tortoise habitat connectivity corridors

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3.5 Intactness model ….or Terrestrial Disturbance Index (*Submitted to Endangered Species Research*)

S.K. Carter, K.E. Nussear, T.C. Esque, I.I.F. Leinwand,
E. Masters, R.D. Inman, Natasha B. Carr, and L.J. Allison

Connecting landscape approaches and species-level conservation: quantifying development to inform management of Mojave and Sonoran desert tortoise habitat.

1. **To what extent may existing development threaten desert tortoise habitat rangewide?**
2. **Do protective designations correspond with lower development levels of desert tortoise habitat?**
3. **Are there relatively undeveloped areas of desert tortoise habitat that warrants additional protection?**

*Paper includes Mojave and Sonora desert tortoises

Methods

Map potential Desert Tortoise Habitat

Develop a generalized of terrestrial development index (TDI)
cultivated agriculture, energy development, surface mines and quarries, pipelines and transmission lines, and transportation infrastructure.

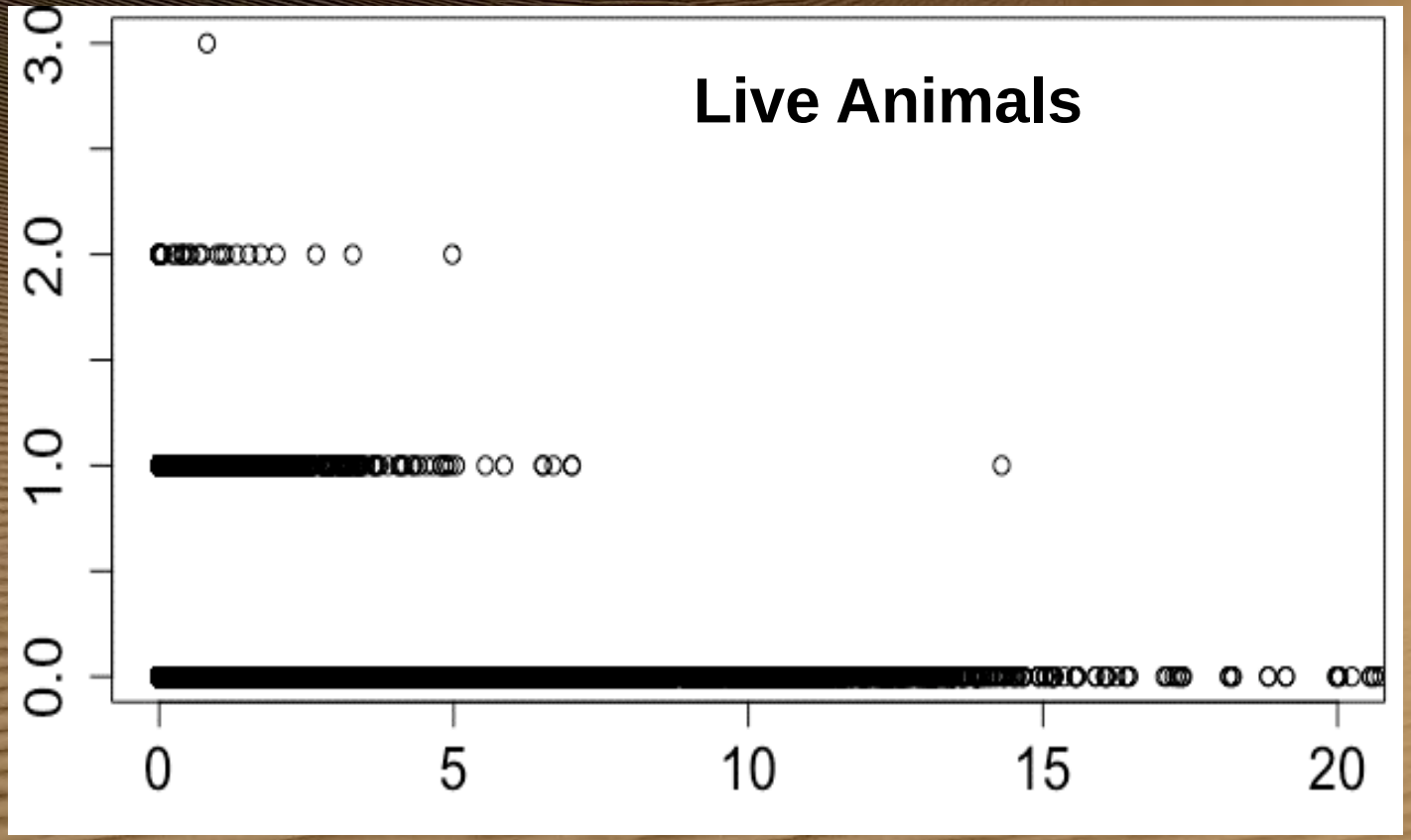
Determining levels of development relevant to desert tortoises –
Disturbance proportion of the pixels = **Terrestrial Disturbance Index (TDI**

Evaluated threats from existing development to potential habitat
The relationship between TDI and desert tortoise abundance (live versus dead) from distance sampling results was analyzed at multiple scales

We mapped and quantified the frequency distribution of TDI on habitat and sorted it by land administrator

No development within 1 km = undeveloped areas or areas least impacted by development

Live tortoise encounter rates were near zero as TDI values rose above 10%



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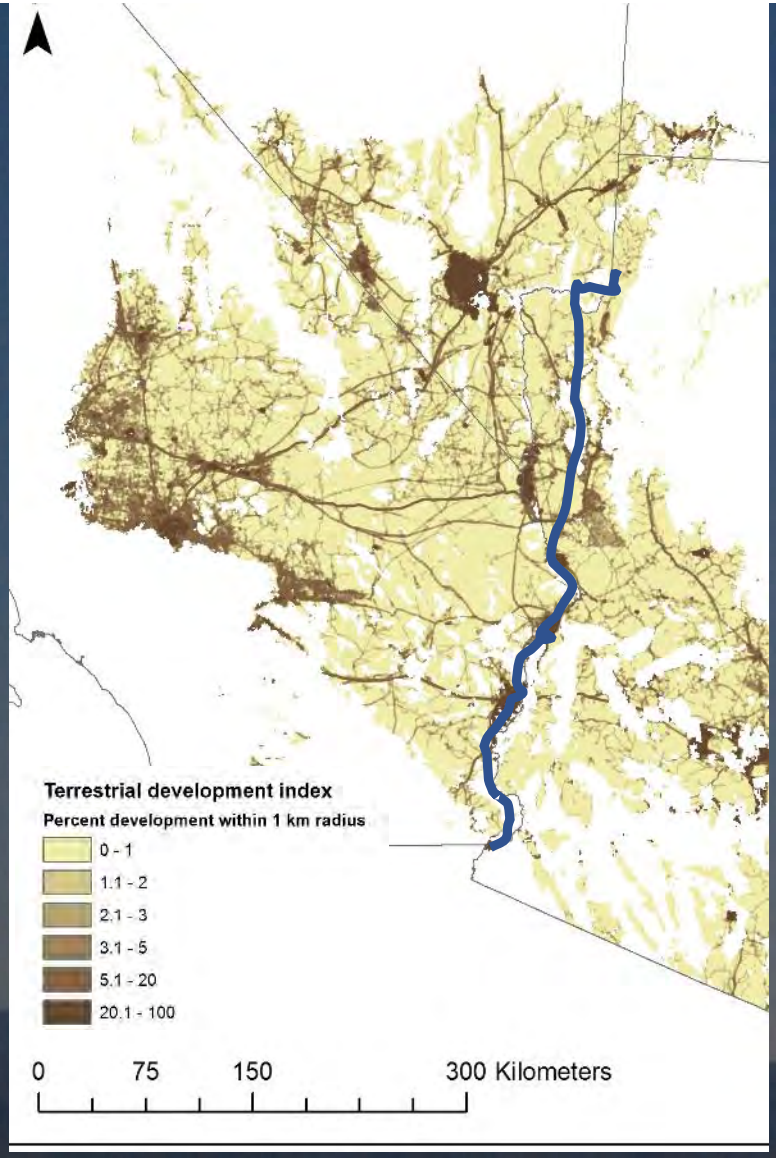
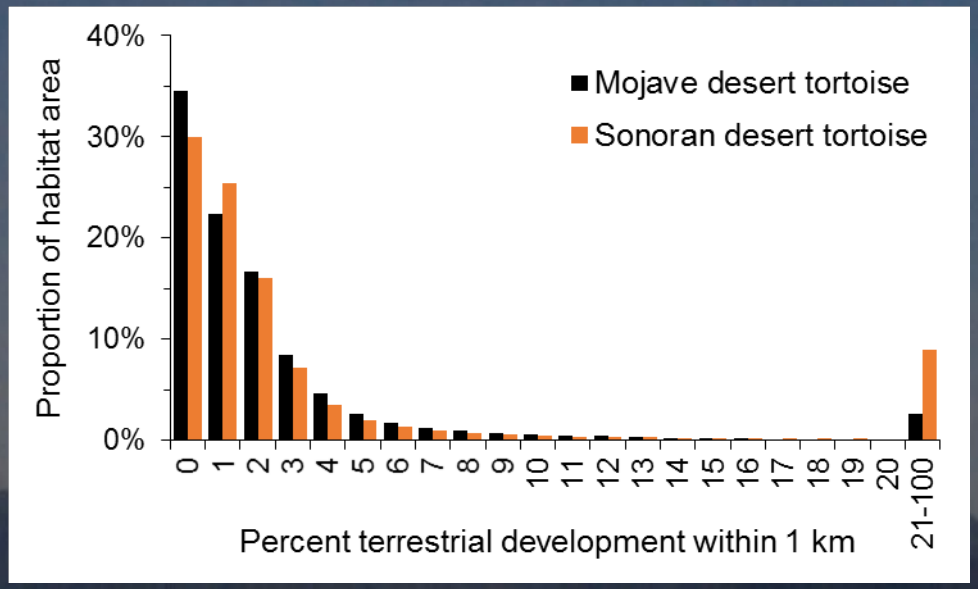


66% of Mojave desert tortoise habitat has development within 1km

5% has TDI of >10%

41-60% of federal lands
19% of State and local lands
7% of Private lands
have no development within 1 km



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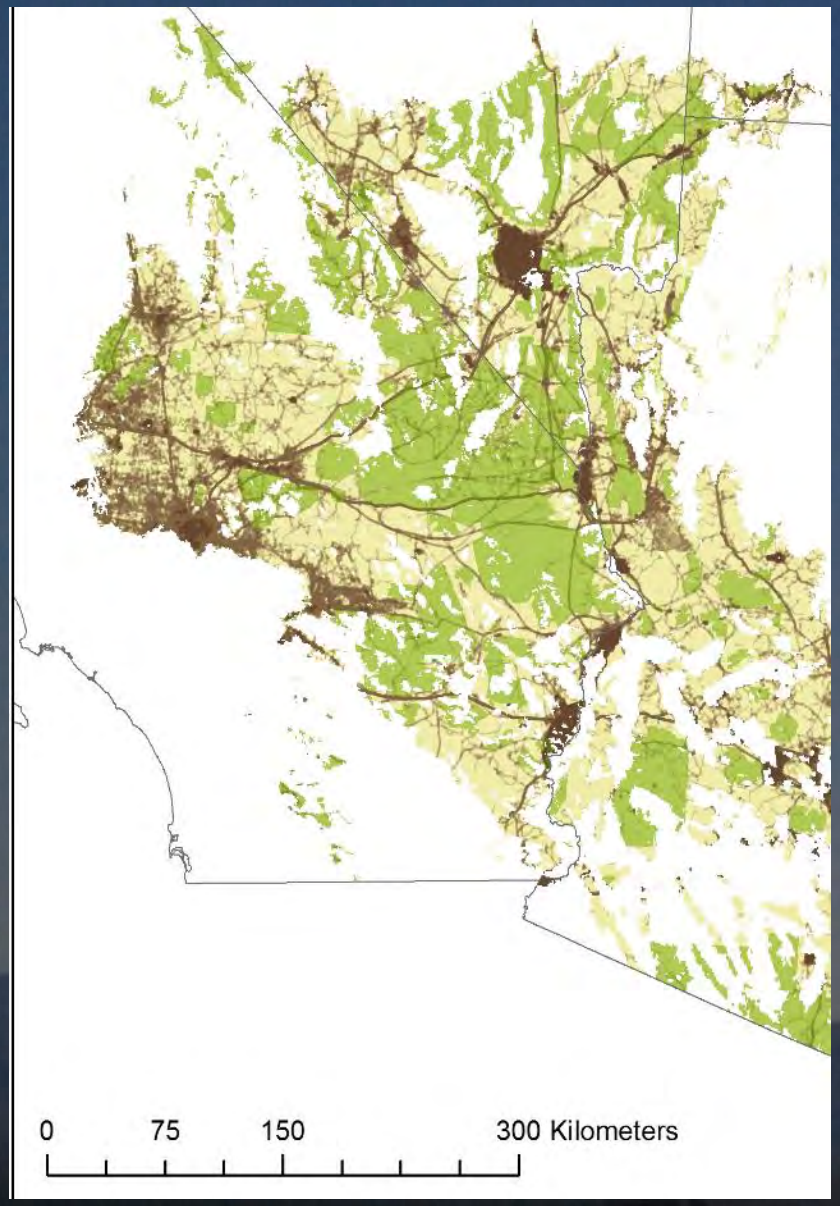


Permanently protected federal lands have substantially lower TDI than lands outside protected areas

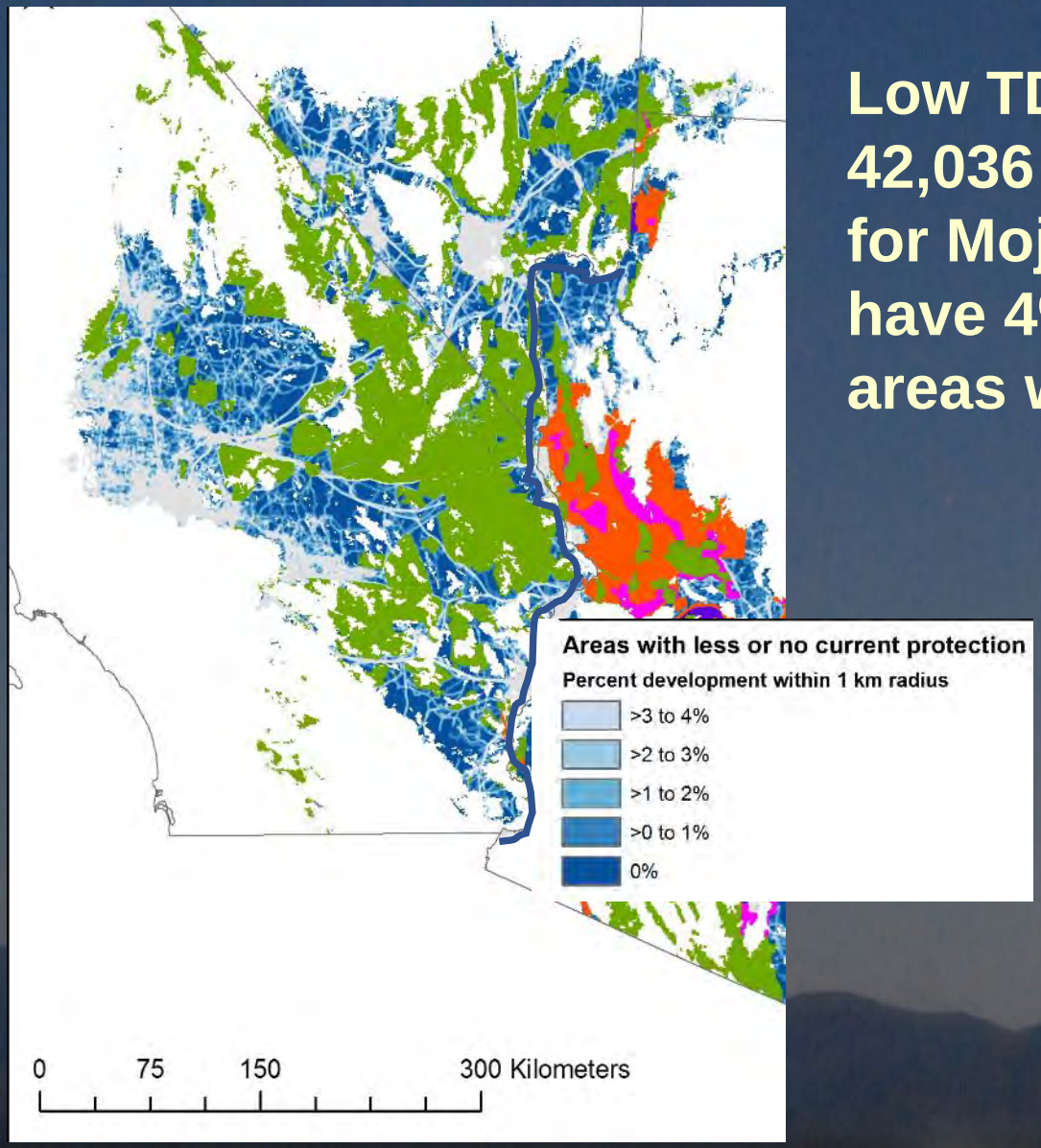
Protected desert tortoise habitat

GAP status 1 and 2 protected areas

Terrestrial development index

Percent development within 1 km radius

- 0 - 1
- 1.1 - 2
- 2.1 - 3
- 3.1 - 5
- 5.1 - 20
- 20.1 - 100



Low TDI areas encompassing 42,036 km^2 of potential habitat for Mojave desert tortoises have 4% or less developed areas within 1 km …..

….. and may be vulnerable to future development because they occur outside of existing protected areas

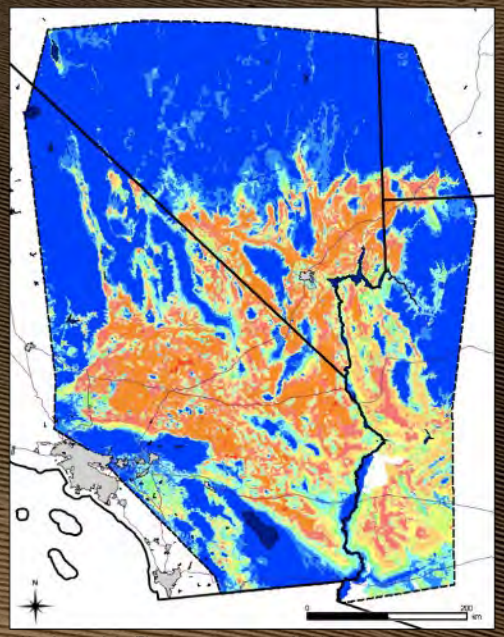
Conclusions

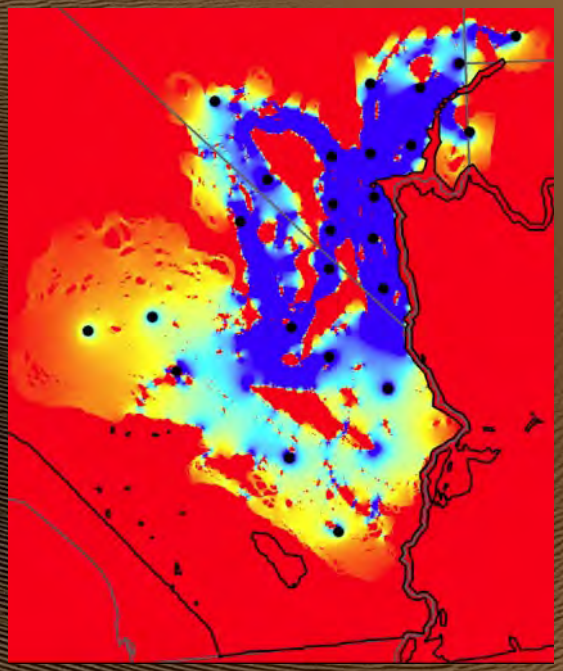
TDI > 10% are associated with fewer live tortoise, and lower values do not have a clear threshold for disturbance responses.

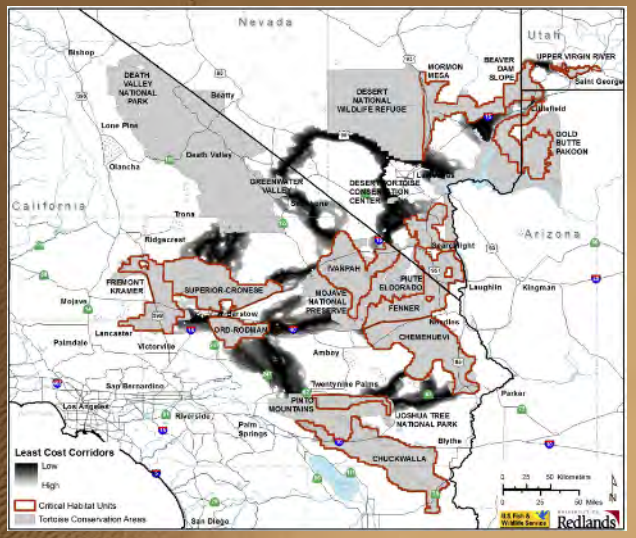
Protected lands are more strongly correlated with higher numbers of live tortoises –
BLM ACECs benefit tortoises

There are substantial undeveloped areas of desert tortoise habitat that would benefit from protection

There is a lot of potential to ask related questions about where the most effectively identify habitat corridors, or where more intensive management might increase the value of habitat to tortoises







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Habitat Suitability
Genetic Connectivity
Spatial Connectivity / Pinch Points
Permeability of Corridors
Resiliency by Redundancy of Corridors / Pathways
Habitat Quality / Patch Dynamics
Requirements versus Stressors
Flexibility / Climate Change
Density Surface / Habitat Quality