APPENDIX F: CASE STUDIES

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CASE STUDIES

F-1 Desert Tortoise Case Study

F-1.1 Distribution and Status

In 2012, the taxonomy of desert tortoise was updated to indicate that there are in fact two species; mainly distinguished by life history, genetics, and habitat preference. Mojave desert tortoise (*Gopherus agassizii*) occurs west of the Colorado River, is listed as Threatened under the Endangered Species Act, and has habitat preferences including digging burrows within valleys. Sonoran Desert tortoise (*Gopherus morafkai*), occurs primarily east and south of the Colorado River, is not listed under ESA, and has habitat preferences for rock crevices in steep, rocky hillsides. Figure F-1 includes current potential distribution of each species, based upon existing predicted habitat distribution models (e.g. Nussear et al. 2009 for Mojave Desert tortoise). For the Sonoran Desert tortoise, data representing the distribution of that population was developed by the Arizona Game and Fish Department, and provided to the Contractor for use in the REA.

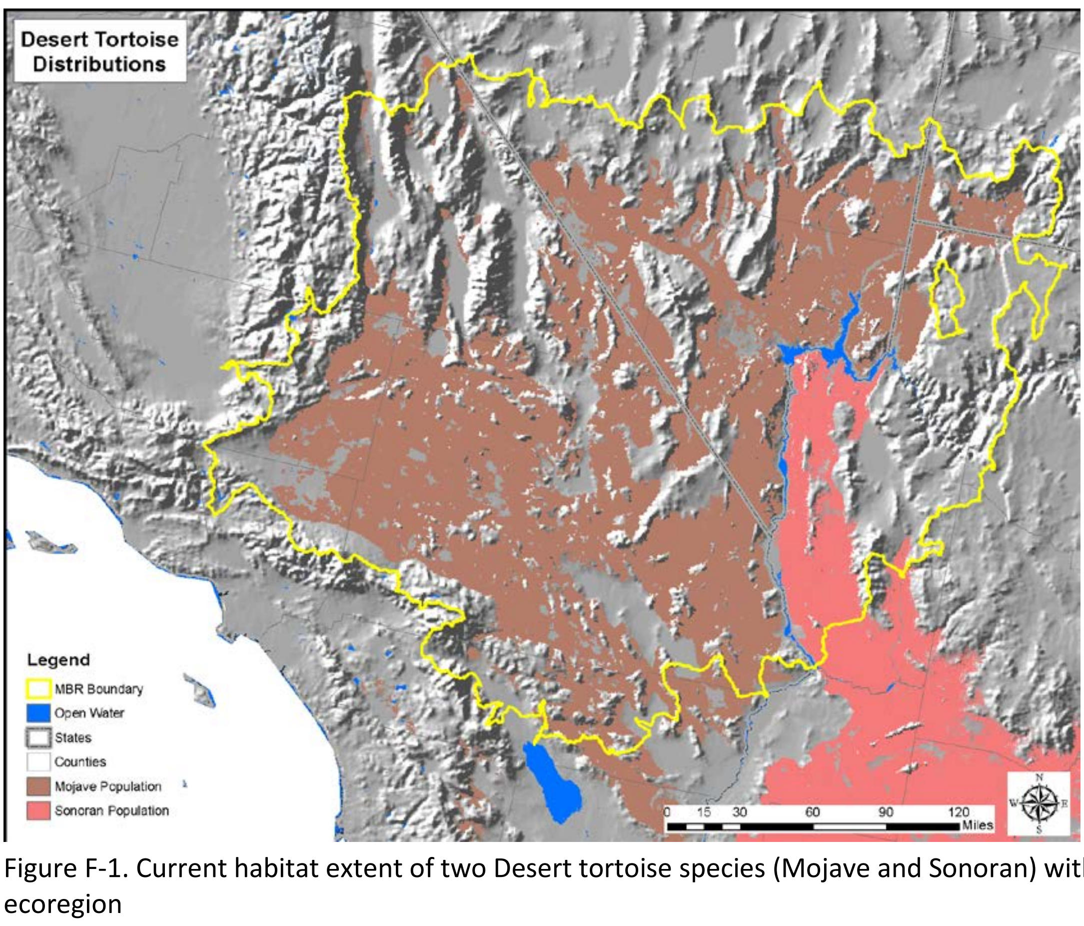

Figure F-1. Current habitat extent of two Desert tortoise species (Mojave and Sonoran) within the ecoregion

Ecological status assessment for Mojave desert tortoise indicates a broad range of scores for landscape condition (Figure F-2) by the 4km^2 grid. Given the common occurrence of desert tortoise throughout the basins of the ecoregion, where virtually all land use is concentrated this result is not unexpected. Fire is a key change agent in desert tortoise habitat with plans developed by the Mojave Desert Initiative to deal with fire and restoration (see section 4.3.1 of Chapter 4).

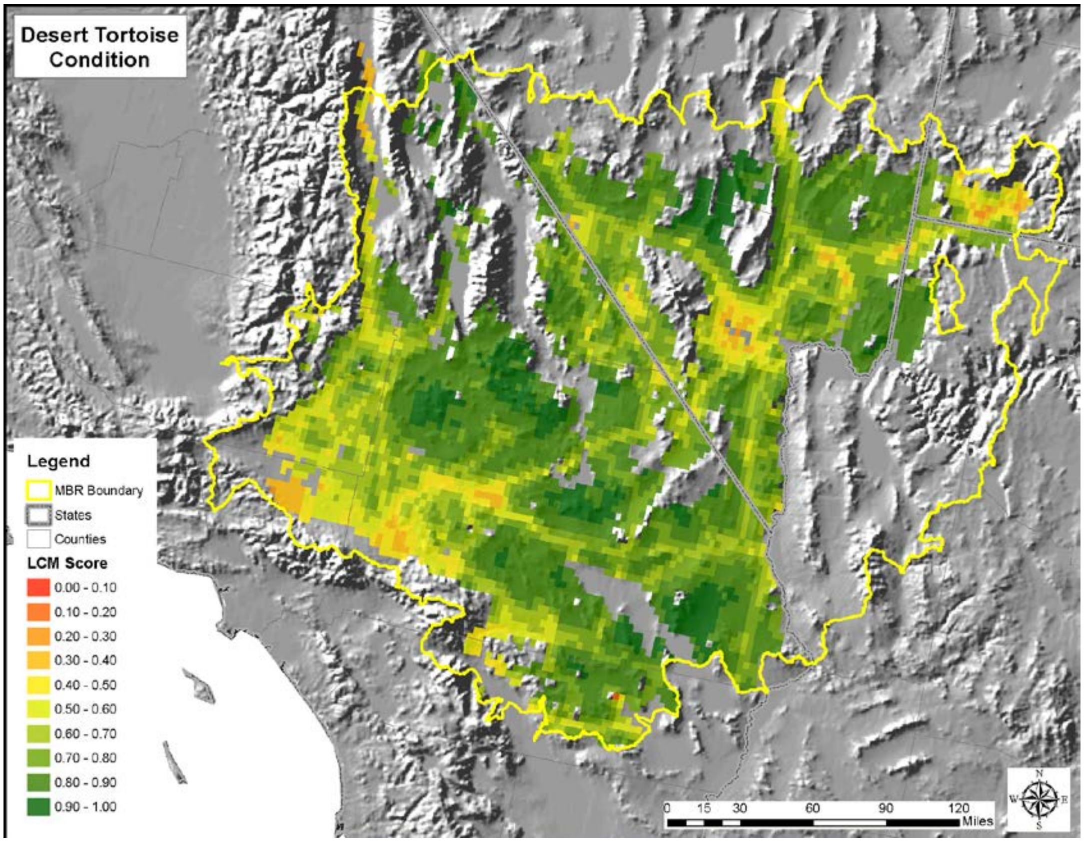

Figure F-2. Ecological status assessment results for the landscape condition indicator, Mojave Desert tortoise occupied habitat

A second indicator of status is relative landscape connectivity. Figure F-3 includes results from the application of *CircuitScape* (www.circuitscape.org), a tool attempting to measure relative potential for population movement and interaction across the region. In this case, the landscape condition model was used as a 'resistance' surface for exploring connectivity potential across the entire mapped distribution of desert tortoise. As a contribution to overall ecological status, areas of potentially concentrated movement among major portions of the MBR population provide an indication of important areas for landscape connectivity, and therefore, ecological status (depicted in Figure F-3 with darker green colors). Warm colors (yellows to oranges) indicate where generalized connectivity exists, and there are many alternative pathways for connecting the current population. Therefore, any given area contributes less to over all ecological status. Areas depicted in red remain connected, but extend to the apparent periphery of the tortoise population in the MBR. Summary scores for this indicator are captured in Figure F-5. Importantly**,** *low connectivity values here do not indicate low quality habitat, merely that the value for connectivity is lower.* Thus, habitat at the edge has lower connectivity value, not necessarily lower habitat value.

Where the conductance *input* surface has broad, uninterrupted areas 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 move across. In the model results, such areas appear as intermediate levels of connectivity, in the yellow range of the spectrum (Figure F-3). 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 patterns of conductance, tortoise movement is constrained to the areas with the highest conductance; the resulting high-connectivity networks or paths appear in green. As options for tortoise movement are reduced through habitat conversion, the intensity of the connection may increase as tortoise movement is channeled through more limited areas. However, the resulting areas of more intense connection 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.

Areas of intense connection on either side of the Grand Canyon should be ignored; this is an artifact of how the CircuitScape model works. Because the conductance surface included areas with tortoise habitat potential values as low as 0.1, and because areas beyond the Grand Canyon with habitat potential near 0 were burned out, CircuitScape forces a potential narrow and intense connection in the only possible areas between the Grand Canyon and the areas on either side of it with near 0 habitat potential. However, given the relatively low habitat potential, these are not likely to be areas of good connection for desert tortoise.

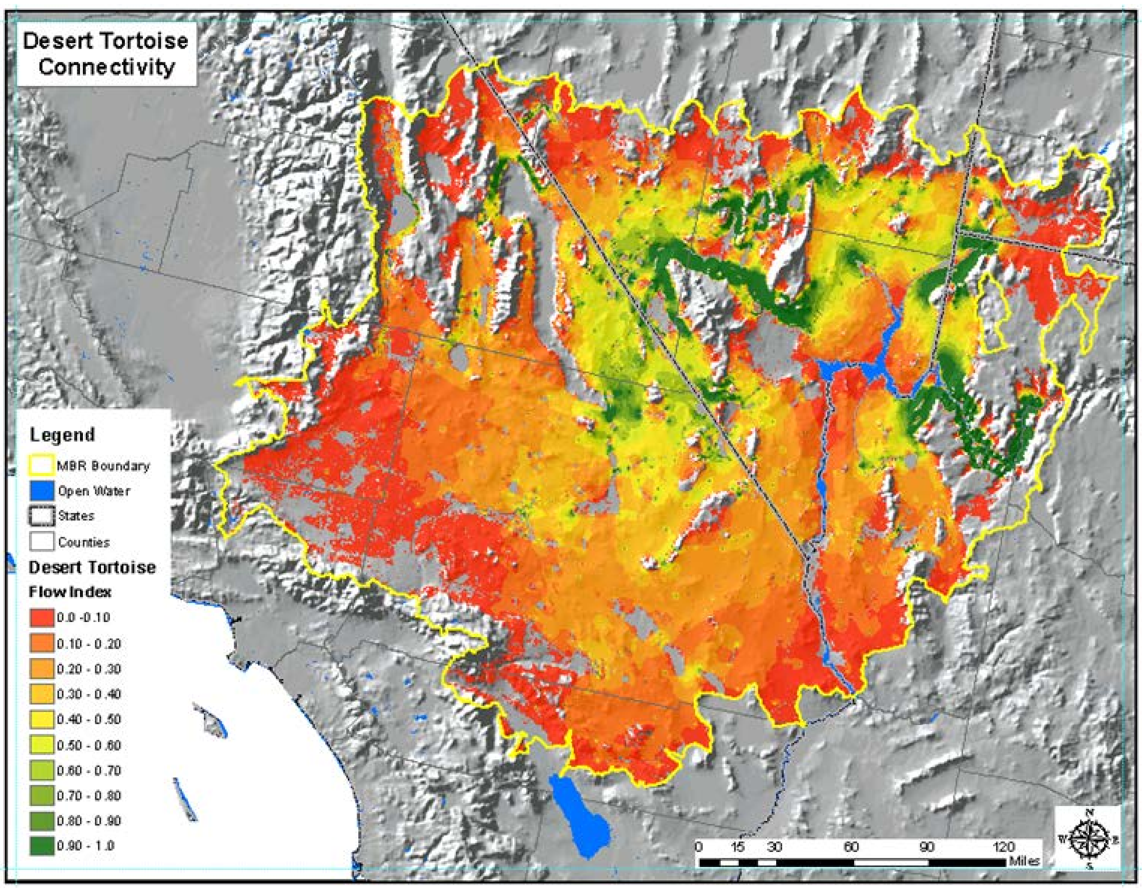

Figure F-3. Model of Mojave and Sonoran desert tortoise habitat connectivity. Warm colors (yellows to oranges) indicate where generalized connectivity exists, and there are many alternative pathways for connecting the current population. Areas depicted in red remain connected, but extend to the apparent periphery of the tortoise populations in the MBR.

F-1.2 Landscape condition change

Development is forecast to increase by a very small amount by 2025 in the MBR. Showing the 2025 development footprint against any CE in an ecoregion-scale map will not show much to the reader. Using the landscape condition model for current versus 2025, one can highlight areas of projected change, with a range of scores for the amount of change. Then a CE distribution, in this case Mojave and Sonoran Desert tortoise, can be overlaid with the landscape condition change map to reveal areas with potential future development impacts (Figure F-4). In this map, areas of non-Desert tortoise habitat are more opaque; where the landscape condition change shows with the full color ramp is desert tortoise habitat. One can see very little forecasted future development in most areas of desert tortoise, but the areas around Las Vegas and in the western Mojave are predicted to have significant change in development. This 2025 landscape condition model did not include potential areas of renewable energy development.

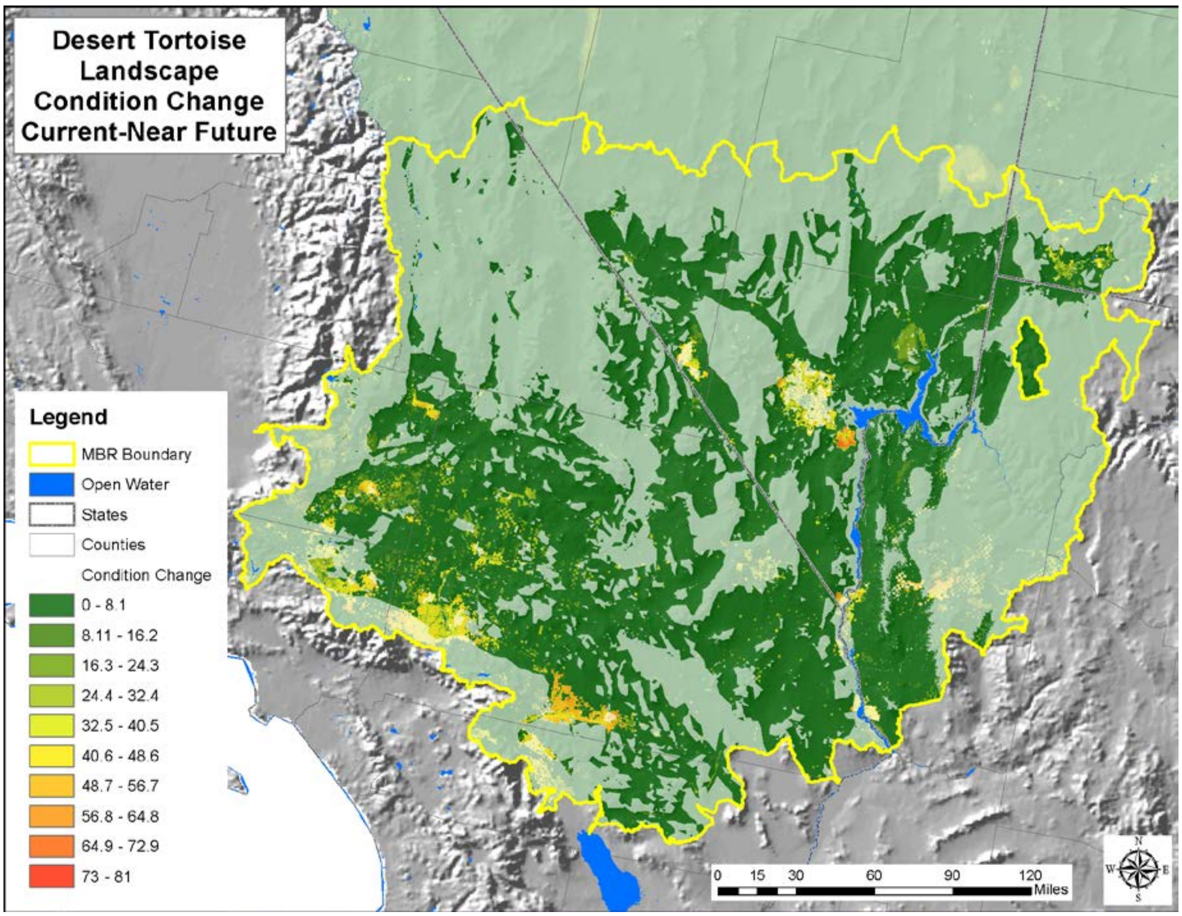

Figure F-4. Areas of Mojave and Sonoran Desert tortoise habitat overlain with change in the landscape condition, from current to 2025. Opaque areas are not desert tortoise predicted habitat, the full color ramp shows the areas of habitat; dark green indicates little to no change from current to 2025; while yellow to dark orange or red indicates increasing amounts of projected change.

F-1.3 Climate Change and Desert Tortoise

Overall, the longer-term perspective for Desert tortoise within the ecoregion appears to be quite challenging (Barrows 2011). Multiple climate regime forecasts were analyzed, comparing the climate regime that describes the current Mojave and Sonoran Desert tortoise distribution with the location of the same climate as forecasted for approximately 2060. Six climate forecasts were utilized here. Where at least two forecasts agree, their results were summarized (Figure F-5 and Figure F-6). These depict forecasted "contraction" "overlap" and "expansion" relative to the current distribution of the 2 desert tortoise species within the ecoregion. By "contraction" these areas in dark blue indicate where the forecasted temperature and precipitation patterns are significantly different from current, in all cases here being warmer. The pink "expansion" areas indicate where current climate for desert tortoise appears to be forecasted to occur by 2060 where it does not occur today. The areas within the bright green "overlap" zone provide the highest potential "refugia" for retaining desert tortoise, at least in terms of the climate regime for which they are currently adapted.

Note that the AMT desired to know the full climate envelope (Figure F-6) for the Sonoran population (currently limited east of the Colorado River) to support possible assisted migration/translocation to suitable areas under future climates.

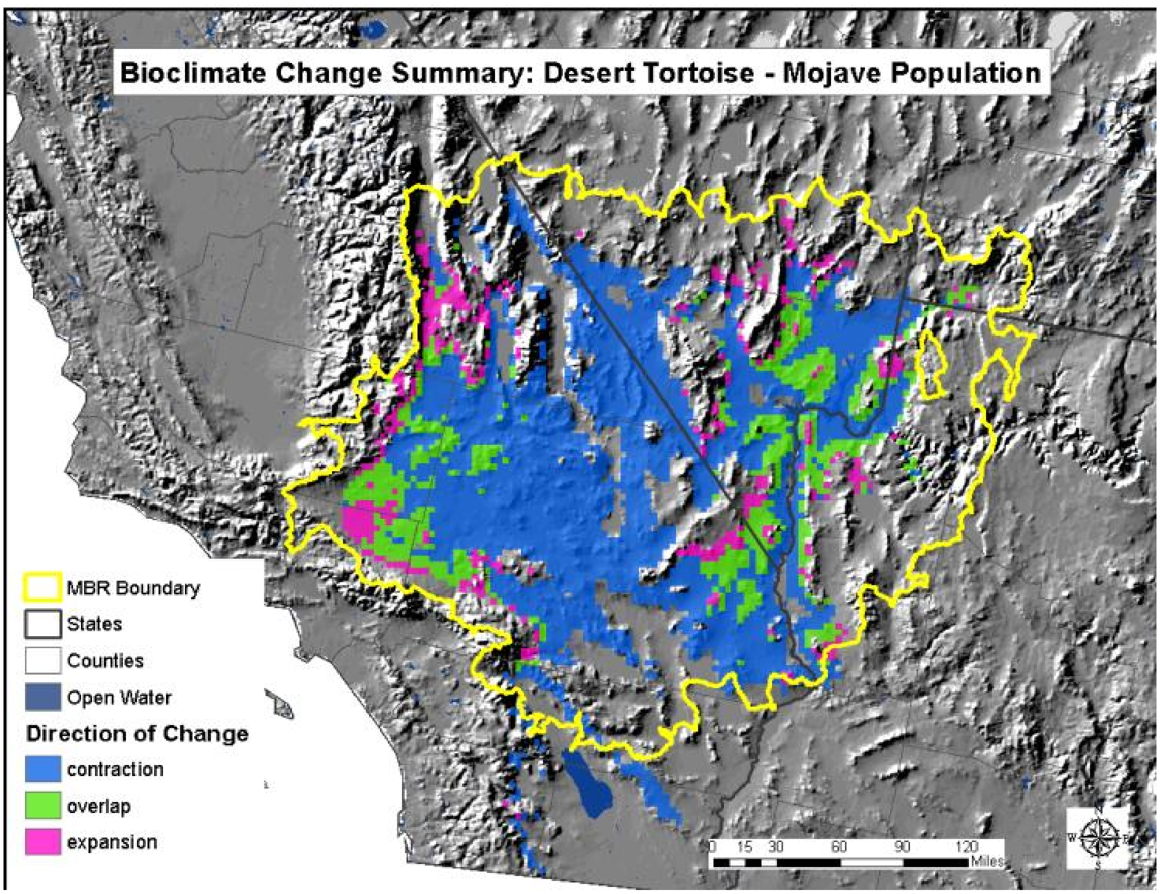

Figure F-5. Climate envelope forecast for Mojave desert tortoise as of 2060. This climate envelope forecast does not match current distribution of the Mojave Desert tortoise because it represents the potential change in the climate envelope from the current climate envelope, as of 2060. It does not attempt to predict actual movement of tortoises (e.g. across the Colorado River).

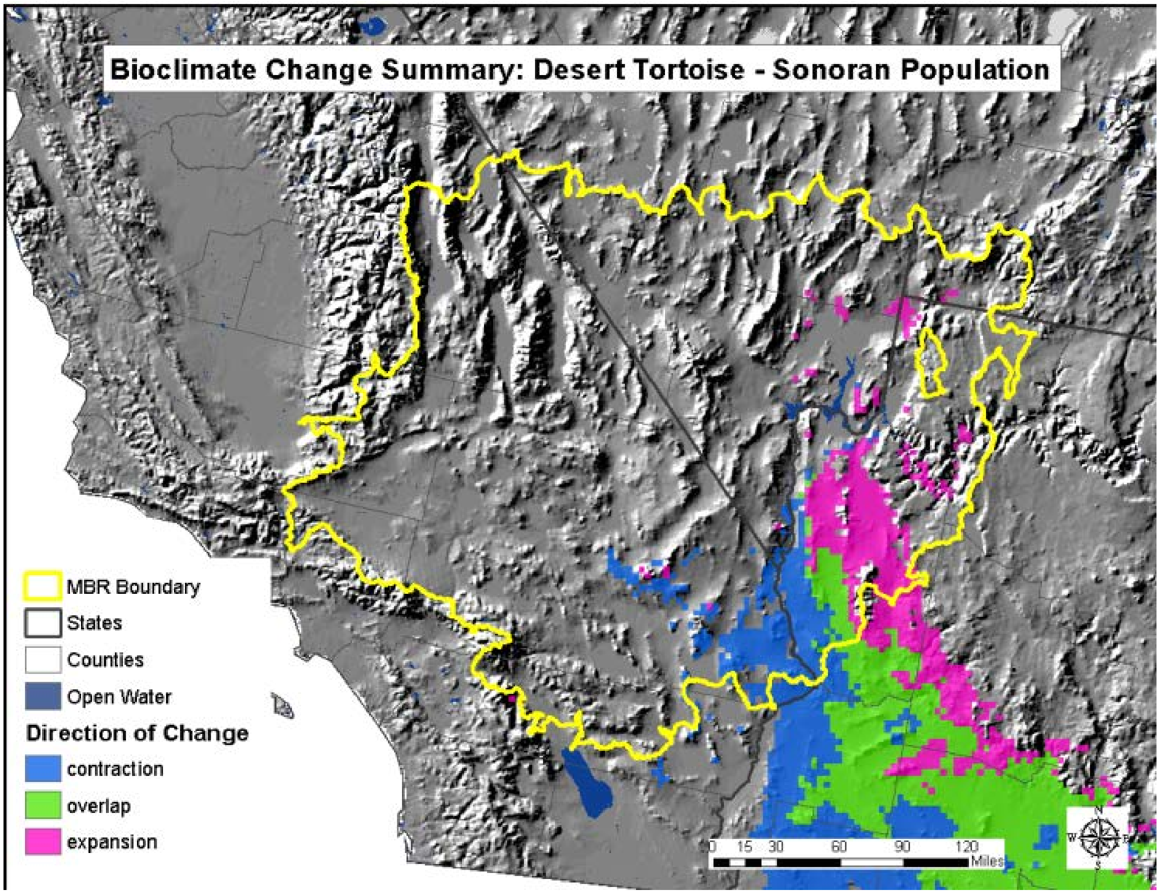

Figure F-6. Climate envelope forecast for Sonoran desert tortoise as of 2060. This climate envelope forecast does not match current distribution of the Sonoran Desert tortoise because it represents the potential change in the climate envelope from the current climate envelope, as of 2060. It does not attempt to predict actual movement of tortoises (e.g. across the Colorado River).

F-2 Fire Regime Departure Case Study – Mojave Mid-Elevation Mixed Desert Scrub (including Joshua Tree-Blackbrush desert scrub)

Mojave Mid-Elevation Mixed Desert Scrub occurs in 91% of the watersheds of the ecoregion. Two variants of this vegetation were modeled, including “mesic” and “thermic” variants. Here the “mesic” variant which occurs in 52% of the ecoregion’s watersheds is discussed. The natural fire regime in these landscapes has been affected throughout the 20th century by grazing, fire suppression, and the increase of fine-fuels as a result of invasive annual grasses (Whisenant and Wagstaff 1991).

By first constructing a conceptual model of successional dynamics, one can develop a powerful simulation tool to better understand the current conditions and forecast future trends. As noted in the methods section, state-and-transition models were developed using the Vegetation Dynamics Development Tool (VDDT) and simulations were run in the Path Landscape Model (ESSA Technologies). Models were run initially using historic conditions and fire regimes in order to characterize the Natural Range of Variation (NRV) which is used as a reference to compare to current and future conditions.

Given expected fire frequencies, one can anticipate a mix of successional stages for a given vegetation type across a defined landscape (in this case, a 5th level watershed). Changes to those fire frequencies, (e.g., through introduction of fine fuels or fire suppression over decades), results in a different distribution of vegetation succession class. For example, historical fire suppression might result in a proportional increase in late successional stages. Introduction of new fine fuels could result in increased fire frequency and a proportional increase in early successional stages. This change from NRV can be measured as an index of Ecological Departure (ED). Ecological Departure describes the dissimilarity between NRV and current, or predicted future, combinations of successional stages. ED is driven by two interacting factors, including a) the distribution of natural seral classes change, and b) the proportion of natural seral stages are displaced by uncharacteristic states. Uncharacteristic states could include areas where invasive non-native vegetation dominates, or in some cases, 'invasion' by native species; as occurs with juniper invasion from pinyon-juniper woodlands into nearby shrublands.

Current vegetation was then modeled by appending current, uncharacteristic states and transitions to the historic model. For example, the Mojave Mid-Elevation Mixed Desert Scrub model adds five uncharacteristic states to the reference model. These uncharacteristic states are the result of the introduction of annual grasses into the region and/or effects juniper invasion into this desert scrub.

A map of succession classes describes the current mixture of vegetation stages. An updated view of the succession classes for the entire ecoregion (Figure F-7) includes early (A-B), intermediate (C-D), and late (E) successional stages. It also includes uncharacteristic vegetation stages, relative to expected natural patterns, including areas where invasive annual grasses dominate the landscape. It can also include uncharacteristic native vegetation, such as where pinyon pine and junipers have extended into adjacent desert scrub due to historic land uses and changes in fire regimes.

Ecological Departure was reported for each CE by each 5th-level watershed. These calculations compare tabular estimates of NRV Succession Class distributions against observed SClass distributions from updated LANDFIRE SClass maps for each watershed. Not all watersheds with this vegetation have reported scores for departure. Minimum area thresholds were applied to each vegetation type to ensure that calculations were completed where there was sufficient aerial extent present to support the characteristic proportions of successional stages. This calculation of departure provides a 0.0 – 1.0 score for each CE within each watershed; with numbers closer to 0.0 showing increasingly severe departure.

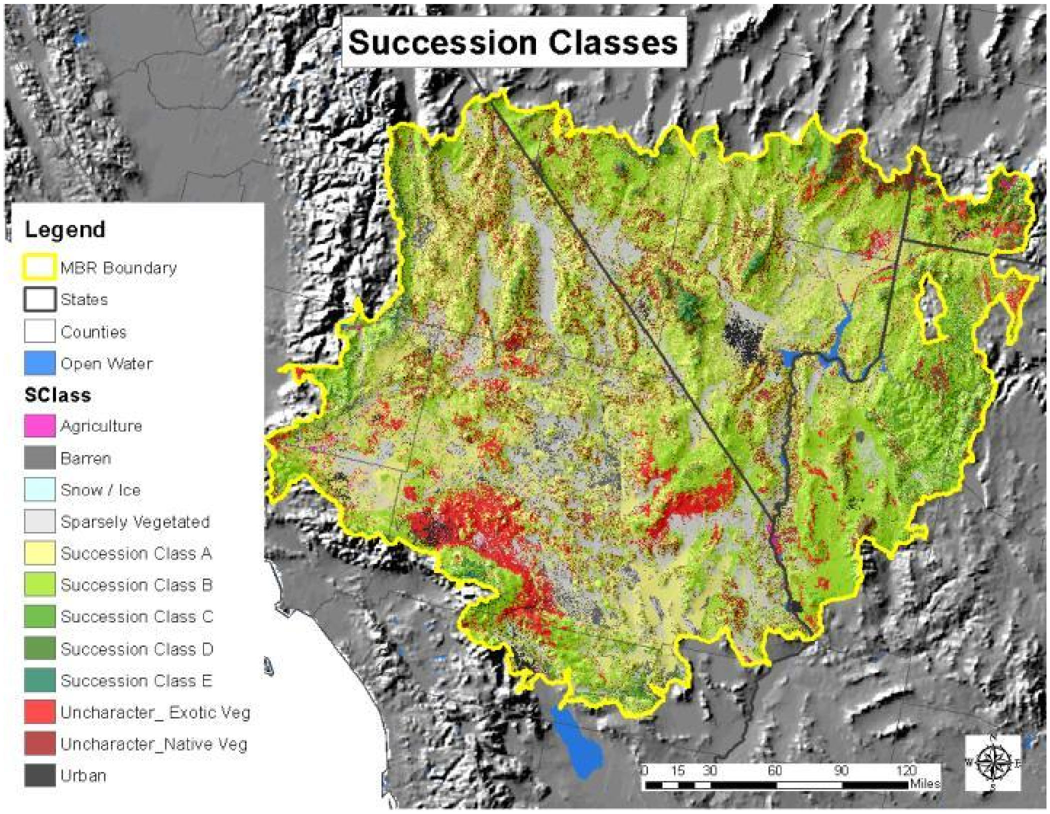

Figure F-7. Updated succession class map for the ecoregion. These succession classes (SCLass) describe the stages within a systems ecological sere. SClasses are defined by relative age and canopy closure; for example Succession Class A captures all early seral stages whereas Class E captures late seral - closed canopy systems. Not all systems are divided into all 5 classes; 2-, 3-, and 4-class systems are common.

Current Departure (Figure F-8) indicated the full range of current departure scores for Mojave Mid-Elevation Mixed Desert Scrub (mesic variant). It indicates that approximately 50% of watersheds where this variant occurs are in a moderately, or severe, state of departure (yellows to reds, scores from 0 to 0.6).

Trends in fire regime departure, at least over the upcoming decades, also indicate some similar trends to those of the landscape condition indicator; i.e., where current status is already scoring lower, those low scores are forecasted to continue. Each state-and-transition model can be run out for future decades, and forecasted conditions may be translated back to each watershed. Two views of forecasted fire regime departure scores by watershed are provided (Figure F-9 and Figure F-10) for Mojave Mid-Elevation Mixed Desert Scrub (Joshua tree and blackbrush communities) across the ecoregion.

As can be seen from the figure, the models do not predict dramatic overall changes in fire regime departure over the next several decades, although there is some improvement in some watersheds and continued degradation in others over the next 50 years. The models also predict that the proportion of the CE in uncharacteristic states (e.g., invasive annual grass dominance or invasion by junipers) will increase over the same period, with those watersheds with the lowest initial percentage of uncharacteristic classes (Figure F-7) showing the greatest increase in these undesirable states. Those watersheds currently with about 10% uncharacteristic states (e.g. with invasive annuals under native shrubs, or with pinyon-juniper invasion) are predicted to transition to be in approximately 30% uncharacteristic states by 2060. In contrast, those watersheds that are currently most converted (~55%

uncharacteristic states) continue to degrade, but much more slowly, reaching ~64% uncharacteristic by 2060.

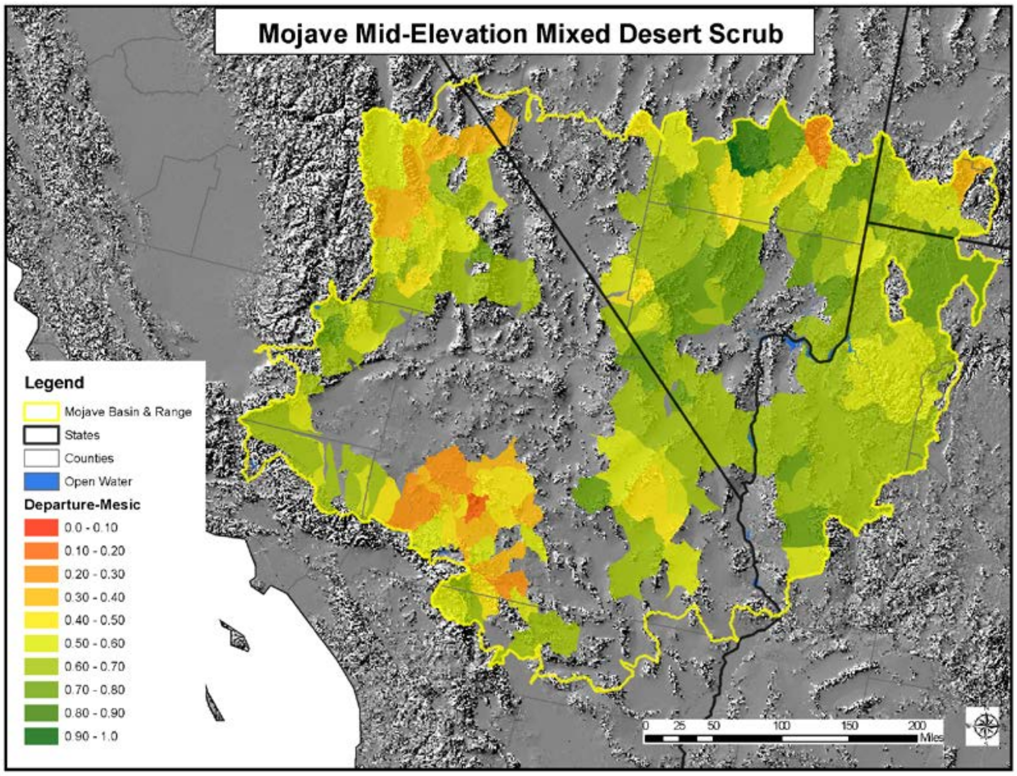

Figure F-8. Current Ecological Departure scores for the Mojave Mid-Elevation Mixed (Joshua tree-blackbrush) Desert Scrub (Mesic).The departure scores range from 0 (highly departed) to 1.0 (not departed) from NRV. No data areas lacked sufficient extent of the vegetation type to estimate fire regime departure.

While one should view the 2060 forecast as having high uncertainty, and this forecast cannot truly integrate the many interacting effects of climate change and the expansion or contraction of invasive plant species and fine fuels. These models do, however, factor in current knowledge of known successional dynamics and realistic timeframes for vegetation response to disturbance, and simulations that increase fire probabilities over time show that several decades or a century are required for significant additional changes in ED. The models also seem to suggest that the proportion of uncharacteristic states will continue to increase over the next 50 years, possibly stabilizing in that time.

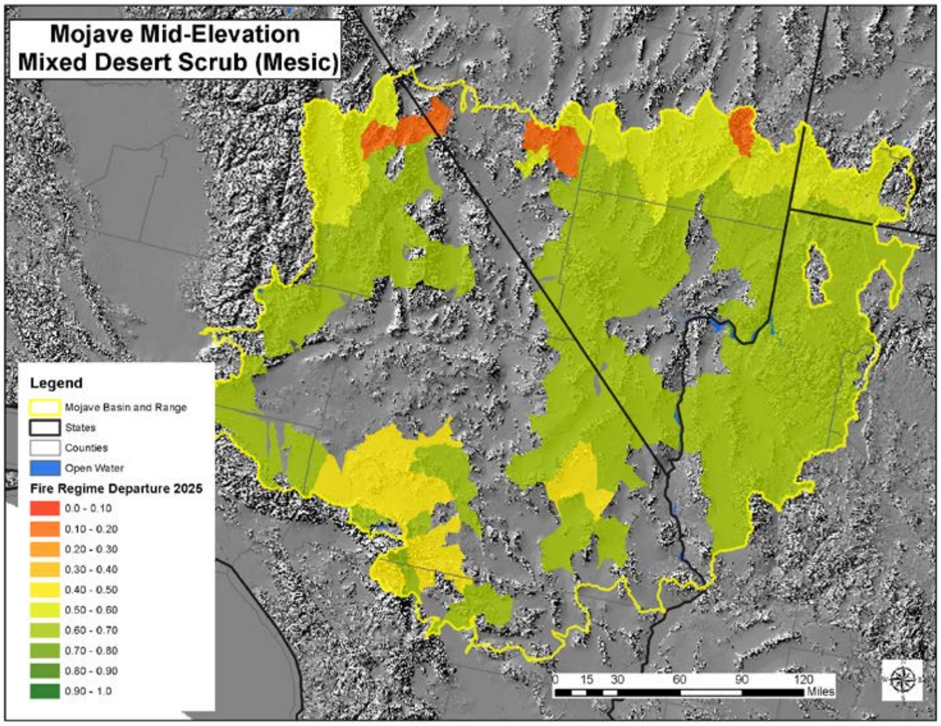

Figure F-9. 2025 Departure: Fire regime departure scores for Mojave Mid-Elevation Mixed (Joshua tree-blackbrush) Desert Scrub (mesic variant) by 5th level watershed. No data areas lacked sufficient extent of the vegetation type to estimate fire regime departure.

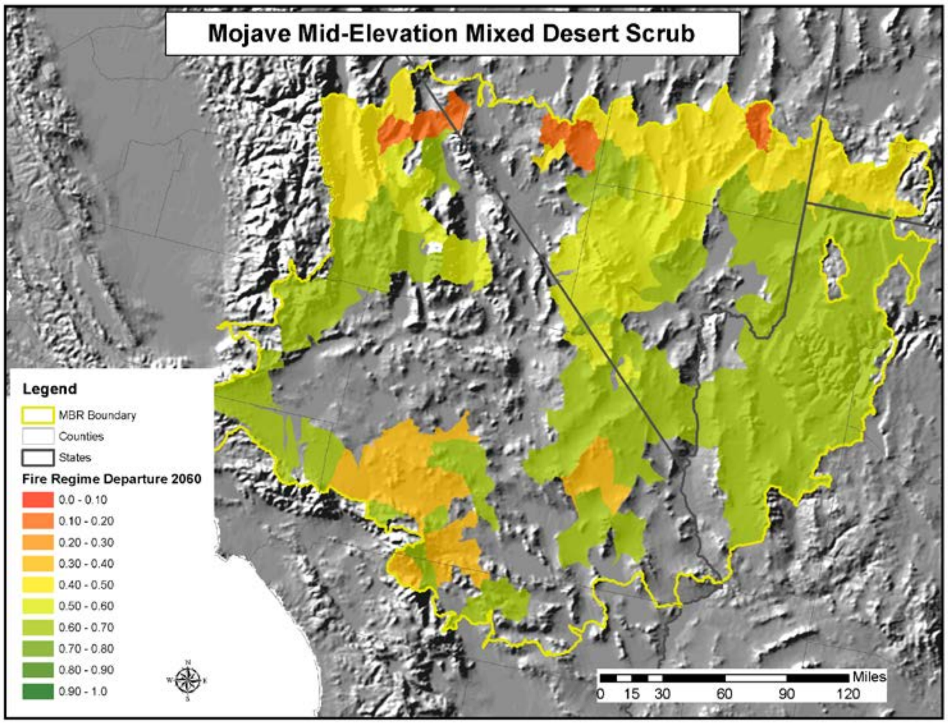

Figure F-10. 2060 Departure Fire regime departure scores for Mojave Mid-Elevation Mixed (Joshua tree-blackbrush) Desert Scrub (mesic variant) by 5th level watershed. No data areas lacked sufficient extent of the vegetation type to estimate fire regime departure.

F-3 References Cited

Barrows, C.W. 2011. Sensitivity to climate change for two reptiles at the Mojave-Sonoran Desert interface. Journal of Arid Environments 75:629-635.

Nussear, K. E., Esque, T.C., Inman, R.D., Gass, Leila, Thomas, K.A., Wallace, C.S.A., Blainey, J.B., Miller, D.M., and Webb, R.H. 2009. Modeling habitat of the desert tortoise (Gopherus agassizii) in the Mojave and parts of the Sonoran Deserts of California, Nevada, Utah, and Arizona. U.S. Geological Survey Open-File Report 2009-1102, 18 pp.

Whisenant, S. G., and F. J. Wagstaff. 1991. Successional trajectories of a grazed salt desert shrubland. Vegetatio 94:133-140.