# Reducing Environmental Impacts of Solar Development on the Desert Tortoise

***Purpose of our project***

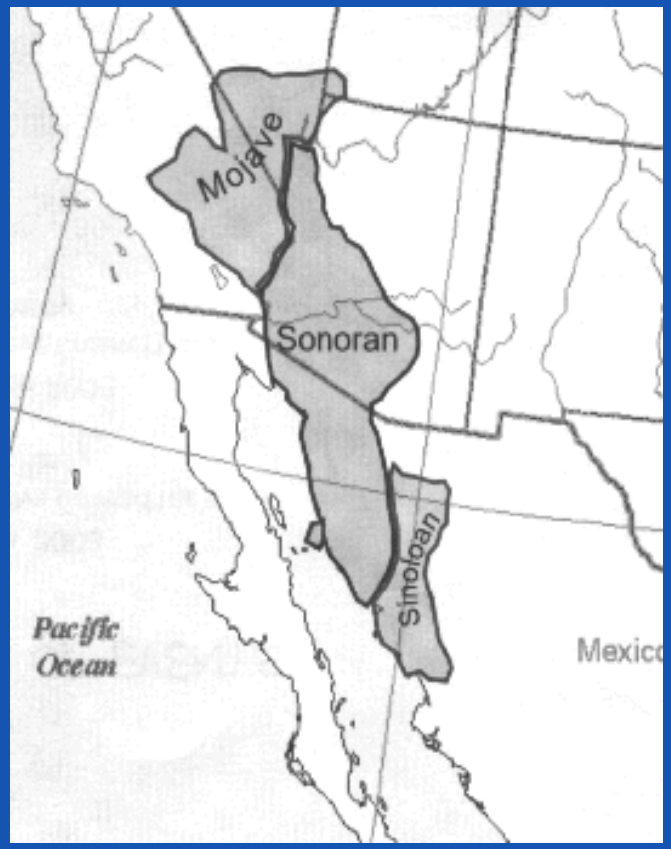
Provide access to sound and transparent scientific information and decision support technology on the potential threats, impacts, and mitigation actions affecting desert tortoises in the California Mojave desert

The ultimate product: web-based framework for conducting spatially-explicit and fully-documented impacts analyses of solar energy projects on the desert tortoise at project scale

UNIVERSITY OF Redlands
THE REDLANDS INSTITUTE

U.S. FISH & WILDLIFE SERVICE
DEPARTMENT OF THE INTERIOR

# Mojave Population of the Desert Tortoise

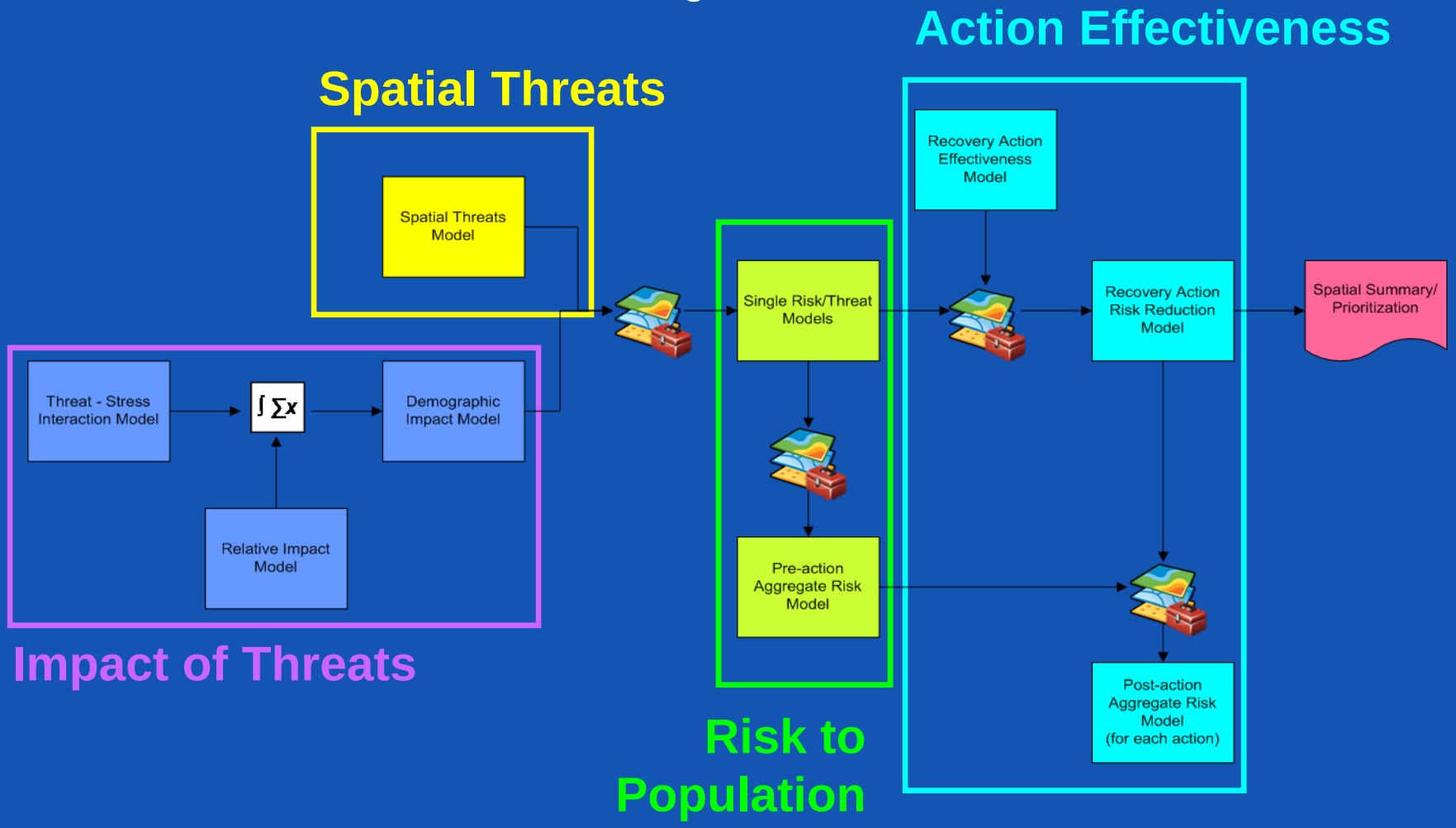



*Listed as Federally Threatened in 1990*

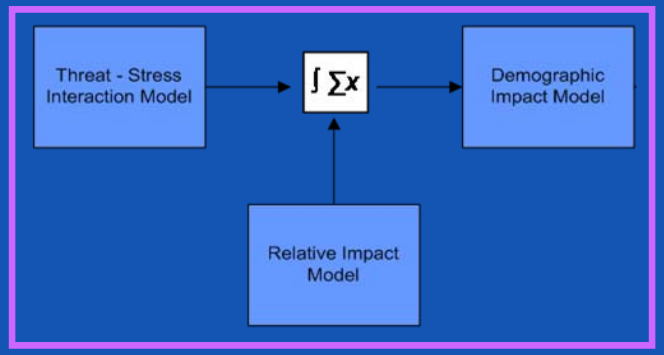
*Since then no evidence of recovery >> new strategy needed*

# Spatial Decision Support System

*Evaluates effects of different management actions for desert tortoise recovery*

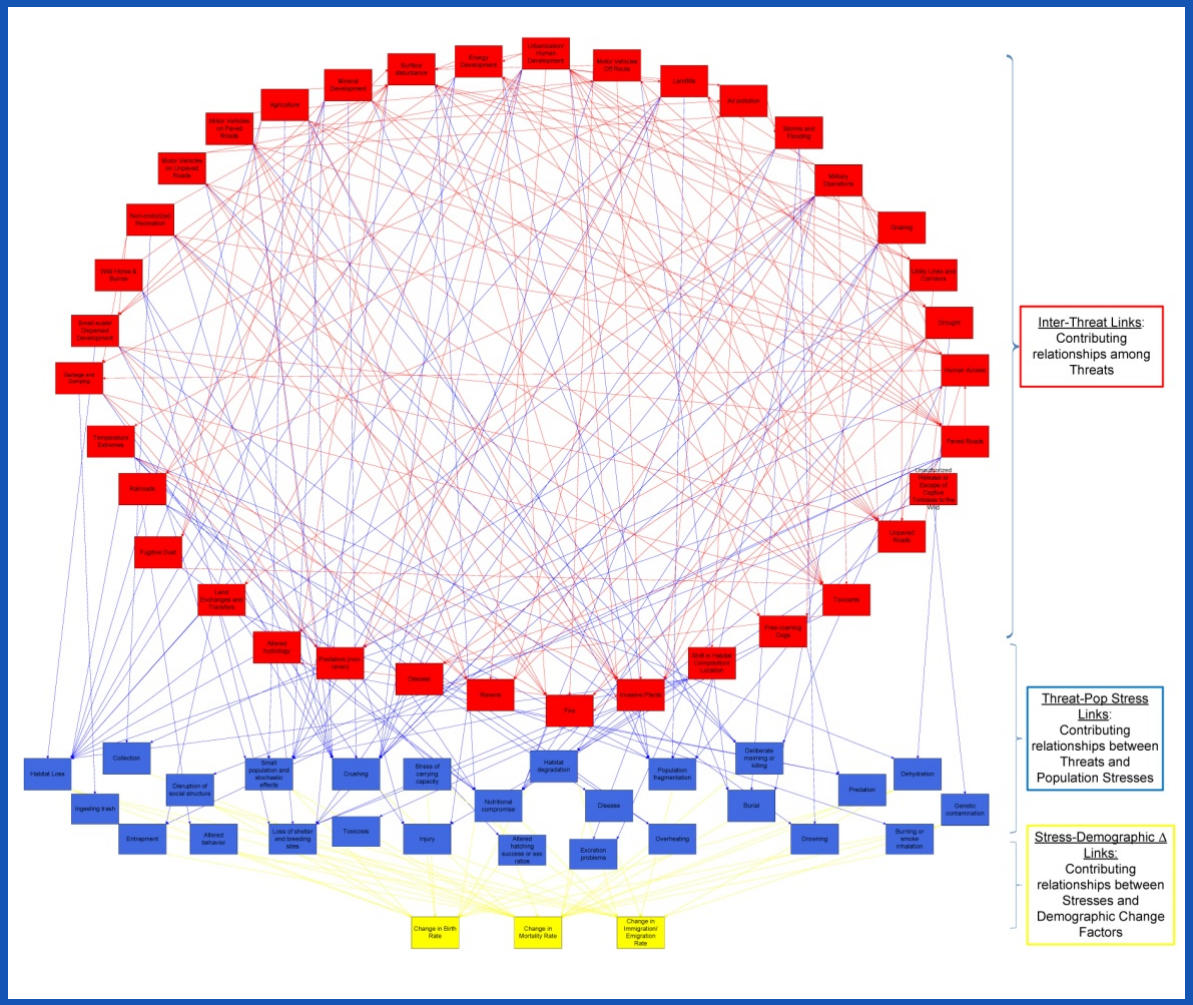


# Spatial Decision Support System




## Impact of Threats

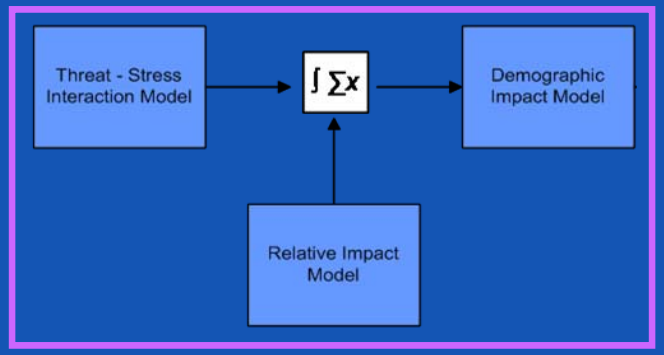
## Estimates the contribution of each individual threat to tortoise decline




*Utilizes Salafsky et al. 2008 lexicon for biodiveristy conservation*

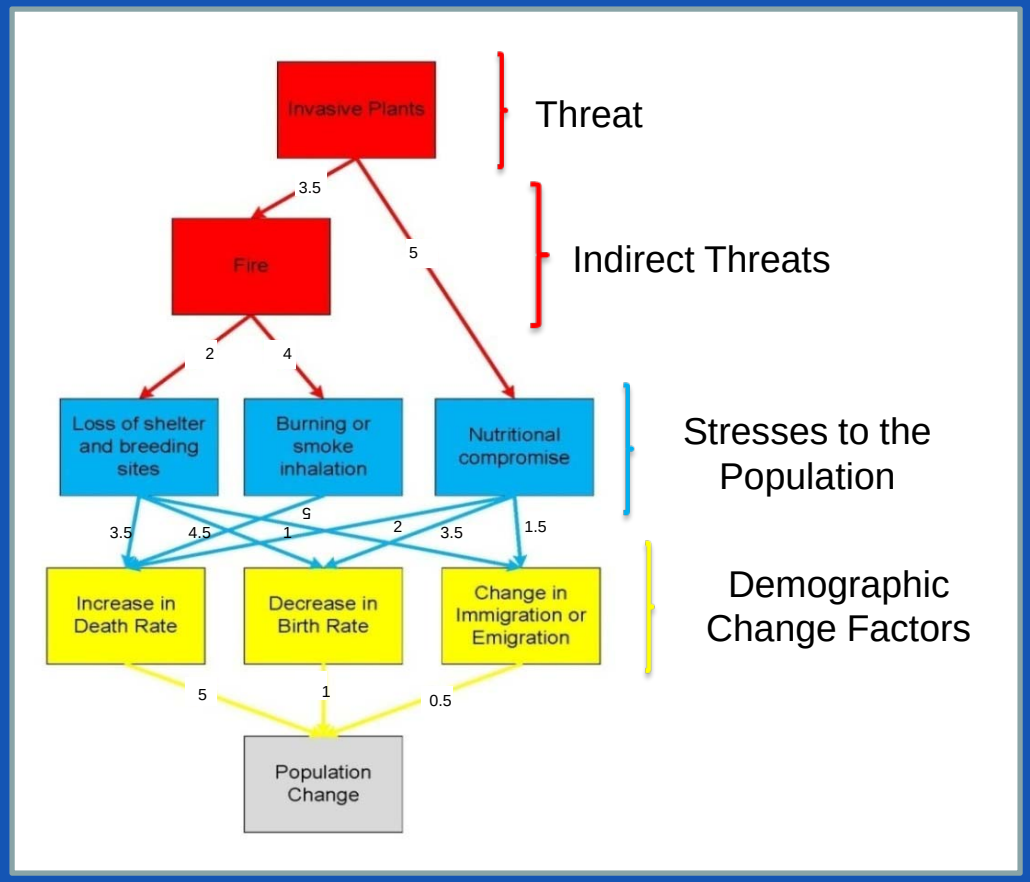
*Every link is defined with citations as available*

# Spatial Decision Support System




**Impact of Threats**

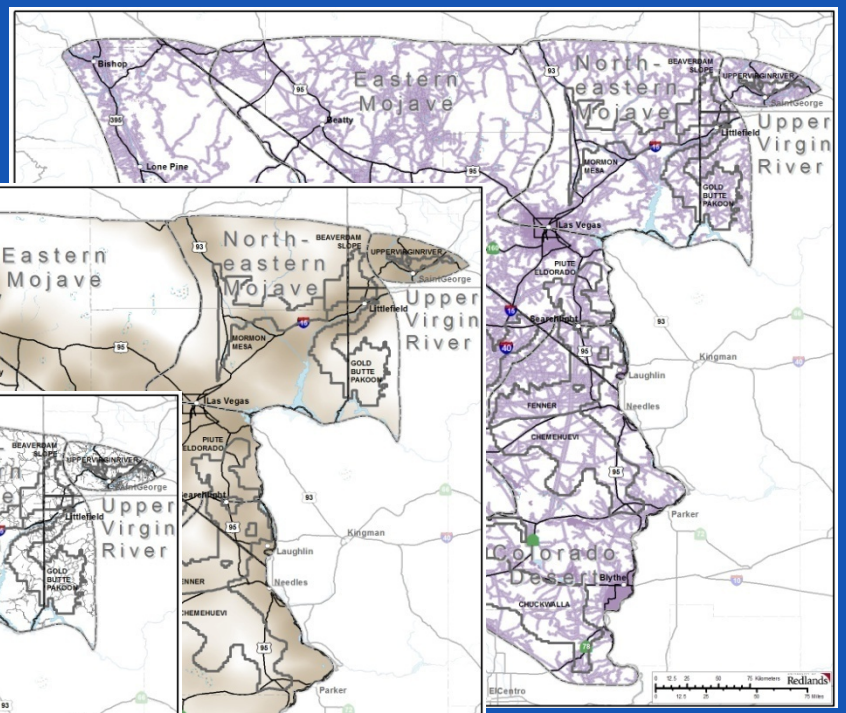
**Estimates the contribution of each individual threat to tortoise decline**



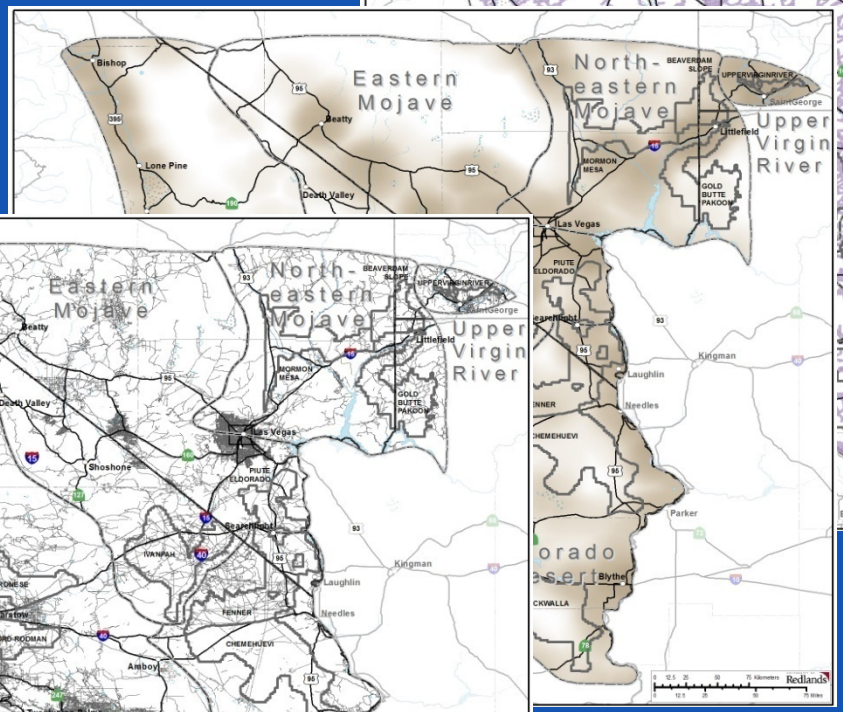

*Utilizes expert assessments to quantify the relative strength of relationships between threats and population demographic change factors*

# Spatial Decision Support System

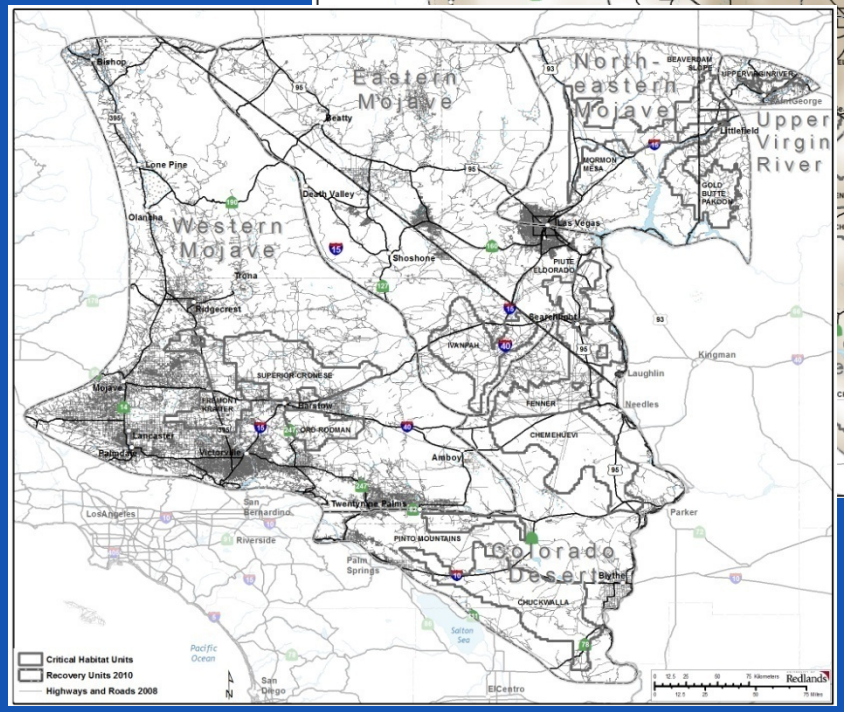
## Spatial Threats




*Invasive Plants*



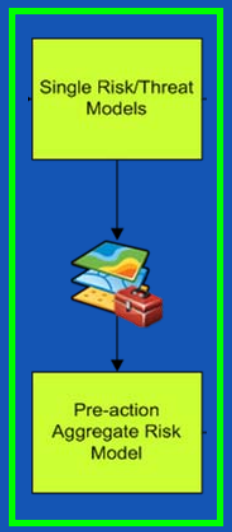

*Ravens*




*Roads*

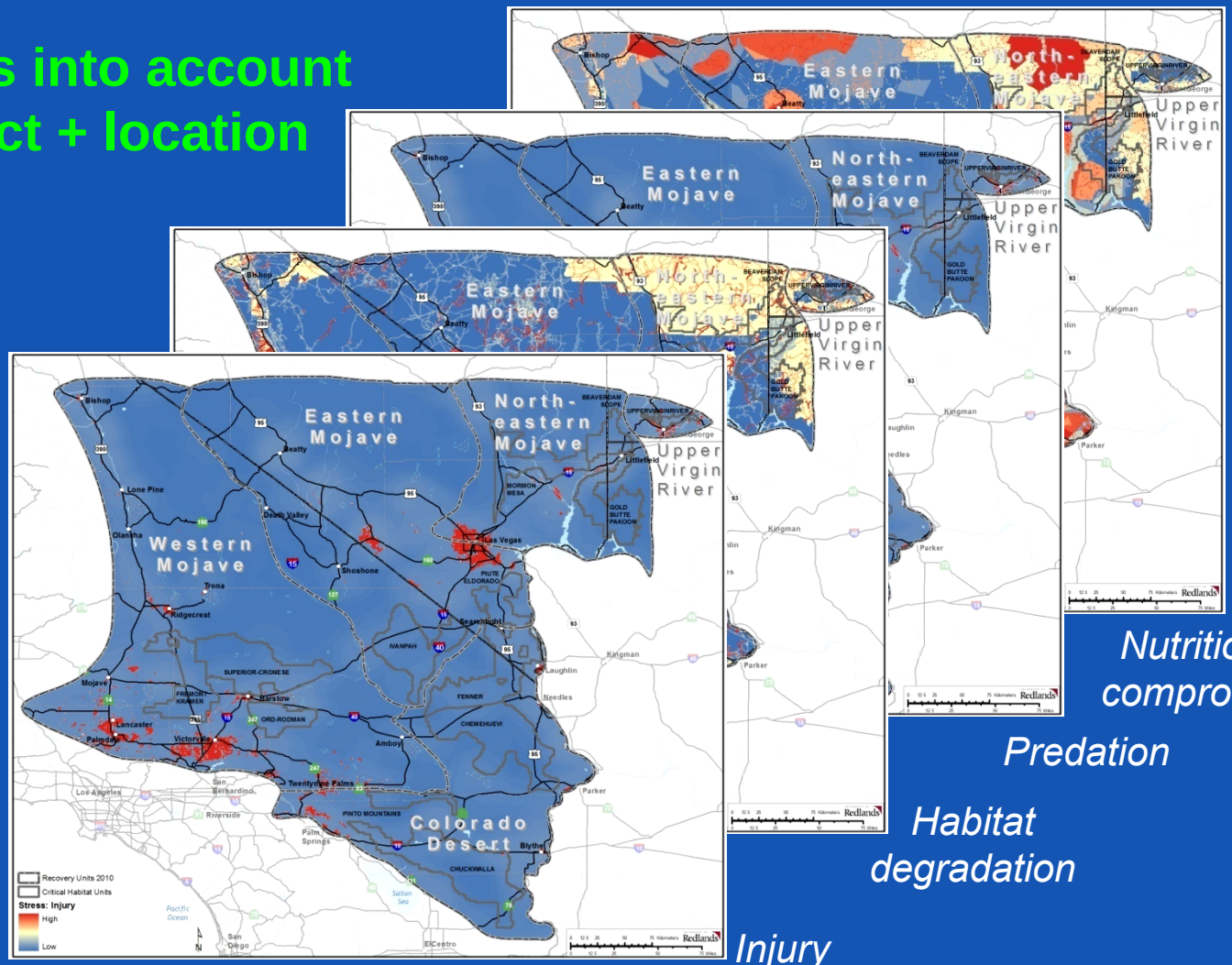
**Locations of threats to desert tortoise**

# Spatial Decision Support System




**Takes into account impact + location**

**Risk to Population**




*Nutritional compromise*

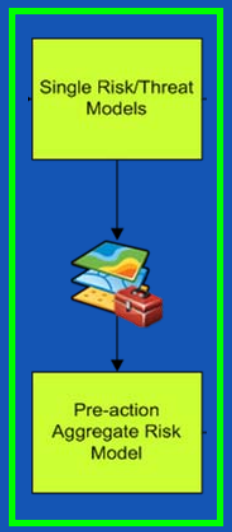
*Predation*

*Habitat degradation*

*Injury*

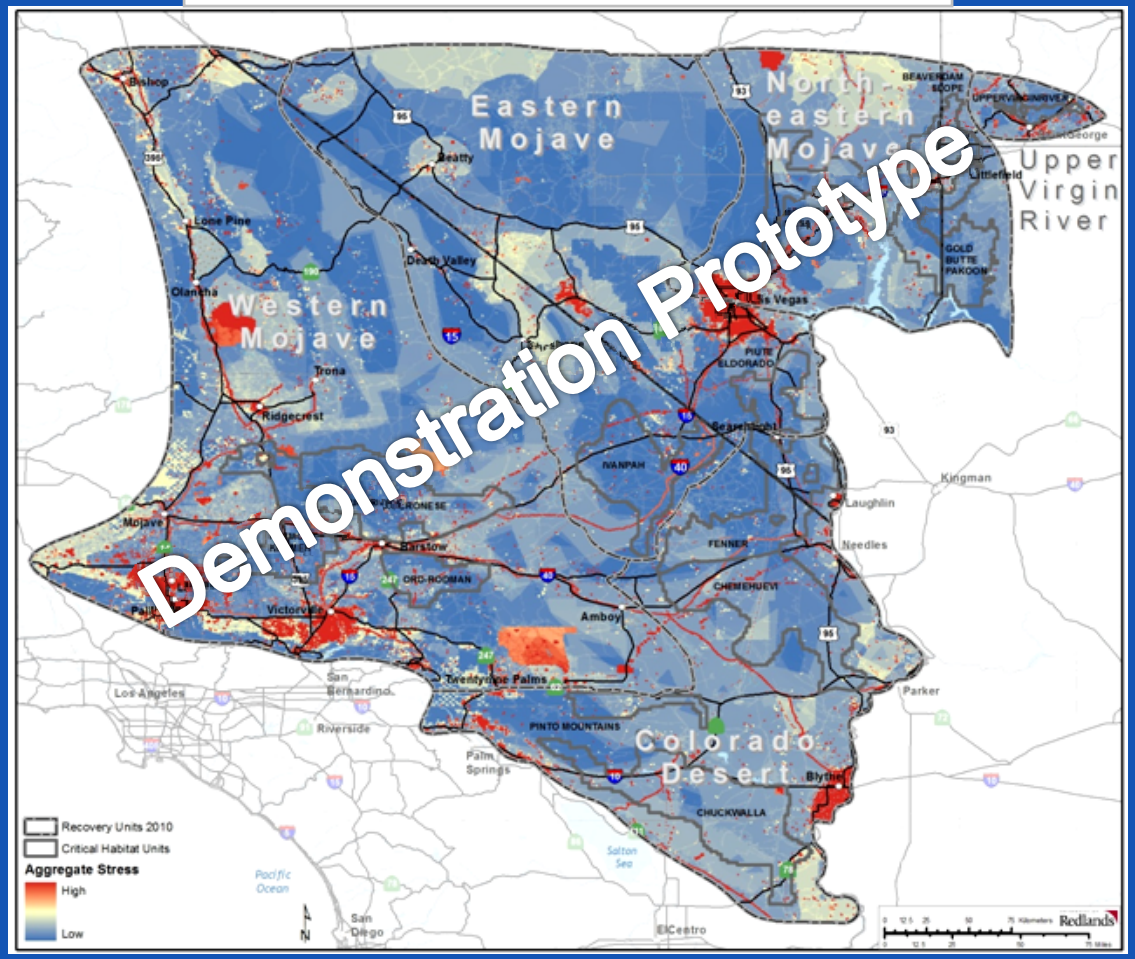
*Spatial contribution of each stress to tortoise decline = risk to the tortoise*

# Spatial Decision Support System




**Risk to Population**

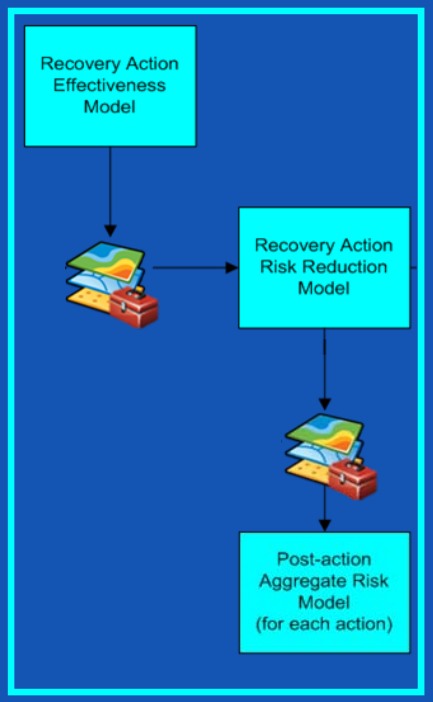
***Aggregate Risk to the Tortoise***




*Aggregate contribution from all threats and stresses to tortoise decline*

# Spatial Decision Support System

## Action Effectiveness



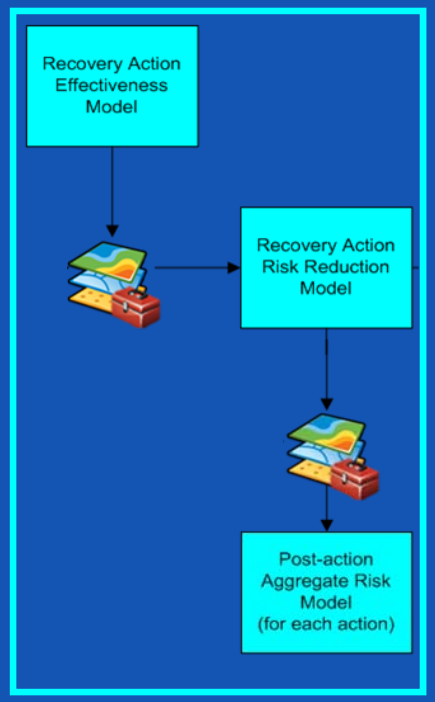

**Takes into account how individual recovery actions effect threat–stress links**

| Recovery Action/ Threat–Stress | Mortality–Disease | Habitat degrad–OHV | Collection–Human access | Nutritional comp–Grazing |
|---|---|---|---|---|
| Close Roads | 1.1 | 4.6 | 3.25 | 0 |
| Connect Habitat | 1.7 | 0 | 0 | 0 |
| Environmental Education | 2.5 | 3.5 | 3.9 | 0 |
| Control Ravens | 0 | 0 | 0 | 0 |
| Close allotments | 0 | 0 | 0 | 4.8 |
| Increase Law enforcement | 0 | 4.9 | 3.3 | 0 |
| Revegetation | 0.8 | 3 | 0 | 0.5 |

*Utilizes expert assessments of threat–stress and action relationships on a scale of 0 (none) to 5 (high)*

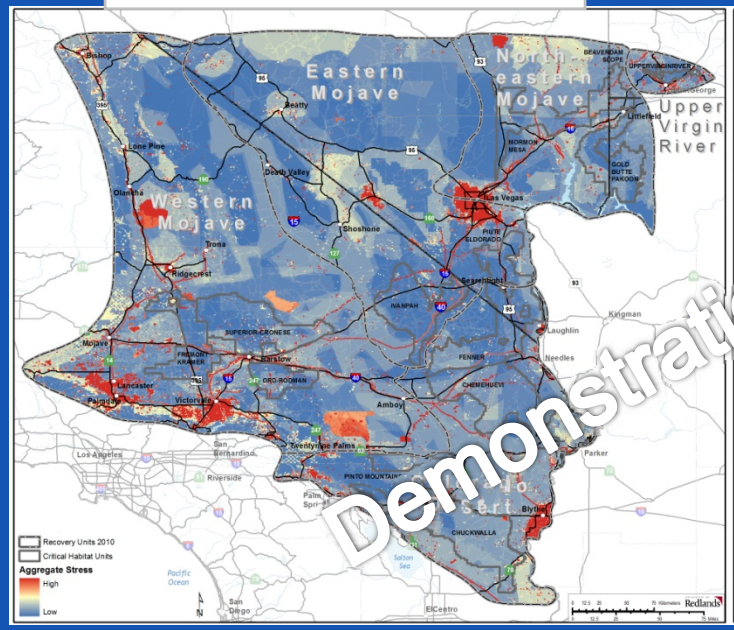
# Spatial Decision Support System

## Action Effectiveness

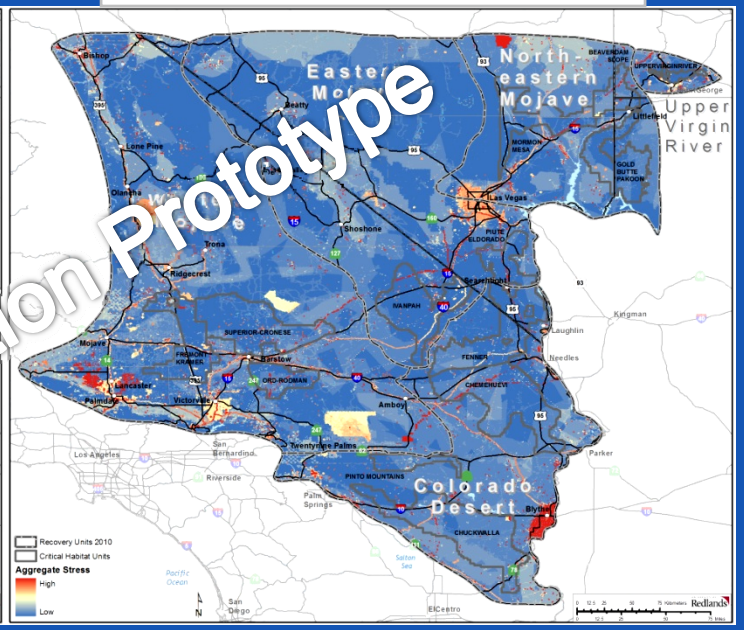



**Takes into account how individual recovery actions effect threat–stress links**

***Aggregate Risk to the Tortoise***




***Remaining Risk after Remove-all-Predators Action***




*Post-action population stress severity (risk to the tortoise) as a result of the hypothetical action of removing all tortoise predators*

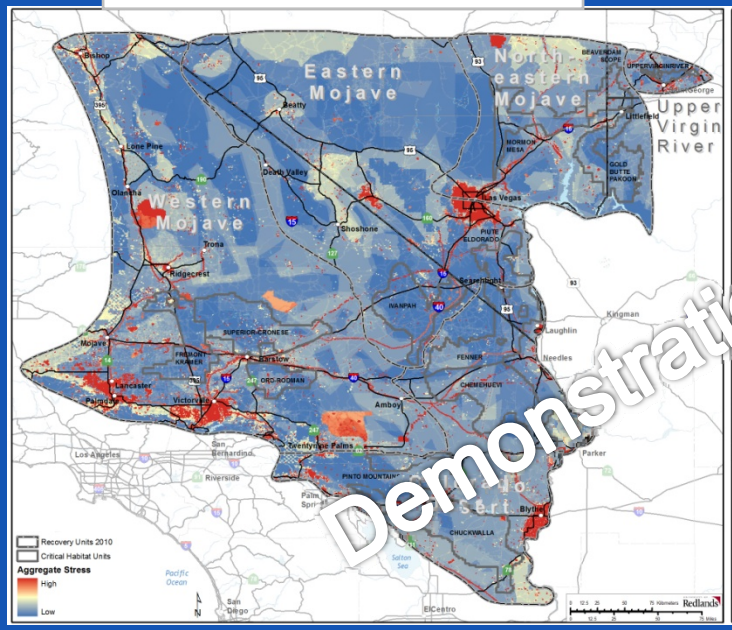
# Spatial Decision Support System

Spatial Summary/ Prioritization

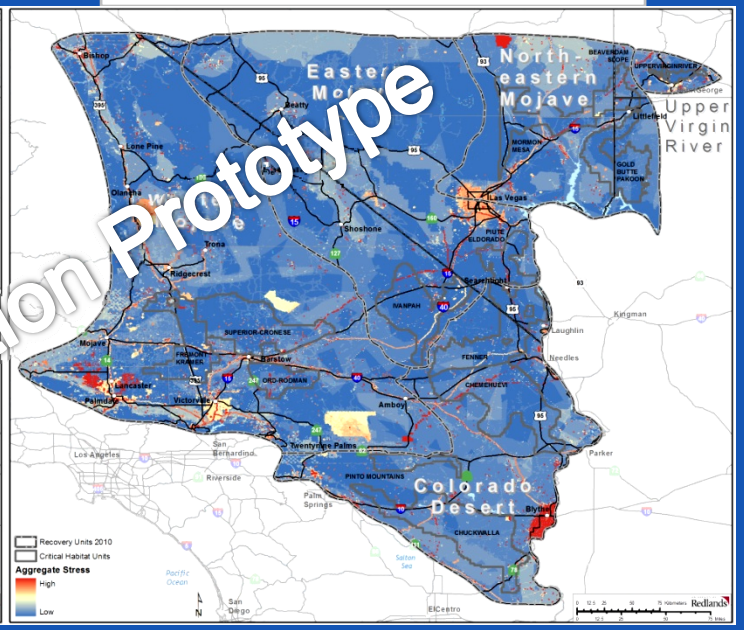
**Compares remaining threat severity across recovery actions**

**Extent of threat after actions**

*Aggregate Risk to the Tortoise*




*Remaining Risk after Remove-all-Predators Action*




*After remove-all-predators action, Δ risk to the tortoise = +464,000*

# Spatial Decision Support System

## Utilize prioritization to create Recovery Action Plans

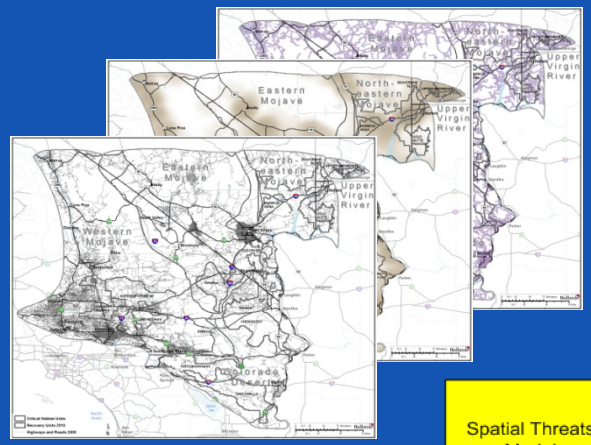
**Extent of threat after actions**

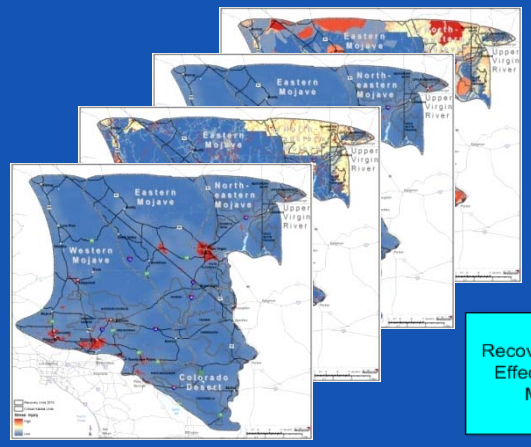
| UTAH: Upper Virgin River Recovery Unit | | |
|---|---|---|
| **Action** | **Δ overall risk** | **Rank** |
| Increase law enforcement | 970 | 1 |
| Close OHV routes | 832 | 2 |
| Decrease subsidies to predators | 458 | 3 |
| Restore habitat | 183 | 4 |
| Environmental education | 154 | 5 |
| Install culverts for connectivity | 70 | 6 |

Demonstration Prototype

*Change (decrease) in overall risk is calculated for all possible actions within a given area, actions can then be prioritized according to total risk reduction*

# Spatial data processing and management system designed to help the RITs prioritize, track and evaluate recovery efforts




Spatial Threats Model

Recovery Action Effectiveness Model

| Recovery Action/Threat | Disease | OHV routes | Collision | Cattle Grazing | Air Pollution |
|---|---|---|---|---|---|
| Close roads | 1 | 3 | 2 | 0 | 0.5 |
| Connect fragmented Habitat | 1 | 0 | 0 | 0 | 0 |
| Environmental Education | 2 | 3 | 3 | 0 | 1 |
| Control Ravens | 0 | 0 | 0 | 0 | 0 |
| Fence Roads | 0 | 0 | 3 | 0 | 0 |
| Increase law enforcement | 0 | 3 | 3 | 0 | 0 |
| Revegetation | 0 | 3 | 0 | 0 | 1 |

Threat - Stress Interaction Model

$\int \sum x$

Demographic Impact Model

Relative Impact Model

Single Risk/Threat Models

Recovery Action Risk Reduction Model

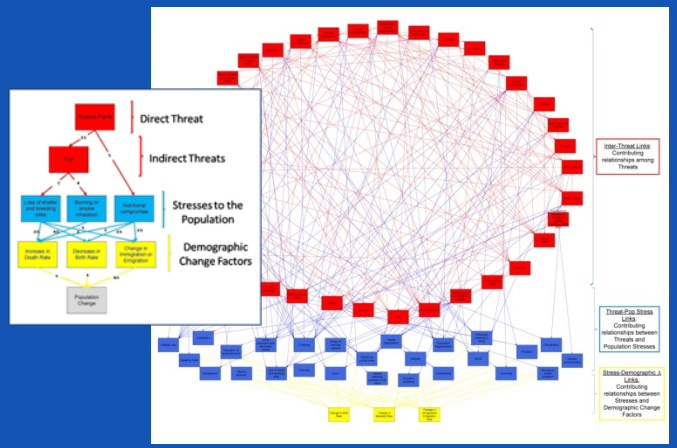
Spatial Summary/ Prioritization

Upper Virgin River Recovery Unit

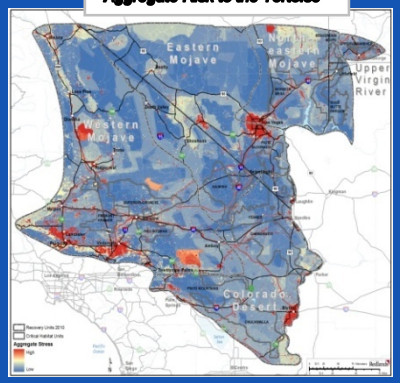
| Action | Average | Rank |
|---|---|---|
| Increase law enforcement | 6.60 | 1 |
| Close roads | 5.32 | 2 |
| Environmental education | 4.58 | 3 |
| Control ravens | 2.23 | 4 |
| Connect fragmental habitat | 1.54 | 5 |
| Conduct revegetation | 0.07 | 6 |

Pre-action Aggregate Risk Model

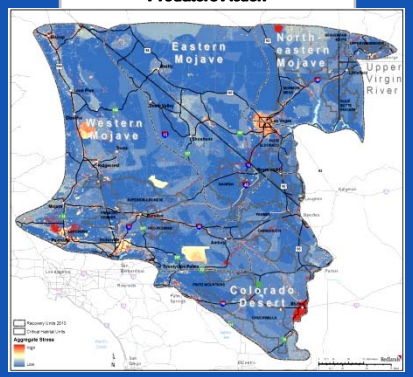
Post-action Aggregate Risk Model (for each action)




***Aggregate Risk to the Tortoise***

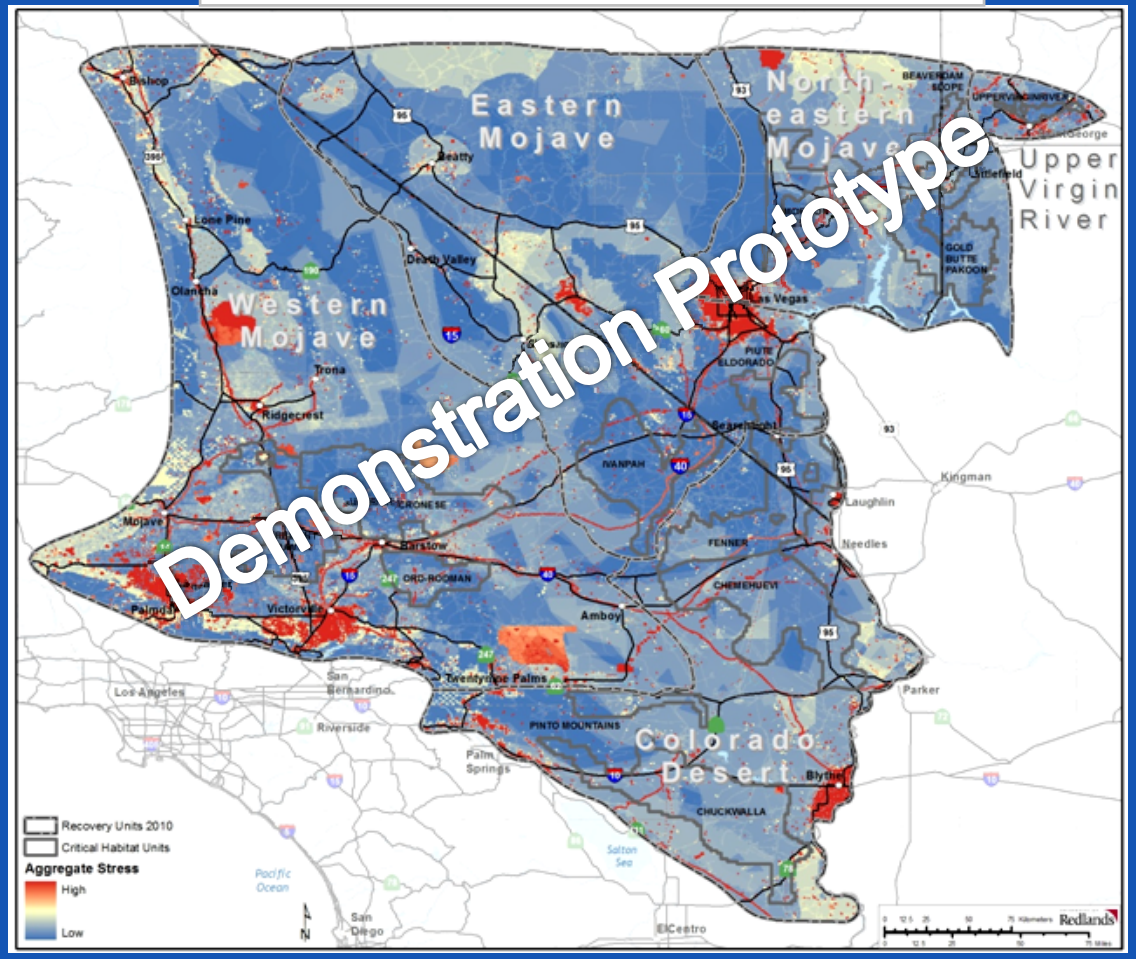



***Remaining Risk after Remove-all-Predators Action***



# Spatial Decision Support System

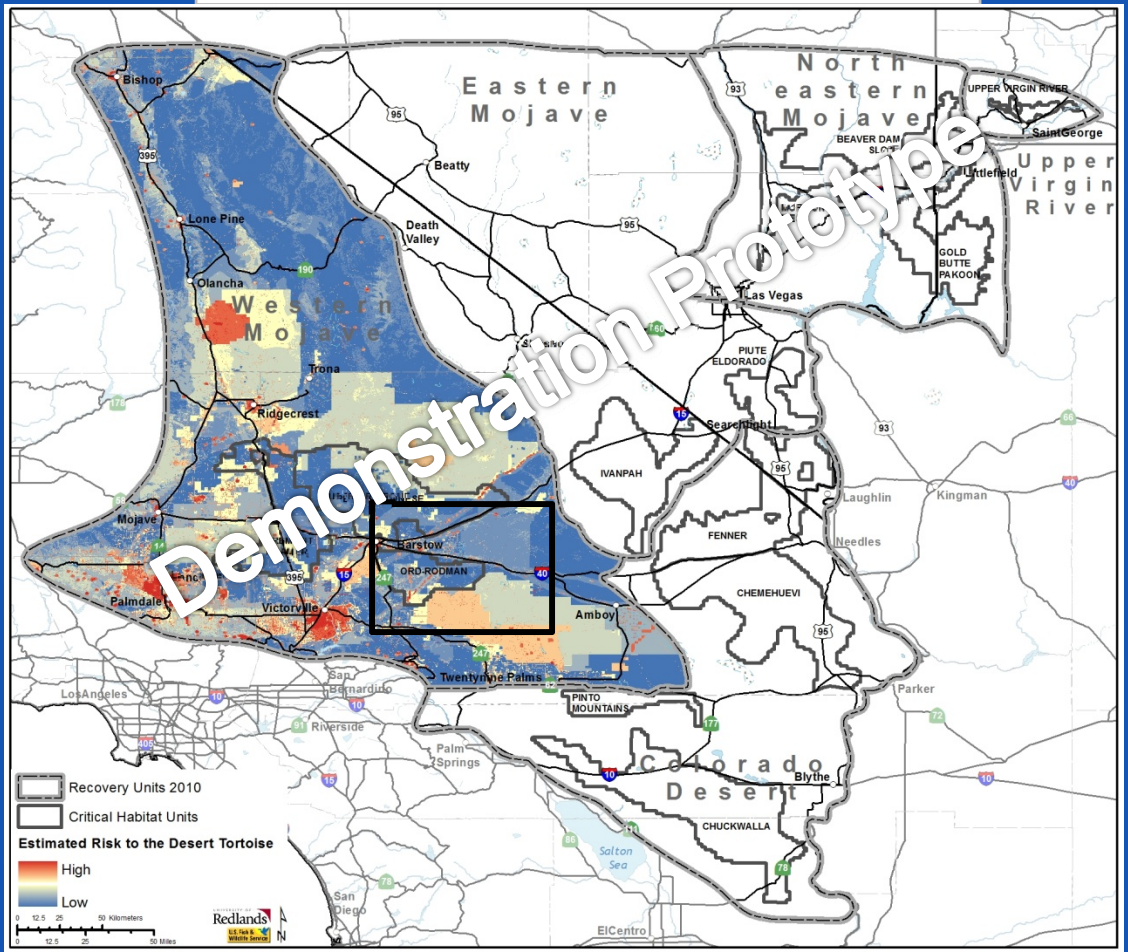
***Aggregate Risk to the Tortoise***




*Potential Tool for Quantifying Solar Development Impacts and Mitigation Needs for the Desert Tortoise?*

# Spatial Decision Support System

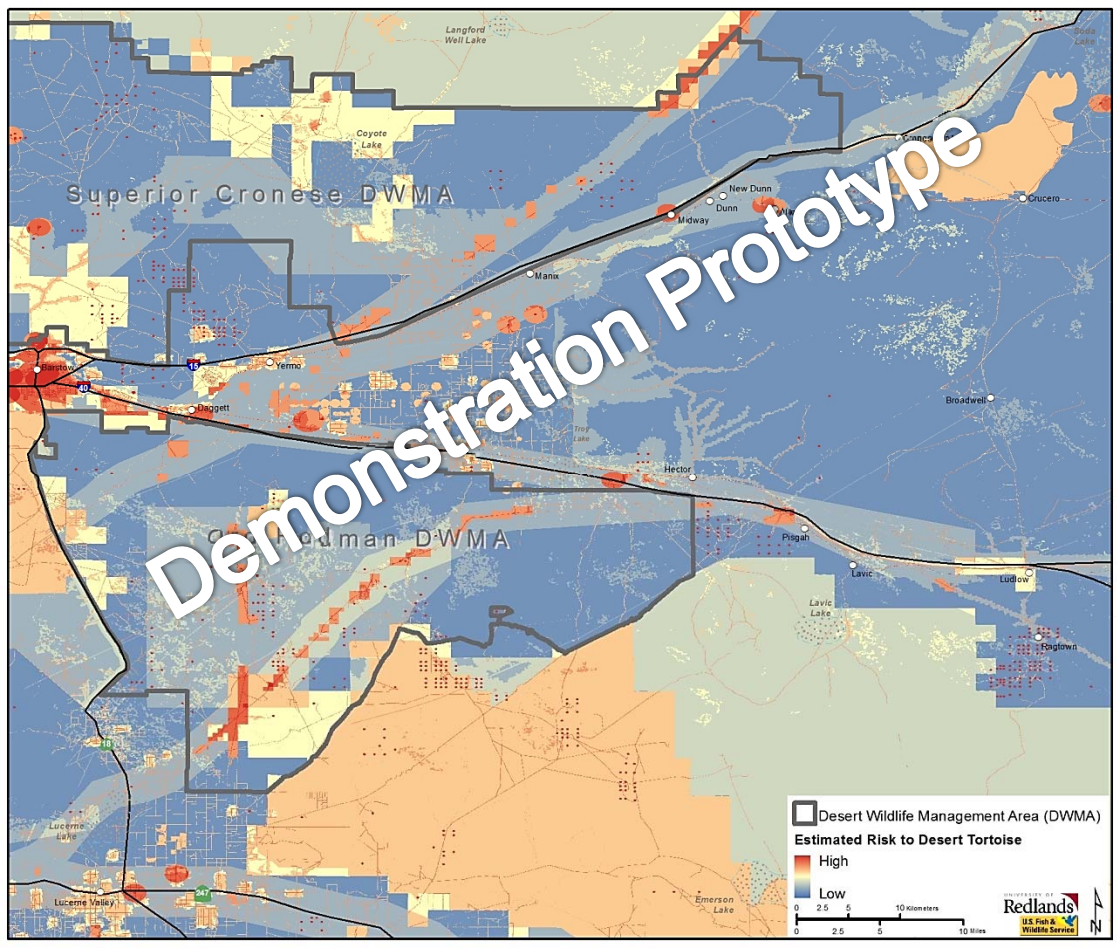
## *Aggregate Risk to the Tortoise*




*Potential Tool for Quantifying Solar Development Impacts and Mitigation Needs for the Desert Tortoise?*

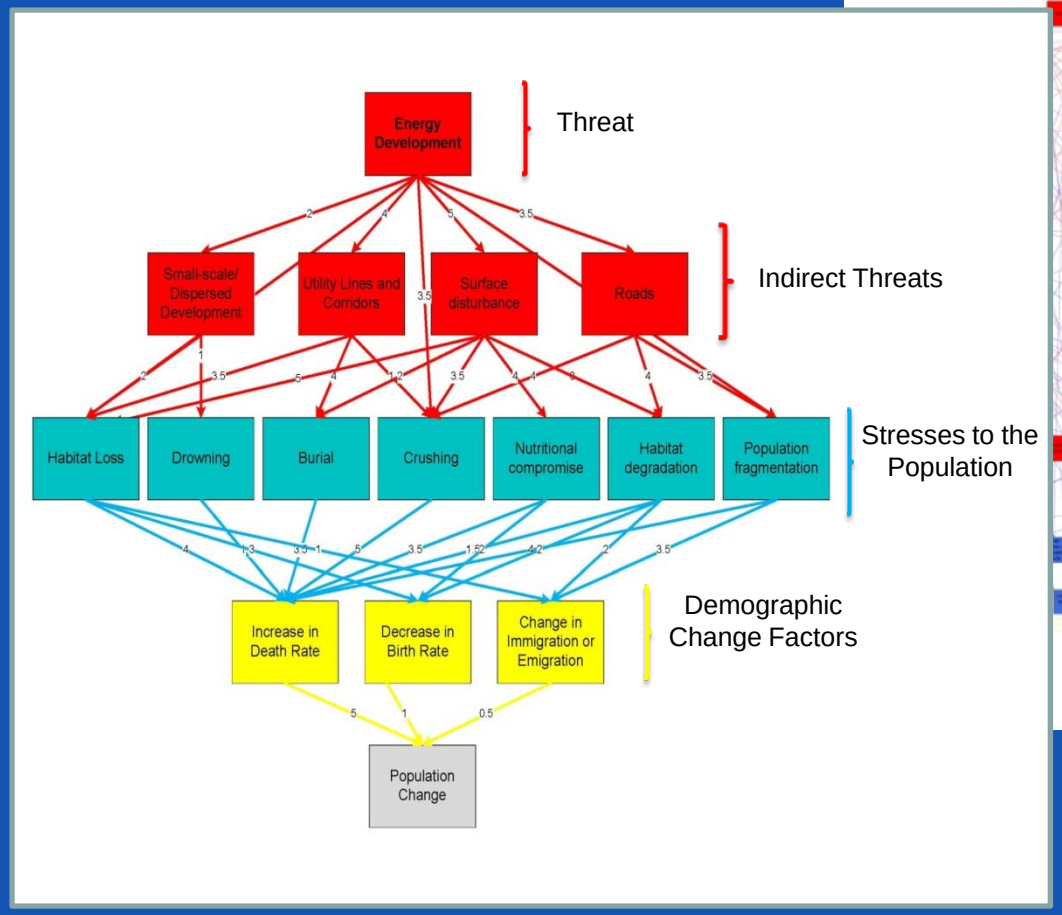
# Spatial Decision Support System

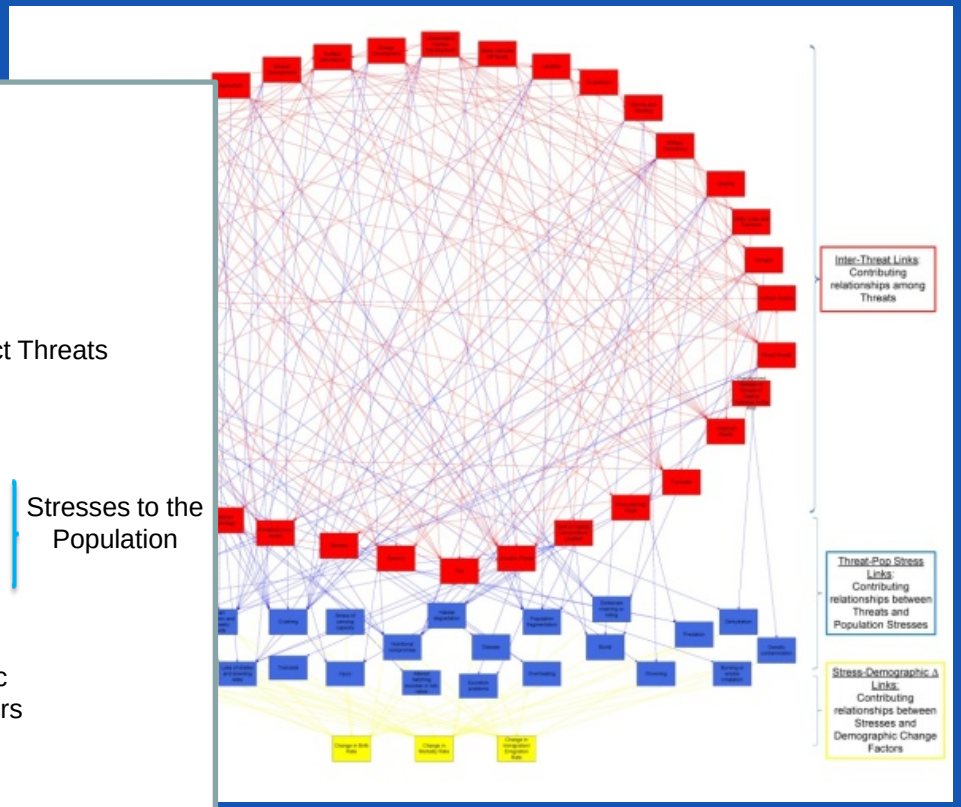
***Aggregate Risk to the Tortoise***




*Potential Tool for Quantifying Solar Development Impacts and Mitigation Needs for the Desert Tortoise?*

# Spatial Decision Support System

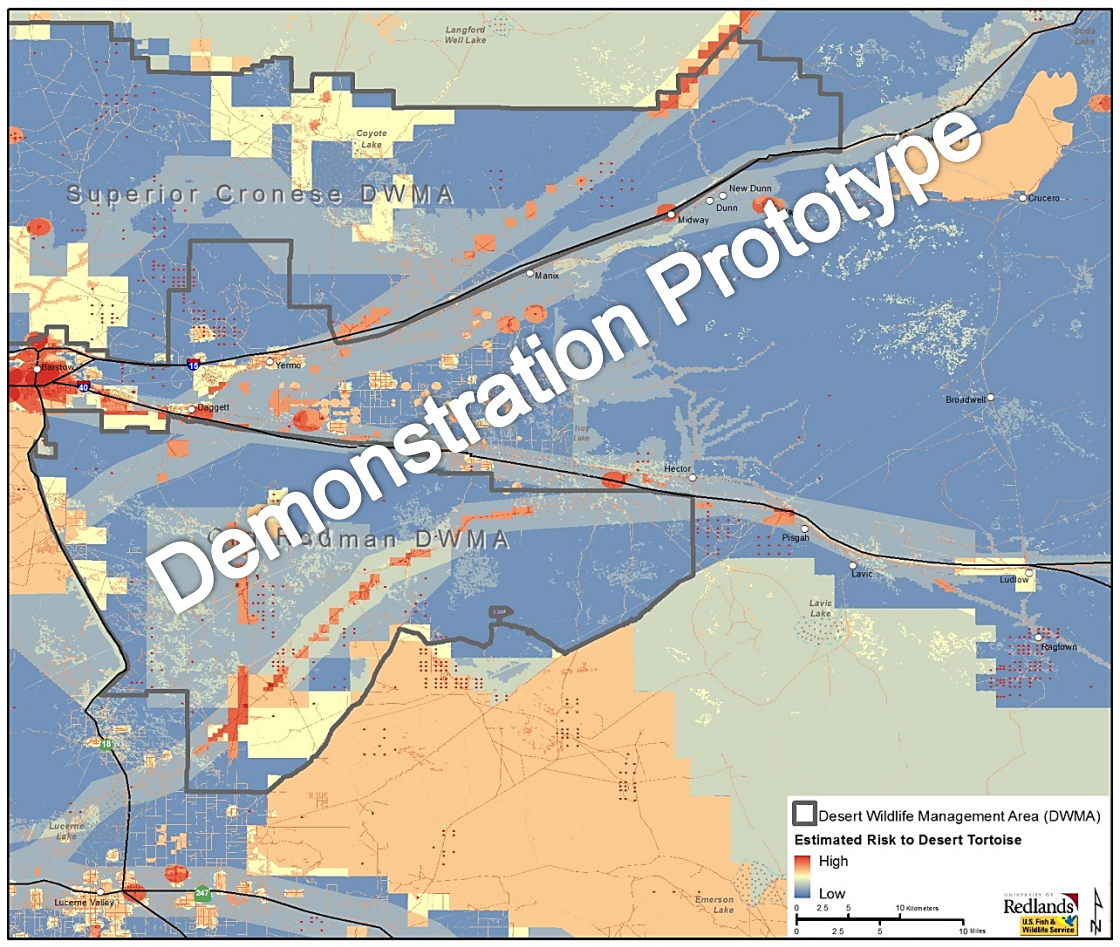



*Potential Tool for Quantifying Solar Development Impacts and Mitigation Needs for the Desert Tortoise?*

# Spatial Decision Support System

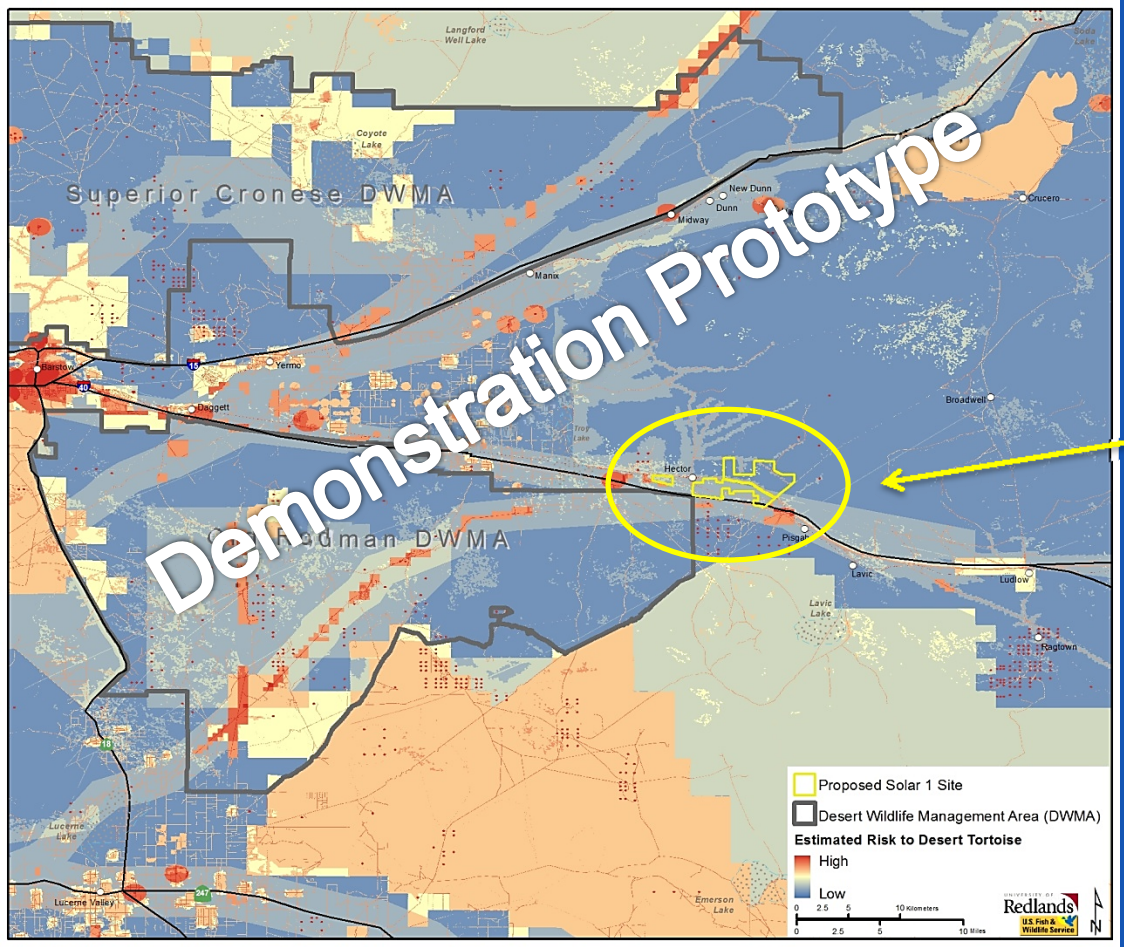
## *Aggregate Risk to the Tortoise*




*Potential Tool for Quantifying Solar Development Impacts and Mitigation Needs for the Desert Tortoise?*

# Spatial Decision Support System

***Aggregate Risk to the Tortoise***

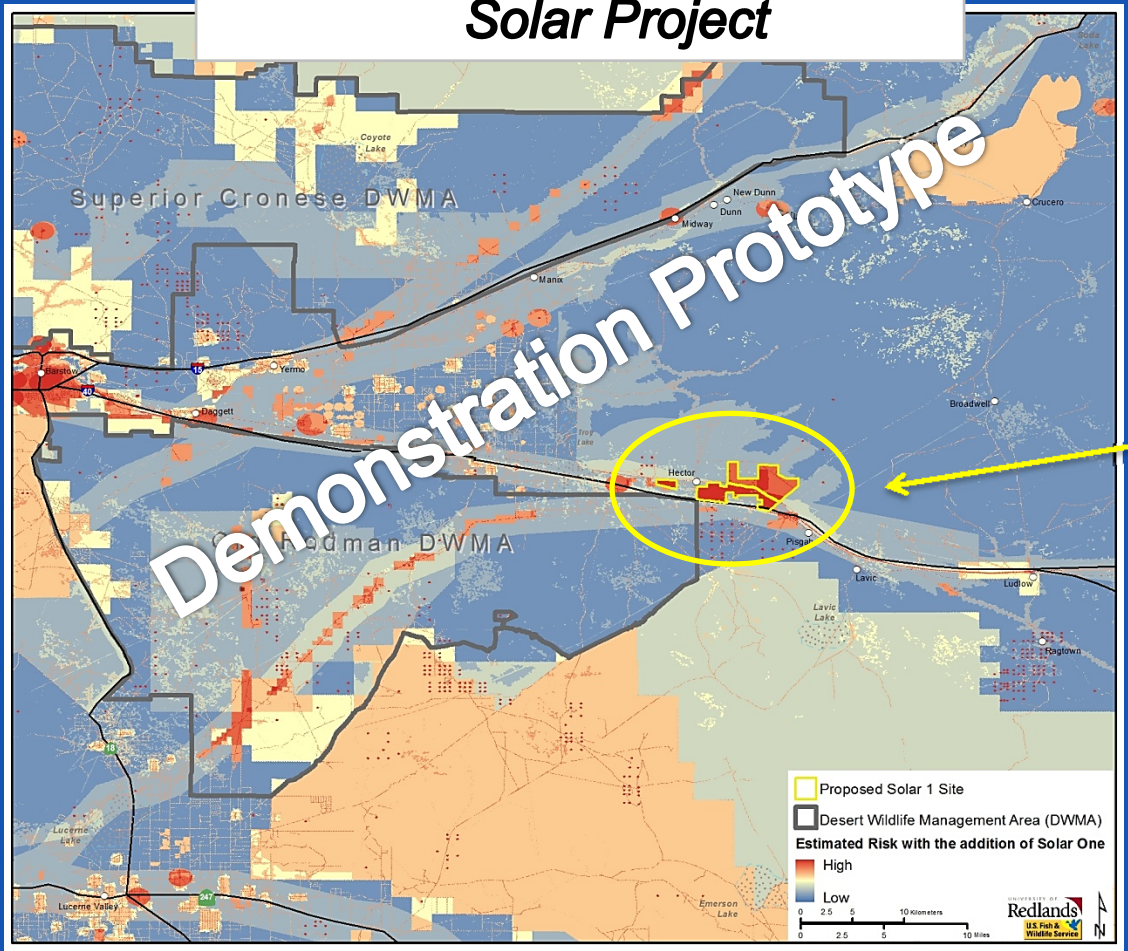



*Addition of proposed solar development project*

*Potential Tool for Quantifying Solar Development Impacts and Mitigation Needs for the Desert Tortoise?*

# Spatial Decision Support System

***Increased* Risk with Addition of Solar Project**

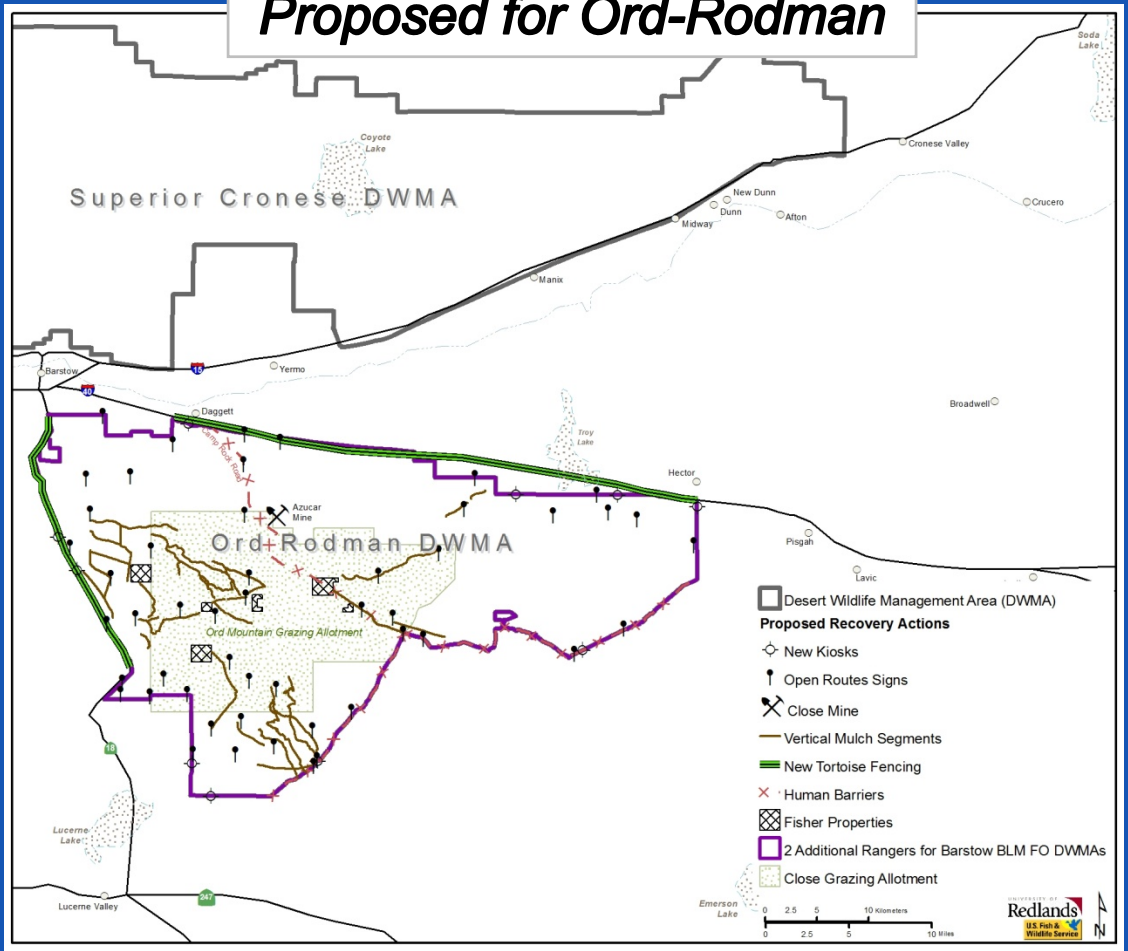



*Run model with the addition of proposed solar development project*

*After addition of solar project, Δ overall risk to the tortoise = 21,000*

# Spatial Decision Support System

***Recovery Actions Proposed for Ord-Rodman***




*What sets of recovery actions will result in a Δ overall risk to the tortoise in an opposite, off-setting amount?*

# Spatial Decision Support System

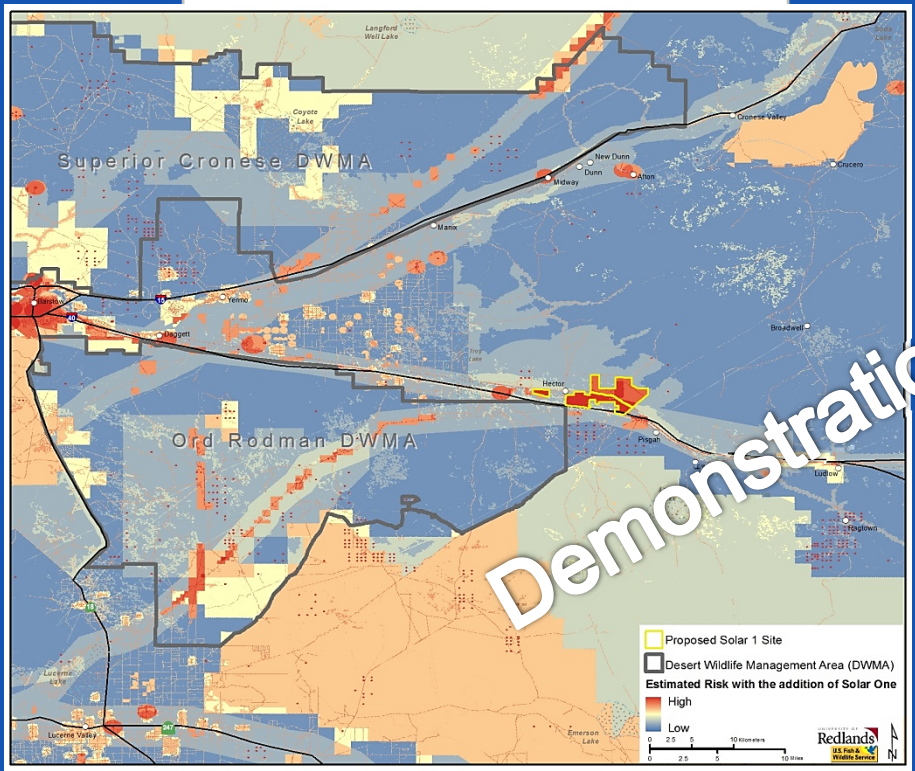
| Proposed Management Actions | Decreased Risk to the Tortoise |
|---|---|
| Increase law enforcement ( 2 rangers in BLM Barstow jurisdiction) | 18,000 |
| Remove grazing in Ord Rodman (acquire Fisher properties, ~2500 acres; designate Ord-Mountain allotment as unavailable) | 8,200 |
| Install + maintain tortoise fencing | |
| a. State Route 247 (~20 miles) | 2,000 |
| b. Interstate 40 (~25 miles) | 4,000 |
| Restoration of 100 miles of closed roads (vertical-mulching) | 2,400 |
| Install + maintain human barrier fencing | |
| b. Camp Rock Road (both sides through DWMA, on DWMA side along DWMA boundary) | 1,100 |
| a. south DWMA boundary and Johnson OHV area | 600 |
| Install + maintain open route signs | 1,300 |
| Install + maintain environmental education kiosks at Ord-Rodman access points | 1,000 |
| Mine closure (close Azucar mine) | 100 |
| **TOTAL** | **38,700** |

Demonstration Prototype

*Change in overall risk is calculated for a suite of actions within a given area, actions can then be prioritized according to total risk reduction*

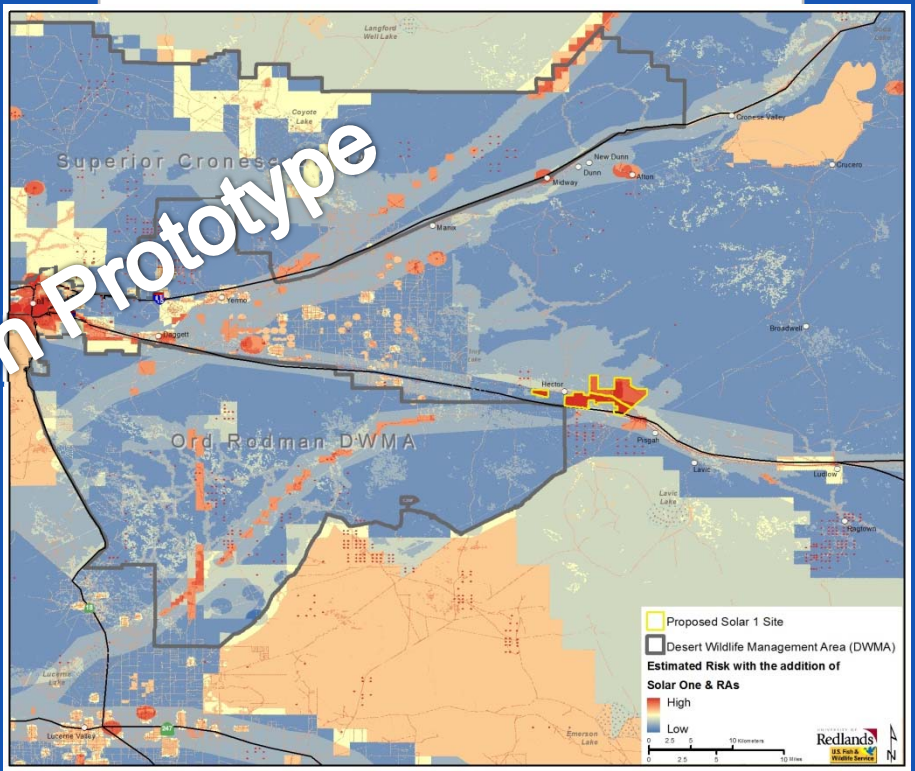
# Spatial Decision Support System

***Increased* Risk with Addition of Solar Project**




*Δ overall risk to the tortoise = 21,000*

***Decreased* Risk after Completion of Recovery Actions**




*Δ overall risk to the tortoise = 38,700*

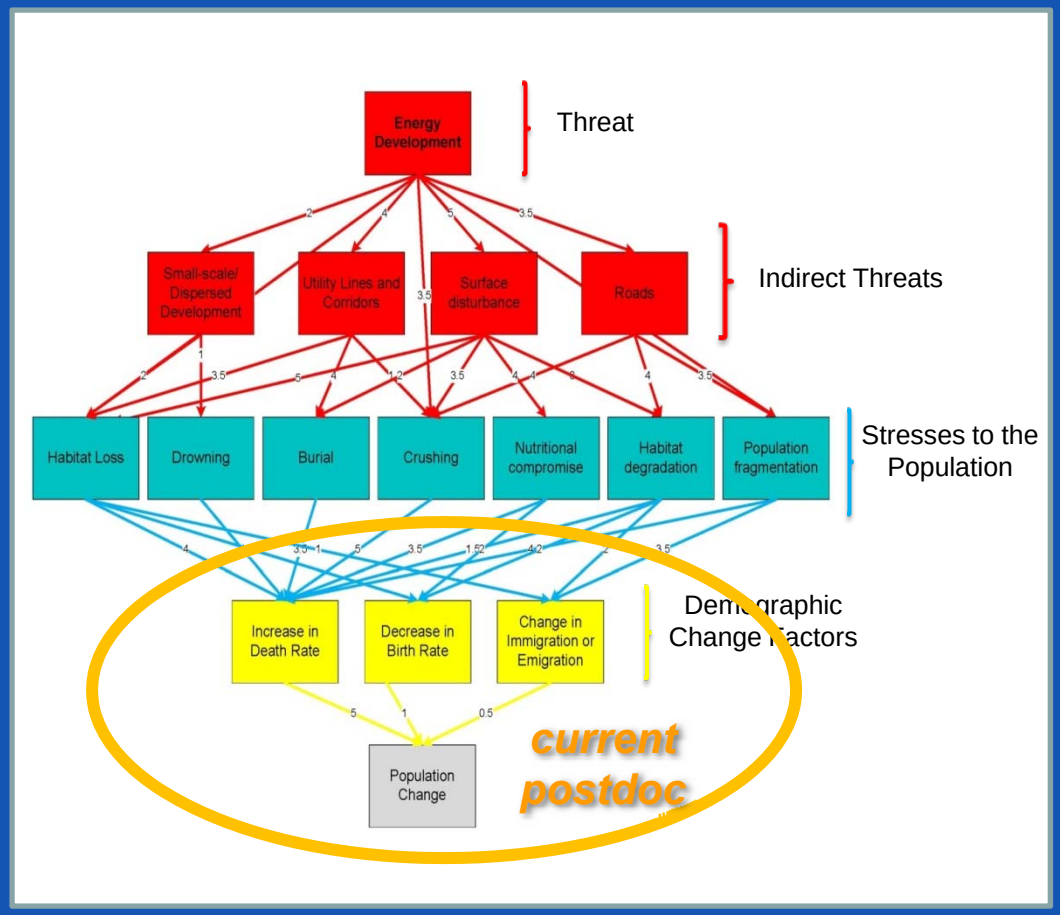
Demonstration Prototype

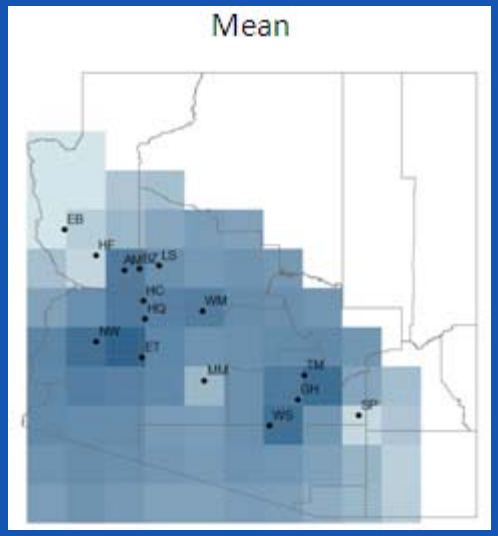
# Reducing Environmental Impacts of Solar Development on the Desert Tortoise

***Objectives of our project***

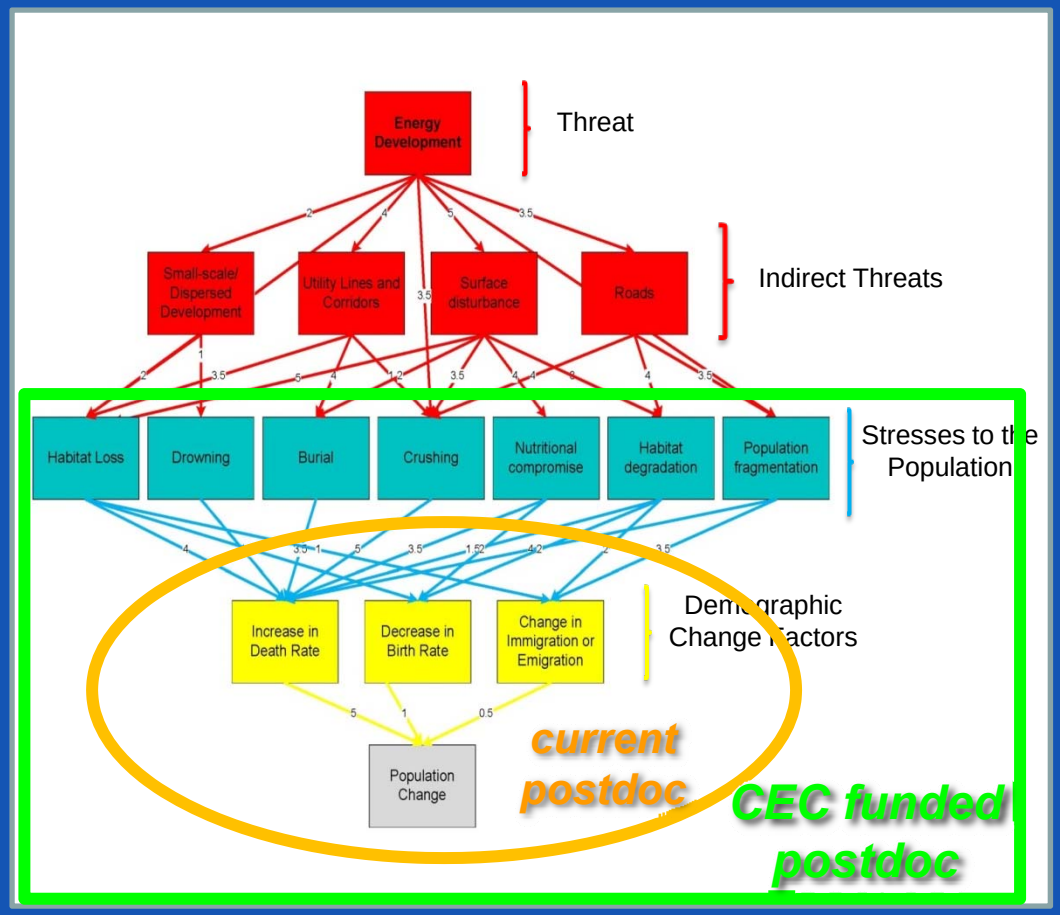
1. Improve existing impact and recovery models within the SDSS to evaluate impacts of solar development on the desert tortoise
   - Energy development model
   - T-T, T-S, RA to T-S effect area models
   - Impact scores calibrated by habitat potential
   - Demographic change model
   - Monitoring metrics
2. Develop tools to allow users to upload GIS data or sketch spatial footprints and key attributes of proposed solar projects and recovery actions to evaluate impacts and mitigation scores

# Improvements through collaboration



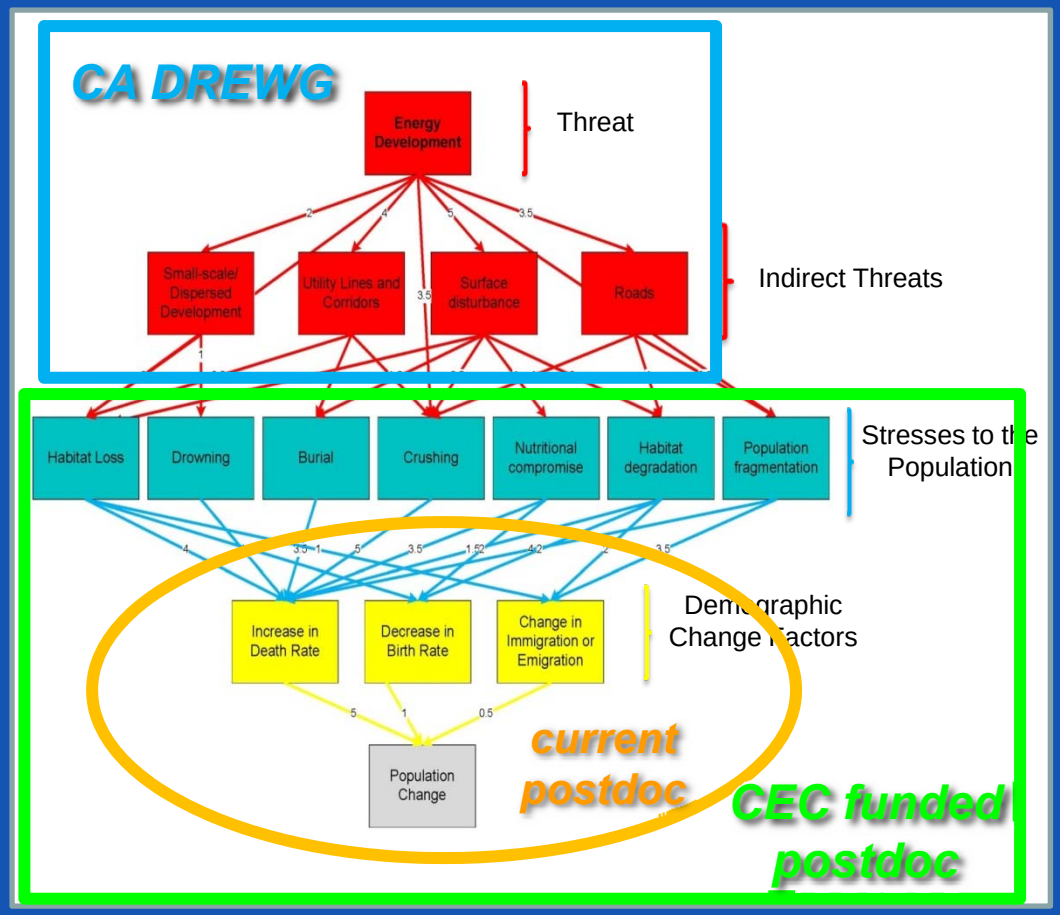
# Improvements through collaboration




**CEC Post Doc**

- **Covariates = Stress > Demographic Changes**
- **Changes in survivability surfaces**
- **Temporal T-S calculations**

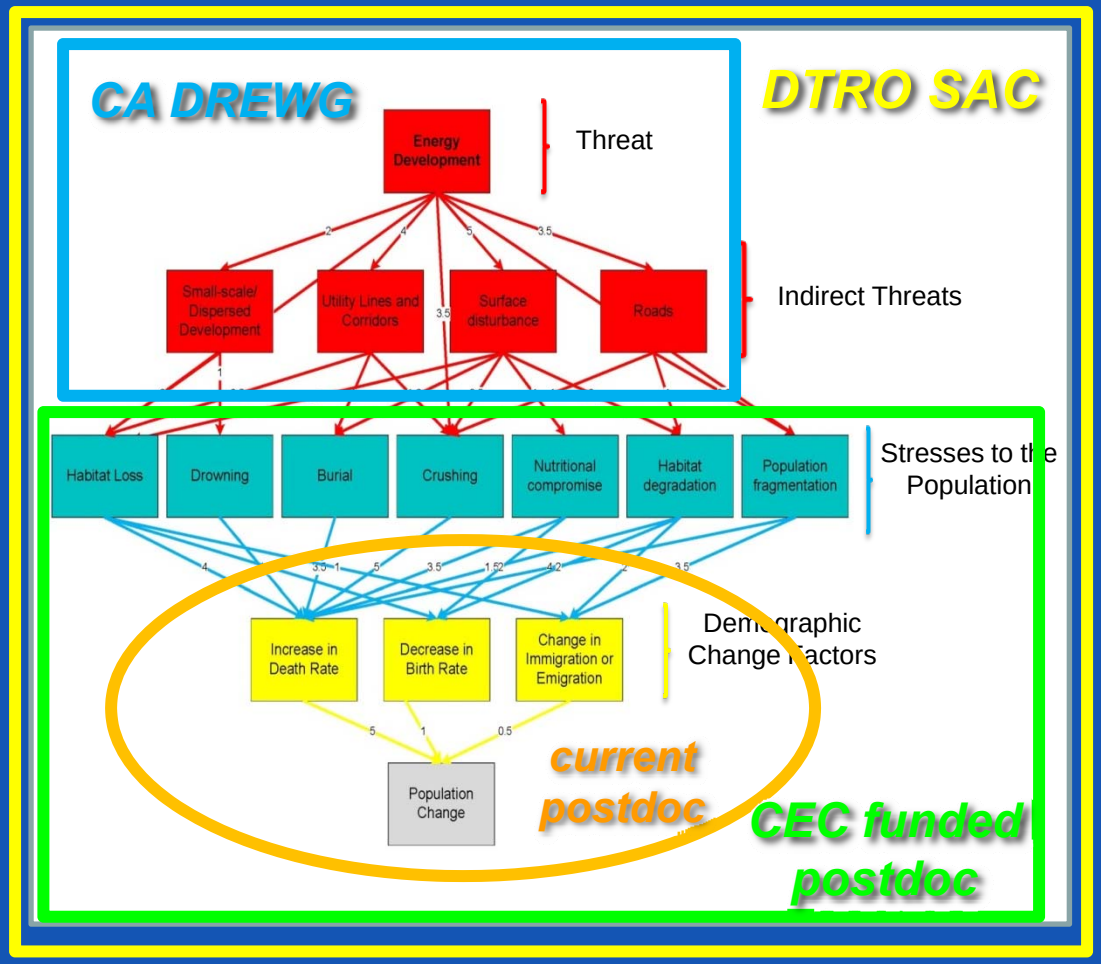
# Improvements through collaboration




**Modeling at Installation Scale**

- **T-S interactions**
- **Installation characteristics**
- **Minimization Measures**

# Improvements through collaboration

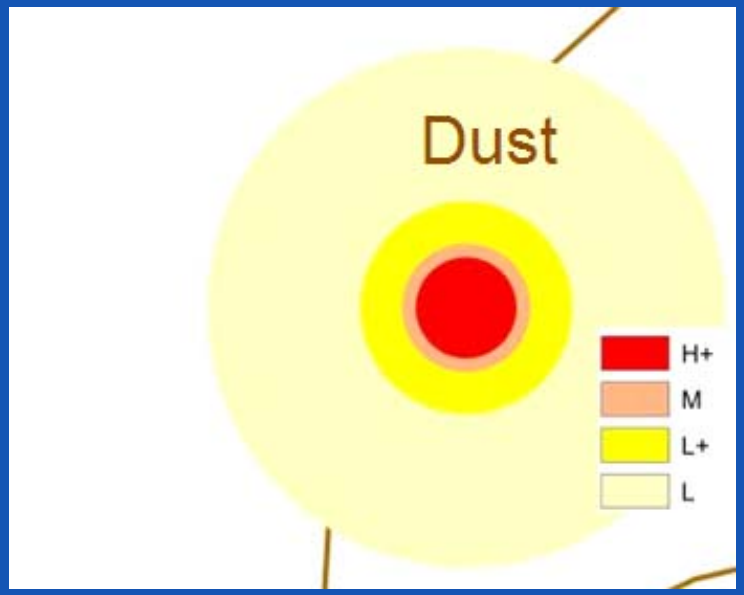


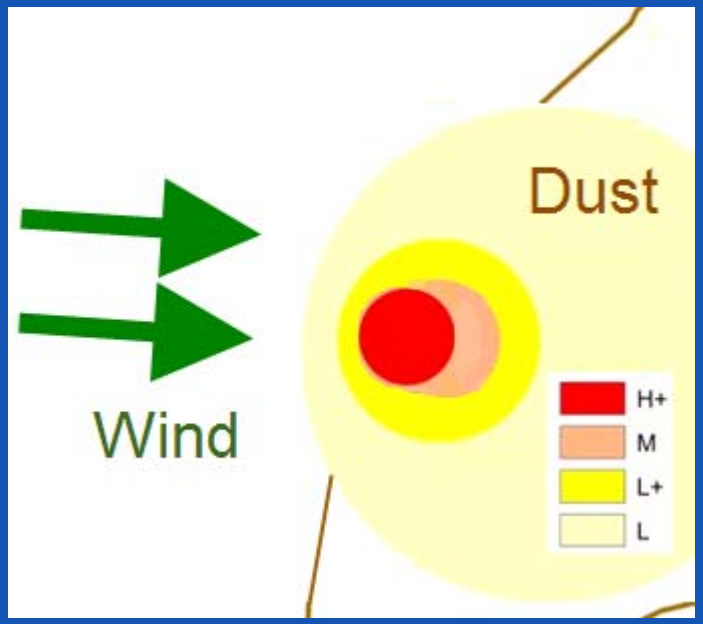

**Collaboration**

- **Spatial variation of weights**
- **Non-linear interactions**
- **Feedback loops**
- **Catastrophic events**

# Identifying & improving key interactions

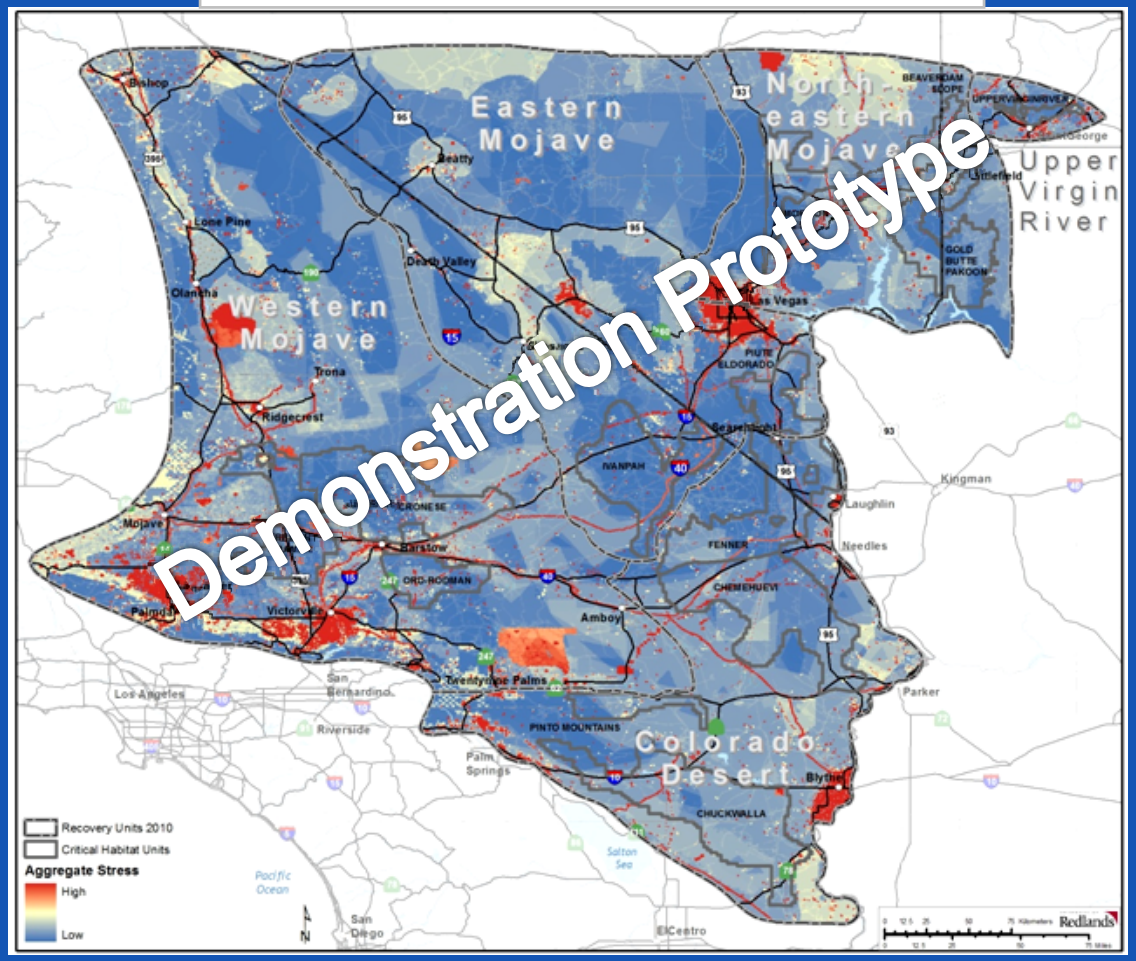
- Sensitivity >> iterative system improvement
- For example, action at a distance
  - Current: footprints and buffers
  - CEC: spatial modeling – e.g., fugitive dust



# Calibrating Risk with Habitat Value

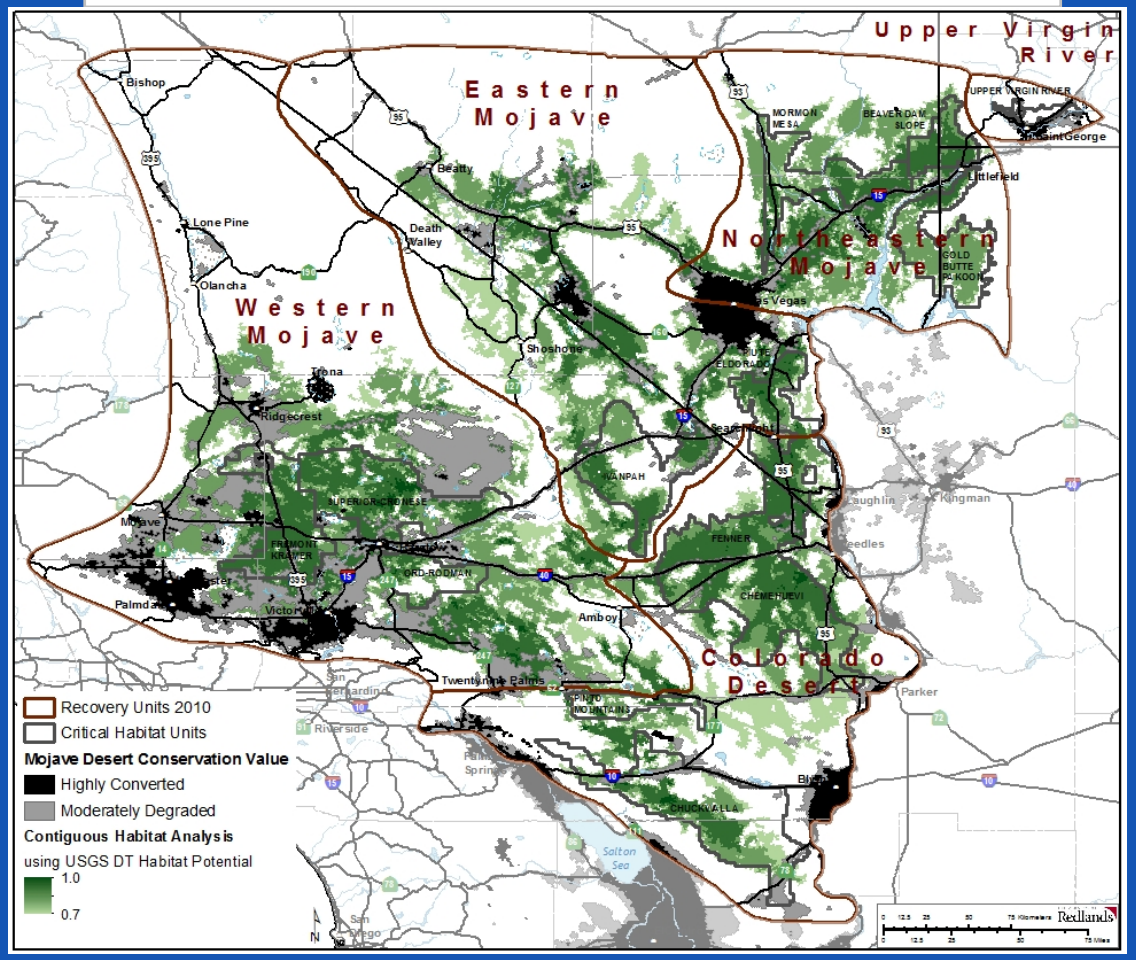
***Aggregate Risk to the Tortoise***




*Need to incorporate information that takes into account where there are and where there aren't tortoises on the landscape*

# Calibrating Risk with Habitat Value

***Modeled Contiguous High-value habitat***




*Estimation of where there are and where there aren't tortoises on the landscape*

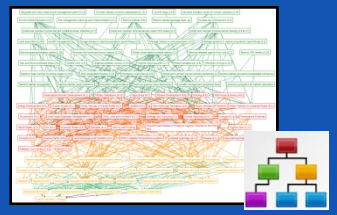
# Reducing Environmental Impacts of Solar Development on the Desert Tortoise

*Objectives of our project*

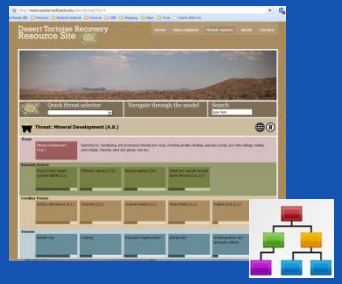
1. Improve existing impact and recovery models within the SDSS to evaluate impacts of solar development on the desert tortoise
   - Energy development model
   - T-T, T-S, RA to T-S effect area models
   - Impact scores calibrated by habitat potential
   - Demographic change model
   - Monitoring metrics
2. Develop tools to allow users to upload GIS data or sketch spatial footprints and key attributes of proposed solar projects and recovery actions to evaluate impacts and mitigation scores

# Products and Deliverables

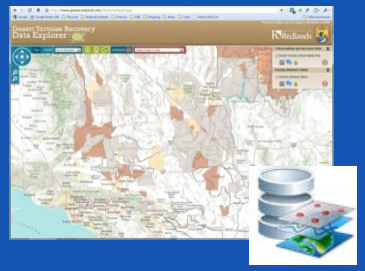
1. Expert knowledge encapsulated and quantified within the SDS models that are documented and transparent



2. Common modeling framework for interacting with and querying the SDS models, designed and developed on standard and open web services




3. Documented spatial and non-spatial data related to landscape condition and desert tortoise threats in the Mojave Desert




4. Web-based framework for conducting spatially-explicit and fully-documented impact analyses of solar energy projects on the desert tortoise at the project scale

# Web-Based Tools

Develop web-based tools to allow users to interact with the models and data to evaluate the impacts of project siting scenarios and mitigation options.

Proposed features of these tools include:

1) Defining the geographic extent and key attributes of a proposed project by sketching or uploading GIS data

2) Evaluation and reporting of:

- Existing threats and potential demographic and temporal impacts to the species
- Suggested mitigation measures and targets based on cumulative impact scores
- Suggested implementation and effectiveness monitoring plans and metrics

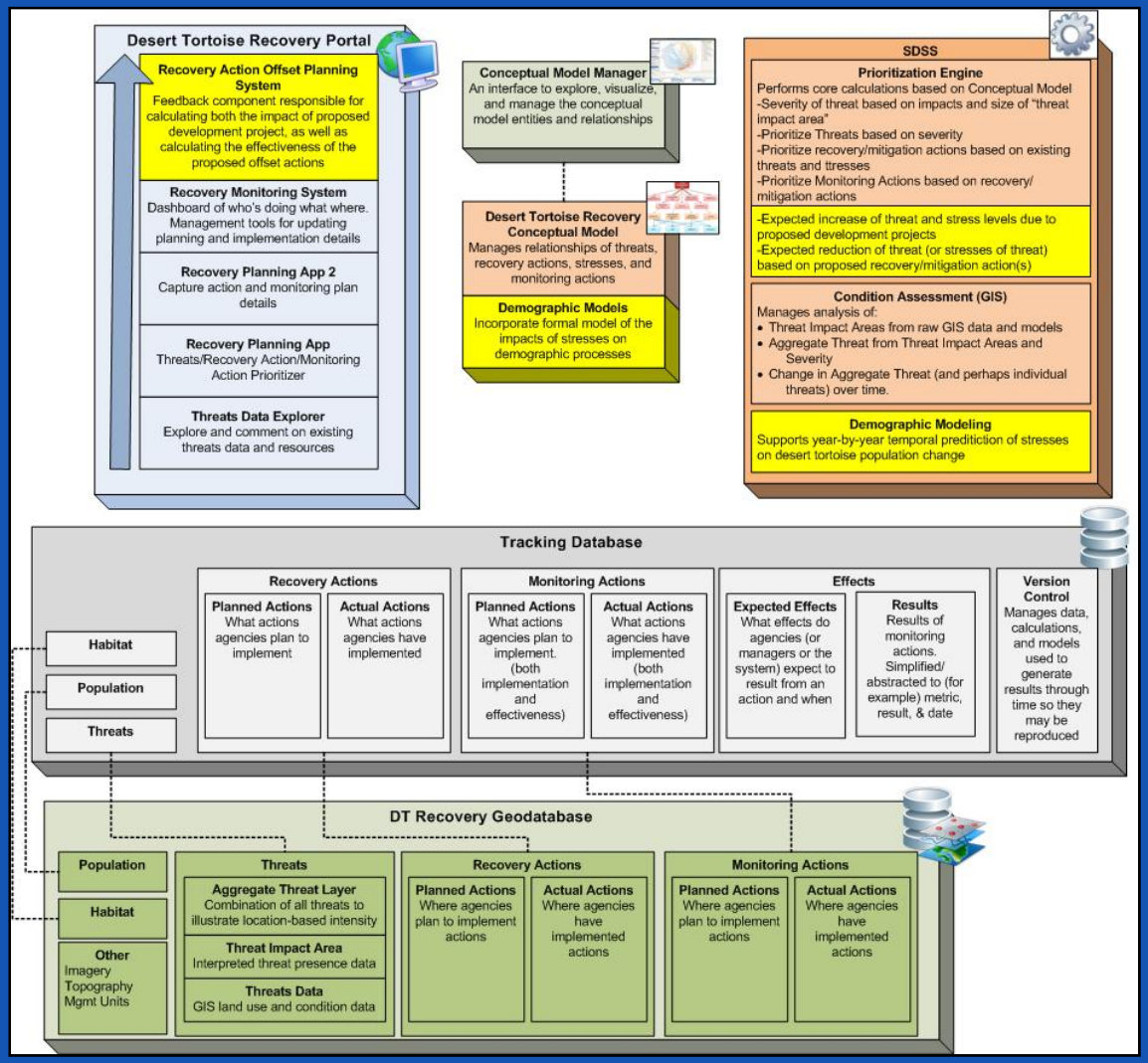
# Web-Based Tools

System components are being designed and developed on top of and in parallel with a Desert Tortoise recovery and tracking system.

The team will work with partners and stakeholders to define requirements (features and security) and to design use cases and the user interface.

Likely hosts include:

- Mojave Data Ecosystem Program (MDEP)
- US Fish and Wildlife Service
- University of Redlands



# Project Schedule

| Task | Activity | 2011 | | | | 2012 | | | | 2013 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 |
| 1.0 Project Management | Management, CEC meetings (1, 2, 3, 4), stakeholder and SAC review workshops (5, 6, 7), interim and final reports (8) | 1 | 5, 6 | | 2 | 7 | 3 | | | 8 | 4 |
| 2.0 Extend Conceptual Models | Extend conceptual model framework for solar energy development; written summaries (9) (10) | | | | 9 | | 10 | | | | |
| 3.0 Data Management | Data development, integration, maintenance and quality management; inventory (11) and summary (12) | | | | 11 | | | | | 12 | |
| 4.0 Solar Energy Model Development | Develop and extend solar energy project models; written summaries (13) (14) | | | | 13 | | 14 | | | | |
| 5.0 Demographic Model Development | Revise and develop new tortoise demographic models; draft technical report (15); research summary (16); model description (17) | | | | | | | 15 | | 16, 17 | |
| 6.0 Web Application Development | Development, delivery of web application and services (18) | | | | | | | | | 18 | |

# Thank you

Catherine Darst: cat_darst@fws.gov

Philip Murphy: philip_murphy@spatial.redlands.edu

Nathan Strout: nathan_strout@spatial.redlands.edu