REGIONAL ASSESSMENT

STATELINE SOLAR FARM PROJECT

BLM CASE FILE NUMBER CACA-48669

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Date:
27 July 2012

NatureServe
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Suggested citation: NatureServe. 2012. Regional assessment: Stateline solar farm project. Technical report prepared for Desert Stateline, LLC. NatureServe, Arlington, VA.

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1 Introduction

1.1 Purpose and overview of assessment

The purpose of this regional assessment is to provide additional characterization of the potential ecological effects of two proposed alternatives for the Stateline solar project, given existing conditions in the Ivanpah Valley Watershed. Specific objectives include characterizing the general ecological health of the ecosystems of the Ivanpah Valley Watershed, providing a demographic summary of the Mojave desert tortoise for the watershed, and assessing the potential for habitat connectivity for desert tortoise within the watershed and beyond, using existing data.

1.2 Assessment approach

To provide a general ecological characterization and assess habitat connectivity for the Mojave desert tortoise, two modeling tools were utilized: NatureServe's Vista[1] software, and the Circuitscape[2] software. These tools were used to examine the cumulative effects of infrastructure features on habitat quality and loss, and to examine their potential impacts on habitat connectivity for the Mojave desert tortoise. Most ecological or environmental modeling tools are designed to focus on a limited set of variables; no single tool can address all variables of interest and make predictions about their impacts on all types of biodiversity. Therefore, it is frequently necessary to apply a series of tools or models to look at different variables and interpret the suite of results to begin to develop a picture of the effects of different variables on biological resources. Together, these tools provided a characterization of the quality and loss of habitat, and potential for habitat connections under current conditions and under the two proposed Stateline alternatives.

Data available for the Mojave desert tortoise for the Ivanpah Valley Watershed were used to develop a partial demographic profile. Existing population size and density information for the Valley were compiled and summarized. Tortoise observation data from various survey and monitoring projects were compiled into a single data set to create raw estimates of demographic variables and used to inform other components of the regional assessment.

1.3 Assessment areas and context

1.3.1 Ivanpah Valley Watershed

The Ivanpah Valley Watershed (Figure 1) is the primary area of interest in this regional assessment. This area formed the boundary for the local-scale connectivity modeling and the cumulative effects modeling. It is an arid landscape located in the eastern part of the Mojave Desert along the California and Nevada state line, with the bulk of the watershed in California. It is situated in the southern portion of the revised Eastern Mojave Recovery Unit[3], per USFWS' recently updated recovery plan for desert

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[1] Vista is a freely available decision support software (www.natureserve.org/prodServices/vista/overview.jsp)

[2] Circuitscape is a freely available connectivity modeling tool (www.circuitscape.org/Circuitscape/Welcome.html)

[3] "Recovery units for the desert tortoise are…geographically identifiable units essential to the recovery of the entire listed population; each unit is necessary to conserve the genetic, behavioral, morphological, and ecological diversity necessary for long-term sustainability of the entire listed population. [They] collectively cover the entire range of the species." (USFWS 2011b)

tortoise (USFWS 2011b). The New York Mountains and the southern portion of the McCullough Range form its eastern edge, while the Clark Mountains and smaller ranges bound the western side. The valley itself is oriented roughly north-south and the Ivanpah Dry Lake lies in the north central part. The valley is part of a closed drainage basin, with surface flow draining through the complex of desert washes and bajadas into Ivanpah Dry Lake.

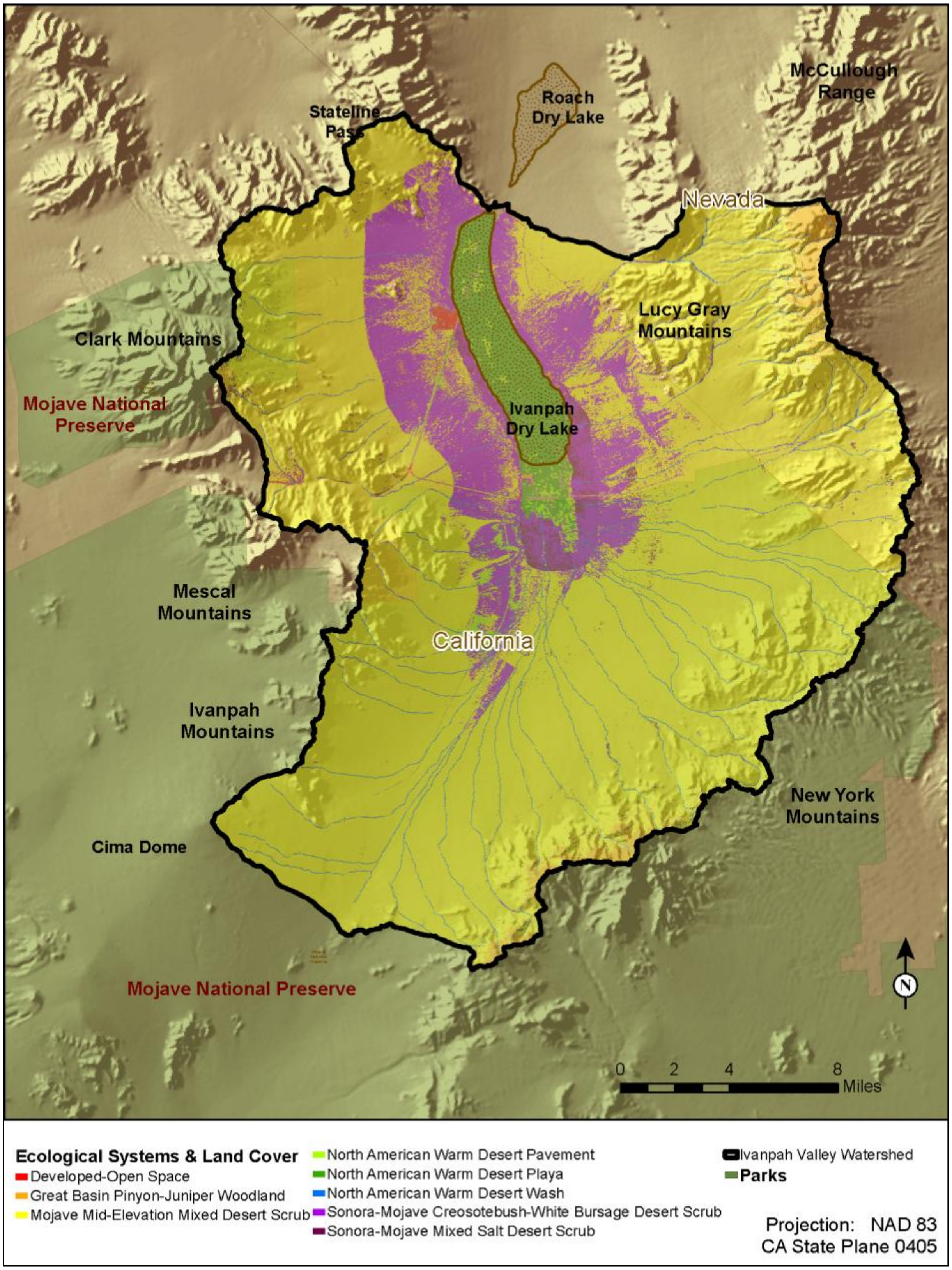
Figure 1. Overview of Ivanpah Valley Watershed.

Elevation ranges from approximately 795 meters at the dry lake bed to approximately 2400 meters in the highest peaks of the Clark Mountain Range. A complex of desert washes flow from the base of the mountain ranges and Cima Dome into the dry lake. Vegetation in these wash areas is predominantly Mojave Mid-Elevation Mixed Desert Scrub, and the Sonora-Mojave Creosotebush-White Bursage Desert Scrub. The unvegetated dry lake bed is classified as North American Warm Desert Playa. Table 1 summarizes the extent of the ecological systems present in the study area (USGS 2010 as updated by NatureServe) and Figure 2 illustrates them visually.

Table 1. Proportion and extent of ecological systems present in the Ivanpah Valley Watershed.

Ecological System Type	Percentage	Sq Miles	Acres
Mojave Mid-Elevation Mixed Desert Scrub	77.2%	407.4	260,763
Sonora-Mojave Creosotebush-White Bursage Desert Scrub	12.0%	63.1	40,381
North American Warm Desert Playa	3.6%	18.8	12,033
Great Basin Pinyon-Juniper Woodland	2.1%	11.0	7,023
North American Warm Desert Wash	2.1%	10.9	6,975
North American Warm Desert Pavement	1.1%	5.9	3,768
Sonora-Mojave Mixed Salt Desert Scrub	0.8%	4.5	2,858
Great Basin Xeric Mixed Sagebrush Shrubland	0.3%	1.7	1,075

Figure 2. Ecological systems of the Ivanpah Valley Watershed.



1.3.1.1 Land management and uses

Most of the land in the Ivanpah Valley Watershed is federally owned and much of it is managed for biodiversity conservation. It is located in the Eastern Mojave Recovery Unit as identified in the updated desert tortoise recovery plan (USFWS 2011b). The Eastern Mojave Recovery Unit is one of five revised recovery units spanning the range of the Mojave desert tortoise. Each of the units has individual recovery criteria and they are collectively designed to contribute to the overall recovery goal and long-term viability of the Mojave desert tortoise across its range. Tortoise conservation areas (TCAs) serve as "focal areas for recovery within each recovery unit;" they are areas of tortoise habitat within a variety of designations, including critical habitat, Desert Wildlife Management Areas, Areas of Critical Environmental Concern, national parks, monuments, and wildlife refuges, and other managed lands. USFWS (2011b) provides the following definitions for some of these designations:

- **Desert Wildlife Management Areas (DWMA):** General areas recommended by the 1994 Recovery Plan within which recovery efforts for the desert tortoise would be concentrated. DWMAs had no specific legal boundaries in the 1994 Recovery Plan. The Bureau of Land Management formalized the general DWMAs from the 1994 Recovery Plan through its planning process and administers them as Areas of Critical Environmental Concern.
- **Critical Habitat:** Specific, legally defined areas that are essential for the conservation of the desert tortoise, that support physical and biological features essential for desert tortoise survival, and that may require special management considerations or protection. Critical habitat for the desert tortoise was designated in 1994, largely based on proposed DWMAs in the draft Recovery Plan.
- **Area of Critical Environmental Concern (ACEC):** Specific, legally defined, Bureau of Land Management designation where special management is needed to protect and prevent irreparable damage to important historical, cultural, scenic values, fish and wildlife, and natural resources (such as the desert tortoise) or to protect life and safety from natural hazards. Designated critical habitat and ACEC boundaries generally, but not always, coincide with legal boundaries.

The southern portion of the study area is in the Mojave National Preserve. The northern portion is almost entirely managed by the Bureau of Land Management. Most of the land in the triangle bounded by Interstate 15, Route 164, and the California/Nevada state line is the Ivanpah Desert Wildlife Management Area (DWMA). The Piute/Eldorado Valley Area of Critical Environmental Concern (ACEC) is located in the northeast portion of the study area. West of Interstate 15 and north of the Preserve, most of the land is part of the Clark Mountain grazing allotment. The Preserve, DWMA, and ACEC are all part of the network of tortoise conservation areas and are managed all or in part for conservation of wildlife and other biological resources, including desert tortoise. Privately owned lands are located in the communities of Primm, Nevada and Nipton, California, and include the Primm Valley Golf Course. Figure 3 illustrates land ownership within the study area.

In addition to livestock grazing and uses associated with the communities of Primm and Nipton, other land uses in the study area include mining (Mountain Pass Mine), energy development, and a range of recreational activities. A Union Pacific rail line runs through the east side of the study area. Transmission lines, the Kern River gas pipeline, and other energy or mining-related infrastructure are also located in the watershed. A number of infrastructure development projects have been approved or proposed in or near the watershed:

Approved Projects

1) BrightSource Energy’s Ivanpah Solar Electric Generating System (ISEGS) project[4]
2) First Solar’s Silver State North project (0.8 mile north of the Ivanpah Valley Watershed)
3) AT & T fiber-optic cable maintenance project
4) Southern California Edison’s Eldorado to Ivanpah Transmission Line Upgrade[5] project
5) Interstate 15 Joint Port of Entry[6] project
6) Mountain Pass Lateral gas pipeline[7] (Kern River pipeline)

Proposed Projects

1) First Solar’s Stateline project
2) First Solar’s Silver State South project (just outside and to the north of the Ivanpah Valley Watershed)
3) Desert Xpress high-speed rail
4) Ivanpah Valley Airport (1.1 miles north of the Ivanpah Valley Watershed)

Potential Project

5) Potential wind energy development in Mountain Pass (Iberdrola Renewables)

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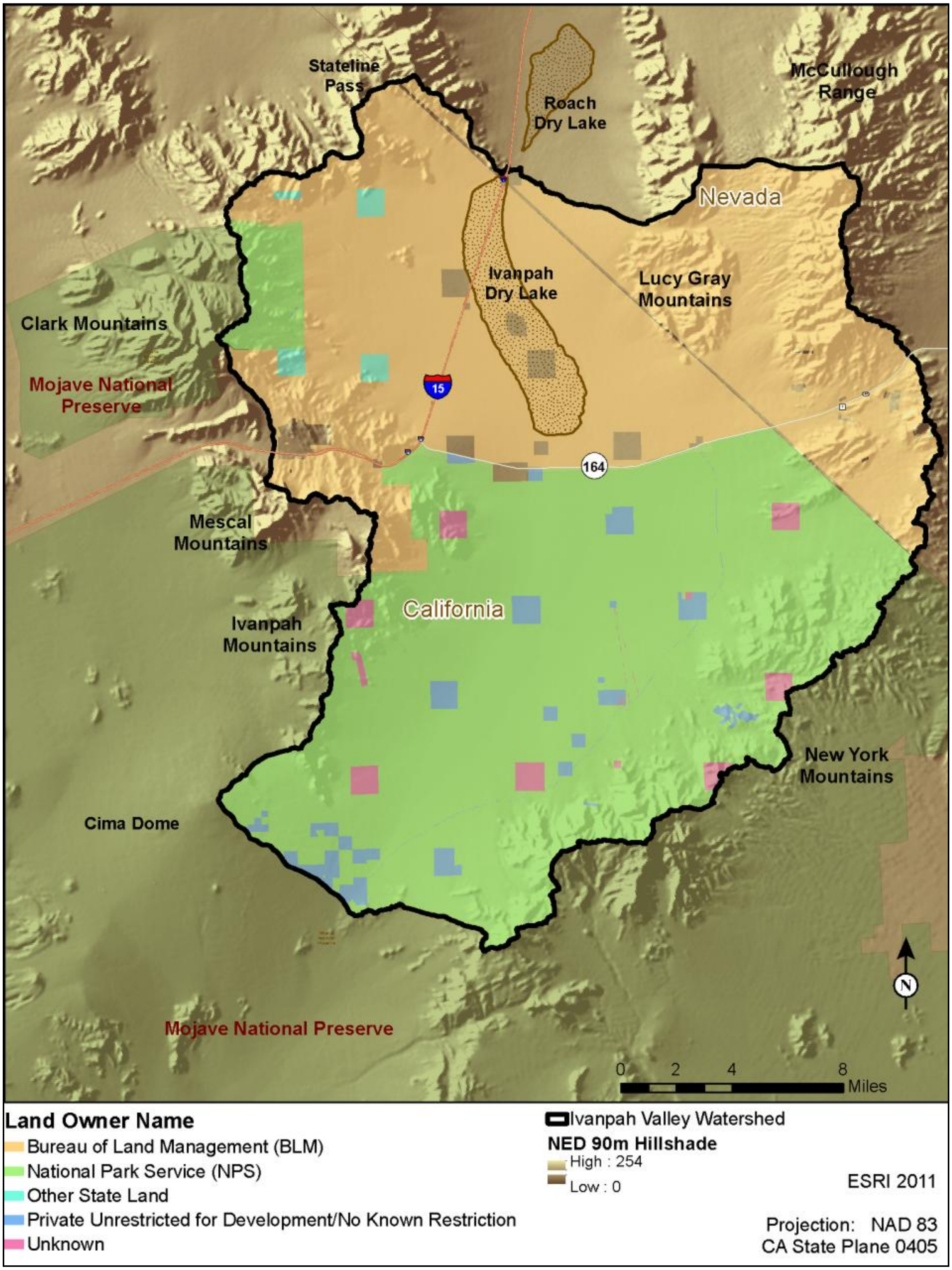
[4] California Energy Commission’s ISEGS project website: www.energy.ca.gov/sitingcases/ivanpah/index.html

[5] Eldorado to Ivanpah Transmission Line Project website: www.cpuc.ca.gov/environment/info/ene/ivanpah/ivanpah.html

[6] BLM’s Joint Port of Entry Environmental Assessment website: www.blm.gov/ca/st/en/fo/needles/jpoe__ea.html

[7] Kern River’s Mountain Pass Lateral website: http://www.kernrivergas.com/InternetPortal/BackDesktop.aspx?TabID=162&TabParentID=142

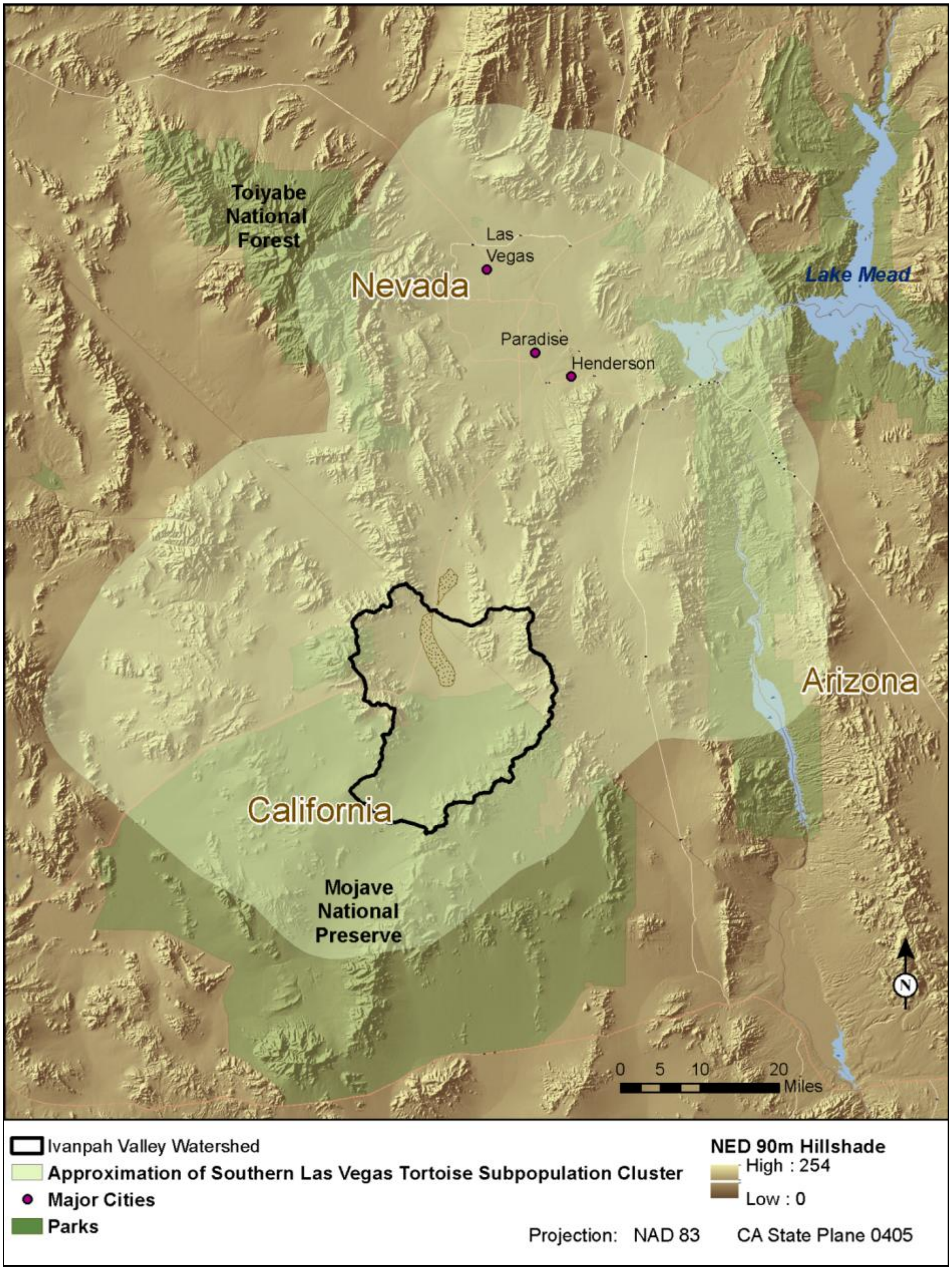
Figure 3. Land ownership in the Ivanpah Valley Watershed.



1.3.2 Desert tortoise subpopulation cluster geography

Areas that may be significant relative to the larger desert tortoise population were reviewed to provide a larger context for the regional assessment. Hagerty and Tracy (2010) completed genetic research to characterize population structure and gene flow of the Mojave desert tortoise. They estimated a series of population and subpopulation clusters for the range of the desert tortoise. The Ivanpah Valley Watershed lies within the southern Las Vegas subpopulation as defined in their research. For the sole purpose of providing a larger and meaningful unit of analysis, the extent of the southern Las Vegas subpopulation cluster was roughly approximated from their publication and used as one of the areas of analysis in the cumulative effects assessment (Figure 1 and Figure 4). This approximation corresponds to the southern portion of the Eastern Mojave Recovery Unit.

Figure 4. Approximation of extent of southern Las Vegas desert tortoise subpopulation, per Hagerty and Tracy (2010).



1.3.3 Mojave Basin and Range Ecoregion

The geographic range of the Mojave desert tortoise lies almost entirely within the Mojave Basin and Range ecoregion[8] (Figure 5). The intent of the landscape-scale connectivity assessment for desert tortoise habitat was to evaluate connectivity between the Ivanpah Valley Watershed and the surrounding areas of desert tortoise habitat. However, NatureServe has compiled and developed a large series of data sets and models for a Rapid Ecological Assessment for this ecoregion for the Bureau of Land Management. Given the significant overlap between the geographic range of the Mojave desert tortoise and the Mojave Basin and Range ecoregion, and the availability of these data sets and models, it was efficient to build on those existing data sets and models and conduct the landscape-scale connectivity assessment for the entire Mojave Basin and Range ecoregion. The specific data sets and models that were modified or updated to meet the needs of this regional assessment are described in detail in the sections of the report where data inputs and methods are discussed. They are also listed in Appendix A. This report focuses on the connectivity results in the area surrounding the Ivanpah Valley Watershed; however, the model outputs are available for the entire ecoregion.

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[8] As defined in the US EPA's Level III ecoregions (US EPA 2011) and used by the Bureau of Land Management.

Figure 5. Mojave Basin and Range Ecoregion.

2 Desert Tortoise: Overview and Demographic Summary

2.1 Desert tortoise taxonomy and status

Until recently, *Gopherus agassizii* was treated as a single species; in response to accumulated evidence suggesting it may be more than one species, it has been treated as two subpopulations in recent years. Genetic analysis recently confirmed the subpopulations are two distinct species (Murphy *et al.* 2011). The Mojave species is classified as *Gopherus agassizii*, Agassiz's desert tortoise, while the Sonoran species is *G*. *morafkai*, or Morafka's desert tortoise (Figure 6). The Mojave subpopulation was originally listed as Threatened under the US Endangered Species Act (ESA) in 1990. *Gopherus agassizii* is the species of interest in this regional assessment; it is also commonly referred to as the Mojave desert tortoise, and that common name is used throughout this report.

Figure 6. Range map for *Gopherus agassizii* and *G. morafkai*.

Included with permission from USGS; based on Murphy et al (2011) research

2.2 Habitat

The Mojave desert tortoise is almost entirely confined to warm creosote bush (*Larrea tridentata*) vegetation characteristic of the Upper Sonoran life zones of the Mojave and Colorado deserts. Specific habitat associations vary geographically, as do substrate preferences. In the Mojave Desert, the tortoise occurs in creosote scrub, creosote bursage (*Ambrosia dumosa*), shadscale (*Atriplex*) scrub, Joshua tree (*Yucca brevifolia*) park, and, more rarely (in the northern periphery of their range), in mixed blackbush scrub between 3,500-5,000 feet elevation. In the warmer and lower Colorado Desert, tortoises generally are confined to creosote scrub and wash woodland habitats. Often native desert grasses, especially galleta (*Hilaria/Plueraphis*) and Indian rice grass are associated with high tortoise densities, and the former species provides significant forage for adults. Exotic Mediterranean weed grasses (*Schizmus* and *Bromus*) are abundant across the Mojave Desert.

Most often tortoise habitats are associated with well-drained sandy loam soils in plains, alluvial fans, and bajadas, though tortoises occasionally occur in dunes, edges of basaltic flow and other rock outcrops, and in well-drained and vegetated alkali flats. In the Mojave Desert, sandy loam soils may be obscured by a surface of igneous pebbles or a veneer of desert pavement. Tortoise burrows are most often proximate to washes and arroyos in this Mojave Desert habitat (Woodbury and Hardy 1948, Luckenbach 1982). However, north of St. George, Utah, they occur in burrows excavated directly into cliffs of red sandstone.

Topographic features affect tortoise distribution and movement. Both very low-elevation regions and high-elevation mountain ranges at least partially restrict tortoise movement and therefore gene flow. Hagerty et al (2011) note that elevation is a determining factor for temperature regimes, soil type, vegetative cover, and steepness of terrain; areas of extremely high or low elevations may limit tortoise movement and therefore gene flow due to their associated thermal regimes, soils, vegetation, and terrain.

2.3 Threats

A range of stressors have been documented or observed for the Mojave desert tortoise and informed inputs to various components of the regional assessment. In a review of desert tortoise status, USFWS (2010c) found that habitat loss, degradation, and fragmentation continue to impact desert tortoises: “In particular, human populations, paved and unpaved roads, non-native invasive plants and the associated threat of wildfire, and prospective energy development (especially renewable energy development and associated utility corridors) have increased. These threats result in continued habitat loss, population fragmentation, nutritional compromise, soil erosion, and indirect impacts associated with increased human presence, including illegal dumping, human subsidies for predators, and introduction of toxins. Since the time of listing, off-highway vehicle areas and trails have been formally designated, but unauthorized use continues to be a significant source of habitat degradation. Many grazing allotments within Critical Habitat have been retired; however, large areas are also still grazed.”

Perhaps the most widespread, and recent cause of increased mortality has been upper respiratory tract disease (Jacobson 1994). The causal agent is a mycoplasma, *Mycoplasma agassizii*. Drought and concomitant poor nutrition may compromise tortoise immune systems, making them more vulnerable to infection. However, even healthy, well-fed tortoises may become infected (USFWS 1994). The Sonoran Desert population apparently has not been negatively affected by habitat loss or respiratory disease to the same degree as have populations in the Mojave and Colorado deserts, though local losses have occurred.

Ravens, along with coyotes, feral dogs, and cats are “subsidized” predators that have semi-urban populations enlarged by feeding on the refuse and rodents associated with human garbage dumps and backyards. They may be significant predators on young (< 7 years old or 120 mm plastron length) tortoises. However, in the south-central Mojave Desert, Bjurlin and Bissonette (2004) found that neonatal desert tortoises are less susceptible to predation than was previously thought, perhaps because of their cryptic coloration and secretive habits. The impacts of subsidized predators on tortoise populations as a whole is unknown (USFWS 2010c).

2.4 Genetic population structure

As summarized by USFWS in the updated recovery plan (USFWS 2011b), historically the population of Mojave desert tortoise was relatively continuously distributed across its range (Germano *et al.* 1994, Nussear *et al.* 2009), except for breaks created by significant topographic barriers (Hagerty and Tracy 2010). Murphy *et al.* (2007) concluded that historically, gene flow among subpopulations was high, indicating a correspondingly high level of habitat connectivity. Isolation by distance characterizes the population structure of this species (Britten *et al.*, 1997, Edwards *et al.*, 2004, Murphy *et al.*, 2007, and Hagerty and Tracy 2007); populations become genetically isolated with increasing distance. This all indicates that tortoise movement and gene flow can be characterized as a continuous-distribution model (Allendorf and Luikart 2007), rather than a metapopulation model. This has implications when modeling habitat connectivity for desert tortoise; habitat must be relatively continuous for gene flow to occur. Loss of connectivity may result in the genetic isolation of a population.

2.5 Range-wide population trends

Tortoise populations are declining in several areas throughout its range (USFWS 2010). During the past two decades annual declines in individual populations have varied between 3% and 59%. More important, many of these losses are adults which otherwise would reproduce and incur a natural attrition of only 2% annually. USFWS (1990) categorized the status of the Mojave Desert population as “declining.” In California, habitat has been reduced 50-60% since the 1920s. In California's western Mojave, populations may have declined nearly 90% since 1940, and as much as 70% locally between 1976-1984 (Berry 1984; however, see Bury and Corn 1995). Demographic analyses agree with field censuses in showing rapid population decline in the western Mojave Desert (Doak et al. 1994). At the Desert Tortoise Natural Area (Kern County, California), a decline through the early 1980s to early 1990s has reduced the tortoise population by 88%; a similar 84% decline has been reported for Johnson Valley (USFWS 1994). At Joshua Tree National Park (then a Monument), populations appear to have remained stable and locally robust (up to 200 tortoises/sq mi). As of the publication of the initial desert tortoise recovery plan, the overall estimated rate of decline for *Gopherus agassizii* over the previous fourteen years was 4.6% annually (USFWS 1994). At Chuckwalla Bench in the eastern Colorado Desert, a population decline began in the early 1980s and continued through 1990 (Berry 1992), culminating in a 60-70% population loss. However, adjacent Colorado Desert Chemehevi and Ward Valley populations remain the largest and most robust in the entire range (USFWS 1994). In the revised recovery plan (USFWS 2011b), USFWS reiterates Tracy *et al.* (2004) conclusion that the combined set of available data and analyses are insufficient to develop accurate estimates of population trends for the Mojave desert tortoise both within individual recovery units and range-wide. However, USFWS notes the available data indicate “appreciable declines at the local level in many areas (Berry 1984, Luke et al. 1991; Berry 2003; Tracy et al. 2004).”

Density in different areas ranges from less than 3 to 71 per square mile (Berry 1986, Freilich et al. 2000). In the eastern Mojave Desert of northern Arizona, southwestern Utah and southern Nevada, more 75-95% of the populations now average fewer than 50 tortoises per square mile. In this region only Piute Valley, Cottonwood Valley, 40 Mile Canyon and Coyote Springs, Nevada, and the Paradise Canyon-St. George Hills area of Utah supported tortoises densities in the 100 per square mile range and absolute population sizes that were favorable to long term viability. In California, densities are lowest in the far western (Antelope Valley) Mojave Desert, and highest in the west/central (Superior-Cronese) and eastern Mojave Desert and locally in the northern Colorado Desert.

The original Desert Tortoise Recovery Plan (USFWS 1994, Appendix F) provided a detailed regional account of local population densities for the threatened Mojave population, summarized by the original Recovery Units:

1) Northern Colorado Desert, 10-275 adults per square mile
2) Eastern Colorado Desert, 5-175 per square mile
3) Upper Virgin River DWMA, up to 250 per square mile
4) Eastern Mojave Desert, 10-350 per square mile (formerly up to 440 per square mile at Goffs, San Bernardino County, California)
5) Northeastern Mojave Desert, 5-90 per square mile
6) Western Mojave Desert, 5-250 per square mile

2.6 Ivanpah Valley Watershed population

In this assessment, the intent was to develop a baseline demographic profile for the desert tortoise in the Ivanpah Valley Watershed, characterizing variables such as 1) population density, 2) sex ratios, 3) recruitment, 4) disease status, 5) survivorship, and 6) annual egg production. Published information was reviewed to compile and describe population density in portions of the Ivanpah Valley Watershed. Tortoise observation data collected in the valley for a variety of purposes were compiled into a spatial data set to provide a partial demographic profile, including calculations of raw sex ratios and age classes; these numbers have not been adjusted for sampling bias or other errors to determine the actual sex ratio and age classes. Available data lacked information necessary to characterize recruitment, disease status, survivorship, or egg production.

2.6.1 Density estimates

Numerous surveys for the Mojave desert tortoise have been conducted in the vicinity of the Ivanpah Valley Watershed for a variety of purposes. The U.S. Fish and Wildlife Service is conducting on-going monitoring in parts of the valley using line distance sampling techniques as part of its long-term, range-wide monitoring for the tortoise (see USFWS 2010a). The Nevada and California state heritage programs have also conducted surveys documenting tortoise observations in the Valley as part of their mission to maintain and provide state-wide data on the occurrence of the biological resources of the state. In several instances, infrastructure projects have been proposed and tortoise surveys conducted in the proposed project areas to meet regulatory requirements. The following infrastructure projects have been recently approved or completed in the vicinity of the watershed, while others are proposed:

Approved Projects

1) BrightSource Energy's Ivanpah Solar Electric Generating System (ISEGS) project[9]
2) First Solar's Silver State North project (0.8 mile north of the Ivanpah Valley Watershed)
3) AT & T fiber-optic cable maintenance project
4) Southern California Edison's Eldorado to Ivanpah Transmission Line Upgrade[10] project
5) Interstate 15 Joint Port of Entry[11] project (footprint not readily available)
6) Mountain Pass Lateral gas pipeline[12] (Kern River pipeline)

Proposed Projects

1) First Solar's Stateline project
2) First Solar's Silver State South project (just outside and to the north of the Ivanpah Valley Watershed)
3) Desert Xpress high-speed rail
4) Ivanpah Valley Airport (1.1 miles north of the Ivanpah Valley Watershed)

Although tortoise observation data compiled by USFWS and various entities for infrastructure projects were collected and aggregated, the variation in survey methods and the incomplete coverage of the watershed by the survey efforts currently prevents the development of a density estimate for the extent of the Ivanpah Valley Watershed. Available estimates of desert tortoise population size and density relating to the Ivanpah Valley Watershed are summarized here. The most complete characterization of population density and overall population size relating to the Ivanpah Valley Watershed is from the USFWS' range-wide monitoring work for the Mojave desert tortoise. The northeast lobe of the Ivanpah Critical Habitat Unit (CHU) lies within the watershed evaluated in this assessment. In their summary of density and size estimates for subsets of the Northeastern Mojave Recovery Unit in their Biological Opinion on the re-initiation of the ISEGS project, density estimates for the Ivanpah CHU have ranged from 2.9 to 18.4 tortoises per square mile (USFWS 2011a) (Table 2). Recent population estimates for this CHU range from over 16,000 individuals in 2008 down to approximately 2,600 individuals (Table 3). These numbers apply to the entire CHU, which is somewhat larger and only partially overlaps the Ivanpah Valley Watershed, and cannot readily be used to extrapolate population and density estimates to the Ivanpah Valley Watershed.

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[9] California Energy Commission's ISEGS project website: www.energy.ca.gov/sitingcases/ivanpah/index.html

[10] Eldorado to Ivanpah Transmission Line Project website: www.cpuc.ca.gov/environment/info/ene/ivanpah/ivanpah.html

[11] BLM's Joint Port of Entry Environmental Assessment website: www.blm.gov/ca/st/en/fo/needles/jpoe__ea.html

[12] Kern River's Mountain Pass Lateral website: http://www.kernrivergas.com/InternetPortal/BackDesktop.aspx?TabID=162&TabParentID=142

Table 2. USFWS population density estimates for Ivanpah Critical Habitat Unit.

Year	Density
2001	7.3
2002	14
2003	-
2004	12.2
2005	11.9
2007	16.9
2008	18.4
2009	10.4
2010	2.9

Densities are listed as number of desert tortoises per square mile.

Table 3. USFWS population abundance estimates for Ivanpah Critical Habitat Unit.

Year	Population Abundance	Population Abundance: Range
2008	16,301	6,143-43,248
2009	9,272	3,990-21,547
2010	2,622	1,075-6,390

Surveys for desert tortoise have been completed for infrastructure-related projects proposed within various parts of the Ivanpah Valley Watershed. Population size and density estimates were developed for current and proposed solar projects and are summarized below. Tortoise surveys were completed for other infrastructure projects as well (e.g., maintenance of the AT&T fiber-optic cable, Desert Xpress high-speed rail). No live tortoises were observed in limited surveys for the AT&T project or the Desert Xpress project. The western portion of the proposed Eldorado-Ivanpah Transmission Line Project extends across the northern portion of Ivanpah Valley Watershed to the vicinity of the ISEGS project; the average tortoise density estimate for the entire project area was 5.2 individuals per square mile (CPUC and BLM 2010). The project areas highlighted with detailed population or density estimates below are generally located in the northern part of the Ivanpah Valley Watershed; the Silver State project is located just north of the northern border of the watershed, east of Interstate 15. Based on these project surveys, density point estimates range from approximately 7 to 20 individuals per square mile in this area.

Using the formula described in USFWS revised protocol (USFWS 2010c), Ironwood Consulting (2011) developed the population and density estimates summarized in Table 4 for the 6,100-acre study area for the proposed Stateline project.

Table 4. Stateline study area population abundance and density estimates based on 2008-2011 data.

Population: Point Estimate	Population Range	Density Estimate	Density Range
69	27 - 180	7.2	2.8 - 18.9

Densities are listed as number of adult desert tortoises per square mile. Ranges are based on 95% confidence intervals.

For the BrightSource ISEGS project, USFWS developed overall density estimates for the combined project area (Table 5). Population estimates for the ISEGS project study area are based on spring 2011 surveys and 2010 clearance surveys and construction monitoring. The estimates shown are based on the site and time-specific estimate of probability that a tortoise is above ground of 0.84. The density estimates were calculated assuming that the project acreage is 3,454 acres, as referenced in the Biological Opinion. USFWS also revised population size and density point and range estimates for the ISEGS translocation recipient sites as shown in Table 6. All of the ISEGS estimates are compiled from the Biological Opinion for the ISEGS project (USFWS 2011a). USFWS' population estimates for the Silver State project (USFWS 2010a) are summarized in Table 7.

Table 5. USFWS tortoise population estimates for ISEGS project.

Population: Point Estimate†	Population Range (based on 95 percent confidence interval*)	Density: Point Estimate	Density Range
84	51 - 141	15.6	9.4 - 26.1

*Tortoise number estimates were rounded to the nearest whole number for subsets of the ISEGS area prior to summation, as well as for the total point and range estimate values.

Table 6. Population and density estimates for ISEGS translocation recipient sites.

	Size (acres)	Individuals Located During Survey	Population: Point Estimate	Population Estimate Range	Density: Point Estimate	Density Range
Unit 1 Recipient Site	3,222	22	44	21 - 94	8.7	4.0 - 18.6
Unit 2 Recipient Site	2,342	13	26	12 - 59	7.1	3.1 - 15.9
Unit 3 Recipient Site	3,911	43	86	43 - 170	14.1	7 - 27.7
Interstate 15 Recipient Site	1,273	16	32	15 - 68	20.2	9.9 - 40.6
Total for Recipient Sites	10,748	94	188	91 - 391	11.2	6 - 24

These values are for tortoises larger than 160 mm; densities are provided as number of individuals per square mile.

Table 7. USFWS tortoise population estimates for Silver State projects (outside the Ivanpah Valley Watershed).

	Size (acres)	**Population: Point Estimate**	**Population Estimate Range**	**Density: Point Estimate**	**Density Range**
Project site	2,966	88	42 - 123	19	9 - 26.5

The U.S. Forest Service Fire Effects Information System provides the following range-wide summary of tortoise population densities (Meyer 2008):

> Estimates of desert tortoise densities vary from less than 8 individuals/km² [3 individuals/mi²] on sites in southern California (Berry 1986) to over 500 individuals/km² [193 individuals/mi²] in the western Mojave Desert (Marlow, personal communication cited in Luckenbach (1982), although most estimates are less than 150 individuals/km² [58 individuals/mi²] (Averill-Murray et al., 2002; Bury et al., 2002; Germano and Joyner 1988; Grover and DeFalco 1995; Rundel and Gibson 1996; and Wilson and Stager 1992). Of 29 sites in California, 8 sites had densities less than 8 individuals/km² [3 individuals/mi²], 6 sites had densities from 8 to 39 individuals/km² [3 to 15 individuals/mi²], and 13 had densities from 42 to 184 individuals/km² [16 to 71 individuals/mi²] (Berry 1986).

Current densities observed within and around the Ivanpah Valley Watershed are within the commonly observed estimates summarized by Meyer 2008. While additional infrastructure will result in the loss of tortoise habitat and the translocation of tortoises, the long-term impacts of either of the Stateline alternatives on natural tortoise densities in the area immediately around the Stateline footprint or throughout the Ivanpah Valley Watershed as a whole is unknown.

2.6.2 Other demographic estimates

As noted previously, the tortoise observation data compiled for this regional assessment have been collected from a variety of survey efforts, using different methods and over a range of time periods. The surveys have been conducted for one of two purposes: either as part of USFWS' long-term, range-wide monitoring of the Mojave desert tortoise, or as infrastructure project-related surveys initiated to meet regulatory requirements. The areas surveyed by USFWS and for the Silver State projects extend beyond the Ivanpah Valley Watershed; the USFWS data summarized here cover the entire Ivanpah CHU and Mojave National Preserve, and the Silver State survey area is just north of the Ivanpah Valley Watershed.

The observation data sets from various survey and monitoring efforts in or near the Ivanpah Valley Watershed are summarized in Table 8 below. As part of USFWS' range-wide monitoring effort, tortoise observation data have been collected in most years since 2001 in the Ivanpah CHU and on the Mojave National Preserve using line distance sampling techniques; these data were packaged for each of those two managed areas. The Ivanpah CHU and Mojave National Preserve overlap and tortoise observations found in the area of overlap were included in both data sets; when the two data packages were combined, duplicate observations were identified and removed. More information on the USFWS data and monitoring work is available in the 2010 draft annual report on the monitoring program (USFWS 2010b).

Three sets of tortoise observation data included in this assessment were collected as part of regulatory requirements for approved and proposed solar projects. Observation of radio-tagged tortoises is on-going for the BrightSource ISEGS project; data available as of late October 2011 are included in this assessment. Surveys have also been conducted at different times for the Silver State and Stateline solar projects and observations from those data sets are included as well.

Although these data were compiled and aggregated, the variation in survey methods and the incomplete coverage of the watershed by the survey efforts currently prevents the calculation of other demographic variables for the extent of the Ivanpah Valley Watershed. They can be characterized, but only as raw summaries. These observation data were also used to inform the condition threshold used in another component of this regional assessment. Table 8 lists and characterizes the data sets compiled for the regional assessments.

Table 8. Characterization of tortoise observation data sets for the Ivanpah Valley Watershed and vicinity.

Source of data	Tortoise observation data set	Time period of data collection	# of live obs	Female (live)	Male (live)	Unknown (live)	# of dead obs
Contractor	ISEGS transmitter data	Oct 2010 – Oct 2011	440	127	161	152	NA
Contractor	Silver State survey	April – May 2011	102	28	30	43	NA
Contractor	Stateline survey	April 2008 Oct 2008 Oct 2009 Mar-May 2011	55	17	21	17	153
USFWS	Ivanpah CHU Line Distance Sampling Data combined with Mojave National Preserve Line Distance Sampling Data*	2001 field season*	11	3	3	5	40
		2002 field season*	49	13	14	22	353
		2004 field season*	75	19	30	26	175
		2005 field season*	14	6	2	6	10
		2007 field season	13	4	3	6	26
		2008 field season	10	1	4	5	10
		2009 field season	5	1	2	2	9
		2010 field season	11	1	4	6	46

*The Ivanpah CHU line distance sampling data and Mojave National Preserve line distance sampling data were provided as two separate packages; when they were combined for the four sampling years for which both data sets are available, duplicate observations were removed to get a unique set of tortoise observations for each of those four years for that combined geography.

Based on these compiled observations, simple summaries of sex ratios, age classes, and sex ratios within age classes were calculated and summarized in Table 9. These estimates were calculated using the full set of compiled observation data, which covers not only the Ivanpah Valley Watershed, but also the Ivanpah CHU, Mojave National Preserve, and the Silver State project area just north of the watershed.

Based on these varied data, 345 live tortoise observations have been collected, and 822 observations of carcasses have been collected. *Without correcting for sampling bias or other sources of error* (e.g., potential error in sexing tortoises or estimating what proportion of tortoises of unknown sex are likely to be male or female), the *raw* sex ratio in live animals is 1.22:1; there is a slightly higher proportion of males in the carcass observations: 1.27:1. If observation data were available from a single consistent survey effort and sampling biases and other error could be adequately accounted for, the actual sex ratio may be different. Without such data, the actual sex ratio for desert tortoises in the Ivanpah Valley Watershed could not be determined. Desert tortoise populations usually have a sex ratio around 1:1 (Meyer 2008), although actual sex ratios that are biased toward either males or females have been observed by Averill-Murray et al. (2002) and Germano and Joyner (1998).

Based on the raw data, approximately 34% of live animals observed are 180 mm or larger (midline carapace length) and considered adults or subadults, and 66% of live animals were smaller than 180 mm (Table 10). Thirty-six percent of live observations are 160 mm or larger. Smaller and younger individuals are less likely to be observed during surveys designed using random sampling methods and as Turner et al. (1987) note, there isn't an easy way to address those biases and determine the actual size distribution of a desert tortoise population. However, survey data from Ivanpah include comprehensive and clearance surveys, which are likely to increase the rate of observation of smaller individuals. How well the raw percentages summarized for Ivanpah reflect the actual proportions of juveniles and adults cannot be determined. For comparison, raw percentages observed in the Goffs study (Turner et al. 1987) are summarized in Table 11. The Ivanpah observations show a higher proportion of smaller tortoises than the observations at Goffs. Without a more thorough study of the tortoise population within the Ivanpah Valley Watershed, the significance of this difference cannot be determined.

Table 9. Summary of tortoise observation data in or near Ivanpah Valley Watershed.

Live/Dead	Age/Size Class	Male	Female	Unknown	Sex Ratio	Total Observations
Live	All	113	93	139	1.22:1	345
	180 mm or larger	53	43	21	1.23:1	117
	160 mm or larger	53	43	29	1.23:1	125
	<180 mm	60	50	118	1.20:1	228
	<160 mm	60	50	110	1.20:1	220
Carcass	All	183	144	495	1.27:1	822

Table 10. Number and percentage of live tortoises in different size classes in or near Ivanpah Valley Watershed.

	180 mm or larger	160 mm or larger	<180 mm	<160 mm
# of observations	117	125	228	220
% of observations	34%	36%	66%	64%

Table 11. Number and percentage of tortoise observations in Goffs study in two size classes (Turner et al. 1987).

	Total # of animals	# 180 mm or larger	# <180 mm	Percentage 180 mm or larger	Percentage <180mm
1983	449	219	230	49%	51%
1984	279	179	100	64%	36%
1985	278	175	103	63%	37%
1986	251	173	78	69%	31%

3 Ecological Health Assessment

3.1 Cumulative impacts assessment approach

To characterize current and future ecosystem and tortoise habitat health in the Ivanpah Valley Watershed, a cumulative effects assessment was conducted using a pair of complementary approaches. NatureServe's landscape condition modeling tool was used to evaluate cumulative impacts of infrastructure features and land uses (i.e., grazing) specifically on tortoise habitat within the Ivanpah Valley Watershed. NatureServe's Vista software was used to assess cumulative impacts of infrastructure and land uses, as well as land management, on the major ecological systems present in the Ivanpah Valley Watershed (see list of systems in Table 1) and on those same systems across the approximated extent of the southern Las Vegas desert tortoise subpopulation (Figure 4). The categorical response approach available in the Vista software was used in this part of the assessment. Physical features including roads, residential development, utilities, energy infrastructure, and other types of development were addressed in both approaches. A series of data sets indicating the current location and projected or proposed future locations of these features were used to assess current and future cumulative effects of these features on desert tortoise habitat and ecological systems of the Ivanpah Valley Watershed. In particular, footprints of current solar projects were included for the assessment of current conditions, while the two proposed alternatives (B and D) for the Stateline solar project were included in the assessment of future cumulative effects. The approved transmission line and fiber-optic cable upgrades were reflected in footprints of existing linear utilities. A footprint for the port of entry was not readily available and therefore could not be included. The port of entry will have a relatively small, linear footprint (133 acres) adjacent to Interstate 15; the implications of its absence in these assessments are noted for each of the two approaches in the following discussion.

3.1.1 Landscape condition-based approach

The Landscape Condition Model provides an index of the aggregated effects of the infrastructure and other land uses under consideration. In this assessment, grazing was the other relevant land use. The model incorporates the on-site intensity of the infrastructure or land use and extends the effects of these features off-site in all directions using a decreasing function according to their intensity at their origin, such that intensive development features have an off-site effect that extends with greater impact than features with less intensity at their origin.

The cumulative effects of these infrastructure features and livestock grazing were modeled for the Ivanpah Valley Watershed using the landscape condition approach for the following scenarios: 1) current conditions (including the ISEGS project), 2) current conditions plus approved projects (adding the Mountain Pass Lateral pipeline[13]), and 3) a pair of future conditions scenarios. The two future scenarios included all current and approved projects plus the addition of the Stateline alternatives: one addressed Stateline Alternative B and the other addressed Stateline Alternative D. Because the footprints of the AT&T fiber-optic cable maintenance project and the Eldorado-to-Ivanpah transmission line upgrade are represented by existing infrastructure, in effect they were treated in both the current conditions scenario and the current plus approved projects scenario (as well as the pair of future scenarios). Because the interstate is assumed to have a very high on-site intensity and a substantial distance effect extending out from it, it was assumed that the interstate's impacts would either far outweigh or adequately reflect the impact of the much less extensive port of entry lying immediately adjacent to it.

The models were used to estimate the ecological integrity of tortoise habitat in the study area under current conditions, and its integrity and degree of loss under future conditions. The amount of tortoise habitat that is currently available and meets a series of thresholds of landscape condition was calculated. The amount of habitat that will remain once additional infrastructure is built and that meets the various thresholds was calculated and compared with the currently available habitat. The Landscape Condition Model is described in more detail in Section 3.2.2.

3.1.2 Categorical response approach

A second approach was used to assess the cumulative effects of these features on ecological systems (listed in Table 1) and their integrity or viability. A simple categorical response (positive, neutral, or negative) was assigned for each ecological system for each infrastructure type or land management category. Ecological systems were assumed to have a negative response to infrastructure features, a positive response to areas designated for conservation-oriented management (e.g., ACECs), and a neutral response to grazing. The spatial delineations of these features (infrastructure, land management) were combined into aggregated footprints reflecting the following scenarios: 1) the combined current infrastructure and land management classes, and 2) a pair of future scenarios that combined current and *projected* infrastructure and land management. Stateline Alternative B was represented in one future scenario, while Alternative D was represented in the other. In this ecosystem-level assessment covering a broader geographic area, "projected" infrastructure included not only approved projects, but also the following proposed projects: Silver State South, the Desert Xpress high-speed rail line, and the Ivanpah Valley Airport. Because the total extent of all infrastructure projected to be present in the future (estimated to be over 20,000 acres) is very large in comparison to the size of the port of entry, and lacking a footprint for that feature, it was assumed that the absence of the 133-acre port of entry would have a negligible effect on the results of this assessment.

The extent of each ecological system type was compared to the extent of infrastructure and other features included in the spatial scenarios. Areas where the ecological systems overlap with scenario features having a negative impact on those systems were mapped and quantified to indicate the

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[13] The pipeline had not been completed at the time of modeling and therefore was included in the current conditions plus approved projects, rather than the initial current conditions scenario.

associated loss of ecological integrity. The integrity of ecological systems in the Ivanpah Valley Watershed was evaluated under each of the three scenarios to quantify the impacts of the projected infrastructure developments.

3.2 Data and information inputs

In order to model cumulative effects using these two approaches, a series of data, information, and intermediate models were compiled or developed for use as inputs to the models.

3.2.1 Data

Two categories of spatial data were compiled for use in this assessment: 1) data sets or data models representing the distribution of the biological elements (desert tortoise, ecological systems, and 2) data sets containing the mapped locations of existing, approved, and proposed infrastructure features, developed areas, and other similar features of interest for this assessment. The USGS desert tortoise habitat potential model (Nussear *et al.* 2009) was used for the distribution of desert tortoise. The distribution of ecological systems (see Figure 2) was represented using the LANDFIRE ecological systems layer (USGS 2010, as recently updated by NatureServe for the Mojave Basin and Range Rapid Ecoregional Assessment for the Bureau of Land Management). The data sets compiled to represent infrastructure, development and similar features are generally summarized in the following section on the landscape condition index. In addition to being used to build the tortoise-specific Landscape Condition Model, these data sets were also used to build the scenarios evaluated using the categorical approach.

3.2.2 Landscape condition index

In conjunction with the data containing the spatial distribution of the biological features of interest, a Landscape Condition Model was used to assess cumulative impacts to tortoise habitat. This index of landscape condition serves as a general indicator for the condition of the biota and ecological systems present on a landscape. Modeled indicators such as the landscape condition index are used when comprehensive field surveys of a particular area are not feasible or not available for the area of interest. This index of landscape condition is modeled on the presence of various infrastructure features, anthropogenic land uses, and other factors (e.g., invasive species) that may negatively affect native biodiversity. The model goes beyond a basic anthropogenic footprint by incorporating the intensity of the impact of the footprint feature or land use (e.g., an interstate highway has a greater impact than an unpaved road) and the distance to which the effects of the feature or land use are felt (i.e., for some features the impact extends with decreasing intensity to some distance away from that feature). Comer and Hak (2009) developed methods for modeling landscape condition that account for the relative intensity of the impact of the feature, as well as a distance decay function. They developed a nation-wide model illustrating these methods using data sets reflecting a range of development and other anthropogenic features and influences, along with general site intensity and distance decay scores. Results of this model were compared to over 2,000 field observations of species occurrence quality in the Pacific Northwest; there was good correspondence between landscape condition as predicted by the model and quality or condition of species as observed in the field. (This model was reviewed and approved for use in the BLM’s Mojave and Central Basin and Range Rapid Ecoregional Assessments.) The landscape condition index refers to the numeric indicator of condition that is generated in the Landscape Condition Model. Index values are unitless numbers ranging from 0.0 to 1.0, with 0 being the lowest condition and 1 being the highest. For assessment and summary purposes, these values have generally been multiplied by 100 in this report.

For this assessment, two sets of desert tortoise-specific Landscape Condition Models were developed. Most of the inputs included in these models are various types of infrastructure and development; however, grazing allotments were also included in all model versions because of the potential effects of grazing on the condition of tortoise habitat.

The first set of three Landscape Condition Models were used as inputs to the connectivity assessment. One condition model reflected features and land uses specific to the study area that are currently present. Two additional models were developed to represent projected future landscape conditions, one for each of the Stateline alternatives: the two Stateline alternatives, the Silver State South solar project, the Ivanpah Valley Airport, and the Desert Xpress high-speed rail line. In addition to infrastructure features and grazing allotments, these models also included a projection of invasive annual grasses for the region. Through interaction with fire, invasive annual grasses may also substantially degrade the condition of tortoise habitat (Brooks and Pyke 2001).

A second set of condition models was developed to reflect the chronological cumulative impact of infrastructure projects for assessing tortoise habitat condition. One condition model reflected features and land uses specific to the study area that are currently present, including the ISEGS project that is under construction. A second model reflected current features and the addition of approved projects. The Mountain Pass Lateral pipeline was included in the second model, and the transmission line and fiber-optic cable upgrades were reflected in existing utility features. (A footprint for the Joint Port of Entry was not readily available.) A final pair of models was developed to represent projected landscape conditions under either of the Stateline alternatives. These reflected both current and approved projects, plus the addition of either Stateline Alternative B or D, with one model for each alternative. (Projects that have been proposed but not yet approved were not included in any of these models.) These four models were used to evaluate tortoise habitat condition within the watershed (see Section 3 in this report).

A number of adjustments were made to the model input layers and their intensity or decay scores to reflect the effects of various inputs on desert tortoise. With the exceptions of high-volume highways (Boarman 2002) and wind farms (Lovich and Daniels 2000), correlations between the presence and intensity of infrastructure features and the presence and density of desert tortoise populations adjacent to such features has not been quantified. The intensity and decay scores were reviewed and adjusted to be generally consistent with the relative ranking of similar inputs used in the USFWS Desert Tortoise Recovery Office’s (DTRO’s) Spatial Decision Support System (SDSS) for desert tortoise. For example, solar projects were assigned somewhat lower (more intense) site intensity scores (relative to the national model) because they completely remove habitat for desert tortoise for the lifetime of the project. Transmission lines and major roads were assigned slightly lower distance decay scores due to their potential to promote the presence of corvids, which prey on juvenile tortoises (Boarman 2002). A data set used by DTRO representing a range of developed recreation areas was added to the model because of the potential indirect effects of such recreation areas on desert tortoise (corvids, various human activities associated with recreation areas); they also were assigned lower intensity and decay scores. Grazing allotments were added to the model, but with higher values to represent the relatively diffuse impacts that livestock may have on desert tortoise. Although portions of Interstate 15 are fenced in the study area, the decay score used for highways in the condition model reflected the documented impact of high-volume highways (per Boarman 2002) with decreasing effects extending out to 2 km beyond the highways. The decay score for wind infrastructure was consistent with the potential lesser effects of wind projects. Different features of wind projects were found to have different effects in the Lovich and Daniels (2002) study. However, spatial data for wind projects only includes an overall footprint that encompasses all of the types of infrastructure associated with such projects. Therefore, wind infrastructure was assigned a decay score reflecting a relatively limited distance decay.

For the two future condition models used in the connectivity assessment, the risk model for invasive annual grasses[14] was included as an input – specifically, areas predicted to have greater than 45% cover of invasive annual grasses. Because it is a risk model rather than the mapped extent of invasives, it was treated as having no distance effects. While the grasses model does not include a projected timeframe, invasives are predicted to continue to spread and are therefore included in the future conditions models.

Inputs to the tortoise-specific model and assumptions regarding the intensity and distance decay effects of these features are summarized in Table 12. The lower the site intensity score, the greater the impact; the lower the distance decay score, the farther away the impact is felt. The decay to zero is the distance at which the impact of the feature is nearly zero.

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[14] NatureServe developed a risk model of invasive annual grasses as part of the Rapid Ecological Assessments (REAs) for the Mojave Basin and Range ecoregion and the Central Basin and Range ecoregion. Cheatgrass (*Bromus tectorum*), red brome (*Bromus rubens*) and *Schismus* spp. are among the species on which the model is based. More information on that model will be available in the detailed REA report appendices.

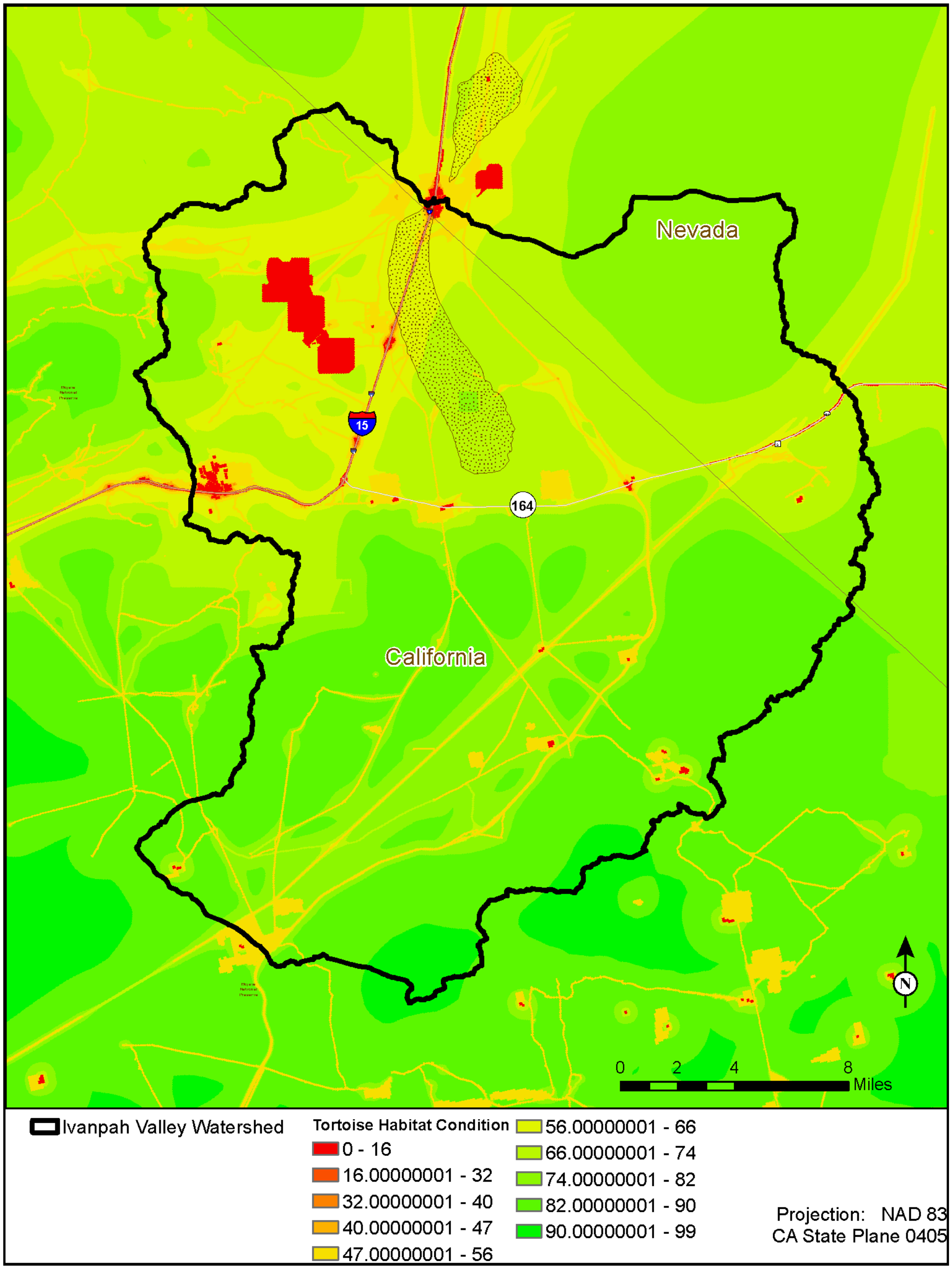
Table 12. Inputs to Landscape Condition Model.

Category	Data set or subset	Site intensity	Distance decay score	Distance decay to zero (meters)
Development	High intensity development	0.05	0.05	2,000
Development	Medium intensity development	0.5	0.5	200
Development	Military urban areas	0.05	0.05	2,000
Development	Developed recreation areas	0.5	0.5	200
Roads	Primary and secondary highways	0.05	0.05	2,000
Roads	Local, neighborhood and connecting roads	0.5	0.5	200
Roads	Other unclassified roads	0.5	0.5	200
Roads	Unimproved roads and 4WD tracks	0.7	0.5	200
Roads	Trails / non-motorized	0.9	0.7	143
Railroads	Railroads	0.5	0.7	143
Extractive / Other	Mines/landfills	0.05	0.5	200
Energy	Solar	0.05	0.5	200
Energy	Oil and gas wells	0.5	0.5	200
Energy	Wind	0.8	0.6	167
Other Linear	Pipelines	0.7	0.5	200
Other Linear	Utility	0.7	0.5	200
Other Linear	Water transmission (canals, ditches)	0.5	0.7	143
Agriculture	Row crops and irrigated pasture	0.5	0.5	200
Grazing	Grazing allotments	0.8	1	0
Invasive species*	Modeled risk of invasion by annual grasses: percent cover predicted to be 45% or greater	0.8	1	0

*Included only for projections of future condition, for connectivity modeling

Including a distance effect for each input means that the effects of the infrastructure feature are calculated, with decreasing intensity, a certain distance from that feature. When two or more features are within a certain distance of each other, their distance effects will overlap and decrease the condition according to the combination of their two decay scores. If sufficiently small, an area of habitat surrounded by a road, a railroad, and a solar project footprint would be impacted by the distance effects of all three of those features, according to the area of overlap and each feature's decay scores. The distance decay component of the model quantifies the synergistic effects of multiple features on a given landscape. Figure 7 illustrates the condition model for current conditions: the red end of the spectrum indicates relatively poorer landscape condition (values closer to 0) while greens indicate relatively better condition (values closer to 100). Within the watershed, Interstate 15 is the feature having the highest intensity and greatest distance decay scores. The interstate itself has the lowest condition (shown in red), and it has a decreasing effect on the area to either side of it. The distance decay is indicated by the yellow band extending out on either side of it. The solar footprints are treated with similar site intensity, but a much smaller distance effect. Southwest of the ISEGS project, local roads and other linear features with some distance effects converge to decrease condition in that area. Primm, Nevada, the golf course, and Mountain Pass Mine on the west side of the watershed are other features with poorer condition (lower/worse site intensity scores) and varying distance effects. In general, when these features are sufficiently close to each other, their distance effects can overlap and worsen the condition in a given area.

Figure 7. Landscape condition model reflecting current conditions.



Higher (better) landscape condition is shown in greens; lower (poorer) landscape condition is shown in the orange to red colors. Values shown here have been multiplied by 100 and therefore are illustrated on a scale from 0 to 100 rather than 0 to 1.

3.2.3 Scenarios of current and future conditions

To evaluate the effects of infrastructure, land uses and other factors on the ecological systems using a categorical approach, three spatial scenarios were developed. Consistent with the landscape condition approach, the spatial scenarios were designed to represent current and project future ground conditions. The following infrastructure and other features were represented in the current conditions:

- High intensity development
- Medium intensity development
- Developed recreation areas
- Military urban areas
- Primary and secondary highways
- Local, neighborhood and connecting roads
- Dirt roads and 4WD tracks
- Trails / non-motorized
- Other unclassified roads
- Railroads
- Pipelines
- Other utilities
- Water transmission (canals, ditches)
- Renewable energy footprints (solar, wind)
- Oil and gas wells
- Mines/landfills
- Grazing allotments
- Land protection and management intent

General land ownership information from the USGS Protected Areas Database of the United States (PAD-US, USGS 2011) was used to indicate "land protection and management intent." Areas being managed for the preservation of biological diversity (such as ACECs) were assumed to have a positive impact on ecological systems. Land protection and management status was assumed to be the same under both current and future conditions. Livestock grazing was incorporated using BLM grazing allotment boundaries; it was assumed to occupy the same area for both current and future conditions. The two future scenarios were designed to represent projected future ground conditions. One scenario represented Stateline Alternative B, the other represented Alternative D. Other features projected for the future and represented in both future scenarios include the following:

- Desert Xpress Railroad
- Ivanpah Valley Airport

These differ from the landscape condition models in that they reflect the spatial extent of various infrastructure footprints and land uses (such as grazing) *without* consideration of the intensity or distance effects of that land use. However, this approach can incorporate the ability of land management practices or policies to improve ecological condition; for example, in this assessment, land permanently protected from conversion to anthropogenic uses and managed for biodiversity conservation is assumed to have a positive effect on ecological systems. However, the presence of any infrastructure or other feature to which an ecological system has a negative response will still result in loss of that system's distribution where the feature overlaps with beneficial land management. A listing of the data sets used to build these scenarios is provided in Appendix A.

3.2.4 Estimating ecological integrity

The size and condition of the areas of tortoise habitat and ecological systems are two key determinants of overall ecological integrity. The Landscape Condition Model was used to assess the condition of tortoise habitat. Average condition values for locations where live tortoises have been observed informed this evaluation. It is important to keep in mind that the landscape condition values do **not** equate to tortoise habitat potential as modeled by Nussear et al (2009). The landscape condition model is designed to provide a general indication of the current ecological *condition* of a landscape, based on the presence of and distance from a variety of anthropogenic features and land uses (such as roads, developed areas, energy infrastructure, and livestock grazing). The USGS tortoise model (Nussear *et al*. 2009) is a model of habitat *potential* or *suitability*, which is based on environmental variables including elevation, precipitation, surface roughness, soil density, perennial plant cover, and others. A particular location may have excellent landscape condition but be entirely unsuitable for desert tortoise, such as high-elevation mountain ranges with no roads or other development nearby. Conversely, a particular location may have lower landscape condition values due to proximity to infrastructure or development, yet still be inhabited by desert tortoise because it has the appropriate elevation, soils, vegetation, and other environmental characteristics necessary for the species. Methods for identifying the landscape condition thresholds are described in the next section.

3.2.4.1 Estimating landscape condition of tortoise habitat

The condition threshold is the landscape condition index value beyond which the integrity of the habitat is assumed to be degraded to the point that the affected area would not function as habitat for the species or system of interest. As noted previously, the landscape condition index provides condition values ranging from 0.0 to 1.0, with 1 being the highest or best possible condition. While landscape condition can be calculated in unitless and relative values, there is no scientific research that has quantified the relationship between such relative values and the actual impact on a given species or ecosystem. With the exceptions of high-volume highways (Boarman 2002) and wind farms (Lovich and Daniels 2000), correlations between the presence and intensity of infrastructure features and the presence and density of desert tortoise populations adjacent to such features has not been quantified. The assumptions regarding the relative impact of various infrastructure features are documented in the input scores to the Landscape Condition Model (Table 12). The average condition values for locations where live tortoises have been observed in or near the watershed were used to inform the assessment of tortoise habitat condition.

The locations of all live tortoises observed since the year 2000 within the Ivanpah Valley Watershed (as part of a variety of survey efforts) and at least 200 meters away from the ISEGS project footprint were selected and the landscape condition values for these 363 locations were summarized. Condition values at the locations of recent live tortoise observations ranged from a low of 0.05 to a high of 0.86; the average condition is 0.67. Excluding the 27 observations that overlapped with current infrastructure footprints, the average condition is 0.69. For reference, condition values in the solar footprints, high intensity development, or Interstate 15 is 0.05; values on Nipton Road and similar features are 0.50. Most of the tortoise observations in the watershed are distributed relatively close to roads and other infrastructure, in part because many of the observations were collected for impact assessments for planned infrastructure, which tends to be closer to roads and other existing infrastructure. Condition values were also summarized for a second set of tortoise observations. USFWS has an on-going, range-wide monitoring program as part of the desert tortoise recovery effort and has conducted regular surveys in the Ivanpah CHU. The average condition value for live observations sampled by USFWS in the greater Ivanpah CHU is 0.83; condition values ranged from a low of 0.50 to a high of 0.93. These samples were taken in random locations (see USFWS 2010b for more on sampling design) across an area that has relatively less infrastructure than the Ivanpah Valley Watershed.

To characterize tortoise habitat condition in the watershed, calculations were performed in a Geographical Information System (GIS) and spreadsheet software. The condition models were converted to integer format, intersected with the watershed and with tortoise habitat patches in the watershed, and various averages of landscape condition calculated using the resulting value attribute tables. The results of these calculations are summarized and discussed below.

3.3 Current and projected status of tortoise habitat and other habitats

3.3.1 Condition of tortoise habitat

The current extent of *potential* tortoise habitat in the Ivanpah Valley Watershed is estimated at 186,600 acres based on the USGS tortoise habitat potential model[15]. The area of suitable habitat on the west side of Interstate 15 totals approximately 37,100 acres, while the habitat to the east and south of the interstate is 149,500 acres. On average, the current condition of potential habitat throughout the watershed as indicated by the Landscape Condition Model is 0.72. At the watershed level, this value changes very little with the addition of approved projects or either of the Stateline alternatives. The noticeable change is in the area west of Interstate 15; with the addition of either Stateline alternative, the average condition drops from 0.57 to 0.53. Table 13 summarizes the average condition for the watershed as a whole and the two portions of the watershed divided by the interstate.

Table 13. Average landscape conditions values within the Ivanpah Valley Watershed under current, approved, and proposed development.

	Current Conditions	Current + Approved	Stateline Alternative B	Stateline Alternative D
West of I-15	0.57	0.57	0.53	0.53
East of I-15	0.75	0.75	0.75	0.75
Entire watershed	0.72	0.71	0.73	0.71

The percent of the suitable tortoise habitat in the Ivanpah Valley Watershed at various condition thresholds for current conditions, current conditions plus approved projects, and current and approved projects plus the two Stateline alternatives is summarized in Table 14, Table 15, and Table 16 and

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[15] Areas with habitat ***potential*** of 0.6 or higher in the USGS model were defined as tortoise habitat. Habitat potential as defined by the USGS model does **not** equate to habitat or landscape ***condition*** as defined by the landscape condition model.

illustrated in Figure 8, Figure 9, Figure 10, and Figure 11, respectively. Because Interstate 15 substantially fragments tortoise habitat in the watershed, the tables summarize landscape condition for the area west of the interstate (Table 14), the area east of the interstate (Table 15), and the watershed as a whole (Table 16). Although raw landscape condition values range from 0 to 1, the figures showing the condition values use a scale from 0 to 100.

Table 14. Amount of suitable tortoise habitat at various condition thresholds under current and future conditions west of Interstate 15.

Condition Thresholds		Current Conditions	Current + Approved	Stateline Alternative B	Stateline Alternative D
0.65	**Acres**	17,000	14,200	13,300	13,200
	%	46	38	36	36
0.70	**Acres**	2,900	2,500	2,500	2,500
	%	8	7	7	7
0.75	**Acres**	300	200	200	200
	%	1	<1	<1	<1
0.80	**Acres**	0	0	0	0
	%	0	0	0	0
0.85	**Acres**	0	0	0	0
	%	0	0	0	0

Table 15. Amount of suitable tortoise habitat at various condition thresholds under current and future conditions east of Interstate 15.

Condition Thresholds		Current Conditions	Current + Approved	Stateline Alternative B	Stateline Alternative D
0.65	**Acres**	133,600	133,600	133,800	133,700
	%	89	89	89	89
0.70	**Acres**	118,400	118,400	118,900	118,800
	%	79	79	80	79
0.75	**Acres**	88,000	88,000	88,400	88,400
	%	59	59	59	59
0.80	**Acres**	67,200	67,200	67,700	67,700
	%	45	45	45	45
0.85	**Acres**	20,100	20,100	21,100	21,100
	%	13	13	14	14

Table 16. Amount of suitable tortoise habitat at various condition thresholds under current and future conditions throughout Ivanpah Valley Watershed.

Condition Thresholds		Current Conditions	Current + Approved	Stateline Alternative B	Stateline Alternative D
0.65	**Acres**	150,700	147,800	146,800	146,900
	%	81	79	79	79
0.70	**Acres**	121,300	120,900	121,200	121,300
	%	65	65	65	65
0.75	**Acres**	88,300	88,200	88,500	88,600
	%	47	47	47	47
0.80	**Acres**	67,200	67,200	67,700	67,700
	%	36	36	36	36
0.85	**Acres**	20,100	20,100	21,100	21,100
	%	11	11	11	11

3.3.1.1 Current tortoise habitat condition

With existing infrastructure, the extent of habitat that is highly suitable for desert tortoise *and* has higher condition values (0.65 or greater) in the area west of Interstate 15 is already somewhat limited. The distance effects of Interstate 15 and the ISEGS project, as well as local roads and transmission corridors, have reduced landscape condition in that area. As noted above, habitat suitable for desert tortoise based on Nussear *et al.* (2009) model is approximately 37,100 acres. Of that area, approximately 46% has a condition value of at least 0.65 (Table 14). Very little area is 0.7 or greater; again, this reflects the distance effects of various infrastructure features in this area. East of the interstate, the infrastructure footprint is smaller and 89% of that area has a condition value of at least 0.65, and nearly 60% is at 0.75 or greater (Table 15).

Considering tortoise habitat in the Ivanpah Valley Watershed as a whole, 81% meets the 0.65 threshold for condition (Table 16 and Figure 8). The remaining 19% of habitat is below that threshold, indicating distance effects from roads, the railroad, and other infrastructure features throughout the area. At a condition threshold of 0.75, 47% of the tortoise habitat meets that threshold.

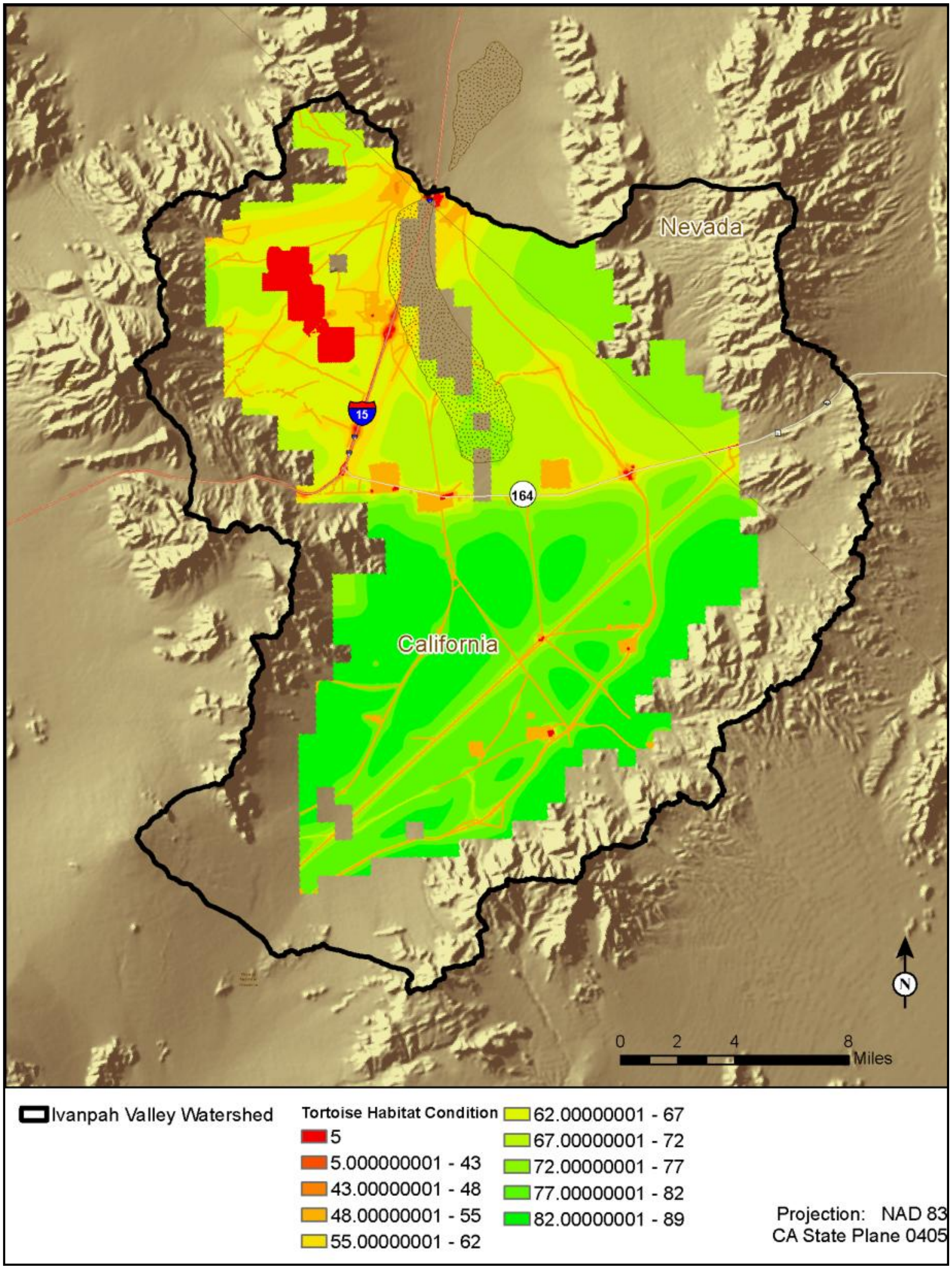
3.3.1.2 Tortoise habitat condition with projected infrastructure

West of Interstate 15, with the addition of *approved* projects, the proportion of suitable habitat having a condition value of 0.65 or greater drops from 46% to 38%, a decrease of approximately 2,800 acres (Table 14). This initial decrease is the direct result of the addition of the Mountain Pass Lateral pipeline and the distance effects along its length. The addition of either Stateline alternative results in an additional drop to 36% of the habitat in a condition of 0.65 or higher. The reduction in acres at this threshold is smaller than the actual Stateline footprints; this is because parts of those areas were already at condition values below 0.65 prior to the addition of the Stateline alternatives.

With the addition of either approved projects or approved projects in conjunction with one of the Stateline alternatives, the proportion of suitable tortoise habitat at a given condition values remains essentially unchanged across the four scenarios in the area east of the interstate. This is because none of the added infrastructure is east of the interstate and the distance effects don't extend across the interstate.

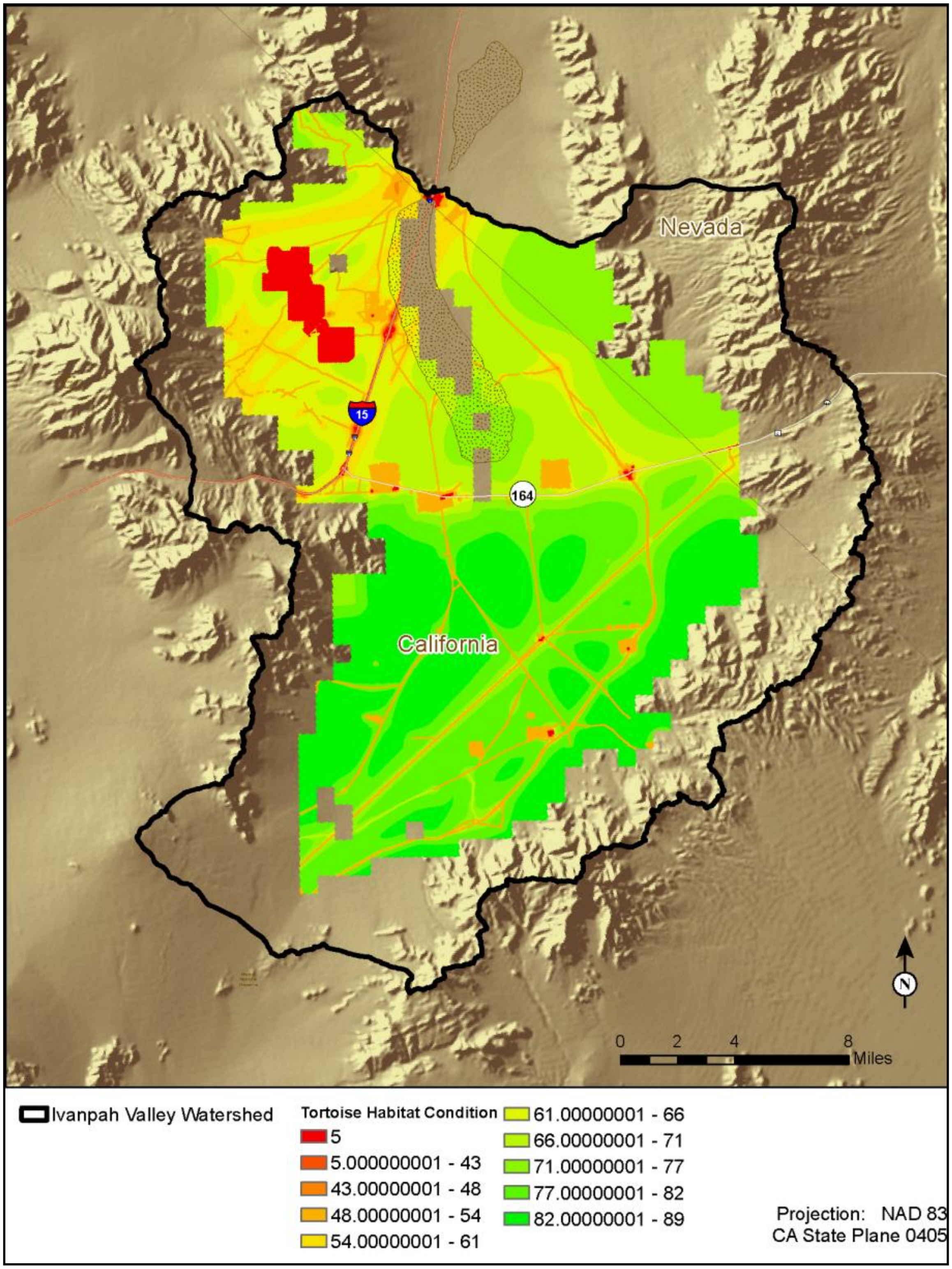
When considered at the watershed scale, the addition of approved and proposed projects causes relatively little change in condition. Once any project is added, the percent of the watershed at the 0.65 condition threshold drops from 81% to 79%; at higher condition thresholds, the percentages are unchanged between current conditions and the addition of various projects. This is because the footprint of either of the Stateline alternatives is a relatively small proportion – just over 1% - of the available tortoise habitat in the watershed.

Figure 8. Tortoise habitat at various landscape condition thresholds, under current conditions.



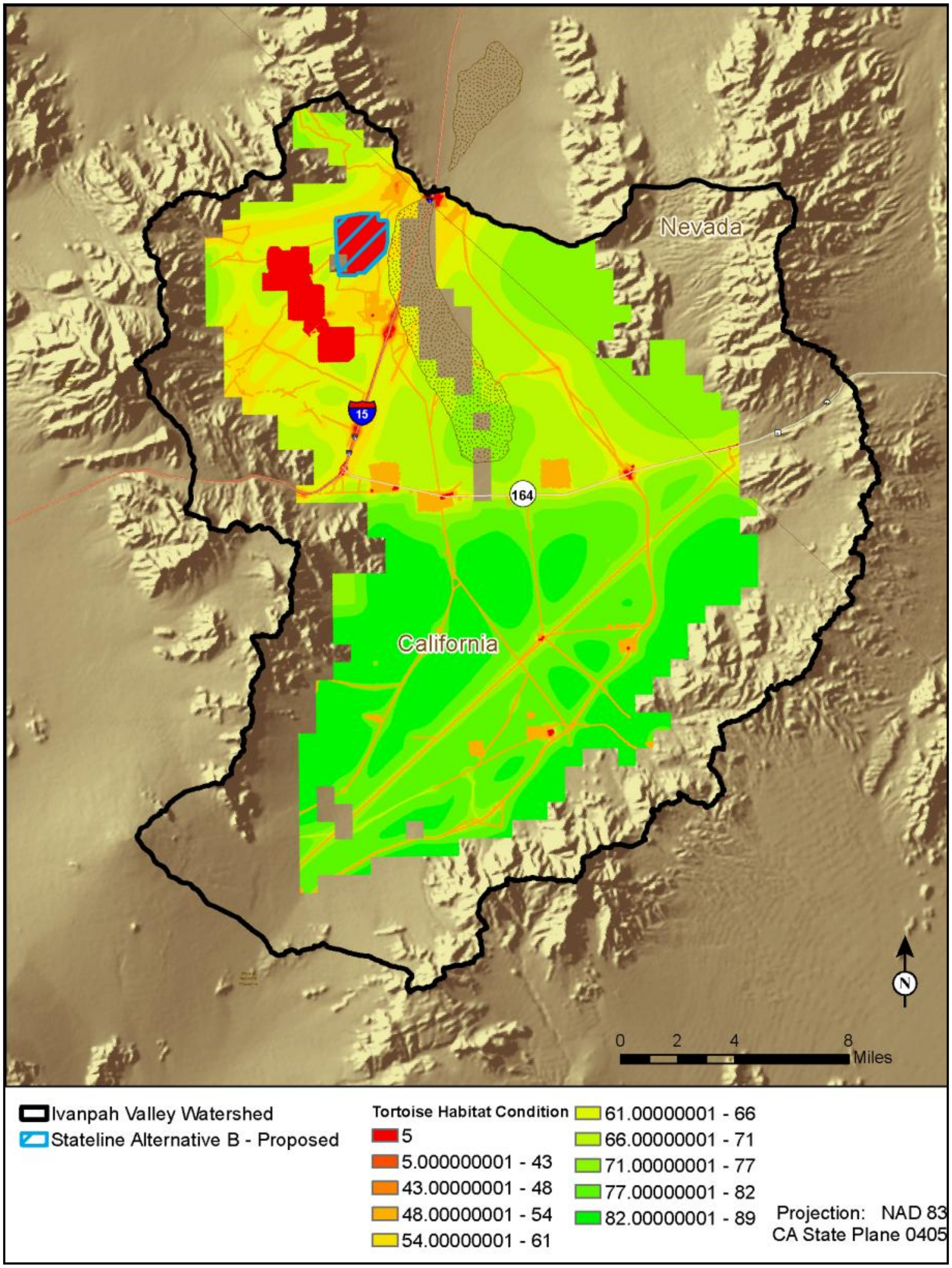
The landscape condition of tortoise habitat patches is displayed in values from 0 to 100, rather than 0 to 1.

Figure 9. Tortoise habitat at various landscape condition thresholds with all currently approved projects completed.



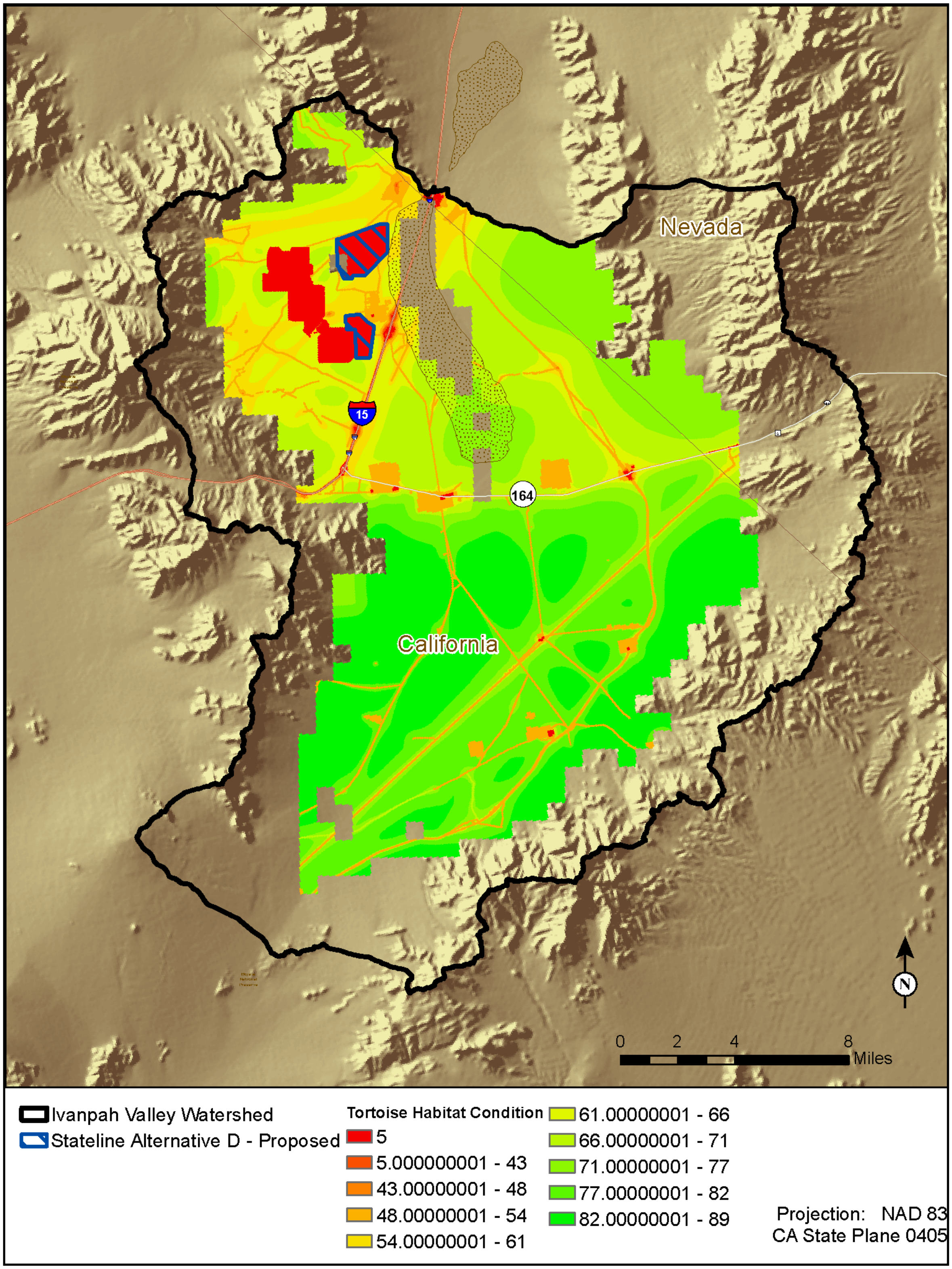
The landscape condition of tortoise habitat patches is displayed in values from 0 to 100, rather than 0 to 1.

Figure 10. Tortoise habitat at various landscape condition thresholds with all currently approved projects completed and with Stateline Alternative B.



The landscape condition of tortoise habitat patches is displayed in values from 0 to 100, rather than 0 to 1.

Figure 11. Tortoise habitat at various landscape condition thresholds with all currently approved projects completed and with Stateline Alternative D.



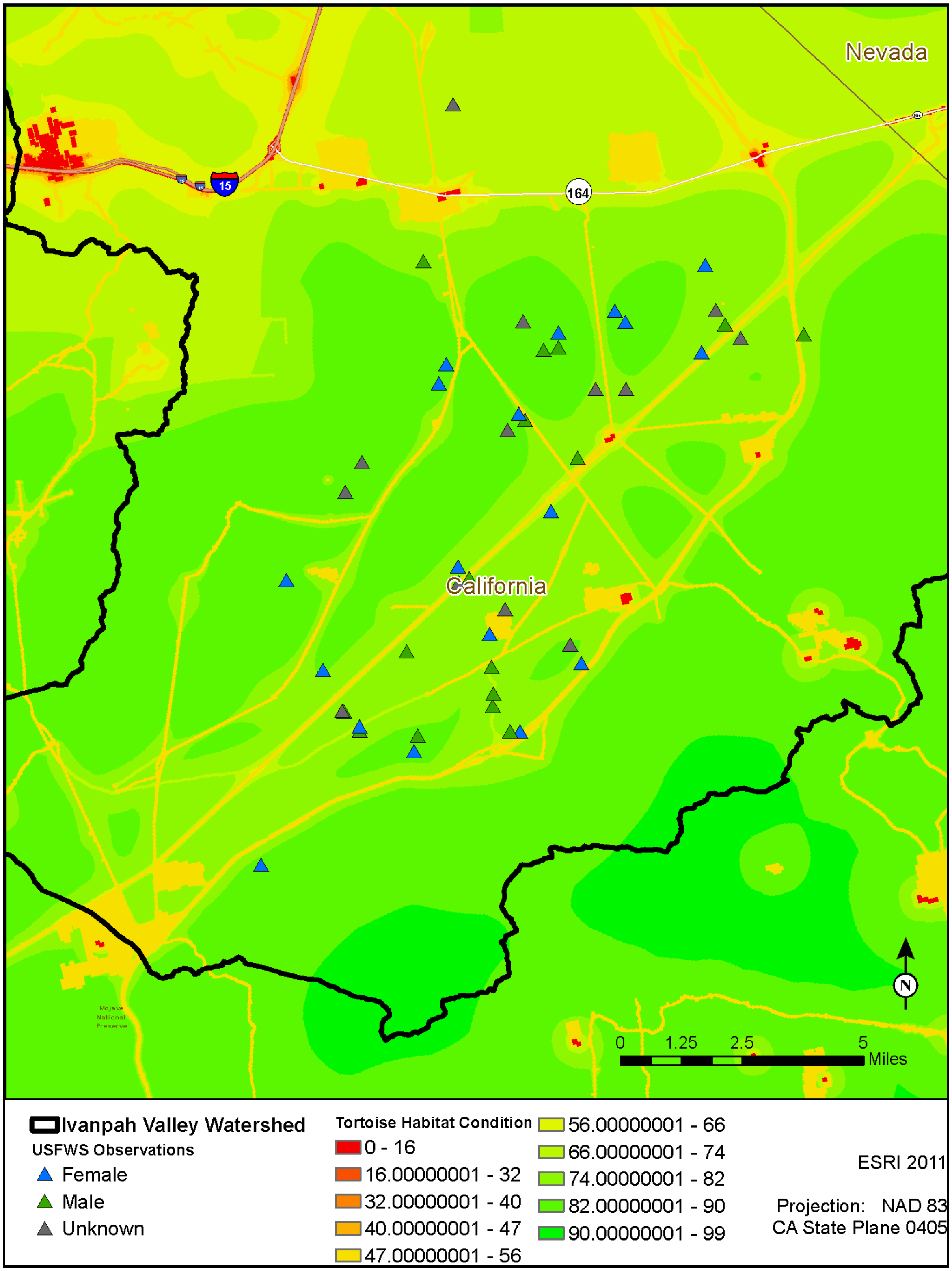
The landscape condition of tortoise habitat patches is displayed in values from 0 to 100, rather than 0 to 1.

3.3.1.3 Interpreting condition results

To interpret these results, several considerations are important to keep in mind. The reader is reminded that the landscape condition values do not equate to tortoise habitat potential as modeled by Nussear *et al*. (2009). The landscape condition model is designed to provide a general indication of the ecological *condition* of a landscape, based on the presence of and distance from a variety of anthropogenic features and land uses. Nussear *et al*.'s (2009) model is a model of habitat *potential* or *suitability* specifically for desert tortoise, which is based on environmental variables including elevation, precipitation, surface roughness, soil density, perennial plant cover, and others. A particular location may have excellent landscape condition but be entirely unsuitable for desert tortoise; high-elevation mountain ranges with no roads or other development nearby fall into this category. Conversely, as indicated by USFWS tortoise observation data, a particular location may have lower landscape condition values yet still be inhabited by desert tortoise.

Although the national condition model was compared to a variety of species observations and a positive correlation between high condition values and field observations of high-quality species occurrences was found (Comer and Hak 2009), specific correlations between the intensity and distance effects of infrastructure features and their impact on tortoise habitat or populations have generally not been quantified, with a few exceptions noted below. Furthermore, there generally does not appear to be a correlation between the presence or absence of infrastructure features adjacent to or near tortoise habitat, and the presence or density of tortoises in these adjacent habitat areas (R. Averill-Murray, pers. comm.), aside from those exceptions. If the habitat quality is otherwise similar, tortoises may be found with similarly high (or low) densities whether the habitat adjoins a paved county road, or whether it is in a more remote location. Figure 12 illustrates live tortoise observations collected as part of USFWS' on-going monitoring effort; the observations are distributed at a range of distances from linear infrastructure, including low-volume local roads. Relationships between tortoise populations or burrow locations and a few specific infrastructure types have been studied and shown to have varying effects. Higher-traffic-volume highways that are not fenced have been repeatedly confirmed to depress tortoise populations within 0.4 km or more of the highway (Boarman 2002). Conversely, a study of a wind farm near Palm Springs, California showed tortoise burrows to be preferentially located closer to the unpaved, low-traffic roads or under concrete pads present in the installation (Lovich and Daniels 2000). For infrastructure and development that has not been researched with regard to potential effects on the Mojave desert tortoise, it may take time for any impacts of infrastructure in the area surrounding the infrastructure to have a measurable effect on populations of such a long-lived species.

Figure 12. Live tortoise observations collected in USFWS line distance sampling in relation to landscape condition.



The landscape condition of tortoise habitat patches is displayed in values from 0 to 100, rather than 0 to 1.

3.3.2 Compatibility of ecological systems

Using the categorical approach of evaluating habitats in Vista, the percentage of each ecological system that is compatible (does not overlap) with infrastructure and other land uses under the current and two future scenarios within the Ivanpah Valley Watershed was calculated (Table 17). The Sonora Mojave Creosotebush – White Bursage Desert Scrub type is of greatest interest because it is preferred vegetation cover for desert tortoise. Ten percent of its extent in the Ivanpah Valley Watershed is negatively impacted by current infrastructure (conversely 90% of its extent is compatible with various land uses); that number rises to 15% under either of the Stateline alternatives. Based on the USGS tortoise habitat model, the Mojave Mid-Elevation Mixed Desert Scrub is also expected to provide suitable habitat for desert tortoise; this type is less impacted by various land uses under both current and projected conditions, with 96% of its extent not in conflict with either current or projected future land uses. These two types dominate the complex of desert washes draining into the Ivanpah Valley. As mapped with remotely sensed imagery, desert washes are delineated separately from the two scrub types and have a relatively limited spatial extent. The results indicate that washes also remain largely (96%) free of overlap with current and proposed land uses.

Table 17. Acreage and percent area of ecological systems that do not overlap with infrastructure and other features under current and projected future conditions.

		Current Conditions		Alternative B		Alternative D	
Habitat Type	**Total Acres**	**Acres**	**%**	**Acres**	**%**	**Acres**	**%**
Desert Tortoise Habitat (USGS model)	171,401	165,057	96	161,646	94	161,568	94
Mojave Mid Elevation Mixed Desert Scrub	259,640	250,538	96	248,826	96	248,539	96
Sonora Mojave Creosotebush White Bursage Desert Scrub	40,221	36,200	90	34,298	85	34,766	86
North American Warm Desert Playa	12,007	11,673	97	11,663	97	11,660	97
Great Basin Pinyon Juniper Woodland	7,019	6,954	99	6,943	99	6,932	99
North American Warm Desert Wash	6,976	6,711	96	6,696	96	6,696	96
North American Warm Desert Pavement	3,754	3,422	91	3,388	90	3,358	90
Sonora Mojave Mixed Salt Desert Scrub	2,866	2,803	98	2,791	97	2,778	97
Great Basin Xeric Mixed Sagebrush Shrubland	1,079	1,079	100	1,079	100	1,079	100
Inter Mountain Basins Big Sagebrush Shrubland	879	870	99	870	99	870	99
North American Warm Desert Riparian Woodland and Shrubland	233	218	94	218	94	218	94
North American Warm Desert Bedrock Cliff and Outcrop	130	113	87	111	86	111	86

This model provides a simple summary of the spatial extent of habitats that do not overlap with current or proposed land uses that are known or assumed to have negative impacts on those habitats. It does not quantify the indirect effects of these land uses, such as habitat fragmentation. In addition, field-based data on factors such as grazing impacts or location and density of invasive species were not available. While the spatial extent of habitat loss is relatively small, these additional factors that are not accounted for in this model should be considered in conjunction with the direct habitat loss.

An assessment of the extent of the ecological systems compatible with current and proposed future land uses was also completed for the estimated geographic extent of the Southern Las Vegas subpopulation cluster of desert tortoise (shown previously in Figure 4) as identified by Hagerty and Tracey (2010). Complete results for systems having over 1,000 acres present in this geography are provided in Appendix B. At that scale, the two ecological systems of greatest relevance to desert tortoise, Mojave Mid Elevation Mixed Desert Scrub and Sonora Mojave Creosotebush White Bursage Desert Scrub, are largely not in conflict under both current and proposed future conditions (97% and 92% respectively under current conditions, and 96% and 92% respectively under future conditions). This high level of compatibility is likely due to the fact that both current and proposed infrastructure that creates conflict have relatively small footprints (e.g., proposed renewable projects) or narrow footprints (i.e., created by linear features such as proposed transmission lines). Although treated separately with the landscape condition approach, desert tortoise habitat was also included in this assessment and found to have a similarly high level of compatibility (93% both currently and in the future). At this geographic scale, the impact of localized projects is less apparent.

4 Desert Tortoise Habitat Connectivity Assessment

4.1 General approach

4.1.1 Modeling scales: spatial and temporal

Habitat connectivity was modeled at both the landscape scale and within the Ivanpah Valley Watershed study area. At the landscape scale, the intent was to identify the presence of potential connections between tortoise habitat in the Ivanpah Valley Watershed and surrounding areas. Within the watershed, the models attempted to identify connections between the habitat patches within the valley, based on finer-scale features. For both scales, a series of models were developed to compare potential connections under current conditions and under future conditions. Current conditions reflected the existing development (roads, railroads, towns) and other infrastructure (solar development, mines, oil and gas wells, and utilities). Future conditions reflected current developed and infrastructure combined with proposed energy development, including Stateline Alternatives B and D, the Desert Xpress high-speed rail system, the Ivanpah Valley Airport, and a range of utility upgrades as compiled by BLM.

4.1.2 Modeling tool and data inputs

Circuitscape is a modeling tool based on electrical circuit theory that can be used to model habitat or landscape connectivity (www.circuitscape.org/, Shah and McRae 2008). Two inputs are required: 1) a layer representing the habitat areas to be assessed for connectivity, and 2) a layer indicating habitat quality, barriers to movement, or other features affecting a species' ability to disperse across the landscape. The model is designed to treat the habitat areas being assessed as electrical nodes and the second input as an electrical conductance layer. It applies “current” to the nodes, and the current flows according to the relative conductance (see Shah and McRae 2008). Circuitscape uses the pair of inputs to identify the network of pathways or areas having the highest connectivity (least resistance to species movement) between specified habitat patches or point locations. Version 3.5.6 was used for this assessment.

4.2 Landscape-scale connectivity modeling

For the landscape scale, modeling was completed for the Mojave Basin and Range ecoregion. This ecoregion represents a substantial portion of the geographic range of the Mojave desert tortoise. Some data sets were already available to model tortoise habitat connectivity across the Mojave Basin and Range, and it was relatively straightforward to update other input data sets for that region. Therefore, the area modeled for landscape-scale connectivity was expanded from the habitats immediately surrounding the Ivanpah Valley Watershed to the entire Mojave Basin and Range ecoregion. The model outputs are available for the entire ecoregion. However, in this report, discussion and visual representation of the results is centered on the Ivanpah Valley Watershed and the immediately surrounding areas of tortoise habitat.

4.2.1 Approach

Landscape-scale tortoise habitat connectivity was modeled under current conditions with existing renewable energy projects and other infrastructure, and projected future conditions, incorporating proposed renewable energy projects including both Stateline alternatives, Ivanpah Valley Airport, Desert Xpress railroad, planned utility infrastructure additions, and projected increases in development.

The Large-Scale Translocation Site (LSTS) for desert tortoise is located just north of the Ivanpah Valley Watershed, and west of Interstate 15. This facility is one of the locations where previously captive desert tortoises from Clark County, Nevada may be released, and where tortoises being relocated from infrastructure project sites in southern Nevada may be released. It is approximately 22,000 acres in size and is characterized by creosote bush and white bursage scrub community (Field *et al.* 2007). It presents an interesting circumstance for modeling habitat connectivity. Although the area is tortoise habitat and supports a density of approximately 5.7-7.7 tortoises per square mile (USFWS, unpublished data), three sides are fenced with tortoise exclusion fencing, and the west side is effectively blocked by the Spring Mountains. Therefore, it currently poses a barrier for the natural movement and gene flow of the tortoise population as a whole.

To examine the impacts of the proposed future infrastructure, as well as the presence of the LSTS, current conditions and four sets of future conditions were modeled as follows:

1. Current infrastructure, development and land uses; LSTS treated as a barrier to tortoise movement
2. Future infrastructure, development and land uses, with Stateline Alternative B, other proposed infrastructure; LSTS treated as a barrier to tortoise movement

3. Future infrastructure, development and land uses, with Stateline Alternative D, other proposed infrastructure; LSTS treated as a barrier to tortoise movement
4. Future infrastructure, development and land uses, with Stateline Alternative B, other proposed infrastructure; LSTS treated as open habitat permitting tortoise movement
5. Future infrastructure, development and land uses, with Stateline Alternative D, other proposed infrastructure; LSTS treated as open habitat permitting tortoise movement

4.2.2 Data sources, model inputs and methods

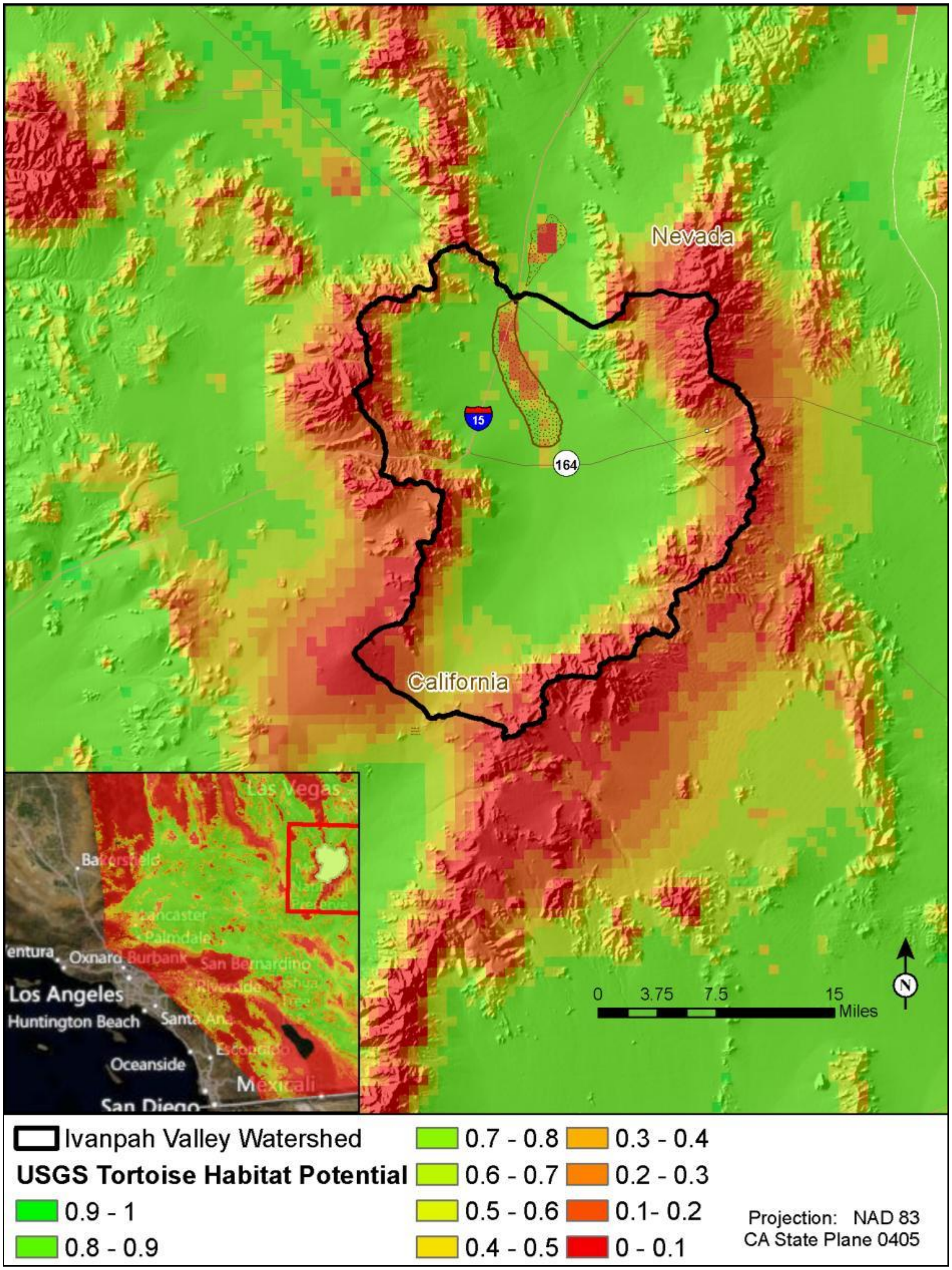
4.2.2.1 Tortoise habitat

Areas of tortoise habitat to be assessed for connectivity may be defined in a number of ways. For example, managed or protected areas may be assessed for connections. In this assessment, all available tortoise habitat was evaluated, regardless of ownership or management, to get a complete picture of connectivity. The U.S. Geological Survey (USGS) developed a model of tortoise habitat potential based on documented tortoise observations and the range of values for key environmental variables (e.g., elevation, precipitation, soil texture, vegetation) using Maxent modeling software (Nussear *et al.* 2009). Habitat potential values range from 0 to 1, with 1 having the highest potential. This model, illustrated in Figure 13, served as the foundation for the tortoise habitat areas identified for use in this assessment.

Areas with higher potential to be tortoise habitat are relatively extensive at the scale of the Ivanpah Valley Watershed. Nearly the entire valley has high potential as tortoise habitat, and this high-potential habitat extends continuously to the north toward Las Vegas (Figure 13). However, the model has a relatively coarse resolution (1 km cells) and land that is developed or otherwise converted to anthropogenic uses (roads, agricultural land) was not removed from the model. To evaluate the potential for habitat connections for tortoise in greater detail and identify connections both between and within patches of tortoise habitat, accounting for converted lands, tortoise habitat was characterized as a series of point locations, rather than extensive patches.

The USGS model was used as the foundation to create the series of 166 points representing tortoise habitat throughout the Mojave Basin and Range ecoregion to be assessed for connectivity; tortoise habitat within the Ivanpah Valley Watershed was represented by 6 points. Areas with high habitat potential (0.7 or higher) were selected and converted to polygons. Polygons smaller than 4,000 acres were removed. Point centroids were generated for these habitat polygons, and additional points were added within the habitat polygons to create a more extensive distribution of tortoise habitat areas to connect. The resulting points were assessed for landscape-scale connectivity across the Mojave Basin and Range ecoregion in Circuitscape.

Figure 13. USGS model of habitat potential for desert tortoise.



4.2.2.2 *Conductance surfaces*

A landscape conductance surface for desert tortoise was built using three inputs: 1) the USGS tortoise habitat potential model (Nussear *et al.* 2009), 2) the Landscape Condition Model described previously, and 3) a model of steepness. Three versions of this surface were created: one incorporating current infrastructure, and the other two incorporating proposed future infrastructure, including Stateline Alternatives B and D.

The USGS model of tortoise habitat potential (Nussear *et al.* 2009) was a critical input for the conductance layer. It provided a known probability of a particular area being suitable for tortoise occupancy or movement. Higher habitat potential equates to higher conductance; therefore, the values were not altered to build the overall conductance surface.

Human infrastructure has the potential to partially or completely impede the movement of tortoise across a landscape. In addition to accounting for the infrastructure footprint, it was also important to address the intensity of the infrastructure impact and distance to which it is felt, relative to desert tortoise. Therefore, the Landscape Condition Model described previously in the cumulative impacts assessment section was the second of the three inputs used to create the conductance surfaces. The initial Landscape Condition Models were created at a 30 meter resolution. Values ranged from 0 to 1; the higher values indicate better condition. In the connectivity assessment, poor landscape condition (lower values) contributes low conductance to the overall conductance surface, landscapes in better condition (higher values) have better conductance.

A model of steepness was developed using slope values from the 30 meter Digital Elevation Model (DEM). This layer provides a unitless index of terrain steepness throughout the assessment area. High values indicate very steep areas, while low values are flatter areas. Steep terrain is less conducive to tortoise movement, while flatter areas are more conducive. Therefore, the inverse of the steepness values were calculated and served as the actual input to the overall conductance surface.

The three raster inputs of tortoise habitat potential, Landscape Condition Model, steepness (inverse) were multiplied together and then multiplied by 1000 to create a spread of values in the final conductance surface. Data processing was completed so that the final conductance surfaces were at a 500 meter resolution.

A conductance surface was created for current conditions, as well as four conductance surfaces reflecting future infrastructure and other variables, as summarized previously in Section 4.2.1 of this report.

4.2.3 Circuitscape set-up and outputs

Circuitscape was run in “pairwise” mode. In this mode, each possible combination of pairs of habitat points are compared and individually modeled in Circuitscape, with one of the points acting as a source of current, and the other acting as the ground. Circuitscape averaged the results of each pairwise comparison to create a single output reflecting the average connectivity among the points. As described above, a series of conductance inputs reflecting the following current and future conditions were used:

1. Current infrastructure, development and land uses; LSTS treated as a barrier to tortoise movement
2. Future infrastructure, development and land uses, with Stateline Alternative B, other proposed infrastructure; LSTS treated as a barrier to tortoise movement
3. Future infrastructure, development and land uses, with Stateline Alternative D, other proposed infrastructure; LSTS treated as a barrier to tortoise movement
4. Future infrastructure, development and land uses, with Stateline Alternative B, other proposed infrastructure; LSTS treated as open habitat permitting tortoise movement
5. Future infrastructure, development and land uses, with Stateline Alternative D, other proposed infrastructure; LSTS treated as open habitat permitting tortoise movement

4.2.4 Results and discussion

The results of the Circuitscape model runs for each of the five current and future conditions are presented in the five maps in this section (Figure 14 through Figure 18). (The full results, as well as model inputs, are provided in a separate geodatabase for viewing and manipulation.) The potential for desert tortoise to disperse across the landscape is represented by the degree of connectivity in the results. In each connectivity layer, the red end of the spectrum indicates the greatest connectivity; the blue end of the spectrum indicates low connectivity. The point representations of the tortoise habitat patches being connected are displayed as black dots.

Where the conductance *input* shows wide swaths of high conductance between two habitat points, desert tortoises can move diffusely through such areas; the entire area is suitable for them to occupy or disperse across. In the model results, such areas appear as intermediate levels of connectivity, in yellow. In these areas, tortoises are not constrained to a narrow path or network of paths of suitable habitat, but instead may move diffusely across the landscape. If the area between two habitat points has highly variable conductance, tortoise movement is constrained to the areas with the highest conductance; the resulting high-connectivity networks or paths appear in red. As options for tortoise movement are reduced through habitat conversion, connectivity or current density may increase as tortoise movement is channeled through more limited areas. However, the resulting areas of higher current density are not necessarily more important to provide connectivity for tortoise movement than the remaining diffuse areas of intermediate connectivity; they simply highlight the more constricted networks or paths for tortoise movement as a result of habitat conversion. Additional analyses and field assessment are necessary to determine the actual importance of any particular connectivity area.

At the landscape scale, the intent was to identify potential connections between tortoise habitat in the Ivanpah Valley Watershed and tortoise habitat patches surrounding the Valley. For the purposes of this assessment, the discussion of areas of potential connectivity is focused on connections between tortoise habitat in the Ivanpah Valley Watershed and areas immediately surrounding it. However, the maps are provided at a scale that illustrates some of the additional regional connections, and the models were run for the entire Mojave Basin and Range ecoregion.

The patterns of connection between the watershed and the areas immediately surrounding it are relatively similar in the five scenarios that were modeled. Therefore, a detailed summary of potential connections for current conditions is presented, followed by a brief overview of potential connections for the two scenarios incorporating Stateline Alternative B and D, where the LSTS is treated as a barrier to natural tortoise movement. Differences in connections between these two scenarios and current conditions are highlighted. Finally, an overview of the connections for Stateline Alternatives B and D, where the LSTS is treated as though it were not a barrier, are presented. Again, differences in connections between the various scenarios are highlighted. A discussion of the consideration and limitations for interpreting and using this information is presented following the figures.

The following discussions of the modeled areas of habitat connectivity for desert tortoise and their potential to serve as viable tortoise linkages between the Ivanpah Valley Watershed and surrounding areas were based on a visual comparison of the areas of potential connectivity identified using Circuitscape with other reference layers, including USGS topographic maps, Nussear et al's (2009) model of tortoise habitat potential, and the conductance surfaces used as inputs to the connectivity models. Users of this assessment should similarly view the connectivity model results in conjunction with those other reference layers. In addition to the layers mentioned above, other layers that could be useful include a detailed vegetation or habitat layer in conjunction with a soils layer, and any tortoise observation data that may be available for the area under consideration.

4.2.4.1 Current conditions: potential tortoise habitat connections

4.2.4.1.1 Potential areas of viable connection

The area around Stateline Pass and the area immediately south of it around old Kelly and Umberci Mines appears in the Circuitscape results as an area of potentially important connection (Figure 14). The area around Stateline Pass is of greatest interest in relation to the proposed Stateline solar project. The model of tortoise habitat suitability shows values of 0.4 to 0.6 in the area (suitability values range from 0 to 1 with 1 being the most suitable). Although the Circuitscape results show a relatively wide area of high connectivity, the area constituting the pass is relatively narrow in places, no more than a few hundred yards wide. The 1-kilometer resolution of the tortoise habitat model is relatively coarse in relation to the estimated minimum width of 1.4 miles hypothesized to be necessary for tortoise habitat linkages (USFWS 2011a, USFWS 2012). However, in the area highlighted in Circuitscape, the tortoise habitat model shows potential values in this area of 0.4 and 0.5. Areas near here were evaluated by USFWS (2011a) for their potential as linkages; ground surveys should be completed to assess tortoise occupancy and suitability for on-going inhabitation.

On the north side of the watershed, east of I-15, there is a north-south connection east of the two dry lake beds and west of the Lucy Gray Mountains (Figure 14). The tortoise habitat potential in this area is high, and tortoises are present there. USFWS evaluated this linkage in its Biological Opinion (USFWS 2011a) for the ISEGS project, in the context of the proposed Silver State South project, noting that its width and habitat quality offer the best potential for connectivity from the eastern patch in the Ivanpah Valley Watershed to that patch's extension to the north. However, they also note that varying resource availability, climate change, and stochastic events in this relatively small area may increase the risk of local extirpation, thus reducing its potential as a long-term linkage.

The model shows the area between Cima Dome and the New York Mountains at the southern end of the Valley as a good potential connection (Figure 14). The tortoise habitat potential in that area is on the lower side, but includes values around 0.4 in the central strip of that connection. However, this connection was evaluated in USFWS' Biological Opinion for the ISEGS project (USFWS 2011a). The width, habitat potential (per Nussear and others model), infrastructure and other factors led to their conclusion that its potential as a linkage is severely limited. Monitoring is already on-going in this area; line distance sampling detected no tortoises in the area from 2007 to 2010 (USFWS 2011a).

4.2.4.1.2 Areas of questionable connection

Keany Pass, just south of Stateline Pass, was identified as a potential connection in the model results (Figure 14). It is a narrow pass serving as a transmission line corridor, and the tortoise habitat potential is poor.

In general the east side of the watershed is bounded by mountain ranges that generally form barriers to tortoise passage. The model suggests there may be a few areas that may provide connections for tortoises (Figure 14):

1) The pass at the southern end of the McCullough Mountains, where Route 164 crosses from California into the Piute Valley toward Searchlight, Nevada is shown as a potential corridor for connection to the east side of the New York Mountain Range.
2) A pair of potential connections were identified through the New York Mountains, one near Castle Peaks, and one near Willow Wash, the old Boomerang Mine, and the community of Barnwell. If these potential connections were surveyed in the field, it would also be important to survey the area to which it provides a connection: the Nussear model shows low habitat potential in the area just east of the New York Mountains as well.

However, reviewing the inputs, the tortoise habitat potential in these passages is around 0.1 or 0.2. The connectivity model likely identified theses passages because of the surrounding areas of No Data – it forced connections through the narrow strips that were available because the strips did not pose complete barriers and there were no other options. Although Nussear *et al.*'s (2009) habitat model indicates there is low potential for tortoises using these passages, it may be worth confirming through field surveys. For all three potential connections, it would also be important to confirm that there are tortoise populations in the part of the Piute Valley and Lanfair Valley to which the passages are connecting; in the areas immediately to the east of these potential connections, the tortoise habitat suitability is also relatively low; these connections through the mountains may not serve a purpose for tortoise movement and genetic exchange with adjacent populations.

4.2.4.1.3 Areas of connection identified by the model that are unlikely to be viable tortoise habitat connections

On the north side of the valley on either side of the watershed boundary, the red bands spanning I-15 appear to connect the small northwestern lobe of the watershed to the area east of I-15 and Roach Dry Lake; there is a series of small red corridors crossing the interstate and the lake beds, and a narrow corridor running between I-15 and Roach Dry Lake (Figure 14). However, because of the interstate, the presence of Primm, and the dry lake beds, which tortoises are unlikely to cross, this area is highly unlikely to serve as a viable, long-term connection for desert tortoise. These corridors likely appeared because of the configuration of small, complete barriers (pixels of No Data) that were present in the area; the model forced habitat connections between the remaining low-conductance areas that were available.

On the west side of the watershed boundary, around Interstate 15 and Mountain Pass, there are a few small “hot” areas of potential connection (Figure 14). Again, the tortoise habitat potential is low here, and the connections likely resulted because the lowest potential areas were treated as complete barriers, thereby forcing connections through these narrow strips of poor habitat. The presence of Interstate 15 in this narrow pass and the surrounding terrain make it unlikely that this is a viable, long-term connection for tortoises.

4.2.4.2 Stateline Alternatives B and D and other infrastructure: potential tortoise habitat connections

Figure 15 and Figure 16 illustrate the connectivity results for the two Stateline alternatives and other proposed future infrastructure.

4.2.4.2.1 Potential areas of viable connection

At the landscape scale, in the area immediately surrounding the Ivanpah Valley Watershed, the overall patterns of connection are very similar to that of the current conditions. The potential connection around Stateline Pass and the Kelly and Umberci Mines is present; it appears as even more of a bottleneck under both alternatives. This is because either of the two proposed footprints narrow the width of the habitat to the north, constraining that connection somewhat.

Similarly, the north-south connection east of I-15 and west of the Lucy Gray Mountains is reduced in width as a result of the spatial constraint of the proposed Silver State South project; it becomes more of a bottleneck. Therefore, the corridor shows higher connectivity values.

4.2.4.2.2 Areas of questionable connection

The value or intensity of the Keany Pass connection present in the current conditions is substantially reduced, as is the intensity of the connections on the east side of the watershed. However, these connections are questionable, as described previously.

4.2.4.2.3 Areas of connection identified by the model that are unlikely to be viable tortoise habitat connections

On the north side of the valley on either side of the watershed boundary, the potential connection spanning I-15 has intensified as a consequence of the additional spatial constraints presented by the proposed airport footprint and the Stateline footprints. It is narrower and has higher connectivity values. However, as noted previously, the interstate, community of Primm, and the dry lake beds make this unlikely to have served as a tortoise habitat connection. Although still present, the hot spots around Mountain Pass are substantially reduced as well.

4.2.4.2.4 Impacts of Stateline alternatives on landscape-scale connectivity

Under either of the two alternatives, the area of tortoise habitat will be reduced in the northwest corner of the Ivanpah Valley. However, these footprints appear to have relatively limited impact on connectivity in and out of the Valley. The red band of connection between the northwest portion of the Valley and tortoise habitat on the other side of the Clark Mountains near Mesquite Lake intensifies somewhat with the addition of either footprint because the footprints reduce the overall habitat available for tortoises to move through. The Ivanpah Valley Airport footprint contributes to this intensification as well. One consideration in viewing the model results for Stateline Alternatives B and D is the implications of Circuitscape "seeing" a connection across Interstate 15 on the northern edge of the watershed, between the two dry lake beds. Because it interprets this as a connection, when the solar and airport footprints are added, it intensifies the entire band of connection from the area just west of Stateline Pass all the way to the east of the proposed Silver State South project, to the edge of the Lucy Gray Mountains and continuing in a northeasterly direction. If this central area of connection right around the interstate were not present, it would not intensify the potential Stateline Pass connection to the same degree. Assuming no other habitat losses occur in the area between Stateline Pass and the solar footprints, the potential for Stateline Pass and nearby areas to serve as a viable connection for desert tortoise is primarily dependent on the habitat quality and spatial configuration of the pass, rather than the addition of either solar footprint.

Figure 14. Landscape-scale connectivity: current conditions.

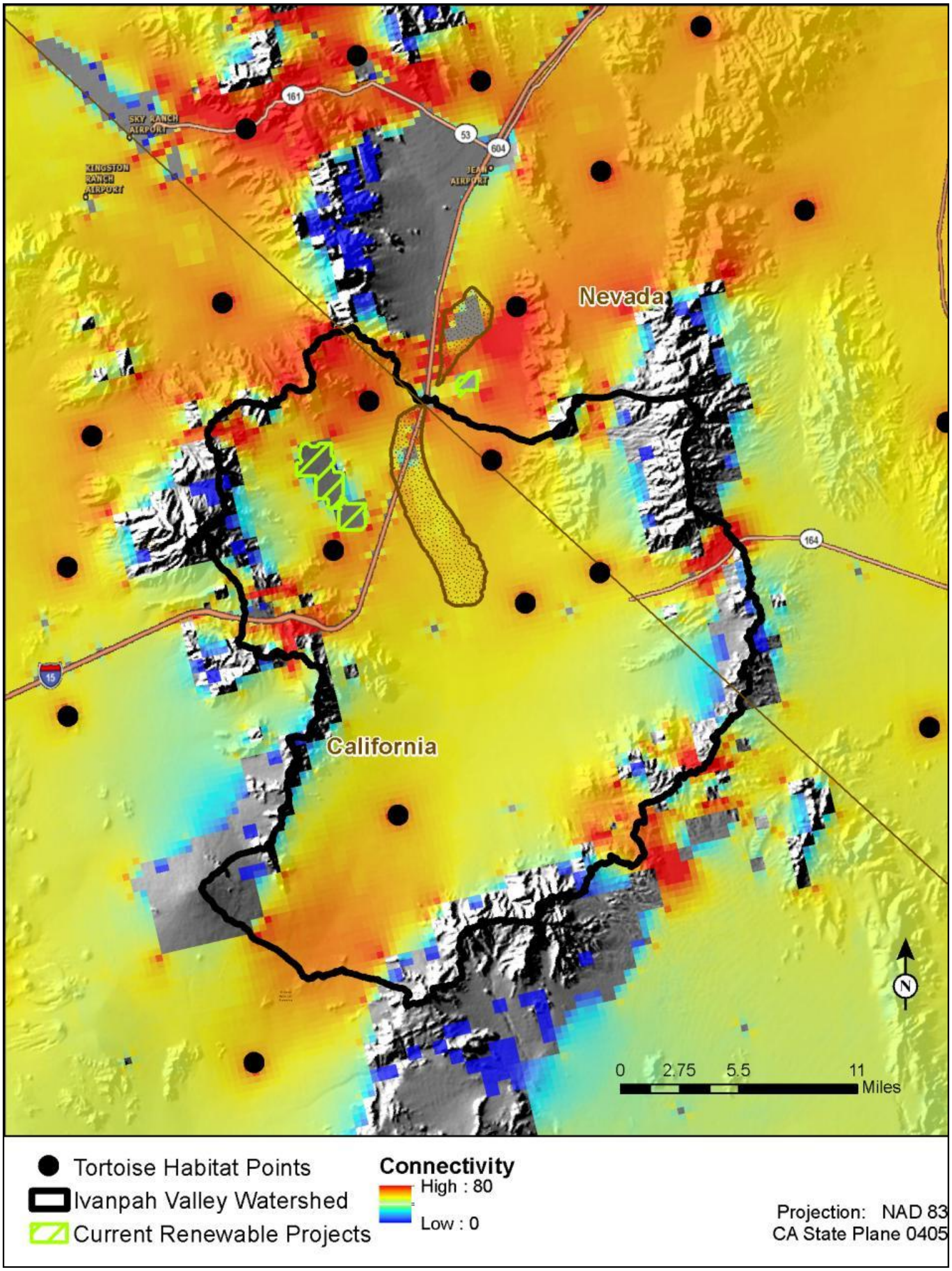


Figure 15. Landscape-scale connectivity: future conditions, Stateline Alternative B.

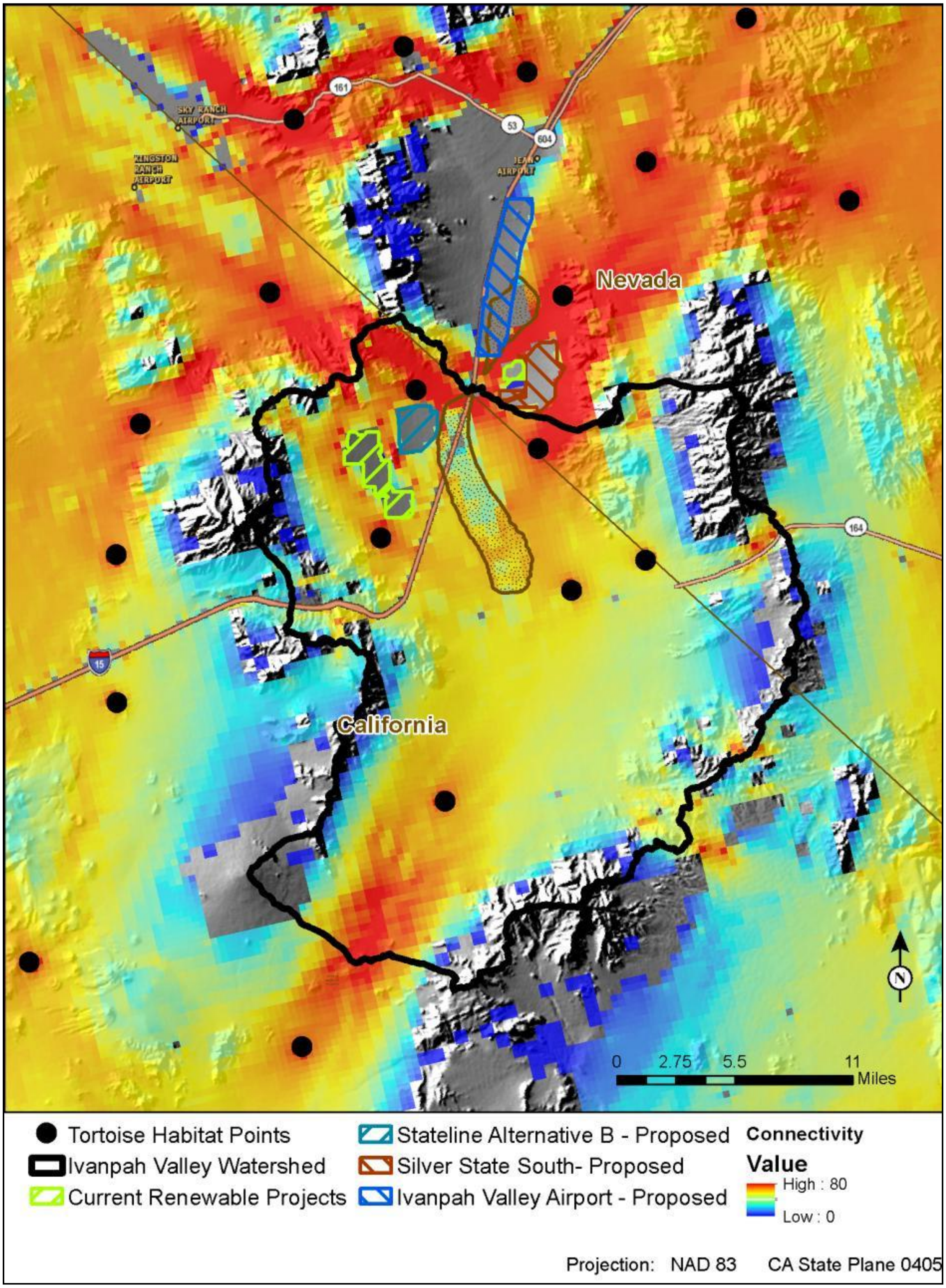
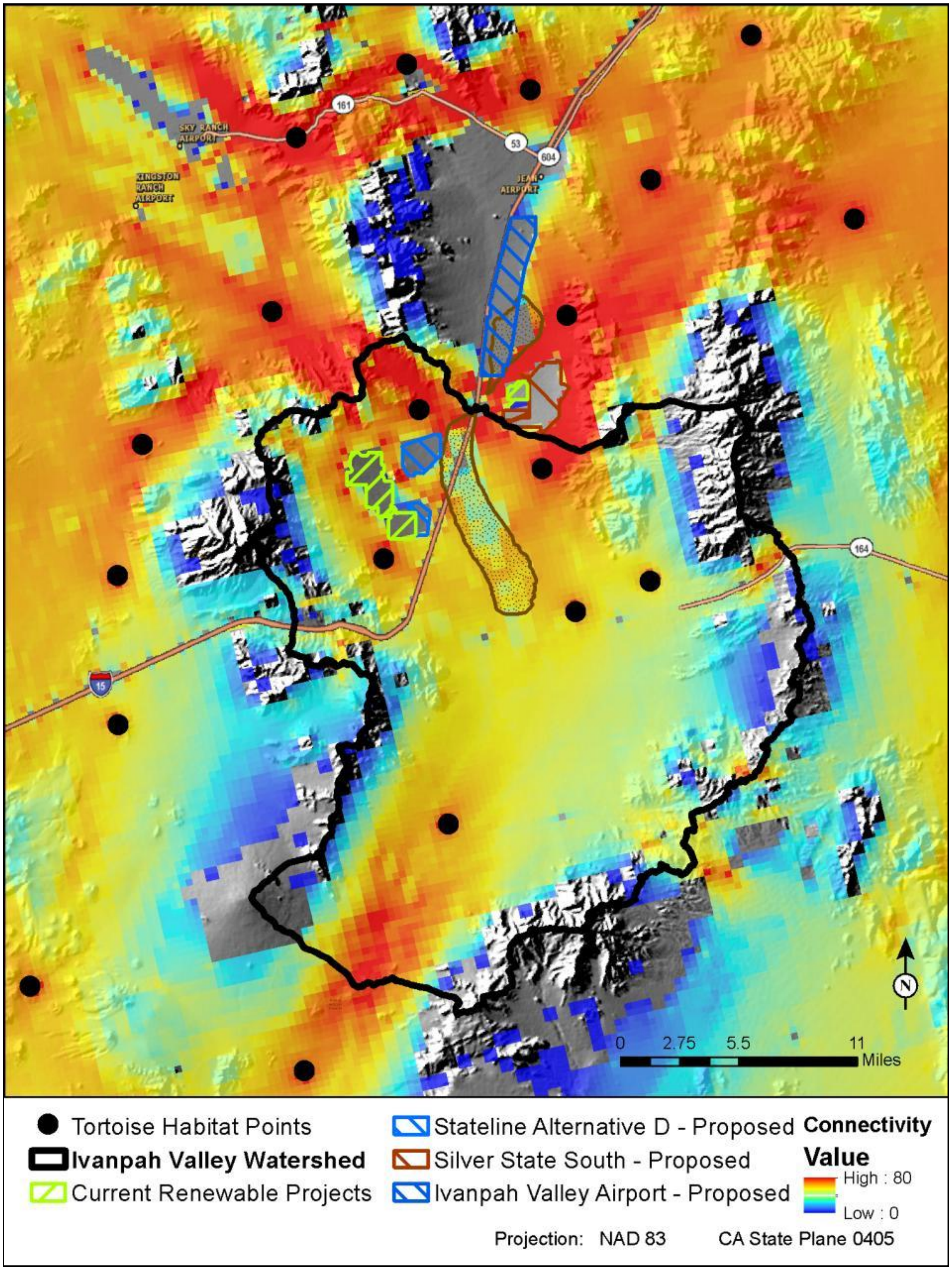


Figure 16. Landscape-scale connectivity: future conditions, Stateline Alternative D.



4.2.4.3 LSTS and connectivity

The Large-Scale Translocation Site for tortoise just north of the Ivanpah Valley Watershed is unusual in that it offers good tortoise habitat but presents a barrier to natural tortoise movement. The LSTS currently creates a barrier to movement between the patch on the west side of Interstate 15 in the Ivanpah Valley Watershed and the habitat both within the LSTS and to its north; mountains form a barrier on its western side and the remaining three sides are fenced with tortoise exclusion fencing. A pair of connectivity models were run using the two sets of future conditions (Stateline Alternatives B and D, plus other proposed future infrastructure), but treating the LSTS as open, unfenced habitat (Figure 17 and Figure 18).

With either set of proposed future infrastructure projects, if the LSTS no longer posed a barrier to tortoise movement, it would have a substantial effect on habitat connectivity in and out of the Ivanpah Valley Watershed. Under both sets of proposed future infrastructure, including Stateline Alternatives B and D, the “opening” of the LSTS creates a north-south corridor on the west side of Interstate 15, extending from the northwest part of the Ivanpah Valley Watershed to the area just north of Jean, Nevada. Although the connectivity results don’t illustrate this, the area north of Jean (but south and west of the Las Vegas metropolitan area) has good tortoise habitat potential according to the USGS model (taking developed areas into account); the western side of the Las Vegas metro area breaks the potential connection from continuing north and meeting with another potential band of connectivity running east-west along the north side of Las Vegas.

All other areas of connection between the Ivanpah Valley Watershed and the immediately surrounding areas are approximately the same in extent and intensity as those modeled for Stateline Alternatives B and D where LSTS was treated as a barrier.

Figure 17. Landscape-scale connectivity: future conditions, Stateline Alternative B, LSTS not treated as barrier.

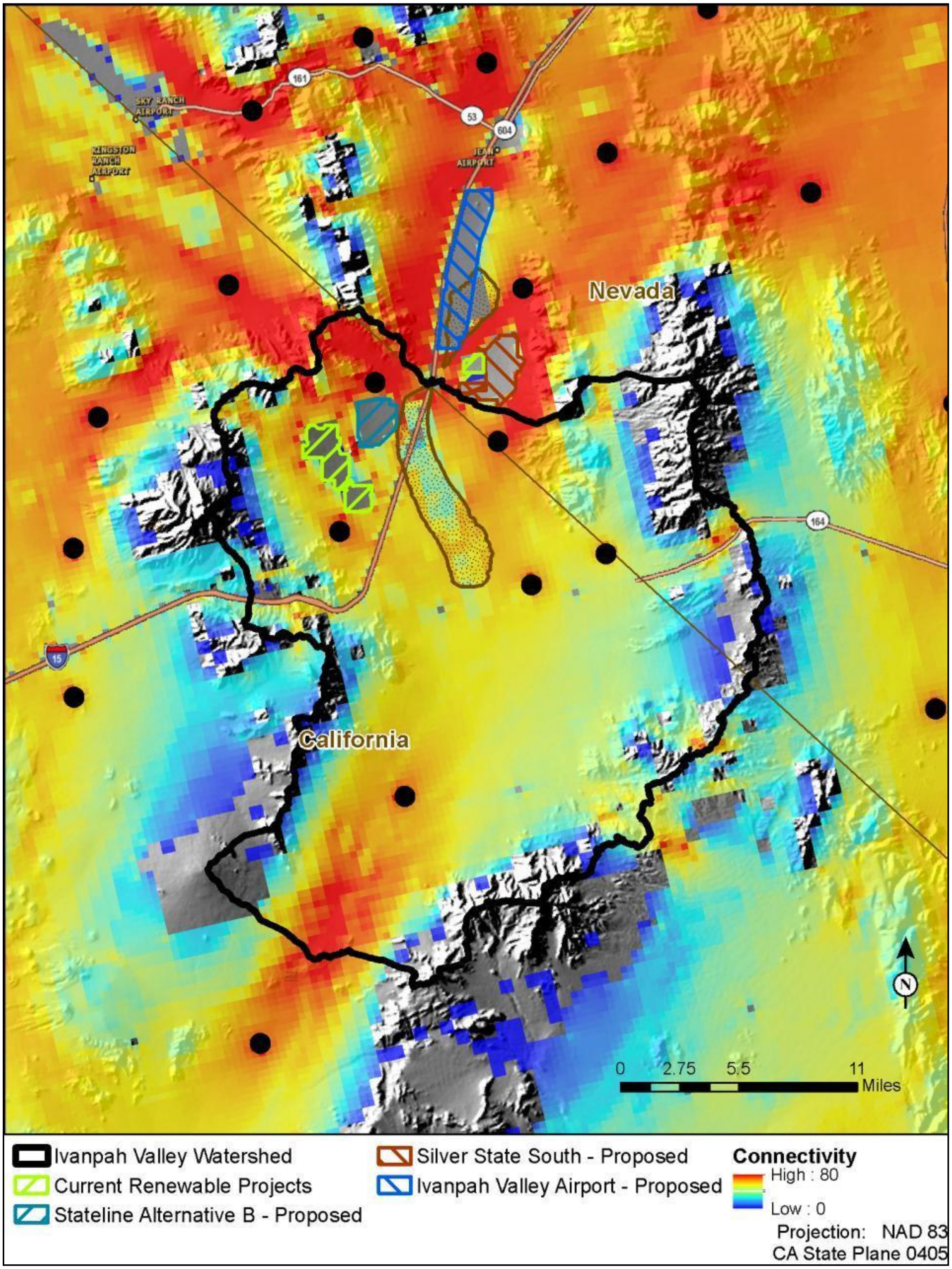
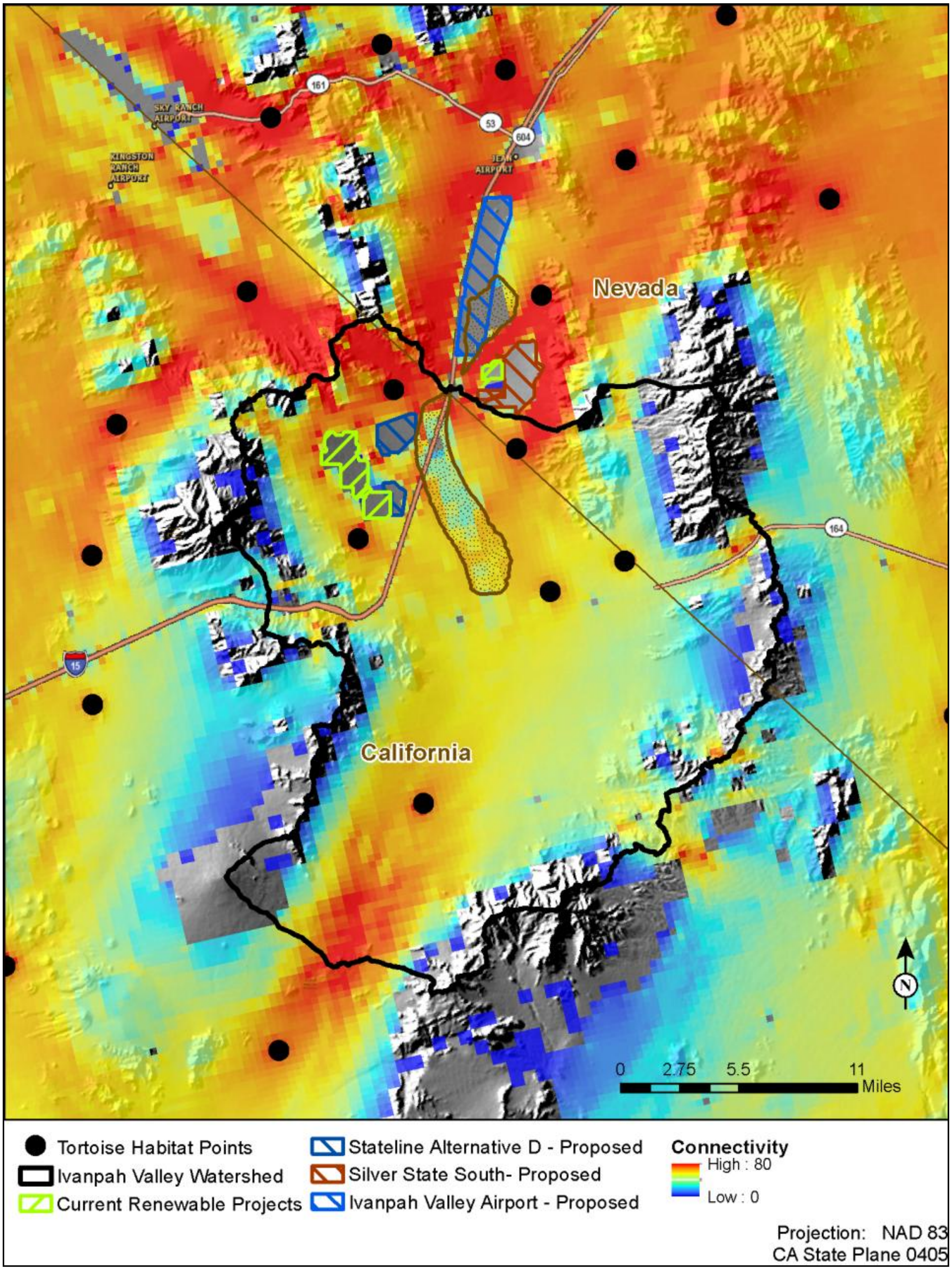


Figure 18. Landscape-scale connectivity: future conditions, Stateline Alternative D, LSTS not treated as barrier.



4.2.4.4 Interpreting the landscape-scale connectivity results: considerations, recommendations, and limitations

There are some important and related considerations for interpreting the specific desert tortoise results in this assessment. As described previously, movement and gene flow of the Mojave desert tortoise can be described as a continuous-distribution model; that is, gene flow occurs through their continuous distribution across a landscape of suitable habitat, rather than by individuals migrating through or across areas of unsuitable habitat to access areas of suitable occupied habitat. Consequently, the relatively discrete areas or bands of high connectivity shown in the connectivity model results are not corridors in the sense that many tortoises will regularly pass through them to get to other, more suitable habitat. Instead, these areas have the potential to act as population linkages by providing a limited area of habitat that a smaller number of individuals may occupy and thereby interact with individuals in adjoining larger habitat areas. Because these linkages aren't movement corridors in the metapopulation sense, it is important for the linkages to be of sufficient size and quality to permit their on-going occupancy by desert tortoise over time. However, the design of Circuitscape is not intended to address home range sizes, movement distances, or other spatial requirements for the size and configuration of potential habitat connections. USFWS has used tortoise home range size and movement patterns to hypothesize a minimum width of 1.4 miles for potential habitat linkages (see USFWS 2012). When reviewing the conductance outputs, understanding these types of spatial requirements is necessary to begin to assess these potential connections.

In addition to reviewing the results with an understanding of the spatial requirements of desert tortoise, it is also important to review the results with an adequate understanding of the inputs to the model and detailed knowledge of the landscape on the ground. From a practical standpoint, it is not possible to develop a conductance data set that represents the area and the species' needs with complete and detailed accuracy. In addition, the model software will try to find connections through narrow bands that may have poor conductance. Therefore, the model outputs must be compared to the model inputs and to detailed information or knowledge of the local landscape features and configuration to determine whether areas of connection identified by the model actually have potential to be viable for the species being assessed.

With these considerations in mind, the summary discussion of potential linkages in this assessment is a starting point for evaluating potential linkages. A field assessment of site-specific conditions, such as habitat quality, current tortoise occupancy, and potential for edge effects or other constrictions, is required to fully assess the potential for these areas to provide habitat connections with long-term viability.

One consequence of evaluating points rather than patches of habitat in the Circuitscape software is that it will show high levels of connection immediately around the habitat points that were assessed. It appears that each habitat point is a hot-spot for connectivity. This is an artifact of how the model works, and those hot-spots should generally be ignored. Instead the user should view the broader patterns of connection across the landscape, without particular reference to the points. In this particular assessment, because the patches of potential habitat for desert tortoise are so large, even with features like Las Vegas and various infrastructure footprints removed, it is somewhat more difficult to evaluate the landscape-level connections when modeling with patches. The advantage of using points rather than patches in this particular situation is the ability to see continuous patterns of connection across a landscape, including within the extensive tortoise habitat patches.

4.3 Local connectivity modeling

Connectivity was also modeled at a local scale to address potential changes in connections within the Ivanpah Valley Watershed using methods similar to those used in the landscape scale modeling. The primary difference was the addition of culvert data to show potential connections via culverts across Interstate 15 and across the Union Pacific Railroad line. Adjustments to the approach and methods needed to model local connectivity are highlighted in the following sections. Two model variations were run: one using tortoise habitat patches, and one using habitat points. In addition to the difference in the geographic scope of the modeling and the use of both patches and points, the other differences are 1) resolution of data (30 meter), 2) only three model scenarios because LSTS is not relevant at this scale; and 3) use of culverts as short-circuits across barriers to tortoise movement. Tortoises have been documented to use culverts as passages underneath roads (Boarman 1995; Boarman and Sazaki 1996), and in conjunction with barrier fencing, culverts may facilitate tortoise passage while reducing mortality associated with busy roads (Boarman *et al*. 1997). At the local scale, the model results were not highly informative. The modeling approach is described below, and alternative models of tortoise-specific landscape permeability are presented.

4.3.1 Approach

Consistent with landscape-scale modeling, both current and future conditions were modeled using Circuitscape. Because the LSTS is outside of the Ivanpah Valley Watershed, only two sets of future conditions were modeled: one reflecting Stateline Alternative B and one representing Stateline Alternative D. As with landscape-scale modeling, habitat patches were derived from the USGS desert tortoise habitat potential model with impervious surfaces and solar infrastructure footprints removed. In the Ivanpah Valley Watershed, under both current and proposed future conditions, there are three habitat patches, divided by Interstate 15 and the Union Pacific Railroad. A set of 63 tortoise habitat points was derived from the three larger patches using a detailed local roads layer for use in a second set of model runs for the current and two future conditions. The following three sets of current and future conditions were modeled at the local scale:

1. Current infrastructure, development and land uses
2. Future infrastructure, development and land uses, with Stateline Alternative B
3. Future infrastructure, development and land uses, with Stateline Alternative D

4.3.2 Data sources, model inputs and methods

All data inputs for the local modeling were converted to a 30-meter resolution. The various LCMs and the steepness model were at 30-meter resolution in their original form; the tortoise habitat model used to define habitat patches and as an input to the conductance layer was resampled to 30-meter resolution to make it compatible with other input layers.

4.3.2.1 Habitat patches and points

Available data on tortoise habitat constrained the local connectivity modeling. Finer delineations or models of quality tortoise habitat were not available; therefore, the 1-kilometer resolution USGS model was used to define tortoise habitat patches within this area as described in the landscape scale modeling. The main difference was using the Union Pacific Railroad to further split the eastern patch into two patches in order to permit the assessment of the influence of culverts on connectivity in that area, as well as along Interstate 15. (The data were also resampled to 30 meters.) Using this data, the resulting habitat patches are separated largely by narrow corridors created by the interstate and railroad. For the current and future conditions, the appropriate set of infrastructure footprints were clipped out of the patches. (For example, to model conditions under Stateline Alternative D, the Alternative D footprint was clipped out of the patch.)

A set of 63 tortoise habitat points was derived by using a detailed buffered roads layer to divide the three patches into smaller patches and calculate the centroids of those patches larger than 150 acres. The habitat points were used in a second set of model runs to determine whether the results using points might be more informative.

4.3.2.2 Conductance surfaces

The same three inputs were used to build conductance surfaces for local connectivity modeling: 1) the USGS desert tortoise habitat potential model, 2) the Landscape Condition Models, and 3) the steepness model. The three inputs were clipped to the Ivanpah Valley Watershed, resampled as needed to 30 meters, and multiplied together to get conductance surfaces. The three original LCMs, representing current conditions, Stateline Alternative B plus other proposed future infrastructure, and Stateline Alternative D plus other proposed infrastructure, were used to create the three variations on the conductance surface. After the three conductance surfaces were created, the Interstate 15 corridor was modified so that conductance values there were just above zero so that it would be treated as a substantial barrier to movement within the Valley. (In the landscape-level modeling, it also appeared as a barrier, but to a lesser degree due to the combining of the LCM with the steepness and habitat inputs.)

4.3.2.3 Short circuit layer

Point locations of culverts mapped along Interstate 15 and along the Union Pacific Railroad were buffered by 200 meters and included as a short-circuit layer. The buffering was necessary to ensure that the resulting areas of connection are wide enough to span the linear features (highway and railroad) dividing the patches. (If the culverts are treated as unbuffered 30-meter pixels, the connections they create don't cross the linear features, in addition to being too small to be visible in a map.)

4.3.3 Circuitscape set-up and outputs

Circuitscape was run in "pairwise" mode for both the patches and the points. In this mode, each combination of pairs of tortoise habitat patches or points are assessed in Circuitscape. Circuitscape averaged each of the pairwise assessments to create a single output reflecting the average conductance among the patches. The maximum conductance value for each pixel in each of the pairwise assessments was also identified to create a single output reflecting the maximum conductance for any given location between the patches.

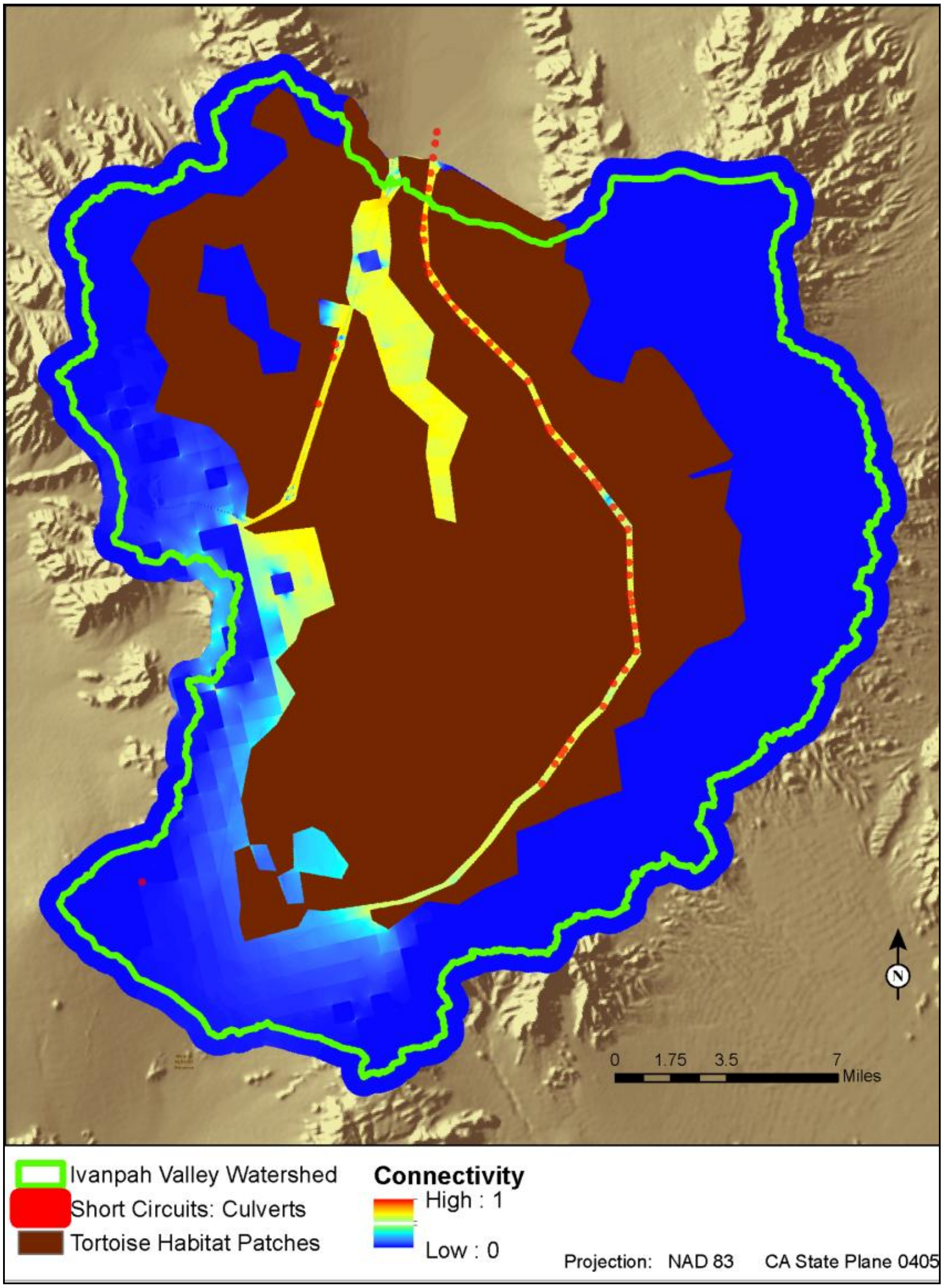
4.3.4 Areas of connectivity

Because the habitat patches are coarsely defined and primarily separated by narrow corridors created by the interstate and railroad, the Circuitscape results are not surprising (Figure 19). Although the interstate has very low conductance, and the railroad has somewhat low conductance, the distance between the patches is short enough that the current somewhat readily jumps across these barriers. The culverts, as expected, create areas of high connectivity where there is greater potential for tortoise movement.

As with the landscape-level modeling, the habitat patches are sufficiently coarsely defined that either of the Stateline alternatives simply creates a hole in the patch. Those holes are complete barriers to movement within the patch in those areas, but they don't affect movement from the outer edges of any one patch to another adjacent patch.

The results of modeling local connectivity using habitat points instead of patches are not shown. Because the habitat is relatively continuous, the model results in a network of paths that simply connect the dots, rather than provide an accurate indication of areas of higher and lower connectivity.

Figure 19. Local connectivity under current conditions, using tortoise habitat patches.

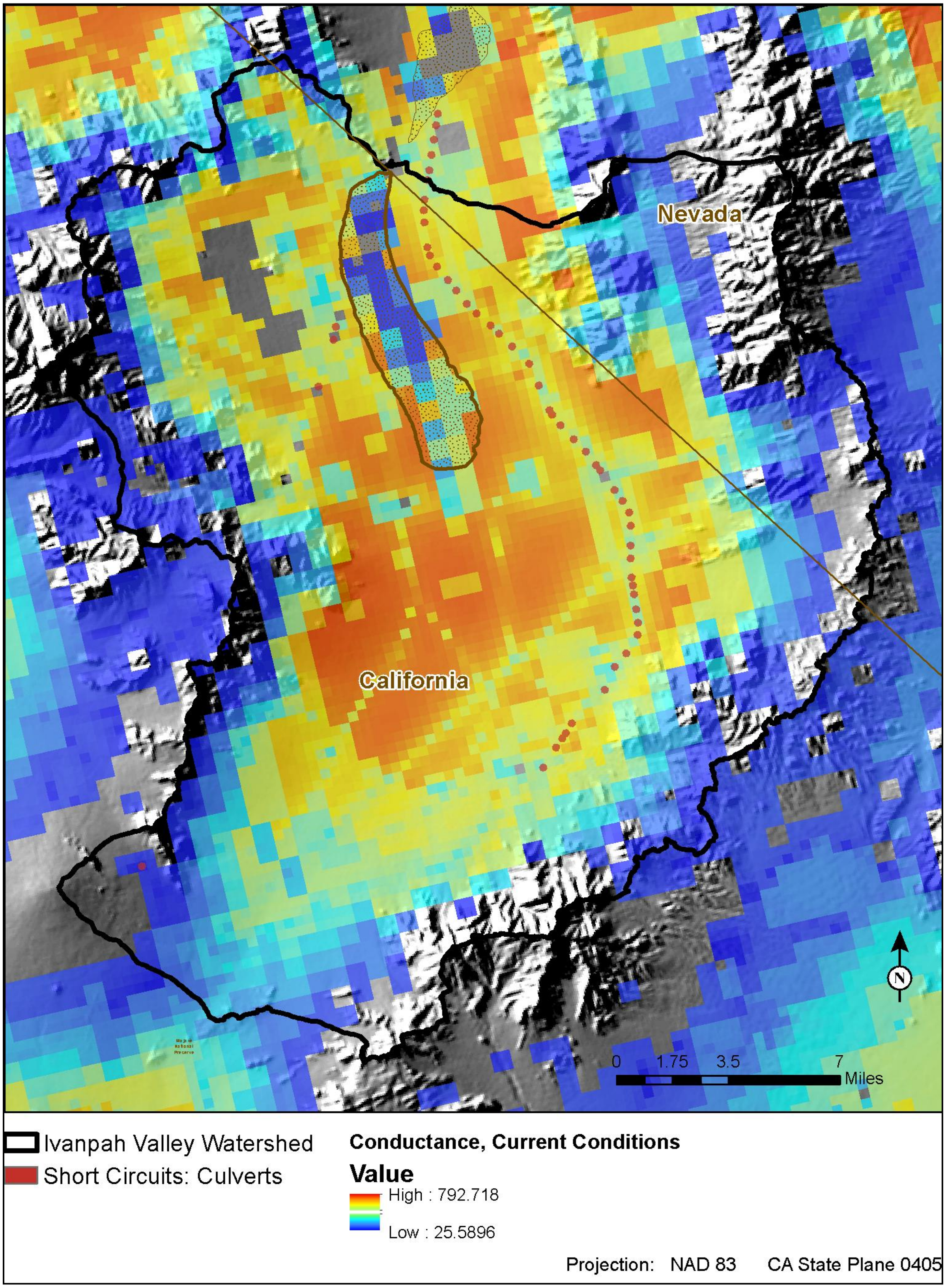


The local model was not re-run to reflect an updated watershed boundary. The culverts created small "hot" red points of connection across the interstate and railroad, which are not easily visible even with the 200 meter buffer placed on the culvert inputs; the actual culvert locations are overlaid to make these connections more visible.

If tortoise habitat were more fragmented and discontinuous in the Ivanpah Valley Watershed, with greater distances between patches in this watershed, using Circuitscape to model connectivity might be more informative. Given the particulars of this study area and species of interest, it may be more informative to reference the three conductance surfaces developed as inputs for Circuitscape as custom representations of connectivity for desert tortoise. The following figures (Figure 20 through Figure 22) illustrate the conductance surfaces. Unlike the results of connectivity models, the conductance surfaces don't show paths or networks of path that are most conducive to tortoise movement, nor do they account for distance. They illustrate the relative conductivity of each pixel in the landscape based on landscape condition, steepness, and tortoise habitat potential. Their display is conceptually consistent with the connectivity results shown earlier, with the red end of the spectrum showing the highest conductance, and the blue end showing the lowest conductance. High conductivity indicates high potential for tortoise to disperse across a given pixel, while low conductivity indicates low potential for tortoise to move across the pixel. The culverts are shown in red as areas of short circuits, or connections.

Within the Ivanpah Valley Watershed, the interstate presents the most substantial barrier to tortoise movement. In some sections it is fenced, and tortoises that attempt to cross unfenced segments are unlikely to survive. There are a few culverts offering potential for connection across the interstate just north of the study area on the Nevada; two other underpasses near the golf course will provide opportunities for movement across the study area on the California side (USFWS 2011a). For tortoises located in the habitat on the west side of the interstate, the area north of the ISEGS project and around Stateline Pass offer the best possibility for maintaining connections to the larger tortoise population. However, as noted previously, that potential needs to be confirmed with ground surveys. The other linear features in the study area, such as local roads, permit successful tortoise movement, although there may be limited mortality associated with some roads. In general, the southern and eastern parts of the watershed offer greater connectivity by virtue of having a smaller overall infrastructure footprint. In addition, the Union Pacific railroad has a relatively dense distribution of culverts, potentially allowing more frequent passage across the railroad by desert tortoises. The addition of the Stateline project will fragment habitat on a very localized scale. Most other infrastructure features in the watershed create gaps in available habitat; the larger issue is overall habitat degradation and loss within the study area. The earlier section (Section 3.3.1) discussing the condition of tortoise habitat throughout the study area under current conditions and with the proposed Stateline alternatives summarizes habitat quality and loss at this scale.

Figure 20. Conductance surface for current conditions.



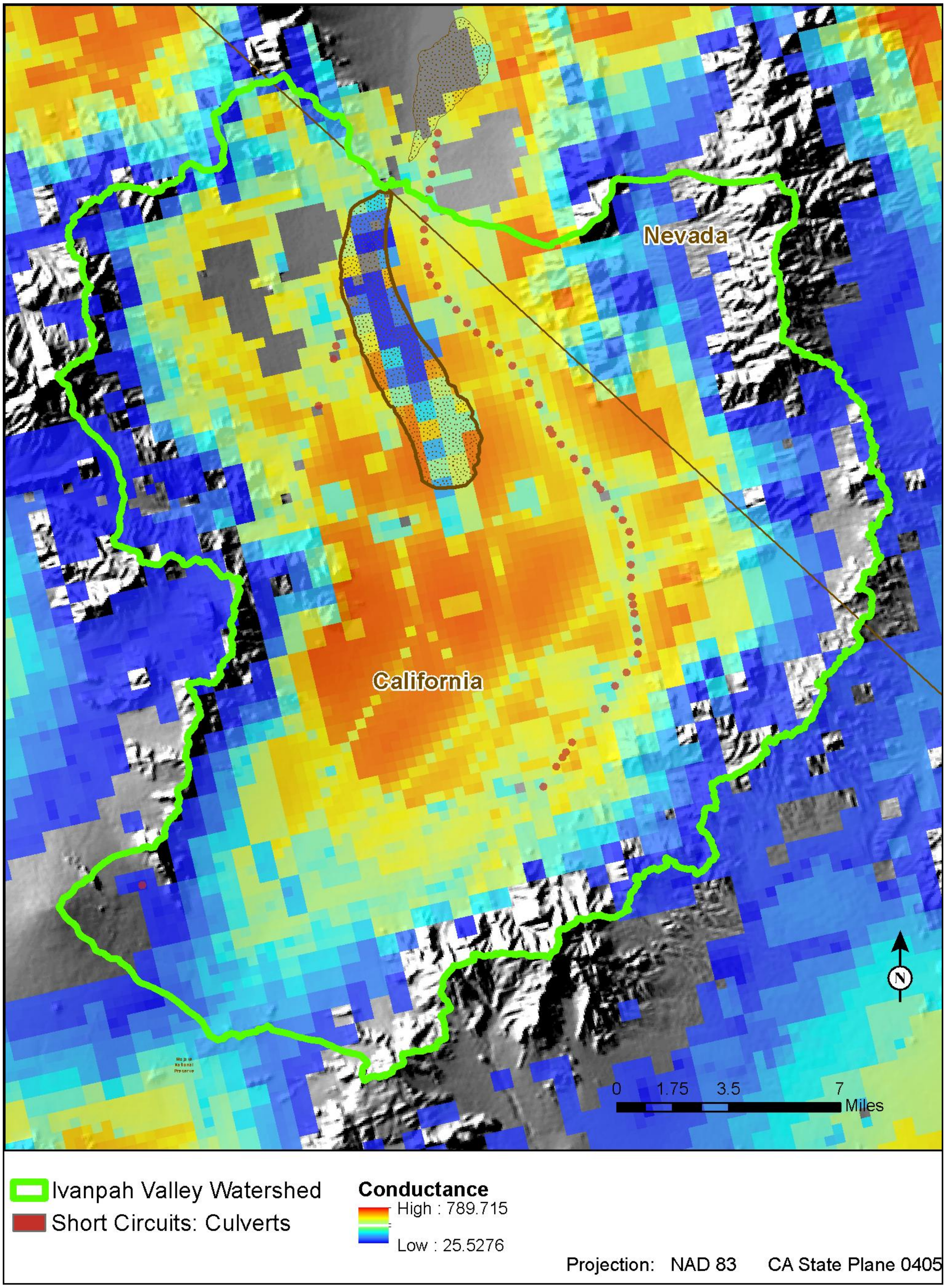
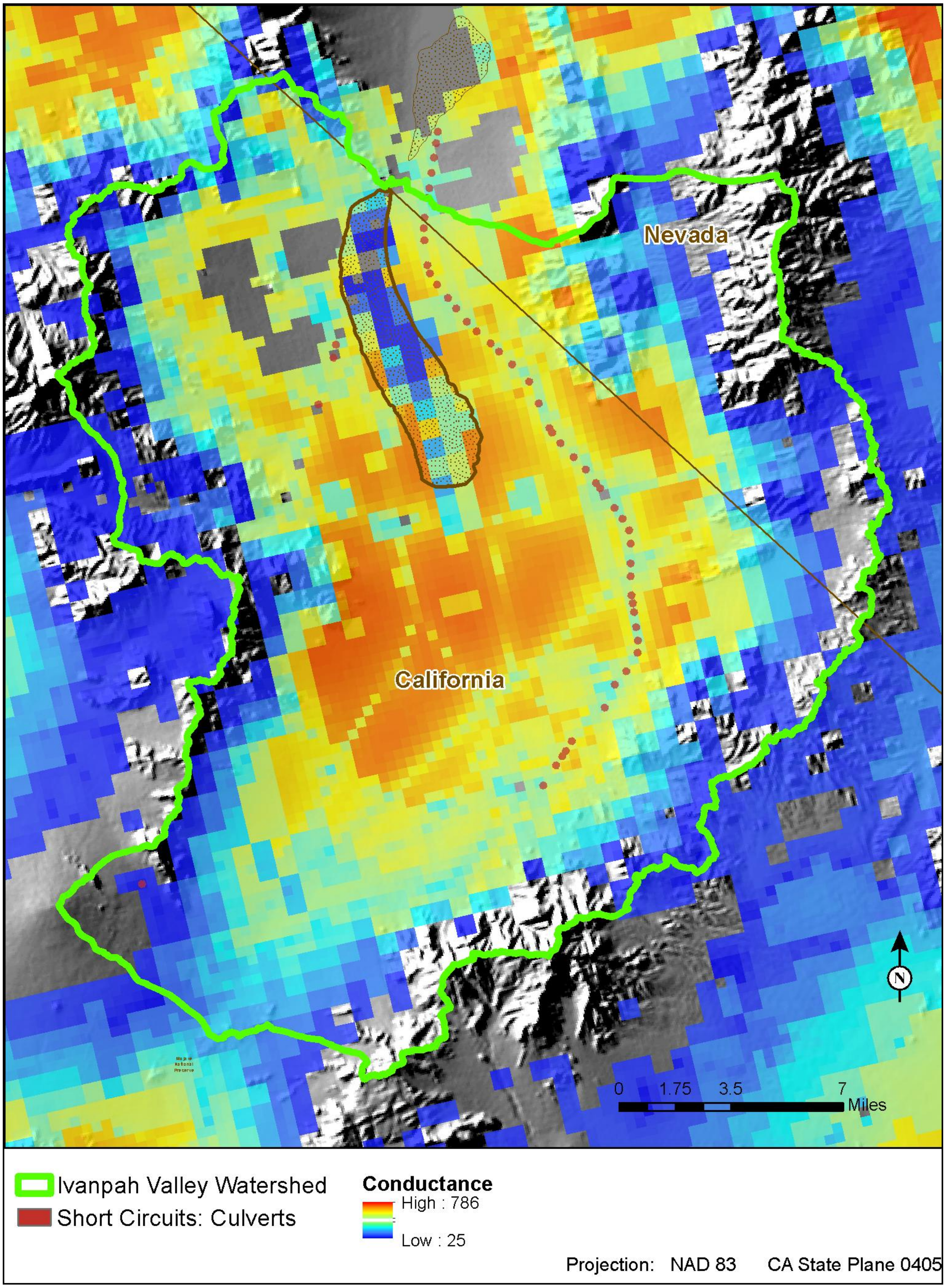


Figure 21. Conductance surface for Stateline Alternative B and other proposed infrastructure.

Figure 22. Conductance surface for Stateline Alternative D and other proposed future infrastructure.



5 Conclusions

5.1 Habitat condition

The primary effect of the Stateline solar project will be the immediate loss of tortoise habitat within the project footprint and associated off-site impacts of its construction and on-going operation (see below for discussion of uncertainty regarding off-site impacts). This represents approximately 1.2 to 1.3% of the suitable tortoise habitat in the Ivanpah Valley Watershed. To provide context for understanding the ecological effects of this proposed project, the change in condition of available tortoise habitat was evaluated and the cumulative impacts on ecological systems were assessed.

5.1.1 Desert tortoise habitat

The landscape condition model used to approximate the health of desert tortoise habitat provides context for the habitat loss associated with either of the Stateline alternatives. At the watershed scale, 81% of potential tortoise habitat has a condition value of 0.65 or greater (close to averaged observed value of 0.67); with the addition of approved projects or the Stateline project, 79% of tortoise habitat still meets that threshold.

In the tortoise habitat located west of Interstate 15, the impact of existing and proposed infrastructure is apparent. Currently, 46% percent of the potential tortoise habitat has a condition value of 0.65 or greater. That drops to 38% with the addition of *approved* projects, and to 36% with the addition of either of the Stateline alternatives.

In the area west of Interstate 15, a significant portion of tortoise habitat has been lost to the combined footprints of the ISEGS project, the golf course, local roads, transmission line and other utility corridors, and other features. Aside from the direct loss of habitat due to these footprints, the question remains of the degree to which the effects of these features may extend beyond their footprint and impact tortoise populations. Because the relationship between various infrastructure features and tortoise populations has generally not been quantified, a minimum or recommended condition value for desert tortoise cannot be identified with any certainty. For such a long-lived species, many years of tortoise observations in areas with and without infrastructure would be needed in order to determine the potential indirect effects of infrastructure features on tortoise populations. Either of the Stateline alternatives will result in an additional direct reduction in habitat in this part of the watershed. The impact of the project on tortoise populations beyond the proposed project footprint is not clear; following is a discussion of various possibilities.

If the area west of Interstate 15 were free of *existing* infrastructure, the area of suitable habitat for desert tortoise (per Nussear et al. 2009 data) would be approximately 57 square miles (37,000 acres). If the following additional assumptions are made, then the tortoise population in the area west of Interstate 15 may not be viable, regardless of the current condition values, or the addition of any new infrastructure:

1. A minimum genetically effective viable population is 5,000 individuals (see USFWS 1994)

2. This area could support tortoise densities of 20 individuals per square mile (based on the higher densities observed in surveys in or near the watershed; see Table 6 in particular, and also Table 4, Table 5, and Table 7)
3. The population in this area is isolated from the rest of the desert tortoise population by the Clark Mountains and by Interstate 15

At densities of 20 individuals per square mile and *without* current infrastructure (but assuming the interstate as a barrier), this area could support approximately 1,100 tortoises. To approach the minimum viable population size of 5,000 individuals, densities throughout this area would have to be approximately 87 animals per square mile. If current infrastructure is taken into account, and if condition values are assumed to have bearing on tortoise populations, approximately 17,000 acres or 26 square miles of this area are in adequate condition (0.65 or greater) for desert tortoise. At 20 tortoises per square mile, this area could support approximately 520 individuals; densities would have to approach 200 animals per square mile to meet the assumed minimum viable population size. Again, if this area is indeed isolated from adjacent populations by the interstate, it is unlikely that it can support a viable population even in the absence of existing infrastructure (aside from the interstate).

If existing and planned culverts and similar structures are confirmed to provide sufficient passage for tortoises across the interstate, then the area of the entire watershed can be considered in terms of its potential to support a viable population. East of the interstate, approximately 209 square miles (133,600 acres) has a condition value of .65 or greater. Assuming densities of 20 animals per square mile, the area having that condition value could support 4,180 animals. Taken together with the area west of the interstate, the Ivanpah Valley Watershed has the potential to support the minimum population size needed for long-term viability. If a negative relationship between low condition values and tortoise populations were confirmed (that is, low condition negatively impacts tortoise populations), this would place greater importance on maintaining the remaining habitat throughout this watershed. With the addition of already approved projects, approximately 231 square miles having condition values of 0.65 or more remain throughout the watershed; assuming densities of 20 animals per square mile, approximately 4,620 animals could be supported. With the addition of the Stateline project, the area having condition values of 0.65 or more drops slightly to approximately 230 square miles, which could support approximately 4,600 individuals. At relatively high densities for this watershed, even under current conditions with approved project, the watershed may not be able to support a minimum viable population of 5,000 individuals. If a neutral relationship between low condition values and tortoise populations were discovered (and therefore habitat with lower condition values had no negative impacts on tortoise populations), and population densities were high (at least 20 animals per square mile) throughout the area east of the interstate, the eastern portion of the watershed alone could potentially support a minimum viable population with the current infrastructure footprint. If the lower density values that were observed in the various surveys in the watershed and the Ivanpah CHU (ranging from 7 to 15 animals) are assumed, and if condition is positively correlated to tortoise populations, then the watershed is even less likely to support a population that is viable over the long term.

With available information, particularly concerning the level of connectivity between the tortoise habitat west of Interstate 15 and adjacent tortoise habitat, and the relationship between condition values and tortoise populations, definitive conclusions on the impacts of the Stateline alternatives beyond their immediate footprints are not possible.

5.1.2 Ecological systems

Under current conditions, the three ecological systems that are preferred habitat for desert tortoise largely do not conflict (don't overlap) with current and projected infrastructure and land uses. Ninety percent of the Sonora Mojave Creosotebush – White Bursage Desert Scrub is currently not in conflict with existing infrastructure, and with the addition of projected infrastructure, that proportion drops to 85%. Ninety-six percent of the Mojave Mid-Elevation Mixed Desert Scrub does not overlap with either current or future land uses. The desert wash ecological system type is similarly not in conflict with current and projected development or other infrastructure.

5.2 Habitat connectivity

5.2.1 Landscape scale connectivity

The Ivanpah Valley Watershed is part of the southern Las Vegas population or genotype cluster identified by Hagerty and Tracy (2010); an approximation of this area based on that publication is shown in Figure 4. Therefore, it was important to evaluate the potential impacts of the proposed Stateline project on connectivity in and out of the valley. With long-lived animals such as desert tortoise, genetic clusters identified in current genetic analysis will most likely represent movement patterns and genetic exchange that was taking place prior to anthropogenic influences (USFWS 1994 as cited by Hagerty and Tracy 2010). The Las Vegas cluster, then, is likely to represent tortoise movement that was taking place on the order of 30 to 50 years ago or more. Some degree of movement in and out of the Ivanpah Valley Watershed and associated genetic exchange with tortoises in the area surrounding it has historically been frequent enough for this to be part of a single genetic cluster.

As modeled in this assessment, the Stateline project is not projected to have a large impact on connectivity at the landscape scale; the Stateline footprint does not overlap with any of the potential connections in and out of the watershed. Given the presence of Interstate 15, ISEGS, Ivanpah Dry Lake, and the LSTS to the north, tortoise movement in and out of the patch on the west side of the interstate is already constrained, unless the Stateline Pass area is confirmed to be a viable linkage or culverts under the interstate are confirmed to provide adequate linkages. If Stateline Pass were a viable linkage, the Stateline project footprint does not directly impinge on that passage. Existing infrastructure and geographic features already limit connectivity in and out of the north end of the Ivanpah Valley Watershed; areas of potential landscape-scale connections are generally similar with or without the presence of the Stateline project. Other proposed infrastructure footprints near the northern edge of the watershed overlap the potential corridors of connection in and out of the north end of the watershed, thus narrowing the width of these connections.

If the Large-Scale Translocation Site (LSTS) were not present in its current location, that would provide a potentially viable corridor for desert tortoise movement to the area around Jean, Nevada. However, if such a possibility were to be considered, there is still a question of how the habitat around Jean would further connect with tortoise habitat to the north; the Las Vegas metropolitan area and Interstate 15 corridor may pose barriers beyond the vicinity of Jean.

5.2.2 Local connectivity

As expected, the results of the local connectivity modeling highlight the *potential* for culverts to provide connections between the areas of tortoise habitat that are separated by Interstate 15 and the Union Pacific railroad. Along the Union Pacific railroad within the watershed, culverts are often spaced a few hundred meters apart; the greatest distance between them is less than 1.5 miles. Within the watershed, there are currently three culverts under Interstate 15. As with the potential landscape-scale habitat connections, culverts in the watershed need to be assessed to confirm whether their location, frequency, size, and other characteristics are sufficient to permit successful tortoise movement and gene flow. In particular, an evaluation of whether the number of passages under the interstate is sufficient to maintain adequate genetic exchange would be informative.

Aside from the potential connections provided by culverts, the local model results did not permit the identification of finer-grained areas of connection within the watershed given the available data. Instead, the conductance surfaces used as inputs in the Circuitscape model can be interpreted as an indicator of how easily tortoises can move across the watershed. Based on those conductance surfaces, the addition of either Stateline alternative will have relatively limited additional impact on tortoise movement throughout the Ivanpah Valley Watershed as a whole, although it will create localized fragmentation within the habitat patch to the west of Interstate 15. As expected, the conductance surfaces illustrate that the more limited infrastructure footprint in habitat to the east of Interstate 15 more readily allows tortoise movement in that area.

The landscape-scale model results provide information on connectivity in a localized portion of the watershed: the area bounded by the Clark Mountains on the north and west and Interstate 15 on the east and south. In this portion of the Ivanpah Valley Watershed, the Stateline project will constrain tortoise movement in the corridor between the ISEGS project and the barrier formed by the combination of Interstate 15 and Ivanpah Dry Lake by removing a portion of that habitat; the corridor between the ISEGS project and the Clark Mountains will become the main corridor permitting tortoise movement between the northern and southern parts of this habitat patch.

5.3 Limitations

Inputs used to develop the landscape condition model were based on the best available information and included review by USFWS DTRO biologists. However, the lack of an established or quantified correlation between many of the infrastructure features used to model tortoise habitat condition and effects on tortoise populations is a primary limitation of the ecological health assessment. This includes the lack of quantification of the relationship of site intensity and distance decay scores for various infrastructure features with their potential impacts on tortoise habitat and populations.

The major limitations of the connectivity assessments relate to the need for expert review of the results. The modeling software does not account for species-specific requirements for connectivity linkages; areas of connectivity identified by the model need to be reviewed with that information in hand. Even with careful design, model inputs cannot perfectly reflect ground conditions; consequently, the model may still identify areas of connectivity that are inconsistent with on-the-ground observation. In general, the connectivity model results provide a series of *potential* linkages and areas of connection that require further expert evaluation.

This assessment was intentionally focused on the effects of proposed solar infrastructure on the ecological integrity and connectivity of tortoise habitat. However, there are numerous other factors, such as climate change and disease, which affect desert tortoise and may have synergistic impacts on the tortoise population. In reviewing the results of this assessment, such factors should also be considered.

6 Acknowledgments

We would like to thank the USFWS Desert Tortoise Recovery Office, particularly Catherine Darst, Desert Tortoise Recovery Biologist, for providing input and comment on the data and approaches used in these assessments, as well as DTRO data sets. Data and input on assessment approaches provided by Chris Blandford, Ironwood Consulting and Brad McRae (Circuitscape) were also appreciated.

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8 Appendices

Appendix A. Data sets used in the regional assessment

Many of the data sets used for various modeling steps in this assessment were obtained by NatureServe for use in the Rapid Ecoregional Assessments conducted for BLM, and in many instances BLM provided the data sets directly.

Data sets used in scenario evaluations for cumulative effects/ecological health assessment and in Landscape Condition Model

1. **Urban/Rural Development**. This class is derived from the Integrated Climate and Land Use Scenarios (ICLUS) and its related spatial database, Spatially Explicit Regional Growth Model (SERGoM) (EPA, 2010). SERGoM data uses US Census block housing units, protected lands, groundwater well density, and road accessibility to estimate housing density. This class attempts to apply a footprint to a wide array of housing density classes put forth in the ICLUS/SERGoM dataset. This raster dataset is a classification of base case scenario from ICLUS v1.2 which is produced using the SERGoM v3 model, depicts housing density for the coterminous US in 2000, based on 2000 US Census Bureau block (SF1) datasets. Urban and rural development was defined as less than 160 acres per housing unit.

2. **Renewable Energy – Solar Energy**. Solar project footprints were obtained from BLM and verified by BLM state offices between June and October, 2011. Detailed footprints for the Stateline project and Silver State South project were provided by First Solar in November 2011 and February 2012, respectively.

3. **Renewable Energy – Wind Energy**. Wind project footprints were obtained from BLM and verified by BLM state offices between June and October, 2011.

4. **Mines/landfills**. This class includes major landscape disturbances, including open pit mines, tailings piles, leach pads, landfills and other refuse areas. Full metadata is available for this layer as a modeling product developed by NatureServe for the REA.

5. **Oil and Gas Wells**. BLM provided state locations of oil and gas wells in the ecoregion. These were point locations assembled from state regulatory agencies.

6. **Military Urbanized Areas**. This class resulted from the desire to identify an urban footprint within military reservations in the ecoregion, given that the ICLUS/SERGoM excluded these areas from analysis. The Urban/Developed class was extracted from the National Land Cover Dataset (NLCD) 2006 and clipped to military reservation boundaries.

7. **Railroads**. BLM provided a current railroad network from the National Transportation Atlas Database (NTAD). The section of the Desert Xpress high-speed rail line crossing the study area was heads-up digitized from one of the project documents.

8. **Canals/Ditches**. This class represents most major water transmission infrastructure- canals, ditches and aquaducts in the ecoregion. This was derived from a corresponding class (canal/ditch) in the National Hydrography Database (NHD) Plus.

9. **Utilities – Transmission lines**. These are major high voltage transmission lines (generally larger than 115kV which tie major plants to the electrical grid) obtained from BLM. This dataset is part of a larger GIS mapping application (EV Energy Map) for the North American energy industry.

10. **Pipelines**. The BLM provided a clip from the National Pipeline Mapping System to represent this natural gas pipeline infrastructure.

11. **Crops/Irrigated Pastures**. This class was derived from the NLCD 2006 to represent areas transformed by row crops, irrigated pastures (including alfalfa and grass) and orchards.

12. **Roads- Primary and Secondary**. The BLM Ground Transportation Linear Features dataset was used to represent roads. Primary and secondary roads consist of state, county and federal public highways. This class consists largely of interstates and other separated, limited access highways but also major urban thoroughfares that are under state or local government jurisdiction. Roads that directly support the access to primary and secondary roads are also included features like ramps, cloverleaf structures. Vehicular numbers and speeds are generally high.

    Example classes from the BLM GTLF:

    - Primary road with limited access or interstate highway, separated
    - Secondary and connecting road, state and county highways, major category
    - Access ramp, the portion of a road that forms a cloverleaf or limited access interchange

13. **Roads- Local, Neighborhood, Rural**. This class two consists of light duty roads that are local, neighborhood or rural in nature. The surface of the road in rural areas is commonly composed of dirt or gravel but will often be paved, especially in urban areas. These roads may be public or private. The number and average speed of vehicles transiting this type of road is lower than in primary and secondary roads. This is the most common class of road in the ecoregion. This class has the most overlap with class three and depending on the data source used in the GTLF, there may be significant classification error.

    Example classes from the BLM GTLF:

    - Local, neighborhood, and rural road, city street, unseparated, underpassing
    - ROAD_ LIGHT-DUTY GRAVEL (CLASS 3B)
    - Private Road for service vehicles logging_ oil fields_ ranches_ etc

14. **Roads- Unimproved, (4-wheel drive)**. This class of road consists of unimproved or four-wheel drive roads. These roads are almost always dirt or unconsolidated material and rarely, if ever receive any maintenance. Traffic volumes and average speeds are generally low. This class has the most overlap with class two and depending on the data source used in the GTLF, there may be considerable classification error.

    Example classes from the BLM GTLF:

    - 4WD_ rough bladed_ 2-track surface
    - ROAD_ FOUR-WHEEL DRIVE (CLASS 5)_ LOCATION APPROXIMATE
    - ROAD_ UNIMPROVED (CLASS 4)_ LOCATION APPROXIMATE
    - Vehicular trail, road passable only by four-wheel drive (4WD) vehicle, major category
    - trail class 5 4x4

15. **Trails (non-vehicular)**. The trail class intends to capture all paths or tracks that generally exclude or prohibit vehicular traffic. These include foot paths, bike paths and but may occasionally include trails used by ATVs and other small motorized vehicles (either lawfully or unlawfully). Level of use is unknown and may vary greatly depending on location.

    Example classes from the BLM GTLF:
    - Walkway, nearly level road for pedestrians, usually unnamed
    - TRAIL
    - foot_ pack_ bike_ ATV (only type of road in a WSA)
    - Bike Path or Trail
16. **Risk of invasive annual grasses**. This model was developed by NatureServe for the BLM REA and is a risk of invasion, rather than actual mapped extent of invasive annual grasses.

Data sets used to develop conductance inputs for landscape and local connectivity modeling

17. USGS habitat potential model for desert tortoise (Nussear *et al*. 2009)
18. Steepness (created by NatureServe)
19. Impervious surfaces as modified by USFWS; originally from the National Land Cover Dataset (NLCD) 2006

Other data sets used

1. LANDFIRE ecological systems for ecological health / cumulative effects assessment
2. Solar footprints provided by First Solar
3. Infrastructure footprints (Desert Xpress, Ivanpah Valley Airport) digitized by NatureServe from project documents

Appendix B. Percent area of ecological systems compatible with infrastructure and other features in Southern Las Vegas subpopulation geography.

Because of the large geographic extent of the area assessed for this summary, the difference between future conditions under Stateline Alternatives B and D is negligible; the acreages and percentages are the same. Therefore, only one set of future results (for Stateline Alternative B) is listed.

	Entire Extent of Southern Las Vegas cluster		Current Conditions: Compatible			Future, Alternative B: Compatible	
Habitat or Ecological System	**Total Acres**	**Avg Condition**	**Acres**	**Avg Condition**	**Percent**	**Acres**	**Percent**
Desert Tortoise Habitat	2,151,211	0.75	2,006,362	0.77	93.27%	1,994,606	92.72%
Mojave Mid Elevation Mixed Desert Scrub	2,063,266	0.79	1,991,332	0.8	96.51%	1,986,967	96.30%
Sonora Mojave Creosotebush White Bursage Desert Scrub	1,290,893	0.74	1,186,384	0.78	91.90%	1,181,667	91.54%
North American Warm Desert Pavement	161,284	0.65	130,142	0.76	80.69%	129,380	80.22%
North American Warm Desert Badland	133,623	0.52	93,065	0.69	69.65%	92,353	69.11%
Great Basin Pinyon Juniper Woodland	119,869	0.77	113,901	0.79	95.02%	113,805	94.94%
North American Warm Desert Wash	116,877	0.75	108,511	0.79	92.84%	108,283	92.65%
North American Warm Desert Playa	87,328	0.61	68,554	0.75	78.50%	64,992	74.42%
North American Warm Desert Bedrock Cliff and Outcrop	56,743	0.79	54,610	0.81	96.24%	54,607	96.24%
Great Basin Xeric Mixed Sagebrush Shrubland	14,065	0.84	14,031	0.84	99.76%	14,031	99.76%
Inter Mountain Basins Big Sagebrush Shrubland	13,674	0.8	13,388	0.8	97.91%	13,388	97.91%
Sonora Mojave Mixed Salt Desert Scrub	7,088	0.72	6,672	0.73	94.14%	6,660	93.97%
Southern Rocky Mountain Ponderosa Pine Woodland	4,351	0.73	4,211	0.75	96.79%	4,211	96.79%
Southern Rocky Mountain Mesic Montane Mixed Conifer Forest and Woodland	3,478	0.73	3,394	0.74	97.61%	3,394	97.61%
North American Warm Desert Riparian Woodland and Shrubland	3,312	0.59	2,721	0.68	82.15%	2,721	82.15%
Mogollon Chaparral	2,559	0.8	2,532	0.8	98.97%	2,532	98.97%
Inter Mountain Basins Subalpine Limber Bristlecone Pine Woodland	1,728	0.76	1,714	0.76	99.22%	1,714	99.22%
Inter Mountain Basins Cliff and Canyon	1,555	0.76	1,489	0.77	95.81%	1,489	95.81%
Sonora Mojave Semi Desert Chaparral	1,197	0.78	1,183	0.79	98.84%	1,183	98.84%