Effects of Utility-Scale Solar Developments

on the *Gopherus Agassizii*

in the Mojave Desert

Geography 368 – Desert Southwest Field Seminar

Jessica T Stodola

*Mojave desert tortoise (Gopherus agassizii). Photograph: Kimberleigh J. Field*
Table of Contents

Abstract 3

Introduction 3

Habitat 4

Reproduction 5

Umbrella Species 6

Utility-Scale Solar Energy Development 6

Construction and Decommissioning Impacts 8

Operational and Maintenance Impacts 8

Habitat Fragmentation 9

Translocation 11

Options 12

Conclusion 12

Bibliography 13
Abstract

The Desert Tortoise (gopherus agassizii) was placed on the threatened species list in 1990 to protect its’ declining number through the US Endangered Species Act. With the threats to their declining population persisting, recovery of the desert tortoise is slow. The new construction of utility-scale solar developments being built to address the energy crisis adds a new threat through the degradation and loss of habitat. Due to minimal research regarding the impact that utility scale solar developments could potentially have on the desert tortoise populations, the full scale effects are unknown.

Introduction

Prior to the mass development of the desert, the population of the desert tortoise was more than 150 per square kilometer. A drop in population below 20% within the local populations and losses almost reaching 90% among adult females in some regions preempted placing the species on the threatened species list, protecting them through the US Endangered Species Act in 1990. Research has found that “adult females are the most crucial life stage for population longevity, such that even a small increase in their mortality rate could result in a population crash” (Edwards et al, 2004). Many efforts have been made over the last two decades to aid in the recovery of the desert tortoise through research, desert wildlife management areas and land-use planning (Averill-Murray, 2012). The problem with land use in the Mojave Desert is that it is only increasing, especially with the popularity of solar energy taking hold. Deserts are the best location for solar energy developments with its abundance of sunshine; unfortunately many of these areas are in desert tortoise habitats and minimal research has been conducted in regards to the potential long term effects of these facilities. The effects of solar facilities, such as habitat fragmentation caused by roads may affect population densities, but research has given
some insight regarding options to minimize these effects. The desert tortoise has many obstacles to overcome in order to increase their numbers high enough to be removed from the threatened species list, which is only becoming more difficult through advancing urbanization and industrialized usage of the desert.

**Background**

**Habitat**

The desert tortoise has many adaptive characteristics that had allowed it to thrive in the Mojave Desert. The desert tortoise can live up to a year without any water due to its slow metabolism and will tend to burrow, spending most of its time dormant during times of low water availability. During periods of increased precipitation, the desert tortoise has a habitat area of up to 3.9 square kilometers and has been known to travel up to 11 kilometers (FWS.gov, p 10, 2011). Tendencies to burrow below the surface increase with seasons, such as hibernation during the winter time, and stress from lack of precipitation or habitat disruption. Tortoises have also been known to burrow together, both in the wild and in captivity (Spotila et al, 1994).

The habitat of the desert tortoise (*gopherus agassizii*) is north and west of the Colorado River. Figure 1 shows the areas in which the desert tortoises can be found. The desert tortoise (*gopherus morafkai*) found to the east of the Colorado River vary only slightly in DNA (Edwards et al, 2004).
Burrow placements were once believed to have been restricted to just the valleys and lowlands, but through the research of Averill-Murray et al, it was found that tortoises dig their burrows higher up on the landscape. Many burrows have been found below rock piles, banks of washes, incised washes, caliche caves, and valley floors (Averill-Murray, 2005).

Reproduction

The desert tortoises have very long lives in comparison to most desert wildlife living to be around 80 years old (BLM.gov, 2007). The female desert tortoise has choice in her mate (Spotila, 1994) and they mate in the fall with the increase of testosterone and lay eggs in the spring once they emerge from hibernation (Rostal et al, 1994). Sexual maturity happens generally between the ages of 12 and 20 years old, laying up to 15 eggs (BLM.gov, 2007). The temperature of the eggs determines the sex of the tortoise, also called environmental sex determination (ESD). Variations in desert temperature can have a great impact on how many males versus females are produced. To produce a 50/50 ratio a soil temperature of 31.8 C is required and to achieve the lowest mortality the eggs must be kept at a temperature between 28 C and 33 C (Spotila et al, 1994a). Higher temperatures (greater than 31.0 C) producing more females and lower temperature (24.0 to 26.0 C) producing more males (Spotila et al, 1994b). Males on average tend to be about 50% more massive than females, with males having a larger
body mass in the spring than in the fall and females having a smaller body mass in the spring than in the fall (Rostal et al, 1994).

_Umbrella Species_

Being listed as a threatened species, the desert tortoise is an umbrella species that protects many others through the Endangered Species Act. Many animals share burrows with the desert tortoises like “insects, spiders, rodents, lizards, snakes, kit foxes, and burrowing owls” and the also threatened Mohave ground squirrel (USGS.gov). Tortoises and their eggs also provide food to other animals through predation. Animals like the Gila monster, ravens, and coyotes depend on tortoises for sustenance. Due to the length of time that desert tortoises live, they have certain environmental requirements, which help to protect the native flora and protect against invasive grasses and forbs (USGS.gov).

Utility Scale Solar Energy Development (USSED)

There are many urban developments that contribute to the decline of desert tortoises, such as “housing developments, landfills, sewage treatment ponds, and military bases (Kristan et al, 2004). However, there is one that has not been addressed until recently with the demand for renewable energy. Utility-scale solar energy developments are being backed by the federal government, for which billions of dollars in loans are being offering to those who would like to build large scale solar energy plants in the deserts of the US southwest (Reardon, 2012). The problem lies in the fact that most of the areas that are prime real estate are protected due to the threatened *gopherus agassizii*.

Solar Energy Zones (SEZ) have been established using a list of 25 criteria in efforts to minimize ecological impacts (Lovich, 2011). The 25 criteria fit under the following five mitigation measures listed in Figure 4 as designated by the Bureau of Land Management (BLM),
Department of Energy (DOE) and the Department of Interior (DOI). These criteria have been used to narrow down the area of public land available for potential use by energy companies.

**Figure 4**

**Design Features and Mitigation Requirements**

*Design features* are mitigation measures that have been incorporated into the proposed action or alternatives to avoid or reduce adverse impacts. The proposed programmatic design features of the Solar Energy Program would apply to all utility-scale solar energy ROWs on BLM-administered lands under both action alternatives. Additional design features have been proposed for individual SEZs.

*Mitigation measures* are measures that could reduce or avoid adverse impacts. Mitigation measures can include (40 CFR 1508.20):

- Avoiding the impact altogether by not taking a certain action or parts of an action;
- Minimizing the impact by limiting the degree of magnitude of the action and its implementation;
- Rectifying the impact by repairing, rehabilitating, or restoring the affected environment;
- Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; and
- Compensating for the impact by replacing or providing substitute resources or environments.

Currently there are 17 zone locations, covering 115,335 ha, that have been determined by the above criteria as shown in Figure 5. The 17 zones are considered “preferred alternative,” but even through this rigorous criterion about 162,000 ha of the desert tortoise’s habitat will still be directly affected and a total of approximately 769,000 ha affected both directly and indirectly (Lovich, 2011).

Figure 6 shows the map of the “annual average direct normal solar resource data based on a 10-kilometer satellite-modeled data set for the period from 1998 to 2005” and the white line the runs through California, Nevada, and Arizona is the habitat of both the *gopherus agassizii* and
the *gopherus morafka* habitat (Lovich, 2011). The desert tortoise’s habitat lies within the greatest concentration solar energy in the country.

**Construction and Decommissioning Impacts**

Construction and decommission of solar facilities come with their own set of ecological impacts. Significant ground disturbance can be expected from large construction vehicles necessary to build the solar energy facilities, along with the construction of roads to get to and from the site. With increased traffic comes the increased probability of running over tortoises and other wildlife. The ground disturbance would also affect any wildlife that would happen to be hibernating beneath the surface. Ground disturbance also effects soil density and therefore water infiltration rates and secondary plant succession.

Alterations to the food supply would also have a dramatic effect on the wildlife (Lovich, 2011).

<table>
<thead>
<tr>
<th>Impacts due to facility construction and decommissioning</th>
<th>Impacts due to facility presence, struction and operation, and maintenance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Destruction and modification of wildlife habitat</td>
<td>Habitat fragmentation and barriers</td>
</tr>
<tr>
<td>Direct mortality of wildlife</td>
<td>to movement and gene flow</td>
</tr>
<tr>
<td>Dust and dust-suppression effects</td>
<td>Noise effects</td>
</tr>
<tr>
<td>Road effects</td>
<td>Electromagnetic field effects</td>
</tr>
<tr>
<td>Off-site impacts</td>
<td>Microclimate effects</td>
</tr>
<tr>
<td>Destruction and modification of wildlife habitat</td>
<td>Pollution effects from spills</td>
</tr>
<tr>
<td></td>
<td>Water consumption effects</td>
</tr>
<tr>
<td></td>
<td>Fire effects</td>
</tr>
<tr>
<td></td>
<td>Light pollution effects, including polarized light</td>
</tr>
</tbody>
</table>

(Lovich, 2011)
In order to get the maximum efficiency of the photovoltaic cells they need to be free of dust particles. With the removal of local vegetation, changes to the landscape, and the use of vehicles for the construction of the solar energy facility, there is a drastic increase to the amount of dust particles in the air. This dust not only has an impact on the solar energy retention of the panels, but also on the ecosystems, causing wind erosion, affecting fertility and water-retention ability in the soil, and damage to plant life. In an attempt to reduce the amount of dust particles in the air, a multitude of different dust suppressants are used. These dust suppressants impact the way water runoff behaves by either increasing the volume of runoff or the amount of solids suspended in the runoff load (Lovich, 2011).

**Operational and Maintenance Impacts**

Of the impacts to the environment, none are as problematic as those from long term operation and maintenance of the solar energy facilities. While noise effects, electromagnetic field generation, microclimate effects, potential pollutants from spills, water consumption, light pollution, and fire risks are all major issues of habitat degradation, habitat fragmentation has one of the greatest impacts on the desert tortoise (Lovich, 2011).

**Habitat Fragmentation**

Habitat fragmentation is caused by roads and other barriers like fencing. Barriers impair an animal’s ability to move freely, disrupting genetic exchange. Impedance of genetic flow (Lovich, 2011) can cause adverse effects to life expectancy, population densities, and growth (Aponte et al, 2003). Roads are great for attracting reptiles due to the heat they have stored up from the day and emit during the evenings and increased vegetation density along roadsides (Lovich, 2011). Road related deaths are one of the leading causes for human related population
declines in the already threatened desert tortoise (Ruby et al, 1994). Many efforts have been put forth to minimize the vehicle related deaths, but few have proven to be effective.

Roads create barriers that can have an effect on the gene flow of a species. Researchers, Edward et al, found “a significant, positive correlation between genetic distance (pairwise $\Phi_{ST}$) and geographic distance of our sample populations” (Edwards et al, 2004). Their research showed that human created barriers have serious effects on desert tortoise movement. If a population of isolated tortoises experienced a dramatic population decline, the normal process of tortoises migrating from other regions would be impossible without human intervention.

Habitat fragmentation has a number of other effects on the desert community. A study was conducted on the red-footed Amazonian tortoise and the effects of isolation on an island in which the “presence or absence of particular species in fragments or different size, increases and decreases in population density, enhanced or depresses reproductive success and survival, increased or reduced predation rates, and of course accelerated extinction” (Aponte et al, 2003). The researchers found that reduced predation on the island, tortoise populations increased, but as a result maturity happened at a much slower rate due to increase in competition for resources and therefore a lower body growth (Aponte et al, 2003).

On the opposite end, however, research was done in Arizona, south and east of the Colorado Desert where the desert tortoise has been listed by the Arizona Game and Fish Department as a Species of Special Concern. Researchers have found areas of isolation created by urban developments in which these areas are experiencing bottleneck populations (Edwards et al, 2004). As human developments encroach upon the desert tortoise habitat, the tortoises become susceptible to a variety of threats like road mortality, people illegally taking them as pets, and exposure to diseases from escaped, domesticated tortoises. Tortoises are also attacked
by dogs running lose, both domestic and feral (Edwards et al, 2004). Juvenile tortoises are more at risk from dog attacks, because of their softer shells and therefore have a higher mortality rate than older tortoises.

**Options**

*Translocation*

Excessive declines in population could potentially be remedied by translocation of tortoises from other areas. However, this practice has not always been very successful, especially if the threat to the area has not been remedied (Edwards et al, 2004). Relocation of gopher tortoises in Florida have found that after 17 years 41% to 43% of translocated tortoises had survived, depending on the location and 11 out of 31 were found to have upper respiratory tract disease (Ashton, 2007). Retention rates can be increased by relocating juvenile and female tortoises that have minimally cohesive social structures (Ashton, 2007) and has also been used as a means to move tortoises from sites approved for solar energy developments.

*Fencing and Tunnels*

Preventing tortoises from traversing roads while, addressing the issue of habitat fragmentation has proven to be a laborious task for researchers and the California Highway Department. Through research of different types of fencing and barriers which included chicken wire, railroad ties, sheet metal, plastic and various other materials a best combination approach was taken. In order to keep desert tortoises from crossing roads a barrier was needed and the ideal barrier would be effective in changing tortoise behavior while not increasing the mortality of other species. The material used would also need to be inexpensive, easy to construct, be durable over a long length of time, and require minimal maintenance (Ruby et al, 1994). Ruby et
al constructed a cloth fence that allowed tortoises along with humans to be able to see through and that didn’t cause other wildlife to become ensnared in it.

To address the issue of habitat fragmentation, a PVC tunnel was constructed that allowed tortoises to pass underneath of roads. Since tortoises will follow a fence line until it ends, the fence is used as a guide to the PVC piping which allows them to cross over to the other side.

Obstacles

As with any endangered or threatened species there are obstacles to overcome to increase population numbers until they no longer need protection from the Endangered Species Act. Recovery is determined by a set of three criteria: over a 25 year period the population trend of the species must be increasing in number, the population has to well spatially distributed, and there needs to be net loss of the habitat necessary to support a flourishing population (Averill-Murray et al, 2012). These criteria won’t be met if urban developments like utility-scale solar energy developments are allowed to spread into the desert tortoise’s habitat. Careful consideration is being taken by the government to ensure that there are minimal effects to the environment by the solar energy companies.

Conclusion

The desert tortoise has a long road to recovery ahead of it and it isn’t getting any easier with urban settlements branching out further and further into the desert. Added to urban sprawl is the onset of utility-scale solar energy development construction which will span many square kilometers across the desert. The construction, operation, and maintenance will each carry with it their own set of environmental impacts that will affect the local wildlife including the threatened *Gopherus agassizii*. While the government is taking action to minimize the anthropological impacts of building these large scale developments through fencing, tunnels, and translocation,
greater research is needed to understand the full scale effect these developments may have on the ecosystems and ways to minimize those effects further.

**Bibliography**


