CENTRAL BASIN AND RANGE
RAPID ECOREGIONAL ASSESSMENT

FINAL REPORT

REA Final Report for
U.S. Department of the Interior
Bureau of Land Management
Rapid Ecoregional Assessments
June 2013

It is the mission of the Bureau of Land Management to sustain
the health, diversity, and productivity of the public lands for the
use and enjoyment of present and future generations.

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COVER PHOTO

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TITLE PHOTO

Autumn landscape, Lamoille Canyon, Humboldt-Toiyabe National Forest, Nevada. USDA Photo by Susan Elliot. Used under Creative Commons license CC BY 2.0. *http://flic.kr/p/ax64DY*

CENTRAL BASIN AND RANGE RAPID ECOREGIONAL ASSESSMENT

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Rapid Ecoregional Assessments: Purpose and Scope

Working with agency partners, BLM is conducting rapid ecoregional assessments (REAs) covering approximately 450 million acres of public and non-public lands in ten ecoregions and combinations of ecoregions in the American West. The goal of the REAs is to identify ecological resource status, potential to change from a landscape viewpoint, and potential priority areas for conservation, restoration, and development. REAs are intended to serve BLM's developing Ecoregional direction that links REAs and the BLM's Resource Management Plans and other on-the-ground decision making processes. Ecoregional direction establishes a regional roadmap for reviewing and updating Resource Management Plans, developing multi-year work for identified priority conservation, restoration and development areas, establishing Best Management Practices for authorized use, designing regional adaptation and mitigation strategies, and developing conservation land acquisitions. While REAs produce information designed to be integrated into specific management processes they are not decision documents and stop short of integrating the findings into management actions. The Bureau of Land Management (BLM) chose to retain responsibility for all aspects of integrating the assessment into management actions and decisions. The BLM asked United States Geological Survey (USGS) to provide a peer review for technical and scientific accuracy. Key components of the Central Basin and Range (CBR) REA include:

Defining the Assessment Region

BLM provided specific criteria for delineating the geographic extent of REAs: the level III ecoregion delineation of the Commission for Environmental Cooperation and all 5th level Hydrologic Units (HUCs) that intersect the ecoregion boundary. The resulting CBR ecoregion is shown in Figure 1-1. Including the buffer, it is approximately 138,945 miles^2 or 359,869 km^2 in size; BLM manages 58% of the ecoregion.

Management Questions

The basis of the assessment work in an REA is to answer management questions. A total of 62 management questions were assessed. Most management questions fall into these general categories:

- Where is it? (e.g., conservation elements, change agents, high biodiversity areas)
- Where does it coincide with other features? (e.g., conservation elements overlain with change agents).
- Where and how might the conservation elements be affected by change agents, either now or in the foreseeable future? (e.g., forecast change in ecological status based on change agents).

There are several more specific and complex management questions dealing with issues such as connectivity, renewable energy, and potential for ecological restoration. Some results of the assessments are highlighted in this summary; example management questions are treated in the report but due to space limitations, complete treatment is provided in the appendices.

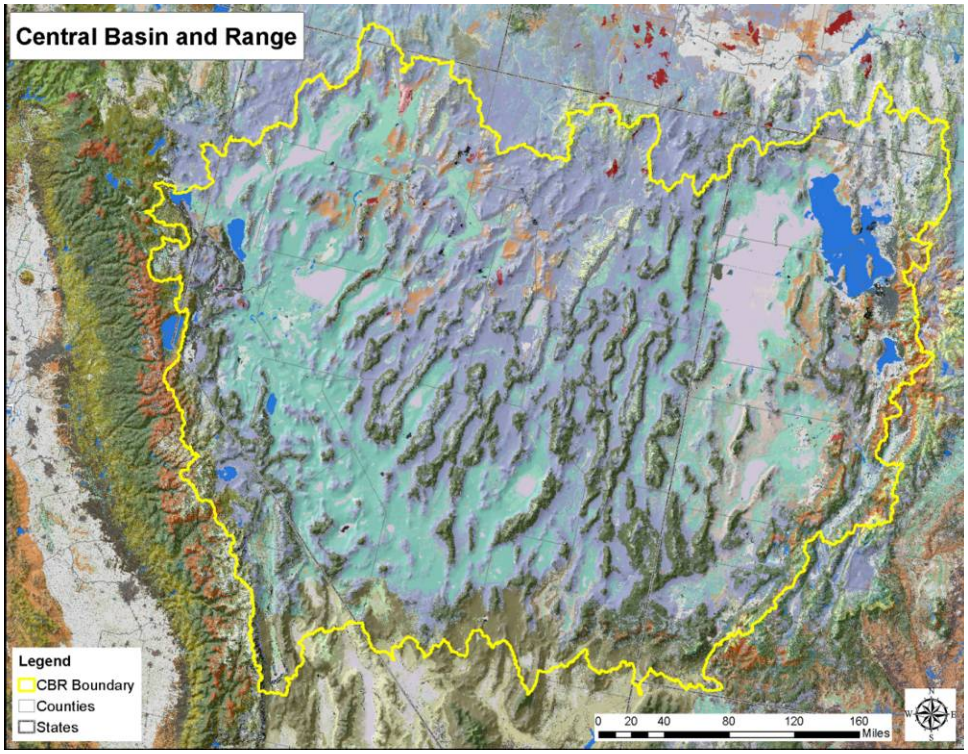

Figure 1-1. Project Boundary (in yellow) for the Central Basin and Range Ecoregion; the colors represent the mapped distributions of many ecological systems found in the western U.S.

Conservation Elements

For REAs, a key component is "conservation elements" representing ecosystems, species, and sensitive soils of management interest. See Table 1 for a breakdown of conservation elements.

Table 1. Number of conservation elements by category.

Conservation Element Category	Number of Elements
Basin Dryland Ecosystems	10
Basin Wet Ecosystems	6
Montane Dryland Ecosystems	7
Montane Wet Ecosystems	3
Terrestrial Habitat-Based Species Assemblages	9
Landscape Species	28
Local Species	318
Soils of Conservation Concern (7 types: wind erodable, water erodable, droughty soils, three-classes of hydric soils, gypsum soils, excess sodium, calcium carbonates)	

Additionally, another feature category used in the assessments is **Places**. Management questions called for identifying where certain places exist, and status and trends within those places. The three Places categories assessed were:

Places Class I: Areas of High Biodiversity not yet formally designated but identified as conservation priorities by a variety of agencies and other organizations (e.g. TNC Portfolio Sites). BLM manages a total of 12.7 million acres of lands identified as high priority for conservation, or 14.38% of the ecoregion. Adjusting for overlapping categories, some 3.6 million additional acres have been identified by non-governmental organizations for more specific land conservation measures on BLM land than are currently designated.

Places Class II: Designated Areas of Ecological and Cultural Value delineating legally protected lands/waters (e.g. ACEC), plus a few exceptions that represented known species recovery lands (e.g. critical habitat recommended for recovery of Desert Tortoise). BLM and the U.S. Forest Service manage the vast majority of designated lands in the ecoregion, with a combined total of nearly 16.5 million acres. The BLM share of these lands account for 9.2 million acres, or 10.4% of the ecoregion. The National Park Service is third, managing just over one million acres in this category.

Places Class III: all other public lands not part of the above two categories.

Change agents

Change agents are those features or phenomena that have the potential to affect the size, condition and landscape context of conservation elements. Four classes of change agents were included in the assessment: wildfire, development, invasive species, and climate change. Change agents act differentially on individual conservation elements and for some conservation elements may have neutral or positive effects but in general are expected to cause negative impacts. Change agents can impact conservation elements at the point of occurrence as well as offsite. Individual change agents can also be expected to act synergistically with other change agents to have increased or secondary effects.

REA Products and Results

The following sections summarize key results of the REA. The body of the report provides a summary section on methods used to generate the results. Extensive appendices provide complete details on methods and data used and data products delivered to BLM contain further details in their metadata. After this section is a summary of *Key Limitations and Data Gaps* that users of the REA products should be aware of to properly apply these products; specific limitations are provided in the report chapters.

Conservation Elements Distribution and Status

Conservation element distribution data came from a broad variety of sources but especially from Southwest ReGAP and State Wildlife Agencies (including natural heritage programs). In addition, modeling was conducted specifically for this REA to generate several CE distributions for which existing data inadequately represented current distributions. A scorecard approach was used for reporting on the current ecological status of a given conservation element throughout its distribution in the ecoregion. Using this approach, indicators were chosen to provide a measurement for a limited set of **key ecological attributes**, or ecological drivers, for each conservation element. Given the rapid and regional nature of an REA, indicators were used that could readily be drawn from existing data. A landscape condition model was used for all species to incorporate effects of human development. For some species invasive annual grasses vulnerability was also used (Figure 1-2). The landscape condition model used development change agents and ranked their proportional impact on the condition of the landscape at their point of occurrence and a distance away from it (Figure 1-3).

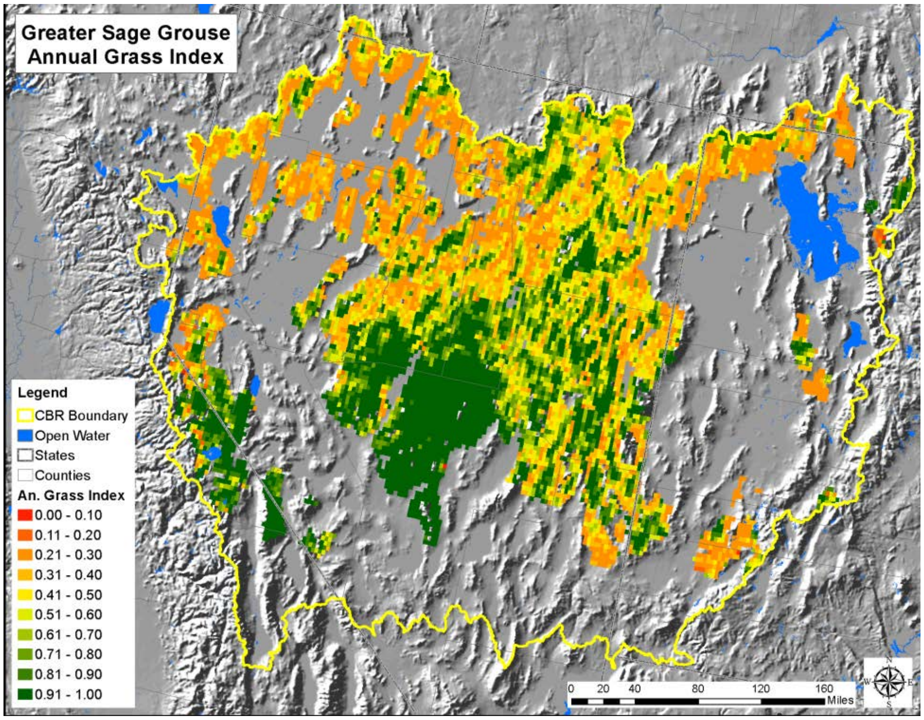

Figure 1-2. Ecological status assessment results for the invasive annual grass indicator throughout the occupied Greater sage-grouse occupied habitat. Warm colors indicate high potential for invasives, cooler colors have less potential.

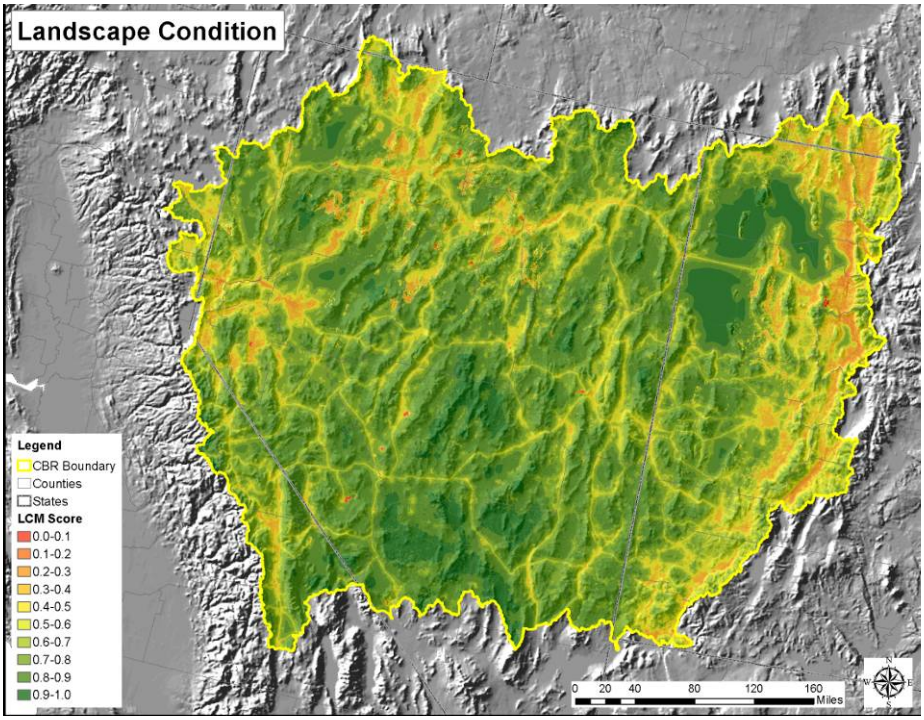

Figure 1-3. Current landscape condition indicator based on development change agents. The landscape condition model incorporates general landscape impacts at the point of the development change agent and a distance from it. Dark green indicates the most intact locations, while red and dark orange the most impacted.

Among the 28 landscape species in this ecoregion, landscape condition tends to be moderate to high across most of their distribution but with concentrated areas of low scores. This reflects the relatively dispersed, but also pervasive, effects of roads and other localized development change agents occurring across these generally widespread conservation element distributions (averaging 37,000 km^2). However, where landscape species tend to occur at lower elevations in all or part of the habitat range, lower scores becomes evident where roads and others forms of development tend to be concentrated.

Change Agents Current and Future

Maps representing current change agent distributions were derived from a large number of sources and in some cases augmented with spatial modeling to derive expected distributions. Future distribution of change agents included maps of planned/potential distribution (e.g., renewable energy) or models (e.g., climate change). Climate change results are presented in a separate section below. Currently and by 2025, wildfire and invasive annual grasses are by far the greatest management concerns. The natural fire regime in these landscapes has been affected throughout the 20th century by a combination of other change agents such as livestock grazing, fire suppression, and the introduction of fire prone invasive annual grasses. Models initially characterized natural range of variation in several variables and then integrated altered conditions (e.g., dominance of invasive annual grasses) for forecasting trends in fire regime. Fire regime departure can then be measured as degrees of departure from the ecosystem's natural range of variation. Fire regime departure for upland ecosystems in the inter-mountain basins (such as salt desert scrub and big sagebrush shrubland) is overall more severe (Figure 1-4), and reflects a similar spatial pattern to that provided by the invasive annual grass indicator when used as an ecoregional-scale indicator of ecological integrity (Figure 1-5).

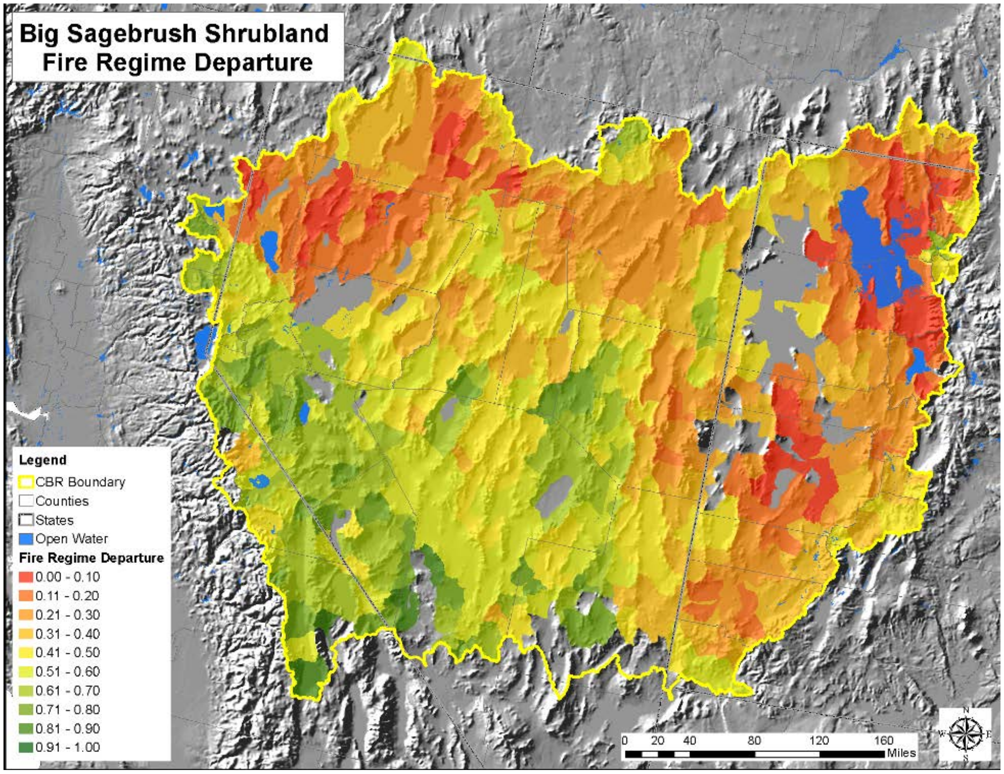

Figure 1-4. Fire regime departure index scores by 5th level watershed for Big Sagebrush Shrubland (gray watersheds lack presence of Big Sagebrush Shrubland). The values in the legend indicate how similar fire regime is to natural range of variation, low scores (warm colors) indicate higher departure.

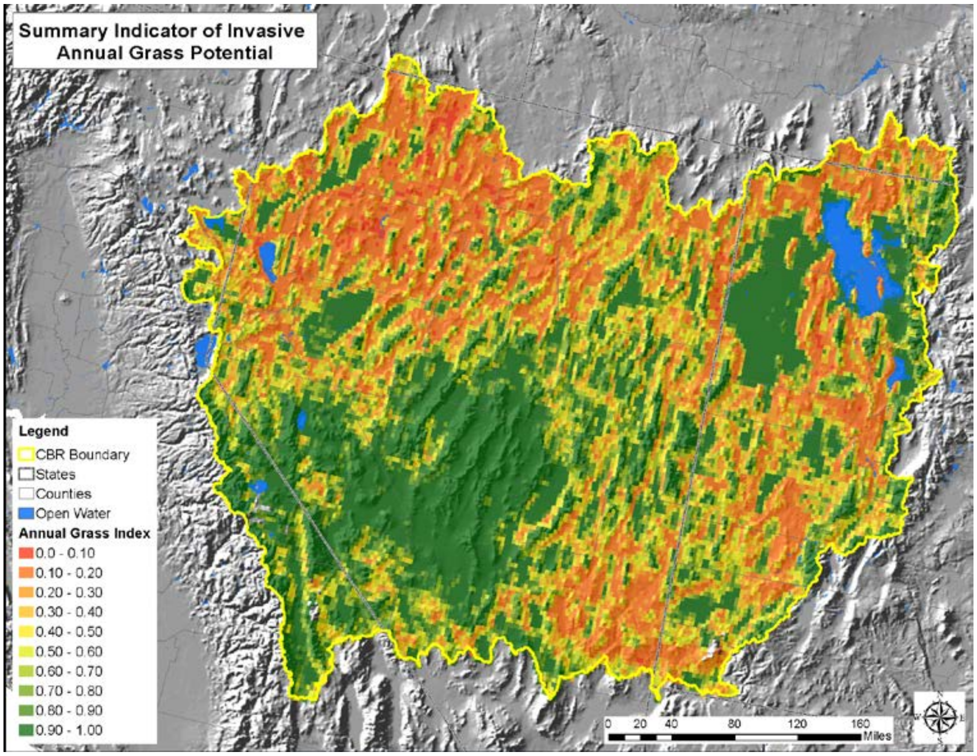

Figure 1-5. Summary Indicator of Potential Abundance of Invasive Annual Grass for the Central Basin & Range, scaled from 0.0 (= low integrity, red) to 1.0 (= high integrity, green).

All development types currently only occupy approximately 7% of the ecoregion and are only expected to increase another ½ percent by 2025. That said, renewable energy development is a key concern for managers. While the current and expected 2025 renewables footprint amounts to only 0.2% of the ecoregion, the potential (as mapped by NREL) covers the majority of the area (Figure 1-6).

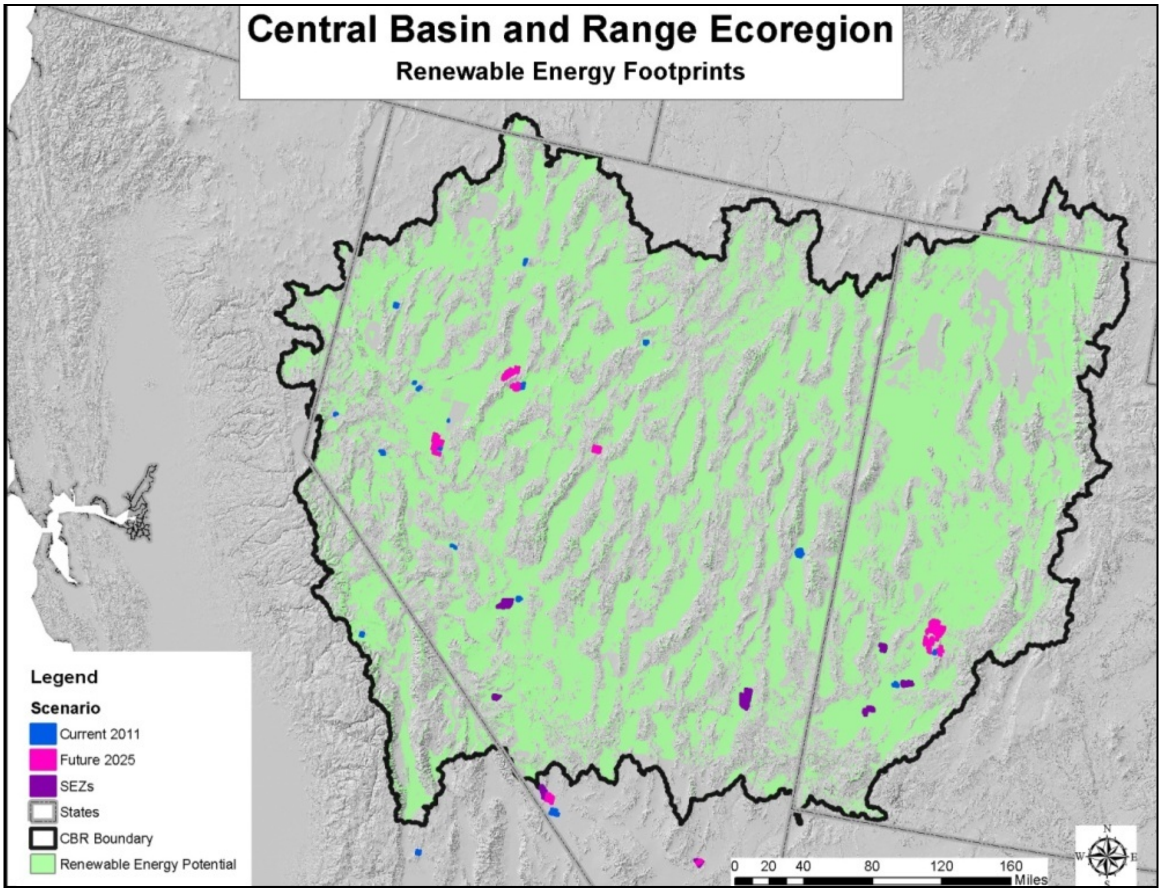

Figure 1-6. Renewable energy in the current (blue) and 2025 (pink and purple) scenarios and total potential (green)

Integrated Assessments Current and Future

A large number of management questions simply asked "where is this feature?" Integrated assessments required the assessment of the combination of inputs such as where change agents overlap with conservation elements. Still other assessments required complex modeling of multiple input interactions such as identifying potential habitat restoration or mitigation areas for Greater sage-grouse given potential renewable energy development (Figure 1-7).

Aquatic conservation elements are critical in arid landscapes, providing water to most wildlife and habitat for a large number of rare species. This REA assessed a large number of management questions related to aquatic ecosystems and current and potential effects of change agents. Aquatic conservation elements included upper and lower elevation perennial streams and any associated riparian areas, springs and seeps, lakes and reservoirs, greasewood flats, washes and playas. While these assessments were most impacted by lack of regional and fine scale data, sufficient information existed to complete the basic assessments.

Five Key Ecological Attributes and their nested 14 indicators of ecological status were applied variously to each aquatic conservation element. Effects of development and high density urban areas along the eastern and western margins of the ecoregion and along the highway corridors are integrated in the Landscape Condition Index (Figure 1-3). Stressors on intact hydrologic flow were assessed by surface and ground water use. Stressors on water quality were assessed by the amount of nitrate and mercury dry atmospheric deposition. Additional stresses on water quality were measured locally through the sediment loading index within a 100m buffer around each aquatic conservation element and the number of state-listed impaired waters for rivers and lakes, summarized by watersheds. Invasive species are of great importance to managers and the report provides information on the known location and abundance of aquatic and terrestrial invasive species. All of the indicators consistently show impacts from the heavily developed urban and agricultural use areas in the northwestern quadrant of the ecoregion; along the Wasatch Front; in the Owen's Valley and environs; along the I-80 corridor; and in certain interior watersheds where large mines and other impacts occur (Figure 1-8).

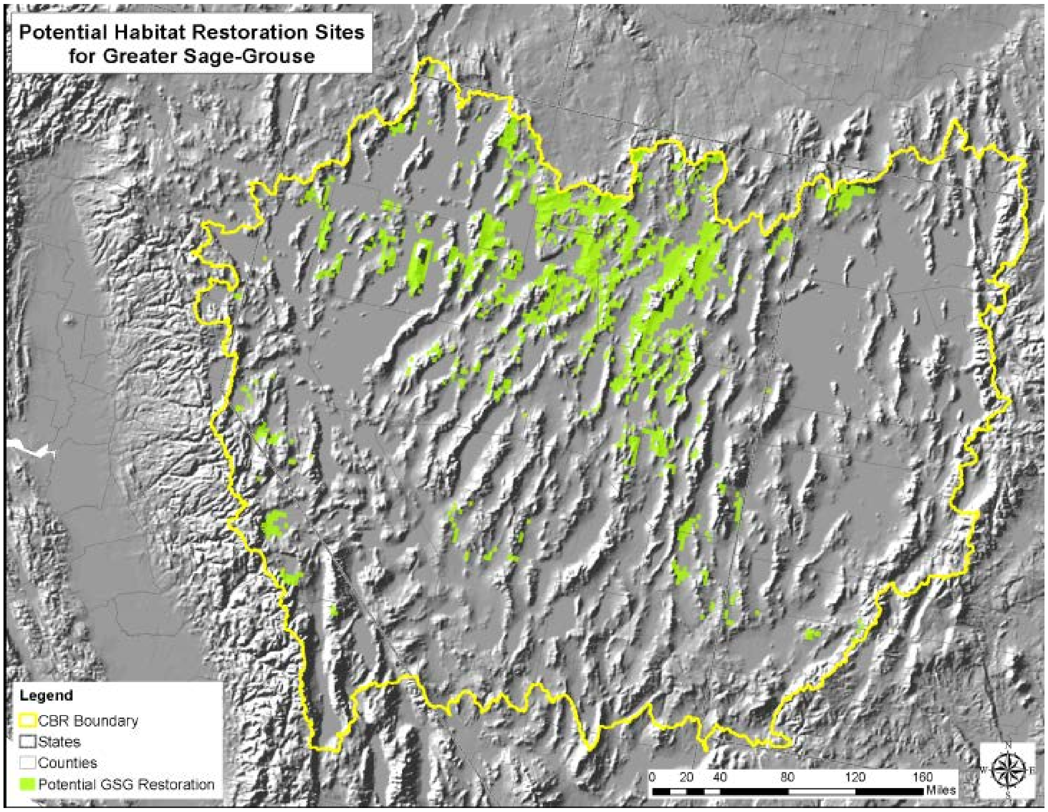

Figure 1-7. Potential mitigation areas for Greater sage-grouse (green)

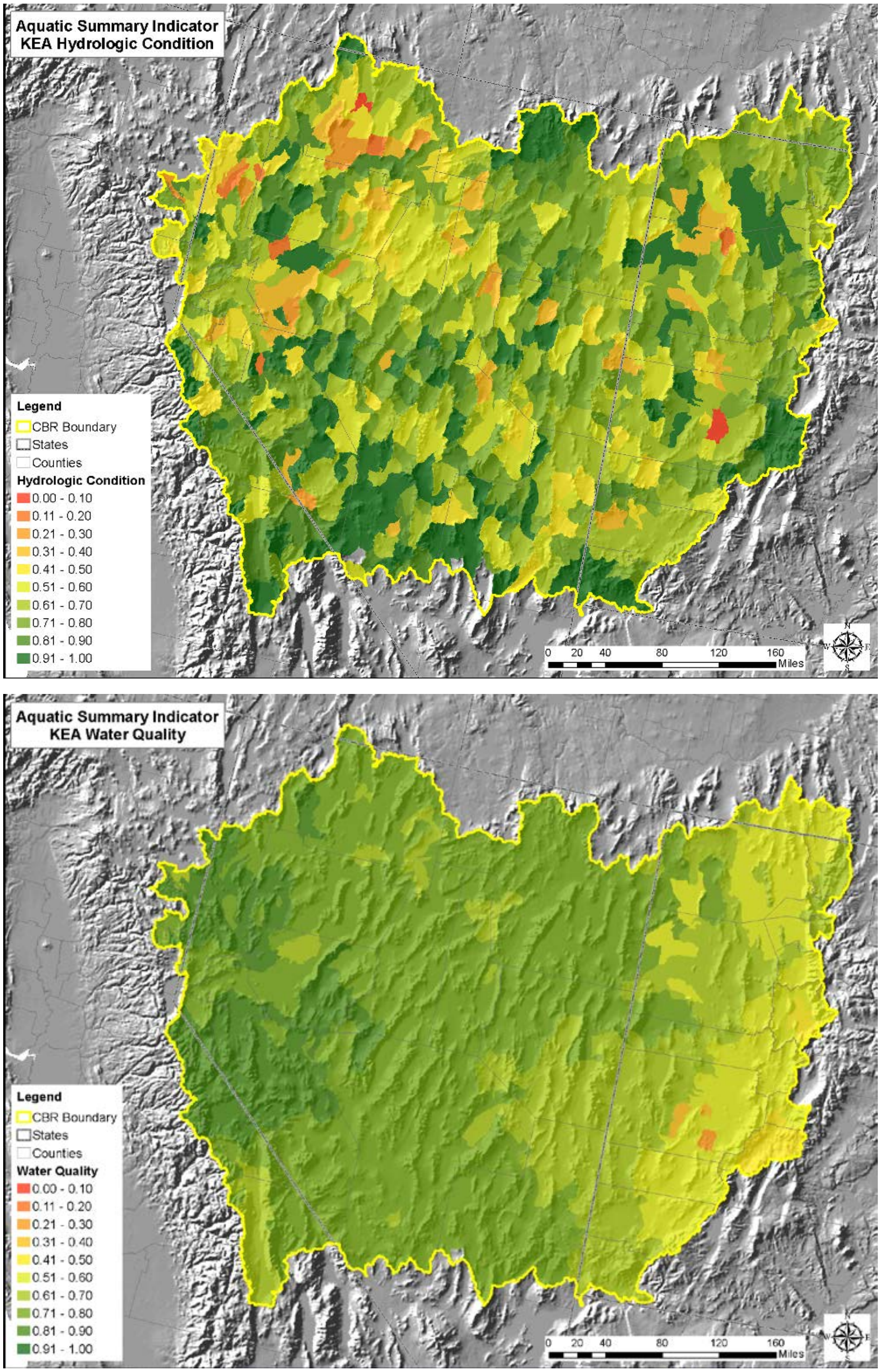

Figure 1-8. Maps depicting the degree of stress on hydrologic integrity: stress on surface water use, groundwater use, flow modification by diversion structures, flow modification by dams, and condition of groundwater recharge zones (top); stress on water quality from mercury and nitrate deposition, and sediment loading (bottom). In the legend, low scores (warm colors) represent more severe change agent effects for the given indicator.

Climate Change Assessment

Two main forms of analysis were conducted: a) evaluation of climate space trends across the ecoregion; and b) analysis of potential change in climate envelopes for selected terrestrial conservation elements. Climate space trends analysis documented and compared forecasted trends in climate variables against measured values from 1900-1980 that serves as a baseline for comparison. Subsequent interpretation of climate space trend results gauged potential climate change impacts on hydrologic and fire regimes in the ecoregion. Climate envelope analysis is further described below.

Over the coming 2-5 decades, forecasts indicate the potential for truly profound transformation in many ecosystems across the CBR. Climate space trends indicate the potential for extreme growing season temperatures throughout the vast majority of the ecoregion (Figure 1-9). These forecasts appear to most intense along the southern CBR, and throughout the other largest basins.

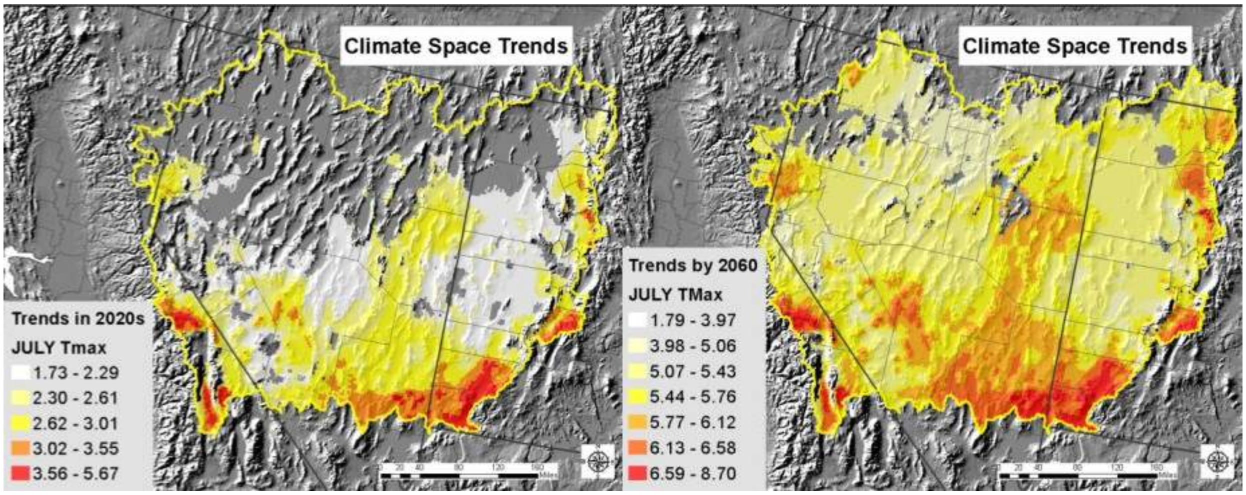

Figure 1-9. Change in maximum temperature (°F) from current climate for July 2020 and 2060

An overlay of grazing allotments on the forecasted climate change for the decade of the 2050s (Figure 1-10) indicates those that are forecasted to experience more intense climate change. Individual grazing allotments occur in areas that span the range from zero to as many as 12 monthly temperature or precipitation variables that are forecasted to deviate by at least 2 standard deviations from their 20th century mean. These variables include maximum temperature, minimum temperature, and total precipitation variables for each of 12 months. The summer maximum temperatures and spring through fall minimum temperatures are the most pervasive and significant variables contributing to these patterns. Many grazing allotments and herd management areas in the southern and eastern portions of the CBR are projected to experience significant climate change, mostly in spring and summer temperatures. These overlays may be used to quantify these trends relative to any desired configuration of existing managed land units; either at regional, state, or local scales. Managers of these areas will need to consider the potential implications of climate stress, as it is forecasted, and its implications.

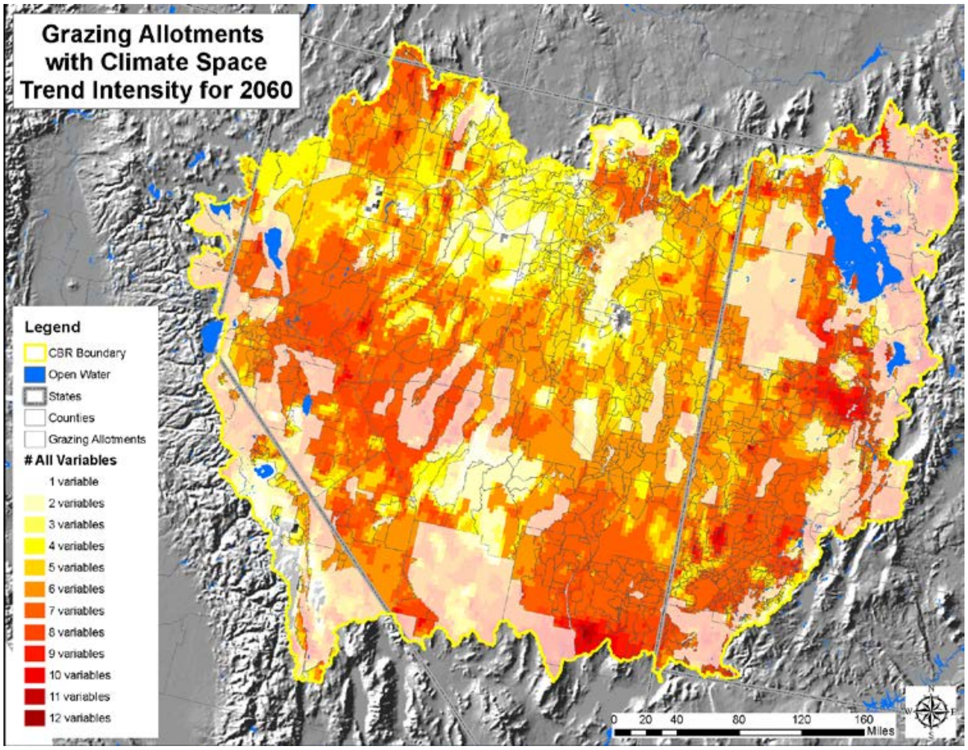

Figure 1-10. Grazing allotments overlain on climate space trend intensity for 2060. Darker red areas indicate a greater degree of forecasted climate change.

Climate envelope analysis first described the set of values for temperature and precipitation that characterize the current distribution of a given conservation element. Then, the same combination of variables is mapped using climate forecasts for upcoming decades. The comparison of forecasted to current climate envelope distributions provides one indication of the direction and magnitude of potential climate-induced stress for a given conservation element.

Resulting maps indicate areas that potentially will not provide suitable climate where the conservation element currently exists (contraction), may retain suitable climate (overlap), or provide suitable climate in areas outside the conservation element’s current distribution (expansion) (Figure 1-11). Dramatic climate envelope shifts are forecasted for Greater sage-grouse, with only a relatively small proportion of the current distribution forecasted to retain the climate regime close to that currently supporting this species. More generally, species that rely on sagebrush habitat have higher loss in climate envelope compared to other species. In particular Pygmy Rabbit, Sage Sparrow, and Columbian Sharp Tailed Grouse, are projected to experience severe climate envelope loss by 2060.

Looking out to 2060, there is potential for considerable changes to the current distributions of many conservation elements lowest-elevation basins throughout the ecoregion could transition from cool semi-desert into very warm and sparsely-vegetated desert landscapes more typical of the Mojave Basin and Range. When the overlap areas of major vegetation types’ climate envelopes are combined (Figure 1-12), one can identify areas ranging in importance for retaining these vegetation types (i.e., “climate refugia”) as well as areas that appear not to offer refugia to any current vegetation types. Given the combination of existing models, one can begin to visualize the potential expansion of sparse desert pavement, the expansion of some desert playas, and the slow expansion/transformation to vegetation characteristic of the Mojave ecoregion. Much of what is currently the vast ‘sagebrush sea’ within this ecoregion could see increasing predominance of salt-desert scrub. The exact mechanisms for transforming vegetation will likely vary by type and location, but the overall nature of that change could perhaps become more clearly predicted using results of this REA. Interestingly, this same process could result in a decrease in expansion of cheatgrass as conditions in many places become too dry. But these invasive species could be replaced by red brome and others now invading the northern Mojave Desert as climatic conditions in the CBR become suitable for that species. Similarly, the expansion of juniper and pine into adjacent big sagebrush shrubland could be limited or reversed in places by expanding drought conditions and increasing fire return intervals.

Overall patterns in current and future conditions suggest that, while substantial concern exists for the ecological integrity of many landscapes across the CBR, many good management alternatives remain. There has clearly been substantial conservation investment, and there is no shortage of opportunity to address the many challenges faced by land managers within this ecoregion.

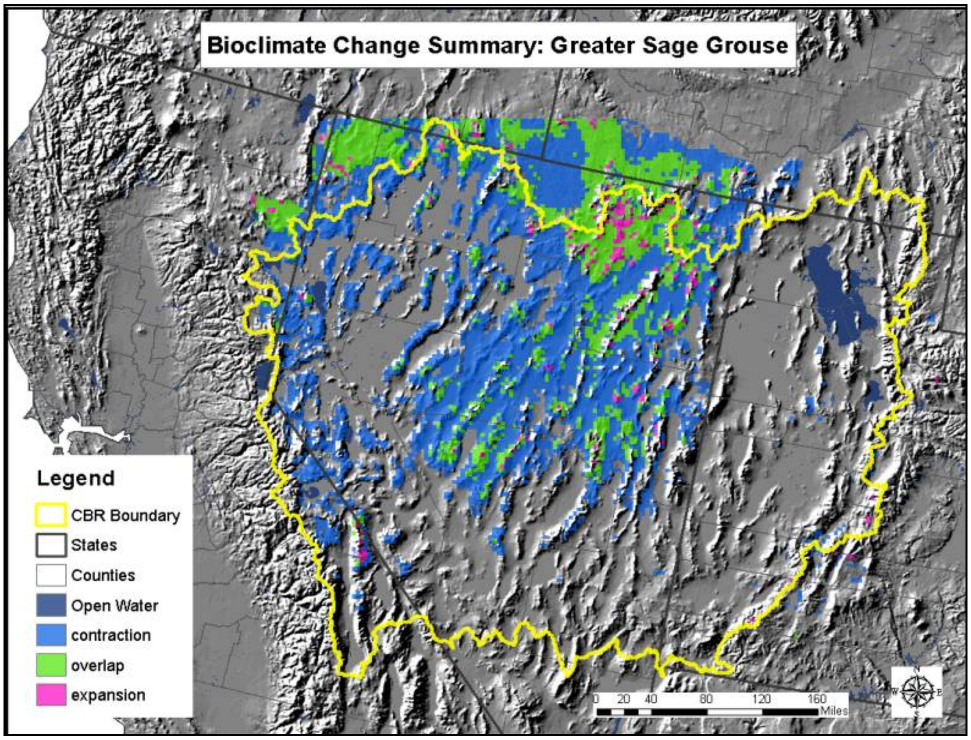

Figure 1-11. Climate envelope forecast for Greater sage-grouse as of 2060. Blue areas indicate contraction of the Greater sage-grouse current climate envelope, suggesting future climate stress for the species.

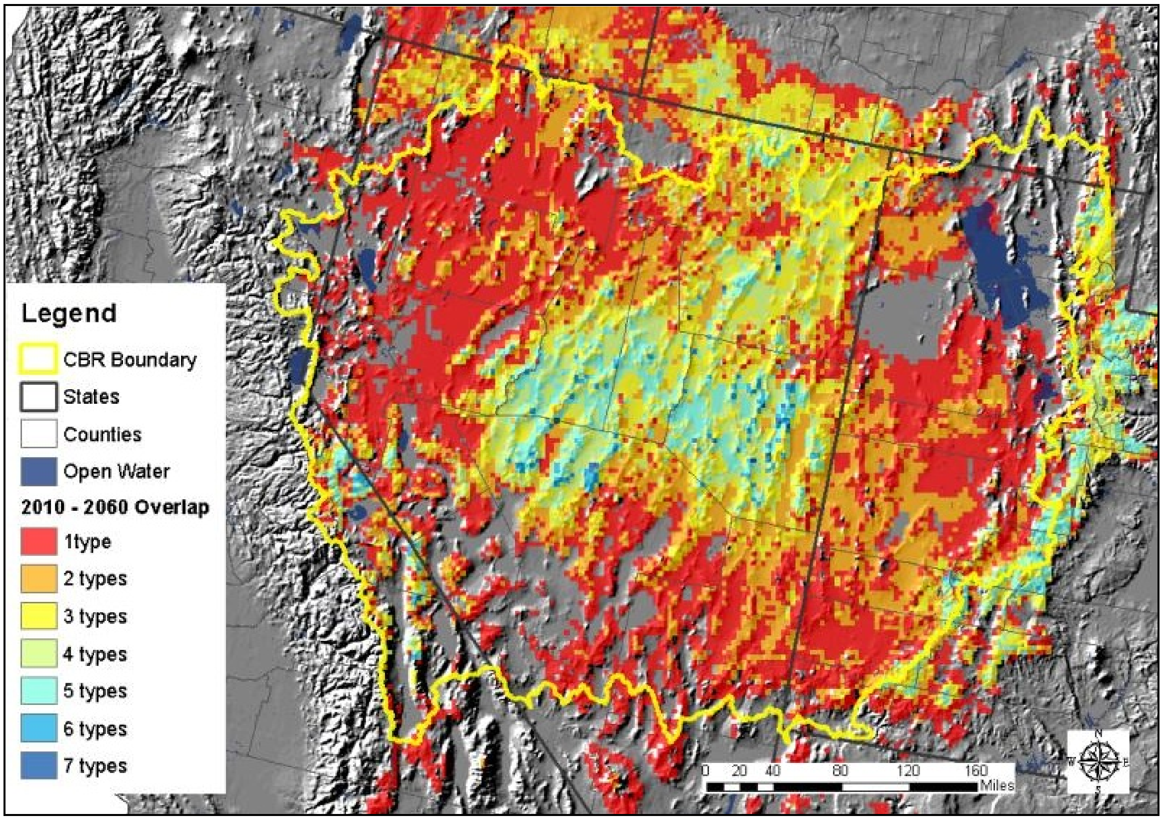

Figure 1-12. Potential climate-change refugia based on 2060 forecasts of climate envelopes for major vegetation types within the ecoregion.

Key Limitations and Data Gaps

A rapid ecoregional assessment must take advantage of hundreds of existing data sets, often applying them for purposes never contemplated by their original developers. This fact, and the strong need for transparency and repeatability, requires considerable documentation of sources of information and assessment methods to facilitate understanding of uncertainty and appropriate application by product users. In order to manage this uncertainty, the REA process included a series of mechanisms for documenting the data sets, information sources, processing steps, and outputs. This information is contained in the methods section of the report, the appendices, and the data product metadata.

As remote sensing, GIS, and modeling capabilities have increased along with computing capacity, scale constraints in regional analyses have generally been reduced such that relatively fine-scale mapping and analyses at sub-mile^2 or kilometer^2 resolutions are feasible. However, climate change data, which are a key component of REAs, are still relatively coarse (e.g., 4 – 15 km^2 pixels). Some other products, such as fire regime departure models, express effects at broader spatial scales of several thousand acres. Therefore, a variety of scales and resolutions are used in an REA to represent the finest practical and defensible scale of analyses and presentation depending on the source information and available modeling methods and tools. Numerous gaps in current knowledge and data were also identified and documented in the chapters.

The fact that an REA is by definition intended to be a rapid assessment utilizing existing data rather than gathering new empirical data creates some important limitations:

- A very large number of analyses were required for this REA, conducted over a short timeframe and therefore modest resources were available for each individual analysis. The REA products are useful for the intended purposes, but they are not comparable to results of focused, multi-year studies on particular management questions.
- REA results are intended to inform landscape-scale direction that can provides context for management decisions through the step-down process.
- Only data considered relatively complete for the ecoregion could be used; therefore, although certain areas of the REA may have had more recent or more precise data, they were not used because it was not consistently available REA-wide.
- Very few source data sets and models had rigorous, quantitative accuracy assessments conducted on them; therefore it is infeasible to provide such information for REA results. Instead a qualitative ranking of confidence was required by BLM to provide information on uncertainty to users, but further consideration of source data quality used in each analysis is encouraged.
- As conditions change and new data is developed, REAs should be updated to incorporate new information.

1 BLM's Approach to Ecoregional Direction and Adaptive Management

Assessments help managers address problems. They provide information that can be integrated into future management action. The success of this assessment ultimately depends on how well it helps inform management decisions. Did it significantly improve understanding about the conditions of the resources being studied within the ecoregion and the consequences of particular actions? (Was it contextual?) Was that understanding integrated into managers' thinking to guide future action? (Was it integrated?) Did the assessment lead to potential solutions for the management questions? (Was it pragmatic?) (Johnson and Herring 1999).

The contract for this assessment clearly called for it to produce information designed to be integrated into specific management processes. However, the contract also clearly stopped short of including efforts to actually integrate the findings into management actions and is a toolbox and not a decision document. The BLM chose to retain responsibility for all aspects of integrating the assessment into management actions and decisions.

This section discusses a proposed process by which the BLM may integrate this assessment into management actions and decisions. This proposal is merely conceptual; no process has yet been established as a commitment or accepted as a responsibility by the BLM. The final success of this assessment depends on the BLM's efforts to integrate it into management. BLM recognizes the need and is in the process of developing a process to successfully integrate this assessment into management actions and decisions.

This proposed process helps address the environmental changes the West is experiencing. To be effective, the process must address landscape/ecoregional challenges at multiple scales and across multiple jurisdictions. All BLM programs can contribute to this effort, as can all geographies. There are examples of where individual components of the BLM are developing very creative answers to these challenges. The BLM is attempting to explore innovative approaches to incorporate a process for landscape direction across programs and geographic scales. The following paragraphs briefly describe a systematic approach to these ecoregional challenges.

Managing resources at multiple-scales: Traditionally, the BLM has undertaken resource management project by project, permit by permit, land use plan by plan without systematically assessing landscape scale effects. To effectively address the environmental changes the West is experiencing, resource managers will have to develop the capacity to evaluate effects at multiple geographic scales.

Managing resources across ownerships and jurisdictions: Traditionally, resource managers have focused on activities within their own administrative units. To effectively address the environmental changes the West is experiencing, resource managers will have to develop the institutional and technical capacity to work across ownerships and jurisdictions.

Managing resources across programs: Traditionally, resource management has been defined by programs (e.g. wildlife, range, minerals). To address the environmental changes the West is experiencing, resource managers will have to more effectively integrate activities across programs by inter-disciplinary management.

Standardizing and integrating data: The ability to collect, synthesize, and share geospatial information about resource conditions, change agents such as wildland fire, and on-the ground management activities is a critical part of this effort. Without the ability to compile and correlate such information within and outside of BLM, it is extremely difficult to achieve conservation, restoration, and adaptation strategies and to evaluate the effectiveness of such strategies once implemented.

Systematic integration requires some fundamental shifts to the BLM's traditional business practices. The differences in this management versus traditional management are summarized below. This assessment has helped the BLM to identify what processes are appropriate for the landscape approach. However, not everything the BLM does will be based on a landscape approach, a lot of project work or traditional practices will still occur.

Traditional Practice	Landscape Approach
Project Focus	Landscape Focus
Program/Functional Direction	Integrated Direction Across Programs
Unit Decision Making	Cross Jurisdictional Decision Making
Unit Priorities	Collaborative and Partnership Priorities
Program Accomplishments	Integrated Accomplishments Across Programs with Partnerships
Tend to authorize uses and mitigate ecological values	Ecological values and use authorizations considered equally
Ecological Component (Individual Species)	Ecological Function and Service
Agency Funding	Partnership Leveraged Funding

Many of the landscape approach activities listed above have been part of BLM's business practice at the land use planning scale. BLM is undertaking the following activities at the landscape scale to deal with environmental changes. These activities include:

- *Rapid ecoregional assessments*
  Working with agency partners, BLM is conducting rapid ecological assessments, including this one, covering approximately 450 million acres of public and non-public lands in ten ecoregions and combinations of ecoregions in the American West to identify potential priority areas for conservation and development. Over time, the BLM anticipates collaboration with the Landscape Conservation Cooperatives in periodically updating ecoregional assessments, and identifying science needs.

- *Ecoregional direction*
  BLM is developing a standard ecoregional process, discussed in more detail below, for conserving or developing priority areas and for incorporating REA results into land use planning, environmental impact assessments, use authorizations, conservation and restoration project planning, and acquisition of conservation easements.

Ecoregional direction links REAs and the BLM's Resource Management Planning and other on-the-ground decision making processes. Ecoregional direction helps integrate existing initiatives and program activities, and facilitates coordination across programs, offices, and with partners. Ecoregional direction establishes a regional roadmap for reviewing and updating Resource Management Plans, developing multi-year work plans for identified priority conservation and development areas, establishing Best Management Practices for authorized uses, designing regional adaptation and mitigation strategies, and developing conservation land acquisitions.

Ecoregional direction development begins with conversations among regional partners about stepping the REAs down into management. Partners that guide the step-down process will likely include BLM State Directors (or their representatives) and equivalent peers from other federal, state and Tribal agencies/entities. The partners will review the completed REA and other assessments to evaluate proposed findings and recommendations. The partners will likely:

- Delineate a schedule, process, and expected products;
- Identify proposed and ongoing activities within the region that REA informs. Such activities may include, but are not limited to, proposed or on-going assessments, planning efforts, NEPA analyses, or special area evaluations;
- Communicate with organizations potentially affected by or knowledgeable about the REA;
- Review the REA and other assessments and develop findings and recommendations; and
- Conduct partnership and stakeholder outreach.

The partners will review the REA and report proposed findings and recommendations. Individual partners develop their own respective direction to implement the agreements. In the case of the BLM, this will be in the form of ecoregional direction. In developing ecoregional direction, the proposed findings and recommendations should be discussed with:

- The affected BLM's State Management Teams;
- The leadership of local, state, federal and Tribal partners; and
- The Washington Office if there are potential national policy and coordination issues.

After reviewing the proposed findings and recommendations and discussing them with the leadership of potentially affected partners, the BLM State Director(s) may issue ecoregional direction outlining what the BLM will do over the next 3-5 years to incorporate the Rapid Ecoregional Assessment into management activities. If desired, the partners may coordinate the implementation of ecoregional direction among the participating entities.

Monitoring and adaptive management

Working with partners, the BLM has a national Assessment, Inventory, and Monitoring (AIM) strategy that is identifying core indicators of terrestrial and aquatic condition, performance indicators for fish and wildlife action plans, and scalable sampling designs to help integrate and focus BLM's monitoring activities and facilitate adaptive management.

2 Introduction

2.1 Common Terminology

Following are key terms and abbreviations used throughout this document; a complete listing of terms and abbreviations is found in the glossary and acronym list in Appendix E.

- AMT: Assessment Management Team. This is the team of BLM staff and select partners in the region that developed the initial statement of work (SOW) and provided review and guidance for the contractor throughout the REA.
- CA: Change Agent. These are the features or processes that can negatively impact Conservation Elements (and in some cases can have neutral or beneficial effects on certain CEs). Development, invasive species, wildfire, and climate change effects are the four primary change agents addressed in this REA.

- CBR: Central Basin and Range
- CE: Conservation Element. These are the natural resource features assessed in the REA and include ecological systems, species, hydrologic features, and sensitive soils.
- KEA: Key Ecological Indicator. These are indicators used to assess the ecological status of CEs.
- MQ: Management Question. These are questions important for guiding natural resource management and land use decisions developed by the AMT. The REA provides information and analysis results to address the management questions.
- Places: These are analysis units such as managed and protected areas (e.g., ACECs), herd management areas, grazing allotments, etc.
- REA: Rapid Ecoregional Assessment
- REAWP: REA Work Plan
- SOW: statement of work described in the original request for proposals.
- Forecast/Projection: the terms “forecast(s)” and “forecasted” are used in this report to refer to future predicted distributions or future conditions, such as climate change, future development, or future ecological status of CEs. In some places “projections” is a term used interchangeably with forecasts.

2.2 REA Elements

REAs are grounded in ***management questions (MQs)*** that express the key information needs of managers as expressed by the Assessment Management Team (AMT). REAs describe and map ***conservation elements (CEs)***, which are features of high ecological value or sensitivity. REAs look across all lands in an ecoregion to identify regionally important habitats for wildlife, species of concern, and other features of management interest such as sensitive soils. In some cases, fish, invertebrates, and many other wildlife species are assessed as components of aquatic or terrestrial ecosystems. REAs then gauge the potential of these CEs to be affected by four overarching environmental ***change agents (CAs):*** climate change, wildfires, invasive species, and development (land use, energy development, infrastructure, transportation, hydrologic alterations, etc.). REAs also map and describe ***places,*** including watersheds, lands under different ownership jurisdiction or management, and areas that have been previously identified for conserving important ecological or cultural resources.

In summary, REAs do the following:

- identify and answer important management questions;
- document key resource values, which are referred to as conservation elements, with a focus on regionally significant terrestrial habitats, aquatic habitats, and species of concern;
- describe influences of four environmental change agents: climate change, wildfire, invasive species, and development;
- describe places where management decisions occur or where resource values have been identified;
- assess the effects of current and forecasted trends;
- identify and map key opportunities for resource conservation, restoration, and development;
- identify science gaps and data needs; and
- provide a baseline to evaluate and guide future management actions.

REAs do not prioritize or allocate resource uses or make management decisions. They provide science-based information and tools for land managers and stakeholders to consider in subsequent resource planning and decision-making processes.

2.3 How REAs Are Prepared

2.3.1 Teams and Partnering

2.3.1.1 Assessment Management Team

An Assessment Management Team (AMT) composed of BLM managers, partner agencies, and technical specialists from within the ecoregion was assembled by BLM to oversee the REA. At the beginning of the REA process, other federal and state agencies were invited as partners to the Assessment Management Team, including representatives of the Western Governors Association and Landscape Conservation Cooperatives. USGS was retained as a peer reviewer of REA products. The AMT guided the assessment and oversaw the work of the contractors who performed the technical data management and analysis tasks required by the REA. Staff of the BLM's National Operations Center (NOC) were engaged as members of the AMT, coordinated communications, and provided technical standards and oversight to the contractors.

2.3.1.2 Technical (Contractor) Team and Collaboration

This REA was conducted as a collaboration between the AMT (see Acknowledgements for listing) and NatureServe. The NatureServe team included the following partner organizations and individuals:

- NatureServe
- Sound Science LLC
- California Academy of Sciences
- Dr. Healy Hamilton
- Nevada Natural Heritage Program

Team members were generally organized thematically around CEs (terrestrial and aquatic subteams) and CAs (development, fire, invasives, climate subteams), although many staff played overlapping roles. The AMT and affiliated participants (see Acknowledgements) were loosely organized into similar thematic subteams to advise the NatureServe team in particular areas such as fire, invasives, hydrology, etc. They interacted primarily via face-to-face workshops and topical webinars. These subteams also provided review of draft products.

2.3.2 Defining the Ecoregion

BLM selected the Level III ecoregion delineation of the Commission for Environmental Cooperation (CEC; http://www.cec.org/Page.asp?PageID=122&ContentID=1329&SiteNodeID=498, last accessed June 30, 2012) as the basis for the REA boundaries, although in some cases Level III ecoregions have been combined or truncated for practical application. To support edge-matching across REAs and to capture CA effects at REA boundaries, contractors were required to expand the REA boundary by including all 5th level Hydrologic Units (HUCs, watersheds) that intersect the ecoregion boundary. The CBR ecoregion (Figure 2-1) includes the area within the boundary of ecoregion number 13 as originally defined by Omernik (1987) and USEPA (2007), plus the area within a buffer surrounding the ecoregion. Including the buffer, it is approximately 138,945 miles^2 or 359,869 km^2 in size.

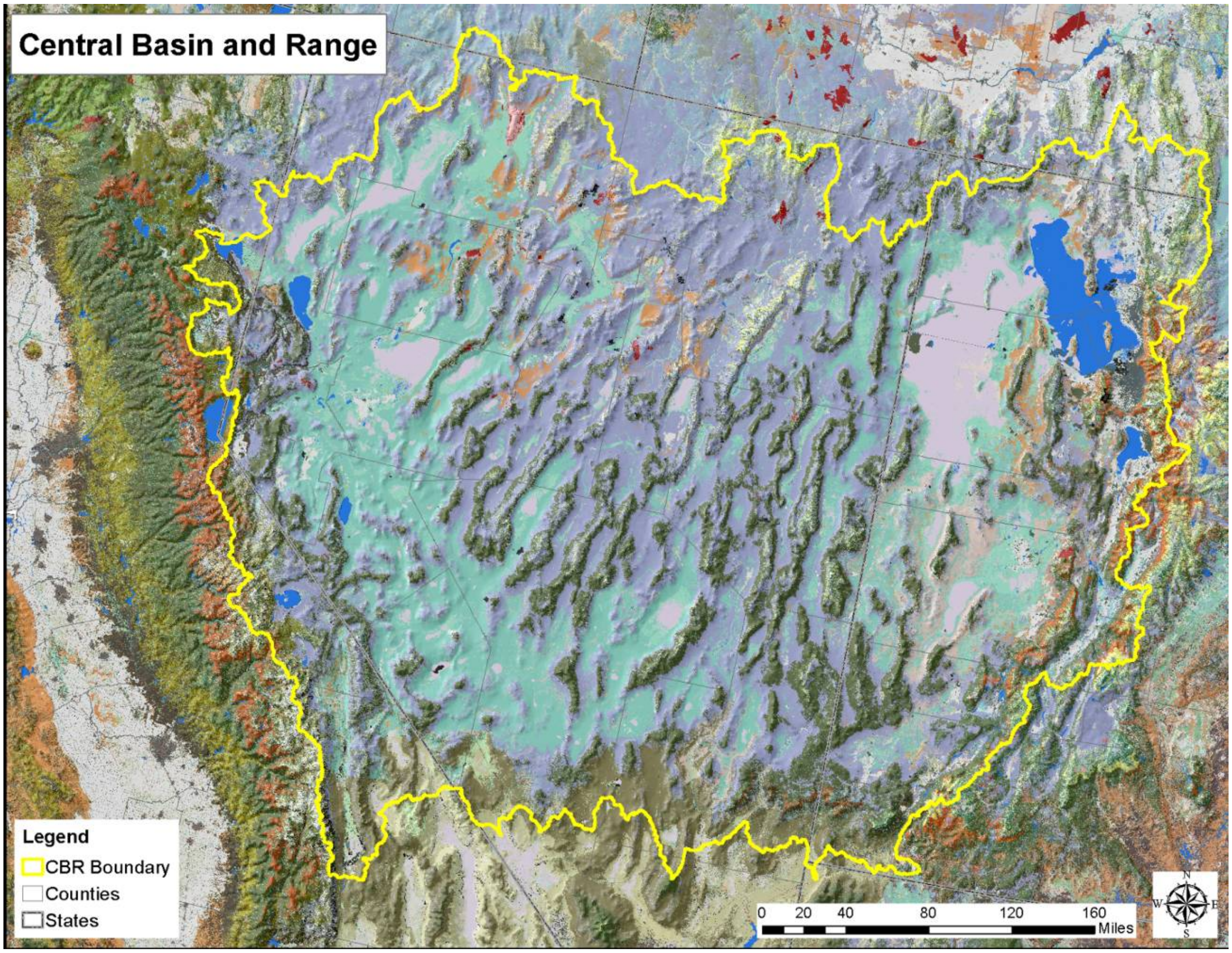

Figure 2-1. Project Boundary (in yellow) for the Central Basin and Range Ecoregion; the colors represent the mapped distributions of many ecological systems found in the western U.S.

2.3.3 REA Phases and Workflow

REAs are prepared in two phases. The first phase is the ***pre-assessment***, which refines management questions posed by the Assessment Management Team (AMT), solidifies the lists of CEs and CAs, and identifies the data and methods available for analysis. The second phase is the ***assessment,*** in which the analysis is conducted and the assessment report, maps, and supporting documents are prepared. The phases of the REA are organized into seven tasks (Figure 2-2); the CBR REA was conducted according to these phases and tasks.

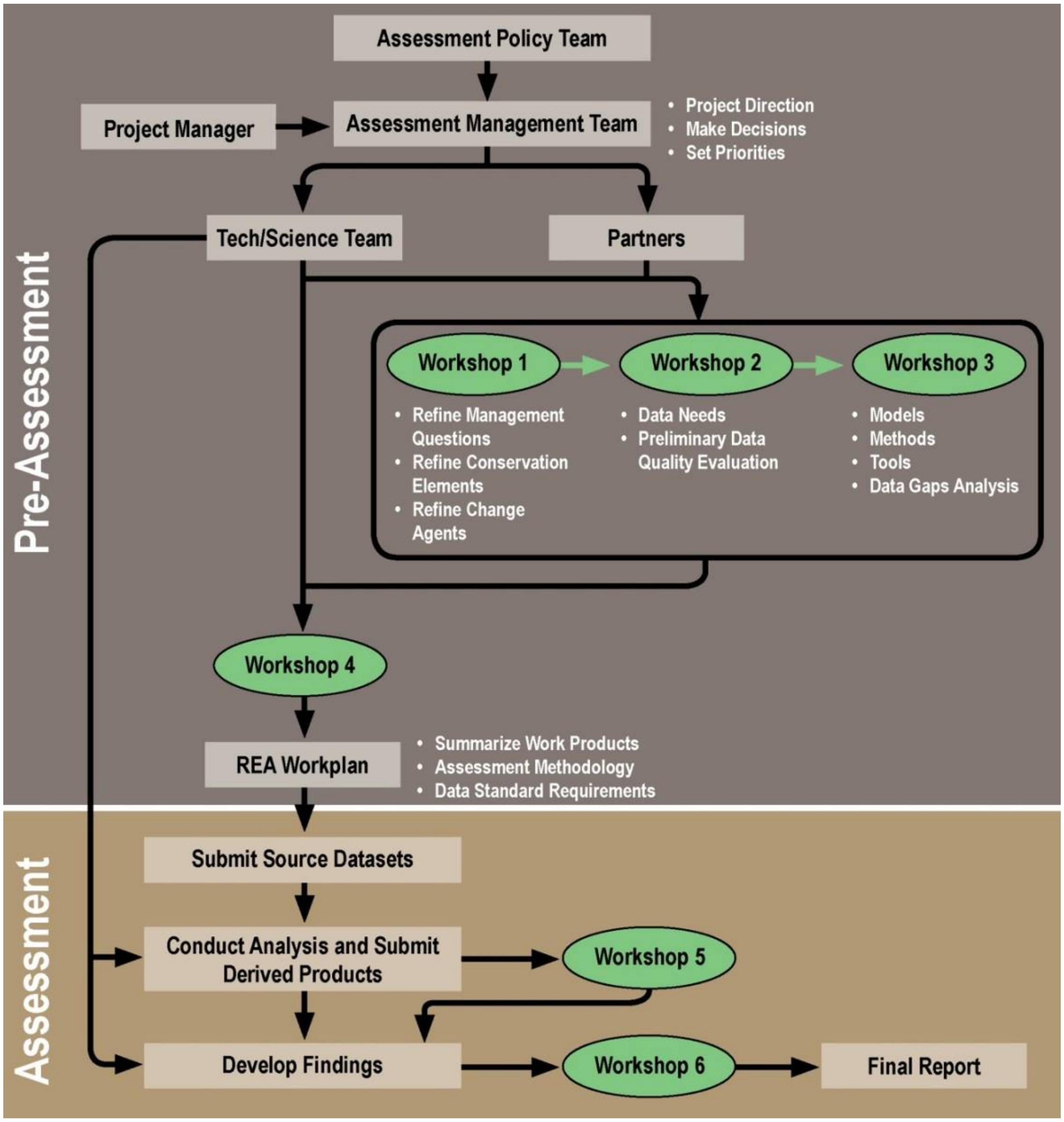

Figure 2-2. REA workflow divided into pre-assessment and assessment phases with regular workshops. Contents of each of the first three workshops are listed beneath each workshop symbol in white text. Workshop 4 marked the preparation of the workplan with formal timelines, workflow, and review process. Workshops 5 and 6 provided forums for presenting analyses and products described in the final report.

2.3.4 Management Questions

The AMT held meetings prior to Phase I to identify Management Questions (MQs) of interest for assessment. A number of MQs were provided in the Statement of Work to be treated as candidate MQs that would be evaluated for feasibility of assessment through Tasks 1-4. A total of 102 MQs were established as candidates. Most MQs fall into the following generalized categories:

- Where is it? (e.g., CEs, CAs, Places)
- Where does it coincide with other features? (e.g., CEs with CAs)

- Where and how might the CEs be affected by CAs, either now or in the foreseeable future?

There are several more specific and complex MQs dealing with issues such as connectivity, renewable energy, and potential for ecological restoration.

The questions were evaluated by the contractor over the course of the REA based on the following considerations:

- **Data availability**: do data exist to answer the MQ?
- **Model availability**: do suitable methods exist or could feasibly be created to answer the MQ?
- **Clarity**: did the MQ need to be rephrased to provide an unambiguous answer or to fit the availability of data or modeling methods to answer it?

Recommendations by the contractor for modifying or deferring the MQs (and in some cases adding or splitting MQs) were presented to the AMT at AMT workshops and/or in memoranda and were accepted, modified, or rejected. Additions, deferments, and changes to MQs from the original list provided in the SOW were tracked in the MQ table (Table 2-1). The result was assessment of 61 MQs. The table also provides cross references to CEs and CAs addressed in the MQ. Appendix E has the entire original list of management questions, along with a record of issues and discussions pertinent to each MQ.

Because of the large number of MQs assessed in this REA, not all MQ results could practically be addressed within set page limits of this report; however full results for all MQs are provided in the appendices. A separate pair of case studies are provided; one for greater sage-grouse, and another for fire regime departure.

Table 2-1. List of final Management Questions with relevant conservation elements (or other units, such as ecoregion-wide) and relevant change agents. MQ# refers to the original assigned identification number. Individual CEs are not listed due to space constraints.

MQ #	Final Management Question	Relevant Conservation Elements or other unit	Relevant Change Agents
A. Species			
1	What is the current distribution of potential habitat for each species CE?	Each CE (landscape species)	
2	Where are current locations of species CEs that are potentially affected by **existing** change agents (and thus potentially at risk)?	Each landscape species CE crossed with CAs	All CAs
3	What is the current distribution of suitable habitat, including seasonal habitat and movement corridors, for each landscape species and species assemblage CE?	Each CE (landscape species and species assemblages)	
4	Where are **existing** change agents potentially affecting this current habitat and/or movement corridors, for landscape species and species assemblage CEs?	Each CE (landscape species and species assemblages) crossed with CAs	All CAs
5	Where are species CEs whose current locations or suitable habitats overlap with the potential future distribution of CAs (other than climate change)?	Subset of CEs with restricted habitats (landscape species)	All CAs
6	What is the relative survey intensity to date within the ecoregion for species CEs ?	Each CE	
7	Given current and anticipated future locations of change agents, which habitat areas remain as opportunities for habitat enhancement/ restoration?	Subset of landscape species CEs	
8	Where are potential areas to restore connectivity or intact habitat for greater sage-grouse based on current locations of change agents?	Selected subset of habitats and locations.	
9	Where will landscape species CEs experience climate outside their current climate envelope?	Each CE (landscape species)	Climate Change
B. Native Plant Communities			
10	Where are intact CE vegetative communities located?	All CEs that are vegetative communities (coarse filters)	
11	Where are the likeliest **current** locations for high-ecological-status examples of each major terrestrial ecological system?	All CEs that are vegetative communities (coarse filters)	

MQ #	Final Management Question	Relevant Conservation Elements or other unit	Relevant Change Agents
12	Where are **existing** and **potential future** CAs (aside from climate change) likeliest to affect current communities?	All CEs that are vegetative communities (coarse filters) crossed with CAs	All CAs
13	Where will current locations of these communities experience significant deviations from normal climate variation?	All CEs that are vegetative communities (coarse filters)	Climate Change
C. Terrestrial Sites of High Biodiversity			
14	Where are sites identified (but not necessarily designated) for High Biodiversity?	Ecoregion-wide, NatureServe Places I category	
15	Where will CAs (aside from climate change) potentially affect sites of high biodiversity?	Non-designated High Biodiversity sites (NatureServe Places I category) crossed with CAs	All CAs
16	Where will locations of these High Biodiversity sites experience significant deviations from normal climate variation?	All High Biodiversity sites (NatureServe Places I & II category)	Climate Change, potentially other CAs
D. Aquatic Sites of High Biodiversity			
18	Where are Aquatic High Biodiversity sites?	All Aquatic High Biodiversity sites (NatureServe Places I category)	
19	Where will these Aquatic High Biodiversity sites be potentially affected by Change Agents (aside from climate change)?	All Aquatic High Biodiversity sites (NatureServe Places I category) crossed with CAs	All CAs
20	Where will current locations of these Aquatic High Biodiversity sites experience significant deviations from normal climate variation?	All Aquatic High Biodiversity sites (NatureServe Places I category)	Climate Change
E. Specially Designated Areas of Ecological Value			
21	Where are specially designated areas of ecological or cultural value?	Ecoregion-wide, NatureServe Places II category	
F. Soils			
28	Where are sensitive soil types within the ecoregion?	Ecoregion-wide, Sensitive Soils	
29	Where will target soil types overlap with CAs (aside from climate change) under each time scenario?	All sensitive soil types crossed with CAs	All CAs
G. Aquatic Ecological Function and Structure			
36	What is the condition (ecological status) of aquatic conservation elements?	All aquatic CEs	Hydrologic alternation, Invasive species, Development

MQ #	Final Management Question	Relevant Conservation Elements or other unit	Relevant Change Agents
39	Where are the aquatic CE occurrences with the most degraded condition (ecological status)?	All aquatic CEs	Hydrologic alteration, Invasive species, Development
H. Grazing, Wild Horses and Burros			
23	Where are the current Herd Management Areas (HMAs)?	Wild horses, Burros	
26	Where will CAs (excluding climate change) overlap HAs, HMAs, and GAs under each time scenario?	Allotments, Grazing	All CAs
27	Which HAs, HMAs and GAs will experience climate outside their current climate envelope?	HMAs, Allotments, Grazing	Climate Change
I. Fire History and Potential			
40	Where have fires greater than 1000 acres occurred?	Ecoregion-wide	Wildfire (increased and/or decreased frequency)
42	What areas now have unprecedented fuels composition (invasive plants), and are therefore at high potential for fire?	Ecoregion-wide	Wildfire (increased and/or decreased frequency)
43	Where are places that in the future will have high potential for fire?	Ecoregion-wide	Wildfire (increased and/or decreased frequency)
J. Invasive Species			
44	What is the current distribution of invasive species included as CAs?	Ecoregion-wide	All invasive species CAs
45	What areas are significantly ecologically affected by invasive species?	Ecoregion-wide	All invasive species CAs
46	Focusing on the distributions of terrestrial and aquatic CEs that are significantly affected by invasives, which areas have restoration potential?	Areas identified as significantly affected by invasives.	All invasive species CAs
47	Given current patterns of occurrence and expansion of the invasive species included as CAs, what is the potential future distribution of these invasive species?	Ecoregion-wide	Invasive annual grasses Invasive aquatic species
K. Development			
48	Where are current locations of development CAs?	Ecoregion-wide	Development, Transportation and Energy Infrastructure
49	Where are areas of planned or potential development CAs?	Ecoregion-wide	Development, Transportation and Energy Infrastructure
50	Where do development CAs cause significant loss of ecological integrity?	Ecoregion-wide	Development, Transportation and Energy Infrastructure

MQ #	Final Management Question	Relevant Conservation Elements or other unit	Relevant Change Agents
51	Where do current locations of CEs overlap with development CAs?	All CEs	Development, Transportation and Energy Infrastructure
52	Where is recreational use?	Ecoregion-wide	Recreation (land-based, water-based)
L. Oil, Gas, and Mining Development			
83	Where are the current locations of oil, gas, and mineral extraction?	Ecoregion-wide	Extractive energy development
M. Renewable Energy Development			
81	Where will locations of renewable energy [development] potentially exist by 2025?	Ecoregion-wide	Renewable energy development
87	Where are the current locations of renewable energy development (solar, wind, geothermal, transmission)?	Ecoregion-wide	Renewable energy development
88	Where are the areas identified by NREL as potential locations for renewable energy development?	Ecoregion-wide	Renewable energy development
89	Where are the areas of low renewable and non-renewable energy development that could potentially mitigate impacts to CEs from potential energy development?	Among current and potential development sites.	Renewable energy development
90	Where do current locations of CEs overlap with areas of potential future locations of renewable energy development?	All CEs, relevant other resources (including water)	Renewable energy development
N. Surface and Subsurface Water Availability			
30	Where are current natural and man-made surface water resources?	All surface water bodies	
31	Of the current surface water resources (both natural and man-made), which are perennial, ephemeral, etc?	All surface water bodies	
34	Where are the likely recharge areas within a watershed?	All relevant areas	
35	Where will the likely recharge areas (relating to aquatic CEs) identified in MQ 34 potentially be affected by Change Agents?	All identified recharge areas crossed with CAs	Many CAs
O. Groundwater Extraction and Transportation			
54	Where will change agents potentially impact groundwater-dependent aquatic CEs?	Ecoregion-wide: springs and seeps CEs	All CAs
56	What is the present distribution of municipal and agricultural water use of groundwater resources in relation to the distribution of aquatic CEs?	Ecoregion-wide: aquatic CEs	Groundwater extraction

MQ #	Final Management Question	Relevant Conservation Elements or other unit	Relevant Change Agents
57	Where are the aquatic CEs showing degraded ecological status from existing groundwater extraction?	Ecoregion-wide: aquatic CEs	Hydrologic Alteration
P. Surface Water Consumption and Diversion			
58	Where are artificial water bodies including evaporation ponds, etc.?	Ecoregion-wide	
60	Where are the areas of potential future change in surface water consumption and diversion?	Ecoregion-wide	Hydrologic alteration, Climate change, Development
62	Where are the CEs showing degraded ecological status from existing surface water diversion?	Relevant aquatic CEs	Hydrologic alteration, Development
Q. Atmospheric Deposition			
80	Where are areas affected by atmospheric deposition of pollutants, as represented specifically by nitrogen deposition, acid deposition, and mercury deposition?	Ecoregion-wide	Air and Water Quality: Fugitive dust, air pollution, atmospheric deposition
R. Climate Change: Terrestrial Resource Issues			
65	Where will changes in climate be greatest relative to normal climate variability?	Ecoregion-wide	Climate Change
66	Given anticipated climate shifts and the direction shifts in climate envelopes for CEs, where are potential areas of significant change in extent?	Ecoregion-wide	Climate Change
67	Which native plant communities will experience climate completely outside their normal range?	CEs that are plant communities (coarse filter).	Climate Change
68	Where will current wildlife habitats experience climate completely outside its normal range?	Select relevant wildlife species	Climate Change
69	Where are wildlife species ranges (on the list of species CEs) that will experience significant deviations from normal climate variation?	Select relevant wildlife species	Climate Change
S. Climate Change: Aquatic Resource Issues			
71	Where will aquatic CEs experience significant deviations from historic climate variation that potentially could affect the hydrologic and temperature regimes of these aquatic CEs?	Ecoregion-wide: aquatic CEs	Climate Change, Hydrologic alteration

2.4 Modeling

Conceptual Modeling

Science-based assessments such as REAs must compile and synthesize large amounts of existing knowledge and data for the area being assessed. Conceptual models provide a practical mechanism for summarizing current knowledge, documenting assumptions, and illustrating how those assumptions and data have been integrated to produce assessment results. Conceptual models are commonly provided as descriptive text or "box-and-arrow" diagrams. An overarching conceptual model was developed to briefly synthesize current understanding about the ecoregion as a whole. The conceptual model for the ecoregion lays out an overall framework for understanding pattern and process throughout the ecoregion, and provides an ecologically based framework for organizing the assessment. Numerous specific conceptual models were then developed to describe the current understanding of each CE, CA, and their likely interactions (see Appendix B Section B-1.1 for models for CEs).

Spatial Modeling

Conceptual models can often be translated into spatial models that can be used to investigate and answer management questions by combining mapped information. Spatial models can be illustrated conceptually using process diagrams showing how spatial data inputs will be combined and processed. The actual processing of the spatial data results in the spatial model, displayed as a map. For the REA, these spatial models aim to directly address the assessment needs of the MQs. Spatial modeling included the following:

- Generating distribution maps of current and/or potential future distribution of CEs, CAs and Places from existing data.
- Analyzing the spatial coincidence of CAs, CEs, and Places
- Evaluating the effects of CAs on CEs (e.g., on the forecasted extent or potential ecological status of CEs).
- Summarizing effects in terms of ecological status indicators across Places.
- Conducting specific advanced analyses to answer MQs such as identifying potential areas for restoration or mitigation.

2.4.1.1 Key REA Products

The following list is not exhaustive but describes the general categories of products resulting from the REA; case studies provide examples of how these products can be utilized and are provided as separate documents:

- Conceptual and spatial process models
- Metadata for all geospatial products
- Geospatial maps of the distribution of CEs
- Geospatial maps of ecological integrity by 16 km^2 (4x4 km) grid cell
- Geospatial maps of the distribution of CAs
- Geospatial maps of the distribution of Places
- Geospatial results of assessments, including ecological status of CEs
- Tabular results of assessments
- Final report
- Appendices to final report, including results for MQs

2.5 Ecoregional Conceptual Model

Current recommended approaches (e.g., Gross 2005) were used to organize a conceptual model for the ecoregion, drawing upon a wealth of existing descriptive information, including conceptual models developed for the National Park Service Inventory and Monitoring programs (Miller 2005, Chung-MacCoubrey et al. 2008), ecoregion descriptions of the NRCS (NRCS 2006), U.S. Forest Service (McNab et al. 2007) and the Great Basin Ecoregional Blueprint of The Nature Conservancy (Nachlinger et al. 2001). The purpose of this model is to articulate key assumptions about regional landscape pattern and process to inform the selection and analysis of conservation elements and change agents. As mentioned above, this overarching description and model also provides an organizing framework for the series of component models for the ecoregion.

The Central Basin and Range – as defined for North America by CEC - lies to the immediate east of the Sierra Nevada, to the north of the Mojave Basin and Range, to the west of the Wasatch/Uinta Mountains, and south of the Northern Basin and Range ecoregions. It is largely contained within the Forest Service's Intermountain Semi-desert and Desert Province and M341-Nevada-Utah Mountains Semidesert - Coniferous Forest - Alpine Meadow Province as defined by McNab et al. (2007) and the Western Range and Irrigated Region of NRCS (NRCS 2006). It falls into the Inter-Mountain Basins EcoDivision as defined by NatureServe (Comer et al. 2003, Comer and Schulz 2007). The Central Basin and Range boundary is closely aligned with the Great Basin ecoregion, as defined and used by The Nature Conservancy (Nachlinger et al. 2001).

As described by USEPA (2007), "The Central Basin and Range ecoregion is internally drained and is characterized by a mosaic of xeric basins, scattered low and high mountains, and salt flats. It has a hotter and drier climate, more shrubland, and more mountain ranges than the Northern Basin and Range ecoregion to the north. Basins are covered by Great Basin sagebrush or saltbush-greasewood vegetation that grow in aridisols; cool season grasses are less common than in the mollisols of the Snake River Plain and Northern Basin and Range. The region is not as hot as the Mojave Basin and Range ecoregion to the south and it has a greater percent of land that is grazed."

The ecological boundary of the Central Basin and Range is more readily distinguished by fairly sharp vegetation changes along its western and eastern edges, with abrupt transitions into high-montane environments. As noted in the EPA ecoregion description, the transitions are less abrupt along the southern borders, as cool semi-desert transitions into the warm desert of the Mojave Basin and Range. The northern transition into the Northern Basin and Range is more subtle, as sagebrush vegetation dominates much of that transition.

The ***temporal bounds*** of this conceptual model include the past two centuries, but center on the 20th century and decade of 2001-2011. This time period reflects the climatic regimes, ecological patterns and processes, and change agents that are most applicable to this assessment. Although the REA evaluated climate-induced stress and land use scenarios for future time periods, the overarching ecoregional conceptual model is based on knowledge and assumptions up to the present.

Biophysical Controls

Regional Physiography: Between the Sierra Nevada to the west and Wasatch ranges to the east, more than three hundred long, narrow, roughly parallel mountain ranges are separated by broad elongated valleys (Grayson 1993). According to Nachlinger et al. (2001), "the valley floors are highest in the center of the ecoregion and lowest at the western and eastern margins, the result of stretching tectonic forces. The structures of mountain ranges are roughly similar, but their compositions are diverse. The structure is the result of high angle block faulting. The ranges are uplifted horsts and the basins are lowered grabens. Granite and basalt mountains occur in the west and south, rhyolite mountains prevail in the center, and limestone mountains predominate in the east. Elevations in the

Central Basin and Range range from 324 m (1,063 ft) on the east flank of the Inyo Mountains to 4,342 m (14,246 ft) at the summit of the White Mountains, both in the southwest portion. Valley floors in the Lahontan and Bonneville basins average 1,150-1,525 m (3,800-5,000 ft) above sea level, whereas valley floors in the central sections average 1,675-1,950 m (5,500-6,400 ft) in elevation."

Regional Climate Regime: Due to its location in the rain shadow of major mountain ranges, the climate of the Central Basin and Range is semiarid. The Sierra Nevada range effectively captures much of the moisture from east-moving Pacific fronts while the Rocky Mountains intercept moisture coming from the Gulf of Mexico. There is also a limited Mediterranean influence (winter precipitation and pronounced dry summers) as defined through some bioclimatic classifications (Cress et al. 2008, Sayre et al. 2009). The climate regime is somewhat continental; with relatively high annual temperature fluctuations due to distance from moderating oceanic climates (Hidy and Klieforth 1990). As Nachlinger et al. (2001) noted, "…Temperatures have both daily and seasonal extreme variation while spatial distinctions occur from valley floors to mountaintops. The mountains tend to be cooler and windier than the valleys. Surface air heating during the day yields very high valley temperatures, often accompanied by strong local turbulence that creates dust devils. At night, valleys lose heat rapidly by radiation and cool air pools below warmer air above. The cold winter temperatures are typically 10° to 40°F and the hot summers are typically 50° to 90°F. Daily temperatures vary up to 68°F, while seasonal averages vary more than 73°F (<32° to >105°F). Near the heart of the Central Basin and Range, Elko boasts a 150°F temperature range, from –43° to 107°F (Trimble 1989)." However, given the proximity and influence of the Great Salt Lake, temperatures are comparatively moderate. Salt Lake City temperatures average 29°F in January and 78°F in July.

Also from Nachlinger et al. (2001), "...There are three principal precipitation regimes in the ecoregion. Frontal cyclones from the Pacific cause winter maximum precipitation mostly as snowfall in the western and northern Central Basin and Range. Cold continental cyclones result in spring maximum precipitation in the central and eastern Central Basin and Range. Summer thunderstorms in subtropical air masses from the Gulf of Mexico cause a secondary summer maximum in the southeastern Central Basin and Range, which is often heaviest in the valleys. The average annual regional precipitation is 216 mm (8.5 in), however there is great variation. In Wendover, the average is 114 mm (4.5 in), while at the base of the Ruby Mountains only 95 km (60 mi) to the west, the average is 432 mm (17 in). At the edges of the ecoregion, the average annual precipitation in the rain shadow of the Sierra Nevada is 127mm (5 in), while it is 254 mm (10 in) along the Wasatch Front. No surface water leaves the Central Basin and Range except by evaporation. At Pyramid Lake, evaporation exceeds precipitation about twelve to one."

Due to tectonic stretching, the earth's crust is relatively thin throughout the ecoregion more so than any other place in North America (Fiero 1986), allowing water to percolate from heated subterranean zones. As a result, springs - many of them thermal - are found throughout the ecoregion. Some 30,000 springs are estimated to occur in the Central Basin and Range ecoregion (Sada 2001).

Major Systems for Conceptual Modeling

Existing model concepts developed by Chung-MacCoubrey et al. (2008) were adapted to characterize climatic and regional physiographic pattern. These pervasive influences of climatic regimes interacting with the basin and range physiography provide overarching biophysical controls on nested systems. Affected in part by variation in solar radiation and air density, seasonal temperature regimes vary along longitudinal, latitudinal, and elevational gradients. Seasonal precipitation regimes vary along these gradients, but are also affected by rain-shadow effects. Combined, these controlling regimes set up regional patterns in wind, dry/wet atmospheric deposition, and air quality (e.g., visibility).

Major model components are illustrated in Figure 2-3 and Figure 2-4; acknowledging the central role of water in this desert ecoregion, upland "dry-land" ecosystems driven generally by water scarcity are initially distinguished from aquatic, riparian, and wetland ecosystems driven by water flow regimes.

Given the influence of interacting climate and physiography, the “dry” and “wet” systems are further divided into “Montane Dry Land” vs. “Basin Dry Land” and “Montane Wet” vs. “Basin Wet” systems. The dry land systems include natural drivers of soil moisture infiltration, erosion, soil organic matter accumulation, and natural disturbance dynamics such as wind throw and wildfire. These vary considerably between higher, cooler montane settings and warmer basin settings. Likewise, “wet” systems, including streams, larger rivers, lakes, springs, desert sinks, wetlands, and riparian environments, are strongly driven by seasonal water flow regimes and the relative influence of surface to groundwater dynamics. Montane wet systems are most strongly driven by surface water flow regimes, while those within the basins combine surface flow dynamics with groundwater flows and evaporation. All of these natural abiotic drivers constrain and influence biotic responses, such as predator/prey dynamics, herbivory, etc.

The human dimension is included as a distinct model component (Figure 2-3), as socioeconomic and demographic drivers of change in land and water use and policy overlay on other model components. While there are many positive interactions (e.g., economic development, outdoor recreation, and solitude), natural system drivers such as herbivory, wildfire, and biotic soil crust processes are directly altered through grazing regimes and altered fire regimes in the dry land systems. Predator/prey dynamics are influenced by human/wildlife conflicts, hunting, habitat alteration by horse/burro congregation, noise, artificial lighting, and resource collecting (e.g., plants). Land conversion and introduction of invasive plant species closely follow human land use patterns for settlements, energy development (e.g., mining, oil/gas, solar, wind farms, geothermal), irrigated agriculture, or transportation/communication infrastructure. Within wet systems, the human dimension appears through water withdrawals or diversions, water pollution, wetland alterations through hydrologic alteration, conversion, livestock trampling, or introduction of invasive species.

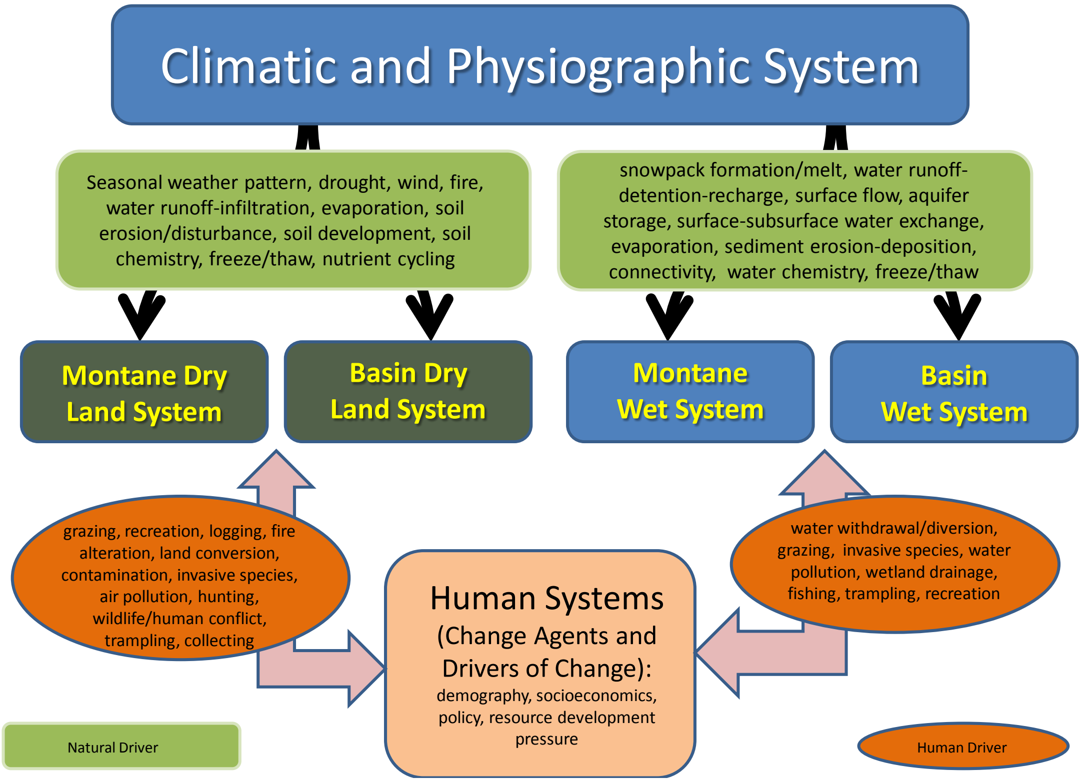

Figure 2-3. Conceptual model for the CBR ecoregion

Subsystem Models

Subsystem models follow from these four broad components. Categories for regional submodels are defined to provide organizational cohesion to the assessment. Additional detail is introduced within each of these component models, organizing natural drivers in terms of “slow” physical drivers, such as landform and soil development; properties and processes that change on decadal and longer timeframes, vs. “fast” physical drivers, such as wildfire and flooding regimes, soil erosion, and other dynamics that occur over relatively short time frames. Biotic drivers, including the responses and interactions of biota within stated physical bounds and regimes, are also differentiated here.

The Montane Dry Land System includes a series of submodels that encompass landscape pattern, dynamics, and biotic assemblages for alpine uplands, subalpine woodlands and forests, montane mixed conifer forests, pinyon-juniper woodlands, and montane shrublands (including montane sagebrush and chaparrals), and montane cliff and canyon environments (Figure 2-4). While proportionally more limited in extent than Basin systems, these systems characterize both National Forest and BLM lands throughout the ecoregion. The Basin Dry Land System includes a series of submodels that encompass landscape pattern, dynamics, and biotic assemblages for semi-desert shrublands, shrub steppe, desert scrub, desert cliff and outcrops, and sand dunes (Figure 2-4).

The Montane Wet System includes a series of submodels that encompass landscape pattern, dynamics, and biotic assemblages for alpine-to-montane lakes, streams, wetlands, and riparian communities. Again, of most limited over extent in the ecoregion, these systems characterize both National Forest and BLM lands across the ranges of the ecoregion. The Basin Wet System includes a series of submodels that encompass landscape pattern, dynamics, and biotic assemblages for low-elevation lakes, streams, desert springs, marshes, floodplain and riparian communities, and seasonally or intermittently wet desert washes, playas and greasewood flats (Figure 2-4).

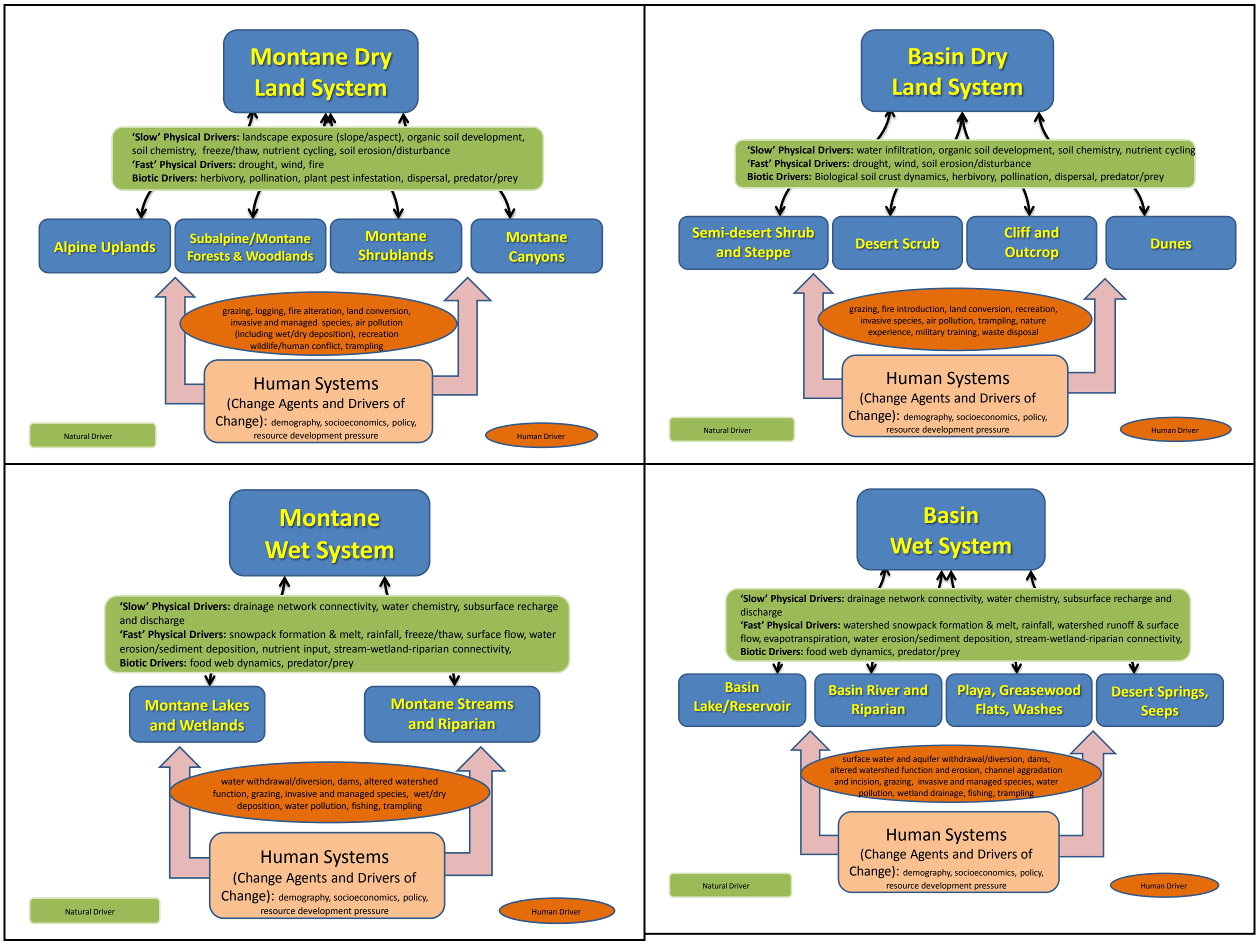

Figure 2-4. SubSystem Model Components for the Central Basin and Range ecoregion

2.6 REA Building Blocks: Conservation Elements and Change Agents

2.6.1 Conservation Elements

A first step in most natural resource assessments is the identification of the features to provide a focus. One must ask and answer: ***What is it that we wish to evaluate and assess?*** For Rapid Ecoregional Assessments, features that are the targets of assessment are referred to as "conservation elements" (CEs). Key to selection of conservation elements is establishing clarity of purpose. ***What do we need to learn from the assessment?*** For this REA, CE selection focused on the ecological resources of the ecoregion supporting regional biodiversity; along with selected resources of particular management interest.

To define the conservation elements, a "coarse filter/fine filter" approach (Jenkins 1976, Noss 1987, Hunter 1990) was adapted to the ecoregion. This approach has been used extensively for regional and local landscape assessments since the 1970s. "Coarse filter" focal ecological resources typically include all of the major ecosystem types within the assessment landscape. Next, one poses the question: if all major ecosystem types are managed and conserved in sufficient area and landscape configuration, which of the "vulnerable" species will have sufficient habitat addressed by the assessment? For this REA, vulnerable species were those meeting a set of criteria proposed to and accepted by the AMT (see below Fine-filter section). Those species that are not adequately addressed through ecosystem-scale management are included as additional foci for assessment – the “fine filter” (see below). This approach, therefore, sets up a multi-level strategy to define an effective focus for assessment.

Coarse Filter Elements

The “coarse filter” includes 26 terrestrial and aquatic ecological system types and communities that express the predominant ecological pattern and dynamics of the ecoregion (Table 2-2). These classified units a) characterize each component of the ecoregion’s conceptual model, b) define the majority of this ecoregion’s lands and waters, and c) reflect described ecological types with distributions concentrated within this ecoregion. NatureServe ecological classifications provided the basis for several existing national or regional map products (e.g., NatureServe national map, ReGAP in CA and SW region, LANDFIRE) and may be readily reconciled with locally-desired classification systems for ecological sites and plant communities. NatureServe databases and existing map products were used to establish the proposed list of these core CEs, which was then refined during the assessment process. Appendix B Section B-1.1 includes an annotated listing for each of the coarse filter units, along with detailed conceptual models. A list of seven soils types of conservation concern were also identified using BLM criteria.

Table 2-2. Coarse filter Conservation Elements for Central Basin and Range Ecoregion

Level 2 in ecoregional conceptual model	**Ecosystem Name**	**Approx. % Ecoregion**
Basin Dry Land Ecosystems		**58.5%**
Desert Scrub	Inter-Mountain Basins Mixed Salt Desert Scrub	20.0%
Desert Scrub	Mojave Mid-Elevation Mixed Desert Scrub	2.0%
Semi-desert Shrub & Steppe	Inter-Mountain Basins Big Sagebrush Shrubland	19.5%
Semi-desert Shrub & Steppe	Great Basin Xeric Mixed Sagebrush Shrubland	9.6%
Semi-desert Shrub & Steppe	Inter-Mountain Basins Semi-Desert Shrub-Steppe	3.1%
Semi-desert Shrub & Steppe	Inter-Mountain Basins Semi-Desert Grassland	1.0%
Semi-desert Shrub & Steppe	Inter-Mountain Basins Big Sagebrush Steppe	1.8%
Semi-desert Shrub & Steppe	Colorado Plateau Mixed Low Sagebrush Shrubland	<1%
Dunes	Inter-Mountain Basins Active and Stabilized Dune	<1%
Basin Wet Ecosystems		**14.3%**
Playa, Greasewood Flats, Washes	Inter-Mountain Basins Playa	5.7%
Playa, Greasewood Flats, Washes	Inter-Mountain Basins Greasewood Flat	5.1%
Playa, Greasewood Flats, Washes	Inter-Mountain Basins Wash	<1%
Basin Lake/Reservoir	Great Basin Lake/Reservoir	2.2%
Basin River & Riparian	Great Basin Foothill-Lower Montane Riparian Woodland and Shrubland/Stream	1.2%
Desert Springs, Seeps	Great Basin Springs and Seeps	<1%
Montane Dry Land Ecosystems		**19.5%**
Subalpine/Montane Forests & Woodlands	Great Basin Pinyon-Juniper Woodland	13.8%
Subalpine/Montane Forests & Woodlands	Rocky Mountain Aspen Forest and Woodland	<1%
Subalpine/Montane Forests & Woodlands	Inter-Mountain Basins Subalpine Limber-Bristlecone Pine Woodland	<1%

Level 2 in ecoregional conceptual model	Ecosystem Name	Approx. % Ecoregion
Subalpine/Montane Forests & Woodlands	Inter-Mountain Basins Aspen-Mixed Conifer Forest and Woodland	<1%
Montane Shrublands	Inter-Mountain Basins Montane Sagebrush Steppe	3.9%
Montane Shrublands	Inter-Mountain Basins Curl-leaf Mountain-mahogany Woodland and Shrubland	<1%
Montane Shrublands	Great Basin Semi-Desert Chaparral	<1%
Montane Canyons	Inter-Mountain Basins Cliff and Canyon	<1%
Alpine Uplands	Rocky Mountain Alpine Turf	<1%
Montane Wet Ecosystems		**1.3%**
Montane Streams & Riparian	Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland/Stream	<1%
Montane Streams & Riparian	Rocky Mountain Subalpine-Montane Riparian Woodland and Shrubland/Stream	<1%
Soils of Conservation Concern (7) (occurring across major systems of the ecoregion conceptual model: wind erodable, water erodable, droughty soils, hydric soils, gypsum soils, excess sodium, high calcium carbonates)		

Fine-Filter Element Selection

The “fine-filter” includes species that, due to their conservation status and/or specificity in their habitat requirements, are assumed to be vulnerable to being impacted or lost from the ecoregion unless resource management is directed towards their particular needs. Species meeting initial selection criteria could then fall into one of two general categories; a) those that might be effectively treated as a species assemblage; i.e., their habitat and known populations co-occur sufficiently to treat them as a single unit of analysis, and b) those species to be treated individually.

Selection criteria for vulnerable species inclusion and treatment in the assessment included:

a) All taxa listed under Federal or State protective legislation (including species, subspecies, or designated subpopulations)
b) Full species with NatureServe Global Conservation Status rank of G1-G3[1]
c) Full species or subspecies listed as BLM Special Status and those listed by applicable SWAPs with habitat included within the ecoregion
d) Full species and subspecies scored as *Vulnerable* within the ecoregion according to the NatureServe Climate Change Vulnerability Index (CCVI).

Appendix B Section B-1.1.1 includes a list of species under these criteria. Criterion d) involved application of the NatureServe CCVI to candidate species that might otherwise NOT be included in the assessment, but for their resulting status under the CCVI. Specific selection criteria for the sub-analysis included:

a) Taxa listed of conservation concern in the Great Basin Ecoregional Assessment of The Nature Conservancy (Nachlinger et al. 2001)
b) Full species with NatureServe Global Conservation Status rank of G3?-G3G4
c) Subspecies with NatureServe Status Rank of T1-T3

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[1] NatureServe Conservation Status Rank definitions: G1 = globally critically imperiled , G2 = globally imperiled, G3 = globally vulnerable. See http://www.natureserve.org/explorer/ranking.htm for detailed explanation.

While not all species meeting these criteria were evaluated using the CCVI, results for all treated species are found in Appendix D Section D-2.3.4. Future efforts with local partners could further augment the master list of species to be treated within future REA iterations.

Fine-Filter Element Treatment

Given the established list of species for the REA, several distinct approaches were used to treat species in the assessment. Every species was assigned to one of the below four approaches for the assessment by biologists familiar with life history and habitat relationships of taxonomic groups. These assessment approaches included:

- Species assumed to be adequately represented ***indirectly through the assessment of major*** "coarse filter" ecological systems. For example, species strongly affiliated with desert springs were treated in the REA through assessment of desert springs themselves.
- Species assumed to be adequately represented ***indirectly as ecologically-based assemblages***. That is, due to group behavior and similar habitat requirement, a recognizable species assemblage is defined and treated as the unit of analysis. Examples include migratory bird stopover sites or rare species assemblages associated with particular substrates.
- Species ***best addressed as individuals*** in the assessment. These include those species meeting the criteria for assessment that cannot be presumed to be included in the previous two categories. This includes two subcategories of species: **"landscape species"** that range over wide areas within the ecoregion and with clearly distinct habitat requirements from all other taxa of concern (Table 2-3), and **"local species"** that have very narrow distributions, generally limited to one BLM management jurisdiction.
- Species on the list that were not treated individually as landscape species, nor indirectly through assemblages or coarse filters, were included with the "local species" approach.

This categorization for treatment of species led to the focused development of both conceptual and spatial models for landscape species (Table 2-3) and ecologically-based species assemblages (Table 2-4). Local species were addressed solely by assembling existing locality information and summarizing it by 5th level watershed. Appendix B Section B-1.1.1 provides a master listing of species, including their mode of treatment in the REA.

Table 2-3. List of Landscape species for CBR

Taxonomic Group	# of Species	CBR Landscape Species
Birds	15	Bald Eagle, Brewer's Sparrow, Clark's Nutcracker, Columbian Sharp-tailed Grouse, Cooper's Hawk, Ferruginous Hawk, Golden Eagle, Greater Sage-Grouse, Loggerhead Shrike, Northern Harrier, Prairie Falcon, Sage Sparrow, Sage Thrasher, Savannah Sparrow, Swainson's Hawk
Mammals	7	Big Brown Bat, Brazilian Free-tailed Bat, Desert Bighorn Sheep, Kit Fox, Mule Deer, Pygmy Rabbit, White-tailed Jackrabbit
Reptiles	6	Coachwhip, Common Kingsnake, Great Basin Collared Lizard, Northern Rubber Boa, Northern Sagebrush Lizard, Western Patch-nosed Snake

Table 2-4. List of Vulnerable Species Assemblages for CBR

Species Assemblage CEs in the CBR and placement in Ecoregional Conceptual Model		
Level 1	**Level 2**	**Species Assemblage Name**
Basin Wet System	Basin River & Riparian	Migratory waterfowl & shorebirds
Montane Dry Land System	Alpine Uplands	Carbonate (Limestone/Dolomite) alpine
		Non-carbonate alpine
	Subalpine/Montane Forests & Woodlands	Montane conifer
Basin Dry Land System	Cliff & Outcrop	Azonal carbonate rock crevices
		Azonal non-carbonate rock crevices
	Desert Scrub	Gypsum soils
	Semi-desert Shrub & Steppe	Clay soil patches
		Sand dunes/sandy soils (when deep and loose)

Areas of High Biodiversity Significance and Specially Designated Areas of Ecological Value were originally proposed by the AMT as potential conservation elements; instead these already prioritized or designated lands were used as spatial reporting units for selected analyses. Below is a concise summary by category of conservation elements that were included in this ecoregional assessment (Table 2-5).

Table 2-5. Summary of Final Conservation Elements for Central Basin and Range Ecoregion

Conservation Element Category	**Number of Elements**
Basin Dryland Ecosystems	10
Basin Wet Ecosystems	6
Montane Dryland Ecosystems	7
Montane Wet Ecosystems	3
Soils of Conservation Concern	7
Terrestrial Habitat-Based Species Assemblages	9
Landscape Species	28
Local Species	318

2.6.2 Change Agents

Change agents (CAs) are those features or phenomena that have the potential to affect the size, condition and landscape context of conservation elements. CAs include broad regional agents that have landscape level impacts such as wildfire, invasive species, grazing, climate change, and pollution as well as localized impacts such as development, infrastructure, and extractive energy development. CAs act differentially on individual CEs and for some CEs may have neutral or positive effects but in general are expected to cause negative impacts. CAs can impact CEs at the point of occurrence as well as offsite. Individual CAs can also be expected to act synergistically with other CAs to have increased or secondary effects. All change agents were reviewed to determine potential impacts to conservation elements, if the impact is currently present, will remain present in the future, or is not present but considered a future impact. The list of proposed CAs from the AMT was reviewed and a variety of sources were consulted to:

1. Identify additional potential CAs and whether they are currently affecting the ecoregion, are expected to in the future, or both.
2. Characterize the ecological effects of each CA
3. Identify potential CEs that could be affected
4. Characterize potential CE impacts from the CAs

Grazing was not initially identified as a change agent by the AMT in the pre-assessment phase, however at the initiation of the REA in the first AMT workshop, the addition of grazing was discussed. Some members believed grazing, as a land use managed at the Field Office level, was not relevant to ecoregion assessment; others thought it was relevant but did not believe the data were available. The key management question related to grazing is the relative effect of grazing – at various levels of intensity – on the ecological status of conservation elements. The decision was made to further investigate data availability. Inquiries by the contractor to the GIS data manager at the National Operations Center indicated that suitable ecoregion-wide digital grazing data had not been compiled sufficiently to address the key management question. The effort to obtain, standardize, and integrate data from Field Offices would exceed the time and resources available for the Rapid Ecoregional Assessment. Grazing is instead addressed through several MQs dealing with grazing allotments and herd (management) areas. While these MQs do not address the grazing land use as a change agent, they seek to provide information on how these grazing management areas may be impacted by other change agents. Lack of specific grazing data and effects research has been identified to be addressed in future assessments.

Class I Wildland Fire

Alterations to the expected natural fire regimes, through active fire suppression and/or introducing novel fire regimes with exotic weed species, can significantly alter vegetation structure and composition, leading to habitat degradation among CEs and increased risk of uncontrollable wildfire events.

Class II Development

Land use practices, such as road building, energy extraction, OHV use, recreation, alternative energy development, and others, are likely to reduce the integrity and connectivity of habitat and corridors for movement, thereby reducing dispersal success for many species. Many of these actions also result in habitat loss, disturbance, soil erosion, and sedimentation, causing further stress to aquatic and terrestrial ecosystems. This CA includes fourteen different development types that were addressed within the following four categories (see Appendix A, Sections A-1.1 and A-1.2 for details about development types):

- Urbanization
- Energy development (hydrocarbon, solar, geothermal, and wind)
- Mines and refuse management
- Recreation (concentration areas and diffuse)

Subcategories within Urbanization and Energy development have both been treated within a current (~2011) scenario and what could be reliably forecasted to 2025.

Class III Invasive Species

According to the SOW, 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 (modified from BLM Handbook 1740-2, Integrated Vegetation Handbook). For purposes of this REA, non-native invasive species were the focus of analysis, were identified through interactions with the AMT, and included such species as Russian olive (*Elaeagnus angustifolia*), tamarisk (*Tamarix* spp.), cheatgrass (*Bromus tectorum*), red brome (*Bromus rubens*), and a number of exotic noxious forbs. Invasive exotic aquatic species include such taxa as American Bullfrog (*Lithobates catesbeianus*), common carp (*Cyprinus carpio*), guppy (*Poecilia reticulate*), Mexican molly (*Poecilia sphenops*), shortfin molly (*Poecilia mexicana*), New Zealand mudsnail (*Potamopyrgus antipodarum*) and others. Both terrestrial and aquatic invasive species are of management concern throughout the CBR ecoregion.

Encroachment of pinyon-juniper woodlands into sagebrush or other ecosystems was not a component of the "invasive species" assessment; rather was assessed via fire regime departure and succession class analyses (see detailed methods in Appendix A Section A-1.1.3).

Class IV Climate Change

Climate change, referring to regional change in temperature and precipitation regime (i.e., the seasonality, total amount, extreme events) that results from elevated atmospheric CO_2 and global temperatures, could cause stress across the CBR ecoregion. It is expected to act synergistically with other ecosystem stressors, such as invasive species spread or altered fire regimes. Especially within this arid ecoregion, both abrupt and substantial shifts in the amount and timing of precipitation could dramatically affect aquatic food-webs, species viability, forage productivity, and exacerbate stress on water consumption around human population centers. Shifts in phenology (e.g., the seasonal timing of flowering, insect emergence, etc.) could cause substantial disruption to existing inter-species dependencies, while potential regional shifts in species range could seriously fragment populations and trigger substantial losses over the coming decades. Inter-annual shifts in both temperature and precipitation could likely further exacerbate alterations to fire regimes introduced by invasive plants.

At the same time, land managers must cope with increasing uncertainty brought by the potentially unprecedented effects of climate change. This increases the need to develop data, methods, and tools to better forecast conditions over the coming decades. For this reason, several analyses built on climate forecasts of monthly temperature and precipitation for the region to investigate and document the potential trends in climate and their effects on conservation elements.

2.7 Assumptions and Limitations

A rapid ecoregional assessment must take advantage of many existing data sets, often applying them for purposes never contemplated by their original developers. This fact, and the strong need for transparency and repeatability, requires careful documentation and management of uncertainty. In order to manage this uncertainty, the REA process included a series of mechanisms for documenting the data sets, information sources, processing steps, and outputs. The steps of this process offer opportunities to manage the inherent uncertainties associated with REAs:

- **Data Documentation.** Throughout tasks 2-3 of the REA, several hundred extant data sets were documented in terms of their thematic and spatial precision, accuracy, and completeness, relative to the ecoregion. FGDC-compliant metadata were developed and provided for all data sets ultimately generated in the REA, and the project database provided additional opportunities to capture expert perspective on the relative utility of each data set for the intended modeling purposes of the REA.

- **Repeatability.** Conceptual modeling provided an important mechanism for stating the many assumptions that apply in any complex process. Scientific references used in the REA are provided for easy access by subsequent users. All spatial models include documentation of processing steps, including using ESRI ModelBuilder™ so that spatial models may be repeated, analyzed in detail, and updated when new input layers become available.
- **Calibration.** In some instances, during the course of spatial model development, there were opportunities for sensitivity analysis (e.g., with fire regime models), comparison of similar models (e.g., with multiple climate forecast models), and error documentation (e.g., with vegetation map distributions).
- **Interpretation.** Finally, inherent in the design of the REA is a series of judgments about the appropriate interpretation of analysis results. This design aims to limit the potential for misinterpretation by subsequent users. For example, the selection of 5th level watersheds as primary reporting units reflects a judgment about the expected resolution of analysis - based on the resolution of modeling inputs – and appropriate spatial scale for interpreting results. Where results are summarized as a single score for a given 5th level watershed, this indicates that available data do not permit interpreting variation around that score for smaller patches within that watershed.

2.7.1 Limitations: Issues of Scale & Certainty

As remote sensing, GIS, and modeling capabilities have increased along with computing capacity, scale constraints in regional analyses have generally been reduced such that relatively fine-scale mapping and analyses at sub-mile^2 or kilometer^2 resolutions are feasible. However, climate change data, which are a key component of REAs, are still relatively coarse (e.g., 4 – 15 km^2 pixel) even though available spatial resolution has been improving rapidly. Some other products, such as fire regime departure models, aim to express effects at broader spatial scales of several thousand acres. Therefore, a variety of scales and resolutions are used in an REA to represent the finest practical and defensible scale of analyses and presentation depending on the source information and available modeling methods and tools.

The fact that an REA is by definition intended to be a rapid assessment utilizing existing data rather than gathering new empirical data creates some important limitations:

- REA results are intended to inform landscape-scale direction rather than site-level decision making.
- A very large number of analyses were required for this REA, conducted over a short timeframe and therefore modest resources were available for each individual analysis. The REA products are useful for the intended purposes, but they are not comparable to results of focused, multi-year studies on particular management questions.
- Only data considered relatively complete for the ecoregion could be used; therefore, although certain areas of the REA may have had more recent or more precise data, they were not used because it was not consistently available REA-wide.
- Very few source data sets have had rigorous, quantitative accuracy assessments conducted on them; therefore it was not feasible to provide such information for REA results. Instead a qualitative ranking of confidence was defined with BLM to provide information on uncertainty to users, but further consideration of source data quality used in each analysis is encouraged.

3 Summary of Methods

3.1 Data Management

Data Discovery. Based on the materials developed for Phase I Task 1, NatureServe identified data to evaluate for possible inclusion in the assessment to represent CEs, CAs, and Places. Working closely with BLM to minimize redundancy in data requests, the responsibility for identifying datasets was assigned to various team members based on areas of expertise. When possible, full datasets were obtained along with all supporting metadata and reports. BLM provided a number of datasets for evaluation and use. When the data were not immediately available for review, minimum metadata and supporting materials, and sample data were obtained to allow initial assessment of usability for the REA. As each member of the team obtained and compiled their source datasets, the information was entered in the Master Data List maintained by NatureServe and the appropriate team experts notified so they could begin the data quality evaluation process.

Data Documentation. NatureServe created a secure collaborative workspace for the NatureServe REA project team. A detailed checklist for use by project team members was developed that encompassed the data documentation requirements for each type of data deliverable, from raw source data to those generated as modeling outputs. This helped ensure that each dataset had the required documentation, including FGDC metadata, models (as appropriate), layer files, and other supporting documentation, as well as adhered to BLM specified standards for mapping, file formats and file names.

Data Delivery. Initial data delivery was for “raw” source datasets that were identified by NatureServe as part of the data discovery process. These datasets were delivered in adherence to BLM specified standards and metadata were largely provided “as is” with the addition of BLM keywords. Where no metadata existed, NatureServe created minimal metadata with information about how to obtain detailed documentation for that dataset. Many additional datasets were generated as the result of modeling or other spatial analyses, and were documented and delivered to BLM meeting delivery requirements, including complete metadata.

NatureServe delivered to BLM thematic data “packages” that consist of a particular Conservation Element (CE) or Change Agent (CA), Places, or integrated assessment result, along with all of the dependent datasets used as inputs to the creation of the CE, CA, or assessment result. A deliverable package consists of:

- a map document (MXD) with layer groups for the data theme and the related dependent datasets,
- all datasets not previously delivered (sources and analysis outputs) with a layer (LYR) file and FGDC metadata attached to the dataset and also as both XML and TXT files,
- GIS process models and supporting methods documentation.

Map documents and layer files were made available by the NOC through the BLM Data Portal for review, distribution, and storage.

3.2 Models, Methods, Tools

3.2.1 Conceptual Models

3.2.1.1 Conservation Element Characterization and Conceptual Models

Conceptual models were developed for conservation elements. The same basic format was applied with some variation for each of the REA’s coarse filter, landscape species, and ecologically-based species assemblage CEs. Conceptual models combine text, concept diagrams, and tabular summaries in order to clearly state assumptions about the ecological composition, structure, dynamic processes, and interactions with major CAs within the ecoregion. These conceptual models lead then to spatial models intended to gauge the relative ecological status of each CE within 5th level watersheds. All conceptual models applicable to the ecoregion are found in Appendix B, Section B-1.1.

Each model begins by characterizing the CE itself, and how it nests within the broader conceptual model for the ecoregion. In the illustrative example below, the Montane Dry Land System component of the CBR ecoregional concept model, subsystem models include all Subalpine/Montane Forests and Woodlands. Within that component of the subsystem model, Great Basin Pinyon-Juniper Woodland is located. The next component of the model clarifies relevant taxonomic relationships, with "(CES304.773)" referring to the standard NatureServe element code for this ecological system type. LANDFIRE Biophysical Settings, also utilizing the NatureServe classification, use codes **1210190, 1310190** for this type as it occurs in the western CBR (Landfire map zone 12) and eastern CBR (Landfire map zone 17), respectively.

MONTANE DRY LAND SYSTEM

Subalpine/Montane Forests & Woodlands

Great Basin Pinyon-Juniper Woodland
[NatureServe code CES304.773; LANDFIRE Biophysical Setting code: 1210190, 1310190]

Conservation Element Characterization

CE conceptual models aim to further specify the taxonomy of the CE, and then indicate the ecological characteristics that will form the focus for spatial modeling in the assessment. This section includes a narrative of the CE distribution, relevant life histories for species, and other ecological characteristics. For coarse filter units especially, characteristic environment or biophysical setting, landscape dynamics, and floristic composition are described. Classification comments may include additional information on the relationship of this CE to related ecological classifications. For example, with terrestrial coarse filter CEs, a direct linkage is provided between the CE concept and Ecological Site Descriptions (ESD) that have been approved and published for the ecoregion. There are additional ESDs in development, but the listing was limited to those published as of 2011. A listing of species strongly associated with coarse filter CEs is also included. An additional section captures information about known threats to the CEs, and altered dynamics. Cited literature and references for each characterization pertains to the CE for its distribution both within and outside the ecoregion. Reference to literature from outside the ecoregion was included given its relevance to assumptions being made for elements within the ecoregion for the REA. A references section is provided for each CE in its conceptual model.

3.2.2 Distribution Models

Spatial models are commonly documented in the form of 'box-and-arrow' diagrams for each analysis (or category of analyses) that illustrate data inputs, analytical processes, and outputs. GIS process models explain how distribution maps for certain CEs and CAs were created for those features that lacked complete or acceptable distribution data from existing sources. Spatial models for assessments are described in subsequent sections below. In this REA, mapping of actual **distribution** as best possible, whether current known occupied habitat or predicted habitat, was the spatial method employed. Range mapping, which depicts the generalized area of possible occurrence of a species or ecosystem, such as one might find in a wildlife field guide, was too spatially coarse to answer REA management questions, and was therefore not utilized.

3.2.2.1 CE Distribution Models

Spatial modeling for CEs first takes the form of distribution modeling, indicating the probable location of the CE. Most often, this simply refers to the current known location, such as the mapped distribution of, e.g., the Great Basin Lower Montane Riparian Woodland and Shrubland/Stream. However, distributions for CEs take several forms. For some landscape species CEs, spatial distributions are developed for two or three distinct seasonal habitat components. For example, as specified in its conceptual model, mule deer is spatially represented using three distinct map units: summer range, winter range, and year-around range. Terrestrial coarse filter units have been mapped in two forms: their current distribution and their biophysical setting. The biophysical setting, as developed for LANDFIRE, aims to depict the potential distribution of the type, given natural landscape disturbance regimes like wildfire. That is, it is a map for the combination of climate, landform, and soil characteristics that, given assumptions of natural disturbance processes, would likely to support a given vegetation type. Therefore, biophysical setting is useful for approximating the historic distribution of the ecosystem type, prior to alterations by intensive human activities.

One additional form of CE distribution modeling comes in the form of climate envelope models, where the climate variables that characterize the current distribution of the CE are developed, and then forecasted to future decades using the predicted climate distributions. These models should not be construed to predict the future distribution of a given CE, *but rather simply to indicate the degree and magnitude of potential change in climate regime relative to a particular CE*. Below is a summary of the primary methods used in distribution modeling for CEs.

Deductive and Inductive Models

Deductive models use existing mapped information, and then recombine them according to a set of rules determined by the modeler. Working within ArcGIS, ModelBuilder™ was used to describe interactions among spatial data sets. This contrasts with ***inductive models,*** where most commonly geo-referenced observations (e.g., known observations of a given species) are combined with maps of potential explanatory variables (climate, elevation, landform, soil variables, etc.). Statistical relationships between dependent variables (observations) and independent explanatory variables are used to derive a new spatial model (Phillips et al. 2004).

In many instances for this REA, existing data were previously derived through inductive modeling of varying forms. Some included applications of CART, or Classification and Regression Trees to mapping many land cover types (e.g., Lowry et al. 2007). Others applied tools such as Maximum Entropy for deriving distribution models for individual species (see e.g., Phillips et al. 2006, Elith et al. 2011). Review of existing spatial models led to suggestions for their refinement, which were implemented through deductive methods. In other instances, only deductive, or only inductive methods were used to derive wholly new spatial models. Wherever feasible, final models were validated using georeferenced samples that were not previously used in model development. Following is a brief summary to illustrate each category of spatial models. Appendix B Section B-1.2 includes detailed explanations of all spatial models used for CE distributions.

Terrestrial coarse filter CEs were defined and described using the NatureServe ecological systems classification (Comer et al. 2003) and depicted initially with data derived from SW ReGAP, CAGAP, and LANDFIRE EVT (for CA portions); all of which used inductive modeling methods. LANDFIRE BpS and the Great Basin Integrated Landscapes effort (Comer and Hak 2009a) provided two versions of potential distributions. Each of these current and potential distributions was reviewed by NatureServe regional vegetation ecology staff familiar with the western U.S. and the ecosystem concepts, to determine where error occurred that could be addressed using deductive modeling with ancillary spatial data (e.g., landforms, soils, hydrography, elevation, etc.).

Similarly, aquatic/wetland coarse filter CE distributions were developed through similar methods to terrestrial coarse filter CEs. The NatureServe terrestrial ecological systems map depicts current distributions of the primary wetland and riparian components of aquatic coarse filter CEs. These data were reviewed and segmented using SSURGO and STATSGO, where available, for depicting hydric soils with natural land cover; National Wetland Inventory (NWI) as additional back-up for wetland locations; and NHD Plus (1:100K and 1:24K scale data) for streams, lakes, intermittent washes, and playas. Multiple source data sets on desert spring and seep locations were acquired, reconciled, and combined to create one dataset of spring and seep locations.

Landscape Species and Species Assemblages

Landscape Species CE distributions were either directly from BLM and REA partners (e.g., Greater sage-grouse, mule deer, desert bighorn sheep); or derived through deductive modeling steps (e.g. pygmy rabbit, prairie falcon and kit fox). Some landscape species were represented spatially using multiple habitat components (e.g., winter range vs. summer range for mule deer), as established in conceptual models and then articulated as distinct spatial models. Southwest ReGAP maps provided the starting point for most landscape species, with existing habitat location or habitat suitability models available for all but the California portion of their distribution. The same rules were applied (e.g., vegetation type, elevation thresholds, etc.) to extend these models into California as appropriate. See species-specific summaries in Appendix B Section B-1.2.5 for detailed explanation. For ecologically-based species assemblages, Maximum Entropy (Maxent) was used with available georeferenced observations to produce a probability surface for suitable habitat that might support a given CE (e.g., Guisan and Thuiller 2005, Liu et al. 2005). Map surface inputs included vegetation type, vegetation structure, climate variables, landform, landscape position, and soil variables among others. These models provide limited predictive power for the actual occurrence of CE populations but can provide a powerful indication of the location of habitats that are most similar to known occupied habitat. Again, see Appendix B Section B-1.2.4 for detailed explanations of each species assemblage model.

Local Species

Local species data were derived primarily from field observations and/or Element Occurrence records from Natural Heritage programs. For overview and detail of Natural Heritage Program methodology, see http://www.natureserve.org/prodServices/heritagemethodology.jsp. Species presumed to be addressed in the REA through assessment of coarse filter CEs, and those local-scale species to be treated within summaries by watershed, required no additional modeling steps; Section B-1.2.8 of Appendix B has a complete explanation.

3.2.2.2 Change Agent Distributions

Current distribution data for the broad group of CAs were highly variable. Following are situations where CA distribution modeling was required and general approaches used. Specific information is found in the appendices (see Appendix A Section A-1.2 in particular) and in output metadata.

Class I Wildfire

As a change agent, wildfire was treated in two distinct forms: a) mapping known fire perimeters and b) gauging fire regime departure for landscapes supporting a given CE. Documented fire perimeters were derived from BLM-managed and nationally-standardized data sets for events occurring since 1980. Fire perimeters up through 2007, in combination with invasive annual grass models (see methods cited below), were used to update LANDFIRE Succession Class (SClass) maps, which had been previously completed using 2000-2002 satellite imagery (see Vogelmann et al. 2011). Fire regime departure information built upon extensive investments by the LANDFIRE effort (see e.g., Keane et al. 2006, Rollins and Frame 2006) for both conceptual and spatial modeling for this REA. For each applicable coarse filter CE, a state-and-transition model was developed using the Vegetation Dynamics Development Tool (VDDT) and simulations were run in the Path Landscape Model (ESSA Technologies). Models initially characterize Natural Range of Variation (NRV), and then integrate altered conditions (e.g., invasive plant effects) for forecasting trends. Original LANDFIRE models were updated by the Nevada Chapter of The Nature Conservancy, prior to initiation of the REA. See Appendix A Section A-1.1.3 for detailed explanations of all fire-regime models.

The departure measure used here is the LANDFIRE FRCC Departure Index. This indicator gives a summary of how departed the final conditions resulting from each model run are from the reference landscape conditions. It is calculated by comparing the reference percentage of each succession class (SClass) to the percentage resulting from a given model run. See Appendix A Section A-1.1.3 for detailed explanation of departure calculations. Fire regime departure was reported for each CE by the 5th-level watershed. For each fire-dependent CE, where its areal extent was over 10% of the total watershed area, an estimate of current (and forecasted) fire regime departure was calculated. These calculations compare tabular estimates of NRV Succession Class Distributions against observed SClass distributions from updated LANDFIRE SClass maps for each watershed. This calculation of departure provides a 0-100% score for each CE within each watershed.

Since SClass maps were updated to approximately 2007 for the REA, information was available to provide new “starting conditions” for simulating a forecasted set of successional proportions out to 2060. While it was infeasible to complete this type of simulation for each watershed, the predominant 2-5 combinations of current SClass proportions was developed for each CE as the basis for these forecasts. For example, for a given CE there might be three most-characteristic forms of current SClass proportions, representing minimal, moderate, and more extreme fire regime departure. The SClass combinations most characteristic of those three types are known, and tied to their relevant watersheds today. Once forecasted models were completed for each type/departure combination, their resultant scores were tied back to the relevant watershed for REA reporting.

Class II Development

Distribution information for development CAs was generally sufficient for REA purposes. Specific development CAs requiring distribution modeling and their methods follow:

Urban Development

Existing land cover maps are inadequate to depict low density “exurban” type development and urban growth modeling is required to project where development is most likely to occur in the future. While urban development was not modeled as a part of the REA process, information was extracted from previous modeling work. The Integrated Climate and Land Use Scenarios (ICLUS) and its related spatial database, Spatially Explicit Regional Growth Model (SERGoM) (USEPA 2010) to represent the “urban footprint” for current, 2025 and 2060 scenarios. SERGoM data uses U.S. Census block housing units, protected lands, groundwater well density, and road accessibility to estimate housing density. The Urban Development class for this REA applies one footprint to a wide array of housing density classes put forth in the ICLUS/SERGoM data set. The AMT agreed that the threshold between urban and rural development would be defined as 160 acres per housing unit. Areas where housing density exceeded this threshold would be considered developed. This was consistent with the classes defined by the ICLUS/SERGoM and captures exurban residential classes (very low density residential development). Most rural ranchlands common in the ecoregion occur in areas of housing density less than 160 acres per housing unit and are therefore not considered urban.

Recreation

Relative levels of dispersed recreation use were modeled through established approaches (e.g., Theobald 2008) that combined data on population with accessibility. This assumed that the majority of visitors to BLM and other public lands accessed these areas via the road transportation infrastructure via an automobile. This approach relies on three fundamental components: *push* (population centers), *pull* (known features that draw visitors), and *access* (the road network and known access points). In response to comments and suggestions obtained at AMT workshops, four types of recreation were modeled: aquatic (fishing, boating), non-motorized recreation, and two forms of motorized recreation (OHV enthusiast, and OHV hunter/rockhounder). Future scenarios of recreational use were developed using census population projections at the urban centers for 2030. Relatively high uncertainty in this modeling led to the conclusion to use the outputs only for recreation-specific MQs and not to combine them with other CAs in other assessments.

Disturbed lands (mines and landfills)

The results of this model depict barren areas representing active or non-reclaimed inactive mines and landfills/refuse areas in the Central Basin and Range ecoregion. Mines and landfills were intended to be represented by two separate datasets. However, after accuracy assessment results indicated that the two classes were frequently cross-identified (e.g., tailing piles as landfills), the AMT elected to combine the two classes to form one theme. To improve the map, additional data were provided by BLM (abandoned mining lands) and further refinement was done by digitizing mine locations using recent air photos (see Appendix A). A final accuracy assessment was conducted by selecting a random sample of 20 input points verifying these places with digital air photos and USGS topographic maps. Model distributions of future mines or landfills was not required of the MQs and thus not conducted.

Relative Landscape Condition

Ecological condition commonly refers to the state of the physical, chemical, and biological characteristics of natural ecosystems, and their interacting processes. Many human land uses affect ecological condition, (e.g., through vegetation removal or alteration, stream diversion or altered natural hydrology, introduction of non-native and invasive species, etc.). Landscape condition assessments commonly apply principles of landscape ecology with mapped information to characterize ecological condition for a given area (e.g., USEPA 2001, Sanderson et al. 2002). Since human land uses - such as built infrastructure for transportation or urban/industry, and land cover such as for agriculture or other vegetation alteration – are increasingly available in mapped form, they can be used to spatially model inferences about ecological stress and ecological condition.

Maps of this nature can be particularly helpful for identifying relatively unaltered landscape blocks, or for making inferences about the relative ecological integrity of natural habitats on the ground. They can also be used for screening ecological reference sites; i.e., a set of sites where anthropogenic stressors range from low to high. Ecological condition within reference sites is often further characterized in the field to determine how ecological processes respond to specific stressors, but spatial models can provide a very powerful starting point to build upon (Faber-Langendoen et al. 2006, 2012). Knowledge from reference sites may then apply to surroundings for many types of environmental decisions.

The **Landscape Condition Model** (LCM) used in this REA builds on a growing body of published methods and software tools for ecological effects assessment and spatial modeling; all aiming to characterize relative ecological condition of landscapes (e.g., Knick and Rotenberry 1995, Forman and Alexander 1998, Trombulak and Frissel 1999, Theobald 2001, Seiler 2001, Sanderson et al. 2002, Riitters and Wickham 2003, Brown and Vivas 2005, Hansen et al. 2005, Leu et al. 2008, Comer and Hak 2009a, Theobald 2010, Rocchio and Crawford 2011). The intent of this model is to use regionally available spatial data to transparently express user knowledge regarding the relative effects of land uses on natural ecosystems and habitats. The authors' expert knowledge forms the basis of stressor selection, and relative weightings, but numerous examples from published literature have been drawn upon to parameterize the model for application in this ecoregion. Independent data sets were drawn upon for subsequent model evaluation. This current model has been developed and evaluated for the entire western United States, and then customized for use within the ecoregion. Western regional model development and evaluation was completed in cooperation with the Western Governors Association landscape connectivity working group (J. Pierce pers. comm. 2012, Comer and Hak *in prep*).

See Appendix B Section B-1.4.1 for a detailed description of the model. Each input data layer is summarized to a 90m grid and, *where the land use occurs*, given a **site impact score** from 0.05 to 0.9 (Table 3-1) reflecting presumed ecological stress or impact. Values close to 1.0 imply relatively little ecological impact from the land use. For example, a given patch of 'ruderal' vegetation – historically cleared for farming, but recovering towards natural vegetation over recent decades, is given a Very Low (0.9) score for site impact as compared with irrigated agriculture (High Impact 0.3) or high-density urban/industrial development (Very High Impact 0.05). Certainly, there are some ecological values supported in these intensively used lands, but their relative condition is quite limited when compared with areas dominated by natural vegetation (Table 3-1).

A second model parameter – *again, for each data layer* - represents a **distance decay** function, expressing a decreasing ecological impact with distance away from the mapped location of each feature as applied to the Euclidian Distance value described above (Table 3-1). Mathematically, this applies a Geographically Weighted Regression function, based on the formula that characteristically describes a "bell curve" shape that falls towards plus/minus infinity (Appendix B Section B-1.4.1). Those features given a high decay score (approaching 1.0) result in a map surface where the impact value dissipates within a relatively short distance. Those features given a low decay score (approaching 0.0) create a map surface where the per-pixel impact value dissipates more gradually with distance away from the impacting feature. Values for each layer will approach 1.0, symbolizing negligible impact, at the distance listed in the right-hand column (Table 3-1).

A second LCM was developed for the 2025 time frame; this utilized the same input development datasets as for the current LCM. Only four development features had projected changes by 2025: an urban growth forecast for the year 2030 by the ICLUS/SERGoM; the Section 368 transmission corridors (West-wide Energy Corridor Programmatic EIS); approved and priority renewable energy projects on federal land that have begun the environmental permitting process with BLM (but are not yet approved as of May 2011); and the Solar Energy Programmatic EIS Zones (SEZs).

The result is a map surface indicating relative scores between 0.0 and 1.0 (Figure 3-1). This provides one composite view of the relative impacts of land uses across the entire ecoregion. Darker green areas indicate apparently least impacted areas and orange to red areas most impacted.

Table 3-1. Ecological stressor source, site-impact scores, and distance decay scores implemented for the landscape condition model for CBR

Ecological Stressor Source	Site Impact Score	Presumed Relative Stress	Distance Decay Score	Impact Approaches Negligible
Transportation				
Dirt roads, 4-wheel drive	0.7	Low	0.5	200m
Local, neighborhood and connecting roads	0.5	Medium	0.5	200m
Secondary and connecting roads	0.2	High	0.2	500m
Primary Highways with limited access	0.05	Very High	0.1	1000m

Ecological Stressor Source	**Site Impact Score**	**Presumed Relative Stress**	**Distance Decay Score**	**Impact Approaches Negligible**
Primary Highways without limited access	0.05	Very High	0.05	2000m
Urban and Industrial Development				
Low Density Development	0.6	Medium	0.5	200m
Medium Density Development	0.5	Medium	0.5	200m
Powerline/Transmission lines	0.5	Medium	0.9	100m
Oil /gas Wells	0.5	Medium	0.2	500m
High Density Development	0.05	Very High	0.05	2000m
Mines	0.05	Very High	0.2	500m
Managed and Modified Land Cover				
Ruderal Forest & Upland	0.9	Very Low	1	0m
Native Veg. with introduced Species	0.9	Very Low	1	0m
Pasture	0.9	Very Low	0.9	100m
Recently Logged	0.9	Very Low	0.5	200m
Managed Tree Plantations	0.8	Low	0.5	200m
Introduced Tree & Shrub	0.5	Medium	0.5	200m
Introduced Upland grass & forb	0.5	Medium	0.5	200m
Introduced Wetland	0.3	High	0.8	125m
Cultivated Agriculture	0.3	High	0.5	200m

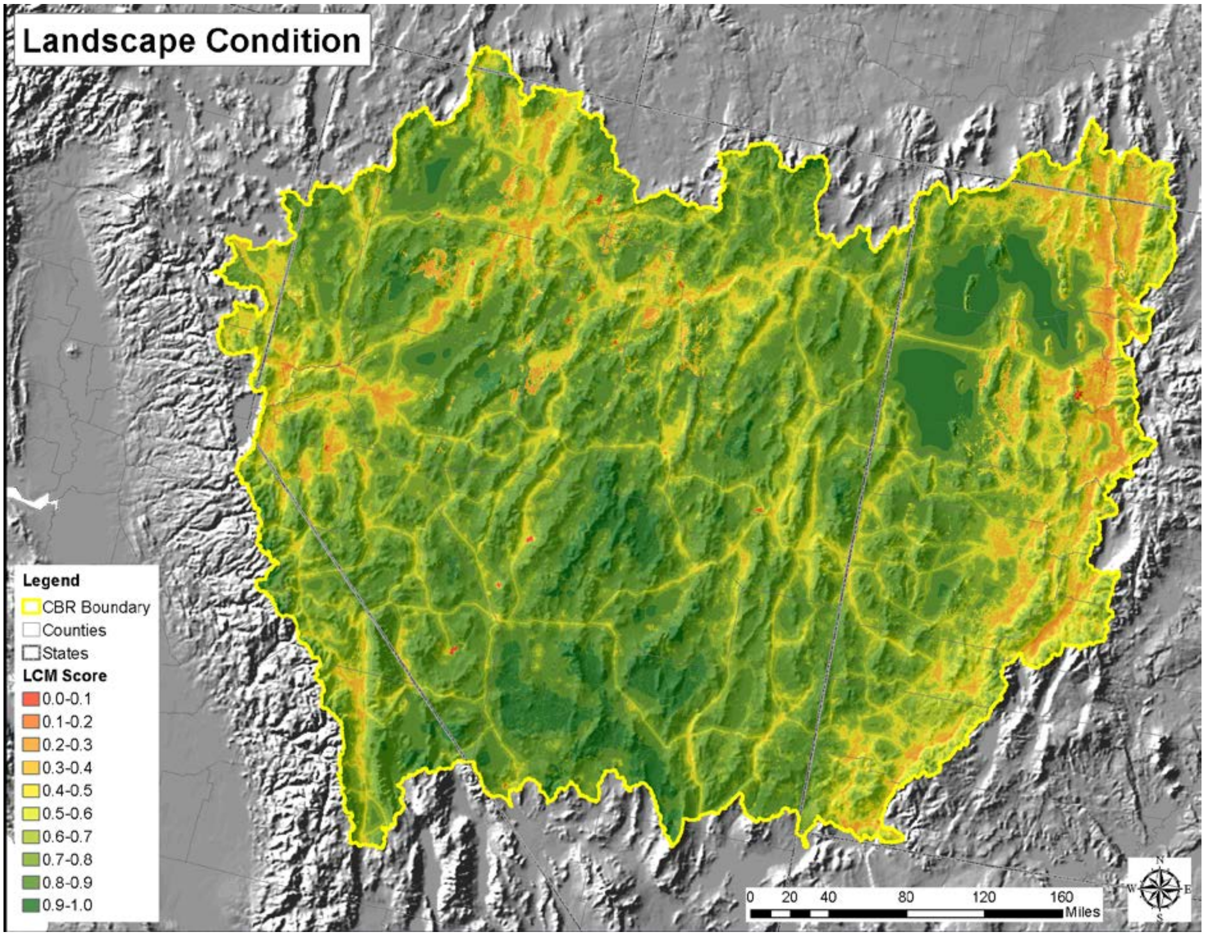

Figure 3-1. Landscape Condition model (90 m) for the Central Basin and Range ecoregion. Darker green areas indicate apparently least impacted areas and orange to red areas most impacted.

Class III Invasive Species

Invasive Plant Species

To leverage existing location records of invasive species, spatial models of potential presence and/or abundance were developed for three floristic groups: biennial and perennial forbs, woody species invasive to riparian areas, and annual grass species. A spatial model was developed for each group utilizing a combination of inductive and deductive modeling methods to define areas of high potential for their occurrence. See Appendix A Section A-1.2.2 for detailed explanation of these models. Using the master database of plant locality records with a suite of environmental variables and inductive modeling with Maximum Entropy and CART methods, the resultant surfaces for biennial and perennial forbs, and for woody riparian species, represent their potential presence. Since georeferenced samples for invasive annual grasses tended to include relative cover values, five distinct models were developed to indicate the potential for their presence in a series of abundance levels (<5%, 5-10%, 10-25%, 25-45%, and >45%).

Aquatic Invasive Species

An index of aquatic invasive species impact was developed and implemented; it was reported for each 4th and 5th level watershed (see Appendix A Section A-1.2.2 for details). The Aquatic Invasive

Species Index reports both within each watershed and potential for invasives surrounding each watershed.

Class IV Climate Change

Climate change represents a globally pervasive stress on natural ecosystems. Temperature and precipitation regimes drive ecosystem productivity and natural dynamics, such as the rate of plant growth, the frequency of natural wildfire, and the seasonal flow of streams. Paleoecology has shown that past episodes of climate change triggered ecosystem change at regional and local scales with varying speed and intensity (e.g., Wells 1983, Betencourt et al. 1990). As the current rate of global change increases, society can expect profound shifts in key ecological processes to cascade through natural systems, resulting in altered productivity, changes to species composition, local extinctions, and many instances of ecological degradation or collapse (IPCC 2007b).

Currently we do not sufficiently understand the many linkages between key climate variables and ecosystem dynamics across diverse landscapes of this ecoregion. One certain conclusion that we can draw from our collective experience is that communities and ecosystems will not simply 'move' as climate changes, but will instead transform in unprecedented ways because of the controlling link between climate and many ecosystem processes (Fagre et al. 2009); including the individualistic responses of species (Gleason 1926, Finch 2012). Studies attempting to address these issues in the interior southwest include Neilson et al. 2005, Rehfeldt et al. 2006, Archer and Predick 2008, Bradley 2010, Abatzoglou and Kolden 2011, Rowland et al. 2011, and Finch 2012, among others.

Two main forms of analysis included a) evaluation of climate space trends across the ecoregion; and b) analysis of potential change in climate envelopes for selected terrestrial CEs. The spatial modeling work for climate change in this REA is detailed in Appendix A Section A-1.2.4 (climate space trends), and Appendix B Section B-1.3 (climate envelopes for CEs). Climate space trends analysis aims to document and compare forecasted trends in climate variables against measured values from the 20th century. The period of 1900-1980 serves as a practical baseline for comparison. This time period was chosen because a) it started with the oldest available climate records suitable for our purpose, and b) approximately 1980 was the point at which a human influence on climate change has been documented (Lee et al. 2006, Solomon et al. 2007). Subsequent interpretation of climate space trend results aimed to gauge potential climate change impacts on hydrologic and fire regimes in the ecoregion. Climate envelope analysis first describes the set of values for temperature and precipitation variables that characterize the current distribution of a given CE. Then, the same combination of variables is mapped using climate forecasts for upcoming decades. The comparison of forecasted to current climate envelope distributions provides one indication of the direction and magnitude of potential climate-induced stress for a given CE.

Climate Space Trend Analysis

Future climate space was derived from a large number of climate models vetted for the IPCC's 4th Assessment Report (IPCC 2007a). Only the A2 greenhouse gas emissions scenario was examined in the climate-related forecasts for this REA because it best represents the trajectory of greenhouse gas emissions today. Available climate data sets for this REA differed in terms of a) spatial resolution, b) supplied climate variables, and d) temporal data available to form a 'current' baseline and future time periods. The primary time period for forecasts included the mid-century period (2050-2070) summarized by 4km^2 and 15km^2 grid. The grid sizes were determined by the source data sets, with EcoClim data being 4km^2 resolution, and USGS Hostetler data being 15km^2 resolution. EcoClim data provide a longer time period for establishing baseline climate regime – extending back to 1900, while the USGS data set enabled characterization of 'baseline' conditions as of 1980. EcoClim data provided a limited suite of climate variables (monthly values for Minimum Temperature, Maximum Temperature, and Total Precipitation; or TMin, TMax, Total Precip) while the USGS Hostetler data set included numerous options for daily, monthly, and annual estimates, including Growing Degree Days, monthly evapotranspiration, monthly snow-water equivalents, etc. (see Appendix A Section A-1.2.4). For Ecoclim analyses, graphs were used to initially investigate the magnitude of change between modeled future seasonal climates and observed historical and current climates, as defined by monthly characterization of temperature and precipitation. For both Ecoclim and USGS data sets, historic mean and standard deviations for each variable from each grid cell were compared against forecasted estimates. Those variables forecasted to reach outside of 1 and 2 standard deviations from the baseline mean were highlighted spatially for further analysis. These spatial data were then summarized for ecoregion-scale interpretations (see Section V and Appendix A Section A-2.2.2).

Climate-Change Effects on Dynamic Processes

The potential impacts of climate change on aquatic coarse filter CEs were explored using output from the above-described climate space trends analysis using both the Ecoclim and USGS Hostetler climate data. Map output from that analysis indicated grid cells with substantial forecasted deviation from baseline mean values. These mapped areas were overlain on aquatic CE distributions. Qualitative assessment and interpretation of these forecasted relationships focused on the potential consequences of these departures for watershed hydrology, specifically for recharge, runoff and evapotranspiration rates (see Section V and Appendix D Section D-2.3.2).

Fire regime models developed for terrestrial coarse filter CEs provided one avenue for exploring potential climate-change effects in uplands (Appendix B). Given broader identified patterns of temperature and precipitation, models for major vegetation types were evaluated for the potential to include plausible changes in expected fire return interval that might result from frequent drought and/or indirect effects of invasive species spread. This enabled qualitative assessment of the relative contribution of climate-change on fire regimes in the ecoregion over upcoming decades.

Spatial Trends in CE Climate Envelopes

In order to provide one indication of the direction and magnitude of potential climate-induced stress for individual CEs, PRISM (4 km^2) climate data were used to identify statistical correlations between a systematic grid-selection of observed locality data and current climate (TMax, TMin, Total Precip). Maximum Entropy was the software algorithm applied in this analysis; resulting in a map of the CEs current climate envelope. This provides an indication of the relative significance of certain climate variables that appear to strongly influence CE distribution, such as the precipitation in summer months, or minimum temperature in certain winter months. This relationship was then forecasted using EcoClim data to map climate envelope distributions out to the 2030s and 2050s, based on decadal averages from future climate scenarios. This analysis was applied to major vegetation and landscape species CEs. It was **not** applied to coarse filter CEs whose distributions are strongly constrained by geophysical features (e.g., dunes, cliff & canyon, aquatic CEs); but instead applied to CEs where a shifts in climate envelope might provide useful insights into the potential direction and magnitude of range shift to be experienced by individual species. This approach did not presume that current distributions delineate all biophysical limits of each CE distribution, but rather that they reflect current central tendencies of these foundational climate variables for that distribution. Suggestions to include additional non-climate variables in these models were rejected because in many instances their forecasted distribution could not be reliably established for the 2030s or 2050s time periods. For example, vegetation composition and structure both have substantial influence on many landscape species distributions. However, in nearly all cases these factors are not fully understood, and future distributions of these variables cannot be reliably forecasted to 2030s and 2050s. Therefore, a more pragmatic approach was taken, focusing on climate variables alone.

Results for each CE were combined in maps indicating zones of potential 'contraction' 'expansion' and 'overlap' with current envelope distribution (see Section V and Appendix B Section 2.4.2). The analysis included here centers on combinations where two or more forecast models agree on distributions for the 2050s. However, all individual models and analyses for the 2030s were provided to BLM for subsequent detailed analysis.

Building on these climate model results, ecologists should have additional insight for understanding the probable nature of habitat change within the ecoregion for upcoming decades, and be better able to develop practical strategies for climate change adaptation.

3.2.3 Assessment Models

The general assessment model is depicted in Figure 3-2. This is a scenario-based model for the specific timeframes of the AMT MQs: 2011, 2025, and 2060. The 2011 assessment deals with existing CE and CA distributions and conditions on the landscape. 2025 deals primarily with expansion of development CAs. 2060 includes modeled urban expansion but primarily deals with modeled climate changes. As indicated in the figure, the scenarios are cumulative meaning that CA effects beginning with 2011 are added to the subsequent scenarios such that the 2060 scenario is an aggregation of current CA distributions, 2025 expanded CA distributions, and 2060 expanded CA distributions.

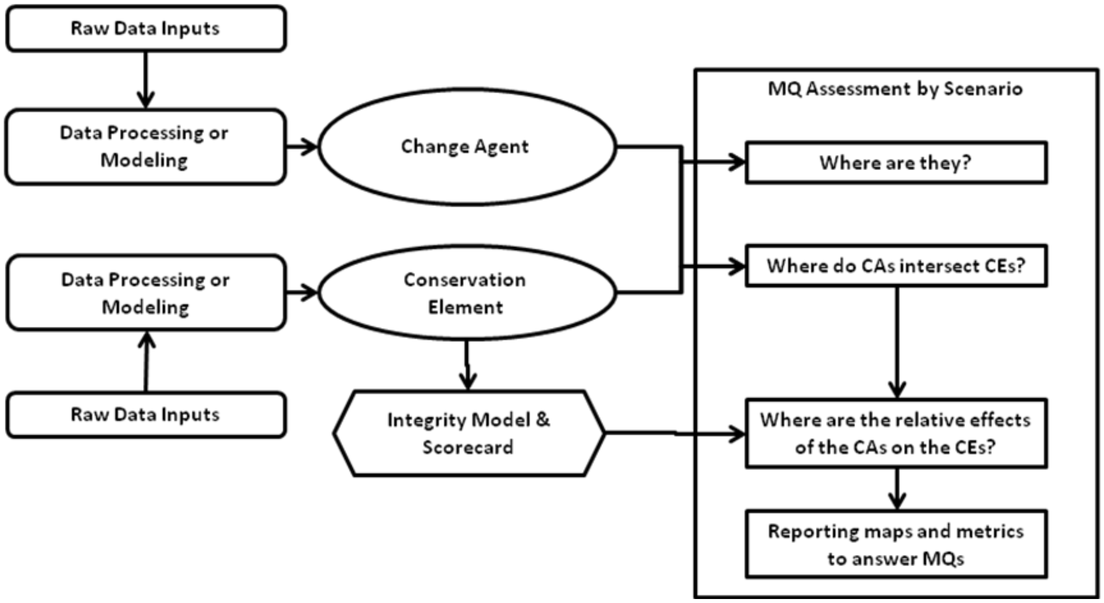

Figure 3-2. General Conceptual Model of Ecoregional Assessments

Each assessment was first proposed as a graphical model specifying inputs, analytical (typically geospatial analyses) processes, and outputs. These models were reviewed by the AMT and revised as needed. Several were prototyped which resulted in further refinement. Models were converted to ESRI Model Builder models to conduct the work and were provided as such to BLM.

Following the assessment hierarchy of Figure 3-2, modeling methods for these assessments are briefly summarized; further details are presented in the spatial modeling sections of the appendices and in the metadata of outputs.

3.2.3.1 Where are the CEs?

In addition to above mentioned distribution models that simply indicate where a given CE is likely to occur throughout the ecoregion, a 'gap analysis' was completed by overlaying current distributions of all CEs with two combinations of lands. The first simply summarized areal extent by major land managing agency throughout the ecoregion. The second completed a similar overlay, but instead of land managing agency, the analysis focused on categories of land management. This analysis used lands designated in the national Protected Areas Database (PADUS) as "GAP Stewardship Status 1 and 2" lands. These indicate current designated lands, such as National Parks, ACECs, and other protected areas where biodiversity conservation is a very strong focus of management. A second category of land management priority includes lands identified as 'high priority' priority sites, but not designated as such. Summary statistics for each CE indicate proportional representation within current designated protected areas, additional areas identified as 'high priority' for protection, and all other lands.

3.2.3.2 Where do CAs Intersect CEs?

After generation of CAs and their aggregation into the respective scenarios, CAs and CEs were intersected to answer the initial part of MQs asking where and to what degree CAs may co-occur with CEs. Outputs include the option to develop maps of each CE distribution with areas of CA intersect indicated with a separate value for the overlapping CA or more than one CA. Statistics on the area and proportion of the CE overlapped by each CA and total area and proportion of the CE overlapping with all specified CAs are included. Several MQs indicate the desire to report these findings in terms of specific management units, such as herd management areas and grazing allotments. These results are provided in Appendix D Section D-2.1.

3.2.3.3 Where are the relative effects of CAs on CEs?

Beyond reporting on the potential co-occurrence of CAs and CEs, relative effects of those co-occurrences are primarily addressed by gauging ecological status of CEs within a given assessment scenario (i.e., current conditions vs. forecasted conditions at 2025). The approach taken was based upon existing methods (e.g., Parrish et al. 2003, Faber-Langendoen et al. 2006, Unnasch et al. 2008, Faber-Langendoen et al. 2012) aiming to gauge ecological integrity. Ecological integrity is 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. Therefore, methods for assessment first aim to characterize reference conditions for each CE, including natural composition, structure, and dynamic processes (Parrish et al. 2003, Unnasch et al. 2008) and then characterize common stressors and their observed ecological effects (Faber-Langendoen et al. 2012).

For the REA, this characterization is done in the CE conceptual model (Appendix B Section B-1.1). Conceptual models for each CE were used to characterize natural attributes, primary change agents, and current knowledge of their effects on each CE. Current knowledge of CA effects on CEs was documented to reliably differentiate where CAs are likely to cause ecological stress to a given CE. Where CAs can be viewed as 'stressors' to CEs, the potential responses to each stressor was identified. Measurable indicators were then identified to gauge that effect.

NatureServe's ecological integrity framework (Faber-Langendoen et al. 2006, Unnasch et al. 2008, Rocchio and Crawford 2011, Faber-Langendoen et al. 2012) provides a practical approach to organize criteria and indicators for this purpose. This framework results in a scorecard for reporting on the ecological status of a given CE within a given location and, if needed, facilitates the aggregation and synthesis of the component indicator result for broader measures of ecological integrity at broader scales. Using this framework, indicators are chosen to provide a measurement for a limited set of **key ecological attributes** for each CE. Key ecological attributes (KEAs) are the critical patterns of biological structure and composition (key ecosystem states) and the critical ecological processes, environmental regimes, and other environmental constraints that dictate their natural variation over space and time (key ecosystem dynamics) (Parrish et al. 2003). KEAs for a given CE may include natural characteristics, such as native species composition, or stressors, such as effects of invasive species, or other relevant change agents that are well known to affect the natural function and integrity of the CE.

KEAs, in generalized form, are briefly described and justified in the right-hand column of Table 3-3. For example, "landscape condition" is identified as a key ecological attribute, applicable to all CEs. Landscape dynamics that support ecological systems or species habitat are affected by fragmenting effects of land use (Franklin 1993, Farig 2003). Land use impacts vary in their intensity where they occur, as well as their ecological effects with distance; so an indicator aiming to characterize stressors to landscape condition for each CE is appropriate to address this KEA. Another KEA example includes contiguous "extent" or patch size; e.g., the area of unfragmented riparian corridor required to support natural flooding and sediment deposition and scour processes upon which aquatic and wetland species depend (Allan 2004).

Components of an overall CE conceptual model are illustrated below (Figure 3-3 and Figure 3-4) where KEAs have already been identified. These illustrate assumptions about linkages between CAs and Stressors (A), Stressors and expected Responses (B) and the Indicators used to gauge Stressors and their Responses (C), for a given CE.

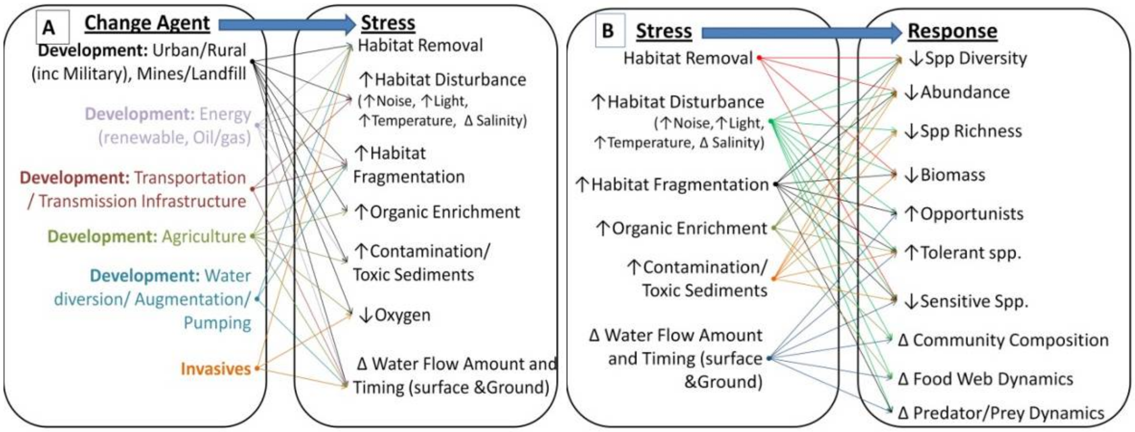

Figure 3-3. Example of conceptual model linking change agents, ecological stressors and their anticipated effects for a wetland/aquatic coarse filter CE

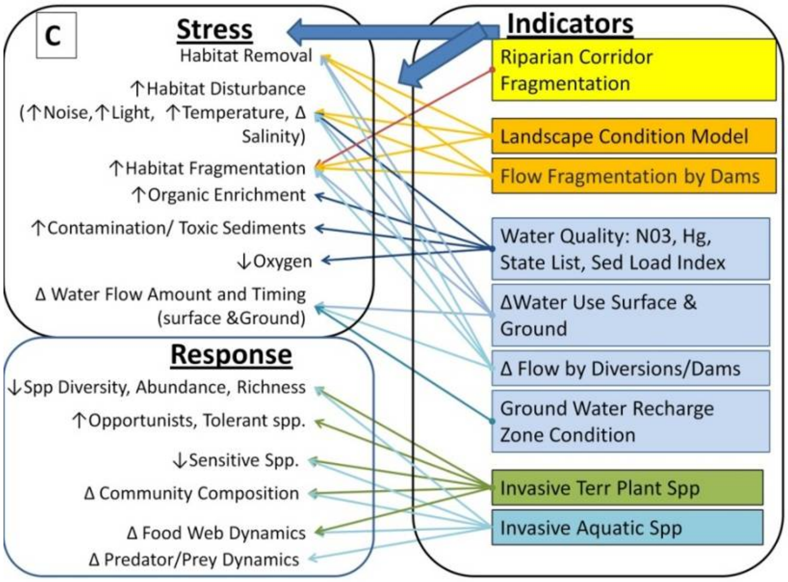

Figure 3-4. Example of conceptual model linking ecological stressors and their anticipated responses to their measurable indicators for a wetland/aquatic coarse filter CE

With these observations and assumptions described, indicators are identified and measured to compare current or forecasted conditions to reference conditions; resulting in a series of ecological status scores for each CE. Given the rapid and regional nature of an REA, stressor-based indicators were relied upon. Many direct measures of ecological condition require field-based observation and measurement, while many indicators of ecosystem stress can be addressed using remote sensing and spatial modeling. The primary reporting unit for ecological status of CEs is the 5th level watershed; however, for landscape species and the species assemblages, a 4 km^2 grid was used at the request of BLM to match the spatial scale of adjacent REAs being completed by other contractors.

Spatial models reflecting these indicators therefore serve as the link between the conceptual models and the spatial representation of ecological status. Again, Table 3-3 provides a summary of KEAs and indicators applicable to CEs in the ecoregion. The table also indicates the subset of CEs where a given KEA and/or indicator has been applied. In the table, the KEAs are organized by major rank factors of **Landscape Context**, **Condition,** and **Relative Extent**. Again, Appendix B Section B-1.4 includes summary listing of indicators used for each CE, and detailed explanations of each indicator where spatial models were developed.

3.2.3.4 Aggregated Ecological Status Scores

The Ecological Status Scorecard is designed to report on ecological status indicators for individual CEs and for aggregated groupings of CEs (e.g. all aquatic coarse filter CEs with the same KEAs or indicators applied). The score is normalized between 0 and 1 with 1 being highest ecological status and 0 being lowest. Displaying the indicators with individual scores allows user to interpret which particular ecological attribute in a reporting area is driving the ecological status of the CE. The mean index scores of these indicators may then be averaged by each Key Ecological Attribute (where >1 indicator score is available). For example, for a given aquatic CE, indicator scores for *Condition of Groundwater Recharge Zone*, *Flow Modification by Dam, Ground Water Use, Perennial Flow Modification by Diversion Structures,* and *Surface Water Use,* have been reported individually and averaged for an overall score for the Key Ecological Attribute of ***Hydrologic Condition*** (see Appendix B Section B-2.1.4 for detailed explanation of the KEA Hydrologic Condition).

Where broader patterns among indicator scores are desired, the ecoregional conceptual model (Figure 2-3 and Figure 2-4) provides a practical framework for grouping together coarse filter CEs and their component ecological status scores. For example, *Fire Regime Departure Index* scores were reported for each applicable coarse filter element (e.g., *Great Basin Pinyon-Juniper Woodland*) and for the Level 2 aggregation of four woodland types listed under *Subalpine/Montane Forests & Woodlands* (see Table 2-2 in the Introduction).

3.2.4 Summary Indices of Ecological Integrity

A simple, overall index of ecological integrity was desired to summarize conditions in the ecoregion. However, upon review of the various options for building such an index, several factors contributed to the conclusion that several distinct, but complimentary, indices would provide the best summary information on ecological integrity. The first factor was the distinct nature of many groups of CEs and their chosen indicators of ecological integrity or status. Combining results for terrestrial coarse filter, landscape species, and aquatic CEs implies the combination of scores for indicators that are decidedly non-complimentary (e.g., scores for water quality having very limited effect on terrestrial ecological integrity). A second factor was that two primary spatial reporting units were selected for use in the REA. As previously mentioned, the 5th level watershed unit was selected as one primary reporting unit. This reporting unit was appropriate for addressing aquatic integrity; it was also relied upon to encompass sufficient area of upland vegetation to address indicators of fire regime departure for individual vegetation CEs. However, in the latter case an overall score for fire regime departure, if summarized by watershed would necessarily combine scores for high and low elevation vegetation types. Therefore, four summary indices of integrity, reported by watershed, were developed. The first summarized fire regime departure scores for types falling with Montane Upland and Basin Upland categories of the ecoregion-wide conceptual model (Table 2-2). Aquatic integrity was reported at the 5th level watershed for the KEAs of hydrologic condition and water quality. Discussion with the AMT during several workshops supported this approach.

In addition, a 4 km^2 grid was used to report on overall indicators of Landscape Condition Index (Table 3-2) and Invasive Annual Grass Index (Appendix B Section B-1.4.1), providing two additional ecoregion-scale summary indices of ecological integrity. This approach resulted in six complimentary, summary indices of ecological integrity (Table 3-2).

Table 3-2. Summary indices of ecological integrity with associated reporting units

Summary Indicator	Montane Upland	Basin Upland	Aquatic/Wetland, and Riparian
Landscape Condition	4km^2 grid		
Invasive Annual Grass	4km^2 grid		
Fire Regime Departure	Watershed	Watershed	
Hydrologic Condition			Watershed
Water Quality			Watershed

Table 3-3. Indicators used for ecological status assessment of CBR Conservation Elements (*italics indicates applicable CE categories*)

Indicator	**Definition** *(all scaled to 0-1 score)*	**KEA & Indicator Justification**
Rank Factor: Landscape Context		
Key Ecological Attribute: Landscape Condition *(all CE types)*		
Landscape Condition Index	This indicator is measured by intersecting the mapped area or habitat distribution map of the CE with the LCM layer and reporting the average LC index value for the CE or habitat within each 5th level watershed, or 4x4 km^2 units for species. Landscape Condition Index is a 90x90 m^2 unit resolution map surface that incorporates a land use intensity rating and a distance decay function, reflecting decreasing ecological impact with distance from the source. The results are a score for landscape condition from 0 to 1 with 1 being very high landscape condition and values close to 0 likely having very poor condition (*see Appendix B for detail of variations in application among CEs*).	Ecological conditions and landscape dynamics that support ecological systems or species habitat are affected by fragmenting effects of land use (Franklin 1993, Farig 2003). Land use impacts vary in their intensity where they occur, as well as their ecological effects with distance.
Key Ecological Attribute: Landscape Connectivity *(applied only to Greater Sage-Grouse Leks)*		
Landscape Connectivity Index	This indicator provides a measure of relative landscape connectivity from the perspective of a given CE for each 270 m^2 grid cell that defines its distribution. The spatial index is derived from output of a *CircuitScape* model (http://www.circuitscape.org), which applies circuit theory to an algorithm that evaluates potential landscape connections across the individual CE distribution. The Landscape Condition Index surface (a 90 m^2 grid rescaled to 270 m) for the ecoregion is used as a 'resistance surface' for *CircuitScape* to characterize relative landscape connectivity among population locations (in the case of Greater sage-grouse, lek localities). Relative connectivity is measured as 'current flow' values per 270 m^2 grid cell. Highest current flow areas depict connectivity zones where high-levels of species movement might expect to be concentrated. The 270 m^2 connectivity surface is overlaid on the distribution of the CE and average square unit values are calculated per 4 km^2 grid cell. The resulting index values range from 0 to 1, with 0 having 1 having very high importance for connectivity.	The relative degree of landscape connectivity affects the movement of individuals of a species, potentially constraining access to critical habitat resources (Knick and Rotenberry 1995, Farig 2003).

Indicator	Definition *(all scaled to 0-1 score)*	KEA & Indicator Justification
Key Ecological Attribute Surrounding Watershed Land Use Context *(Aquatic CEs only***):**		
Perennial Flow Network Fragmentation by Dams	Number of intersections with NHD perennial streams. The total number of intersections per watershed defines the index score.	The degree of fragmentation of continuous aquatic habitat directly affects processes and populations for aquatic species (Allan 2004, Ward and Stanford 1989).
Rank Factor: Relative Extent		
Key Ecological Attribute: Relative Extent *(selected terrestrial coarse filter CEs only)*		
Change in extent	This indicator is assessed by comparing the mapped current extent (circa early 2000s) of the CE, per 5th level watershed, with the mapped extent of the biophysical setting (BpS) layer for the same CE, reporting the percent change between the two extents (positive or negative).	The proportion of change due either to conversion to other land cover or land use, or potentially its expansion due to alterations to natural disturbance processes, can provide a useful indication of alteration to natural disturbance regimes (Noss et al. 1995).
Key Ecological Attribute: Extent / Size *(riparian/riverine aquatic CEs only)*		
Riparian Corridor Continuity	Indicates the degree to which the riparian areas (buffered by 200 m) exhibit an uninterrupted corridor. A measure of the linear, continuous unfragmented riparian corridor based on Landscape Condition Index (LCI), to measure how many fragments are created by the interruption of the natural riparian corridor by non-natural land use.	Unfragmented riparian corridors support individual animal movement, gene flow and natural flooding and sediment deposition and scour processes upon which aquatic and wetland species depend (Belsky et al. 1999, Allan 2004, Hansen et al. 2005).
Rank Factor: Condition		
Key Ecological Attribute: Fire Regime *(vegetated terrestrial coarse filter CEs only)*		
Fire Regime Departure Index	This indicator is assessed by calculating and summarizing the updated LANDFIRE Succession classes (SClass) layer which characterizes current vegetation succession classes for the distribution of each CE within each 5th-level watershed. The resulting proportional calculation for current conditions is compared to the expected proportions, as derived from the VDDT or Path-Tools model characterizing the expected natural range of variation (NRV). This comparison defines the degree of departure (%). The SClass Departure Index is calculated by subtracting the Departure percent from 1 to produce a normalized scale from 0 to 1 with 1 being no departure from NRV in distribution of succession classes and 0 being complete departure from NRV.	A mix of successional classes among patches of a given vegetation type results from fire and other natural disturbances. Through field observation and modeling, one can establish a working hypothesis for the expected proportional mix of successional classes where human alterations are limited. Departure from the mixture predicted under NRV indicates uncharacteristic disturbance regime and declining integrity (Agee 1998, Brooks et al. 2004).

Indicator	Definition *(all scaled to 0-1 score)*	KEA & Indicator Justification
Key Ecological Attribute: Stressors on Biotic Condition		
Invasive Annual Grass Index *(selected terrestrial CEs only)*	This indicator is measured using the mapped area or habitat distribution of the CE with an abundance map of introduced invasive annual grass species. The output is predicted percent cover of invasive annual grass species within each 5th level watershed. The Invasive Annual Grass Index is calculated by multiplying the invasive annual grass cover percent by 4 then subtracting the product from 1 to produce a normalized scale from 0 to 1 with 0 being 25% or greater cover of invasive annual grasses and 1 being invasive annual grasses absent.	Invasive annual grass species displace natural composition and provide fine fuels that significantly increase spread of catastrophic fire (Brooks et al. 2004).
Presence of Invasive Aquatic Species *(Aquatic CEs only)*	The number of invasive taxa (known status).	Invasive species displace natural composition and affect natural foodwebs (Vitousek et al. 1996, Harju 2007, Shigesada and Kawasaki 1997).
Presence of Invasive Plant Species *(Aquatic CEs only)*	Number of known locations of non-native introduced tamarisk, Russian olive, and annual grasses.	Increased non-native plant species reduces habitat quality for numerous wildlife species, decreases forage for livestock, reduces ecosystem native species richness, increases soil erosion potential and decreases ecosystem resiliency and resistance to damage from impacts, including climate change (Chornesky and Randall 2003, Johnson et al. 2009).
Key Ecological Attribute: Stressors on Hydrologic Condition *(Aquatic CEs only)*		
Condition of Groundwater Recharge Zone	Measures the landscape condition of the likely groundwater recharge zone (areas above 2000 m within each 10 digit HUC (watershed)) by percent area in hard-surface development as determined in LCI.	Hard surface development within a groundwater recharge zone can divert and reduce the amount water entering the groundwater (NJSWBMP 2004, Flint and Flint 2007).
Flow Modification by Dams	"F" Index (Theobald et al. 2010a) -- Dams and their storage capacity relative to annual stream discharge.	Higher storage capacity is an indicator of greater impact to natural flow regimes of the downstream river or stream segments (Graf 1999, Theobold et al. 2010a).

Indicator	**Definition** *(all scaled to 0-1 score)*	**KEA & Indicator Justification**
Groundwater Use	The ratio of total flow per watershed (calculated from NHD) to the groundwater use as reported by USGS SWPA study (this is not a quantitative groundwater budget).	This indicates the degree to which surface water is being consumed for human use relative to availability within each watershed. The greater the use, the less water is available to support aquatic species, specifically higher ground water use is likely to draw down water tables and therefore springs (Manning 1999, Patten et al. 2007).
Perennial Flow Modification by Diversion Structures	Number of aquaducts intersecting or branching from NHD perennial streams. Total per watershed.	This indicates the amount of flow modification and change in hydrologic regime. (Poff et al. 2010).
Surface Water Use	Ratio of total watershed flow (calculated from NHD) to surface water use as reported by USGS SWPA study.	The greater the use relative to supply, the less water is available to support aquatic species (Richter et al. 1997).
Key Ecological Attribute: Stressors on Water Quality *(Aquatic CEs only)*		
Atmospheric Deposition-Nitrate Loading (NO_3)	Rate of deposition of NO_3 per unit area within watershed.	This indicator is used a representative indicator of nutrient loading pollutant. Increased nitrogen in aquatic systems can increase algal growth and decrease oxygen content (Fenn et al. 2003a, 2003b).
Atmospheric Deposition-Toxic Mercury Loading (Hg)	Rate of deposition of mercury (Hg) per unit area within watershed.	This indicator is used to represent the amount of toxic pollutants. Toxic pollutants affect reproduction, growth and neurologic functioning of aquatic animals. Mercury in particular accumulates up the food chain and can affect human health as well (Peterson et al. 2009, Ward et al. 2010).
Sediment Loading Index	Index values of total suspended sediment (developed by NSPECT) which are based on percent of land uses (NLCD) that contribute excess sedimentation and suspended solids via surface water runoff and overland flow into a wetland, as measured within the 200 m buffer area.	Different surrounding land uses contributes to the sediment loading in adjacent waters. Increased sediment clogs fish gills, reduce successful spawning, decrease visibility and increase pollutant loadings, especially heavy metals (Salomons et al. 1987, Apitz et al. 2005).
State-Listed Water Quality Impairments	Measures the integrity of water quality conditions in individual water bodies based on the presence and severity of state listings of water quality impairments for State 303(d) reporting requirements under the federal Clean Water Act –excluding nutrient enrichment, which is addressed by a separate key ecological attribute.	This indicator is a direct measure of pollutants, turbidity and sediments that exceed state standards. Polluted water negatively affects aquatic species health and ability to successfully reproduce (USEPA 2004).

4 Existing Conditions in the Central Basin and Range Ecoregion

The chapter is organized around key management questions related to a) current status of managed lands, b) the distribution of conservation elements, c) the distribution of change agents currently acting upon the landscape, and d) the current ecological status of selected conservation elements as a factor of their interaction with change agents. The existing conditions throughout this ecoregion reflect the accumulated effects of past land use and management decisions. Appendices are cited throughout, providing information where greater detail may be found on a particular issue. Note that issues of data confidence are important in interpreting and using these results and are addressed in the Summary and Conclusions chapter.

4.1 *Current Status of Managed Lands*

Where are sites identified (but not necessarily designated) for High Biodiversity?

Where are Aquatic High Biodiversity sites?

Where are specially designated areas of ecological or cultural value?

This section of the assessment considered lands that are designated for conservation and those not currently designated but otherwise identified by various organizations as having high significance for ecological or cultural values. These areas occur across multiple land management agency jurisdictions throughout the ecoregion. Within this REA, **Places I** lands indicate sites that have been previously identified as priority areas for conservation by other non-governmental organizations, but do not necessarily have a protective designation. These places can include areas of high significance identified through private conservation plans, such as The Nature Conservancy ecoregional portfolios, or similar sites.

Places II lands have been formally designated for management to conserve significant ecological or cultural values. These can include land attributed by the USGS Gap Analysis Program as “Gap Status 1-2” (http://www.gap.uidaho.edu/padus/State_Standard2011_May24.pdf) which tend to include protected areas such as ACECs, National Parks, designated Wilderness lands, and Research Natural Areas, etc. In this category, designated recovery areas for listed species were also included. One example of this was the red-legged frog (*Rana draytonii*), with designated area located along extensive portions of the ecoregion's western margin. The delivered spatial data products allow distinguishing the source of the priority areas; see Appendix C Section C-1.3 for further information.

Overall, current designated lands (in Places II) encompass 21.9% of the ecoregion (Table 4-1). Identified priority areas (Places I), *which tend to overlap with already designated lands*, encompass 27.8% of the ecoregion (Table 4-2).

Figure 4-1 includes this non-overlapping view of Places II and Places I lands. This suggests that more specific land conservation measures have been recommended by non-governmental organizations for some 5.9% of the ecoregion. That would equate to approximately 5.2 million acres (NOTE: a significant proportion of that areal extent includes the Great Salt Lake, at some 1.2 million acres).

Table 4-1. Aerial extent of lands designated for significant ecological and cultural value (Places II), in nearest thousands of acres. For example BLM has over 9 million acres legislatively or administratively designated for ecological values, out of the 10's of millions of acres of BLM lands in the ecoregion.

Place II Owner/Manager	**Acres (1,000)**	**% of ecoregion**
Bureau of Land Management (BLM)	9,215	10.4
Forest Service (USFS)	7,269	8.2
National Park Service (NPS)	1,025	1.1
Fish and Wildlife Service (FWS)	697	0.8
No data *(from PADUS* – potentially various managers)*	390	0.4
State Fish and Wildlife	332	0.4
Department of Defense (DOD)	286	0.3
Agricultural Research Service (ARS)	55	<0.1
Native American Land	45	<0.1
Other State Land	44	<0.1
Bureau of Reclamation (BOR)	28	<0.1
State Park & Recreation	28	<0.1
The Nature Conservancy (TNC)	23	<0.1
City Land	20	<0.1
State Land Board	14	<0.1
Total Area Places II Lands	**19,471**	**21.9%**

* PADUS is the Protected Area Database of the U.S.

The BLM and the U.S. Forest Service manage the majority of designated lands in the ecoregion (Table 4-1), with a combined total of nearly 16.5 million acres. The BLM share of these lands account for 9.2 million acres, or 10.4% of the ecoregion. The National Park Service is third, managing just over one million acres in this category. BLM manages a total of 12.7 million acres of lands identified as high priority for conservation (Places I), or 14.38% of the ecoregion (Table 4-2). Again, given the overlap of these two Places categories, this suggests that some 3.57 million additional acres have been identified for more specific land conservation measures by non-governmental organizations on BLM land than are currently designated. A common finding in western conservation lands is that designated areas tend to occur in mountainous areas whereas identified priority areas seek to supplement those with more lowland areas (Figure 4-1).

Table 4-2. Aerial extent of lands in nearest thousands of acres prioritized for their ecological and cultural value (Places I), in nearest thousands of acres. This table indicates the current owner/manager of prioritized lands, not who designated those lands. See Appendix C Section C-1.2 for further information.

Places I Owner/Manager	**Acres (1,000)**	**% of ecoregion**
Bureau of Land Management (BLM)	12,786	14.38
No data	7,193	8.09
Forest Service (USFS)	1,661	1.87
Department of Defense (DOD)	1,235	1.39
State Land Board	515	0.58
Native American Land	371	0.42
Department of Energy (DOE)	319	0.36
City Land	311	0.35
State Department of Natural Resources	112	0.13

Places I Owner/Manager	**Acres (1,000)**	**% of ecoregion**
Bureau of Reclamation (BOR)	99	0.11
State Park & Recreation	36	0.04
Other State Land	31	0.03
Private Conservation Land	13	0.01
All Others	<10	<.01
Ecoregion Total Area and % Places I Lands	**88,925**	**27.8%**

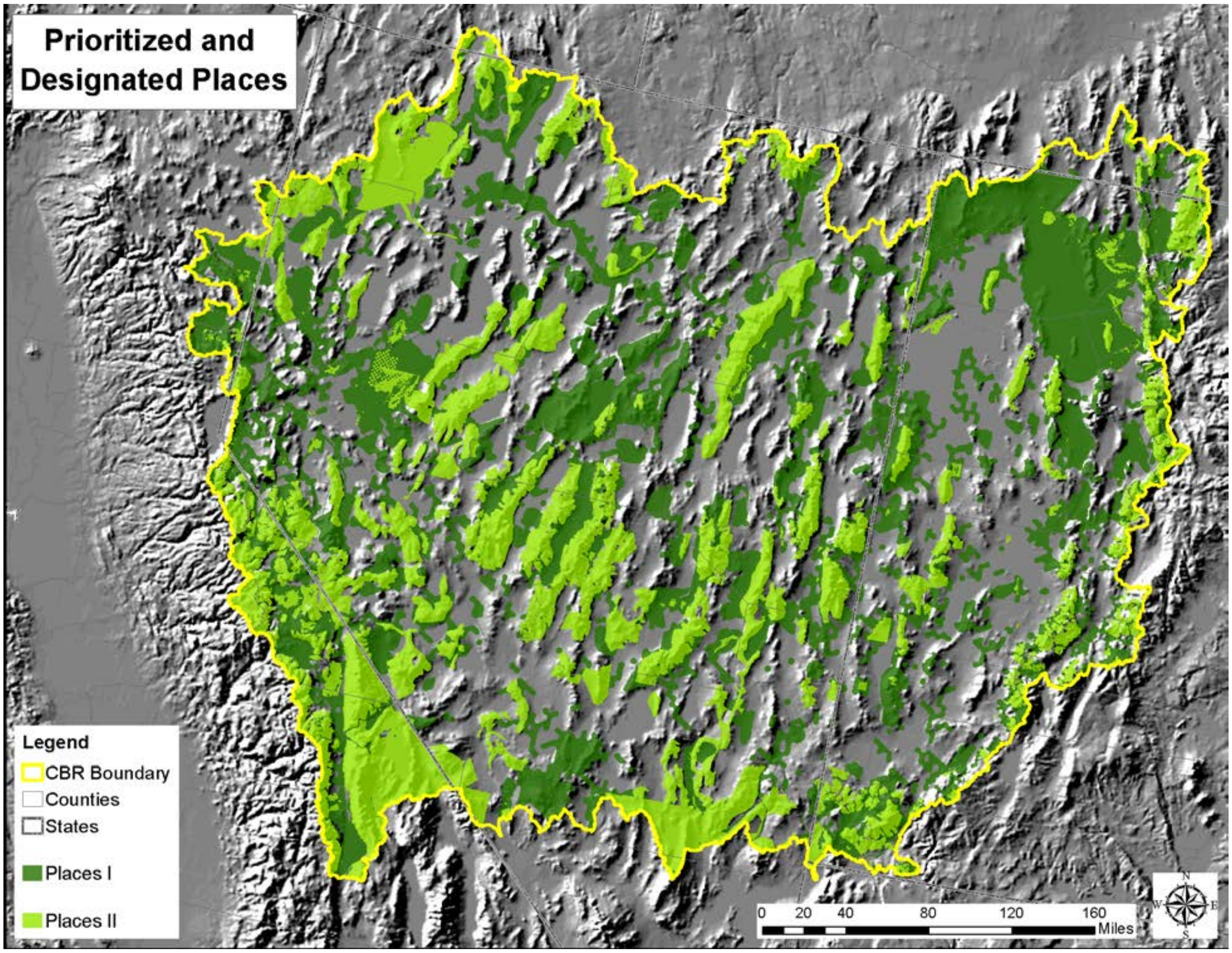

Figure 4-1. Existing lands designated for high ecological or cultural value (Places II) overlain on undesignated area identified for high ecological or cultural value (Places I). The dark green areas are Places I that are not already included in a designated areas (light green) such as wilderness or ACEC (Places II).

4.2 Distribution of Conservation Elements

Where are intact CE vegetative communities located?

Where are sensitive soil types within the ecoregion?

What is the current distribution of suitable habitat, including seasonal habitat and movement corridors, for each landscape species and species assemblage CE?

This REA included a very broad and deep selection of CEs and, therefore, this section provides brief answers to management questions pertaining to the location of CEs. Results are illustrated with examples of high-interest CEs that will be used throughout this report. Complete results for all assessed CEs can be found in Appendix B Section B-1.1 where one can find information on the relative at-risk status of all conservation elements, be they species already considered at-risk of extinction, or relatively common and abundant vegetation types.

The conservation elements in this assessment include a number of terrestrial and aquatic ecosystems (the coarse filter CEs), and individual landscape species. Other species were assessed as components of vulnerable species assemblages. All of the CEs were spatially mapped within the ecoregion. In this section, several management questions are assessed, and results are highlighted for several CEs.

The introductory chapter included a summary of areal extent represented by each terrestrial coarse filter CE (Table 2-2). Full descriptions of each type are found in Appendix B Section B-1.1.3. These elements encompass 93.6% of the surface area of the CBR. The upland shrub-dominated basins of the ecoregion include Inter-Mountain Basins Mixed Salt Desert Scrub (20%), Inter-Mountain Basins Big Sagebrush Shrubland (19.5%), and Great Basin Xeric Mixed Sagebrush Shrubland (9.5%) as major types. Where water can accumulate across these basins, Inter-Mountain Basins Playa (5.7%), and Inter-Mountain Basins Greasewood Flat (5.1%) are most common. Open water, primarily as reservoirs and several natural lakes, encompass 2.2% of the ecoregion surface.

Throughout the mountain ranges, most in a north-south orientation, Great Basin Pinyon-Juniper Woodland (13.8%) and Inter-Mountain Basins Montane Sagebrush Steppe (3.9%) are predominant upland types. Given that these proportions are defined by current extent, it is probable that the 13.8% area of pinyon-juniper woodland includes areas of expansion or encroachment into adjacent shrubland types (Burkhardt and Tisdale 1976). Riparian and montane stream communities are common at high elevation and draining down across basin floors, but encompass very little areal extent. Similarly, numerous springs and seeps are scattered throughout the ecoregion, but in areal extent are extremely minor.

Three of the major upland types that characterize the ecoregion's upland environments include Inter-Mountain Basins Mixed Salt Desert Scrub, dominating most basin bottoms, Inter-Mountain Basins Big Sagebrush Shrubland, extending across higher-elevation basins and plateaus, and across many low mountain ranges, Great Basin Pinyon-Juniper Woodland (Figure 4-2). Distribution maps of other terrestrial coarse filter CEs are provided in Appendix B Section B-2.1.

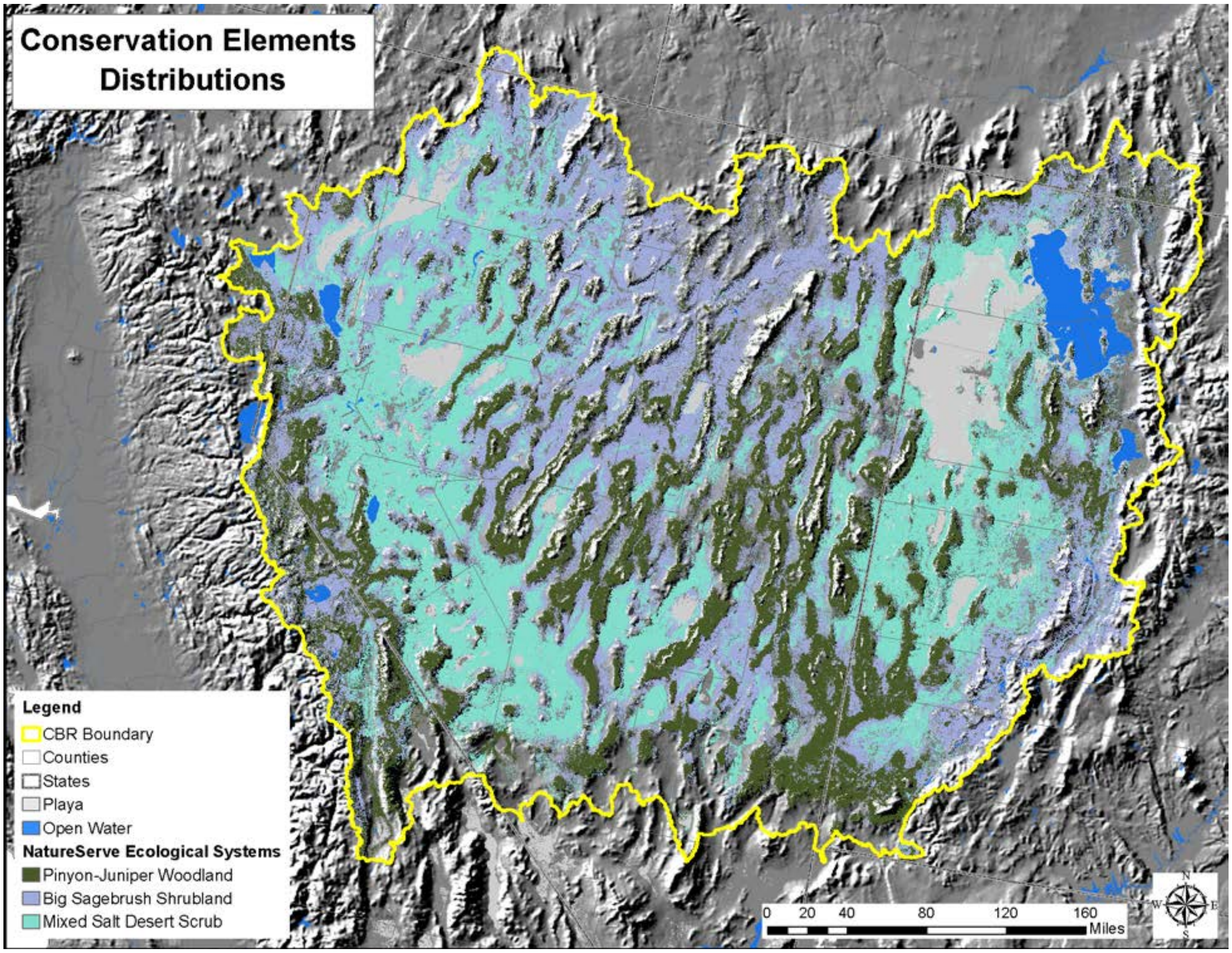

Figure 4-2. Current distribution of three predominant upland vegetation types in the Central Basin & Range ecoregion

A number of soil types are sensitive to degradation in various forms, including sensitivities to water erosion and wind erosion. Hydric soils, characteristic of wetlands, as well as some riparian and desert playas, are quite sensitive to compaction and other forms of degradation that affect natural hydrology and water resource values. Other soil types, such as gypsum outcrops reflect extremes in soil chemistry that preclude establishment by many plant species where re-vegetation is desired after disturbance. The distributions of the sensitive soils were modeled from the Soil Survey Geographic Database (SSURGO) and the State Soil Geographic Database (STATSGO) using criteria defined by a BLM Soils Specialist; details are provided in Appendix B Section B-1.2.2 . Use of the spatially coarse SSURGO and STATSGO datasets for mapping soils distribution result in many cases results in over-depiction of distribution; for example the mapped distribution of soils sensitive to wind erosion (Figure 4-3) will have inclusions of non-erodable soils due to the coarse nature of the input datasets. Appendix B Section B-1.2.2 includes information on all seven sensitive soil types that were mapped for purposes of this assessment.

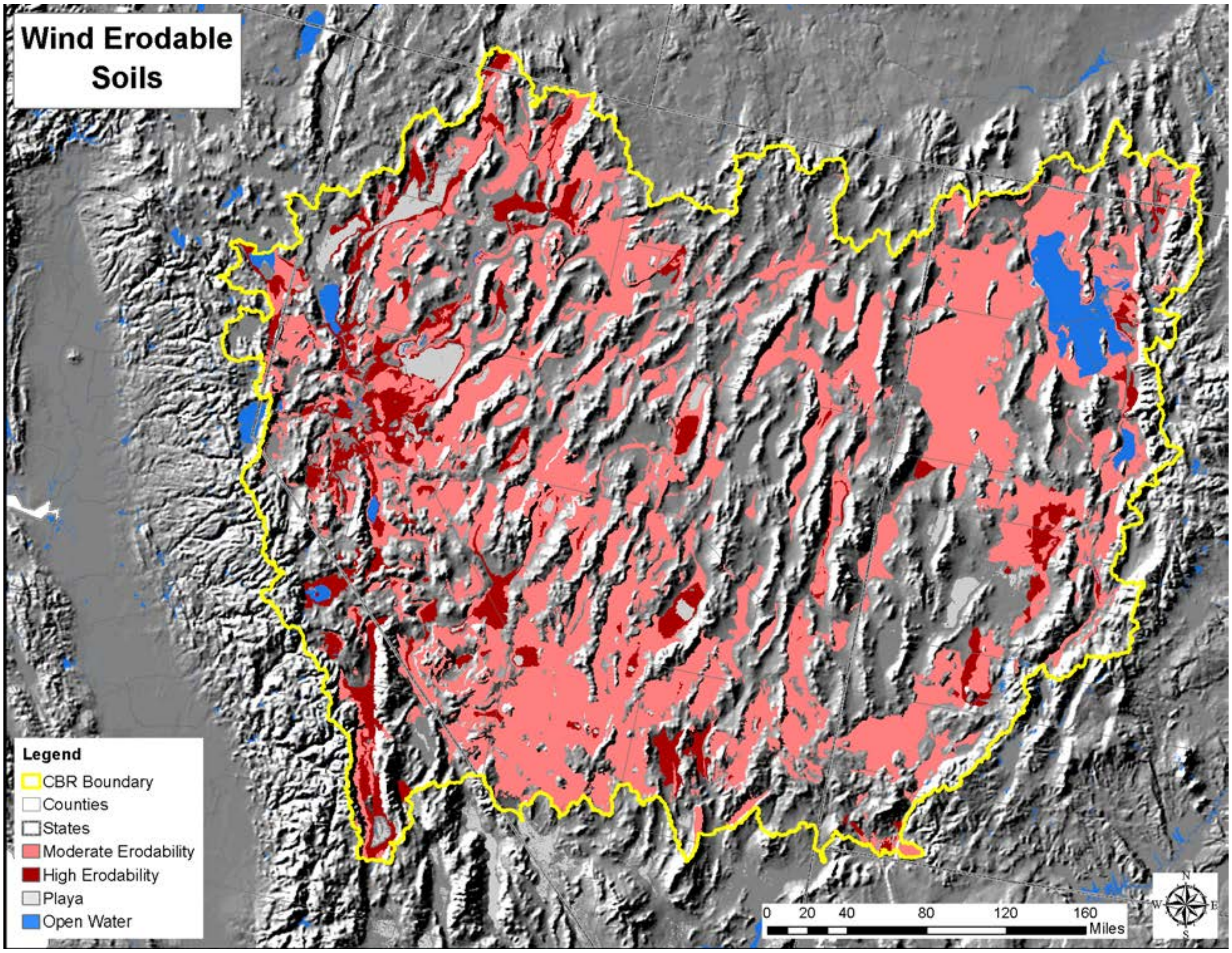

Figure 4-3. Modeled distribution of wind erodible soils in the Central Basin & Range ecoregion. Erodability was thresholded into high and moderate using criteria provided by a BLM soils scientist.

Landscape species selected for the REA also occur throughout the ecoregion, current distributions are provided here for Desert bighorn sheep (Figure 4-4), Mule deer (Figure 4-5), Pygmy rabbit (Figure 4-6), and desert seeps and springs (Figure 4-7). An important landscape species CE, **Greater sage-grouse**, is discussed and results of the assessment presented in a case study, provided as Appendix F. For both desert bighorn and mule deer, the distributions are derived from habitat use areas compiled by the BLM from state Fish and Wildlife agencies that are partners in WAFWA and provided to the REA contractor. Distribution maps of other landscape species CEs are provided in Appendix B Section B-2.1.

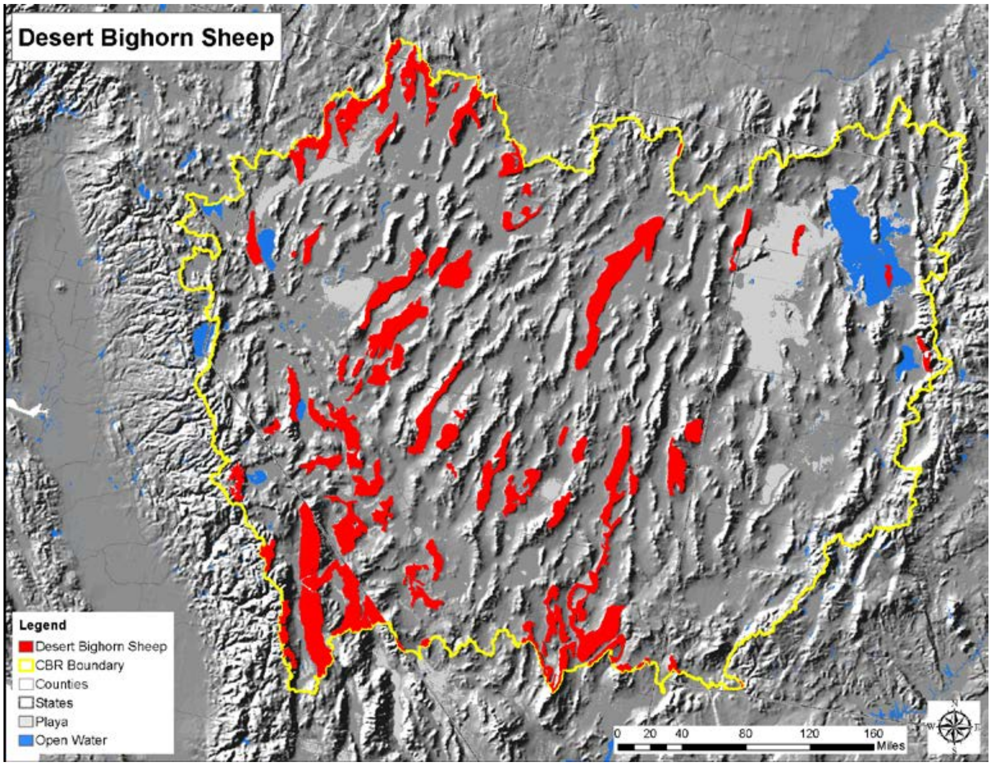

Figure 4-4. Current distribution of Desert bighorn sheep in the Central Basin & Range ecoregion

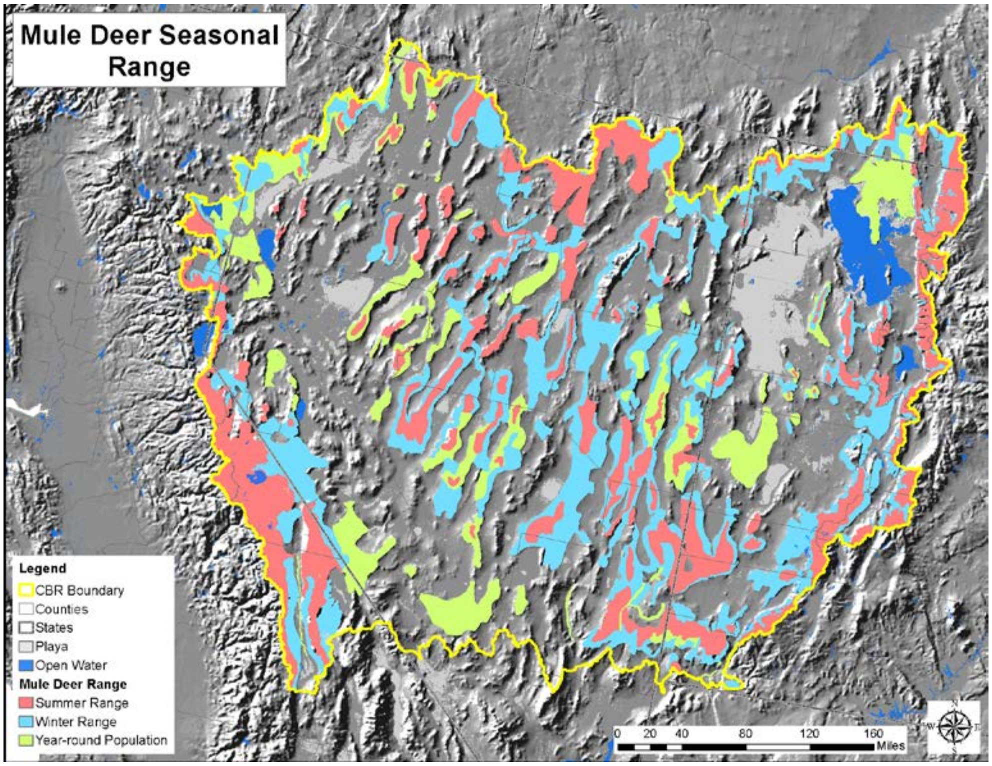

Figure 4-5. Current distribution of Mule deer – seasonal range in the Central Basin & Range ecoregion

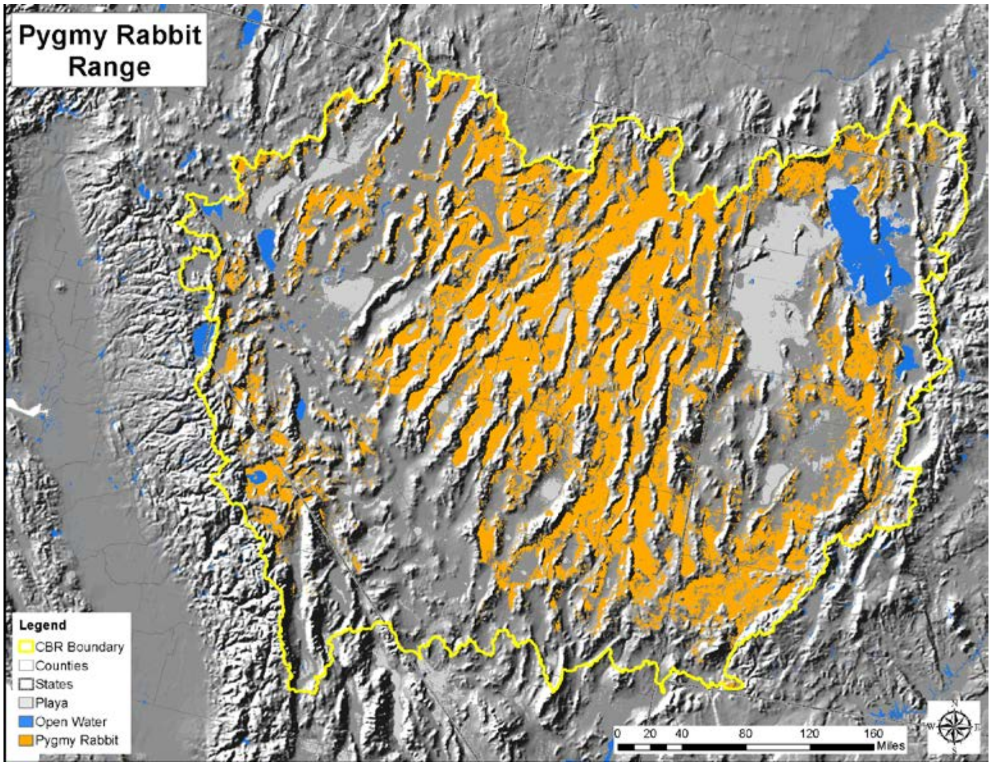

Figure 4-6. Current habitat distribution of Pygmy rabbit in the Central Basin & Range ecoregion

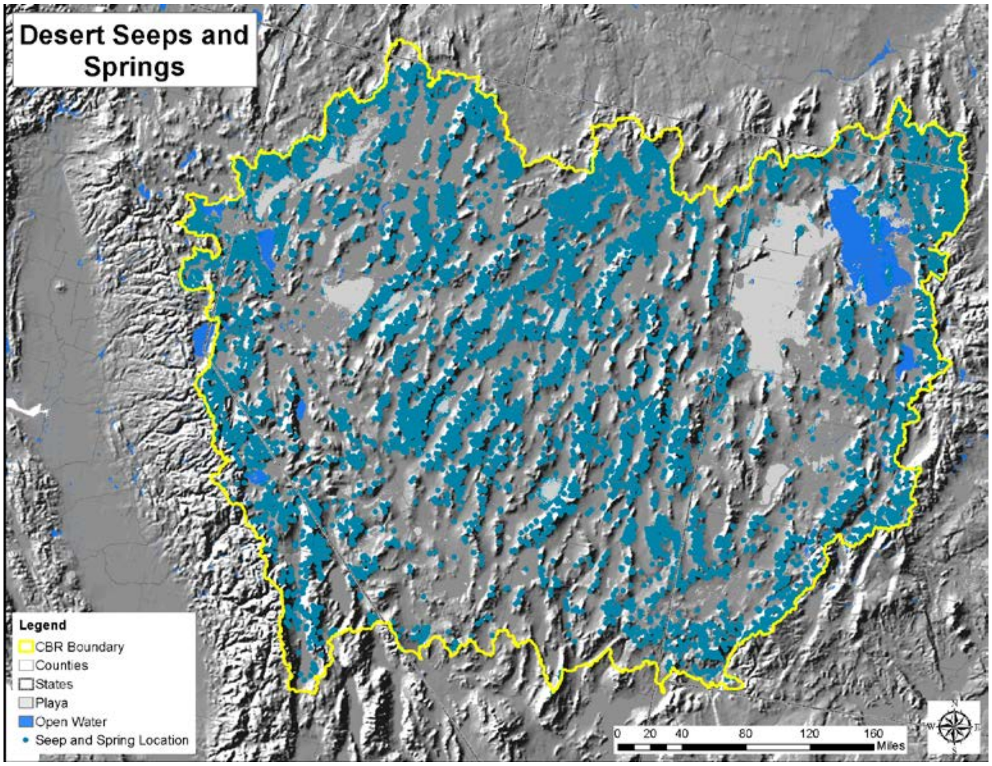

Figure 4-7. Current distribution (point-locations) of nearly 17,000 seeps and springs in the Central Basin & Range ecoregion

4.3 Change Agent Distribution and Intensity

Where have fires greater than 1000 acres occurred?

Where are current locations of development CAs?

Where are the current locations of oil, gas, and mineral extraction?

Where are the current locations of renewable energy development (solar, wind, geothermal, transmission)?

What is the current distribution of invasive plant species included as CAs?

What is the current distribution of invasive aquatic species included as CAs?

A wide variety of change agents (CAs) occur across the ecoregion, affecting natural processes and productivity, and limiting ecological resiliency. Many of these effects have been documented elsewhere in recently research (e.g., Davies et al. 2011). This section summarizes the distribution, overlap, and relative intensity of selected major change agents across the ecoregion. This section focuses on wildfire occurrence, development patterns, and invasive species as primary change agents. There are many management questions addressed by this component of the assessment and some results for these are highlighted here. Appendix A contains details of methods and results for all these CAs.

4.3.1 Class I Wildfire

Fires of varying size and intensity occur throughout the ecoregion; and their changing nature and effects on vegetation have been well documented (e.g., Chambers et al. 2005, Brooks and Chambers 2011). This section only reports on fire occurrence within the ecoregion. Subsequent sections report fire regime effects on ecological status and address MQs pertaining to fire regime departure.

Since 1980 a total of 8,523,560 acres (9.3% of the ecoregion) have burned at least once by a fire >1,000 acres across the CBR (Figure 4-8). Approximately half of all CBR watersheds included fires of >1,000 acres since 1980, with concentrations occurring throughout the eastern and northeastern portion, and along the western fringe of the ecoregion within California. Nearly 50% of the 5th- level watersheds include burned area between 1,132 and nearly 72,927 acres. Twenty-four watersheds included burnt area over 55,000 acres. Due to limitations in existing data, this map does not include fire occurrences < 1,000 acres in size, or overlapping fire events from multiple years, so overall area experiencing fire in recent decades is higher than these mapped areas.

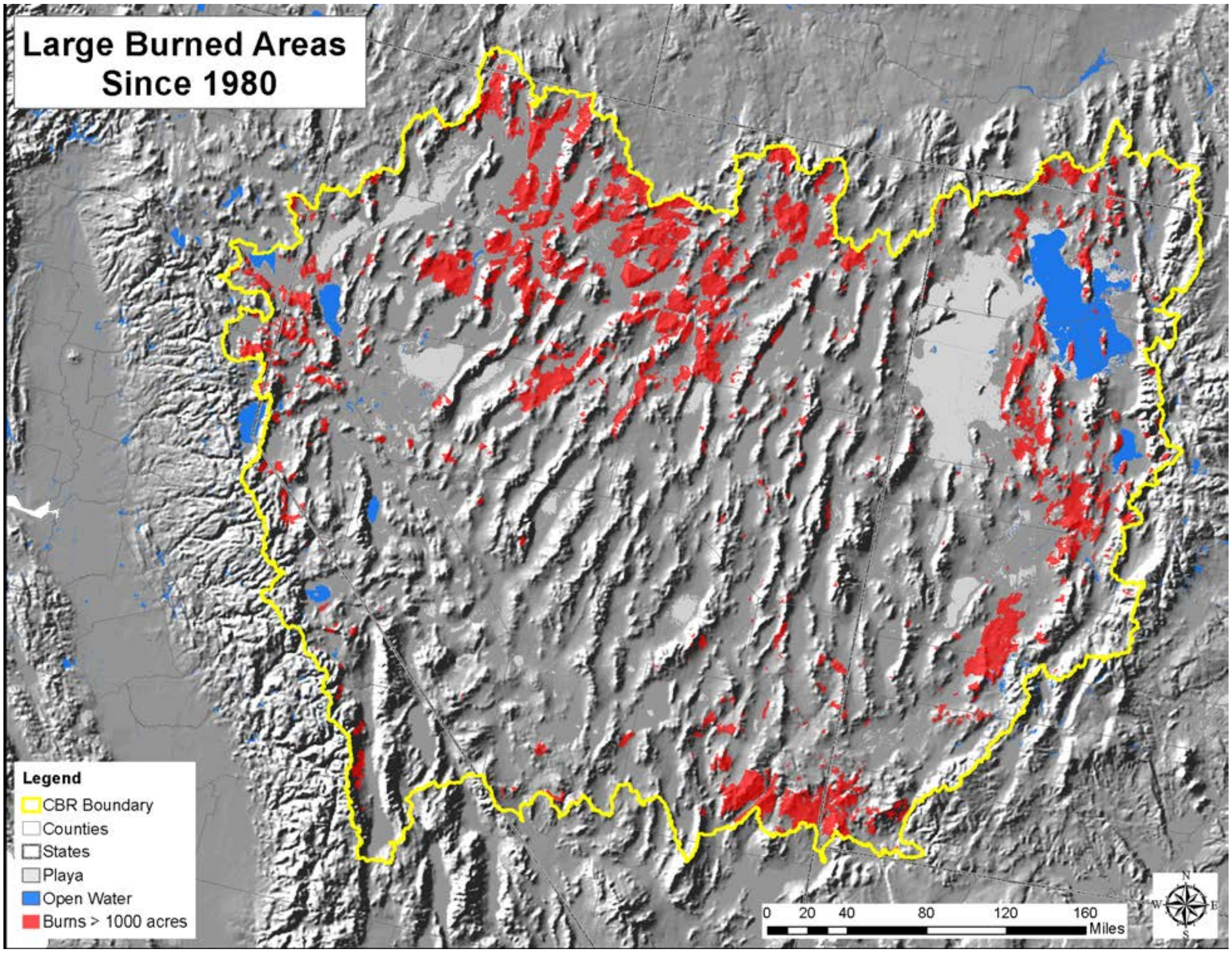

Figure 4-8. Large areas (greater than 1000 acres) burned since 1980 within the Central Basin & Range ecoregion

4.3.2 Class II Development

Developed area in the ecoregion (~7%) is presently not extensive compared to many areas of the U.S. outside of Alaska. Currently, the dominant development type is urban concentrated in the east and western extremes of the area and representing ~2% of the ecoregion. Here, urban development consists of three classes of urbanization which vary widely in unit density: urban, suburban and exurban. Other important CAs are roads (~2%), crops and irrigated pastures (<2%) found in the in the river valleys, and multiple overlapping CAs (Table 4-3). Renewable energy sources currently only occupy 0.03% of the ecoregion, split between wind and geothermal sites.

Table 4-3. Area (in thousands of acres) and percent of each development CA in the Central Basin & Range ecoregion

Change Agent Name	**Acres (1,000)**	**Percent**
No Development Change Agent	*82,618*	*92.91*
Urban Development	1,718	1.93
Roads Rural Neighborhood or Private	1,466	1.65

Change Agent Name	Acres (1,000)	Percent
Crops or Irrigated Pasture	1,451	1.63
Multiple Change Agents	1,102	1.24
Roads Unimproved 4wd	181	0.20
Roads Principal or Secondary	108	0.12
Mine or Landfill	81	0.09
Primary Electric Utility Line	73	0.08
Railroad	32	0.04
Water Canal or Ditch	29	0.03
Pipeline	18	0.02
Renewable Energy Geothermal	17	0.02
Non-motorized trail	12	0.01
Military Urbanized Area	8	0.01
Renewable Energy Wind	7	0.01
Renewable Energy Solar	3	0
Roads Unknown Type	2	0
Oil or Gas Well	0.2	0

4.3.2.1 Modeled Effects of Development: Landscape Condition Model

As referenced in the methods section, a landscape condition model integrates mapped information on the location of development change agents in order to express common ecological stressors. The intent of the model is to enable spatial expression of the relative effects of land uses on natural ecosystems and habitats. See Appendix B Section B-1.4.1 for a detailed description of the model. The result is a map surface indicating relative scores between 0.0 and 1.0 (Figure 4-9). This provides one composite view of the relative impacts of land uses across the entire ecoregion. Darker orange to red areas indicate apparently most impacted areas and darker green areas least impacted.

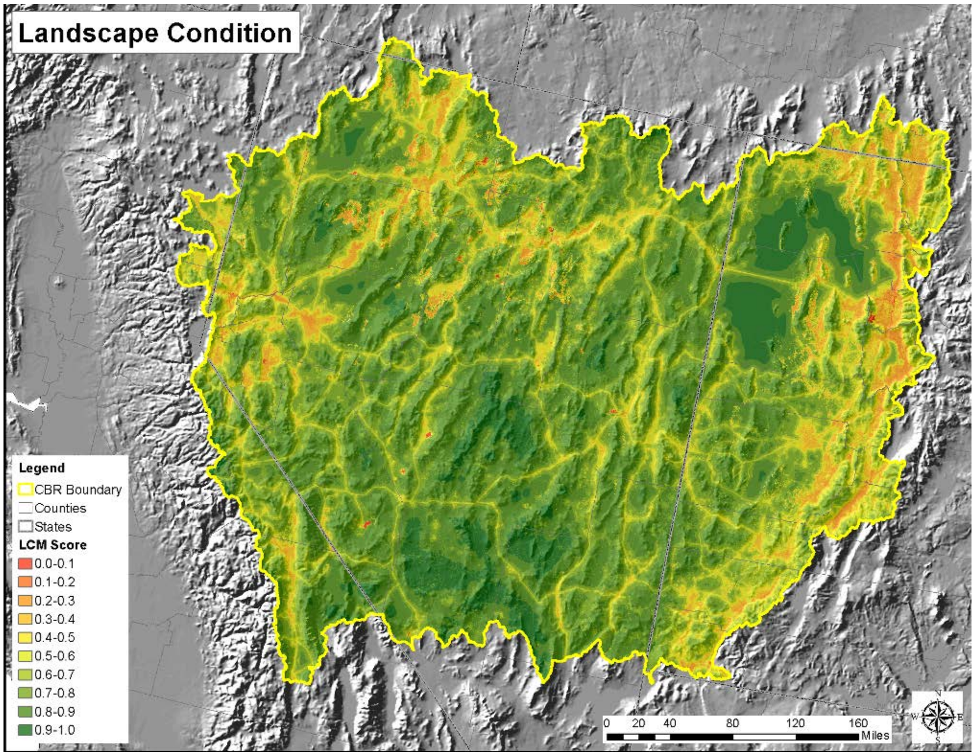

Figure 4-9. Landscape Condition model (90 m) for the Central Basin & Range ecoregion

4.3.3 Class III Invasive Species

4.3.3.1 Terrestrial Invasive Species

Invasive plant species, especially non-native annual grasses such as cheatgrass (*Bromus tectorum*), have been well-documented for their substantial effects on ecological processes throughout the ecoregion (e.g., Chambers et al. 2005, 2007, Davies et al. 2011). Detailed analyses of the location and abundance of invasive plants, segmented into categories of annual grasses, annual and biennial forbs, and woody species occurring in riparian areas, are found in Appendix A Section A-2.1.4.

Annual grass location and potential abundance was modeled using field observations and environmental data. Field records indicated both presence and percent cover of annual grass species in the sample. Spatial models therefore depict a probability that invasive annual grasses could be present at a given abundance, as measured by percent cover (the model includes 5 different classes of potential abundance). An overwhelming proportion of the CBR is predicted by this model is predicted to support annual grasses at 45% cover (Figure 4-10). Although disturbance is a driver of the competitive success of these invasive annual grasses, one can assume that future disturbances will continue in the same patterns as presently (Bradley and Mustard 2006). This is undoubtedly the most severe circumstance on an ecoregion scale in the western United States.

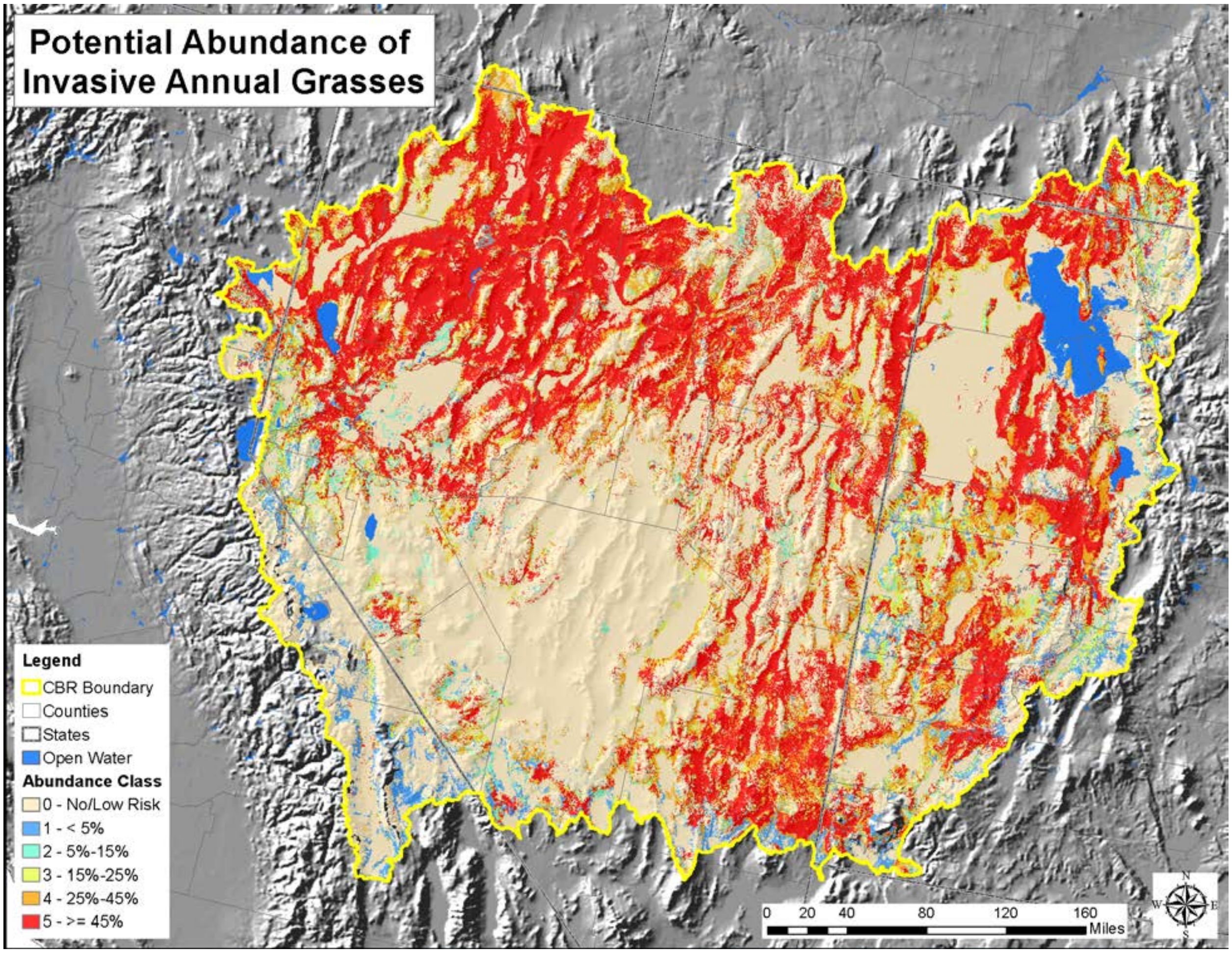

Figure 4-10. Potential abundance of invasive annual grasses in the Central Basin & Range ecoregion, modeled into 5 abundance classes. The model was based on known occurrences of invasive annuals and modeled habitat factors such as adjacency to recent fires, surficial lithology, landform, elevation, aspect and slope.

4.3.3.2 Aquatic Invasive Species

There are rapidly increasing novel species introductions and establishment of aquatic invasive species in the ecoregion. Spatial characterization of the distribution of such species in the ecoregion was hampered by a small number of databases containing surveyed locations of such species. These databases also lacked records for sites that were surveyed but no taxa were found. A majority of the CEs within watersheds had no reported invasive taxa in the available databases. This could have been a result of surveys that did not find any invasives or watersheds where no surveys occurred (i.e. no data). Therefore, any CE within a watershed that did not have an invasive reported was rated as 'no data' = Undetermined. Two watersheds included records of 3 invasive species; eight watersheds (including the Great Salt Lake) included records of two invasive species. Nineteen watersheds include records of one invasive species. Invasive exotic aquatic species include various combinations of American Bullfrog (*Lithobates catesbeianus*), common carp (*Cyprinus carpio*), guppy (*Poecilia reticulate*), Mexican molly (*Poecilia sphenops*), shortfin molly (*Poecilia mexicana*), New Zealand mudsnail (*Potamopyrgus antipodarum*) and others.

4.3.4 Summary of Current CA Intensity

Where will CAs (aside from climate change) potentially affect sites of high biodiversity?

Where will these Aquatic High Biodiversity sites be potentially affected by Change Agents (aside from climate change)?

Where will development CAs overlap HAs, HMAs, and GAs under each time scenario?

Where will target soil types overlap with CAs (aside from climate change) under each time scenario?

These analyses address MQs that asked where CAs (excluding climate change) overlap certain types of places. This section provides results for grazing allotments (GAs) and Herd Management Areas (HMAs), all other results are presented in Appendix D Section D-2.1.

While development change agents are unlikely to cause significant impacts to the sensitive soils, off-road recreation use could pose a more serious threat to erodible soils, currently and in the future. Suitable data for representing recreation were limited; discussion with the AMT lead to a conclusion to model recreation uses to answer one MQ but the modeled recreation results were deemed inadequate for assessment against other features. Detailed results for soils are provided in Appendix D Section D-1.2.4, and for recreation in Appendix A Section A-2.1.3.

4.3.4.1 Development change agent overlap with grazing allotments (GAs) and herd management areas (HMAs)

Herd areas (HAs) are included with HMAs as they were integrated in the same dataset provided by BLM (Figure 4-11). HMAs occupy 16,049,496 acres in the ecoregion with a total CA overlap of 2.4% of HMA area. The total area of all GAs in the ecoregion is 58,998,175 acres and the proportion overlapped by one or more development CAs is 4.21% (Figure 4-11). In both types of management units rural roads (~1.8%) are the dominant CA type. Grazing allotments have an additional 1% each urban areas and crops/irrigated pasture overlapping; but all other development types for both GAs and HMAs have under 1% of overlap with either. Overlap between urban development (restricted to private lands) and grazing allotments (an element of public land) may be attributable to discrepancies between the BLM's grazing allotments and the protected areas database (USPAD) used to assist developing the maps of the urban footprint. There appear to be a number of irregularities between the USPAD and the BLM's grazing allotment layer which would generate irregularities such as private [urban] land appearing to occur in the grazing allotments. General relationship of these management units to development CAs is most easily visualized in their overlap with the LCM model in the figures below. See Appendix D Section D-2.1 for complete results for each HMA and GA.

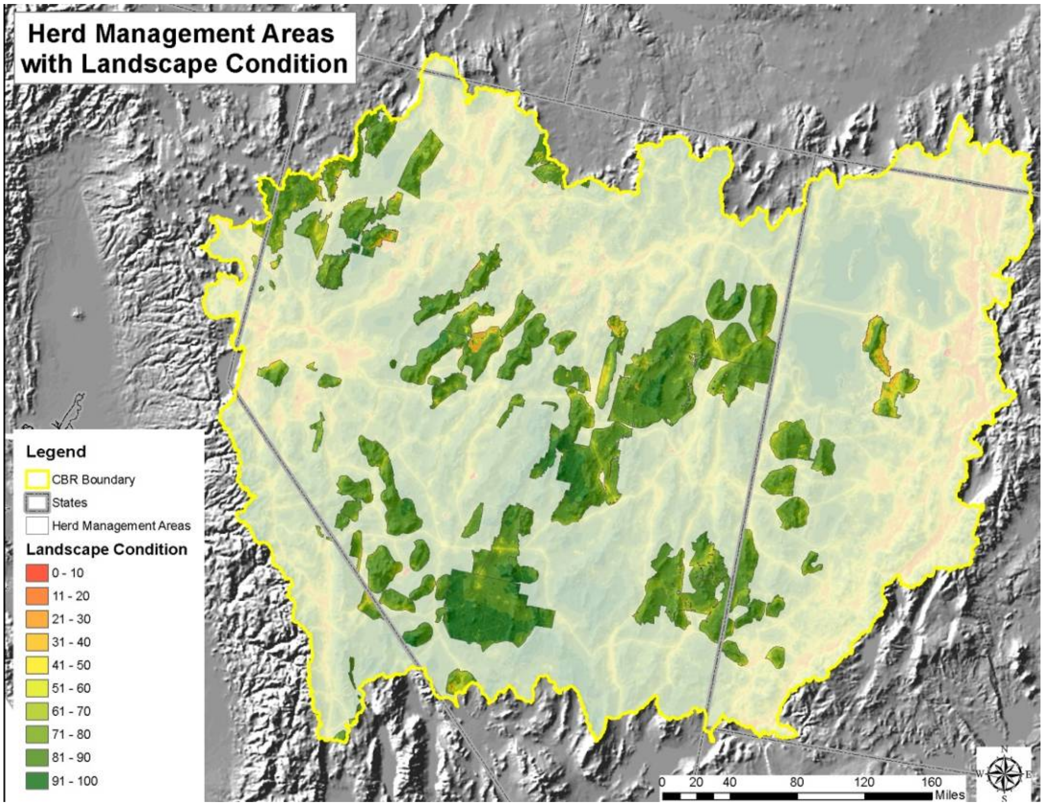

Figure 4-11. Location of HMAs and relationship to "development" as represented by the landscape condition model. This map shows the full color ramp for the landscape condition model within HMA boundaries; dark green indicates apparently unimpacted condition, red to dark orange apparently highly impacted.

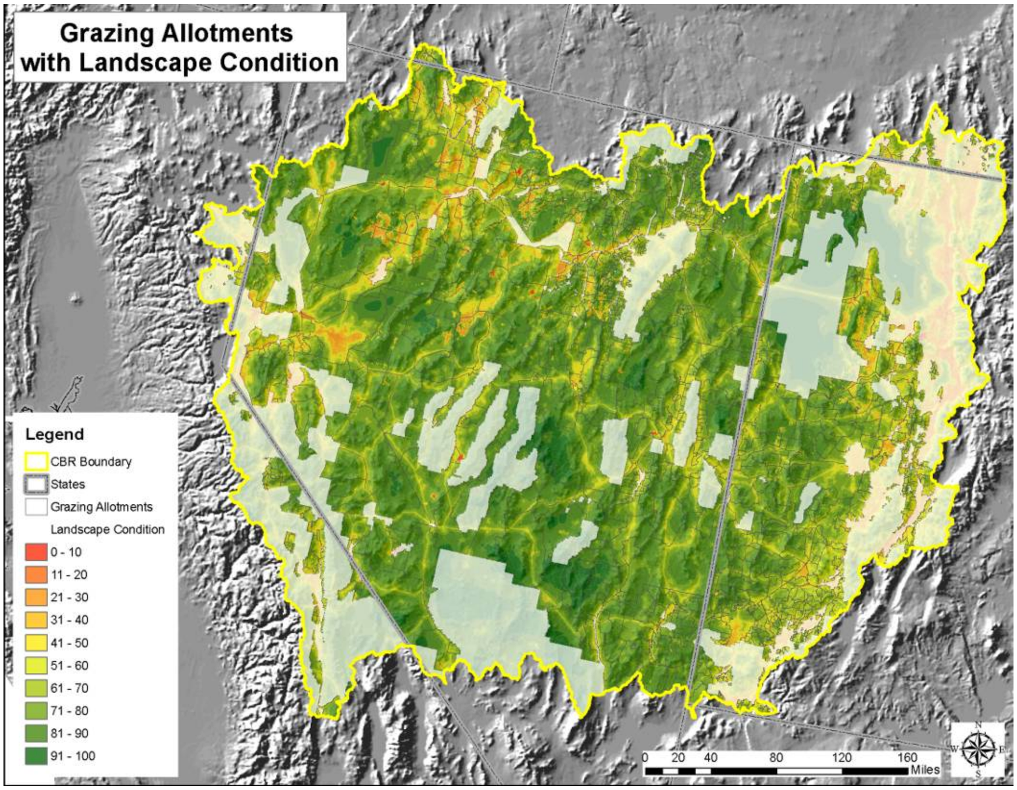

Figure 4-12. Location of GAs and relationship to "development" as represented by the landscape condition model. This map shows the full color ramp for the landscape condition model within GA boundaries; dark green indicates apparently unimpacted condition, red to dark orange apparently highly impacted.

4.4 Effects on CEs

4.4.1 Development and CE Distributions

Where do current locations of CEs overlap with development CAs?

Results for this assessment are provided below in tabular format (Table 4-4) using development as the CA. Because the development footprint is so small for this ecoregion, maps are not provided here, instead tabular results summarize development overlap with CEs. Results are sorted by CE group and descending percentage of development overlap by individual CEs by group. Those CEs with the largest percent of overlap include: the Inter-Mountain Basins Semi-Desert Grassland, Great Basin Springs and Seeps, Bald Eagle, and Migratory Shorebirds and Waterfowl Species Assemblage. Detailed results in Appendix D Section D-2.1 provide the area and percent of each CE by specific CA overlap, however the key CAs represented in the overlap with CEs are: urban development; all classes of roads; solar, wind and geothermal renewable energies; mines; landfills; oil or gas wells; military urbanized areas; railroads; canals; electric utility lines; pipelines; crops or irrigated pasture. Note that further analyses into CE status (next section) address *effects* of CAs on CEs, this analysis *merely reports spatial overlap*.

Table 4-4. Percent (nearest 10th) of CEs' overlap by development CAs

Assessment Approach	Conservation Element Name	Percent Overlapped by Development*
Terrestrial Coarse filter	Inter-Mountain Basins Semi-Desert Grassland	28.9
	Great Basin Semi-Desert Chaparral	13.9
	Inter-Mountain Basins Cliff and Canyon	8.1
	Colorado Plateau Mixed Low Sagebrush Shrubland	7.1
	Rocky Mountain Aspen Forest and Woodland	7.0
	Inter-Mountain Basins Montane Sagebrush Steppe	6.1
	Inter-Mountain Basins Big Sagebrush Shrubland	5.4
	Inter-Mountain Basins Semi-Desert Shrub-Steppe	4.8
	Inter-Mountain Basins Mixed Salt Desert Scrub	4.3
	Inter-Mountain Basins Aspen-Mixed Conifer Forest and Woodland	4.3
	Inter-Mountain Basins Big Sagebrush Steppe	3.9
	Great Basin Xeric Mixed Sagebrush Shrubland	2.7
	Mojave Mid-Elevation Mixed Desert Scrub	2.6
	Great Basin Pinyon-Juniper Woodland	2.2
	Rocky Mountain Alpine Turf	1.9
	Inter-Mountain Basins Curl-leaf Mountain Mahogany Woodland and Shrubland	1.4
	Inter-Mountain Basins Active and Stabilized Dune	0.9
	Inter-Mountain Basins Subalpine Limber-Bristlecone Pine Woodland	0.3
Aquatic Coarse filter	Great Basin Springs and Seeps	25.2
	Great Basin Foothill and Lower Montane Riparian Woodland and Shrubland	21.6
	Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland/Stream	20.6
	Inter-Mountain Basins Greasewood Flat	7.2
	Rocky Mountain Subalpine-Montane Riparian Woodland and Shrubland/Stream	6.4
	Inter-Mountain Basins Wash	5.8
	Inter-Mountain Basins Playa	1.1
	Great Basin Lake / Reservoir	1.0
Landscape Species	Bald Eagle	58.0
	Loggerhead Shrike	54.2
	Golden Eagle	44.3
	Savannah Sparrow	26.4
	Ferruginous Hawk	21.7
	Northern Rubber Boa	19.7
	Swainson's Hawk	11.6
	Northern Harrier	11.2
	Prairie Falcon	10.0
	Big brown bat	8.6

Assessment Approach	Conservation Element Name	Percent Overlapped by Development*
	Colombian sharp-tailed grouse	7.8
	Cooper's hawk	6.8
	Brazilian free-tailed bat	6.8
	Mule Deer Class F Summer Range	6.6
	Common Kingsnake	5.5
	Greater Sage-Grouse Breeding Density 100%	5.3
	Pygmy Rabbit	5.2
	Sage Thrasher	5.1
	Brewer's Sparrow (Breeding)	5.1
	Coachwhip	5.0
	Mule Deer Class D Summer Range	4.7
	Sage Sparrow	4.6
	Mule Deer Class B Summer Range	4.5
	Greater Sage-Grouse Occupied Habitat	4.0
	Kit Fox	3.9
	Northern Sagebrush Lizard	3.9
	Great Basin Collared Lizard	3.7
	Greater Sage-Grouse Breeding Density 25%	3.7
	Western Patch-nosed Snake	3.5
	Greater Sage-Grouse Breeding Density 50%	3.2
	Greater Sage-Grouse Breeding Density 75%	3.1
	Clark's nutcracker	2.2
	Brewer's Sparrow (Migratory)	1.9
	Desert big horn	1.4
Species Assemblage	Migratory Shorebirds and Waterfowl Species Assemblage	22.4
	Montane Conifer Species Assemblage	8.9
	Sand Dunes and Sandy Soils Species Assemblage	8.5
	Gypsum Soils Species Assemblage	8.4
	Azonal Noncarbonate Rock Crevices Species Assemblage	7.2
	Clay Soil Patches Species Assemblage	5.6
	Azonal Carbonate Rock Crevices Species Assemblage	4.3
	Carbonate Alpine Species Assemblage	1.3
	Noncarbonate Alpine Species Assemblage	0.6

*includes; urban development; all classes of roads; solar, wind and geothermal renewable energies; mines; landfills; oil or gas wells; military urbanized areas; railroads; canals; electric utility lines; pipelines; crops or irrigated pasture.

4.5 Ecological Status of Conservation Elements

In the REA, ecological status is the term used for measuring ecological integrity of each CE as they occur across the ecoregion. Ecological status is measured for CEs using criteria and indicators suited to their ecological requirements. Different combinations of indicators (Table 3-1), applied primarily with spatial models to the current distribution of CEs, were then summarized by broader spatial analysis units.

4.5.1 Ecological Status: Terrestrial Coarse filter Conservation Elements

Where are intact CE vegetative communities located?

Where are the likeliest current locations for high-integrity examples of each major terrestrial ecological system?

Where do development CAs cause significant loss of ecological integrity?

What areas are significantly ecologically affected by invasive species?

What areas now have unprecedented fuels composition (invasive plants), and are therefore at high potential for fire?)

Ecological status was assessed and reported for the terrestrial coarse filter CEs at the scale of 5th level watershed. Ecological status indicators are scored from high (1.0) to low (0.0) values for the distribution of each CE within each watershed. Higher scores indicate relatively higher ecological status. Indicators for these CEs included the landscape condition model index, calculation of fire regime departure, the potential abundance of invasive annual grasses, and for some CEs, an index of change in extent over the past century. In general, coarse filter CEs were assessed separately for all four indicators, while landscape species were assessed with the first two indicators. Appendix B Section B-2.1.1 shows detailed results for each CE.

As explained in the methods, 5th level watersheds encompass 10s to 100s of thousands of acres, and the watershed scores are an area-weighted roll up from an individual CE distribution. Therefore, a highly developed watershed like those including Reno or Salt Lake City can display higher ecological status for a given CE, but this would be the case where the CE's distribution in that watershed is apparently little influenced by development. For example, for Inter-Mountain Basins Big Sagebrush Shrubland, the effects of landscape condition, invasive annual grasses, fire regime departure, and change in extent (displayed here using per-watershed scores) vary considerably across the ecoregion (Figure 4-13 through Figure 4-16).

Overall, findings indicate expected trends in ecological status among terrestrial coarse filter CEs (see e.g., Chambers et al. 2011, Brooks and Chambers 2011). One could expect that the highest elevation ecological systems throughout the CBR tend to occur in the most remote and un-impacted landscapes, and the landscape condition indicator scores substantiate this (Appendix B Section B-2.1.1). However, fire regime departure scores are low beginning at upper montane (even subalpine) elevations, such as among Aspen Forests, Aspen-Mixed Conifer Forest and Woodland, and Great Basin Pinyon-Juniper Woodland. The pattern among the invasive annual grass indicator is clear, with types occurring at lower elevations throughout the basins of the ecoregion also frequently scoring poorly, indicating high risk of invasive annual grasses. This is sometimes not-yet coupled with fire regime departure, where fire frequency remains very low in some desert scrub types while they appear to be accumulating invasive plant abundances.

Inter-Mountain Basins Mixed Salt Desert Scrub reflects the patterns generally found in the upland types of low elevation basins and around the fringes of the lower montane (Figure 4-17 through Figure 4-20). The landscape condition scores reflect the relatively minor impacts of development. Conversely the invasive annual grasses scores, change in extent and to some extent fire regime departure, suggest that invasives have already had an impact on this ecosystem, and may have introduced an altered fire regime. Great Basin Pinyon-Juniper Woodland (Figure 4-21 through Figure 4-24), as a lower montane ecosystem is relatively unimpacted by development, but scores for invasive annual grasses, fire regime departure and change extent suggest many areas of this ecosystem are currently degraded, or have expanded into adjacent areas of sagebrush (change in extent can be either an expansion from expected NRV conditions, or a contraction/loss).

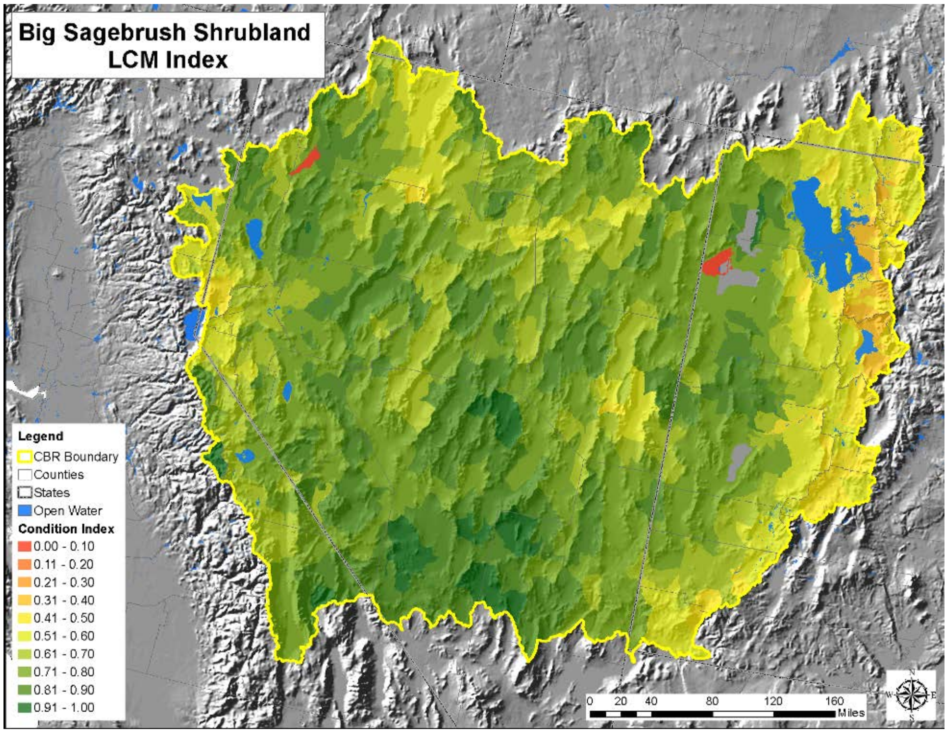

Figure 4-13. Landscape Condition Index scores by 5th level watershed for Big Sagebrush Shrubland. Ecological status is scored from high (1.0, dark green) to low (0.0, red) values for the distribution of each CE within each watershed.

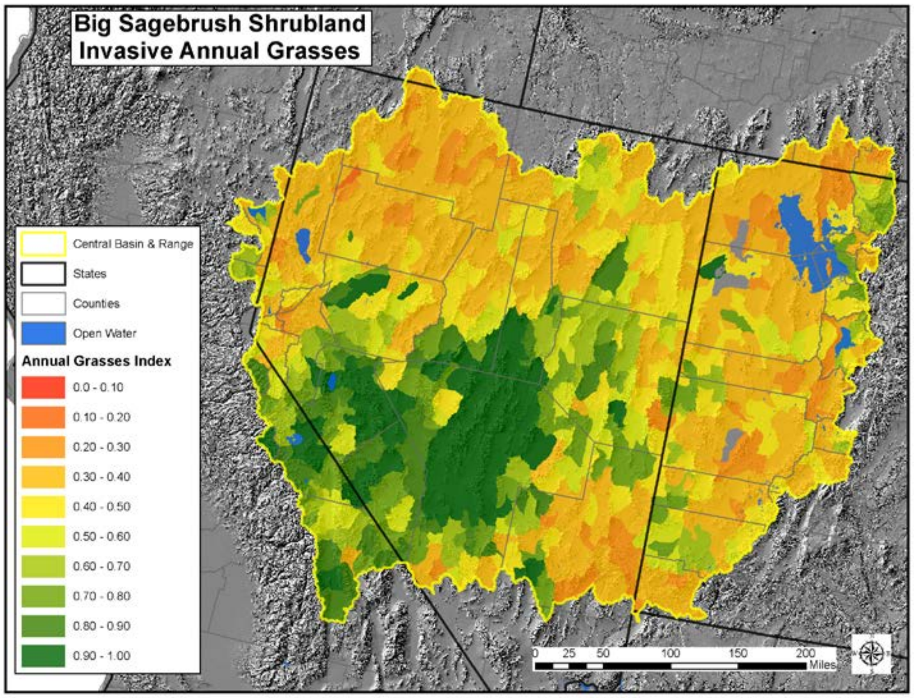

Figure 4-14. Invasive Annual Grass Index scores by 5th level watershed for Big Sagebrush Shrubland. Ecological status is scored from high (1.0, dark green) to low (0.0, red) values for the distribution of each CE within each watershed.

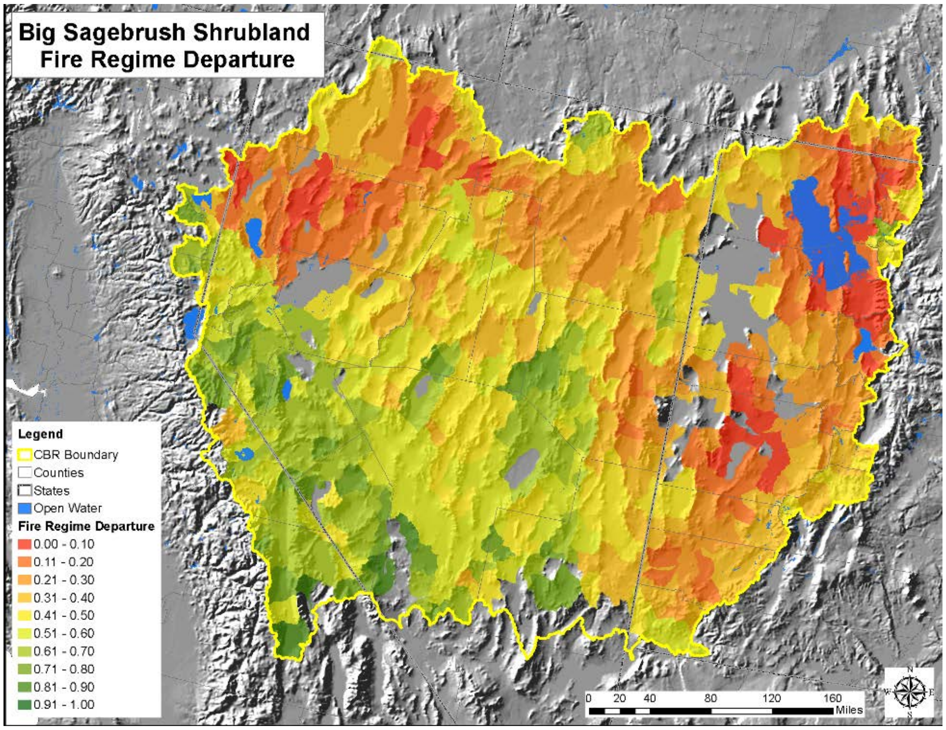

Figure 4-15. Fire Regime Departure Index scores by 5th level watershed for Big Sagebrush Shrubland. Ecological status is scored from high (1.0, dark green) to low (0.0, red) values for the distribution of each CE within each watershed.

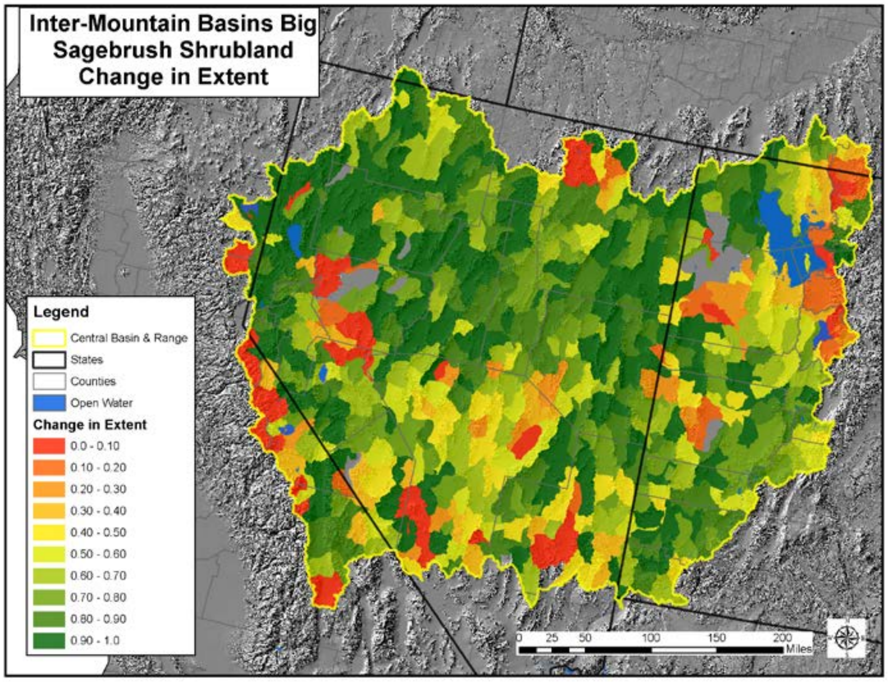

Figure 4-16. Change in Extent scores by 5th level watershed for Big Sagebrush Shrubland. Ecological status is scored from high (1.0, dark green) to low (0.0, red) values for the distribution of each CE within each watershed.

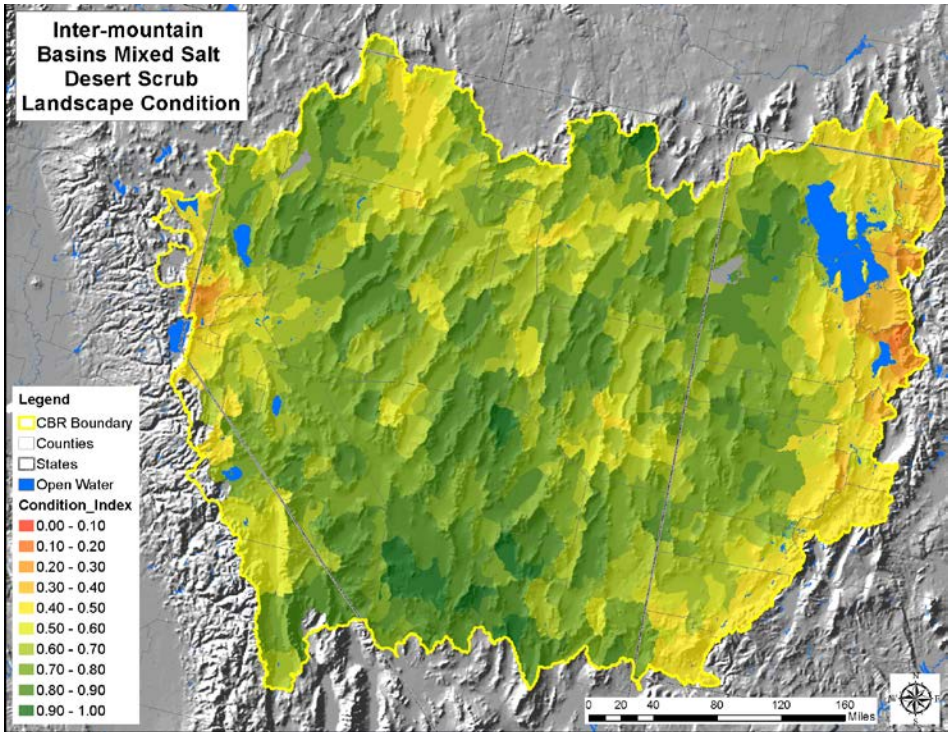

Figure 4-17. Landscape Condition Index scores by 5th level watershed for Inter-Mountain Basins Mixed Salt Desert Scrub. Ecological status is scored from high (1.0, dark green) to low (0.0, red) values for the distribution of each CE within each watershed.

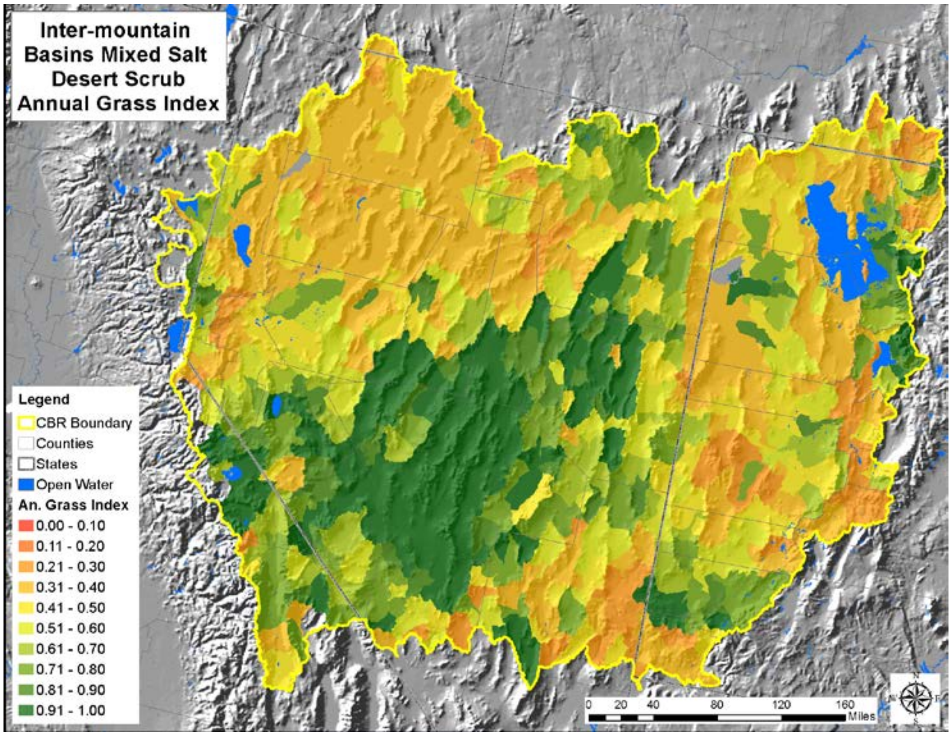

Figure 4-18. Invasive Annual Grass Index scores by 5th level watershed for Inter-Mountain Basins Mixed Salt Desert Scrub. Ecological status is scored from high (1.0, dark green) to low (0.0, red) values for the distribution of each CE within each watershed.

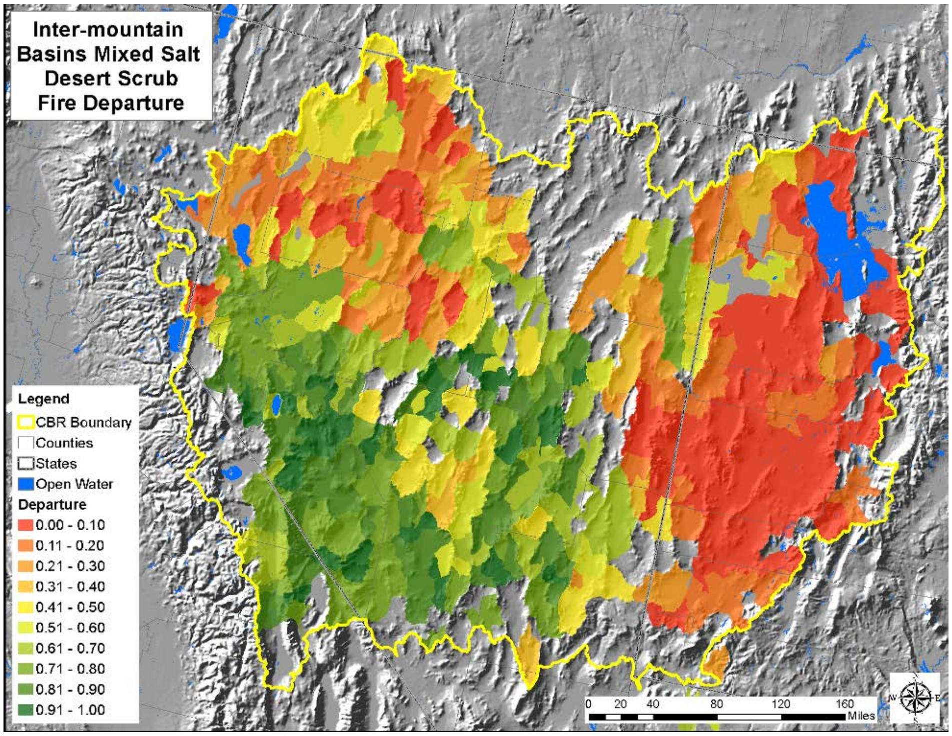

Figure 4-19. Fire Regime Departure Index scores by 5th level watershed for Inter-Mountain Basins Mixed Salt Desert Scrub. Ecological status is scored from high (1.0, dark green) to low (0.0, red) values for the distribution of each CE within each watershed.

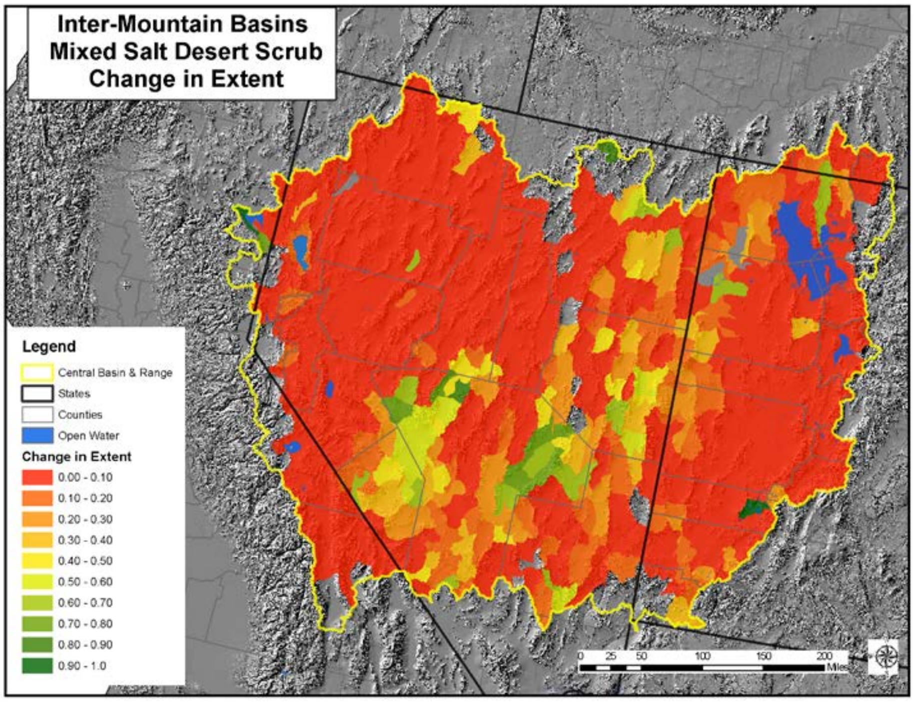

Figure 4-20. Change in Extent scores by 5th level watershed for Inter-Mountain Basins Mixed Salt Desert Scrub. Ecological status is scored from high (1.0, dark green) to low (0.0, red) values for the distribution of each CE within each watershed.

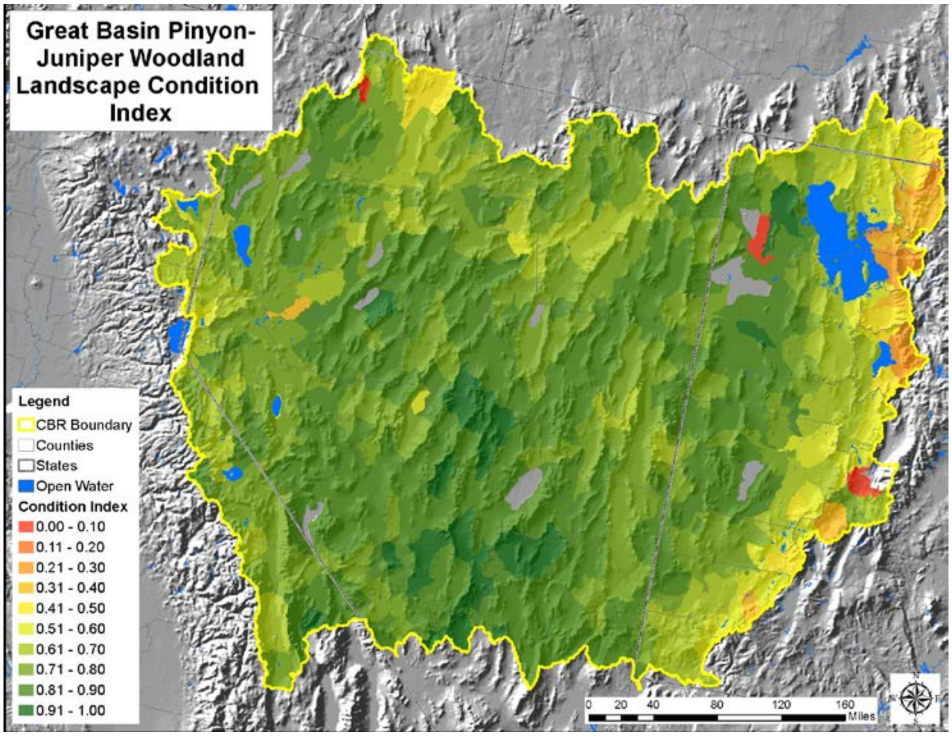

Figure 4-21. Landscape Condition Index scores by 5th level watershed for Great Basin Pinyon-Juniper Woodland. Ecological status is scored from high (1.0, dark green) to low (0.0, red) values for the distribution of each CE within each watershed.

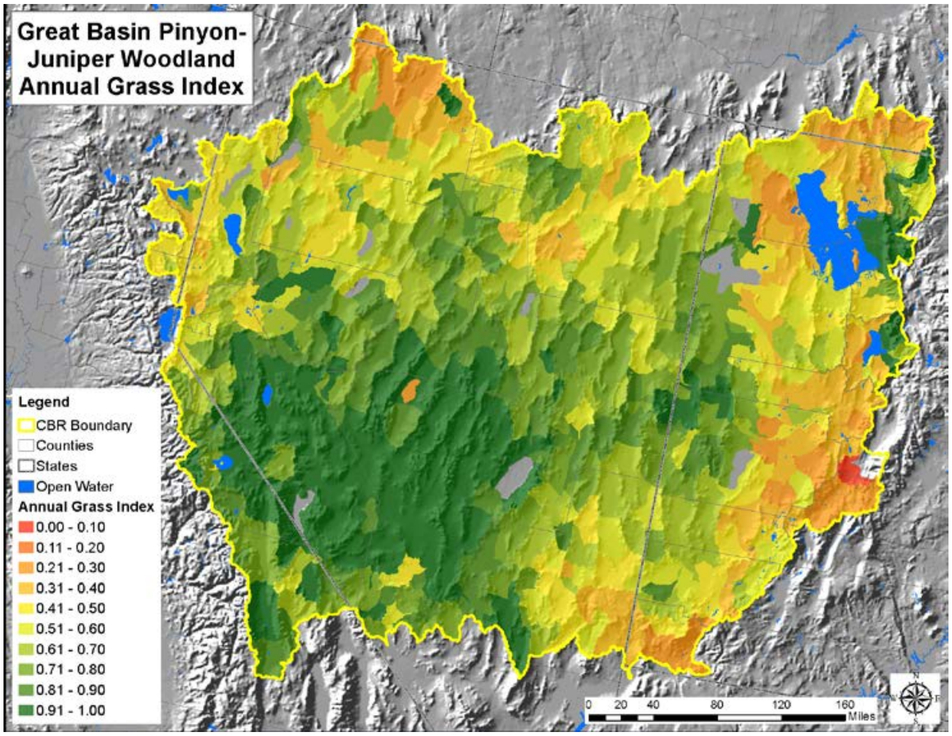

Figure 4-22. Invasive Annual Grass Index scores by 5th level watershed for Great Basin Pinyon-Juniper Woodland. Ecological status is scored from high (1.0, dark green) to low (0.0, red) values for the distribution of each CE within each watershed.

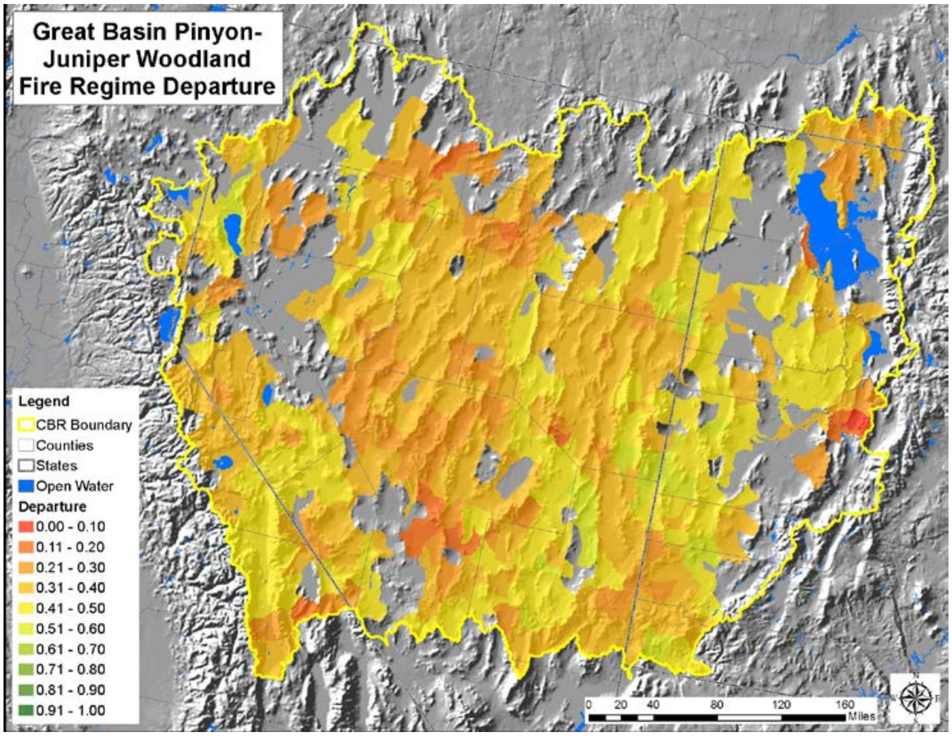

Figure 4-23. Fire Regime Departure Index scores by 5th level watershed for Great Basin Pinyon-Juniper Woodland. Ecological status is scored from high (1.0, dark green) to low (0.0, red) values for the distribution of each CE within each watershed.

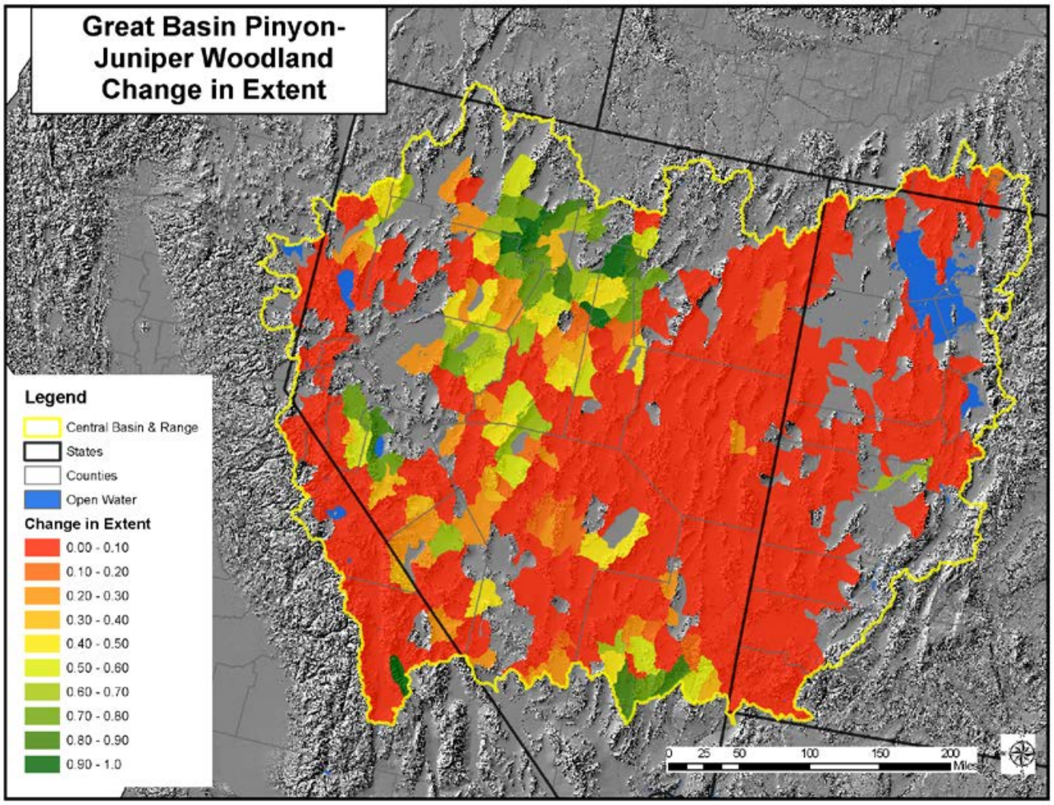

Figure 4-24. Change in Extent scores by 5th level watershed for Great Basin Pinyon-Juniper Woodland. Ecological status is scored from high (1.0, dark green) to low (0.0, red) values for the distribution of each CE within each watershed.

Appendix B Section B-2.1.1 shows detailed results for each coarse filter CE. One could expect that the higher elevation ecological systems, and those characteristic of the most remote portions of the CBR ecoregion, would tend to occur in the least-impacted landscapes. For most types across this semi-arid landscape, that holds true. The landscape condition indicators tend to be high for most types, with the general pattern of higher impacts (lower status) along the eastern fringes of the ecoregion and other areas such as in the vicinity of Reno.

Fire regime departure appears to have affected vegetation beginning at montane elevations, such as among Great Basin Pinyon-Juniper Woodland, but also has effected those at higher elevations such as the aspen and aspen-mixed conifer forests (Appendix B Section B-2.1.1). This indicator may correspond in certain types with both the invasive annual grass and change in extent indicators. For example, the change in extent indicator for Great Basin Pinyon-Juniper Woodland suggests the effects of altered fire regime and related juniper and pinyon expansion from neighboring woodlands. Across many types, the expected pattern among the annual grass indicator is clear, with types occurring at lower elevations throughout the basins of the ecoregion frequently scoring poorly indicating high risk of invasive annual grasses.

There are indeed complex interactions between fire, invasives, forecasted climate change, and past management practises. While these models do factor in current knowledge of known successional dynamics and realistic timeframes for vegetation response to disturbance, there may be considerable variation across the distribution of any one ecosystem in fire history, fire regimes, and the effects of on-the-ground management activities. This variation could not be fully accounted for in a rapid assessment such as this.

4.5.2 Ecological Status: Landscape Species

Where are existing change agents potentially affecting this current habitat and/or movement corridors, for landscape species and species assemblage CEs?

Where do development CAs cause significant loss of ecological integrity?

What areas are significantly ecologically affected by invasive species?

Landscape species selected for the REA also occur throughout the ecoregion. Most of the ecoregion land area supports one or more landscape species of management interest. Ecological status assessment for landscape species was completed for each distribution and summarized in a 4km^2 grid. A total of 22,333 grid cells comprise the CBR ecoregion. This was in contrast to the 632, 5th level watersheds, the spatial analysis units used for coarse filter CE assessments. The emphasis was on using the landscape condition model (for all species) and for others, the landscape condition indicator was used in combination with invasive annual grasses vulnerability.

Among the 28 landscape species in this ecoregion, landscape condition tends to be moderate to high across most of their distribution but with concentrated areas of low scores. This reflects the relatively dispersed, but also pervasive, effects of roads and other localized development change agents occurring across these generally widespread CE distributions (averaging 37,000 km^2). However, where landscape species tend to occur at lower elevations in all or part of the habitat range, lower scores become evident where roads and others forms of development tend to be concentrated.

The following figures provide several examples of landscape condition indicator scores relative to the current distributions of Desert bighorn sheep (Figure 4-25), Pygmy rabbit (Figure 4-26), and both summer and winter ranges for Mule deer (Figure 4-27, Figure 4-28). Status assessment maps and tabular summaries for other landscape species CEs are found in Appendix B Section B-2.1.2. Results for the assessment of **Greater sage-grouse** are provided in the case study presented in Appendix F.

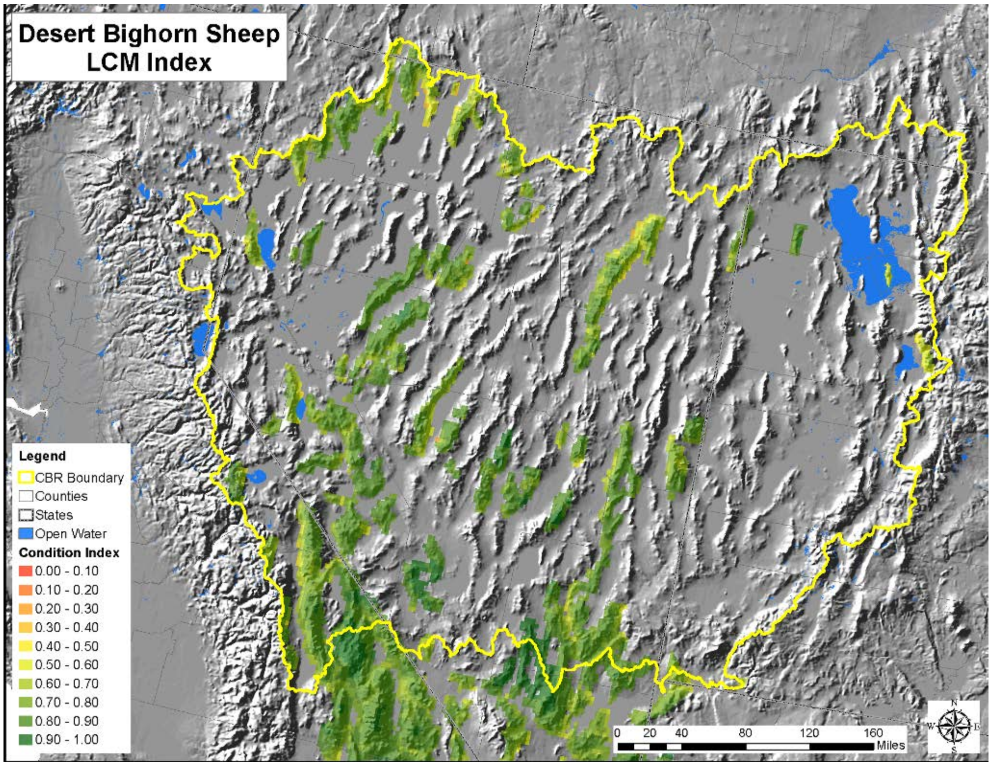

Figure 4-25. Landscape Condition Index scores for Desert bighorn sheep. Ecological status is scored from high (1.0, dark green) to low (0.0, red) values for the distribution of each CE within each 4x4 km grid cell.

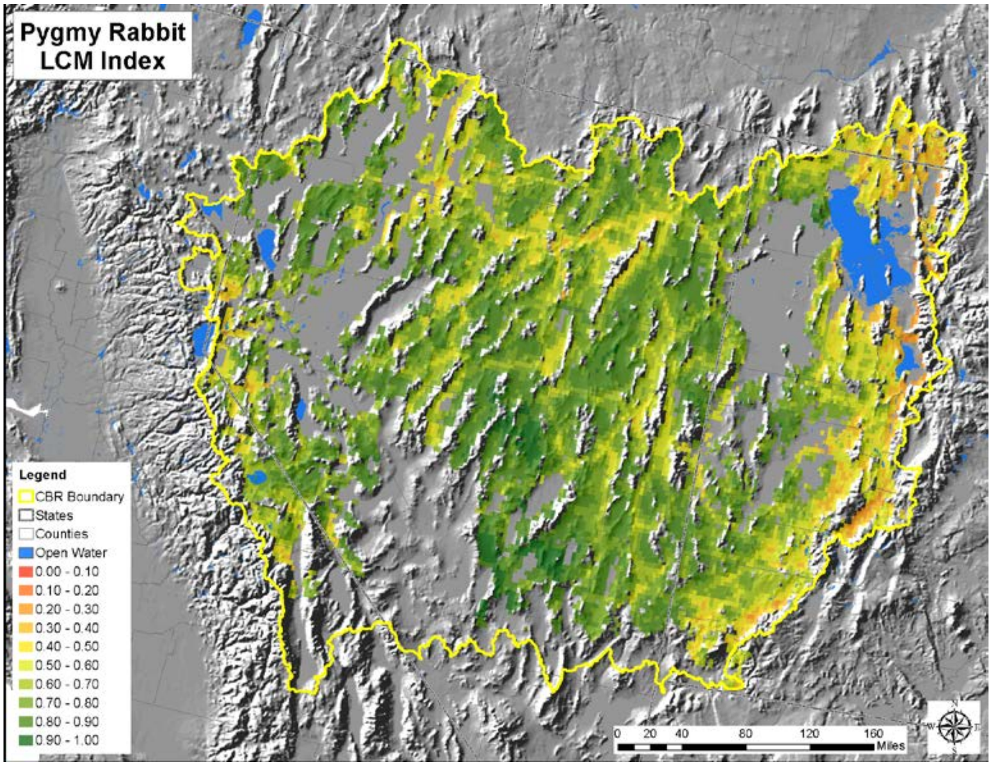

Figure 4-26. Landscape Condition Index scores for Pygmy rabbit. Ecological status is scored from high (1.0, dark green) to low (0.0, red) values for the distribution of each CE within each 4x4 km grid cell.

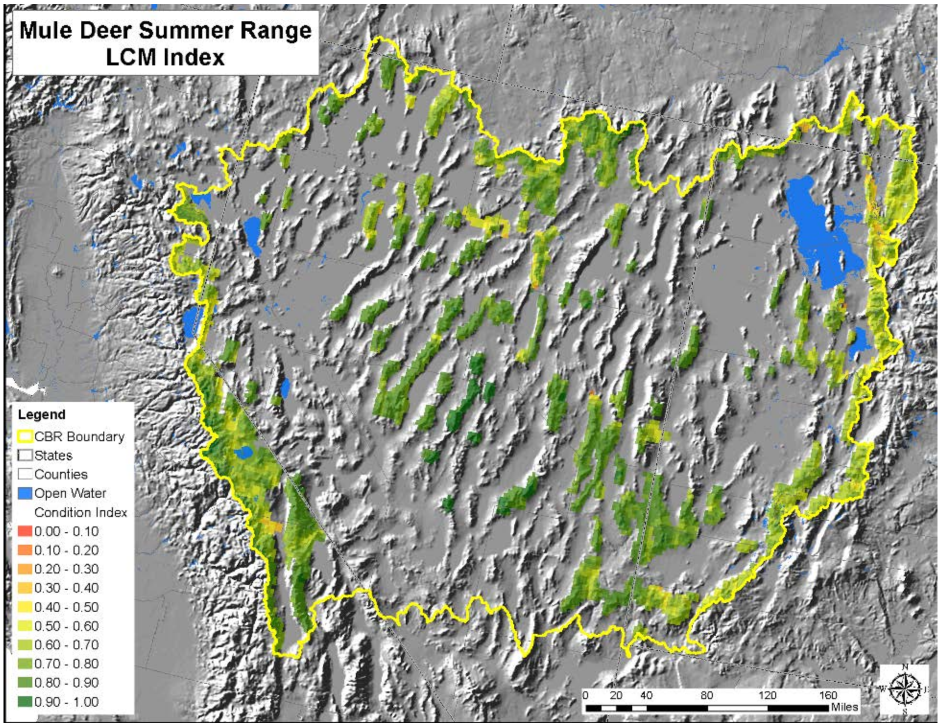

Figure 4-27. Landscape Condition Index scores for Mule deer summer range. Ecological status is scored from high (1.0, dark green) to low (0.0, red) values for the distribution of each CE within each 4x4 km grid cell.

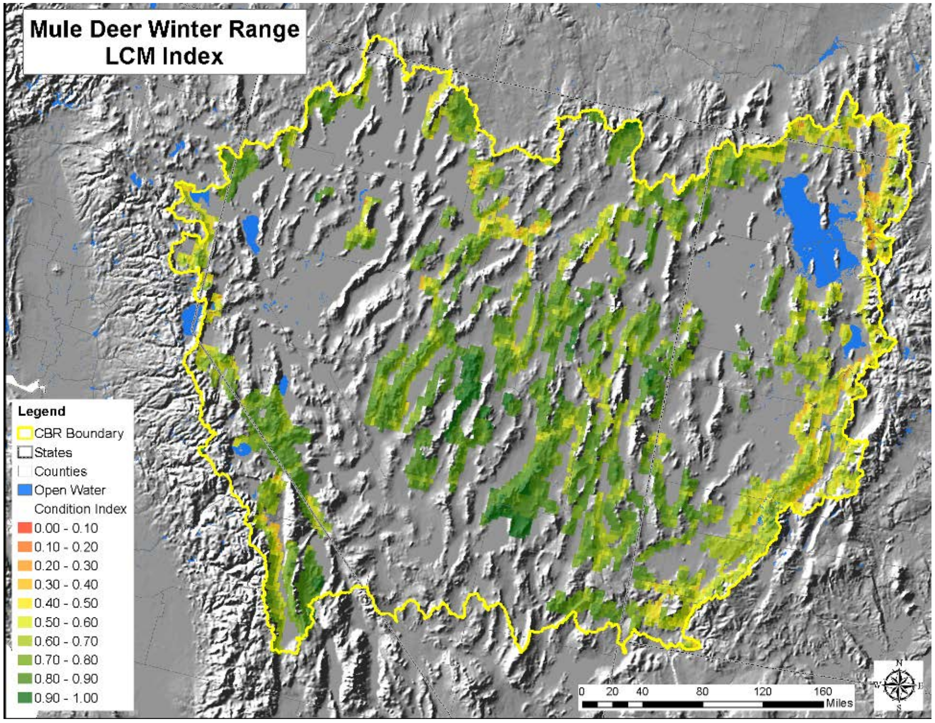

Figure 4-28. Landscape Condition Index scores for Mule deer winter range. Ecological status is scored from high (1.0, dark green) to low (0.0, red) values for the distribution of each CE within each 4x4 km grid cell.

4.5.3 Ecological Status: Aquatic Conservation Elements

What is the condition (ecological integrity) of aquatic conservation elements?

Where are the aquatic CE occurrences with the most degraded condition (ecological integrity)?

Where are the aquatic CEs showing degraded ecological integrity from existing groundwater extraction?

Where are areas affected by atmospheric deposition of pollutants, as represented specifically by nitrogen deposition, acid deposition, and mercury deposition?

What areas are significantly ecologically affected by invasive species?

Ecological status was estimated for all aquatic CEs using Key Ecological Attributes (see Methods chapter) and multiple nested indicators suited to individual CE's ecological requirements. Different combinations of indicators (see Table 3-1 above and Table 4-5 below), applied primarily with spatial models to the current distribution of CEs, were then summarized by 5th level watersheds. Some indicators are measured or averaged to the watershed scale, and other indicators are measured at the CE occurrence level, as indicated in the table below. Twelve of the indicators have high confidence (discussed below), 8 are illustrated below.

Aquatic CEs, all treated as 'coarse filter' elements, include upper and lower elevation perennial streams and any associated riparian areas, springs and seeps, lakes and reservoirs, greasewood flats, washes and playas. Marshes were not specifically included as a conservation element.

The 14 indicators of ecological status, applied variously to each CE, show persistent patterns (e.g., large spread of scores for atmospheric deposition of nitrate and mercury). Results for Great Basin Foothill and Lower Montane Riparian Woodland and Shrubland and Stream are illustrative for many aquatic CEs in this ecoregion, and will be used as illustration in the results section below. They show that the most impact is coming from development, agriculture and high density urban areas along the western, eastern and northern portions of the ecoregion as summarized in the LCM (Figure 4-29). In this section results that directly pertain to the 5 aquatic resource management questions are summarized below. Results for all indicators and their combined Key Ecological Attributes of Hydrologic Condition and Water Quality can be found in Appendix B Section 2.1.4.

Table 4-5. Key Ecological Attributes and Indicators measured for Aquatic Coarse Filter CEs. CE names have been truncated to save space. GB LM Rip = Great Basin Foothill and Lower Montane Riparian Woodland and Shrubland/Stream, RM LM Rip = Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland/Stream, RM UM = Rocky Mountain Subalpine-Montane Riparian Woodland and Shrubland/Stream, IMB = Inter-Mountain Basins.

KEAs and Indicators		**CE Name**							
Key Ecological Attribute	**Red Font** = Local Scale, measured at CE occurrence **Black Font** = Watershed Scale, measured or averaged to watershed	**Lakes & Reser-voirs**	**Springs & Seeps**	**GB LM Rip & Stream**	**RM LM Rip & Stream**	**RM UM Rip & Stream**	**IMB Grease-wood Flat**	**IMB Wash**	**IMB Playa**
I. Change in Extent/Size	1. Riparian Corridor Continuity	N	N	Y	Y	Y	N	N	N
II. Surrounding Land Use Context	2. Landscape Condition Index	Y	Y	Y	Y	Y	y	Y	Y
	3. Fragmentation by Dams	Y	N	Y	Y	Y	N	N	N
III. Stressors on	4. Surface Water Use	Y	Y	Y	Y	Y	y	Y	Y

KEAs and Indicators		CE Name							
Key Ecological Attribute	**Red Font** = Local Scale, measured at CE occurrence **Black Font** = Watershed Scale, measured or averaged to watershed	**Lakes & Reser-voirs**	**Springs & Seeps**	**GB LM Rip & Stream**	**RM LM Rip & Stream**	**RM UM Rip & Stream**	**IMB Grease-wood Flat**	**IMB Wash**	**IMB Playa**
Hydrology Condition	5. Groundwater Use	Y	Y	Y	Y	Y	y	Y	Y
	6a. Perennial Flow Modification by Diversion Structures	Y	N	Y	Y	Y	N	N	N
	6b. Flow Modification by Dams	N	N	Y	Y	Y	N	N	N
	7. Condition of Groundwater Recharge Zone	Y	Y	Y	Y	Y	y	Y	Y
	KEA-Hydrologic Condition (average of Indicators 4-7)	Y	Y	Y	Y	Y	y	Y	Y
IV. Stressors on Water Quality	8a. Atmospheric Deposition -Nitrate Loading (NO_3)	Y	N	Y	Y	Y	y	Y	Y
	8b. Atmospheric Deposition - Toxic Mercury Loading (Hg)	Y	N	Y	Y	Y	y	Y	Y
	9. State-Listed Water Quality Impairments	Y	N	Y	Y	Y	N	N	N
	10. Sediment Loading Index (within 100 m buffer)	Y	Y	Y	Y	Y	N	N	N
	KEA- Water Quality (average of indicators 8-10)	Y	N	Y	Y	Y	y	Y	Y
V. Stressors on Biotic Condition	11. Presence of Invasive Plant Species	N	Y	Y	Y	Y	Y	Y	Y
	12. Presence of Invasive Aquatic Species	Y	Y	Y	Y	Y	N	N	N

4.5.3.1 Aquatic Assessment Limitations

KEA III, *Stressors on Hydrology Condition*, has five indicators (Table 4-5). None of these provides a direct measure of the degree or spatial extent of modification of hydrologic conditions such as stream or spring discharge, or spring or wetland water levels, upland infiltration & runoff. Discharge and water table data are sparsely available across the ecoregion and where they exist, they are limited to highly localized conditions, short periods of record, and/or post-date major hydrologic modifications. For stream systems, the national StreamStats program often can provide a reasonable substitute for actual field data of sufficient spatial extent and record length. Unfortunately, Nevada had not completed its implementation of StreamStats at the time of this analysis, making it impossible to use this data system as a substitute even for flow data. Further, StreamStats data would not allow for an assessment of how hydrologic conditions may have changed over recent decades. As a result, the focus was on measures of the dominant anthropogenic causes of hydrologic alteration in this desert ecoregion: surface water impoundment, diversion, and use; groundwater use and modifications of groundwater recharge zones. Measures of dominant causes of alteration serve as surrogate measures of actual alteration.

KEA IV, *Stressors on Water Quality*, has four indicators, three of which are measures of causes of water quality impairment. Data on actual water quality conditions are sparsely available outside of water-bodies that are subject to intensive human use or that have received discharges of pollutants. For example, data are readily available on waters in the Carson-Reno area related to studies of the impacts of historic mine wastes. The spottiness of water quality data made it necessary to use surrogate indicators based on causes of stress to water quality. Data were included on State-Listed Water Quality Impairments, as reported by states to the U.S. Environmental Protection Agency. However, these data pertain only to water-bodies where concerns have been raised concerning potential failures to meet designated uses under the federal Clean Water Act. Within this ecoregion, these data therefore are also very sparsely distributed, and do not provide a representative sample of data on water quality across all water-body types and settings. Nitrate and mercury deposition per watershed was derived using data from the National Atmospheric Deposition Program (NADP), National Trends Network and the Mercury Deposition Network (NADP 2012), which maintains a network of monitoring stations throughout the nation. Fewer than ten stations are located irregularly across the CBR ecoregion and immediately surrounding ecoregions, mostly at higher elevations.

KEA V, *Stressors on Biotic Condition*, has two indicators dealing with exotic invasive species, in order to answer the last management question listed above. Unfortunately these were the weakest indicators. The data available for known presence of invasive plant species (tamarisk (*Tamarix* spp.), Russian olive (*Elaeagnus angustifolia*), annual grasses) and aquatic invasive species), while available across the ecoregion, were sparsely distributed. As a result, these data give a false picture of reality on the ground. Early in the REA process, the assessment team considered using data on native species distributions and condition as indicators of biotic condition for aquatic CE types. For example, the distribution and condition of native trout species would provide information on the biotic condition of higher-elevation, coldwater streams. Unfortunately, this proved impossible within the limitations and criteria established for the REA. To illustrate, it was decided not to use native fish species distribution data for four reasons: (1) maps of the historic or expected current geographic ranges of species were available but could not be used as substitutes for data on actual current distribution on a stream-by-stream basis; (2) data for the entire ecoregion were not available; (3) data on native fishes were available for Utah, but these data did not meet the ecoregion-wide criteria as stated in Chapter 2, section 2.7.1.1 Limitations: Issues of Scale & Certainty; and (4) the location and status of native fish species were not the subjects of any management questions.

Data were actively sought on stream benthic macroinvertebrates, collected as parts of systematic studies of stream biotic condition for purposes of building multi-variate measures of stream biotic integrity. The Western Center for Monitoring and Assessment of Freshwater Ecosystems (WMC) and the National Aquatic Monitoring Center (NAMC) maintains a regional database of such data, from which an attempt was made to obtain multi-variate measures of stream biotic integrity. Scott Miller, Director of the BLM “Buglab” at the NAMC (http://www.usu.edu/buglab/) provided a copy of this dataset for review, clipped to the ecoregion. Unfortunately, the available data were spatially very sparse and necessarily limited to perennial stream reaches only. The individual states within the ecoregion are all developing stream bioassessment programs based on common methods, and it was hoped that state data could be used to complement the data provided by the NAMC. However, only Utah had bioassessment data available beyond those contained in the regional database. Nevada is rapidly building its stream bioassessment metrics, and its data should be available soon but not in time for this REA. California reports that it is the process of building a digital database for its bioassessment data, but that this database will not be functional for data extraction for some time. Further, the data available from the NAMC included both reference and impacted sites. It was difficult to summarize this information on a watershed scale, as a single stream might have highly impacted (negative scores) and reaches of the highest quality. Integrating sparsely collected, very-fine scale data into a regional assessment always raises such challenges. As a result, it was determined that it would not be feasible to use the stream bioassessment data for this REA.

4.5.3.2 Results

The conservation element “Great Basin Lower Montane and Foothill Riparian Woodland and Shrubland/Stream” is illustrative for many aquatic CEs results in this ecoregion because it is wide-spread. Results for all Aquatic CE’s can be reviewed in Appendix B Section B-2.1.4. Here results highlight 8 indicators that show the most impact and two KEAs that summarize the bottom line for aquatic integrity for the ecoregion. All of the indicators consistently show impacts from the heavily developed urban and agricultural use areas in the northwestern quadrant of the ecoregion, along the Wasatch Front, in the Owen's Valley and environs, along the I-80 corridor, and in certain interior watersheds where large mines and other impacts occur. Development and high density urban areas along the eastern and western margins of the ecoregion and along the highway corridors is summarized in the Landscape Condition Index and where these have direct impacts to riparian corridor continuity (Figure 4-29). Stressors to intact hydrologic flow are shown by surface and ground water use (Figure 4-30). Stressors to water quality are shown by the amount of nitrate and mercury dry atmospheric deposition (Figure 4-31). Additional stresses to water quality are measured locally through the sediment loading index within a 100m buffer around each CE, and the number of state-listed impaired waters for rivers and lakes, summarized by watersheds. These data show where these types of impacts tend to be concentrated (Figure 4-32). Invasive species are of great importance to managers and known location and abundance of aquatic and terrestrial invasive species are reported, but unfortunately results are based on very poor data (i.e., few documented locations) (Figure 4-33). Lastly, illustrated is a way to summarize multiple indicators through the Key Ecological Attribute Hydrologic Condition and Water Quality (Figure 4-34).

Riparian Corridor Continuity

The Great Basin Foothill and Lower Montane Riparian Woodland and Shrubland/Stream is the most abundant riparian CE in the ecoregion and has the most fragmentation (lowest scores of continuity) because it primarily occurs along valley bottoms where roads, towns, power lines, agriculture, and other development tends to be concentrated. Many interior watersheds fall into middle range of fragmentation due to many un-paved roads, while many watersheds have low levels of fragmentation. Some watersheds with great amount of corridor fragmentation have seemingly contradictory high Landscape Condition index scores for the same watershed (Figure 4-29). This is because the former is measured at the local occurrence level where the impact must occur within the 100 m buffer and be lower than 0.70 to count as enough impact to fragment the corridor; while the latter is an average for the amount of human footprint found throughout each watershed (Figure 4-29). A threshold of 0.70 was chosen because it represents the amount of impact is about 1/3 of the total scale, the threshold between a "B" rating and a "C" rating. Scores higher than this are still functioning, while scores lower than this show increasing vulnerability to additional stress.

Landscape Condition Index

The landscape condition index is measured through a model that incorporates all human development impacts, including urban density, railroads, location of mines, minor roads and major highways. Most of the ecoregion is in a state of moderate impact with only small number of watersheds in an un-impacted condition and a few watersheds with high levels of development. The highest impacted watersheds are located primarily in the northwestern and northeastern sections of the ecoregion, where the highest concentration of human populations; the least impacted are in the southern central portion, where few roads and towns occur (Figure 4-29).

Historic and contemporary land use practices have impacted hydrologic, geomorphic, and biotic structure and function of aquatic resources. Human land uses both within buffer zones as well as in adjacent and upland areas have fragmented many riparian reaches which has reduced connectivity between riparian and wetland patches and upland areas. The intensity of land use within the surrounding watershed affects downstream wetlands and riparian areas. Land use impacts vary in their intensity, affecting ecological dynamics that support ecological systems, including effects on nutrient and sediment loading, and surface water runoff in the surrounding 5th level watershed. The Landscape Condition Model index is a surrogate measure for direct impacts of land use affecting the amount and timing of water, sediments, nutrients and animal movement within the surrounding landscape that supports the aquatic corridor and other resources.

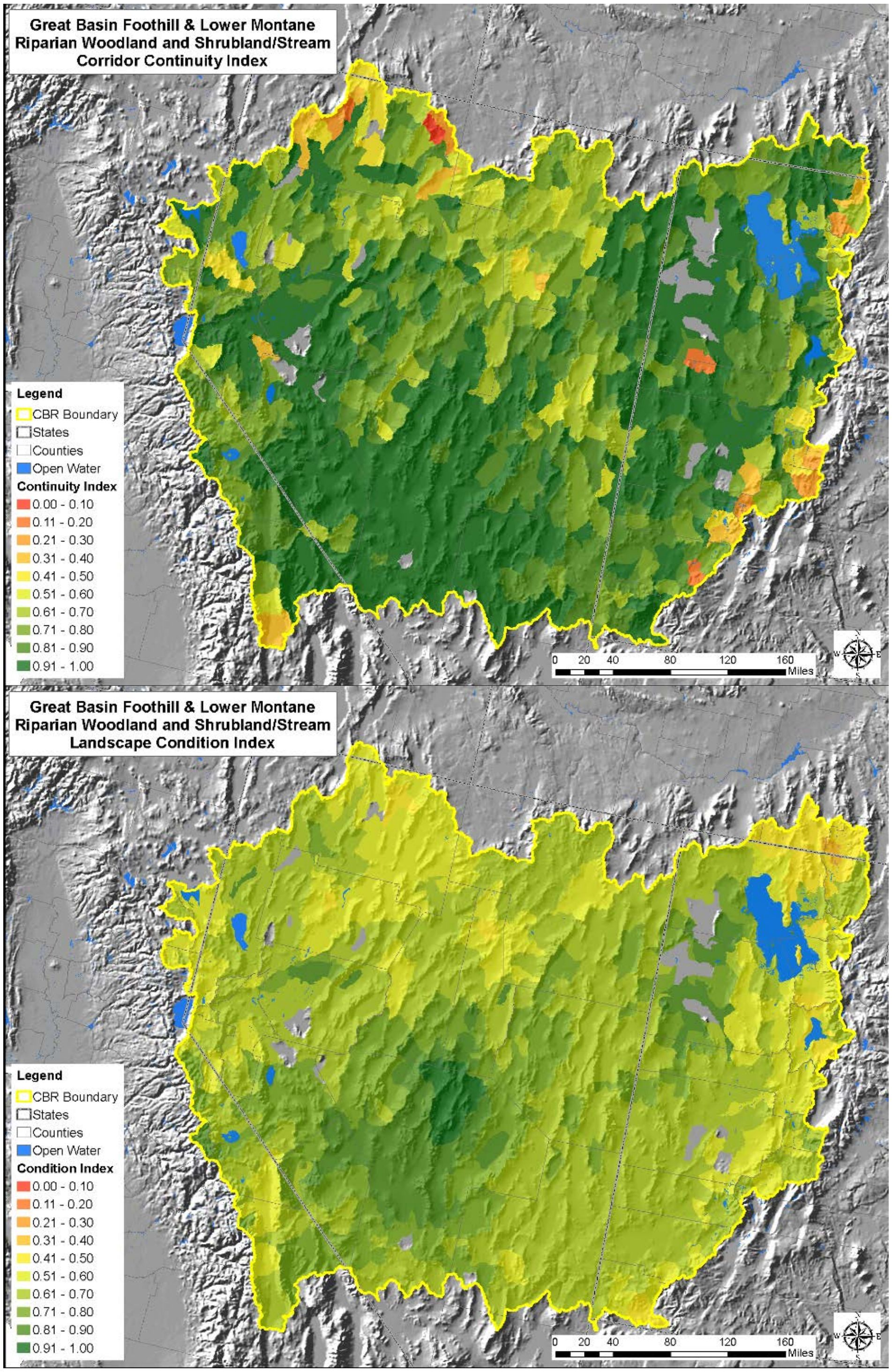

Figure 4-29. Riparian Corridor Continuity (top) and average Landscape Condition Index (bottom) scores. Riparian Corridor Continuity is the degree of fragmentation measured by an overlay of the Landscape Condition Model 30 m pixels onto 100 m buffered occurrences of the riparian CE. Average Landscape Condition Model scores by watershed shows the urban density relative to Great Basin Lower Montane and Foothill Riparian and Streams distribution within the Central Basin & Range Ecoregion. Color ramp on both figures indicate that red is the highest impact, and green the lowest, along a normalized index of 0-1.

Indicator 04 Surface Water Use relative to annual flow

Surface water use for agriculture and public water supply in desert ecoregions removes water from natural surface waters including from streams, rivers, springs outflows, and lakes, where it otherwise would have supported natural aquatic ecosystems. Consumptive use of surface waters affects these natural ecosystems in several ways: (1) it reduces the total amount of surface water available to support these natural ecosystems, and to support downstream ecosystems that naturally received their discharge; (2) the timing of water withdrawals alters the timing of water availability (i.e., the hydrologic regime) in these natural ecosystems and their downstream dependents; and (3) return flows (if any) from surface water use may alter the chemistry of natural surface waters as well as contribute to further changes in their hydrologic regime. See Appendix B Section B-2.1.4. for more detailed information on methods and references.

Surface water use in the CBR ecoregion is greatest in four sections of the ecoregion: (1) the basin floor and toe of the slope of the Wasatch Front, from the vicinity of the Great Salt Lake south to the Virgin River valley; (2) a cluster of valleys in northwestern Nevada, northwest of Winnemucca; (3) scattered watersheds along the basin floor and toe of the slope of the Sierra Nevada Range, both north and south of Carson City; and (4) along streams flowing out of scattered mountain ranges in the center of the Central basin, including in the vicinity of Elko, NV. Most of these instances involve only the use of local surface water supplies without contributions from inter-basin transfers, other than perhaps from immediately adjacent watersheds. Alterations to natural stream, river, and possibly lake hydrologic regimes are likely significant in these watersheds (Figure 4-30).

Indicator 05 Groundwater Use relative to annual flow

Groundwater use is the CBR ecoregion is highest in approximately the same four sections of the ecoregion where surface water use is also highest. Most of these instances involve center-pivot irrigation for agriculture and these areas exhibit high densities of such irrigation systems. Center-pivot systems are highly visible in satellite imagery that allowed verification of these results. Withdrawals from alluvial, basin fill, and regional aquifers have the potential to affect the hydrologic regime of perennial streams, wetlands, and springs in all affected watersheds (Figure 4-30). Natural groundwater discharges in semi-desert ecoregions, including the CBR ecoregion, support islands and corridors of aquatic and riparian biodiversity within these ecoregions, which in turn often support rare or unique biotic assemblages.

Natural groundwater discharges in semi-desert ecoregions, including CBR, support islands and corridors of aquatic and riparian biodiversity within these landscapes, which in turn often support rare or unique biotic assemblages. The integrity of ecosystems strongly affected by groundwater discharges depends both on the amount of groundwater discharged to the ecosystem; and (usually) on the unique temperature and chemistry regimes of the groundwater, as well (e.g., Winkler 1977, Constantz 1998 Manning 1999, Deacon et al. 2007, Patten et al. 2007, Jones et al. 2009, Abele, ed. 2011, BLM 2011). Groundwater use for agriculture and public water supply in these ecoregions removes water from aquifer systems, the potentiometric surfaces and natural discharges of which originally supported groundwater levels in wetlands; spring discharges and stream baseflows; subsurface discharges to lakes; and surface water levels in wetlands that received inflows from these latter sources. The removal of groundwater therefore has the potential to disrupt several kinds of natural aquatic ecosystem types.

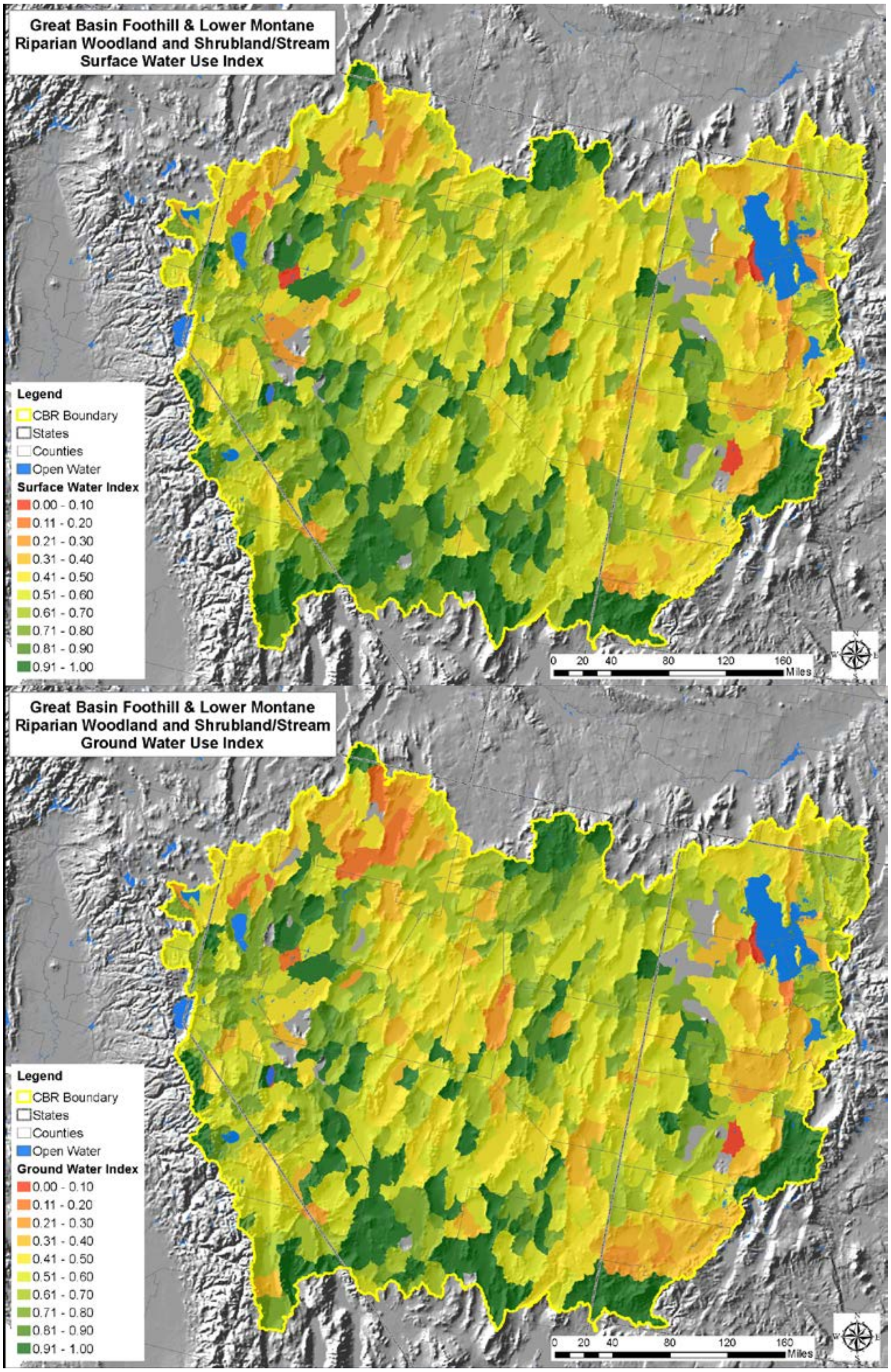

Figure 4-30. Surface Water Use (top) and Groundwater use (bottom) by watershed. Values were calibrated for watershed size and degree of wetness by dividing annual use by the total annual average surface flow. Results were highly skewed, even after log transformation: some watersheds have no water use, and others have extremely high values due to trans-basin imports. Index values were calculated by log transformation and normalized to range between 0 (red) with the highest use/impact and 1 (green) with the lowest use/impact to aquatic conservation elements.

Indicator 08a Atmospheric Nitrate Deposition

The indicator serves as a representative of a broad class of common air pollutants, consisting of oxides of nitrogen and sulfur (often denoted NOx and SOx). When deposited back on the earth surface through precipitation (i.e., carried with rainfall, snowfall, etc.), these compounds can alter the pH and/or the nutrient balances of the soils and waters into which they are deposited, with ecological consequences. Geographically comprehensive data do not exist for this ecoregion on water pH and nutrient concentrations, nor on bioassessment indicators, with which to assess stresses to water quality. The assessment of nitrate deposition therefore provides a means to assess a common source of alteration (stressor) that may affect water pH and nutrient concentrations. While nitrate deposition is also important to terrestrial ecosystems, as it can give some invasive annuals such as cheatgrass a competitive advantage, it was not assessed as a status indicator for the terrestrial ecosystems.

Atmospheric nitrate deposition affects all aquatic CEs except Springs and Seeps, which are thought to be too small to be affected. Atmospheric deposition of nitrate across the CBR ecoregion follows a clear pattern, with high rates of deposition across all of western Utah and along the Owens Valley in California. The high rates in Utah presumably are caused by the concentration of urban and industrial activity along the Wasatch Front, with local air circulation patterns carrying the emissions westward into the Central Basin. The high rates along the Owens Valley may be a result of air transport from the greater Los Angeles area to the south, emissions from Edwards AFB and the China Lake military reserves, or local farming practices and/or vehicle emissions along US 395. However, although the zone of high concentration along the Owens Valley extends well southward into the MBR ecoregion, it does not extend south of Edwards AFB. This distribution suggests that the source(s) of the deposition along the Owens Valley is/are located in the military reserves and/or along the highway but this was not confirmed. Nitrate deposition alters nutrient regimes in aquatic CEs that receive runoff from the affected watersheds; and causes acidification of alpine/sub-alpine lakes and wetlands in watersheds with granitic bedrock geology (Figure 4-31).

Indicator 08b Atmospheric Mercury Deposition

Atmospheric mercury deposition affects all aquatic CEs except Springs and Seeps, which are thought to be too small to be affected. Atmospheric deposition of mercury across the ecoregion follows a clear pattern, with two zones of higher deposition: (1) along the Wasatch Front, especially from Provo to Cedar City, Utah; and (2) within a cluster of watersheds north and northwest of Battle Mountain and Winnemucca, Nevada. The high rates in Utah presumably are caused by the concentration of urban and industrial activity along the Wasatch Front, with local air circulation patterns carrying the emissions westward into the Central Basin. Mercury deposition also occurs at higher rates at higher elevations, in association with precipitation. The high rates in northern Nevada are associated with well-documented emissions from several mining ore processing facilities in this area (Fenn et al. 2003a, 2003b) (Figure 4-31).

Once atmospheric mercury is deposited into wetlands it gets converted to a biologically reactive, toxic compound (methyl-mercury) through digestion by anaerobic bacteria. This compound bio-accumulates through the food web in wetlands, lakes and streams that receive inflows from these environments. Top aquatic predators (e.g., native trout) and insectivorous and larger avian predators that feed along these lakes and streams accumulate toxic body loads, leading to impaired neurological development and reduced reproductive success (Weimeyer et al. 2007, Darnall and Miles 2009, Naftz et al. 2009, Wurtsbaugh et al. 2011). However, within the national database, even the highest deposition rates for mercury in the CBR ecoregion do not rise to the level of true mercury deposition “hotspots” such as are known elsewhere in the conterminous U.S. Such hotspots receive much higher deposits of mercury, resulting in body loads in top predators sufficient to cause biological harm. The regional data on mercury deposition within the CBR ecoregion do not identify any such hotspots. To reiterate, the deposition of mercury is what was assessed, not the bioaccumulation issues that occur. There are problems with bioaccumulation, but for this ecoregional analysis only the atmospheric deposition was assessed. There certainly are mercury fish advisories within the Central Basins Ecoregion (e.g., http://fishadvisories.utah.gov/advisories.htm#utah), but the bioaccumulation of mercury was not part of the assessment.

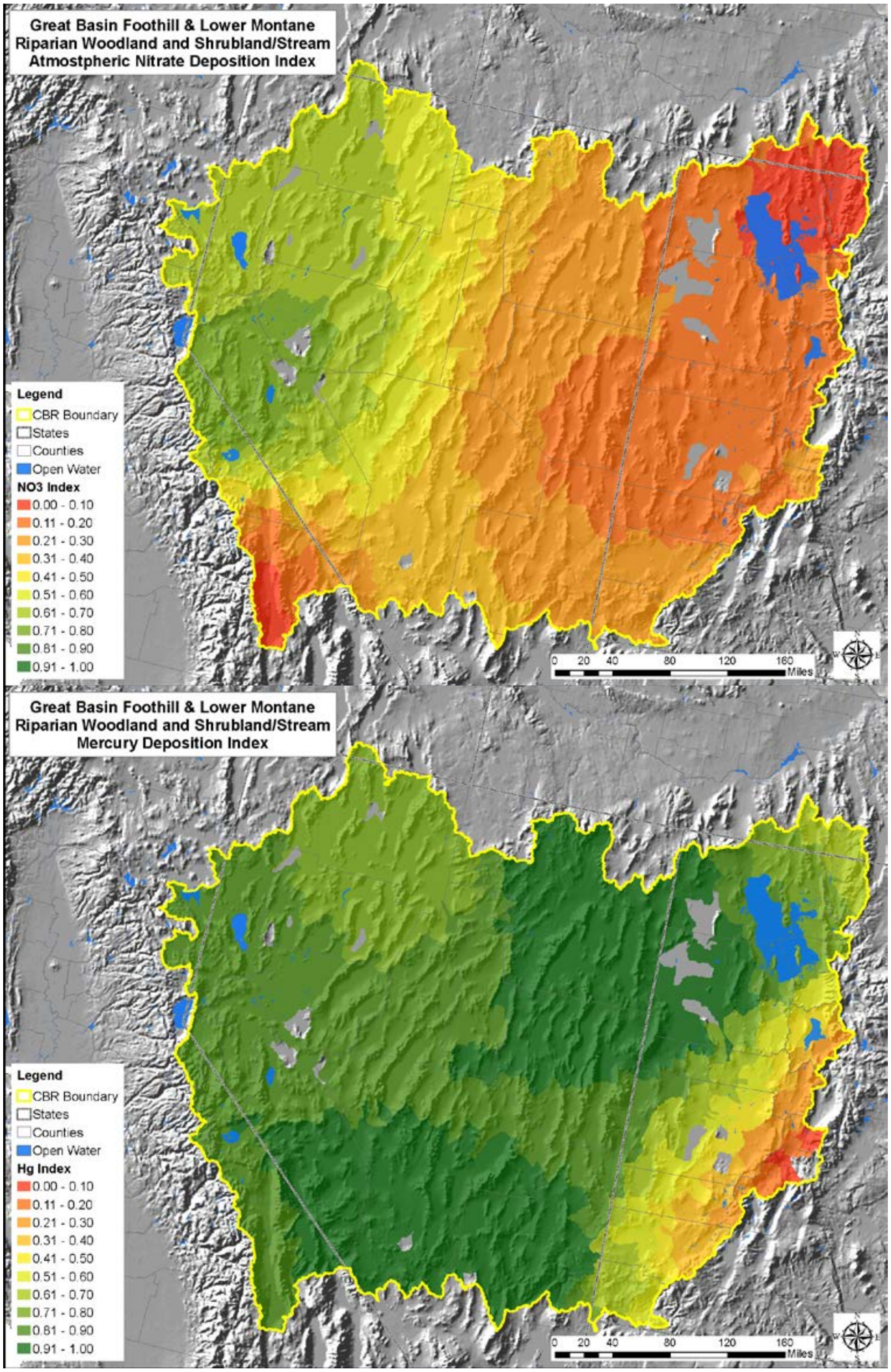

Figure 4-31. Atmospheric nitrate deposition (top) and mercury deposition scores (bottom). Mercury values were calibrated for natural background mercury levels. Index scores are normalized between 0 (red) with highest impact and 1 (green) with least impact.

Indicator 09 State Listed Water Quality Impaired Waters

Only 18 watersheds (Figure 4-32, bottom) had listed impaired water quality issues (see Appendix B Section 2.1.4, indicator #09 for details). For riparian CEs, the percent of the total stream miles impaired is reported, while for lakes/reservoirs, watersheds are summarized by the percentage of impaired water bodies. The locations of these impacted waters are scattered throughout the ecoregion with the majority of impacted watersheds in the western, eastern and northern portions of the ecoregion (Figure 4-32).

Indicator 10 Sediment Loading Index

This index is a surrogate for a direct measure of the amount of suspended solid sediment. It is calculated by first calculating the percent cover of each land use/cover type within a 100 m buffer on each side of riparian aquatic CEs, then multiplying those percentages by a national standard sediment loading index for each type of land use/cover (NSPECT 2004). It was important to apply both this index and the surrounding landscape (see Indicator Surrounding Land Use Context) to get a more accurate picture of impact on the aquatic resources. This is because the amount of natural vegetative cover within the buffer area can decrease the sediment loading of the larger surrounding area, and conversely, certain land use/cover may be a source of sediment within the buffer zone that may otherwise be surrounded by non-sediment producing land use/cover (Figure 4-32).

Indicator 11 Presence of Invasive Plant Species

The combined data from known tamarisk, Russian olive and annual invasive grass species reveal infestations in just 12% of the aquatic conservation element locations. All the Aquatic CEs show the same trend of 1-2 watersheds with many invasives, 10-20 watersheds with 4-8 invasive species points, and many with much less. This low number was believed to be due to a lack of specific inventory for invasive species. It is recommended to look at the potential for invasion by species in the models presented in section on change agents (Figure 4-33).

Indicator 12 Presence of Aquatic Invasive Species

For aquatic invasive species, the data are also very poor. Only 38 records of aquatic invasive species occurrences were located for the ecoregion. However, this lack of data/observations does not mean aquatic invasives have been confirmed to not occur. Worst scores occur in watersheds with high human traffic either in the form of roads, highways and railroads, or associated with popular boating destinations such as Washoe Lake (Figure 4-33).

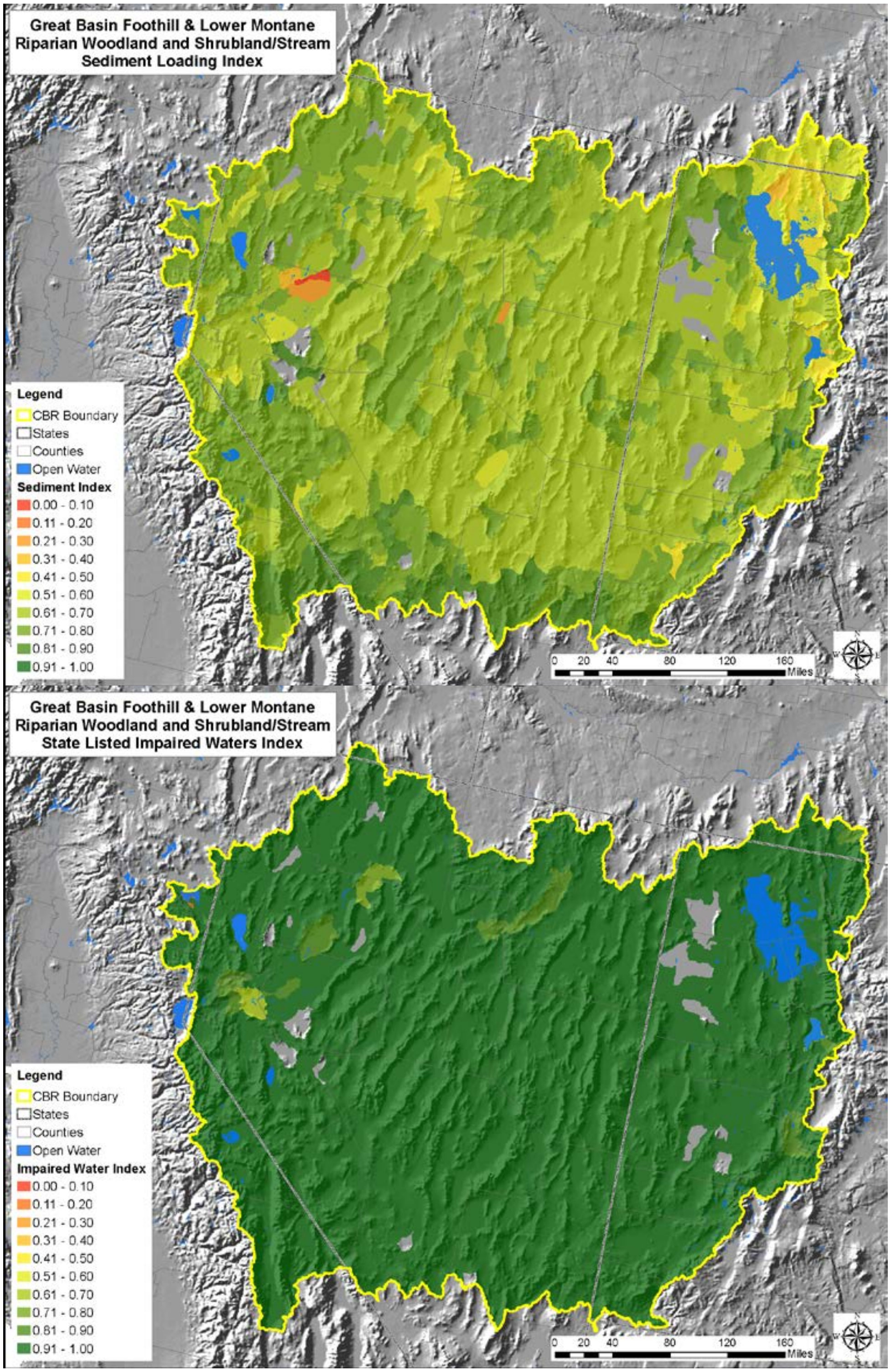

Figure 4-32. Sediment loading index scores (top) and State listed impaired waters (bottom). Red indicates the lowest scores (poor condition) and dark green the highest (good condition). All scores within this ERA are standardized between 0 and 1, where 1 indicates good condition and 0 indicators poorest or worst conditions . Poor scores indicate high sediment loads (top) or several State Impaired water permits (bottom).

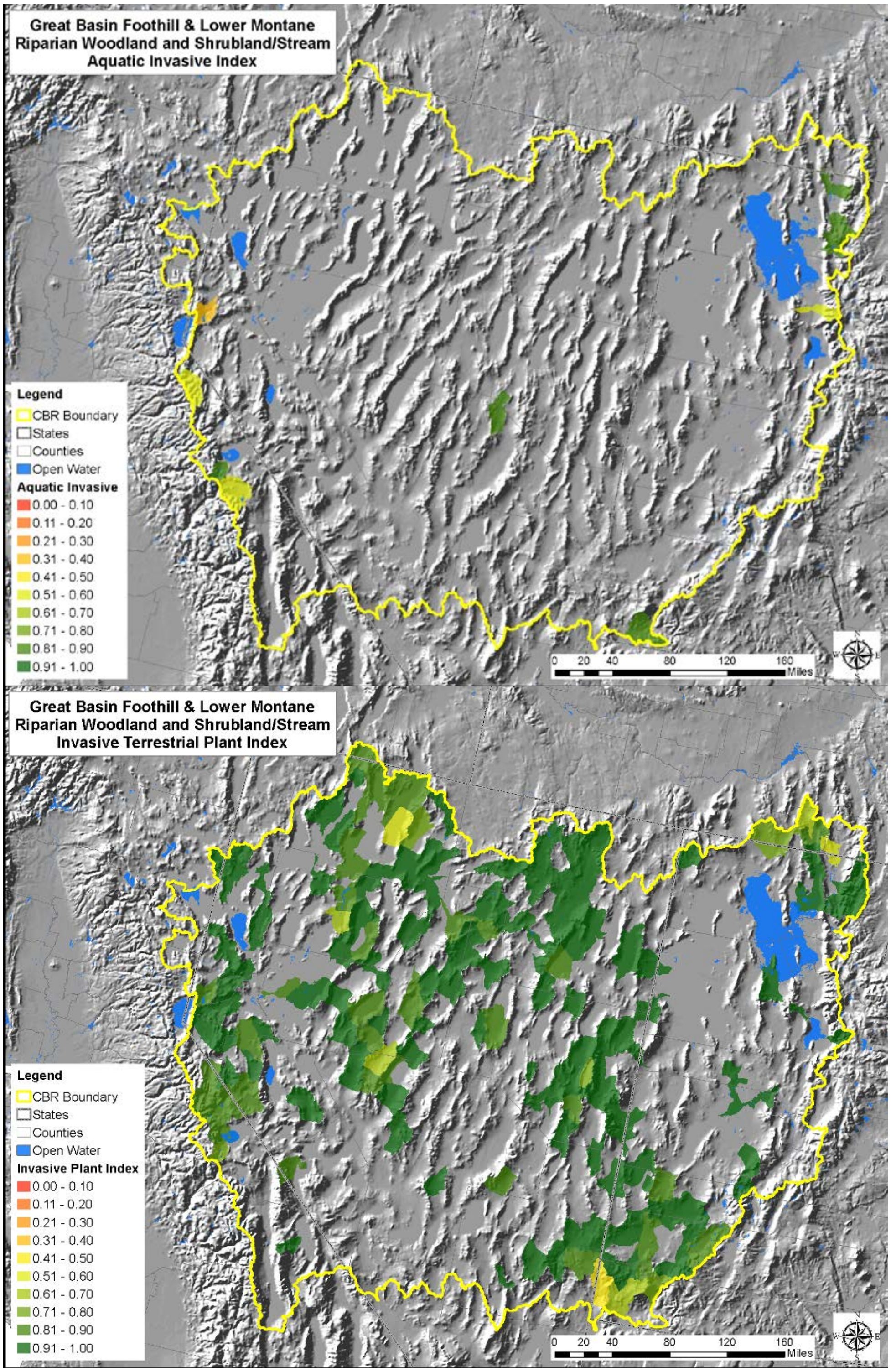

Figure 4-33. Stressors on Biotic Condition include presence of aquatic invasive species (non-native mussels, didymo, etc. (top)) and invasive terrestrial plant species such as tamarisk, Russian olive and non-native annual grasses (bottom). These indicators are based on known, documented presences of these species, for which data locations are very poor. Areas with no color do not confirm the absence of invasive species in those areas.

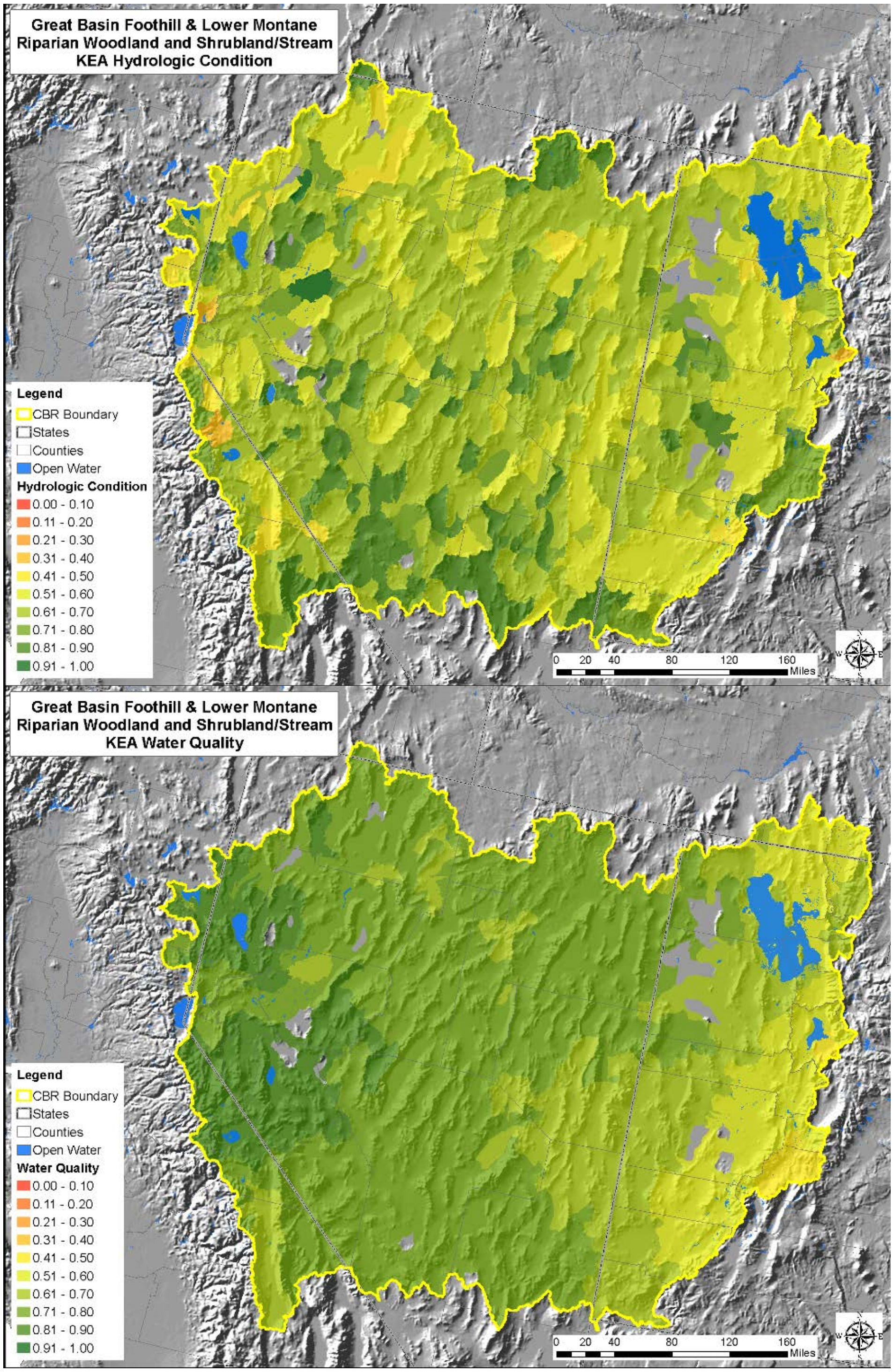

Figure 4-34. Two Key Ecological Attributes for Great Basin Foothill Riparian and Stream: hydrologic condition and water quality. KEA Hydrologic Condition (top) summarizes 5 indicators all measuring the degree of stress on hydrologic condition: Surface water use, Ground Water use, number of aqueducts, flow modification by dams, and condition of groundwater recharge zones (not all of these individual indicators are shown). Similarly, the KEA Water Quality (bottom) is summarized by the 4 indicators: nitrate and mercury atmospheric deposition rates, state-listed water impairments and sediment load index within 100 m of each CE occurrence.

4.5.3.3 Summary/Synthesis

The above results for the “Great Basin Lower Montane and Foothill Riparian Woodland and Shrubland/Stream” CE illustrate the intensity of stressors on one coarse filter conservation element. As noted above, the sparseness and/or lack of representativeness of the available data on direct measures of aquatic CE condition required the use of surrogate indicators of stressors to provide at least a coarse-scale picture of CE condition. The spatial distribution of altered conditions for this individual CE also is roughly representative for all coarse filter aquatic CEs in the ecoregion. As noted above, the spatial distribution of indicators of stress to aquatic CEs roughly conforms to the spatial distribution of intense human settlement, agriculture, and mining activities across the ecoregion. However, diversions of surface water from upstream locations or separate basins to support water use in other locations, creates a larger footprint for alterations to aquatic CEs than would be inferred from just the watershed level Landscape Condition Model Index score alone, which only considers level of human use within a watershed.

The indicators for which confidence is highest are the remotely measured indicators such as the landscape condition model index, which is very accurate on the amount of roads and urban area. The raw data on surface water use and groundwater use also warrant high confidence, as they rest on a nationally consistent methodology for tracking water use at the scale of individual census tracts. However, even these data on water use could be improved through more spatially refined ground-truthing. The regional data on atmospheric deposition, in turn, rest on data from a relatively small number of monitoring stations, extrapolated through kriging (a spatial statistics method) to a regional grid. The overall spatial pattern in the deposition estimates is, therefore, likely reliable, but individual watershed values should not be viewed as highly precise. The reliability of other spatial data, e.g., on natural ground cover types identified from 30m imagery, similarly requires ground-truthing. Again the overall spatial pattern is illustrative but local details may not be as reliable. The status of an aquatic CE at the local scale, for example, will be greatly affected by stressors that were not able to be measured for the REA rapid ecoregional assessment, such as grazing impacts and local invasives impacts not included in data used.

It was recognized early in the REA process, however, that no single indicator for any of the five KEAs would likely provide highly reliable data, either on actual CE status or on the intensity of stressors. For this reason, included are multiple indicators for each Key Ecological Attribute. These indicators were selected to be complementary rather than redundant, so that their common patterning could be used with confidence as an indicator of the spatial patterning of ecological status by KEA. Thus, while the precise watershed to watershed differences for any single indicator may be questioned, the concordance of information among the indicators for each KEA provides a reliable indicator of KEA status.

4.5.4 Summary Indices of Ecological Integrity

As stated previously, ecological integrity is defined to express 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. Six summary indices of integrity, reported by watershed, were developed. The intention here is to provide a series of comprehensive indicators for ecological integrity, appropriate for different major aspects of the ecoregional landscape. These six indicators, each scaled from 0.0 (= low integrity) to 1.0 (= high integrity) can provide a complimentary perspective on the integrity of the ecoregional landscape (Table 4-6).

Table 4-6. Summary indices of ecological integrity with associated reporting units

Summary Indicator	Montane Upland	Basin Upland	Aquatic/Wetland, and Riparian
Landscape Condition	4km^2 grid		
Invasive Annual Grass	4km^2 grid		
Fire Regime Departure	Watershed	Watershed	
Hydrologic Condition			Watershed
Water Quality			Watershed

The first indicator summarized terrestrial landscape condition (Figure 4-35). As utilized in numerous places elsewhere in this assessment, this indicator was summarized here by 4km^2 grid cell. This indicator provides a concise visual summary of landscape intactness relative to built infrastructure and land conversion across the ecoregion. Generally, the indicator's score reflects the relative distance from major population centers and transportation corridors, clearly highlighting the most remote landscapes coinciding with the highest relative scores. Management directions aiming to restore landscape intactness in currently fragmented situations, and to maintain current levels of intactness where it currently remains, should be a consideration for meeting ecological goals across the CBR.

The second summary indicator compliments landscape condition by summarizing the potential abundance of invasive annual grass; also summarized by 4km grid cell (Figure 4-36). Mapping this summary indicator required the combination of values from 5 distinct invasive annual grass models; each of which predicts the location of multiple invasive annual grass species at different cover abundances (see Appendix B Section B-2.2). An area and abundance weighting formula was used to combine per-pixel values from each model as they fell within each summary grid cell. This applied score gives areas with no invasive annual grass extent the greatest proportional weight and the calculated value will be equal to 1. As invasive annual grasses encroach into the analysis unit the maximum value of 1.0 is degraded progressively with pixels representing the >45% cover value having the greatest ability to drive down the maximum value, as seen in the northern and eastern portions of the ecoregion (Figure 4-10 and Figure 4-36).

This provides a distinct perspective indicative of this pervasive ecological change occurring across much of the ecoregional landscape, with the introduction of annual grasses through a variety of past and current land uses, and their extensive spread throughout most basins of the northern and eastern halves of the CBR. Basins in the central Nevada, and extending west into California, appear to be least impacted by invasive annual grasses. Management directions aiming to restore native vegetation where invasive grasses have become abundant (where feasible), and to maintain current conditions where invasive grasses are at low levels, should continue to be major considerations for meeting ecological and fire management goals across the CBR.

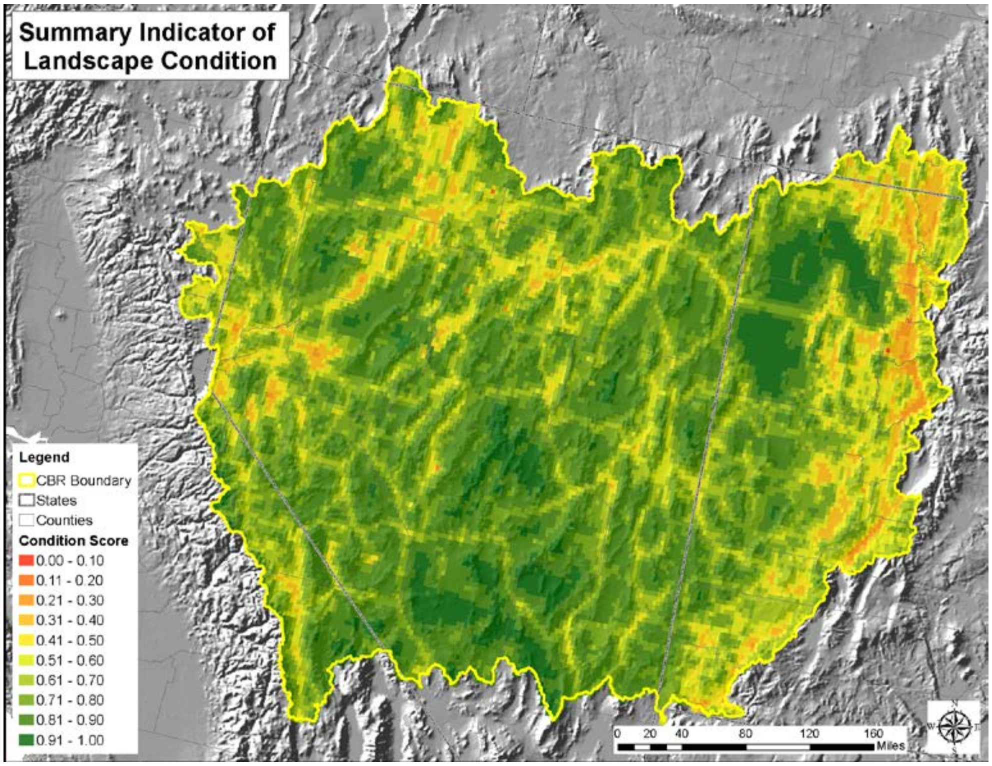

Figure 4-35. Summary Indicator of Landscape Condition for the Central Basin & Range, scaled from 0.0 (= low integrity, red) to 1.0 (= high integrity, dark green).

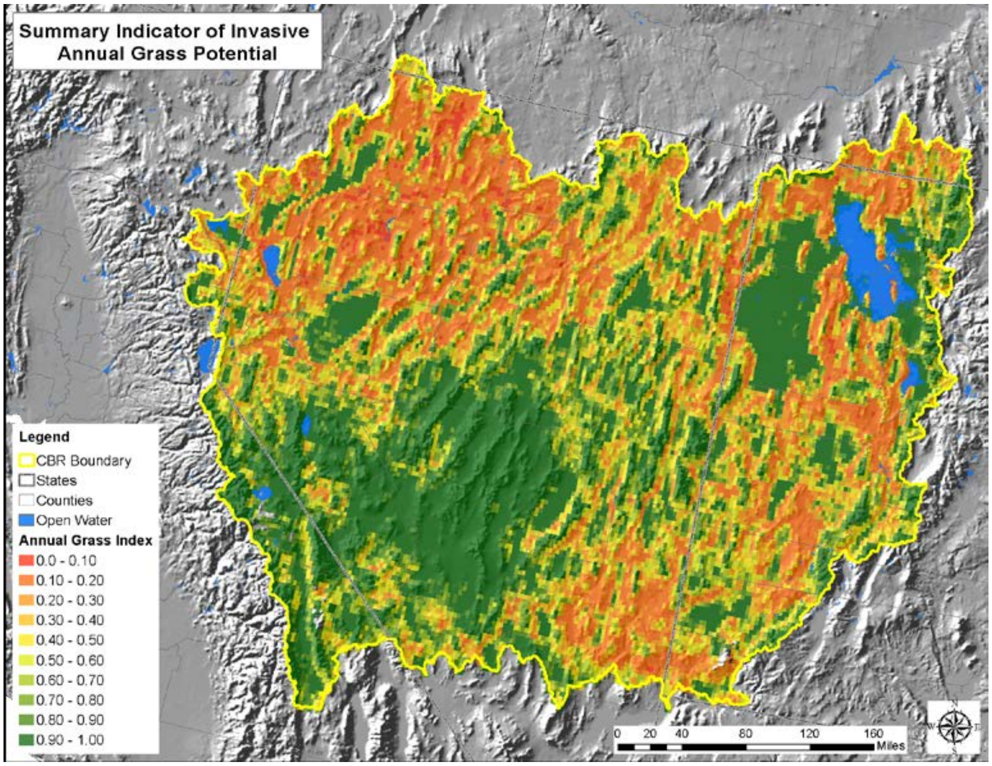

Figure 4-36. Summary Indicator of Potential Abundance of Invasive Annual Grass for the Central Basin & Range, scaled from 0.0 (= low integrity, red) to 1.0 (= high integrity, green).

The third and fourth summary indicators summarize fire regime departure scores for types falling with Montane Dry Land and Basin Dry Land categories of the ecoregion-wide conceptual model (Basin Dry Lands are ecosystems found in the inter-mountain basins, rather than in the montane zone, and include sagebrush, salt desert scrub and the desert scrub coarse filter types). This distinction was made to better differentiate the distinctive fire regimes and fuel conditions that characterize the elevational gradients across the basin and range landscape. Since 5th level watersheds were used as spatial reporting units, they necessarily include vegetation from across this elevational gradient. But these two summary indicators were derived from vegetation CE scores that were organized within Montane Upland vs. Basin Upland categories of the ecoregional conceptual model.

These indicators suggest overall that substantial fire regime departure has occurred throughout the Montane Uplands (montane forest and shrubland vegetation) of the CBR. Many watersheds, shaded in the yellow (0.5 scores) to dark orange (0.2 scores) range (Figure 4-37), indicate quite severe departure. This indication of integrity is concentrated in central Nevada, and in the SE Nevada/SW Utah border watersheds of the ecoregion. Fire regime departure for upland ecosystems in the inter-mountain basins (such as salt desert scrub and big sagebrush shrubland (Figure 4-38) is overall more severe, and reflects a similar spatial pattern to that provided by the invasive annual grass indicator. This was expected, as the occurrence and abundance of annual grasses has been a primary contributor to fire regime departure throughout the basin upland vegetation of the CBR.

The last two summary indicators address aquatic ecosystems and utilized estimates of hydrologic condition and water quality, also summarized by 5th level watershed (Figure 4-39 and Figure 4-40). Hydrologic Condition summarizes 5 individual measures of stress on hydrologic intactness, including surface water use, ground water use, number of diversions, flow modification by dams, and condition of groundwater recharge zones. Figure 4-39 indicates the high degree of variation in these summary scores across the ecoregion, with no clear regional pattern as is evident in other summary indices. While current population centers and most intensive land uses explain much of this pattern, there are impacts to hydrologic condition occurring in quite remote portions of the ecoregion.

Water quality summarizes 4 measures (Figure 4-40), including nitrate and mercury deposition rates, state –listed water impairments and sediment load indices. A clearer regional gradient, with generally decreasing scores from west to east reflects both patterns of atmospheric deposition with major wind patterns (west to east) as well as concentrated land use patterns along the eastern portion of the ecoregion.

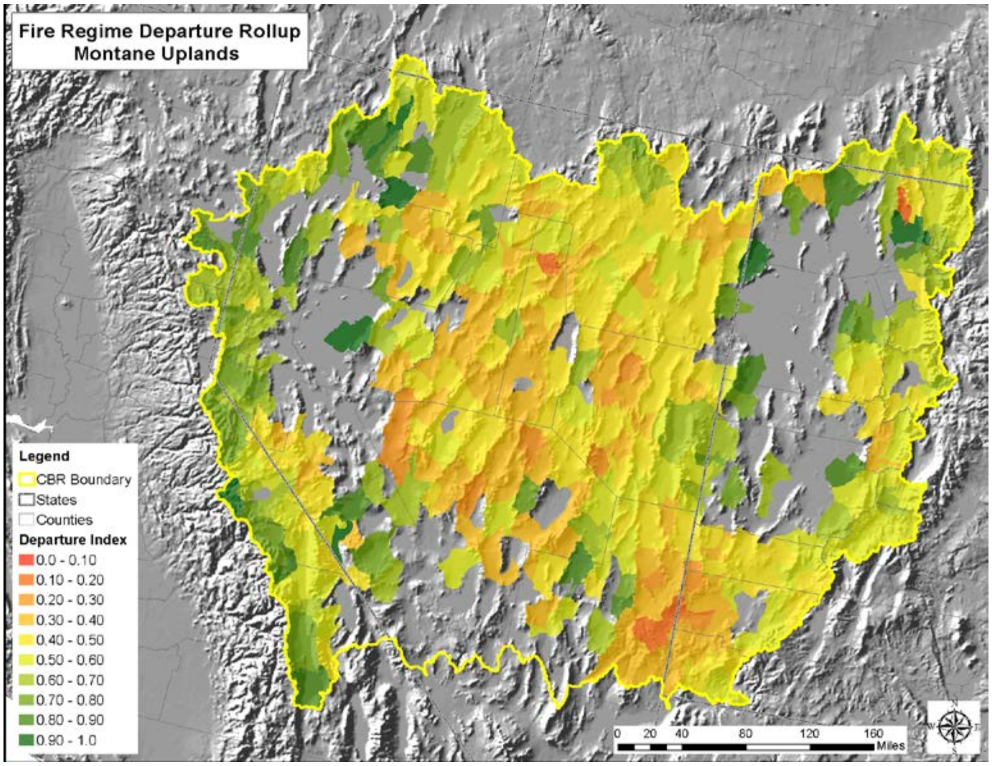

Figure 4-37. Summary Indicator of Fire Regime Departure – Montane Dry Land systems for the Central Basin & Range, scaled from 0.0 (= low integrity, red) to 1.0 (= high integrity, green).

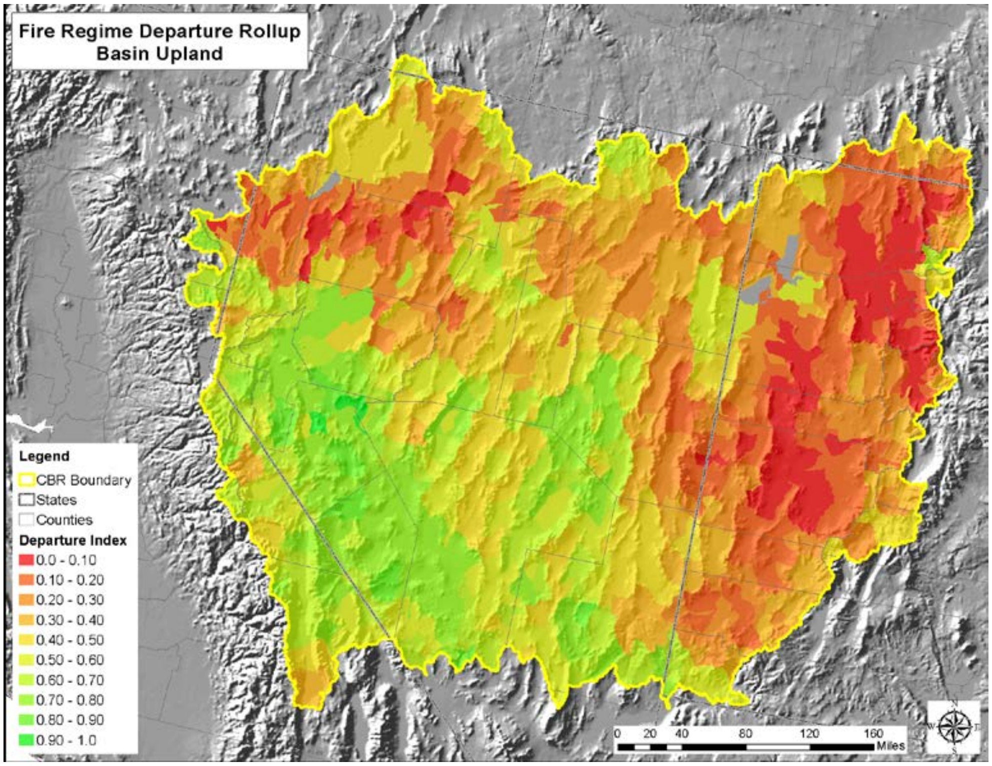

Figure 4-38. Summary Indicator of Fire Regime Departure – Basin Dry Land systems for the Central Basin & Range, scaled from 0.0 (= low integrity) to 1.0 (= high integrity).

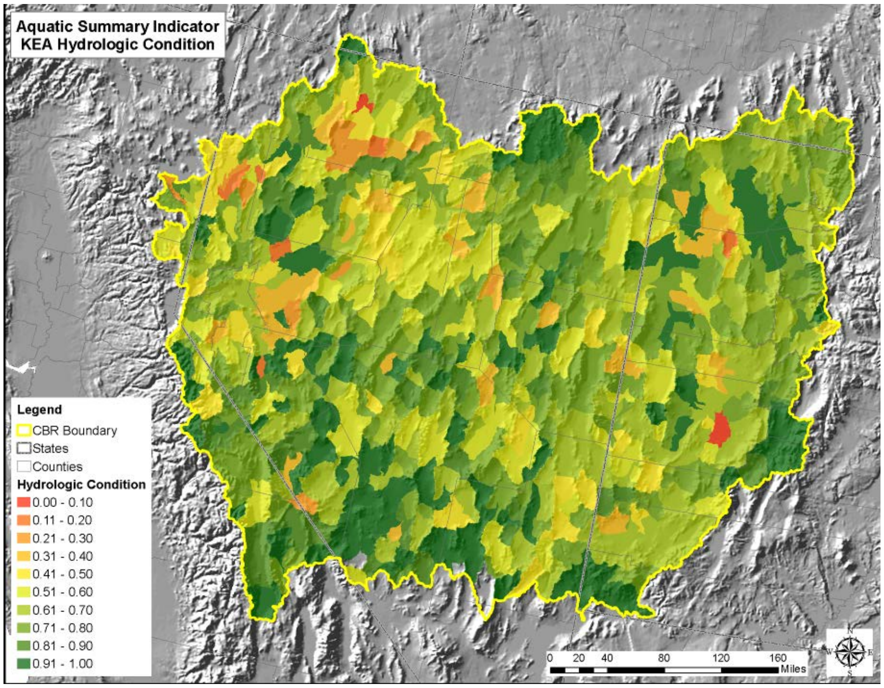

Figure 4-39. Summary Indicator of Hydrologic Condition for the Central Basin & Range, scaled from 0.0 (= low integrity) to 1.0 (= high integrity). This summary indicator for the KEA includes individual indicators of stress on surface water use, groundwater use, flow modification by diversion structures, flow modification by dams, and condition of groundwater recharge zones.

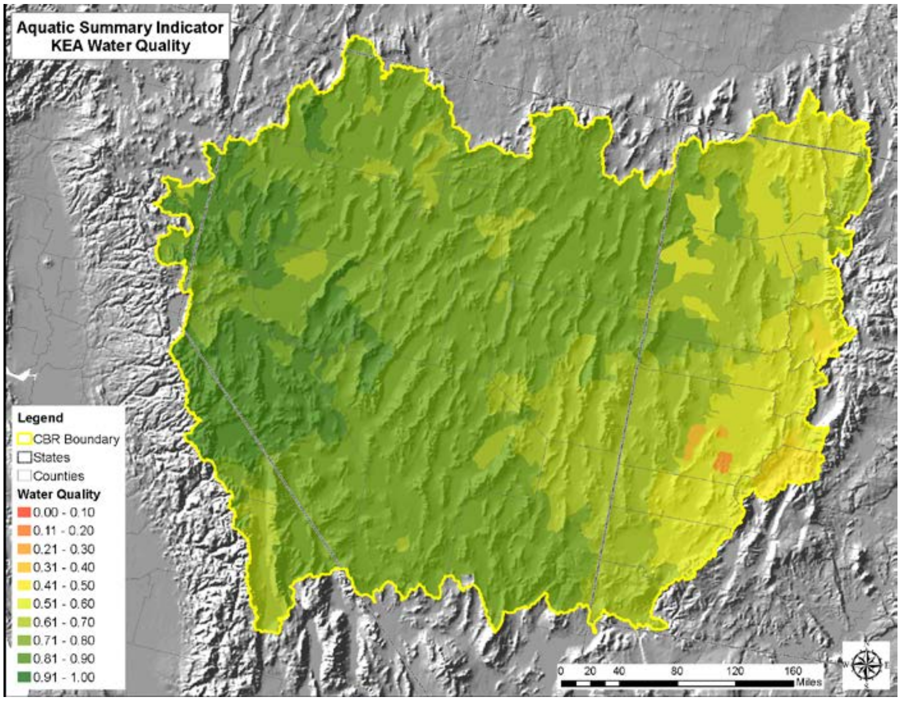

Figure 4-40. Summary Indicator of Water Quality for the Central Basin & Range, scaled from 0.0 (= low integrity) to 1.0 (= high integrity). This summary indicator for the KEA includes individual indicators of stress on water quality from mercury and nitrate deposition, state-listed water quality impairments, and sediment loading.

4.6 Summary

This ecoregion's stewardship is overwhelmingly dominated by federal lands and the Bureau of Land Management is the primary manager of the ecoregion; followed by the U.S. Forest Service. This same pattern holds for lands that have been designated, or otherwise identified as important for conserving ecological and cultural resources. BLM share of designated conservation areas account for 9.2 million acres, or 10.36% of the ecoregion. Additional levels of protective management have been suggested by a variety of organizations for an additional 3.7 million acres of BLM lands within the ecoregion.

While most of the ecoregion's native wildlife remains, there can be little doubt about the legacies of change agents that affect ecological processes, productivity, and the provision of habitat for biodiversity. In applying a 'coarse filter/fine filter approach' to ecoregional assessment, one can see clear patterns in the distribution and current ecological condition of conservation elements; most in direct response to change agents: invasive plant species, alterations to wildfire regimes, and development. Development, in the form of roads, other linear infrastructure, urban areas, mining and other industry, have a relatively small overall footprint in this ecoregion. Approximately 7% of the land surface is currently occupied by these uses. Development, however, tends to occur in areas of productive soils, surface and groundwater availability, and areas topographically suitable for roads, transmission, and pipelines which also tend to be favored for wildlife movement and so may impact some of the most productive and sensitive resources. While current development has already removed resource values within their immediate footprint, many will continue to have effects on their immediate surroundings as well as be sources of other CAs such as invasive species and pollution.

Much more pervasive, however, are the effects of expanding invasive species, and their interacting effects on wildfire regimes. There is little doubt that invasive plant infestation reaches quite high levels among natural habitats within this ecoregion. Nearly every 5th level watershed is quite vulnerable to, if not already seriously infested by, invasive annual grasses. For this typical cool-desert and dry-montane woodland vegetation, fire suppression and introduced invasive plants have had substantial altering effects on natural fire regimes. These effects include increased size and severity of wildfire events, conversion from perennial bunchgrasses, forbs and shrubs to annual grasses, and related fragmentation of habitat for species such as Greater Sage-grouse. The relative size and frequency of wildfire events will in all likelihood continue to increase across many CE distributions. While this assessment was unable to directly address grazing effects on vegetation, one can presume additional interacting effects quite likely have occurred, especially where grazing densities have resulted in soil compaction and erosion.

The ecological status of aquatic conservation elements shows a consistent pattern across all aquatic CEs. Most of the impact is coming from more developed areas of the ecoregion, where agriculture and urban development are greatest. Hydrology shows highest stressor impact in high surface and ground water use areas, which tend to coincide with heavy agricultural and urban development. These patterns could be further affected if the inter-basin transfer of water increases, withdrawal rates increase in current and proposed future projects are developed such as the Southern Nevada Groundwater Project. Water quality is greatly affected by nitrate loading from atmospheric deposition; atmospheric mercury levels, while present, are among the lowest in the country. There are problems with bioaccumulation of mercury, but for this ecoregional analysis only the atmospheric deposition was assessed. There are mercury fish advisories within the CBR (e.g., http://fishadvisories.utah.gov/advisories.htm#utah), but the bioaccumulation of mercury was not part of the assessment. Lower elevation riparian areas, washes, playas, greasewood flats, springs and lakes are experiencing greater degrees of CA impacts than those in higher elevations, with the exception that flow modification by dams has a greater impact on upper elevation riparian resources as dams are generally located higher in the watershed.

Assessment of current conditions in the ecoregion is limited in some areas by insufficient data. For example, the current location and effects of aquatic invasive species was difficult to adequately assess due to data limitations. Similar limitations were found in data related to grazing intensity relative to the type of native vegetation within each grazing allotment or herd management area.

Overall patterns in current conditions suggest that, while substantial concern exists for the ecological integrity of many landscapes across the CBR, many good management alternatives remain. Given the current configuration of land ownership and formal protective designations, there has clearly been substantial conservation investment, and there is no shortage of opportunity to address the many challenges faced by land managers within this ecoregion.

5 Potential Future Conditions in the Central Basin and Range Ecoregion

This chapter provides a concise overview of findings related to conservation element distributions, change agents, and their relationships to managed lands throughout the ecoregion from present day through 2060. Appendices are referenced where the reader may obtain greater detail on a particular assessment. The chapter is organized around key management questions related to: a) the distribution and intensity of change agents forecasted to be acting upon the landscape as of 2025, b) the forecasted change to ecological status of conservation elements as of 2025, c) the forecasted changes in climate and potential effects by 2060, and d) an overall summary of trends among these REA components. A discussion of knowledge and data gaps is provided in Chapter 6. As in the Current Conditions chapter, selected CEs are used to illustrate the assessments.

5.1 Forecasted Change Agent Distribution and Intensity Changes

This section summarizes the changes in distribution, overlap, and relative intensity of selected major change agents across the ecoregion from current to 2025 but also includes a 2060 urban growth forecast and the unbounded timeframe of the total potential renewable energy development scenario. This section focuses on development types and invasive annual grasses as primary change agents. Forecasts related to wildfire are treated only as they may affect conservation elements.

5.1.1 Class II Development

Where are areas of planned or potential development CAs?

All development included in the current scenario was retained for the 2025 scenario. Only four development features had projected changes by 2025: an urban growth forecast for the year 2030 by the ICLUS/SERGoM; the Section 368 transmission corridors (West-wide Energy Corridor Programmatic EIS); approved and priority renewable energy projects on federal land that have begun the environmental permitting process with BLM (but are not yet approved as of May 2011); and the Solar Energy Programmatic EIS Zones (SEZs).

The proportion of the ecoregion that would be developed by 2025 increases 0.5%, or from less than 7.1% currently, to 7.6% by 2025 (Table 5-1). While this increase is proportionately small, this represents nearly 500,000 acres in additional development. The dominant development CA currently is urban development which remains dominant in 2025 according to the SERGoM urban growth model (USEPA 2009; see methods in Appendix A Section A-1.2.1) and also increases considerably more proportionately than any other development CA (see 'Urban Development' in Table 5-1). The SERGoM model also projected changes further into the future and results for 2060 are detailed in Appendix A Sections A-1.2.1 and A-2.1.1. Urban expansion is forecast to increase by 8% between 2010 and 2025 and slowing to 2% from 2025 to 2060 for a total of 10% increase over present. While most of this growth is expected near the existing large urban areas on the Wasatch Front and Reno-Carson City, water limitations may limit the potential for urban growth, at least in its present form. Other notable increases in development CAs include solar and wind renewable energy (note that increases in mines or non-renewable energy were not assessed due to lack of data). Details on changes in renewable energy area are provided in the section below. Methods for current and future development change agents are described in detail in Appendix A Section A-1.2.1.

Table 5-1. Area and percent of each development CA in the Central Basin and Range currently, by 2025, and change in percent. Area is expressed in thousands of acres, percent is expressed in whole percent except change expressed as + increase or - decrease within 1/100th percent, 0= no change).

Change Agent Name	Current Acres (thousands of acres)	Current %	2025 Acres	2025 %	Change in acres	Change in %
No Development Change Agent	82618	93	82134	92	-485	-0.54
Urban or Rural Development	1718	2	2023	2	305	0.34
Roads – rural, private, local	1466	2	1538	2	72	0.08
Crops or irrigated pasture	1451	2	1381	2	-70	-0.08
Multiple Overlapping CAs	1102	1	1096	1	-6	-0.01
Roads Unimproved or 4wd	181	0	190	0	9	0.01
Roads principal or secondary	108	0	116	0	8	0.01
Mine or landfill	81	0	78	0	-3	0.00
Electric utility line	73	0	91	0	18	0.02
Railroad	32	0	30	0	-2	0.00
Water canal or ditch	29	0	27	0	-3	0.00
Pipeline	18	0	17	0	-1	0.00
Renewable Energy Geothermal	17	0	68	0	51	0.06
Roads - non motorized trails	12	0	12	0	0.2	0.00
Military Urbanized Area	8	0	7	0	-1	0.00
Renewable Energy Wind	7	0	46	0	39	0.04
Renewable Energy Solar	3	0	3	0	0	0.00
Roads Unknown	2	0	2	0	0.09	0.00
Oil or gas well	0.2	0	0.2	0	0	0.00
Renewable Energy SEZ	0	0	68	0	68	0.08

5.1.1.1 Renewable Energy Trends

Where will locations of renewable energy [development] potentially exist by 2025?

Where are the areas identified by NREL as potential locations for renewable energy development?

Renewable energy trends are expressed as changes in the amount of area of renewables and proportional changes among them by 2025 utilizing data on renewable energy projects on federal land that have begun the BLM environmental permitting process as of May 2011. These projects were considered the most likely to exist in the near-future scenario because they are either approved as of that date or are a priority for approval (see Figure 5-1). The 2025 scenario included the modified solar energy zones identified under the Supplemental Solar Energy Programmatic EIS being led by the BLM and DOE. Also assessed was the total potential renewable energy footprint (free of any specific timeframe) that included the current and 2025 renewable energy and all areas of high potential according to NREL. Individual MQ results follow; see Figure 5-1 for consolidated map of renewable energy trends from current through potential.

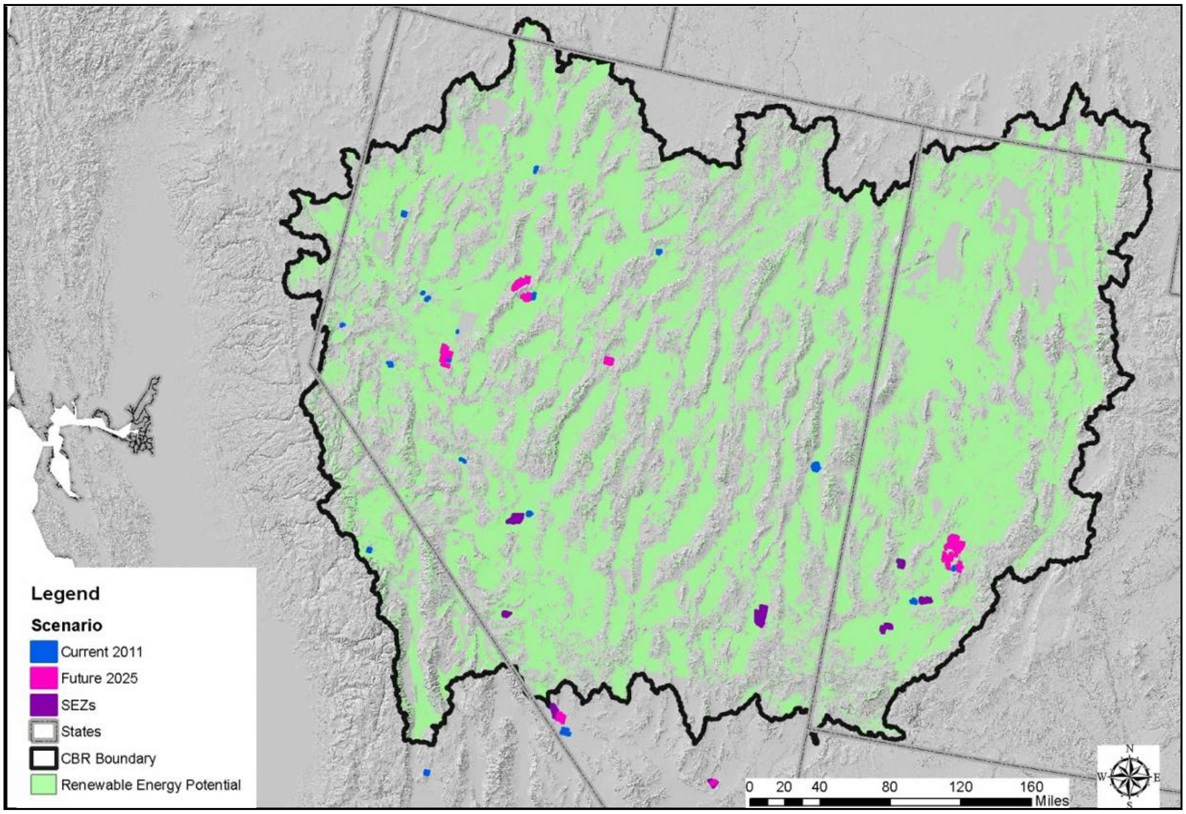

Figure 5-1. Renewable energy in the current and 2025 scenarios and total potential. See text for details on what is contained in each scenario. SEZs are included in the 2025 scenario but shown separately for clarity.

2025 Renewable Energy: By 2025 the renewable energy footprint is forecasted to increase relative to current while remaining a small proportion overall. Renewable energy sources increase by nearly 8x in area from the current 0.03% of the ecoregion to 0.2% with increases in all three renewable energy types. The solar SEZ in particular adds 67,846 acres to the 2025 renewable energy footprint. See Figure 5-2 for total expected area by energy type and comparison to current.

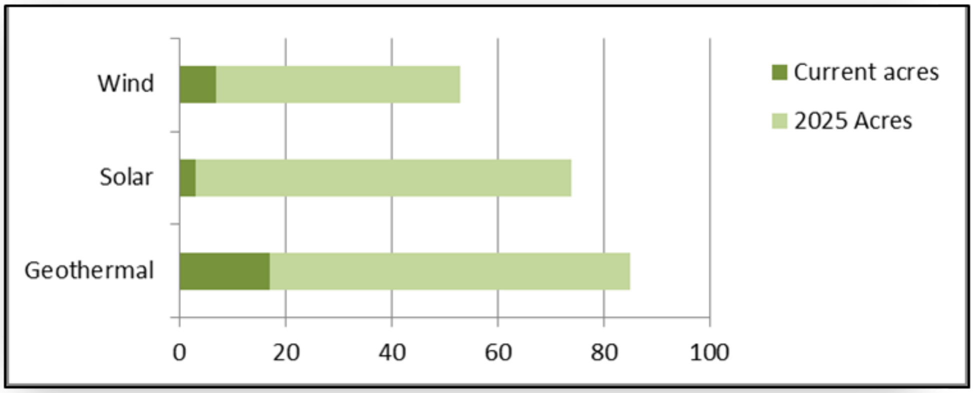

Figure 5-2. Current and future renewable energy area in thousands of acres. Dark shade is current, light shade is additional area added by 2025.

Total Potential Renewable Energy Footprint: This assessment was free of any particular timeframe but instead mapped the total renewable footprint based on the NREL capability maps. Renewable energy has the potential to increase dramatically in this ecoregion. However, the potential is based on sampled and modeled data by NREL and many other factors such as accessibility to roads and transmission and conflicts with other values will affect the location and amount of areas actually developed. The area of priority renewable energy zones expressed in state zone maps is considerably smaller than the total potential footprint. Results are provided in Figure 5-3 per each energy type.

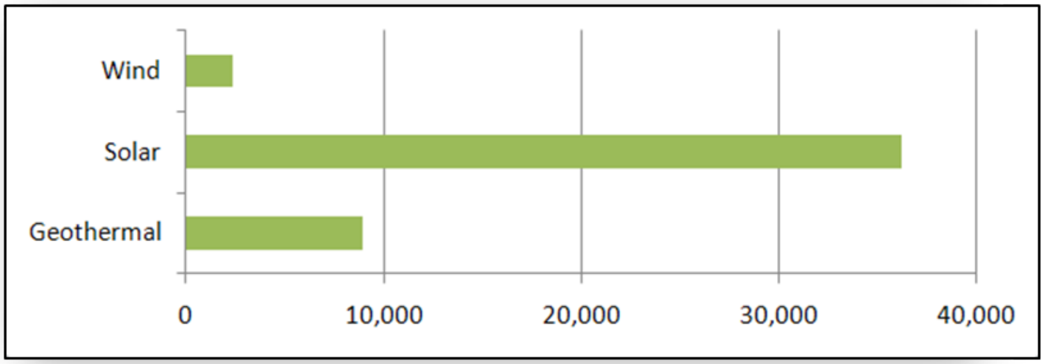

Figure 5-3. Potential future renewable energy area in thousands of acres

5.2 Summary of 2025 CA Intensity

Where will CAs (excluding climate change) overlap HAs, HMAs, and GAs under each time scenario?

Where will CAs (aside from climate change) potentially affect sites of high biodiversity?

Where will these Aquatic High Biodiversity sites be potentially affected by Change Agents (aside from climate change)?

Where will target soil types overlap with CAs (aside from climate change) under each time scenario?

These analyses address MQs (see box above) that asked where future CAs (excluding climate change) overlap certain types of places and sensitive soils. Because development has such a small overall areal footprint and is projected to change a very small amount by 2025, results are provided in tabular format in Appendix D Section D-2.1 and summarized below; maps are not provided.

5.2.1 Change in development CA overlap with herd management areas (HMAs) and grazing allotments (GAs)

Herd areas (HAs) are included with HMAs as they were integrated in the same dataset provided by BLM and hereon referred to jointly as HMAs. As found in the current conditions chapter, GAs and HMAs remain largely free of overlap by development CAs (95% and 97% respectively). CA overlap with GAs increases by 0.4% from current to 2025 while HMA's CA overlap increases by only 0.2%. In both types of management units, rural private roads remain the dominant CA type by a large margin but increases by 2025 have different sources of overlap. For GAs, the largest increase in CA overlap is caused by urban and rural development (0.2% increase) followed by the solar energy SEZ CA (0.1%). For HMAs, the solar SEZ was by far the dominant cause of the increase (0.1%). Further details can be found in Appendix D Sections D-2.1.5 and D-2.1.6.

5.2.2 Development change agent overlap with high biodiversity sites (Places I)

The Places I sites are those identified by various non-governmental organizations as priorities for conservation but are not currently designated for that purpose. There is very little change forecast in overlap of development CAs with biodiversity sites between current and 2025. The current area of overlap increases from just less than 10% to just over 10%. The single biggest increase is caused by urban and rural development (0.6%) which also remains as the dominant development CA type in biodiversity sites. While specific site and CE conflicts should be reviewed (e.g. for greater sage-grouse), overall these results indicate that these priority sites are not imminently threatened by development CAs. See Appendix D Section D-2.1.3 for maps and quantities.

5.2.3 Change agent overlap with sensitive soils

Development change agent overlap with sensitive soils increases <1% between current and 2025 scenarios. The soil type experiencing the largest change is the Hydric Soil (the option using the most inclusive version for its mapped extent) at 0.75%. USDA NRCS (http://soils.usda.gov/use/hydric/intro.html) defines a hydric soil as *a soil that formed under conditions of saturation, flooding or ponding long enough during the growing season to develop anaerobic conditions in the upper part*. Detailed results are provided in Appendix D-2.1.4.

5.3 Summarized trend in landscape condition change as of 2025

Consistent with forecasts of the development change agents, the summary map of landscape condition (based on those change agents) for current and 2025 do not indicate a large degree of change. For the most part, increased urbanization is forecasted to occur in and around current locations, so for the ecoregion as a whole relatively little difference may be observed (Figure 5-4 and Figure 5-5). In addition to expansion of development around existing areas, the intensity of condition impacts increases in developed areas as observed in conversion from orange tones in current to red tones in 2025. Two areas indicating significant forecasted change in landscape condition (Figure 5-5) on BLM lands in southern Nevada (lighter green areas) appear to be lands designated as ‘urban open space’ in the SERGoM urban/exurban forecast model, even though they are publically owned lands. These abnormalities were introduced in the analysis due to classification error in SERGoM and were rectified in the CA and CE intersect analysis but could not be rectified in the landscape condition model during the timeframe of the REA.

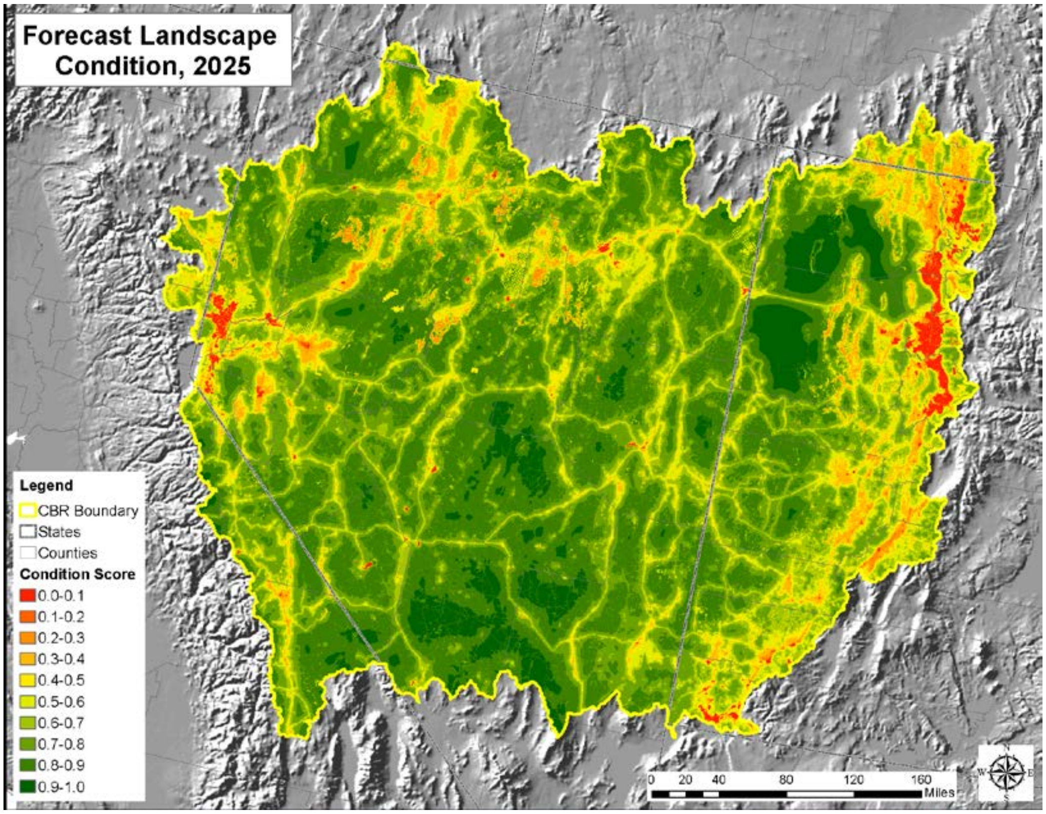

Figure 5-4. Forecasted landscape condition as of 2025; red indicates highly developed areas, while dark green indicates unimpacted areas.

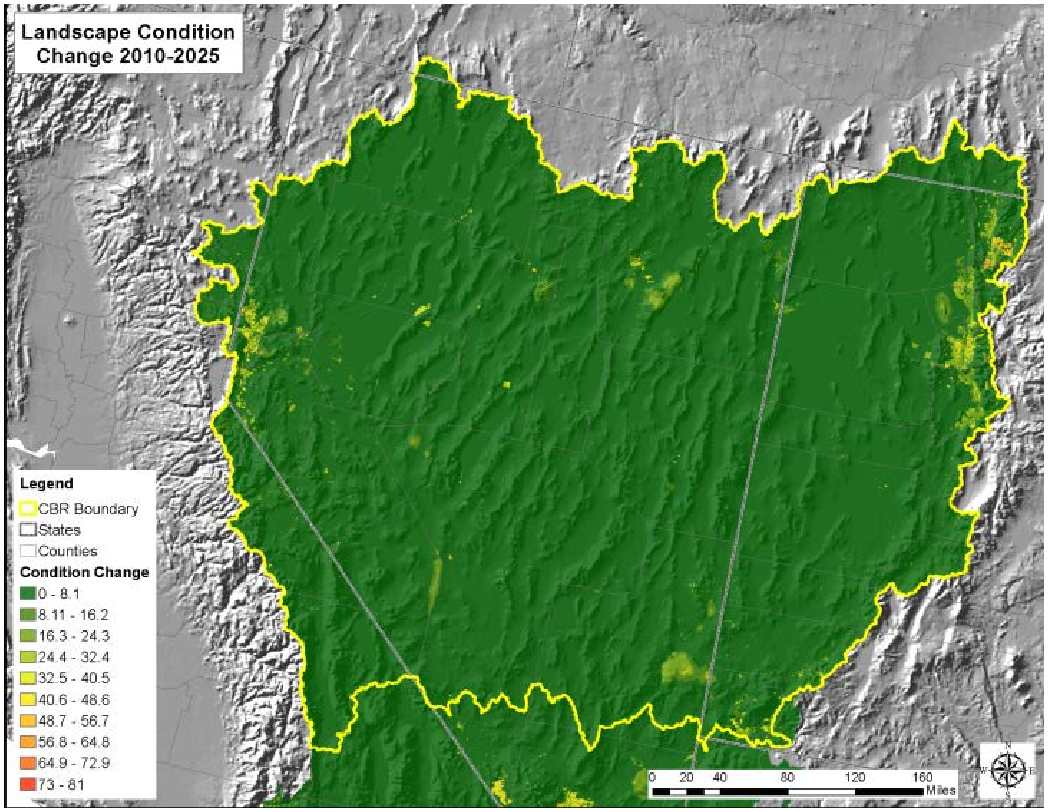

Figure 5-5. Forecasted change in landscape condition between 2012 and 2025. Very little change can be seen when viewed at the scale of the ecoregion, although locally there are increases in development.

5.4 Near-term (2025) Effects on CEs

5.4.1 Effects on CE Distributions

Detailed results on overlap of CEs with current development CAs were presented in the current conditions chapter. The following sections present key changes forecast by 2025 and results for these MQs.

5.4.1.1 Change in development CA overlap with CEs

> *Where are species CEs whose current locations or suitable habitats overlap with the potential future distribution of CAs (other than climate change)?*
>
> *Where do current locations of CEs overlap with areas of potential future locations of renewable energy development?*

As reported in other overlap analyses, change from current to 2025 is not substantial because the total development CA footprint only increases 0.5%. Results for individual CEs are highly variable however, so information is provided here on those CEs experiencing >1% (rounded) changes in development CA overlap with CEs:

- Bald Eagle (4% increase in development CA overlap)
- Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland/Stream (3% increase)
- Migratory Shorebirds and Waterfowl Species Assemblage (2%)

The key development CA causing this change for all three CEs is urban and rural development in the same proportion as their overall reported change. Detailed results are provided in Appendix D Section D-2.1.

5.4.1.2 Landscape species CE overlap with potential renewable energy

This assessment intersected the combined footprint of the landscape species CEs with the total potential renewable energy footprint. Fifty-one percent of the combined landscape species distribution is overlapped by potential renewable energy (Figure 5-6). While this assessment suggests the potential for large numbers of CEs and large areas of habitat to be impacted, as was pointed out in the renewable energy trends assessment earlier, only a small proportion of the total potential is expected to be developed.

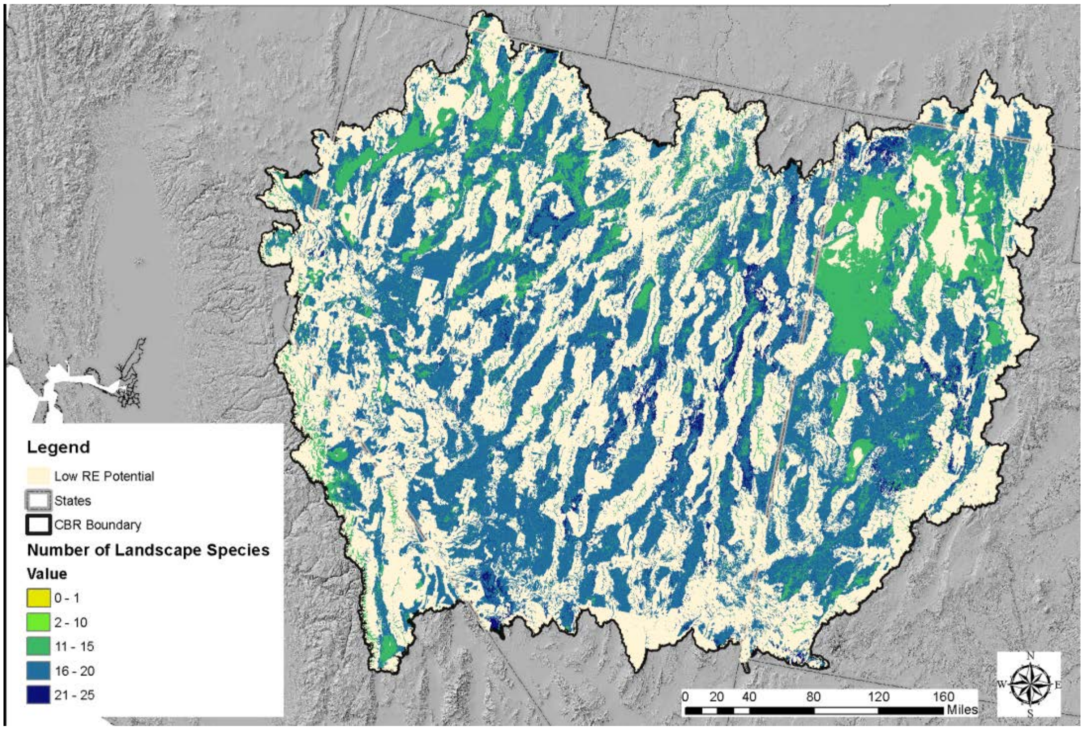

Figure 5-6. Landscape Species habitat distribution overlap with potential renewable energy development. The color ramp shows the number of landscape species that are coincident with areas that have some degree of renewable energy potential. Most areas of the ecoregion have the potential to overlap with at least one landscape species (yellow), some areas coincide with a large number of landscape species (dark blue).

5.5 Ecological Status – 2025-2060 Forecasts

> *Where are existing and potential future CAs (aside from climate change) likeliest to affect current communities [and other terrestrial CEs]?*

As previously described for summarizing current conditions, ecological status is measured for individual CEs using criteria and indicators suited to their ecological requirements. When characterizing current conditions, different combinations of indicators were applied with spatial models to the current distribution of CEs, and then summarized and reported by broader spatial analysis units. Forecasting to

2025 imposes limitations on this type of analysis. Landscape condition scores were recalculated using forecasted 2025 land use data to create forecasted ecological status scores. Simulations of fire regime departure were also run to provide forecasted trends out to 2060. While detailed results are available in Appendix B, following are highlights of several notable results from across different categories of CEs.

5.5.1 Change in Ecological Status: Terrestrial Coarse Filter Conservation Elements

Appendix B Section B-2.3 provides detailed results of the forecasted change in ecological status for each terrestrial coarse filter CE. Watershed scores are totaled with status scores for the landscape condition indicator, first for current and then with forecasts for 2025. The 2025 landscape condition indicator incorporated 2025 renewable energy projects and zones. Another table (Appendix B Table B-38) for each CE describes forecasted trends in fire regime departure for relevant CEs as of 2060. Ecological status indicators are scored from high to low values for the distribution of each CE within each 5th level watershed. Higher scores indicate relatively higher ecological status.

Overall, for the Landscape Condition and Fire Regime Departure indicators, ecological status over the upcoming decades appears to show stable or modestly decreasing trends. Trends in landscape condition are consistent with previous discussion of development CA trends. However, some localized areas throughout the ecoregion are forecasted to experience substantial change due to urban growth or energy development. Generalizing from individual CE results, ecological status indicators for landscape condition tend to remain roughly stable, or decrease by several percentage points for each CE, when combining scores across all watersheds.

Trends in the Fire Regime Departure indicator also indicate some similar trends to those of the landscape condition indicator over the upcoming decades; i.e., where current status is already scoring lower, those low scores are forecasted to continue. Since each state-and-transition model for fire regimes can be run out for future decades, forecasted conditions may be translated back to each watershed. Two views are provided of forecasted fire regime departure scores by watershed (Figure 5-7) for big sagebrush shrubland across the ecoregion. As the 2025 forecast map indicates, current trends in departure are forecasted to increase in intensity, primarily in watersheds where departure scores are currently more severe (see Figure 4-15). This basic pattern appears to hold for the following several decades for big sagebrush shrublands. Because this forecast cannot truly integrate the many interacting effects of climate change and the expansion or contraction of invasive plant species and fine fuels, one should view the 2060 forecast as having high uncertainty but all of these factors will increase the frequency of fire. These models do, however, factor in current knowledge of known successional dynamics and realistic timeframes for vegetation response to disturbance, and simulations increasing fire probabilities show that several decades or a century are required for significant additional changes in expected departure. Thus, in this instance the forecast indicates relatively minor differences in forecasted departure between 2025 and 2060.

These results suggest that management priorities guided primarily by the analysis of current conditions should hold for the upcoming decades. Where current conditions suggest needs for habitat restoration and management focus, forecasts for upcoming decades for landscape condition and fire regime departure suggest those same management directions.

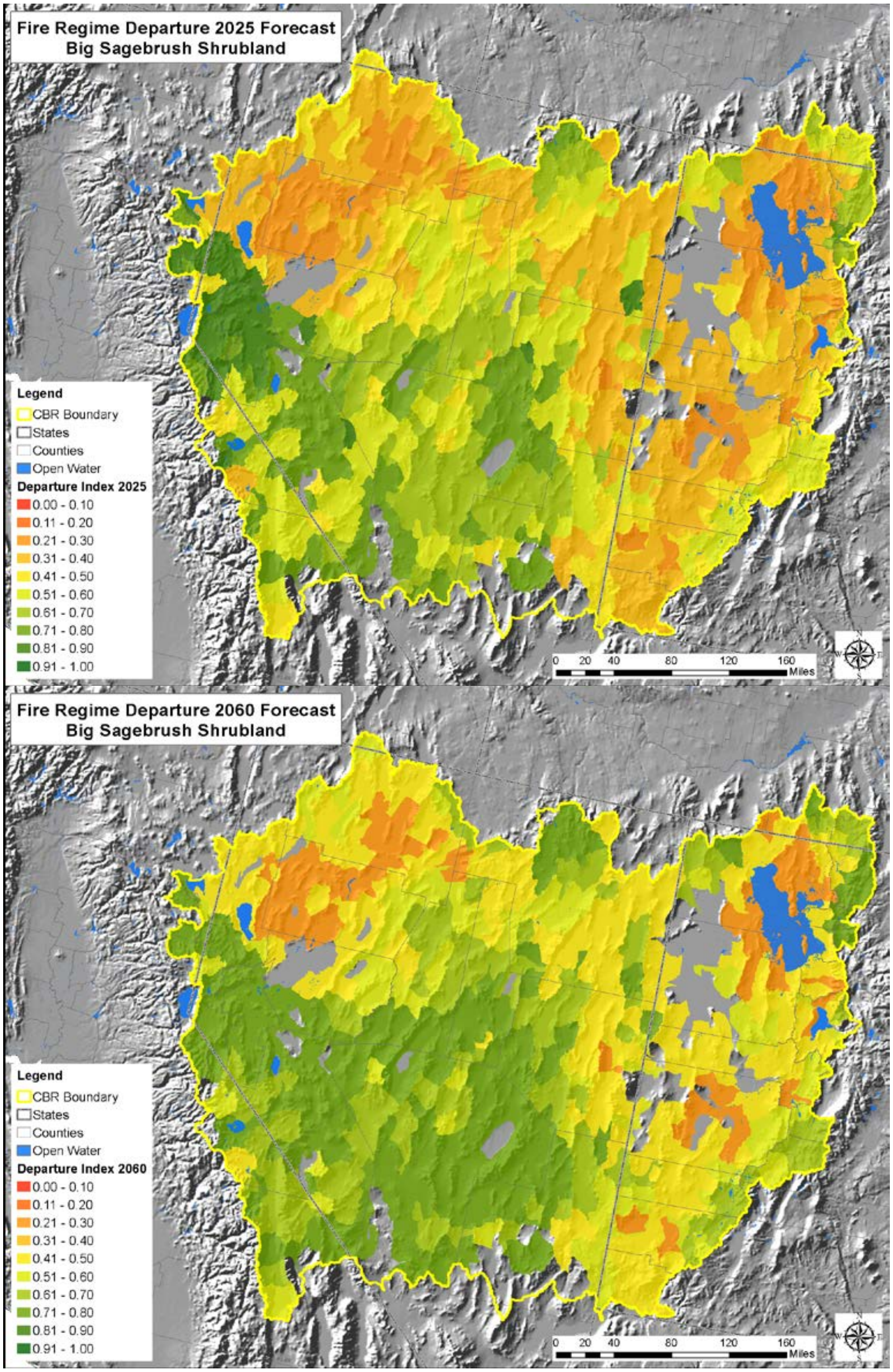

Figure 5-7. 2025 and 2060 Forecasts of fire regime departure for Inter-Mountain Basins Big Sagebrush Shrubland. Red and orange indicate high departure; dark green low.

5.5.2 Change in Ecological Status: Aquatic Conservation Elements

Where will change agents potentially impact groundwater-dependent aquatic CEs?

Where are the areas of potential future change in surface water consumption and diversion?

This section addresses the potential impacts on groundwater-dependent aquatic CEs and changes to surface water use from development. Answering these questions requires (a) identifying where (in which watersheds) development is forecast to change in ways that would affect water use, and (b) estimating how much of the resulting change in water use will impact groundwater-dependent CEs.

The assessment of the development change agent only provides estimates of future urban development, not development of agriculture. The assessment of these management questions therefore must focus on the potential impacts of urban development on groundwater and surface water use, respectively. The data on current water use required for this analysis come from the U.S. Geological Survey, Southwest Principal Aquifer (SWPA) study (Anning et al. 2009, McKinney and Anning 2009). Detailed methods, rationale and limitations are discussed in Appendix B Section B-2.1.4 and B-2.3.4, under the assessments of Aquatic CE Indicators Surface Water Use, and Groundwater Use.

The projected values for watershed change in Public Water Supply (PWS) surface water use 2010-2030 range from a minimum of 0% to a maximum of over 1,200%, and the projected values for change in PWS groundwater use 2010-2030 range from 0% to over 6,000%. Thus, all changes are positive; no watershed is projected to decrease in either PWS surface or groundwater use. The distributions of values are highly skewed for both variables. Most watersheds show little or no change, and only a handful show a large change. For PWS surface water use, only 10 watersheds out of 631 show a change greater than 25%. For PWS groundwater use, only 26 watersheds show a change greater than 25%, with ten of these showing a change greater than 100%.

Watersheds with an estimated 2010-2030 increase in PWS surface water use greater than 10% occur in two major clusters: (1) a nearly continuous band of metropolitan areas extending southward from Logan to the area around Utah Lake, Utah; and (2) the Reno-Sparks metropolitan area. Just one watershed covering Cedar City, Utah, also has an estimated increase in PWS surface water use greater than 10%. In turn, watersheds with an estimated 2010-2030 increase in PWS groundwater use greater than 25% occur in five major clusters: (1) the metropolitan area around and immediately north of Logan, Utah; (2) the metropolitan area immediately south of Utah Lake, Utah; (3) the area including and surrounding Cedar City, Utah; (4) the area including and immediately south of Elko, Nevada, extending from around Wells in the east to Carline in the west; and (5) the general area of Reno-Sparks-Carson City, Nevada, extending east as far as the areas of Yerrington (SE of Carson City) and Fernley (east of Sparks), Nevada. These results correspond to the area of greatest projected urban growth in the ecoregion. The estimates of the potential impacts of this growth on surface and groundwater resources, respectively, depend on the present-day (2010) observed relative rates of PWS surface versus groundwater use.

All of the watersheds with projected increases in PWS surface water use contain at least one occurrence of the 6 surface water-dependent CEs (lakes, lower and upper elevation riparian/streams, washes and playas). The projected increases in PWS surface water use from 2010 to 2030 therefore pose threats to almost the entire spectrum of aquatic CE types supported by surface water flows present in the ecoregion in the affected watersheds.

All of the with watersheds projected increases in PWS groundwater use also contain occurrences of the groundwater-dependent Springs and Seeps and Greasewood Flat CEs. They also contain reaches of upper and lower elevation riparian/stream CEs with perennial flow as well as lake CEs that receive inflows from perennial streams. All of these CE types depend on groundwater discharges, likely to predominantly be shallow alluvial aquifers. Unfortunately, it is not possible to identify which specific aquifers support which CE occurrences, and which aquifers support PWS groundwater withdrawals, using the regional-scale data available. Consequently, it is impossible to assess the potential impacts of the projected increases in PWS groundwater use on specific individual groundwater-dependent CE types or occurrences. Nevertheless, watersheds with large projected increases in PWS groundwater use warrant close attention, to determine how such increases might affect individual aquatic CE types.

5.6 Mitigation and Restoration Sites

Opportunity areas for ecological restoration, if effectively identified, provide for efficient allocation of scarce resources aimed at meeting management goals for targeted natural resources. Sites suitable for ecological restoration can also be targeted where natural resource mitigation is required. This is often the case where development actions in one location will clearly destroy certain resource values. If those same resources occur in a potential restoration site, compensatory mitigation could be concentrated in those areas.

Methods for these assessments are explained in Appendix D Sections D-2.1 and D-2.2; results are shown in the following sections. It was not within the scope of this MQ to determine if sufficient mitigation area exists to mitigate all potential CE area impacted.

5.6.1 Habitat Restoration Opportunities

Given current and anticipated future locations of change agents, which habitat areas remain as opportunities for habitat enhancement/ restoration [for greater sage-grouse]?

This analysis addressed a management question seeking potential habitat restoration sites, given forecasted development impacts as of 2025.

Greater sage-grouse habitat was selected to demonstrate how this question can be answered within the ecoregion for any CE. As opposed to sage-grouse lek locations, occupied habitat area for GSG was the focus; in this case using a 4km^2 grid as the spatial reporting unit. Robust site selection for this purpose first considered the distribution and relative ecological status of this landscape species CE. Output was used from the per pixel ecological status scores for the indicators of landscape condition and invasive annual grasses. Those pixels indicating intermediate ecological status for either indicator suggest a need for investment in habitat restoration. From this pool of potential areas, forecasted land use for 2025 was overlain. This eliminated pixels from the pool that are likely to be developed over the coming decade.

Output was then used from the climate space-trend forecasts as of 2025, filtering potential sites for those where forecasted climate change is least intense. These areas include sites where temperature and precipitation variables are forecasted to be within 1 stdv of the 20th century baseline value (see Appendix A Section A-1.2.4 and Section 5.7.1 of this report for detail on climate space trend analysis).

This series of filters led to the identification of a number of areas (Figure 5-8) (intermediate status scores for landscape condition and invasive annual grasses; low likelihood of future development; and low climate change stress by mid-century). These areas, located along higher latitudinal and elevation gradients throughout the CBR, appear to provide a robust set of locations where GSG habitat restoration investments might be concentrated. Of course, given REA data limitations, these results should be considered to be preliminary. Field evaluation of these areas would provide more specific insights into a) the relative severity of existing landscape conditions and invasive species effects, b) the actual distribution of habitat relative to existing and proposed development patterns, and c) local management context, partners, and issues, that could either support or challenge efforts for habitat restoration.

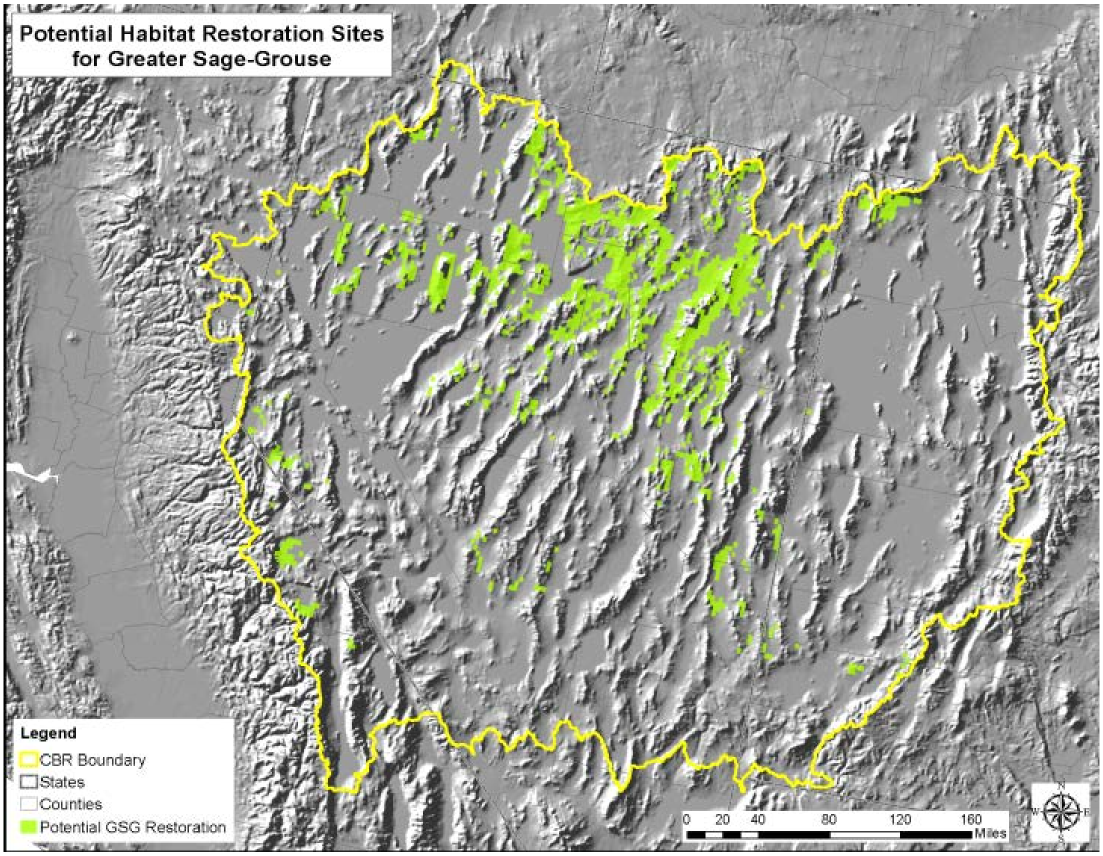

Figure 5-8. Potential habitat restoration sites for Greater sage-grouse

5.6.2 Potential Renewable Energy Mitigation Opportunities

Where are the areas of low renewable and non-renewable energy development that could potentially mitigate impacts to CEs from potential energy development?

To answer this question, areas with low renewable energy potential (did not contain any renewable areas in the current, 2025, or potential scenarios) were intersected with the Landscape Condition Model (LCM) results. The resulting map (Figure 5-9) displays areas with low renewable energy development potential and their current condition to further inform their suitability for mitigation. Further details are provided in Appendix D Section D-2.2. While it is not anticipated that the full potential of renewable energy would be developed in the ecoregion, there are ample mitigation opportunities with over 43 million acres in the ecoregion presenting very little potential for renewable energy development. Note that further modeling and filtering of results could provide additional precision to the result (as was described in Memorandum 3c for this MQ) but the AMT concluded that simpler analysis was appropriate for an REA and mitigation for individual projects takes into account a large number of factors and local information.

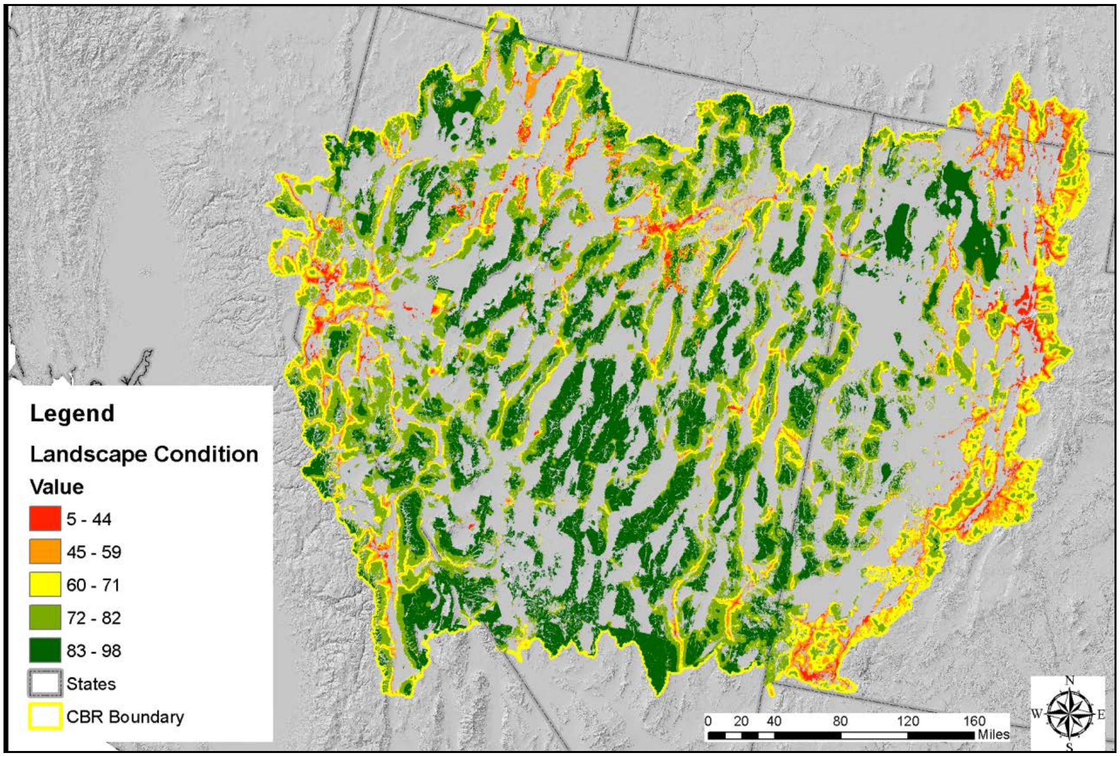

Figure 5-9. Potential mitigation areas for renewable energy development. All shaded areas have low renewable energy development potential. Areas in red are likely to be in very poor condition due to human activities and thus may not offer suitable mitigation options. Green areas are likely to be in very good condition but may not meet requirements if restoration must be conducted for mitigation. Yellow areas have intermediate condition and may represent the most suitable mitigation opportunities where restoration is required.

5.7 Climate Change

The following section addresses a series of management questions posed to assess the potential effects of climate change within the ecoregion. These questions were addressed through two major forms of analysis; both centering on comparisons of 20th century climate regimes with trends forecasted up through 2060.

5.7.1 Climate Space Trends

Where will changes in climate be greatest relative to normal climate variability?

The first climate-change management question is related to detecting locations where climate is forecasted to depart significantly from 20th century conditions.

See Appendix A Sections A-1.2.4 and A-2.2.2 for detailed explanation of methods and results relative to these analyses. The strength of the climate space trend analysis using the PRISM and EcoClim datasets is the ability to describe natural climatic variation over a relatively long baseline, in this case the years 1900-1979. For each month and each variable (maximum daily temperature, minimum daily temperature, total precipitation), the mean and standard deviation were calculated to characterize 80 years of climatic variability. Then, using an ensemble mean from 6 global climate models (GCMs), every

4km² pixel in the CBR was analyzed to calculate if and when projected future climate change values exceed this measure of natural variability (at 1 and 2 standard deviations from the baseline mean).

Results for precipitation suggest there is no strong trend toward either wetter or drier conditions in any month for the Central Basin. With the exception of a slight increase in summer “monsoon” rains toward the south and east, there are no significant forecasted trends in precipitation for any other months in either the near term (2020s) or midcentury (2050s) time slices.

Two factors contribute to this result. First, natural variability in precipitation is high in this region, with the standard deviation often exceeding the average values for most months. Thus, a very substantial increase or decrease in forecasted precipitation would be required to produce statistically significant trends in precipitation changes. A second factor contributing to this result is the lack of consensus among climate models in their forecasts of future precipitation regimes. In a multi-model ensemble, climate models that project wetter futures are averaged with climate models that project drier futures. The ensemble result therefore produces a muted signal of precipitation changes, but reflects the reality of the state of the science for climate modeling.

Overall climate-space forecasts for 2060 temperatures can be summarized in the form found in Figure 5-10. This map displays a count for each pixel where one or more of the 24 monthly temperature variables (maximum and minimum temperature X 12 months) are forecasted to depart by at least 2 standard deviations from the 20th century baseline mean values. This analysis indicates the locations where concentrated change (or lack of change) in these monthly variables could occur.

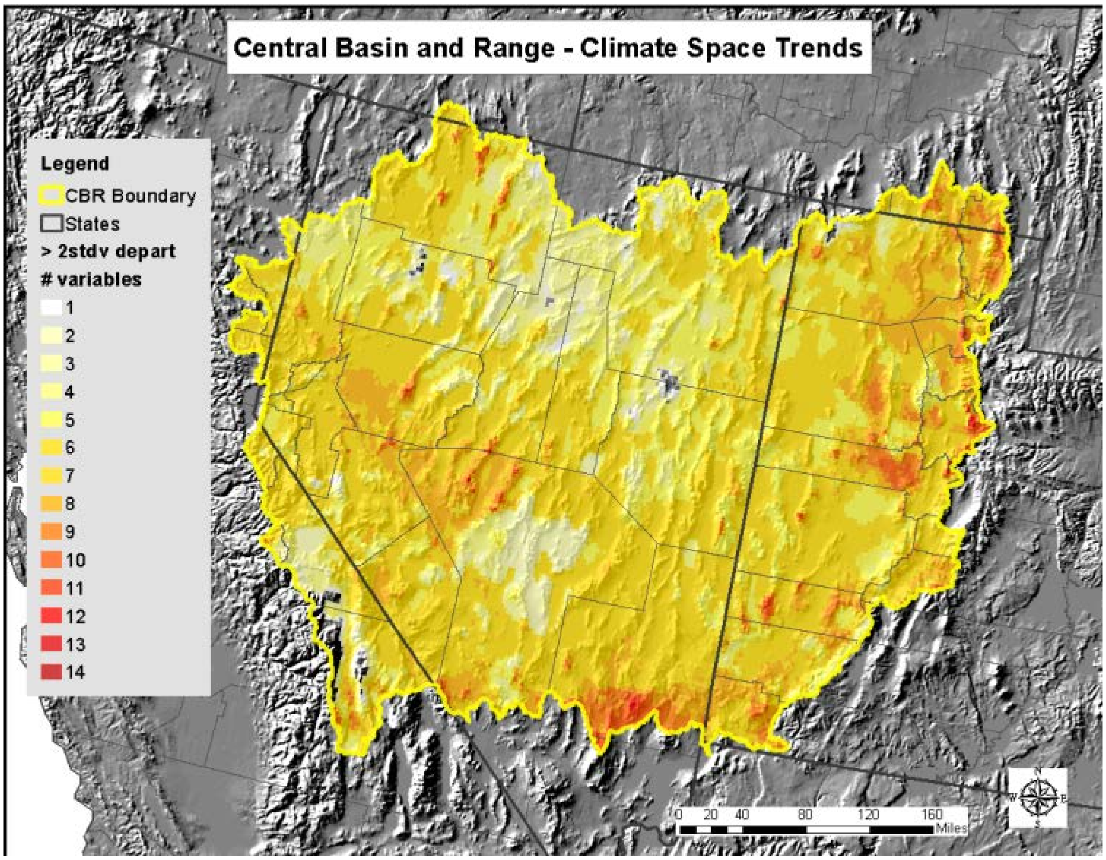

Figure 5-10. Composite 2060 forecast where temperature variables depart by > 2 stdv. Displays a count for each pixel where one or more of the 24 monthly temperature variables (maximum and minimum temperature X 12 months) are forecasted to depart by at least 2 standard deviations from the 20th century baseline mean values.

In portions of the ecoregion, up to 14 of the 24 monthly temperature variables were forecasted to depart by at least 2 standard deviations from the baseline. These areas of concentrated forecasted climate change occur along the southern end of the ecoregion – in the south-north transition from the Mojave Desert, in several mountain ranges and adjacent basins throughout the west-central and northern portion of the ecoregion, and among basins and foothills along the eastern margin of the ecoregion. Areas forecasted to experience the least amount of change are concentrated in north-central and south-central Nevada. These areas (light colored in Figure 5-10) may be further evaluated in this light for their potential to provide some degree of climate-change refugia.

Significant increases in maximum monthly temperatures are forecasted by the ensemble of climate models for the Central Basin ecoregion, and these model projections have a strong seasonal distribution. For November through June for the 2020s, less than 5% of the CBR area is projected to experience statistically significant increases in monthly maximum temperature of one standard deviation beyond the values of the 20th century baseline. In contrast, for this same near future time slice, July, August and September may see similarly significant maximum temperature increases over 50, 65, and 70% of the CBR ecoregion, respectively. The spatial distribution of these projected changes by the 2020s (at least one standard deviation of change) is concentrated toward the southern half of the ecoregion; with forecasted maximum temperature extremes reaching 6 degrees F (Figure 5-11). October is forecast as a transitional month, with 17% of pixels affected by statistically significant maximum temperature increases, concentrated in the southwestern portion of the ecoregion.

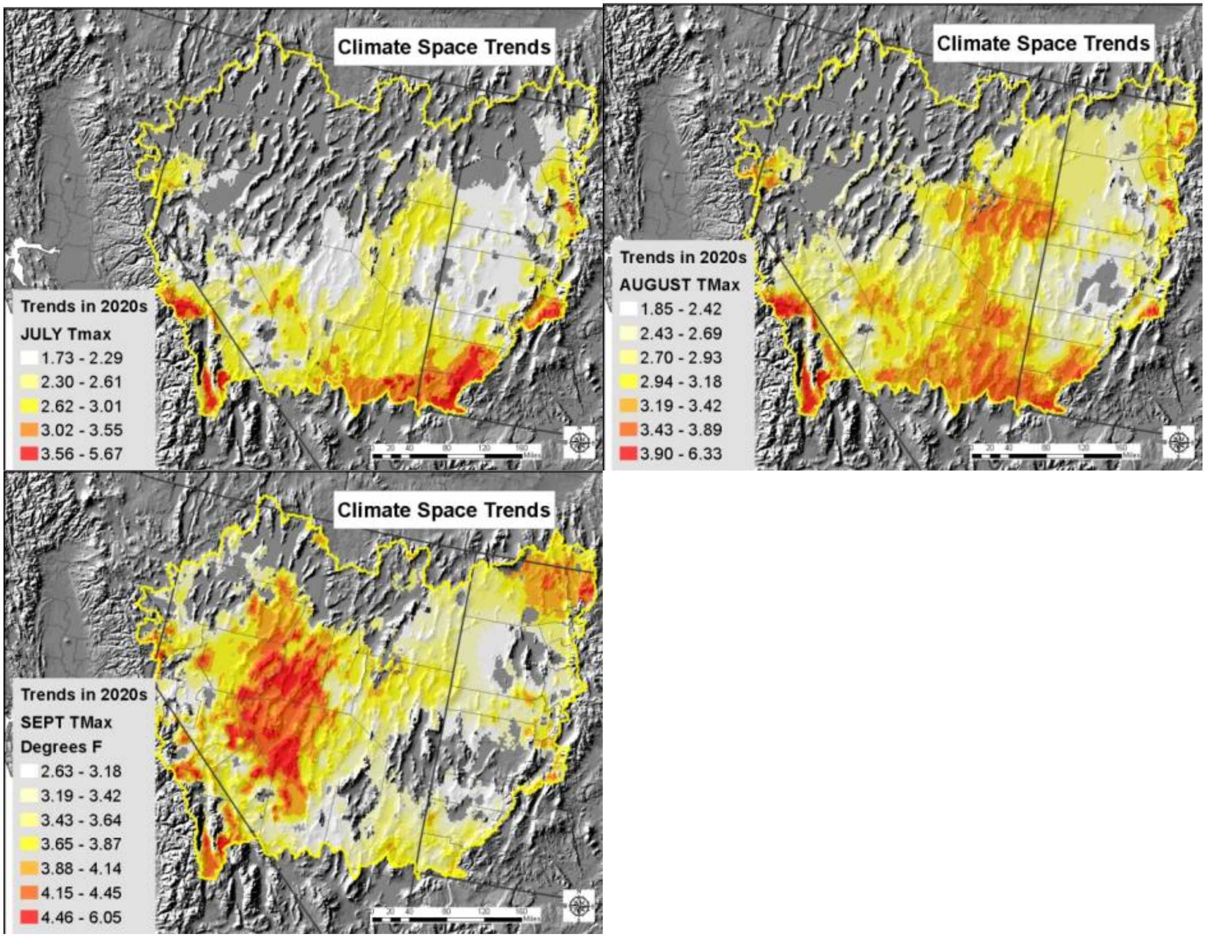

Figure 5-11. Forecasted monthly maximum for summer temperature change (degrees F) by the 2020s, for July, August and September summarized by 4km2 grid. Grid cells displayed are those where the change is greater than 1 standard deviation from the baseline mean.

By 2060, the 6 GCM ensemble forecasts substantial increases in maximum temperatures for all months (Table 5-2), with the greatest increases concentrated during the summer. For July and August by 2060, 90% and 85% of the CBR area, respectively, is forecast to experience monthly maximum temperatures *two* standard deviations beyond the values of the 20th century baseline (Table 5-2, Figure 5-12). Model results for 2060 for November and December, in contrast, suggest only about half of the ecoregion will experience maximum temperatures one standard deviation beyond the baseline values.

Table 5-2. Summary of areal extent of climate change for individual variables which have at least 2 standard deviations of projected change from the baseline (1900-1979) mean

Variable (month, 2060 forecast)	% of Area with Value > 2 stdev departure	Grid Cells > 2 Stdev departure forecast 2060			
		Mean Departure from Baseline (degrees F)	Min	Max	StDev
January Min Temp	0.2%	7.67	6.24	8.77	0.57
March Min Temp	0.6%	5.62	4.67	6.97	0.50
April Min Temp	8.9%	4.94	3.68	6.71	0.39
May Max Temp	0.005%	5.57	5.57	5.57	NA
May Min Temp	4.4%	4.52	3.79	6.26	0.31
June Max Temp	6.6%	6.52	5.43	9.06	0.39
June Min Temp	**54.6%**	5.42	4.24	8.22	0.47
July Max Temp	**90.5%**	5.51	4.25	8.70	0.45
July Min Temp	**90.6%**	6.03	4.17	9.47	0.59
August Max Temp	**85.1%**	6.14	4.46	8.59	0.39
August Min Temp	**93.9%**	6.76	4.71	9.76	0.55
September Max Temp	9.5%	6.09	5.07	7.46	0.42
September Min Temp	**90.6%**	6.77	4.98	10.12	0.56
October Max Temp	0.6%	7.16	5.68	8.33	0.46
October Min Temp	**61.2%**	5.76	4.33	8.27	0.58
November Min Temp	0.1%	5.39	4.57	5.87	0.36
December Min Temp	0.1%	6.05	5.43	7.57	0.62

The 6 GCM average model forecasts that monthly minimum temperatures will experience the most significant changes both in rate and magnitude, among the three climate variables examined with the PRISM and EcoClim datasets (Table 5-2). Again, there is a strong seasonal signal to these projections. As early as the 2020s, July, August, and September minimum temperature (i.e., night-time temperature) are predicted to exceed one standard deviation beyond the 20th century baseline for 90% of the area of the Central Basin. By the 2050s, the increases in monthly minimum temperature become even more pervasive and severe. For every month during the 2050s, nearly all of the CBR is projected to exceed one standard deviation beyond the 20th century baseline; and for July through September the models predict that 90% of the region will experience monthly minimum temperatures *two* standard deviations beyond baseline values (Table 5-2), and for October 61% of the ecoregion.

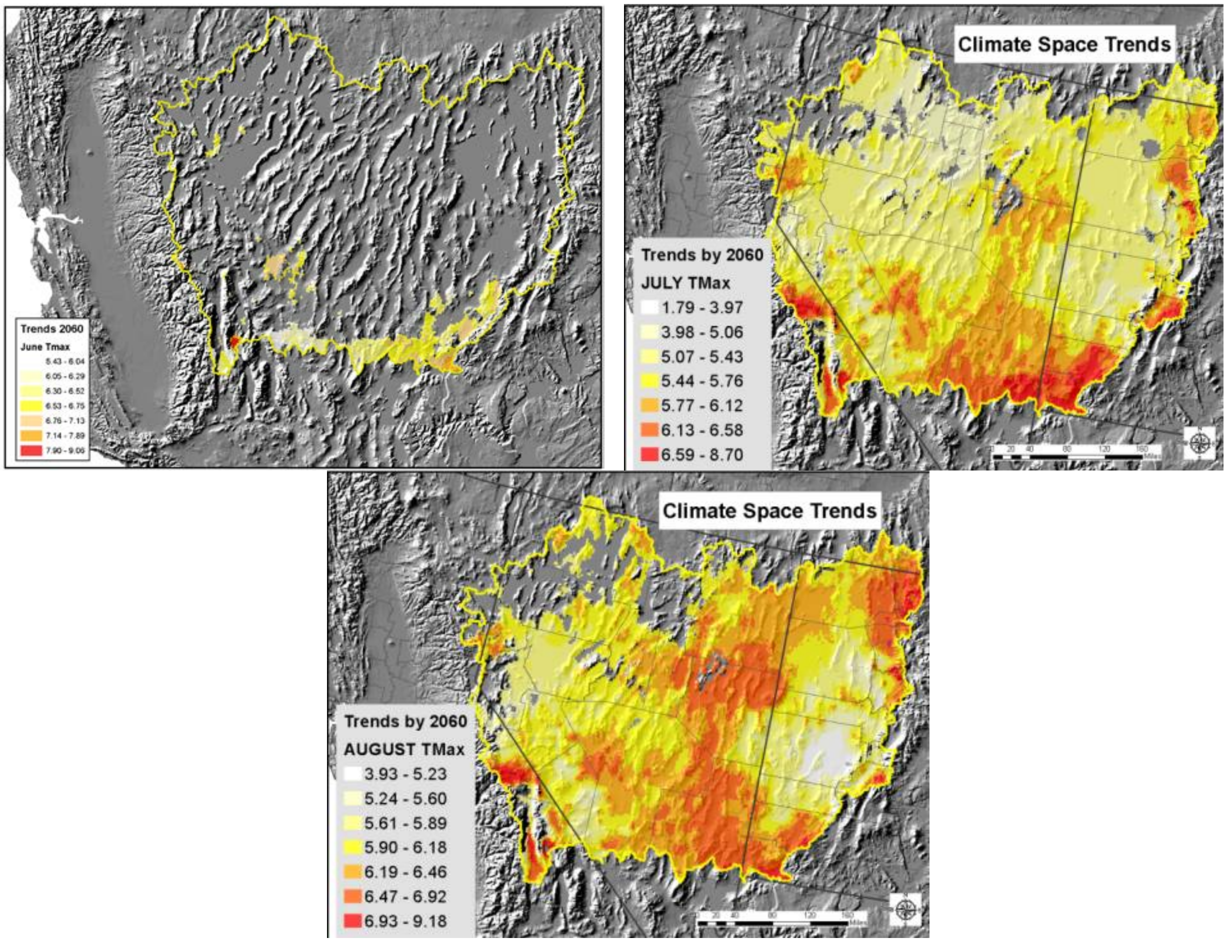

Figure 5-12. Forecasted monthly maximum summer temperature increases (degrees F) for 2060, for June, July and August; grid cells displayed are those where the change is greater than 1 standard deviations from the baseline mean. June shows little projected area of change, while July and August suggest much of the CBR will be significantly warmer.

Some of the potential effects of these climate forecasts on landscape species and vegetation CEs are discussed in section 5.7.2.1. But these climate space trends could have some of the following generalized effects on other change agents and upland landscape dynamics, such as wildfire. These could include:

1. Increased temperature and longer growing seasons may result in more rapid accumulation of fuels in forested and montane shrubland systems. This could be exacerbated by insect infestations on larger scales and frequencies (Brown et al. 2004, Raffa et al. 2008).
2. Increased frequency and duration of droughts will increase fire frequency in these same forest and shrubland systems (Brown et al. 2004, Westerling et al. 2006).
3. Increasing temperature and longer growing season will result in expansion of invasive annual grasses and forbs into elevations where they are currently temperature limited or replacement of one exotic annual grass with another; with potential to introduce novel effects on fire regimes in vegetation such as montane sagebrush steppe and higher-elevation woodland and forest (Abatzoglou and Kolden 2011, Rivera et al. 2011).

4. Increasing spring temperatures and increased frequency and duration of droughts may limit the growth of annual grasses, reducing fuel loading and fire frequency; especially throughout basins currently dominated by mixed salt desert scrub, xeric sagebrush, and big sagebrush shrubland (Abatzoglou and Kolden 2011, Rivera et al. 2011).
5. Increasing drought conditions will support increasing wind erosion, with related effects on biodiversity, air quality, and visibility (Archer and Predick 2008).
6. Increased temperature, with or without changes in precipitation patterns, may favor drought tolerant, shallow-rooted species over deep-rooted species dependent on snow melt to recharge deep water, although experimental evidence is variable (e.g., Schwinning et al. 2003).

5.7.1.1 Potential Climate Change Effects on Aquatic CEs

Where will aquatic CEs experience significant deviations from historic climate variation that potentially could affect the hydrologic and temperature regimes of these aquatic CEs?

The EcoClim climate space analysis results are not ideal for assessing the impacts of climate change on aquatic CEs. As noted and explained above, the bioclimate envelope modeling based on the PRISM and EcoClim data focuses on vegetation and vagile species, for which movement, reproduction, and dissemination of propagules is not confined to water. In addition, the PRISM and EcoClim data do not include information on snowpack formation and snowmelt. Although itself a function of temperature and precipitation, snowpack water content (specifically, April 1 Snow Water Equivalent) significantly affects the timing and magnitude of snowmelt within the ecoregion (e.g., Mote 2006, Christensen and Lettenmaier 2007, Das et al. 2009, McCabe and Wolock 2009, Brown and Mote 2009, USBOR 2011). The late-winter/early-spring snowmelt pulse plays an important role in shaping higher-elevation stream hydrology and recharge in the ecoregion. Forecasts of temperature and precipitation therefore provide greater information of relevance to aquatic ecosystems in the ecoregion when combined with information on snowpack. Therefore, the PRISM-EcoClim results provide a first approximation[2].

One management question specifically asks for information on the spatial distribution of the forecasted impact of climate change on aquatic CEs. The spatial patterns discussed above for monthly total precipitation, and monthly maximum/minimum temperatures, provide initial insights for answering this question. Specifically, the aquatic CEs in the CBR ecoregion would be affected by forecasted increases in monthly minimum and maximum temperatures and, to a more limited extent (both spatially and within the year), increases in monthly precipitation. The forecasted changes in temperature are moderate for the 2020s, but become severe for the 2050s.

The forecasted changes in temperature and precipitation patterns would be expected to result in several effects on aquatic CEs in the CBR ecoregion, as discussed by Melack et al. 1997, Field et al. 1999, Mote 2006, Christensen and Lettenmaier 2007, Chambers and Pellant 2008, Brown and Mote 2009, Covich 2009, Das et al. 2009, Dettinger et al. 2009, McCabe and Wolock 2009, Cayan et al. 2010, Isaak et al. 2010, Miller et al. 2010, USBOR 2011:

- higher evapotranspiration rates leading to an earlier, more rapid seasonal drying-down of stream/riparian and lacustrine CE occurrences;
- increased water stress in basin-floor phreatophyte communities (e.g., greasewood flats), and later, less frequent, or briefer wetting of playas;

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[2] Results for USGS Hostetler data analysis are included in Appendix D.

- shrinkage of areas of perennial flow/open water, coupled with higher water temperatures at locations/times when water temperatures are not controlled by groundwater discharges or snowmelt;
- persistence of these hydrologic conditions later into the fall or early winter; and
- reduced groundwater recharge in the mountains and reduced recharge to basin-fill deposits along the mountain-front/basin-fill interface; and
- more erosive mid/late summer runoff events in those areas experiencing increased July/August precipitation, potentially with associated channel down-cutting and expanded deposition of the eroded sediment in lower-elevation gravel fans.

Based on the ways in which these hydrologic factors affect ecological dynamics in the aquatic CEs, persistence of these hydro-meteorological impacts over multiple decades could result in several long-term impacts at both high and low elevations, as discussed by many of the authors cited above, and also by Jager et al. 1999, Harper and Peckarsky 2006, Hultine et al. 2007, Martin 2007, Chambers and Wisdom 2009, Jackson et al. 2009, and Seavy et al. 2009:

- Loss of riparian vegetation at lower elevations where the frequency and spatial extent of seasonal flows determines the spatial limits of this vegetation;
- Loss of basin-floor phreatophyte (deep-rooted plants that obtain water from ground water sources) communities as a result of lower near-surface ground elevations;
- declines in the spatial extent and biodiversity of perennial streams and open waters as a result of shrinkage and warmer temperatures;
- Reduced discharge to springs and seeps as a result of reduced aquifer recharge;
- A continuation of normal "warm-season" aquatic ecological dynamics later into the fall as a result of seasonally normal (baseline) overnight near-freezing temperatures becoming less common in many areas until later in the fall; and
- A possible de-coupling of the places and timing of emergence of insects, the plants on which they depend, and the animals that feed on the insects, as individual species respond to different cues from air and water temperatures, water availability, and flow conditions.

5.7.1.2 Potential Climate Change Effects on Managed Lands

Which HAs, HMAs and GAs will experience climate outside their current climate envelope?

Where will locations of High Biodiversity sites experience significant deviations from normal climate variation?

Other related management questions aim to apply this climate analysis to clarify these patterns as they relate to specific groups of CEs and places. Here we simply demonstrate how these MQs can be investigated using data compiled for this REA. See Appendix D Section D-2.3 for detailed results related to these management questions.

A simple overlay of grazing allotments with forecasted significant climate change for the decade of the 2050s (

Figure 5-13) provides an initial indication of allotments that occur in portions of the ecoregion that are forecasted to experience more intense climate change by 2060. Individual grazing allotments occur in areas that span the range from zero to as many as 12 monthly temperature or precipitation variables that are forecasted to deviate by at least 2 standard deviations from their 20th century mean (

Figure 5-13). Again these variables include maximum temperature, minimum temperature, and total precipitation variables for each of 12 months.

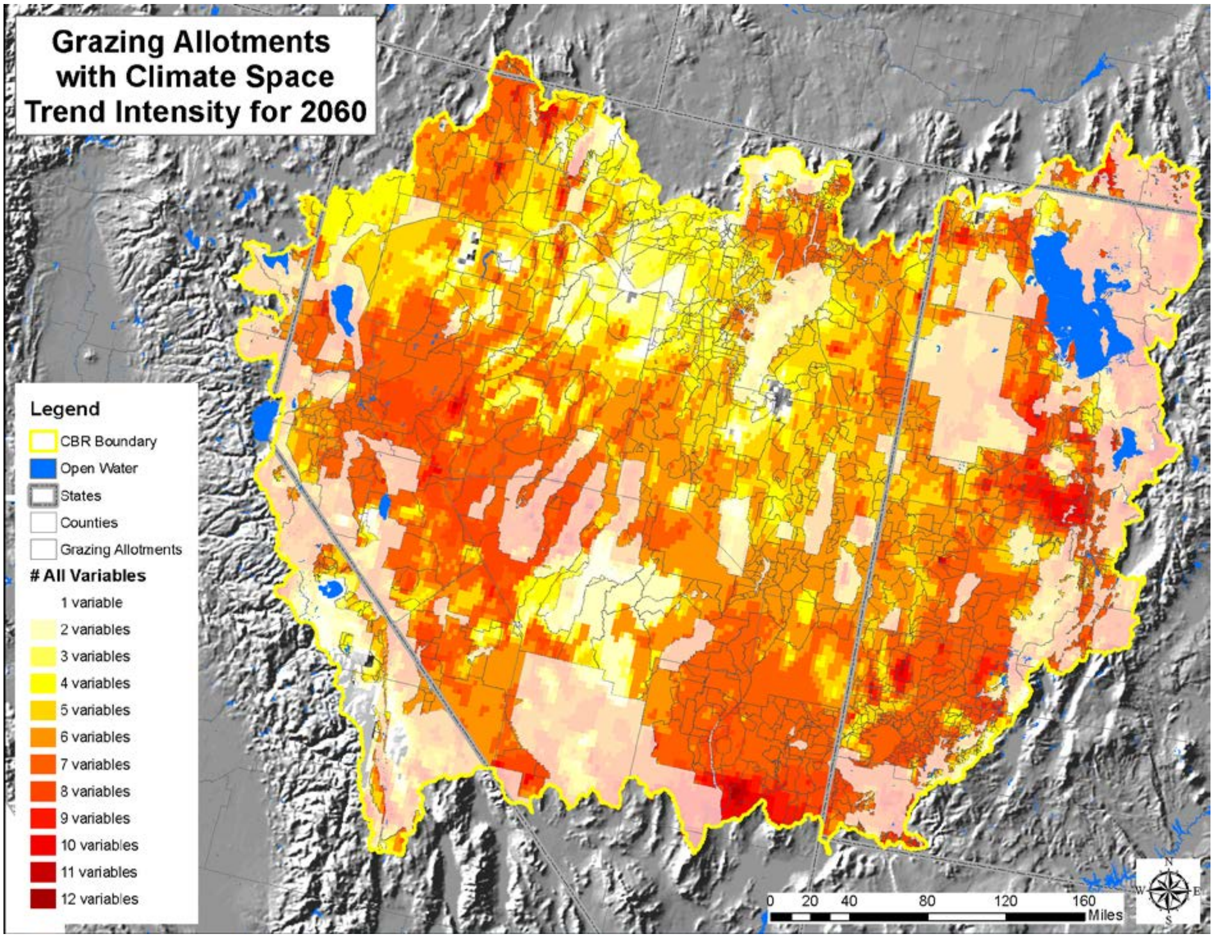

Figure 5-13. Grazing allotments overlain on climate space trend intensity for 2060. Darker red areas indicate a greater degree of forecasted climate change.

A similar overlay for herd management areas (Figure 5-14), and for areas prioritized for biodiversity conservation *that are currently outside of designated protected areas* (Figure 5-15) are other examples.

The climate space analysis presented in the previous section indicates that the summer maximum temperatures and spring through fall minimum temperatures (Table 5-2) are the most pervasive and significant variables contributing to these patterns. Many grazing allotments and herd management areas in the southern and eastern portions of the CBR are projected to experience significant climate change, mostly in spring and summer temperatures; and many high biodiversity sites will also. These overlays may be used to quantify these trends relative to any desired configuration of existing managed land units; either at regional, state, or local scales. Managers of these areas will need to consider the potential implications of climate stress, as it is forecasted, and its implications.

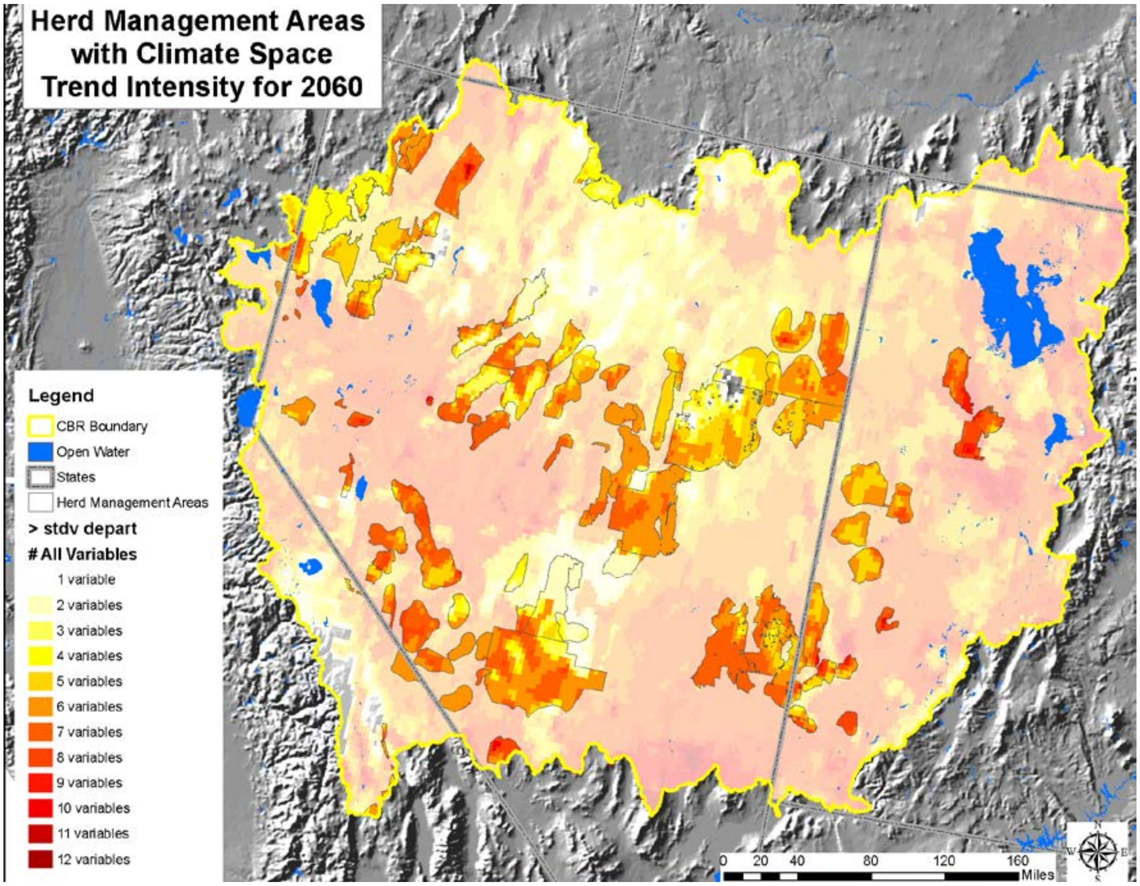

Figure 5-14. Herd management areas overlain on climate space trend intensity for 2060. Darker red areas indicate a greater degree of forecasted climate change.

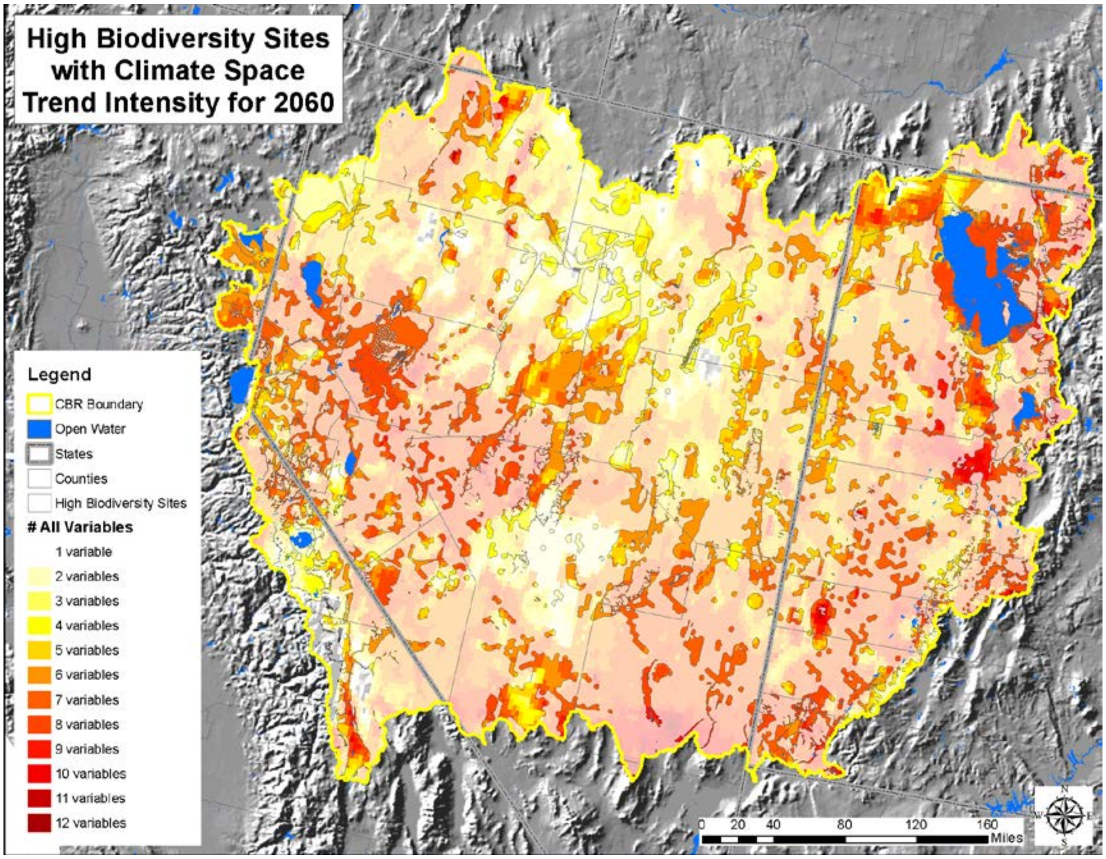

Figure 5-15. Areas identified for biodiversity values, but not currently designated, overlain on climate space trend intensity for 2060. Darker red areas indicate a greater degree of forecasted climate change.

5.7.2 Climate Envelope Analysis

Given anticipated climate shifts and the direction shifts in climate envelopes for CEs, where are potential areas of significant change in extent?

Which native plant communities will experience climate completely outside their normal range?

Where will current wildlife habitats experience climate completely outside its normal range?

Where are wildlife species ranges (on the list of species CEs) that will experience significant deviations from normal climate variation?

Where will landscape species CEs experience climate outside their current climate envelope?

Climate envelope models provide an indication of the magnitude and direction shift in climate regime as it relates to the current distribution of upland conservation elements, such as landscape species and major vegetation. These models indicate potential changes in vegetation or species distribution based solely on climatic requirements, and do not attempt to predict where species might actually move, since many other factors will affect species adaptation and movement. For example, changes in land use will variably affect the probabilities of persistence of species in the face of a changing climate. However, inasmuch as vegetation change is subject to fire and invasive species, dispersal capability, and other factors, the results are a simplification of where climatic conditions may support growth in the future. For these reasons, results are less certain for areas indicating CE expansion than loss (contraction in distribution may occur). Full results of these analyses are found in Appendix B Section B-2.4.2. Combined with the NatureServe Climate Change Vulnerability Index (CCVI) results (see Appendix D Section D-2.3.4), this bioclimatic assessment is a vulnerability assessment (Glick et al. 2011) of coarse filter and landscape species CEs.

5.7.2.1 Forecasted Climate Change Effects on Terrestrial CEs (landscape pattern effects)

2060 climate envelope forecasts: ecosystems. Climate envelope forecasts to 2060 developed for vegetation assemblages show a number of recurring patterns among types. As described in the methods, climate envelope forecasts were completed using six distinct climate models. In most cases, a clear shift to higher elevation, and to the north, can be observed in each model. Differences among types tend to be in the forecasted magnitude of change, i.e., the relative proportion of current distribution where the climate envelope is forecasted to move elsewhere. There were also differences among the six forecasts for a given CE. In order to create each summary map, results reflect the combination of models where at least two of the six agree for a given CE. Illustrated here is the common pattern with Inter-Mountain Basin Big Sagebrush Shrubland (Figure 5-16) of the difference between current and climate envelope forecasts for 2060. Green areas indicate where current climate envelope distributions “overlap” with forecast. Blue areas indicate potential contraction, where current climate characteristic of big sagebrush shrubland will be replaced by significantly different climate regime. Pink areas indicate where current climate regime for Big Sagebrush is forecasted to occur outside of the current sagebrush distribution by 2060. One could initially view these pink areas as potential “expansion” zones for this characteristic climate regime.

The degree of bioclimate ‘overlap’ vs. ‘contraction’ for major vegetation in the ecoregion varies from type to type, but undoubtedly, considerable change in climate regime is indicated from these forecasts. In some cases, substantially more than 50% of the area of the current climate distribution is lost over the next 50 years. Viewing these results for sagebrush shrubland next to those for mixed salt desert scrub, the next most abundant vegetation type in the ecoregion, one can see the tendency for mixed salt desert scrub to expand into adjacent lands currently occupied by big sagebrush shrubland (Figure 5-17). This pattern is evident throughout much of ecoregion, and coincides with results from other related studies (e.g., Bradley 2009, 2010). In the southern portions of the ecoregion, one can see a forecasted contraction of mixed salt desert scrub, with potential expansions there from desert scrub species characteristic of the Mojave Desert to the south.

One might also anticipate the expansion of sparse to completely unvegetated plains, and if there are areas of high potential for wind or water erosion, a slow transition towards desert pavement throughout southerly portions of the ecoregion where mixed salt desert scrub currently dominates, and apparently severe increases in temperature regimes are forecasted (Wainwright et al. 1999).

Looking further upslope, the climate envelope for Great Basin pinyon-juniper woodland is forecasted to retreat northward to some degree, but overall there appears to be considerable overlap (green) area throughout this ecoregion. One could perhaps anticipate wildfire dynamics between the predominant big sagebrush shrubland along the lower-elevation margins of these woodlands to be a proximal mechanism of vegetation change, and there may be further shifts in what are incompletely understood dynamics of woodland expansion into adjacent sagebrush (e.g., Miller and Wiegand 1994, Bradley 2010).

See Appendix B Section B-2.4.2 for the full set of mapped forecasts of climate envelopes for upland vegetation throughout the ecoregion. By viewing these forecasts together, and for a given portion of the ecoregion, one can develop a clearer set of hypotheses about the type and magnitude of vegetation change that may be occurring in the coming decades. The actual mechanisms of vegetation change may vary from type to type, with unprecedented fire events precipitating vegetation shift in some locations, while severe drought, pest infestation, and/or plant die-off causing shifts among other vegetation types.

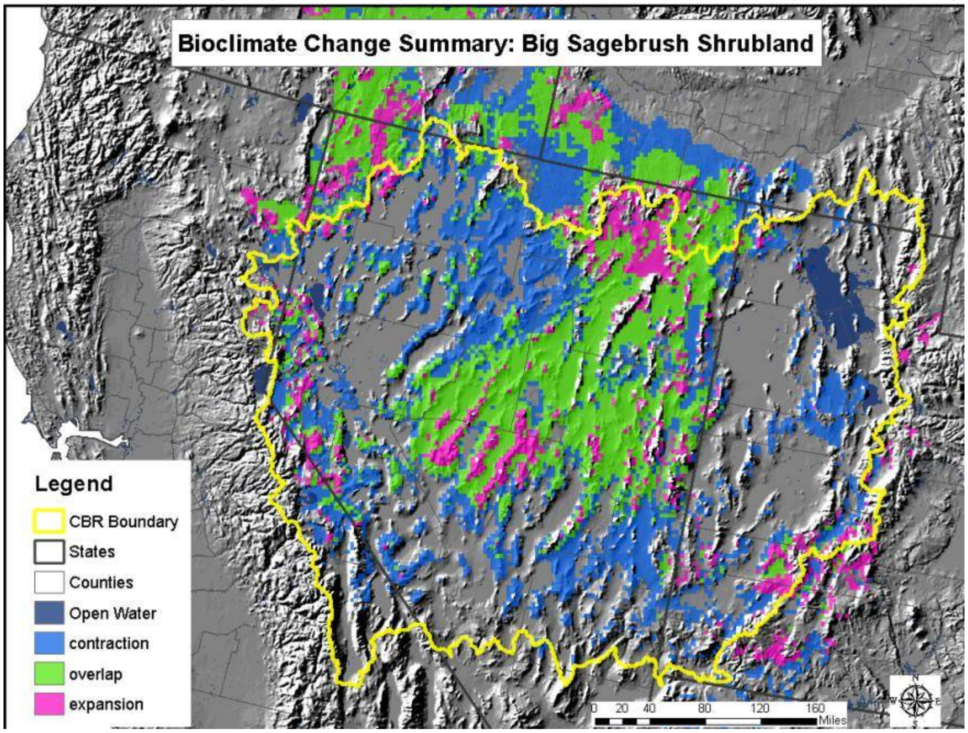

Figure 5-16. Forecasted climate envelope changes for Inter-Mountain Basins Big Sagebrush Shrubland within the CBR as of 2060. Results for each category (contraction, overlap, expansion reflect agreement among 2 or more of 6 distinct spatial models).

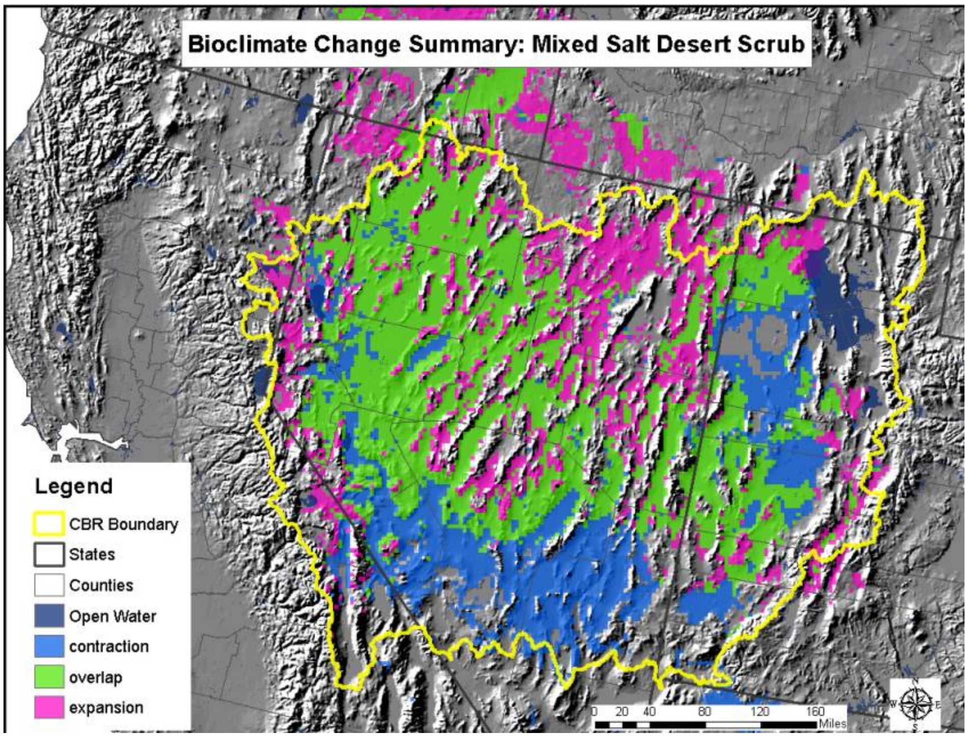

Figure 5-17. Forecasted climate envelope changes for Inter-Mountain Basins Mixed Salt Desert Scrub as of 2060. Results for each category (contraction, overlap, expansion reflect agreement among 2 or more of 6 distinct spatial models).

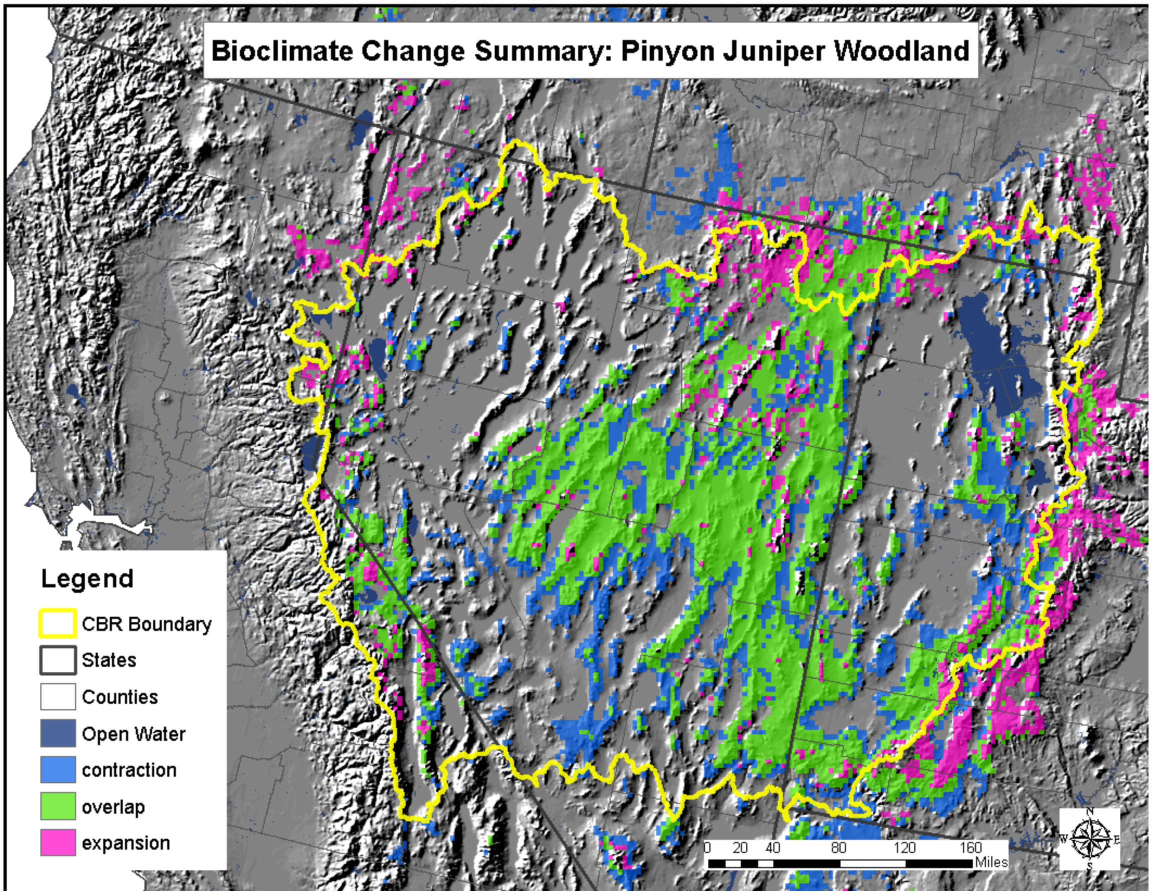

Figure 5-18. Forecasted climate envelope changes for Great Basin Pinyon-Juniper woodland as of 2060. Results for each category (contraction, overlap, expansion reflect agreement among 2 or more of 6 distinct spatial models).

2060 climate envelope forecasts: landscape species. Related management questions for landscape species were addressed here through similar means. One example of climate envelope forecasts for the combined winter and summer ranges of desert bighorn sheep as of 2060 is provided (Figure 5-19). Here one can observe a relatively stable prediction for much of the southerly distribution, with contractions forecasted for higher elevation and more northerly locations, and “expansion” into selected inter-montane basins throughout the central portions of the ecoregion. As mentioned previously, more dramatic climate envelope shifts are forecasted for Greater sage-grouse (Figure 5-20), with only a relatively small proportion of current distribution forecasted to retain the climate regime close to that currently supporting this species. More generally, species that rely on sagebrush habitat have higher loss in climate envelope compared to other species. In particular Pygmy Rabbit (Figure 5-21), Sage Sparrow, and Columbian Sharp Tailed Grouse, are projected to experience severe climate envelope loss by 2060.

Species that are high in maintained climate envelope are birds of prey and ungulates. One might anticipate this result for species that occur across a relatively broad range of temperature and precipitation. For a given level of forecasted change by 2060, these species would tend to have greater proportion of their current distribution falling within a similar future climate. The top species with the highest maintained climate envelope are Golden Eagle, Swainson’s Hawk, Cooper’s Hawk, and Bald Eagle. The Ferruginous Hawk and the Northern Harrier are the only raptors that seem to be the anomaly in that they are projected to have a much reduced climate envelope overlap.

Ungulates such as mule deer were analyzed using distinct models for their seasonal range. This is because there are distinct areas, often occurring across an elevation and temperature gradient that capture key aspects of their life history. Summer range tends to be at higher elevations where more lush vegetation supports reproduction. Winter range tends to be at low elevations where survival of fawns is critical for population recruitment. Year-around range tends to be at middle elevations where these deer might be found in low densities any time. From this analysis, year -around mule deer range is projected to maintain a majority of their climate envelope by 2060 (Figure 5-22). However, at the elevational extremes, mule deer seasonal ranges (winter and summer) are forecasted to experience substantial contractions (see Appendix B Section B-2.4.2).

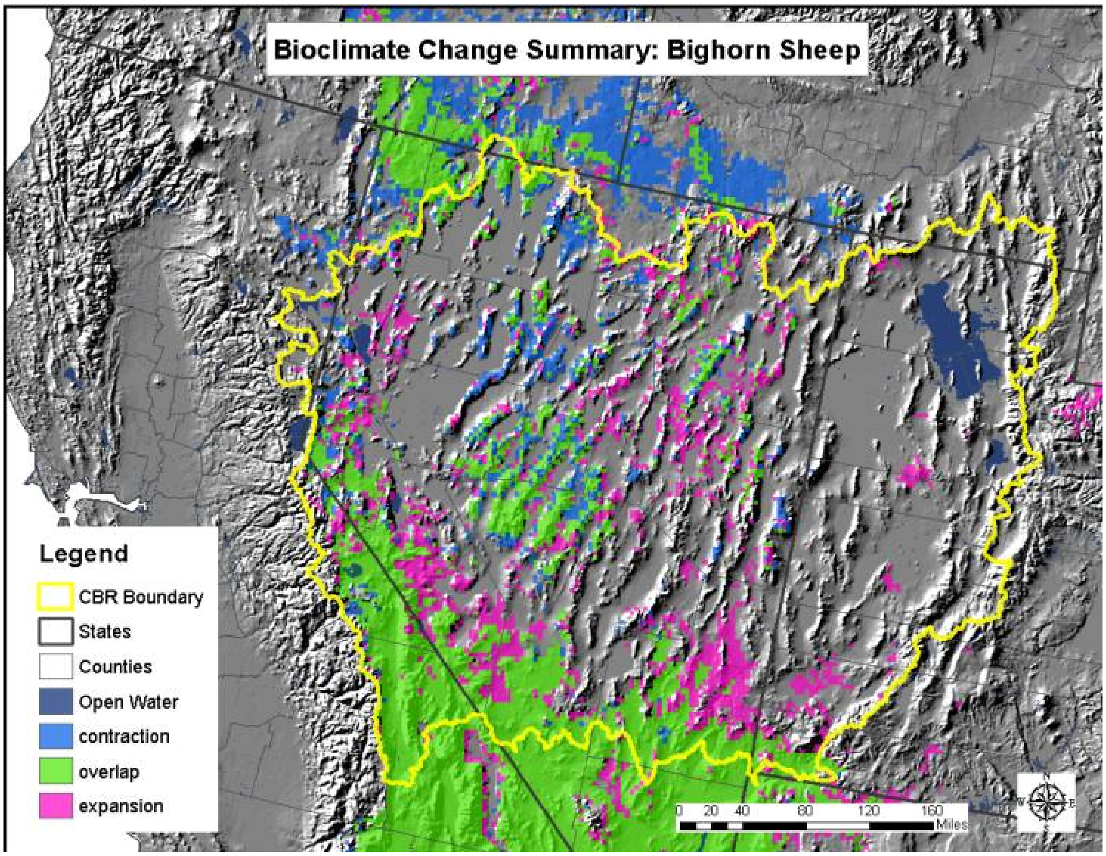

Figure 5-19. Forecasted climate envelope changes for Desert bighorn sheep as of 2060

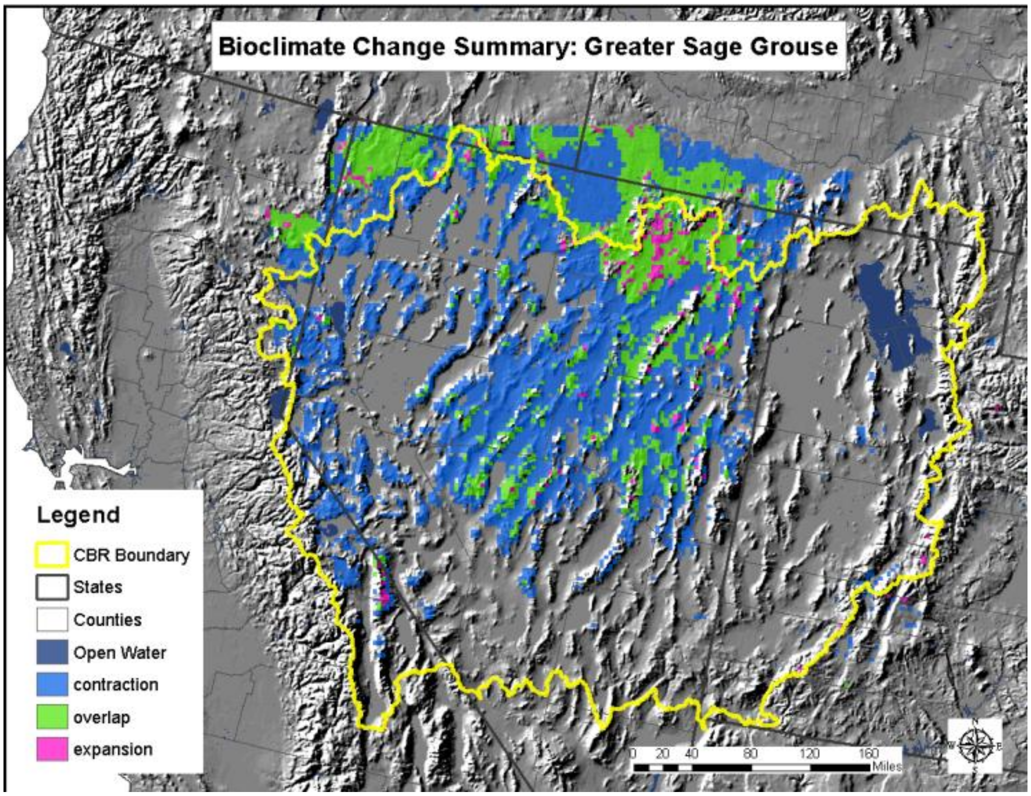

Figure 5-20. Climate envelope changes for Greater sage-grouse (core occupied habitat) as of 2060

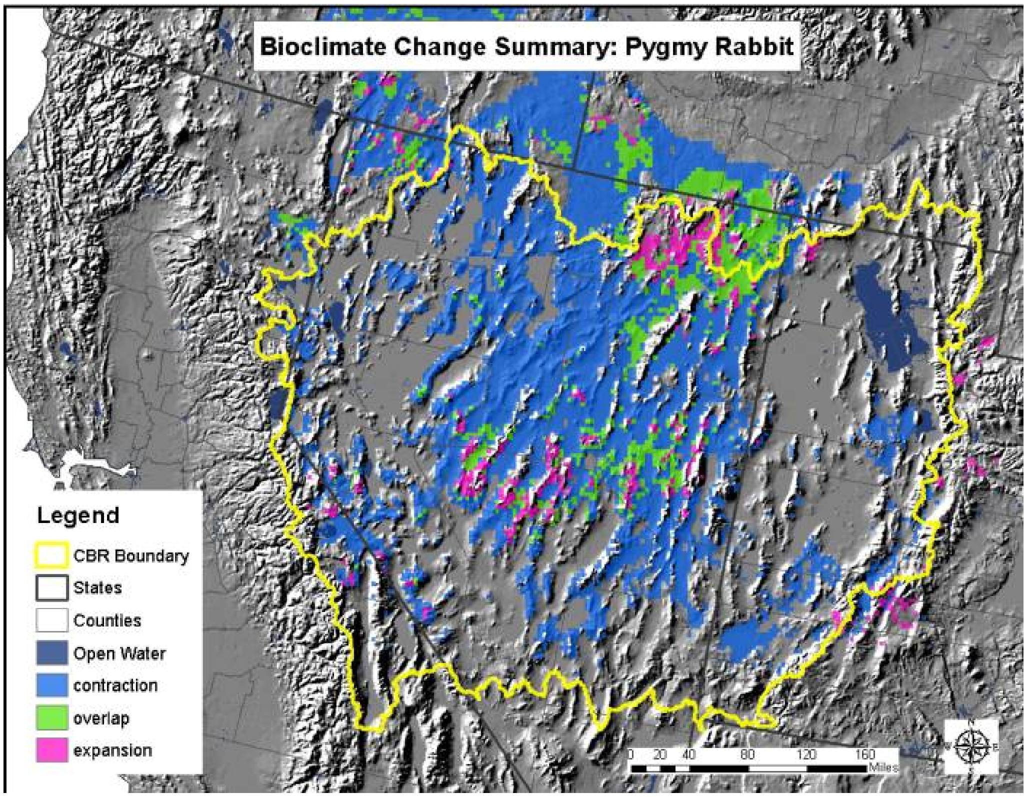

Figure 5-21. Forecasted climate envelope changes for Pygmy rabbit as of 2060

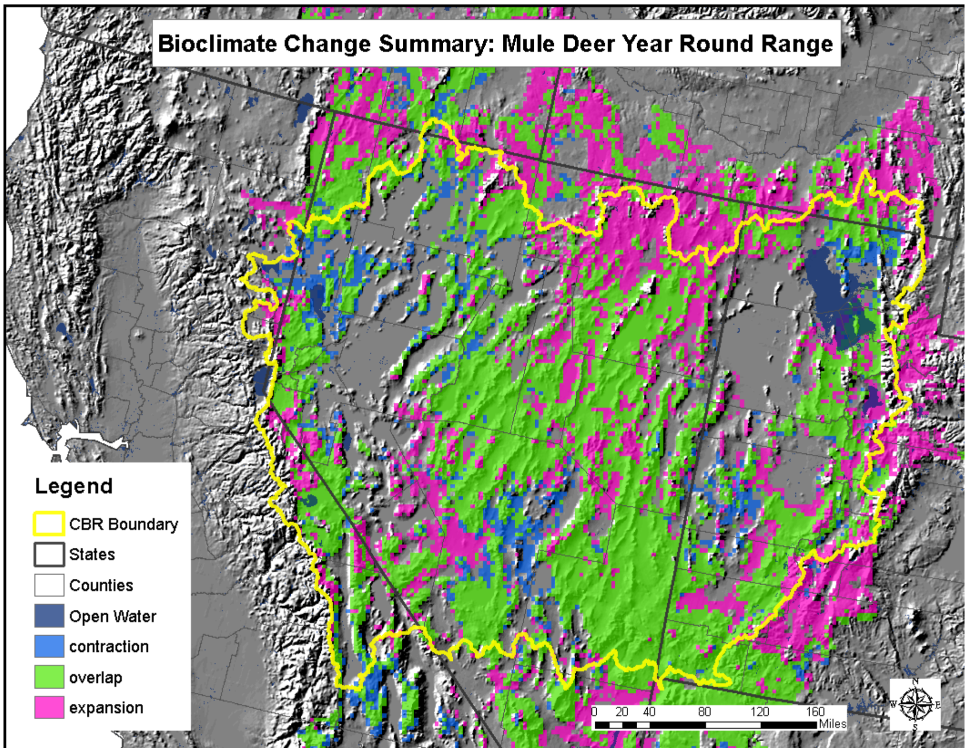

Figure 5-22. Forecasted climate envelope changes for Mule deer year-round range as of 2060.

5.7.2.2 Combining climate envelope forecasts for multiple CEs

One additional application of climate envelope models is to explore the results of overlaying multiple forecasts for major vegetation types of the ecoregion. For each envelope summary, where “overlap” is indicated (in green from previous figures), this suggests that climate regimes characteristic of current distributions for the type are forecasted to be maintained. Therefore, by combining multiple envelope forecasts for major vegetation types, one can begin to identify portions of the ecoregion where multiple lines of evidence suggest that 2060 climate regimes will tend to be closer to current regimes. In some areas of the CBR, as many as seven major vegetation types show an overlap between current and forecasted climate envelopes (Figure 5-23). The mountain ranges and inter-montane basins of central Nevada, along with isolated mountain ranges along the west and eastern margins of the ecoregion, appear to be locations forecasted to experience the least severe shifts in climate regime, at least from the perspective of climate envelopes that characterize major vegetation.

However, this analysis also indicates several areas, primarily concentrated around the Great Salt and Bonneville basin, and basins throughout the southwestern portion of the ecoregion, where no climate envelope overlap is indicated for major vegetation. This provides additional indication of the potential for desert basins to experience effects of severe increases in temperature.

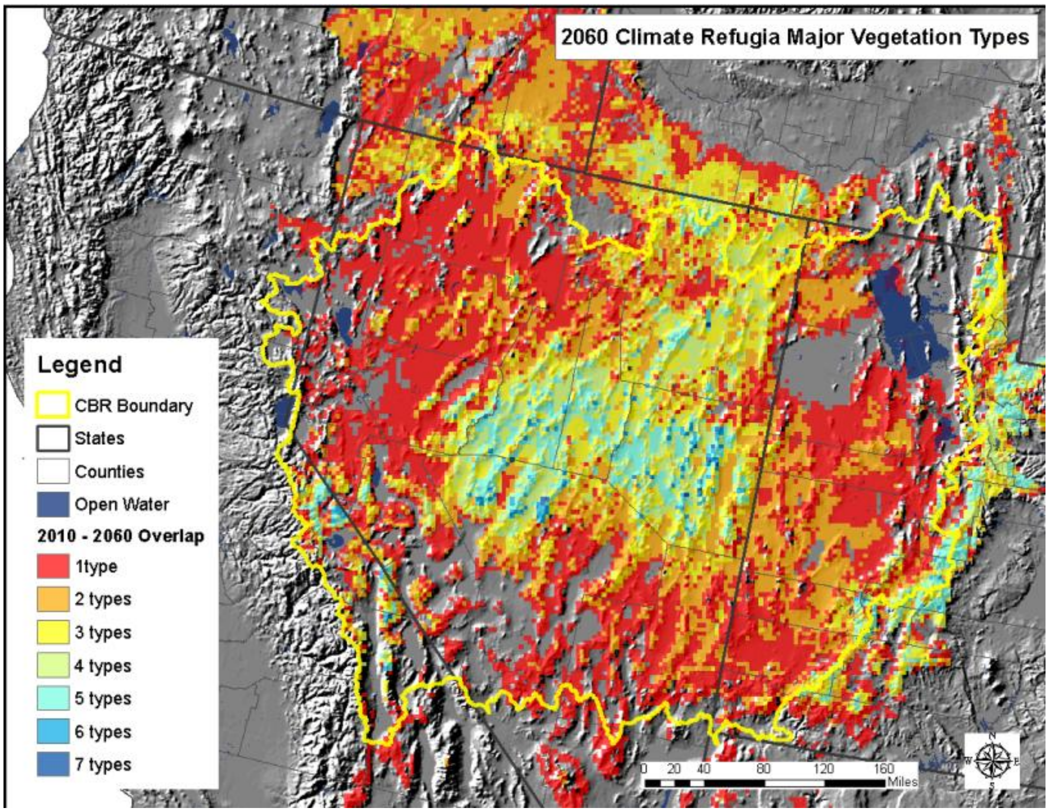

Figure 5-23. Potential climate-change refugia based on 2060 forecasts of climate envelopes for major vegetation types within the ecoregion. This map indicates where between one and 7 types are forecasted by 2060 to have climate envelopes overlapping current distributions; thus providing one indication of potential climate-change refugia.

6 Summary and Conclusions

The Central Basin and Range ecoregion includes some of the most extensive and remote natural landscapes within the conterminous United States. Development is limited to concentrated areas of urban, industrial and agricultural development and the vast majority of native species and communities remain intact. However, a very long history of land and water use has caused substantial disruption to many ecological processes that underpin the production of numerous ecosystem services (Davies et al. 2011).

Areas with High/Low Resource Values

Given the full range of resources addressed through this assessment, including representative ecological system types, sensitive soil types, landscape species, vulnerable species assemblages, and local species, one can presume to encounter at least one focal resource occurring across at least 90% of this ecoregion surface. Only in areas where natural land cover has been entirely removed would one encounter circumstances where the targeted resources for this assessment are completely lacking. One could certainly identify relatively high concentrations of local species, summarized in this assessment by 5th level watershed, as one indication of the locations where sensitive resources are concentrated across the ecoregion (Appendix B Section B-1.2.8). This indicates watersheds where as many as 47 species of concern have been documented; most often concentrated along the southern margins of the ecoregion.

The other primary indication of relative resource value within the ecoregion, at least as it relates to biodiversity representation, can be found in the mapped distribution of Places; either designated or prioritized by previous planning efforts (Figure 4-1). While this REA is an assessment, as opposed to a prioritization or plan, prior planning efforts are reflected in these data layers. Currently, lands designated for ecological or cultural value account for nearly 22% of the ecoregion surface. These lands tend to be concentrated at higher elevations across the ecoregion. Additional lands suggested as high-priority for conservation reflect a more comprehensive representation of natural habitats, and therefore encompass additional area (approximately 6% of the ecoregion); mostly within basins.

Areas Where Conservation Elements are Currently at Risk from Change Agents

Review of the Landscape Condition model and summary landscape integrity map (Figure 4-35) provides a primary indication of the location of change agents, especially where those change agents relate to built infrastructure. Major urban areas along east and west margins, plus along major transportation corridors, form concentration zones for these CAs. Given the relatively pervasive distribution of CEs across the ecoregion, one can presume that the zones of potential conflict among these CAs and CEs would generally follow these patterns. These areas are where stress on available water resources is currently the greatest.

Invasive species, especially from annual grasses, along with fire-regime alteration and associated risks, are prevalent throughout the ecoregion, but clearly reach their highest levels of infestation in the northern portions of the ecoregion.

Areas Expected to have Substantial Impact from Change Agents in the Future

While patterns of development appear to be concentrated in relatively small proportional extent of the ecoregion, a pervasive change agent over the coming 50 years will continue to be invasive species and the interacting effects with fire regime departure. Secondly, climate change and its particular interacting effects on other CAs, may also prove to be quite substantial.

Current patterns of altered fire regimes, largely explained by the pervasive infestation of introduced fine fuels, can be expected to continue to influence vegetation productivity throughout the coming decades. In some instances, a predominance of later successional stages among shrublands and woodlands, perhaps brought on grazing-induced loss of fine fuels and wildfire suppression, has been reversed through increased fire patch size and frequency in recent decades. However, since these dynamics have likely been caused by the introduction of invasive fine-fuels, stand-replacing fires can result in a shift to predominant non-native, early-succession, vegetation (Miller 2005).

Over the coming 2-5 decades, forecasts indicate the potential for truly profound transformation in many ecosystems across the CBR. These include:

- Higher than normal summer temperatures across most grazing allotments
- Severe contraction in characteristic bioclimates for Inter-Mountain Basins Big Sagebrush Shrubland, Greater sage-grouse, pygmy rabbit.
- Bioclimate contraction indicated for Great Basin Pinyon-Juniper Woodland, Inter-Mountain Basins Mixed Salt Desert Scrub is overall less severe, but still quite severe within southern portions of the ecoregion.

Climate space trends indicate the potential for extreme growing season temperatures throughout the vast majority of the ecoregion. These forecasts appear to be most intense along the southern end of the ecoregion, and throughout the other largest basins.

Climate envelope analysis, looking out to 2060, also indicates the potential for rather profound transformation. As indicated by many individual models, and in combination, lowest-elevation basins throughout the ecoregion, perhaps most intense in the southern CBR, could transition from cool semi-desert into very warm and sparsely-vegetated desert landscapes more typical of the adjacent Mojave Basin and Range. Given the combination of existing models, one can begin to visualize the expansion of sparse, or unvegetated plains, the expansion of some desert playas, and the slow expansion or transformation to mixed salt-desert scrub. Much of what is currently the vast 'sagebrush sea' within this ecoregion could see increasing predominance of salt-desert scrub. Again, the exact mechanisms for transforming vegetation change will likely vary by type and location, but the overall nature of that change could perhaps become more clearly predicted using results of this REA.

Interestingly, this same process could result in a decrease in expansion of cheatgrass, as conditions in many places become too dry (Bradley 2009, 2010). But that invasive species could be replaced by red brome and others now invading the northern Mojave Desert. Similarly, the expansion of juniper and pinyon pine into adjacent big sagebrush shrubland could continue to expand, or be limited in places by expanding drought conditions and increasing fire return intervals (Bradley 2010).

6.1 High-Priority Data/Knowledge Gaps

As remote sensing, GIS, and most conceptual and spatial modeling capabilities have increased along with computing capacity, scale constraints in regional analyses have generally been reduced such that relatively fine-scale mapping and analyses at sub-mile^2/kilometer^2 resolutions are feasible. However, climate change data, which are a key component of REAs, are still relatively coarse (e.g., 4 km^2 pixel) even though available spatial resolution has been improving rapidly. Some other products, such as fire regime departure models, aim to express effects at broader spatial scales of several thousand acres. Therefore, a variety of scales and resolutions are used in an REA to represent the finest practical scale of analyses and presentation depending on the source information and modeling methods.

The fact that an REA is by definition a rapid and regional assessment that utilizes existing data; this creates some important limitations:

- REA results are intended to inform landscape-scale direction that can provides context for management decisions through the step-down process.
- A very large number of analyses were required for this REA, conducted over a short timeframe and therefore modest resources were available for each individual analysis. The REA products are useful for the intended purposes, but they are not comparable to results of focused, multi-year studies on particular management questions.
- Only data considered relatively complete for the ecoregion could be used; therefore, although certain areas of the REA may have had more recent or higher resolution data, it was not used because it was not available REA-wide.
- Very few source data sets have had rigorous, quantitative accuracy assessments conducted on them; therefore it is infeasible to provide such information for REA results. Instead a qualitative ranking of confidence was defined with BLM to provide information on uncertainty to users, but further consideration of source data quality used in each analysis is encouraged.
- As noted elsewhere, limitations in available data were in part treated throughout the REA process by emphasizing transparency, repeatability, and applying expert judgment. These included: a) documentation of input data, b) documenting modeling processes, and c) using expert judgment in the selection of spatial reporting units and analysis interpretation, in order to avoid mischaracterization of analysis results.

Based upon this rapid assessment, numerous gaps in current knowledge and data were identified. Below are high-priority gaps where future investments would be productively focused.

- **Conservation Element distributions** – Most terrestrial and aquatic coarse filter CEs were mapped for this assessment by building upon existing national data. The NatureServe expert team completed review and refinements, and as feasible, some measure of final map accuracy was documented. Given this, gathering and maintaining georeferenced samples for all major vegetation type, vegetation structure, and successional status, continues to be of highest priority. One cannot adequately evaluate the quality of critical data sets, such as maps for vegetation type, or succession class for fire regime models, without a robust field sample data set. Several thousand samples were used for these purposes in this REA, but a goal of several hundred samples per type, per MLRA, is advisable (Lowry et al. 2007).

  Sensitive soils were mapped using best-available map inputs, but efforts to apply expert-derived criteria (provided by BLM) for each type highlighted weakness in existing soils data sets, such as the digital soil survey (SSURGO), in this desert landscape. Clearly, investments to improve the completeness and accuracy of these data should be a high priority.

  Landscape species distributions are typically somewhat generalized, indicating a range of possible areas where the species might be found. Most of these used in this REA were developed by the regional gap analysis projects. However, in order to provide meaningful answers to most management questions, a more rigorous characterization of habitat usage and quality is needed. Just as Mule deer or Greater sage-grouse were represented using seasonal range or habitat components (e.g., lek sites with relative densities), most landscape species worthy of REA attention require more specific characterization, mapping, and evaluation of seasonal range and/or populations. With this next level of information developed, tools aimed at evaluating landscape linkages, individually suited to each species, can be appropriately applied.

  While local species played only a limited role in the REA, there remains substantial need to support ongoing, systematic field inventory for a majority of local species; in many cases where field surveys have only occurred through opportunistic research. Given the relatively high concentration of endemic and at-risk species in this ecoregion, this should be a continued priority, especially where knowledge of their potential occurrence coincides with areas forecasted for some form of habitat alteration or development.

- **Development change agent distribution** – Development patterns across the ecoregion appear to be reasonably well described with existing data sets. One weakness identified through the REA was the spatial representation from surface disturbances, such as from open-pit mines and gravel pits. Similarly, the ability to adequately represent motorized and non-motorized recreational usage was highlighted as a weakness in current data sets. Additional investments in these particular areas should yield useful outcomes for subsequent assessment and planning. Forecasts of some development trends may be vulnerable to poorly integrated information on infrastructure plans, such as those currently maintained as proprietary information by energy or mining companies and utilities.

- **Treatment of grazing effects** – given several management questions intended to clarify past, current, and forecasted future effects of grazing across the ecoregion landscape, it became clear that readily available, region-wide data were limited to a) the location of grazing allotments, and b) estimated numbers of grazing animals by allotment. Data on the actual effects of grazing, which vary based on interacting factors like allotment size, characteristic vegetation, and grazing intensity, were not readily available across the ecoregion. Gathering, organizing, and analyzing these data should be a clear, very high, priority for future assessment and planning decisions by BLM and other land managers.

- **Landscape condition models** – Following from development change agents, landscape condition modeling is also vulnerable to incomplete representations of surface disturbance. In particular, older roads that have been closed to traffic have been removed or are no longer maintained in roads data, although the effects from surface disturbance persists for decades after closure. Given the settings for landscape condition modeling fall into the realm of expert judgment, there remains considerable potential to test, calibrate, and customize the model used in this REA.

- **Invasive species risk models** – Invasive plant models face similar constraints as many CE distribution models. Many field-based and georeferenced samples indicating the species and cover of these species is required to develop robust models. Additional time and effort is needed to integrate processed satellite imagery, ideally multi-date images capturing early spring green-up, in order to better predict invasive plant species abundance and risk of invasion. Freshwater aquatic species were very poorly represented in existing data sets for this ecoregion, so all results and conclusions related to these should be viewed as preliminary. Substantial investment in the inventory and monitoring of aquatic nuisance and invasive species is needed throughout this ecoregion.

- **Fire regime models** – While a substantial base existed for this REA, as a result of prior national and regional efforts, this area of both conceptual and spatial modeling remains in early stages. One could expect substantial benefits from regionally customized and field-validation of models for most vegetation types in the ecoregion. Similarly, there are likely substantial benefits to be gained by more rigorous characterization and mapping of selected landscape species habitats; and for those with considerable fire regimes (e.g., Pygmy rabbit), the customized development of new fire regime models would be warranted.

- **Change in extent** – as an indicator of ecological status for several major vegetation types, these analysis and results should be considered preliminary. The approach was vulnerable to errors present in LANDFIRE BpS predictions of historical extent for some types. While this was accounted for in part by reporting at the relatively large watershed reporting units, there remains room for considerable error in selected locations throughout the ecoregion. Improvements to LANDFIRE BpS data, primarily through better integration of soils data, may address these concerns. Fortunately, this type of investment compliments development of Ecological Site Descriptions, so investments in this area could provide numerous benefits for future assessment, management, and monitoring and ecoregion and local scales.

- **Landscape Linkages and Landscape Permeability** – as mentioned above, more rigorous characterization and mapping of habitat for landscape species would present many new opportunities to model landscape linkages to better understand the likely pathways for movement across the landscape. Highest priority here would be for landscape species that are vulnerable to fragmentation.

- **Surface Hydrology** - Improving management of surface-water ecosystems in these ecoregions requires better quantitative representation of not merely average behavior but the range of variation in key hydrologic variables such as annual and seasonal stream discharge, timing of flow maxima and minima, timing of the annual snowmelt cycle and the “center point” of discharge, and so forth (Poff et al. 2010, Richter et al. 1997).
    - Stream/river water management in both ecoregions, therefore, would be aided by completion of StreamStats for all watersheds within the ecoregions. Alternatively, water management would be aided by completion of regional runoff and baseflow models or watershed water budget models. This is a challenge because of the unique topography,

    geology, and climate of the ecoregion. Building and calibrating models that can generate such output may well require additional gauging data (Richter et al. 1997).
  - Better data on discharge at springs and seepage wetlands would also help inform management of these unique habitats but this is a matter of hydrogeology, which is discussed separately below. Perennial flows in streams and rivers are also crucial to ecological dynamics in these fluvial systems; this topic is also addressed below (Brown et al. 2011).

- **Hydrogeology** - Discharges of groundwater support localized habitats such as perennial flow reaches along streams at higher elevations, springs and seepage wetlands, and perennial flow reaches along rivers across basin floors. The former support unique aquatic species assemblages, including sensitive fish species, and are threatened by changes in weather affecting snowpack/snowmelt, the critical variable affecting recharge of the local aquifers that support their perennial flows.
  - A better understanding is needed concerning the coupling of high-elevation precipitation, local recharge, and perennial flow, to help identify higher-elevation watersheds with potentially greater sensitivity/insensitivity to climate change – similar perhaps to the work carried out by Isaak and others in the Pacific Northwest (Boise area) (e.g., Isaak et al. 2011).

- Springs and seepage wetlands, and some closed-basin lakes also support unique biotic assemblages, often shaped by unique hydrogeochemical regimes. Protection of these resources requires a high level of certainty concerning the aquifers that support these ecosystems, and the sensitivity of these aquifers to groundwater withdrawals (Flint and Flint 2007).
  - The spatial data available for the ecoregion is inadequate to identify which aquifers discharge to which natural lakes, springs and seeps – this data gap was identified and discussed with the BLM early in the REA. The controversies associated with the BLM Clark, Lincoln, and White Pine Counties Groundwater Development Project Draft Environmental Impact Statement (2011), and the competing groundwater models of SNWA and other stakeholder groups concerned with this project, highlight the importance of closing this data gap. Groundwater models continue to improve for both ecoregions, but may need to be coupled with improvements in the chemical “fingerprinting” of discharges to better associate them with specific geological sources.

- Perennial flow reaches along basin-floor rivers and their riparian corridors also support unique biotic assemblages, particularly where these rivers pass over/through bedrock features that force groundwater to the surface. The source(s) of perennial flow vary from one river to another, consisting of unique combinations of discharge from both basin-fill and alluvial aquifers (Poff et al. 2010, Richter et al. 1997).
- The integrity of the groundwater flows that support springs, seeps, perennial stream flows, and groundwater contributions to lakes depends not only on the distribution and magnitude of withdrawals, but on the integrity of recharge.
  - Natural recharge zones for regional and basin-fill aquifers need to be better identified and mapped, to better support their management to restore, sustain, or perhaps even enhance recharge. These zones may consist of horizontally distributed belts of land across specific topographic or geological zones, and vertically distributed zones of fluvial recharge descending from higher elevations (Brown et al. 2011).

- **Water Chemistry/Water Quality** -The biotic assemblages of higher-elevation streams in both ecoregions may be especially sensitive to changes in water temperature and sediment loads brought about by changes in climate or in riparian condition and watershed runoff (Richter et al. 1997, Poff et al. 2010, Brown et al. 2011).

    - There is a need to better understand the coupling of high-elevation precipitation, local recharge, perennial flow, riparian and watershed condition, and water temperature and sediment transport. An improved understanding would to help identify higher-elevation watersheds with potentially greater sensitivity/insensitivity to climate change and watershed modification. The potential impacts of fire on stream ecosystems (sediment loads, temperature) across higher-elevation watersheds may need consideration in such research.
    - It is possible that these models could be enhanced by improved data on stream chemistry and water quality impairment (chemistry, sediment, temperature), to help the models distinguish the effects of altered physical habitat condition (altered flow, geomorphology) from those of altered water quality. In addition, water quality (chemistry) sampling of higher-elevation streams is needed to balance the past emphasis of state assessments of impairment on the larger water bodies.

  - **Stream Bioassessment** - The expected near-future completion of the Nevada state stream bioassessment methodology and associated “Observed/Expected” indicators will fill a crucial gap in the availability of digital data on stream macroinvertebrate community integrity in the CBR. The data from Utah are already available. Otherwise, the BLM “Buglab” database remains one of the best in the country. The data from California are not expected to be available digitally for several years. In addition, it should be noted that benthic macroinvertebrate bioassessments in the ecoregion focus on perennial streams. Complementary programs focused on lakes and wetlands would assist management of these other resources as well.

- **Climate Change Analyses** – as described previously, current climate data are limited in this area by a number of factors. Weather stations, forming the basis for characterizing the 1900-1980 ‘baseline’ at 4km^2, have relatively low density with respect to the size of the CBR. For the ongoing 15km^2 analyses, the baseline is restricted to a shorter time period, 1961-1990, and the baseline climate values are model outputs, although strongly forced by observations. Significant climate change was defined based on the variability of climate over these two baseline periods. Given the observed high variability in this basin and range landscape, one should be careful to not over interpret the findings for climate space trends. These analyses are based not only on these 20th century baselines, but upon the rapidly developing science of climate forecasting.

  A concerted effort was made to produce climate change effects analyses that include a broad range of variables derived from a wide range of global and regional climate model outputs. Moving beyond monthly temperature and precipitation, the analysis includes variables such as evapotranspiration and soil moisture that feed into the understanding of ecological features, such as future fire regimes and streamflow. The available data require a tradeoff between spatial resolution, number of climate model outputs, and climate variables analyzed.

  The approach to managing these uncertainties has been appropriate for the task and constraints imposed by the REA process, but it is also encouraged that care be taken with interpretation of the findings. Future investment could further refine these REA results. Additional climate datasets, both improved global and regional climate models, as well as independent weather station data, are available to further test the hypotheses of climate-induced change.

- **Areas high potential hydrocarbon energy development** – Given the volatile nature of hydrocarbon markets and technologies for extraction, one should take care in the interpretation of these REA findings as they pertain to potential development zones in this sector.
- **Areas of most likely renewable energy development** (i.e., constrained by transmission access) – with some similarities to hydrocarbon development, the sensitivities of investors to factors such as the existing or planned placement of transmission corridors, or the rapid shifts in technology (e.g., heights of wind turbines), can have dramatic effect on the potential for renewable energy development. Our findings should be carefully considered in this light.

6.2 Lessons Learned and Recommendations for Further Study

Given the description above of key data/knowledge gaps, the following recommendations are provided for further study. As noted in the introduction, an almost infinite number of analyses and products are possible with the information developed in this REA.

Among the most important areas of further study will be the application of REA findings to establishing ecoregional direction under BLM's Landscape Approach. This new approach implements an adaptive framework aimed at providing a clear focus for investments and clear lines for feedback and continual improvement. REA analyses are intended to provide a useful regional perspective as partners engage together to set priorities for management actions that will be documented in updated resource management plans. BLM is encouraged to consider creating a distinct information feedback from subsequent planning phases to ensure that future ecoregional assessments:

- Engage all appropriate partners in the oversight and guidance given to each REA; clarifying needs for the full array of social, economic, and ecological issues to be addressed.
- Answer the critical management questions in ways that will provide true insight for planning decisions to be taken over the upcoming decades.
- Organize data in ways that maximize efficiency in data collection, management, model building, and product distribution.

Through subsequent planning and management implementation, a series of more specific questions will need to be asked and answered that will provide important insight for evaluating products of the REA. For example, field implementation and monitoring will likely present opportunities to:

- Update data on the probable location of conservation elements, their apparent ecological status, and relative responses to various change agents. These data will support updating CE distribution maps, as well as for conceptual and spatial models related to their ecological status.
- Update data on the location and rate of CA expansion/contraction to allow rapid re-evaluation of actual and potential effects on CEs and other CAs.
- Validating all model assumptions, especially as they relate to identification of potential sites for CE habitat restoration and/or mitigation.
- Updated information on Places, such as the boundaries of existing and proposed priority conservation areas.

Climate Change Forecasting - Some more specific recommendations include the potential priority investments related to climate change modeling. Based on the climate envelope modeling of both landscape species and vegetation assemblages, additional, finer scale spatial climate analysis of species and vegetation types projected to lose at least 50% of their existing bioclimate envelopes is recommended. For the vegetation types, all forms of sagebrush habitat are forecast to be disproportionately impacted by climate change according to the REA results. Distribution data for all sagebrush habitats exists at finer spatial resolution than the $4km^2$ climate data available for the REA. Conducting climate space trend analyses is recommended for all four sagebrush vegetation types using PRISM 800m2 data supplemented by SNOTEL data (that will specifically improve understanding of PRISM interpolated precipitation data). Rather than the relatively coarse modeling effort aimed at forecasting future loss, gain, or maintenance of sagebrush habitat bioclimatic envelopes using species distribution modeling algorithms, climate space trends employing existing high resolution climate data from 1900-2010, applied to a specific vegetation type distribution, will produce a fine resolution map of where sagebrush vegetation types are currently experiencing the most, and the least, stress from climate change that is already occurring. These results can be compared to forecasts from climate models to relate existing climate change impacts to model projections, improving understanding of the confidence that can be applied to spatial and temporal climate projections. The data now exist for such an analysis, which could be produced relatively quickly and inexpensively. These results would inform BLM management of the spatial distribution of sagebrush vegetation types that are most vulnerable and most resilient to changes in climate changes that are already occurring.

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