BLM Manager's Guide to Climate Change Assessment

Application of the Yale Mapping Framework

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Introduction

Background

In 2011-12 the Bureau of Land Management (BLM) became involved in a philanthropic initiative via Yale University to develop practical guidance for conducting climate change analyses for biological resources. The guidance became the Yale Mapping Framework (Yale Framework). During this time, BLM's Nevada State Office (NVSO) and NatureServe partnered in a pilot project to test and inform further iterations of the Yale Framework. This pilot project was conducted in an approximately 25 million acre transition from the Central Basin and Range ecoregion south into the Mojave Basin and Range ecoregion utilizing data recently developed in Rapid Ecoregional Assessments (REAs) for those ecoregions. This pilot project (NVSO Yale Pilot Project) was the most complete test of the Yale Framework and the only one conducted for BLM. Subsequently, BLM contracted with NatureServe to convert its pilot project report to Yale University into manager's and technical guides for replicating analyses conducted for the pilot. The result of this initial modest effort should be informative to BLM planners and managers and is similar to a larger effort that resulted in similar types of guides for the US Fish and Wildlife Service for Refuge Vulnerability Assessment and Alternatives (RVAA). Those guides also contain very relevant information for BLM practitioners and may be accessed at https://connect.natureserve.org/publications/rvaa.

Purpose and Use of the Guides

This BLM manager's guide is intended to provide an overview of the Yale Framework (as adapted for BLM purposes from here on referred to as the BLM Yale Framework) and practical recommendations for projects utilizing the guide. The Yale Framework is a work in progress and thus this guide should be considered dynamic as should all guidance involving climate change. This guide acts as the introductory companion to the *BLM Technical Guide for Application of the Yale Mapping Framework.* That guide gives more detailed, technical descriptions of how to conduct the analyses based on the pilot work described above. Note that the guides generally utilize terminology from BLM's Rapid Ecoregional Assessments; a glossary is provided in this guide but key terms and abbreviations used throughout include:

- REA: Rapid Ecoregional Assessment. Regional landscape assessments conducted by BLM throughout the western U.S.
- CE: Conservation Element. Natural resources, generally the species and ecosystems of interest, but may also include other features like sensitive soils
- CA: Change Agent. Development, wildfire, invasive species, and climate change were specifically addressed in the REAs but may include any other CAs of interest in step down assessments.
- MQ: Management Question. Formal expression of desired information so that analyses performed in an REA will provide information of specific interest to management in the ecoregion.
- Yale Framework or Yale Mapping Framework: the set of analysis types created by a Climate Change Science Committee assembled by Yale University.
- BLM Yale Framework: the adaptation of the Yale Framework for BLM applications.

- NVSO Yale Pilot project: a pilot project conducted by the BLM Nevada State Office and NatureServe to test the Yale Mapping Framework.

These guides do not provide a complete set of guidance for conducting vulnerability assessment and adaptation planning but do cover a broad set of useful analyses. The RVAA guides described above provide additional guidance and references to additional resources and tools and a large number of other relevant guides exist or are in development.

Overview of the Yale Mapping Framework

A complete overview and description of the Yale Framework can be found at http://databasin.org/yale where the goals of the Yale Framework are summarized as:

The Yale Framework assists conservation planners in selecting the assessment and modeling strategies that are most relevant to their specific needs. Rather than supplanting existing techniques, the Yale Framework provides simplified and flexible advice on models and data, and presents a list of commonly used datasets that can be helpful to planners. The Yale Framework also provides a structured menu of options that assist resource managers in determining the best possible approach to conservation, as opposed to offering a prescriptive approach to natural resource management.

The main navigation to the Yale Framework is a matrix that identifies types of analyses or "adaptation approaches" relative to three levels of ecological organization: species, ecosystems, and landscapes. Because, as of this writing, the Yale Framework is in a state of review and modification, it is not reprinted here but should instead be accessed at the website above. While an adaptation of the matrix is provided in a later section, the two are meant to be complementary as described in that section and thus Yale's Framework and supporting material should be viewed as an important resource for these guides. Also found at the Yale Framework website are several other pilot project reports that document additional or alternative approaches to conduct the analyses.

Relationship of the Yale Mapping Framework to BLM Decision Making

BLM's long term goals are expressed in its Mission Statement: *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."* BLM accomplishes these long term goals through planning and implementation of Land Use Plans (LUP) that include Resource Management Plans (RMP). BLM has developed the Landscape Approach – a long-term, adaptive strategy for managing public land across inter-jurisdictional boundaries and integrated budgets. The Landscape Approach embodies an "adaptive" strategy because it presumes that knowledge remains incomplete and circumstances will change continuously, so management is structured as an ongoing, learning process.

Adaptive frameworks commonly include generalized phases of assessment, planning, implementation, and monitoring. For example Figure 1 illustrates BLM's landscape approach that identifies the sequence of assessments and decision making beginning with Rapid Ecoregional Assessments which inform Ecoregional Direction leading to Field Implementation followed by Monitoring. Assessments seek to understand past, current, and forecasted patterns among key resources and change agents and their interactions across the entire ecoregion. They document trends that need to be addressed in order to achieve agency goals. Central to this phase is the Rapid Ecoregional Assessment (REA) which will provide information on conservation elements (CEs), and where change agents (CAs) and conservation elements interact within a region of interest. This information will form the scientific basis for Ecoregional Direction which will guide revision of subsequent plans. Planning processes specify management goals and objectives, and commonly take shape within RMPs and LUPs that determine areas of emphasis in conservation or extractive resource use, and provide guidelines for site-level activity, including needed restoration and mitigation. Plans are typically developed within a given BLM field office but may be developed over larger landscapes. Monitoring focuses on key parameters identified within prior assessment and planning phases and sets the stage for periodic iterations of the adaptive management cycle.

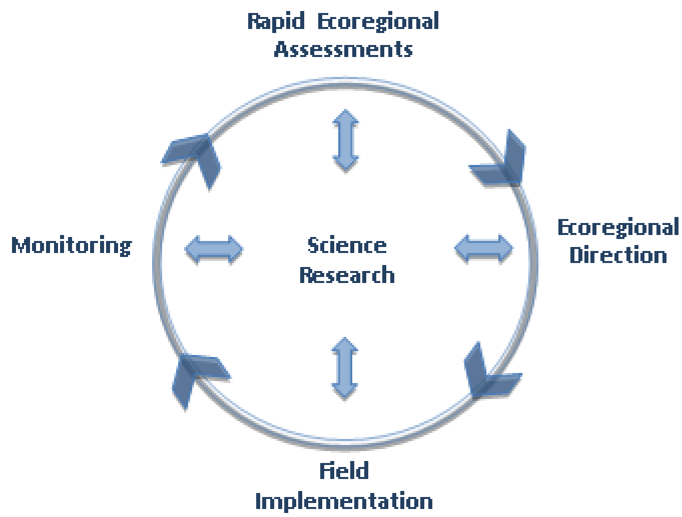

Figure 1. BLM's Landscape Approach indicating the roles of REAs and Ecoregional Direction to shape field implementation and monitoring. Science is at the center of the approach.

BLM must manage resources under a multi-use mandate which includes extractive use of the landscape. BLM also faces the additional challenge of managing landscapes vulnerable to effects of climate change and so may be expected to experience unprecedented rates of ecological change as a result. BLM needs to develop guidance on appropriate strategies for climate-based ecological assessments and the tools for their implementation. Such assessments will be integrated into the Ecoregional Direction providing climate-based tools essential to the long-term success of LUPs and RMPs. The Yale Framework provides a means to develop an effective, scientifically defensible climate adaptation strategy that BLM can use to enhance the effectiveness of policy decisions related to natural resource preservation, climate change adaptation, and compatible land use – all of which are central lynchpins in BLM's mission.

Rapid Ecoregional Assessments as the Foundation

As the flagship effort to provide information on current conservation elements (CEs) and change agents (CAs) (including climate change effects), REA products will be a primary input to the step down analyses described in these guides. The REA program is also evolving and, while a summary of REA approach and objectives are provided here, please see the REA website for current information http://www.blm.gov/wo/st/en/prog/more/Landscape_Approach/reas.html. REAs integrate *wall-to-wall* data on biodiversity and other key resources such as representative vegetation, aquatic ecosystem types, and sensitive species. They also document CAs such as urban/industrial development, invasive species, fire/hydrologic regime alteration, and climate change and their effects on key resources. Each REA develops spatially-explicit land use scenarios as maps of current conditions and forecasted conditions for near term (e.g., 2025) and long term (e.g., 2060) scenarios. Evaluation of current land use scenarios emphasizes assessment of relative ecological integrity for key natural resources. Forecasted land use trends (e.g., renewable energy and other development) are emphasized in the assessment of the near term scenario and climate change effects are emphasized in the long term scenario. The REA produces a variety of data products ranging from acquired source data, modeled/improved data inputs, and assessment outputs for key CEs and CAs for use in a variety of subsequent management decisions.

Applicable Scales & BLM Applications

Planners and managers are often confused about how to integrate and utilize climate change information in their current assessment and planning applications. When future forecasts are spatially coarse and uncertain, how should a manager react to such products? One approach is to not utilize such information and just observe the future unfold. But that approach also brings with it high uncertainty as to whether today's management decisions will be effective into the future and more importantly, will they foreclose opportunities. Understanding what species may become imperiled through climate change in the future can inform what actions are needed now to foster adaptation. When considering how and when to utilize climate change forecasts in decision making, it becomes apparent that the level of decision making is critical for deciding whether and how the assessment results will be useful. In the adaptation of the Yale Framework Matrix to BLM's levels of decision making (Table 1), the applicability of Analysis Types to different levels of decision making are categorized as Direct, Indirect, or Not Applicable (NA). The analysis types presented are those utilized in the NVSO Yale pilot project; additional analyses are possible and are presented on the Yale Framework website (http://databasin.org/yale).

The categorizations of applicability were established by the NVSO Yale Pilot project team, others may come to different conclusions. Note that for Site or Activity Planning, most analyses are deemed Indirect; this is primarily because of the coarse spatial scale of climate-forecast data and uncertainty about outcomes. However, the application of the climate change forecasts to this level of decision making can still be useful by providing useful insights for managers who can then translate generalized patterns to practical implications on the ground. In one example, a field office biologist noted that for species translocation (from sites to be developed), the climate change forecasts inform whether a candidate translocation site has a high probability of maintaining appropriate climate for the target species and or whether the translocated population would be able to move to other sites as climate changes. This approach, therefore, allows more flexibility in considering future forecasts rather than rejecting the information as too coarse or uncertain for RMP or Site Planning decisions.

Table 1 presents the adaptation of the Yale Framework (BLM Yale Framework) resulting from the NVSO Yale Pilot Project conducted by BLM and NatureServe. The Yale Mapping Framework Adaptation Objectives are numbered and in bold at the top of each Analysis Type but are presented in a different order here according to anticipated order of actually conducting the various analyses. The Analysis Types under the bold numbered Yale Framework Adaptation Objectives are used to identify the primary steps in the summary below and in the Technical Guide and so may be used to navigate to further descriptions of these types. Primary analysis types are underlined and secondary analyses are bulleted. In the cells under Levels of Decision Making, the attribute has to do with relevance of the analysis type to support decision making; Direct means the analysis results will directly inform decision making, Indirect means that the results will provide some useful information but are only relevant in the context of other information,, and question mark (?) means that the analysis was not addressed in the pilot project or the team could not come to a conclusion about applicability.

Table 1. Yale Framework adapted for BLM Application.

Analysis Type **(#) Yale Framework Adaptation Objective** Primary BLM analyses within objective • Secondary BLM analyses	**Levels of Decision Making[1]**			
	Issue ID	**Regional Strategy**	**Land Use Plans**	**Site or Activity Planning**
(1) Protect current patterns of biodiversity Assess current CE distribution & status • Map current CE distributions • Map areas of CE concentration • Conduct gap analysis of current protection	**Direct**	**Direct**	**Direct**	**Indirect**
(2) Protect large, intact, natural landscapes Model connectivity and integrity • Model CE and landscape connectivity • Assess current ecological integrity assessment	**Direct**	**Direct**	**Indirect**	**Indirect**
(4) Identify and appropriately manage areas that will provide future climate space for species expected to be displaced by climate change Map climate trends • Model historical, recent, and current climate trends • Model future climate change and trends Model future climate envelopes of CEs	**Direct**	**Direct**	**Direct**	**Indirect**
(5) Identify and protect climate refugia Model potential climate refugia • Combine CE climate envelope models	**Direct**	**Direct**	**Indirect**	**Indirect**

Analysis Type **(#) Yale Framework Adaptation Objective** Primary BLM analyses within objective • Secondary BLM analyses	**Levels of Decision Making**[1]			
	Issue ID	**Regional Strategy**	**Land Use Plans**	**Site or Activity Planning**
(3) Protect the geophysical setting Model **enduring features** • Model landscape heterogeneity[2]	**?**	**?**	**?**	**?**
Incorporates all Yale Framework Objectives Assess impacts and develop strategies and alternatives • Assess current and future impacts on CEs • Create mitigation and adaptation strategies and alternatives	**Direct**	**Direct**	**Direct**	**Direct**

1. Note that these levels of decision making apply to BLM, they can be generalized as follows: Issue Identification, Strategy Development; Planning, and Implementation.
2. Note that NVSO staff did not find biophysical heterogeneity mapping particularly informative so the applicability to levels of decision making apply only the modeling potential climate refugia.

REAs utilize management questions (MQs) to guide assessments. Table 2 references MQs utilized in the NVSO Yale pilot project to the analysis types from**Error! Reference source not found.** and their relevance to the different levels of BLM decision making. This information is provided as another way to visualize applicability related to specific types of MQs.

Table 2. BLM Yale Framework by Management Questions.

Management Questions Addressed	**BLM Analysis Type**	**Levels of Decision Making**[1]			
		Issue ID	**Regional Strategy**	**Land Use Plans**	**Site or Activity Planning**
What proportion of CE values are currently found within lands with management aimed at their conservation?	Assess current CE distribution & threats	**Direct**	**Direct**	**Direct**	**NA**
What is the current ecological integrity of CEs and what changes to management might maintain or restore ecological integrity?	Assess current CE distribution & threats	**Direct**	**Direct**	**Direct**	**Indirect**

Management Questions Addressed	BLM Analysis Type	Levels of Decision Making[1]			
		Issue ID	Regional Strategy	Land Use Plans	Site or Activity Planning
By 2025, what proportion of CEs are likely to be affected by renewable energy and other forms of urban/industrial development?	Assess near future threats to current and future CE distribution	**Direct**	**Direct**	**Direct**	**Direct**
By 2060, what proportion of CE distributions are likely to occur outside current distributions, and what proportions might be affected by development by 2025?	Assess near future threats to current and future CE distribution	**Direct**	**Direct**	**Direct**	**Indirect**
By 2060, what portion of BLM managed land is likely to occur with climate regimes significantly departed from 20th century character? and…which climate variables might contribute most to that change?	Map climate trends on lands and waters	**Direct**	**Direct**	**Indirect**	**Indirect**
By 2060, what proportion of CE distributions are likely to occur within their 20th century climate regime, and what areas within and outside of those distributions might provide robust local-scaled refuge from a changing climate?	Model potential climate refugia	**Direct**	**Direct**	**Indirect**	**Indirect**

1. Note that these levels of decision making apply to BLM, they can be generalized as follows: Issue Identification, Strategy Development; Planning, and Implementation.

Applying the BLM Yale Framework

This section provides brief descriptions and graphic examples of the Analysis Types listed in Table 1; a complete technical description and methods for each analysis are provided in the Technical Guide. In this section we also characterize the degree that the analyses products are already provided by a completed REA and more specifics are provided in the Technical Guide. It is important to note that there are variations in the types and nature of REA products because of different project objectives and contractor methods. These differences can result in different starting points for projects using REA products; in other words, depending on which REAs overlap your project area, you may have to do additional work to create the base of information needed to conduct an Analysis Type. Figure 2 illustrates the workflow of the analyses; note that rather than a sequential workflow, several analyses are dependent on outputs of other analyses.

An adaptive approach is essential in applying this framework because both climate change and our knowledge and ability to model change and effects is rapidly evolving. Aligning assessment and planning processes is necessary to better foresee rapidly changing conditions and provide insights into the type, location, and timeframe for appropriate management action. The latter factor, *timeframes* tend to differ for assessment vs. planning. Timeframes for ecoregional assessments pertain to the prior century, current conditions, and forecasts extending over the coming 50 years. In contrast, planning decisions are taken within 1, 5, 10, or perhaps 15 year planning cycles. Therefore, a key challenge is to glean insights from assessments organized around longer timeframes that will inform the planning decisions of the coming decade. Determining which actions to take today, versus postponing them for subsequent cycles of assessment, will become an increasingly critical facet of natural resource management in the 21st century.

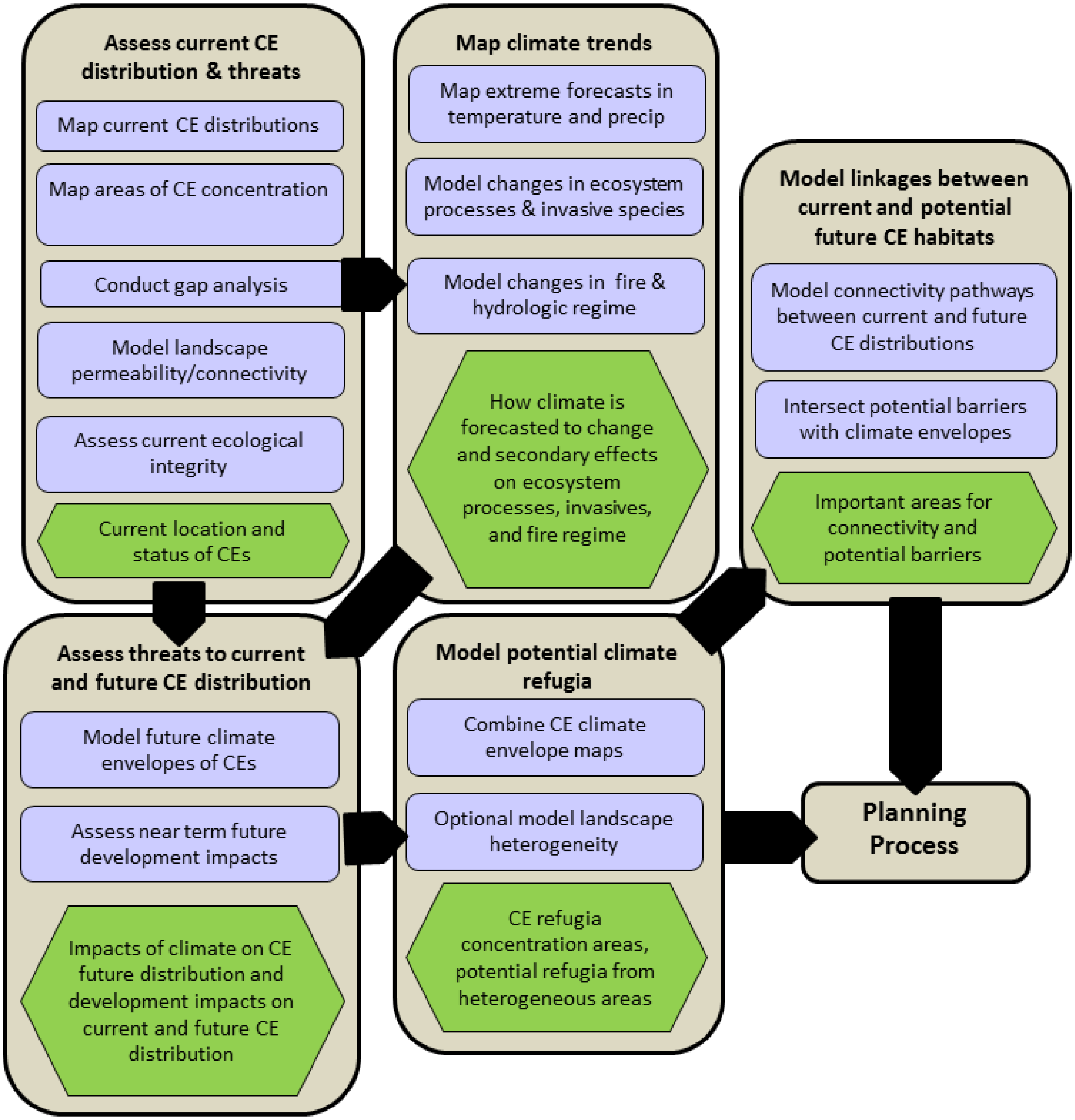

Figure 2. BLM Yale Framework workflow. Key analysis types are in blue boxes, outputs are in green hexagons.

Summary of Analyses Types

Assess Current CE Distribution & Status

This is a broad set of analyses supporting the mapping and assessment of current conservation status and ecological condition of CEs.

Map current CE distributions

The most basic management question is "where is it?" Mapping where CEs are known to exist or can probably exist is also critical to most other analyses. The REAs typically obtain best available data on CE distribution and in some cases augment this data with modeling to develop maps of probable CE suitable habitat (Figure 4). Step down projects will need to review the REA data for CEs and determine if there are better data within the step down project area or there are gaps or inadequacies in the data that need to be filled prior to proceeding further with analyses. This may involve gathering and using more accurate local data and or developing CE distribution models that provide high confidence CE maps for CEs not included in the REAs.

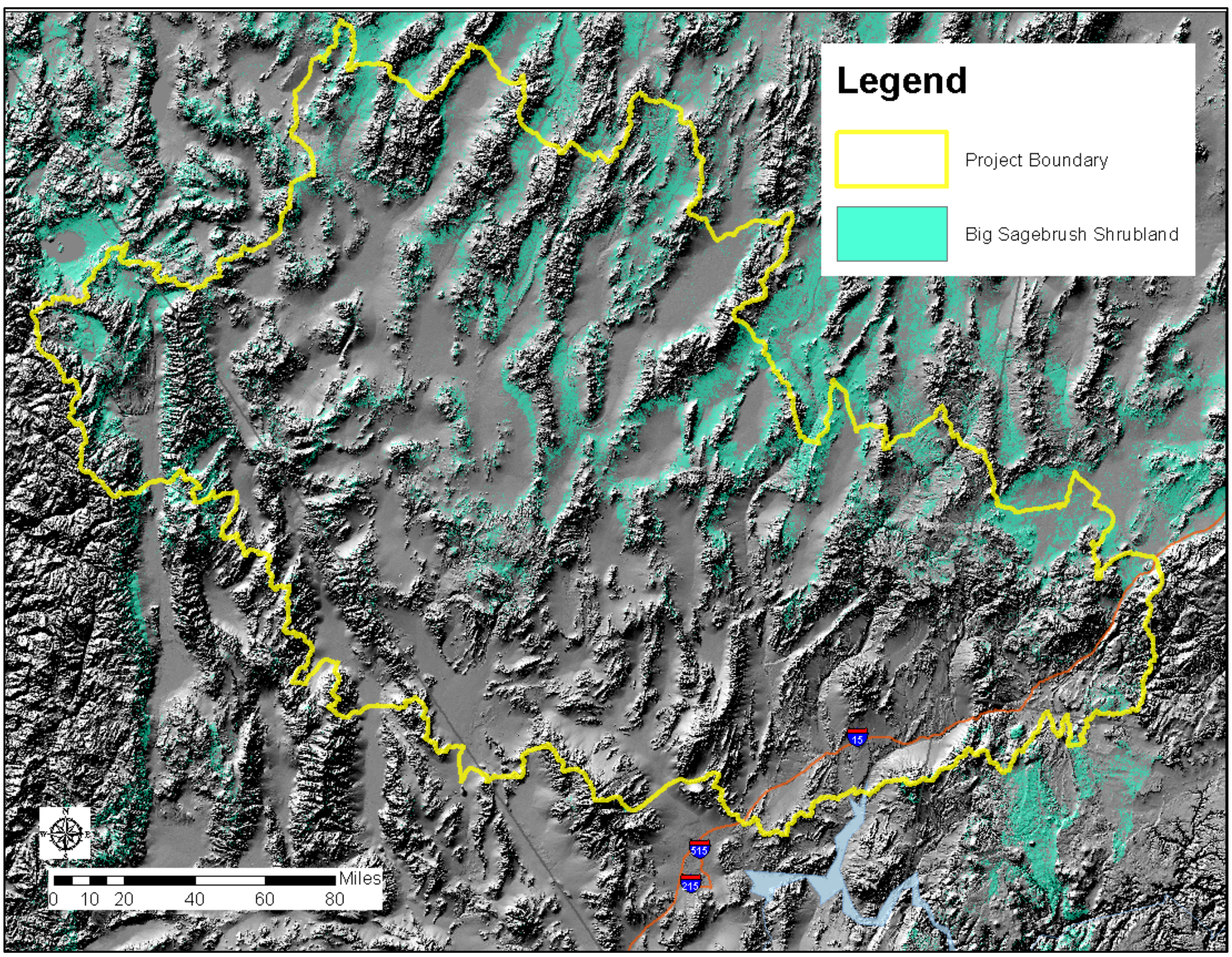

Figure 4. Map of Big Sagebrush Shrubland from the NVSO Yale Pilot Project.

Map areas of CE concentration

Areas of CE concentration are often of management interest where they can represent ecologically important concentration areas such as T/E species or migratory bird stop overs. These can be developed as maps of overlapping distributions for these relatively rare CEs. Such concentration areas often represent conservation priorities because they are areas where many CEs can be impacted or benefit from land use and management decisions. However, limitations in the data used to map concentrations need to be evaluated carefully. Not all areas of overlap may have conservation value as they may represent overlaps in edges of generalized CE ranges (where distribution confidence may be low). The REAs may have mapped concentration areas already but they may need to be updated if different CE distribution data was obtained for the step down project.

Conduct gap analysis of current protection

To understand potential conservation needs and priorities, quantifying the proportional representation of CEs within current and proposed protected areas is a common starting point. A *gap analysis* documents the proportional distribution of each CE within USGS GAP Stewardship Status 1 and 2 lands (i.e., high-levels of biodiversity protection) *vs.* lands identified as priority (but as yet undesignated) conservation areas *vs.* all other lands within the study area (see the USGS Gap Analysis Program for more information http://gapanalysis.usgs.gov/) (Figure 5). This information conveys a basic sense of the protection status of each CE throughout the planning area and within each ownership category. To understand BLM's proportional role in conservation of CEs, CE distributions can be overlaid with land ownership maps to quantify CE distribution by land manager and highlight the relative contributions by BLM field offices. This clarifies areas where management change might be considered. For example, from the NVSO Yale Pilot project, Inter-Mountain Basins Big Sagebrush Shrubland, with over 2.5 million acres in the study area, has 21% of its distribution within designated protected areas, 24% falls within lands identified by groups as conservation priority areas, and some 60% of that area falls within BLM lands. An REA may have conducted this assessment already for the CEs it considered but CE data and land stewardship data may need to be augmented or improved with local data.

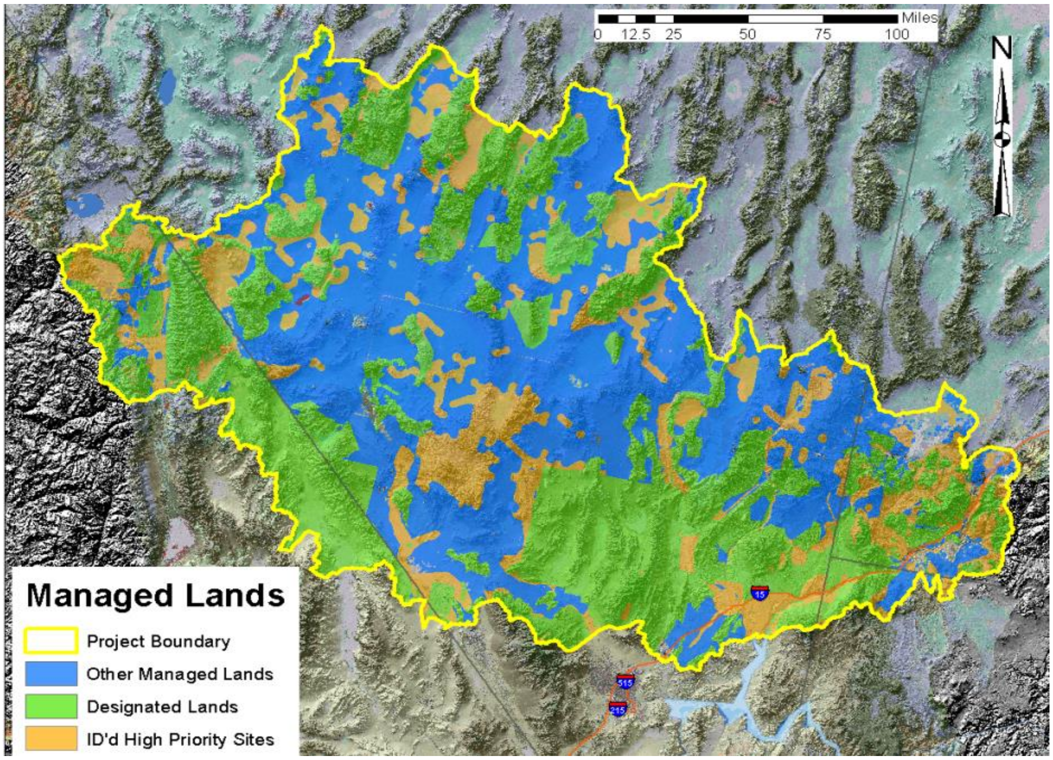

Figure 5. Map of all managed lands (blue), lands currently designated for conservation (green), and lands identified by various groups as conservation priorities (gold) in the NVSO Yale Pilot Project area. This map forms the basis for conducting a gap analysis of CE representation in such lands.

Model Connectivity and Integrity

Model CE and landscape connectivity

Ecological connectivity can encompass a wide range of phenomena; all of which are important to current ecological integrity and for climate change adaptation. In this analysis type, the focus is on the maintenance of current connectivity for CE integrity; later the issue of connectivity between current and future CE distributions is addressed. Most commonly, “connectivity” relates to landscape linkages for individual species (Figure 6). A broader view of connectivity might simply be called “landscape permeability” aiming to more generally reflect the relative connectedness of any given place to other surrounding portions of the regional landscape. This concept and approach do not generally reflect particular needs or constraints of individual species, but instead provide a general indication of the potential for connectivity throughout an area that may support any number of biodiversity connection needs. These could include generalized species movements for pollinators, birds, plants, or for disturbance dynamics, such as wildfires. While NVSO Yale Pilot Project participants did not find landscape permeability models as useful for decision making (being not explicitly tied to individual species’ needs), maintaining general connectivity is important. Such general models also do not require the level of knowledge required to model individual species connections; knowledge often lacking.

Connectivity modeling was highly variable among REAs; some contain connectivity models for select CEs and may have conducted general landscape connectivity/fragmentation analysis.

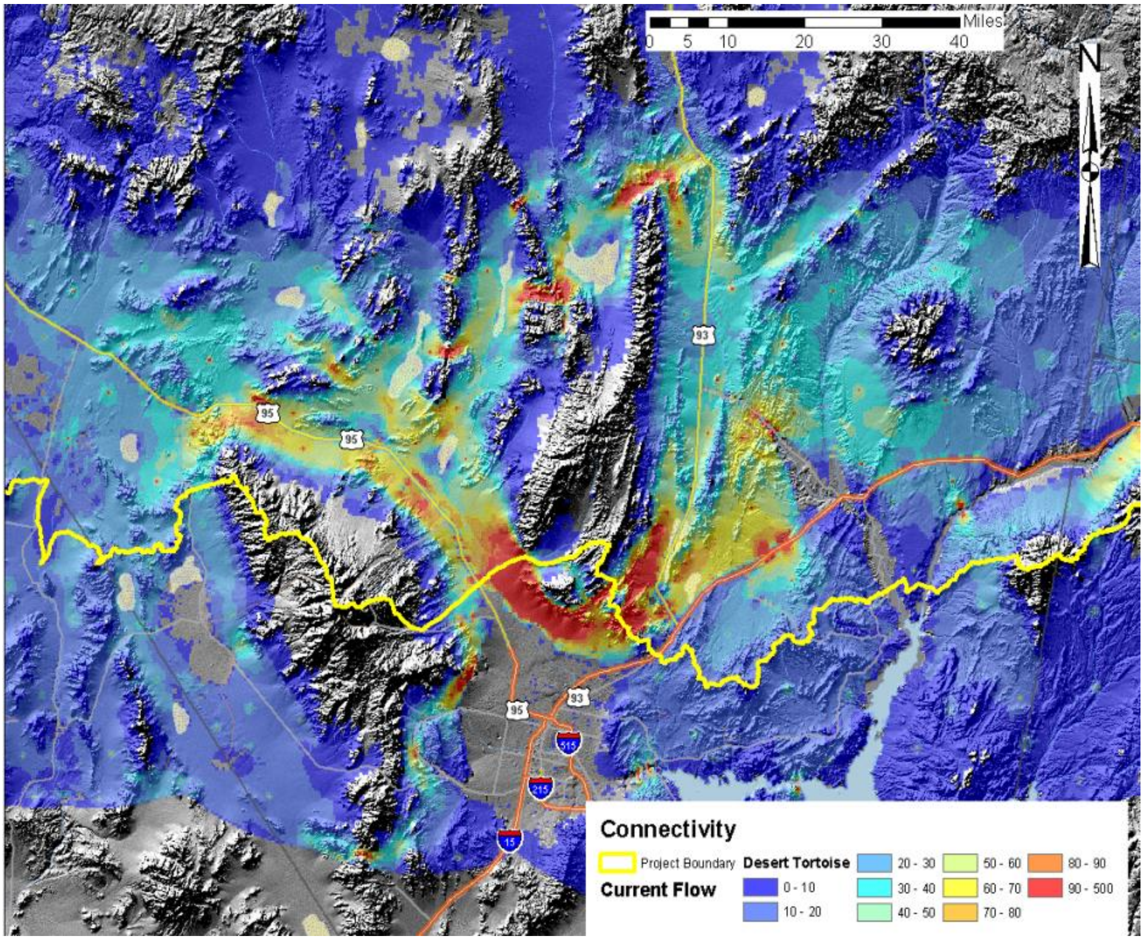

Figure 6. Example model of potential connectivity intensity for Mojave desert tortoise. Warmer shades indicate areas of potentially greater flow and constriction utilizing Circuitscape software. Such model outputs may be converted with additional modeling to more discreet connectivity corridors.

Assess current ecological integrity

Ecological integrity is a function of the response of a CE to the effects of CAs. Conceptual models are developed in the REAs to document current knowledge about the effects of primary CAs on each CE. The CBR and MBR REAs used a form of NatureServe's method to calculate ecological integrity. This method translates conceptual models into a "scorecard" of indicators for reporting on the ecological integrity of a given CE within a given location. Indicators are chosen to gauge a limited set of key ecological attributes, or ecological drivers, for each CE. Key ecological attributes may include natural characteristics, such as native species composition (with indicators typically measured in the field). Indicators may also be addressed through remote sensing and spatial modeling; these often focus directly on known ecological stressors. Given the rapid and regional character of an REA, stressor-based indicators are utilized. Three primary indicators of ecological integrity include a spatial model of landscape condition, a predictive map of invasive annual grass abundance, and measures of wildfire regime departure. Figure 7 shows the relative scores for invasive annual grasses, as related to the distribution of pygmy rabbit (*Brachylagus idahoensis*). While ecological integrity indicators from the REA aimed to provide a landscape-scale snapshot of current conditions, BLM planners and field staff indicated that this level of information would assist considerably in their resource allocations for ecological restoration and monitoring. Other REAs took a variety of approaches to assessing ecological integrity, most of which are simpler roll ups of weighted CAs applied equally to all CEs. The detailed approach used in the CBR and MBR REAs could also benefit from further work to customize the indicator inputs and responses for individual CEs combined with local data in a step down assessment.

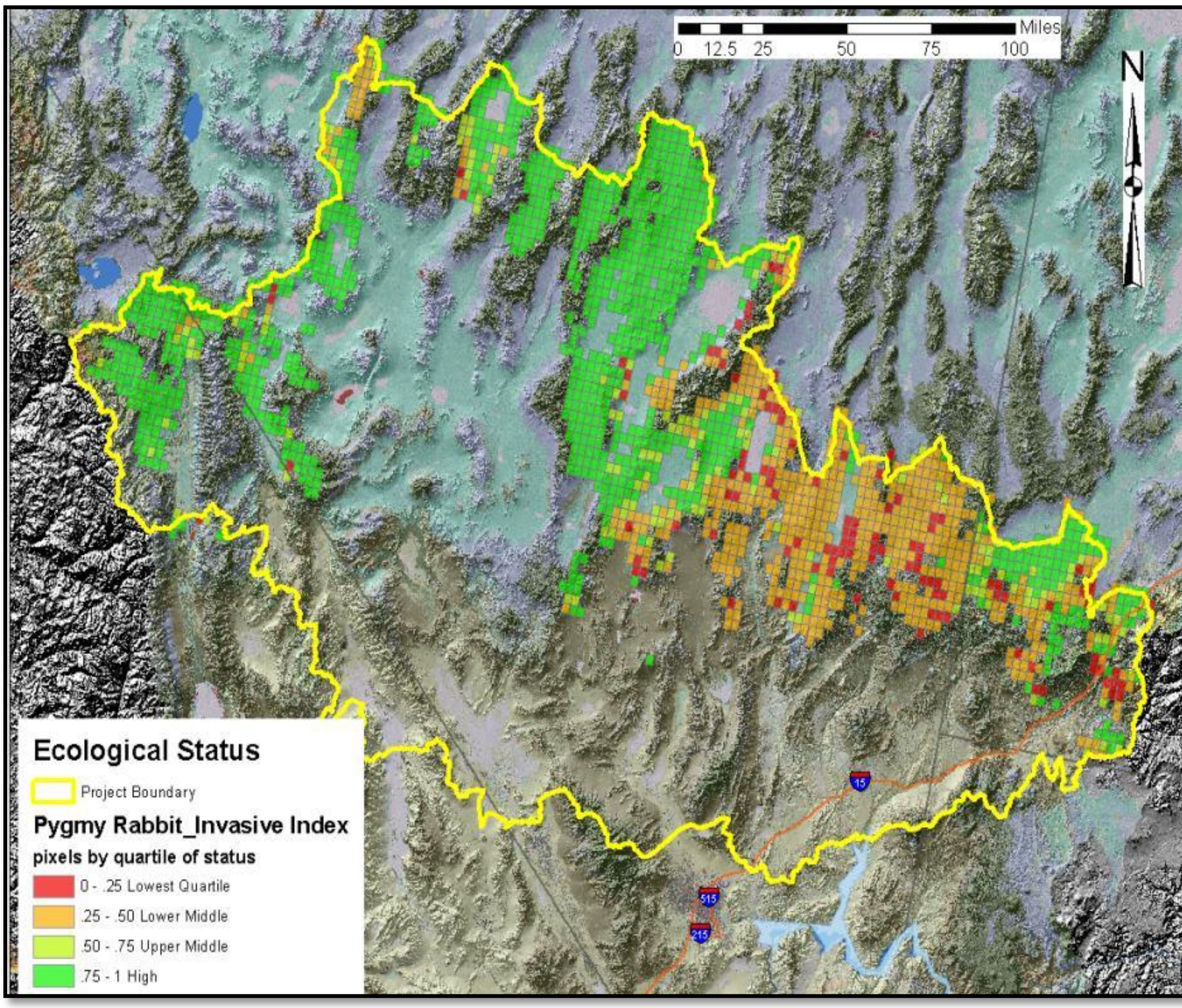

Figure 7. Ecological status map by 4 km reporting units in the NVSO Yale Pilot Project. Red and orange pixels indicate very low to moderately low status based on invasive species potential.

Having addressed current CE distribution, connectivity, and integrity; the next analysis types introduce climate change trends and effects.

Map Climate Trends

Model historical, recent, and current climate trends

Analyses of how climate may be changing over time support many different assessments and provide the information to develop adaptation strategies. In order to assess the degree of forecasted change in climates, a baseline of 20th century measures of temperature and precipitation values are needed for comparison to future forecasts. For example, one can calculate the mean, variance, and standard deviations for monthly maximum temperature for each month of the year to understand previous climate variation. These measures often come from the PRISM data set [1], but it is important to select a timeframe from this data set that includes sufficient natural variation and pre-dates current expectations of the onset of climate change to assess potential climate change trends (e.g., 1905-to-1980 was used to calculate average values in the CBR and MBR REAs). The same measurements from subsequent time periods (each preferably in the range of 10-30 year periods) allow you to detect significant changes, either in observed data from recent years, or from forecast values for upcoming decades. For example, in order to detect near term trends, the CBR and MBR REAs used a recent (1980-1995) timeframe and also current data (1995-2010) to plot the values and visualize (and quantify) significant changes and trends (Figure 8) indicating that climate has been changing over this timeframe. In the figure, individual circles represent individual climate observations charted for their value of temperature vs. precipitation. January minimum temperatures and total precipitation for the entire CBR ecoregion are depicted with each circle reflecting measures from each 4km^2 grid cell for each year. This combination of values is referred to as the “climate envelope” of this variable (January temperatures and precipitation) for the CBR landscape. Values (circles) for each time period are color coded to visualize the shift in observed climate measures. When placed on a graph, the nature of climate change is revealed; with this example indicating a several degree increase in temperature over time periods while precipitation appears to hold to relatively constant.

[1] http://www.prism.oregonstate.edu/index.phtml

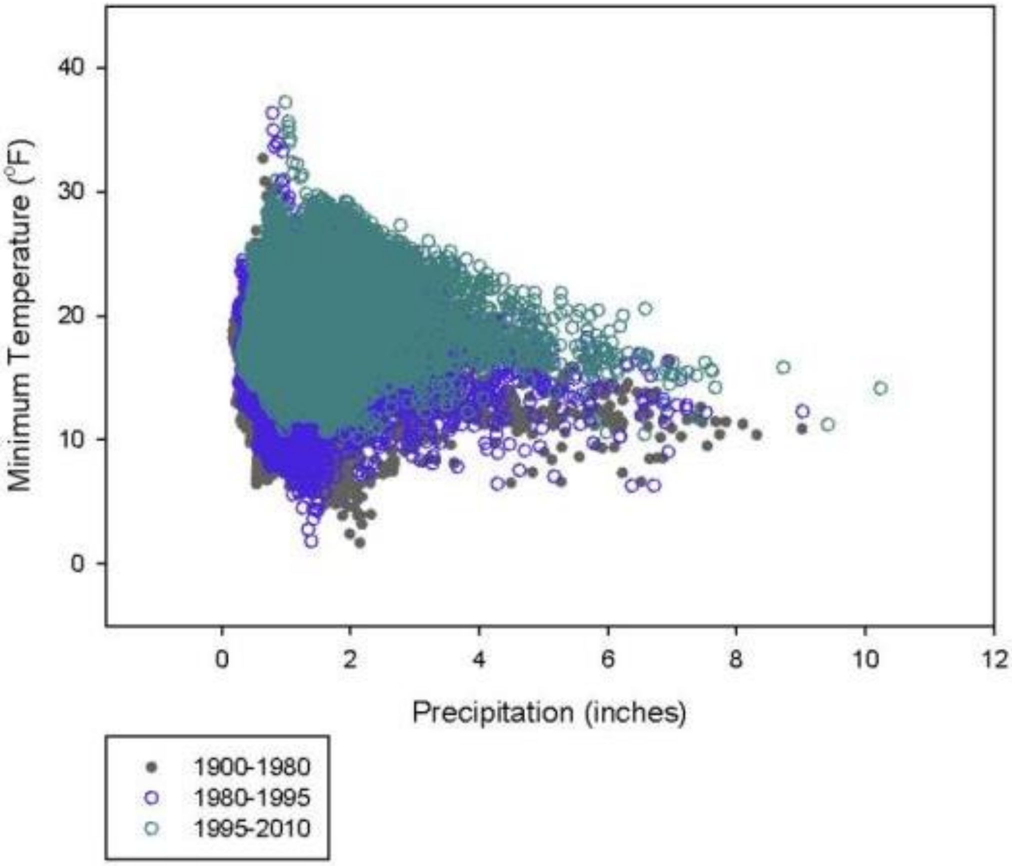

Figure 8. Comparison of historical, recent, and current climate observations in the CBR REA for January minimum temperature and monthly precipitation. Note the progressive trend for warmer minimum temperatures but no obvious change in precipitation.

Model future climate change and trends

This analysis type requires a model of forecasted climate change at one or preferably more future timeframes that can then be compared to historical data and recent trends. The REAs typically utilize a timeframe of 50 years from present for future climate models but may (as in CBR and MBR) incorporate a near term (2020-2030) intermediate timeframe. Climate modeling is not something anticipated to be conducted by BLM directly or for step down projects; it is highly complex and specialized and best conducted over large regions. It is, however, important to understand which climate data is used to address uncertainty in the assumptions in climate change models. It is also advisable to use results from multiple global climate models (IPCC 2007) and to downscale the coarse global models to a finer resolution (e.g., 2-15 km^2 pixels) to incorporate local climate variations.

The simplest and most direct climate change forecast is expressed as a map of temperature or precipitation change by pixel for a given area (Figure 9). The user of such data need to be cognizant of the uncertainties in climate forecasts but these data provide explicit values of change that can be used to model the effects of climate change and feed into climate envelope modeling described later.

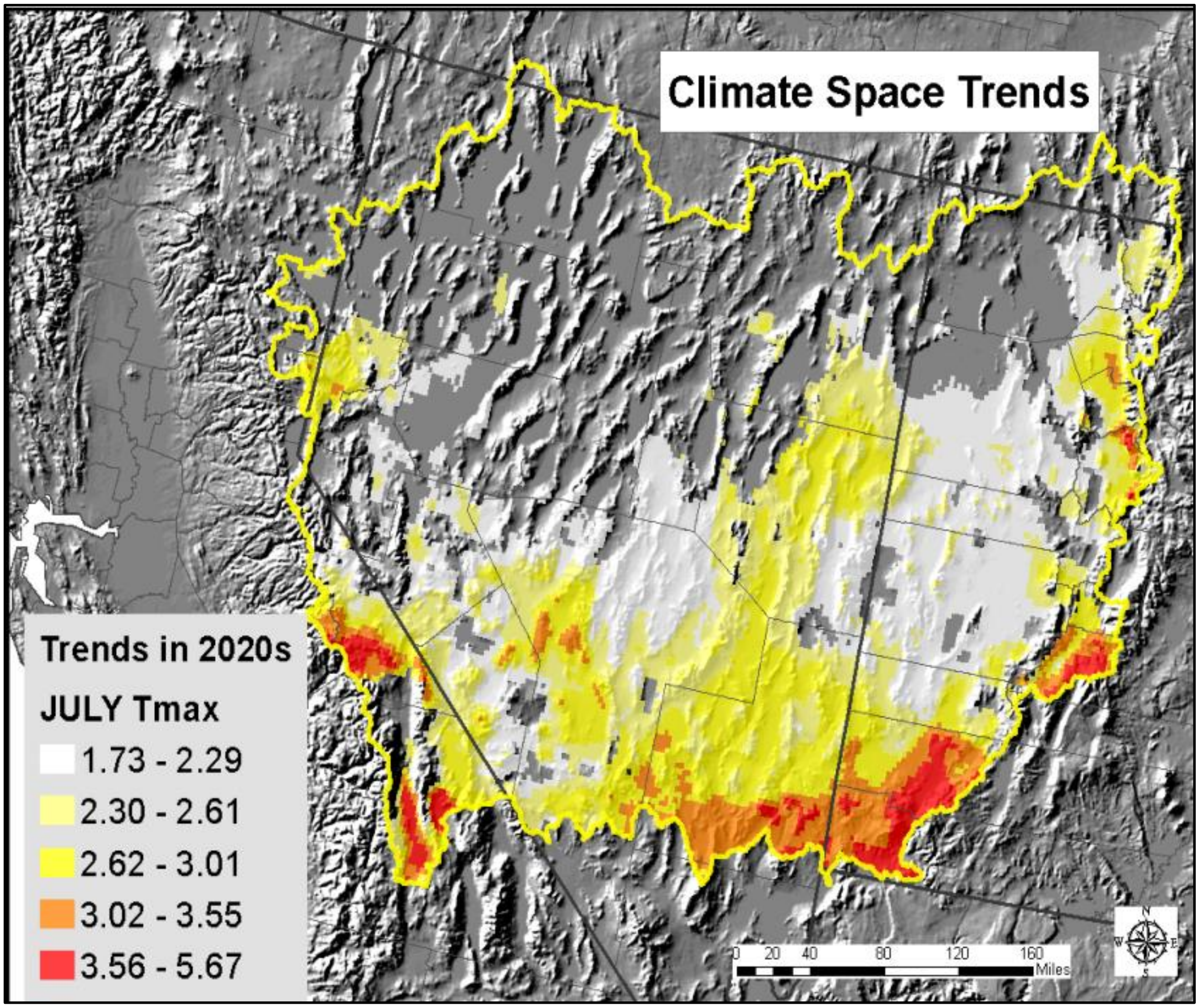

Figure 9. Forecasted change in maximum temperature for July for the period 2020-2029. Values are degrees Fahrenheit increase over baseline 20th century July maximum.

A very large number of the above maps can be generated; therefore it is useful to have an approach to summarize and visualize overall climate change. One approach uses an analysis referred to as "climate space trends." This analysis calculates the mean, variance, and standard deviations (stdv) for monthly climate variables between historical and forecast future climate. For example, if one compares a climate forecast for the decade of 2050-2059 against the historical baseline, and forecasted values are outside of 2 stdv from the baseline, this indicates that the forecasted climate values extend beyond >95% of all 20th century measurements (i.e., statistically a very significant change). This forecasted deviation - on a per-pixel basis - provides a map of forecasted climate stress. Figure 10 summarizes output where as many as six monthly maximum temperature values are forecasted to depart by > 2 stdv from the 20th century mean values. This map indicates that significant change is forecasted throughout this area by 2060, but some areas (darker red) are forecasted to change more than others.

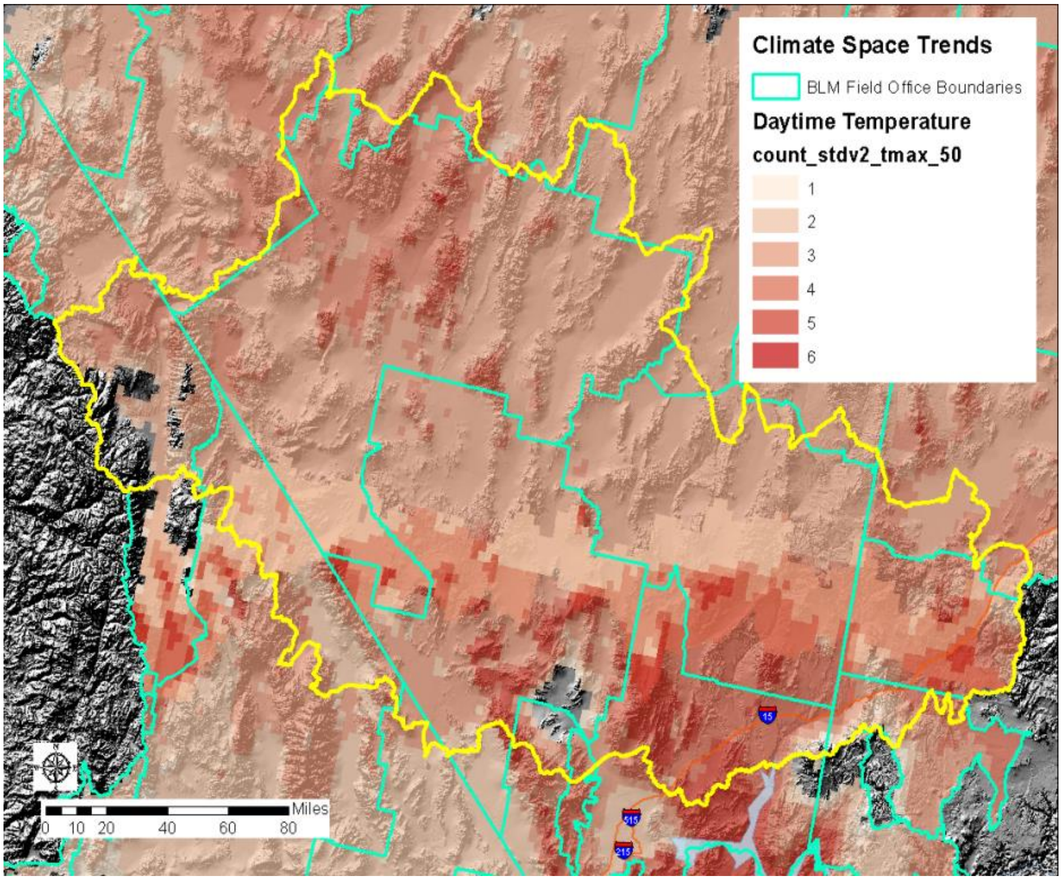

Figure 10. A summary map of climate space trends from the NVSO Yale Pilot Project. Darker shades indicate areas where most months of climate variables (temperature and or precipitation) are forecasted to deviate from historical climate.

Once identified, users can investigate exactly which variables explain the significant deviation(s). For example, a given 4 km^2 pixel might indicate that 4 different variables are forecasted to deviate by 2 stdv by 2060. One could then clarify that those variables are in fact maximum temperature for the months of May, June, July, and August.

These forecasts can be linked to other models, such as hydrologic models designed for local basins, or fire regime models, where temperature and precipitation trends can influence forecasts of fire return intervals. Climate change assessment was one of the more standardized aspects of the REAs although they used different baseline time ranges and different downscaled climate data. The basic REA outputs should be suitable, however, to understand climate trends in the project area.

Model Future Climate Envelopes of CEs

Understanding where CE's may lose distribution, maintain their distribution (refugia), or expand their range is one of the most desired information products for climate change assessment and adaptation planning. Forecasting where individual CEs may occur under future climates is a complex activity with high uncertainty because of the number of variables and interactions that limit a CE's distribution, and how each of those variables may independently be affected by climate change. Climate envelope modeling is one method used to understand the potential generalized effects of climate on CE distributions. Climate is the primary determinant of a CE's overall potential range with other variables (e.g., soil, vegetation, competition) further limiting and defining the CE's actual distribution. Climate envelopes are derived by using the current observed climate variables (primarily temperature and precipitation ranges) of a CE (preferably from its total range) to map the CE's potential range. When a CE's characteristic variables that define the current climate envelope are plotted on future climate scenarios (e.g., for the year 2060), it depicts where the CE's known climate tolerances or envelope may exist in the future. Where the current envelope or distribution and the future envelope overlap, that area defines where the current distribution of the CE may remain into the future, or the "refugia." Where the future climate envelope does not overlap the current envelope or distribution it identifies areas that potentially will no longer support the CE. Finally, the remaining areas of the future climate envelope indicate where the CE may expand its range in the future; because today's current climate regime is forecasted to occur in new areas (Figure 11).

Multiple versions of future distributions may also be created based on different climate models and these can be compared for model agreement to obtain a higher confidence result. Climate envelope modeling was not common among all REAs; the CBR and MBR REAs created a fairly robust set of such models, including comparisons among climate models. It is possible to refine climate envelope models using additional variables such as soils, slopes, and other features not generally affected by climate over short timeframes. The resulting maps can then approximate a future distribution by constraining the future envelope based on these variables. The value of such an approach depends on the drivers of a CE's distribution, for example one would not use current vegetation because that would be expected to change considerably with climate change.

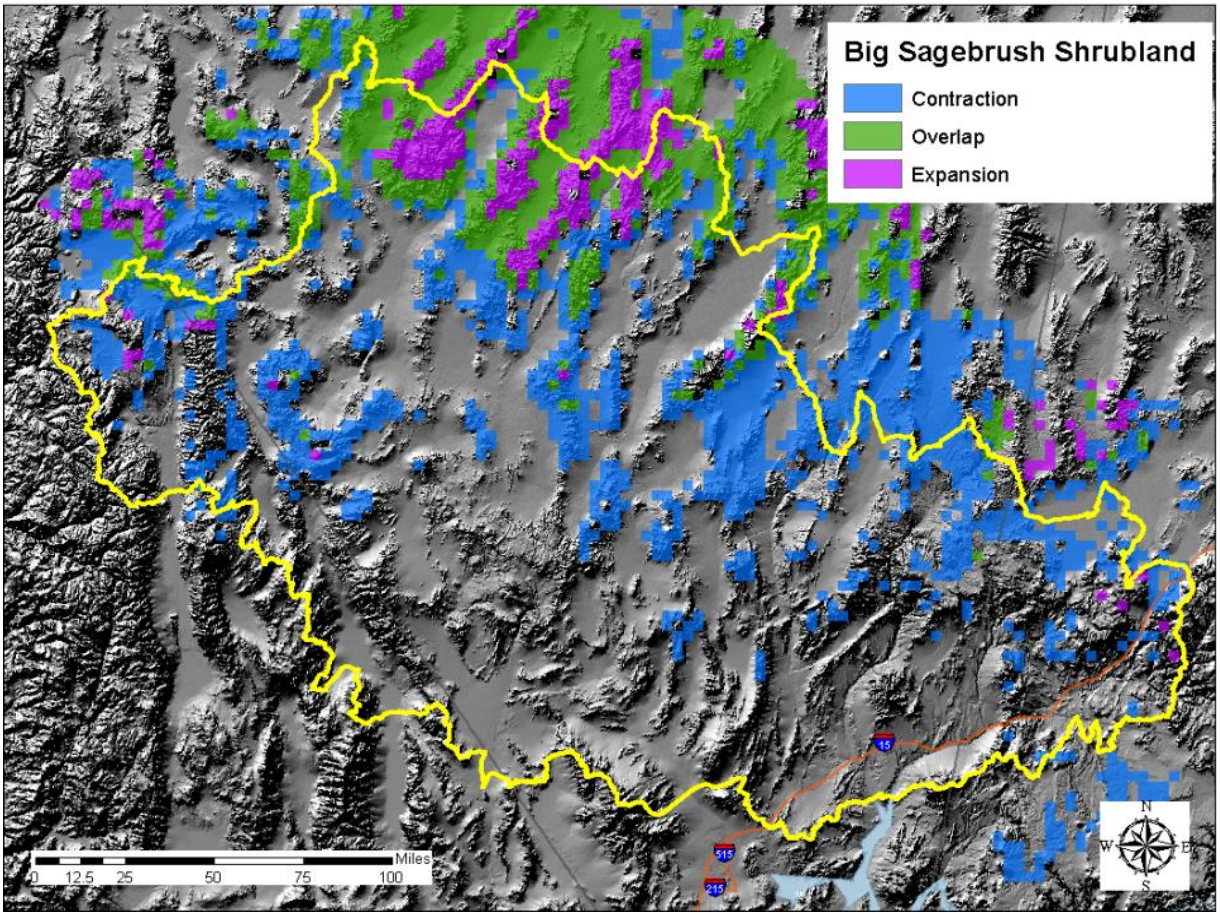

Figure 11. Climate envelope for big sagebrush shrubland from the NVSO Yale Pilot project. Contraction (blue) are areas of current adapted climate expected to no longer occur, Overlap (green) areas will remain within adapted ranges, and Expansion (magenta) areas will experience adapted climate in the future and could allow expansion of the CE into new areas.

Model Potential Climate Refugia

This Analysis Type includes two sub analyses providing different or combined analyses to understand where potential climate refugia may exist and for which CEs.

Combine CE climate envelope models

Individual CE climate envelope modeling was described above; this section builds on that work to define potential climate refugia for multiple CEs. Potential refugia from climate change may be identified in a number of ways. Combining the forecasted climate envelopes of individual CEs, especially when developed for major, characteristic CEs in the area (such as vegetation type), can provide one means to do so. Figure 12 provides an example from the NVSO Yale Pilot project that indicates the overlap of climate envelope forecasts from all major upland vegetation types within the study area. This technique provides a count for the number of types per pixel (from a 4km^2 grid) where individual models show an overlap between current and forecasted 2060 envelopes. For 15 vegetation types mapped, as many as eight types coincide at selected northern and high-elevation locations throughout the study area. These higher numbers indicate general zones where, from a combination of models, forecasts indicate lesser degrees of ecologically-relevant climate change. This contrasts with western basins where no upland vegetation models indicate overlap between forecasted and current climate envelopes. A similar, albeit distinct pattern emerges with the same type of analysis of models for the seven targeted landscape species in the study area. But the selection of CEs for this type of analysis should be carefully considered. Major vegetation types integrate much of the biophysical character (i.e., the synecology) of a regional landscape, while species necessarily reflect autecology (i.e., individualistic responses) that may skew results for this type of application.

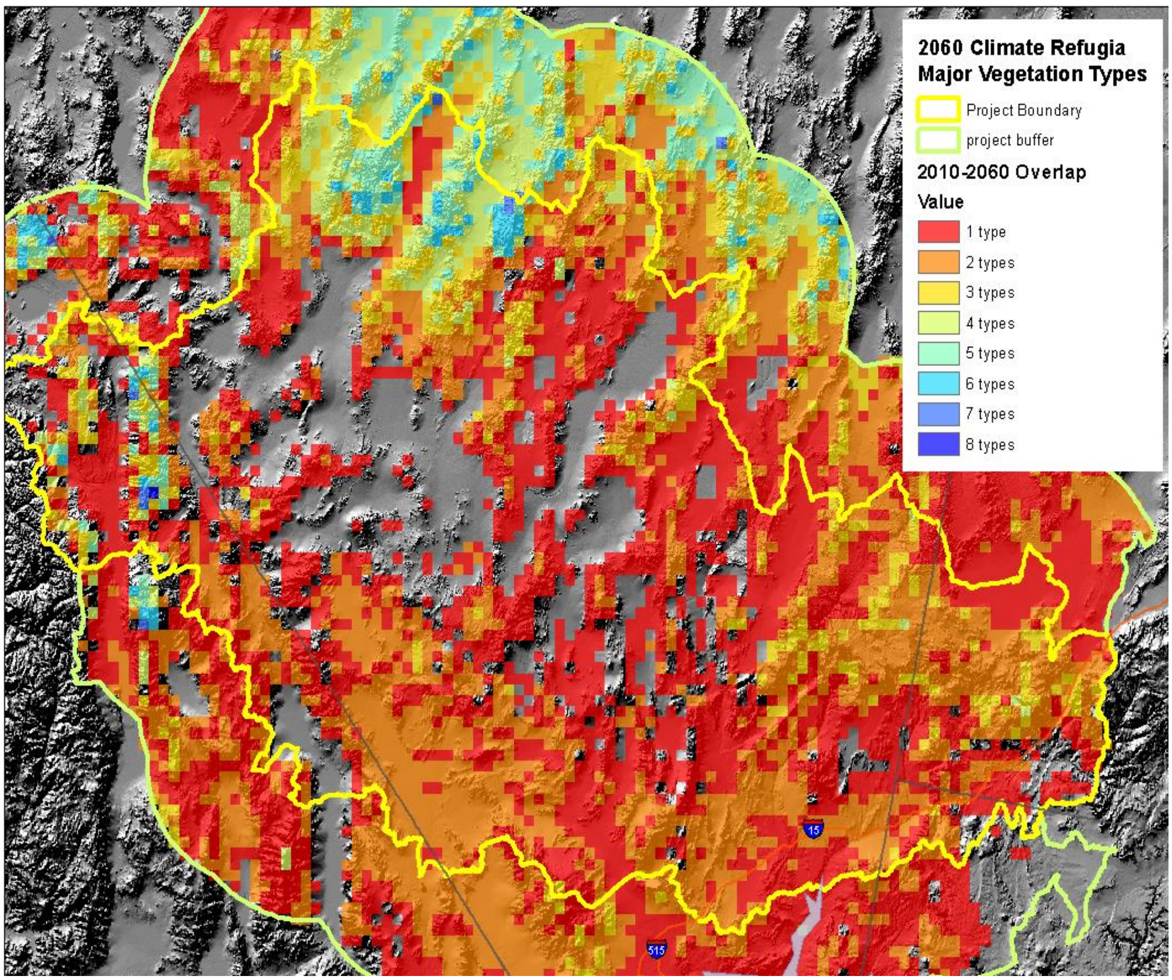

Figure 12. Combined climate envelope refugia maps for major vegetation types in the NVSO Yale Pilot project. Cooler colors have greater overlap of refugia. Note gray areas that are not modeled to retain any current vegetation types.

As noted earlier, modeling CE climate envelopes was not common among the initial REAs and may exist only for the CBR and MBR ecoregions. Creating combinations of these maps (where they exist) is a simple overlay process in a GIS.

Model Linkages between Current and Potential Future CE Habitats

As evident in CE climate envelope models (e.g., Figure 11), the range of species and habitats is expected to shift (and shifts have already been documented throughout the world). Maintaining connectivity between current occupied habitat, refugia, and potential expansion areas will be critical to allow CEs to adapt to climate changes. Within the 50 year assessment horizon of the REAs, most of these shifts are contiguous meaning that the contraction, overlap (refugia), and expansion areas are adjacent so rather than requiring specific adaptation corridors, the key adaptation strategy will be to maintain adequate habitat condition and contiguity to allow movement. Assessment of current barriers and proposed projects that may pose barriers between areas will be important. This particular analysis was not conducted for the NVSO Yale Pilot project but we illustrate the concept in (Figure 13). For CEs that have very low mobility and climate envelope models showing dramatic range contraction, additional analyses may be required to understand how such CEs' adaptation may be facilitated. This type of connectivity analyses was not conducted for REAs and would require custom analyses.

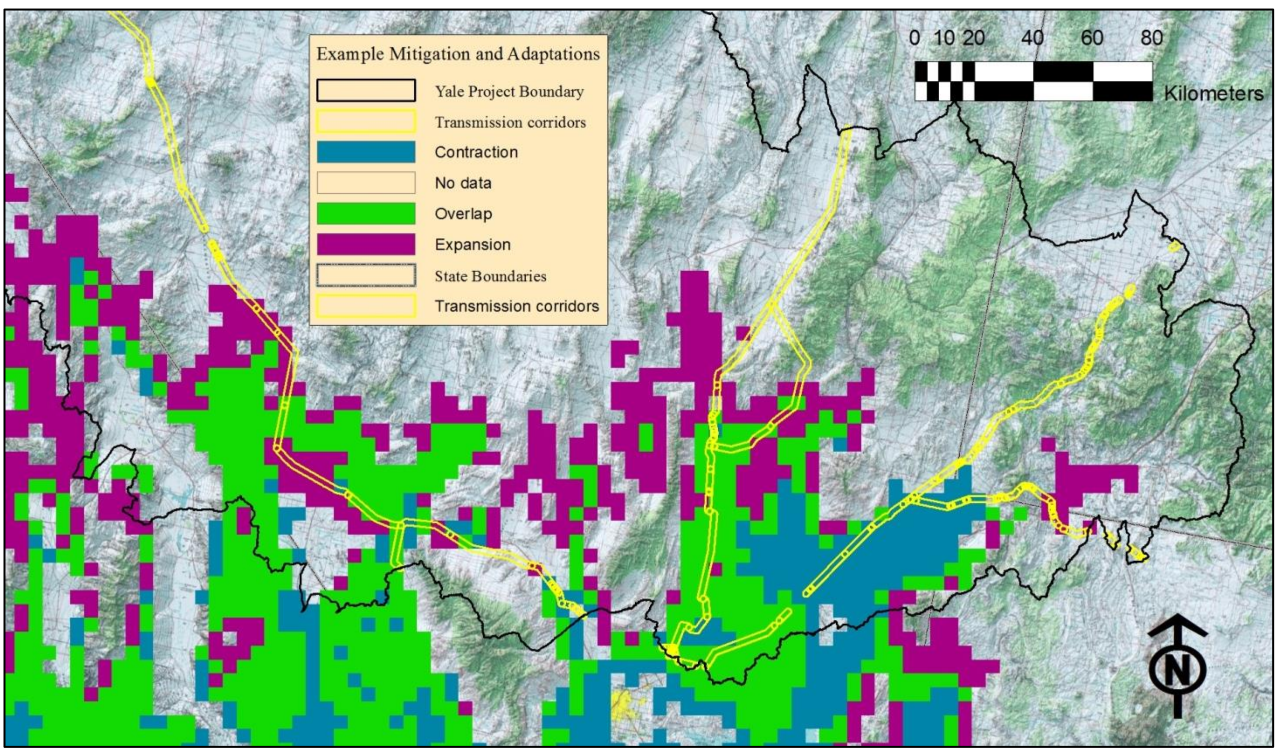

Figure 13. Overlay of transmission corridors (yellow) on desert tortoise climate envelope map. Note several sections of corridors appear capable of separating northern refugia and expansion areas from southerly areas of range.

Model Enduring Features

Species will respond individualistically to climate change making it very difficult to predict with certainty where they will occur in the future, thus complicating adaptation planning. This analysis type emphasizes protection of representative examples of all enduring features, such as the ecological land classification units referenced below under modeling landscape heterogeneity. This approach presumes that by conserving those geophysical components of habitats that will endure under climate change, one can likely represent habitat niches into the future, regardless of the species occupying them. This approach takes its inspiration from calls to "conserve the ecological stage." That is, regardless of "the actors" (e.g., species) the geophysical landscape provides "the stage" for dynamics among species over geologic and evolutionary timeframes. Also referred to as "land facets," the use of geophysical variables predates climate change applications as a way of representing habitat niches or conservation features with more readily available data.

The analysis utilizes combinations of geophysical variables (see earlier section on landscape heterogeneity) to define enduring feature CEs. For example, these could be mapped ecological land units, Forest Service Ecological Land Types, mapped expressions of BLM's Ecological Site Descriptions, or LANDFIRE Biophysical Settings. These CEs can then be assessed like other CEs for proportional representation (see earlier section on gap analysis) and potential impacts from CAs (see later section on assessing impacts) to help inform land use and management planning.

Further investigation of these enduring feature CEs can lead to articulating hypotheses about the types of novel ecosystems likely to develop under probable climate change. These could inform interim management actions (such as weed abatement and seeding) to make them more amenable to transition to desired novel ecosystem states.

This is the most speculative of approaches included within the Yale Framework. This assessment was not conducted for the REAs or the NVSO Yale Pilot project, therefore, methods are not provided in the technical guide. Instead, see that section on the Yale Framework website (http://databasin.org/yale/using/matrix/6) for more information and a pilot project report and data.

Model landscape heterogeneity

This analysis subtype combines aspects of enduring features and refugia described above to identify areas that may be able to retain species longer because they offer more micro-climatic niches within a given area. This could allow species to more readily find suitable conditions to persist longer in or near their current distribution. Geophysical features such as slope, aspect, the physical/chemical properties of soils, etc., determine the type and location of biotic assemblages (e.g., vegetation pattern), so one approach to providing a buffer against uncertain climate change is to ensure that local-scale ecological heterogeneity is considered in the design of conservation and management actions. For example, if one were prioritizing lands to secure high-quality habitat for a given wildlife species, you could favor inclusion of areas with a high degree of geophysical heterogeneity. As climate changes, these areas with diverse topography and soils are more likely to retain micro-climatic refugia, and a broader diversity of "niche space" for targeted wildlife than less heterogeneous areas.

Two different approaches to mapping landscape heterogeneity are described for this analysis type. The first approach models *geophysical heterogeneity* following methods commonly applied for ecological land classification (see Barnes et al. 1982) or what has more recently been referred to as "ecological land units" (ELUs) (Anderson and Ferree 2010). The aim of ecological land classification has traditionally been to map areas of high potential for biomass productivity (e.g., for forest or rangeland production) using landform, soil, and drainage characteristics of the landscape. These methods were developed in Europe, especially where centuries of land use had removed natural vegetation and so may have relevance where climate change can be expected to have significant changes on current vegetation.

Typical data sets that are combined to model geophysical heterogeneity include the digital elevation model (DEM, to model landform, slope, aspect, relative landscape position, and solar insolation), soils, and surficial geology. This approach requires careful selection variables and decisions about how they will be combined into a common data set. For example, while field ecologists will be able to use their expert judgment to select variables such as elevation, slope, and aspect, as being relevant to this task, selection of soil or surface geology variables can be quite challenging. Compounding this selection is the interaction of mapped information of varying spatial resolution and reliability.

Using a combination overlay approach, one can create a map of ELUs for gauging geophysical heterogeneity. Figure 14 depicts a map of zones of high heterogeneity, where the ELU map was intersected with a $4km^2$ grid, and the numbers of ELUs per grid cell were totaled. Those $4km^2$ grid cells highlighted in red contain above average diversity of ELUs. Using the same grid as the downscaled climate data allows then a ready comparison of areas of expected moderate to high climate change and areas of high landscape heterogeneity to identify locations of management interest.

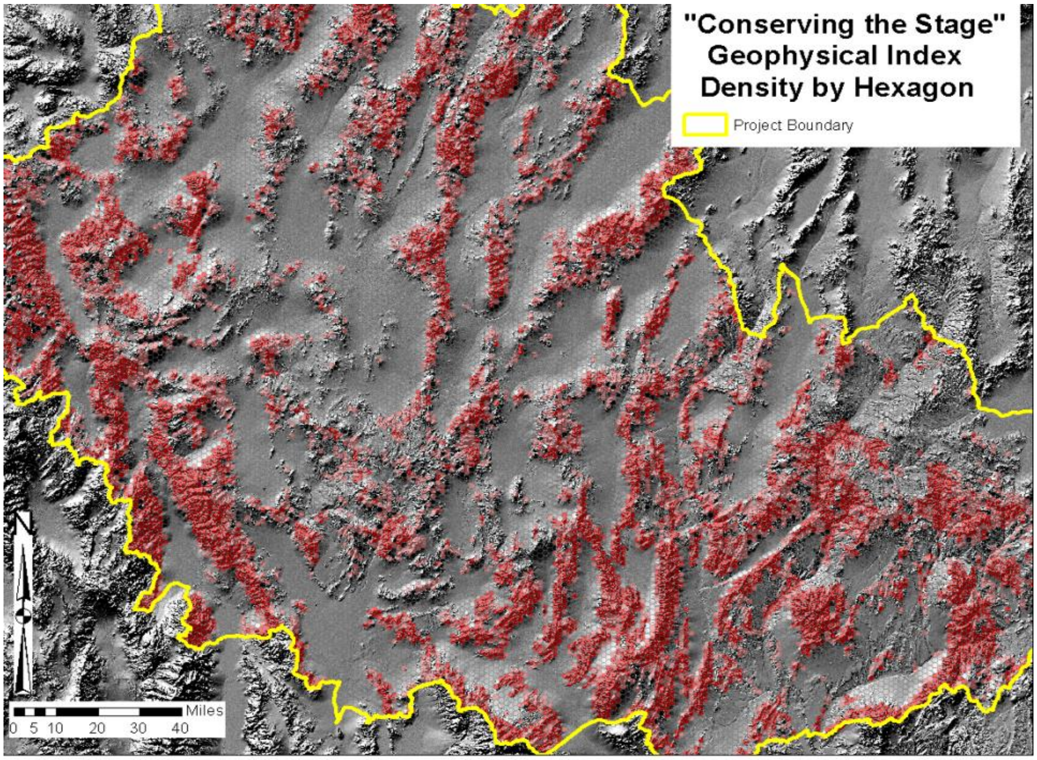

Figure 14. Geophysical heterogeneity index values. Darker shades indicate selected 4 km^2 hexagons reflect above average densities of types.

The second approach models *biophysical heterogeneity* utilizing the existing national map of Biophysical Settings developed and maintained through the inter-agency LANDFIRE effort. This national map depicts the predictive distribution of some 500 terrestrial ecological system types in a 30m^2 grid; given assumptions of natural disturbance processes. While this map does not incorporate the same level of local detail derived from the landform model, it uses natural vegetation pattern to integrate ecologically-relevant pattern that one would be unlikely to achieve through mapping ELUs because ecological systems integrate landscape variables in ways that are meaningful to vegetation pattern.

By applying the same combination approaches as for the ELU map, Figure 15 includes the result using the BpS depiction of biophysical heterogeneity. It produces a very similar, albeit distinct result than the ELU map. In this basin and range landscape, topographically diverse mountain ranges will tend to include above average heterogeneity, whether it is identified through geophysical features or biophysical features; therefore it may also be useful to stratify the landscape into say basin areas vs. montane areas and treat them separately.

This general type of application for using landscape heterogeneity as a climate-change buffering aid in biodiversity reserve network design has been used extensively over the past decade (see e.g., Nachlinger et al. 2001, Neely et al. 2001[2]). By combining distributions of species or vegetation interest with these maps of heterogeneity one can more confidently secure some degree of climate change buffer.

To utilize the index to identify potential refugia for individual CEs, the index is overlain with the CE current distributions or ideally in combination with the climate envelope maps for each CE (Figure 16). There is some reasonable potential that, as individual species respond to climate stress across this study area, areas with climate envelope overlap *and* high local heterogeneity will likely provide the most secure climate change refuge. Those heterogeneous areas located within forecasted climate envelope contraction zones might have some additional time to adapt, relative to less heterogeneous areas. This work was not conducted for REAs and, if desired, will require custom analyses for the project area.

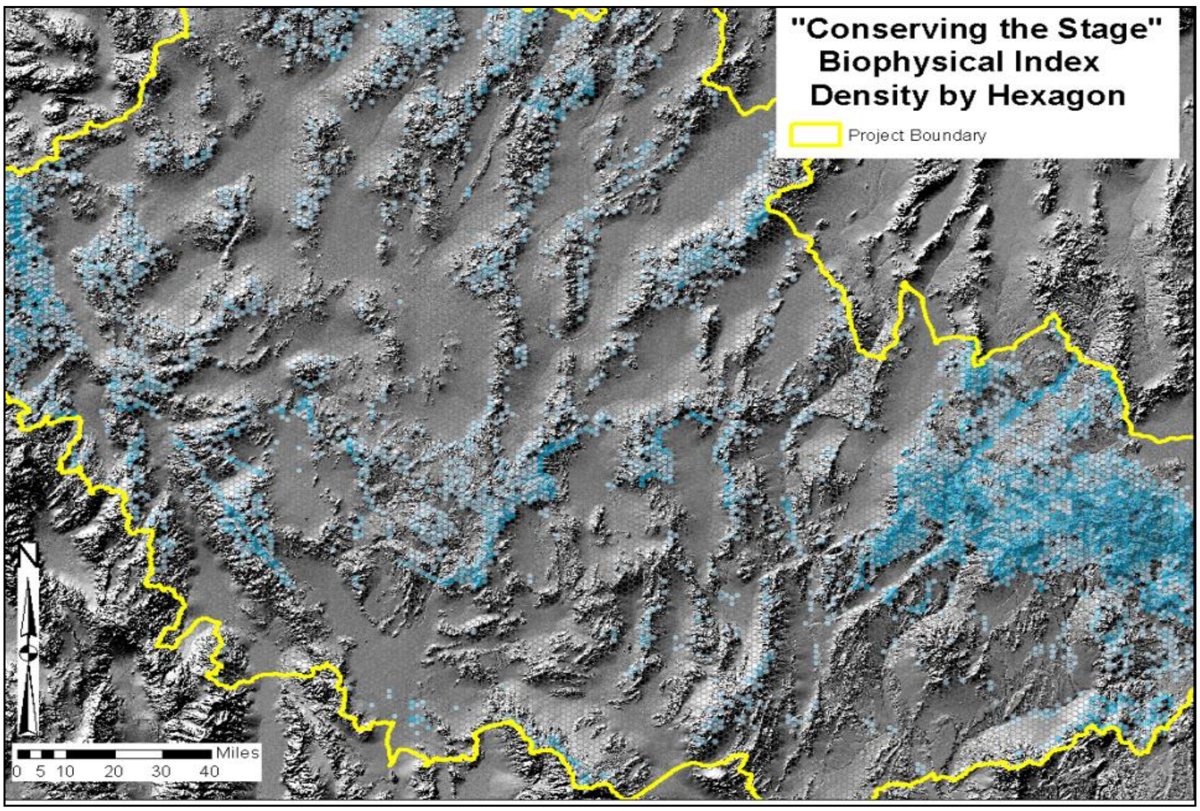

Figure 15. Biophysical heterogeneity index values. Darker shades indicate selected 4 km^2 hexagons reflect above average densities of types.

[2] Methods for TNC portfolio design, including these methods http://conserveonline.org/workspaces/cbdgateway/era/standards/std_11

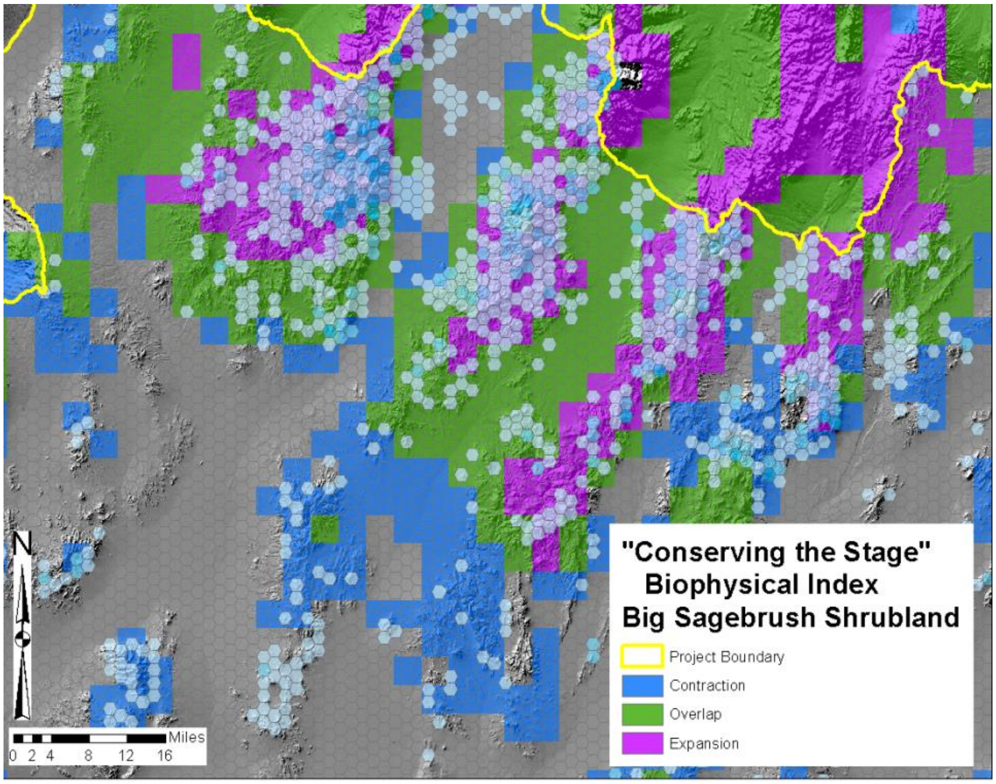

Figure 16. Overlay of biophysical heterogeneity index (w/ above average scores) on climate envelope forecasts for Big sagebrush shrubland. Of particular interest are areas of blue and green overlap with selected hexagons indicating additional refugia potential.

Assess Impacts and Develop Strategies and Alternatives

Assess current and future impacts on CEs

These assessments quantify the potential impacts to CEs from current and proposed/forecasted CAs. The results are used to understand the location and nature of impacts to inform mitigation actions (avoid, minimize, restore, offset). While the Yale Framework presents these as separate assessments for current vs. future CE distribution, it is useful to consolidate these assessments such that both sets of CE distributions and impacts can be quantified together. This integrated assessment also reveals, for example, whether a CA might fragment the connection between current and potential future CE distribution. The results of the assessment then help, in particular, to avoid areas that will have high levels of conflict for current and future CE concentration areas and will inform areas that can be mitigated to provide highest current and future benefits.

The process for this analysis first characterizes scenarios for current and near term (e.g., 2025)(Figure 17). Scenarios may be available from the REAs that typically include current conditions and one scenario for the near term (e.g., 2025) in addition to the long term (2060) climate focused scenario. For step down analysis, the objective is to map complete scenarios with respect to all land use (including conservation), management practices, and all CAs. The REA scenarios may be augmented with more current and or detailed local information on CAs and typically include proposed/planned developments (e.g., urbanization, infrastructure, and energy) as well as current and future forecast invasive species and current fire plus current/planned beneficial management/protection. Additional scenarios may also be desired and Scenario Planning methods can be used to determine useful scenarios for assessment (a detailed guidance document on scenario-based planning is in development with expected publication summer 2013 at this location: http://www.wcsnorthamerica.org/ConservationChallenges/ClimateChange.aspx).

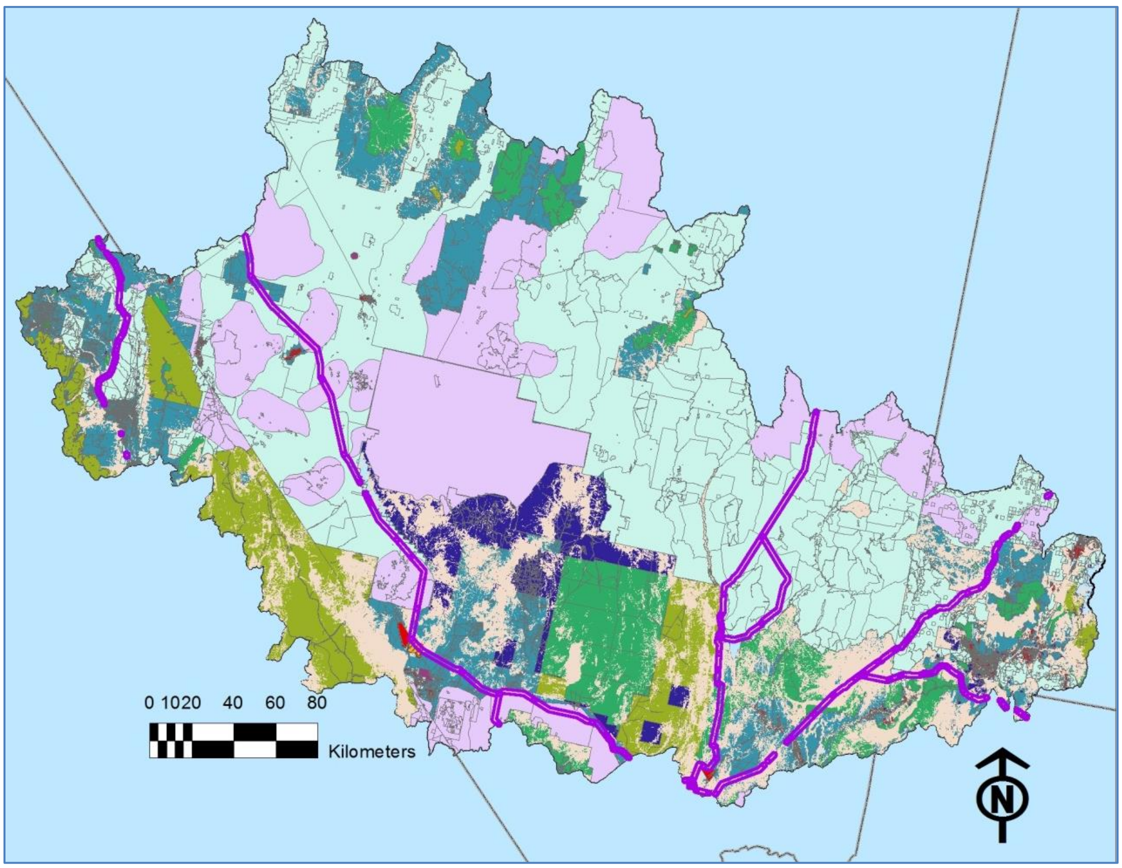

Figure 17. Example scenario map for 2025 from the NVSO Yale Pilot project. Purple lines are proposed transmission corridors.

Next, expert information on ecological response of CEs to CAs and management/protection practices are integrated in the assessment model to quantify areas of each conservation element as compatible or in conflict with a scenario (Figure 18 and Figure 19). This approach is not a replacement for ecological integrity assessment (see earlier section), which provides a more specific and nuanced view of how CAs affect biodiversity but rather provides a rapid assessment of the sum of CA effects on the potential distribution of CEs. Instead of, or in addition to, a simple categorical (negative, neutral, beneficial) response of CEs to CAs, a landscape condition model can be utilized to understand how CE condition may change including offsite effects of CAs. The REAs used a variety of approaches to assess impacts on CEs by CAs but generally did not include individual CE responses; that information would need to be developed by a project using biological expertise.

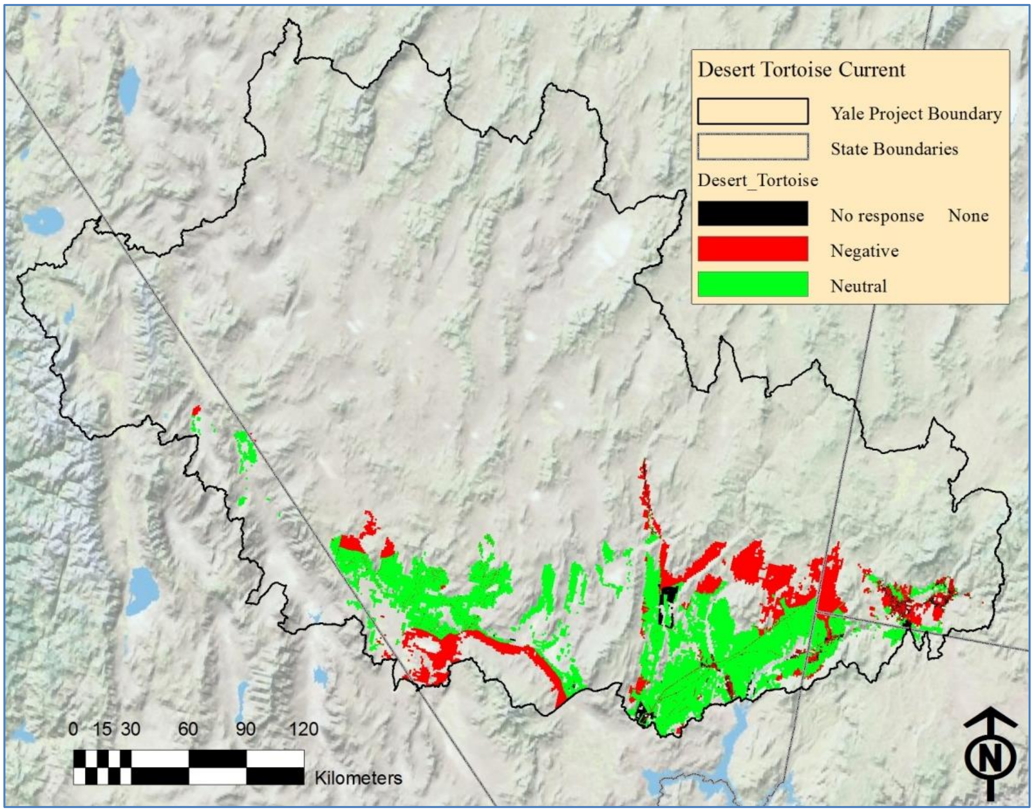

Figure 18. Example CE impact map for desert tortoise from the NVSO Yale Pilot project. Red areas have conflict with CAs in the 2025 scenario.

Goal Performance by Element

Elements (44 elements)

Name	Distribution Area (acres)	Occs	Avg Condition	Goal	Goal Met	Compatible Area (acres)	Occs	Avg Condition	Percent of goal
North American Warm Desert Wash	369,930	15296	0.79	100 percent of area	N	237,543	10839	0.81	64.21%
Sand Dunes Sand Soils Species Assemblage	611,966	176	0.66	100 percent of area	N	258,346	51	0.67	42.22%
Gypsum Soils Species Assemblage	128,281	88	0.64	100 percent of area	N	52,612	34	0.62	41.01%
Yellow billed Cuckoo	62,165	20	0.72	100 percent of area	N	35,472	14	0.77	57.06%
Maricopa Tiger Beetle	208,433	6	0.62	100 percent of area	N	105,779	5	0.68	50.75%
Merriam's Kangaroo Rat	562,079	8	0.6	100 percent of area	N	282,188	8	0.65	50.2%
Mule Deer - Winter Range	3,120,876	26	0.78	100 percent of area	N	2,020,562	23	0.8	64.74%
Inter Mountain Basins Wash	488,324	4836	0.81	100 percent of area	N	340,520	3821	0.82	69.73%
Burrowing Owl	30,178	10	0.75	100 percent of area	N	26,136	10	0.76	86.61%
Inter Mountain Basins Active and Stabilized Dune	1,428	1	0.75	100 percent of area	N	0	0	0	0%
Blaine's Pincushion	41	2	0.67	100 percent of area	N	0	0	0	0%
Inter Mountain Basins Aspen Mixed Conifer Forest and Woodland	0	0	0	100 percent of area	N	0	0	0	NaN%
Schlesser's Pincushion	338	18	0.68	100 percent of area	N	0	0	0	0%
Inter Mountain Basins Semi Desert Grassland	0	0	0	100 percent of area	N	0	0	0	NaN%
Greater Sage Grouse	1,477,266	17	0.83	100 percent of area	N	1,182,571	12	0.85	80.05%
Inter Mountain Basins Big Sagebrush Steppe	0	0	0	100 percent of area	N	0	0	0	NaN%
Mule Deer - Year Round Range	2,152,681	15	0.85	100 percent of area	N	1,715,606	12	0.86	79.7%
North American Warm Desert Badland	30,401	3855	0.66	100 percent of area	N	20,821	3146	0.71	68.49%
Mule Deer - Summer Range	2,231,930	16	0.76	100 percent of area	N	1,659,617	14	0.77	74.36%
Inter Mountain Basin Subalpine Limber Bristlecone	1,888	1	0.78	100 percent of area	●	1,843	1	0.78	97.62%

Figure 19. Example cumulative impacts assessment report from NVSO Yale Pilot project. Far right column is percent of the CE current distribution forecast to be retained under the 2025 scenario.

Combining maps of individual CE assessment results provides an index of conflict (Figure 20) that can identify conflict hotspots to help prioritize areas for mitigation action that can benefit multiple CEs.

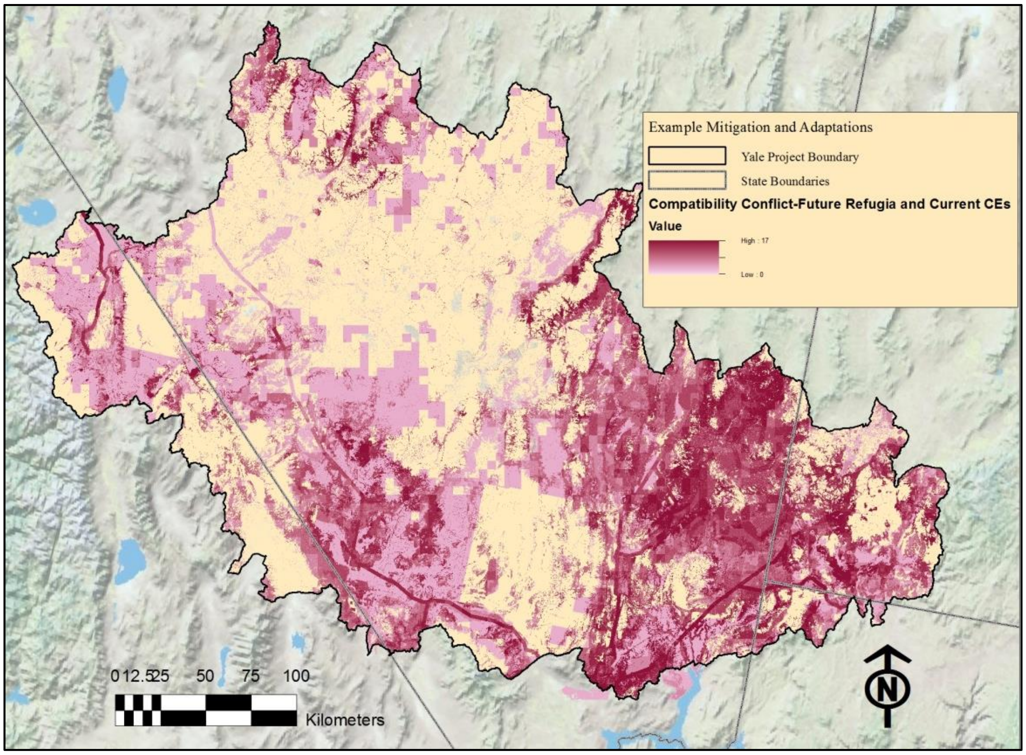

Figure 20. Combined impact map for current CE distributions and future climate envelope maps assessed against the 2025 scenario for the NVSO Yale Pilot project. Red shades are areas of CE conflict, the darker the shade the more CEs in conflict in those locations.

Create mitigation and adaptation strategies and alternatives

The key purpose of the impact analyses from the previous section is to inform mitigation actions for non-climate impacts and adaptation actions for climate changes. This is best accomplished by linking current biodiversity retention and restoration with potential future biodiversity distribution to identify "robust" strategies (Glick et al. 2011) and avoid maladaptive responses. Essentially this means prioritizing areas to receive mitigation and or restoration actions that will provide current and likely future benefits. This can include applying avoidance mitigation to proposed development that will reduce current impacts by relocating development to other areas but taking care not to conflict with expected future areas of concentration for CE refugia (Figure 21). These steps are inherent but not explicit in the Yale Mapping Framework; but were demonstrated in the NVSO Yale Pilot Project as illustrated in Figure 21. A fairly extensive treatment of development of strategies and plan alternatives is described in the Refuge Vulnerability Assessment and Alternatives guides found here: https://connect.natureserve.org/publications/rvaa with additional treatment in several other guides (Cakex.org has a library with many guidance documents).

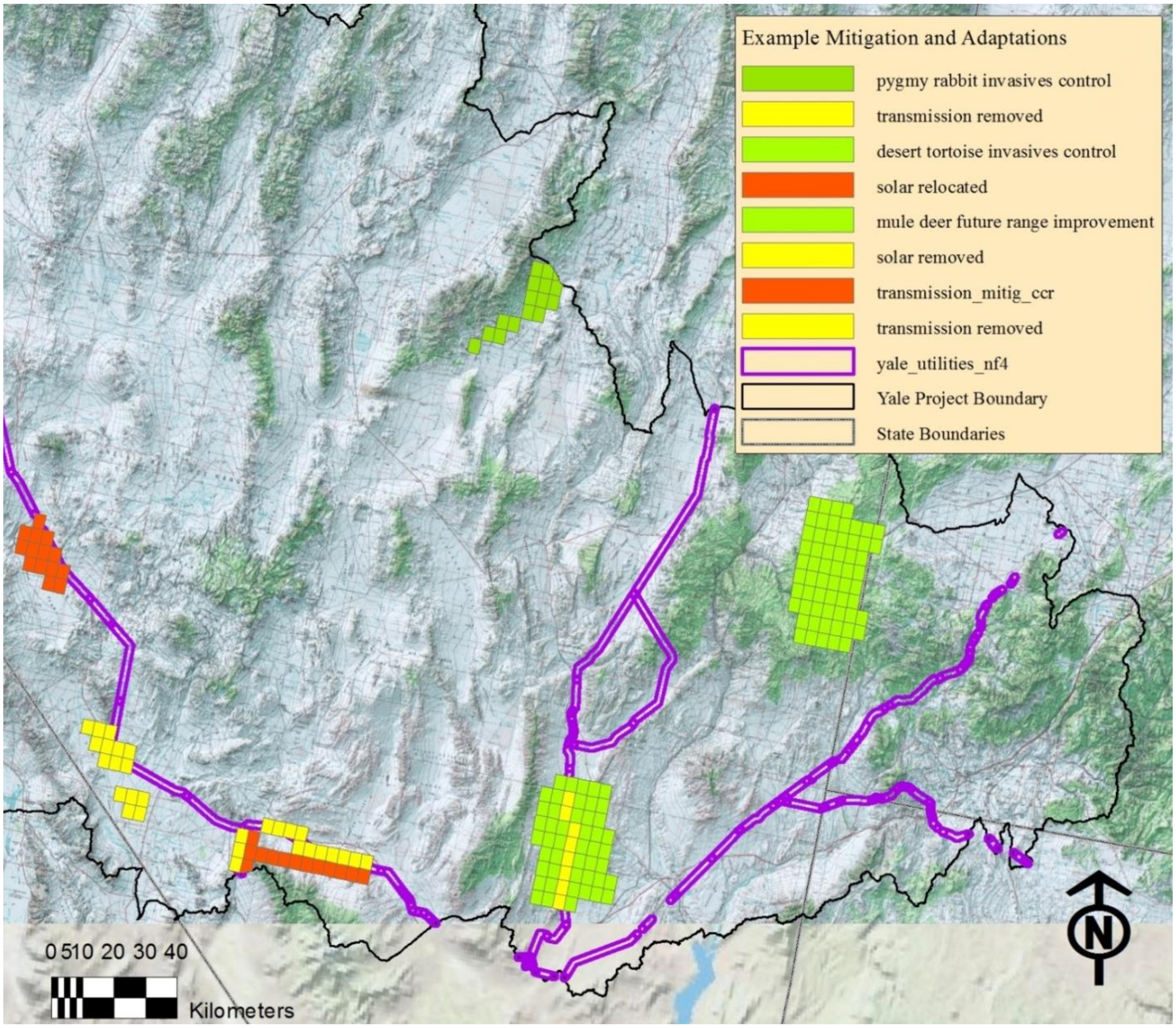

Figure 21. Example adaptation and mitigation features (for illustration purposes only).
Green areas indicate places to conduct restoration actions of burns and current and future invasive species spread. Yellow areas use avoidance to remove proposed solar plants and transmission lines from environmentally sensitive areas. Orange areas indicate where solar and transmission could be relocated to reduce impacts on current biodiversity patterns and future refugia concentrations. Mitigations conducted using NatureServe Vista Site Explorer tool.

Practical Considerations in Applying the Yale Framework

What is Needed to Conduct the Analyses

Timeframe

A considerable portion of any spatial assessment and planning activity is usually devoted to identifying and gathering existing data. Therefore, it is recommended to utilize the outputs of the area's REA as that project will have consolidated and created a large amount of the inputs needed for this work. Conducting a project without the benefit of an REA would require a very large effort, especially for the climate change components which are best done over large regions. Once REA products are in hand, additional local data can be used to fill any gaps not covered by the REA (e.g., additional CEs) or to provide more precise or recent data. The NVSO Yale Pilot project was conducted over six months concurrent with the REA but was able to benefit from most of the REA draft products. However, many of the additional analyses were done as demonstrations and lacked the investment of time, review, expert input, etc., of an actual implementation which could be expected to add time. Depending then on the scope of the project, status of the REA, and capacity and skills of the team, the project may require 4 - 12 months.

Cost

Cost is highly variable depending on the amount of work in addition to the REA products and whether the work is done in house totally, partially, or is contracted out. The NVSO Yale Pilot project budget was approximately $100,000 in 2012 for outside GIS and scientific work which did not include any BLM costs.

The Project Team

This section describes the set of roles and skills needed to conduct a project similar to the NVSO Yale Pilot project. A single project team member may have more than one of the required skill sets; for example, a staff member managing the project may also write and edit the final report. A BLM unit may have internal capacity to cover these skills or it may need to look to partners or an external contractor. A very rough approximation of the amount of time that might be needed from the team member filling the specified role during the course of the project is included. The time estimates are provided as time units/month for ongoing involvement, assuming a 6-month project timeline, or a total amount of time units for one-time or periodic involvement.

- **Project Management** (6 days/month): Oversees all aspects of the project, assuring participants understand and perform their roles, secure bids and manage consultant contracts, coordinate all communication, and manage the budget and schedule. While Project Management needs will vary during different phases of the project, this estimate is an average over the entire project with most time likely required at project startup and near its conclusion.

- **GIS/Data Manager/Lead** (4 days/month): Oversees all spatial data management and GIS work. May be same position as the individual conducting geospatial analyses (see below). While this time is averaged by month, most of the work will be concentrated in the middle of the project.

- **Lead Biologist** (2 days/month): Coordinates all biological input to the analyses and participates in scoping, review, strategies, and alternatives development. May review geospatial results and develop interpretations and conclusions. While this time is averaged by month, most of the work will be concentrated in the earlier (expert knowledge input) and later (GIS output review) phases of the project.

- **GIS Analyst** (6-8 days/month): Acquires and processes data, conducts all geospatial analyses, develops interpretive products, presents results, writes methods and documentation for report, and works with staff to convert strategies into spatial alternatives. This work will be concentrated in the center phase of the project. For projects pursuing advanced modeling, a broader team of analysts/modelers will be required and time requirements may be substantially higher.

- **Report Editor** (10 days): Develops report outline, compiles contributions from participants, and edits report.

Suggestions for an Effective and Efficient Project

Conduct a multi-partner landscape project

REAs are wall-to-wall assessments and subsequent ecoregional direction is intended to identify strategies that are most efficiently taken by or with partners in the ecoregion. The step down work described in this guide likewise should be conducted wall-to-wall and will be of broad benefit to other federal, state, and local planning agencies in the project area. Other agencies are adopting cooperative information and assessment development approaches such as USFWS' Refuge Vulnerability Assessment and Alternatives (https://connect.natureserve.org/publications/rvaa) and Federal Highway's Integrated Ecological Framework approach. In fiscal terms, the cost of the technical work can be distributed over multiple partners, thus realizing substantial cost savings for each participant. There are other benefits to this approach as well, such as:

- Gaining access to a broader set of knowledge, data, and expertise which may streamline many tasks and allow them to be conducted through in-kind contributions

- Developing a much deeper shared understanding of each partner's objectives and how those objectives and resources are inter-related as a solid foundation for on-going collaborative planning and implementation in a landscape.

Maintain team interaction

This work is technical and requires review of both inputs and outputs of the assessment analyses by affected staff and partners. Over the course of the project it is easy for participants to become disconnected while technical work is being completed. The use of strategic, periodic workshops is recommended to keep the technical team and staff connected, to keep everyone informed about the work, and to keep the technical team on track to provide useful outputs. Ideally multiple in-person workshops will be conducted to review results and give ample time to digest and discuss the results and identify strategies. In case funding limitations and availability of staff to make time for multiple meetings precludes such an approach, it is recommended that creative use of the internet be used. For example, the technical team can conduct webinars on the products then post the products on a secure portal where participants can access them according to their own schedules and post comments; this approach was used in the Colorado Plateau and Sonoran Desert REAs. A follow up webinar after a brief time could then allow group discussion of their thoughts on need for management change and strategies.

Obtaining Further Assistance

Climate change is an evolving science that results in evolving policy and guidance. Climate change is being addressed through an integrated interdisciplinary and multi-team approach. Further assistance with this project or the use of the NatureServe Vista software (used in the NVSO Yale Pilot Project) in future climate change work can be directed to the following:

BLM Climate Change Policy and Guidance within Nevada – Branch Chief Renewable Resources and Planning, Joe Tague, 775-861-65565, jtague@blm.gov

Nevada BLM Climate Change Strategy – Soil, Air, Water Program Lead, Sarah Peterson, 775-861-6516, speterson@blm.gov

BLM NV Landscape Approach – Healthy Lands Program Lead, John Wilson, 775-861-6613, jwilson@blm.gov

BLM CBR and MBR REA and Vista Information – Wildlife and T&E Program Lead, Sandra Brewer, 775-861-6626, sbrewer@blm.gov

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Glossary

For convenience the complete glossary from the Central and Mojave Basin and Range REAs is provided though it contains terms not used in this guide.

Adaptive management	A management framework founded on the concept of monitoring the outcomes or effects of management actions (and their interactions with other events) and adjusting on-going management decisions and actions based on those outcomes.
Areas of Critical Environmental Concern (ACEC)	Areas within the public lands where special management attention is required to protect and prevent irreparable damage to important historical, cultural, or scenic values, fish and wildlife resources or other natural systems or processes, or to protect life and safety from natural hazards (FLPMA 1976).
Aridisols	The central concept of Aridisols is that of soils that are too dry for mesophytic plants to grow. They have either: (1) an aridic moisture regime and an ochric or anthropic epipedon and one or more of the following with an upper boundary within 100 cm of the soil surface: a calcic, cambic, gypsic, natric, petrocalcic petrogypsic, or a salic horizon or a duripan or an argillic horizon, or (2)A salic horizon and saturation with water within 100 cm of the soil surface for one month or more in normal years. An aridic moisture regime is one that in normal years has no water available for plants for more than half the cumulative time that the soil temperature at 50 cm below the surface is >5° C. and has no period as long as 90 consecutive days when there is water available for plants while the soil temperature at 50 cm is continuously >8° C.
Assessment Management Team (AMT)	BLM's team that provides overall direction and guidance to the REA and makes decisions regarding ecoregional goals, resources of concern, conservation elements, change agents, management questions, tools, methodologies, models, and output work products. The team generally consists of State Resources Branch Managers from the ecoregion, a POC, and possibly agency partners.
Attribute	A defined characteristic of a geographic feature or entity.
Biophysical Setting (BpS)	As developed for LANDFIRE aims to depict the potential distribution of the ecosystem, given natural landscape disturbance regimes like wildfire. As used by LANDFIRE, the biophysical setting equates to the historical distribution of the ecosystem type, prior to alterations by European settlement and current human activities.

Change Agent	An environmental phenomenon or human activity that can alter/influence the future status of resource condition. Some change agents (e.g., roads) are the result of direct human actions or influence. Others (e.g., climate change, wildland fire, and invasive species) may involve natural phenomena or be partially or indirectly related to human activities.
Coarse Filter	A focus of ecoregional analysis that is based upon conserving resource elements that occur at coarse scales, such as ecosystems, rather than upon finer scale elements, such as specific species. The concept behind a coarse filter approach is that preserving coarse-scale conservation elements will preserve elements occurring at finer spatial scales.
Community	Interacting assemblage of species that co-occur with some degree of predictability and consistency.
Conservation Element	A renewable resource object of high conservation interest often called a conservation target by others. For purposes of this TO, conservation elements will likely be types or categories of areas and/or resources including ecological communities or larger ecological assemblages.
Core Conservation Elements	The set of conservation elements that has been reduced from the complete set of conservation elements identified during the assessment initiation and pre-assessment phases.
Data Management Plan (DMP)	The assessment's plan for managing data, provided by the BLM, describing data standards, responsibilities, security, and other requirements for data management.
Dataset	A collection of related data.
Deductive models	Using existing mapped information, and then recombine them according to a set of rules determined by the modeler; typically working within ArcGIS, ModelBuilder™ was used to describe interactions among spatial datasets.
Development	A type of change (change agent) resulting from urbanization, industrialization, transportation, mineral extraction, water development, or other non-agricultural/silvicultural human activities that occupy or fragment the landscape or that develops renewable or non-renewable resources.
Didymo	*Didymosphenia geminate*, a species of diatom considered to be a nuisance species
Distribution (as in *species distribution*)	In this REA the spatial methods employed was mapping of actual **distribution** as best possible, whether current known occupied habitat or predicted habitat. (see *Range Mapping*)

Downscale	The process of transferring information from a coarser resolution to a finer resolution (e.g., from 15 km pixels to 4 km pixels), commonly conducted when converting global climate model outputs to regional climate change data. Conversely, "upscaling" is the process of transferring information from a finer resolution to a coarser resolution.
Ecological Integrity	The ability of an ecological system to support and maintain a community of organisms that have the species composition, diversity, and functional organization comparable to those of natural habitats within the ecoregion.
Ecological Status	The condition of a criterion (biological or socio-economic resource values or conditions) within a geographic area (e.g., watershed, grid). A rating (e.g., low, medium, or high) or ranking (numeric) is assigned to specific criteria to describe status. The rating or ranking will be relative, either to the historical range of variability for that criterion (e.g., a wildland fire regime criterion) or relative to a time period when the criterion did not exist (e.g., an external partnerships/collaboration criterion). (also see *Status)*
Ecoregion	An ecological region or ecoregion is defined as an area with relative homogeneity in ecosystems. Ecoregions depict areas within which the mosaic of ecosystem components (biotic and abiotic as well as terrestrial and aquatic) differs from those of adjacent regions (Omernik and Bailey 1997).
Ecosystem	The interactions of communities of native fish, wildlife, and plants with the abiotic or physical environment.
Element Occurrence	A term used by Natural Heritage Programs. An element occurrence generally delineates the location and extent of a species population or ecological community stand, and represents the geo-referenced biological feature that is of conservation or management interest. Element occurrences are documented by voucher specimens (where appropriate) or other forms of observations. A single element occurrence may be documented by multiple specimens or observations taken from different parts of the same population, or from the same population over multiple years.
Exposure	Generally realized through RVAA Steps 4 and 5 to characterize scenarios that map the location and type of stressors. In Step 6, resources are intersected with scenarios to map which stressors they are exposed to. Simply being exposed to a stressor does not mean any particular resource itself is stressed.

Extent	The total area under consideration for an ecoregional assessment. For the BLM, this is a CEC Level III ecoregion or combination of several such ecoregions plus the buffer area surrounding the ecoregion. (see *Grain*).
Fine Filter	A focus of ecoregional analyses that is based upon conserving resource elements that occur at fine scale, such as specific species. A fine-filter approach is often used in conjunction with a coarse-filter approach (i.e., a coarse-filter/fine-filter framework) because coarse filters do not always capture some concerns, such as when a T&E species is a conservation element.
Fire Regime	Description of the patterns of fire occurrences, frequency, size, severity, and sometimes vegetation and fire effects as well, in a given area or ecosystem. A fire regime is a generalization based on fire histories at individual sites. Fire regimes can often be described as cycles because some parts of the histories usually get repeated, and the repetitions can be counted and measured, such as fire return interval (NWCG 2006).
Fragmentation	The process of dividing habitats into smaller and smaller units until their utility as habitat is lost (BLM 1997).
Geographic Information System (GIS)	A computer system designed to collect, manage, manipulate, analyze, and display spatially referenced data and associated attributes.
Grain	Grain is the spatial unit of analysis for ecoregional assessment and is the smallest area analyzed and used for regional planning purposes. The many data and model outputs incorporated into an ecoregional analysis are usually upscaled or downscaled to grain scale. The grain for ecoregional analysis may be a regular size and shape (e.g., square, hexagon) but also may be defined by a particular level of hydrologic unit or similar geographic feature.
Grid Cell	When used in reference to raster data, a grid cell is equivalent to a pixel (also see *pixel*). When a raster data layer is converted to a vector format, the pixels may instead be referred to as grid cells.
Habitat	A place where an animal or plant normally lives for a substantial part of its life, often characterized by dominant plant forms and/or physical characteristics (BLM 1990).
Heritage	See *Natural Heritage Program.*
Heritage Program	See *Natural Heritage Program.*

Hydrologic Unit	An identified area of surface drainage within the U.S. system for cataloging drainage areas, which was developed in the mid-1970s under the sponsorship of the Water Resources Council and includes drainage-basin boundaries, codes, and names. The drainage areas are delineated to nest in a multilevel, hierarchical arrangement. The hydrologic unit hierarchical system has four levels and is the theoretical basis for further subdivisions that form the *watershed boundary dataset* 5th and 6th levels. (USGS 2009).
Indicator	Components of a system whose characteristics (e.g., presence or absence, quantity, distribution) are used as an index of an attribute (e.g., land health) that are too difficult, inconvenient, or expensive to measure (USDA et al. 2005).
Inductive models	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.
Information Platform	Information Technology infrastructure used to support communication and collaboration of BLM's Ecoregional Assessments. Platform includes GIS hardware and software tools to manage, store, archive, and share data within the BLM and with our partners.
Infrastructure	Buildings, roads, utilities, equipment and other structures or facilities. In an RVAA, infrastructure can be considered both as a feature to preserve as well as a stressor on resources.
Invasive Species	Species that are not part of (if exotic non-natives), or are a minor component of (if native), an original community that have the potential to become a dominant or co-dominant species if their future establishment and growth are not actively controlled by management interventions, or that are classified as exotic or noxious under state or federal law. Species that become dominant for only one to several years (e.g., short-term response to drought or wildfire) are not invasives (Modified from BLM Handbook 1740-2, Integrated Vegetation Handbook).
Key Ecological Attribute	An attribute, feature, or process that defines and characterizes an ecological community or system or entity; in conjunction with other key ecological attributes, the condition or function of this attribute or process is considered critical to the integrity of the ecological community or system in question. In the BLM REAs, various analyses were conducted to calculate scores or indexes indicating the status of key ecological attributes for various Conservation Elements (CEs).

Land Health	Degree to which the integrity of the soil and the ecological processes of ecosystems are sustained (BLM Handbook H-4180-1).
Landscape Species	Biological species that use large, ecologically diverse areas and often have significant impacts on the structure and function of natural ecosystems (Redford et al. 2000).
Landscape Unit	Because an REA considers a variety of phenomena, there will be many phenomena and process (or intrinsic) grain sizes. These will necessarily be scaled to a uniform support unit, which herein is called a *landscape unit*. This landscape unit will be the analysis scale used for reporting and displaying ecoregional analyses.
Land-Use Plan (LUP)	A set of decisions that establishes management direction for land within an administrative area, as prescribed under the planning provisions of FLPMA; an assimilation of land-use-plan-level decisions developed through the planning process outlined in 43 CFR 1600, regardless of the scale at which the decisions were developed. The term includes both resource management plans and management framework plans (BLM 2007).
Maladaptive response	Certain adaptive actions that might be taken to mitigate stressor impacts on one resource may cause stress to another resource. For example, engineering efforts to protect mission-critical infrastructure (e. g., primary access road to a refuge) from sea level rise, may prevent a wetland type from migrating (adapting) to the sea level rise. The impact on the wetland type would be a maladaptive response to the adaptive action taken to protect the access road. Assessing maladaptive response is equivalent to assessing vulnerability in the RVAA but happens once strategies (Step 7) are turned into alternative management scenarios in Step 8 and then reassessed for beneficial and maladaptive outcomes by revisiting Step 6.
Management Questions	Questions from decision-makers that usually identify problems and request how to fix or solve those problems.
Metadata	The description and documentation of the content, quality, condition, and other characteristics of geospatial data.
Model	Any representation, whether verbal, diagrammatic, or mathematical, of an object or phenomenon. Natural resource models typically characterize resource systems in terms of their status and change through time. Models imbed hypotheses about resource structures and functions, and they generate predictions about the effects of management actions. (Adaptive Management: DOI Technical Guide).

Mollisols	The central concept of Mollisols is that of soils that have a dark colored surface horizon and are base rich; they are typically formed in grasslands. Nearly all have a mollic epipedon. Many also have an argillic or natric horizon or a calcic horizon. A few have an albic horizon. Some also have a duripan or a petrocalic horizon.
Native Plant and Animal Populations and Communities	Populations and communities of all species of plants and animals naturally occurring, other than as a result of an introduction, either presently or historically in an ecosystem. (BLM Manual H-4180-1).
Native Species	Species that historically occurred or currently occur in a particular ecosystem and were not introduced (BLM 2007b).
Natural Community	An assemblage of organisms indigenous to an area that is characterized by distinct combinations of species occupying a common ecological zone and interacting with one another (BLM 2007b).
Natural Heritage Program	An agency or organization, usually based within a state or provincial natural resource agency, whose mission is to collect, document, and analyze data on the location and condition of biological and other natural features (such as geologic or aquatic features) of the state or province. These programs typically have particular responsibility for documenting **at-risk species and threatened ecosystems. (See natureserve.org/ for additional information on these programs.)**
Occurrence	See *Element Occurrence*.
Pixel	A pixel is a cell or spatial unit comprising a raster data layer; within a single raster data layer, the pixels are consistently sized; a common pixel size is 30 x 30 meters square. Pixels are usually referenced in relation to spatial data that are in raster format. In this REA, some pixels sizes included 90 x 90 m, 4 x 4 km, and 15 x 15 km (also see *Grid Cell*).
Population	Individuals of the same species that live, interact, and migrate through the same niche and habitat.
Range Mapping (as in *Species Range*)	A spatially coarse depiction; the generalized area of possible occurrence of a species or ecosystem, such as one might find in a wildlife field guide; was not utilized in this REA.
Rapid Ecoregional Assessment (REA)	The methodology used by the BLM to assemble and synthesize that regional-scale resource information, which provides the fundamental knowledge base for devising regional resource goals, priorities, and focal areas, on a relatively short time frame (less than 2 years).

Rapid Ecoregional Assessment Work Plan (REAWP)	The work plan (scope of services) that guides the Phase II Assessment component of a REA. This document fully establishes the design of the Phase II effort, and is essentially the 'blueprint' for that work effort and resulting products.
Regionally-Significant Resource	A native plant, wildlife, or fish resource or other ecosystem resource or service that has more than locally significant qualities, which give it special worth, consequence, meaning, distinctiveness, or cause for concern, especially compared to other similar resources. Generally, regionally-significant resources within a specific ecoregion occur in two or more field offices.
Resource Value	An ecological value, as opposed to a cultural value. Examples of resource values are those species, habitats, communities, features, functions, or services associated with areas with abundant native species and few non-natives, having intact, connected habitats, and that help maintain landscape hydrologic function. Resource values of concern to the BLM can be classified into three categories: native fish, wildlife, or plants of conservation concern; regionally-important terrestrial ecological features, functions, and services; and regionally-important aquatic ecological features, functions, and services.
Scale	Refers to the characteristic time or length of a process, observation, model, or analysis. ***Intrinsic scale*** refers to the scale at which a pattern or process actually operates. Because nature phenomena range over at least nine orders of magnitude, the intrinsic scale has wide variation. This is significant for ecoregional assessment, where multiple resources and their phenomena are being assessed. ***Observation scale***, often referred to as sampling or measurement scale, is the scale at which sampling is undertaken. Note that once data are observed at a particular scale, that scale becomes the limit of analysis, not the phenomenon scale. ***Analysis*** or ***modeling scale*** refers to the resolution and extent in space and time of statistical analyses or simulation modeling. ***Policy scale*** is the scale at which policies are implemented and is influenced by social, political, and economic policies.
Scaling	The transfer of information across spatial scales. ***Upscaling*** is the process of transferring information from a smaller to a larger scale. ***Downscaling*** is the process of transferring information to a smaller scale.
Special Status Species (SSS)	Plant and animal species that are federally listed as threatened or endangered; proposed threatened or endangered; candidate species; state listed as threatened or endangered or listed by a BLM state director as sensitive (BLM 2001b).

Status	The condition of a criterion (biological or socio-economic resource values or conditions) within a geographic area (e.g., watershed, grid). A rating (e.g., low, medium, or high) or ranking (numeric) is assigned to specific criteria to describe status. The rating or ranking will be relative, either to the historical range of variability for that criterion (e.g., a wildland fire regime criterion) or relative to a time period when the criterion did not exist (e.g., an external partnerships/collaboration criterion).
Step-Down	A step-down is any action related to regionally-defined goals and priorities discussed in the REA that are acted upon through actions by specific State and/or Field Offices. These step-down actions can be additional inventory, a finer-grained analysis, or a specific management activity.
Stressor	A factor causing negative impacts to the biological health or ecological integrity of a Conservation Element. Factors causing such impacts may or may not have anthropogenic origins. In the context of the REAs, these factors are generally anthropogenic in origin.
Subwatershed	A subdivision of a *watershed*. A *subwatershed* is the 6th-level, 12-digit unit and smallest of the hydrologic unit hierarchy. Subwatersheds generally range in size from 10,000 to 40,000 acres. (USGS 2009).
Value	See *Resource Value*.
Vulnerability	By coupling the exposure of resources to stressors in Step 6 with the assessment of resource responses to stressors developed in Step 4, the effect of stressors on the resources (i.e., their vulnerability) results can be calculated.
Watershed	A watershed is the 5th-level, 10-digit unit of the hydrologic unit hierarchy. Watersheds range in size from 40,000 to 250,000 acres. Also used as a generic term representing a drainage basin or combination of hydrologic units of any size (USGS 2009).
Watershed Boundary Dataset (WBD)	A National geospatial database of drainage areas consisting of the 1st through 6th hierarchical hydrologic unit levels. The WBD is an ongoing multiagency effort to create hierarchical, and integrated hydrologic units across the Nation (USGS 2009).
Wildland Fire	Any non-structure fire that occurs in the wildland. Three distinct types of wildland fire have been defined and include wildfire, wildland fire use, and prescribed fire (NWCG 2006).

Acronym List

For convenience the complete REA acronym list is provided from the Central and Mojave Basin and Range REAs though it contains acronyms not used in this guide.

AADT	Annual Average Daily Traffic
ACEC	Area of Critical Environmental Concern
AFB	Air Force Base
AGI	Annual Grasses Index
AML	Appropriate Management Level
AMT	Assessment Management Team
AR4	Intergovernmental Panel on Climate Change - Fourth Assessment Report
ArcGIS	Arc Geographic Information System
ARRA	American Recovery and Reinvestment Act
AUC	Area Under the (ROC) Curve
AUM	Animal Unit Month
AWC	Available Water Capacity
AWS	Associate Weather Services
BCM	Basin Characterization Model
BLM	Bureau of Land Management
BpS	Biophysical Settings
CA	Change Agent
CA GAP	California Gap Analysis Project
CA ReGAP	California Regional Gap Analysis Project
CART	Classification and Regression Tree
CBR	Central Basin and Range

CCVI	Climate Change Vulnerability Index
CD	Compact Disc
CE	Conservation Element
CEC	Commission for Environmental Cooperation
CO	Contracting Officer
COR	Contracting Officer's Representative
CVS	Conservation Value Summary
DCMP	Desert Conservation Management Plan
DDTF	Data Delivery Tracking Form
DEM	Digital Elevation Model
DMP	Data Management Plan
DOD	Department of Defense
DOE	Department of Energy
DOI	Department of Interior
DQE	Data Quality Evaluation
DRECP	Desert Renewable Energy Conservation Plan
DRI	Desert Research Institute
DRS	Division of Resource Services
DSS	Decision Support System
DVD	Digital Versatile Disc
EFC	Environmental Flow Components
EIA	Ecological Integrity Assessment
EIS	Environmental Impact Statement
ENSO	El Nino Southern Oscillation

EO	Element Occurrence
EPA	Environmental Protection Agency
EPCA	Energy Policy and Conservation Act
ERA	Ecoregional Assessment
ESA	Endangered Species Act
ESD	Ecological Site Description
ESRI®	Environmental Systems Research Institute, Inc.
ET	Evapotranspiration
EVT	Existing Vegetation Type
FAO	Food and Agriculture Organization
FCC	Federal Communications Commission
FGDC	Federal Geographic Data Committee
FLPMA	Federal Land Policy and Management Act
FO	Field Office
FRCC	Fire Regime Condition Class
FRI	Fire Return Interval
FTP	File Transfer Protocol
G-1, G-3	Globally Imperiled-Globally Vulnerable
GA	Grazing Allotment
GAP	Gap Analysis Project
GBPJW	Great Basin Pinyon-Juniper Woodland
GCM	General Circulation Model
GFDL	Geophysical Fluid Dynamics Laboratory
GFF	government-furnished facilities

GFM	government-furnished material
GFP	government-furnished property
GIS	Geographic Information System
GSG	Greate
HA	Herd Area
HMA	Herd Management Area
HMAs	Herd Management Areas
HRV	Historical Range of Variation
HU	Hydrologic Unit
HUC	Hydrologic Unit Code
IBA	Important Bird Areas
ICLUS	Integrated Climate and Land Use Scenarios
IDIQ	Indefinite Delivery/Indefinite Quantity
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
JPEG	Joint Photographic Experts Group
KEA	Key Ecological Attribute
Kw	K factor (soil erodibility)
LANDFIRE	Landscape Fire and Resource Management Planning Tools Project
LCM	Landscape Condition Model
LF	LANDFIRE
LFRDB	LANDFIRE Reference Database
LRU	Landscape Reporting Unit
LU/LC	Land Use/Land Cover

LUP	Land Use Plan
MaxEnt	Maximum Entropy (modeling software)
MBR	Mojave Basin and Range
MDI	Mojave Desert Initiative
MQ	Management Question
MRDS	USGS Mineral Resource Data System
MRLA	Multiple Resource Land Area
NADP	National Atmospheric Deposition Program
NAMC	National Aquatic Monitoring Center
NAS	USGS Nonindigenous Aquatic Species
NCAR	National Center for Atmospheric Research
NCEP	National Centers for Environmental Prediction
NED	National Elevation Dataset
NEPA	National Environmental Policy Act
NGO	Non-Governmental Organization
NHD	National Hydrography Dataset
NHD Plus	National Hydrography Dataset Plus
NID	National Inventory of Dams
NL	Natural Landscapes
NLCD	National Land Cover Dataset
NOC	BLM National Operations Center
NPMS	National Pipeline Mapping System
NRCS	Natural Resource Conservation Service
NREL	National Renewable Energy Laboratory

NRV	Natural Range of Variability
NTAD	National Transportation Atlas Database
NVDEP	Nevada Department Environmental Protection
NWI	National Wetland Inventory
OHV	Off-Highway Vehicles
ORV	Off-road Vehicle
PADUS	Protected Area Database of the U.S. *(see USPAD)*
PCM	Parallel Climate Model
PEIS	Programmatic Environmental Impact Statement
PET	Potential Evapotranspiration
PJ	Pinyon-Juniper
PL	Place
PLSS	Public Land Survey System
POC	Point-of-Contact
PRISM	Parameter-elevation Regressions on Independent Slopes Model
PWS	Public Water Supply
QA/QC	Quality Assurance/Quality Control
QC	Quality Control
RAS	Rangeland Administration System
REA	Rapid Ecoregional Assessment
REAWP	Rapid Ecoregional Assessment Work Plan
ReGAP	Regional Gap Analysis Project
RegCM	International Centre for Theoretical Physics Regional Climate Model
RETI	Renewable Energy Transmission Initiative

RMP	Resource Management Plan
ROC	Receiver Operating Characteristic
SAGEMAP	Sagebrush and Grassland Ecosystem Map Assessment Project
SAR	Sodium Adsorption Ratio
SClass	Succession Class
SDM	Species Distribution Model
SERGoM	Spatially Explicit Regional Growth Model
SMA	Surface Management Agency
SO	State Office
SOW	Statement of Work
SSURGO	Soil Survey Geographic Database
STATSGO	State Soil Geographic Database
STDV (stdv)	Standard Deviation (also *stdev*)
SUNY	State University of New York
SW ReGAP	Southwest Regional Gap Analysis Project
SWAP	State Wildlife Action Plan
SWEMP	Southwest Exotic Plant Mapping Program
SWPA	Southwest Principal Aquifer study
T&E	Threatened and Endangered
TNC	The Nature Conservancy
TO	Task Order
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USFWS	United States Fish and Wildlife Service

USGS	United States Geological Survey
USGS-CD	USGS 15km dynamically downscaled climate model outputs
USPAD	U.S. Protected Areas Database *(see PADUS)*
VDDT	Vegetation Dynamics Development Tool
WBD	Watershed Boundary Dataset
WGA	Western Governors' Association
WHB	Wild Horse and Burro
WMC	Western Center for Monitoring and Assessment of Freshwater Ecosystems