Integrating Scenario Planning Tools with Wildlife Planning Tools: Informing Land Use Planning in a Rural Desert Landscape via the Morongo Basin Alternative Futures Project

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Abstract

The Morongo Basin Alternative Futures project was undertaken as part of a multi-year regional conservation planning project facilitated by the Sonoran Institute in a rural Mojave Desert setting in Southern California. This innovative approach integrated a normative scenario planning process with a wildlife modeling effort using freely available scenario planning and wildlife modeling software modules in a proprietary Geographic Information Systems setting. Results from this project demonstrate that the integration created a value-added synergy not possible with the implementation of either modeling effort on its own; thus, both analyses were strengthened as useful resources to support thoughtful ongoing and future choices about where and how growth proceeds in the Morongo Basin.

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Executive Summary

The Morongo Basin Alternative Futures project was conceived and implemented as part of a multi-year regional conservation planning undertaken by the Morongo Basin Open Space Group, a collaborative regional planning organization, and facilitated by the Sonoran Institute in a rural Mojave Desert setting in Southern California. The impetus for the project was devising an innovative way to answer questions from local decision makers and land managers that essentially asked "What would the Morongo Basin look like if we *don't* plan for conservation?" Making a case for thoughtful planning and conservation in this area would need to combine both answers to the "what if" type questions about how policy choices made now would impact development patterns 20 or 25 years in the future, as well as address the essential conservation value, expressed across a spectrum of stakeholders in the Morongo Basin, of protecting wildlife connectivity and habitat.

Thus, this innovative approach to integrating a normative scenario planning process, in which the values of the local community were used to develop a set of "alternative futures", with a wildlife modeling process that both *informed* and *was informed by* the scenario planning, was conceived and implemented. Results from the Morongo Basin Alternative Futures demonstrate that the integration created a value-added synergy not possible with the implementation of either modeling effort on its own. As a result both analyses and their results gained value as useful resources in ongoing and future choices about where and how growth proceeds in the Morongo Basin.

The four project objectives were designed to produce products that local decision makers and land managers can reference in helping to chose development patterns that will sustain community values—wildlife, open space, community identity and economic development—over the long term. The objectives:

1. Generate a set of scenario development patterns for the year 2035 reflecting alternative approaches to growth suggested by local stakeholders.

2. Utilize the set of development patterns to visualize the impacts of existing and possible structures on wildlife habitats and movement in the Morongo Basin for each alternative scenario, by integrating scenario output into wildlife analyses.

3. Based on the results of the scenario analyses and the wildlife analysis, suggest which scenario approaches (or combinations thereof) will best serve to support community values.

4. Provide resources and mapping to alert decision makers and developers regarding critical "block points" or other considerations that exist or are possible based on expected growth that can be gleaned from the Alternative Futures analyses.

Development patterns for five alternative scenarios were modeling using Envision Tomorrow Software; Scenario 3, the Compact Development and Conservation scenario, incorporated initial output from Wild Planner, the wildlife modeling module used in the analysis. Envision Tomorrow results, in the form of numeric metrics, differentiated the impacts of the five different scenarios from each other; those results support the wisdom of reducing impacts and the economic benefits of creating compact development patterns that reflect local conservation values.

Results from Wild Planner that examined the impacts on habitat and connectivity for seven different species demonstrated the critical impact that even a small number of development structures can have on an animal's habitat and movement, offering the opportunity to fine tune future development choices to direct growth into the most appropriate and least impactful areas. The results indicate that *any* planned development is better for wildlife than just allowing the Morongo Basin to build out without thoughtful planning.

The implementation of the project highlighted the importance of incorporating experts in such a project as needed to assist community and regional planning efforts to monitor both inputs and results, as well as the critical nature of capacity and support in enabling the use of open access and open source software. The effective utilization of freely available modeling tools in the project strengthens the case for making such tools widely and openly available in an atmosphere of collaborative support for making wise choices about land use in our communities.

Project Background—Why Alternative Futures?

Setting

The Morongo Basin is a 1,400 square mile portion of the Mojave Desert in Southern California that still enjoys its rural lifestyle and abundant wildlife, but is experiencing development pressures both from nearby large population centers (California's Inland Empire, Los Angeles, San Diego) and from the increasing use of the desert setting for energy development. The economy of the area, which supports a resident population of approximately 66,000, is firmly based in tourism generated by Joshua Tree National Park and on the presence of the Marine Corps Air Ground Combat Center at Twentynine Palms. While there has been a long history of local involvement around land use issues[1], in 2006 a group of government, business and community leaders recognized the need for a regional approach to development planning and conservation in the Morongo Basin and formed a collaborative planning partnership, the Morongo Basin Open Space Group (MBOSG).

[1] A prime example of local leadership in conservation and land use issues is the Morongo Basin Conservation Association, a non-profit 501-c-4 organization that has been "looking after the environmental and economic welfare of the Morongo Basin since 1969."

[2] Unfortunately, as of November 2012 that website is no longer functional; however a Morongo Basin conservation

The goal of the MBOSG, which included representation from federal, state and local governments, the development community and local non-profits, was to provide local communities and land managers with information and support to make forward-looking decisions about conservation and growth in this region of the Mojave Desert. Upon hiring a full time regional land use planner in early 2008, community outreach was undertaken to introduce local stakeholders to the regional planning effort via a "Treasures Mapping" exercise. As part of that outreach, groups such as local Rotary Clubs were given maps of the area and asked to pinpoint the locations of their most valued places and treasures in the basin. The resultant maps and responses were used to create a database of these important areas, as well as to reflect back to the community the recognition of the importance of local desert landscapes and their wildlife attributes to local residents and to visitors. A popular response to a treasured place was "my backyard"; and included in the "unmappable" responses gathered in the outreach were such values as dark night skies, clean air, ridge tops and desert wildflowers that pervade the basin.

The next step in the regional planning effort after the mapping of community treasures was a conservation priority setting (CPS) project. Beginning with a two and a half day workshop in 2009, the CPS project was undertaken to define conservation values and identify conservation priorities for the basin. Five conservation values were analyzed and their priorities mapped and published in September 2012 as the *Morongo Basin Conservation Priorities Report: A strategy for preserving conservation values*. Prior to report publication, parcel-based results of the CPS analysis were made available as Geographic Information Systems (GIS) files to local governments, and to the public via an Internet website developed as a capstone project by a student in the M.S. GIS program at the University of Redlands[2].

Need for Alternative Futures and Call to Action

Following the success of the CPS workshop and community outreach, and while the CPS analysis and results were being prepared for print distribution, the MBOSG saw the need to build on the collaborative planning foundation established by its work to date by informing attitudes about approaches to growth taken by local governments making decisions about development patterns. In the Morongo Basin, those entities included two incorporated areas—the city of Twentynine Palms and the town of Yucca Valley—and the remaining unincorporated areas of the planning area in San Bernardino County. While some infrastructure and public functions are undertaken in the community of Morongo Valley by a Community Services District, and while the village of Joshua Tree convenes a Municipal Advisory Council which acts as liaison between local residents and businesses and the County supervisor, land use decision making in those communities and all other unincorporated areas in the MBOSG planning area (the Morongo Unified School District boundary) ultimately rests with the County.

While the work of MBOSG had been mostly embraced by the "choir", including local collaborative partners and community stakeholders, once the potential impact of the work began to be realized, MBOSG collaborative regional planning work began to be seen as somewhat

[2] Unfortunately, as of November 2012 that website is no longer functional; however a Morongo Basin conservation non-profit was recently awarded $4500 in emergency grant funds to contract with GreenInfo Network to re-establish the website and public access to CPS results.

threatening, and the need for planning for growth by a non-governmental body was questioned by some of the local decision makers and land managers. Example attitudes included: "There is plenty of space here for all the people and critters," "I don't think we need to restrict growth in any fashion—we need growth to support our economies and the animals will always be here," and, the most relevant to MBOSG's subsequent choice of focus—"Show me what it would look like if we *don't* plan for wildlife."

Scenario planning alone could not address the "show me, what if" request. By using scenario planning in combination with wildlife modeling tools, the potential impacts of different development choices on the treasures that the community had identified could be considered in advance. Thus, the Morongo Basin Alternative Futures project was conceived—a project integrating Envision Tomorrow scenario modeling tools and Wild Planner wildlife modeling tools.

Questions about what the Morongo Basin would look like without planning for conservation and why scenario planning is important were being posed by local decision makers and land use planners in the context of the economic realities of the past several years that impacted local government budgets and perceptions of the value of growth to the communities. The Morongo Basin conservation planning effort has always embraced the question of where and how growth occurs, and worked to provide resources and products that support an appropriate balance between growth and conservation.

In addition to the local, basin-based perceived need, it was also recognized that the Morongo Basin, as part of the larger California Mojave Desert, is part of several larger, regional-scale planning efforts at the state and federal level that will have profound impacts the future of the desert ecosystem. Such impacts include the ability of plants and animals to persist in view of proposed large scale energy developments, as well as to respond to changes in climate that are predicted to affect both temperature and precipitation regimens in this area that already experiences of temperatures and marginal precipitation. Results of the Alternative Futures inquiries were designed to be used to respond to existing and proposed plans for management and development of the Morongo Basin in the context of these larger scale planning efforts, many of which are related to national efforts to take advantage of the abundance of solar and wind resources in the California deserts.[3]

Project Objectives

Based on perceived need and applicability, Alternative Futures project objectives and research goals were focused on how to integrate wildlife and habitat indicators into a typical scenario

[3] These include the ongoing Desert Renewable Energy Conservation Plan for seven California Counties, a Habitat Conservation Plan/Natural Community Conservation Planning process; the BLM's six-state Solar Programmatic EIS (Record of Decision issued October 2012) that sets aside lands for potential solar development on BLM lands; BLM land planning in the area for the Marine Land Acquisition and Airspace Establishment project exploring the expansion of the Marine Corps Air Ground Combat Center at Twentynine Palms (www.29palms.marines.mil/Staff/G4InstallationsandLogistics/LandAcuisition.aspx); as well as the West Mojave Resource Management Plan amendments and implementation that include possible surplus lands exchanges or transfers.

analysis to produce products that local decision makers and land managers can reference in helping to chose development patterns that will sustain community values—wildlife, open space, community identity and economic development—over the long term. Fregonese Associates' Envision Tomorrow software was chosen to model scenarios; Wild Planner from Craighead Institute was employed to model wildlife habitat and connectivity.

Thus, the project objectives were:

1. Generate a set of scenario development patterns for the year 2035 reflecting alternative approaches to growth suggested by local stakeholders. (For the conservation-oriented development pattern, integrate results from initial wildlife analyses to inform scenario development).

2. Utilize the set of development patterns to visualize the impacts of existing and possible structures on wildlife habitats and movement in the Morongo Basin for each alternative scenario, by integrating scenario output into wildlife analyses.

3. Based on the results of the scenario analyses and the wildlife analysis, suggest which scenario approaches (or combinations thereof) will best serve to support community values.

4. Provide resources and mapping to alert decision makers and developers regarding critical "block points" or other considerations that exist or are possible based on expected growth that can be gleaned from the Alternative Futures analyses.

Project Implementation—Using Envision Tomorrow and Wild Planner

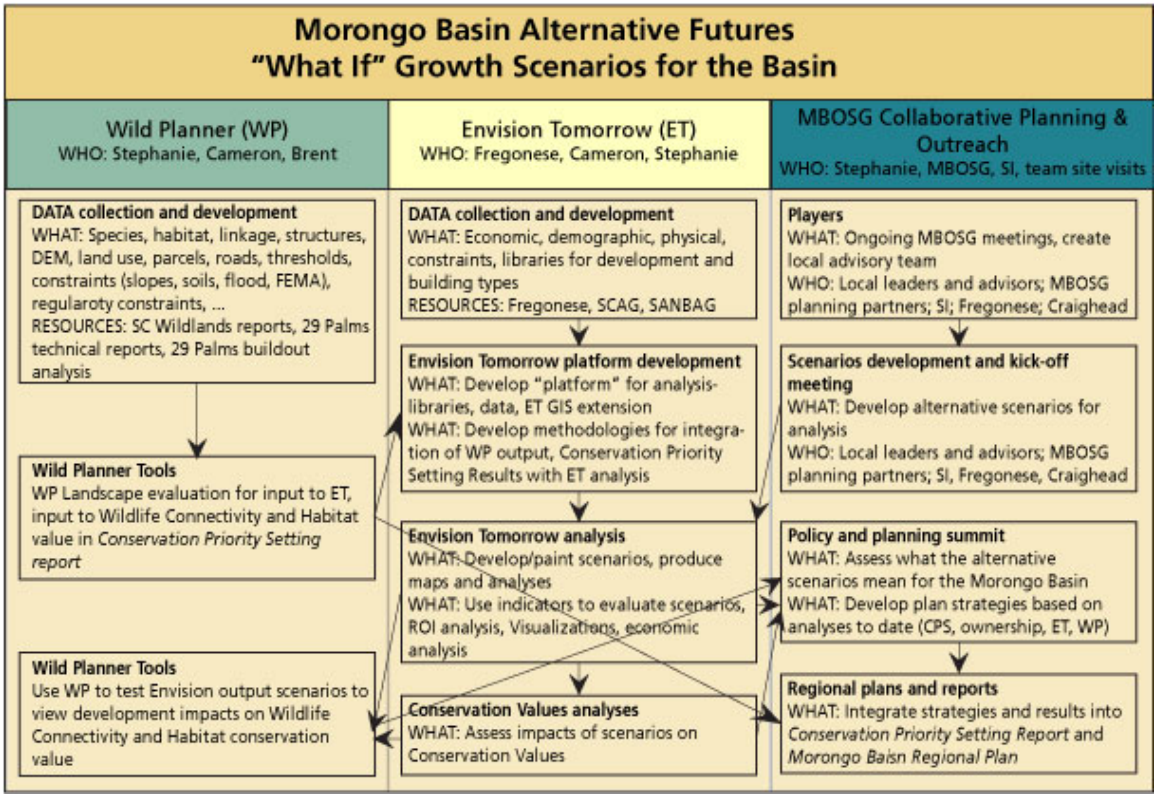
Once the objectives were set, questions of how this project would be implemented were raised. Funding for the project came in part from support made available to ongoing MBOSG planning efforts through the Desert Legacy Program of The Community Foundation Serving San Bernardino and Riverside. Additional funding was made available through Western Lands and Communities, a Joint Venture of the Lincoln Institute of Land Policy and the Sonoran Institute, organizations with a keen interest in supporting and facilitating access to tools for planning (see Holway et al. 2012). Both the scenario planning and wildlife planning modeling tools were available from the developers without charge; supporting the goals of creating an open source/open access environment for planning decision making. The GIS platform necessary to implement and run both of the modeling tools (Esri's ArcGIS) does require a paid license; however, Esri provides some cost breaks for non-profit organizations to purchase and license the software.

The integration of scenario and wildlife modeling was a learning process, designed to understand how different software programs could be made to "talk" with each other and, by communicating, add value to the context of the larger collaborative planning effort being undertaken. The ability of different software programs and their extensions (here referring to the widely used Esri ArcGIS software and the numerous extensions created to work with that state of

the art software) to assimilate output and generate input in a seamless manner is an issue in the larger context of open source/open access software. The current state of the art when using open source or open access tools often involves manipulations of data output as well as programming and reformatting that require some level of expertise. Several of these instances of manipulation that allowed data to flow between the Envision Tomorrow scenario software and the Wild Planner wildlife modeling tools are discussed in sections below.

The diagram in Figure 1 was used to introduce the Alternative Futures project to the stakeholders participating in public meetings conducted by the Open Space Group during 2011, and depicts the integration of the Envision Tomorrow and Wild Planner software programs with the MBOSG community planning process.

Figure 1: Interactions between Alternative Futures Project Components



In addition to dialogue between software platforms, the Alternative Futures project also involved dialogue and interaction between staff and experts who conducted the individual analyses, provided input data and who worked to integrate and synthesize the results. The MBOSG facilitator served as the main liaison between most of the experts and the community; some local experts and MBOSG participants were called on to provide local calibration parameters to the Envision Tomorrow worksheets, such as the input based on a Developer Interview Survey developed by Fregonese Associates (see Appendix A).

Figure 2 summarizes the assemblage of software, expertise and inputs that were necessary to implement the Alternative Futures project.

Figure 2: Alternative Futures Project Software, Expertise, and Inputs

Alternative Futures Project Software, Expertise and Inputs

Software	Description
ArcGIS	GIS software developed by Esri
Envision Tomorrow	ArcGIS and Microsoft Excel extension, developed by Fregonese Associates, scenario modeling
Wild Planner	ArcGIS Toolbox developed by Craighead Instititute, wildlife modeling
Expert	**Expertise**
Fregonese Associates	Envision Tomorrow
Sonoran Institute	ArcGIS, Envision Tomorrow, data preparation for Wild Planner, community planning, economics
Craighead Institute	Wild Planner
Source	**Inputs**
Southern California Assocated Governments	Population estimates and projections; Envision Tomorrow building and development types libraries
SC Wildlands (now Science and Collaboration for Connected Wildlands)	Focal species GIS files and species parameters
Local developers	Envision Tomorrow calibration parameters based on Developer Interview Survey
Morongo Basin Open Space Group stakeholders	Development of scenarios, building and development types
U.S. Bureau of the Census, State of California Department of Finance, California Employment Development Department	Demographic and jobs/housing data for scenario development

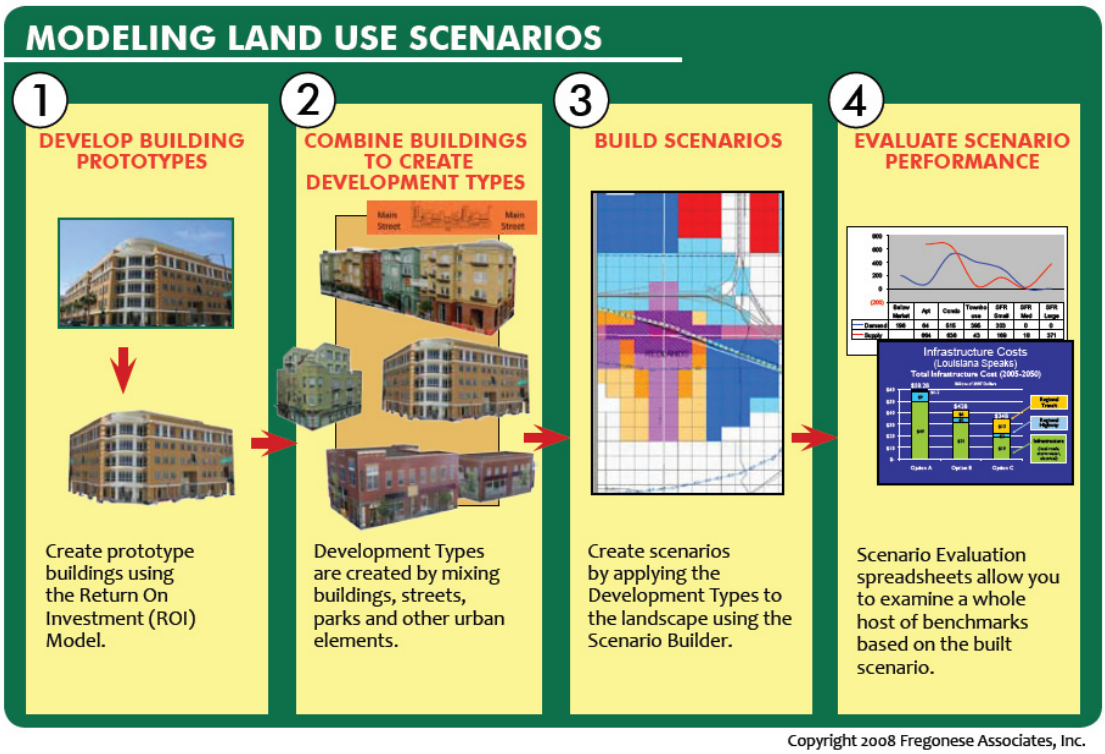
Initial implementation of the Alternative Futures project was undertaken along two parallel tracks—one using Envision Tomorrow's Scenario Builder, the other involved an initial analysis of habitat and connectivity using Wild Planner tools. Envision Tomorrow is designed to allow planners and communities to design and test the ways in which different land use and transportation choices—alternative scenarios—will shape local neighborhoods and open spaces. The Wild Planner conservation planning tool excels at modeling the cumulative effects of development on wildlife, building on regional wildlife analyses (such as the SC Wildlands linkage designs) to "drill down" to identify very specific priority areas for conservation action. (Appendix J in this document contains a number of such species-specific recommendations).

The discussion below describes development of the Alternative Futures scenarios via implementation of the Envision Tomorrow component of this work, followed by a discussion of implementing and integrating Wild Planner into the Alternative Futures planning effort.

Alternative Future Scenarios Development

The creation of scenarios using the Envision Tomorrow modeling software depends on the development of a set of *building prototypes* that are combined to represent a set of *development types* appropriate to the area of interest being modeled. The building prototypes and development types are defined and captured in an Envision Tomorrow *scenario spreadsheet* (an Excel spreadsheet that interacts with the ArcGIS software). Scenarios are built by "painting" different development types on a GIS-based map of the area of interest. The scenario spreadsheet, including its parameter and indicator metrics, is updated in the GIS environment to reflect the spatial extent of the areas "painted" with the different development types. The impacts of these different Alternative Futures can then be evaluated using the metrics that the program produces based on spreadsheet parameters. Figure 3 illustrates the steps in the scenario modeling.

Figure 3: Using Envision Tomorrow to Model Land Use Scenarios



Fregonese Associates © 2008

Defining the Scenarios

Defining the five scenario themes that were ultimately used in the project was an iterative process that overlapped the discovery and development of other inputs (e.g. the building

prototypes and development types depicted in Figure 3 above). Discussions were held as part of bimonthly MBOSG meetings that occurred between June and October of 2011 around which scenarios would best help demonstrate and assess the impacts of different approaches to development and growth. This approach to scenario planning, where the premises of the chosen scenarios are based in different approaches to major policy and land use choices, is an instance of the "normative" scenario planning that has been extensively implemented in communities and regions to assess how the answers to different "what if" policy choices for a relatively short planning horizon will affect the development forms of the considered area[4]. This approach resulted in the spectrum of scenarios described below.

From a longer list of eight scenarios brainstormed in the initial meetings, the number of total scenarios was reduced with further deliberation and discussion (for the most part eliminating perceived overlaps and redundancies). Five scenarios were selected from a number of proposed scenarios as Alternative Futures for the Morongo Basin. Additionally, a base (or existing) scenario and full buildout scenario were developed for comparison purposes. Several of the scenarios reflected the aims and vision of regional planning efforts as articulated by the Open Space Group and participants in public meetings, namely:

- **conservation values** (the five analyzed in the Conservation Priority Setting process: Protection of the Marine Base Mission, Protection of the National Park Mission, Wildlife Habitat & Connectivity, Community Identity, and Community Views & Treasures; see Appendix B);

- **conservation science** (wildlife linkage design studies[5] prepared by SC Wildlands); and

- the four MBOSG **regional planning goals** (Buffers and Separators, Connectivity, Community Values, Water Quality and Quantity; see Appendix C).

Figure 4 below summarizes the five scenarios and how they reflect the regional planning interests described above. It should be noted that all of the scenarios are designed to be balanced approaches in their own right; that is, each scenario contains elements of the others. However, the different scenario emphases have been created to demonstrate how different policy approaches could manifest in terms of land use development patterns (as shown by the results of the scenario analysis), resource utilization (indicated by the values of the metrics developed by Envision Tomorrow) and impacts on wildlife connectivity and habitat (as measured by Wild Planner tools).

[4] This type of normative scenario planning can be contrasted with a more anticipatory type of scenario planning known as *exploratory scenario planning*, that is designed to incorporate into scenario planning some of the uncertainty in local futures than results from changes that are beyond local control, for example climate change, economic fluctuations, and demographic and population shifts.

[5] *A Linkage Design for the San Bernardino-Little San Bernardino Connection*, 2005, performed as part of the South Coast Missing Linkages study; and *A Linkage Design for the Joshua Tree-Twentynine Palms Connection*, 2008, funded by Open Space Group planning partners (The Wildlands Conservancy and Joshua Tree National Park) to support local conservation planning. The reports are available at www.scwildlands.org/reports.

Figure 4: Alternative Futures Scenarios

Scenario	Description	Regional Planning Interests Reflected
Scenario 1	Existing General Plans	Community Values
Scenario 2	Jobs/Housing Balance and Fit	Community Values
Scenario 3	Compact Development and Conservation	Wildlife Connectivity & Habitat; Community Identity; Conservation Science (Linkage designs and Wild Planner); Buffers and Separators; Water Quality and Quantity
Scenario 4	Rural Living Emphasis	Community Views and Treasures; Community Identity; Community Values
Scenario 5	Base and Park Mission Protection	Base Mission Protection; Park Mission Protection; Buffers and Separators

Different "scenario thinking" approaches for each scenario made use of different data sets and potential policy approaches to growth in the Morongo Basin, while starting from the same basis of existing development and population in the region[6]. As explained above, the scenarios were intended to be realistic approaches that balanced some elements of all of the approaches to growth, but emphasized a particular aspect of where and how growth might occur. The descriptions below elaborate on the rationale for each of the five scenarios in the context of current conditions and anticipated futures, and summarize the approach used in implementing the scenario in Envision Tomorrow.

- *Scenario 1* utilizes existing general plans and the associated zoning from the plans to distribute growth across the region. Twenty years ago all the land in the basin was under the jurisdiction of the County of San Bernardino. Around that time the City of Twentynine Palms and the Town of Yucca Valley incorporated, so current land use within those boundaries is regulated and zoned by those entities. That said, the City and the Town inherited county zoning, and there have not been major changes to that general approach to zoning (which includes large spatial areas of lands zoned as "Rural Living"[7]) since that time. The Town is currently undertaking a General Plan update that may impose changes; however a recently adopted updated City General Plan does not impose any major changes on land use zoning. *In this scenario, growth is directed to the areas*

[6] A Morongo Basin base population for 2010 of 66,235 persons was used for the analysis, based on data from the Southern California Association of Governments. A projected 2035 population of 83,117 was used for the scenario modeling, based on state and regional growth projections. Thus, each scenario was designed to distribute an additional 16,882 persons (more or less) across the landscape. Envision Tomorrow is used primarily to model future, rather than existing, development.

[7] Rural Living is a county zoning designation that is reflected in current Town and City zoning codes, as well as in much of the unincorporated area of the Morongo Basin. The Rural Living designation is most commonly used on 1 to 10 acre parcels, and most of the land area outside the cores of the Town and City is zoned Rural Living.

currently zoned for the type of growth reflected by the development type assigned, in roughly the proportions of existing development.

- *Scenario 2* employs recent California Employment Development Department job mix numbers to simulate a jobs/housing balance in the Morongo Basin that resembles the California profile[8]. Envision Tomorrow calculates job creation as a function of development type, and that information is used interactively to model jobs and housing growth in the basin. The current job profile of the area is more heavily weighted toward retail than the state profile. To mirror the state mix, the area would need to retool its employment profile by developing more town-centered, "urban" spaces that offer more office jobs and potential for employment that provides desirable local jobs, rather than relying on jobs that take residents outside the area to work.

- Participants in public meetings held by the MBOSG also expressed desires for a diversity of jobs at a variety of skills levels, jobs that take advantage of the skills of retirees, and jobs that support the demographic profile of the Morongo Basin and keep medical visits in the basin. Renewable energy jobs were also cited as holding potential for local residents. There are many aspects of this scenario that could be expanded on in a more in-depth examination of jobs and housing in the Morongo Basin. *This scenario directs growth and development in a manner that distributes employment to mirror the state's distribution, while directing adequate housing for employees in locations near the workplaces. Growth is directed by locating development types that provide the desired job mix in locations where housing development tended to exist (infill and in existing communities), including an emphasis on mixed use development.*

- *Scenario 3* uses initial results from Craighead Institute's Wild Planner, conservation science results from the SC Wildlands linkage design studies, and the existing planning boundaries of the four largest communities in the Morongo Basin (unincorporated Morongo Valley and Joshua Tree, and the incorporated communities of Yucca Valley and Twentynine Palms) to direct growth. For areas in denser community centers that already have development, growth is envisioned with an emphasis on infill. In relatively more rural areas, growth is directed toward lower conservation priority areas for wildlife, including areas deemed "compromised" by the Wild Planner analysis, avoiding SC Wildlands wildlife linkage areas and avoiding higher quality linkage areas as determined by the Wild Planner analysis. *In this scenario, growth is directed both to infill and existing developments in established communities, as well as some growth in rural living areas that did not overlap either: SC Wildlands linkage design areas; parcels ranked as a High Priority for Wildlife Habitat & Connectivity in the Morongo Basin Conservation Priority Analysis; or the areas identified as "not yet impacted" as defined by the initial Wild Planner analysis.*

[8] The distribution for California employment used in the scenario was 46% office, 33% retail and 21% industrial. Job growth percentages used mimic population growth, such that a total of approximately 6,000 new jobs were being added to existing jobs.

- *Scenario 4* acknowledges the desires on the part of many who move to the desert to experience their own "piece of the desert", by directing residential growth to the previously described areas zoned Rural Living in the basin. In part, the existing development pattern throughout the basin is a legacy of the Small Tract Act of 1938. One of the last of the homestead acts in the U.S., the Small Tract Act created a checkerboard of public/private lands in the basin that is reflected today in land ownership patterns that include many 2 to 10 acre parcels of alternating and juxtaposed private and public land. This scenario continues that pattern, with some consideration of keeping the wildlife linkage designs intact, as backyard wildlife is one of the community treasures that local residents have said they value. There is an inherent contradiction in this approach in that additional (as well as existing) development has the potential to negatively impact the quality of habitat and connectivity for local wildlife. *In this scenario, the focus of residential growth is directed primarily to areas zoned rural living of the city, town and county, while respecting the general locations of the SC Wildlands linkage design areas.*

- *Scenario 5* makes direct use of the Morongo Basin Conservation Priority Setting (CPS) project results summarized in the *Morongo Basin Conservation Priorities Report: A strategy for preserving conservation values,* specifically targeting growth to protect and enhance the missions of the local Marine base and national park. During the CPS process, Park and Base personnel contributed to developing the criteria for prioritizing parcels by defining specific *qualities* of a parcel that are important in helping them best perform their missions (these mission protection features are listed in Appendix B). This approach acknowledges that mission fulfillment for the base and the park is affected by land use activities beyond their borders. *Development under this scenario is generally directed away from those parcels ranked as "high priority" for these two conservation values—Park Mission and Base Mission. As with all the scenarios, this one is approached as a balanced and realistic alternative to growth and development in the basin that puts an emphasis on mission protection, while modeling growth using all of the development types that were part of the Envision Tomorrow analysis.*

Modeling Assumptions

A base population for 2010 of 66,235 persons was used, based on data from the Southern California Association of Governments. A projected 2035 population of 83,117 was used for the scenario modeling, based on state and regional growth projections. Thus, each scenario was designed to distribute an additional 16,882 persons across the landscape. Envision Tomorrow is designed to model future, rather than existing, development, therefore the scenarios were "painted" onto parcels that were either vacant (the majority) or assigned for infill or redevelopment.

For purposes of the modeling there were no major changes in boundaries assumed, including the boundaries of the marine base, the national park, or the two local incorporated jurisdictions. While there is a current proposal waiting final approval to expand the lands that the Marine Base uses for training, this would impact BLM lands in the area, not developable private lands. Similarly, some BLM lands on the north boundary of Joshua Tree National Park are included in the proposed California Desert Protection Act, which is awaiting consideration in Congress, and

could potentially be transferred to the Park changing its boundaries but not impacting private lands. Either the Town or City could potentially annex adjacent County lands into their jurisdiction, although in that event it is likely that existing zoning would remain relatively intact for the foreseeable future. It should be noted that a 2009 proposal by Yucca Valley to annex the area to the north and east of the town known as Yucca Mesa was met with fierce local opposition; the City of Twentynine Palms currently encompasses a large land area that includes much undeveloped area.

Building and development types used in the Envision Tomorrow modeling were derived for the most part from a library that had been used by Fregonese Associates and Sonoran Institute in rural Garfield County, Colorado[9]. While the Garfield County types were used as a basis, there were several adjustments that needed to be made to many of the parameters, including adjusting the landscaping parameters to reflect the desert setting as well as modifying some of the square footage parameters, reworking rural block sizes based on actual measurements taken from current air photos, tweaking densities of intersections based on road patterns in the basin, adjusting housing densities upward in cities and downward in suburban areas, developing a mixed use approach that was more horizontal than vertical to reflect current and anticipated development configuration, and adjusting assumptions about square footage per employee for job estimates based on California data. The Envision Tomorrow "Developer Interview Survey" (see Appendix A) was used to calibrate planning assumptions in the Envision Tomorrow software based on responses by local developers. It should be noted that the expertise and experience of Fregonese Associates was essential to help calibrate the parameters and assumptions for the modeling; this was done in concert with discussions of and feedback regarding the on-the-ground reality of the landscape by local Morongo Basin experts and stakeholders.

Community Concerns

The ongoing development of the platform and inputs for the scenario modeling were reviewed and discussed at a number of meetings of the MBOSG. The following are some comments and discussion that were considered at the October 2011 meeting of the MBOSG. While these are specific to the Morongo Basin Alternative Futures project, they are likely representative of the types of concerns that local stakeholders may have regarding this type of analysis. Thoughtfully anticipating and responding to concerns during and after a project such as the one presented here can help to increase both the ownership in and the credibility of the final project, leading to an increased probability of the results being incorporated into decisions about where and how growth occurs.

Stakeholder comments included:

- The rural living emphasis scenario [Scenario 4] assumes that there will be continued permitting of septic systems at 1–20 acre densities. Is this a reasonable assumption? Over a 20–30 year time horizon, this assumption may be valid for the unincorporated areas,

[9] Southern California Associated Governments (SCAG) offered to share its building and development libraries for the project; however the suitability of the libraries was not deemed appropriate for the rural desert setting.

less likely for the Town (which is currently under a state mandate to develop a sewage treatment program), and possibly the City or parts of the City.

- How are sustainability and sustainability principles being incorporated into the scenarios? For example, the local organization Transition Joshua Tree is working with many sustainability principles, including providing more food locally. How can these concepts be integrated into the scenarios?

- In general, a balanced approach to growth and development was seen as most important. The real future will likely be a balance of all of these approaches to development. A "preferred alternative" scenario will likely incorporate elements of more than one scenario.

- Scenarios should be realistic in terms of compliance with local and state regulations and mandates, such as AB 32 and SB 375 and the Regional Housing Needs Allocation[10], with regard to jobs, housing and compact transit-oriented development.

- Make sure to call on the expertise and advice of MBOSG partners and the jurisdictions involved to create the best inputs for the scenario modeling.

Envision Tomorrow Processing Platform

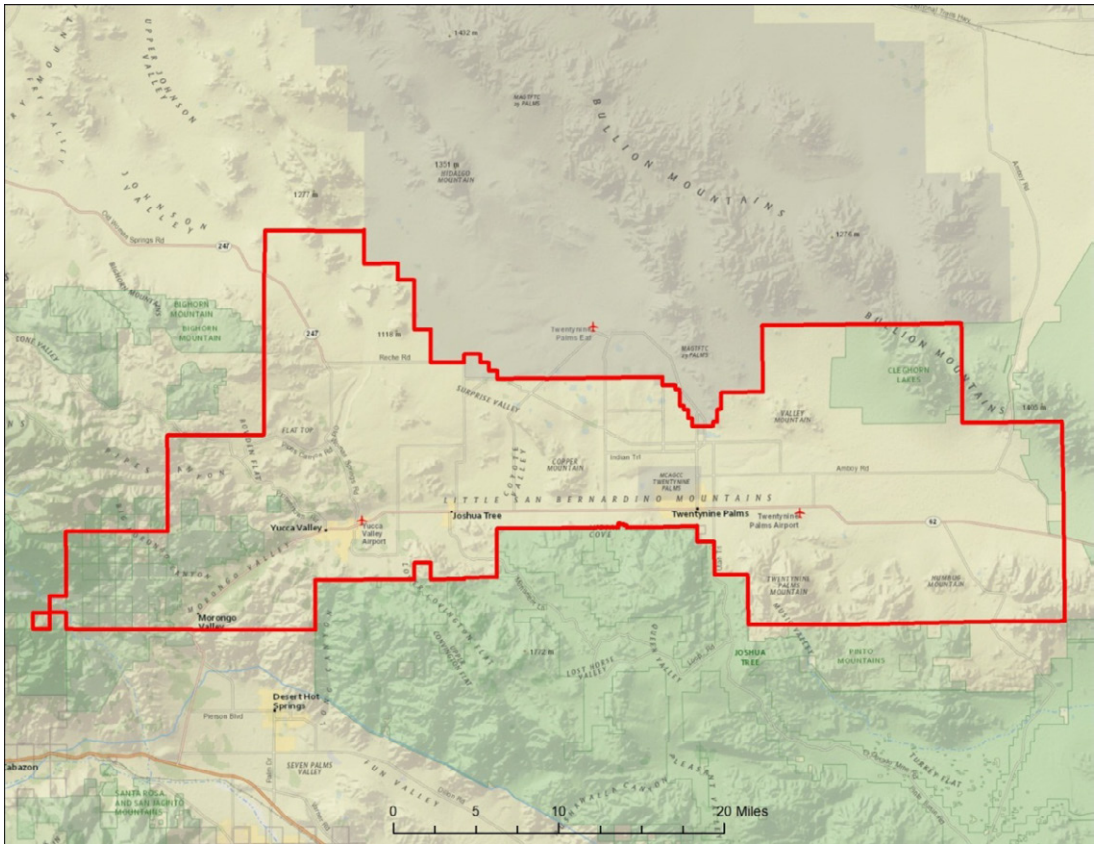
There are two primary types of data that need to be prepared for an Envision Tomorrow scenario process: 1) data for the GIS "platform", and 2) development-specific data to create the building prototype library and scenario spreadsheet. Both are discussed in separate sections below.

Envision Tomorrow Platform Data

The Envision Tomorrow platform is based on assessor's parcels. Parcel data for the Morongo Basin was available directly from the San Bernardino County website and was obtained in June 2011. The publicly available parcel data is a GIS dataset containing both spatial data and attribute data. The attribute data for each parcel includes a unique identifier (the Assessor's Parcel Number—APN), ownership information, value of land and improvements and a use code. The spatial data are the parcel boundaries. For the purposes of this analysis, the county parcel dataset was subset to coincide with the boundary of the Morongo Unified School District Boundary—the project area of the MBOSG. Subsequently, those parcels that fell within with Marine Base and Joshua Tree National Park were removed. The resultant modeling area (Figure 5) contained approximately 64,000 parcels.

[10] AB 32 is California's Assembly Bill 32—the California Global Warming Solutions Act. SB 375 is California's Senate Bill 375, The Sustainable Communities and Climate Protection Act of 2008, landmark legislation designed to reduce greenhouse gas emissions through transportation and land use planning. The City, Town and County need to allocate housing needs and plan for allocations based on state and regional mandates. If jurisdictions do not comply with planning for regional housing needs in their housing elements and general plans there can be penalties. The Morongo Basin is a small part of the SCAG regional planning area. See http://www.scag.ca.gov/factsheets/pdf/2009/SCAG_RHNA_Factsheet_0509.pdf for a brief SCAG factsheet on RHNA—the Regional Housing Needs Allocation.

Figure 5: Morongo Basin Showing Spatial Extent of Envision Tomorrow Modeling Area



Development patterns—that is, the arrangement of physical structures across the landscape—are a critical consideration in examining possible futures and the impacts that development may have on wildlife connectivity and habitat, open spaces, viewsheds, and other valued characteristics of the Morongo Basin. While spatially explicit structure data was not available for the Morongo Basin, existing development data was needed for both the Envision Tomorrow and Wild Planner analyses. Inputs for Envision Tomorrow were readily derived from parcel data based on data contained in the parcel GIS data set that indicated whether a parcel had been improved or not, using the value listed in the Improvement field of the GIS database. However, Wild Planner needs to know the exact location of the structure. Anticipating these requirements, structures were geo-located onto the parcels using the methodology below and stored in a separate GIS "structures" layer.

> Presence or absence of a structure was determined using the "Improvement Value" field in the parcel database. If any improvements were done to the parcel, i.e. if the improvement value was greater than $0, the parcel was assigned a structure. For parcels under five acres, the structure was automatically assigned to the center of the parcel. For parcels over five acres, structures were digitized using Esri streaming imagery that allowed the GIS operator to digitize a structure based on the actual location as viewed on the imagery.

More data processing was needed to create a GIS platform compatible with the Envision Tomorrow "paint tools", which are used to assign development types to areas on the ground

using a set of mouse-driven tools to select different parcels (or portions thereof) by "painting" them with different colors symbolizing the different development types. The GIS portion of the Envision Tomorrow package communicates with the Excel scenarios spreadsheet that is viewable onscreen in a window that is available during processing. Each parcel (or portion thereof) can only be assigned to one development type. For that reason, as there are many large developable parcels in the analysis area which would likely be subdivided for development, larger parcels were subdivided so that they could be assigned different development types. Based on consideration of the landscape and using the SCAG work as a model, the parcel grid was broken up such that all parcels larger than five acres were divided into *five acre portions*, thus allowing higher resolution assignment of development types via painting with the Envision paint tool.

Following the adjustment of the larger parcels to smaller components, the parcel grid was modified to reflect physical and legal building constraints existing in the Morongo Basin. This created a "buildable layer" for the Envision Tomorrow analysis that prevented the user from imposing new development types onto lands not available for development. Elements removed from the buildable layer included: protected areas, public land, water, conservation easements and roads and rights-of-way. Then this "buildable layer" shapefile was imported into an Esri file geodatabase format and linked to the Envision Tomorrow processing tools using the Envision Tomorrow ArcGIS Extension. This layer was the platform used to create the canvas for all five scenarios.

Envision Tomorrow Development Data

Envision Tomorrow creates scenarios that assign different development types to actual parcels on the ground; the development types are assembled from building types, the most basic component parts of an Envision Tomorrow scenario (refer to Figure 3). Building types are mathematical representations of individual buildings, developed using a detailed Excel spreadsheet that tracks numerous metrics associated with the construction, rent, energy use, parking and price of the building. These building types are then bundled into the development types which correspond roughly to neighborhoods. In the Envision Tomorrow spreadsheet a development type is defined by the percentages of different building types, and includes parameters on land use, redevelopment rates, jobs and housing. Each development type consists of at least one building type, usually more, and several "urban character" metrics associated specifically with neighborhoods, such as street width and parks/open space.

Given the detailed nature of the data, and regional nuances associated with building costs, building and development type libraries must be tailored to the region. Data that went into the assembly of the building and development typologies was the result of inputs from multiple sources, including: the libraries used in a recent Sonoran Institute project in Garfield County, Colorado, a rural area with some similarities to the Morongo Basin; and a building library provided by Mark Butala at the Southern California Association of Governments (SCAG). The SCAG development types had been used in other Envision Tomorrow projects in Southern California. Although the Morongo Basin is located in reasonable geographic proximity to the areas of the SCAG analyses, the building types used by SCAG generally represented development densities much higher than those currently found in or projected as being

acceptable in the Morongo Basin. Thus, the Garfield County data was the main basis of the libraries, however in the final analysis the building and development types were "truthed" using input from local developers, local stakeholders (including several discussions at MBOSG meetings) and from the Sonoran Institute planner/facilitator on the ground. As discussed in the section above on assumptions, a developer interview spreadsheet that Fregonese Associates developed was used in the interviews (Appendix A), and Fregonese Associates assisted with a final revision and review of the scenario spreadsheets.

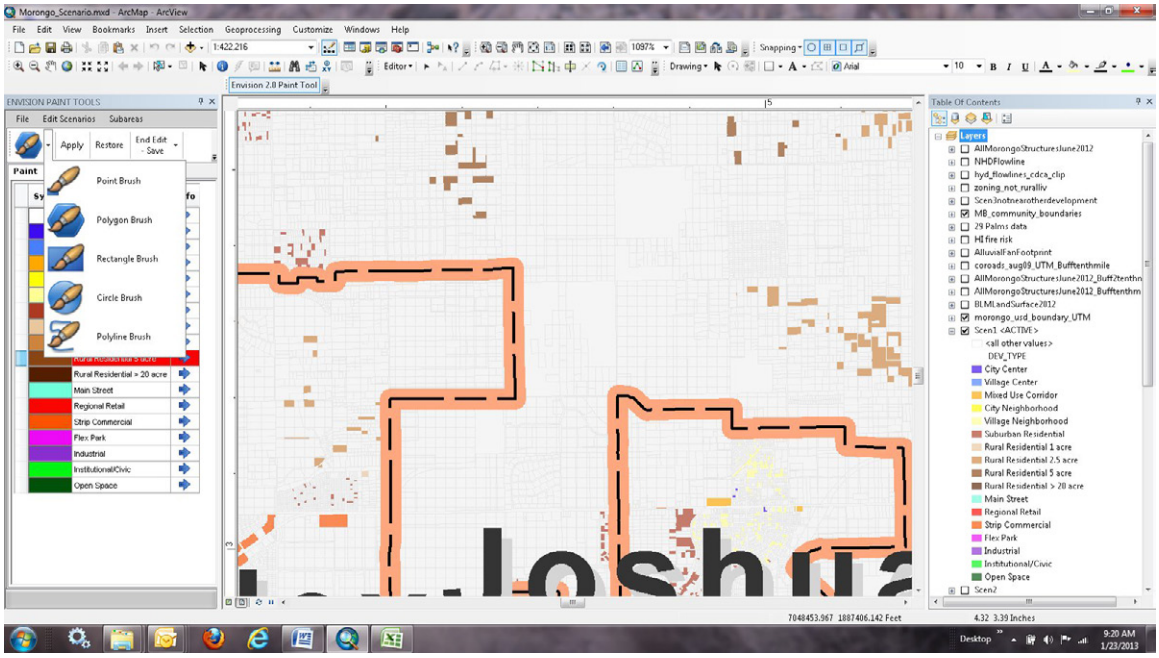
Twenty-six building types were defined and used in assembling seventeen[11] different development types. The building and development types and their descriptions can be found in Appendix D.

"Painting" the Scenarios

Once the scenarios were defined, the development types "paintbox" was used to assign a development type to each parcel (or 5-acre portion of the parcel for the larger parcels) by painting developable parcels. As noted above, parcels with certain characteristics and land uses (protected areas, public lands, water, conservation easements, roads and rights-of-way) were excluded from this buildable layer so they could not be assigned a development type. The "palette" used for painting included the parcels layer described above and shown in Figure 5, as well as additional GIS data layers that informed the painting—for example, community boundaries, locations of major desert washes, topography, wildlife linkage designs, results from the conservation priority setting analysis, and other layers as appropriate to the aims of the five alternative approaches to growth and development. Figure 6 shows a screen copy of one of the painting environments.

[11] "Open Space" is included in the list of development types, even though there are no structures allocated in those areas.

Figure 6: Painting Development Types in the Envision Tomorrow Environment



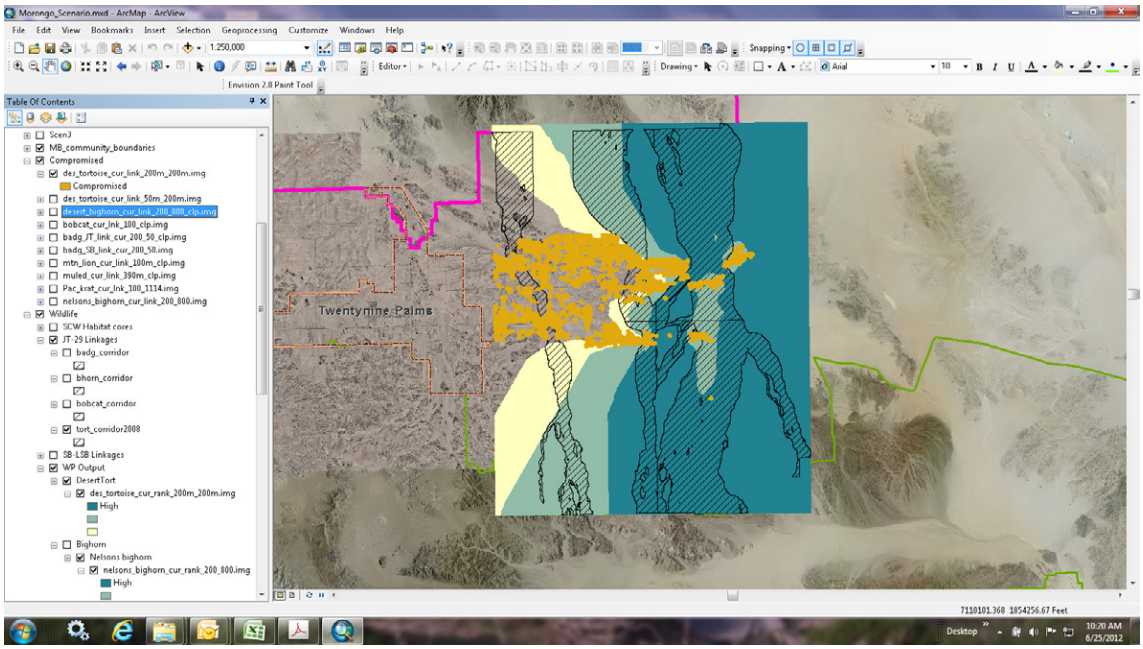
The Envision Tomorrow Extension uses the linkage between itself, the Excel file and the ArcGIS software to update the numerous metrics calculated for each scenario. Depending on the operator, the calculations and update can be set up to occur more or less often or when prompted, to save on computational resources. Care needs to be taken to follow the protocols for opening and saving the spreadsheets—the toolkit as used is not immune to operator error. For example, it is possible to open two instances of the Envision Tomorrow spreadsheet simultaneously, resulting in confusion and possible data corruption. An envisioned "firewall" of sorts that reduces the ability of the operator to make unintended errors when manipulating the components (GIS software, extension, and spreadsheet) would be considered a welcome upgrade.

Three different Sonoran Institute staff members contributed to the scenario painting for the five different scenarios (refer to Figure 4). This presented some advantages and disadvantages; two members of the team had more experience with the Envision Tomorrow software, but were not as familiar with the on-the-ground reality. The local land use planner had more local experience, but was less adept and experienced with the software. Of course expertise, experience and knowledge of place are all important considerations when assigning components of such a project, and should be considered in terms of allocation of personnel and time.

The first instance of integrating the scenario and wildlife tools occurred during the painting of Scenario 3, the Compact Development and Conservation scenario. The initial Wild Planner analysis, described more fully below, produced a set of GIS-based maps for core and movement habitat representing areas that were compromised or not compromised for the different focal species. Using rank scores that define the degree to which areas are more or less compromised as a guide layer, development was directed toward areas that were already more compromised, avoiding new development in unimpacted areas. Figure 7 is a screen capture showing the use of Wild Planner outputs to inform scenario development in Envision Tomorrow. While these Wild

Planner results were one of several considerations (noted above) taken into account when painting Scenario 3, it is of note that the use of these layers in conjunction with the SC Wildlands linkage design layers contributed a "value added" component to what would otherwise have been a more one-dimensional analysis.

Figure 7: Using Wild Planner Output to Inform Envision Tomorrow Scenario Development



Areas symbolized in brown represent the more compromised areas for Desert Tortoise, while the blue and light yellow areas represent high (blue) to moderate (yellow) quality linkage areas.

Initial scenario painting efforts mistakenly attempted to place roughly 83,000 people in the study area, by modeling *both* the existing and future population and development patterns, instead of only *new* development and population. After conferring with Fregonese Associates, this erroneous modeling of existing development was eliminated and only new population and growth was modeled, adding the approximately 17,000 persons that are the difference between SCAG's 2010 population estimate of the Morongo Basin and its 2035 population projection. The mistake cost time and effort, and provides a lesson learned that recommends more explicit review and check-in with experts when they are available (which is not always the case when using freely available software and modules).

Formatting Envision Tomorrow Output as Input to Wild Planner

One of the primary objectives of the Alternative Futures project was to integrate species-specific wildlife metrics into a scenario planning process that is traditionally aimed at modeling the built environment. Wild Planner, a set of conservation planning tools developed by the Craighead Institute that excel at modeling the cumulative effects of development, was selected to compliment Envision Tomorrow, in part because of its proven ability to model wildlife habitats

and movement in other settings, and in part due to the mutual compatibility of data inputs and outputs with the Esri ArcGIS platform.

While Envision Tomorrow and Wild Planner can be viewed as natively compatible in that both tools assist and inform site specific decisions while taking into account the regional setting, they have different spatial analytic structures: Envision Tomorrow is based on average building densities assigned to vector *polygons*, while a Wild Planner analysis derives from spatially explicit structure locations, represented as *points* in the GIS. To utilize the polygon based results of an Envision Tomorrow scenarios analysis as input to Wild Planner, average building densities need to be translated into specific points, corresponding to new building structures that would be expected to contribute, along with existing building structures, to the development patterns resulting from each the five alternative approaches to future development.

Turning a polygon density value into points turned out not to be a simple translation, and is a good example of the types of "communications issues" that arise when attempting to integrate different modeling tools. Envision Tomorrow does not generate any information specific to building location within a parcel, so a methodology to assign points to represent density was developed by Sonoran Institute's GIS manager.

When developing a methodology to translate polygon values to points, a number of considerations were necessary. For example, there were the expected urban/rural differences. In town centers, density (which translates to the number of dwelling units per acre multiplied by the acreage of the parcel) is generally *equal to or greater than* one structure per parcel. In rural areas density is most often *lower* than one structure per parcel. Given the location of most wildlife habitat and movement corridors in more rural areas of the Morongo Basin, development on the lower-density, less urban parcels generally has the highest potential for impacts on wildlife connectivity. Thus the way in which points representing structures were assigned on the map was important to Wild Planner, in that the arrangement of points, representing structures, influences model results.

Parcel-specific structure densities were determined by multiplying parcel acreages by average dwelling unit density for each development type (see Appendix E for a table of development type densities). Structure densities were then reduced by the respective proportion of multifamily dwelling units that actually constitute single structures. For example, an apartment building with eight units was reduced from eight structures to one structure, based on the development types. It can be noted that the quantity of multi-family units was very limited in the low-density portions of each scenario, and many were located (as a result of the scenario painting) in areas with habitat already compromised, meaning that empirically the impacts to wildlife were likely less than had the multi-family units been located in previously uncompromised areas.

Structure densities estimated to be *above* one dwelling unit per parcel in build-out scenarios were rounded off to the nearest unit per acre and the structures placed at random within each parcel in the model. Structure densities that were lower than one dwelling unit per parcel were combined into large multi-part features that spanned the entire study area and encompassed the sum of per-parcel structure density for the model. Then, the model distributed those "structure points" across each development type in the scenarios, showing how potential build-out might get expressed on

the landscape. These lower density points were merged with the higher density points from each scenario and combined with the existing structures, to create a layer of building points for each scenario that was used as the input to Wild Planner modeling.

Wild Planner Inputs to Scenarios

As discussed, the Morongo Alternative Futures project used output from Wild Planner analyses at two different times during the project:

1. Inputs to Scenarios. Output from Wild Planner analyses of Core Habitat, Intactness of Connectivity and Movement, and Ranking Linkage Quality were used as inputs to developing Scenario 3, to assist in decision making about where to "paint" development on the landscape.

2. Scenarios Evaluations. Output from the five Alternative Futures Scenarios (plus the base scenario and the full build out scenario) was analyzed using Wild Planner to evaluate Core Habitat, and Intactness of Connectivity and Movement as above.

Choosing Species for Modeling

Wild Planner analyses used the same focal species that were chosen by SC Wildlands for linkage designs for the San Bernardino–Little San Bernardino (Penrod et al. 2005) and Joshua Tree–Twentynine Palms (Penrod et al. 2008) connections. While full details of the selection process are included in the SC Wildlands reports; briefly, the selection process for focal species is described here:

Collaborative workshops were held to select focal species that "capture a diversity of movement needs and ecological requirements, from species that require large tracts of land to those with very limited spatial requirements (Penrod et al. 2008)" and included both habitat generalists and habitat specialists. Twenty-three species were chosen for San Bernardino–Little San Bernardino and 25 species were chosen for Joshua Tree–Twentynine Palms by experts with knowledge of the local species and landscapes. From these sets of plants and animals, a subset of species were chosen for landscape permeability analysis as "focal species", based on the assumption that generating a linkage design based on the needs of these species would serve as an "umbrella" to accommodate all of the species considered in the analysis.

Five species were chosen for San Bernardino–Little San Bernardino and four species for Joshua Tree–Twentynine Palms (Figure 8). Badger and Desert Bighorn Sheep were present as a focal species in both linkage design analyses, thus a total of seven species were used in the Wild Planner Analysis. An attempt to include the Mojave Fringe-toed lizard as an eighth species in this analysis is discussed below.

Figure 8: Focal Species Used by SC Wildlands for the Morongo Basin Linkage Design

Joshua Tree to Twentynine-Palms Connection Focal Species
Badger Desert Bighorn Sheep Bobcat Desert Tortoise
San Bernardino-Little San Bernardino Connection Focal Species
Badger Mule Deer Mountain Lion Desert Bighorn Sheep Pacific Kangaroo Rat

The time and expense of the Wild Planner analyses was significantly reduced by using species previously identified by local and regional experts as part of the SC Wildlands investigations and by using SC Wildlands detailed literature reviews, data summaries, and habitat layers to define the parameters of the Wild Planner analyses. It should be noted that in project areas where these types of resources are not available, researchers will need to conduct their own species selection process and gather the necessary background information for input to the Wild Planner models. A review of the methods available and suggested methods for selecting focal species are provided by Brock and Atkinson (2013).

Mojave Fringe-toed Lizard

In addition to the species selected for landscape permeability analysis by SC Wildlands, an attempt was made to include the Mojave fringe-toed lizard as an additional species of interest because of its unique habitat requirements related to sand dunes and sand deposition, its high sensitivity to habitat loss, fragmentation and degradation, and the occurrence of several large areas of highly suitable habitat in the Wonder Valley area in the eastern portion of the Morongo Valley. This lizard has been the focus of many research studies (Barrows 1997; Griffiths et al. 2002; Barrows, Allen and Rotenberry 2006) and is classified as a species of special concern by the California Department of Fish and Game and a sensitive species by the Bureau of Land Management (BLM). South of the Joshua Tree National Park to the south of the Morongo Basin, the Coachella Valley fringe-toed lizard is a federally listed threatened species and there is great concern in this area regarding the impacts of encroaching suburban development on desert sand dune communities (Barrows, Allen and Rotenberry 2006) and concerns that active management of sand dune habitats may become necessary to mimic the natural processes that maintain habitat (Barrows 1997; Barrows and Carpenter 2006) in the wake of extensive modification of sand transport mechanisms due to development.

After initial attempts to model the fringe-toed lizard, this species was subsequently dropped from analysis due to technical difficulties in modeling. However, the attempt to include it was fortuitous in that it revealed a heretofore not recognized limitation in the Wild Planner toolset that will likely lead to future refinement of the tools. Fringe-toed lizards require blow-sand and

are negatively impacted by sand stabilization created by fences and structures that create windbreaks, either intentional or not. This means that negative influences around human develops only occurs *downwind*, while the current implementation of the Wild Planner model assumes that influences extend *equally in all directions*. Thus, the fringe-toed lizard serves as an example that some species will require more sophisticated methods for estimating zones of influence around human developments than Wild Planner currently provides.

Wild Planner Data Inputs and Analysis Parameters

Wild Planner is designed to use the results of regional conservation assessments to "drill down" to finer scales to estimate potential effects of development patterns on wildlife habitat and movements. Wild Planner requires several species-specific parameters for tool input. The Wild Planner User's Manual (Brock 2011) details the selection and use of these input parameters, which are listed in Appendix F.

As mentioned previously, the availability of SC Wildlands linkage design studies and associated data layers greatly facilitated Wild Planner analysis by eliminating the bulk of the work that is usually required for developing data inputs and analysis parameters for Wild Planner tools. The SC Wildlands studies identified appropriate focal species for analysis, conducted extensive literature reviews for each species to determine habitat requirements, determined minimum sizes for habitat patches and habitat cores for each species, and provided GIS layers of habitat and connectivity. This work provided the bulk of inputs needed for Wild Planner analysis. The literature reviews provided in the reports significantly reduced the time and expense of determining the remaining parameters of corridor widths and influence distances by reducing the number of scientific papers reviewed from hundreds to a few dozen. Appendix G summarizes the analysis parameters used for Wild Planner analysis.

Point data representing existing structures are needed for the Wild Planner analyses. If these data are not freely available from county or state governments, obtaining GIS layers of existing structures can sometimes present a challenge. If structures layers cannot be obtained for free, many U.S. counties offer them for a fee[12]. When adequate structures layers are not available, they can be digitized from aerial imagery that is freely available for the U.S. and regularly updated. However, digitizing can significantly increase the cost of a project, due to the technical expertise and time needed to accomplish this. To create Morongo Basin structures layers, structures were inferred from parcel layers and tax records. Although the Morongo study area is entirely within San Bernardino County, portions of the study area could be influenced by development in Riverside County. Therefore, the structures layer used in the Wild Planner analyses included structures in Riverside County that were within 9 km (the longest influence distance for any species) of the study area boundary.

One innovation that the Alternative Futures project exemplifies is the integration of the metrics of the built environment with species-specific spatially explicit wildlife modeling. Following

[12] For example, a state-wide structures layer for Montana is available for download from the Natural Resources Information System managed by the Montana State Library. The state of Idaho also offers a structures layer for download but as of the date of this report, that layer only contains structures for a few counties. For most Idaho counties, users must contact the counties directly and the counties may charge a fee for the data.

species identification and assembly of the essential data layers and parameters for use in Wild Planner, maps that depicted core habitat and connectivity and movement for each species were developed. These maps were used during the "painting" of the Envision Tomorrow conservation scenario (Scenario 3; see Figure 7 above) in order to better establish a wildlife-friendly development pattern.

In the second component of the Wild Planner analysis, similar habitat and connectivity maps were developed to evaluate the potential impacts of the scenarios generated in Envision Tomorrow. That process is described in the section directly following; results of the Wild Planner scenario analyses (and of the Envision Tomorrow analyses) are summarized in the section titled "Results of Alternative Futures Modeling".

Wild Planner Scenarios Evaluations

Wild Planner analyses typically include an *existing development scenario* as well as a *full build out scenario* that is used to identify areas that are important to wildlife and vulnerable to loss through development. To this suite, the Alternative Futures project added the *five Alternative Futures scenarios* that were the results of the Envision Tomorrow scenario development (listed in Figure 4 above), totaling seven scenarios for analysis.

The full build out analysis requires developing a buildable area layer that excludes areas that cannot be developed due to legal or other constraints[13], and then imposing structures onto all the parcels where a structure could potentially be built legally. While the probability of *all* legally buildable parcels being built on is unlikely in the foreseeable future, especially in rural areas such as the Morongo Basin, the full build out analysis is useful in that it can identify possible bottlenecks or potential problem areas that, while they may only represent a small percentage of legally buildable parcels, could impact connectivity and habitat in profound ways. By running an analysis that looks at *possible* build out, these potential problem areas can be planned for in a proactive manner.

Scenario Processing

Based on the Envision Tomorrow datasets, Wild Planner GIS layers of structures and roads were obtained or developed for each scenario. In this phase of the Wild Planner analysis, structures are represented by points and roads by lines. Wild Planner analyses were performed using tools from the Wild Planner software toolkit; a screen capture in Appendix H shows the software in use and includes a list of the available tools that implement operations in three categories: Landscape

[13] Depending on the location of the study, obtaining conservation easement layers that show the locations of lands where development is prohibited or restricted can sometimes pose a challenge due to either confidentiality concerns or more likely the fact that that type of data is not routinely assembled by local governments. In some cases this information can be obtained from easement holders (for example land trusts) through data use agreements. In response to these and other issues around conservation easement information, a partnership that includes the Conservation Biology Institute, Defenders of Wildlife, Ducks Unlimited, Inc., Trust for Public Land and NatureServe has come together to create the National Conservation Easement Database, which currently provides information at the website http://nced.conservationregistry.org/. Other inputs to the full build-out analysis can usually be readily obtained through local, state, or federal governments.

Evaluation Tools, Policy Tools and Utilities. The seven Wild Planner scenarios were assembled as follows:

- The *existing development* scenario was represented using existing structure and roads layers without modification.

- A *full build out scenario* was developed using the **Simulate Build out** tool in Wild Planner. This tool examines all parcels that overlap the buildable area of the analysis area and inserts a point at the centroid of the buildable portion of each parcel that does not currently contain a structure. The tool then generates a simulation of the resultant build out road network by generating a line from each added point to the existing road network following the shortest distance along the lowest elevation gradient. Thus the **Simulate Build out** tool simulates the density and approximate location of structures and roads that would occur if every currently available and legally buildable parcel were developed.

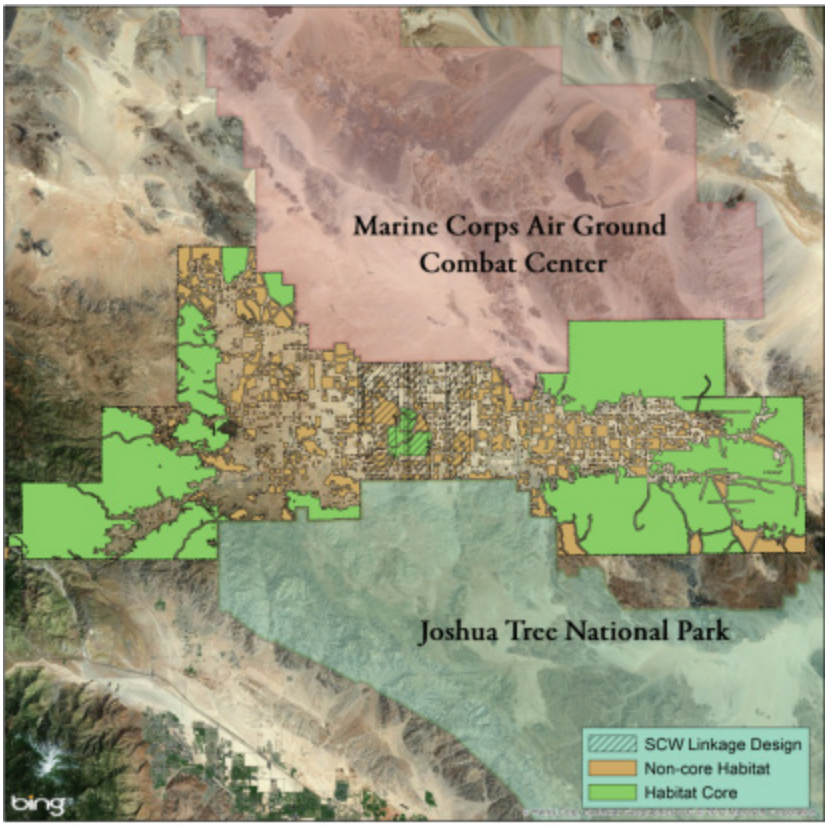
- The *five Envision Tomorrow development scenarios* were converted to point layers representing the location of new structures that would be built under a given development emphasis. (A discussion of the manipulations needed to create these point layers from Envision Tomorrow output in a format appropriate for Wild Planner input is included above in the section titled "Formatting Envision Tomorrow Output for Wild Planner"). To convert these point layers to scenarios for Wild Planner testing, the **Generate Roads** tool was used to simulate additional roads that could result from the additional development modeled by each Envision Tomorrow scenario. This **Generate Roads** tool uses the same process described for the **Simulate Build out** discussed above, except it generates a road pattern from a user-defined structures layer rather than on the computer-generated full build out pattern. Simulated roads and Envision Tomorrow structures were merged with existing roads and structures to create layers representing the total pattern of development under a given scenario. Although these process steps are easy to perform manually, they could easily be incorporated into a potential Envision Tomorrow to Wild Planner conversion tool.

Habitat and Connectivity Analysis

Habitat Analysis

The location and amount of core habitat under each of the seven development scenarios and for each of the focal species was estimated using the **Evaluate Habitat Patches** tool. *Core habitat* is defined as patches of sufficient habitat quality that are outside the specified influence distance of houses and roads and greater than or equal to the minimum patch size requirements for the species analyzed. Although the emphasis of the Morongo Basin planning effort is to protect wildlife connectivity, analyses of core habitats were performed to identify areas within the basin that could support individuals or populations of focal species in relatively undisturbed conditions. These patches of undisturbed habitat can also serve as important "stepping stones" for connectivity (see an example in Figure 9).

Figure 9: Core Habitat for Bobcat



The *minimum home range size* reported for each species in the SC Wildlands linkage design reports was used for the *minimum patch size* parameter (Appendix G). Therefore, any patch large enough to support ≥ 1 individual home range was considered a habitat core for purposes of this analysis. *Influence distance* parameters were extracted from the SC Wildlands linkage design reports or from additional literature review (Appendix G). If more than one disturbance or influence distance was reported in the literature, the greatest distance applicable to the area was used. An exception to this rule was Desert Bighorn sheep, which need a buffer of 14.5 km (9 miles) from domestic sheep and goats to protect them from infectious disease (Carlsen and Erikson 2010) but are reported to respond to human disturbance with 0.8 km. The 0.8 km influence distance was used since the location of domestic livestock in the study area is not known. Influence distances from roads was assumed to be the same as from structures unless a different distance was reported in the literature or suggested by expert knowledge.

Specifying an appropriate analysis area is critical for deriving meaningful results from Wild Planner, particularly in areas like Morongo Basin that lie between large blocks of protected land. Wild Planner calculates percent area of core habitat remaining under a given development scenario. If a large percentage of the analysis area includes protected land, the loss of habitat due to development will be masked even if the loss is severe. But if all protected areas are eliminated from analysis, then the negative effects of development are exaggerated because the analysis will not account for protected "sanctuaries" that mitigate the effects of development. For this study, a separate analysis area was created for each species by restricting analysis to areas of potential

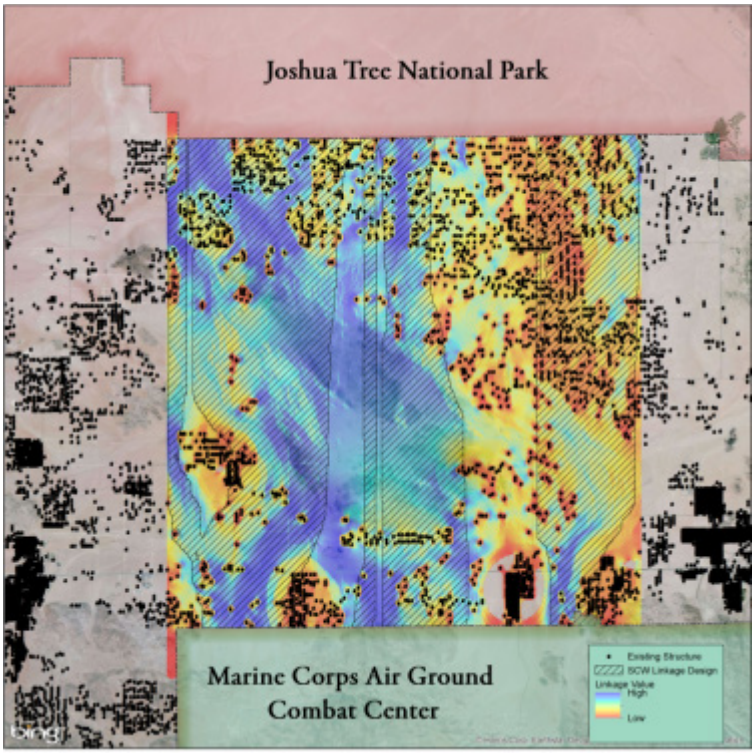
habitat identified by SC Wildlands that were within the Morongo Basin study area but excluding the protected habitat anchors of Joshua Tree National Park, San Bernardino National Forest, and the Marine Corps Air Ground Combat Center. Therefore, analysis was restricted to the matrix of protected and unprotected habitat areas potentially affected by development.

Results from the Habitat analysis are presented for each species in the "Results of Alternative Futures Modeling" section below.

Connectivity Analysis

Wild Planner offers a set of tools for analyzing connectivity. The tools are designed to be used in sequence, where the output of each tool becomes an input to subsequent tools to estimate areas of undisturbed movement habitat (Figure 9), and areas of high and low linkage quality and measure overall landscape resistance to movement (see example in Figure 10). To create a baseline of current connectivity for each focal species in the study area and identify areas vulnerable to development, initial analyses were run on existing development and full build out scenarios.

Figure 10: Bobcat Connectivity under Current Conditions



Colors represent relative value of current density. Areas of high current density indicate where animal movement is likely to be concentrated.

With all Wild Planner tools, careful consideration of appropriate analysis extent is important for meaningful results. Ideally, analysis should focus on areas identified as important linkages at regional scales, but should not be confined strictly to individual linkage boundaries. The proper

analysis area will include areas where individual animals are most likely to travel along corridors while analyzing areas outside mapped linkages that may be important for providing refinement options for linkages when fine-scale development patterns are considered. This also avoids propagating errors inherent in coarse scale analysis. In general, selecting too large of an extent is better than too small for connectivity analysis.

For this portion of the project, analysis areas for connectivity were defined as the rectangle containing an individual species' linkage design corridor polygons identified by SC Wildlands. Source patches for connectivity tool inputs include areas of suitable habitat for each species within each of the three habitat anchors. Therefore, the connectivity analysis estimates the movement between Joshua Tree National Park and Twentynine Palms Marine Base, and/or between San Bernardino National Forest and Joshua Tree National Park throughout the extent of the linkage designs for each species.

Initial connectivity analyses used the **Evaluate Movement Landscape** and **Rank Linkage Zones** tools from the Wild Planner toolkit. Evaluate Movement Landscape produces a simple binary map of areas suitable for species movement and Rank Linkage Zones estimates relative linkage quality of suitable movement areas. Prior to analyzing the output of the Envision Tomorrow scenarios, Rank Linkage Zones was replaced with a significantly modified version of the tool and the initial scenarios were reanalyzed. This new tool, **Measure Landscape Resistance**, uses a more sophisticated algorithm for mapping linkage quality or importance at fine scales, and measures overall landscape resistance to movement. The latter is particularly useful for scenario testing because it provides a *metric for comparing the relative impact* of scenarios on animal movement. This tool utilizes Circuitscape, which is open source software that uses electrical circuit theory to measure connectivity (see the "Species Findings" section below and Appendix J for more details).

Implementation Observations

As the scenario-wildlife modeling integration undertaken by the Morongo Basin Alternatives Future was a prototype project, it is instructive to include several observations here regarding this implementation. Envision Tomorrow is typically implemented in regions of higher population density, so the building prototypes used in the Morongo Basin needed to be adjusted to reflect lower-density development. The Return on Investment spreadsheets that describe each building prototype were tailored to both building costs, and rent/sales expectations in the area, which helped determine the type of construction that was financially feasible in the area. The parameters used to determine outputs were adjusted to reflect inputs from the local developers (using the survey instrument from Appendix A) as well as modifications to reflect a desert landscaping environment.

Scenario painting was initially approached under the assumption that we were modeling both existing development and potential new development. While the newest versions of Envision Tomorrow do incorporate existing development, the version available at the time of painting was not designed to capture existing development patterns beyond basic presence/absence of a structure. This error in implementation was corrected, but following a significant input of effort based on the incorrect premise.

This is the first application of Wild Planner outside the Northern Rocky Mountains region. The tool has proven adaptable and has yielded some interesting results. Not surprisingly, applying Wild Planner to a new region has also yielded surprises. The biggest surprise arose from analysis of the desert fringe-toed lizard which is threatened by sand stabilization caused by windbreaks and structures. This means the zone of disturbance for this species is directional and one-sided since it aligns with the downwind direction from structures. Wild Planner is not designed to simulate this type of disturbance pattern, but Craighead Institute is exploring the possibility of including this capacity in future versions.

An example of the synergy of integrating the scenario and wildlife modeling tools can be found in an instance where the linkage designs are shown by the Wild Planner analysis to be blocked by development under a certain scenario or build out. In such a case, the Wild Planner analysis helps identify possible alternative habitat outside of the design that may serve as a "Plan B" option for conservation actions. Wild Planner outputs allow local planning efforts to move beyond a binary "inside-outside" consideration of a linkage design by providing additional information about quality of habitat both *within* and *outside* of a linkage area.

Results of Alternative Futures Modeling

The Envision Tomorrow scenario analysis was conducted in line with four objectives:

- Generate a set of scenario development patterns for the year 2035 reflecting alternative approaches to growth suggested by local stakeholders. (For the conservation-oriented development pattern, integrate results from initial wildlife analyses to inform scenario development).

- Utilize the set of development patterns to visualize the impacts of existing and possible structures on wildlife habitats and movement in the Morongo Basin for each alternative scenario, by integrating scenarios output into wildlife analyses.

- Based on the results of the scenario analyses and the wildlife analysis, suggest which scenario approaches (or combinations thereof) will best serve to support community values.

- Provide resources and mapping to alert decision makers and developers regarding critical "block points" or other considerations that exist or are possible based on expected growth that can be gleaned from the Alternative Futures analyses.

Each objective is addressed in the sections below.

Alternative Scenarios—Envision Tomorrow Results

Objective: Generate a set of scenario development patterns for the year 2035 reflecting alternative approaches to growth suggested by local stakeholders. (For the conservation-oriented

development pattern, integrate results from initial wildlife analyses to inform scenario development).

The results of the Envision Tomorrow scenario analysis demonstrated that many of the economic indicators that Envision Tomorrow is programmed to report remained relatively similar across the scenarios, possibly reflecting the balanced approach to the scenarios deemed important to the planning partners, and the relatively small population being modeled. There was the not surprising initial finding that Envision Tomorrow indicators for Scenarios 2 (Jobs/Housing Balance and Fit and 3 (Compact Development and Conservation) both reflected more efficient development patterns inherent in the conservation/compact development approach and the jobs/housing balance that was designed to increase the "office" component of the jobs mix. The major results from the Envision Tomorrow analysis as generated in the scenario spreadsheet metrics are summarized in Appendix I; some highlights are summarized below:

- The amount of *developed acres* was highest in the Rural Living Emphasis scenario—at nearly 10,000 acres, it was nearly double any of the other scenarios and five times higher than the Compact Development and Conservation and scenario. *Square footage*, however, remained relatively constant across all scenarios. While many sustainability indicators remained relatively homogenous across the scenarios, *landscaping water use* in the Rural Living Emphasis scenario was roughly twice that of any other scenario.

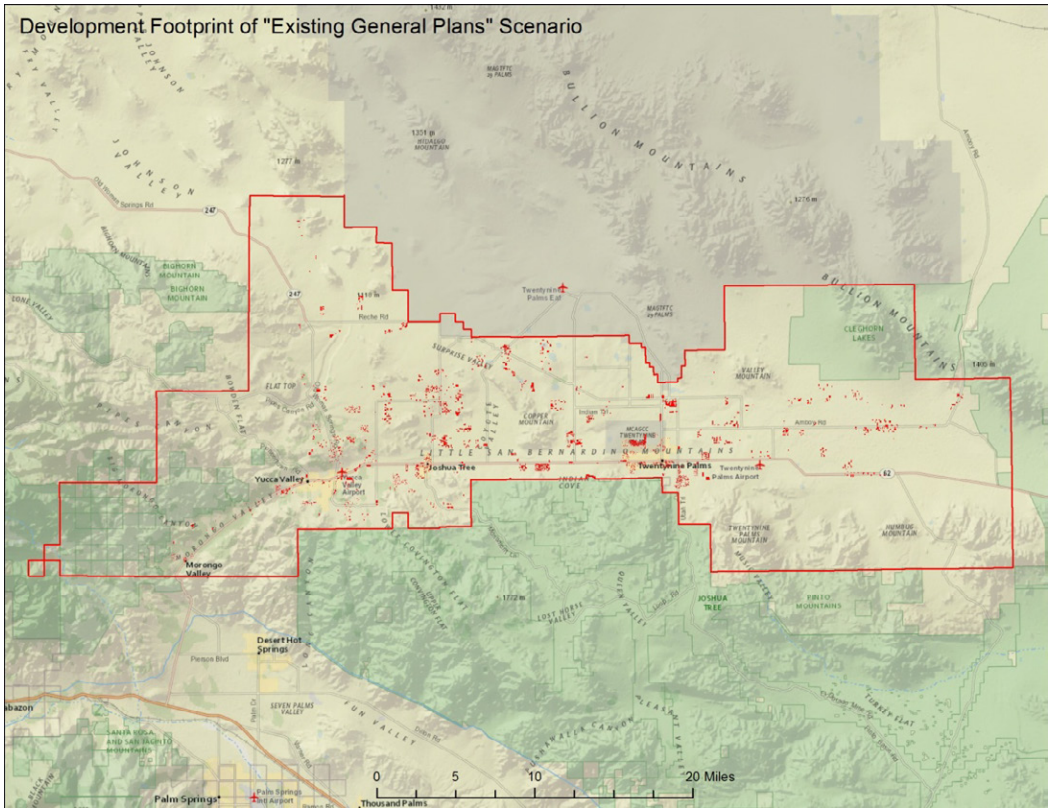
- The Jobs/Housing Balance and Fit scenario required 32,552 parking spaces, which is an average of 4,000 more parking spaces than any of the other scenarios, due to the increased placement of commercial development and employment centers. The scenario focused on a tight development pattern, intended to have low vehicle miles traveled (VMT) scores.

- The Compact Development and Conservation scenario utilized roughly twice the amount of multifamily housing and half the amount of single family housing as the "Rural Living" scenario. Development was also directed toward areas of existing development to encourage a compact pattern. *Home price* was lowest in the Compact Development and Conservation scenario, at an average price of $294,372.

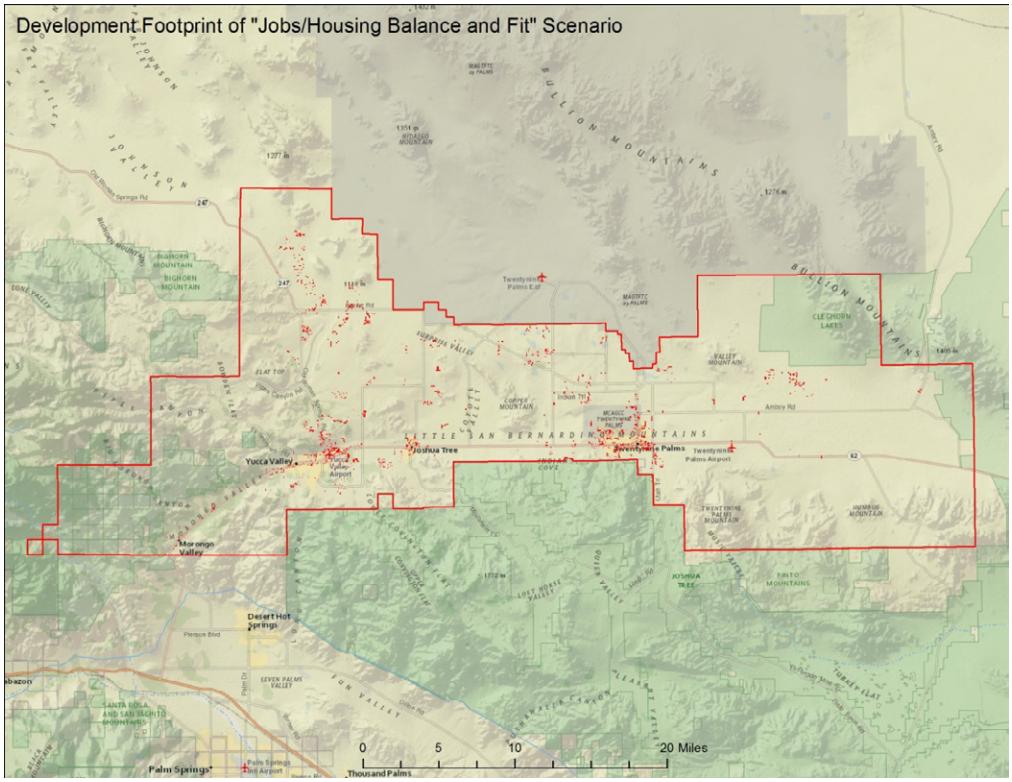
The numeric metrics generated to characterize the scenarios are manifested visually in a mapped display of development patterns across the landscape of the basin. Even across the large spatial extent of the study area, the difference between the alternatives can be perceived simply by symbolizing areas of development footprint in red for all five scenarios, as illustrated in Figure 11 below. A visual inspection of the maps indicates that scenarios 2, 3 and 5 tend to direct development in a more clustered pattern, within or close to areas currently developed.

Figure 11: Development Footprints of Envision Tomorrow Scenarios

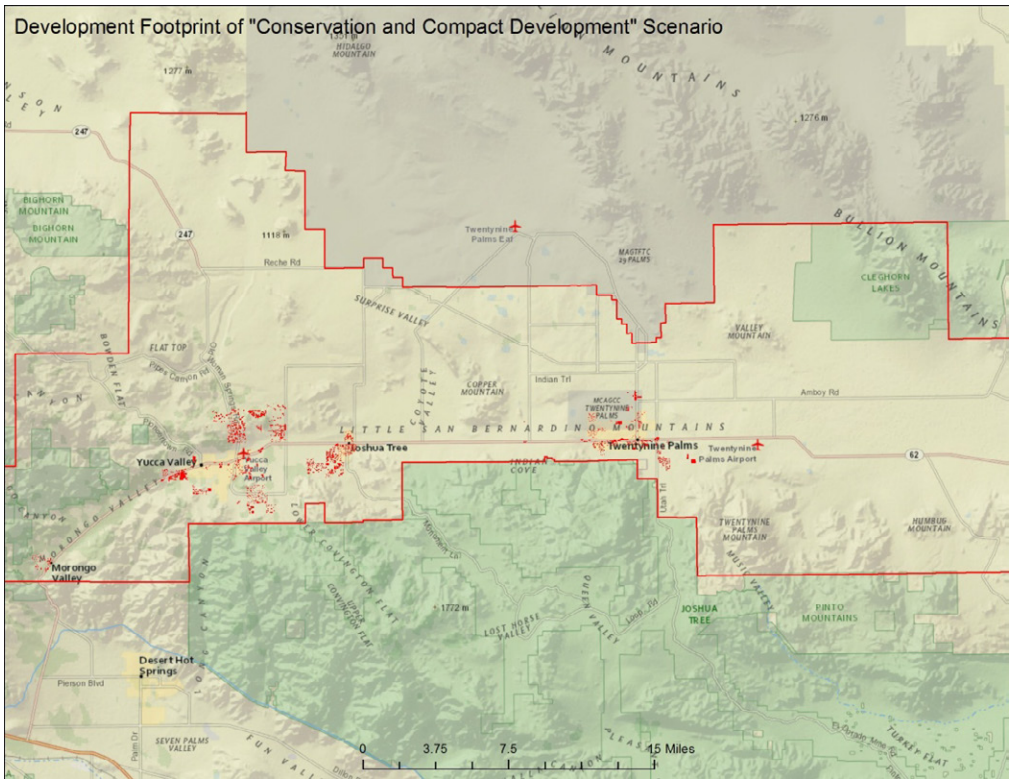
a) Scenario 1: Existing General Plans



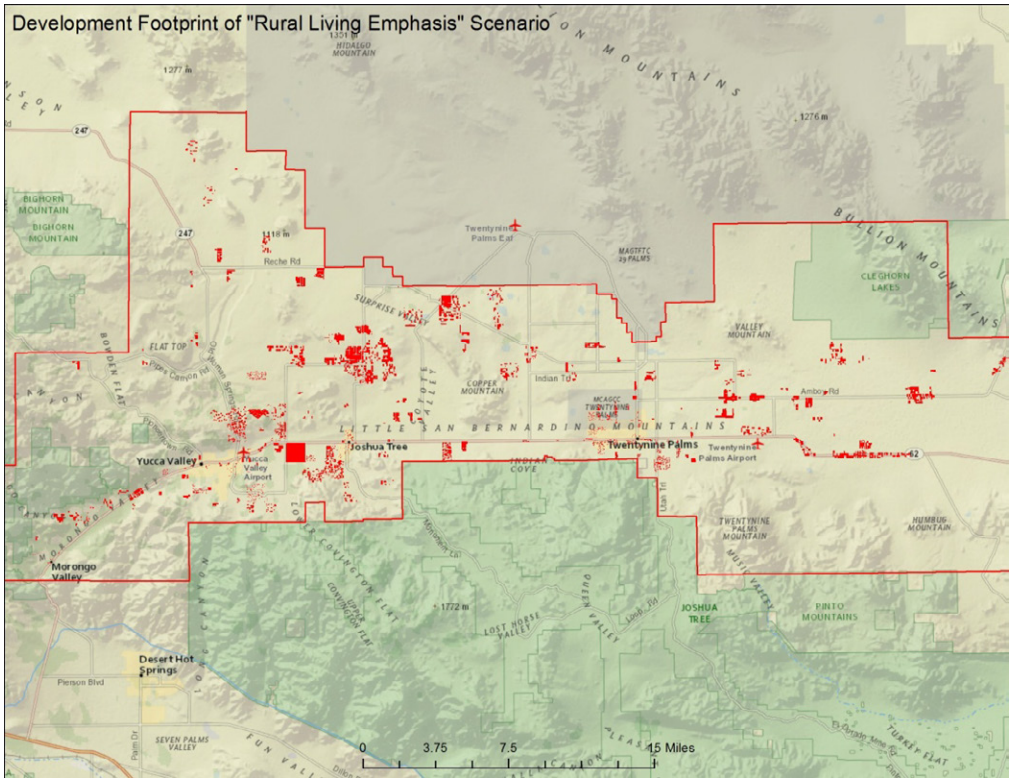
b) Scenario 2: Jobs/Housing Balance and Fit



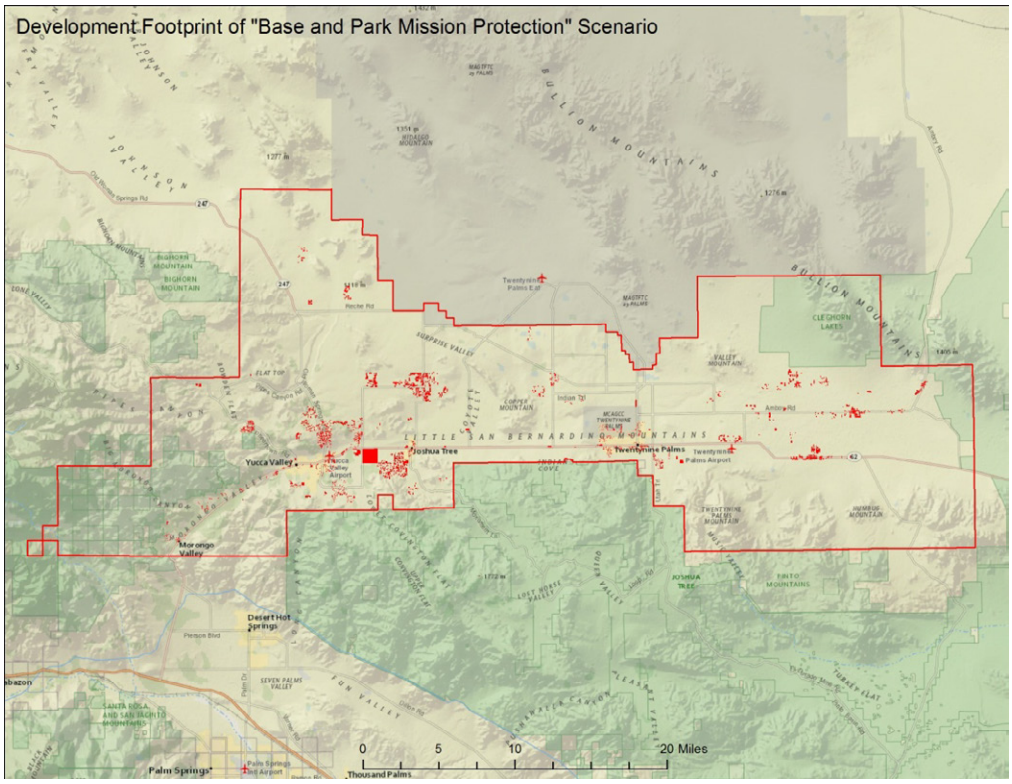
c) Scenario 3: Compact Development and Conservation



d) Scenario 4: Rural Living Emphasis



e) Scenario 5: Base and Park Mission Protection



Wildlife Habitats and Movement under Alternative Scenarios—Wild Planner Results

Objective: Utilize the set of development patterns to visualize the impacts of existing and possible structures on wildlife habitats and movement in the Morongo Basin for each alternative scenario, by integrating scenarios output into wildlife analyses.

Comparing Scenarios

A comparison of development scenarios using Wild Planner habitat and connectivity analyses indicates that *all* Envision Tomorrow development scenarios would result in less habitat loss and better habitat connectivity in the Morongo basin compared with potential full build out. However, while the full build out scenario is instructive for identifying areas vulnerable to development, it is not a realistic development scenario because the number of houses added to the landscape exceeds current predictions for growth in the area within the selected time horizon of 2035.

Among Envision Tomorrow scenarios, Existing General Plans (Scenario 1) results in the greatest loss of both total (0.8 percent) and core habitat (0.7 percent) when averaged across all species (Figure 12). The next worst scenario for habitat loss was Rural Living Emphasis (Scenario 4) with an estimated 0.4 percent loss in total habitat and 0.2 percent loss in habitat core. However, this trend is not uniform across all species, because Scenario 4 resulted in slightly more habitat loss for bighorn sheep, mule deer, and Pacific Kangaroo rat (Figures 13 and 14). But Scenarios 1 and 4 were the two "worst" scenarios in terms of habitat loss for all species.

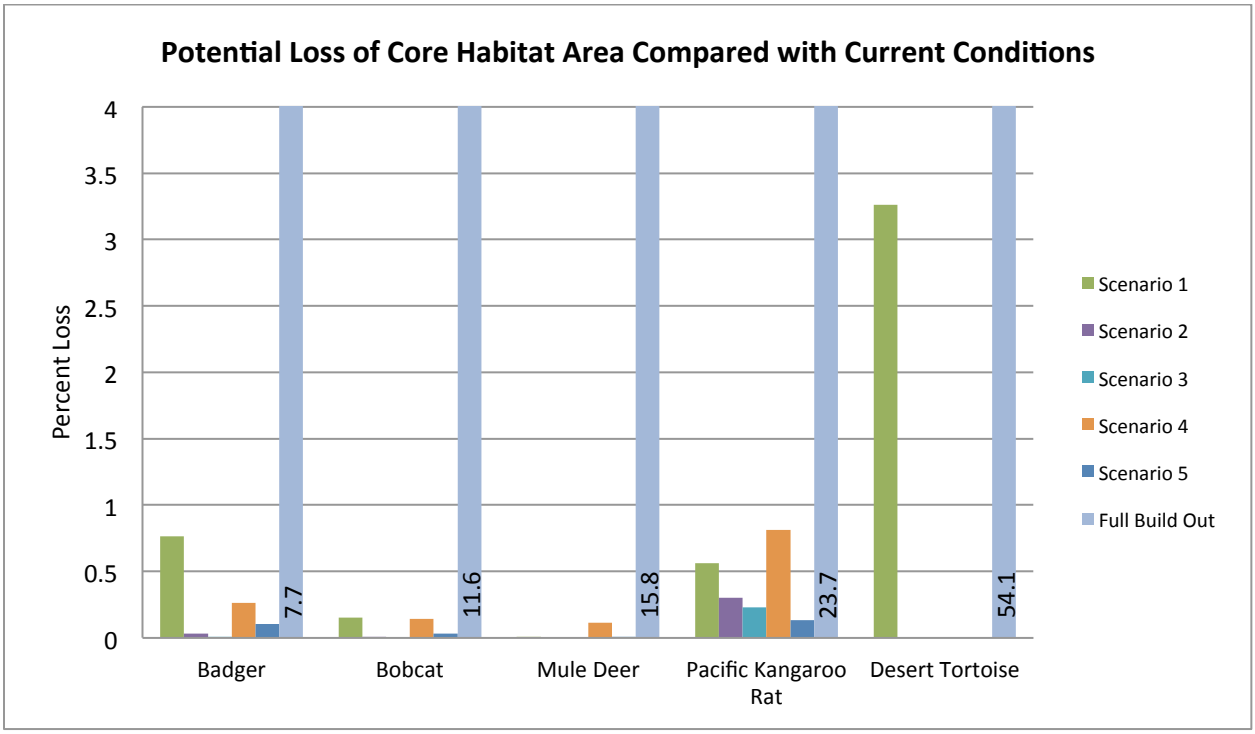
The Rural Living Emphasis (Scenario 4) is also the development scenario deemed to have the most impact on community values, in terms of habitat connectivity, with an estimated 3.5 percent increase in landscape resistance averaged across all species (Figure 12). This result was consistent for all species (Figure 15). Not surprisingly, the Compact Development and Conservation scenario (Scenario 3) minimized habitat loss and maximized connectivity compared to other scenarios (Figure 12). However, the Base and Park Mission Protection (Scenario 5) out-performed Scenario 3 in some cases. Scenario 5 resulted in less core and total habitat loss for Pacific Kangaroo rat (Figures 13 and 14) and lower landscape resistance values for bighorn sheep, mountain lion, and Pacific kangaroo rat (Figure 15). This result reflects the interests and values of the representatives from the Marine base and national park who participated in the CPS analysis that informed Scenario 5, which are strongly based in conserving connectivity throughout the basin to connect both of these large federal land holdings that serve as habitat for local species.

Figure 12: Average Change in Landscape Metrics by Development Scenario

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Full Build out
Landscape Resistance	2.6	1.2	0.7	3.5	1.2	32.8
Total Habitat	-0.8	-0.1	-0.1	-0.4	-0.1	-18.9
Core Habitat	-0.7	0.0	0.0	-0.2	0.0	-16.1

Percent change averaged across all species.

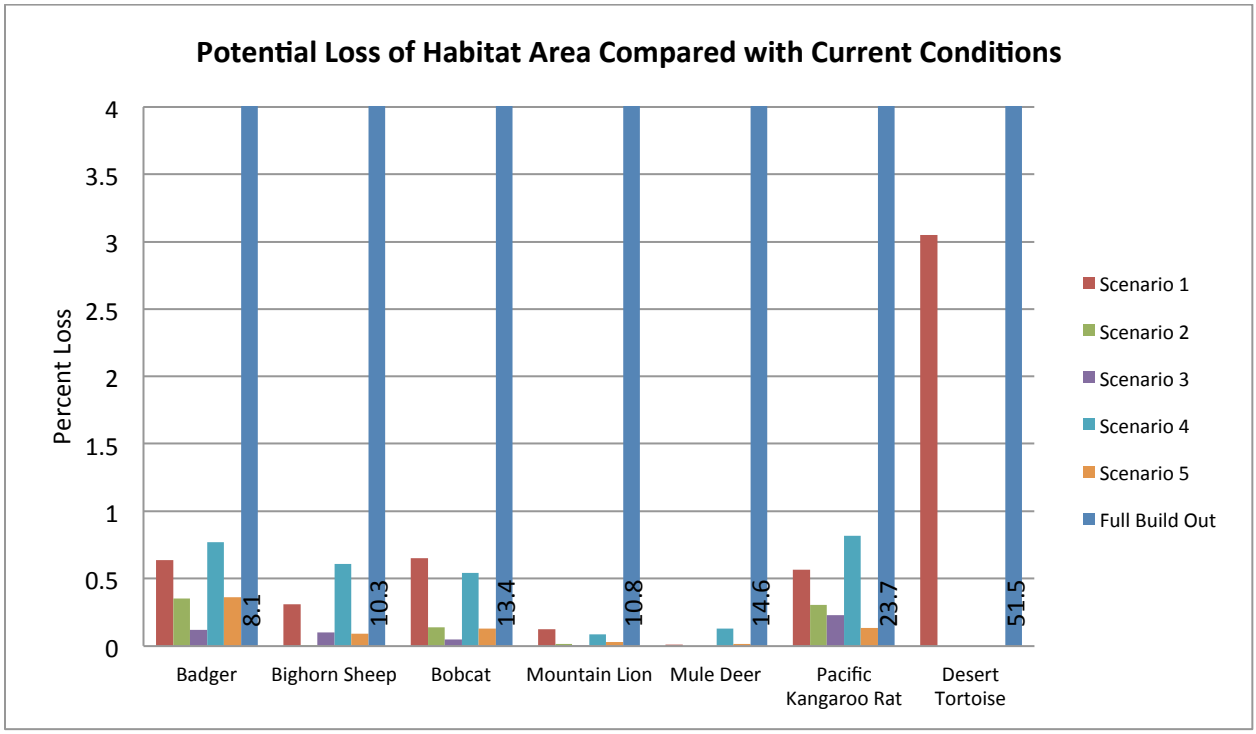
Figure 13: Potential Change in Core Habitat Area by Development Scenario and Species



Values include only habitat patches outside the influence distance for each species that are ≥ the minimum patch size for each species. No core patches for mountain lion or bighorn sheep were found within the study area and those species are excluded from this graph

Note: Bars for full build out are off the scale in this chart for all species. Numbers on full build out bars indicate the estimated percent increase in landscape resistance.

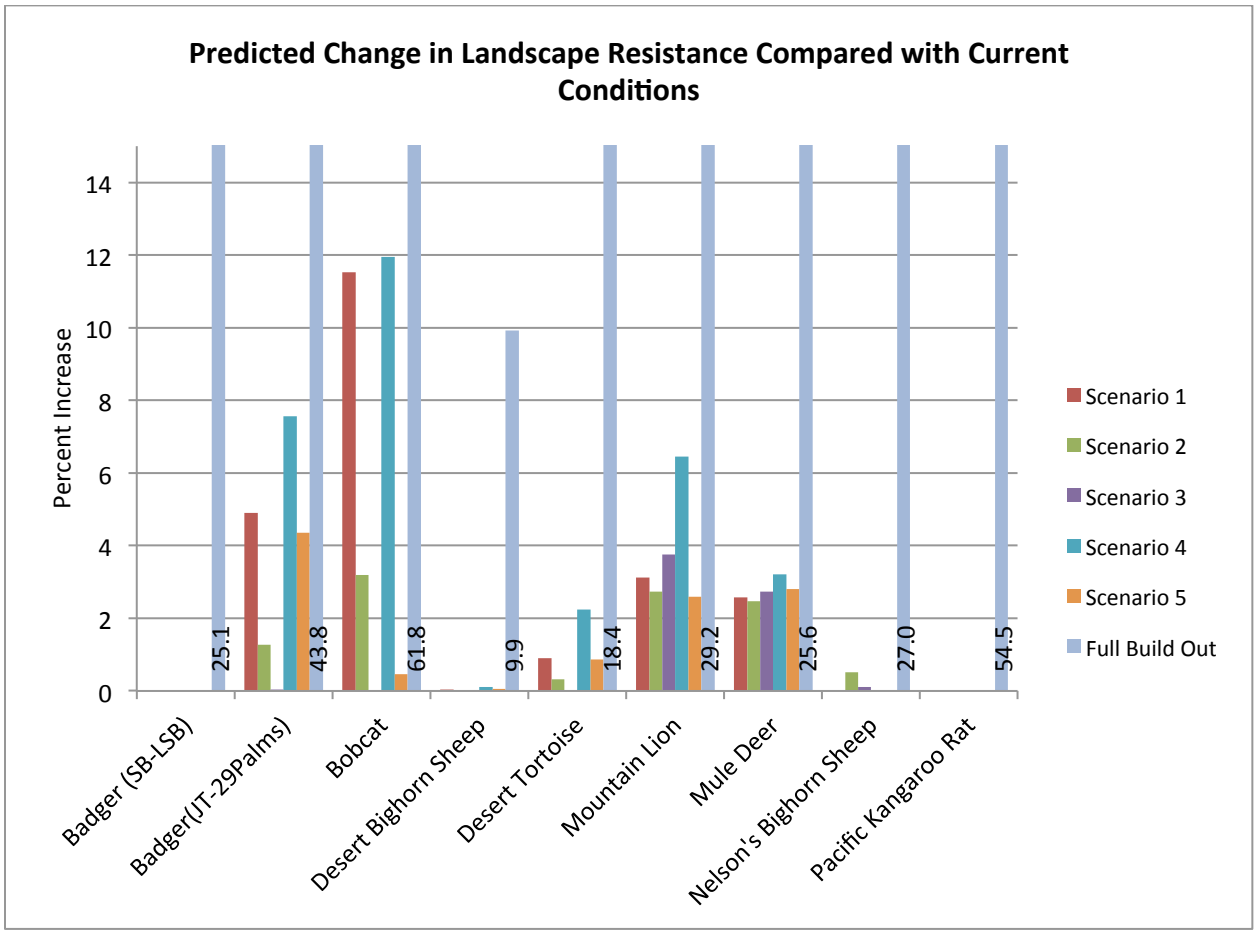
Figure 14: Potential Change in Total Habitat Area by Development Scenario and Species



Values include all habitats (core and non-core) outside the influence distance for each species.

Note: Bars for full build out are off the scale in this chart for all species. Numbers on full build out bars indicate the estimated percent increase in landscape resistance.

Figure 15: Predicted Changes in Landscape Resistance to Movement by Development Scenario and Species



Resistance values are based on electrical circuit theory. Landscapes with low resistance values are expected to provide better habitat connectivity relative to landscapes with higher values.

Note: Bars for full build out are off the scale in this chart for most species. Numbers on full build out bars indicate the estimated percent increase in landscape resistance.

Species Findings

When considering impacts of development, the results outlined and shown above are helpful in informing policies that will help maintain species habitat and connectivity overall in the basin. These results are based on the species-specific findings that were developed for each of the seven target species; those results by species are contained in more detail in Appendix J.

Appendix J contains specific information and maps on areas of the basin that may be especially impacted by different approaches to development for a certain species, and suggests possible approaches to ameliorating the impacts of development in those instances. A brief summary of some of the species-specific highlights from Appendix J includes:

- While overall **badger** habitat within the Morongo Basin appears relatively secure, the analysis indicates that linkage in a full build out scenario in the Desert Hot Springs area (Figure J-4) could become severely compromised as existing vacant parcels near Desert Hot Springs are developed.

- For the **bobcat**, the Wild Planner analysis suggests that a modification of the SC Wildlands linkage design may benefit that species. The SC Wildlands linkage indicates four discrete corridors for bobcat movement. Wild Planner indicates that the easternmost corridor of the four bobcat movement corridors in the SC Wildlands linkage design may already be compromised due to existing development, and existing development patterns dictate that lateral movement between the remaining corridors provides the best options for bobcat movement (Figure J-9).

- It does not appear that **desert bighorn sheep** habitat is significantly threatened by any of the modeled development scenarios, this is due in part to the type of terrain inhabited by the species, which does not tend to overlap with prime areas for building and development. Although planned development does not appear to present a threat to bighorn habitat, an estimated 10% of total habitat could be lost under full build out. This includes areas that should be considered as cores. Therefore, parcels are available for development that could have undesirable impacts on bighorn sheep habitat use.

- Although it appears most available habitat for **desert tortoise** in the study area is compromised, extrapolation from the modeling results indicates that the situation could improve. If efforts to reduce raven populations near development in the Morongo Basin were successful, the estimated disturbance zone around structures would decrease from 8 km to 200 m, eliminating a substantial amount of compromised area and move much of that area into the core habitat category.

- The SC Wildlands linkage analysis identifies a **mountain lion** linkage that follows canyons north and south of Morongo Valley. That linkage minimizes the distance across the valley floor and maximizes the ability of mountain lions to remain concealed within high quality habitat. The Wild Planner analysis indicates that the area where the linkage crosses the valley is already relatively densely developed and is likely compromised with respect to mountain lion usage. Wild Planner further indicates that a gap in development east of the mapped linkage zone may be crucial for maintaining connectivity for mountain lions across the valley and should be maintained as a fail-safe for the original linkage.

- None of the modeled scenario development patterns would result in significant loss of habitat for the **mule deer.** However, an impact on core habitat from Scenario 4 development patterns arises from the location of five proposed structures in the vicinity of Burns Canyon Road, which would result in loss or degradation of about 17 acres of habitat core (Figure J-28b).

  Figure J-28b is a good example of the potential use of the Wild Planner tool to work at finer scales to evaluate proposed development and by adjusting the location of a small

number of structures, to essentially eliminate development impacts for some species. The use of this type of analysis in combination with a linkage design such as those included here provides planners and land owners with additional tools to help determine the potential impacts of various development and conservation choices.

- The discussion on **Pacific kangaroo rat** contains reference to an area where the impact of domestic pets could be possibly reduced to have a positive impact on connectivity for that species (Figure J-34).

Results from the Integration of Wild Planner and Envision Tomorrow

The integration of outputs from the Wild Planner tool with the Envision Tomorrow analysis is an innovative component of this work. Scenario tools for land use planning such as Envision Tomorrow are typically used to model the built environment. Envision Tomorrow is based on building typologies and the metrics associated with individual buildings—water use, floor area ratio, parking spaces, etc. The Envision Tomorrow software excels at aggregating these metrics in different configurations across the landscape.

However, development has numerous impacts that are not simply additive accumulations of individual buildings. Impacts to wildlife cannot be modeled on a building by building basis. Impacts to wildlife depend on the habitat and movement requirements of individual species as well as the spatial relationship among buildings on the landscape.

Wild Planner excels at modeling the cumulative effects of development on wildlife. Wild Planner builds upon regional wildlife analyses such as the SC Wildlands linkage designs and helps users "drill down" to identify very specific priority areas for conservation action. Craighead Institute used the focal species from the Morongo Basin Linkage Designs (the two analyses done by SC Wildlands) to perform their analysis.

This project and the analyses it incorporated demonstrated that where and how growth occurs does make a difference for wildlife connectivity. Looking closer into the spatial aspects of wildlife habitat and connectivity vis-à-vis potential development patterns, provides local decision makers with additional resources to consider smarter approaches to growth, adding value to the existing maps that delineated the SC Wildlands linkage designs, to highlight possible alternative approaches to accommodating wildlife in the context of future growth. The exercise of exploring development given the unlikely event of "full build out" provided signposts to show the locations where just a small percentage of that full build out could occur in the exact locations that could cause problems which could be averted by alternative choices.

It is recognized by the developers of these analyses as well as its users that comparisons of full build out simulations with planned development scenarios should be interpreted with caution. Simulated full build out simply assumes that all available parcels are developed. In many areas, including the Morongo Basin, the number of available parcels for development greatly exceeds what is needed to accommodate realistic projections for population growth[14]. The greater

[14] The Sonoran Institute, with support from the Lincoln Institute of Land Policy, examined issues related to excessive entitlement of land for development throughout the intermountain west. The entitlement of land, largely

impacts predicted for full build out are largely simply due to a greater amount of development represented in the simulation. For example, full build out in the Morongo Basin would result in more than three times more structures on the landscape than any of the planned development scenarios based on projections of population growth. Although full build out simulations can be used as a rough benchmark for "worst case scenario", the probability of this worst case becoming reality should be considered. However, as noted above, full build out simulations are important for identifying areas where crucial wildlife areas are vulnerable to development and where land use planning and policy might be focused to avoid undesirable impacts on wildlife.

Comparisons among planned development scenarios indicate that impacts on wildlife are not simply a function of the *number* of new structures built, but that the *placement* of structures is important. In the Morongo Basin, the development scenario that resulted in the least overall impacts on wildlife connectivity and habitat also contain the greatest number of new structures (Scenario 3 with 11,491) while the two scenarios deemed to have the most potential negative impacts with respect to wildlife contain the fewest new structures (Scenarios 1 and 4, see Figure 16 below). The potential economic impacts of these results are intriguing since it appears that thoughtful planning for wildlife could potentially result in greater total development potential.

Figure 16: Number of New Structures Proposed for each Scenario

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Full Build out
Number of Structures	9,593	9,942	11,491	8,736	9,803	38,794

Wild Planner analyses compliment broad-scale wildlife assessments by estimating patterns of impacts caused by development that are likely to reduce habitat quality or alter animal movements. Several examples in the Morongo Basin analysis (e.g. bobcat, mountain lion, desert tortoise) highlighted areas where preferred or most probable linkages identified by SC Wildlands may already be significantly compromised by existing development. This information can be used by landowners, local conservation stewards and land use planners to restore linkages, modify linkage boundaries, identify alternative linkages, or focus efforts on managing the least impacted portions of linkages.

This work demonstrated that Wild Planner analyses can be scaled to match land use planning decisions. The results for Morongo Basin demonstrate that results can be integrated across species to compare growth scenarios and provide guidance for adopting growth policies that protect wildlife. A focus on individual species can help to find areas where a given scenario could be modified to reduce or eliminate impacts to that species. These impacts can be generalized over a study area (e.g., landscape level loss of habitat or connectivity) or can be very

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through approval of new subdivisions and development agreements between developers and local jurisdictions was greatly exacerbated by the 2000 to 2006 real estate boom and many of these approved subdivisions and lots were left in various stages of economic or legal distress due to the great recession. For additional information on the causes of excess entitlements and best practices for addresses this problem see the reshaping development patterns webpage and the working papers and forthcoming Policy Focus Report linked to that site at www.ReshapingDevelopment.org.

precise and site-specific, such as adjusting the location of individual structures or mitigating threats to wildlife within targeted areas to address wildlife issues.

Mule deer provide an example of the potential for eliminating even small impacts on wildlife in some cases. The worst development scenario for mule deer would impact only 17 acres of core habitat (0.1 percent). But Wild Planner identified the source of even this small impact and provides the possibility of reducing habitat impacts on mule deer to zero without sacrificing development potential.

An example of the synergy generated via this work was observed in the development of Scenario 3, the Compact Development and Conservation scenario, which used outputs from Wild Planner habitat and connectivity analyses. Development of this scenario encountered some instances where, when the linkage designs were shown by the Wild Planner analysis to be blocked by development, the Wild Planner analysis provides the ability to go beyond a linkage design dataset that would have been used as a base layer in a more traditional scenario analysis to identify possible alternative habitat outside of the linkage design that may serve as a "Plan B" option for conservation actions. This value-added aspect of the Wild Planner outputs allows local planning to move beyond a binary "inside-outside" consideration of a linkage design by providing additional information about quality of habitat both *within* and *outside* of a linkage area.

Putting Results to Use

Supporting Community Values

Objective: Based on the results of the scenario analyses and the wildlife analysis, suggest which scenario approaches (or combinations thereof) will best serve to support community values.

While the technical and practical integration of the scenario and wildlife planning software was a fundamental component of the Alternative Futures project, at the core of project was the community planning process being undertaken by the Morongo Basin Open Space Group, and the shared interests in considering the future of the Morongo Basin and how thoughtful choices today could influence the landscapes of tomorrow.

From the outset of the Alternative Futures project feedback from community and stakeholders involved indicated that the interest in the results of the project was not directed toward an interest in one "Preferred Scenario" to guide future growth, but in using the results of the analyses on all the approaches to evaluate the impacts of alternative approaches to growth the different scenarios embody. It was well-voiced that there should be a balance between various approaches; and were the MBOSG still operating as a forum[15], it is likely that a follow up analysis would be undertaken to more carefully dissect the five approaches to generate a hybrid approach that would satisfy a range of interests.

[15] As of September 2012 the Morongo Basin Open Space Group has dissolved and is no longer meeting regularly as a collaborative planning group, however many of the principal participants are still active in regional conservation and planning efforts, and the results of these analyses are being shared with them to support those efforts.

That said, the compelling story that supports the utility of the scenario planning undertaken by this project is the result that the maps and results indicate that any planned development is better for wildlife than just allowing the area to build out without thoughtful planning, and by extension such planning supports the fundamental values of the communities involved. When impacts to habitat and connectivity are assessed by allowing development to occur anywhere it is currently allowed, the results are much worse than any of the scenario approaches. It can be said that in most cases (for most species and economic and social metrics) Compact Development and Conservation (Scenario 3) was better or equal to other scenarios in supporting MBOSG conservation values and planning goals; however all of the scenarios were implemented with a fundamental approach of balance that recognized those MBOSG planning goals and values.

Resources and Mapping to Inform Decision Makers and Developers

Objective: Provide resources and mapping to alert decision makers and developers regarding critical "block points" or other considerations that exist or are possible based on expected growth that can be gleaned from the Alternative Futures analyses.

While the scenario development footprints (Figure 11) are useful to assess implications of alternative development policies at a basin-wide scale, species-based detail from the Wild Planner output in Appendix J can be used at a site level scale to refine and inform both future development and conservation acquisitions. While the data are not intended to take the place of a biological survey by a trained professional, they can provide insights into what sorts of questions should be asked, when making decisions about the use of different parcels of land, both public and private. Results can serve some of the following uses:

- When citizens appear before policy and decision makers at a public forum (local, state or federal), this type of data and analyses can be used along with local knowledge of the area to raise questions regarding the best approaches to development.

- Decision makers can use the results to weigh alternative approaches to development, and generate dialogue and meaningful answers to "what if" questions about impacts of choices.

- Conservation efforts such as those undertaken by land trusts, non-profits, state agencies tasked with protecting habitat and wildlife, or federal agencies (such as the Department of Defense's REPI[16] program) can use this type of value-added information to help prioritize conservation actions.

[16] REPI stands for "Readiness and Environmental Protection Initiative" and is a tool for combating encroachment that would interfere with the ability of military installations to perform their missions and maintain military readiness. REPI projects promote and enable innovative collaborations between the Department of Defense and conservation organizations and other government agencies that benefit both the environment and military readiness. The Quail Mountain Project is one example of a successful REPI project that preserved 955 acres of pristine desert tortoise habitat in the Morongo Basin.

- Developers can utilize species-specific information (such as is presented in Appendix J) to proactively anticipate and mitigate concerns of proposed development projects.

Access to the results of the Alternative Futures project reflects needs similar to that of distributing the results of the Conservation Priority Setting work undertaken by the MBOSG. While summary reports and documents are of interest for sparking dialogue around the results, there is frequently a desire on the part of stakeholder and decision makers for more fine resolution data, that is, people want to know how the analysis evaluates the *backyards* of themselves and their neighbors. Vehicles for disseminating results and educating users on the appropriate use of the data and results can have positive impacts on local decision making. Some of the possible approaches to facilitating access and utilizing the results of this analysis (and this type of analysis) include:

- Create and maintain a **website** that is easy to use, has intuitive user functions and search capabilities, and contains information links to the source data and reports. Care must be taken to present data in a manner that is not perceived to infringe on privacy and respects local norms; for example, in California the names and addresses of property owners are not posted with assessor's parcel data the way they are in other states so that type of data should not be included in a publically assessable results website.

- Distribution of **GIS-based files** to groups that can use them, including developers and local government entities. The capacity to use and interpret this type of data may be limited, but the use of data extracts may be appropriate and possibly transferred to formats that can be used by citizen planners and stakeholders. For example, a complex Esri geodatabase can be reduced to essential data fields and saved as a shapefile that can be used readily in free GIS software such as ArcGIS Explorer. Data layers can be saved in a format that can be displayed on Google Earth free software that includes an imagery base layer and other accessible data for use by planners, citizens and stakeholders.

- Make data results **available** at an appropriate scale and resolution for integration of the **results into other planning processes**, including local planning processes such as general plans, site level development, water planning, fire planning, habitat conservation plans, and resource management plans. The data should be shared in a format compatible with the agency's needs and capabilities.

- Results can be **incorporated into planning tools**, such as the development of local standards and development codes (for example, the development of a model wildlife protection overlay ordinance). This approach goes beyond giving decision makers results that they may or may not have time to peruse, and gives them tools to utilize results to make effective choices.

Findings: Integrating Open Source/Open Access Tools

Beyond the results of the *analyses* that resulted from the integration of open source and open access tools that occurred in the Alternative Futures project, it is useful to explore the *integration*

itself from the perspective of the implementation issues that arose in this project, as harbingers of similar issues that could be anticipated to arise in other projects that attempt to integrate open source and open access planning tools. Integration is considered here from three different perspectives: the *capacity* for integration, the need for effective and efficient *communication,* and the question of what best creates an environment for software and tool developers to benefit from and maintain *participation in open source or open access (*which can be expected to benefit the larger planning and stakeholder communities, over time*)*. While the discussion below separates these components, there is an interdependence among them that manifested during the implementation of this project, and that can be expected to manifest in similar integrations.

Capacity

One of the most appreciated functions of the MBOSG has been its ability, through its relationship with Sonoran Institute and the SI-LILP Joint Venture, to access the *capacity* to develop *products* to assist in the realization of MBOSG regional planning goals (Appendix C). The Conservation Priority Setting Report and this Alternative Futures project are examples of products that utilized existing local capacity in synergy with access to outside expertise to implement this project in a rural setting.

While the local national park and marine base have GIS capacity to serve their respective missions, the ability of Morongo Basin local governments and non-profits to access spatial data in a GIS environment and utilize open source and open access software to tackle local development and conservation issues is, while improving, somewhat limited. The needed expertise (and in the case of ArcGIS—the ownership of licenses) to access and apply the appropriate versions of Envision Tomorrow and Arc GIS and the ability to transform outputs (Envision Tomorrow, Wild Planner) to inputs (Wild Planner, Circuitscape) for use in the overall analysis was in this case provided by expertise and consultants from the Sonoran Institute, Craighead Institute and Fregonese Associates. Simply making a tool available does not guarantee the ability to utilize it, or to apply it correctly, regardless of need.

Even among "experts" experienced in GIS and having some previous Envision Tomorrow experience, the utilization of Envision Tomorrow presented a somewhat steep learning curve; this could be expected with other openly available software. While the Excel spreadsheet is a familiar format, its integration with ArcGIS involves an understanding of the nuances of that linkage and relationship, and a simple mistake such as opening more than one copy of the scenario spreadsheet while working in the Envision Tomorrow environment was known to cause confusion and possible data corruption. In instances of unexpected results, or where the software may have not been designed to handle a specific situation, there may be uncertainty as to how to proceed. While some users may be able to work with developers to resolve the issue, others may chose to accept the results and move forward without a firm understanding of the implications.

Thus, the question of existing capacity is one that should likely be carefully considered when employing open source and open access software. Effective use of tools is dependent not only on the accessibility of the tools, but on the structure of support that could allow a local stakeholder group (or government, or non-profit) to implement a project. Some items for consideration include:

- Is the software platform for utilizing the open source/open access tool available and accessible? For example, many of the planning based open source tools currently need ArcGIS to run, which itself is not open source or open access.

- Do the open source/open access tools come with user manuals or help files that can instruct a relative novice in their use?

- Are there financial resources available to hire, if needed, the tool developers or other experts to assist with implementation?

- Is there online access to a users group, chat group or support system of other users that could support implementation of the tool or tools?

- Is it known that a certain level of expertise (e.g. proficiency in programming language) is understood for the utilization of the open source or open access tool? If so, is that expertise available?

Communication

Some early graphic cartoons explaining the relationships between GIS components included lines between boxes representing links between modules for software, hardware and "liveware". Liveware[17] is a term used to denote the human computer user, a necessary component needed to operate the system and to allow the software and hardware to communicate. Human intervention was essential in this project to enable communication between open access/source modules and programs. That is, there was a need for both programming and manipulation by operators with expertise (a question of available capacity) to allow the different modules (Envision Tomorrow, Wild Planner, Circuitscape, ArcGIS) to interact with each other and produce results.

The skill-set necessary to successfully execute this type of modeling process is a rare one. It requires sufficient GIS skills to manage, process and trouble-shoot the technical challenges. Meanwhile, the ET painting requires enough familiarity with development patterns that operator judgment is an accurate representation of potential scenarios. In other words, this type of implementation requires a high level of both planning and GIS skills, ideally housed in the same person.

The specific instances of implementation of some of these cross-module communications for this project were discussed in the section on Project Implementation and will not be reiterated here, but they can be used to highlight examples of types of communication that are often necessary to implementing integration in an open source/open access environment:

- Transferring development pattern results from Envision Tomorrow to Wild Planner involved several manipulations in the GIS environment to convert the polygon-based Envision Tomorrow results to point-based input for Wild Planner.

[17] Other slang terms for computer operators include wetware, meatware and jellyware.

This is an example of a manipulation that had never been done before, so the stepwise process of manipulating the data was created specific to this instance. Were Envision Tomorrow-Wild Planner integration to be ramped up to many project locations, the manipulation could likely be programmed or streamlined in the GIS environment.

- The previously described integration of Circuitscape with Wild Planner is an example of an integration of open source tools that requires much less intervention than establishing the Envision Tomorrow-Wild Planner lines of communication. Wild Planner simply passes parameters to Circuitscape that are automatically run as a separate process and the results are passed back to Wild Planner for further processing. No intervention from the user is required, with the exception of establishing a parameter to allow Wild Planner to find the Circuitscape executable file in the correct directory in some cases[18].

  While there will not likely be a near future where all open space and open access tools operate in an environment analogous to "plug and play", where no intervention is needed to allow modules to communicate, organizations such as the Open Source Initiative (www.opensource.org) provides a platform for addressing communications issues from a wider perspective, while an initiative to open access to scenario planning tools is underway and being supported by the Lincoln Institute of Land Policy and the Sonoran Institute (www.ScenarioPlanningTools.org).

- When the Esri ArcGIS platform issues upgrades, this impacts the extensions (such as Envision Tomorrow and Wild Planner) that run on that software, necessitating such actions as upgrading the code of the extensions. In the aftermath, incompatible combinations of software often result, mandating changes in the versions being used. When working remotely on different platforms, it is even more crucial that some sort of version control be implemented to allow sharing of data, inputs and outputs.

  This issue impacted the Alternative Futures project, necessitating the upgrade to a newer version of ArcGIS that caused problems for one of the participants in the analysis, due to the relative incompatibility of the new software and older hardware. Also, during the development of this report, it was necessary for one of the participants to downgrade software to re-access portions of this project, which is not currently readily compatible with a newer version of Envision Tomorrow. This upgrade also affected Wild Planner, when an incompatible output file was generated by the new ArcGIS version, necessitating a corresponding update to Wild Planner. While such upgrades are expected over the course of development of these types of tools, the general situation is that the authors of the extensions are responding to changes made at the ArcGIS platform level.

[18] When Circuitscape is called, Wild Planner will first look for the Circuitscape executable file in the default installation directory. If the executable is not found, Wild Planner will search the C: drive of the computer for the executable. If the executable is found, Wild Planner will automatically modify its own code to update the default search path for the executable to speed execution of future runs. If Circuitscape is installed on a drive other than C:, the user will have to modify the 'local_params.py' file in the Wild Planner package with correct installation path. Instructions for this modification are included as notes in the 'local_parms.py' file directly above the line to be modified.

Open Source and Open Access

Envision Tomorrow and Wild Planner were the two main tools used in this project; the discussion below highlights both specific aspects of their use and includes some generalizations for developers and users regarding open source and open access software and tools.

Envision Tomorrow is currently an open source tool, although it is built on two proprietary software packages, ArcGIS and Microsoft (MS) Excel. Currently, Envision Tomorrow is being improved through a partnership with the University of Utah and a grant from the U.S. Department of Housing and Urban Development. The improved version of Envision Tomorrow (Envision Tomorrow+) will include improved methods for including existing development in scenarios, as well as new modules to address vehicle miles traveled and growth projections. Envision Tomorrow+ will also include extensive documentation of the software and assumptions, as well as some support, although the nature of that support is undetermined right now. A strength of Envision Tomorrow is its basis in MS Excel, which, while not open-source, is familiar to professionals in many scientific fields, and allows for easy modification and incorporation of new metrics.

Many open source tools suffer from a lack of technical support from the developer; however, Envision Tomorrow developers (Fregonese Associates) were employed in this project on a contract basis to assist with its implementation. Such affiliations highlight a key benefit to open source developers to making products available to users—not all users have the full capability to use the tools, and will often turn to developers as paid consultants to lift them over the more technically onerous portions of an analysis. Developers of open source or open access tools will find it necessary to determine the amounts (if any) of assistance they are willing to give to users on a *pro bono* basis, and at what point their users will need to engage them as consultants to assist in a project.

From the perspective of the users, simply obtaining and activating the Envision Tomorrow software would not have been necessary and sufficient for performing the Alternative Futures analysis. There were several critical junctures at which Fregonese Associates staff intervened and corrected or refined steps in the process to the ultimate benefit of the project; this type of association was invaluable. Conversely, since the Fregonese Associates staff was geographically remote from the project area and had not previously implemented the Envision Tomorrow analysis in a similar rural desert environment, it was necessary to incorporate input from the "field" to refine certain parameters that are often taken as standard for processing in more urban environments.

The Craighead Institute is currently exploring options for licensing Wild Planner for distribution, but the software and source code will be made available free of charge. A number of open source license agreements have been widely adopted that allow a developer to provide free software without losing all their rights to the software. These include GNU[19] General Public License (GPL), GNU Lesser General Public Licenses (LGPL) and original Berkeley Software Distribution (BSD) license. Currently a GPL, LGPL, or original BSD licenses are options under

[19] GNU stands for "GNU's Not Unix", an early free software system that established a system of licenses under the GNU project that are used by others as licenses for free software.

consideration for Wild Planner, and a final decision on how to proceed will be made in spring 2013.

Developing a user community to exchange ideas and improve the Wild Planner tools would positively support land use planning for wildlife and the Craighead Institute mission. This would best be realized by making the source code freely available to other users. In fact, an older version of Wild Planner has been available for download from Esri for several months, although it has not been widely publicized. The main criteria for licensing are that developers receive proper credit for their work, retain the right to use and develop the software, and encourage the user community to make enhancements freely available. In terms of benefits, the development of enhancements can go both ways as discussed above, the user community can create modules that would merit incorporation into future versions of an open source or open access software package.

Although Wild Planner is intended as open source software, it must be used within the proprietary ArcGIS environment. While other feature-rich GIS software packages are available (e.g. GRASS or Quantum GIS), ArcGIS has become an industry standard with far more users than have open source options. Most users interested in using Wild Planner will be familiar with, and have access to, ArcGIS. Therefore, there is no benefit seen at this time to redeveloping Wild Planner as a purely open source product with no proprietary dependencies. However, it can be noted that there are other open source products that have taken this type of "stand alone" approach, both for developing downloadable products and for provisioning online access to software that can be used to produce results. Such products can be downloaded or implemented independent of a software platform resident on a user's computer or server.

Recommendations: Lessons Learned for Effectively Applying the Integration in Other Settings

Integration Lessons

Integrating Envision Tomorrow and Wild Planner required some technical problem-solving in GIS and coordination and communication among team members, but as the tools are both based on similar GIS platforms, the technical challenges outlined above were relatively routine and in the realm of the expected for this type of project. As noted, there are steps that could be taken (in terms of more well developed capacity, anticipating needs, and possibly automating certain steps), that present opportunities to streamline integration in future projects were this integration to be applied in other settings.

Although Wild Planner was designed for scenario testing, this is the first application that combines Wild Planner with scenarios developed specifically to emphasize regional planning interests not related to wildlife. This approach shows promise for developing scenarios that: 1) satisfy other planning interests, while 2) minimizing negative impacts to wildlife; and 3) drawing attention to critical areas on the ground that are essential for maintaining regional wildlife populations.

A future potential continuation of this work (not included in the current project), could use the results of the Wild Planner analysis to adjust the scenarios, where possible, to eliminate unnecessary impacts on wildlife. Such an approach would work toward the goals of the stakeholders in the MBOSG who expressed concerns in the beginning of the Alternative Futures process for a balanced approach, voicing the sentiment that they were not looking for the "one best" scenario, but to learn from aspects of the different scenarios that worked toward community goals and to develop an approach to policy and growth that was informed and adaptive.

Application Setting

The Morongo Basin shares some similarities with many western rural areas, in that it has a relatively low population base and density; high percentage of land base in public ownership (BLM, National Park Service, Department of Defense, and U.S. Forest Service); high levels of visitation; relative isolation from major Interstate highways, rail transport, retail and professional services; and a group of unique communities inhabited by people with passion for the place, many of whom are increasingly economically challenged. Like some amenity communities, the area depends in large part on tourism for its economy, and there are numerous residential properties that serve as second homes and desert retreats, mostly for Southern California city dwellers. Thus, the natural processes and landscapes are a valued asset to the people who both live in and visit the area deemed worthy of protection and conservation, while at the same time there are concerns about the rights of property owners and a desire for encouraging projects that contribute jobs to the local economy.

For implementing Wild Planner, such a rural setting was somewhat analogous to previous rural, relatively sparsely settled settings (such as Montana) where the habitat and connectivity analyses had previously been conducted. Once the appropriate inputs and parameters for the desert species were obtained, the analyses were readily performed in the California desert setting, and could as readily be implemented in many other types of settings with the same preparation.

That said, it was noted that one of species originally planned for analyses as part of the Alternative Futures project (the fringe-toed lizard) was dropped when it was determined that the specific needs of this species (for windblown sand that influences the absolute directionality of influences of human development, different from most species where influences extend equally in all directions*)* was not accommodated in the current Wild Planner models. This is an example of a situation where having the expertise of the Craighead Institute model developer at the helm during analysis was instrumental in determining whether an analysis was being appropriately conducted, and whether the results were valid. Were a less experienced user of the free software conducting the analysis, it is not certain that this issue would have been detected. A caveat for applying this Envision Tomorrow-Wild Planner integration in other settings thus includes the general admonition to consider the robustness of the models being used and their appropriateness to the specific setting. Capacity and expertise will likely play a role in such a determination.

While it was not an issue in this setting, since the open spaces of the Morongo Basin share some characteristics with the open spaces that the Wild Planner models were initially developed to assess, it should be pointed out that were a more densely populated area to be evaluated using the

Envision Tomorrow-Wild Planner integration, it would be appropriate to examine the Wild Planner models in terms of the scale and resolution at which they operate to assess whether a more "urban" application of Wild Planner would necessitate adjustments in the Wild Planner models or their interpretation.

Conversely, the Envision Tomorrow software, while it has been used in rural settings, has had more implementation in more urban, densely populated areas. This became apparent when the building libraries offered by SCAG were reviewed, and when some of the parameters and suggestions provided by Fregonese Associates were considered for use in this analysis. Many of the building and development types needed to be modified to be more "desert wise" in order to accommodate local stakeholders' perceptions of appropriate future development types. This same type of modification of Envision Tomorrow's input parameters is likely necessary for any new setting, and presents an opportunity for participants to closely consider what types of development forms *beyond* those currently in use could serve their communities in the future.

Conclusion

The take-home message from the integration of Envision Tomorrow and Wild Planner is that the integration created a value-added synergy not possible with the implementation of either modeling effort on its own. By using information from the initial Wild Planner analysis to inform a conservation-oriented scenario in Envision Tomorrow, a more thoughtful approach to visualizing development patterns friendly to wildlife was developed. Using the results of the Envision Tomorrow scenarios to look at impacts on wildlife habitat and connectivity from potential development patterns introduced a new dimension to the customary either/or (current condition/full build out) development proposition. Thus, the impacts of both analyses were strengthened as useful resources in ongoing and future choices about where and how growth proceeds in the Morongo Basin.

The implementation of the Morongo Basin Alternative Futures project highlighted the importance of incorporating experts as needed in such a project to assist community and regional planning efforts and to monitor inputs and results, as well as the critical nature of capacity and support in enabling the use of open access and open source software. The effective utilization demonstrated here of employing freely available modeling tools strengthens the case for making such tools widely and openly available in an atmosphere of collaborative support for making wise choices about land use in our communities.

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Appendix A: Fregonese Associates Developer Interview Survey

Envision Tomorrow

Developer Interview Survey

1. Do you specialize in a particular type of development (i.e. single family, commercial, infill)?

2. Do you tend to work in a particular community or across the region?

3. We expect that at least a portion of future housing and job growth will take the form of mixed-use development, either as infill or in new communities. What is your experience with this kind of development?

4. Some examples of development barriers we have found in other communities include:

   - Lack of regulatory certainty
   - Unfamiliarity of financing institutions with this type of development
   - Parking constraints
   - Fractured land ownership
   - Needed infrastructure upgrades

   If you are interested in infill or mixed-use development, are there barriers you perceive (or experience) in the marketplace or regulatory environment?

Thank you for your input. We use this information to help calibrate our planning assumptions.

About Envision Tomorrow

Envision Tomorrow puts powerful tools in planners' hands to design and test land use decisions at a range of scales.

Whether a city or region wants to maximize growth around transit, identify development (and redevelopment) priorities, test and refine regional transportation plans, or evaluate future transportation emissions, Envision Tomorrow helps to examine the possibilities.

The ROI Model tests the physical and financial feasibility of development. Users can examine land use regulations in relation to the current development market and consider the impact of parking, height requirements, construction costs, rents and subsidies.

Scenario Builder adds scenario-building functionality to ArcGIS. The tool includes real-time evaluation metrics related to land use, sustainability, housing affordability and fiscal impacts.

Questions 5-7 on the next page ➡

Envision Tomorrow

Developer Interview Survey, Cont.

5. A key aspect of our project is to evaluate the impact of planning and regulations on the feasibility of development projects. On the regulatory side, we use a spreadsheet-based model to account for zoning requirements (building heights, parking requirements, setbacks, etc.). Our model also accounts for basic cost and financial assumptions as well: construction cost, rent and sales prices per square foot, financing terms, etc.

Can you provide feedback on the following elements?

Estimated construction cost (per square foot):

Single-family residential	$	/sf
Apartments/condominiums	$	/sf
Office (not including tenant improvements)	$	/sf
Retail (not including tenant improvements)	$	/sf

Estimated rent or sales prices (per square foot):

Single-family residential	$	/sf
Apartments/condominiums	$	/sf
Office	$	/sf
Retail	$	/sf

Other project factors/inputs we should take into account?

Parking Costs (per space)

Surface	$	/space
Structured	$	/space
Underground	$	/space

6. Based on these estimates, we usually aim for creating 15% rate of return for a model project (based on a 25% equity stake). These can be rough approximations; our objective is to identify regulatory parameters that serve as barriers to desired development, or to help estimate the order of magnitude of incentive programs to stimulate desired development. Would you consider this a reasonable return?

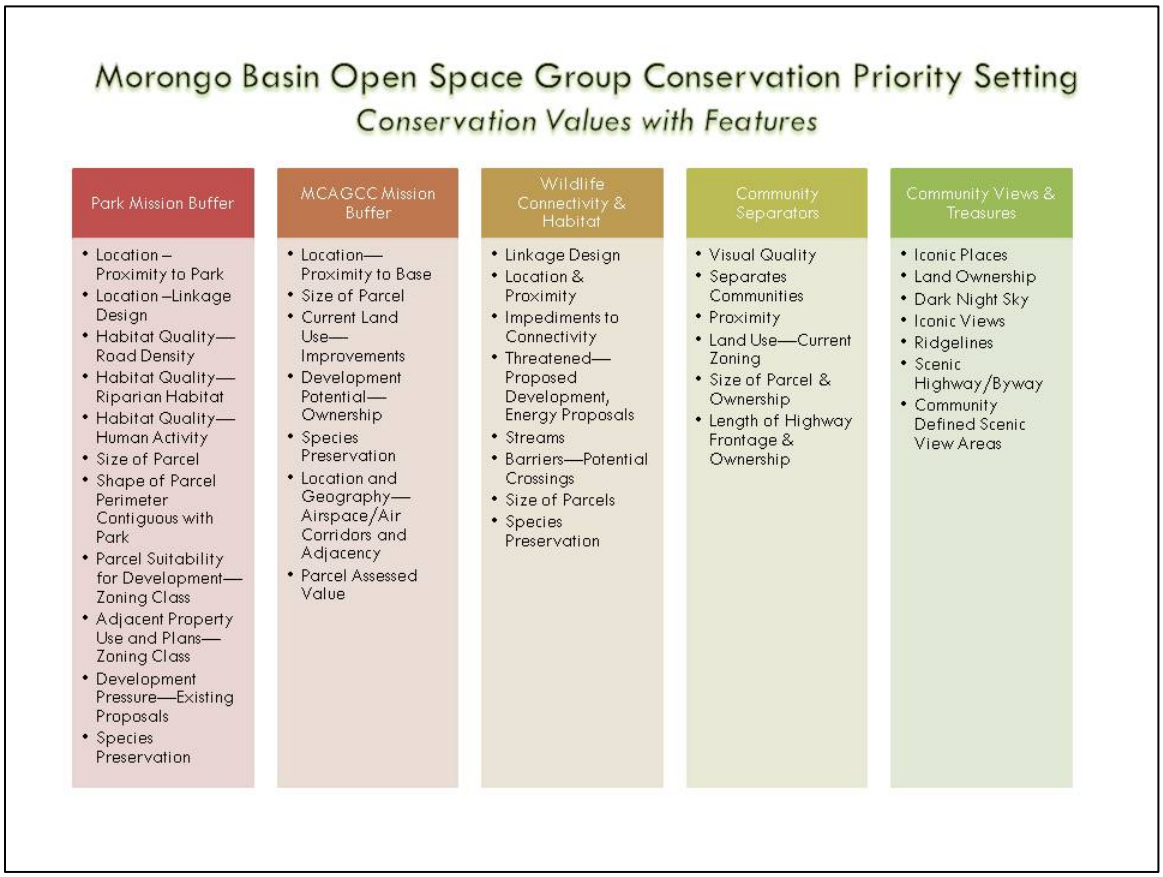
7. Are there product or development types for which you would require a greater or lesser return?

We usually interview a number of people to get a good cross-section of development conditions in an area. May we contact you in the future to help us refine our assumptions?

Name: _____ E-mail: _____

Company: _____ Phone: _____

Appendix B: Conservation Values from Morongo Basin Open Space Group Conservation Priority Setting



Appendix C: Morongo Basin Open Space Group Regional Planning Goals

Morongo Basin Open Space Group
Regional Conservation Planning Goals

Buffers and Separators

- Community Identity
  - Buffers between communities
- Support Base & Park missions
  - Buffers between public lands

Connectivity

- Wildlife Corridors and Habitat
  - Protect ecological linkages and wildlife habitat
  - Protect biologically or ecologically critical areas
- Regional network of trails and open space

Community Values

- Quality of Life and protection of "community character"
- Economic Development
- Support City, County & Town Missions

Water Quality and Quantity

- Protect washes and watersheds
- Protect native groundcover and enhance infiltration

Appendix D: Building Types and Development Types used to Generate Scenarios

Building Types		Description
1	Mixed Use Office 2-story	Retail, commercial-office.
2	Mixed Use Residential 3-Story	Retail, commercial-office, residential mix, residential on upper floors.
3	Mixed Use Residential 5-Story	Retail, commercial-office, residential mix, residential on upper floors.
4	Duplex	Two single family units with shared walls and yard.
5	4-Plex	Four single family units with shared walls and yard area, 2 story.
6	Townhome	Clustered single family units with shared walls. 2 story units. Common yard area. 4 -6 units per building.
7	2-Story Apartment	Higher density apartment building with 10 units per building, amenities such as pool or common areas for workout, meetings.
8	5-Story Apartment	Higher density apartment building with 30 units per building, amenities such as pool or common areas for workout, meetings.
9	Large Lot Single Family (2 du/acre)	Single family suburban home, possibly on septic, yard, garage. 2,000 to 5,000 sf.
10	Single Family Suburban (4 du/acre)	Single family suburban, package treatment or sewer, yard, garage, 1500 – 3000 sf.
11	Compact Single Family (8 du/acre)	Single family suburban, , package treatment or sewer, yard, garage, 1200 – 2400 sf.
12	Rural Living Single Family 1 acre	Single family rural setting, dirt or paved roads, septic, yard, outbuildings, 500-2000 sf.
13	Rural Living Single Family 2.5 acre	Single family rural setting, dirt or paved roads, septic, yard, outbuildings, 500-2000 sf.
14	Rural Living Single Family 5 acre	Single family rural setting, dirt or paved roads, septic, yard, outbuildings, 500-2000 sf.
15	Rural Living Large Lot 20 acres	Single family rural setting, dirt or paved roads, septic, yard, outbuildings, 1500-5000 sf.

Building Types		Description
16	Mobile home	Manufactured home conforming to state and federal laws, single or double wide, 700 – 2000 sf.
17	1-story office	Free standing office, 1 story.
18	3-story office	Free standing office, 3 story.
19	1-story lodging	"Mom and Pop", exterior access to rooms from parking area, 4-20 units, located in neighborhoods or strip development, bed and breakfast.
20	3-story hotel	"Chain", interior access to rooms, 50-100 units, located in strip development or commercial areas.
21	Strip commercial	One story, along highway or arterials, parking lot provided, local and franchise businesses, shared building, each unit (1000-4000 sf).
22	Large format retail	Stand-alone (15-200,000 sf) retail buildings, dedicated parking lot.
23	Main Street retail (1-story)	Local business, on-street parking or parking in rear, unified façade to street, 200-1000 sf.
24	Industrial	Heavy or light industrial use structures, stand-alone or clustered, 800-10,000 sf.
25	Business Flex	Suburban or semi rural business park accommodates office, light industry, warehouses in attached units of varying floor space, one story, 250 – 2000 sf bays or units.
26	Institutional/Civic	Large stand-alone or combined-use buildings (city hall with library), clustered with other institutional or civic uses (campus), dedicated parking, 7500-75,000 sf.

Development Type		Description
1	City Center	Predominantly office, retail, includes mixed use and main street retail, hotel
2	Village Center	Predominantly office, retail, includes mixed use and main street retail. Some multifamily residential, but at lower densities than city-town center
3	Mixed Use Corridor	Mixed use, higher density residential, hotel
4	City Neighborhood	Predominantly higher density multifamily housing with some lower density mixed use and office
5	Village Neighborhood	Predominantly multifamily housing with some higher density single family, some lower density mixed use
6	Suburban Residential	Predominantly single family housing with some multifamily housing, some manufactured homes
7	Rural Residential 1 acres	Single family rural living
8	Rural Residential 2.5 acres	Single family rural living
9	Rural Residential 5 acres	Single family rural living
10	Rural Residential > 20 acres	Single family rural living
11	Main Street	Main street retail, some single and multi-family
12	Regional Retail	Predominantly large format retail with some strip commercial
13	Strip Commercial	Predominantly strip commercial, some large format retail
14	Flex Park	Predominantly business flex, light industrial, some office
15	Industrial	Heavy and light industrial, some business flex
16	Institutional/Civic	Institutional and civic
17	Open Space	No structures, includes protected areas

Appendix E: Development Type Densities

Development Type	Net Density (dwelling units/acre)
City Center	19.46
Village Center	10.04
Mixed Use Corridor	9.02
City Neighborhood	11.63
Village Neighborhood	8.17
Suburban Residential	3.71
Rural Residential 1 acre	0.99
Rural Residential 2.5 acre	0.39
Rural Residential 5 acre	0.20
Rural Residential > 20 acre	0.05
Main Street	5.42

Appendix F: Data Inputs Required for Wild Planner Analysis

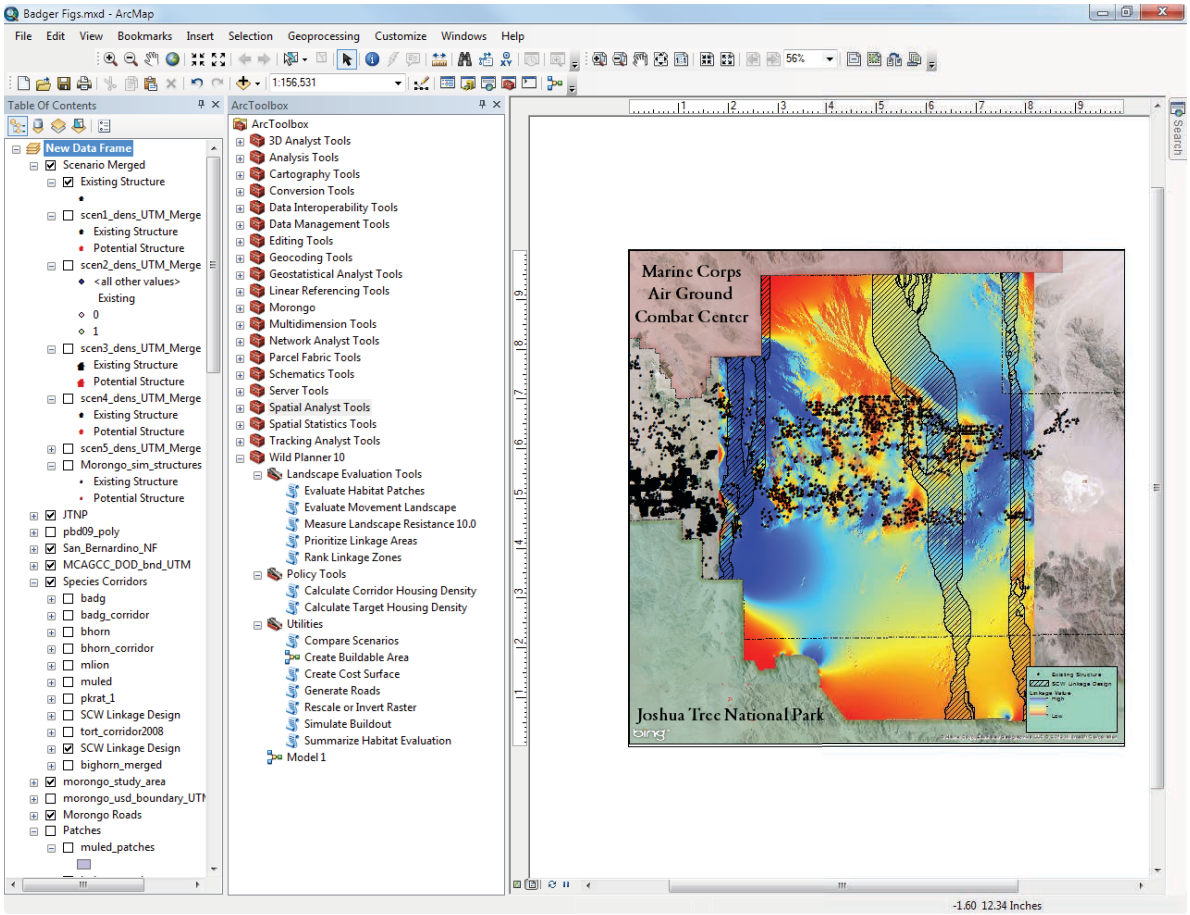
1. List of appropriate focal species that, in combination, will capture conservation needs to meet project objectives.
2. GIS layer of potential habitat for each focal species.
3. GIS layer of priority habitat linkages.
4. Species specific estimates for:
    a. Minimum habitat patch size
    b. Minimum corridor width
    c. Influence distances from houses and roads
5. GIS layers of existing structures (and potential new structures if scenario analysis is desired).
6. GIS layer of existing roads
7. Some analyses may also require GIS layers for land cover and/or elevation which are publicly available for the U.S.
8. Creating full buildout scenarios also requires:
    a. GIS parcel layer
    b. GIS layer of buildable area (typically user created) which may require GIS layers of:
        i. Land ownership
        ii. Conservation Easements
        iii. Slope
        iv. Wetlands
        v. Zoning
        vi. Other criteria that would render a site unsuitable for development

Appendix G: Analysis Parameters used in Wild Planner Analysis

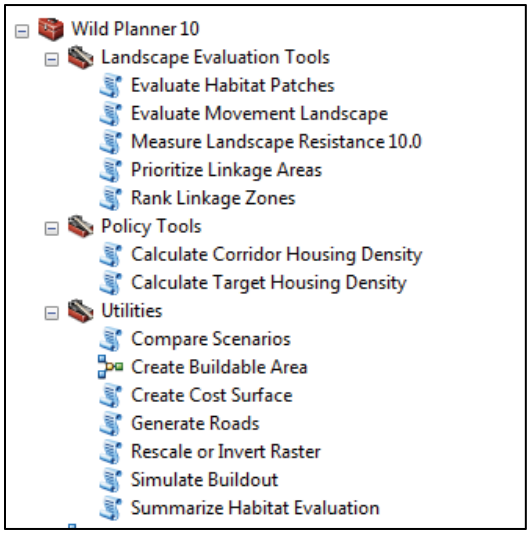
Species	Minimum Habitat Patch	Influence Distance (Structures)	Influence Distance (Roads)	Minimum Corridor Width	Reference
American Badger	400 ha	*50 m	*10 m	200 m*	Penrod et al. 2005; Penrod et al. 2008
Bobcat	9 km2	100 m	100 m (i)	200 m*	Penrod et al. 2008; Tigas, Van Vuren and Sauvajot 2002
Bighorn Sheep (Desert and Nelson's combined)	13 km2	0.8 km	50 m*	200 m*	Penrod et al. 2008; Rodrick and Milner 1991
Desert Tortoise	50 ha	8 km	800 m	200 m*	Boarman 2002; Web, Boarman and Rotenberry 2009.
Mountain Lion	200 km2	100 m	100 m	200 m*	Beier 1995; Penrod et al. 2005
Mule Deer	100 ha	390 m	100 m*	200 m*	Penrod et al. 2005; Taylor and Knight 2003
Pacific Kangaroo Rat	0.5 ha	317 m	100 m*	200 m*	Hall et al. 2000; Penrod et al. 2005

* Undocumented estimate; (i) Inferred from structure distance

Appendix H: Wild Planner Software Screen Capture Including Available Tools



Wild Planner Available Tools



Appendix I. Envision Tomorrow Results by Scenario

	Scenario 1 ***Existing General Plans***	**Scenario 2** ***Jobs/Housing Balance and Fit***	**Scenario 3** ***Compact Development and Conservation***	**Scenario 4** ***Rural Living Emphasis***	**Scenario 5** ***Base and Park Mission Protection***
Developed Acres	4,818	3,598	2,203	9,963	5,865
Development Sq. Ft.	21,176,935	23,384,341	20,432,121	22,274,409	21,205,006
% Residential	72%	66%	71%	72%	70%
% Retail	11%	13%	13%	10%	12%
% Office	6%	6%	6%	6%	6%
% Industrial	11%	15%	10%	13%	12%
Parking Spaces	28,988	32,552	28,691	28,216	28,521
Population	18,477	18,459	18,363	18,745	18,013
Average Household	2.26	2.31	2.06	2.56	2.30
Housing Mix					
% Large Lot Single Family	40%	48%	26%	57%	42%
% Conventional Lot Single Family	17%	17%	19%	13%	16%
%Townhome	5%	3%	6%	3%	4%
%Multifamily	38%	32%	50%	27%	37%
Owner/Renter Mix					
% Owner	62%	68%	50%	73%	63%
% Renter	38%	32%	50%	27%	37%
Average Rent ($)	796	794	809	780	794
Average Home Price ($)*	361,375	334,442	294,372	469,335	380,153
Employment Mix					
%Retail	34%	33%	37%	29%	33%
%Office	48%	45%	47%	49%	48%
%Industrial	18%	22%	16%	21%	19%
Jobs-Housing Ratio**	1.2	1.7	0.9	1.9	1.3
People per Net Acre	4.1	2.7	5.4	0.8	1.7
Housing Units per Net Acre	1.8	2.5	4.7	0.8	1.6
Jobs per Net Acre	1.3	2.2	3.0	0.7	1.2

	Scenario 1 ***Existing General Plans***	**Scenario 2** ***Jobs/Housing Balance and Fit***	**Scenario 3** ***Compact Development and Conservation***	**Scenario 4** ***Rural Living Emphasis***	**Scenario 5** ***Base and Park Mission Protection***
Jobs per Net Employment Acre	21.8	22.5	23.7	21.6	22.7
Energy Use per Household (Million BTU/Yr)	87.1	89.4	82.8	92.7	87.8
Carbon Dioxide Emissions per Household (Tons/Yr)	8.1	8.3	7.7	8.6	8.2
Landscaping Water Use per Household (Gallons/Day)	554.6	499.2	379.5	931.4	594.5
Internal Water Use per Household (Gallons/Day)	139.4	147.6	115.3	174.0	144.1
Waste Water per Household (Gallons/Day)	204.2	214.6	173.1	248.6	210.1
Solid Waste per Household (Lbs/Day)	6.0	6.3	4.9	7.5	6.2
* These prices may be inflated considering current economic conditions and the "relative" lower home prices found in the Morongo Basin. For example, www.city-data.com provides a 2009 average home price for the Joshua Tree Census Designated Place of $183,362. That said the values *relative* to each other for the five scenarios are likely reflective of relative home prices that would result from the alternatives, rather than absolutes.					
** A jobs-to-housing ratio greater than 1.0 indicates that local residents can find available housing in the area; 1.5 is often used as a target value for jobs to housing.					

Appendix J: Major Findings by Species from Wild Planner Alternative Scenarios Analyses

American Badger

Although development has fragmented habitat for badgers within the Morongo Basin, 62% of potential badger habitat within the study area qualifies as relatively undisturbed habitat cores. Most of the core habitat is located on the east and west ends of the study area, but several blocks of habitat core are distributed within the relatively more developed basin center (Figure J-1). The "worst case" scenario of full buildout would reduce core habitat for badger by approximately 8%, leaving 57% of the study area meeting the criteria as habitat cores. Among the planned development scenarios, Scenario 3 (refer to Figure 4 to reference the Alternative Future scenarios by title) resulted in the least impact on habitat with an estimated 0.1% loss of total habitat and less than 0.01% loss of habitat core. Scenario 4 had the greatest loss in total habitat at 0.8% while Scenario 1 resulted in the greatest loss of core habitat, also at 0.8%. These losses are distributed as small reductions of multiple habitat patches throughout developed portions of the study area (Figure J-2). Therefore, badger habitat within the Morongo Basin appears secure.

SC Wildlands mapped separate linkages for badger within the San Bernardino–Little San Bernardino and the Joshua Tree–Twentynine Palms linkage areas. Wild Planner analysis for the San Bernardino–Little San Bernardino linkage roughly follows the SC Wildlands linkage design, although current development around Desert Hot Springs indicates the east end of that linkage may be compromised and badgers may be likely to meander farther to the north of Desert Hot Springs than the SC Wildlands linkage indicates (Figure J-3). A full buildout scenario of this area (Figure J-4) indicates the badger linkage could become severely compromised as existing vacant parcels near Desert Hot Springs are developed. However, this linkage lies entirely outside the Morongo Basin study area boundary[20] and therefore none of the planned development scenarios impact the San Bernardino–Little San Bernardino linkage for badgers.

Figure J-5 shows the Joshua Tree–Twentynine Palms linkage area under current conditions. The results indicate important linkage bottlenecks along the west and east portions of the linkage area. The southern portions of the SC Wildlands linkages are illustrative for interpreting the current density maps produced by Wild Planner via Circuitscape analysis. A misinterpretation might lead to the conclusion that those areas are inferior in quality to areas indicated with higher value. But that is not the case. That area contains a large block of undeveloped potential habitat which means badger movements can be diffused over a wide area resulting in lower current density values. In other words, there are no bottlenecks to movement in that area which would concentrate movements through relatively narrow gaps. As a consequence, linkage value is lower because movement across the area is not sensitive to loss of any particular spot. In addition, the eastern linkages require a longer distance to travel between end points resulting in higher current

[20] Wildlife movement and connectivity occurs across the natural landscape irrespective of the arbitrary boundaries imposed by humans, be they study area boundaries, political boundaries or ownership boundaries. Where to draw the lines delineating a study area is always a consideration; in this instance an existing political boundary (the Morongo Unified School District) was used to coincide with the focus area of the Morongo Basin Open Space Group within San Bernardino County; portions of the SC Wildlands linkage design did in fact extend beyond that boundary.

density along the short paths at the western edge of the linkage area. However, this is an artifact of how the linkage landscape was defined

Therefore, areas of low current density may represent *either* areas that are compromised or unsuitable for movement *or* areas with an abundance of suitable movement habitat that could tolerate some amount of disturbance without compromising the integrity of the movement landscape. Scenario 4 resulted in the greatest loss of connectivity from current conditions (Figure J-6) for badgers in the Joshua Tree–Twentynine Palms linkage with a 7.6% increase in landscape resistance followed by Scenario 1 at 4.9%. This loss results in a moderate narrowing of movement pathways along the western linkage. It is impossible to predict whether this narrowing would result in significant loss of badger movement through the area.

Figure J-1: Current Badger Habitat within the Morongo Basin Study Area

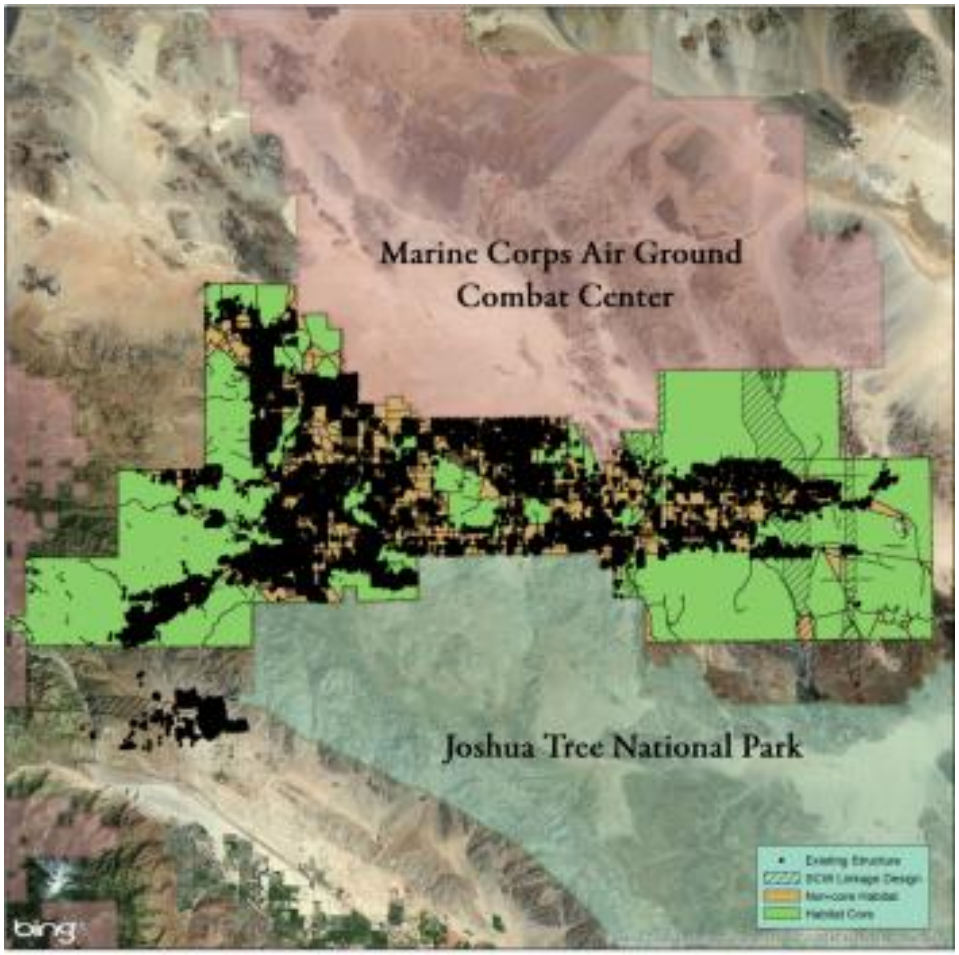


Figure J-2: Example of Areas of Current Badger Habitat that Could Become Compromised under Scenario 1

Other scenarios indicate a similar pattern of compromised areas.

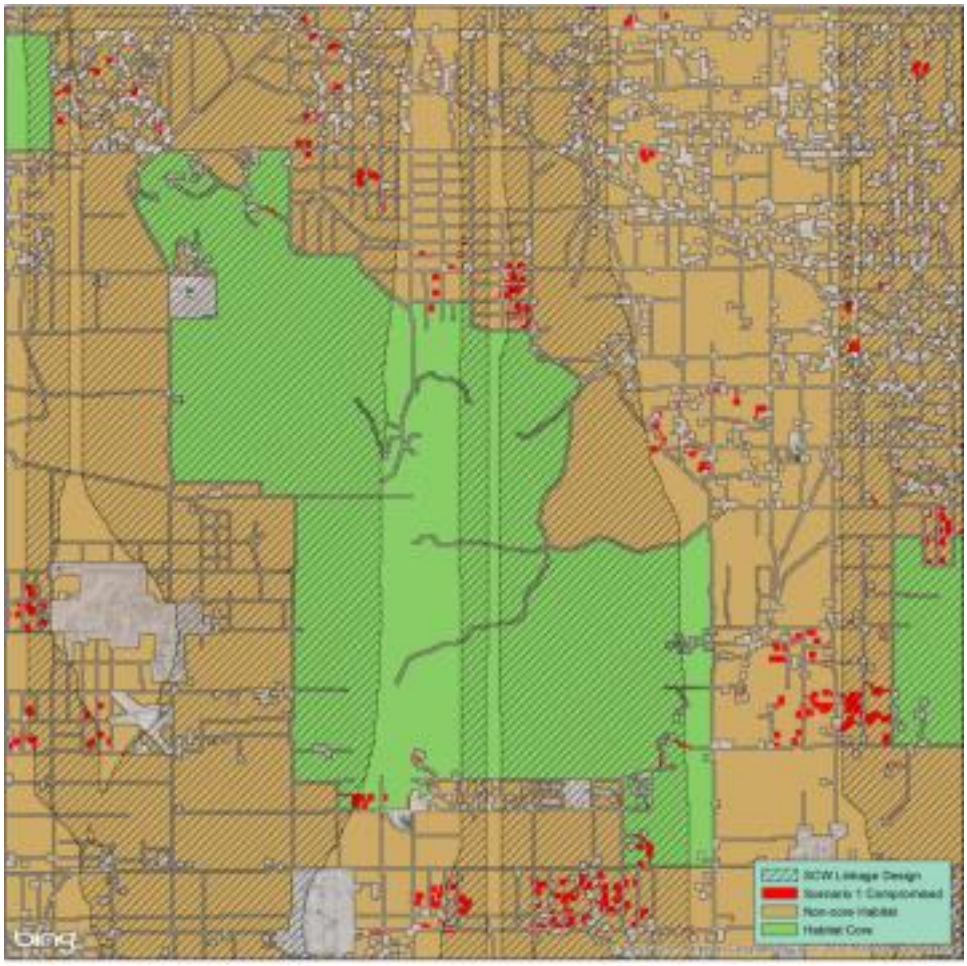


Figure J-3: Badger Connectivity under Current Conditions for the San Bernardino to Little San Bernardino Linkage

Colors represent relative value of current density. Areas of high current density indicate where animal movement is likely to be concentrated.

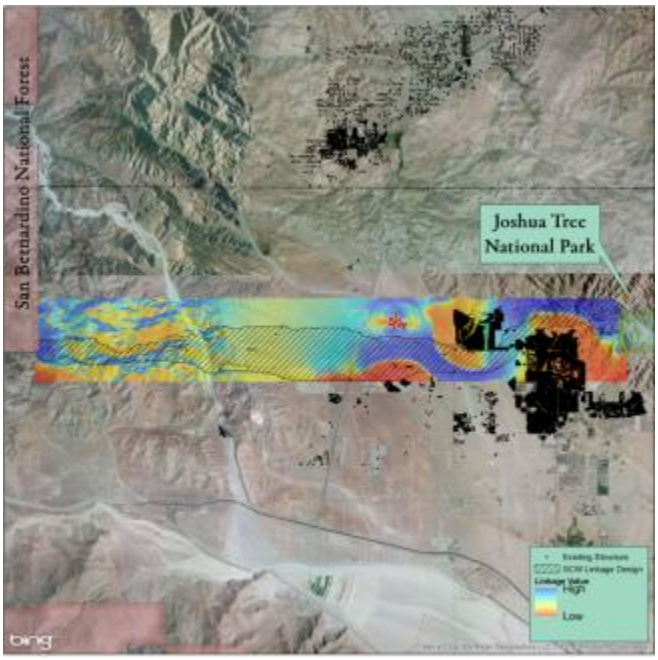


Figure J-4: Badger Connectivity under Full Buildout for the San Bernardino to Little San Bernardino Linkage

Colors represent relative value of current density. Areas of high current density indicate where animal movement is likely to be concentrated.

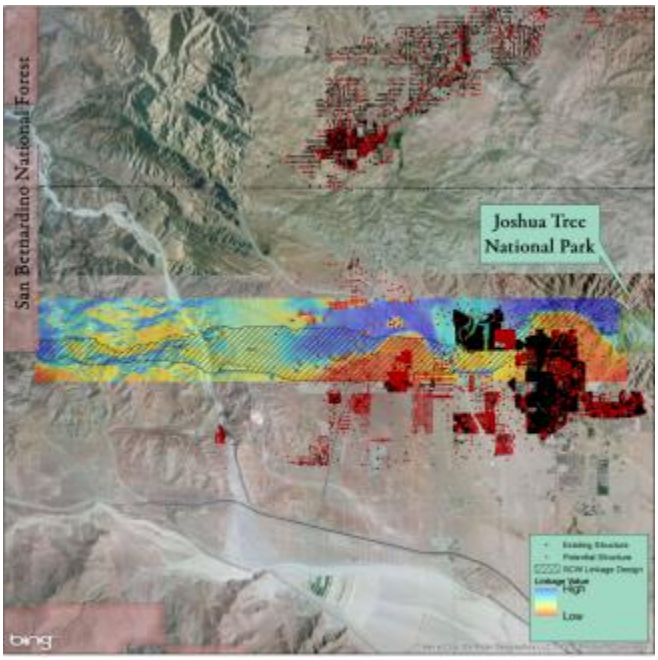


Figure J-5: Badger Connectivity under Current Conditions for the Joshua Tree to Twentynine Palms Linkage

Colors represent relative value of current density. Areas of high current density (darker blue areas) indicate where animal movement is likely to be concentrated.

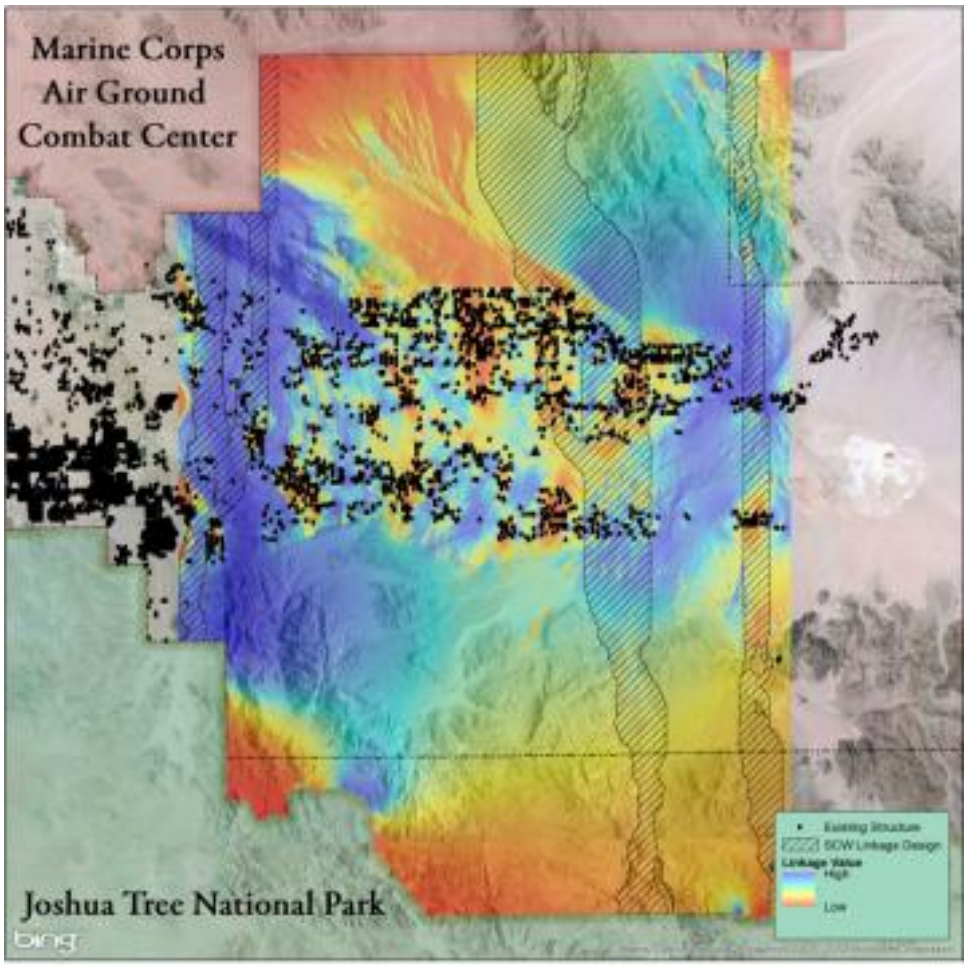
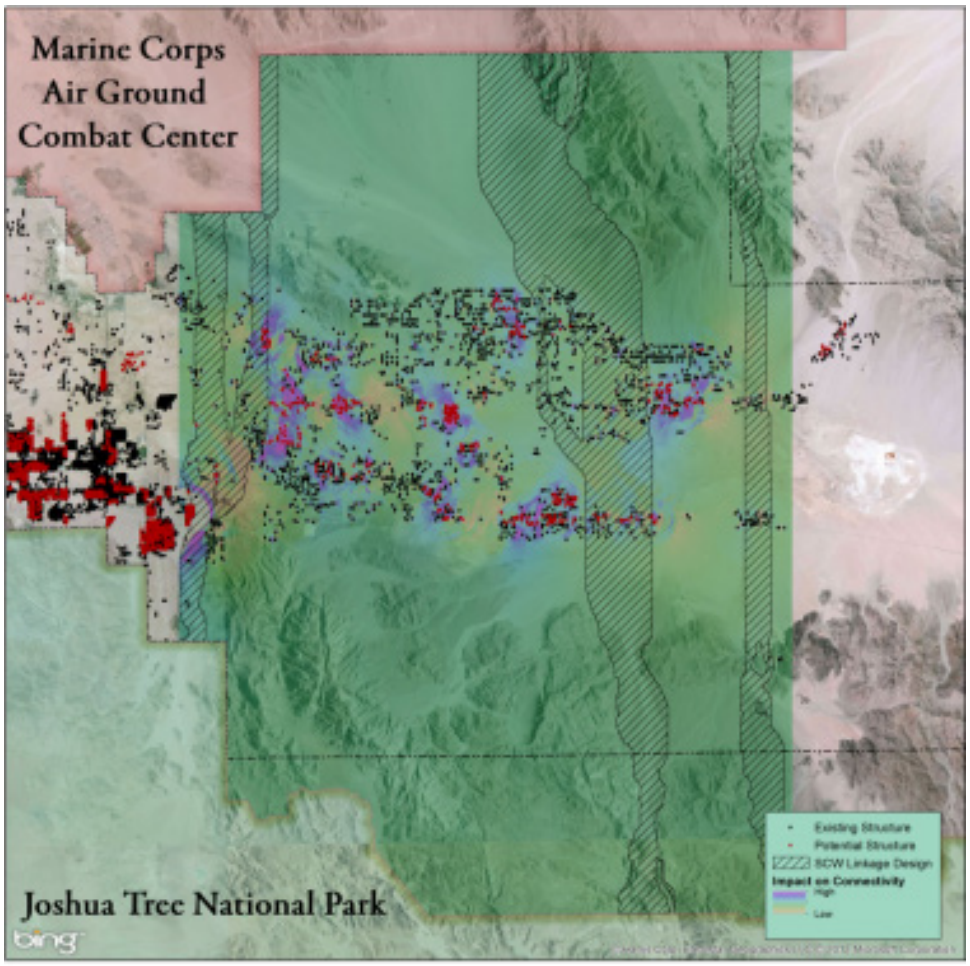


Figure J-6: Potential Change in Badger Connectivity between Current Conditions and Scenario 4 for the Joshua Tree to Twentynine Palms Linkage



Bobcat

Habitat analysis indicates that suitably large blocks of bobcat core habitat surround the perimeter of the Morongo Basin, however habitat within the developed portion of the basin occurs as small fragmented patches (with the exception of a patch of habitat core near the center of the linkage areas for bobcat identified by SC Wildlands; Figure J-7). Although more than 13% of total habitat, including 11% of core, could become compromised or lost under full buildout, none of the planned development scenarios predict significant loss of habitat, so currently habitat for bobcat appears relatively secure. Scenarios 1 and 4 result in the greatest loss of habitat with Scenario 1 contributing to a 0.7% loss of total habitat, and 0.2% loss of core. Scenario 4 is similar with losses of 0.5% and 0.1% for total and core habitat respectively. Areas of additional impact scattered throughout the study area result in small reductions in many habitat patches, most of which are already fragmented (Figure J-8).

It does not appear that planned future development is likely to significantly further impact bobcat habitat within the study area, with the caveat that future development is thoughtfully planned, since there are sufficient undeveloped parcels in the study area to significantly reduce the amount of habitat available for bobcat in the future. The central patch of core habitat within the basin is currently managed by the BLM as an Off Road Vehicle area and therefore may be of limited value as habitat for resident bobcats. However, this area probably provides an important stepping stone for connectivity, particularly since bobcat movement is likely to occur at night when recreational use is likely to be low.

A comparison of connectivity estimated by Wild Planner with the SC Wildlands linkage design indicates that some modification of that design is warranted. The SC Wildlands linkage indicates four discreet corridors for bobcat movement. Wild Planner indicates that the easternmost corridor may already be compromised due to existing development, and that existing development patterns dictate that lateral movement between the remaining corridors provides the best options for bobcat movement (Figure J-9). Under full buildout, resistance to movement could be increased by 62%, resulting in significant restriction to movement in the southern, western, and central portions of the linkage area (Figures J-10 and J-11).

Development patterns modeled by the scenarios analysis and Wild Planner indicated zero to moderate impacts on habitat connectivity for bobcat. Similar to results for badger, Scenarios 1 and 4 were the worst development scenarios in terms of impacts on wildlife, with estimated increases in landscape resistance of 12% for both scenarios. This would result in localized bottlenecks to bobcat movement which could restrict options and impede movement of bobcats dispersing between Joshua Tree National Park and Twentynine Palms Marine Base (Figures J-12 and J-13). Scenario 3 performed the best for bobcat movement, with no measurable increase in landscape resistance compared with current conditions, while Scenario 5 was only slightly worse with an estimated increase of 0.5% increase.

Figure J-7: Current Bobcat Habitat within the Morongo Basin Study Area

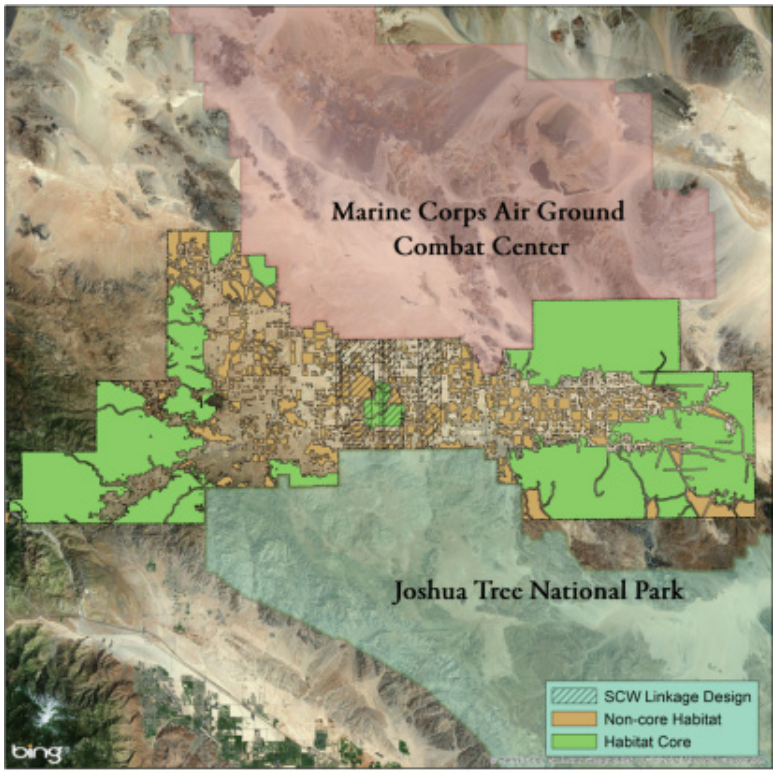


Figure J-8: Example of Areas of Current Bobcat Habitat that Could Become Compromised under Scenario 1

Other scenarios indicate a similar pattern of compromised areas.

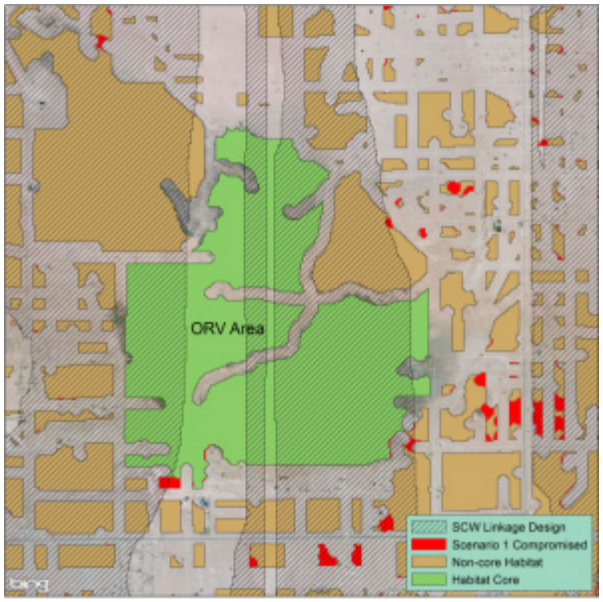


Figure J-9: Bobcat Connectivity under Current Conditions

Colors represent relative value of current density. Areas of high current density indicate where animal movement is likely to be concentrated.

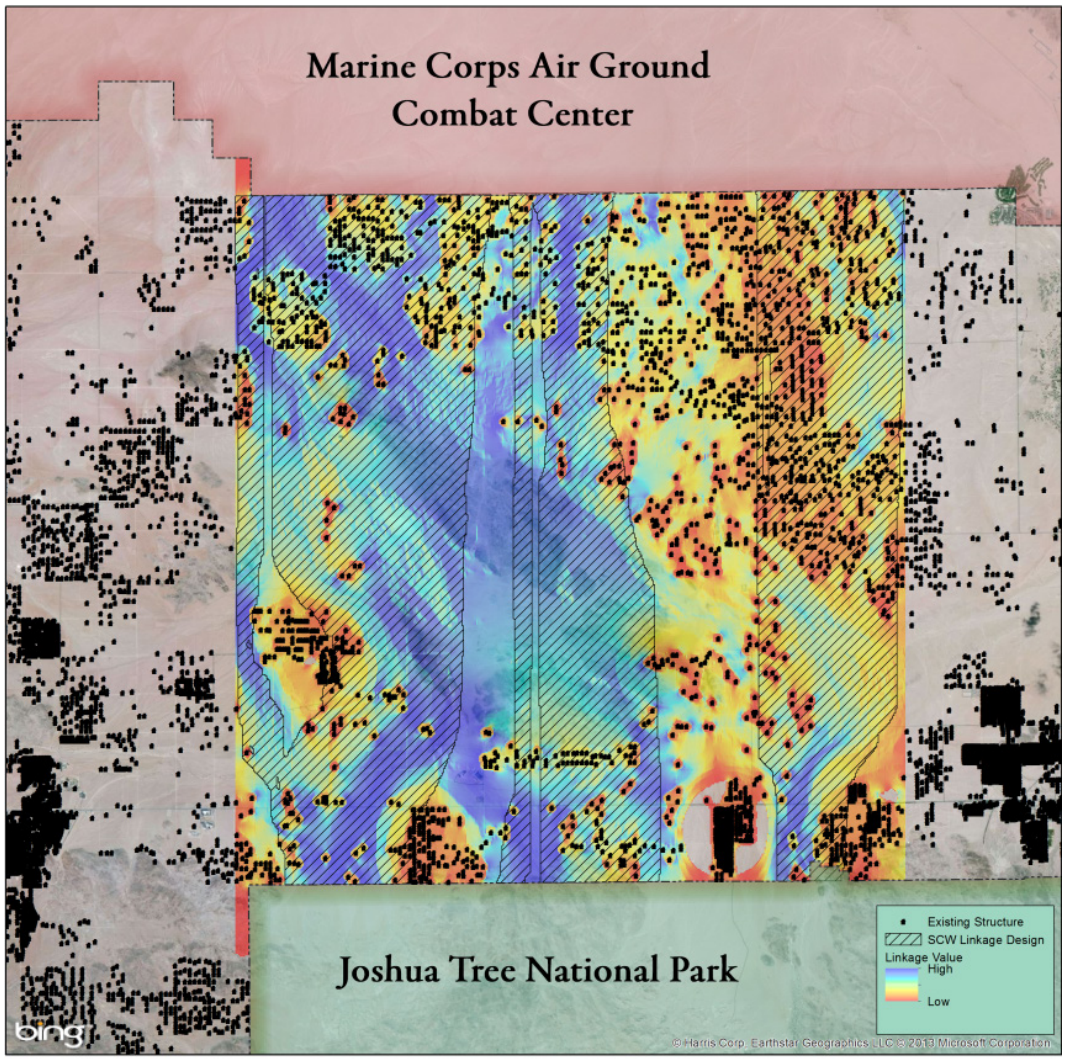


Figure J-10: Bobcat Connectivity under Simulated Full Buildout

Colors represent relative value of current density. Areas of high current density indicate where animal movement is likely to be concentrated.

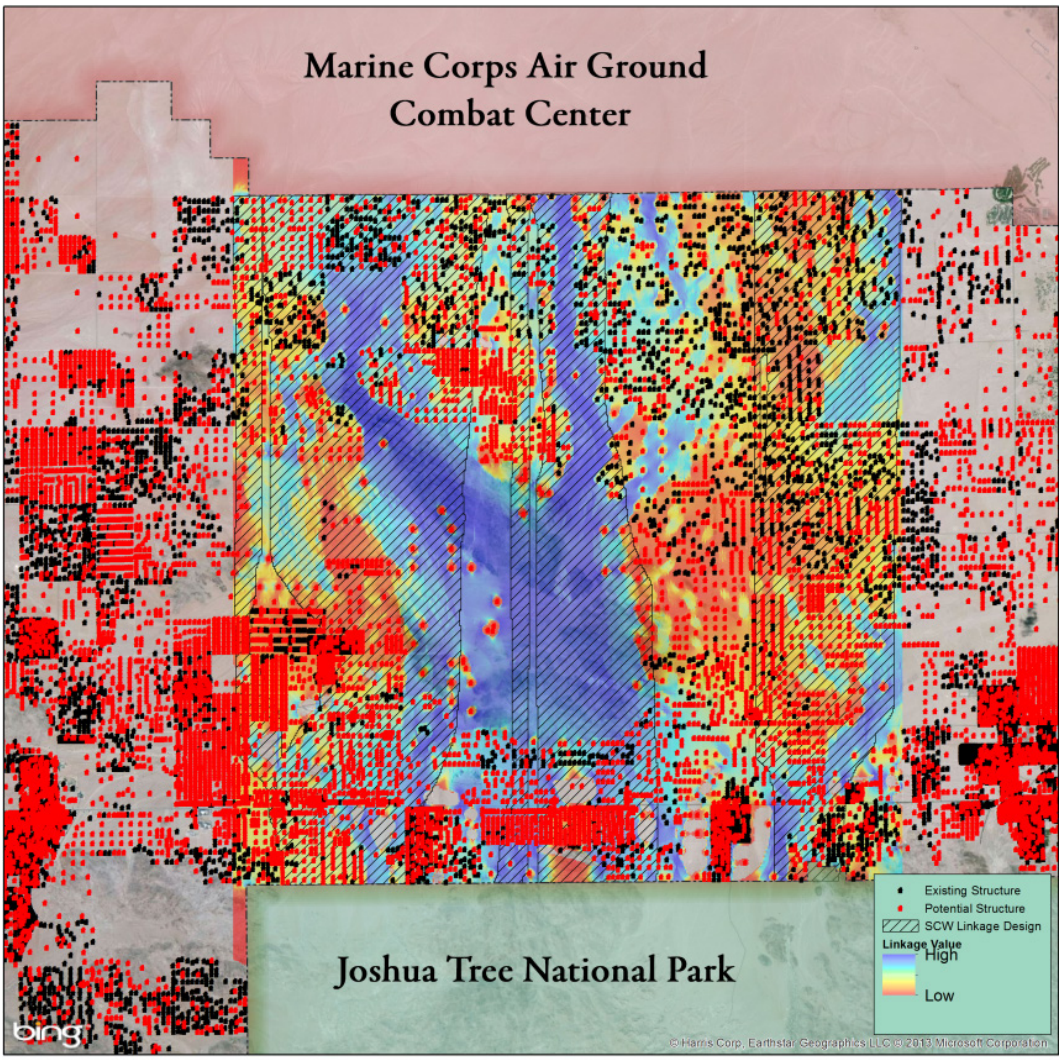


Figure J-11: Potential Change in Bobcat Connectivity between Current Conditions and Full Buildout

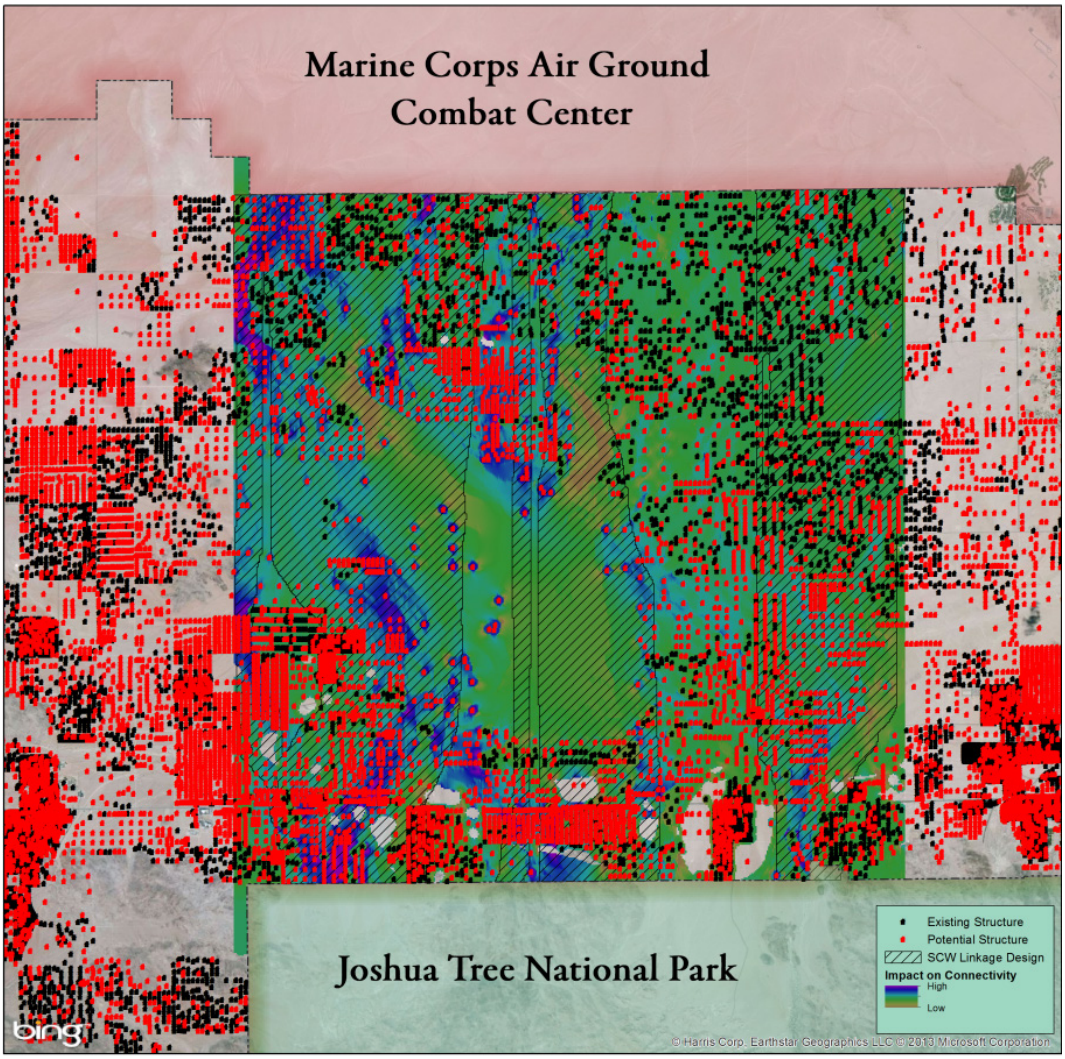


Figure J-12: Potential change in Bobcat Connectivity between Current Conditions and Scenario 1

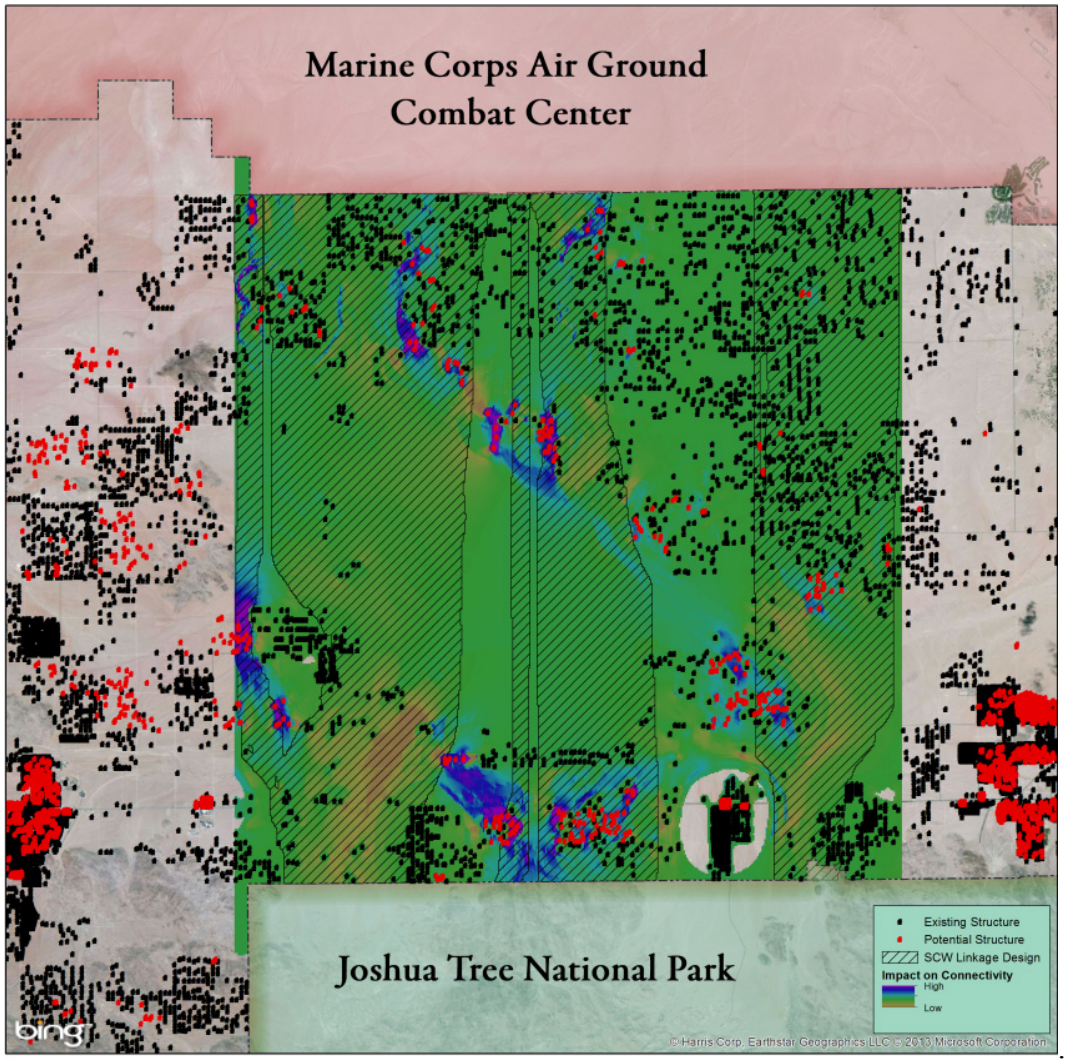
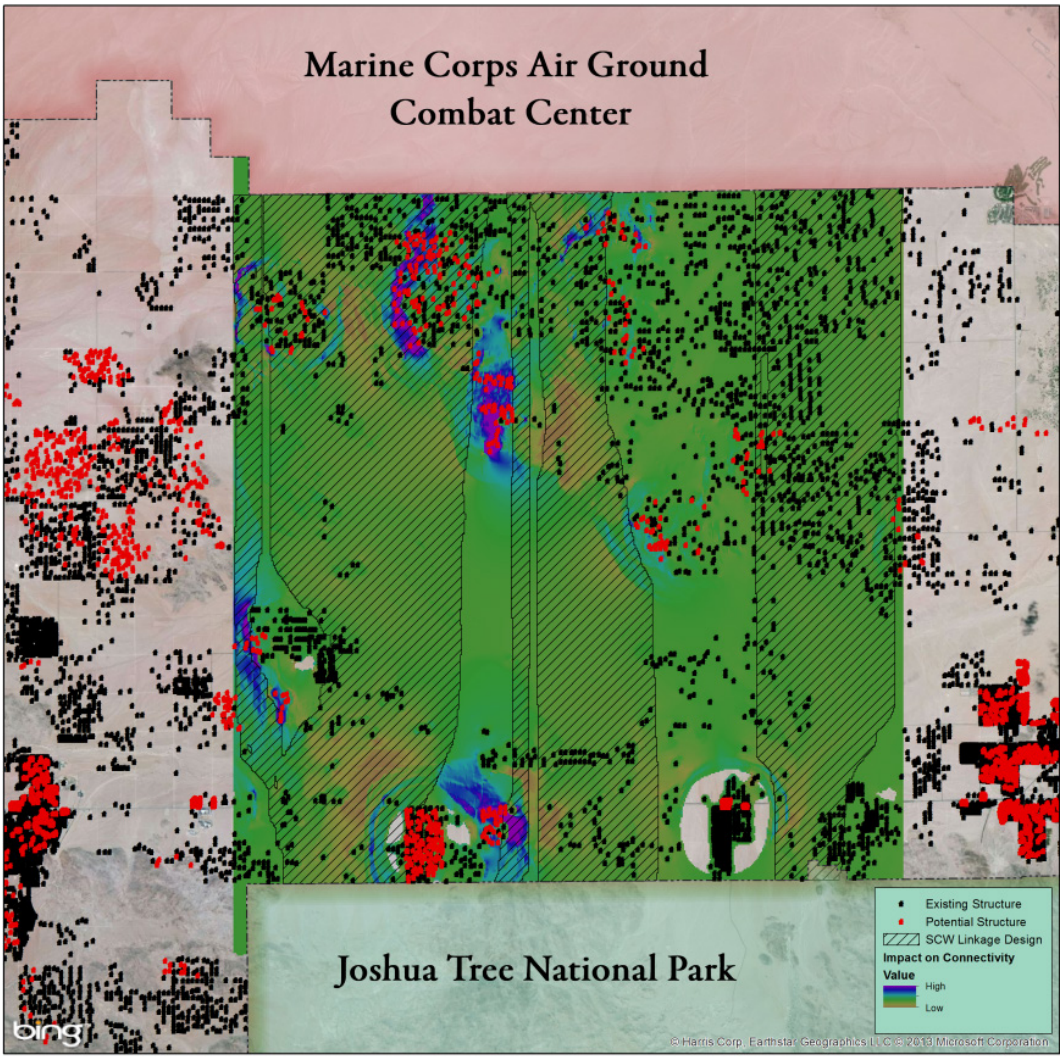


Figure J-13: Potential Change in Bobcat Connectivity between Current Conditions and Scenario 4



Desert Bighorn Sheep

Distinct herds of bighorn sheep occur at the eastern and western edges of the Morongo Basin study area. The eastern herd moves between Joshua Tree National Park and the Twentynine Palms Marine Base while the western herd moves between Joshua Tree National Park and the San Bernardino National Forest. Wild Planner analysis indicates there are no habitat patches sufficiently large to qualify as cores within the Morongo Basin study area. However, concentrations of non-core habitat patches along the eastern and western boundaries of the study area are likely used by bighorn sheep and may be important for maintaining habitat connectivity (Figure J-14). Bighorn sheep habitat is associated with steep terrain that provides security "escape" cover which often occur as small, discreet patches. However, bighorn sheep use areas within 300 m to 1 km from escape cover (Smith et al.1991; Johnson and Swift 2000; Zeigenfuss et al. 2000). Therefore, clusters of small escape patches may represent a cumulative "meta-

habitat" suitable for bighorn sheep. Wild Planner only identifies core habitat based on the size of discrete patches, but future versions of Wild Planner may allow the option of aggregating patches within a specified distance as a single "patch". In view of this limitation, non-core habitat patches near the study area boundaries should be considered potential cores.

It does not appear that bighorn sheep habitat is significantly threatened by any of the modeled development scenarios, this is due in part to the type of terrain inhabited by the species, which does not tend to overlap with prime areas for building and development[21]. Scenario 4 would have the largest impact with a 0.6% loss of total habitat followed by Scenario 1 with a 0.3% loss. However, even these small losses are concentrated mainly in the BLM Off Road Vehicle area and the foothills southeast of the town of Joshua Tree (Figure J-15). Although these areas were probably used by bighorn sheep in the past, surrounding development and their isolation from other suitable habitat have likely eliminated any habitat value they may have and are unlikely to support bighorn sheep use in the future. Although planned development does not appear to present a threat to bighorn habitat, an estimated 10% of total habitat could be lost under full buildout. This includes areas that should be considered as cores. Therefore, parcels are available for development that could have undesirable impacts on bighorn sheep habitat use. It is also important to recognize the risk of domestic livestock disease to bighorn sheep. Domestic sheep and goats can transmit disease that is lethal to bighorn and wildlife managers recommend maintaining a nine-mile buffer between domestic and wild sheep or goats[22]. Efforts should be made to maintain a suitable buffer around important bighorn habitat to avoid disease transmission.

Separate linkages exist for each bighorn sheep herd in the Morongo Basin study area (Figure J-16). The eastern linkage appears secure under all development scenarios. The greatest potential impact modeled is from Scenario 4 with a predicted 0.1% increase in landscape resistance, which is negligible (Figure J-17b). Under full buildout, the increase in landscape resistance could be as high as 10%, although this impact appears to be restricted to the western edge of the linkage area (Figure J-18b).

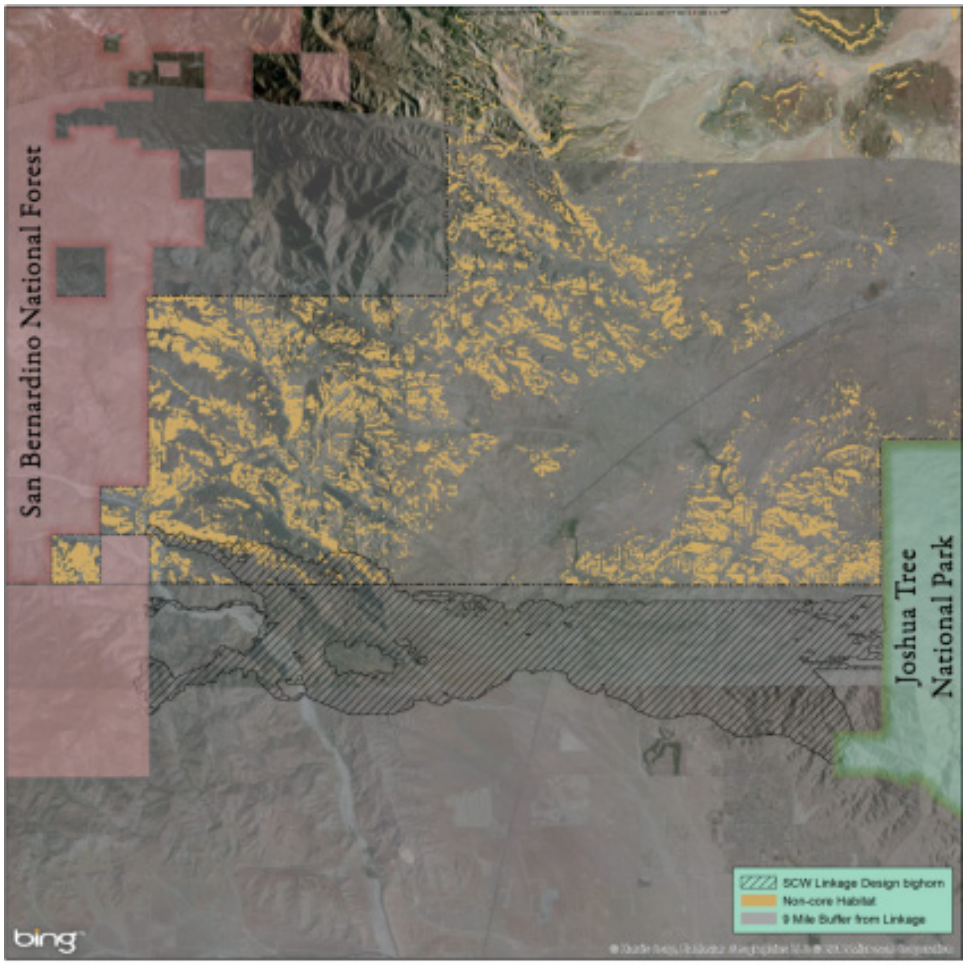
In the western linkage area, none of the planned development scenarios result in large increases in landscape resistance. Scenario 2 is the only scenario with > 0.1% increase with an increase of 0.5%. Although this is a small increase, the impact occurs at the narrowest bottleneck to movement along the linkage and it is the result of a single proposed structure near the southern border of the study area (Figure J-17a). Relocating this proposed single structure would eliminate the impact. This linkage could be significantly threatened by development around Desert Hot Springs (which is outside the study area) but could result in a 27% increase in landscape resistance (Figure J-18a). As previously discussed, these predictions assume that bighorn sheep traveling through these linkages are protected from domestic livestock disease, a reasonable assumption in this area.

[21] In contrast to, for example, the habitat preferred by the desert tortoise which is often flatter, more readily developed lands.

[22] In September of 2011 an informal email and phone survey was conducted regarding domestic sheep and goats in the Morongo Basin. The general consensus was that domestic sheep were rare or non-existent, there were occasional occurrences of domestic goats, mostly in low numbers and fenced in areas not coincident with desert bighorn sheep areas.

Figure J-14: Current Desert Bighorn Sheep Habitat within the Morongo Basin Study Area

(a) Map zoomed to the areas relevant for the western herds of Joshua Tree National Park.



(b) Map zoomed to the areas relevant for the eastern herds of Joshua Tree National Park.

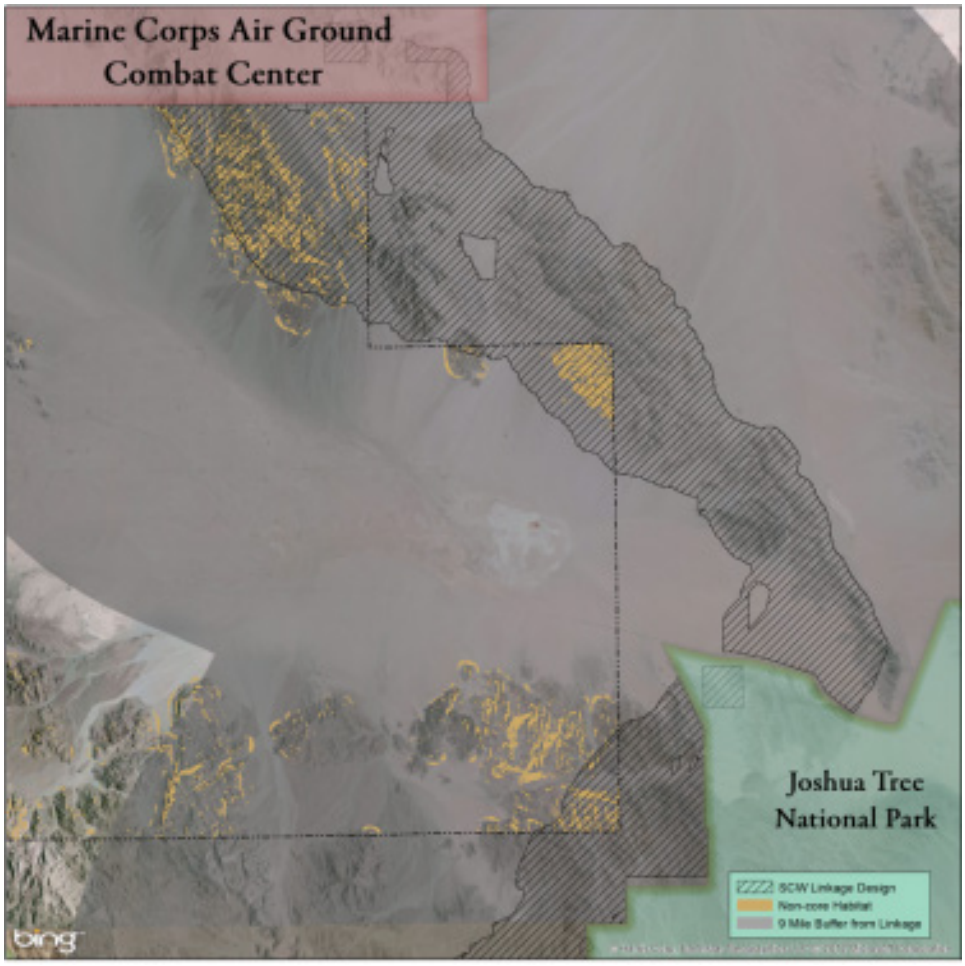
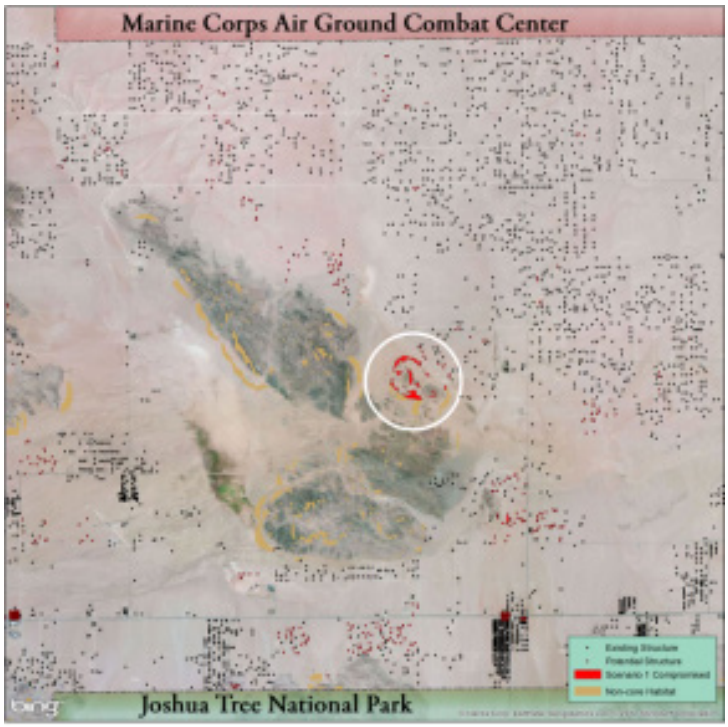


Figure J-15: Examples of Areas of Current Desert Bighorn Sheep Habitat that Could Become Comprised

(a) Areas that could become compromised under Scenario 2. Circles highlight clusters of impact.



(b) Areas that could become compromised under Scenario 4. Circles highlight clusters of impact.

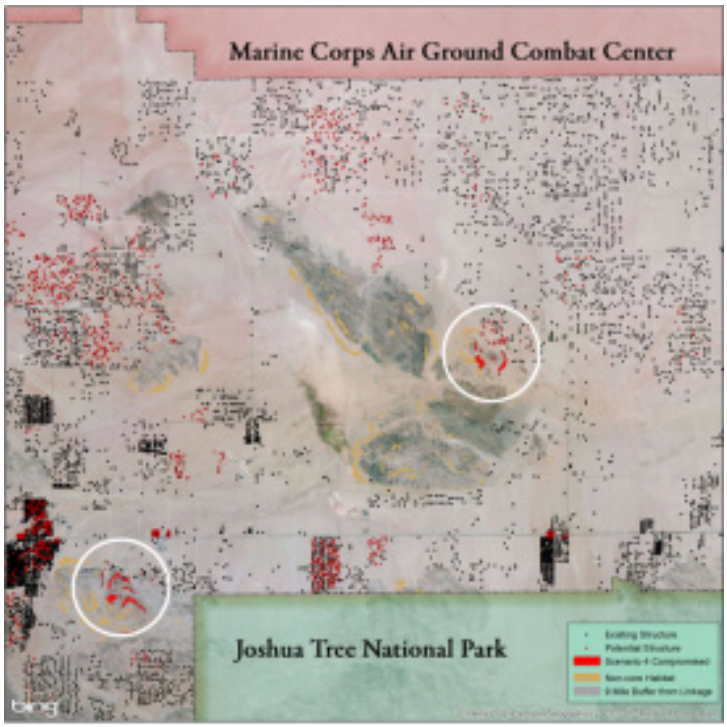
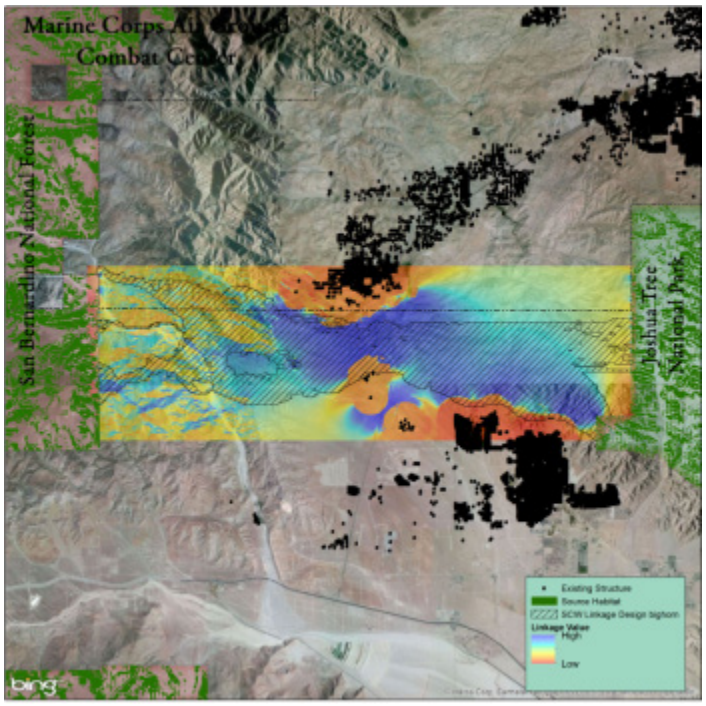


Figure J-16: Desert Bighorn Sheep Connectivity under Current Conditions for the Western and Eastern Herds

(a) Western herds. Colors represent relative value of current density. Areas of high current density indicate where animal movement is likely to be concentrated.



(b) Eastern herds. Colors represent relative value of current density. Areas of high current density indicate where animal movement is likely to be concentrated.

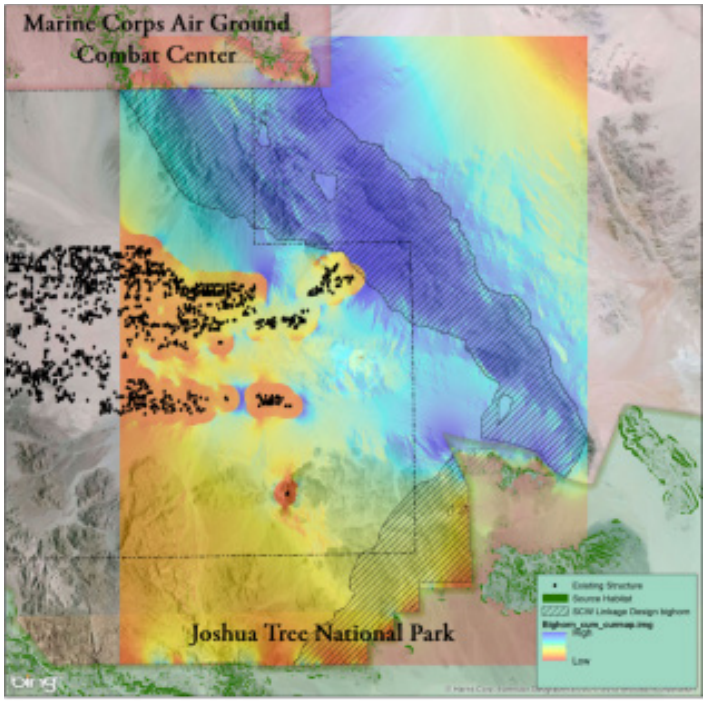
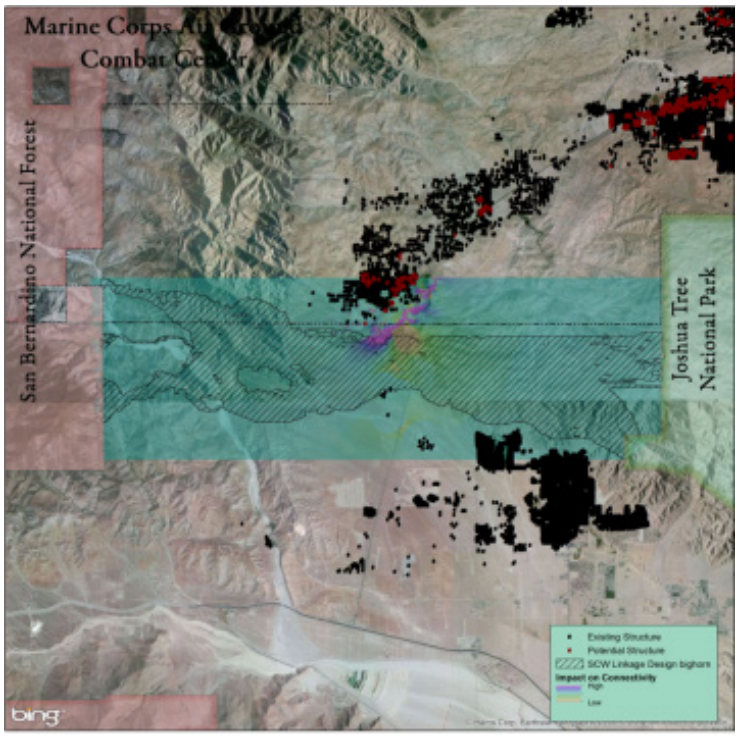


Figure J-17: Potential Change in Desert Bighorn Sheep Connectivity between Current Conditions and Scenarios 2 and 4

(a) Potential Change between Current Conditions and Scenario 2 in the Western Linkage



(b) Potential Change between current conditions and Scenario 4 in the Eastern Linkage

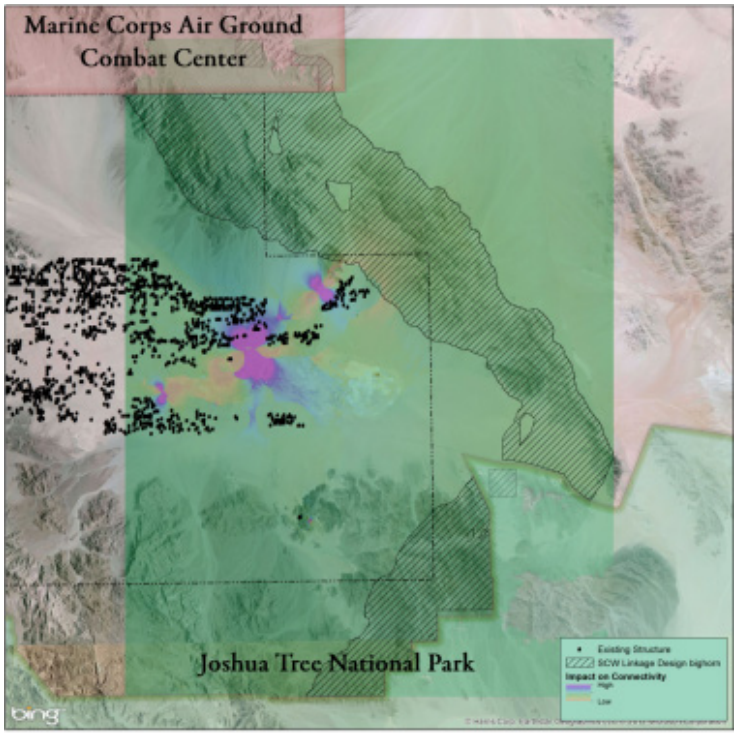
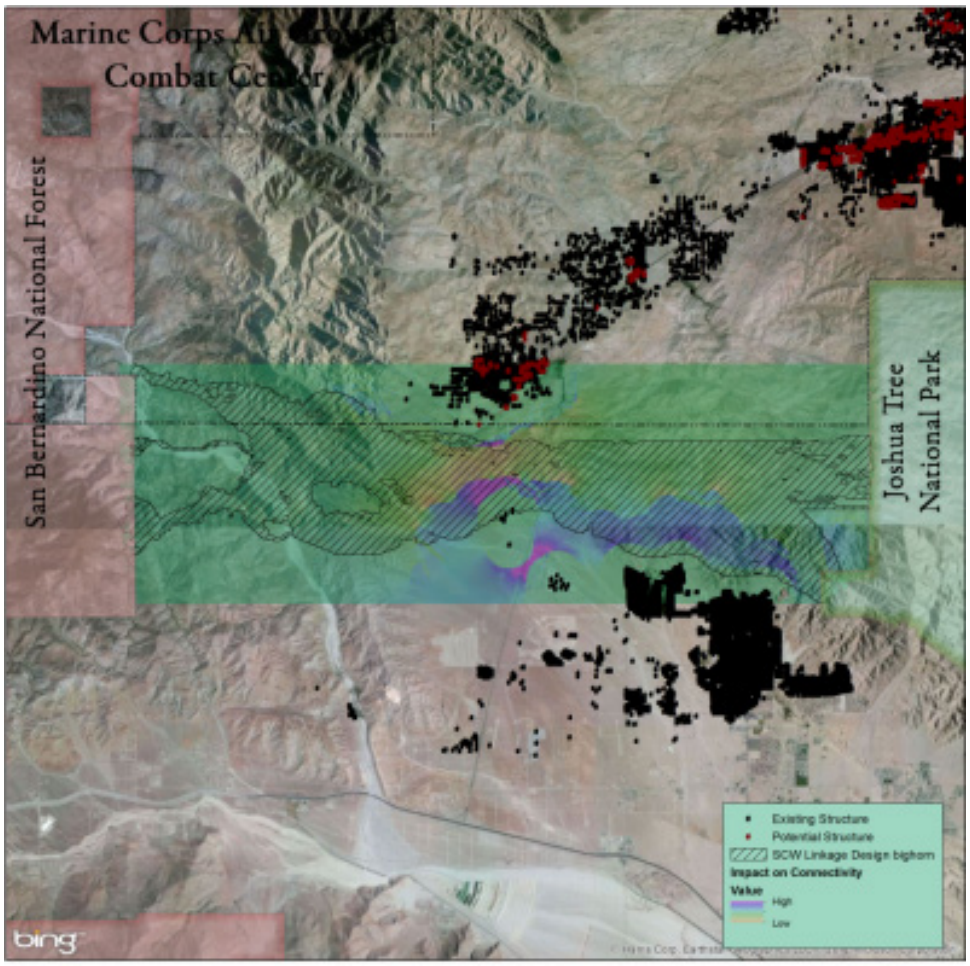
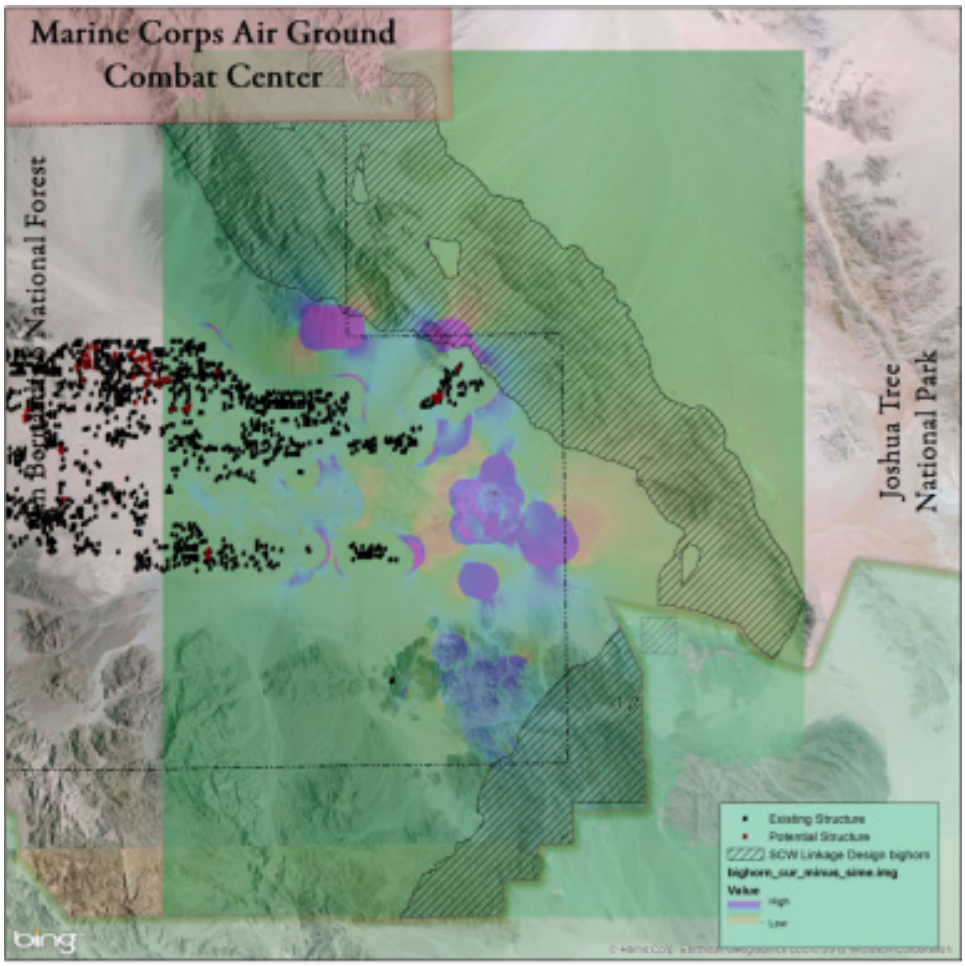


Figure J-18: Potential Change in Desert Bighorn Sheep Connectivity between Current Conditions and Full Buildout

(a) Potential Change in Desert Bighorn Sheep Connectivity between Current Conditions and Full Buildout for the Western Linkage



(b) Potential Change in Desert Bighorn Sheep Connectivity between Current Conditions and Full Buildout for the Eastern Linkage



Desert Tortoise

According to the SC Wildlands analysis and recent desert tortoise habitat suitability modeling performed by the U.S. Geological Survey (Nussear et al. 2009), most of the Morongo Basin study area contains potential habitat for desert tortoise. Although tortoises occur throughout the study area, most of this habitat is compromised by one or more of three major threats to which this species is sensitive: vehicle traffic, domestic pets, and raven predation. Therefore, tortoises living within most of the basin likely have increased mortality, decreased reproduction, or both due to stresses resulting from these threats. Of these stresses, raven predation is likely the most widespread since raven populations increase near developed areas and individuals may prey on tortoises up to 8 km from their nests. As a result of these issues, only 2.7% of the potential habitat in the basin can be assumed to be uncompromised. Of the uncompromised habitat, 93% is core (Figure J-19). This habitat is distributed as two strips along the northern and southern boundaries of the study area.

The only modeled development with any measurable impact on habitat area was included in Scenario 1, with a 3% and 3.2% decrease in total and core habitat respectively. This result is interesting because it is caused by the location of a single proposed structure located 7.3 km from core habitat (Figure J-20). The significance of this impact is questionable because it represents the outer recorded limits of raven predation. The impact of raven predation is expected to decline with increasing distance from a nest until the impact approaches zero at the maximum foraging distance. It seems highly speculative to assume that this single structure would induce ravens to expand nesting to the north and that they would have a significant impact near the maximum foraging distance observed for the species. Nevertheless, this example illustrates that expansion of development north or south of the current development footprint is likely to result in deterioration of habitat quality of the remaining cores.

Although it appears most available habitat for desert tortoise in the study area is compromised, the situation could improve. If efforts to reduce raven populations near development in the Morongo Basin were successful, the estimated disturbance zone around structures would decrease from 8 km to 200 m which eliminate a substantial amount of compromised area and move much of that area into the core habitat category. This is because successful mitigation of raven predation would shift the most wide ranging threat to predation and harassment of domestic dogs which, assuming they are pets, would have a smaller foraging radius. If residents in the study area confined their pets, the disturbance zone around structure might be essentially eliminated leaving any potential habitat patch beyond 800 m from a road in a relatively uncompromised state. So effective mitigation and improved stewardship could theoretically restore substantial areas of formerly compromised habitat.

The best and most secure habitat connectivity is along the westernmost linkage identified by SC Wildlands (Figure J-21). Among the alternative development scenarios it would appear that Scenario 4 would have the greatest impact, with an increase in landscape resistance of 2.2%, followed by Scenario 1 with a modest 0.9% increase in resistance. However, an examination of the location of those impacts reveals a different story. Despite a greater overall impact on landscape resistance, the impact of Scenario 4 occurs mainly within some of the most developed areas of the study area where resistance to movement is already substantial, but the westernmost linkage that is currently the least impacted remains relatively unchanged (Figure J-22b). In contrast, the impact of Scenario 1 extends across the westernmost linkage. Scenario 1 is more likely to impair the best currently available linkage for desert tortoise (Figure J-22a). The vulnerability of this linkage area is illustrated by the full buildout scenario (Figure J-22c) which could result in an 18% increase in landscape resistance which includes significant new development within the westernmost linkage.

Figure J-19: Current Desert Tortoise Habitat within the Morongo Basin Study Area

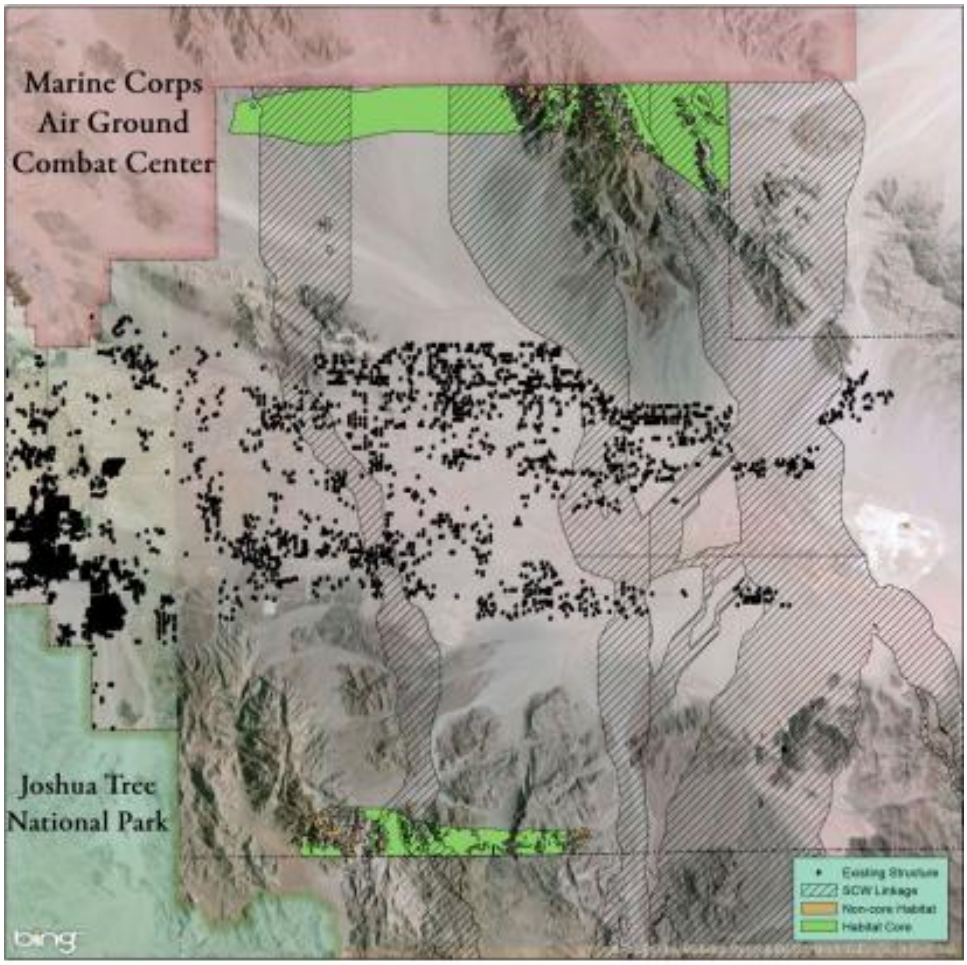


Figure J-20: Example of Areas of Current Desert Tortoise Habitat that Could Become Compromised under Scenario 1

This is the only scenario with measureable impact on habitat. All impacts result from the location of a single proposed structure 7.3 km from a habitat core (white circle).

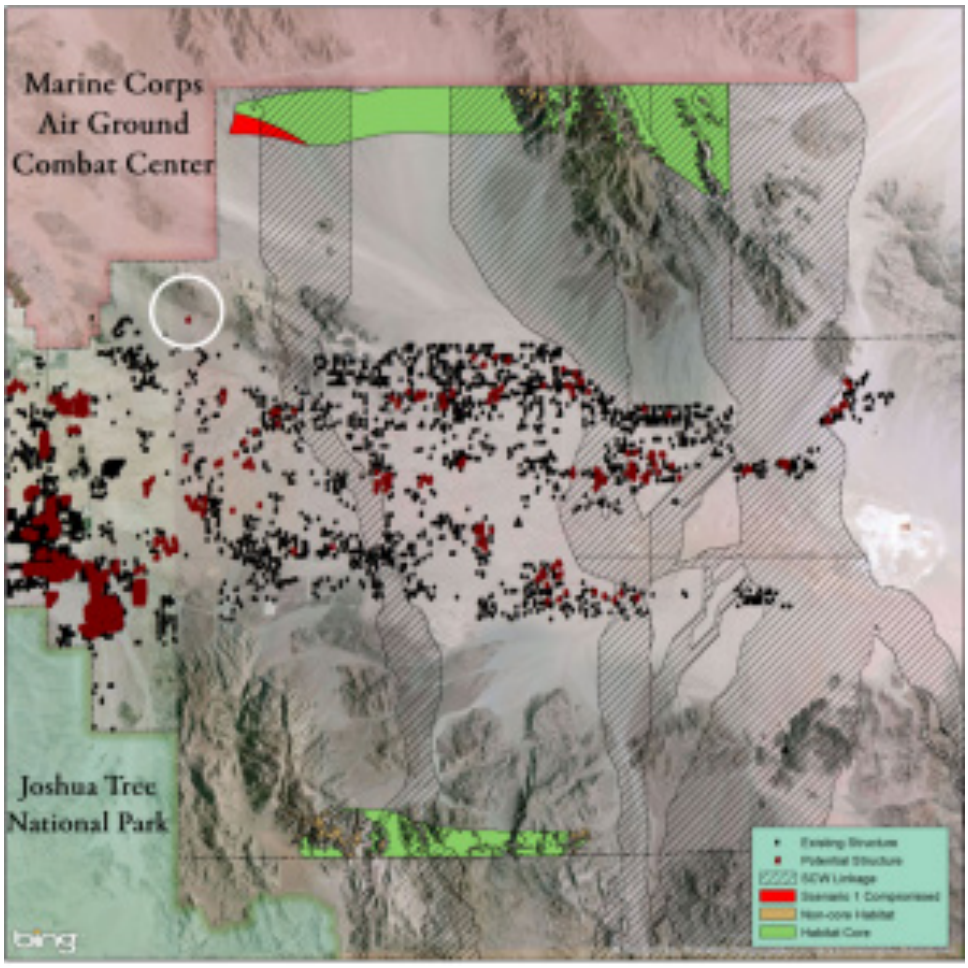


Figure J-21: Desert Tortoise Connectivity under Current Conditions

Colors represent relative value of current density.

Areas of high current density indicate where animal movement is likely to be concentrated. The westernmost linkage appears to provide the best option for maintaining connectivity.

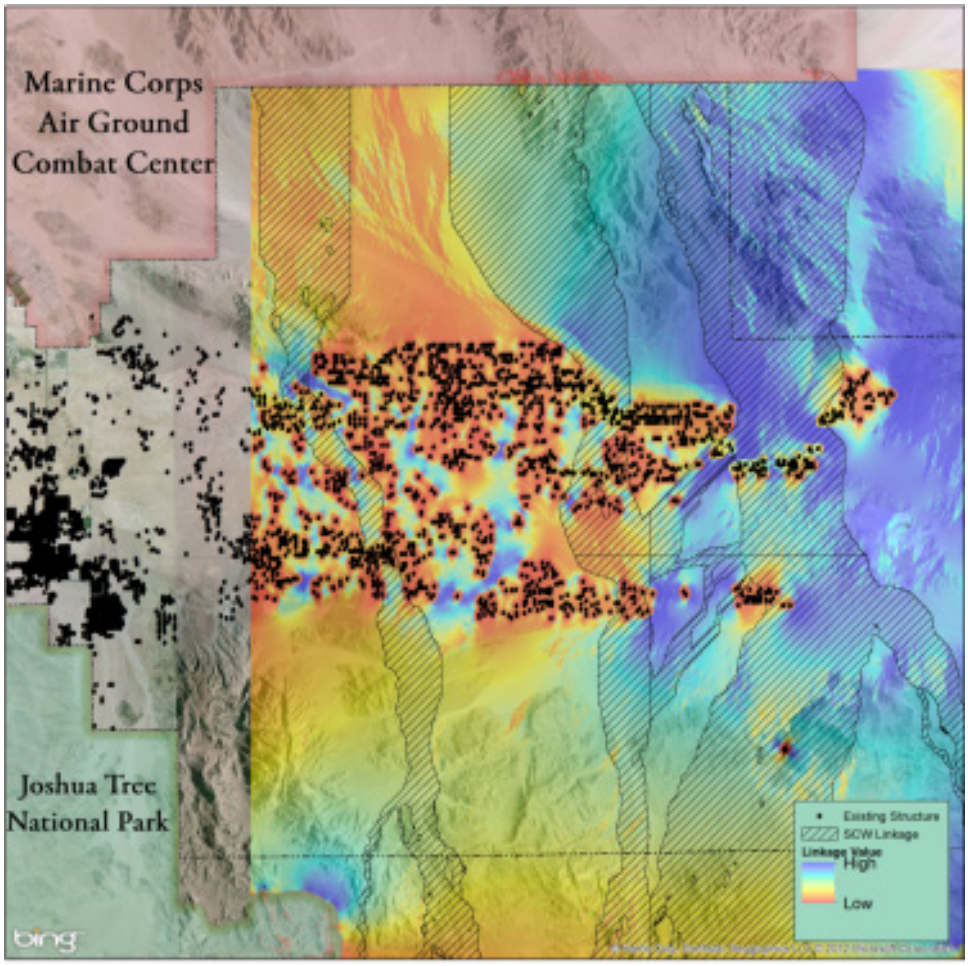
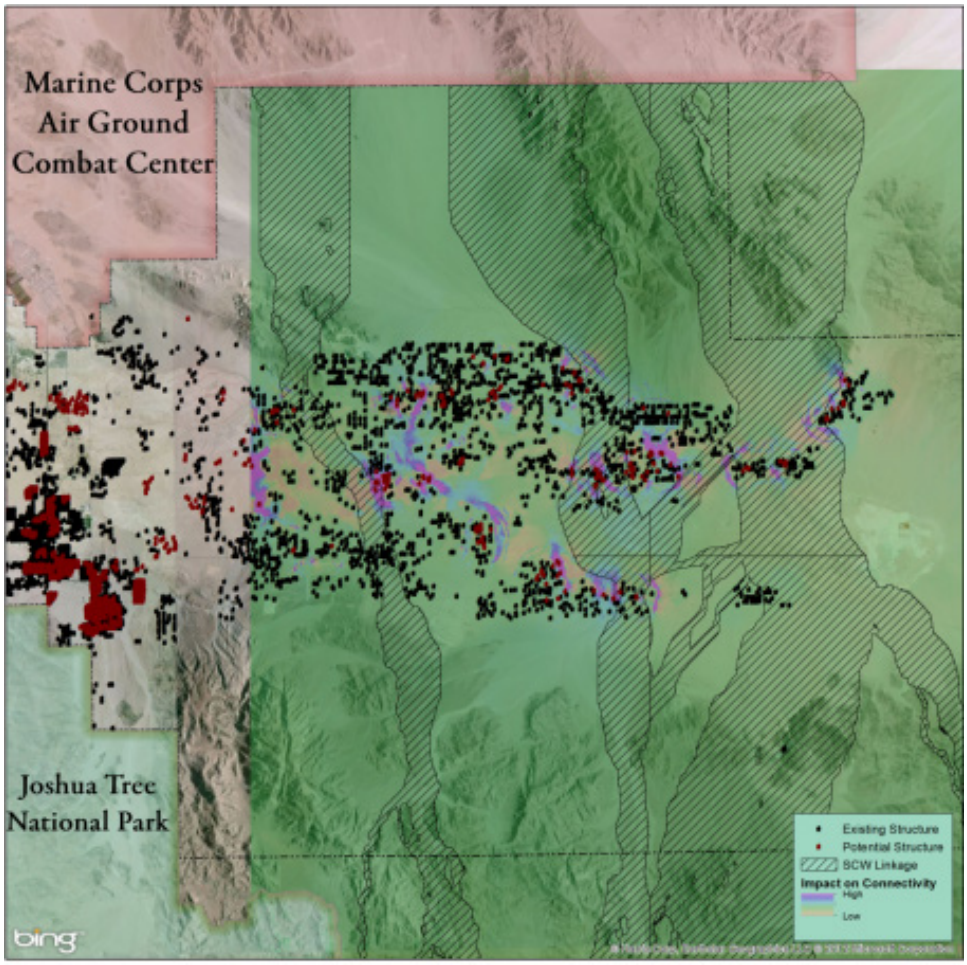


Figure J-22: Potential Change in Desert Tortoise Connectivity between Current Conditions and Scenario 1, Scenario 4, and Full Buildout

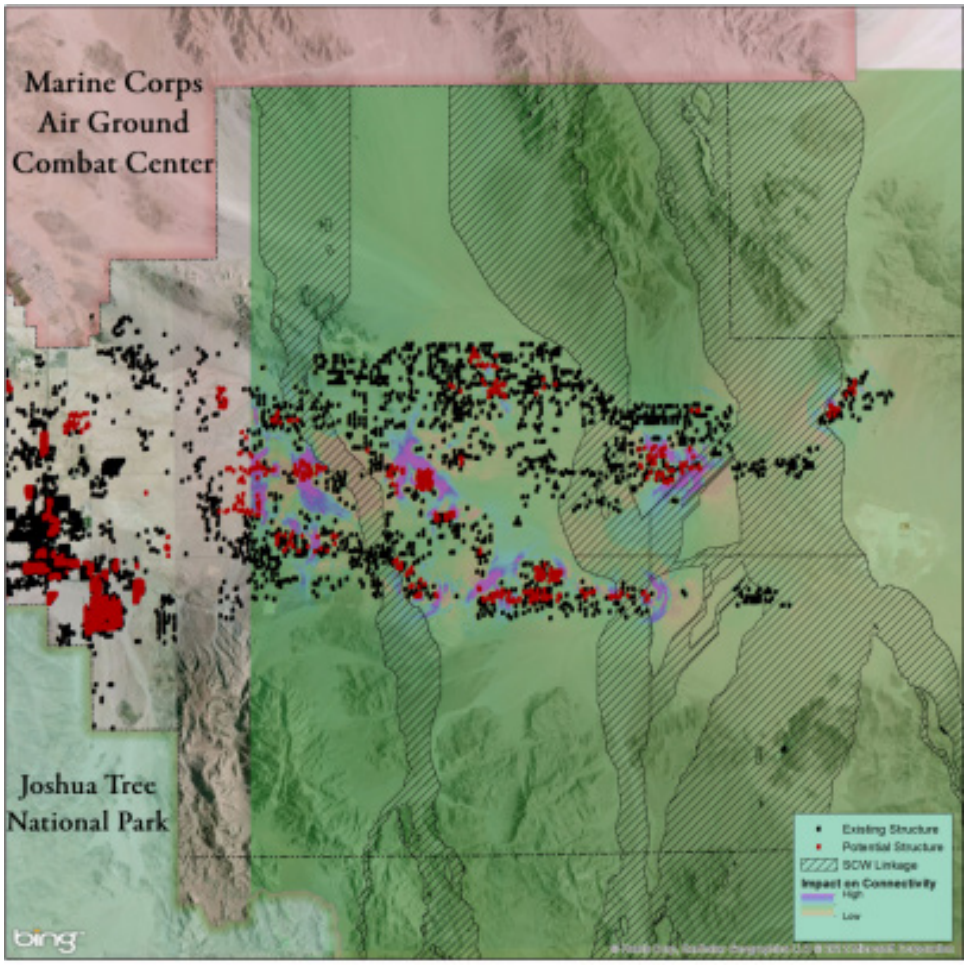
(a) Scenario 1

Scenario 4 and full buildout result in greatest increase in landscape resistance, but Scenario 1 and full buildout result in greater impact on the best available linkage area (westernmost).



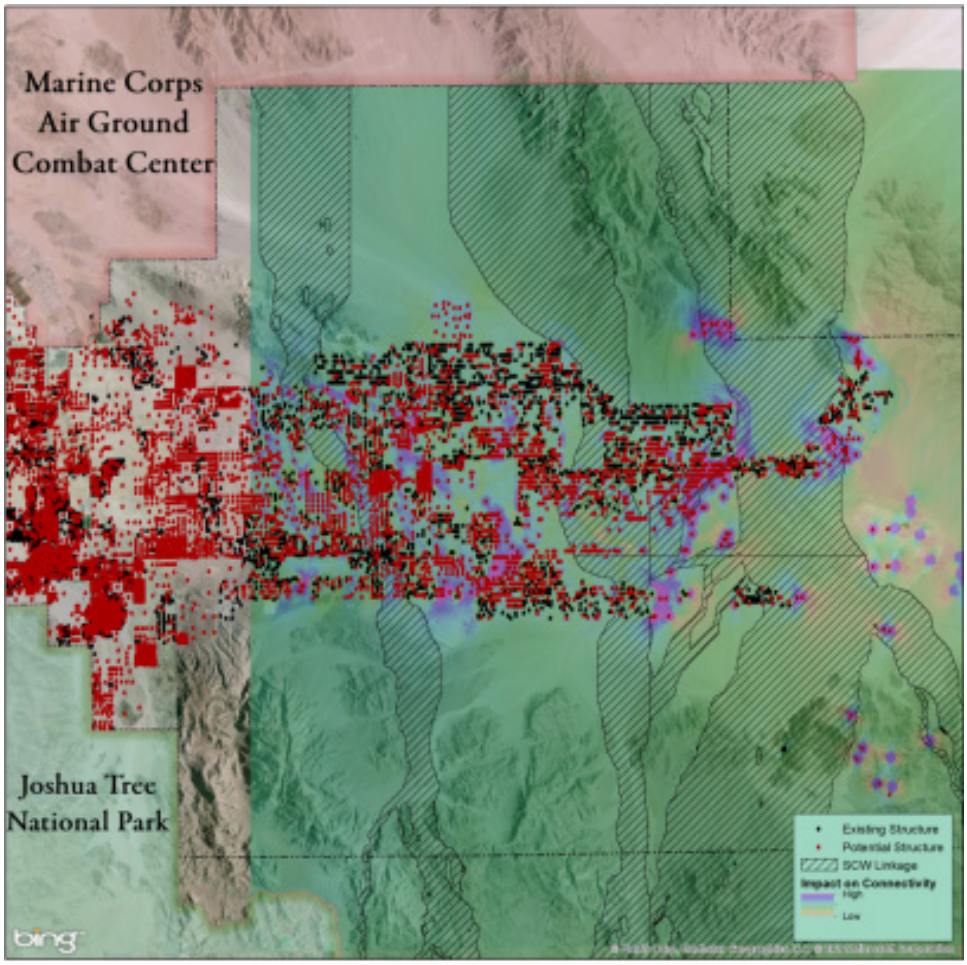
(b) Scenario 4

Scenario 4 and full buildout result in greatest increase in landscape resistance, but Scenario 1 and full buildout result in greater impact on the best available linkage area (westernmost).



(c) Full Buildout

Scenario 4 and full buildout result in greatest increase in landscape resistance, but Scenario 1 and full buildout result in greater impact on the best available linkage area (westernmost).



Mountain Lion

Because mountain lions require large (200 km^2) home ranges, no habitat patches within the Morongo Basin are sufficiently large to provide habitat core. However, this is deceptive because large blocks of habitat occur at the west end of the study area bordering and near the San Bernardino National Forest (Figure J-23). The largest patches are part of a larger (>529 km^2) patch of contiguous habitat that extends into the San Bernardino National Forest. Although the portion of habitat within the Morongo Basin study area is not sufficient to provide core habitat by itself, it is actually part of a large habitat core that straddles the study area boundary. A simulation of full buildout indicates that more than 10% of total mountain lion habitat within the Morongo Basin study area could become compromised (Figure J-24). Much of that loss is modeled to occur within small habitat patch fragments along the fringe of larger habitat blocks,

although it appears that some private inholdings within public land could compromise habitat in the interior of the largest habitat blocks.

Perhaps most significant is potential loss of connectivity within the SC Wildlands Morongo linkage designs that is discussed below. None of the planned development scenarios are predicted to have significant impact on mountain lion habitat in the study area. Scenario 1 would result in the greatest loss with an estimated 0.1% of total habitat compromised with Scenario 4 the next greatest with 0.09% loss. Losses for both scenarios occur within small habitat fragments outside habitat core.

Connectivity analysis for mountain lions in the Morongo basin is an interesting case. The current density map (Figure J-25) indicates a mismatch between the SC Wildlands linkage design and Wild Planner. The SC Wildlands mountain lion linkage follows the steep terrain of Little Morongo Canyon from the San Bernardino Mountains to the Morongo Valley and then up drainages of the Little San Bernardino Mountains to Joshua Tree National Park. This provides a natural corridor for mountain lion movement across the Morongo Valley. However, a substantial amount of development exists in the valley where this linkage crosses so lions attempting to move through this area will likely encounter substantial human-related disturbances that could limit successful attempts to cross the valley. Because Wild Planner integrates development patterns and associated disturbances into connectivity analysis, it predicts better connectivity toward the east of the SC Wildlands linkage where there is less development. But it would be a mistake to assume that one map is "right" and the other "wrong"; the maps show the results of approaching the question of connectivity using different modeling assumptions and parameters and both can inform planning and development choices.

Despite development in the valley bottom, mountain lions are likely to continue to move along drainages within the SC Wildlands linkage until they come to the valley bottom and associated human disturbances. There they will face the choice of trying to continue or, many will likely turn back. In contrast, it is possible that fewer lions will attempt to cross through the alternative highlighted by Wild Planner, due to the absence of landscape features, like the drainage features previously mentioned, that would funnel movement. But those that do cross in that area will encounter fewer disturbances and therefore be more likely to successfully cross. In reality, both connectivity maps represent sub-optimal alternatives and areas identified in both should be managed appropriately if the probability of maintaining good mountain lion connectivity across the study areas is to be maximized.

> *This example illustrates one of the benefits of a multi-species approach to conservation planning. Although the SC Wildlands mountain lion linkage does not include the less disturbed area highlighted by Wild Planner, that area is included in the combined linkage design for all focal species designed by SC Wildlands. Inclusion of other species (mule deer in this case), provides something of a safety net for mountain lion movement. However, this does not mean that simply considering multiple species in an analysis will automatically safeguard planners against limitations of analytical methods.*

All planned development scenarios indicate similar patterns of impacts on mountain lion connectivity with slightly varying degrees of severity. Among modeled scenarios, Scenario 4

resulted in a 6.4% increase in landscape resistance, which was the greatest impact, decreasing to 2.6% for Scenario 5. All scenarios indicate a narrowing of the linkage pathway identified by Wild Planner as the pathway of least resistance, however the amount of narrowing varied slightly by scenarios (Figures J-26a-c). Adjustment of the location of new structures near this pathway could override any differences between scenarios. Simulated full buildout indicates there are enough buildable parcels in the study area to increase landscape resistance for mountain lions by 29%; this could significantly impede movement along the current path of least resistance (Figure J-26c).

Figure J-23: Current Mountain Lion Habitat within the Morongo Basin Study Area

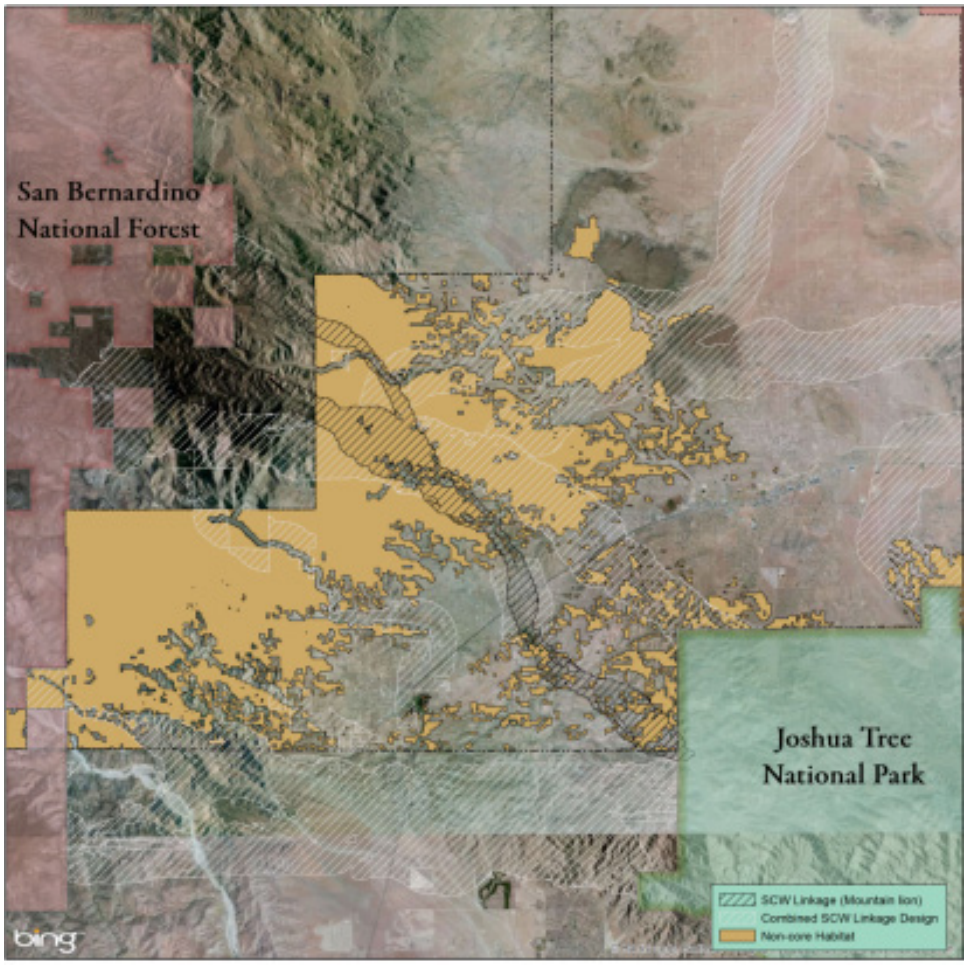


Figure J-24: Current Mountain Lion Habitat that Could Become Compromised under Full Buildout

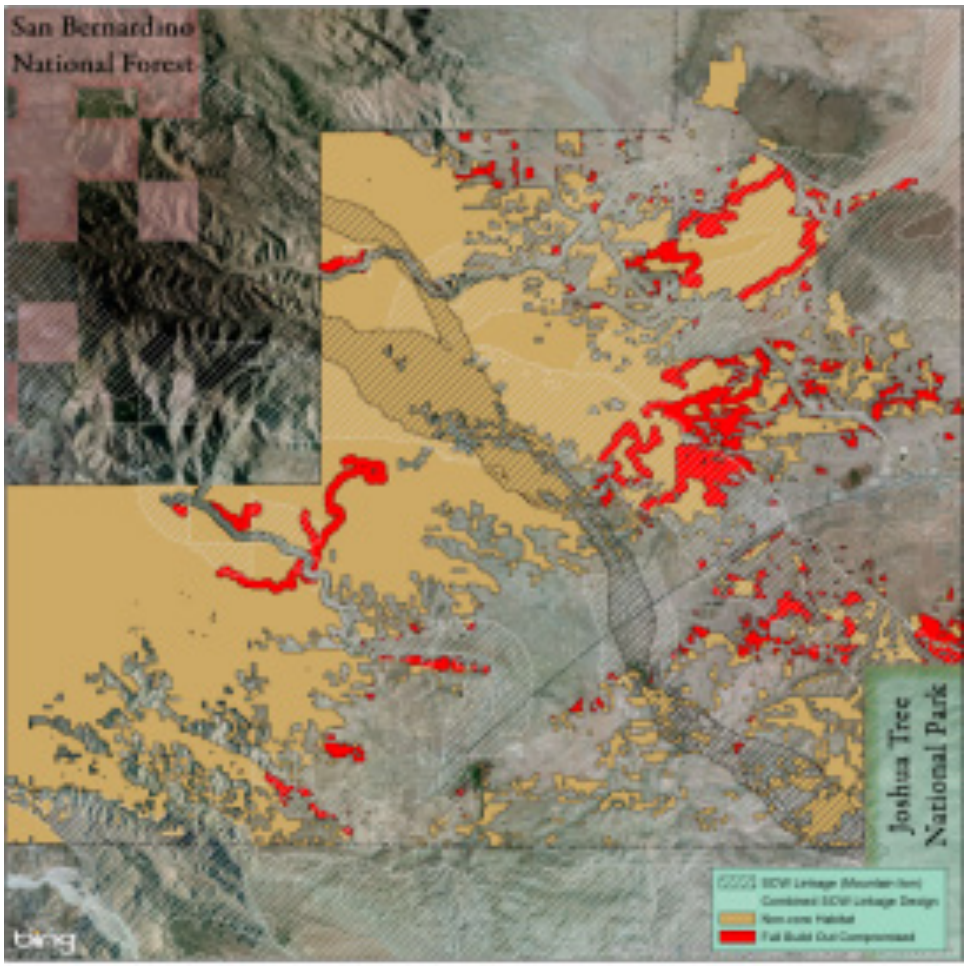


Figure J-25: Mountain Lion Connectivity under Current Conditions

Colors represent relative value of current density. Areas of high current density indicate where animal movement is likely to be concentrated. Mountain lions may be more likely to use the SC Wildlands linkage because of terrain and habitat preference but development along the linkage may impede movement. Current Density indicates and alternative route that may get used less frequently, but contains fewer obstacles to movement.

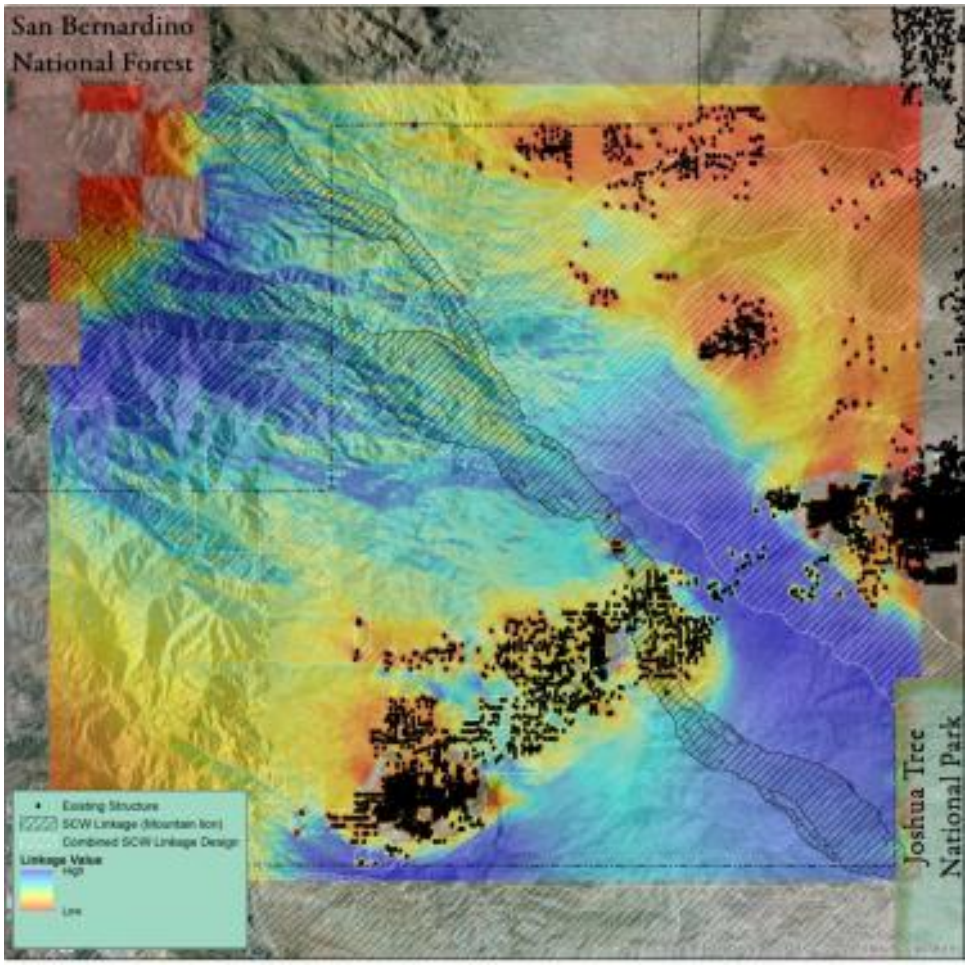
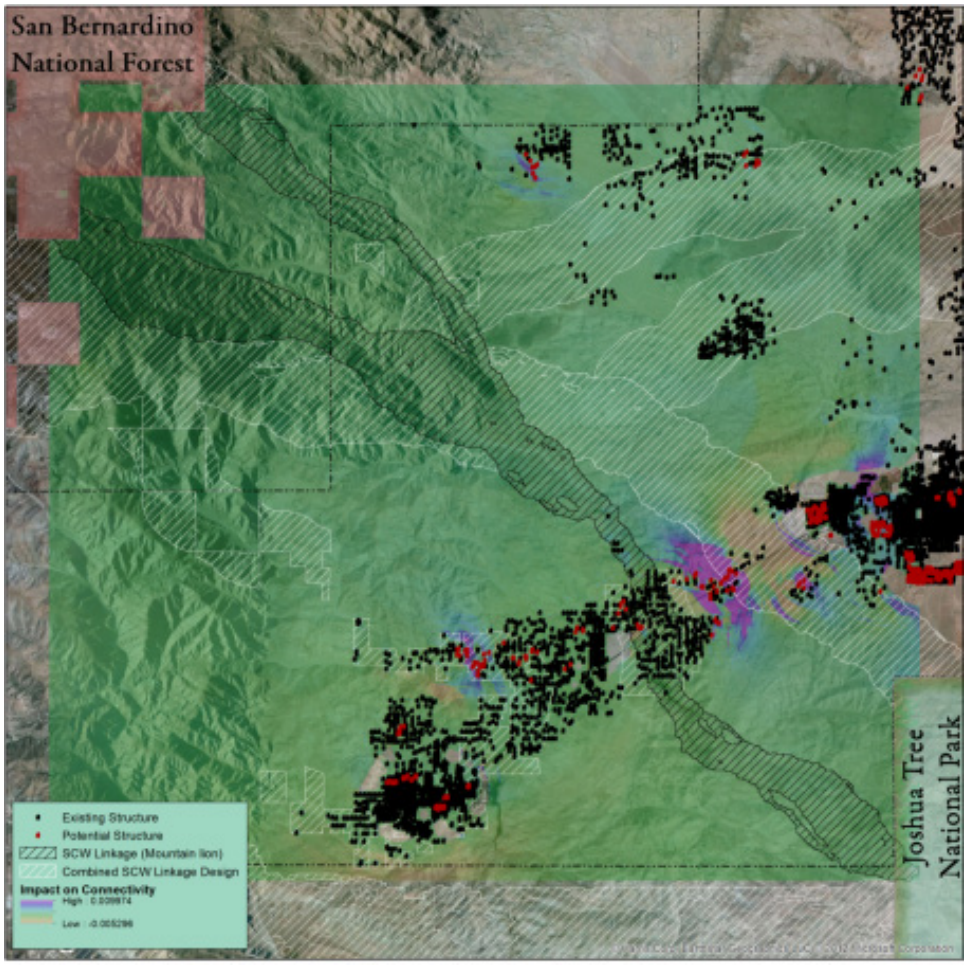
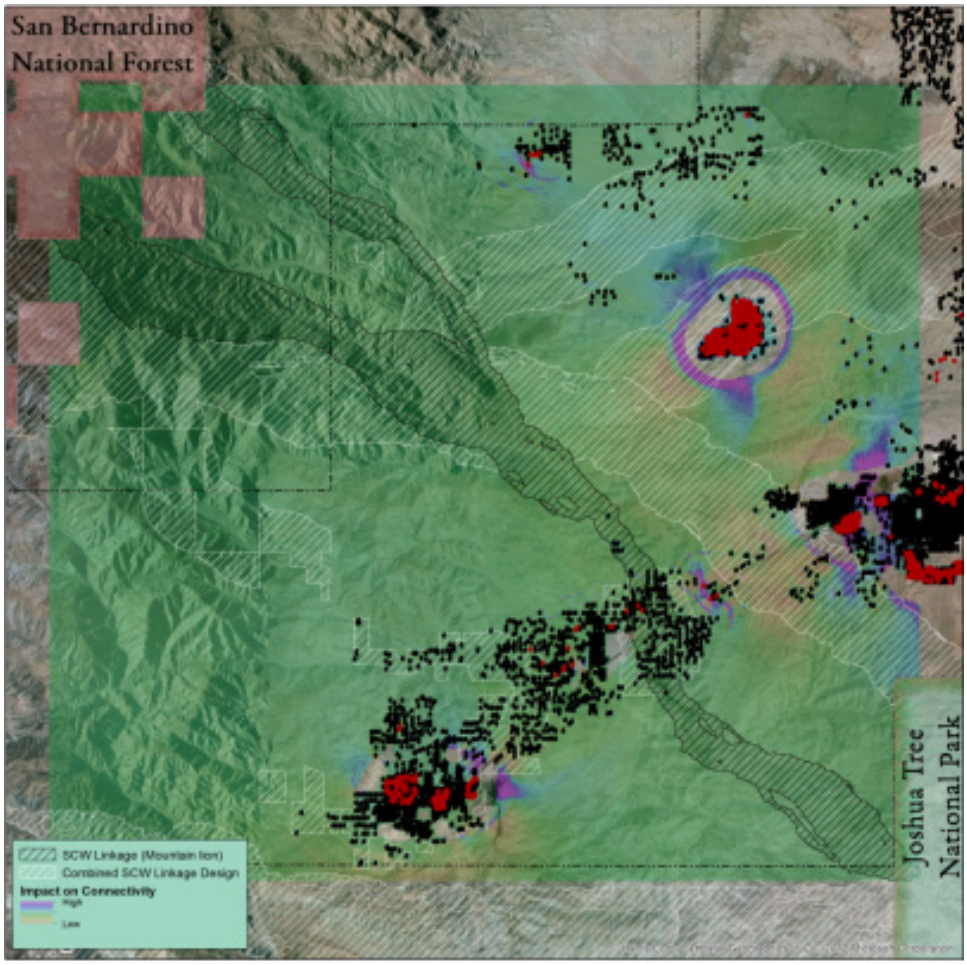


Figure J-26: Potential Change in Mountain Lion Connectivity between Current Conditions and Scenario 4, Scenario 5, and Full Buildout

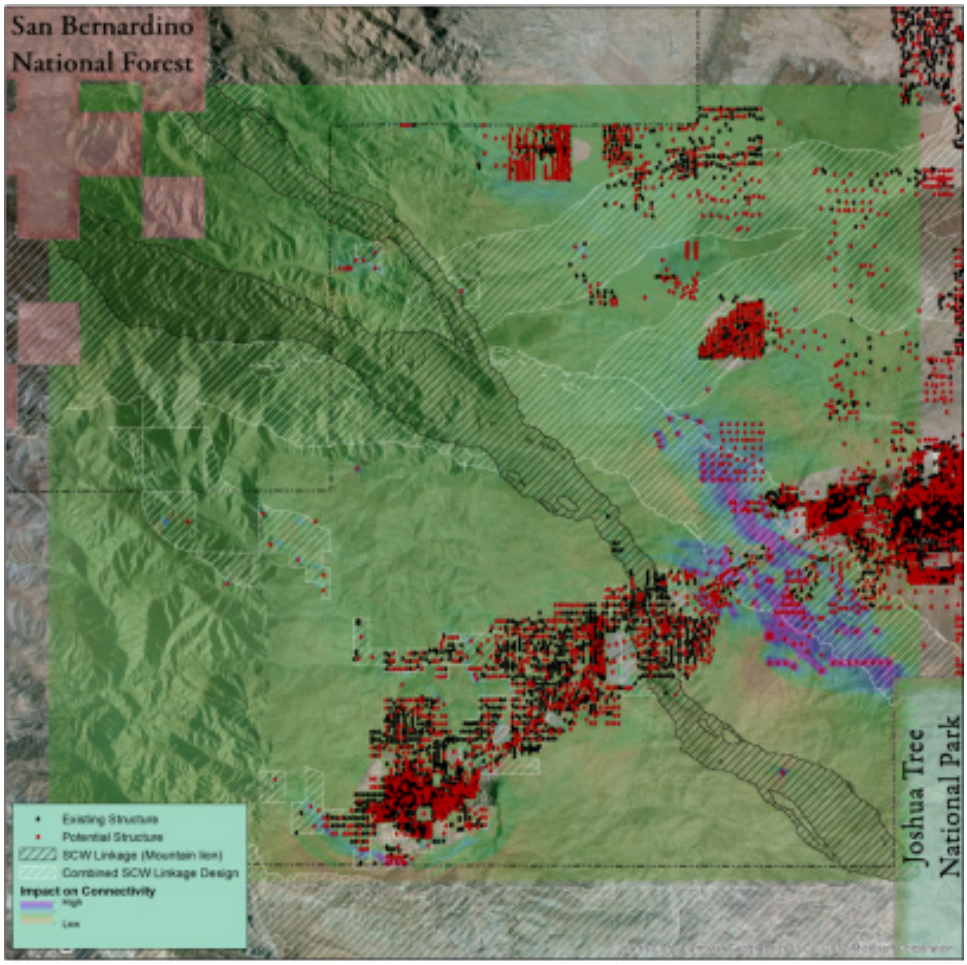
(a) Potential Change in Mountain Lion Connectivity between Current Conditions and Scenario 4



(b) Potential Change in Mountain Lion Connectivity between Current Conditions and Scenario 5



(c) Potential Change in Mountain Lion Connectivity between Current Conditions and Full Buildout



Mule Deer

Large blocks of undisturbed core habitat for mule deer occur along the western edge of the Morongo Basin study area near the San Bernardino National Forest (Figure J-27). Under full buildout, 15% of core and 16% of total habitat would be vulnerable to loss or degradation (Figure J-28a). None of the modeled scenario development patterns would result in significant loss of habitat. With the exception of Scenario 4, all planned scenarios would result in compromising 0–0.01% of either core or total habitat. Scenario 4 would result in 0.1% of both total and core habitat becoming compromised. The impact on core habitat from Scenario 4 development patterns arises from the location of five proposed structures in the vicinity of Burns Canyon Road, which would result in loss or degradation of about 17 acres of habitat core (Figure J-28b).

> *Figure J-28b is a good example of the potential use of the Wild Planner tool to work at finer scales to evaluate proposed development and by adjusting the location of a small*

number of structures, to essentially eliminate development impacts for some species. The use of this type of analysis in combination with a linkage design such as those included here provides planners and land owners with additional tools to help determine the potential impacts of various development and conservation choices.

Habitat connectivity for mule deer estimated by Wild Planner follows along the linkage mapped by SC Wildlands (Figure J-29). Some restriction of this linkage by development along the Twentynine Palms Highway indicates the effective linkage zone may need to be widened to include the area of high current density south of the highway. Planned development scenarios would increase landscape resistance from 2.5% (Scenario 2) to 3.2% (Scenario 4). All of these scenarios have nearly identical patterns of impact that could significantly impede movement of mule deer across the Twentynine Palms Highway (Figure J-30a), and the full buildout scenario indicates impact on connectivity in that area could be more severe (Figure J-30b). Full buildout could increase landscape resistance for mule deer by 26% with those impacts concentrated in the vicinity of the Twentynine Palms Highway and spanning the full width of the linkage area.

Figure J-27: Current Mule Deer Habitat within the Morongo Basin Study Area

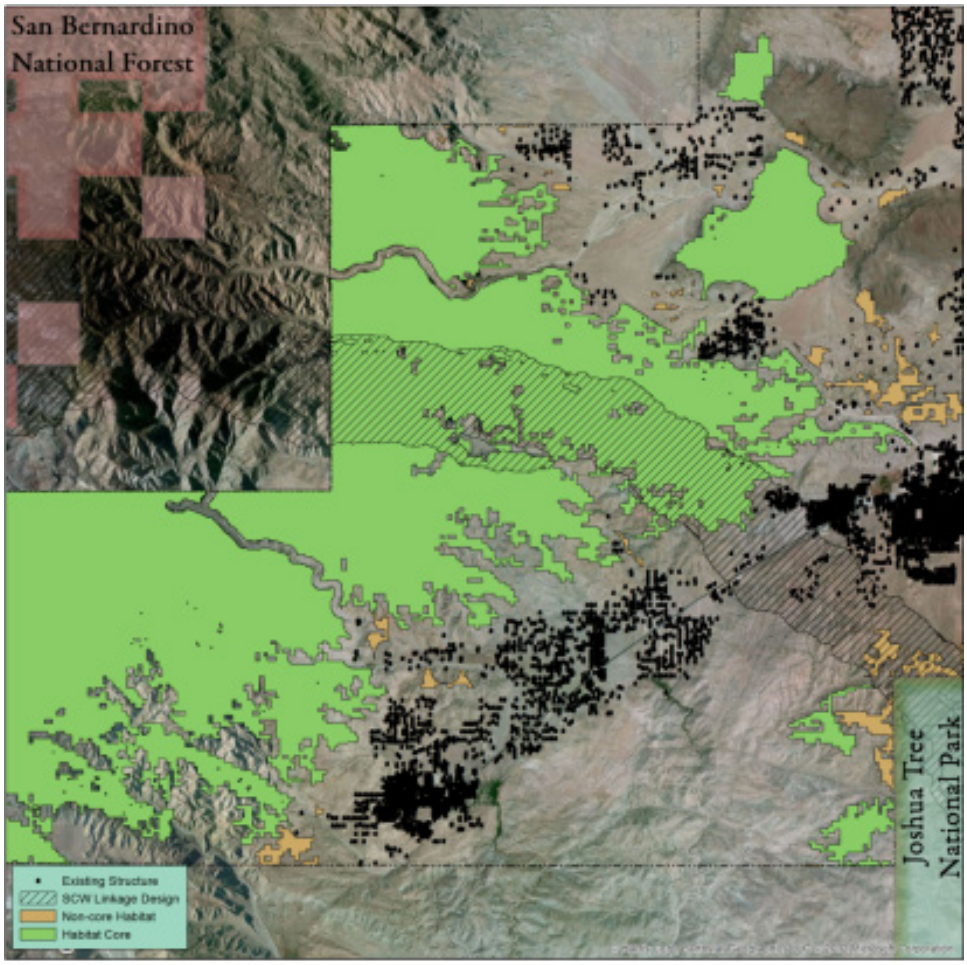
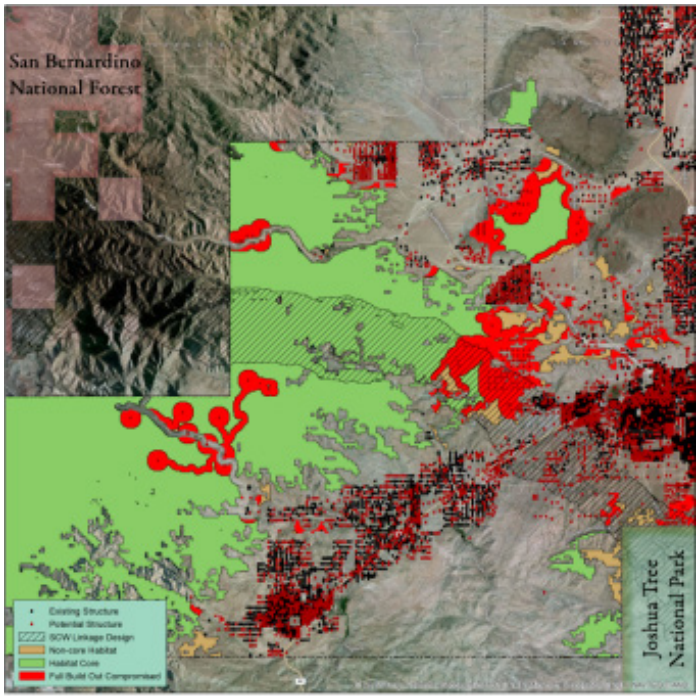


Figure J-28: Current Mule Deer Habitat that Could Become Comprised under Full Buildout and Scenario 4

(a) Full Buildout



(b) Scenario 4

Scenario 4 could result in approximately 17 additional acres of habitat becoming compromised due to additional development south of Burns Canyon Road.

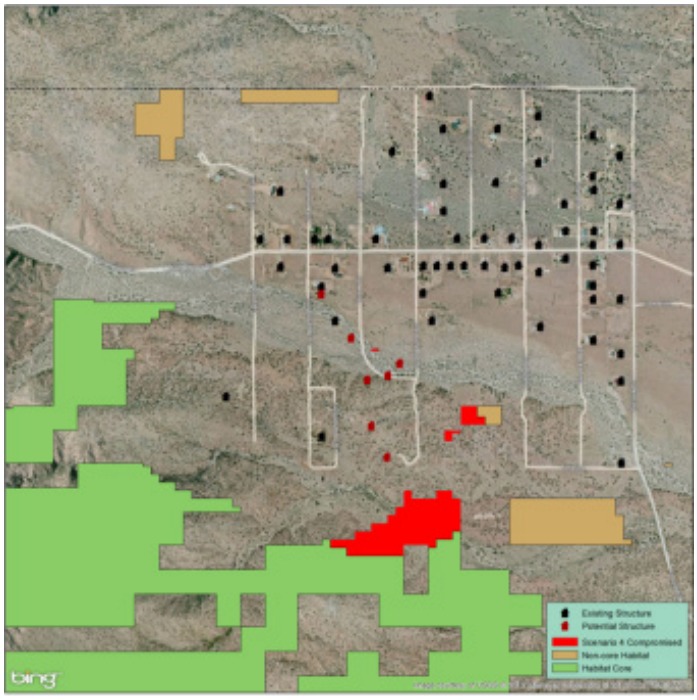


Figure J-29: Mule Deer Connectivity under Current Conditions

Colors represent relative value of current density. Areas of high current density indicate where animal movement is likely to be concentrated. Results of this analysis suggest that a modification of the SC Wildlands linkage area could mitigate restrictions of the linkage area imposed by existing development.

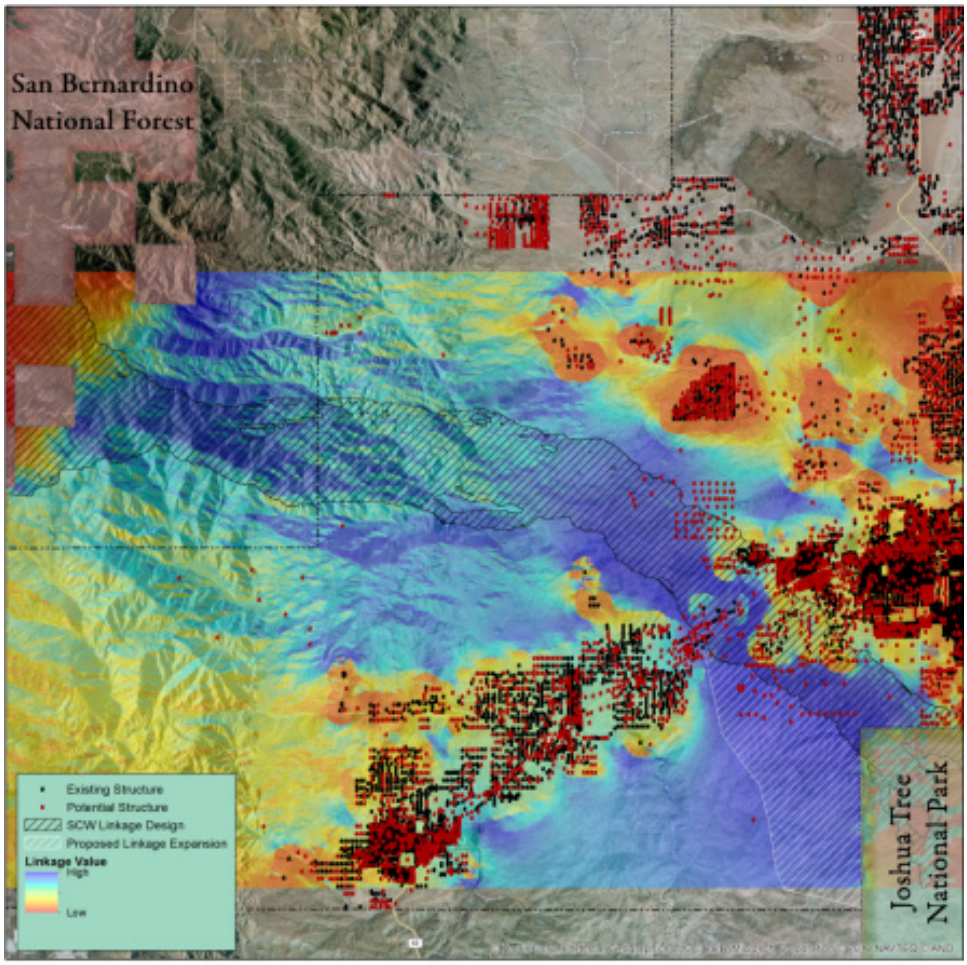
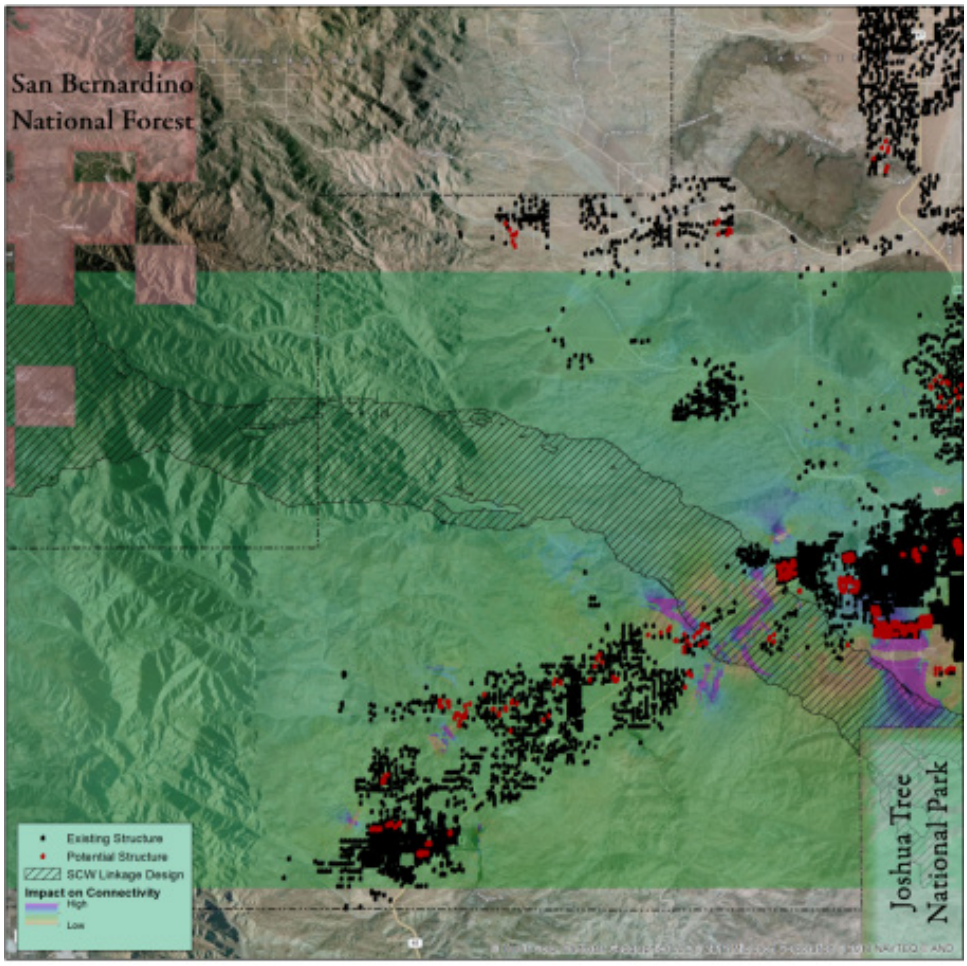
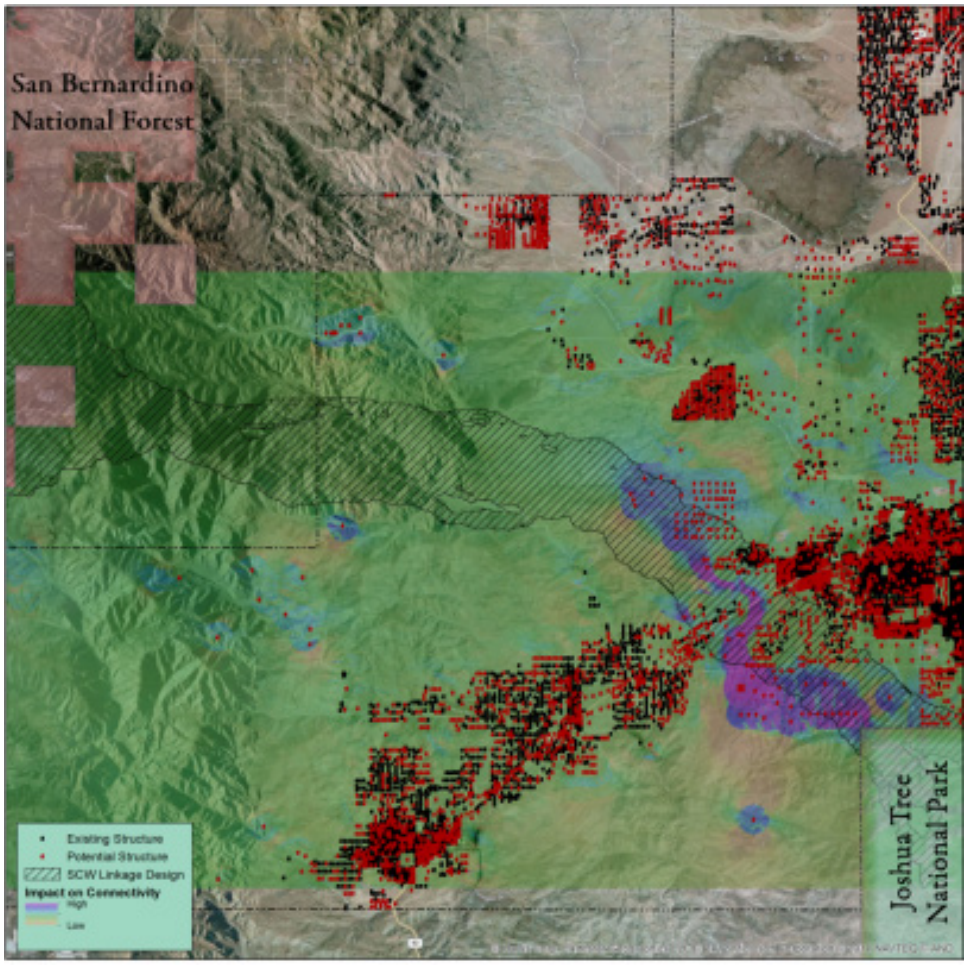


Figure J-30: Potential Change in Mule Deer Connectivity between Current Conditions and Scenario 4 and Full Buildout

(a) Scenario 4



(b) Full Buildout



Pacific Kangaroo Rat

The SC Wildlands habitat analysis for Pacific kangaroo rat only covers the west half of the Morongo Basin study area, so our habitat analysis is limited to that area. Because Pacific kangaroo rats have small home ranges (0.5 ha), nearly all habitat patches are sufficiently large to qualify as cores. Potential habitat cores occur throughout the western (and probably eastern) half of the study area, but are more extensive and less isolated in the western quarter (Figure J-31), however it is likely that many of the more isolated patches no longer support Pacific kangaroo rats. Twenty-four percent of core habitat is vulnerable to development under the full buildout scenario (Figure J-32) and could result in substantial reductions in available habitat within extensive and relatively connected (clustered with other patches) cores. Scenarios 1 and 4 would compromise 0.6% and 0.8% of core habitat respectively and Scenario 5 would compromise only 0.1% current core. Although all modeled development scenarios would affect only very small areas of Pacific kangaroo habitat, the impacts of Scenarios 3 and 5 would be entirely, or almost entirely, restricted to small and relatively isolated patches that may have little or no value as

Pacific kangaroo rat habitat. Impacts from Scenarios 1, 2, and 4, albeit small, are scattered among core habitat patches including some of the largest and most connected (Figure J-33).

Connectivity analysis indicates there may already be significant impacts from current development on Pacific kangaroo rat movement along the SC Wildlands linkage design. Pacific kangaroo rat might benefit by widening the effective linkage to the north to provide opportunities to avoid impacts of current development (Figure J-34a). This could significantly improve connectivity in the area, particularly around development associated with Desert Hot Springs. In addition, a potential restriction to movement is indicated due to a small cluster of structures north of the SC Wildlands linkage design and west of the Twentynine Palms Highway, plus an additional lone structure directly south and in the middle of the linkage area. An education program for residents of those structures to communicate the importance of controlling their pets to eliminate harassment and predation from cats and dogs could greatly reduce the impact of those structures and serve to restore unrestricted movement for kangaroo rats restored.

Because the SC Wildlands linkage design is outside the boundary of the study area, none of the planned development scenarios are predicted to have any impact on Pacific kangaroo rat connectivity between Joshua Tree National Park and the San Bernardino Mountains. However, full buildout around Desert Hot Springs could seriously impact kangaroo rat habitat connectivity (Figure J-34b).

Figure J-31: Current Pacific Kangaroo Rat Habitat in the Western Half of the Morongo Basin Study Area

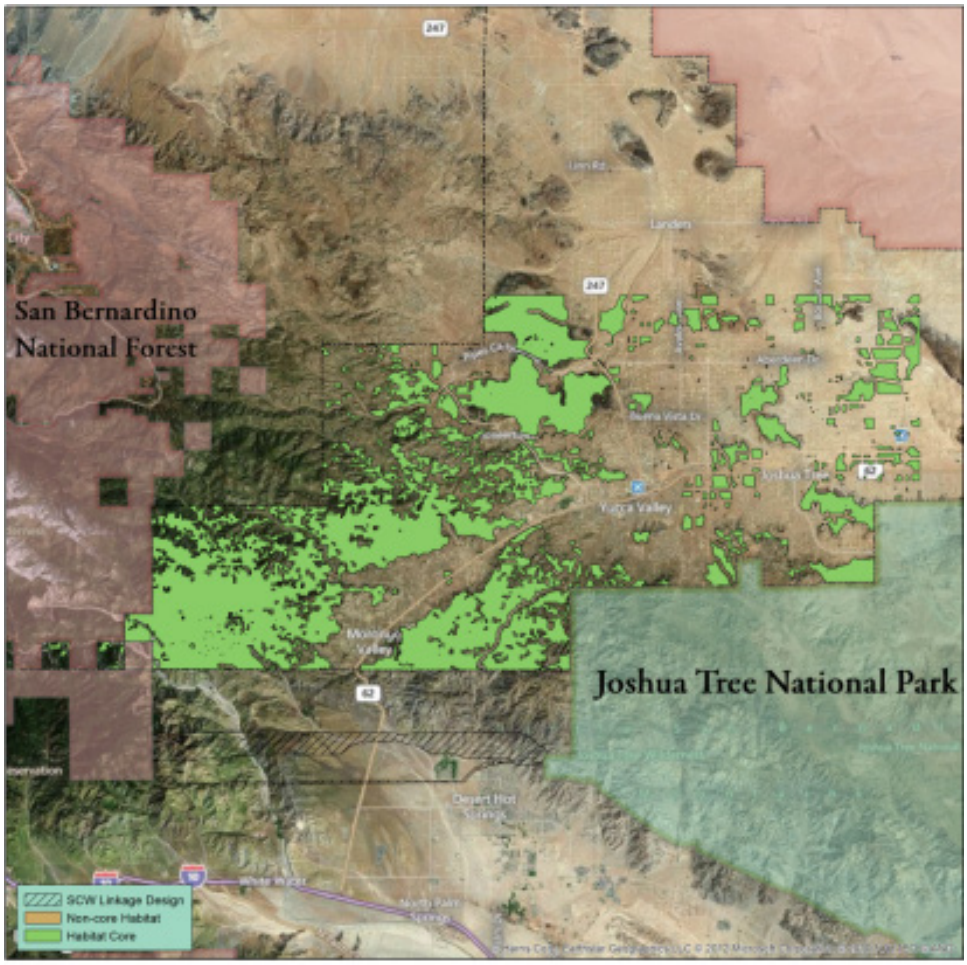


Figure J-32: Potential Compromised Pacific Kangaroo Rat Habitat with Full Buildout in the Morongo Basin

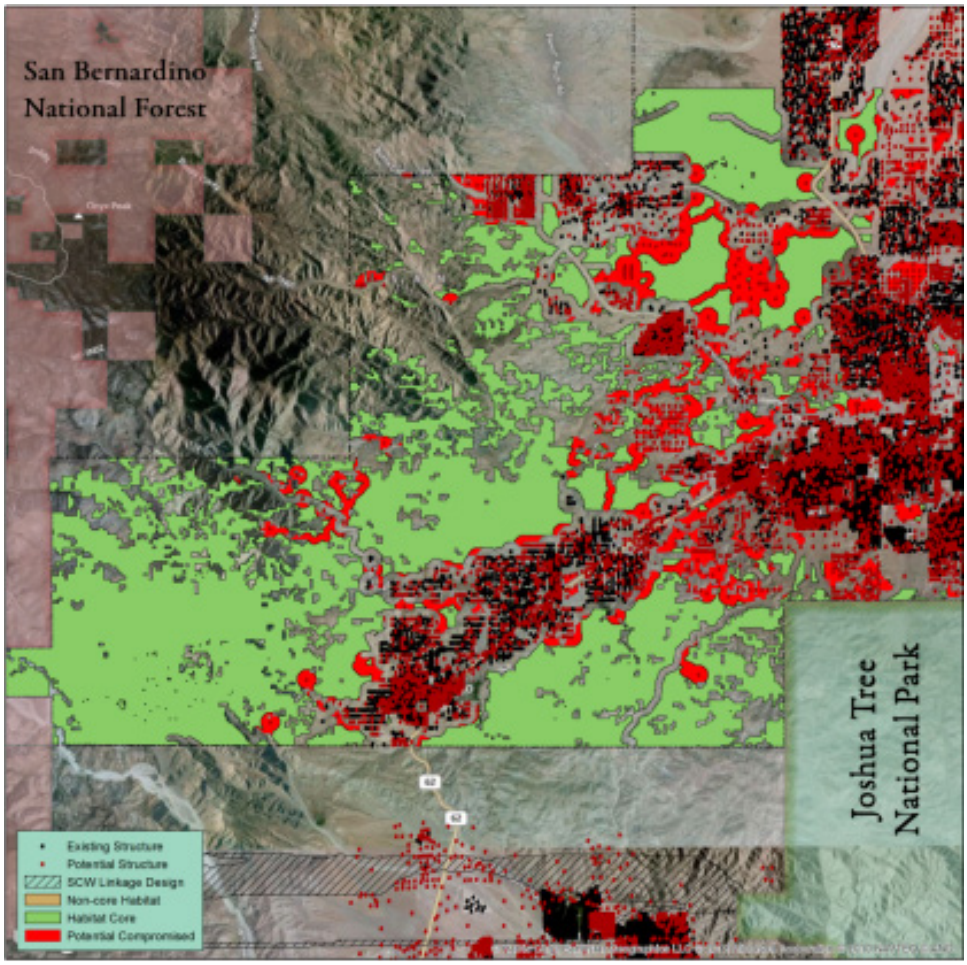
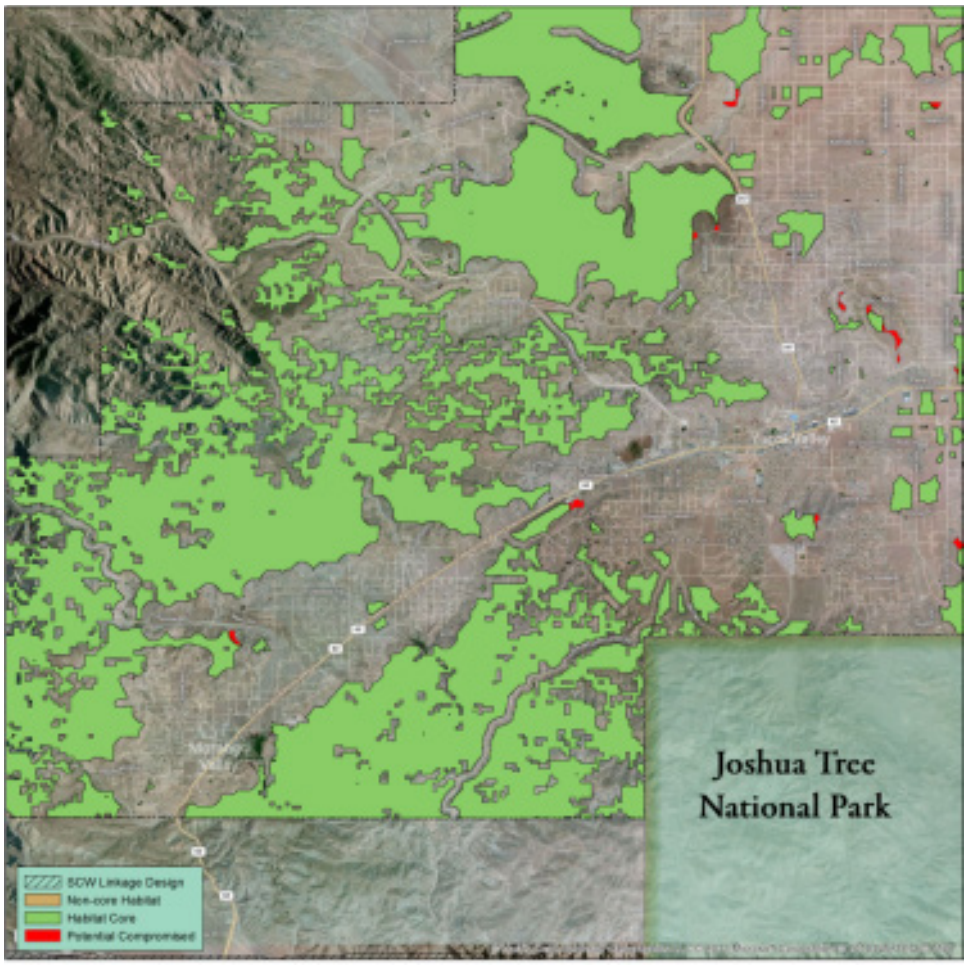


Figure J-33: Example Patterns of Compromised Pacific Kangaroo Habitat under Scenario 1, Scenario 3, and Scenario 4

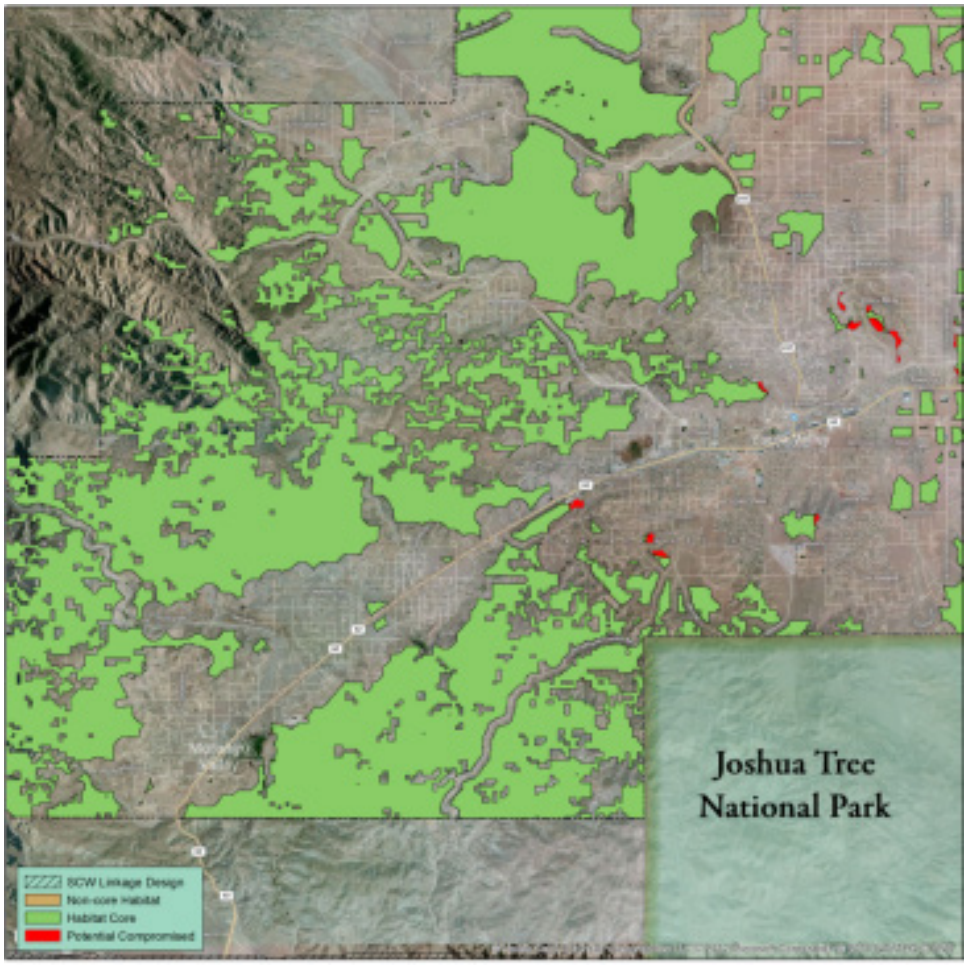
(a) Scenario 1

Scenario 4 impacts the greatest area of habitat but shows a similar pattern of impact as Scenario 1 and 2 (not shown) which includes both small, isolated and large contiguous patches of core habitat. Scenarios 3 and 5 (not shown) impact less area with most or all of the impacts located on small, relatively isolated habitat patches.



(b) Scenario 3

Scenario 4 impacts the greatest area of habitat but shows a similar pattern of impact as Scenario 1 and 2 (not shown) which includes both small, isolated and large contiguous patches of core habitat. Scenarios 3 and 5 (not shown) impact less area with most or all of the impacts located on small, relatively isolated habitat patches.



(c) Scenario 4

Scenario 4 impacts the greatest area of habitat but shows a similar pattern of impact as Scenario 1 and 2 (not shown) which includes both small, isolated and large contiguous patches of core habitat. Scenarios 3 and 5 (not shown) impact less area with most or all of the impacts located on small, relatively isolated habitat patches.

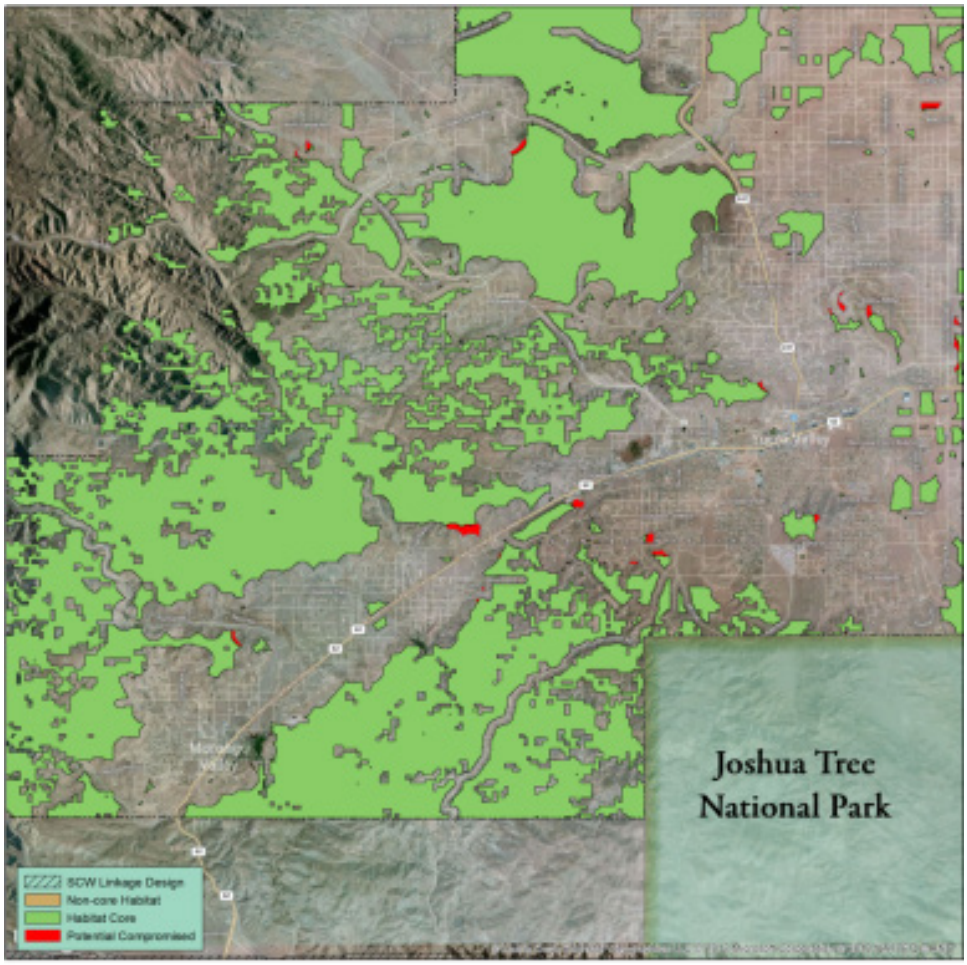
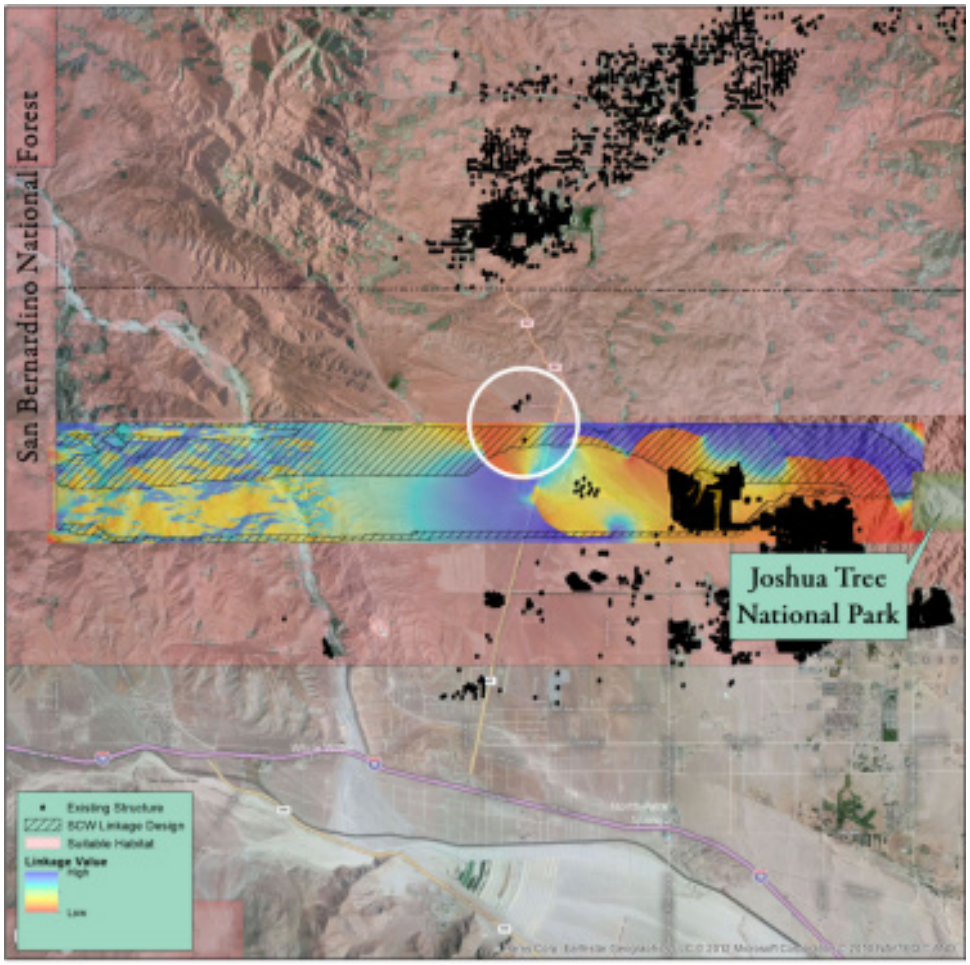


Figure J-34: Pacific Kangaroo Rat Connectivity under Current Conditions and Full Buildout

(a) Current Conditions

Colors represent relative value of current density. Areas of high current density indicate where animal movement is likely to be concentrated. Results indicate that expansion of the linkage area to the north combined with strict confinement of domestic pets in the area circled could improve connectivity for this species. Because the linkage area is outside the Morongo Basin study area, planned development scenarios would not impact connectivity. However, development of existing parcels around Desert Hot Springs may degrade connectivity between Joshua Tree National Park and the Sand Bernardino Mountains.



(b) Full Buildout

Colors represent relative value of current density. Areas of high current density indicate where animal movement is likely to be concentrated. Results indicate that expansion of the linkage area to the north combined with strict confinement of domestic pets in the area circled could improve connectivity for this species. Because the linkage area is outside the Morongo Basin study area, planned development scenarios would not impact connectivity. However, development of existing parcels around Desert Hot Springs may degrade connectivity between Joshua Tree National Park and the Sand Bernardino Mountains.