Translocation Plan for the

STUMP SPRINGS REGIONAL AUGMENTATION SITE

Clark County, Nevada

December 9, 2015
Revised February 8, 2022

Prepared by Clark County, the Bureau of Land Management,
the U.S. Fish and Wildlife Service, and the U.S. Geological Survey

Purpose of translocation: Population Augmentation

Critical Habitat Unit: none

Recovery Unit: Eastern Mojave

Recipient site land ownership: Bureau of Land Management

Action permitted by federal and state wildlife agencies?: Yes

1) Take of wild tortoises and translocation by Yellow Pine: Biological Opinion 08ENVS00-2020-F-0071 and 08ENVS00-2020-F-0071.AMD1
2) Translocation: Environmental Assessment DOI-BLM-NV-S000-2017-0002-EA
3) Take of wild tortoises by Clark County: Biological Opinion 1-5-00-FW-575, Permit TE-034927-0 (Clark County MSHCP)
4) Non-lethal take of resident tortoises during monitoring: FWSDTRO-1 (Roy Averill-Murray, USFWS – Desert Tortoise Recovery Office) or TE-030659 (Todd Esque, USGS)

   State Permits: To be determined

Dates of proposed translocation: Spring 2022 through 2027 or later, subject to described reviews and population targets

Source of translocatees: Development sites within Clark County and Nye County, Nevada, and potentially a limited number of former captives

Number of anticipated translocatees:

Grand total not to exceed 1688 adults (≥180 mm midline carapace length [MCL]) and 1688 juveniles (<180 mm MCL), to be reviewed after release of 768 adults, including tortoises from the following potential projects:

- Approximately 117 adults and up to 117 juveniles from the Yellow Pine Solar development, Clark County (includes 2021 releases)
- Approximately 180 adult tortoises and up to 180 juveniles from the Rough Hat Solar developments, Clark and Nye counties
- Approximately 137 adult tortoises and up to 137 juveniles from the Copper Rays Solar development, Nye County

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General Site Description

The Stump Springs regional population-augmentation site (refer to Table 1 for definitions of terms) lies within an undesignated multiple-use area managed by the Bureau of Land Management (BLM) in the western portion of Clark County, Nevada. The Stump Springs area covers approximately 85,000 acres (344 square kilometers [km^2]) northwest of the town of Sandy Valley (Figure 1). It is bordered by State Route 160 (SR 160) to the northeast. Tecopa Road borders Stump Springs on the northwest, and the California state line forms the southwest boundary. The approximate 4,900-foot (1,500-meter) elevation line in the Spring Mountains generally forms the eastern boundary. The Greater Trout Canyon translocation area lies on the opposite (north) side of SR 160, though tortoise barrier fencing and the highway limit exchange of animals between the sites. Tortoise barrier fencing is projected to be installed along Tecopa Road during 2022.

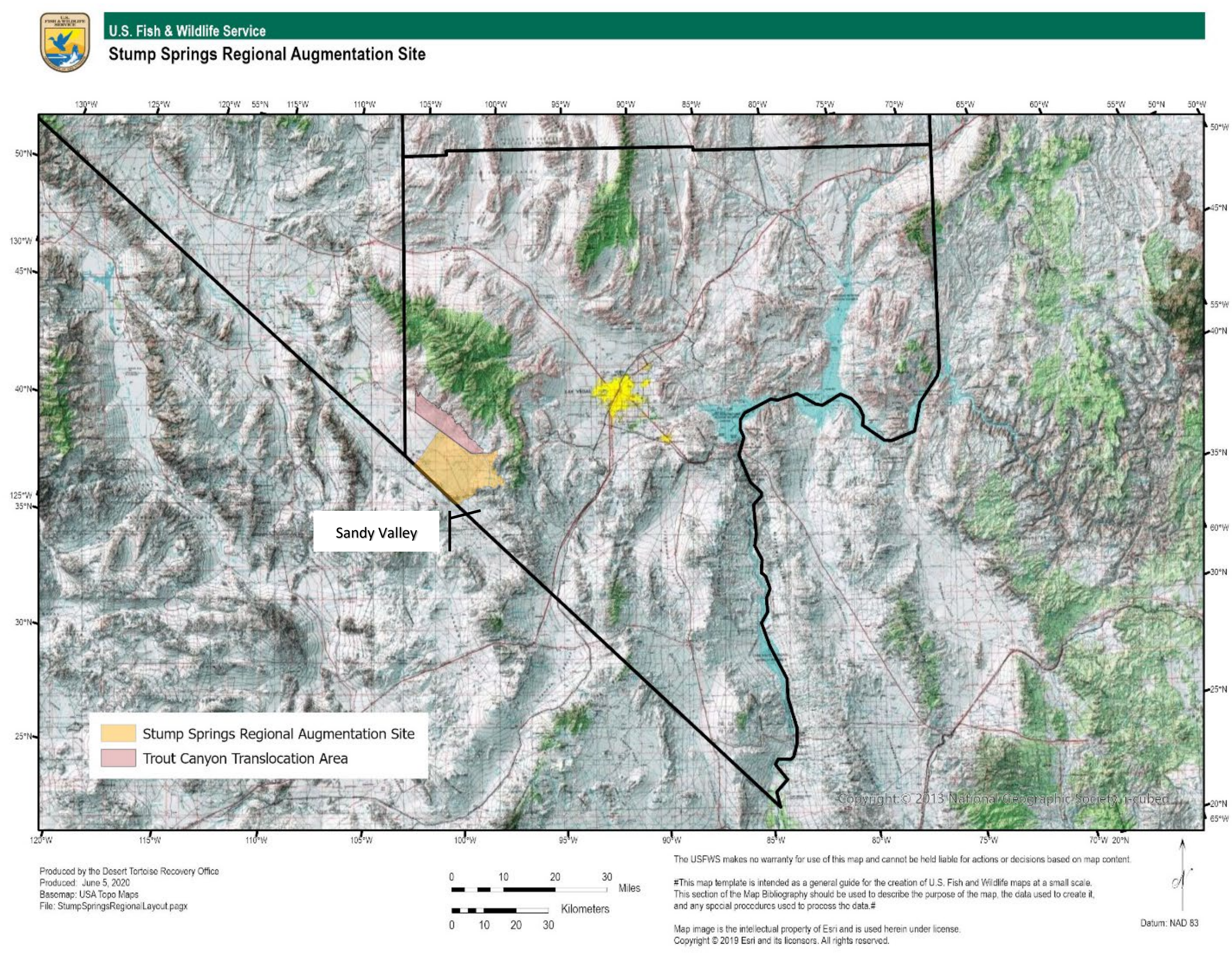

Figure 1. Stump Springs Regional Augmentation Site in relation to the Greater Trout Canyon Translocation Area and southern Nevada.

Table 1. Terms related to the Stump Springs regional population-augmentation site.

Translocation Area	• Encompasses the full population-augmentation site, extending from Tecopa Road to the 4,900-foot elevation line, and bounded by State Route 160 to the north and the California state line to the southwest. Tortoises released in the Release Zone are expected to disperse across the Translocation Area, with few reaching the unfenced boundaries. • Approximately 85,000 acres (344 km^2). • Maximum post-translocation abundance (resident + translocated tortoises) = 1688 adults.
Release Zone	• Area within which tortoises will be physically released. • Boundaries set 6.5 km from perimeter of the Translocation Area, where not bounded by topography or fencing. • 21,150 acres (86 km^2) prior to fencing Tecopa Road; ~33,200 acres (134 km^2) after fence installed (projected in 2022).

The Stump Springs regional population-augmentation site occurs outside of designated critical habitat, but it does lie within suitable, contiguous desert tortoise habitat that may be valuable for population connectivity (e.g., between the Ivanpah Critical Habitat Unit, Death Valley National Park, and areas to the north; United States Fish and Wildlife Service [USFWS] 2012a; Gray et al. 2019). This connectivity is contingent on maintenance of culverts for tortoise passage between the Stump Springs and Trout Canyon areas.

Mojave Desert scrub dominates the Stump Springs site. Small amounts of salt desert scrub, gypsum soils, and mesquite/catclaw habitats occur on the valley floor in the southern portions of the site. Most of the area is on the floor of Pahrump Valley at elevations of 2,600-3,000 feet (800-900 meters). Small, isolated hills and ridges occur in the southern portion of the site. The major drainage direction is northeast to southwest; major washes include Lovell Wash and Potosi Wash.

The Southern Nevada District of BLM has identified the area between Tecopa Road and Pahrump, to the south of SR 160, as having few potential resource conflicts related to commercial solar energy development, and several applications exist in this area. Yellow Pine Solar is closest to proposed development, with tortoise clearance having occurred during Spring 2021 and construction expected to begin during Spring 2022 (Figure 2).

Resident Tortoise Population Trends

<u>Historical Population</u>

No historical population estimates are available specifically for the Stump Springs area. The nearest historical population study plot was a 1-square mile (mi^2; 2.6-km^2) plot within the western end of the Greater Trout Canyon translocation area, approximately 7.5 km northwest of Stump Springs. That plot was surveyed in 1987 and 1992 (Hardenbrook, undated; Holle et al. 1992). In 1987, 31 tortoises were captured at least once (24 >180mm carapace length) on the plot, and the estimated adult tortoise abundance was 30 ± 25 (2 SE), which corresponded to an approximate density of 11.6 adult tortoises/km^2 (Hardenbrook, undated). Surveyors found 28 adult shell remains (ratio of dead:live adults = 1.17), most of which were estimated to have died >2 years prior to the survey. In 1992, 27 tortoises were captured at least once (25 >180mm carapace length), and the estimated adult tortoise abundance was 19 ± 8.6, or an approximate density of 7.3 tortoises/km^2 (Holle et al. 1992). Surveyors found 13 shell remains on the plot (dead:live = 0.52), at least 5 (38%) of which were tortoises marked during the previous survey in 1987. Note that the historical density estimates reported here are undoubtedly biased high due to tortoise home ranges overlapping plot boundaries (Mitchell et al. 2021).

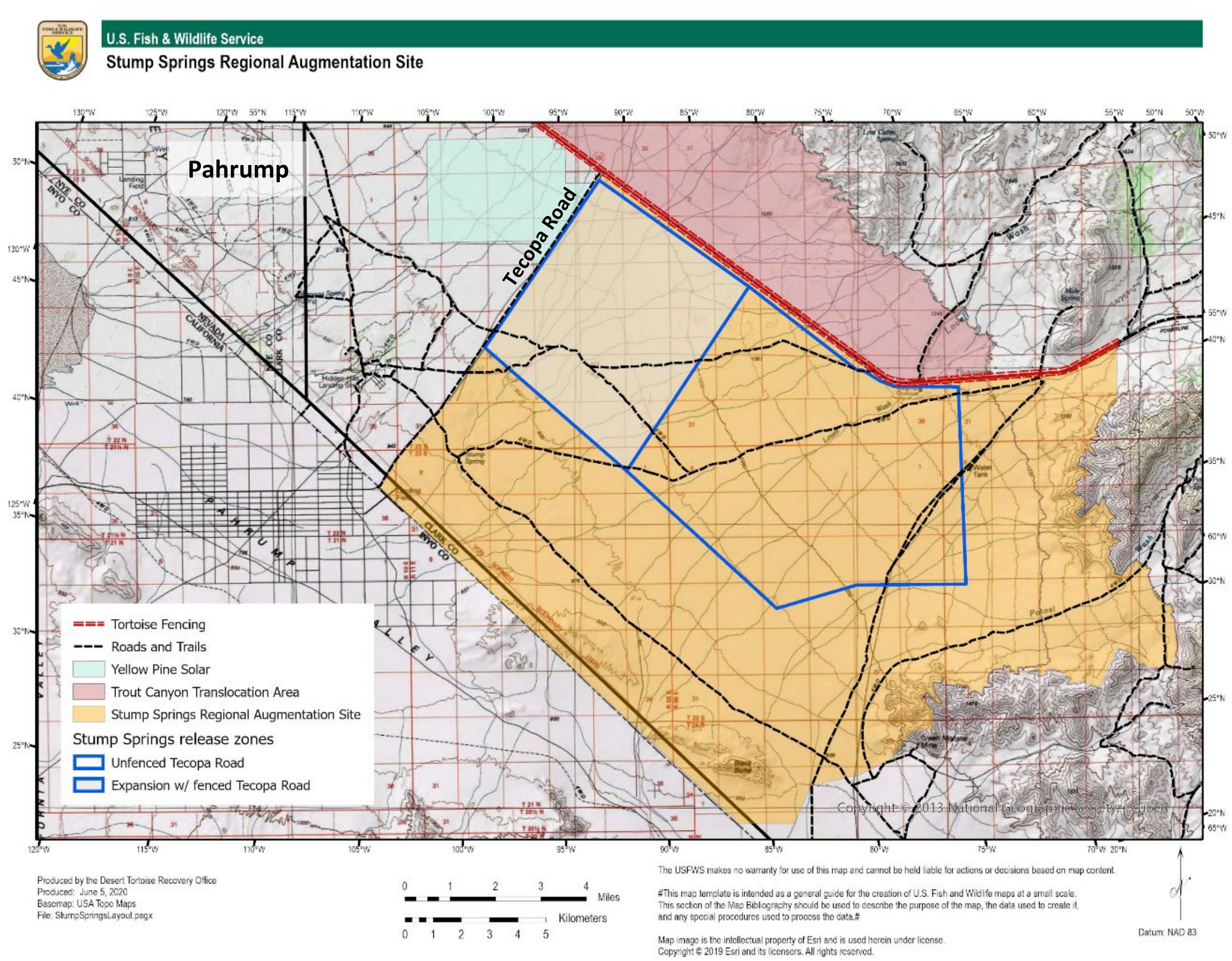

Figure 2. Stump Springs Regional Population-Augmentation Site and release zone.

Broader surveys were conducted southeast of Pahrump, Nevada, during the 2008 range-wide monitoring season, between 19 and 29 May (USFWS 2012b). Field workers surveyed 75 transects totaling 847 km in the area that includes the Stump Springs translocation area. Estimated tortoise density from distance sampling was 2.9 adult tortoises/km^2 (coefficient of variation [CV] = 43.9). Within the entire Pahrump Valley (i.e., north and south of Pahrump), 28 of 58 tortoise detections were of shell remains; the ratio of dead:live tortoises (0.93) exceeded the average for all other monitoring strata in Nevada (range = 0.16–0.83; USFWS, unpubl. data). Twenty-nine full or partial transects were walked within the boundaries of the Stump Springs translocation area, and only 16 of 34 tortoise detections were of live animals. Between 2004 and 2014, estimated tortoise density across the Eastern Mojave Recovery Unit, within which the Stump Springs site lies, had declined to 1.5 adult tortoises/km^2 (Allison and McLuckie 2018).

Contemporary Population

Line-distance sampling surveys were conducted at Stump Springs during Fall 2014 to obtain a site-specific estimate of tortoise density. To adjust for the number of tortoises that could not be detected because they were deep underground in burrows, behavioral observations were obtained for resident tortoises that were outfitted with radio transmitters in the Greater Trout Canyon translocation area, which facilitated estimation of the population proportion that was undetectable while surveys were conducted along transects (USFWS 2012b). After completing 1,068 km of surveys, nine live adult tortoises were found compared to 78 dead tortoises, which corresponded to a density of 0.9 adult tortoises/km^2 (95% CI = 0.24–3.45) for Stump Springs. Although that estimate was based on a small number of live observations, behavioral observations of transmittered tortoises at Trout Canyon indicated that 88% of the population was likely visible and not hidden in burrows. This suggested that the small sample size was primarily reflective of few tortoises inhabiting the area, not tortoises being hidden in burrows at the time of the survey. Thus, the tortoise population at Stump Springs likely suffered a considerable decline between 2008 and 2014.

Stump Springs was most recently surveyed during Fall 2020 (SWCA 2021). A total of 1,360 km of transects were surveyed, during which 18 live adult tortoises were observed. The corresponding abundance estimate was 850 adult tortoises at the 344-km^2 Stump Springs site, or a density of 3.5 adult tortoises/km^2 (95% CI = 0.76–16.44; A. Berger, personal communication, correcting numbers reported in SWCA [2021]). Density at the 122-km^2 Trout Canyon reference site also increased between 2014 and 2020, from 5.9 to 13.1 adult tortoises/km^2, which was likely substantially influenced by translocatees that were released (A. Berger, personal communication, correcting numbers reported in SWCA [2021]). Those results collectively indicated that population growth had occurred over the six years between surveys, but the 2020 density estimate for Stump Springs remained below the estimated minimum viable density of 3.9 adult tortoises/km^2 (USFWS 1994:C25). In such scenarios, translocating tortoises to attain a density of at least 4.0 adults/km^2 is warranted (USFWS 2020b).

Previous Translocations

The first translocations of tortoises to the Stump Springs area occurred in October 2020, when USGS moved 40 juvenile tortoises as part of a research project investigating the influence of environmental and climatic conditions on tortoise habitat quality and spatial ecology. Although we hope that those individuals ultimately will contribute to the resident population of adult tortoises at Stump Springs, their translocation did not fall under the purview of this augmentation plan and are therefore not included herein (see treatment of juveniles in “Population Targets” below).

The first concerted translocations of tortoises as part of this augmentation plan occurred during Spring 2021. Between April and May, a total of 139 tortoises were captured at the Yellow Pine Solar Project area and moved to Stump Springs. Thirty-four of those individuals were females (24%), 52 were males (37%), and 53 were of unknown sex (38%). Eighty-six individuals (62%)

had carapace lengths >180 mm. Transmitters were placed on 115 (83%) of those translocated tortoises to allow post-release monitoring (86 adults and 29 juveniles). Between 10 May and 14 June 2021, 30 transmittered individuals died (26%), primarily from predation (≥72%); among transmittered adult tortoises, 34% (*n* = 29) died. For comparison, among 20 resident tortoises at Stump Springs that were transmittered during the same timeframe, 5% (*n* = 1) died. Five additional tortoises (2 adult females, 3 juveniles of unknown sex) were released in October 2021 after spending several months in holding until temperatures decreased. After the initial pulse of predation-dominated mortality, three more translocated tortoises (1 adult male and 2 juveniles) died at Stump Springs—plus one adult male at Trout Canyon—between July and October. Five additional tortoises (2 adult females, 3 juveniles of unknown sex) were released in October 2021 after spending several months in holding until temperatures decreased. As of the date of this plan, no additional mortalities had been reported.

Based on nonparametric Kaplan-Meier survival curves (Kaplan and Meier 1958), estimated survival probability through the *first 60 days post-release* differed substantially between residents and translocatees (Figure 3A); resident survival was 0.95 (95% CI = 0.86–1.00), whereas translocatee survival was 0.71 (95% CI = 0.63–0.80). Those rates were similar to rates reported from a 5-year study in Eldorado Valley, Nevada, where residents and translocatees had average survival probabilities of 0.96 (range: 0.89–0.99) and 0.79 (range: 0.73–0.93), respectively, and where most mortality of translocated tortoises (82%) occurred during a 7-month window in the first year following translocation (Harju et al. 2020). A Cox proportional hazards model (Cox 1972) estimated that translocatees had 6.86 times higher risk of dying than resident tortoises at Stump Springs during the first 60 days, and a competing risks analysis using cumulative incidence functions (Heisey and Patterson 2006) estimated that translocatees had a 0.21 (95% CI = 0.14–0.29) probability of dying from predation compared to a 0.08 (95% CI = 0.04–0.14) probability of dying from other causes.

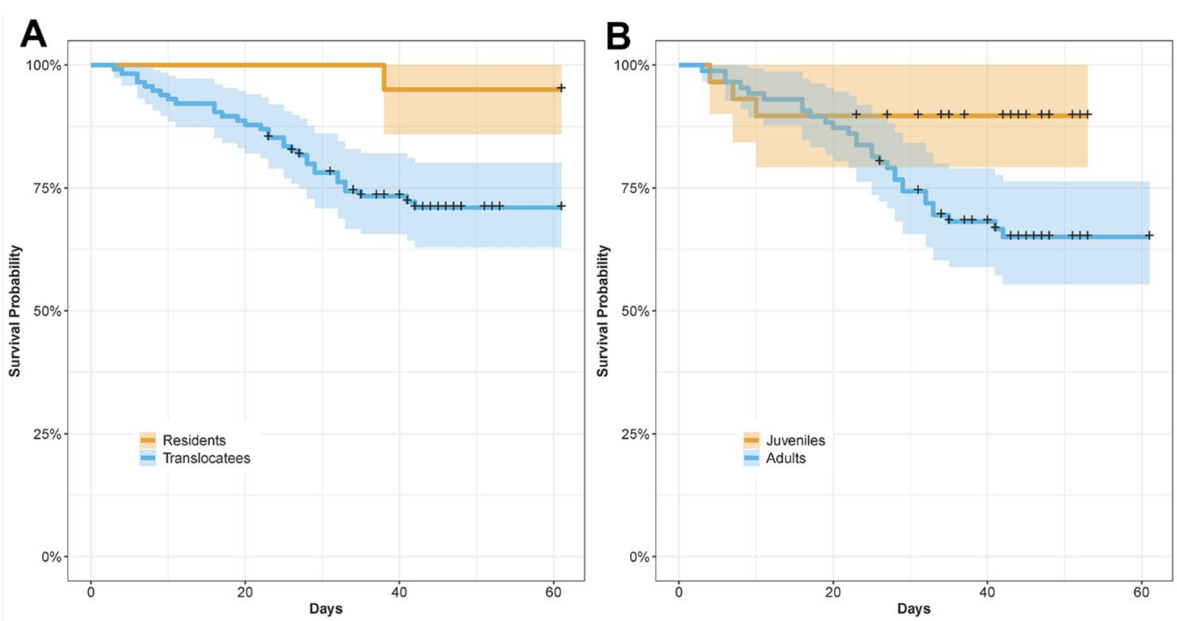

Figure 3. Sixty-day survival curves for A) resident versus translocated tortoises and B) translocated juvenile versus translocated adult tortoises, immediately following releases at Stump Springs during Spring 2021.

Within the translocated group of tortoises (Figure 3B), estimated survival probability through the first 60 days post-release differed by age, such that juveniles had a higher probability of surviving (S = 0.90; 95% CI = 0.79–1.00) than did adults (S = 0.65; 95% CI = 0.55–0.76). Those rates differed from the 5-year study by Harju et al. (2020) in the Eldorado Valley, where adult translocatees had slightly higher average survival rates than juvenile translocatees (S_{Adult} = 0.83; S_{Juvenile} = 0.75). A Cox proportional hazards model estimated that adult translocatees had 3.43 times higher risk of dying than juvenile translocatees at Stump Springs, though the proportional hazards assumption was violated (e.g., survival curves crossed). Collectively, tortoises translocated to Stump Springs were likely much more vulnerable to predation than were resident tortoises in the early days post-translocation.

Projected Translocations

Additional translocations to Stump Springs are projected to occur during Spring 2022 and in subsequent years. Ongoing development at Yellow Pine Solar is expected to result in more adults and juveniles for release at Stump Springs. Results from recent population surveys at the Rough Hat and Copper Rays Solar developments suggest that approximately 180 and 137 adult tortoises, respectively, also may be available for translocation when those projects progress (NewFields 2021a,b), beginning potentially as early as 2023. Additional solar developments also may occur in the area in the future. The Clark County Desert Conservation Program expects to release up to 10 tortoises per year for a number of years beginning at an undetermined date. Additional captive or wild tortoises from currently unknown sources could be translocated in the future as needed/available.

Past or Current Threats to Desert Tortoises

The precise cause(s) of population decline at Stump Springs is unknown. However, several likely contributing factors have been identified, including vehicle collisions along roadways, land development, drought, invasive plant species, predation, and grazing.

Roadways

Historically, vehicular traffic on SR 160 undoubtedly contributed to mortality of desert tortoises that attempted to cross the road. To mitigate this mortality, the Nevada Department of Transportation fenced both sides of the road with tortoise-exclusion fencing during 2007. Tecopa Road is a comparatively less-traveled paved road that also may have contributed to some mortality. Tecopa Road is projected to be fenced with tortoise-exclusion fencing during 2022 as part of Yellow Pine Solar's on-site mitigation.

Several well-used unpaved roads cross the Stump Springs release area, one of which connects SR 160 with the town of Sandy Valley. Off-highway-vehicle (OHV) use within the area is restricted to these existing roads and trails, though illegal off-road and off-trail use has occurred. One motorized event occurs within the unit, the Barstow-to-Las Vegas dual-sport event, which has been held annually in late November for the last 30 years and is expected to continue. This is not a speed-based event and involves street-legal motorcycles traveling on existing roads and trails. Through the translocation area, the event uses Sandy Valley Road, and BLM has never documented an injured tortoise during the event. Direct impacts to desert tortoises along these roads are unknown but are likely much less severe and infrequent than along the previously unfenced SR 160.

Land Development

Two existing utility corridors bisect the area. The 3,500-foot wide West Wide Energy Corridor, established in 2009 as a component of the Energy Policy Act of 2005, runs approximately 18 miles (29 km) through the area in a northwest-southeast direction. A second corridor, designated in the BLM's Resource Management Plan (RMP), is 2,640 feet wide. It runs parallel to, but not contiguous with, the West Wide Energy Corridor for most of its length; within the greater translocation area, the corridors are closest at Tecopa Road (0.18 miles apart). The only current development within these corridors is a single line through the eastern portion of the RMP corridor that may provide roosting or nesting sites for common ravens (*Corvus corax*), which have been documented to depredate desert tortoises in other populations (Kristan and Boarman 2003, Woodman et al. 2013, Berry et al. 2020b).

Multiple mining claims exist that could potentially impact the Stump Springs area. Most of those claims are concentrated in the Spring Mountain foothills within an approximate 6,000-acre (24.3-km^2) block in the southeastern corner of the area. Validity exams have not been conducted on any of the claims, most of which are held by three entities. The BLM has designated one community mineral materials site for commercial sales within approximately 6,400 acres (26 km^2) located near Sandy Valley, but the last recorded use of that site was in 1994.

Drought

Drought has affected the entire region over the last decade. For example, the Palmer Drought Severity Index (PDSI) indicated that the area including Stump Springs experienced drought conditions from January 2014 through September 2015, sporadically in 2016, from April through December 2018, and again from September 2020 through October 2021 (National Climatic Data Center 2021). As of October 31, 2021, the area within and surrounding Stump Springs has been classified as experiencing severe drought, with a PDSI of -3.99 to -3.00 (Hartman 2021). Precipitation outlooks for the Stump Springs area during 2022, relative to the 1991–2020 average, predict below average rainfall through April, average rainfall from May to August, and below average rainfall again from September through November (NOAA/National Weather Service 2021), suggesting that drought conditions are likely to persist in the area.

The increased severity and duration of drought at Stump Springs could result in synergistic, negative effects on desert tortoises (Berry et al. 2020b). Exotic plant species often outcompete native species in drought conditions, thereby reducing forage quality and availability for tortoises. Subsequent to years of adequate rainfall, exotic plants may also facilitate more frequent and severe wildfires during droughts and seasonal dry periods (e.g., fires ignited by lightning strikes and ignitions along highways [Brooks and Matchett 2006]), which can have direct and lasting consequences on tortoise forage availability and habitat suitability (Brooks et al., 2007, Drake et al. 2015). Drought can also cause lower tortoise body weights, elevated blood-urea-nitrogen and uric acid, and, consequently, reduced renal function and increased risk of dehydration (Berry et al. 2002, Christopher et al. 2003). Additionally, tortoise reproductive rates may decline during prolonged droughts, as female tortoises often reduce egg production in response, which can have direct consequences on population growth and viability (Henen 2002). Furthermore, drought can directly lead to elevated tortoise mortality via dehydration and starvation (Berry et al. 2002, Longshore et al. 2003).

Exotic/Invasive Species

A comprehensive vegetation survey has not been completed at Stump Springs, but sampling occurred annually within the Greater Trout Canyon Translocation Area during 2013–2016 (Chiquoine and Sinanian 2014; USGS, unpublished data), which provides an indication of likely similar vegetation conditions as Stump Springs. Although cover was minimal, density of annual plants exceeded 100/m^2 during 2013–2014, and the exotic *Bromus rubens* comprised >70% of the total density of annual plants. Combined, *B. rubens* and *Schismus arabicus* constituted ~90% of the total density of the annual plant community during those survey years, though native annual plants were still present and dominated total annual plant community richness. During the 2015–2016 surveys, *B. rubens* represented 63–66% of the annual forage availability, and combined, *B. rubens* and *S. barbarous* represented 69–83%. Exotic grasses provide insufficient nutrition for tortoises (Drake et al. 2016), and *B. rubens* is particularly problematic because it causes physical injury when consumed throughout the digestive tract (Medica and Eckert 2007, Drake et al. 2016). Annual exotic grasses increase fuel loads and contribute to wildfire intensity and magnitude that can alter ecosystems, degrade habitat, reduce forage, and injure/kill tortoises (Brooks 1999; Drake et al. 2012, 2015; DeFalco et al. 2007).

Ultimately, the prevalence of exotic and/or invasive annual grasses is a primary current threat to desert tortoises at Stump Springs, and additional work to better understand and address this threat is ongoing. The BLM and USGS have been collaborating to identify potential relationships among vegetation community composition, quantitative vegetation attributes, climate, and habitat conditions with measured responses by tortoises (e.g., growth, health, habitat use, and movement) to better understand and define habitat quality for tortoises. That project was initiated during Fall 2020 and involves the study of 40 juvenile tortoises that were released to Stump Springs, but were not part of this translocation plan, and occurred in conjunction with work at four other sites in southern Nevada. Furthermore, BLM, USFWS, Clark County, and other partners have been coordinating on habitat-based recovery actions, as necessary, throughout the duration of the population-augmentation program.

Predation

Desert tortoises are morphologically and behaviorally well-adapted to avoid most predation attempts (Woodbury and Hardy 1948), so historically, predation has been considered a nominal threat to tortoise populations. However, in recent decades, predation has become a primary driver of decline of some tortoise populations in the Mojave Desert. In particular, growing populations of common ravens, largely subsidized by resources created via human activities, have exhibited 'hyperpredation' of tortoises and their nests that, in some cases, contributed to severe tortoise population declines (Berry et al. 2020b). Although ravens have been documented injuring and killing adult tortoises (Woodman et al. 2013), the effects of raven predation are typically most detrimental to the juvenile cohort, which could lead to catastrophic recruitment failure (Kristan and Boarman 2003, Berry et al. 2020b). Additionally, predation of adult and juvenile tortoises by mammals, including American badgers (*Taxidea taxus*) and canids (e.g., coyotes [*Canis latrans*]), can be unsustainable in some years (Esque et al. 2010, Emblidge et al. 2015, Kelly et al. 2021).

Translocated tortoises are initially unfamiliar with the habitat conditions and threats to survival that are present in release areas, which may render them more susceptible to predation than resident tortoises; although, previous studies suggested that other factors, such as drought or land development, may have been the ultimate drivers of mortality, which typically has been equivalent between translocated and resident tortoises in other populations (Field et al. 2007, Esque et al. 2010, Nussear et al. 2012). Nevertheless, our findings from the first releases of tortoises from Yellow Pine to Stump Springs indicated that translocated tortoises were likely much more vulnerable to predation than resident tortoises within the first 60 days post-release. Thus, predation may be a potential formidable threat to translocation success at Stump Springs and implementation of predator reduction or aversion methods prior to tortoise releases may be warranted to attempt to improve post-release survival of translocated tortoises.

Grazing

Four grazing allotments that exist in the area are currently closed. Nevada Department of Wildlife Hunt Management Unit 262 includes and surrounds the translocation area. Portions of two Wild Horse and Burro Herd Management Areas (HMA) also are located within the area. The Red Rock HMA encompasses 25,000 acres (101 km^2) within the area and has an Appropriate Management Level (AML) of 29–49 burros and 16–27 horses. The Wheeler Pass HMA includes about 22,000 acres (89 km^2) in the area and has an AML of 47–66 horses and 20–35 burros. Based on past BLM herd monitoring and utilization studies, the portions of the HMAs that overlap the tortoise translocation area are infrequently used by either horses or burros. Instead, horses and burros more frequently use areas north of SR 160 and areas on the eastern slopes of the Spring Mountains south of SR 160. Therefore, competition for forage within the translocation area is expected to be negligible, though negative impacts of horses or burros on tortoises have been documented in other desert tortoise populations (Berry et al., 2020a).

Specific Goal of Translocation

Unlike many other areas within the range of Mojave desert tortoises, addressing the threats described above may not immediately secure the population at Stump Springs, which is also vulnerable to extirpation because of low density and limited connectivity with tortoises in neighboring areas. In such situations, the Recovery Plan describes a strategy of augmenting populations (USFWS 2011). The primary goals for translocation at the Stump Springs area are to augment the resident tortoise population over time to increase population size and density, and to enhance connectivity in a currently fragmented and low-density area of the Eastern Mojave Recovery Unit (USFWS 2011). Therefore, in addition to characterizing and reducing threats on the landscape, we will use former captive or wild tortoises from development sites in the vicinity of Las Vegas and Pahrump to attempt to increase density. Although these efforts constitute what are commonly known as ‘conservation translocations’, they also represent ‘mitigation translocations’, because most of the translocatees will be moved to Stump Springs to mitigate the effects of development projects on tortoises (Bradley et al. 2020).

Potential Tortoise Population Density

The ultimate objective of translocations within the population augmentation strategy is to increase tortoise density beyond the minimally viable level (>3.9 adults/km^2), with the intent of establishing a viable, self-sustaining population over the long-term (USFWS 2021). For translocation to be successful, a portion of translocated individuals must survive post-release, subsequently establish residency, and ideally reproduce, thereby contributing to density and growth of the resident population (Griffith et al. 1989, Chauvenet et al. 2012). However, most translocation projects eventually reach a point of diminishing returns, such that translocating additional animals has a nominal effect on population dynamics or trajectory. This often occurs when the recipient population reaches ‘subsistence density’, or the maximum number of individuals that the environment can support (Dasmann 1964, Leopold 2019). Because this level represents the density at which surplus resources are unavailable and population crashes may be imminent, attempting to manage a population with the objective of reaching subsistence density is inadvisable (Leopold 2019).

The ideal approach is to manage populations to attain ‘optimum density’, or the population size in an area where adequate resources are available to maximize vital rates and fitness over time (Dasmann 1964, Leopold 2019). However, throughout the Mojave desert tortoise’s range, limited information exists on specific habitat characteristics or measures of habitat quality that relate to levels of tortoise density; although, habitat evaluations and treatments are ongoing in conjunction with density estimation surveys (USFWS 2011). Consequently, the potential optimum density that the tortoise population at Stump Springs could reach and sustain over the long-term is unknown. Therefore, we compared densities recently observed at Trout Canyon and elsewhere in the recovery unit to get an idea of tortoise densities currently supported by similar habitats in the region.

Densities described by a single standard deviation of the mean tortoise density for a recovery unit are not unusually high statistically, and in the Eastern Mojave Recovery Unit, the density represented by the first standard deviation above the mean density is 2.0 adult tortoises/km^2 (Allison and McLuckie 2018, USFWS 2020). Monitoring completed to date at the neighboring Trout Canyon translocation site demonstrates that the area can support densities >2.0 adult tortoises/km^2. Translocation increased the estimated density (abundance) at Trout Canyon from 2.9 adults/km^2 (354 adults) in 2013 to 5.9 adults/km^2 (723 adults) in 2014 (USFWS 2016b) and to 13.6 adults/km^2 (1,660 adults) by 2020. Translocated tortoises at Trout Canyon had slightly depressed survival (0.94, 95% CI: 0.91–0.97) during the first year after translocation, but annual survival thereafter was high and indistinguishable from resident tortoise survival (0.99, 95% CI: 0.98–1.00). Tortoises that were 100–179 mm MCL also had high annual survival, whether translocated or residents (0.99, 95% CI: 0.99–1.00; USFWS, unpublished data). However, we note that initial post-release survival rates of translocated tortoises at Stump Springs were much lower than at Trout Canyon, which suggests that either proportionally more tortoises may need to be released at Stump Springs or predator management may need to be implemented to attain the densities observed at Trout Canyon.

Additionally, based on the range and timing of observed densities for both Trout Canyon and Stump Springs, we attempted to obtain an approximate estimate of the potential subsistence density. As noted above, limited information was available regarding possible relationships between environmental conditions and tortoise densities at Trout Canyon or Stump Springs, so this analytical exercise was necessarily overly simplistic. Specifically, this analysis did not incorporate any information about habitat characteristics or suitability and relied solely on the observed density estimates produced for the two areas. Further, this approach assumed the population followed nonlinear logistic growth with an intrinsic population upper limit (i.e., carrying capacity [*K*]; Soetaert et al. 2010, Leopold 2019, Petzoldt 2020), which has never actually been empirically demonstrated in any wildlife population (Sayre 2008, Chapman and Byron 2018). Nevertheless, the logistic growth model provides a useful theoretical application of density-dependence and obtaining a crude approximation of potential subsistence density provides a starting value for subsequent evaluations after more data are collected (additional details of this analysis are provided in Appendix 3). Based on the logistic growth model, the approximate subsistence density estimated for the Stump Springs – Trout Canyon area was 4.03 adults/km^2. Considering that much higher densities have been estimated for Trout Canyon and elsewhere in the Eastern Mojave Recovery Unit, that crude value may at best be indicative of the lower bound of potential subsistence density at Stump Springs.

We then used simulation and the observed adult tortoise densities in stochastic population projection models that incorporated density-dependence to estimate the potential probability that the Stump Springs population might decline under varying levels of subsistence density and 'pseudoextinction' thresholds over 10 years (Morris and Doak 2002, Stubben and Milligan 2007). Similar to the previous analysis, this simulation exercise was overly simplistic because data limitations forced us to rely solely on the observed density estimates and information about population-environment/habitat relationships were unavailable. Additionally, the pseudoextinction thresholds were hypothetical and represented levels below which we considered undesirable from a population conservation perspective rather than potential levels at which extinction might occur. We evaluated subsistence densities ranging from the above-estimated 4.03 adults/km^2 to the highest density estimated for Trout Canyon, 13.6 adults/km^2, and pseudoextinction thresholds ranging from the lowest density estimated for Stump springs, 0.9 adults/km^2, to the specified minimally viable desert tortoise density of 3.9 adults/km^2. For each scenario, we simulated 1,000 population projections based on the distribution of observed population growth rates at Stump Springs (additional details are provided in Appendix 3).

In general, the probability of the population declining below the specified thresholds declined with increasing potential subsistence density (Figure 4). Although crude, results of this analysis suggest that the Stump Springs population likely would remain above 0.9 adults/km^2 if subsistence density is >11.6 adults/km^2. Thus, the 2020 density estimates for Stump Springs and Trout Canyon, combined with the above results, provide justification for increasing the population targets at Stump Springs. Importantly, additional data will be collected in the future on habitat conditions relative to tortoise population demography to attempt to construct more complex (i.e., realistic) population models and obtain more reliable estimates of potential densities that the study area could potentially support (e.g., by adapting the analytical methods described by Tinker et al. [2021]).

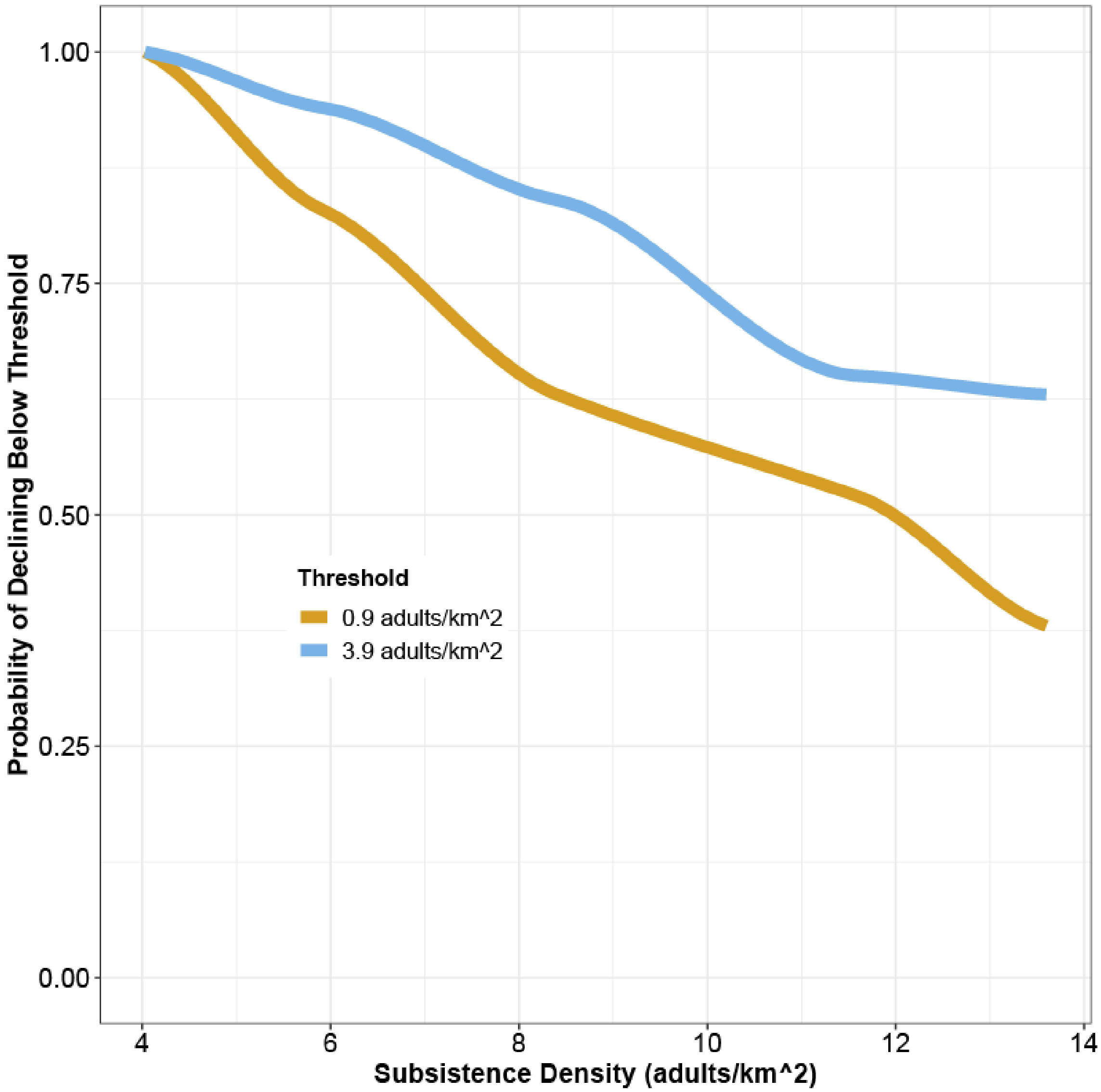

Figure 4. Results of the simulation exercise to estimate the probability of population decline under different potential subsistence densities and thresholds.

Population Targets
Similar to the 2020 version of this plan, we defined the 344-km^2 translocation area to include the approximate 4,900-foot (1500-m) elevational limit, and the release zone is within the expected dispersal distance (6.5 km) of this elevation. Mojave desert tortoises typically occur at elevations <4,100 feet (1,250 m), so to be conservative, we used the smaller area (308 km^2) below 4,100 feet to calculate the number of translocated adults that would bring the area to the targeted densities of adult tortoises/km^2 (Table 2). Targets provided below are based on the density estimates from both the 2014 and the updated 2020 surveys.

Table 2. Calculation of numbers of adult tortoises that may be released to the Stump Springs translocation area (308 km^2).

Previous Targets Based on 2014 Abundance	
Target prior to review	2.0/km^2 × 308 km^2 = 616 adult tortoises
– 2014 abundance	0.9/km^2 × 308 km^2 = 277 adult tortoises
= New adult tortoises before review	*339 adult tortoises*
Maximum post-translocation abundance	3.9/km^2 × 308 km^2 = 1201 adult tortoises
Additional potential tortoises after review	*585 adult tortoises*
Updated Targets Based on 2020 Abundance	
Target prior to review	†5.9/km^2 × 308 km^2 = 1817 adult tortoises
– 2020 abundance	3.5/km^2 × 308 km^2 = 1078 adult tortoises
– # surviving adults from 2021 translocation	*57 adult tortoises*
= New adult tortoises before review	*682 adult tortoises*
Maximum post-translocation abundance	*8.7/km^2 × 308 km^2 = 2680 adult tortoises
Additional potential tortoises after review	*920 adult tortoises*

†Estimated density at Trout Canyon during 2014.
*Median between 5.9 and 11.6 adults/km^2, which were estimated for Trout Canyon in previous surveys.

Given the density estimate at Stump Springs was 3.5 adults/km^2 in 2020, and considering the extent of suitable habitat, we believe that with additional translocations the population can reach densities observed at Trout Canyon. Monitoring at Trout Canyon has shown that translocations can increase a stable tortoise density, at least in the short term, to 5.9–13.6 adults/km^2, which is also within the range of reported densities for the species (Allison and McLuckie 2018).

However, intensive post-release monitoring will need to occur at Stump Springs to attempt to identify demographic responses that may be indicative of the population nearing a possible subsistence density (USFWS 2021). Additional surveys adjacent to the Trout Canyon translocation area also will allow evaluation of the potential subsistence density of another nearby location for future translocations from projects in the area in the event that subsistence density is reached at Stump Springs.

Juvenile tortoises (<180 mm MCL) typically have naturally higher mortality rates than adults (Bjurlin and Bissonette 2004; see also Averill-Murray 2002), so tortoises released in this size category are generally expected to contribute less to the population than, and compete minimally for resources with, adult tortoises. Yet, post-release survival rates were lower for adults than juveniles following the Spring 2021 translocations to Stump Springs, primarily because of predation. Nevertheless, approximately 87% of a wild population typically consists of tortoises <180 mm carapace length (Turner et al. 1987). To be conservative, the number of juvenile tortoises released will not exceed the maximum number of adults that can be released according to the calculations above.

<u>Release Site Considerations</u>

Translocated tortoises will be released within a 21,150-acre (85.6-km^2) release zone (Table 1; Figure 2). Specific release points will be selected close to the time of release and will consider environmental and climatic conditions at that time. The general goal is to distribute tortoises throughout the site while minimizing risks to individuals by staying at least 6.5 km from unfenced portions of paved roads that are not otherwise bounded by topographic features or other hindrances to tortoise dispersal (most desert tortoises are expected to settle within 6.5 km of their release point; USFWS 2020). The BLM will coordinate with the Nevada Department of Transportation (NDOT) to retrofit nine culverts below SR 160 to ensure they are accessible to tortoises. Tortoises translocated from future authorized projects in the area may be released in proximity to the culverts and monitored to investigate their utility in providing tortoise passage below the road (see Monitoring, below). Future releases will consider previous release locations and the current distribution of tortoises within the release zone. Existing roads will be used to access different portions of the release zone, and tortoises will be distributed broadly rather than released within a localized part of the zone. Ongoing work will also monitor tortoise use of artificial burrows and the potential influence of those structures on post-release survival.

<u>Habitat Considerations</u>

Multiple studies have identified the Stump Springs site as being comprised almost entirely of moderate to highly suitable tortoise habitat. In the most recent analysis, Nussear and Simandle (2020) used species distribution models and estimated mean habitat suitability for the entire Stump Springs site was HIS = 0.76 (range: 0.03–0.92; Figure 5).

Approximately 85% (292 km^2) of Stump Springs was estimated to have highly suitable habitat (HSI > 0.66), with most low suitability habitats (HSI < 0.33) occurring at >4,000 ft elevation in the eastern portion of the site. In general, the habitat predictions from the ensemble of models fit by Nussear and Simandle (2020) were similar to the results from Nussear et al. (2009). Furthermore, Stump Springs and the surrounding areas were identified as having moderate to high connectivity potential with other suitable tortoise habitats in the region (Gray et al. 2019).

Nevertheless, at the microhabitat scale, mitigating the spread of exotic annual grasses while restoring native flora (e.g., Esque et al. 2021) remain management priorities for ensuring that suitable habitat conditions for tortoises persist at Stump Springs. Ongoing research by USGS should help inform site-based habitat management and quantify the influence that such improvements may have on tortoise population demography at Stump Springs.

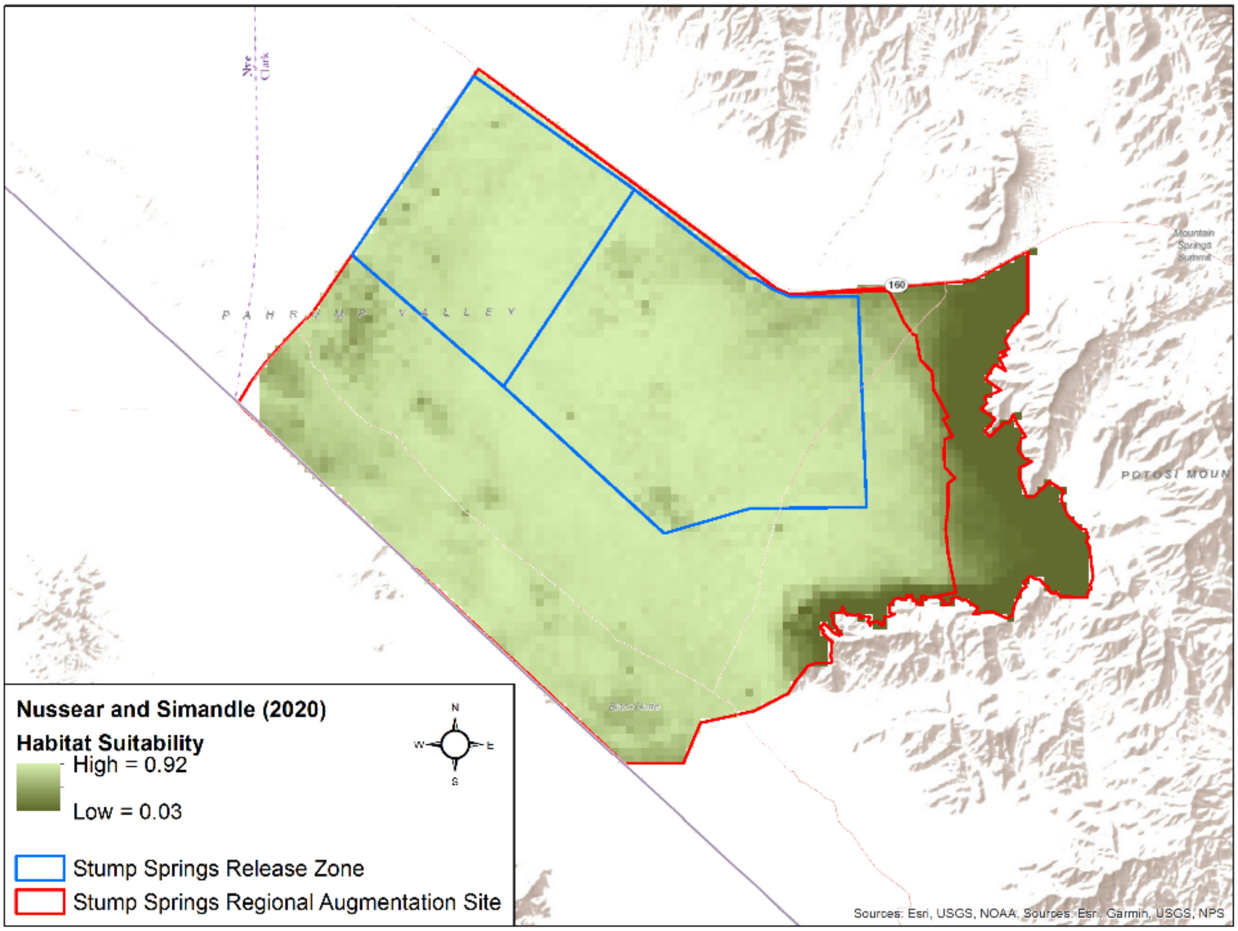

Figure 5. Estimated habitat suitability at Stump Springs, based on an ensemble of species distribution models fit to tortoise occurrence data (from Nussear and Simandle [2020]).

Predation Considerations

As noted previously, predation generally has been considered a nominal impediment to Mojave desert tortoise population growth and long-term viability. However, predation has become a potentially formidable threat to some tortoise populations in recent decades, and the relatively high predation rate on tortoises translocated to Stump Springs during Spring 2021 indicates that implementing pre-release predator control or post-release predator aversion methods may be warranted.

Common ravens have exhibited 'hyperpredation' of juvenile and hatchling tortoises in some populations, which had adverse tortoise demographic effects (Berry et al. 2020, Segura et al.

2020). Multiple short-term management options exist for reducing raven predation on tortoises, including oiling (addling) raven eggs in nests and euthanizing ravens (Boarman 2003, USFWS 2008). Long-term population-level reduction of raven predation may be best accomplished with habitat improvements, primarily by increasing the amount of concealing vegetation cover for tortoises and mitigating encroachment of human developments that are associated with raven population expansion (Kristan and Boarman 2003, Nafus et al. 2017a).

The extent and severity of raven predation on tortoises at Stump Springs is currently unknown, but the GLW Pahrump to Sloan Canyon Switch 230-kV transmission line was erected with steel monopoles, which should mitigate the potential for use by ravens as nesting substrate (SWCA 2021). Ultimately, if raven predation on tortoises increases at Stump Springs, temporal monitoring of both raven and tortoise populations will need to occur to evaluate the magnitude of raven predation. This likely would be best accomplished with point counts to estimate raven density and simultaneously monitoring survival of both translocated and resident tortoises with transmitters to estimate cause-specific tortoise mortality in a competing risks framework (Heisey and Patterson 2006, USFWS 2008).

Many of the mortalities observed in the group of tortoises translocated to Stump Springs during 2021 were consistent with predation by badgers. For example, adult tortoise carcasses were flipped on their carapaces near burrows and decapitation had occurred (Emblidge et al. 2015). Badgers are exceptional diggers that could relatively quickly excavate a tortoise burrow, which increases their potential to be effective predators of desert tortoises. Although badgers primarily prey on small fossorial mammals, small mammal populations in desert environments exhibit boom and bust cycles that closely follow winter precipitation trends (Beatley 1969, Messick and Hornocker 1981). During droughts when small mammal populations are suppressed, badgers and other terrestrial carnivores may exhibit prey switching that could increase their selection for tortoises (Esque et al. 2010, Emblidge et al. 2015), particularly translocated tortoises that are initially unfamiliar with release areas and spend more time in more easily accessible and unprotected locations.

Similar to other mesocarnivores and large carnivores, predation of atypical prey species like tortoises often occurs by just one or a few individuals rather than being a carnivore population-wide phenomenon. Thus, targeted removals of offending individual badgers, whether via translocation or euthanasia, is often effective at reducing short-term predation rates on atypical or sensitive prey species (Trewby et al. 2014), which might be sufficient for improving post-release survival of translocated tortoises. Additionally, some evidence indicates that nonlethal techniques, such as taste or odor aversion, may be effective at deterring badgers and other carnivores from predation of specific species. For instance, distribution of baits treated with ziram (zinc dimethyl dithio-carbamate) reduced bait consumption by badgers to zero after seven days, with avoidance persisting up to 20 days post-treatment (Baker et al. 2005). Disseminating ziram-treated baits throughout the Stump Springs area 7–9 days prior to tortoise translocations, and then placing treated baits near tortoise burrows post-release, might be useful in deterring badgers (and potentially other carnivores) from predating translocated tortoises during the first few weeks following release (e.g., Tobajas et al. 2021).
Canids are known predators of desert tortoises as well, primarily coyotes and foxes (*Vulpes* spp.). Because canids often exhibit compensatory reproduction and high immigration rates, lethal

removals likely would have ephemeral effectiveness and could result in larger canid population sizes with younger age structures, which could result in elevated predation rates (Minnie et al. 2016, Kilgo et al. 2017). Several nonlethal approaches have been developed for effectively reducing canid predation, the most promising of which are fladry and surgical sterilization. Fladry is the most cost-efficient approach and establishing fladry boundaries around populations of other imperiled, burrowing species has been shown to reduce canid predation by ~60% (Windell et al. 2021). However, fladry likely would need to be repetitively applied for each translocation event, prior to and after releases, to be effective, and it is unclear how large of an area at Stump Springs might need to be bounded by fladry.

Targeted sterilization of intact breeding pairs of canids, although initially more expensive and invasive than fladry, is likely to have the longest lasting effects on predation rates and canid population size. For example, capturing and surgically sterilizing at least one member of five breeding pairs of coyotes resulted in a 90% reduction of predation on sheep (Bromley and Gese 2001). Surgically sterilizing just 15 coyotes also resulted in a 242% increase in pronghorn antelope (*Antilocapra americana*) neonate survival (Seidler et al. 2014). Furthermore, the population-level effects of sterilization on canids can be substantial, potentially suppressing canid population size by >70% for 10 years after implementation (Conner et al. 2008). Nevertheless, most evidence indicates that canid predation on tortoises occurs at low rates in most populations and is typically opportunistic rather than targeted predation (Kelly et al. 2021), so occasional application of fladry (e.g., pre- and post-translocation) in tortoise release areas may be sufficient for mitigating predation by canids.

<u>Health Considerations</u>

Health in a population context can be thought of as the ability of a population to perform all its ecological functions with typical efficiency (Hanisch et al. 2012). Inherent in this is the idea that healthy populations should be able to remain resilient and self-sustaining in the face of naturally occurring disease. It is neither possible nor desirable for organisms to be "parasite and disease free", so there is rarely cause to consider translocation unfeasible because of disease or parasites, if reasonable precautions are taken (IUCN 2013). However, all aspects of the translocation process can cause stress-induced disease (but see Drake et al. 2012), and translocation that improves connectivity among populations could increase the incidence of disease in desert tortoises (Burgess et al. 2021). Therefore, strict disease-prevention, quarantine, and handling/release protocols will be implemented based on the most recent guidance available (e.g., Woodford 2000, USFWS 2020) and procedures described below.

Health Status of Resident Tortoise Population

One pathogen of long-standing concern is *Mycoplasma agassizii*, a bacterium known to cause upper respiratory tract disease. Seroprevalence of *M. agassizii* was recorded at levels up to 13% in the region surrounding Stump Springs (and higher levels elsewhere in southern Nevada; Sandmeier et al. 2013). This indicates that *M. agassizii* is not unfamiliar to populations in southern Nevada and that inadvertent release of an infected tortoise from other areas around Clark County to Stump Springs would not introduce a novel pathogen to the population.

To collect data for post-translocation monitoring purposes, we conducted complete health assessments according to standardized protocols (USFWS 2016a), including collection of biological samples, on all possible tortoises found during the Fall 2014 surveys. We conducted 5 health assessments with no suspect or positive titers for either *Mycoplasma testudineum* or *M. agassizii* (95% CI for estimated prevalence = 0–43%; Sargeant 2018) (Appendix 1). There were very mild clinical signs observed in this small group of tortoises, and two had inadequate body condition scores of 3. In contrast, SWCA conducted health assessments on 22 resident tortoises found at Stump Springs during the Fall 2020 surveys. One individual had a positive titer for *M. agassizii*, corresponding to an estimated prevalence of 4.6% (95% CI = 0.8–21.8%), but all individuals had adequate body condition scores ≥4. The documented low prevalence of *M. agassizii* in the region indicates that extensive disease screening for this pathogen is likely unnecessary (IUCN 2013), but the small sample size of tested tortoises at Stump Springs relative to estimated population sizes likely reduces the detection rate (USFWS 2020). Therefore, additional health samples will be collected during subsequent surveys using updated protocols (USFWS 2019a).

Health Status of Translocatees

The tortoises planned to be translocated in this project are former captives or wild tortoises displaced by development. Current guidance developed for wild-to-wild translocation projects provides a structured approach for evaluating health status of individual desert tortoises prior to translocation (USFWS 2016a; Figure 6). Each tortoise to be translocated undergoes screening by a qualified biologist according to the most recent USFWS translocation guidance (e.g., Rideout 2015; USFWS 2016a, 2020). Residual biological samples from those sent to designated laboratories for diagnostic testing are archived at UCLA at a cost of $3000 per project to cover expenses associated with archiving the samples and maintaining the sample bank (USFWS 2000).

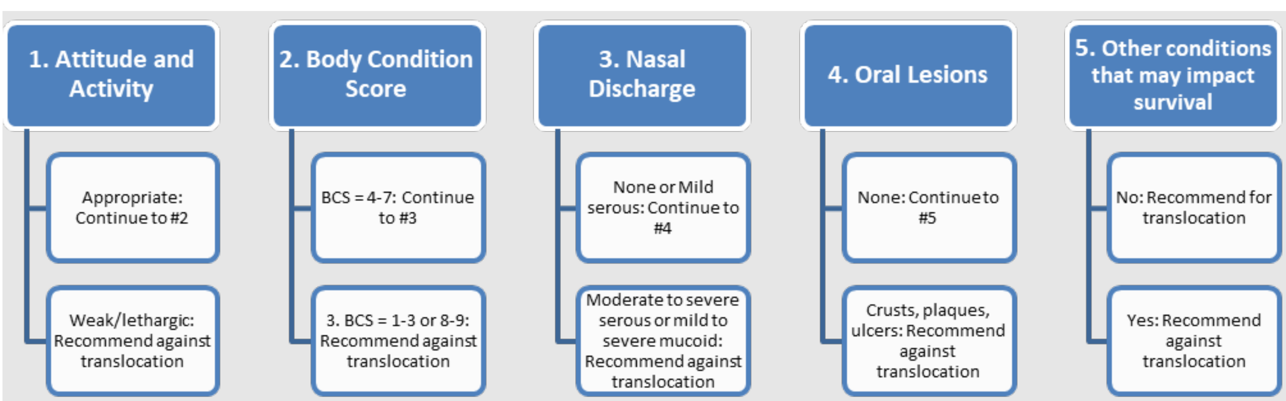

Figure 6. Algorithm for evaluating if desert tortoises are suitable for translocation, taken from USFWS (2016) guidance for translocation projects. BCS = body condition score.

Some tortoises may be translocated to Stump Springs by the Clark County Desert Conservation Program from disparate populations throughout the county (as opposed to a discrete, contiguous population that can be evaluated collectively, such as the Yellow Pine Solar project). Those tortoises will undergo an isolation and evaluation period of 14–30 days as a basic disease-prevention precaution (Rideout 2015) or will otherwise be evaluated according to the most recent USFWS guidance. Clark County obtained a right-of-way grant from the BLM for the use of 32 constructed pens to be used for this function. Health assessments will be completed at the beginning and end of the 14–30-day evaluation period. This precaution will minimize the chance that transitory signs of illness are missed from a single assessment and that an ill tortoise is inadvertently translocated, especially given the documented prevalence of clinically ill (and seropositive) desert tortoises in proximity to urban areas, and to Las Vegas in particular (Tomlinson and Hardenbrook 1993, Jacobson et al. 1995, Jones 2008). Tortoises that do not pass their health assessments will not be translocated. If captive tortoises are released into this area, previous San Diego Zoo Global requirements developed for the former Desert Tortoise Conservation Center (e.g., 90-day quarantine; Appendix 2) will be required for those animals.

Notably, among the tortoises that were captured at Yellow Pine Solar for translocation to Stump Springs during Spring 2021, nine individuals were transferred to holding facilities, primarily because of health issues. One of those individuals had a positive titer for *M. agassizii* and later died at the facility. Thus, implementation of the protocol detailed above has proven to be effective at the site.

<u>Genetic Considerations</u>

The Stump Springs translocation area is located approximately 40 km west of Las Vegas, Nevada. Moving tortoises within 200 km of their origin ensures that translocated tortoises will remain in an equivalent genetic unit (Averill-Murray and Hagerty 2014). However, the risk of inducing outbreeding depression in desert tortoises is low and would only manifest on a time scale of 600 years or more, if at all (Averill-Murray and Hagerty 2014), and higher individual heterozygosity may increase translocation success and post-release survival of desert tortoises (Scott et al. 2020). In addition, the variation in current climate of most desert tortoise habitat in the region from which tortoises are likely to be translocated is within 30% of the projected climate under a moderate emissions scenario (Shyrock et al. 2018; Figure 7), suggesting that translocated tortoises are unlikely to be maladapted to Stump Springs (results were qualitatively similar under a high-emissions scenario). As a result, we consider genetic analysis of individuals as a means of selecting tortoises for translocation to be unnecessary. Negative population effects will be further reduced in the event any translocated individuals do happen to originate from a more distant population (e.g., if a released captive is unknowingly translocated) if they are poorly adapted to conditions in the Stump Springs area and do not successfully integrate into the resident population (Edwards and Berry 2013).

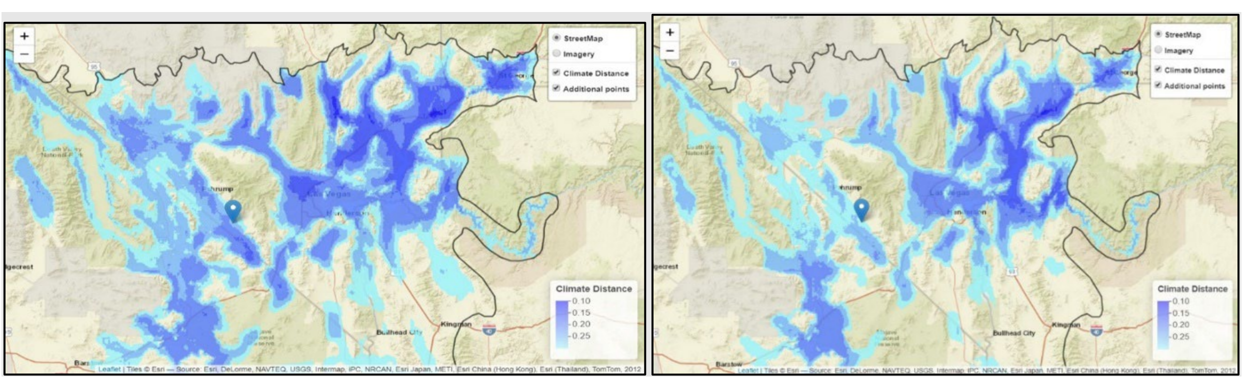

Figure 7. Current climate distance across the northern Mojave Desert relative to Stump Springs in 2010–2040 (left) and 2040–2070 (right) under a moderate-emissions scenario. Lighter to darker shading indicates increasing climate similarity between the current climate across the region with that projected at Stump Springs within the time frame in each panel.

Post-translocation Monitoring

Monitoring at desert tortoise augmentation sites should enable evaluation of any recovery actions and their effectiveness (USFWS 2021). Post-translocation monitoring is necessarily designed to document the effectiveness of translocation, relative to the pre-translocation baseline, as determined by specific criteria for success at four stages over an approximately 30-year period (USFWS 2021; Table 3). In addition to translocations, primary recovery actions will focus on increasing adult tortoise density, reducing the abundance and distribution of nonnative plants, mitigating tortoise mortality from predation, improving connectivity with suitable habitats on the north side of SR-160, and reducing any subsequent major threats to population viability that may be identified. Post-translocation monitoring fees for individual development projects displacing tortoises that will be translocated to Stump Springs will be assessed at $450/acre (adjusted according to the Consumer Price Index beginning in 2022 to cover increased monitoring costs over the 30-year monitoring period).

Table 3. Success criteria for desert tortoise translocations (USFWS 2021). Evaluation of each stage is contingent on success of the previous stage(s).

Stage	**Indicators/metrics**	**Time frame (post-translocation)**
1. Survival and growth of released and resident individuals	a. Survival within 20% of controls[1] b. Increase in CL since release (tortoises released at <180 mm CL)[2]	a. 5 years b. 6 years
2. Evidence of reproduction in released and resident individuals	a. Female reproductive output is similar to controls[3] b. Juvenile segment of the size-class distribution is increasing[2]	a. 5 years b. 9–18 years
3. Population growth	Increasing trend in adult population size[2]	15–20 years
4. Viable population	Adult density >> 4/square km, excluding founders[2]	20–30 years

[1] Measured with radio telemetry
[2] Measured via periodic (*e.g.*, triennial) mark-recapture surveys
[3] Measured via radiographic examination of females during the telemetry-based monitoring

Monitoring will be implemented within an active adaptive management approach (McCarthy and Possingham 2007, Williams et al. 2009, Williams 2011). An integral component of adaptive management is iterative learning that facilities refinement of conservation/management actions and monitoring methods over time as new information (data) is obtained. Although long-term population viability and recovery are primary objectives of the augmentation program, those metrics likely will not be testable for many years from present. Furthermore, new sampling and analytical methods may be developed before viability and recovery can be evaluated. Thus, considering the limited amount of pre-translocation baseline demographic and environmental data that exist for the Stump Springs population, we will explore a variety of monitoring methods to collect multiple types of data. We will then evaluate the effectiveness and utility of those methods and data at relatively short intervals (e.g., every 6 years) to determine which may be most useful for addressing the criteria specified in Table 3 and achieving eventual recovery.

A current optimal analytical approach for such long-term monitoring within adaptive management is provided by the integrated population modeling framework (IPM; Schaub and Abadi 2011, Chandler and Clark 2014), so monitoring at Stump Springs is designed to fit within this framework to allow both short-term and long-term evaluations. Multiple derivations of IPMs exist, but in general, these are hierarchical models with joint likelihoods for demographic process submodels, which facilitates estimation of both observed (e.g., abundance and survival) and latent (e.g., emigration/immigration) demographic vital rates. These models have been effectively used to parse out, quantify, and forecast into the future the influence that translocations, predator management, and other conservation and management interventions can have on populations (Duarte et al. 2017, Saunders et al. 2018). For tortoises at Stump Springs, given the planned recovery actions, this approach will require data collection on age-group-specific (juveniles and adults) survival and cause-specific mortality, population size (adult density), and reproduction (clutch size).

To attempt to identify sample sizes that may be needed to detect differences in survival rates among translocatees, residents, and reference tortoises with sufficient statistical power (≥80%; Rosner 2016, Qiu et al. 2021), we used the 60-day survival analysis results from the Spring 2021 translocations at Stump Springs (details provided in Appendix 3). This provides a likely 'worst-case scenario', because most previous studies of other Mojave desert tortoise populations found that survival was similar for translocatees and residents. Estimated power of the Spring 2021 translocations at Stump Springs was $P = 0.60$, given the hazard ratio, indicating the sample size of 20 transmittered residents may have been too small. Assuming the post-release hazard ratio remains similar to that observed in the Spring 2021 translocations, an estimated 30–40 tortoises in each group need to be transmittered to reliably detect differences in survival rates between groups within the first 60 days post-release (Figure 8). If threats to translocated tortoises, such as predation, are reduced using approaches discussed earlier in this plan, then the hazard ratio should decline. Therefore, we also evaluated scenarios in which the hazard ratio is reduced in increments as a result of pre- and/or post-translocation management intervention, such as implementation of predator control or aversion methods. For example, if the hazard ratio is reduced by 20–30% as a result of management actions, which would increase translocatee survival, then 45–55 tortoises would need to be transmittered in each group to detect a difference in survival rates, if such a difference truly exists. Yet, such sample sizes may not be warranted, because 20–30% increases in translocatee survival would result in $S = 0.89–0.99$, which likely would be similar to resident survival and within the range of survival typical of natural populations, thereby reducing the biological relevance of any statistical difference between translocated and resident survival.

It is important to reiterate that the sample sizes depicted in Figure 8 are for detecting differences in survival *within the first 60 days post-translocation*. Available evidence indicates that translocated tortoises typically do not establish residency until two years post-translocation (Field et al. 2007, Nussear et al. 2012, Farnsworth et al. 2015, Brand et al. 2016), so survival analyses will be conducted at one and two years after release. Such longer-term data collection should require smaller sample sizes of transmittered tortoises to accurately detect survival differences between groups with sufficient power than what our power analysis indicated.

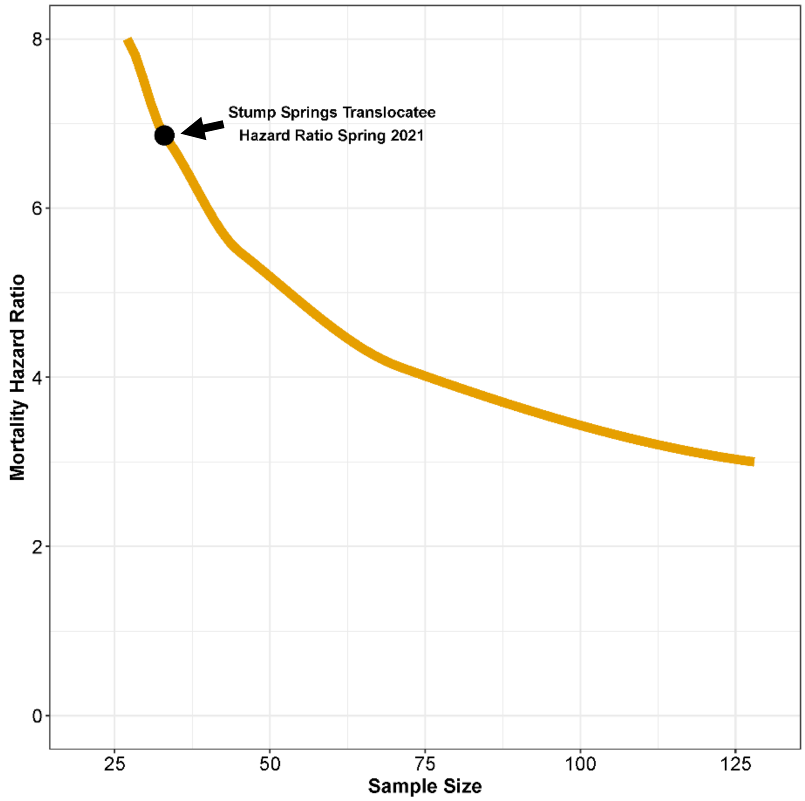

Figure 8. Number of transmittered tortoises needed to detect a difference in survival probability between groups with 80% power under different hazard ratios, within the first 60 days post-translocation.

Triennial surveys of the recipient and reference populations also will occur to estimate adult tortoise abundance and density. These have traditionally been line-distance transect surveys, which, for consistency and long-term standardized comparisons of trends, will continue to be the primary method used. However, the use of demographic plots also will be explored, and newer analytical methods for estimating population size and density have been developed in recent years that may provide more accurate estimates without requiring major changes to the line-distance survey approach, thereby permitting comparisons among analytical methods. For example, the search area-encounter variant of spatially explicit capture-recapture models can be applied to detection data from demographic plots and also modified to estimate abundance and density from line-distance transect surveys, if spatial coordinates of detections are recorded (Royle et al. 2011, Russell et al. 2012, Crum et al. 2021).

Considering only a portion of individual tortoises in the population will be marked and have known individual identity, whereas most tortoises will be unmarked, the search area-encounter analytical approach would need to be adapted to the generalized spatial mark-resight framework (Whittington et al. 2018, Murphy et al. 2019). Doing so would appropriately account for the differential detectability and spatial distributions between marked and unmarked tortoises, while also accommodating the spatiotemporal marking process. Additionally, integrating the radio-telemetry monitoring data that will also be recorded during monitoring can further improve accuracy and precision of abundance and density estimates in the spatially explicit approach (Whittington et al. 2018, Murphy et al. 2019, Mitchell et al. 2021). Therefore, the utility, applicability, and estimate reliability of these alternative analytical approaches will be explored and compared to the traditional method. A major benefit of implementing monitoring in an IPM framework, particularly a spatially explicit variant of IPM (e.g., Chandler and Clark 2014), is that population abundance and density estimation surveys do not need to be conducted annually to obtain reliable estimates of population growth, which the planned triennial frequency of those surveys for desert tortoises are well-suited. For this approach to be optimally effective, less intensive and financially cheaper count-based tortoise occupancy surveys may need to occur during the intervening years between population surveys to provide calibrated *indices* of tortoise abundance and density (Chandler and Clark 2014).

Initial Monitoring Plan (2022 – 2027)

The initial monitoring approach is designed to be extensive so that some of the uncertainty about tortoise augmentations is reduced, knowledge gaps about the Stump Springs resident population and study area are filled, and monitoring can be refined over time to better address the recovery objectives. As such, the initial monitoring plan outlined herein is focused on intensive data collection during the first 6 years from inception (i.e., through 2027), after which data will be analyzed and the monitoring approach reevaluated to identify potential improvements. A six-year interval was chosen because this would allow incorporation of two population surveys that estimate tortoise density and abundance, which, when combined with the 2020 pre-translocation baseline estimates and the annual survival monitoring via telemetry, should facilitate estimation of vital rates and short-term population growth.

Based on results of the above survival power analysis, our intent is to place transmitters on 30–40 tortoises in each translocation group and maintain 30–40 transmittered tortoises in each the resident and reference groups. These sample sizes should provide sufficient statistical power to detect differences in *annual* survival rates among groups across years, if those differences truly exist, while also allowing monitoring of connectivity across SR-160 and tortoise habitat selection at Stump Springs. The sample of translocatees outfitted with transmitters will be monitored for two years, after which surviving translocatees are expected to transition to residents in the population (Field et al. 2007, Nussear et al. 2012, Farnsworth et al. 2015, Brand et al. 2016). Depending on the sample size and sex ratio of residents that are outfitted with transmitters at that time, some translocatees that transition to residents may retain their transmitters, whereas transmitters will be removed from others. Within the resident and reference populations, transmitter deployment will be adult female-biased, though some males will be outfitted with transmitters as well. Data collection skewed towards adult females is warranted because prior research on other desert tortoise populations has demonstrated that adult female survival is the most important predictor of population growth and viability (Doak et al. 1994), and monitoring of females will also allow monitoring of reproductive rates (e.g., clutch size) for inclusion in IPMs and evaluating the criteria in Table 3.

In addition to the telemetry-based monitoring, line-distance transect population surveys will occur every 3 years (2024 and 2027) to estimate tortoise density and abundance. Further, a demographic plot will be established at Stump Springs and surveyed during at least one year prior to the conclusion of the 6-year evaluation period. Surveying of line-distance transects and demographic plots would ideally occur during the same timeframe to permit direct comparisons, but this may be too logistically difficult based on resource allocations and manpower, considering telemetry monitoring also will be occurring when population surveys are conducted. Environmental/vegetation sampling and health assessments also will be conducted in conjunction with population surveys, which, collectively, should facilitate a more thorough evaluation of the factors that may influence optimum and subsistence densities at Stump Springs.

Nevertheless, as part of the adaptive management framework, the population monitoring schedule and methodological approaches will be refined based on results over time, scientific input, and the rate of translocation to Stump Springs. Monitoring other site-based measures that could influence the metrics listed in Table 3 also will be considered, depending on site-specific factors, which potentially could result in the need to re-evaluate prior stages of the success criteria. Furthermore, it is a USFWS priority to gather additional information about the potential long-term effects of translocation. For example, given the lack of environmental- and climatic-based information on subsistence density mentioned in the Specific Goal of Translocation section, developing a habitat-focused project or other monitoring approaches is a priority to evaluate the success of translocations relative to site-specific conditions and to also support our adaptive management approach for other translocation/population augmentation projects. Toward that end, tortoises found during triennial population surveys and all translocated tortoises will be given unique permanent marks to provide the option for comparative monitoring of residents and translocatees via future mark-recapture surveys. Clark County and USFWS also will consider additional monitoring strategies through the County's normal biennial funding process and as translocation numbers materialize. For example, a potential approach would use survivorship and health of translocatees and residents to describe the success of the translocation relative to habitat treatments in different parts of the translocation area or relative to other translocation areas (e.g., Trout Canyon).

Reference Site

The Greater Trout Canyon Translocation Area has been designated as the reference site for Stump Springs. Trout Canyon is geographically proximal, comprised of similar habitat conditions, and subjected to similar climatic conditions as Stump Springs; the last translocations to Trout Canyon occurred in 2014 and no future translocations are planned; and recent population surveys have indicated that the Trout Canyon population has increased substantially in number, and is doing well. Line-transect and demographic plot surveys will occur at Trout Canyon during the same years as the surveys at Stump Springs to enable direct comparisons between the two sites. BLM will coordinate with NDOT to increase connectivity between Stump Springs and Trout Canyon by retrofitting culverts below SR 160 to ensure they are accessible to tortoises. Given the spatial configuration of the two sites, we do not expect the amount of exchange to affect the greater Trout Canyon area abundance- or health-wise, and both sites will be monitored under this plan. Therefore, the Trout Canyon population serves as a useful reference for translocations to Stump Springs.

Adaptive Management Checkpoints

This plan satisfies the first two criteria of adaptive management by: 1) providing clear and measurable objectives and recovery actions, and 2) describing the sampling and analytical methods that will be used to measure progress toward those objectives. The critical third criterion of the adaptive management framework is identifying thresholds or checkpoints that, when met, may warrant conservation or management intervention (O'Grady et al. 2004, Ewen and Armstrong 2007, Nie and Schultz 2012, Lindenmeyer et al. 2013). To be effective, these checkpoints should prioritize the demographic rate(s) most important to population growth, should occur along a continuum rather than as constrained singular go/no-go tipping points, and should facilitate monitoring and analytical refinements over time. Unfortunately, pre-translocation baseline demographic and ecological data specific to the Stump Springs population are limited in both extent and duration, which precludes a formal sensitivity analysis that could be used to identify site-specific population-level triggers (e.g., Laufenberg et al. 2019). Therefore, we relied on a combination of results from previous studies of desert tortoises in other populations and within the Stump Springs and Trout Canyon populations to develop checkpoints, but these likely will be revised as more data become available for analysis (USFWS 2021). It is important to note that initial translocatee vital rates (e.g., survival) will not be included in the evaluations, primarily because of 'release costs' in which translocatees typically have depressed survival and reproductive rates during the first two years post-release (Bertolero et al. 2018). However, available evidence indicates that translocated tortoises surviving approximately two years post-release effectively become residents thereafter; thus, vital rate data from translocatees that transition to residents and retain transmitters will be included in the checkpoints.

Category I Checkpoints: Indicate the population is stable or increasing.

1. The point estimate of *average annual* resident adult female survival probability over a 3-year period, estimated from radio-telemetry monitoring and/or mark-recapture efforts, is within the 90th percentile of the values observed at Trout Canyon between 2014 and 2020, and within 20% of the values observed at Trout Canyon during the same 3-year period.
2. The *triennial* point estimate of adult tortoise density is greater than the minimally viable desert tortoise density (i.e., >3.9 adults/km^2).
3. Nonnative grasses comprise <30% relative cover of the spring annual plant community.
4. No new or increasing threats are identified during the period between population line-distance transect surveys.

If the above conditions are satisfied, then no additional conservation or management intervention is necessary.

Category II Checkpoints: Indicate the population or habitats may be less stable than anticipated but data do not necessarily indicate the population is in decline.

1. The point estimate of *average annual* resident adult female survival probability over a 3-year period, estimated from radio-telemetry monitoring and/or mark-recapture efforts, is within the 95th percentile of the values observed at Trout Canyon between 2014 and

2020, or within 25% of the values observed at Trout Canyon during the same 3-year period.
2. The *triennial* point estimate of adult tortoise density is greater than the minimally viable desert tortoise density (i.e., >3.9 adults/km^2) but the lower bound of the 95% confidence interval is at or below 3.0 adults/km^2.
3. Nonnative grasses comprise 30-50% relative cover of the spring annual plant community.
4. New or increasing threats are identified during the period between population line-distance transect surveys but they are not of a magnitude or imminence that might threaten persistence of population at a density >3.9 adults/km^2.

If any of the above conditions are satisfied, data will be analyzed to attempt to identify the potential causes of said changes and whether management interventions may be needed to reverse trends.

Category III Checkpoints: Indicate threats are likely causing the population to decline below the minimally viable level and immediate intervention may be necessary.

1. The point estimate of *average annual* resident adult female survival probability over a 3-year period, estimated from radio-telemetry monitoring and/or mark-recapture efforts, falls outside the 95th percentile of the values observed at Trout Canyon between 2014 and 2020, or outside 25% of the values observed at Trout Canyon during the same 3-year period.
2. The *triennial* point estimate of adult tortoise density is equal to or below the minimally viable desert tortoise density (i.e., >3.9 adults/km^2).
3. Nonnative grasses comprise >50% relative cover of the spring annual plant community.
4. New or increasing threats are identified during the period between population line-distance transect surveys that are of a magnitude or imminence that could threaten persistence of population at a density of 3.9 adults/km^2.

If any of the conditions above are satisfied, immediate management interventions are warranted to attempt to reverse trends.

Reporting

Field contractors will be responsible for providing annual project reports of all monitoring activities. There are standard permitting requirements for reporting status of transmittered tortoises, which should indicate location, status of battery (whether is it operating, missing, or dead, for instance). Minimum data reported for all live or dead tortoises encountered during annual field work will include identification number, carapace length, sex, live/dead, and UTM location. For each translocated tortoise encountered, the maximum distance between its original release location and encounter that year should be reported. Data should be provided in the appropriate format of spreadsheets, databases, geodatabases, or compiled into a project database if one is provided by USFWS and BLM. USFWS will coordinate a synthesis of monitoring from these reports no less frequently than every five years.

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Appendix 1: Laboratory Results for Tortoises Sampled at Stump Springs During 2014–2020

ID	Health Assessment Date(s)	Sex	MCL	Mass	Attitude/ Activity	BCS	Nasal Discharge	Severity	Oral lesion (yes/no)	Other defect (yes/no)	MYAG ELISA (Titer)	MYTE ELISA (Titer)	MYAG PCR	MYTE PCR	TeHV2 PCR
ST5051	30-Sep-20	M	196	1,250	Appropriate	4	None	0	No	No	Negative (<32)	Negative (<32)	Negative	Negative	Negative
ST5051	28-Sep-21	M	196	1,364	Appropriate	5	None	0	No	No	Pending	Pending	Pending	Pending	Pending
ST5052	3-Oct-20	M	234	2,294	Appropriate	4	None	0	No	No	Negative (<32)	Negative (<32)	Negative	Negative	Negative
ST5053	3-Oct-20	M	274	3,827	Appropriate	4	None	0	No	No	Negative (<32)	Negative (<32)	Negative	Negative	Negative
ST5054	7-Oct-20	M	253	2,825	Appropriate	4	None	0	Not Examined	**Dried mucous discharge on beak**	**Positive (128)**	Negative (<32)	NA	NA	NA
ST5054	23-Sep-21	M	254	3,282	Appropriate	4	None	0	No	No	Pending	Pending	Pending	Pending	Pending
ST5055	7-Oct-20	M	255	2,300	Appropriate	5	None	0	No	No	Negative (<32)	Negative (<32)	Negative	Negative	Negative
ST5055	23-Sep-21	M	257	2,654	Appropriate	5	None	0	No	No	Pending	Pending	Pending	Pending	Pending
ST5056	7-Oct-20	F	180	1,025	Appropriate	4	None	0	No	No	Negative (<32)	Negative (<32)	Negative	Negative	Negative
ST5057	7-Oct-20	F	190	1,375	Appropriate	4	None	0	Not Examined	No	Negative (<32)	Negative (<32)	NA	NA	NA
ST5057	30-Sep-21	F	197	1,658	Appropriate	4	None	0	No	No	Pending	Pending	Pending	Pending	Pending
ST5058	9-Oct-20	F	229	2,174	Appropriate	4	None	0	No	No	Negative (<32)	Negative (<32)	Negative	Negative	Negative
ST5058	23-Sep-21	F	230	2,444	Appropriate	4	None	0	No	No	Pending	Pending	Pending	Pending	Pending
ST5059	8-Oct-20	M	274	3,570	Appropriate	4	None	0	No	No	Negative (<32)	Negative (<32)	Negative	Negative	Negative
ST5059	4-Oct-21	M	279	3,996	Appropriate	5	None	0	No	No	Pending	Pending	Pending	Pending	Pending
ST5060	8-Oct-20	F	221	2,263	Appropriate	4	None	0	No	No	Negative (<32)	Negative (<32)	Negative	Negative	Negative
ST5060	23-Sep-21	F	226	2,376	Appropriate	4	None	0	No	No	Pending	Pending	Pending	Pending	Pending
ST5061	8-Oct-20	F	218	1,895	Appropriate	4	None	0	No	No	Negative (<32)	Negative (<32)	Negative	Negative	Negative
ST5061	23-Sep-21	F	220	2,184	Appropriate	4	None	0	No	No	Pending	Pending	Pending	Pending	Pending
ST5062	8-Oct-20	U	170	924	Appropriate	4	None	0	No	No	Negative (<32)	Negative (<32)	Negative	Negative	Negative
ST5062	23-Sep-21	U	186	1292	Appropriate	4	None	0	No	No	Pending	Pending	Pending	Pending	Pending
ST5063	9-Oct-20	M	192	1,200	Appropriate	5	None	0	No	No	Negative (<32)	Negative (<32)	Negative	Negative	Negative
ST5063	22-Sep-21	M	198	1,338	Appropriate	5	None	0	No	No	NA	NA	Pending	Pending	Pending

Appendix 1: Laboratory Results for Tortoises Sampled at Stump Springs During 2014–2020

ID	Health Assessment Date(s)	Sex	MCL	Mass	Attitude/ Activity	BCS	Nasal Discharge	Severity	Oral lesion (yes/no)	Other defect (yes/no)	MYAG ELISA (Titer)	MYTE ELISA (Titer)	MYAG PCR	MYTE PCR	TeHV2 PCR
ST5064	9-Oct-20	M	208	1,725	Appropriate	4	None	0	No	No	Negative (<32)	Negative (<32)	Negative	Negative	Negative
ST5064	22-Sep-21	M	214	1,716	Appropriate	5	None	0	No	No	Pending	Pending	Pending	Pending	Pending
ST5065	9-Oct-20	M	201	1,575	Appropriate	5	None	0	No	No	Negative (<32)	Negative (<32)	Negative	Negative	Negative
ST5065	22-Sep-21	M	208	1,828	Appropriate	5	None	0	No	No	Pending	Pending	Pending	Pending	Pending
ST5066	10-Oct-20	F	232	2,250	Appropriate	4	None	0	Not Examined	No	Negative (<32)	Negative (<32)	NA	NA	NA
ST5066	22-Sep-21	F	233	2,366	Appropriate	4	None	0	No	No	Pending	Pending	Pending	Pending	Pending
ST5067	16-Oct-20	M	245	2,250	Appropriate	4	None	0	No	No	Negative (<32)	Negative (<32)	Negative	Negative	Negative
ST5067	29-Sep-21	M	245	2,484	Appropriate	5	None	0	No	No	Pending	Pending	Pending	Pending	Pending
ST5068	16-Oct-20	F	177	1,125	Appropriate	4	None	0	Not Examined	No	Negative (<32)	Negative (<32)	NA	NA	NA
ST5068	22-Sep-21	F	183	1,310	Appropriate	5	None	0	No	No	Pending	Pending	Pending	Pending	Pending
ST5069	19-Oct-20	F	155	575	Appropriate	4	None	0	Not Examined	No	Negative (<32)	Negative (<32)	NA	NA	NA
ST5070	21-Oct-20	U	164	780	Appropriate	4	None	0	Not Examined	No	Negative (<32)	Negative (<32)	NA	NA	NA
ST5071	21-Oct-20	M	196	1,100	Appropriate	4	None	0	No	No	Negative (<32)	Negative (<32)	Negative	Negative	Negative
ST5071	30-Sep-21	M	200	1,382	Appropriate	4	None	0	No	No	Pending	Pending	Pending	Pending	Pending
ST5072	22-Oct-20	M	218	1,500	Appropriate	4	None	0	No	No	Negative (<32)	Negative (<32)	Negative	Negative	Negative
FW7814	25-Oct-14					4					<32	<32			
FW7974	26-Oct-14					4					<32	<32			
FW7989	27-Oct-14					3					<32	<32			
FW7848	28-Oct-14					3					<32	<32			
FW8104	29-Oct-14					4					<32	<32			

Appendix 2: Health Eligibility Criteria for Translocation of Captive Tortoises

(based on prior San Diego Zoo Global protocols implemented at the Desert Tortoise Conservation Center)

Initial Assessment of Pen Group Eligibility

- Assess **all** individuals occupying pen concurrently.
- The pen group is preliminarily deemed eligible if no tortoises in the pen have signs of disease.
- If one or more tortoises in the pen show mild to moderate signs of disease, the pen is not eligible for release, and all tortoises in pen will be treated and observed with re-assessment for eligibility after 3 months.
- If one or more tortoises in the pen has a Body Condition Score $\leq$ 3 and/or moderate to severe signs of disease, those individuals receive a follow-up health assessment immediately, and the pen is quarantined for 30 days.

Individual Eligibility

- Pre-release comprehensive health assessment, which includes a full physical exam and collection and banking of biological samples (blood, choanal swab, cloacal swab, nasal lavage) conducted
- Normal behavior for season and time of day
- Normal bodily functions
- No active signs of communicable disease
- Serous 1 nasal and/or ocular discharge **does not disqualify** a tortoise from eligibility if there is no scarring or missing scales around the nares and no other health issues
- No oral lesions
- No white oral cavity
- No bladder stones
- No ectoparasites
- No generalized skin conditions
- Body Condition Score 4-7
- History of maintained or increased weight
- 4 legs and normal ambulation
- No gross disfigurements such as severely flattened carapace, unusually domed or peaked carapace, or grossly enlarged carapace
- Midline carapace length $\leq$ 330 mm

Appendix 3: Details of Statistical Analyses Used in this Plan

Spring 2021 Post-Translocation Survival Analysis
Time-to-event data that were obtained from radio-telemetry monitoring of translocatees and residents were formatted as staggered entry, right-censored survival data. Cox proportional hazards regression models were used to estimate hazard ratios for translocatees versus residents and adult translocatees versus juvenile translocatees, with survival probabilities based on Kaplan-Meier survival curves (Cox 1972). The proportional hazards assumption was tested using Schoenfeld residuals. The survival analysis was conducted with the *survival* package in the R statistical computing environment (Therneau et al. 2000, R Core Team 2021, Therneau 2021). Cause-specific mortality probabilities were estimated using cumulative incidence functions via the *cmprsk* package in R (Gray 2020), which appropriately accounted for competing risks (Heisey and Patterson 2006).

Survival Power Analysis and Sample Size Estimation
To estimate the power of the Spring 2021 radio-telemetry sample sizes at Stump Springs, the Cox proportional hazards model and Spring 2021 time-to-event data were used in the *powerSurvEpi* package in R (Rosner 2006, Qiu et al. 2021). The *powerSurvEpi* package was also used to estimate the sample sizes of transmittered tortoises that would be required for detecting differences in survival rates between groups under 20% incremental changes in the hazard ratio (Rosner 2006).

Subsistence Density Estimation
A combination of adult tortoise density estimates produced for Stump Springs and Trout Canyon during 1987–2020 were compiled and used to attempt to obtain a crude estimate of subsistence density, based on logistic population growth. The following densities comprised the dataset: a) 11.6 adults/km^2 that was estimated for Trout Canyon in 1987; b) 7.3 adults/km^2 that was estimated for Trout Canyon in 1992; c) 2.9 adults/km^2 that was estimated for the Trout Canyon and Stump Springs areas in 2008; d) 0.9 adults/km^2 that was estimated for Stump Springs in 2014; and e) 3.5 adults/km^2 that was estimated for Stump Springs in 2020. The *growthrates* package in R (Petzoldt 2020) was used to fit a simple parametric nonlinear logistic growth model.

Estimating Population Decline Probabilities for Potential Subsistence Densities
Simulation was used to conduct stochastic population projections that incorporated simple density-dependence via the *popbio* package in R (Morris and Doak 2002, Stubben and Milligan 2007), based on the distribution of observed population growth rates and tortoise density estimates for Stump Springs and Trout Canyon during 2008–2020. Two threshold densities were evaluated (0.9 and 3.9 adults/km^2) under the following range of plausible subsistence densities: a) 4.03 adults/km^2 from the above crude subsistence density estimation; b) 5.9 adults/km^2 estimated for Trout Canyon in 2014; c) 8.4 adults/km^2, which was estimated for multiple desert tortoise populations in both the Mojave and Colorado Deserts during 2004–2014 and served as a plausible intermediary between 5.9 and 11.6 adults/km^2 (Allison and McLuckie 2018); d) 11.6 adults/km^2 estimated for Trout Canyon in 1987; and e) 13.6 adults/km^2 estimated for Trout Canyon in 2020. For each threshold density × subsistence density scenario, a total of 1,000 population growth trajectories were simulated for a 10-year period. The probability that the

population would decline below the threshold densities under each subsistence density was estimated based on the proportion of projections with final population sizes that were lower than the thresholds.