Lessons learned from desert tortoise research at a wind farm near Palm Springs, California: 1995-2009

Jeff Lovich
USGS, Flagstaff, AZ

USGS science for a changing world

Why are these lessons important?

- **LARGE-SCALE ALTERNATIVE ENERGY DEVELOPMENT IS HERE ALONG WITH WILDLIFE CONFLICTS**

WIND

- CA is already a leader (2nd to Texas)*

3,000 turbines

258 megawatts annually

4,060 acres

*http://www.blm.gov/ca/st/en/prog/energy/wind.html

- **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****

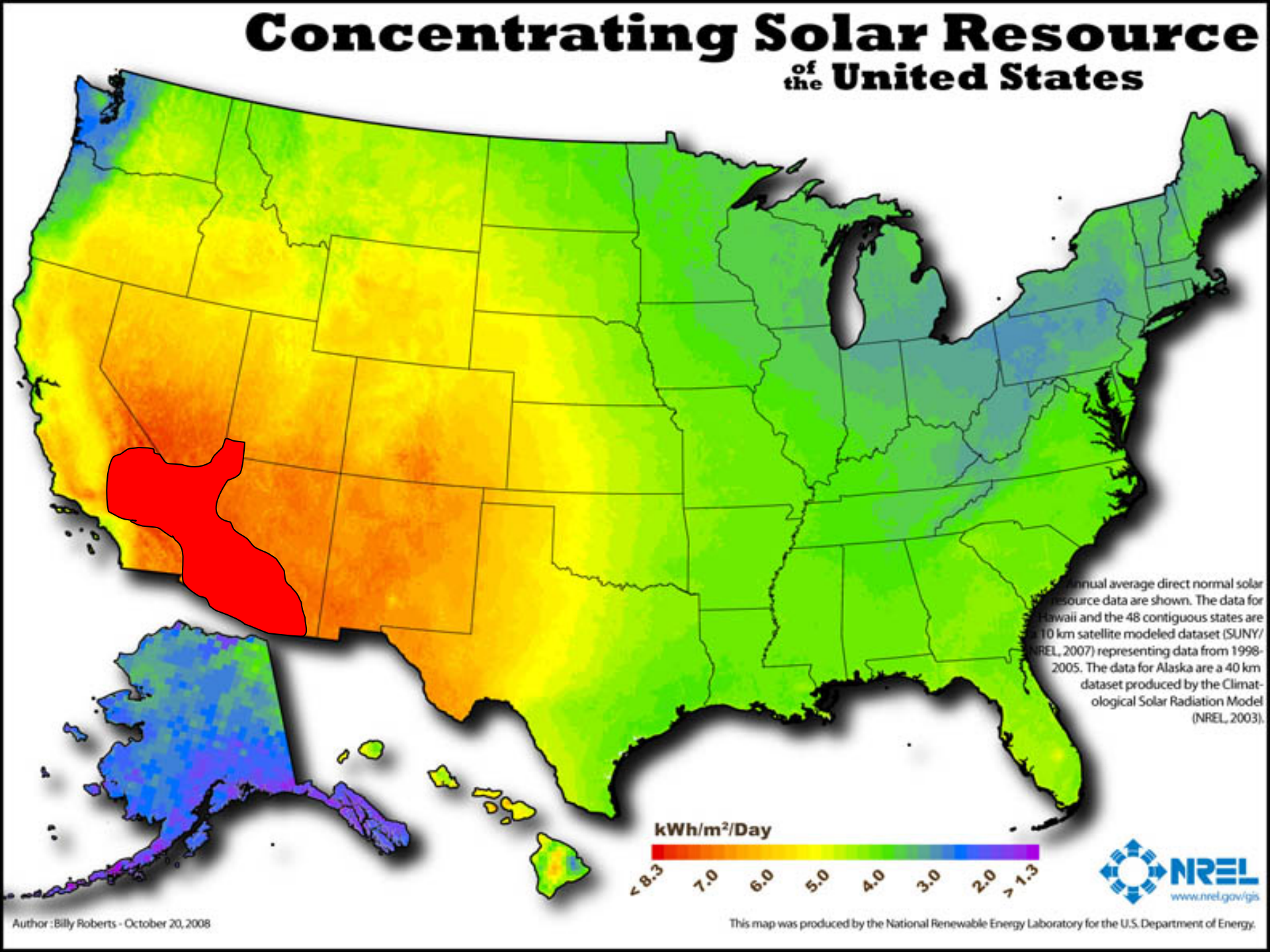
*High Country News, May 11, 2009

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

Large-scale alternative energy development will affect...

- Wildlife
- Vegetation/habitat
- Soil stability
- Water resources
- Recreation
- Visual resources

Concentrating Solar Resource of the United States

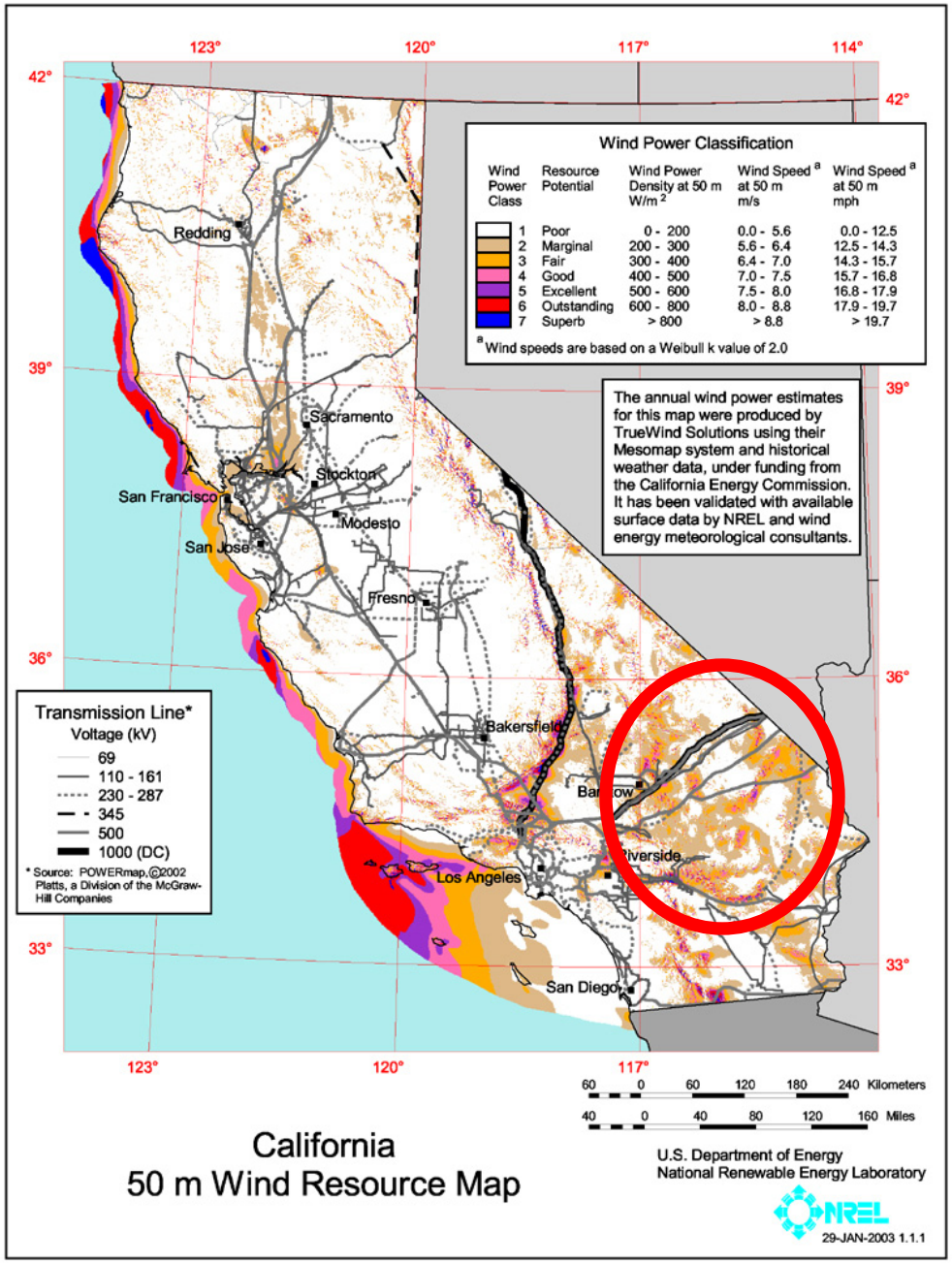


Annual average direct normal solar resource data are shown. The data for Hawaii and the 48 contiguous states are a 10 km satellite modeled dataset (SUNY/NREL, 2007) representing data from 1998-2005. The data for Alaska are a 40 km dataset produced by the Climatological Solar Radiation Model (NREL, 2003).

NREL
www.nrel.gov/gis

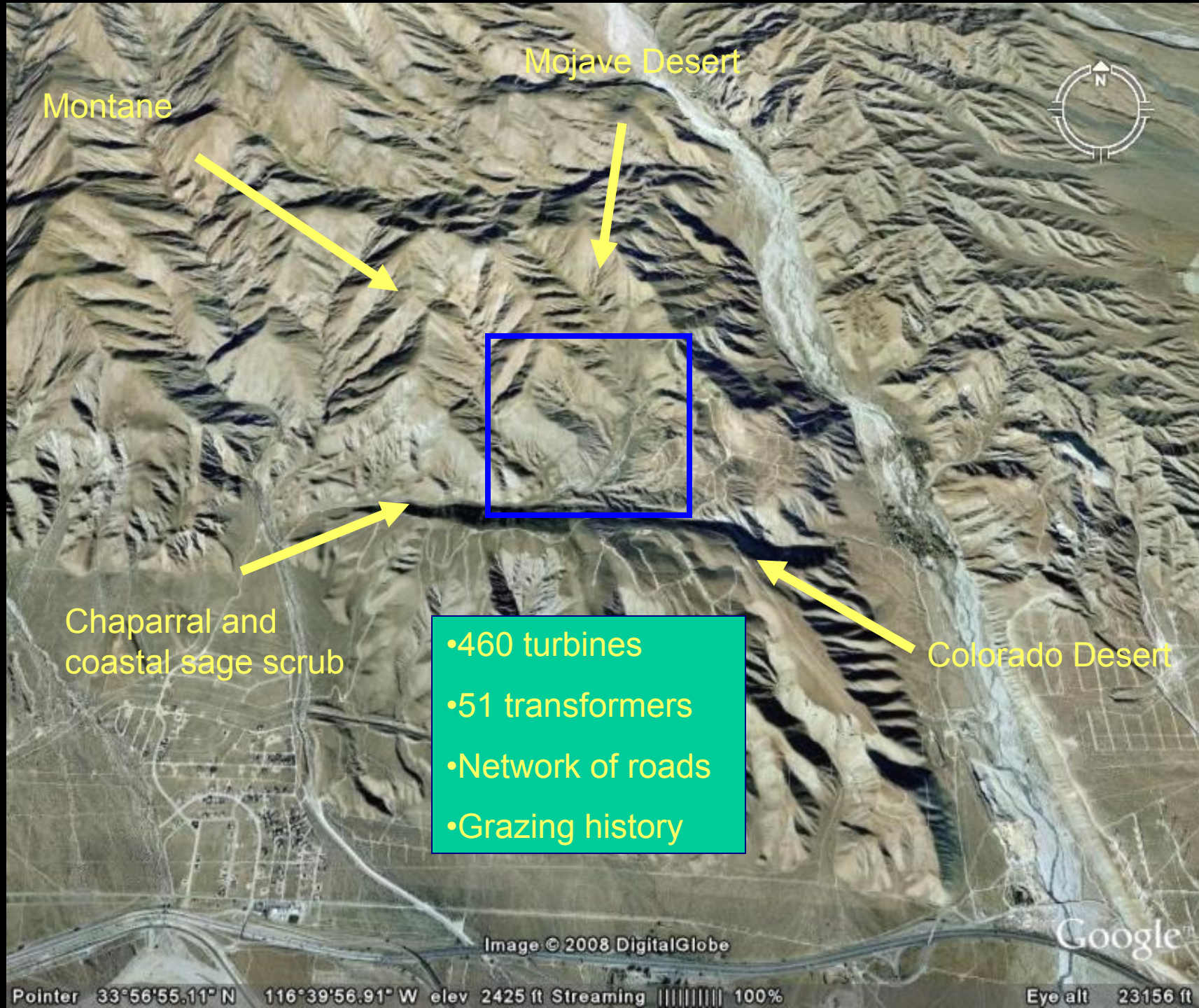
Author : Billy Roberts - October 20, 2008

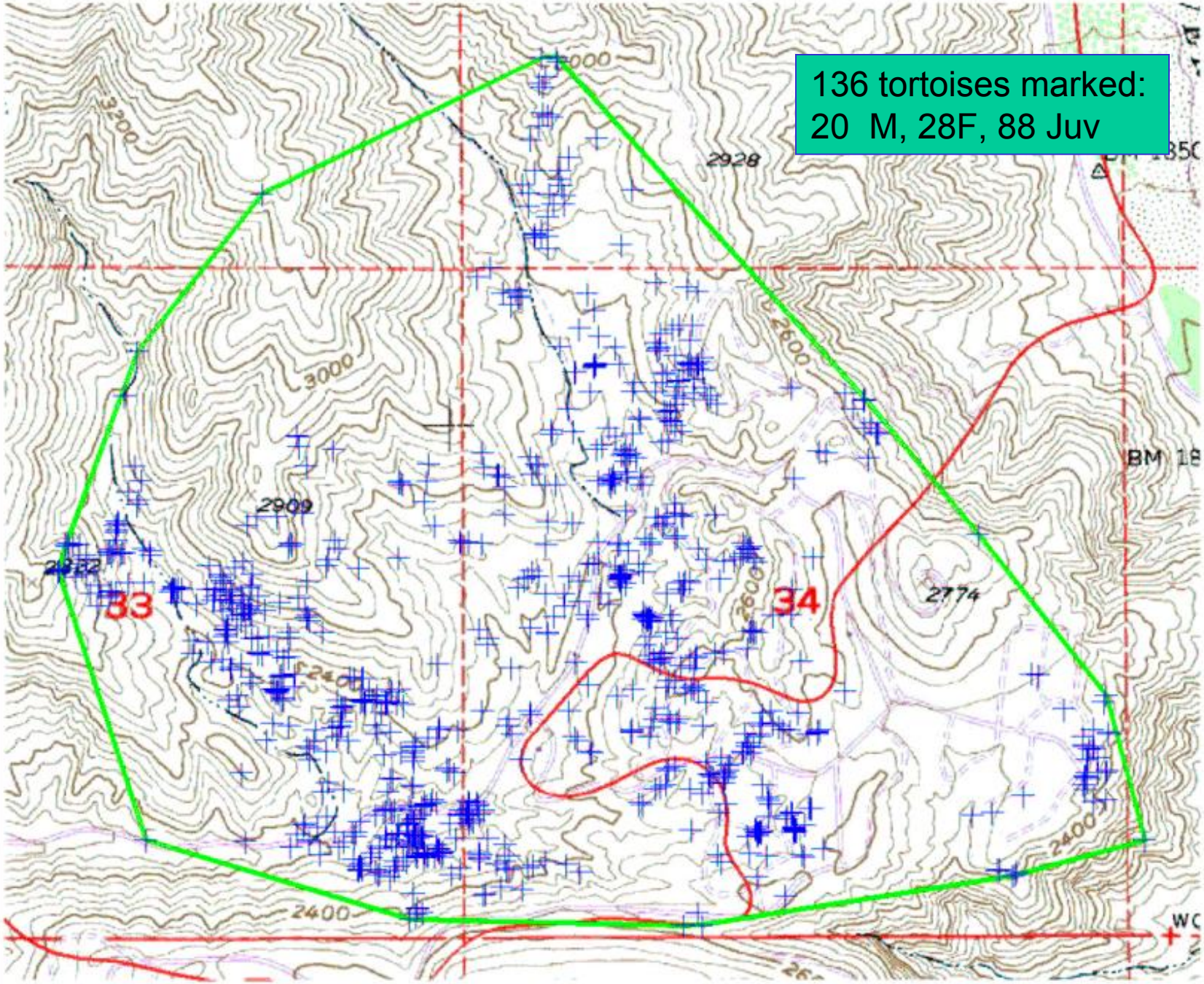
This map was produced by the National Renewable Energy Laboratory for the U.S. Department of Energy.


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.
Transmission Line*
Voltage (kV)
69
110 - 161
230 - 287
345
500
1000 (DC)
* Source: POWERmap, ©2002 Platts, a Division of the McGraw-Hill Companies
Redding
Sacramento
Stockton
San Francisco
Modesto
San Jose
Fresno
Bakersfield
Barstow
Riverside
Los Angeles
San Diego
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

- Review over a decade of tortoise research at a wind farm along with lessons learned
- Site description
- Tortoise burrow microhabitat selection
- Reproductive ecology
- Hatchling ecology/survivorship
- 2009 data
- Future opportunities/unanswered questions


Mojave Desert
Montane
Chaparral and
coastal sage scrub
Colorado Desert
•460 turbines
•51 transformers
•Network of roads
•Grazing history
Image © 2008 DigitalGlobe
Google
Pointer 33°56'55.11" N 116°39'56.91" W elev 2425 ft Streaming 100%
Eye alt 23156 ft


136 tortoises marked:
20 M, 28F, 88 Juv
3200
3000
2928
2600
3000
2909
33
34
2774
2600
2400
2400
2400
BM 18

LESSON #1. Tortoise burrow microhabitat selection at Mesa wind farm is surprising

Tortoise burrow location "decisions"

- Proximity to food sources
- Proximity to potential mates
  - defended home range?
- Thermal environment
- Safety from flooding
- Safety from fire
- Safety from predators

Testable hypotheses

- Desert tortoise burrows are randomly located
- Desert tortoises do not construct their burrows in proximity to wind energy infrastructure

Basic protocol

- Compare the environmental attributes of desert tortoise burrows with those at random points without burrows.

Variables

- Distance to nearest
  - road
  - turbine pad
  - creosote bush
  - brittlebush
  - yucca
  - cactus
  - rock pile
- Aspect
- Slope
- Elevation

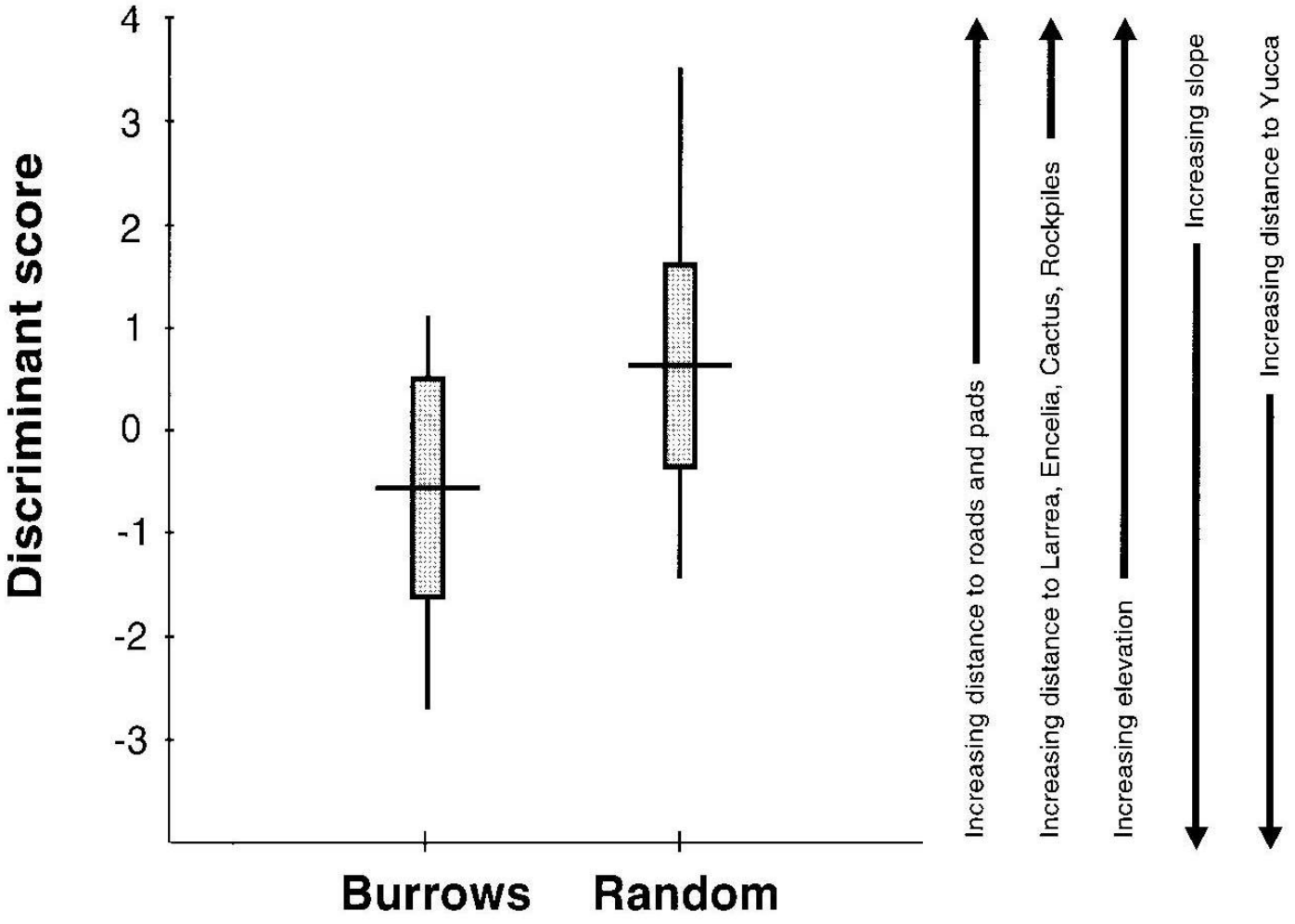
Statistical approach
- Multivariate Analysis of Variance
- Principal component analysis
- Discriminant function analysis

Burrow sites ≠ Random points

MANOVA - Wilk's Lambda = 0.730; df = 9, 54; p = 0.035

Factors that determine burrow locations

- **Factor 1 (30.7%)**
  - distance to roads
  - distance to pads
- Factor 2 (18.6%)
  - distance to creosote bush
- Factor 3 (13.4%)
  - distance to yucca
- Factor 4 (12.1%)
  - distance to brittlebush



Student's t-test, t = -4.788, df = 62, $p < 0.001$)

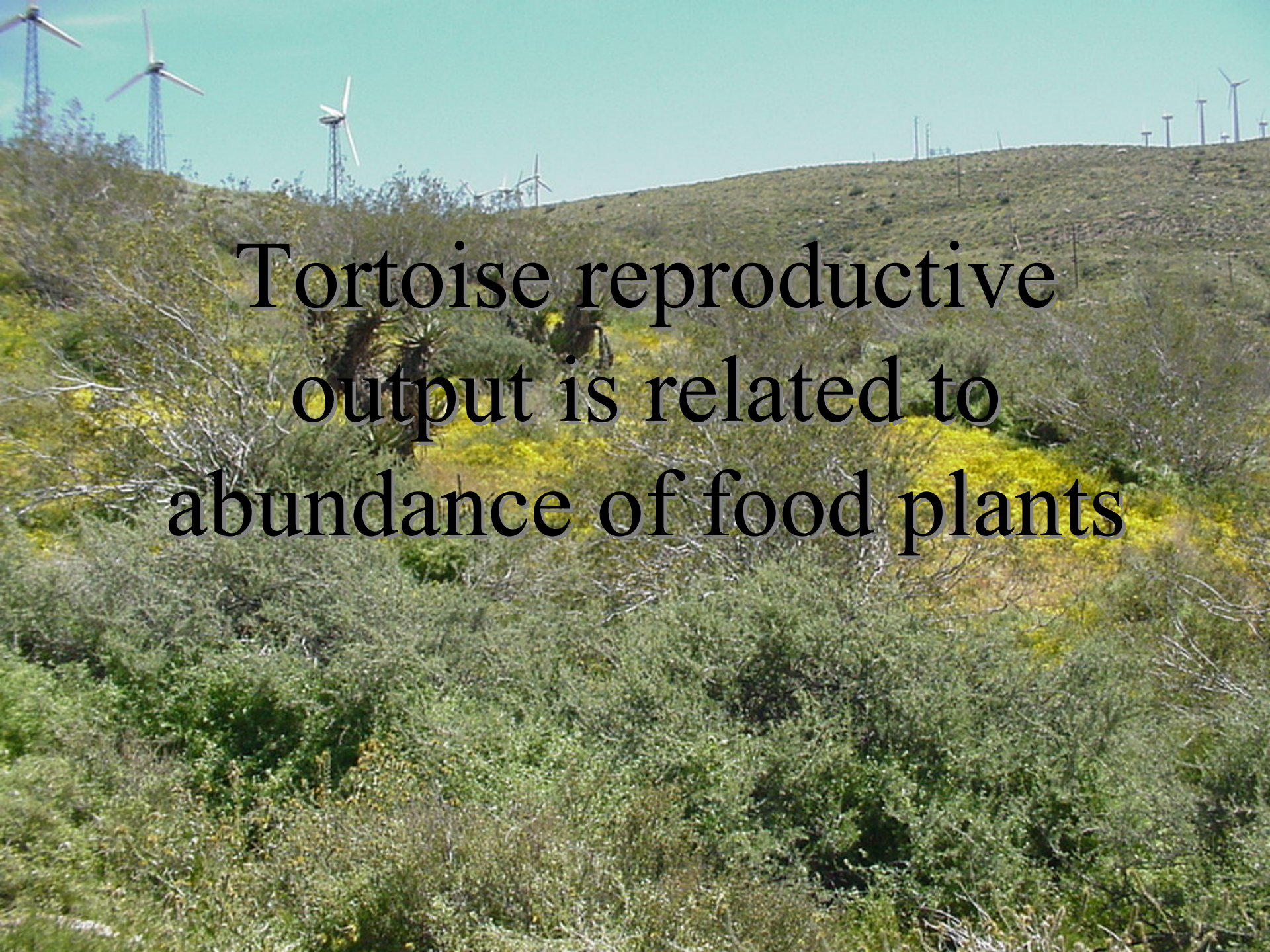

215


DANGER
HIGH
VOLTAGE

Conclusions

- Desert tortoise burrows at Mesa are NOT randomly located
- Desert tortoise burrows are often associated with anthropogenic features of the landscape - closer to roads (*edge enhancement*), pads (*artificial caliche*), creosote bush, cactus, and rock piles than are random points

LESSON #2. Desert tortoise reproduction at Mesa wind farm is sensitive to resource availability just like other sites


Tortoise reproductive output is related to abundance of food plants

Rainfall - Oct, 1996-May, 1997

- Mesa - 95.6 mm
- Mojave Nat. Pres. - 42.1 mm
- Joshua Tree Nat. Park. - <42 mm

Productivity of annual plants is strongly linked to timing and amount of precipitation

USGS

Mesa, 1997

- **9 of 10 produced eggs**
- **72 eggs**
- **16 clutches**
  - 6 second clutches
  - 1 triple clutch
- **mean clutch size**
  1st - 4.33
  2nd - 5.00
  3rd - 3.00

USGS

Mojave National Preserve, 1997

- 12 of 18 females
- 43 eggs
- 12 clutches
  - no second clutches
- mean clutch size=3.58

USGS

Joshua Tree National Park, 1997

- 1 of 8 females
- 5 eggs
- 1 clutch

USGS

Mesa

- 1997

  Rain - 96 mm

  2nd clutches - 66%
  3rd clutches - 11%
  Max. CS = 8

- 1998 (El Niño)

  Rain - 222 mm

  2nd clutches - 100%
  3rd clutches - 36%
  Max. CS = 9

USGS

Conclusions from reproduction studies

- Tortoises can reproduce successfully at this wind energy facility
- Protected status of land appears to be less important than productivity
  - In wet/productive years, more mature females reproduce
  - In wet/productive years, females produce more clutches
  - Average clutch size is about the same in a wet and a dry year

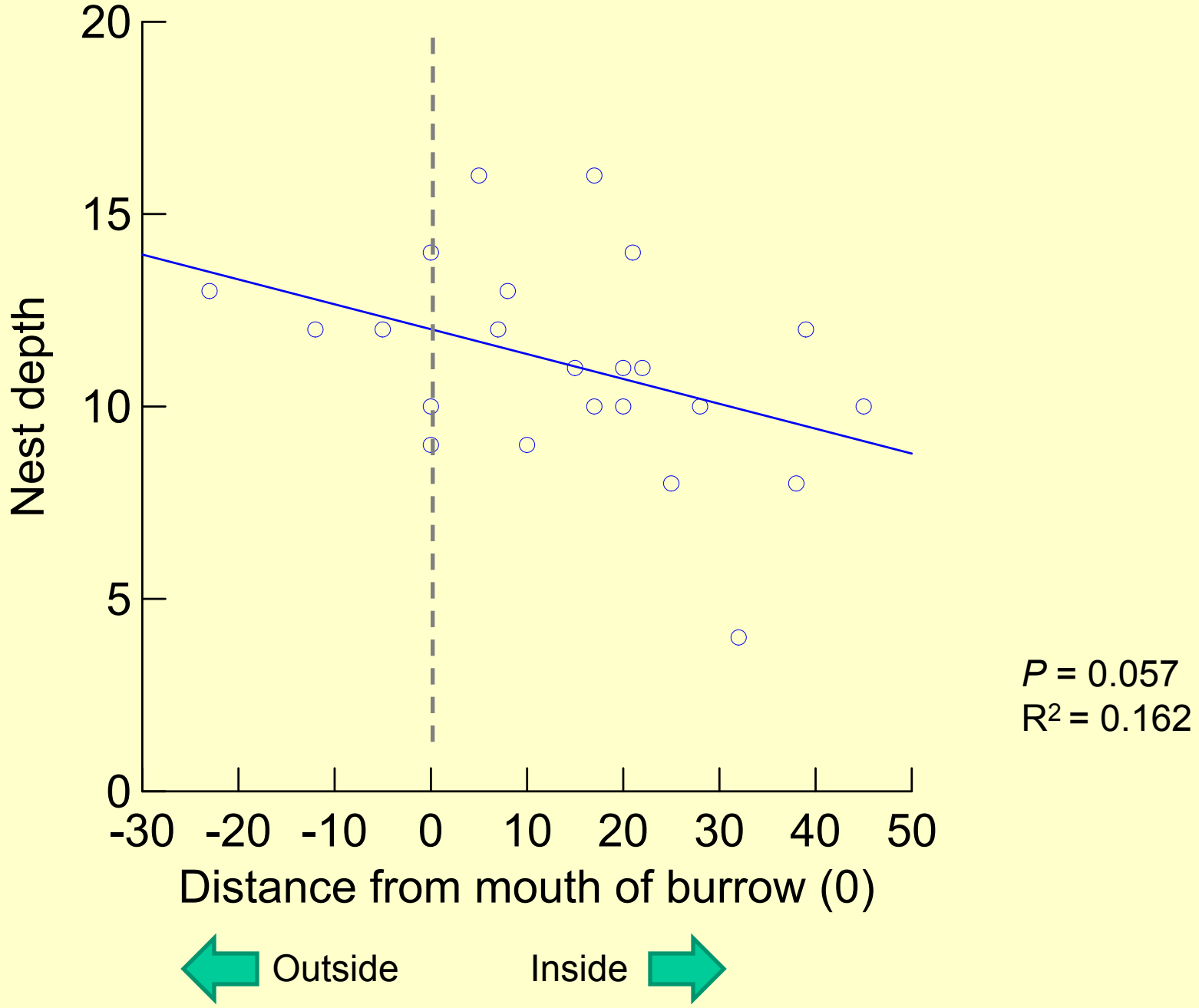

LESSON #3. Nest and hatchling ecology at Mesa wind farm

2000 nesting season

- first clutches 12 May to 8 July (n = 13)
- second clutches 12 June to 3 July (n = 12).

Nest placement

- 17 nests were inside burrows
- 3 nests were directly beneath mouth of burrow
- 3 nests were located on burrow apron
- 1 nest was not near a burrow


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

At day 70…


Emergence
6 August - 29 September

Incubation time for individual hatchlings

Clutch Number	Mean Incubation Time	Range in Days	SE
Both	87.2 Days	76 – 106	0.779
1	91.0 Days	83 - 104	0.836
2	81.5 Days	76 – 90	0.572

USGS
science for a changing world

Nest and hatching success

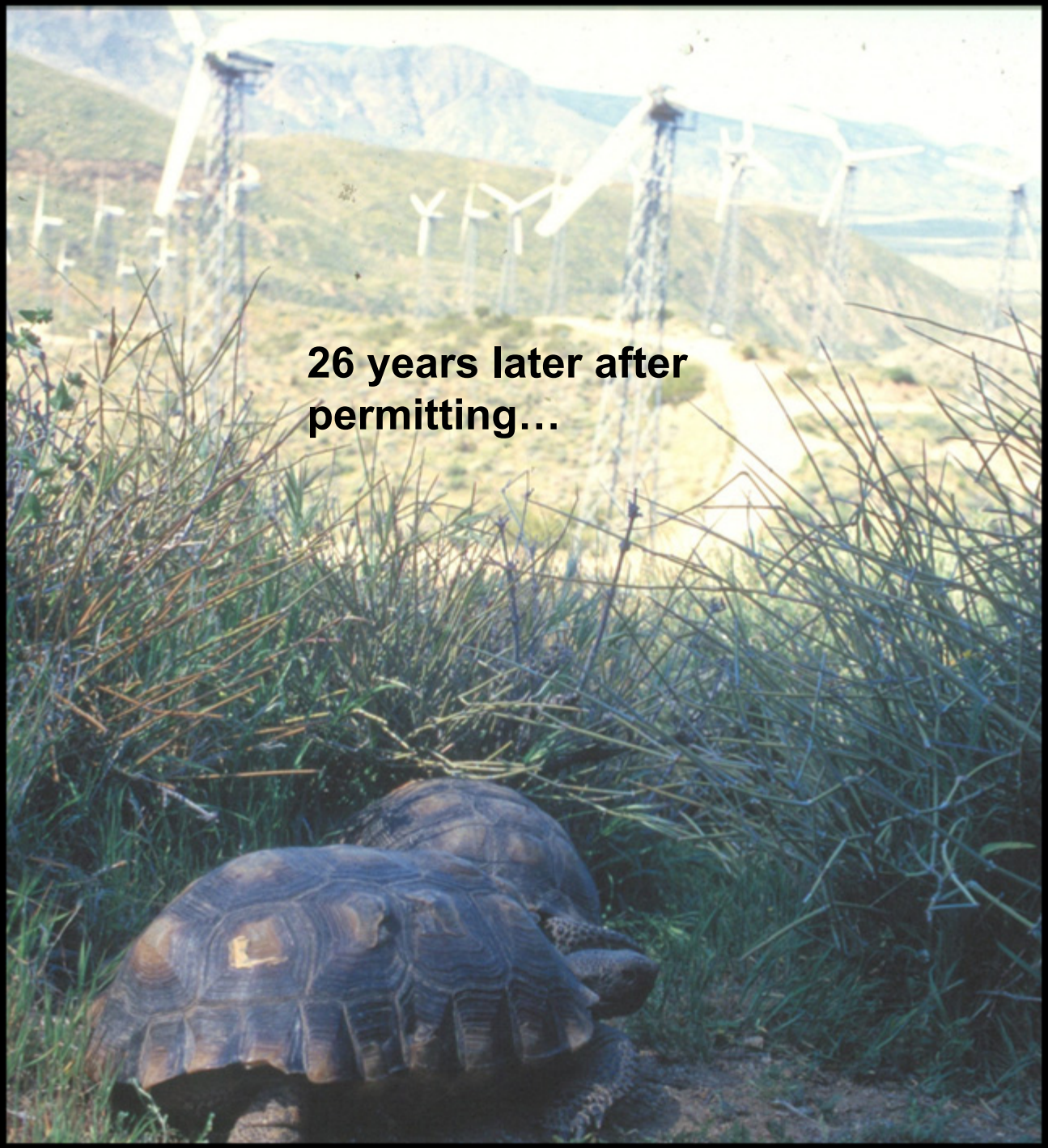
- only 3 of 24 (12.5%) nests were depredated
  - 15% of all eggs were in these 3 nests
  - all depredated nests were 2nd clutches
- 81.3% percent of eggs in surviving nests hatched
- 97% of hatching neonates emerged from surviving nests (=72 hatchlings)

USGS
science for a changing world

Hatchling survivorship

- 5 lost their radios (due to adhesive failure)
- 1 hatchling lost weight (radio removed)

- 2 may have been eaten by predators
- 2 died of natural causes
- 10 were still alive as of 23 January 2001


26 years later after
permitting…

2009 preliminary results

- 13 recaptures out of 17 adult tortoise encounters (**76%**)
- 5 out of 6 females known to produce eggs
  - 3 second clutches
  - 1 third clutch
- Mean clutch size
  - first clutch = 3.5 eggs
  - second clutch = 5.75 eggs
  - a single third clutch of 1 egg
- Preliminary analyses suggest that tortoises living in burned areas have larger activity areas

Population status at Mesa wind farm so far...

- No evidence of a disease epidemic
- No evidence of a population decline
- The population is represented by many size classes
- Reproductive output is consistent and significant
- Hatchlings and juveniles are surviving
- These results are NOT necessarily transferable to other sites/situations

Lessons learned

- Rainfall and productivity are strong determinants of reproductive output, as expected
- Environmental signals can overpower land status/use

  - Location, location, location (proper site location of energy projects is going to be critical)

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

- Productivity (site selection)
- Limited access (protection)
  - maintenance staff awareness
- Adaptable tortoises (“artificial caliche”)
- Edge enhancement effect
  - dirt roads
  - slow speeds
  - low traffic volume

Future opportunities/unanswered questions

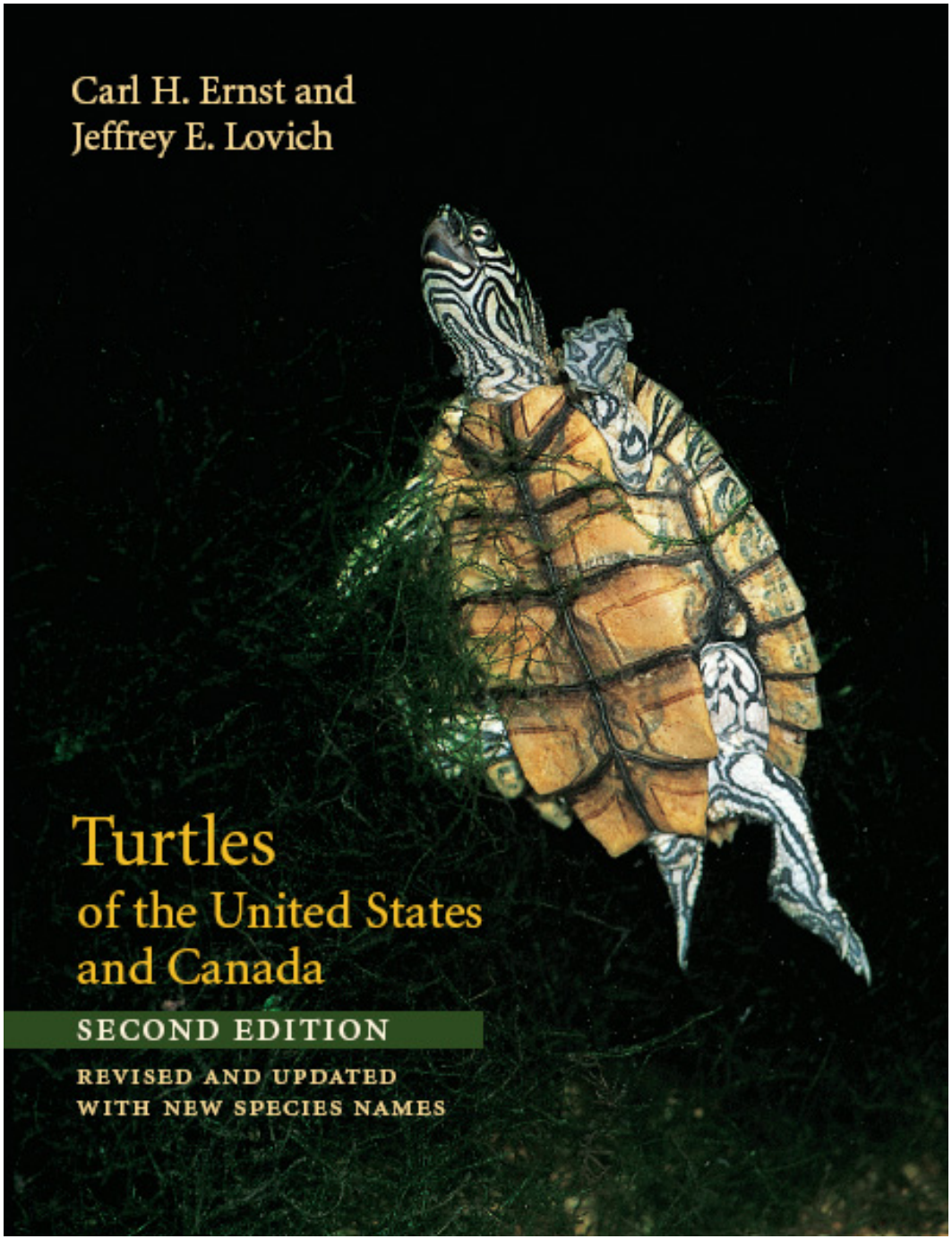
- Is the tortoise population at Mesa still as vigorous as it was 10 years ago?
  - reproductive output
  - demography
  - survivorship
- How will additional wind energy development at the site affect the tortoise population?
- “Before and after” studies are badly needed

Future opportunities/unanswered questions

- Is wind energy development compatible with desert tortoise recovery elsewhere?
- If so, what density of wind energy development is compatible with tortoise recovery?
- Does wind energy development lessen the impact of ravens on tortoises?
- What standards and protocols need to be implemented for wind energy development?
- Develop GIS models to guide site location decisions for resource managers

Thanks!

- Hal Avery
- Curtis Bjurlin
- Gillian Bowser
- Sean Kenna
- Sheila Madrak
- Mark Massar
- Phil Medica
- Kathie Meyer
- Ernie Quintana
- Gavin Wright
- many others



For more information…

THE JOHNS HOPKINS UNIVERSITY PRESS. 2009

- **827 PAGES**
- **5,200 REFERENCES**