VI. Summary Findings and Applications

This chapter presents REA findings designed to help managers visualize the REA products and how they may be used at various scales. The focus of this example is on BLM lands not currently protected, but the models are flexible enough to analyze all areas at the ecoregion, state, or field office scales. These sections identify intact landscapes rich in conservation elements and landscapes where change agents currently affect conservation elements and where changes may occur in the future. This summary presents ways to use the integrity/intactness results with composite species information as an introduction to more local step-down management or planning. Understanding the relationship of these data provides basic ecoregion-level information to begin to identify broad areas of opportunity for development, restoration, conservation, or connectivity that may be examined at multiple scales, both regional and local.

6.1 Using REA Results for Regional Planning

The REA Statement of Work (SOW) required an assessment of regional ecological integrity (condition or health). As defined in the SOW, ecological integrity is "the ability of ecological systems to support and maintain a community of organisms that have the species composition, diversity, and functional organization comparable to those of natural habitats within the ecoregion (Karr and Dudley 1981)." The wildlife species selected as core conservation elements for the REA were intended to be wide-ranging species that represented other species and multiple habitats and that served as indicators of the condition of the ecoregion. See Section 2.4.2 for the landscape species selection process. Besides having broad representation, indicator species should be habitat specialists that express site fidelity for breeding, nesting, or wintering (to reduce interannual variability in sampling) and also be sensitive and responsive to a range of disturbances. However, the ecoregion-wide scope in these REAs did not lend itself well to accommodate an approach using indicator species. Perhaps using more homogeneous subunits, such as Environmental Protection Agency (EPA) level IV ecoregions (Griffith et al. In Preparation a and b), and selecting sets of species guilds at sites on a disturbance gradient within these smaller units would allow the addition of a biological component to the spatial measure of terrestrial ecological integrity.

During the course of the REA, it became apparent that there are few measurable spatial indicators and metrics available for individual species to incorporate into such an effort. Our present state of knowledge required using the condition of vegetation communities, habitats, or landscapes as surrogates for the condition of the species and ecological processes in the region. With BLM approval, the REA focused on landscape intactness, an attribute that could be defensibly supported by existing geospatial datasets and reasonably tracked through time. Although different species may possess different tolerances to regional habitat conditions, species assemblages and natural patterns and processes are typically increasingly compromised by the cumulative effects of the change agents that affect their habitats. Terrestrial and aquatic landscape intactness models served as the foundation against which to assess current and future conservation element status.

This reliance on landscape intactness to represent ecological integrity meant that the presence or absence of a particular species, species rarity, or species richness did not factor into any metric of integrity. High species richness or concentrations of rare or endemic species do not indicate high ecological integrity (Odum 1985, Scott and Helfman 2001). Richness is limited by the partitioning of energy among species (Currie 1991, Hawkins et al. 2003); some of our most valued and intact landscapes support few species (Currie 1991, Hughes et al. 2004). On the other hand, although areas of high species richness should be evaluated separately from integrity or intactness, they are still important for conservation and management decision making. Much of the BLM's management and planning is species-centric. This chapter examines the use of regional concentrations or hotspots of species and resource values as one avenue to regional planning.

6.1.1 NatureServe Natural Heritage Elements

NatureServe summarized Natural Heritage data for the ecoregion by 5th level HUCs enumerating all G1-G3 species (critically imperiled, imperiled, and vulnerable, respectively, throughout their range, Faber-Langendoen et al. 2009) and threatened and endangered species occurring within each HUC. The map identifies specific areas within the ecoregion that are species-richness hotspots for these sensitive fine-filter elements (Figure 6-1A). The richness function map layers represent locations from which occurrences have been recorded, rather than where the species currently occurs. The greatest concentration of these species is along the western border of the ecoregion where the Sonoran Desert meets the Peninsular Ranges of southeastern California, but other concentrations can be observed elsewhere (e.g., southeast of Tucson). Comparing these species concentrations to the same areas on the terrestrial landscape intactness map shows that many of the HUCs with high concentrations of sensitive species do not coincide with areas of High or Very High landscape intactness (green areas in Figure 6-1B). This is not unexpected when one considers that human activities tend to put species at risk, but it is interesting to see the regional pattern.

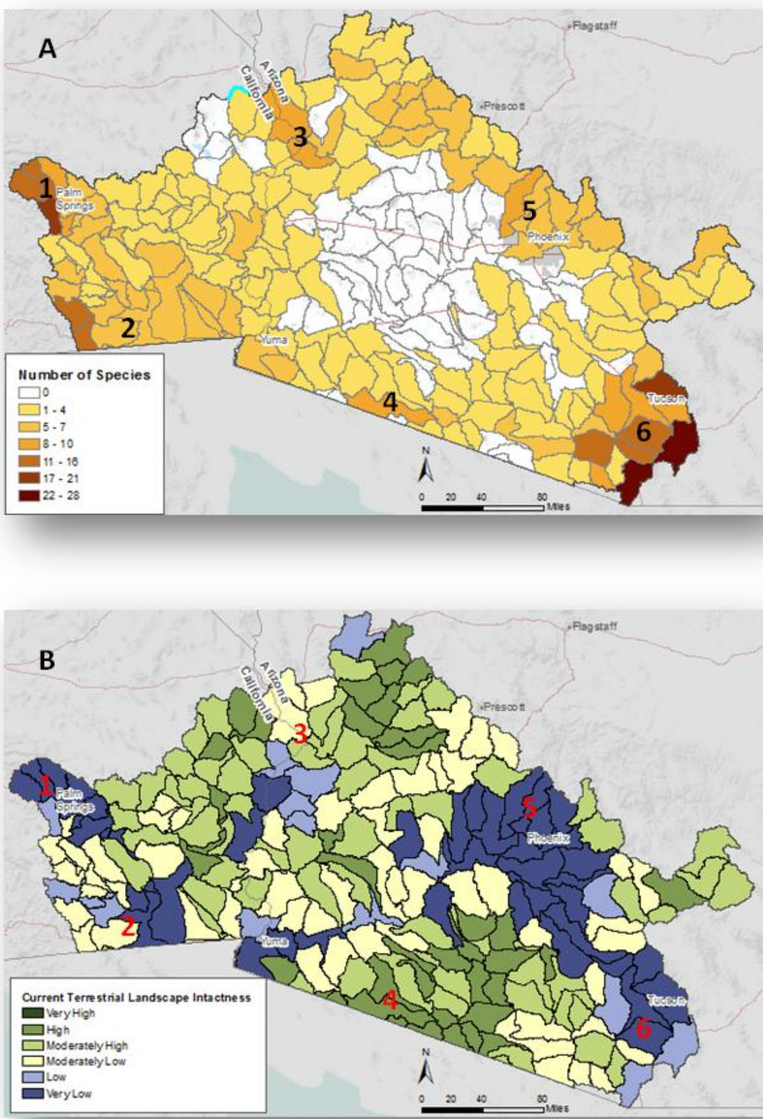
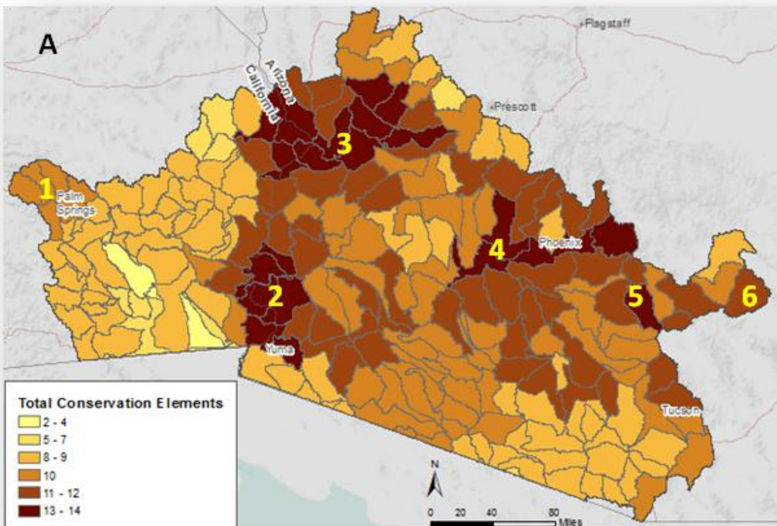


Figure 6-1. (A) Map shows number of G1–G3 species from NatureServe heritage data for the Sonoran Desert ecoregion organized by 5th level HUC and (B) current terrestrial landscape intactness model results. Numbers link areas of high concentration of sensitive species with corresponding areas of relative intactness in the two maps. Summary maps for NatureServe data for all species are provided in Appendix C.

6.1.2 Concentrations of Conservation Elements

As done in the previous section for the heritage data, the collection of REA conservation elements (CEs) was reported by HUC to create CE concentrations or hotspots to compare against regional terrestrial landscape intactness. The list of 15 conservation elements included 11 species, 3 ecological systems and Herd Management Areas (HMAs). The number of conservation elements contained within a single HUC ranged from 2–14. Highest ranking HUCs (those that contained the largest numbers of conservation elements) displayed mixed intactness results. As before, comparisons of concentrations of conservation elements with terrestrial landscape intactness indicated that many of the HUCs with high concentrations of conservation elements show relatively low landscape intactness (Figure 6-2A and Figure 6-2B).



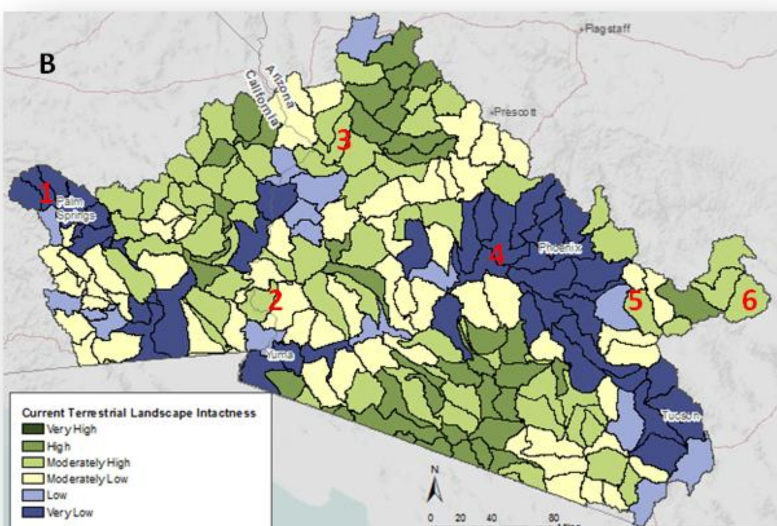


Figure 6-2. Map (A) shows numbers of conservation elements for the Sonoran Desert ecoregion organized by 5th level HUC and (B) current terrestrial landscape intactness model results. Yellow and red numbers link both maps to compare areas of high concentrations of CEs with corresponding areas of relative intactness.

Mapping the conservation element (CE) concentrations at the 4 km reporting unit reveals an improvement in spatial detail with the increase in resolution of the reporting unit (Figure 6-3B). The most apparent difference at the 4 km scale is the ability to detect some of the stream networks and with them the contribution of the aquatic conservation elements to the CE concentrations. The 4 km resolution shows a more textured result when mapped and compared to landscape intactness reported by HUC. The 4 km results are at a scale and detail that more closely matches recognizable topographic changes (mountain ranges) and areas of management interest. When 4 km results such as these are compared to regional intactness mapped at the 4 km unit (as in Figure 6-5A in Section 6.2.1 below), management may be aimed at grid cells with higher levels of intactness or neighboring grid cells of lower intactness that might be candidates for restoration.

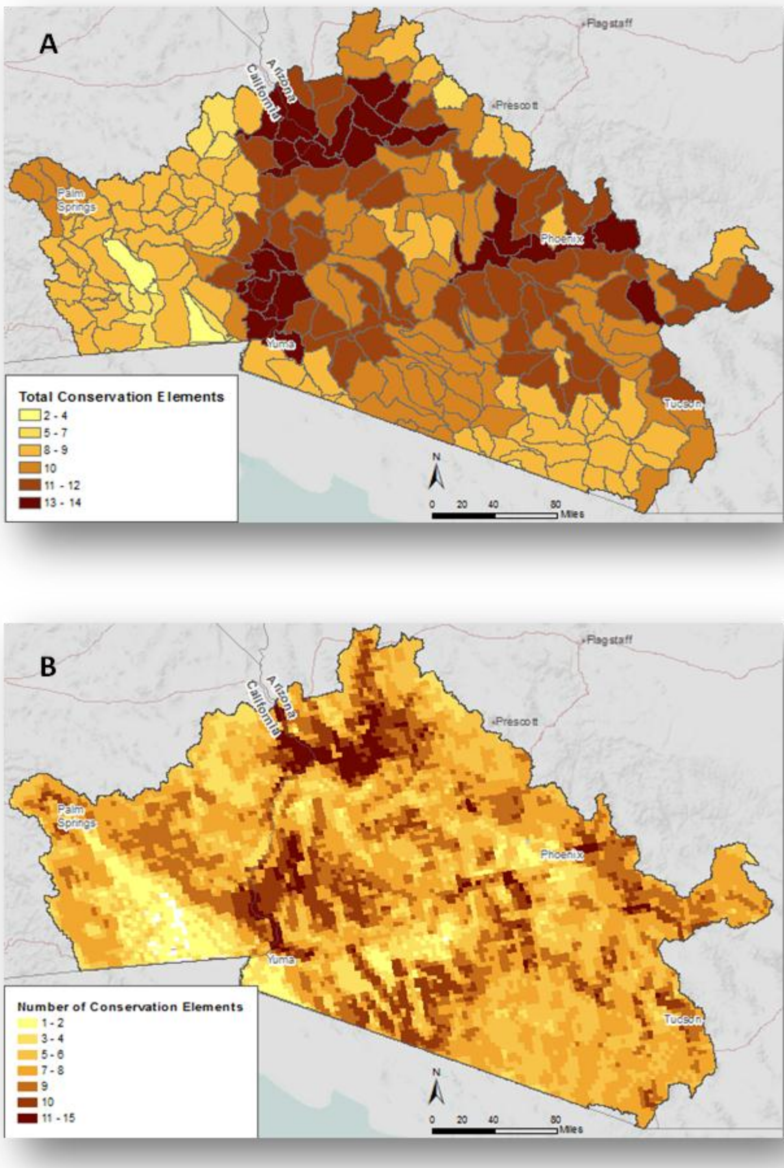


Figure 6-3. Number of conservation elements for the Sonoran Desert ecoregion organized by (A) 5th level HUC and (B) by 4km grid. Spatial detail improves at the 4 km scale showing topographical differences (mountain ranges and basins) and the Colorado River (and with it the contribution of the riparian conservation elements to the CE concentrations).

The sections that follow present an example of organizing REA results for regional planning, an activity that precedes or accompanies local planning using higher resolution data. The 4 km map of concentrations of conservation elements (Figure 6-3B) will be compared to various regional views of intactness and current and future change agents.

6.2 Regional View of Landscape Intactness: Current and Future Risk to Conservation Elements

6.2.1 Comparing Concentrations of Conservation Elements with Regional Levels of Intactness

Three different maps were used to represent the concentrations of *resource values* (see Glossary) and to reveal patterns across the region—1) REA conservation elements enumerated by 4 km grid cell (Figure 6-4A); 2) the number of globally critically imperiled and vulnerable species (NatureServe G1–G3 by 5th level HUC, Figure 6-4B); and 3) the number of USFWS threatened and endangered species recorded by 5th level HUC (Figure 6-4C). Comparing maps 6-4A–C, one can see that Maps 6-4A and 6-4C share two areas in the central region, and maps 6-4B and 6-4C share two hotspots of globally imperiled species and threatened and endangered species at the far eastern and western ends of the region. These additional areas of interest were added to map 6-4A to create one map (6-4D) to represent all three of the of the resource value categories; the map with all the resource values included (6-4D) is used in the following sections when comparing concentrations of conservation elements with intactness maps and maps of future condition. Hotspots occur in the central portion of the ecoregion near the Colorado River and in the boundary areas transitional to adjacent ecoregions—the California coast range, Mojave Desert, Mogollon Rim, and Madrean Archipelago. Protected areas were masked out on the hotspot and intactness maps (green areas) to focus on remaining lands subject to development pressures.

To compare these concentrations of conservation elements to the condition of surrounding habitats, areas of moderately high to high intactness outside of protected areas have been outlined (in pink) on the intactness map (Figure 6-5A) and the higher concentrations of species and other conservation elements outlined in royal blue on the map in Figure 6-5B. A comparison of the two maps shows some broad areas of interest between the two layers. As a first cut in this example, one is drawn to the northern apex of the region, the eastern and western corners, and areas of high intactness or species concentrations near protected areas 1, 2, and 3. The two pink circled areas of higher intactness west of protected area 1 (Kofa National Wildlife Refuge) are both military areas (Yuma Proving Ground and Chocolate Mountains National Gunnery Range) that retain some benefits to wildlife outside of military activities. They create linkages between Kofa, multiple wilderness areas (e.g., Little Picacho, Indian Pass, and Trigo Mountains) to the southwest, and the larger Chuckwalla Desert Wildlife Management Area (DWMA) and Area of Critical Environmental Concern (ACEC) to the west. Greater opportunities may exist for conservation/restoration in the higher intactness-species concentrated area between protected areas 2 (Sonoran Desert National Monument) and 3 (Organ Pipe Cactus National Monument and Cabeza Prieta National Wildlife Refuge) where smaller protected or quasi-protected areas (e.g., Coffeepot Botanical Area, Barry M. Goldwater Air Force Range) could be supplemented to create more robust linkages between the two National Monuments. This is just an example of one route to evaluating these results; in planning situations, of course, there may be valid reasons to restore or protect areas of lower intactness or lower numbers of resource values. The remaining open areas on either side of the Phoenix-Tucson megalopolis (two blue ellipses to the right of 2 in Figure 6-5B) may be just as important as the areas of higher intactness—particularly east of Phoenix in the ecotone between the Sonoran Desert and the Arizona-New Mexico Mountains (e.g., Dripping Springs Mountains); here there are areas of moderately high intactness remaining as well as concentrations of resource values.

The vast amount of information produced by this REA can and must be examined in multiple ways and at multiple scales. In Chapters 4 and 5, individual species distributions were overlaid with landscape intactness to estimate conservation elements' current and future status. To accompany the spatial mapped results, it is useful for managers to have tabular summaries of conservation elements and areas in various intactness classes.

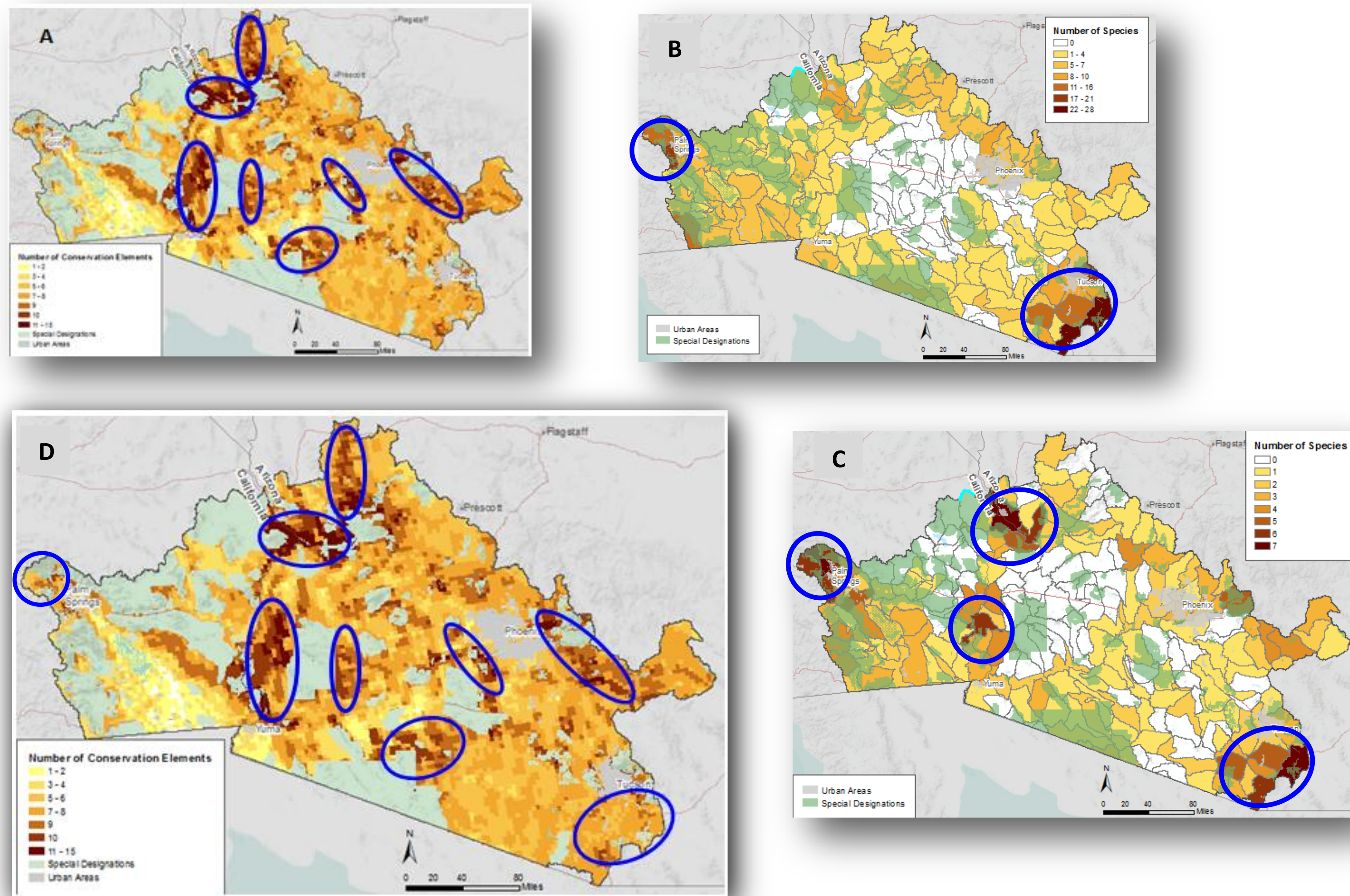
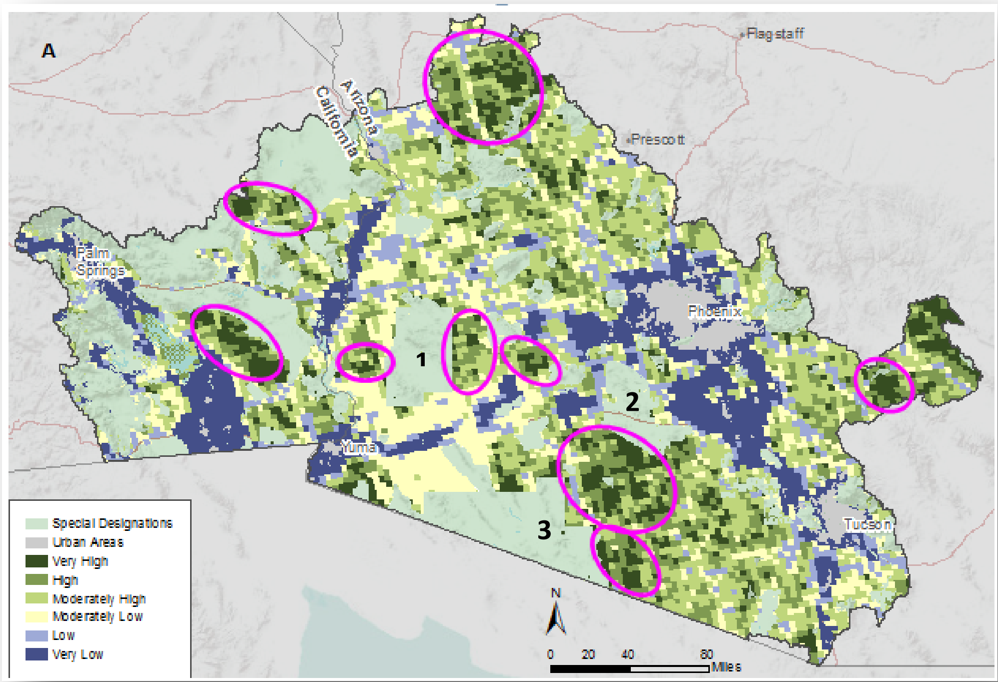


Figure 6-4. Maps of (A) concentrations of conservation elements; (B) globally imperiled species, and (C) USFWS-listed threatened and endangered species, all with highest concentrations circled; and (D) map A with additional areas of interest at western and southeastern ends added from maps B and C. Protected areas are masked out in green.



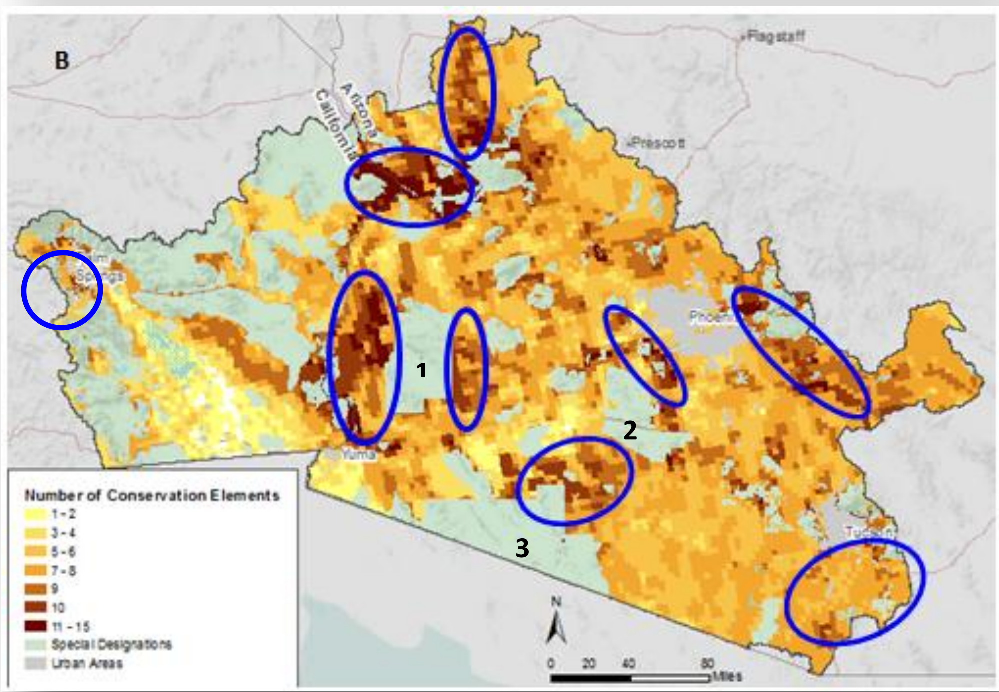


Figure 6-5. Maps of (A) terrestrial intactness for the Sonoran Desert ecoregion and (B) concentrations of conservation elements and resources of concern. Protected areas masked out in green. Numbers mark areas discussed in text. Areas of higher intactness outlined in pink in (A) and higher concentrations of species outlined in blue in (B).

Table 6-1 shows the results for all lands within the Sonoran Desert ecoregion. In this example, the matrix is organized into six different categories. The colored panels indicate High, Medium, and Low intactness classes (red, blue, and yellow, respectively) from left to right with increasing numbers of conservation elements from top to bottom (darker color tones for the higher concentrations of conservation elements). An accompanying map using the same color scheme is provided in Figure 6-6. Acres within each category may be viewed in different ways to assess management options and to inform policy decisions. For example, areas in dark red are those locations that contain high concentrations of conservation elements and the highest levels of landscape intactness. One could view these areas as places of high potential conflict or high protection value. Areas in the light yellow category (Low intactness and low concentrations of conservation elements) may be places where ongoing development is more acceptable assuming specific issues (protection of a rare species) are properly managed. Areas in dark blue (places with high concentrations of conservation elements combined with moderate intactness) may be the best locations for restoration to get the greatest return on investment.

AREA IN ACRES FOR ALL SONORAN DESERT LANDS BY NUMBER OF CONSERVATION ELEMENTS AND INTACTNESS CLASSES

NUMBER OF CONSERVATION ELEMENTS	Very High	High	Moderately High	Moderately Low	Low	Very Low	Totals
0	15.2%		22.3%		16% 11,615	139,321	**150,936**
1	47,334	124,097	100,676	47,443	15,443	209,473	**544,466**
2	83,935	79,102	158,957	115,873	43,143	383,516	**864,526**
3	111,678	106,951	182,244	338,651	102,376	482,626	**1,324,525**
4	206,988	356,554	429,391	490,433	234,490	545,279	**2,263,135**
5	303,069	711,776	1,043,486	621,471	303,854	864,320	**3,847,975**
6	397,828	905,708	1,176,486	725,201	425,894	679,541	**4,310,659**
7	698,480	1,180,297	1,461,101	893,516	445,625	695,834	**5,374,853**
8	866,974	1,568,736	1,819,039	1,125,388	494,645	559,752	**6,434,534**
9	1,191,783	1,339,546	1,576,441	843,879	409,474	319,976	**5,681,098**
10	761,805	707,706	755,138	466,525	171,261	185,819	**3,048,255**
11	51,397	157,870	256,984	158,144	45,032	31,629	**701,056**
12	3,954	55,350	55,350	55,350	15,814	19,768	**205,587**
13		35,582	75,118	19,768	3,954	3,954	**138,376**
14	19.3%	3,954	20.7% 3,954	7,907	3,954		**19,768**
15					6.5% 3,954		**3,954**
Totals	**4,725,226**	**7,333,230**	**9,094,365**	**5,909,548**	**2,730,527**	**5,120,808**	**34,913,703**

Table 6-1. Table lists all lands for all ownerships across the Sonoran Desert with the number of conservation elements on the y-axis and columns for area of lands in 6 intactness classes. The colored panels indicate High, Moderate, and Low intactness classes (red, blue, and yellow, respectively) from left to right and lower and higher numbers of conservation elements (CEs) from top to bottom (lighter and darker colors, respectively). Blue numbers give the percentage of ecoregion acreage in each intactness class. Map with same color scheme (Figure 6-6) accompanies Table 6-1.

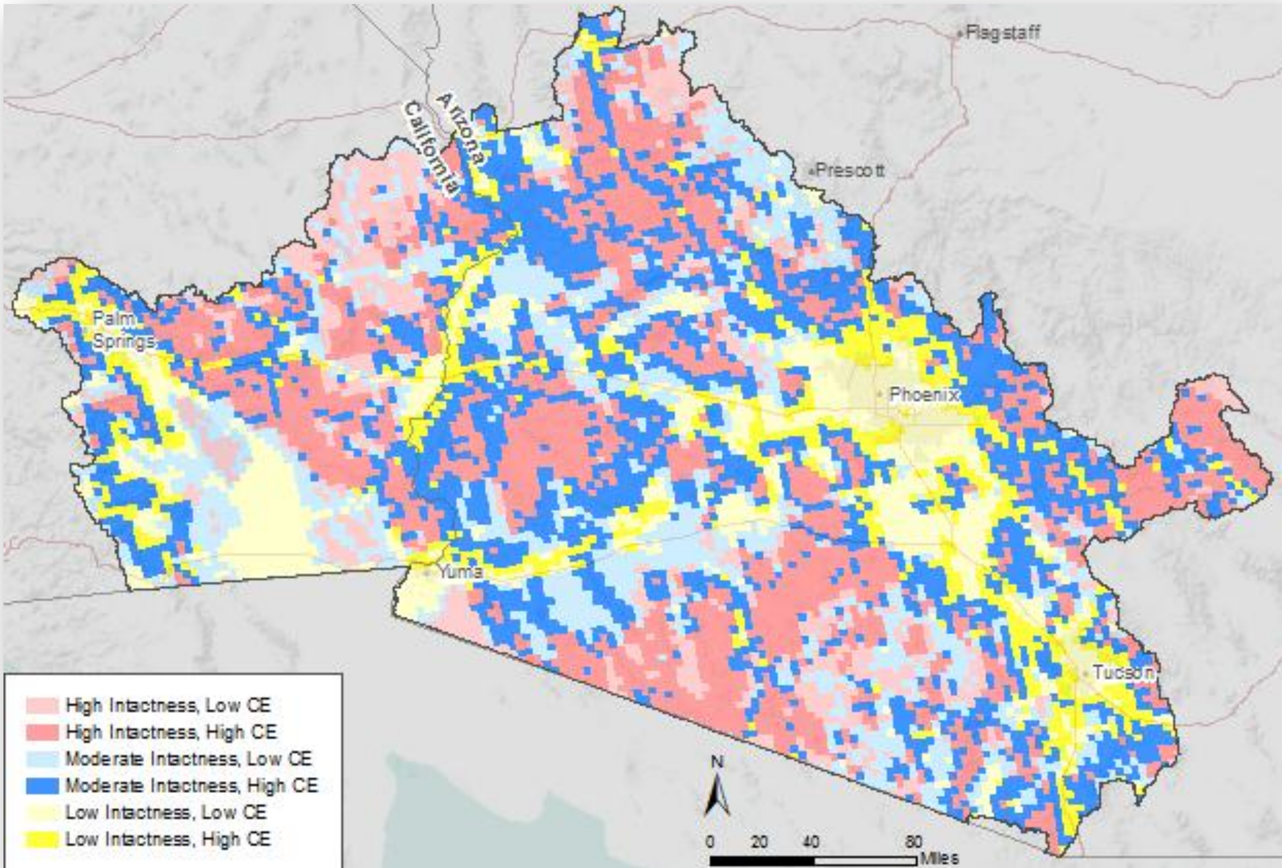


Figure 6-6. Map to accompany Table 6-1 showing 6 classes of intactness by number of CEs for all lands. Colors match color panels in Table 6-1.

Table 6-1 is just one example of how the matrix table can be organized. Depending on the circumstances and issues to be addressed, managers could organize the same data in different ways (Figure 6-7). The standard model presented here (Figure 6-7A) could be changed by increasing (Figure 6-7B) or decreasing (not shown) the threshold for conservation element concentrations. A simpler grid could be applied to the data using a 4 panel instead of a 6 panel organization (Figure 6-7C). Finally, the number of categories could be increased based on the range of conservation element concentrations or number of management options (Figure 6-7D). Managers could also take into account the rare species information by adding the heritage findings (the globally imperiled or threatened and endangered species shown in Figures 6-1B and C) into the matrix diagram. In addition to creating a useful matrix table, one could improve the approach by working at various scales (both regional and local) or within relatively homogeneous landscape areas (such as EPA level IV ecoregions), grouping species into guilds, or ranking species by sensitivity to disturbance.

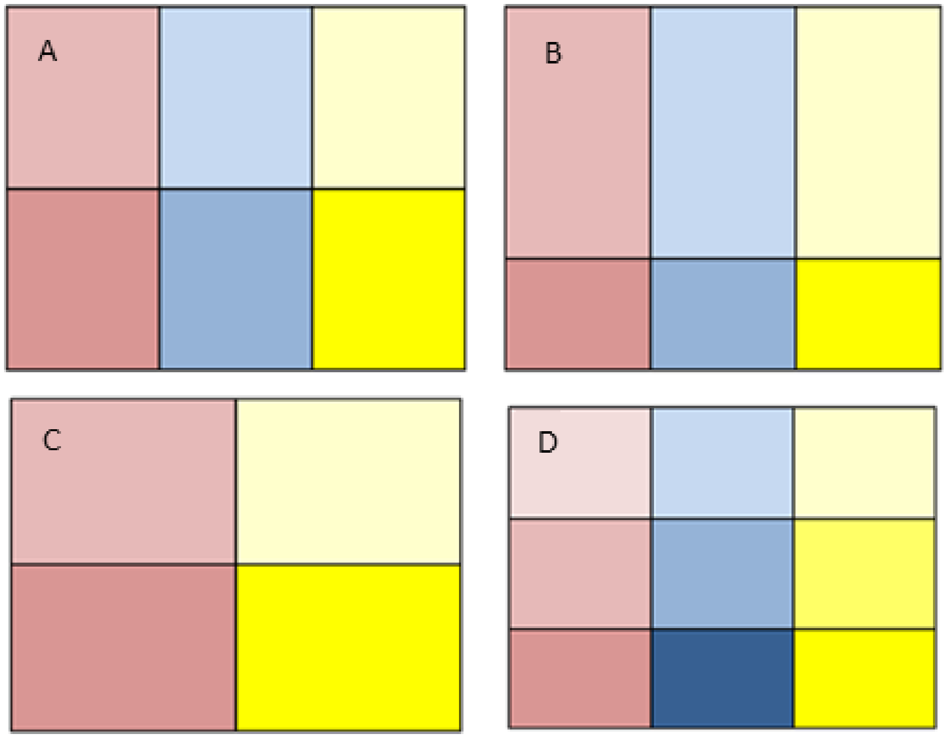


Figure 6-7. Matrix table diagrams offer different options for organizing data comparing concentration of conservation elements (y-axis) and relative landscape intactness (x-axis). Colors correspond to different categories for the combinations. These matrix tables would contain area information as presented in Table 6-1.

The analysis was rerun using the same approach that created Table 6-1, this time excluding all specially designated protected lands and all urban areas. The resulting matrix table (Table 6-2) and companion map (Figure 6-8) emphasize land areas in play across multiple ownerships and reduce the amount of land area being considered by approximately 29 percent (nearly 25,000,000 acres in Table 6-2 compared to nearly 35,000,000 acres in Table 6-1). Finally, although BLM managers will be pursuing a landscape approach to management that stresses cooperative planning across agencies and ownerships, they will also want to examine REA results for BLM lands only (Figure 6-9A, map of intactness on BLM lands and Figure 6-9B, concentrations of conservation elements on BLM lands with designated lands excluded); note maps are the same as those in Figure 6-5A and 6-5B but for BLM lands only). Table 6-3 and companion map (Figure 6-10) present the acreage information for BLM lands only outside of designated lands. The acreage total for BLM lands is almost 7,000,000 acres with over 2,000,000 acres in High or Very High intactness classes. About 785,000 acres of BLM lands, or 11% of the total, occur in the Very High intactness class. The figure is likely an overestimate of very highly intact lands because of inevitable data deficiencies.

AREA IN ACRES FOR ALL LANDS MINUS DESIGNATED SITES AND URBAN AREAS

NUMBER OF CONSERVATION ELEMENTS	Very High	High	Moderately High	Moderately Low	Low	Very Low	Totals
0	14%		25.4%		17.6% 7,794	127,918	135,712
1	25,922	67,209	71,649	47,443	15,422	169,639	397,284
2	58,156	70,176	116,023	91,140	34,516	275,975	645,986
3	43,690	86,355	141,677	278,880	83,023	314,720	948,346
4	114,456	252,793	298,810	377,715	213,098	397,728	1,654,601
5	204,696	505,409	898,370	502,646	270,827	620,629	3,002,578
6	228,014	576,455	944,851	619,605	368,686	537,312	3,274,922
7	431,632	805,749	1,174,321	727,832	355,918	576,649	4,072,101
8	490,919	1,058,369	1,322,983	833,116	389,900	425,929	4,521,214
9	516,444	797,294	1,098,381	589,378	345,983	259,199	3,606,678
10	178,633	371,954	535,639	348,220	152,771	136,254	1,723,470
11	34,311	99,638	206,716	137,974	42,519	27,038	548,196
12	3,954	27,548	39,675	33,969	14,146	17,477	136,770
13		11,901	44,647	11,539	3,954	3,305	75,345
14	14.5%	3,954	3,954	7,907	3,486		19,300
15			21.1%		7.4% 3,615		3,615
Totals	2,330,827	4,734,803	6,897,695	4,607,365	2,305,656	3,889,773	24,766,119

Table 6-2. Table lists all lands minus areas of designated sites and urban lands across the Sonoran Desert with the number of conservation elements on the y-axis and six columns for area of lands in various intactness classes with acreage totals. Blue numbers give the percentage of ecoregion acreage in each intactness class.

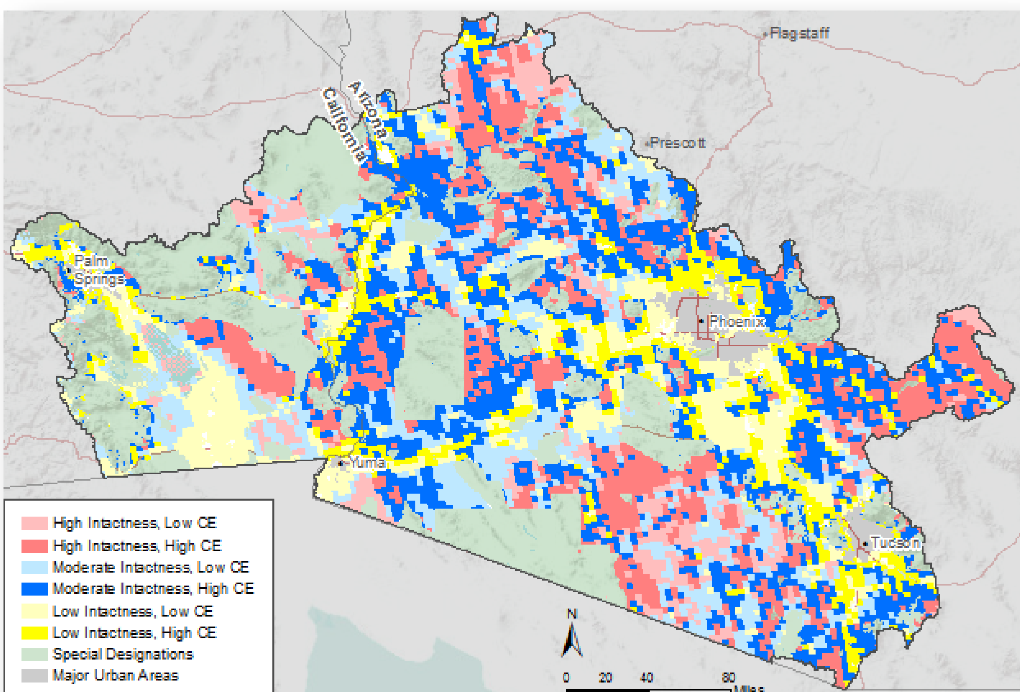
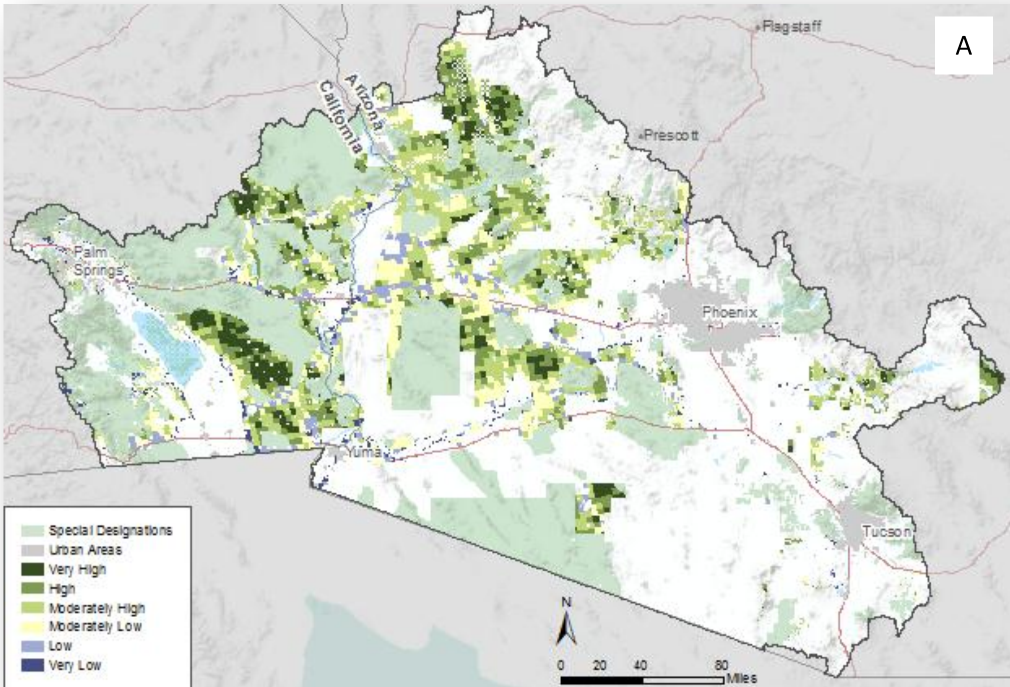


Figure 6-8. Map to accompany Table 6-2 showing 6 classes of intactness by high or low number of CEs. Colors match color panels in Table 6-2. Designated sites masked out in green.



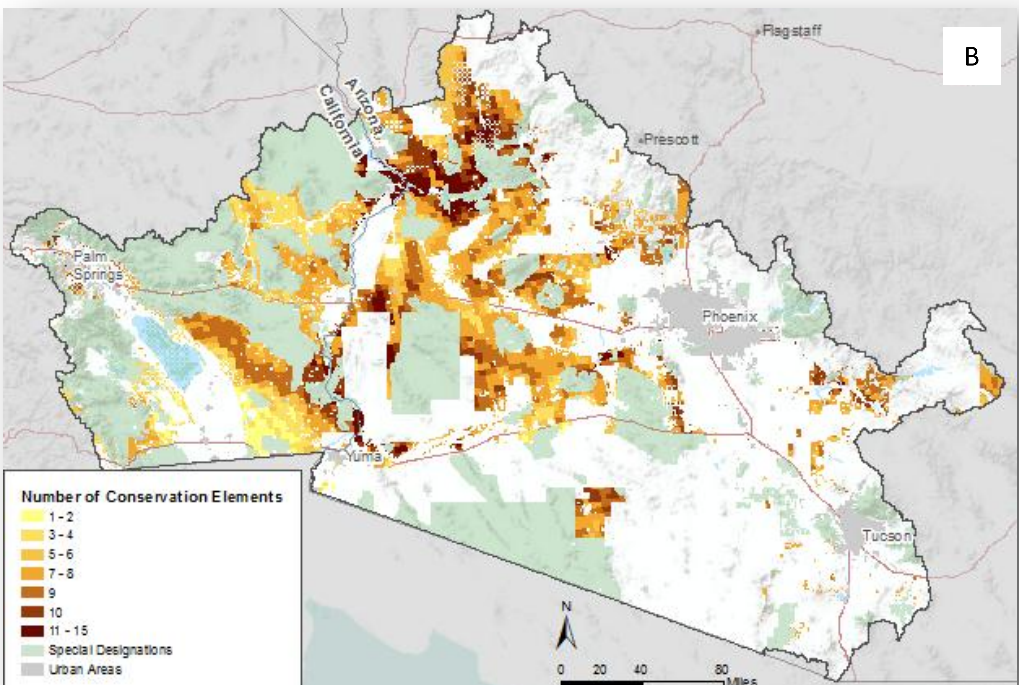


Figure 6-9. (A) Map of intactness for BLM lands outside of designated areas (light green). (B) Map of concentrations of conservation elements for BLM lands outside of designated areas (light green). These maps reproduce Figure 6-5A and 6-5B for BLM lands only.

NUMBER OF CONSERVATION ELEMENTS	Very High	High	Moderately High	Moderately Low	Low	Very Low	Totals
0	13.1%		23.6%		6.3% 6,927	566	**7,493**
1	5,358	12,315	23,610	56	4,450	606	**46,394**
2	21,124	26,091	47,428	24,352	13,572	10,948	**143,515**
3	21,283	46,327	76,995	69,558	26,908	17,172	**258,243**
4	45,760	131,043	106,372	138,038	51,879	25,811	**498,903**
5	27,404	108,711	226,608	98,623	54,082	19,326	**534,754**
6	57,880	117,337	191,184	164,093	78,288	24,160	**632,943**
7	81,971	209,360	299,964	172,001	70,280	33,170	**866,747**
8	21.9% 147,677	369,068	29.8% 481,719	264,576	5.3% 114,898	24,864	**1,402,802**
9	266,553	394,404	505,373	202,557	95,537	20,438	**1,484,861**
10	87,361	153,140	217,932	133,331	53,929	14,967	**660,660**
11	18,933	48,764	111,000	90,122	14,473	8,787	**292,079**
12	3,954	21,606	20,130	6,754	6,570	2,363	**61,377**
13		10,218	24,347	7,920	1,534	1,755	**45,774**
14		2,415	1,475	4,215	2,234		**10,340**
15					2,271		**2,271**
Totals	**785,257**	**1,650,800**	**2,334,138**	**1,376,196**	**597,832**	**204,933**	**6,949,156**

Table 6-3. Table lists all BLM lands minus areas of designated and urban lands for the Sonoran Desert with the number of conservation elements on the y-axis and six columns of area of lands in the various intactness classes with acreage totals. Blue numbers give the percentage of ecoregion acreage in each intactness class.

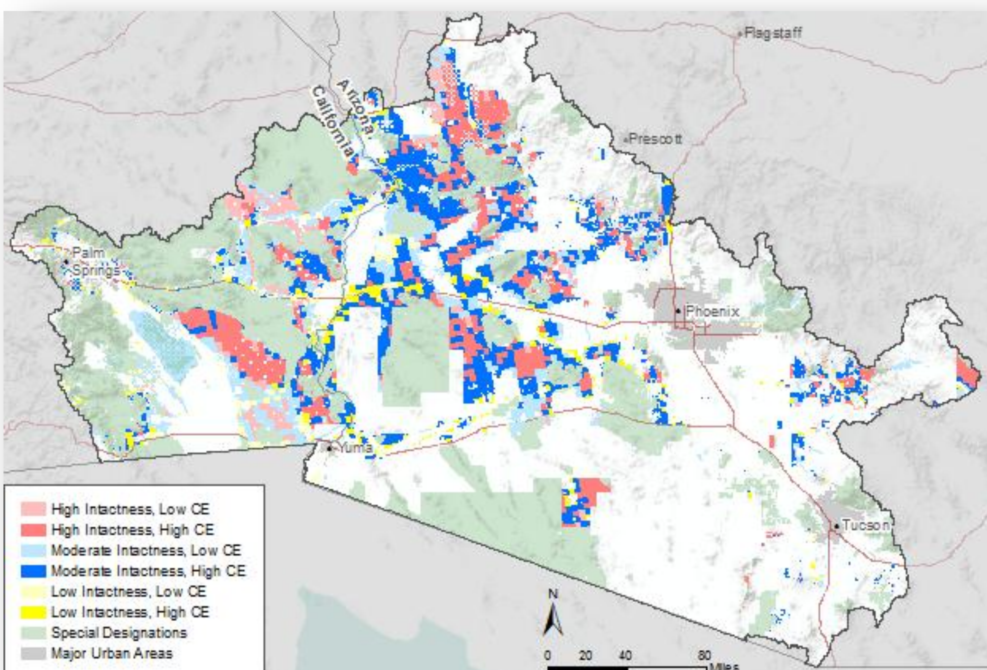


Figure 6-10. Map to accompany Table 6-3 showing 6 classes of intactness by high or low number of CEs for BLM lands minus designated and urban areas. Colors match color panels in Table 6-3.

6.2.2 Exposure of Resource Values to Change Agents

6.2.2.1 Current and Near-Term Future (2025) Development

The status of individual conservation elements relative to current and near-term future (2025) development was determined in Chapters 4 and 5. Areas where concentrations of high concentrations of conservation elements and species of concern are at risk from development pressures can be located as well (Figure 6-11A–D). Four major components of development were assessed for the ecoregion—energy, urbanization (including roads), agriculture, and recreational development—to create the *current* human development footprint (see development fuzzy logic model, Section 4.3.3). Reliable spatial data was available for all but recreation, which was difficult to acquire. Current energy development contained spatial data for both linear features (utility lines and pipelines) and point features (oil/gas wells, mines, and geothermal wells) as well as renewable energy priority projects. The urban development component of the fuzzy logic model averaged urban landcover density and road density based on the transportation data files provided by BLM. When key resource values are compared to the current development map results, the concentration of globally imperiled and threatened and endangered species in the eastern- and westernmost corners of the region and the conservation elements on either side of the Phoenix-Tucson corridor appear to be at the highest risk from development pressures (Figure 6-11A).

The *near-term future* (2025) development model was built from the logic model presented in Section 5.1, which contains the same four major development components—energy, agriculture, urbanization (including roads), and recreational development. Little predictive data were available for future projections; the model relied mainly on available data for future urban expansion and renewable energy, the two biggest development challenges to the ecoregion besides water availability, which could also limit development. The projected near-term renewable energy development included 2011 priority projects and some planned rights-of-way in California. Additional data for the California Desert Renewable Energy Conservation Plan (DRECP) was not developed in time for this assessment. The current and near-term development mapped results appear very similar, with visible changes occurring mostly in the Phoenix-Tucson corridor. Although it is difficult to see on the near-term development map (Figure 6-11B), the Very High development class grew by 1.5% and the High and Moderately High categories each gained about 0.5%., with urban expansion in the Phoenix-Tucson area and urban and renewable energy development along the western Interstate 10 corridor and in the southwestern corner of the ecoregion. In all, the development footprint increased by over 887,000 acres for the near-term (2025) development scenario. The concentrations of resource values (represented by the blue ellipses in Figure 6-11A–D) on the eastern and western ends of the ecoregion as well as those on either side of the Phoenix-Tucson corridor appear to be at greatest risk from increasing near-term future (2025) development (Figure 6-11B). The five remaining areas of resource value concentration in the north and south central portions of the ecoregion do not show visible changes from development pressure in the near term at this small scale. Much of the development pressure (urban, agricultural, and renewable energy development) occurs at lower elevations, and it affects many of the REA core conservation elements that frequent lower elevation habitats: riparian and xeroriparian areas, saltbush and creosotebush basins, and low foothills. However, although other species and habitats in somewhat higher elevations may not experience direct habitat conversion, they are subject to increasing negative effects at the development-wildland interface.

The third map, maximum potential energy development (Figure 6-11C), is more speculative—that is, not based on actual plans for development—with a longer term time frame. The maximum potential energy development results were developed from a fuzzy logic model with three major components—traditional oil and gas, wind energy, and solar energy.

Potential for oil, gas and geothermal development was created by buffering existing wells. Solar resource potential, defined as >5.5 kW/m^2, was obtained from the National Renewable Energy Laboratory (NREL) and added to solar priority projects, selected features from California BLM on verified and preliminary renewable energy rights-of-way, modified solar energy zones (SEZs), and Arizona restoration design energy project data (RDEP). NREL also provided potential wind development data defined by wind power density classes 3 and above at 50 m high. Full page maps for potential solar, wind, and maximum potential energy development across the ecoregion may be found in Chapter 5, Section 5.2, Potential Energy Development, Figures 5-3 through 5-5. Summarized in three classes at 4km resolution, the final composite map for all three energy components covered a fairly large area of the ecoregion (Figure 6-11C). For the ecoregion, over 7,000,000 acres (21%) were classified as having High Potential, almost 3,900,000 acres (11%) Moderate Potential, and almost 24,000,000 acres (68%) Low Potential. Two concentrations of resource values in the far west and central portions of the ecoregion appear to be at highest risk for change from potential energy developments.

Summary tables for future energy development (predominantly renewable energy) accompany the mapped results (Tables 6-4, 6-5, and 6-6). For the summary tables, categories of land area were assessed for the 4 km intactness surface using the intersection of the additional area of future developments and the total concentration of conservation elements per 4 km grid cell. For greater clarity in tracking development types and land areas, the acreage tables were subdivided by adding a third category to create near-term (solar and wind priority projects, Table 6-4), mid-term (near-term projects plus modified SEZs and RDEP, Table 6-5), and maximum potential (or long-term = near-term and mid-term plus NREL wind and solar potential) energy development (Table 6-6).

AREA IN ACRES OF LAND SURFACE AFFECTED BY NEAR-TERM (2025) ENERGY DEVELOPMENT BY NUMBER OF CONSERVATION ELEMENTS AND INTACTNESS CLASS

# of CONSERVATION ELEMENTS	Very High	High	Moderately High	Moderately Low	Low	Very Low	Totals
0	4.9%		46.2%		18.7%		
1							
2							
3				7,556	10,225		17,781
4		1,333	3,731	10,747	2,537	853	19,201
5		2,734	767	4,944	3,726	534	12,705
6		1,230	12,190	10,222	1,886	515	26,043
7	2.2% 26	1,345	15.5% 739	3,744	12.5% 3,772	330	9,956
8		837	1,790	4,013	9,414		16,054
9		182	5,994	300			6,476
10				265			265
11							
12							
13							
Totals	**26**	**7,661**	**25,212**	**41,792**	**31,559**	**2,232**	**108,480**

Table 6-4. Table shows area in acres of land surface in various intactness classes and number of conservation elements affected by near-term (2025) energy development. Near-term energy development is defined by a number of identified 2011 renewable energy priority projects in California and Arizona that are in the approval process.

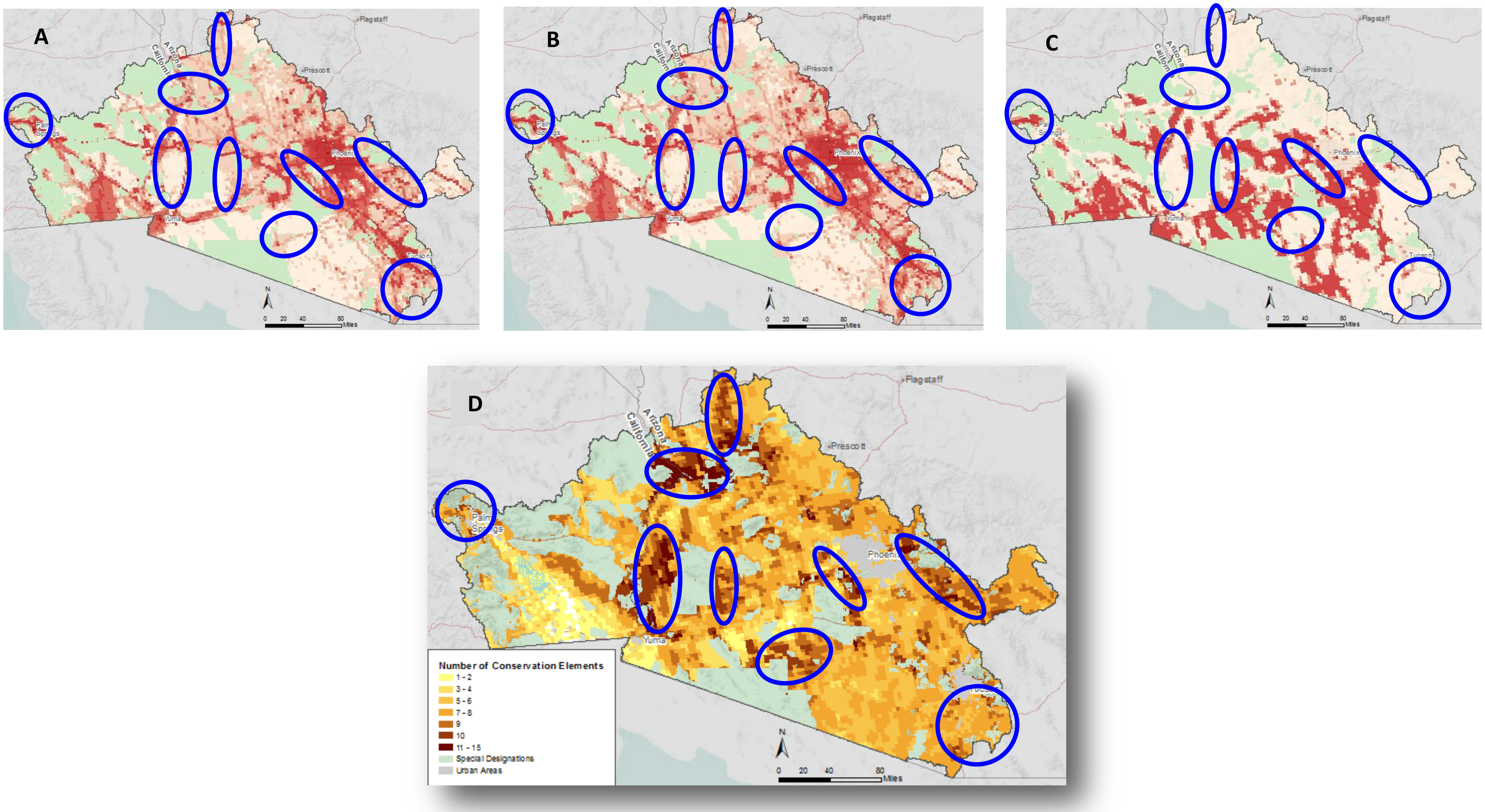


Figure 6-11. Maps indicate (A) current development footprint, (B) near-term future development (2025), (C) future maximum (long term) potential renewable energy development (priority projects, NREL solar energy zones, solar and wind potential), and (D) concentrations of conservation elements and species of concern. On all maps, blue ellipses identify corresponding areas with high concentrations of conservation elements and species of concern. Protected areas masked out in light green.

AREA IN ACRES OF LAND SURFACE AFFECTED BY MID-TERM RENEWABLE ENERGY DEVELOPMENT BY NUMBER OF CONSERVATION ELEMENTS AND INTACTNESS CLASS

# of CONSERVATION ELEMENTS	Very High	High	Moderately High	Moderately Low	Low	Very Low	Totals
0	7.2%		22.2%		30.6%	4	4
1		78	1,793		509	6,522	8,901
2	3,266	2,476	3,470	9,980	1,347	15,766	36,303
3	7	3,954	5,317	17,475	12,581	22,747	62,080
4	5,311	33,081	33,489	57,667	34,632	78,044	242,225
5	9,774	28,195	36,774	61,400	44,138	103,959	284,240
6	4,854	18,102	50,092	60,574	49,573	96,485	279,681
7	4.9% 6,980	34,117	18.5% 63,719	66,127	16.6% 37,919	89,370	298,232
8	4,943	21,236	36,051	47,653	31,143	33,761	174,788
9	392	2,526	33,306	24,563	26,948	14,110	101,845
10	1,191	2,968	3,693	6,334	4,871	15,469	34,526
11				886			886
12							0
13				15		32	46
Totals	36,719	146,732	267,703	352,675	243,661	476,268	1,523,758

Table 6-5. Table shows area in acres of land surface in various intactness classes and number of conservation elements affected by mid-term renewable energy development. Mid-term renewable energy is defined by recent priority projects, modified solar energy zones (SEZs), restoration design energy projects (RDEP), and some planned rights-of-way in California.

AREA IN ACRES OF LAND SURFACE AFFECTED BY POTENTIAL RENEWABLE ENERGY DEVELOPMENT BY NUMBER OF CONSERVATION ELEMENTS AND INTACTNESS CLASS

# of CONSERVATION ELEMENTS	Very High	High	Moderately High	Moderately Low	Low	Very Low	Totals
0	11.1%		25.2%		30.3% 6,968	125,247	132,216
1	21,683	20,270	48,953	47,185	14,471	167,332	319,894
2	59,588	50,802	88,008	69,626	21,663	239,516	529,203
3	28,430	53,331	88,758	210,172	51,778	255,693	688,162
4	44,003	120,376	141,576	242,539	110,792	307,759	967,044
5	55,331	167,562	258,179	207,745	114,796	524,463	1,328,076
6	44,428	240,964	406,506	249,621	152,740	379,724	1,473,981
7	4.9% 38,830	128,949	15.5% 234,026	291,981	12.8% 126,522	361,659	1,181,969
8	36,223	144,897	171,628	168,455	98,001	186,821	806,025
9		22,197	135,621	109,946	78,931	95,343	455,207
10		21,779	54,745	55,629	23,143	55,620	227,037
11		3,063	17,625	19,013	2,077	6,180	47,958
12			461	471	789	5,607	7,328
13			459	2,934		660	4,053
Totals	328,518	974,191	1,646,544	1,675,317	802,671	2,711,625	8,168,154

Table 6-6. Land area in various intactness classes and number of conservation elements affected by maximum potential renewable energy development. Maximum potential renewable energy development subsumes near-term priority projects, mid-term projects described in Table 6-5, plus NREL wind and solar potential areas over an indeterminate, longer-term time frame.

6.2.2.2 Current and Future Risk from the Spread of Invasive Species

Urban area and invasive projections (see logic model Section 5.3) were updated for the near-term future (2025) terrestrial landscape intactness model. The change in urban area and in areas affected by renewable energy development relative to concentrations of conservation elements was covered in the previous future development section (6.1.2.1). The only other future projection data available was that for the spread of invasive species, based on the potential expansion of Sahara mustard as predicted by a MaxEnt model using future climate inputs. The near-term future distribution of Sahara mustard was estimated by projecting the existing model against near-term climate (RegCM3 based on ECHAM5 boundary conditions for 2015–2030). The small amount of increase in invasives shown in the near-term future (Map 6-12A) may indicate that the original MaxEnt model depicting current condition was generous in predicting potential area based on physical and climatic factors, leaving only a small area of increase based on future climate changes. The near-term (2025) change attributed to the spread of invasives shows the highest impacts in the Interstate corridors and areas surrounding Phoenix and Tucson (Figure 6-12). Concentrations of resource values located in the west-central portion of the ecoregion (that were not as affected by development pressures as were others in highlighted areas closer to urban centers, Figure 6-11B) are most highly exposed to the spread of invasive species.

6.2.2.3 Future Risk from Climate Change

The MAPSS climate results were used to predict changes in temperature, precipitation, potential evapotranspiration, and runoff; a number of the key findings from these analyses were selected to assemble into an overall relative climate change map that can be used to assess the relative exposure of the specific conservation elements to climate change effects (Chapter 5, Section 5.4). The fuzzy model inputs included potential for summer temperature change and potential for winter temperature change averaged into a single factor, potential for runoff change from MAPSS modeling, potential for precipitation change, and potential for vegetation change again from MAPSS modeling. Direction of the change is not important—only degree of departure from historic measures. Areas most likely to show the most serious changes are those that either are predicted to change in their vegetation type or as a combination of all the other factors (temperature, precipitation, and runoff). Results were mapped in five separate classes: Very High, High, Moderate, Moderately Low and Low potential for an area to be affected by climate change (Figure 6-13A). Individual species and vegetation communities' response to climate change were presented in Section 5.4. Of the vegetation communities, the lower elevation shrublands in the western portion of the Sonoran Desert show the highest exposure to climate change. Higher elevation areas show less potential for change as expected and may serve as potential refugia. Another area in the northeastern portion of the region shows Very High to Moderately High potential for change. When the climate change map (with designated areas removed, Figure 6-13B) is compared to the map of concentrations of conservation elements and species of concern (Figure 6-13C), most of the species hotspots (outlined in royal blue) are in the Moderate to Moderately Low potential exposure categories. The areas east of Phoenix, in the northern portion, and the west central portion of the ecoregion are in the higher exposure categories. The concentration of threatened and endangered species in the northwest near Palm Springs may be somewhat buffered by proximity to the coast range and somewhat higher elevation 134 m (440 ft.) relative to the Salton Sea basin that is below sea level (therefore hotter) and in full rain shadow (drier).

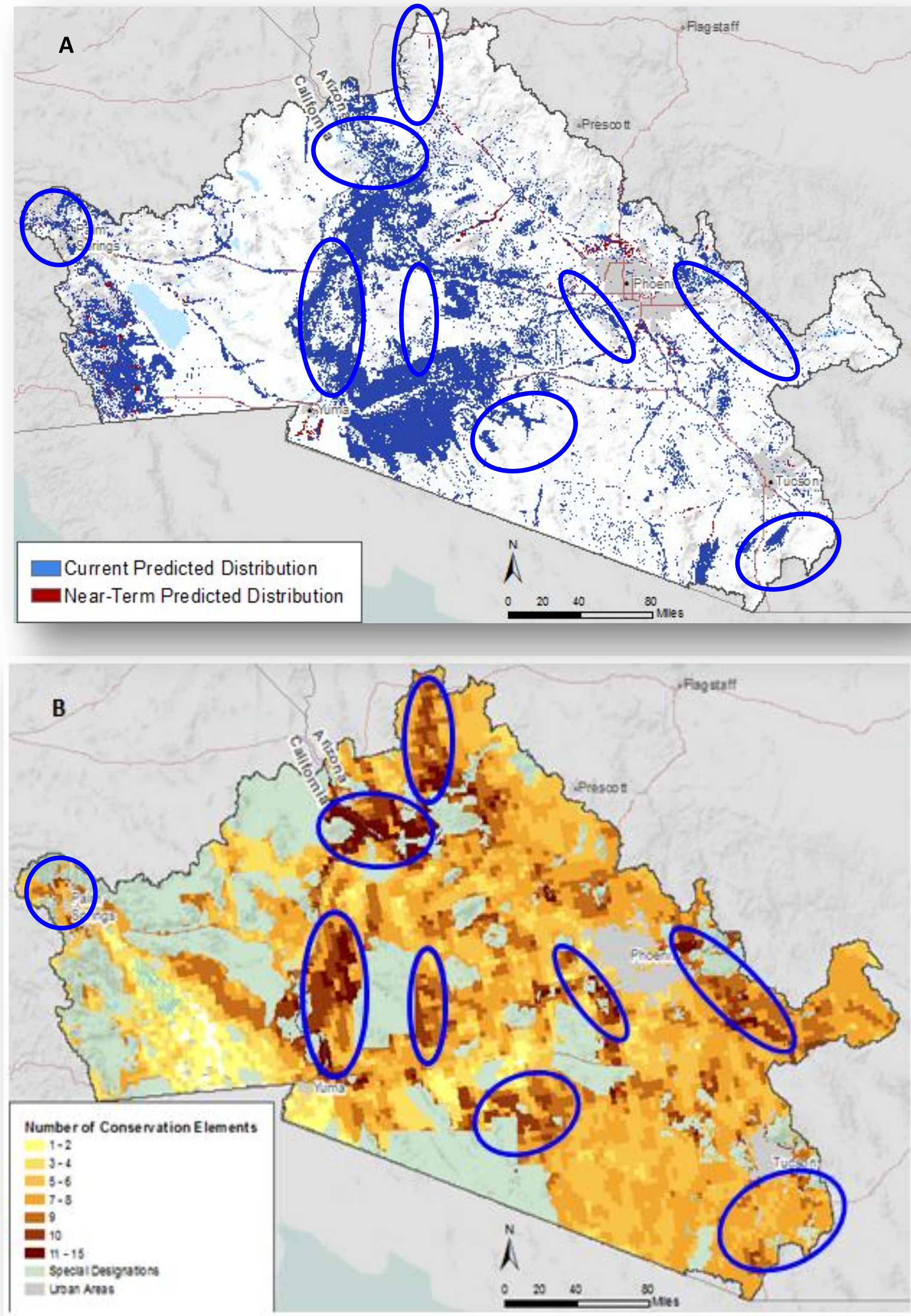


Figure 6-12. Maps show (A) current (in blue) and near-term future (2025, in red) distribution of invasive species compared to (B) concentrations of resource values with designated sites shown in green.

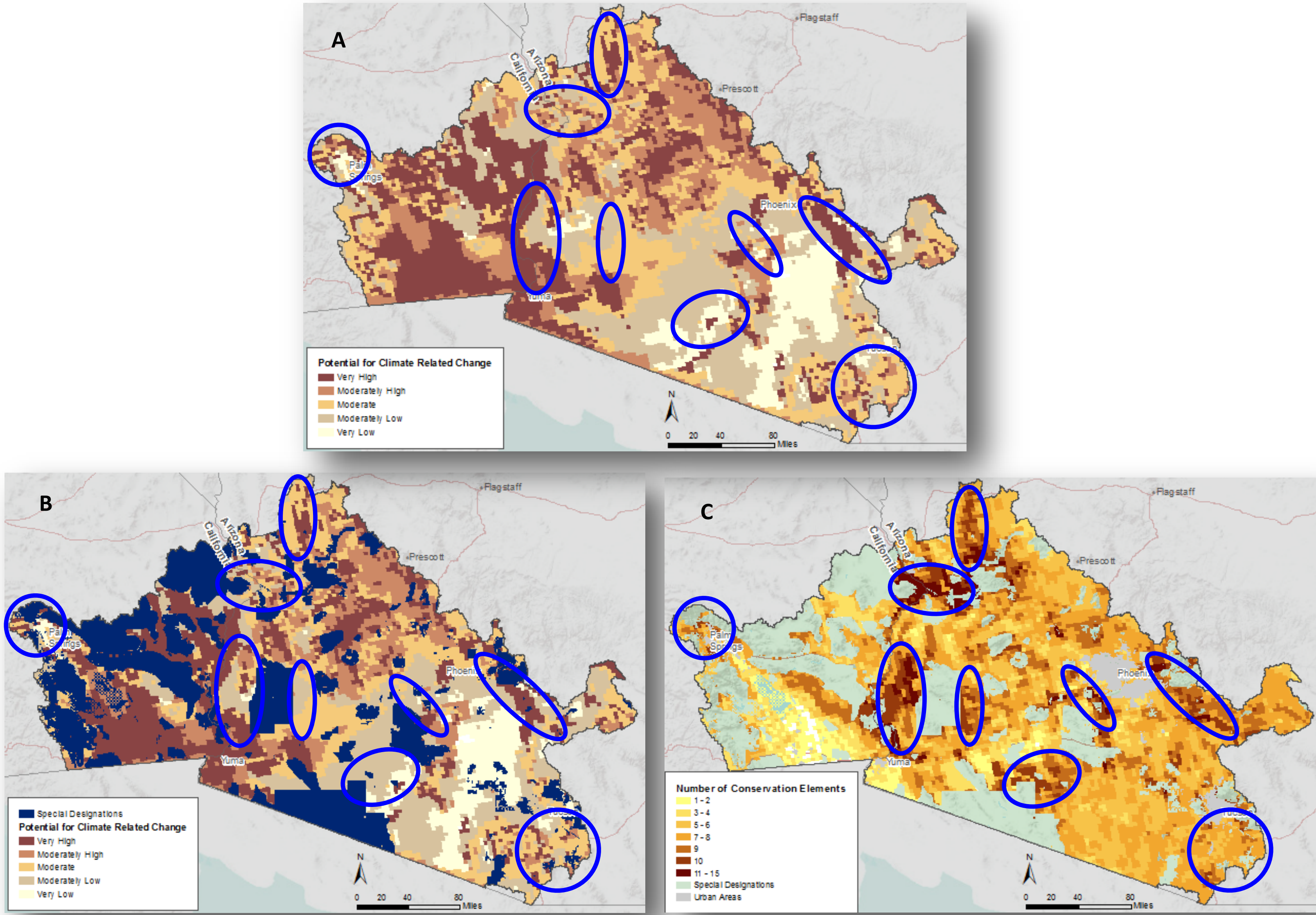


Figure 6-13. Maps of (A) climate change potential (2060), (B) climate change map with designated areas masked in blue, and (C) concentrations of conservation elements. Blue ellipses identify highest concentrations of resource values and allow comparison among the maps.

6.2.3 Connectivity

One of the REA management questions asked, Where are potential areas to restore connectivity? Managers can use the intactness results and the concentrations of resource values presented in this chapter to examine connectivity at various scales across the region.

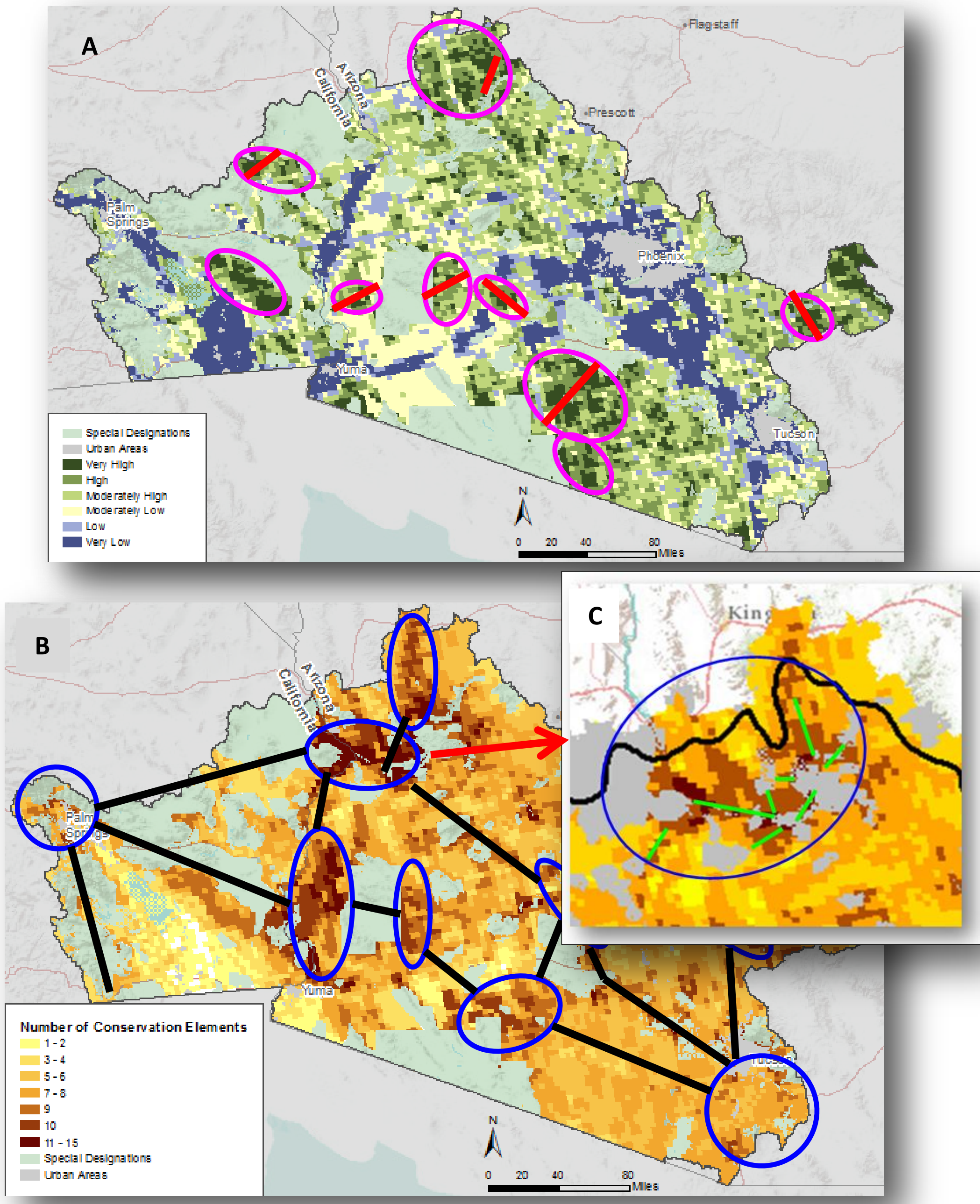


Figure 6-14. Various ways to approach connectivity: at a broad scale (A) between protected areas through corridors of higher landscape intactness, (B) among concentrations of resource values across protected areas as stepping stones, and (C) at a finer scale among protected areas to capture concentrations of resource values.

In Chapter 4, Section 4.2.3.2, a map of a least-cost path analysis was presented for Natural Landscape Blocks for California (Spencer et al. 2010) and general corridor mapping in Arizona (AZDOT 2006) and combined as one scenario of connectivity in the ecoregion. Although a least-cost path analysis should be done at a finer grain than these 4 km grid results, there is value in a regional overview to ponder and assimilate patterns of resource values and the distribution of existing protected areas. Options include searching for corridors and habitat blocks between existing protected areas through patches of higher landscape intactness or among concentrations of resource values across the stepping stones of existing protected areas (Figure 6-14A and B). Once areas of interest are located at a broad scale, evaluations can continue at a finer scale to buffer or connect existing protected areas within an area of interest (Figure 6-14C). In the inset example, connectivity pathways connect a network of wilderness areas, wilderness study areas, and ACECs to the Colorado River to the west and to the adjoining uplands to the east.

6.3 Conclusion

The examples presented in this chapter and Chapter 5 offer a few of the many ways this wealth of REA data and maps may be examined depending on project objectives, area of interest, species of concern, and present or future time frames. All that is required of the user is an understanding of the relatively coarse resolution of the results and an ability to translate the results between scales, from regional to local. Application of the results of the current and near-term future intactness models and conservation element status determinations also depend on an understanding of the limitations of a rapid ecoregional assessment of this kind. The effort is fundamentally limited by available spatial data and ecological thresholds so important to tailoring the logic models. These aspects are only likely to improve in the future as the geospatial technology and science evolve.

This REA will serve as a baseline for future efforts in the Sonoran Desert ecoregion. This REA effort provided the opportunity to inventory available information, to collect and archive an atlas of useful spatial data, and to produce hundreds of mapped products. Users may find information about access to the data at http://www.blm.gov/wo/st/en/prog/more/climatechange.html. The models are well documented and are flexible enough to be modified and improved with the addition of new data. Using the baseline current scenario, the REA components are designed for periodic updating to track the ecological status of Sonoran Desert conservation elements as they respond to landscape change and adaptive management in the coming years.

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Photo: Cholla cactus flowers, Saguaro National Park, National Park Service**.**

Glossary and Acronym List

Adaptive Management: Adaptive management is a systematic process for continually improving management policies and practices by learning from the outcomes of previously employed practices.

ArcGRID: A raster GIS file format developed by Esri**.** The grid defines geographic space as an array of equally-sized square grid points arranged in rows and columns. Each grid point stores a numeric value that represents a geographic attribute for that unit of space. Each grid cell is referenced by its xy coordinate location.

Areas of Critical Environmental Concern (ACEC): Areas within the public lands where special management attention is required to protect and prevent irreparable damage to important historic, cultural, or scenic values, fish and wildlife resources or other natural systems or processes.

Assessment Management Team (AMT): A group of BLM managers that provides overall direction and guidance to the REA and makes decisions regarding ecoregional goals, resources of concern, conservation elements, change agents, management questions, tools, methodologies, models, and output work products.

C_3: Cool-season plants in which carbon dioxide is first fixed into a compound containing three carbon atoms before completing the photosynthesis cycle.

C_4: Warm-season plants in which carbon dioxide is first fixed into a compound containing four carbon atoms before entering the photosynthesis cycle.

C**hange Agent:** An environmental phenomenon or human activity that can alter or influence the future status of resource condition. Some change agents (e.g., roads) are the result of direct human actions or influence. Others (e.g., climate change, wildland fire, and invasive species) may involve natural phenomena or be partially or indirectly related to human activities.

Coarse Filter: A focus of ecoregional analysis that is based upon conserving resource elements that occur at coarse scales, such as ecosystems, rather than upon finer scale elements, such as specific species. The concept behind a coarse filter approach is that preserving coarse-scale conservation elements will also preserve elements occurring at finer spatial scales.

Conceptual models: Conceptual models graphically depict the interactions between a conservation element, the biophysical attributes of its environment, and the change agents that drive ecosystem character. The boxes and arrows that make up the conceptual model represent the state of knowledge about the subject and its relationships to these attributes. Conceptual models are also supported and referenced by scientific literature.

Conservation Element: A renewable resource object of high conservation interest.

Development: A type of change (change agent) resulting from urbanization, industrialization, transportation, mineral extraction, water development, or other human activities that occupy or fragment the landscape or that develop renewable or non-renewable resources.

Ecological Integrity: The ability of an ecological system to support and maintain a community of organisms that have the species composition, diversity, and functional organization comparable to those of natural habitats within the ecoregion.

Ecoregion: An ecological region or ecoregion is defined as an area with relative homogeneity in ecosystems. Ecoregions depict areas within which the mosaic of ecosystem components (biotic and abiotic as well as terrestrial and aquatic) differs from those of adjacent regions.

Ecoregional Direction: Ecoregional direction uses the information from the Rapid Ecoregional Assessments and stakeholders to develop a broad scale management strategy for an ecoregion's BLM-managed lands.

Fine Filter: A focus of ecoregional analysis that is based upon conserving resource elements that occur at a fine scale, such as specific species. A fine-filter approach is often used in conjunction with a coarse-filter approach (i.e., a coarse filter/fine-filter framework) because coarse filters do not capture every management concerns, such as management of endemic species.

Geographic Information System (GIS): A computer system designed to collect, manage, manipulate, analyze, and display spatially referenced data and associated attributes.

Habitat: A place where an animal or plant normally lives for a substantial part of its life, often characterized by dominant plant forms and/or physical characteristics.

Hydrologic Unit: An identified area of surface drainage within the U.S. system for cataloging drainage areas. The drainage areas are delineated to nest in a multilevel, hierarchical arrangement.

Intactness: Intactness may be mapped as a quantifiable estimate of naturalness according to the level of anthropogenic influence based on available spatial data. Intactness considers an assemblage of spatially explicit indicators that helps define the condition of the natural landscape.

Invasive Species: Species that are not part of (if exotic non-natives) or are a minor component of (if native), an original community that have the potential to become a dominant or co-dominant species if their future establishment and growth are not actively controlled by management interventions, or that are classified as exotic or noxious under state or federal law.

Landscape Species: Landscape species use large, ecologically diverse areas. The species often have significant impacts on the structure and function of natural ecosystems.

Logic Model: A logic model is a cognitive map that presents spatial data components and their logical relationships to explain the process used to evaluate a complex topic. Logic models are constructed in a hierarchical fashion relying on symbols, colors, labels, and the physical arrangement of components to communicate how a series of spatial datasets are assembled and analyzed to answer a particular question.

Management Questions: Questions from decision-makers that usually identify problems and request how to fix or solve those problems.

Model: Any representation, whether verbal, diagrammatic, or mathematical, of an object or phenomenon. Natural resource models typically characterize resource systems in terms of their status and change through time.

Native Species: Species that historically occurred or currently occur in a particular ecosystem that were not introduced.

Population: Individuals of the same species that live, interact, and migrate through the same niche and habitat.

Process Models: Process models are diagrams that map out data sources, GIS analyses, and workflow. Process models present the spatial analysis details and allow for repeatability of the same or similar model in the future

Rapid Ecoregional Assessment (REA): The methodology used by the BLM to assemble and synthesize regional-scale resource information, which provides the fundamental knowledge base for devising regional resource goals and priorities on a relatively short time frame (less than 2 years).

Resource Values: As presented in the applications of results in Chapter 6, *resource values* was a phrase used to describe the collection of REA conservation elements plus additional species of concern—NatureServe G1–G3 species and USFWS threatened and endangered species that were used in applications map comparisons.

Status: The condition of a criterion (biological or socio-economic resource values or conditions) within a geographic area (e.g., watershed, grid). A rating (e.g., low, medium, or high) or ranking (numeric) is assigned to specific criteria to describe status.

Step-Down: A step-down is any action related to regionally-defined goals and priorities discussed in the REA that are acted upon through actions by specific State and/or Field Offices. These step-down actions can be additional inventory, a finer-grained analysis, or a specific management activity.

Acronyms

AM	Arbuscular Mycorrhizal
AMT	Assessment Management Team
AUC	Area Under the Curve
ArcGIS	Arc Geographic Information System
BpS	Biophysical Setting
BLM	Bureau of Land Management
CO_2	Carbon Dioxide
CE	Conservation Element
CCVI	Climate Change Vulnerability Index
DEM	Digital Elevation Model
ECHAM5	European Centre Hamburg, Version 5
EMDS	Ecosystem Management Decision Support
EPA	Environmental Protection Agency
ENSO	El Nino Southern Oscillation
EVT	Existing Vegetation Type (LANDFIRE)
FGDC	Federal Geographic Data Committee
FRAGSTATS	Fragmentation Statistics software
FRCC	Fire Regime Condition Classification

G-1, G-3	Globally Imperiled-Globally Vulnerable
GCM	Global Circulation Model
GFDL	Geophysical Fluid Dynamics Laboratory
GENMOM	GENesis-Modular Ocean Model
GIS	Geographical Information System
HMAs	Herd Management Areas
HUC	Hydrologic Unit Classification
IPCC AR4	Intergovernmental Panel on Climate Change Fourth Assessment Report
LAI	Leaf Area Index
LANDFIRE	LANDscape FIRE and Resource Management Planning Tools Project
MAPSS	Mapped Atmosphere Plant Soil System
MaxEnt	Maximum Entropy model
MQ	Management Question
NCAR	National Center for Atmospheric Research
NCEP	National Centers for Environmental Prediction
NetCDF	Network Common Data Form
NHD	National Hydrography Dataset
NREL	National Renewable Energy Laboratory
OHV	Off-Highway Vehicles
PET	Potential Evapotranspiration
PFT	Plant Functional Type
PRISM	Parameter-elevation Regressions on Independent Slopes Model
REA	Rapid Ecoregional Assessment
RegCM3	Regional Climate Model Version 3
RMP	Resource Management Plan
SSURGO	Soil Survey Geographic database
STATSGO	State Soil Geographic
SOW	Statement of Work
SW ReGAP	Southwest Regional Gap Analysis Project
TNC	The Nature Conservancy
URTD	Upper Respiratory Tract Disease
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey