

# Can desert tortoises thrive in engineered habitats?

## A synthesis of solar energy construction methods, tortoise biology, ecological function, and restoration ecology

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Management Oversight Group for the Mojave Desert Tortoise  
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Solar Project, Yellow Pine Solar Project, Rough Hat Clark County Solar Project, Copper Rays Solar Project,  
Golden Currant Solar Project, Mosey Solar Project, Bonanza Solar Project, Kawich Solar Project, and South  
Ridge Solar Project sites**

**The Moapa Band of Paiute Indians provided access to their lands**

**Chip Lewis of the USDI-Bureau of Indian Affairs provided project insights and coordination**

# Goals and Objectives

**Provide framework for the successful experimental repatriation of Mojave desert tortoises into solar projects**

**What criteria are required for success?**

**What else do we need to know? – monitoring and research**

**What role does habitat restoration play?**

**Based on USGS Report**

**Repatriating wildlife to utility scale solar energy generation projects: Can desert tortoises thrive in engineered habitats?**

*In Review*

# Conventional Solar Projects

Vegetation removal

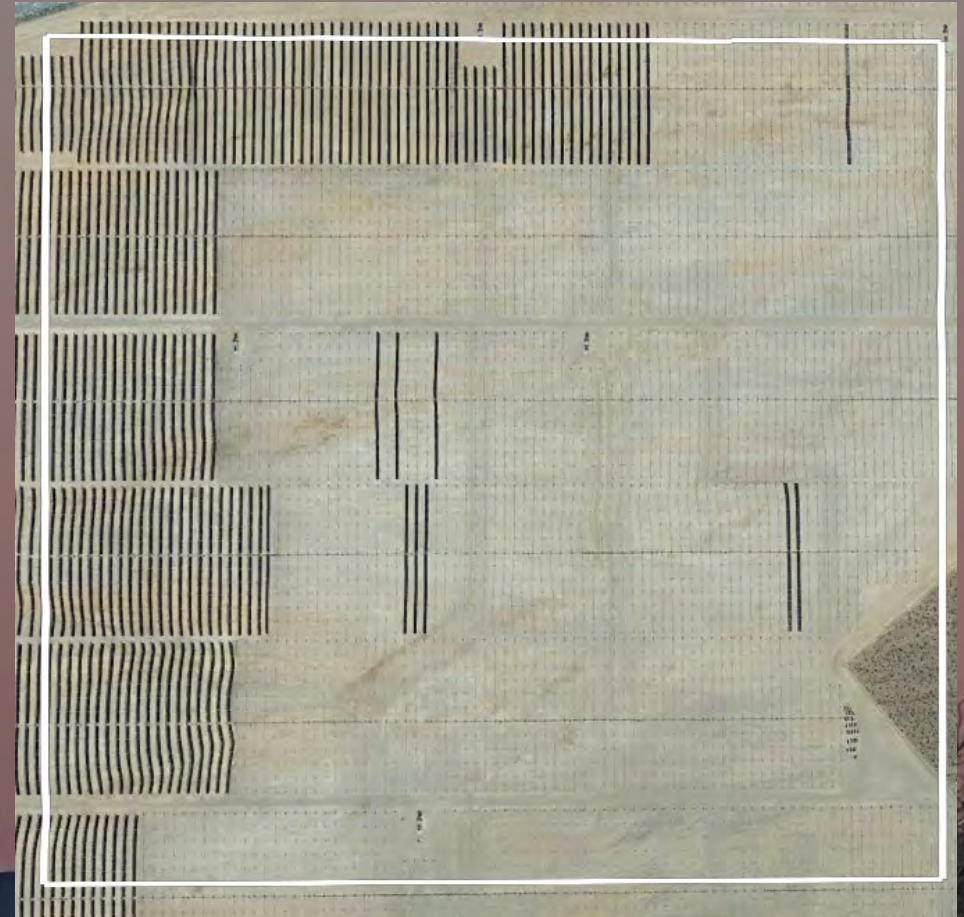
Soil compaction

Modified hydrology  
(soil moisture)

Thermal environment?

Wildlife traps and other dangers...

...inhospitable to desert tortoises, as is



Aerial view (0.57km x 0.57km) Google Earth

# Conventional Solar Projects

Could we re-engineer the Mojave desert?

Vegetation removal – replace perennials  
and annuals

Soil compaction – add a meter of soil

Replace tortoise burrows

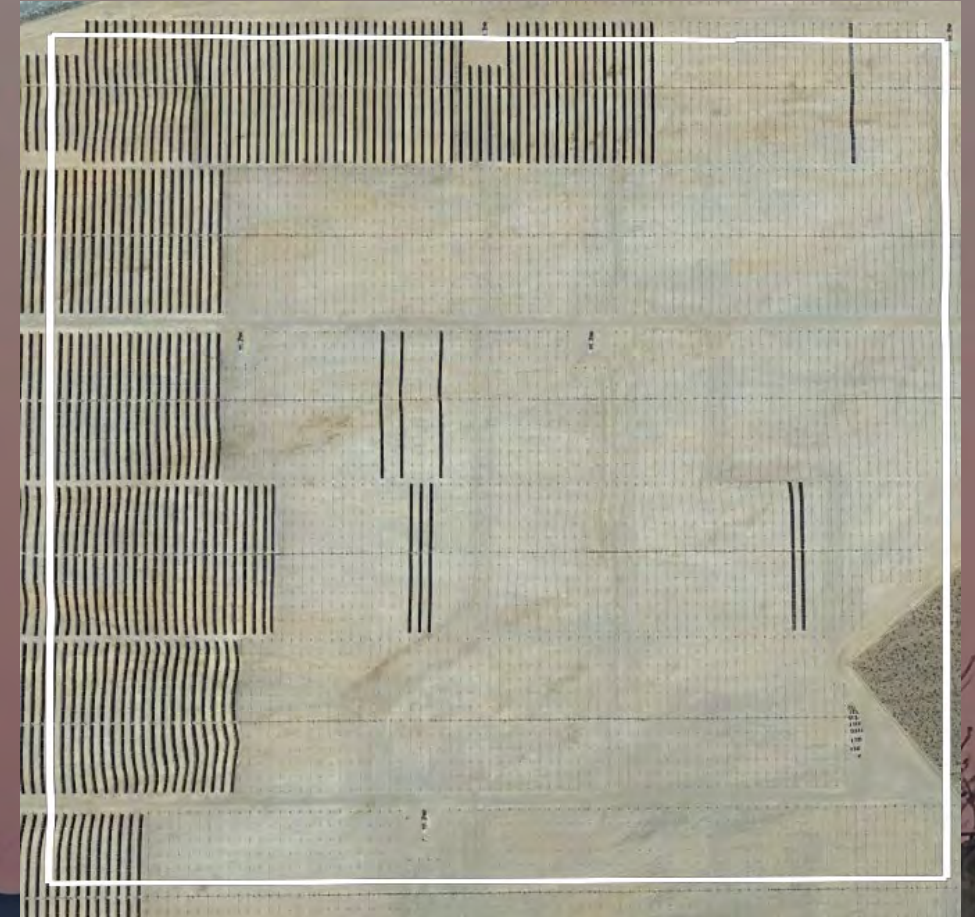
Modified hydrology – re-contour the site  
(soil moisture)

Thermal environment? –

Provide water for restoration

Wildlife traps and other dangers –  
remove traps, raise fences

The community (USDI, Contractors, NGOs)  
Said, “NO!” ... resoundingly



Aerial view (0.57km x 0.57km) Google Earth

Could we protect patches  
Within the boundaries  
of solar projects?

...Probably not



# Could we minimize disturbance – meaningfully? Maybe...

## Adaptive framework for minimizing disturbance

1. Identify “Criteria for repatriation”
2. Pre-construction
  - Planning, planning, planning
  - Baseline data collection
  - Monitoring and Research Design
  - Work with proponents and contractors
3. Construction
  - Monitoring compliance, and work with proponents
  - Restoration salvage
4. Post-Construction
  - Evaluate criteria for repatriation, and work with proponents
  - Identify short term restoration actions
  - Identify long-term restoration actions
5. Monitoring and research, and work with proponents



Photo: B. Gottsacker, USGS

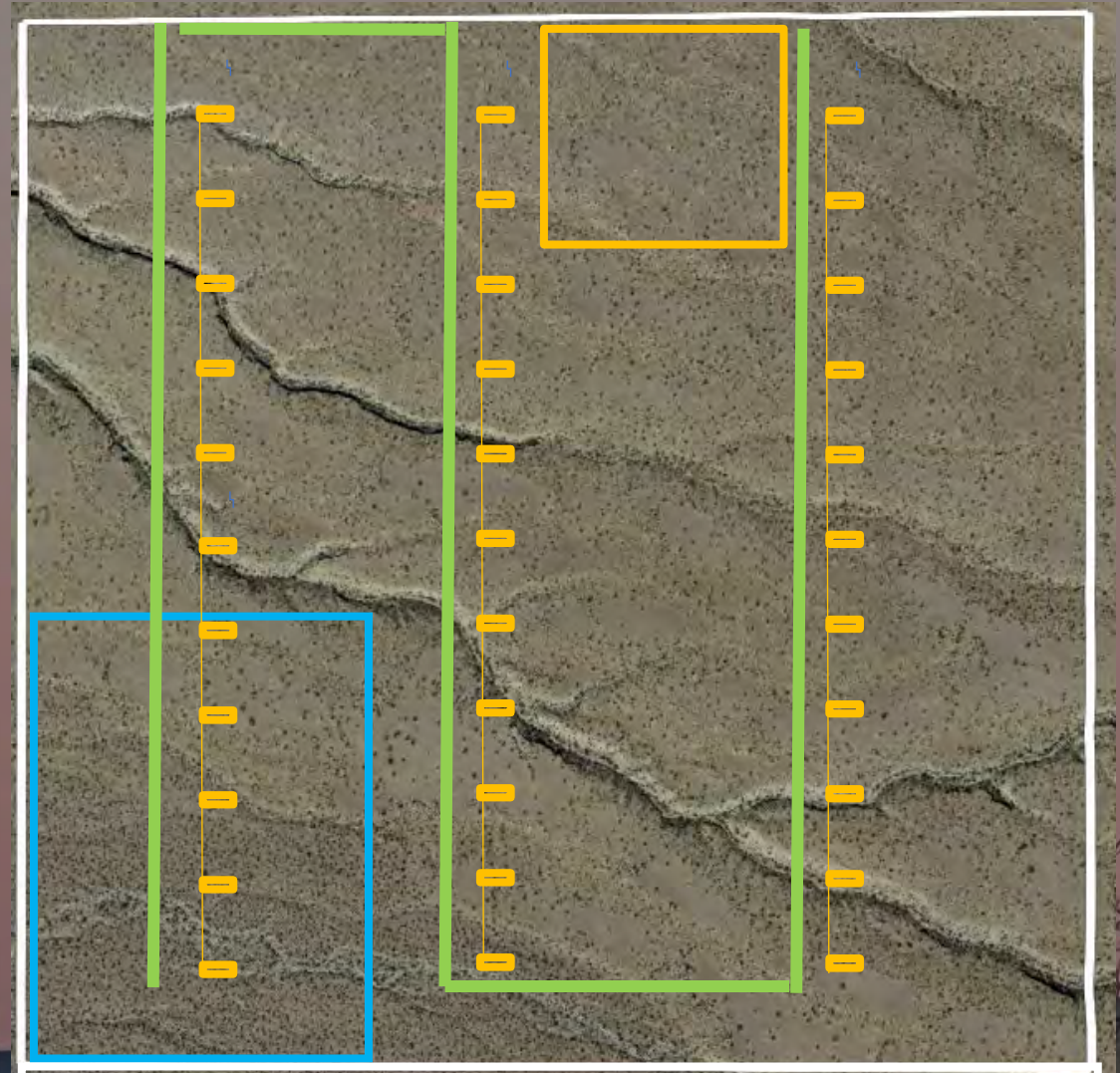
# Criteria for Repatriation

## Criterion Metric

- |   |   |       |
|---|---|-------|
| 1 | Heavy   | <15%  |
|   | [Moderate   | <20%] |
|   | Minimal   | ≥65%  |
| 2 | <10% road disturbance   |       |
| 3 | 80% of perennials intact in minimally disturbed area                  |       |
| 4 | 100% of tort burrows intact (or 120% restored)                        |       |
| 5 | If 1 thru 4 met, tortoises repatriated into minimal or moderate areas |       |



Restoration as needed



Minimal disturbance areas

Moderate disturbance

Heavy disturbance

Perm roads – heavy dist.

# Criteria for Repatriation

## Minimized Disturbance



# Criteria for Repatriation

Moderate Disturbance

Roll and Crush

**Roll & crush apparatus**



# Criteria for Repatriation

Heavy Disturbance

Channelized, compacted, industrial area (energy storage – batteries)

# Pre-Construction project planning for tortoise repatriation

21 plans total  
Federal, State, County, local govt.

Traffic and Transportation Plan  
Flagging, Fencing, & Signage Plan  
Site Restoration Plan  
Invasive Plant Monitoring & Maint. Plan  
Predator Management Plan  
Recreational Plan



Table 2. Management plans that would be implemented before, during, and after construction of solar projects. Some management plans are federal, state, and local specific. Plans mentioned in this document are marked with an asterisk (\*), and address meeting the criteria to repatriate tortoises to solar development projects.

Management Plans	Authority, Regulations, and Citations
Proposed Action Plan	National Environmental Policy Act (NEPA), Environmental Impact Statement (EIS), Code of federal regulations, Title 40
<i>Alternative Action Plan(s)</i>	40 CFR Part 1502.14
Health and Safety Plan	Occupational Health and Safety Administration's (OSHA's) Occupational Health and Safety Standards; 29 CFR Parts 1910 and 1926
Noise Mitigation Plan	National Environmental Policy Act (NEPA), Environmental Impact Statement (EIS),
*Traffic and Transportation Plan	Code of federal regulations, Title 49 and Title 43; Executive Order 11644; State and local specific permits through Department of Transportation
Dust Control and Air Quality Plan	Code of federal regulations, Title 30, Title 43; Regional specific Environmental Protection Agency (EPA) regulations and permits
Stormwater Pollution Prevention Plan	Code of federal regulations, Title 40, Title 43; Regional specific Environmental Protection Agency (EPA) regulations and permits
Spill Prevention Control and Countermeasure Plan	Code of federal regulations, Title 40 (CFR 112); Regional specific Environmental Protection Agency (EPA) regulations and permits
*Flagging, Fencing and Signage Plan	May be required by federal agencies' Records of Decision (RODs), Biological Opinion/Assessment (B.O. or B.A.) or USFWS guidelines. Following ordinance of: 43 CFR 2881.2, Federal Land Policy and Management Act of 1976, Endangered Species Act, local permits, federal recovery plans (i.e., Desert Tortoise Recovery Plan, USFWS 2011, Translocation of Mojave desert tortoise from project sites: Plan development guidance, USFWS 2020b)
*Site Restoration Plan	May be required by federal agencies' Records of Decision (RODs), Biological Opinion/Assessment (B.O. or B.A.) or USFWS guidelines. Following ordinance of: 3 CFR 2881.2, Federal Land Policy and Management Act of 1976, Endangered Species Act Section 7(a)(2), local permits, federal recovery plans (i.e., Desert Tortoise Recovery Plan; USFWS 2011)

# Pre-Construction Project Planning

## Baseline Data Collection

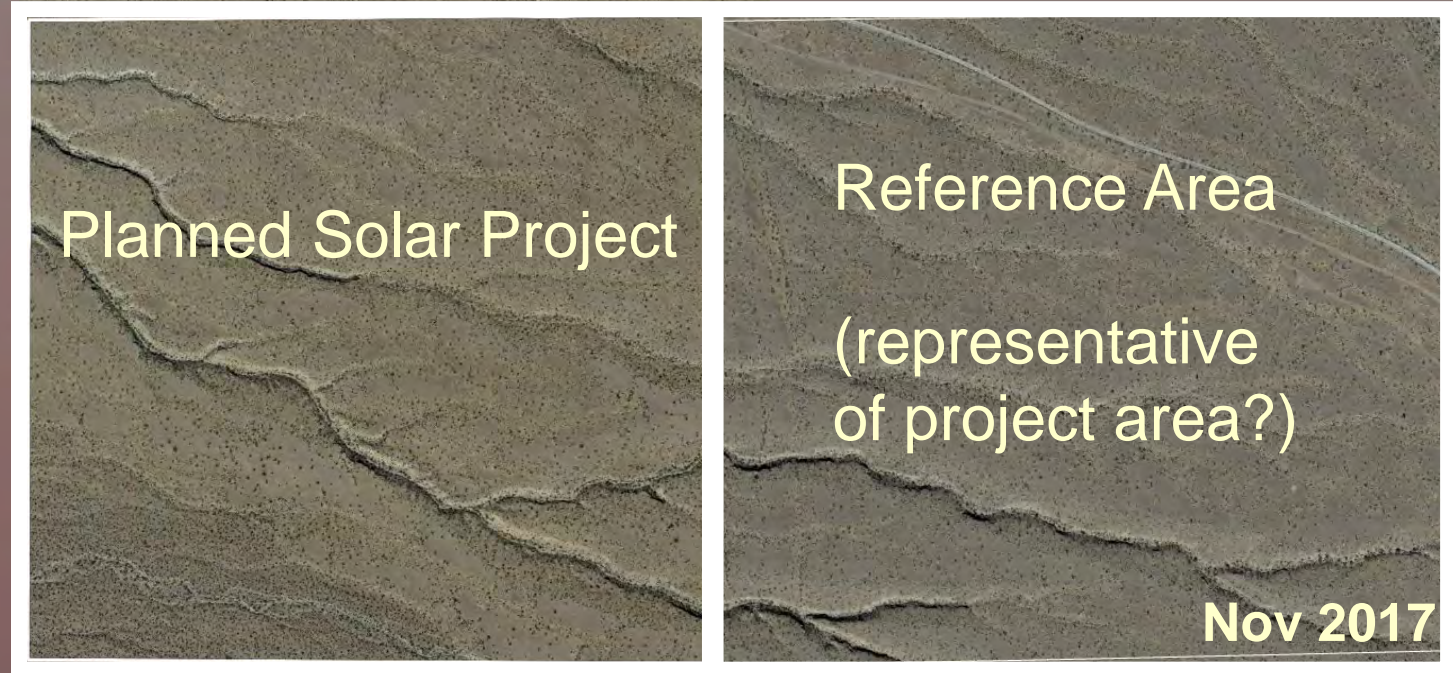
BACI design – Before-After-Control-Impact

### Criteria

Amount of disturbance  
Tortoises and burrows  
Remote sensing  
Roads  
Vegetation  
Ground surveys  
Vegetation

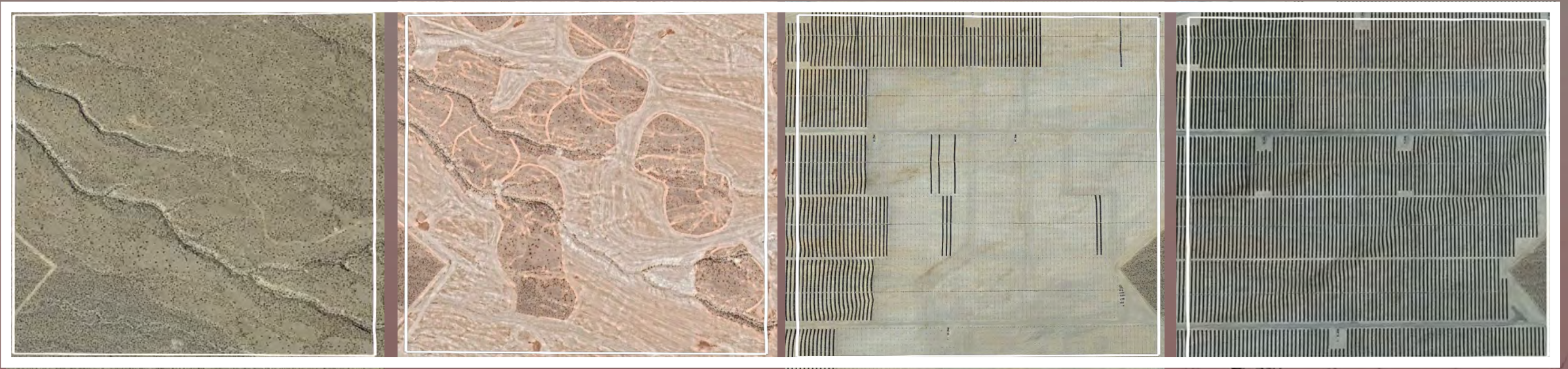
### Additional Issues

Abiotic  
Thermal microsites  
Climate/weather  
Soils  
Compaction  
Stability  
Bulk Density  
Seed bank?



*We only get one chance for baseline!*

# Construction Phases



May 2019

May 2020

March 2021

March 2022

Not to scale

# Construction

Work with proponents to minimize disturbance

Maintain standards

Vegetation

Roads

Burrows

Restoration

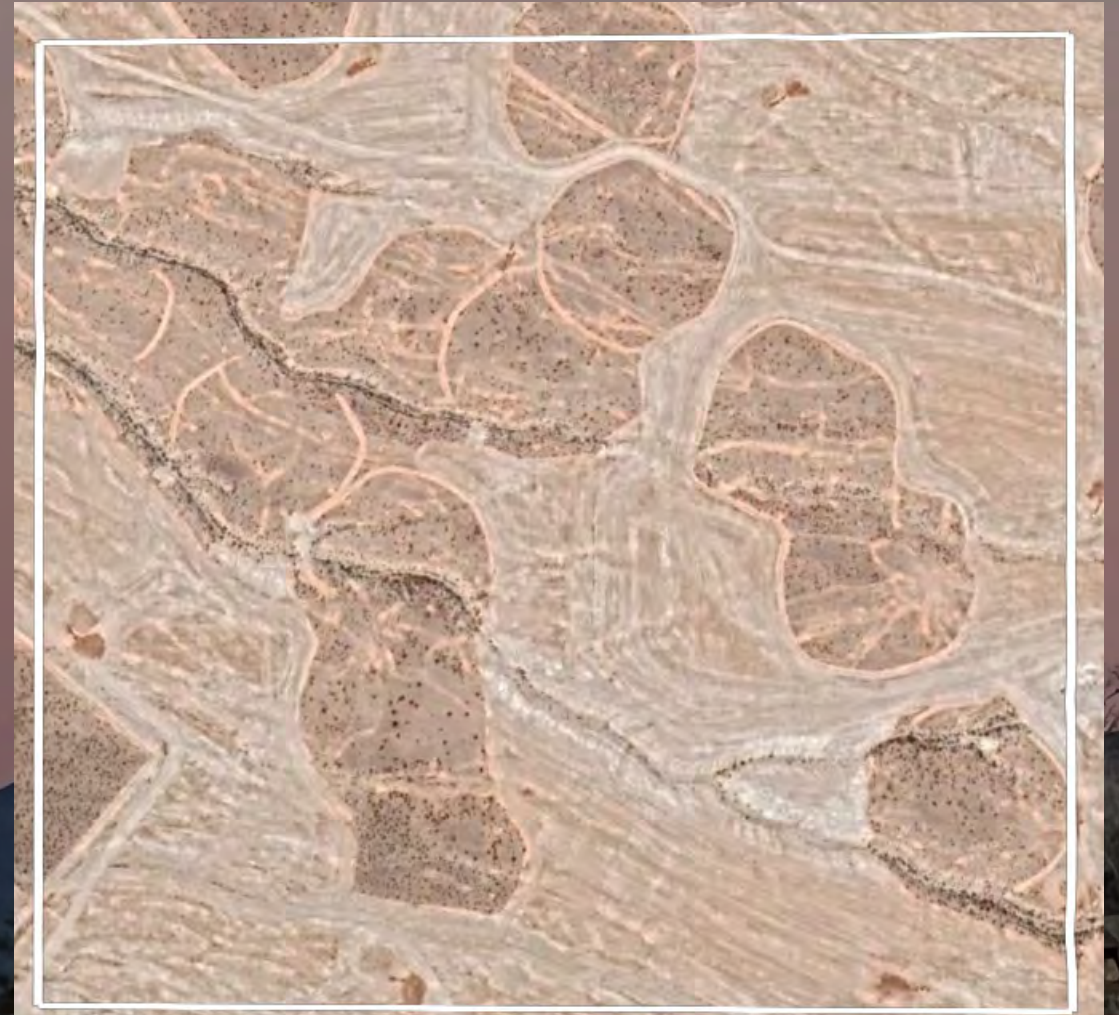
Restoration salvage

Soils

Plants – for re-planting

Vertical Mulch

Rocks



Patchwork for birds to finish nesting

# Post-Construction - Evaluation

## Remote Sensing & Ground Surveys

Were criteria met – for disturbance minimization?

Minimal

Moderate

Heavy

.....permanent roads met?

were temporary routes sufficiently recovered?

.....perennial vegetation standards met?

80% of original plant cover

.....100% of tortoise burrows intact, or  
120% restored?

How well are moderately disturbed areas recovering?  
If criteria not met, then light or intensive restoration  
(seeding, outplanting, soil amendment, vertical mulch)





**Minimal**

**Post-Construction Evaluation**  
**What percentages were achieved?**  
**Were standards met?**



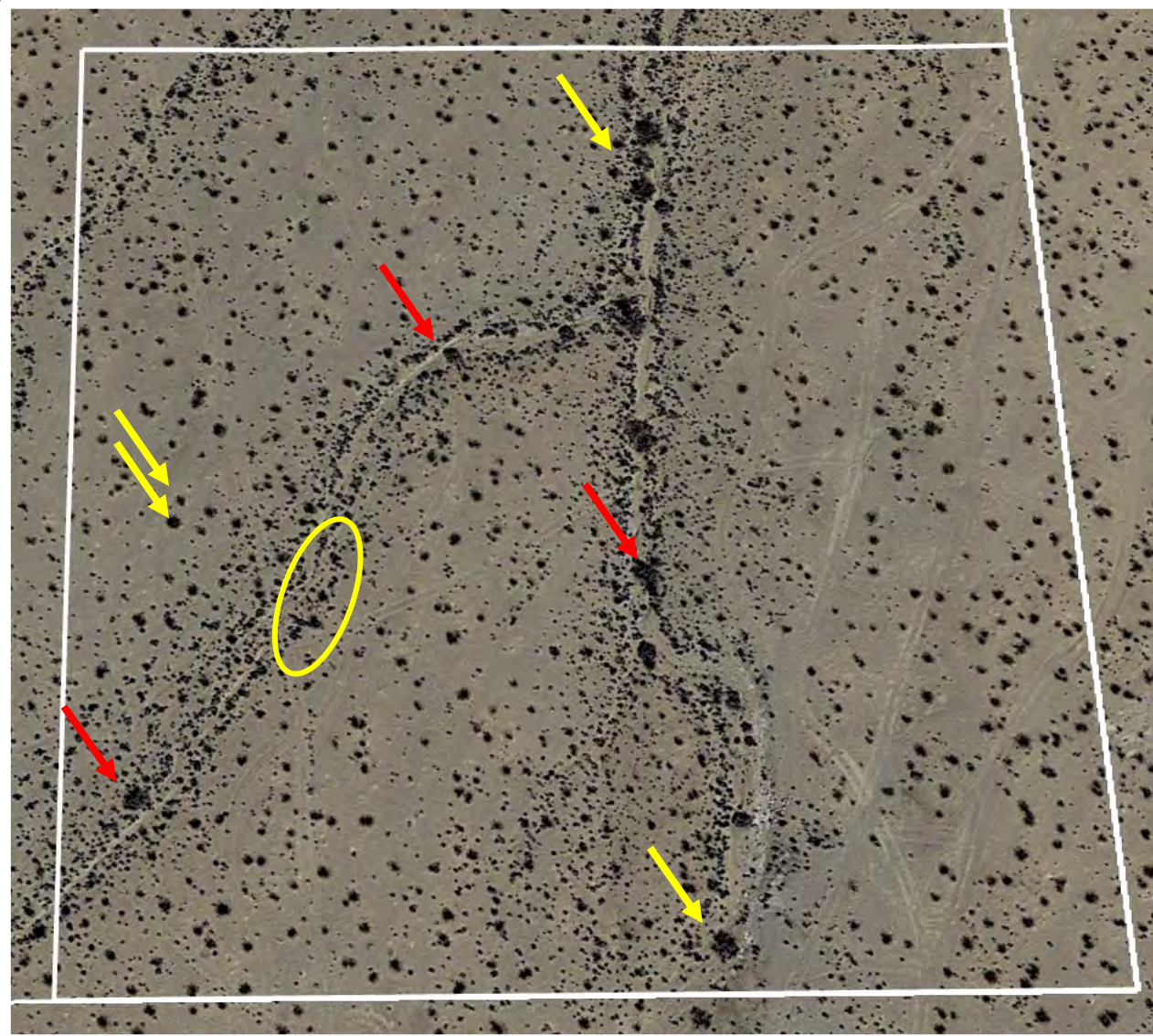
**Moderate**



**Heavy**

# Post-Construction Evaluation

What percentage of native perennial cover is left?



# Post-Construction Evaluation

What percentage of roads & trails remain after construction is complete?

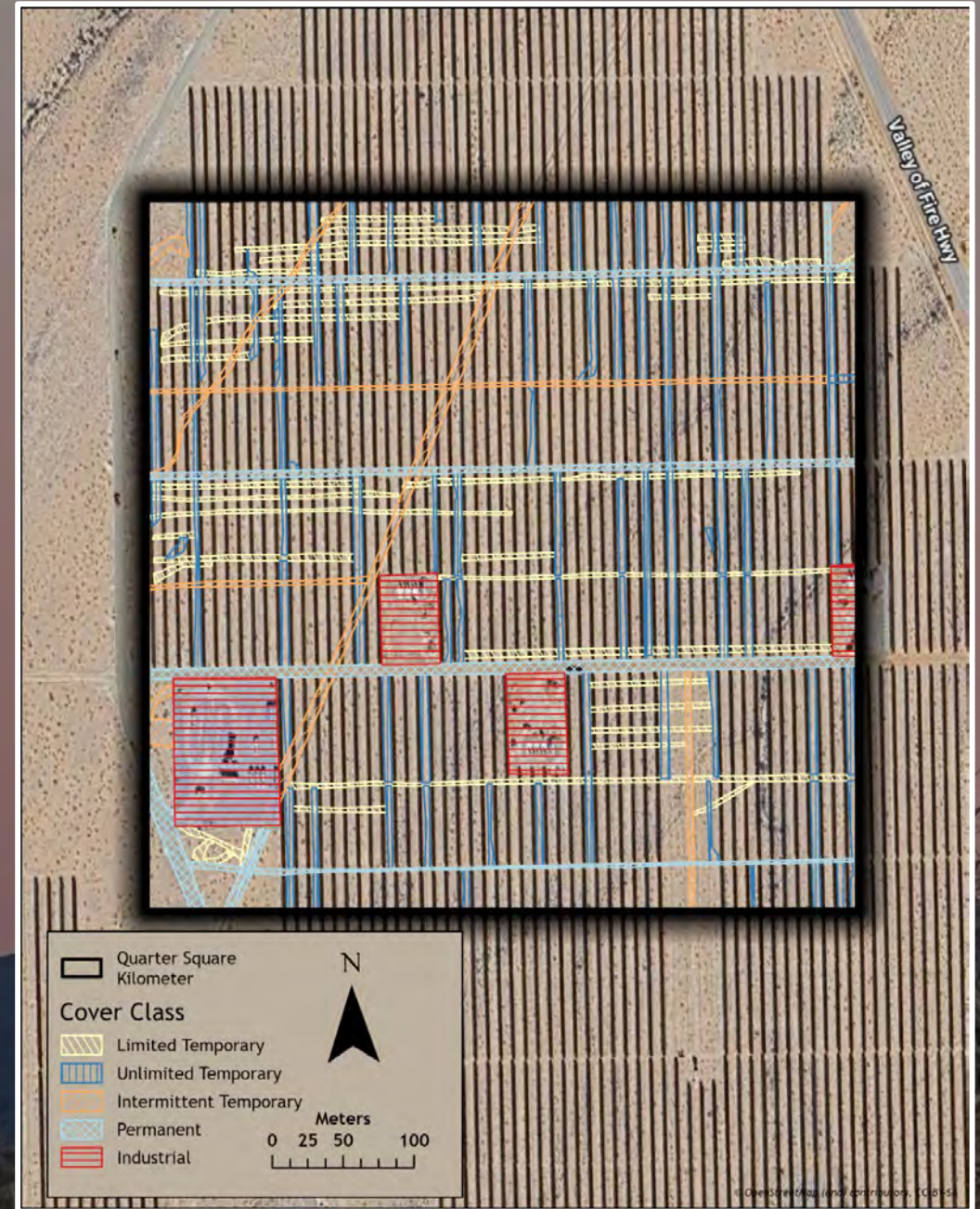
Criterion < 10% road cover

Measured ~17% road cover / 1km<sup>2</sup>

~10 % permanent roads

Light Restoration Activities

Intensive Restoration Activities



# Post-Construction Evaluation Remotely sense roads



# Monitoring and Research

Heat storage soils



Released heat evapo-transpiration



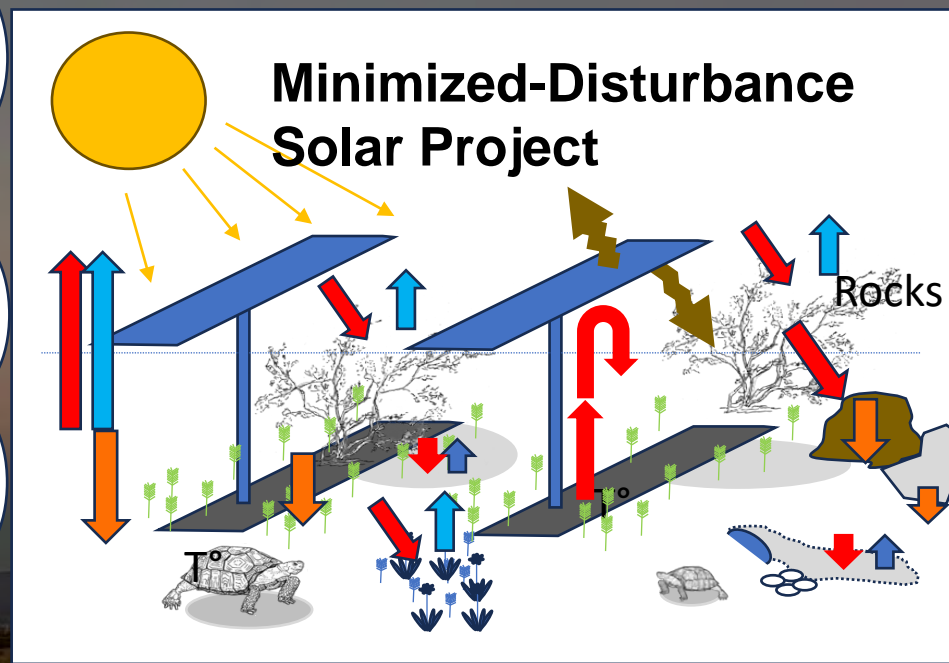
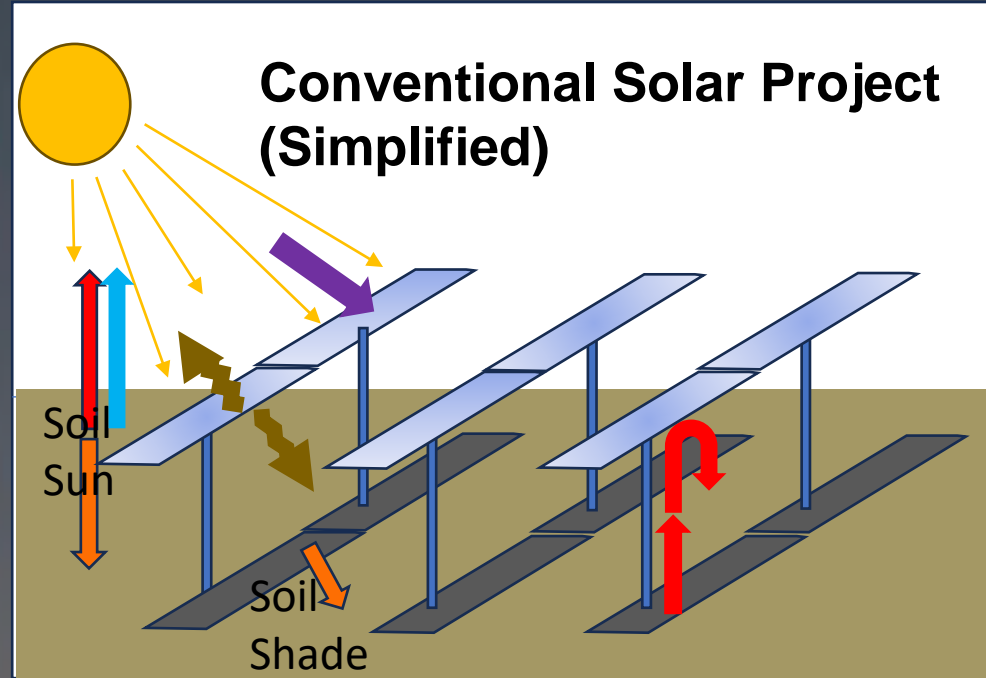
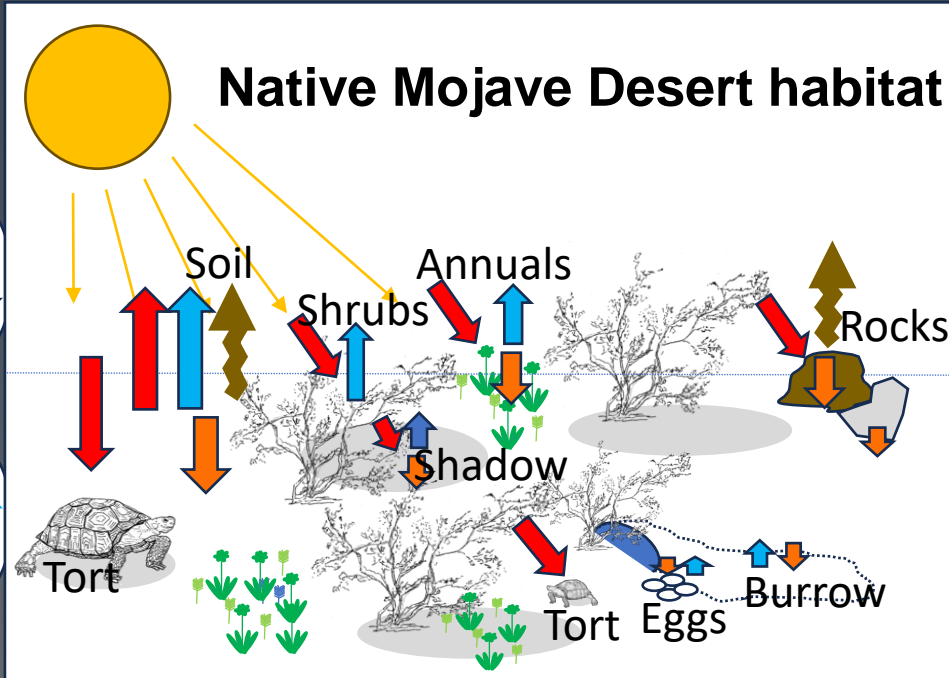
Heat re-radiation



Greater sensible heat fluxes



Energy transferred to electricity



*Adapted from: Barron-Gafford, et al. 2016. Scientific Reports 6. Credit to A. Slade 2023.*

*Tortoise and Creosotebush by Margarete Walden*

# Monitoring & Research

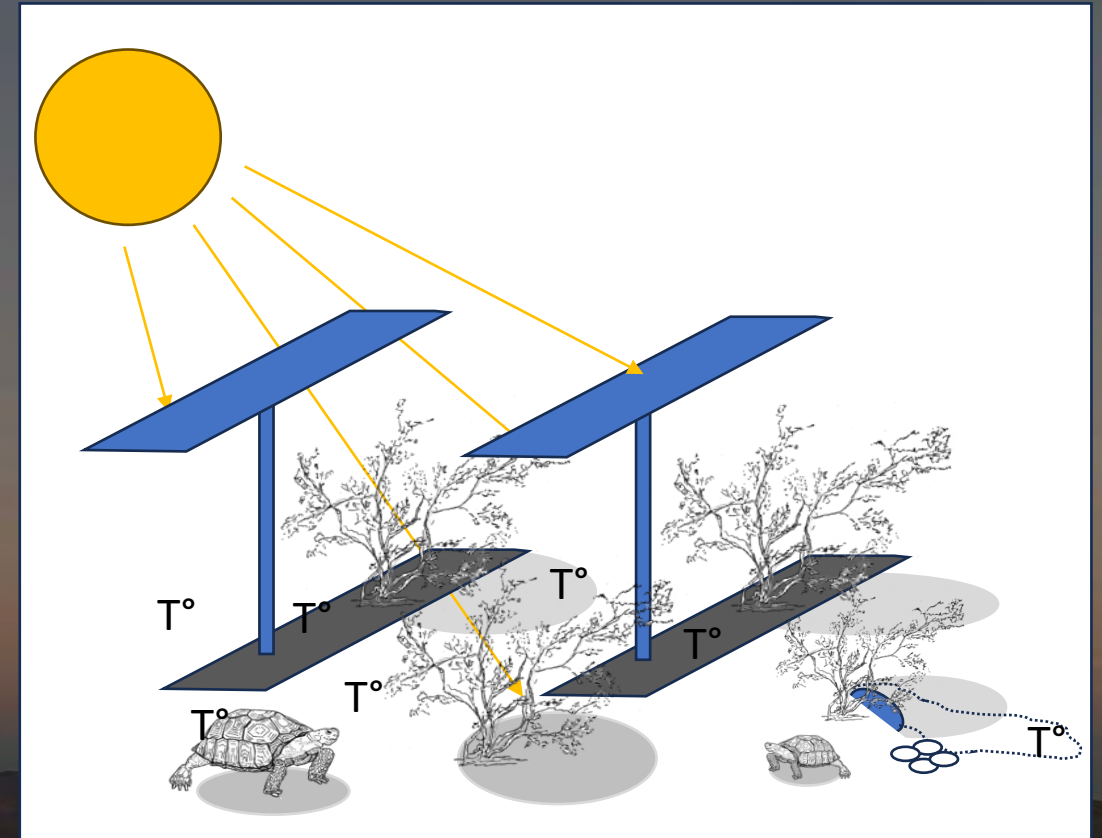
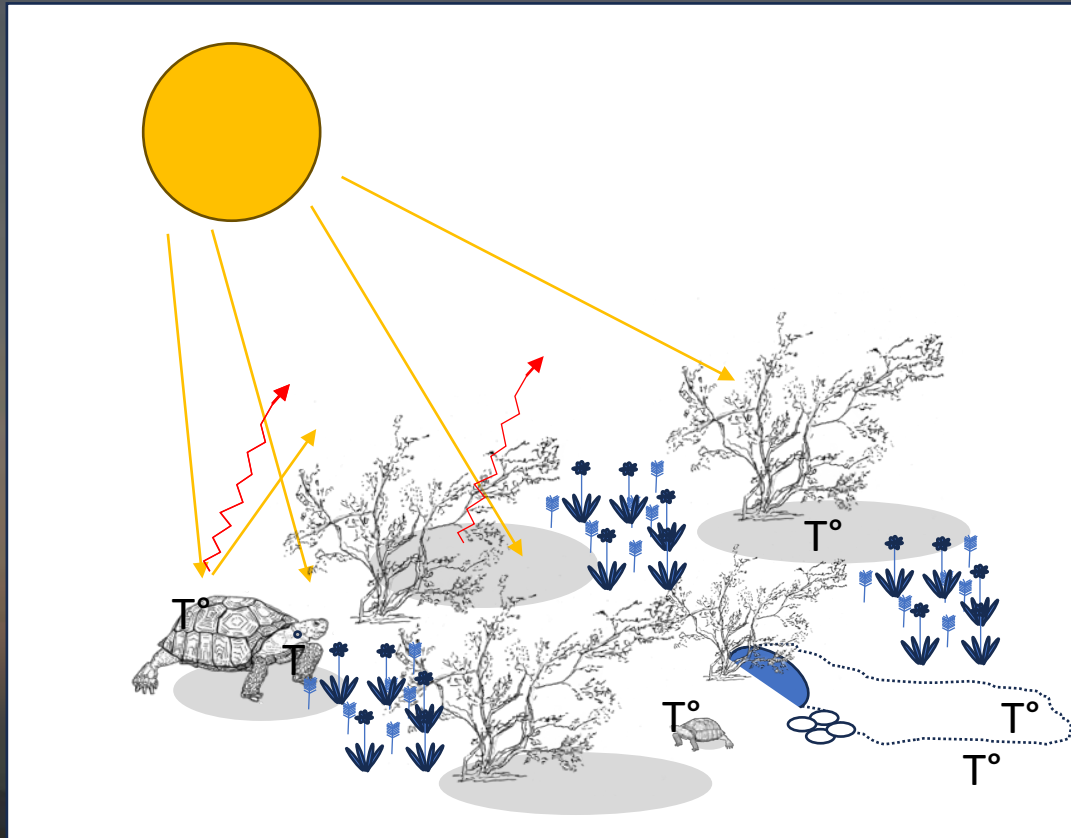
The thermal environment is extremely important to desert tortoises

Digestion

Summer and winter quiescent period

Incubation

Changes in behavior - vulnerabilities



**Thank you**  
**We look forward to discussion**