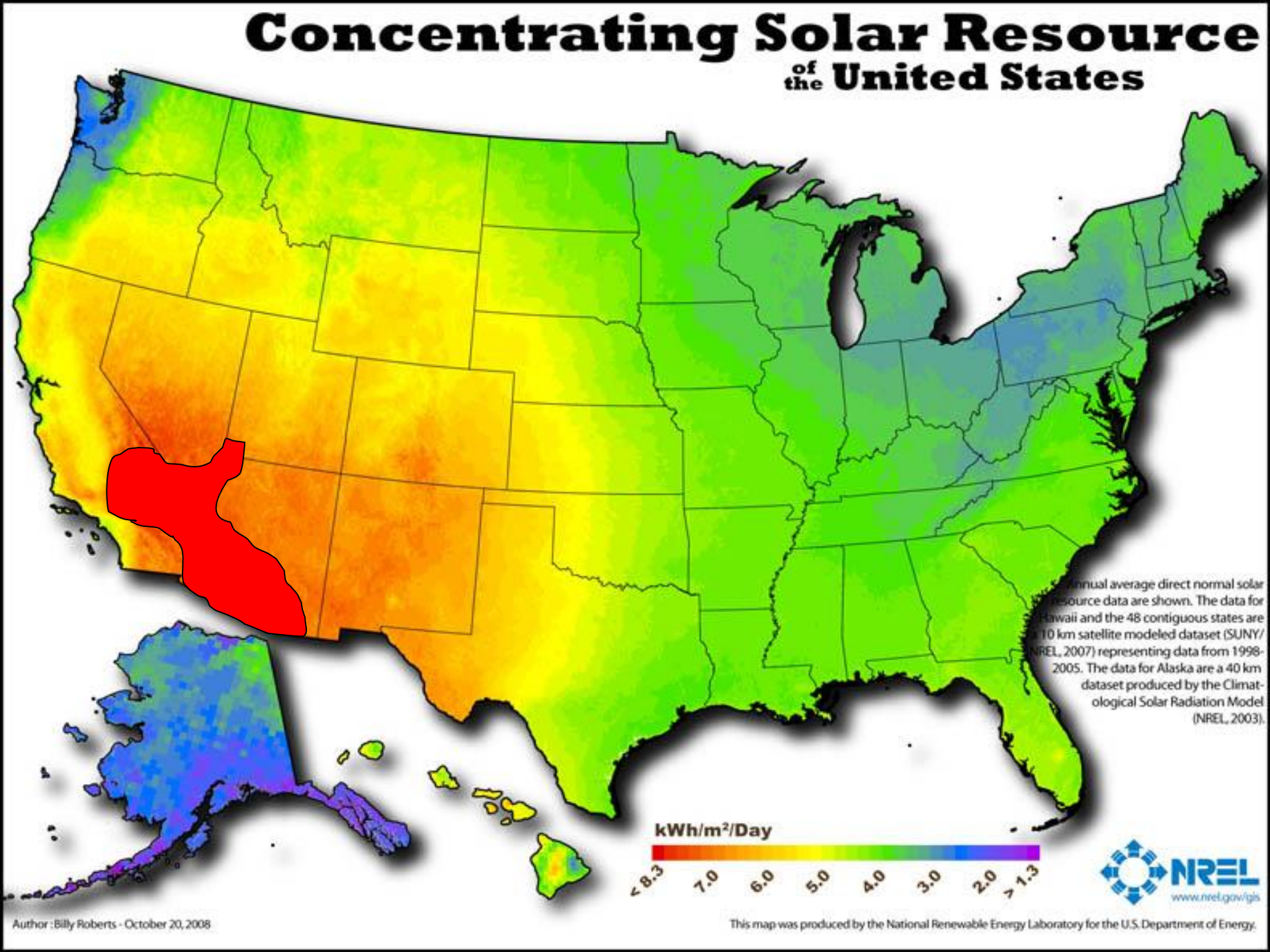
What do we know about the effects of utility-scale renewable energy (USRE) development and climate change on terrestrial wildlife especially the desert tortoise?

Jeff Lovich
USGS, Flagstaff, AZ

USGS science for a changing world

Concentrating Solar Resource of the United States



Annual average direct normal solar resource data are shown. The data for Hawaii and the 48 contiguous states are a 10 km satellite modeled dataset (SUNY/NREL, 2007) representing data from 1998-2005. The data for Alaska are a 40 km dataset produced by the Climatological Solar Radiation Model (NREL, 2003).

NREL
www.nrel.gov/gis

Author : Billy Roberts - October 20, 2008

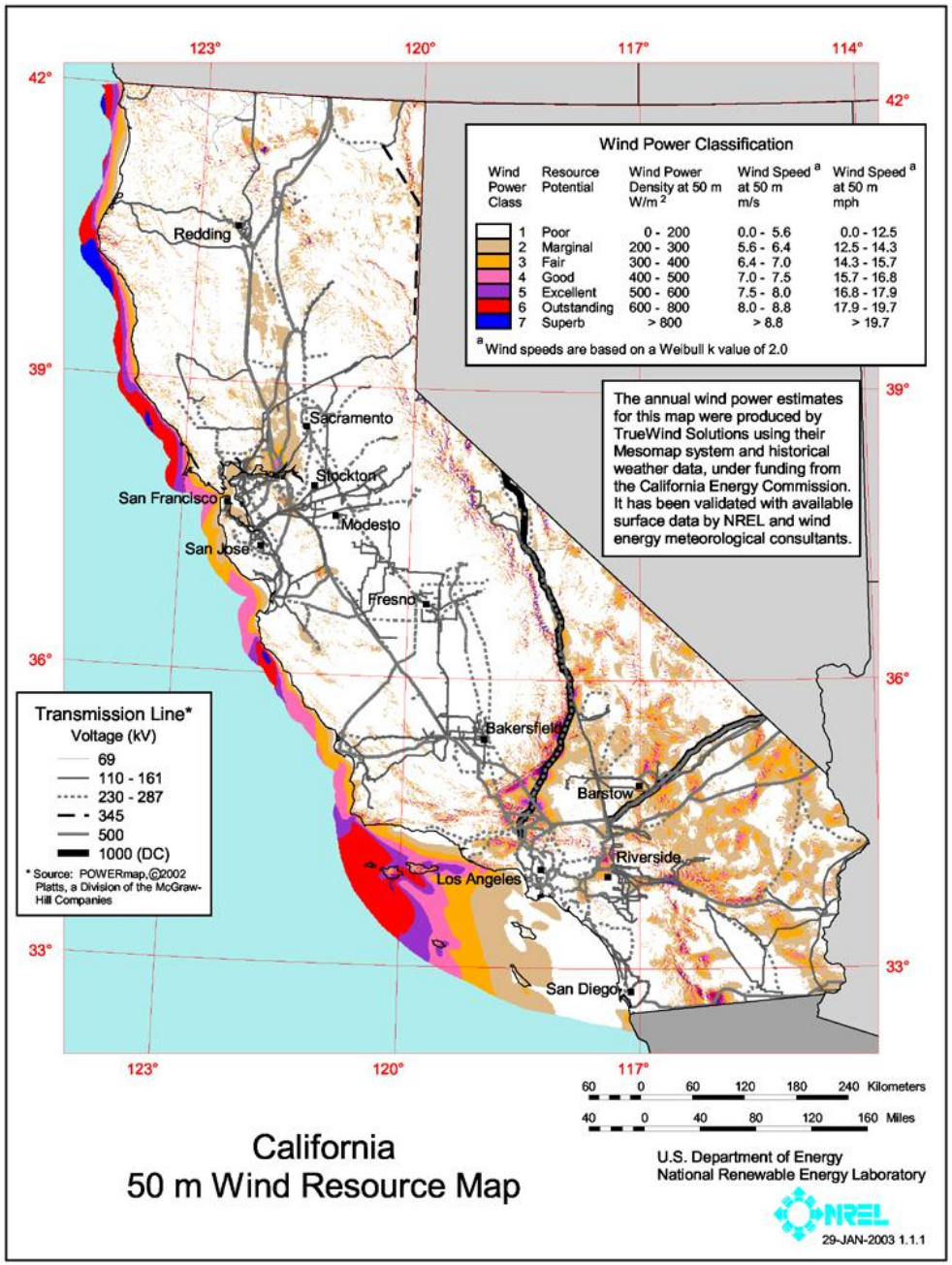
This map was produced by the National Renewable Energy Laboratory for the U.S. Department of Energy.

- **SOLAR**
  - BLM has at least 199 applications for industrial-scale solar plants totaling 1.7 million acres in the desert SW*
  - nearly 1 million acres in CA alone*
  - 718,926 acres proposed in AZ**

*High Country News, May 11, 2009

**http://www.blm.gov/pgdata/etc/medialib/blm/az/pdfs/energy.Par.62807.File.dat/Solar_Applications.pdf

Kramer Junction, CA from Wikipedia


123°
120°
117°
114°
42°
39°
36°
33°
Wind Power Classification
Wind Power Class
Resource Potential
Wind Power Density at 50 m W/m 2
Wind Speed a at 50 m m/s
Wind Speed a at 50 m mph
1 Poor 0 - 200 0.0 - 5.6 0.0 - 12.5
2 Marginal 200 - 300 5.6 - 6.4 12.5 - 14.3
3 Fair 300 - 400 6.4 - 7.0 14.3 - 15.7
4 Good 400 - 500 7.0 - 7.5 15.7 - 16.8
5 Excellent 500 - 600 7.5 - 8.0 16.8 - 17.9
6 Outstanding 600 - 800 8.0 - 8.8 17.9 - 19.7
7 Superb > 800 > 8.8 > 19.7
a Wind speeds are based on a Weibull k value of 2.0
The annual wind power estimates for this map were produced by TrueWind Solutions using their Mesomap system and historical weather data, under funding from the California Energy Commission. It has been validated with available surface data by NREL and wind energy meteorological consultants.
Redding
Sacramento
Stockton
San Francisco
Modesto
San Jose
Fresno
Bakersfield
Barstow
Riverside
Los Angeles
San Diego
Transmission Line*
Voltage (kV)
69
110 - 161
230 - 287
345
500
1000 (DC)
* Source: POWERmap, ©2002 Platts, a Division of the McGraw-Hill Companies
60 0 60 120 180 240 Kilometers
40 0 40 80 120 160 Miles
California
50 m Wind Resource Map
U.S. Department of Energy
National Renewable Energy Laboratory
NREL
29-JAN-2003 1.1.1

Objectives

- Overview of the scientific literature on the effects of USRE development on non-volant wildlife esp. the desert tortoise
- Climate change and desert tortoises: what are the vulnerabilities?


Effects of USRE development on volant wildlife are well-studied

Possible direct effects of USRE development on wildlife

- Mortality/stress associated with development/construction
- Mortality/stress associated with maintenance/operation

Possible indirect effects of USRE development on wildlife

- Habitat alteration (erosion, plant destruction, soil disturbance/invasive species, soil compaction, roads/edge-enhancement, enhanced fire potential)
- Habitat fragmentation
- Noise effects (1^{o} wind)
- Vibration effects (1^{o} wind)
- Electromagnetic effects (1^{o} wind)
- Microclimate effects (1^{o} solar)
- Predator attraction (carcasses of dead birds and bats?)

Noise effects

- elevated levels of vigilance
- increased caution

Noise effects (marine mammals)

- Harbor seals surface farther from sound source of playbacks of turbine sounds than controls
- Closest approaches increased in distance for harbor porpoises
- Echolocation clicks increase 2X during playback

OHV noise effects on desert animals

- hearing loss in kangaroo rats, desert iguanas, and fringe-toed lizards
- interfered with the ability of kangaroo rats to detect predators such as rattlesnakes
- caused unnatural emergence of aestivating spadefoot toads

Brattstrom, B. H. and M. C. Bondello. 1983. Effects of off-road vehicle noise on desert vertebrates. Pages 167-206 *in* R. H. Webb and H. G. Wilshire (eds.) Environmental effects of off-road vehicles: impacts and management in arid regions. Springer-Verlag, New York.

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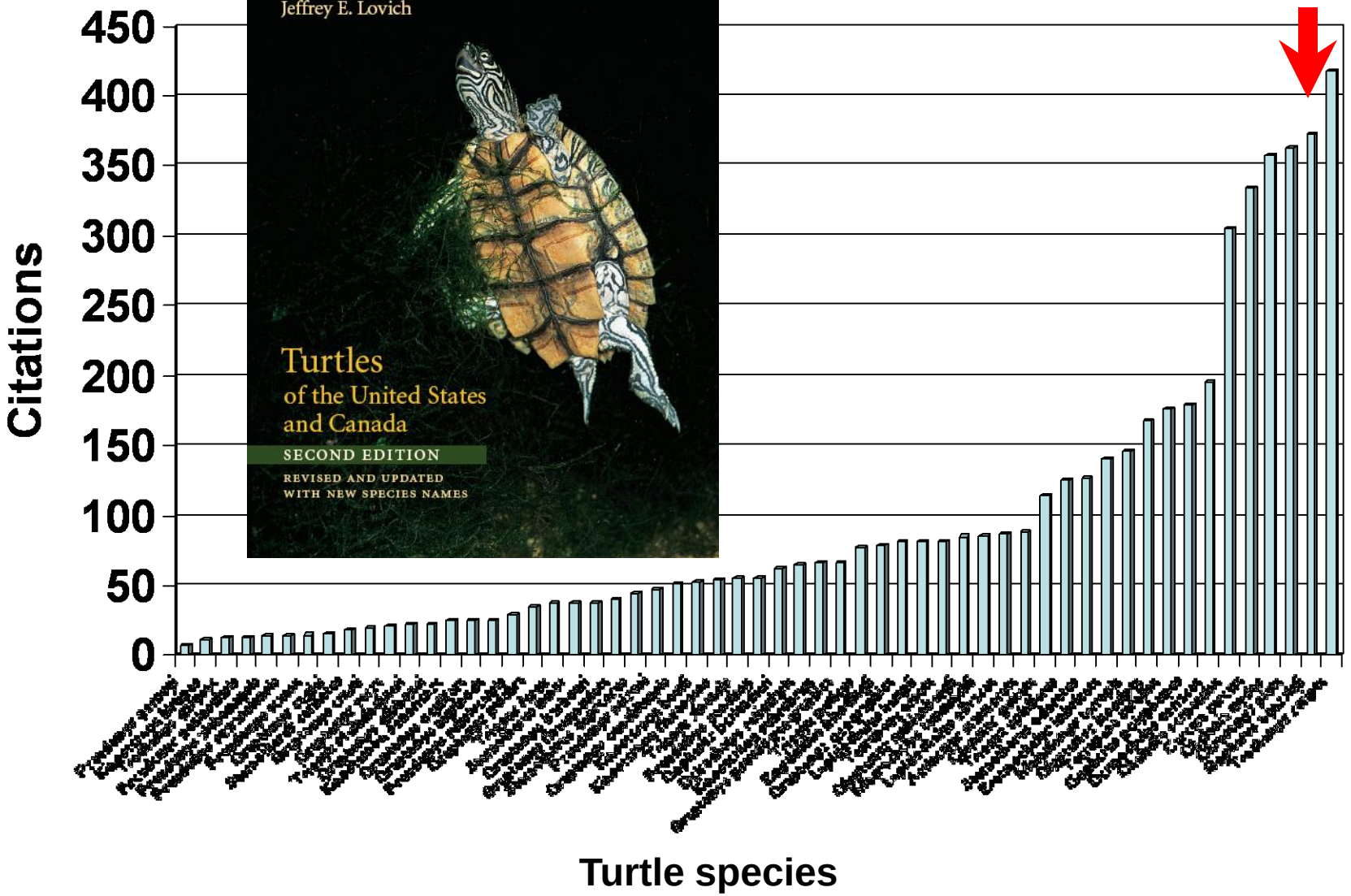
What do we know about USRE development on desert tortoises?

- **Previous recognition of:**
  - need for large land area for wind and solar development
  - importance of desert tortoise even before final listing in 1990
  - desert tortoise can be a "major obstacle" to energy development
  - need to support research (esp. demographics)

Pearson, D.C. **1984**. The desert tortoise and energy development in southeastern California. Herpetologica 42:58-59

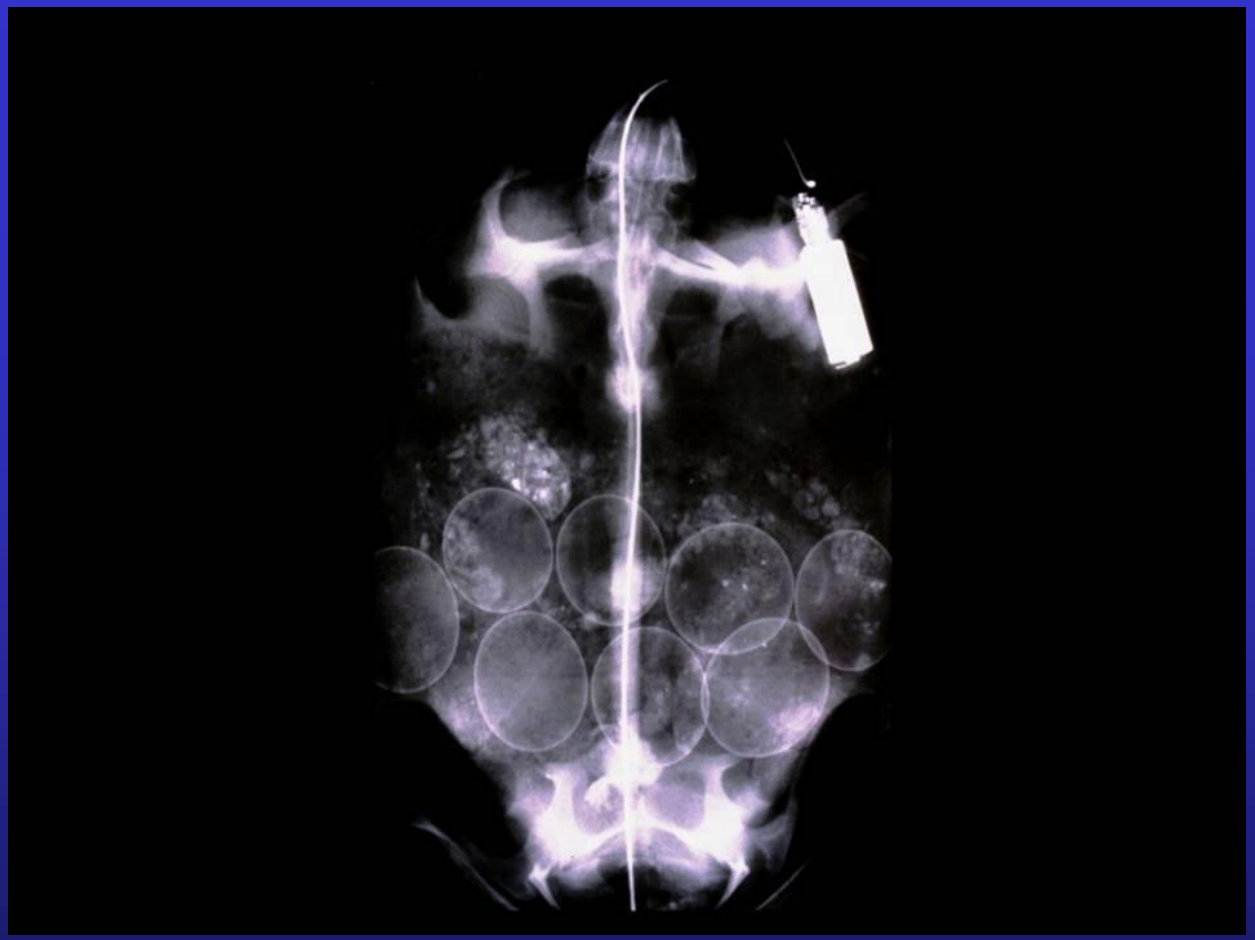
N > 5,200 citations, 58 species



Findings from a tortoise study at a wind energy facility near Palm Springs: a model for things to come?

- Proximity to food sources
- Proximity to potential mates
- Thermal environment
- Safety from flooding
- Safety from fire
- Safety from predators

FINDING # 1. TORTOISE BURROWS CAN BE FOUND IN SURPRISING PLACES



- High proportion of triple clutches
- High annual egg production

FINDING #2. Desert tortoises are reproducing at Mesa wind farm

FINDING #3. Nests produce viable hatchlings and some survive

FINDING #4. Tortoises have persisted at the site in the 27 years since construction began

76% recapture rate in 2009 (98.05% ann. surv.)

These results are NOT necessarily transferable to other sites/situations

Why does the tortoise population at Mesa appear to be thriving, outside of critical habitat?

- Productivity (site selection)
- Limited access = protection
  - maintenance staff awareness
- Tortoises adaptations (use of artificial structure)
- dirt roads, slow speeds, low traffic volume

Comments on potential effects of a warming climate on the desert tortoise

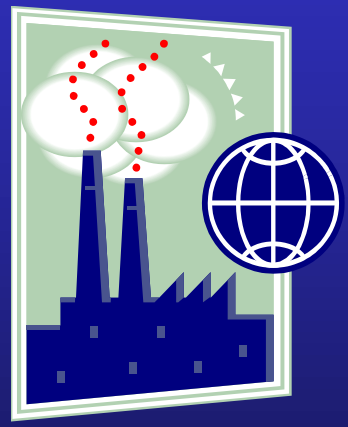
The desert tortoise and climate change sensitivities

- Poorly adapted to desert conditions* - only 1% of evolutionary history in modern desert landscape
- Environmental sex determination

*Morafka, D. J. and K. H. Berry 2002. Is *Gopherus agassizii* a desert-adapted tortoise, or an exaptive opportunist? Implications for tortoise conservation. Chelonian Conservation and Biology 4: 263-287.

Desert tortoise sex-determination

- TSD pattern Ia (cool, warm)
- Pivotal temperature 31.3 - 31.8 C* (relatively high)
- IT ≤ 30.5 C yields 100% **
- IT ≥ 32.5 C yields 100% **

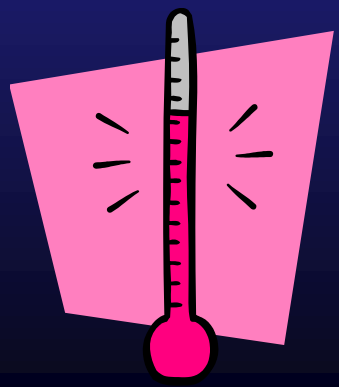


*Lewis-Winokur, V. and Winokur, R.M. 1995. Incubation temperature affects sexual differentiation, incubation time, and posthatching survival in desert tortoises (*Gopherus agassizi*). Can. J. Zool. 73: 2091-2097.

**Rostal, D. C., Wibbels, T., Grumbles, J. S., Lance, V. A., and Spotila, J. R. 2002. Chronology of sex determination in the desert tortoise (*Gopherus agassizii*). Chelonian Conservation and Biology 4(2), 313-318.

Potential responses of desert tortoises to climate change

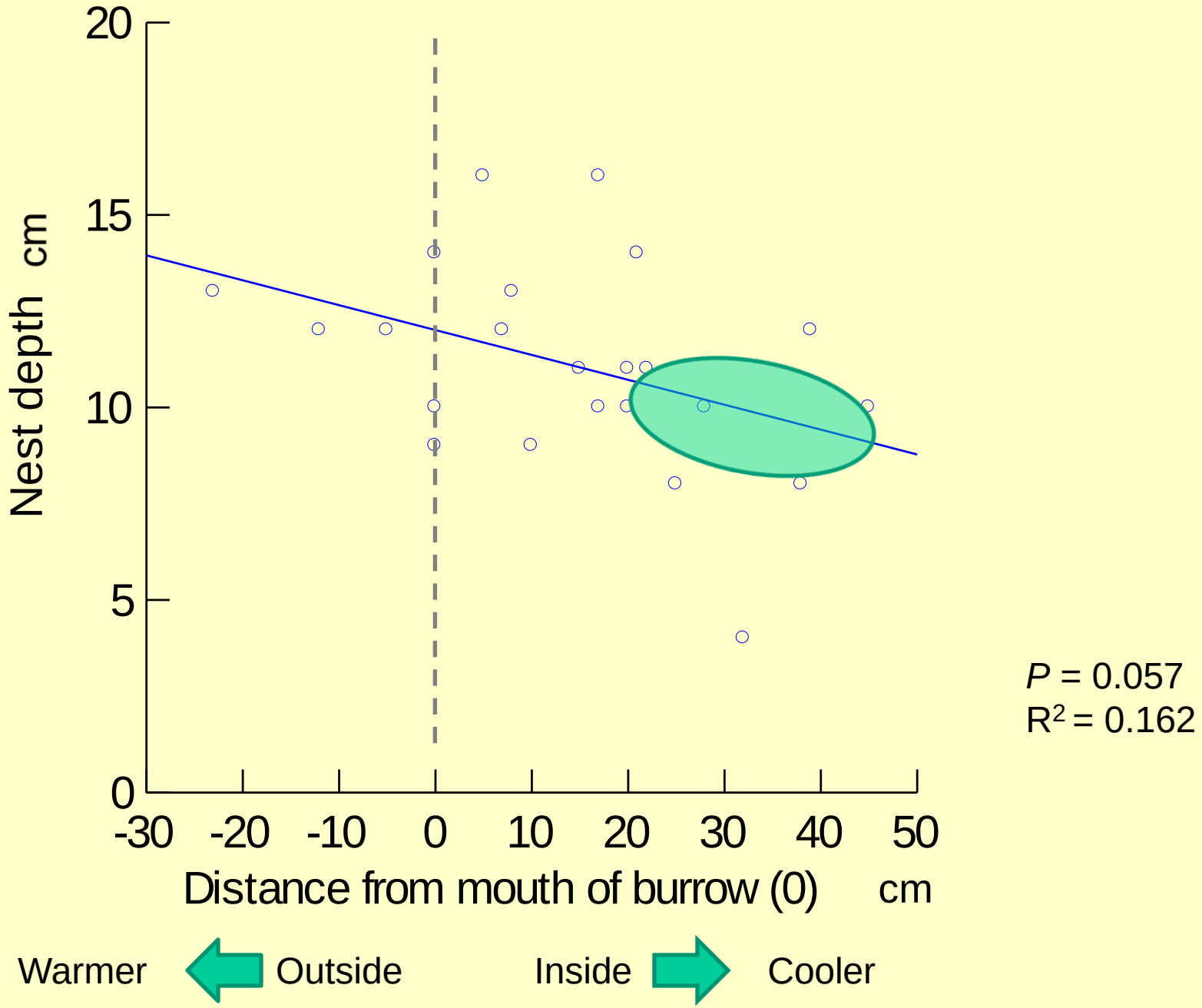
- None – extirpation?
- Evolution - lower/wider threshold temperature for sex determination
- Adaptation
  - shift elevation range upward
  - shift geographic range
  - shift nesting season
  - change nest depth/location



Nesting season

April May June July

April May June July


20
15
10
5
0
Nest depth cm
-30
-20
-10
0
10
20
30
40
50
Distance from mouth of burrow (0) cm
P = 0.057
R2 = 0.162
Warmer
Outside
Inside
Cooler

Questions/needs

- **Is USRE development compatible with wildlife conservation?**
- **What density/design maximizes energy benefits while minimizing negative effects to wildlife?**
- **Where are the best places to “site” energy farms relative to the needs of wildlife?**
- **Before/after studies are needed (replication, experimental design)**
- **How will the desert tortoise respond to climate change?**


Thanks!

Additional citations
(http://profile.usgs.gov/jeffrey_lovich)

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