COLORADO PLATEAU
RAPID ECOREGIONAL ASSESSMENT

(Memorandum I-1-c)

Prepared for:
Department of Interior
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Executive Summary

The objective of this first stage of the Colorado Plateau Rapid Ecoregional Assessment (REA) was to identify the management questions, conservation elements, and change agents which will be used to characterize current conditions and future vulnerability of resources of conservation concern. The Dynamac team has reviewed the Statement of Work (SOW) and evaluated the feasibility and level of effort required to address each management question and conservation element. We have largely accepted all proposed conservation elements and management questions defined in the SOW. We did, however, identify some questions that are beyond the scope of the REA process and suggested revisions. Following guidance provided at the Pre-Work Meeting, through the BLM Point of Contact, and at the first Workshop, we have reworded some questions to provide the greatest opportunity to fully address the intended breadth and scope of this REA. In addition, we suggested and received approval for additional conservation elements, change agents, management questions, and landscape reporting units in an attempt to ensure that the output of this process will be readily incorporated into decision making and management plans at both the Regional and Field Office levels. Some of the management questions provided in the SOW were deleted as a result of Workshop comments and AMT review.

The REA framework was expected to follow a coarse-filter/fine-filter approach to conservation element selection and application. We selected Ecological Systems as *coarse-filters*. To serve the function of *fine-filters* in this REA, we received AMT direction to select a dominant plant species characteristic of each of the six largest geographical Ecological System coarse-filters. In addition, we selected a set of *landscape species* based on an approach adapted from Coppolillo *et al*. (2004). The AMT had identified a list of core species in the SOW which were included among the candidate landscape species conservation elements. Core species which were not selected for inclusion in the suite of landscape species were defined as *desired species* conservation elements. In addition, we identified a suite of conservation elements representing sites and a suite of ecological functions and services of conservation concern as conservation elements. Major change agents were identified by the AMT in the SOW and accepted as important for the Colorado Plateau ecoregion REA, and a basic ecoregion conceptual model was constructed. One part of the REA process, we will assess the current status of each conservation element; identify specific current and near-term vulnerabilities to identified change agents. In addition, we will provide an assessment of potential impact or vulnerability of these conservation elements to climate change.

The selections of management questions, conservation elements, and change agents described in this memorandum represent the end product of several review processes. Following the Workshop and a helpful review of the Draft Memorandum I-1a by the AMT and peer reviewers, we have incorporated the recommended changes in Memorandum I-1-c. Several substantial changes were made, including the approaches to be used for identification of fine-filter species and landscape species. Dynamac reapplied the revised approaches to species selection to obtain the final suites of fine-filter and landscape species listed in this memorandum.

The memorandum contains lists the finalized management questions, coarse-filter conservation elements, fine-filter conservation elements, landscape species conservation elements, desired species conservation elements, and other conservation elements representing sites of conservation concern and ecological functions and services. In addition we list the major change agents affecting these conservation elements that will form the foundation of status and future condition forecasts for this REA. Some of these selections are tentative, and may be dropped at some point during the REA process for lack of data, appropriate approach, method, or tool, or because they may be better addressed within the context of a sub-assessment.

1. INTRODUCTION

The objective of this first memorandum is to identify the subjects that will form the basis of the Colorado Plateau Rapid Ecological Assessment (REA) in the months ahead. The purpose of the REAs is to assess the current status of selected ecological resources at the ecoregional scale and to investigate how this status may change in the future across several time horizons. The knowledge gained from these assessments will provide the basis for future management planning across multiple spatial scales and jurisdictional boundaries and help direct future research in areas where knowledge gaps are identified. To that end, an important component of the REA process will be data compilation. We will use existing data, modeling, and GIS analyses in an attempt to provide answers to management questions.

Current status and future condition of the ecoregion's natural resources will be estimated by examining the relationships between a set of *conservation elements*, and disturbance factors or *change agents.* The REA Task Order defines core conservation elements as biotic constituents (wildlife and plant species and assemblages) or abiotic factors (e.g., soils, regional values) of regional significance in major ecosystems and habitats across the level III ecoregion. This limited suite of conservation elements is designed to represent all renewable resources and values within the ecoregion; as such, the individual conservation elements may serve as surrogates for ecological condition across the ecoregion. Through the individual or interactive effects of change agents, the condition of conservation elements may depart from a model of a minimally-disturbed *reference condition* and thus from a state of ecological or biological integrity (Frey 1977, Karr and Dudley 1981). During the assessment process, we will estimate qualitatively how far from a theoretical reference condition each conservation element has deviated and by what means. This qualitative departure from reference condition will help to provide a snapshot of inferred ecological condition at the scale of both the various landscape reporting units and the ecoregion. Forecasts of how conservation element status is expected to change in the future will be approached in the same manner. The Dynamac team recommends that a more formal development of indicators of terrestrial ecological condition be supported as a future sub-assessment or separate research topic.

The AMT provided a list of core management questions to guide the assessment process. We evaluated each question to determine whether they could be feasibly answered with the inferred approach during the short timeframe of the REA. We identified a few management questions which, based on their language, appeared to require more time or resources to answer than were available for the REA based on our best professional judgment. In such cases, we either recommended the question for consideration as a sub-assessment, or suggested a rewording for AMT consideration to reflect an approach that was within the scope of the REA. In some instances, we identified additional management questions for consideration by the AMT. Following the first Workshop, the AMT reviewed and finalized any suggested changes to management questions.

We also conducted a review of the selection of Conservation Elements. Conservation elements included Ecological Systems (vegetation communities) as coarse-filters, sensitive species as a richness function, landscape species, and a set of desired species identified by the AMT. In addition, a wide range of terrestrial and aquatic sites and ecological services and functions (such as soil stability) were considered for inclusion as conservation elements. For use as coarse-filters in this REA, we identified all Ecological Systems present within the external boundary of the Level III ecoregion. For the Colorado Plateau, we also included the Ecological Systems occurring in the isolated mountainous inclusions within the ecoregion (such as the La Sal Mountains), since some of the landscape species present in the ecoregion use these higher elevation areas. We defined our Ecological Systems based on the vegetation assemblage classes used in the SWReGAP project (Prior-Magee et al. 2007).

The initial selection of species created considerable debate at the first Workshop. This debate centered on the selection process itself, the rationale for inclusion of vulnerable species, and the mixing of vulnerable species and species managed for game. The Dynamac team had assumed that we were to include all of those species identified as core species by the AMT. We initially developed a dichotomous key approach for selecting additional species based on the constraints identified in the SOW. Following the Workshop, we were asked to rerun the *fine-filter species* selection process following the approach outlined in Unnasch *et al*. (2008); and Parrish *et al*. (2003). A later AMT direction requested that we identify a dominant plant species associated with principle coarse filters to serve as fine-filters for the purposes of this REA.

In addition, we were asked to follow the general approach developed by Coppolillo *et al*. (2004) for selection of *landscape species*. In their paper, Coppolillo *et al*. (2004) acknowledged that their approach, while useful for guiding conservation planning efforts, had not been, and probably could not be verified. Landscape species are characterized by their utilization of a wide range of habitats, large home ranges covering a large proportion of the study area, vulnerability to anthropogenic impacts, and high socio-economic value. We used the basic structure of the approach, while redefining some of the component scoring procedures. We then selected a set of 25–30 species from the State Wildlife Action Plan lists and the SWReGAP list, as well as the core species identified in the SOW by the AMT, and proceeded to score each. We used this approach to select a suite of landscape species; those species identified by the AMT that failed to make it on the list as landscape species were reserved as *desired species* for separate assessments.

Assessment of the status of conservation elements must be conducted with reference to both natural and anthropogenic disturbance factors. The concept of reference condition includes natural disturbance dynamics and the full range of potential natural successional trajectories and states. Deviation from the range of natural states characterizing reference condition is due to direct or indirect disturbances of anthropogenic origin (Hughes *et al*. 1986, Hughes 1995). These disturbances represent the change agents of interest in the REA process. Many effects of change agents are obvious, representing changes in land use during development, agriculture, resource extraction, such as logging and mining, and traditional and renewable energy development. Other effects are more diffuse, such as the effects of livestock grazing, and the intentional or unintentional introduction of invasive species. Fire, while it is a natural disturbance agent, often deviates from its characteristic regime, through fire suppression, increased ignition frequencies, and changes in characteristic fuels and fuel loads. In this way fire, at least in the deviation from expected frequencies, can be considered a form of anthropogenic change agent. We accepted the change agents identified by the AMT as clearly important to ecological resources at the ecoregional scale, and we suggested an additional, change agent for AMT consideration.

In the following sections, we will review the finalized selections of reporting units, management questions, conservation elements, and agents of change for the Colorado Plateau REA.

2. REA Study Area and Landscape Reporting Units

2.1 Study Area

This REA will be conducted within the boundaries of the Colorado Plateau ecoregion (Figure 1) and a buffer area consisting of 5th level hydrologic units. The purpose of the buffer is to help ensure agreement between mapped layers generated for REAs in neighboring regions and to avoid problems associated with "edge effects" during GIS analyses.

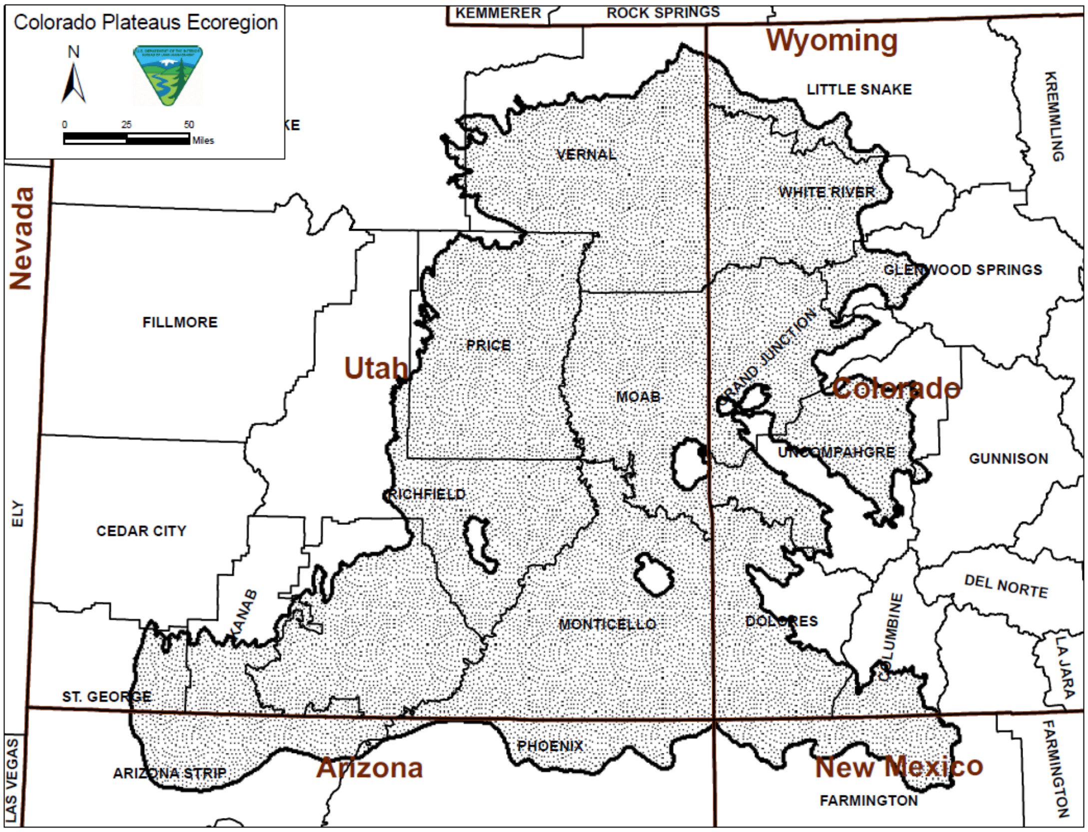

Figure 1. Extent of the Colorado Plateau Ecoregion (shaded).

2.2 Landscape Reporting Units

Assessment data will be summarized in landscape reporting units. These are predefined areas general enough to provide useful information regarding resource status and coarse enough to avoid mapping at an inappropriately fine grain. The resolution of the data will vary. In GIS analyses, it is important to recognize that the information content is only as good as the input data with the coarsest resolution. Summarizing information at a coarse resolution is one means to overcome this limitation, while at the same time providing an ecoregional perspective on the condition of resources of conservation significance.

Two landscape reporting units were identified in the Statement of Work (SOW), 30m pixels for raster data; and the 5th level hydrologic unit. The Dynamac team accepted both and suggested several others to the AMT. We proposed summarizing the assessments within Level IV ecoregions, since there are strong regional differences between resource capability and vulnerability to change agents among these distinct geographic areas (Omernik 1995).The group accepted the use of Omernik level IV ecoregions as a reporting unit. We also recommended the inclusion of aquifer boundaries as landscape reporting units. Our rationale for this was that many of the aquatic resource management questions focus on potential changes in current and future groundwater extraction and recharge on conservation elements dependent on those resources. We felt that summaries of species richness or richness of species of conservation concern by aquifer would be helpful in future planning for water extraction needs. This reporting unit was also accepted by the workshop group and the AMT. Finally, we suggested including a landscape reporting unit that represented the resolution of the 15 km climate data that will be used in the REA. The rationale for using this resolution is that in any geospatial analyses the information content is limited by the coarsest resolution of the data, in this case, the climate data. The 15 km reporting unit was accepted by both the group and the AMT for use in appropriate situations.

3. Basic Ecoregion Conceptual Model

3.1. Introduction

The purpose of the REA is to assess factors that may affect, both positively and negatively, the current and future condition of resources of conservation concern. The reference condition of these resources or conservation elements is dependent on direct and indirect effects associated with natural disturbances or change agents, such as cycles of fire, drought, pests, and pathogens. The range of conditions and the dynamics associated with the condition of these resources prior to European settlement constitutes the operational definition of a theoretical state of ecological integrity. Our actions, from direct conversion of natural vegetation to agriculture or parking lots, to effects of pollutants, spread of invasive species, alteration of fire regimes, resource use, off-road vehicle use, and stresses associated simply with proximity to human activities all impinge upon the condition of these resources. To visualize the tangled mechanisms of changes, conceptual models can be helpful. They are also helpful in defining relationships between conservation elements, threats, and associated change agents that can form the basis for selection of management questions (Figure 2).

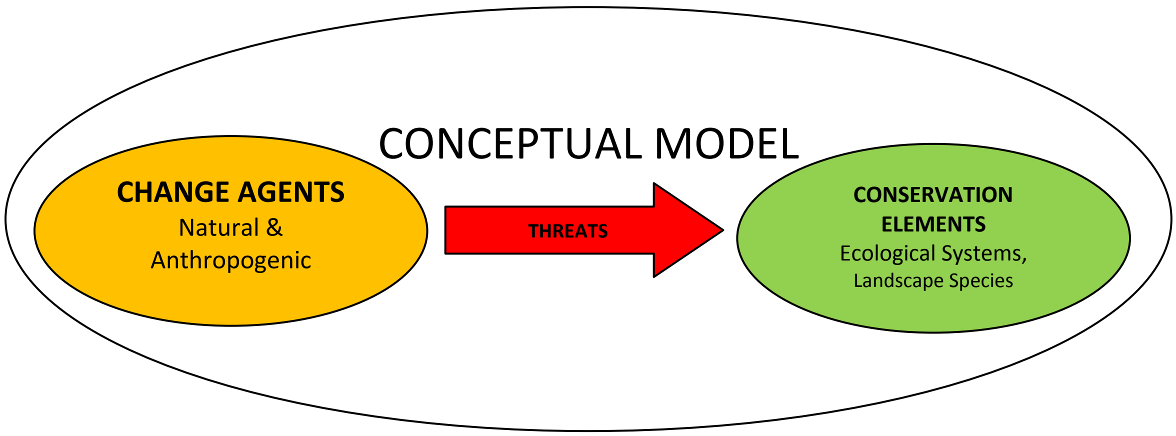

Figure 2. General relationship between change agents, threats or stressors, and the conservation elements in the ecoregion.

3.2. Description of the Basic Ecoregion Conceptual Model for the Colorado Plateau

Woods et al. (2001) describe the Colorado Plateau as "an uplifted, eroded, and deeply dissected tableland. Its benches, mesas, buttes, salt valleys, cliffs, and canyons are formed in and underlain by thick layers of sedimentary rock. Juniper-pinyon woodland dominates higher elevations and is far more extensive than in the Wyoming Basin. Saltbush-greasewood and blackbrush communities are common at lower elevations. Summer moisture from thunderstorms supports warm season grasses not found in the Central Basin and Range. Many endemic plants occur and species diversity is greater than in the Central Basin and Range."

The Colorado Plateau ecoregion has a broad latitudinal range, from the Uinta Basin in the north to the arid canyonlands along the border of Arizona and New Mexico. Climatic influences on the ecoregion vary both with latitude and elevation. Precipitation amounts range from a low of 5-8 inches/year in the shale deserts and arid canyonlands to almost 20 inches/year in the higher pinyon-juniper woodlands, northern Uinta Basin slopes, and escarpment areas such as the Book Cliffs (Woods *et al*. 2001). The southern part of the ecoregion differs from the north in having a summer monsoonal precipitation pattern.

In the basic ecoregional conceptual models in Figures 3 and 4, boxes represent conservation elements, ovals represent classes of change agents, and arrows represent the direct and indirect effects (threats, stresses or positive change) on the ecosystem components, including conservation elements. No distinction is made in these simplified models to distinguish between direct or indirect effects or their magnitude. Figure 3 illustrates the ecoregion under natural conditions representing ecological integrity, and Figure 4 illustrates the same system with the addition of anthropogenic stressors (represented by red arrows) and associated change agents. The present model lacks spatial or temporal components that will be developed later in more detailed models.

Regional climatic conditions represent the dominant natural change agent in the basic ecoregion conceptual model (Figure 3). Secondary natural regional change agents include the natural fire regime and cyclical drought. Natural change agent classes are depicted as orange ovals in the conceptual model. Across the ecoregion, variability in geology, physiography, elevation, aspect, ground and surface water availability, and soil (texture, depth, and water-holding capacity) is reflected in patterns of vegetative cover. Black arrows in the model depict the major interactions between natural abiotic and biotic components.

Four representative natural vegetation (coarse filter or habitat) classes are centrally located in the ecoregion conceptual model. The boxes for vegetation classes are depicted in the conceptual model according to elevational and moisture differences; they represent various combinations of the coarse filter conservation element classes covering more than 1 or 2% of the ecoregion area. (although every vegetation class is included in the coarse-filter selection of conservation elements). The **Upland Forest and Woodland** class mainly includes pinyon-juniper woodland, but it may also cover small inclusions of other woodland and mesic shrubland vegetation types, such as Rocky Mountain Aspen Forest and Woodland or Gambel Oak-Mixed Montane Shrubland, in higher elevation areas, 5th field HUC buffer areas, or mountainous inclusions (e.g., escarpment areas or slopes of the La Sal Mountains). The box marked **Riparian Communities** consists of the coarse filter classes Woody Wetland and Riparian Communities and Emergent Herbaceous Wetlands. The **Semi-Arid Sage and Grasslands** box cover the Shrub/scrub and Semi-arid Grasslands vegetation classes in areas with annual precipitation ranges of 5–13 in/yr. The box marked **Arid Basin Shrubland** represents mainly the Inter-Mountain Basins Mixed Salt Desert Scrub and Southern Colorado Plateau Sand Shrubland. The signature canyonlands, dunes, playas, bedrock, and cliffs of the Colorado Plateau are represented by the **Sparsely-Vegetated and Barren** class. Though biological (cryptogamic) soil crusts might logically fall into several of the coarse filter vegetation classes, we chose to picture soil crust separately in the conceptual model to highlight its importance and to note our proposal to add soil crusts as a conservation element. Soil crusts serve as intermediaries between soil and vegetation, with important stabilization and nitrogen-fixing roles to play (Belnap and Gillette 1998, Belnap 2002, Housman et al. 2006). Wildlife occurrence and abundance is dependent on interactions with all these abiotic factors (such as climate, fire regime, and water availability) and the vegetation classes (representing major habitats).

The overlay of human activities, expressed as anthropogenic change agents and change agent subclasses, are shown in yellow on the conceptual model (Figure 4). The major change agents include wildland fire, invasive species, land and resource use, and climate change. Land and resource use covers major human activities such as urban and industrial development, surface and groundwater extraction, recreation, and grazing. The red arrows mark the interactions of human activities with other model components.

The basic ecoregion conceptual model serves as the source for more detailed conceptual sub-models that will accompany subsequent modeling and assessments. For example, the sub-model for Forest and Woodland Class/pinyon-juniper woodland will show additional detail in interactions between human influences such as land treatments, pinyon-juniper removal, and grazing, and the effects on the vegetation community and surrounding landscape with changes in fire regime, introduction of non-native annuals, increased soil erosion, runoff and stream incision.

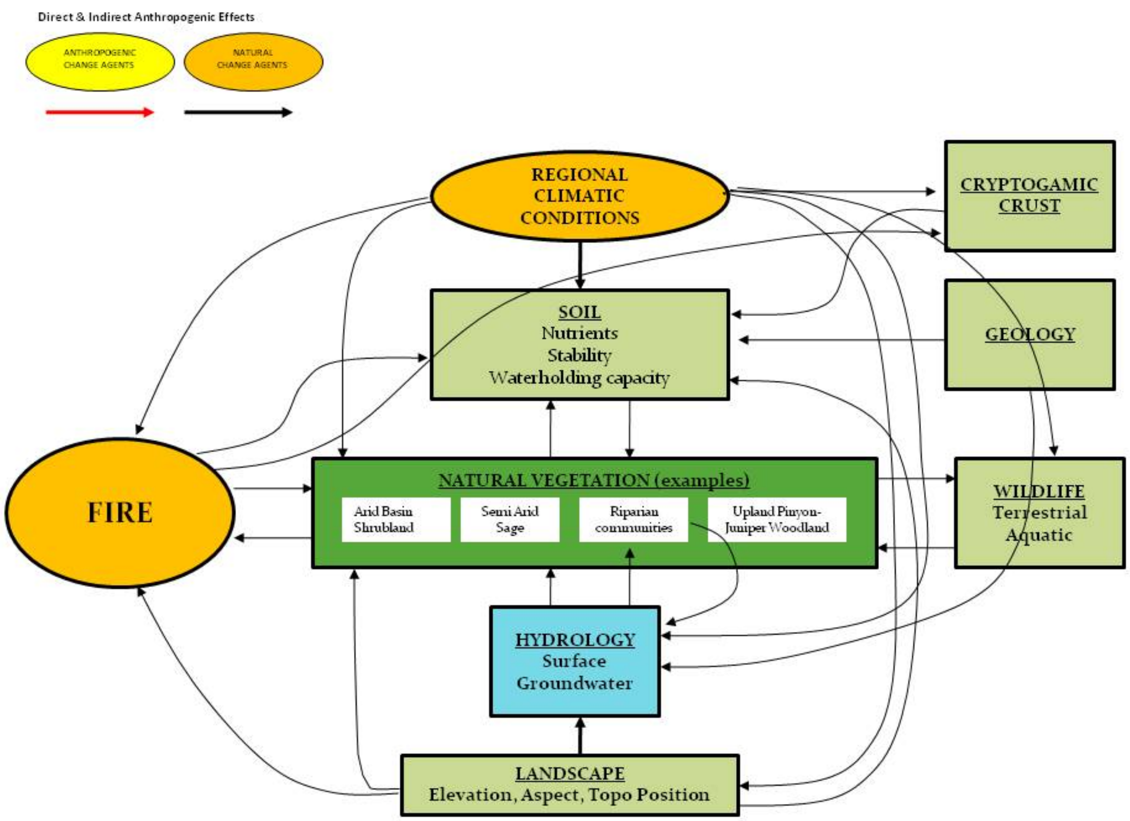

Figure 3. Generalized ecoregion conceptual model for the Colorado Plateau Ecoregion pictured without human influences, with change agents (orange ovals) and associated direct and indirect threats or influences (arrows) on ecosystem components.

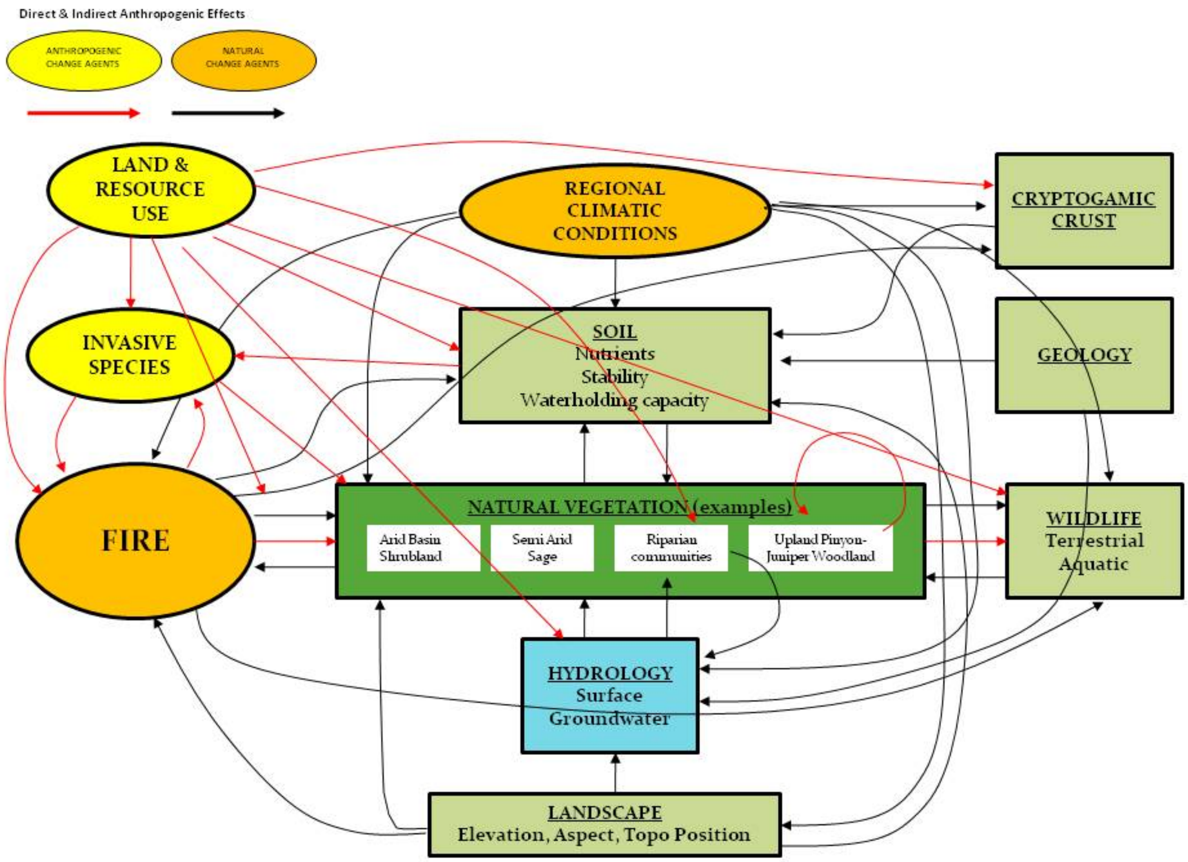

Figure 4. Generalized ecoregion conceptual model for the Colorado Plateau Ecoregion, with both natural and anthropogenic change agents shown (yellow ovals represent anthropogenic change agents; orange ovals represent natural change agents) and associated direct and indirect threats (red arrows represent anthropogenic threats) on ecosystem components.

4. Management Questions

4.1. Introduction

The AMT defined a set of preliminary management questions in the SOW for this REA. These questions were broad in scope. Part of the challenge of this first REA workshop was to gauge the time and resource requirements needed to address the full complement of management questions in a manner that would have utility for BLM for future planning purposes. Management questions fell into two general categories. The first category included what/where questions that could be answered with simple data compilation and summaries. In many instances, we expect the questions may have already been answered in earlier studies.

A second category of management questions suggested the need for considerable analytical processing as well as data compilation.

4.2. Review and Feasibility Assessment of Management Questions

We examined each question and determined the type of data required and the probable approaches and methods that could be used. Management questions were then rated based on these approaches as routine GIS summaries, involved analyses, complex/costly/time consuming analyses, or basic research–beyond scope. It was our intent to address each management question in some manner, if feasible, particularly if the nature of the output would have some utility for BLM and agency partners.

In preparing the draft version of this Memorandum, we highlighted management questions that appeared to require an effort beyond the scope of the REA process. We received helpful guidance from BLM regarding the expected level of effort and the nature of some types of analyses. We revised our time estimates and then prepared suggested revisions of certain management questions to reflect this guidance. These suggestions were reviewed at the first Workshop, and, following AMT review and additions, many have been accepted. In some cases we identified a management question that we felt could not be answered. For example a question related to predicting changes in water temperature in streams across the landscape under a future climate change scenario, based on changes in air temperature and precipitation. It was our opinion that the output would lack both the accuracy and precision needed to infer potential changes in thermal habitat for aquatic species. We indicated that the National Hydrography Dataset stream flow status attribute currently has a high rate of error in the arid ecoregions. We related that in a recent stream survey project conducted by the EPA (Stoddard et al. 2005), many streams identified as perennial were in fact not perennial (Figure 5). This level of uncertainty, we argued, made estimation of future flow and temperature changes unreliable. The reviewers agreed, and the management question was deleted.

Elsewhere, we suggested new management questions for AMT consideration. These were presented in the draft version of this Memorandum and again at the first Workshop. Following review by Workshop participants, USGS peer review, and AMT review, we received a finalized set of management questions that are presented in the following section.

4.3. Approved and Finalized Management Questions

4.3.1. Related to Terrestrial Ecological Features, Functions, and Services as Conservation Elements

QUE (Coarse-Filter Ecological Systems): Where are these intact vegetative communities located?
Resolution: This question related to native plant communities was accepted by the group.

QUE (Coarse-Filter Ecological Systems): What/where is the potential for future change to the community?
Resolution: At the Colorado Plateau meeting the group agreed that it was impossible to predict the potential for future change at the community level, and decided to pick a few species. These species are to be treated as fine-filters and represent coarse-filter Ecological Systems. Overlaying climate information onto limited species distributions will show where the species are most vulnerable.

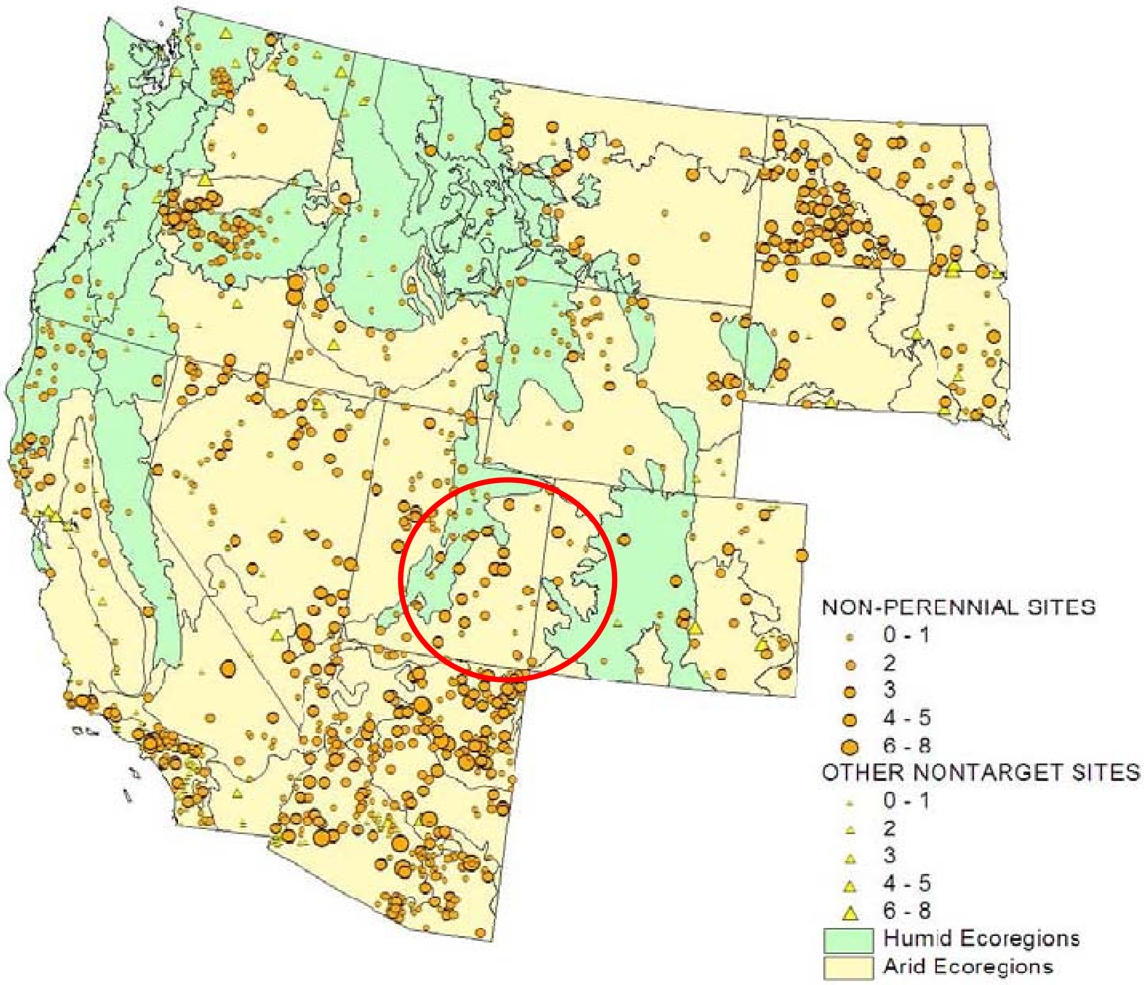

Figure 5. Streams identified as perennial which were non-perennial in the EMAP-West stream survey project (from Stoddard *et al*. 2005).

QUE (Coarse-Filter Ecological Systems): Where are these intact cryptogamic crusts located?
Resolution: This question related to the proposed cryptogamic crusts conservation element was provisionally accepted by the group, pending more information about data availability and modeling capability (Workshop 2).

QUE (Coarse-Filter Ecological Systems): What/where is the potential for future change to the cryptogamic crusts?
Resolution: This question related to the proposed cryptogamic crusts conservation element was provisionally accepted by the group, pending more information about data availability and modeling capability (Workshop 2).

QUE (Soils as Conservation Elements): Where are soils susceptible to wind and water erosion)?
Resolution: Proposed by AMT, and accepted by Dynamac.

QUE (Soils as Conservation Elements): Where are soils with the potential to change from high wind erosion/dust/dunes likely to develop due to climate change or groundwater withdrawal?
Resolution: Proposed by AMT, and accepted by Dynamac.

QUE (Soils as Conservation Elements): Where are soils that have or have potential to have cryptogamic soil crusts?
Resolution: Proposed by AMT, and accepted by Dynamac.

QUE (Soils as Conservation Elements): Where are sensitive (including saline) soils?
Resolution: Proposed by AMT, and accepted by Dynamac.

QUE (Forage as a Conservation Element): Where are the areas of important forage production for livestock, wild horses and burros, and wildlife located?
Resolution: Proposed by AMT, and accepted by Dynamac.

QUE (Forage as a Conservation Element): What is the potential for future change to forage production from change agents? The AMT suggests inclusion of the plant communities with important grass and shrub production with allotment locations. This could include non-native species.
Resolution: Proposed by AMT, and accepted by Dynamac.

4.3.2. Related to Species as Conservation Elements

QUE (Species as Conservation Elements): What is the current distribution of occupied habitat, including seasonal habitat, and movement corridors?
The REA effort will rely on the results of the Western Governors' Association Southwestern States Wildlife Corridor Initiative to provide the data necessary to answer this management question.
Resolution: The question was accepted by the AMT and the group.

QUE (Species as Conservation Elements): What areas known to have been surveyed and what areas have not been surveyed (i.e., data gap locations)?
Dynamac suggested a revision to the question: What areas are known to have been surveyed and what areas are not known to have been surveyed?
Resolution: The revised wording was accepted by the group at the workshop.

QUE (Species as Conservation Elements): Where are change agents affecting these habitat and movement corridors?
To address this management question, Dynamac suggested rephrasing the question to say: Where might change agents have recently (within the last ten years) displaced or negatively influenced occupied or potential habitat and movement corridors?
Resolution: The question was accepted by the group; the AMT suggested removing the word *negatively* and consider both past and present time frames.

QUE (Species as Conservation Elements): Where are habitats that may be limiting species sustainability?
Resolution: The AMT and the workshop participants accepted the management question without discussion.

QUE (Species as Conservation Elements): Where are species populations at risk?
Resolution: The AMT and the workshop participants accepted the management question without discussion.

QUE (Species as Conservation Elements): Where are potential habitat restoration areas?

Resolution: The AMT and the workshop participants accepted the management question without discussion.

QUE (Species as Conservation Elements): Where are potential areas to restore connectivity?
Resolution: The AMT and the workshop participants accepted the management question without discussion.

QUE (Species as Conservation Elements): What/where is the potential for future change to this species in the near-term horizon, 2020 (development) and a long-term horizon, 2060 (climate change)?
Dynamac proposed breaking this question into two time frames and change agent sources and suggested that the question be revised to read: What/where is the potential for future change to this species in the near-term horizon 2020 (development) and a long-term change horizon 2060 (climate change)?
Resolution: The revised wording was accepted by the group.

QUE (Species as Conservation Elements): Where are the current wild horse and burro populations?
Resolution: The question was accepted by the group.

QUE (Species as Conservation Elements): Where are the current Herd Management Areas (HMAs) and Hear Areas (HAs)? The AMT requested a rewording of the question: Where are the current Herd Management Areas (HMAs) and Herd Areas (HAs)?
Resolution: Accepted.

4.3.3. Related to Terrestrial Sites as Conservation Elements

QUE (Terrestrial Sites as Conservation Elements): What is the location/distribution of these sites?
Resolution: This question was accepted by the group.

QUE (Terrestrial Sites as Conservation Elements): What/where is the potential for future change to these high-biodiversity sites in the near-term horizon, 2020 (development) and a long-term change horizon, 2060 (climate change)? Dynamac suggested changing the wording of this question to: What/where is the potential for future change to these high-diversity sites in the near-term horizon, 2020 (development) and a long-term change horizon, 2060 (climate change)?
Resolution: The group agreed to the near-term and long-term aspects of the question.

QUE (Conservation/Reserve Areas as Conservation Elements): Where are the areas?
The USDA-Conservation Reserve Program (CRP) is a program to provide opportunities to agricultural producers and landowners to better conserve and improve their natural resources. We will determine whether the USDA-Farm Service Agency (FSA), the agency responsible for contract development, has an existing geospatial dataset or sets for mapping this resource at the ecoregion scale. We will also attempt to map conservation easements on privately owned lands. We will contact regional or local Soil and Water Conservation Districts (SWCD) or USDA Service Centers for geospatial information availability.
Resolution: This question was accepted as written.

QUE (Viewsheds as Conservation Elements): Where are the viewsheds adjacent to scenic conservation areas?
Resolution: This question was accepted as written.

4.3.4. Related to Aquatic Ecological Features, Functions, and Services Conservation Elements

QUE (Aquatic Features, Functions & Services): Where are the surface waterbodies and livestock and wildlife watering tanks? Dynamac suggested rewording the question: Where are the surface water bodies and livestock or wildlife watering tanks?
Resolution: The question was accepted by the group with the changes suggested by Dynamac.

QUE (Aquatic Features, Functions & Services): What is the persistence of the flow (e.g., perennial, ephemeral) of these systems?
Hydrologic modeling of flow is beyond the scope of an REA, so the Dynamac Team suggested that we answer this question in a more qualitative manner. We will identify those bodies of water which are currently characterized by flow status in the NHD data for a first level summary, recognizing that the accuracy will be low, based on our experiences sampling in the arid west. Dynamac will use estimates of NHD flow error from the EMAP-West probabilistic sampling study to help quantify this level of uncertainty by Strahler order.
Resolution: The question was accepted by the group.

QUE (Aquatic Features, Functions & Services): Which surface waters are likely dependent on seasonal precipitation, and what are the characteristics of their current seasonal flows? Dynamac suggested changing the question to read: Which surface waters are likely dependent on seasonal precipitation, and what are the characteristics of their current seasonal flows?
Resolution: The question was accepted by the group with the changes suggested by Dynamac.

QUE (Aquatic Features, Functions & Services): Where are the aquifers and their recharge areas?
As described above, aquifers will be mapped from available GIS data layers, but the quality of these maps will likely vary from state to state.
Resolution: The question was accepted by the group.

QUE (Aquatic Features, Functions & Services): Which surface waters are likely dependent on groundwater to maintain their ecological condition? Dynamac suggested changing the question to read: Which surface waters are likely dependent on groundwater to maintain their ecological condition?
Resolution: The question was accepted by the group with the changes suggested by Dynamac.

QUE (Aquatic Features, Functions & Services): What is the condition of these various aquatic systems defined by PFC?
Resolution: Accepted as written.

QUE (Aquatic Features, Functions & Services): Where are the degraded aquatic systems (e.g., water quality)?
Resolution: Accepted as written.

4.3.5. Related to Aquatic Sites of Regional Importance as Conservation Elements

QUE (Aquatic Sites): What is the location/distribution of these sites?
These resources will simply be merged into several vector data layers identifying surface water features. The attribute files will contain required information to characterize surface water type, and where feasible, quality.
Resolution: This question was accepted by the group.

QUE (Aquatic Sites): What/where is the potential for future change to these high-biodiversity sites in the near term, 2020 (development), and long term, 2060 (climate change)? Dynamac suggested changing the questions to reflect the near-term and long-term time horizons as suggested for other questions pertaining to future changes.
Resolution: The suggested change was accepted by the group.

4.3.6. Related to Change Agents

QUE (Change Agent - Fire): Where are the areas that have been changed by wildfire between 1999 and 2009? Dynamac suggested a ten-year time period, with a base date of 1999 through 2009, depending on the status of fire map preparation for the 2009 fire season. BLM has both point data and polygon data (for fires 10 acres and larger) in the Wildland Fire Management Information (WFMI) database. In addition, data may be available from LANDFIRE updates. We can prepare a single map layer of available historic fires, color coded to reflect the ten-year time period.
Resolution: This question, as revised by Dynamac to reflect a 10 yr. time frame, was accepted by the group.

QUE (Change Agent - Fire): Where are the areas with potential to change from wildfire?
Resolution: The group accepted this question as written.

QUE (Change Agent - Fire): Where are the Fire Regime Condition Classifications?
Resolution: Accepted as written.

QUE (Change Agent - Fire): Where are collaborative strategic prevention actions taking place?
These coverages will be collected and merged into a vector data layer, identifying features. This may simply be locations of communities that have wildfire protection plans or other strategies, rather than spatially explicit maps of those strategies. The Colorado State Forest Service keeps a list of communities at risk and a template for a standard Community Wildfire Protection Plan. Communities lacking such plans may not be identified, depending on the currency of the data.
Resolution: This question was accepted as written.

QUE (Change Agent - Fire): Where is fire adverse to ecological communities, features, and resources of concern?
Resolution: Accepted as written.

QUE (Change Agent – Invasive Species): Where are areas dominated by this invasive species?
Resolution: This question was accepted by the group.

QUE (Change Agent – Invasive Species): Where are the areas of potential future encroachment from this invasive species?
Resolution: This question was accepted by the group.

QUE (Change Agent – Invasive Species): Where are areas of suitable biophysical setting (precipitation/soils, etc.) with restoration potential?
Resolution: Accept as written.

QUE (Change Agent – Urban & Industrial Development): Where are areas of planned development (e.g., plans of operation, governmental planning)?
Resolution: This question was accepted by the group.

QUE (Change Agent – Urban & Industrial Development): Where are areas of potential development (e.g., under lease), including sites and transmission corridors? Areas of planned and potential renewable energy development are currently available through the Department of Energy, National Renewable Energy Laboratory, BLM sources, Report of Colorado Senate Bill 07-091, and the Western Governors' Association Governor's Energy Office.
Resolution: This question was accepted by the group.

QUE (Change Agent – Groundwater Extraction & Transport): Where are the surface waters that might be vulnerable to flow reduction as a result of groundwater extraction? Dynamac suggestion: Where are the surface waters that might be vulnerable to flow reduction as a result of groundwater extraction?
Resolution: The revised wording was accepted by the group.

QUE (Change Agent – Groundwater Extraction & Transport): Where are the areas of high and low groundwater potential? The question was shortened to read: Where are areas of high and low groundwater potential?
Resolution: The AMT and the workshop group agreed to revise the wording (shorten the question) and approach the question from the point of view of aquifer vulnerability: low, medium, or high risk.

QUE (Change Agent – Groundwater Extraction & Transport): Where are the areas showing effects from existing groundwater extraction? The ability to answer this question is dependent on data availability. There are declines in many areas, so we expect the information to be readily available. We will identify the specific aquifers associated with major changes water availability. Our output must be qualitative, rather than quantitative.
Resolution: Accepted by the group.

QUE (Change Agent – Groundwater Extraction & Transport): Where are artificial water bodies, including evaporation ponds, etc.?
Resolution: Accepted by the group.

QUE (Change Agent – Resource Use): Where are high-use recreation sites, developments, infrastructure or areas of intensive recreation use located (including boating)?
Resolution: This question was accepted as written.

QUE (Change Agent – Resource Use): Where are areas of concentrated recreation travel located (OHV and other travel)?
Resolution: This question was accepted as written.

QUE (Change Agent – Resource Use): Where are permitted areas of intensive recreation use (permit issued)?
Resolution: This question was accepted as written.

QUE (Change Agent – Land Disposals): What are planned areas for disposal that may cause change of Federal ownership?
Resolution: This question was accepted as written.

QUE (Change Agent – Resource Use): Where are the viewsheds most vulnerable to change agents?
Resolution: This question is accepted as written.

QUE (Change Agent – Air Pollution): Where are the designated non-attainment areas and Class I PSD areas?
We will map the Class 1Prevention of Significant Deterioration (PSD) areas in the ecoregion. Class I areas are areas of special national or regional natural, scenic, recreational, or historic value and determined to require special protection. We will also map out areas of non-attainment obtained from the EPA (http://www.epa.gov/air/data/nonat.html).
Resolution: This question was accepted as written by the group.

QUE (Change Agent – Air Pollution): Where are areas producing fugitive dust that may contribute to accelerated snow melt in the Colorado Plateau?
Dynamac suggested revising the question to read: Where are areas producing fugitive dust that may contribute to accelerated snow melt in the Colorado Plateau?
Resolution: The group accepted the revised wording of the question.

QUE (Change Agent – Livestock Grazing): Where does/has grazing occur/occurred?
Resolution: Proposed by AMT, and accepted by Dynamac.

QUE (Change Agent –Grazing): Provisional: Where/How has grazing impacted the current status of conservation elements? The AMT suggested that grazing should be correlated with forage, plant communities, including succession dynamics, wildlife habitat, ecological integrity, aquatic/riparian, soils, Land Health Assessments/PFC, M, I, and C allotments.
Resolution: Proposed by AMT, and accepted by Dynamac.

QUE (Change Agent – Grazing): Provisional: Where/How may grazing impact the potential future status of conservation elements? The AMT indicated that this question should include synergistic effects with other CAs, particularly climate change on forage vulnerability.
Resolution: Proposed by AMT, and accepted by Dynamac.

QUE (Change Agent – Climate Change & Terrestrial Resources): Where/how will the distribution of dominant native plant species and invasive species change from climate change?
Resolution: Accept as written.

QUE (Change Agent – Climate Change & Terrestrial Resources): Where are areas of potential for fragmentation as a result of climate change in 2060?
Resolution: Accept as written.

QUE (Change Agent – Climate Change & Terrestrial Resources): Where are areas of core conservation species change as a result of climate change? We suggest modeling changes in POTENTIAL species distribution between 2010 and 2060 time periods to provide an indication of areas of range contraction, stability, and range expansion. Dynamac suggested changing the question to replace *potential wildlife* with *core conservation species*.
Resolution: The group accepted the suggested changes to the question.

QUE (Change Agent – Climate Change & Aquatic Resources): Where are aquatic/riparian areas with potential to change from climate change?
Resolution: The question was accepted as written. We will use the aridity index, or BOR data as suggested by the AMT.

QUE (Change Agent – Climate Change & Terrestrial Resources): Where are the areas of core conservation aquatic species habitat change? Dynamac suggested revising the question to read: Where are the areas of core conservation aquatic species habitat change?
Resolution: The group accepted the revised wording.

5. Conservation Element Selection

5.1. Introduction

REAs are intended to characterize the current status (baseline conditions) and forecast the future condition of ecological resources in the Colorado Plateau. This process requires identification of a set of conservation elements that can provide a picture of the general condition of the resources of conservation concern within the region. The REA Task Order defines core conservation elements as biotic constituents (wildlife and plant species and assemblages) or abiotic factors (e.g., soils, regional values) of regional significance in major ecosystems and habitats across the level III ecoregion. A limited suite of conservation elements is designed to represent the entirety of renewable resources and values within the ecoregion; as such, it is suggested that the individual conservation elements may serve as surrogates for ecological integrity across the ecoregion. However, in the Statement of Work (SOW), REAs are also defined as "assessments only, evaluating status and potential changes in status for selected core conservation elements." Development of landscape-level indicators of biological or ecological integrity that are based on empirically-derived responses of conservation elements to disturbance are beyond the scope of the REA process since this would require a major research effort. For the purposes of the REAs, BLM and agency partners are currently developing an approach to characterize landscape-level ecological integrity or condition based on existing geospatial data.

. In the absence of a formal research approach, Dynamac proposes using landscape condition estimates, including the condition of landscapes and habitats of a selected suite of species as indicators of the condition of the ecoregion. These estimates will be based primarily on measures of direct anthropogenic disturbance and inferred qualitative levels of stress on the suite of species selected. These assessments, taken collectively, will provide a basis for comparing current and inferred future status within ecoregions.

A number of strategies have been devised to conduct assessments of ecological condition, from rigorous, scientifically-defensible indices of biological integrity or IBIs, to more qualitative, conservation guidance approaches such as those discussed by Parrish *et al*. (2003) and Unnasch *et al*. (2008). Approaches such as these differ in rigor and defensibility, and they also differ in terms of their potential application for programs such as Rapid Ecoregional Assessments. Indices of biotic integrity (IBIs) developed for aquatic ecosystems use systematically-collected species abundance data to develop metrics representing taxonomic richness, trophic categories, or sensitivity to disturbance. Metrics are screened for responsiveness to disturbance, low variability, and lack of redundancy (Hughes et al. 1998, Mebane et al. 2003, Whittier et al. 2007).

The development of indicators of physico-chemical and biotic conditions is grounded in the establishment of a human disturbance gradient (Figure 6). Minimally- or least-disturbed sites serve as a reference model against which to compare the condition of disturbed sites. A collection of reference sites represents the range of natural variability in undisturbed sites that allows the recognition and separation of natural from anthropogenic disturbances at sites influenced by human activities (Hughes et al. 1986, Hughes 1995, Whittier et al. 2007, Lattin et al. In Review), Once natural variability has been documented, the remaining stressor signal associated with anthropogenic disturbances is used to empirically define departure from the reference or least-disturbed condition.

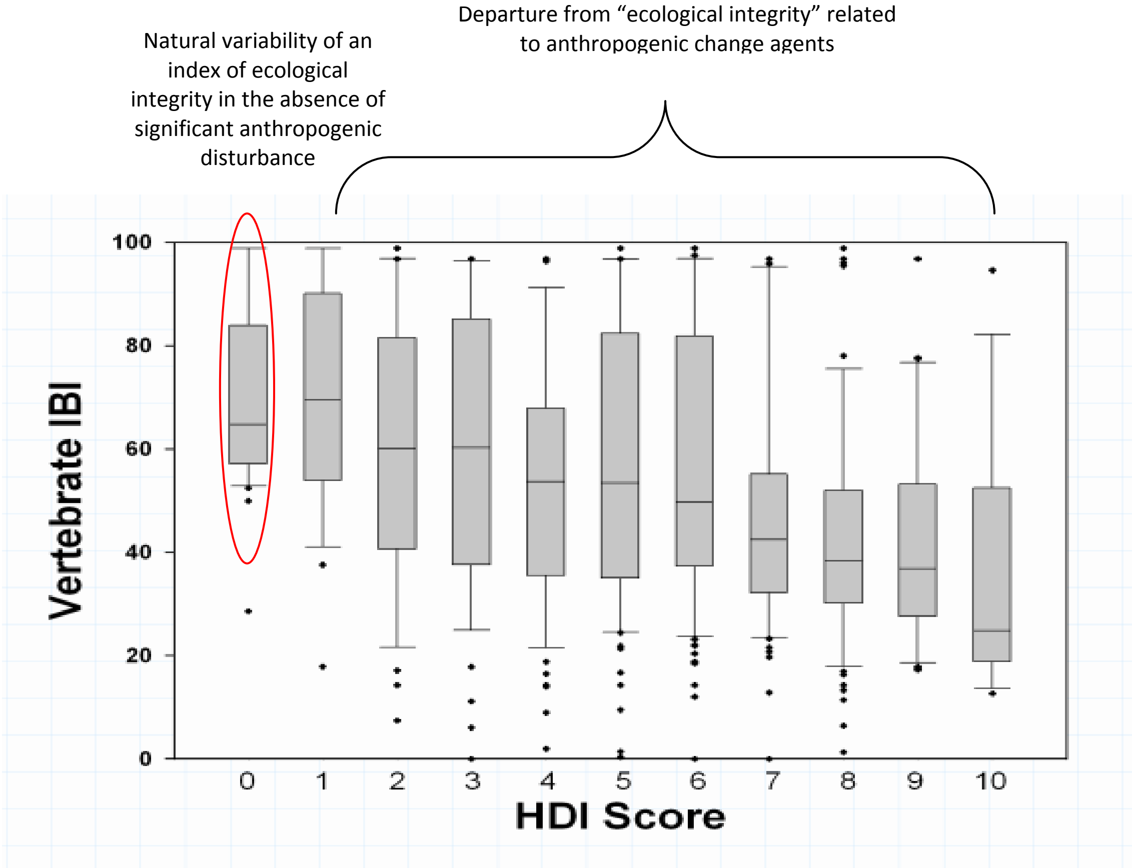

Figure 6. An example of an indicator of ecological integrity (Vertebrate Index of Biotic Integrity or IBI) plotted against a watershed-level human disturbance gradient (Human Disturbance Index or HDI). Variability associated with no detected disturbance (HDI = 0) is representative of variability under reference (least-disturbed) conditions. The range of scores associated with HDI values of 1 or more represent a departure from reference condition. The field sampling, analyses, and calibration of the IBI required more than 5 years and $10,000,000 to develop. By comparison, the development and implementation of the remotely-sensed disturbance index (HDI) required 3 months and less than $10,000. (Lattin *et al*. In Review)

Few indices of *terrestrial* ecological integrity have been developed using the approach described above. Terrestrial indices present even greater challenges than aquatic indices of biointegrity, and terrestrial applications of indices of biotic integrity are limited in the scientific literature (O’Connell et al. 1998, Bradford et al. 1998, Cully and Winter 2000, Bryce et al 2002, Bryce 2006, Mattson and Angermeier 2007).

For the REAs, the Dynamac team will develop an analog to the IBI approach to assess the condition of conservation elements against an operationally defined reference condition based on best professional judgment. We will measure the relative departure in condition away from the reference condition as a qualitative measure of resource status. Each conservation element will be considered a metric of ecological condition. For each metric, we will develop a set of operational definitions of ranges of departures from reference condition, classified as least-disturbed condition, moderately-disturbed condition, and most-disturbed condition. We will attempt to base these classes on threshold percentiles of reference condition. Where this is not feasible, we shall establish clear, easily repeatable operational definitions of these classes using best professional judgment. Ecological condition within landscape reporting units and within the ecoregion will be based on the percent of metrics that are judged to be within the range of least-disturbed condition, the percent of metrics which are judged to be within the range of moderately-disturbed condition, and the percent judged to be within the range of most-disturbed condition. We will summarize relative condition within each landscape reporting unit using an approach comparable to calculating relative risk (RR) in the biological assessment approach (Mattson and Angermeier 2007).

5.2. Conservation Elements

5.2.1. Coarse-Filter Ecological Systems

5.2.1.1. Introduction

Condition assessments within the REA framework were intended to follow the coarse-filter/fine-filter approach. The coarse-filter component is a useful conservation element for the REA process. These conservation elements represent characteristic vegetation assemblages occurring within the ecoregion. We have elected to base these on the vegetation types defined in the SWReGAP project (Figure 7, Prior-Magee et al. 2007). This classification approach will provide the necessary detail to characterize habitat occupancy for the landscape-species conservation elements that will be used as substitutes for fine-filters in this REA.

5.2.1.2. Selection Approach

We elected to include all Ecological Systems present in the ecoregion to serve as coarse filters, rather than just those occupying a large fraction of the landscape, since some of the smaller vegetation classes have importance as habitat disproportionate to their area (Appendix 1).

Dynamac proposed that the AMT add an additional conservation element that provides critical ecosystem functionality in arid regions, cryptogamic or biological soil crusts. This important component of these ecosystems serves to protect soil from wind and water erosion, fix nitrogen, and inhibit the invasion of exotic plants (Belnap and Gillette 1998, Housman et al. 2006, Bowker *et al.* 2008). It is also highly vulnerable to disturbance, both local and severe, as from OHV use (Belnap 2002), and broad and extensive, accompanying the grazing of livestock in these ecosystems. Loss of these crusts can be viewed as a subtle, yet profound stress on these systems. The products from this component of the assessment might be very useful to help predict invasibility of extant natural plant communities by exotic annuals, for example. In addition, they could be a useful indicator of arid ecoregion condition.

Resolution: The decision at Workshop 1 was to consider biological soil crusts as a conservation element until data sources are explored in Workshop 2 and 3.

5.3.1 Fine-Filter Plant Species Conservation Elements

5.3.1.1 Introduction

Dynamac was directed by the AMT to identify a dominant plant species associated with each of the principle Ecological Systems in the Colorado Plateau. These plant species, although they occur in other

Ecological Systems in the ecoregion, represent fine-filter species for the purpose of this REA. Dynamac will characterize their current distribution and vulnerability to change agents, including predicted vulnerability associated with climate change.

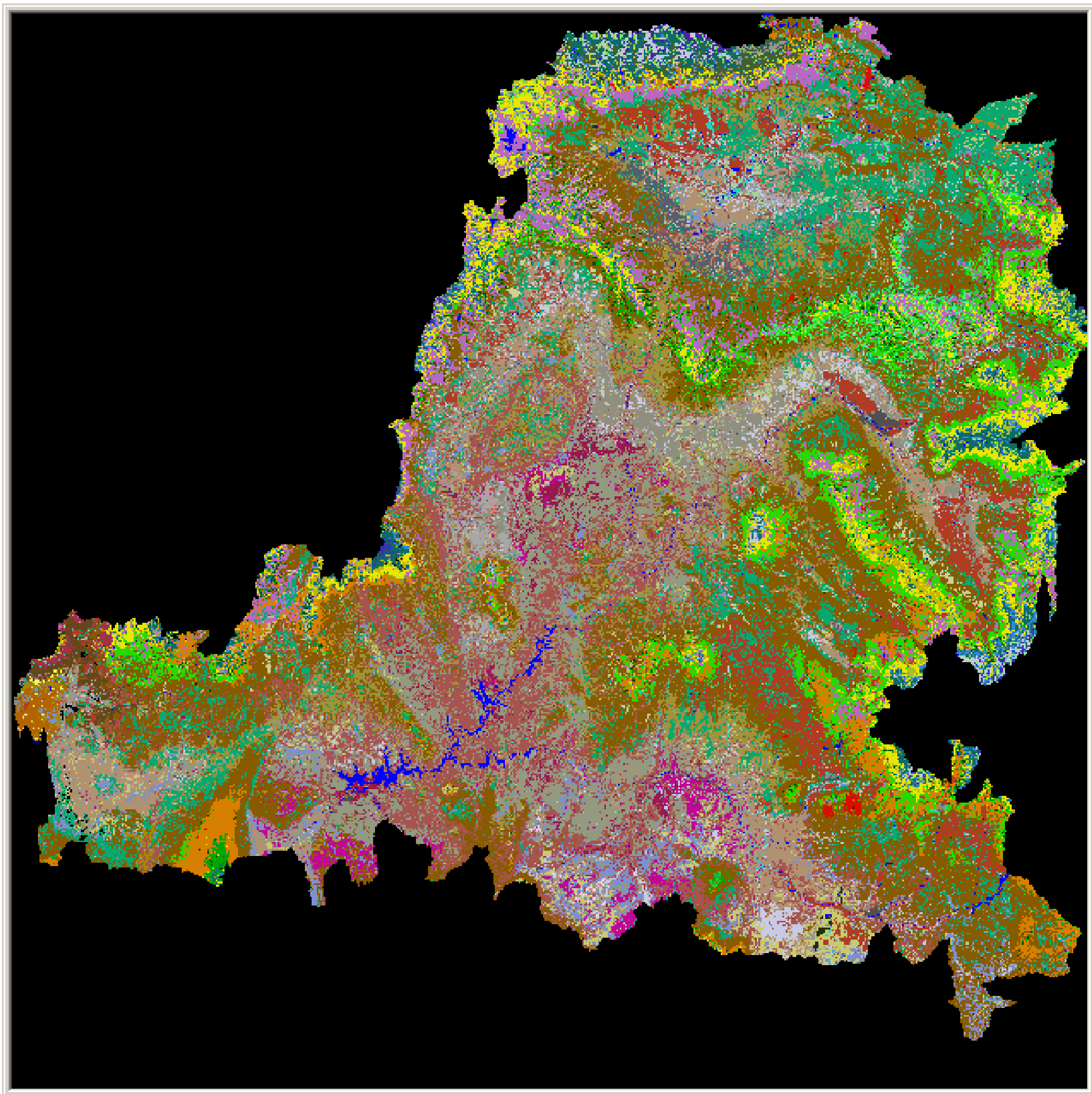

Figure 7. Preliminary distribution of Coarse-Filter Ecological Systems in the Colorado Plateau ecoregion. (SWReGAP data)

5.3.1.2 Selection Approach

We reviewed the descriptions of the Ecological Systems in the SWReGAP program (Prior-Magee et al. 2007). We identified dominant overstory species and selected a single species from each Ecological System. Following review by Wayne Padgett (BLM, Utah), we substituted Wyoming Big Sagebrush (*Artemisia tridentata wyomingensis*) for Basin Big Sagebrush (Artemesia *tridentata tridentata*) that was identified as particularly susceptible to changes in characteristic fire regime and invasion of cheatgrass. Eight species represent 66.5% of the landscape in the Colorado Plateau ecoregion (Table 1).

5.4.1 Landscape-Species Conservation Elements

5.4.1.1 Introduction

The landscape species approach to conservation element selection is roughly analogous to selection of principle components in principle components analysis (PCA). Species are selected that capture a range of important attributes characterizing the environment in which they occur. These include habitat use heterogeneity, large area requirements, vulnerability to anthropogenic disturbance or threats associated with change agents, functional contributions to the ecological system, and relative socio-economic importance (Coppolillo *et al*. 2004). Species are ranked in descending order of aggregate scores for each of these attributes, and selected based on both aggregate score and the ecological systems they use. Each subsequent species is selected on the basis of score and minimum overlap in ecological systems used, until all ecological systems are accounted for. A cross check is then made to ensure that all change agent threats are accounted for as well. The final number of species is expected to be within 4–6, from an original, somewhat arbitrary selection of candidate 10–25 species. The AMT requested that we include the core desired species that they identified in the list of candidate species.

Table 1. Selected plant species (fine-filters) representative of principal Ecological Systems in the Colorado Plateau.

ECOLOGICAL SYSTEM	% OF ECOREGION	SPECIES (Common Name)	SCIENTIFIC NAME
Colorado Plateau Pinyon-Juniper Woodland	20.4%	Pinyon Pine	*Pinus edulis*
Inter-Mountain Basins Big Sagebrush Shrubland	9.1%	Wyoming Big Sagebrush	*Artemisia tridentate tridentata*
Inter-Mountain Basins Montane Sagebrush Steppe	3.9%	Mountain Sagebrush	*Artemisia tridentata ssp. vaseyana*
Colorado Plateau Mixed Bedrock Canyon and Tableland	10.6%	Littleleaf Mountain Mahogany	*Cercocarpus intricatus*
Rocky Mountain Gambel Oak-Mixed Montane Shrubland	4.5%	Gambel Oak	*Quercus gambelii*
Colorado Plateau Pinyon-Juniper Shrubland	6.3%	Utah Juniper	*Juniperus osteosperma*
Colorado Plateau Blackbrush-Mormon-Tea Shrubland	6.3%	Blackbrush	*Coleogyne ramosissima*
Inter-Mountain Basins Mixed Salt Desert Scrub	5.4%	Shadscale	*Atriplex confertifolia*
TOTAL AREA	66.5%		

5.4.1.2 Selection Approach

It became apparent that there was insufficient time to obtain all of the information required to apply the Coppolillo approach as defined. We submitted a request to the BLM Point of Contact for future access to a compiled database containing enough of the needed information to select species using the Coppolillo approach as defined in future REAs. For this REA, we adapted the Coppolillo approach to be applicable within the time limitations following the first workshop feedback.

Selection of landscape species is considered a structured and transparent, albeit somewhat arbitrary, approach to identification of a suite of species for assessment of ecoregional condition. The authors acknowledge that validation of this approach, or any coarse-filter approach, has not been performed, and suggest that such validation my not even be possible. As designed however, it can be a valuable approach for guiding conservation efforts. Its ultimate utility, however, depends on whether the results of the evaluations of condition of a collection of species can help inform the development of management plans.

For the purposes of the REA analyses, we propose the following operational definitions:

Habitat heterogeneity: The number of natural major ecological systems within the ecoregion that the species is known to use (SWReGAP Habitat Relationship Reports), divided by the total number of ecological systems in the ecoregion, and scaled between 0 – 1, with higher values representing greater utility as a landscape species for the REA (Prior-Magee et al. 2007).

Area requirements: A binned estimate of the approximate home-range (NatureServe) size class, scaled between 0–1 (< 1km^2 = 0, 1 – 10km^2 = 0.25, 10 – 25km^2 = 0.5, 25 – 50km^2 = 0.75, >50km^2 = 1) as recommended by Coppolillo *et al*. (2004). A binned estimate (based on SWReGAP species distribution maps) of the approximate proportion of the ecoregion used by the species (<5% = 0, 5 – 10% = 0.25, 10 – 25% = 0.5, 25 – 50% = 0.75, >50% = 1). These two measures will be summed and divided by 2 to normalize the area-requirement metric.

Vulnerability to anthropogenic disturbance: We based the vulnerability criterion on a reclassification of the Global and State ranking systems (NatureServe). A rounded G-rank of G5(or T5) was assigned "0", G4(or T4) was assigned "0.25", G3(or T3) was assigned "0.5", G2(or T2) assigned "0.75", and G1(or T1) assigned "1".State ranks were averaged and assigned scores in the same way. The vulnerability score was based on the higher of the G-rank (T-rank) and S-rank for each candidate species. The vulnerability scores were intended to reflect the status of the species within the ecoregion, from secure (0), apparently secure (0.25), vulnerable (0.5), imperiled (0.75), or critically imperiled (1.0).

Functionality: Functions are defined as (1) predation, (2) prey base, (3) seed dispersal, (4) seed predation, (5) pollination, (6) mechanical disturbance, and (7) strong competitive interactions. Species lacking a strong role for a specific function are assigned a 0, those with a clear role received a score of 1, based on best professional judgment. The function scores are summed and then divided by the maximum number of functions a species on the list received to normalize the functional score.

Socio-economic significance: The score is based on the sum of following binary characteristics: (1) a flagship species, (2) has a positive social value, (3) has a negative social value, (4) has a positive economic value, and (5) has a negative economic value, based on best professional judgment. The score ranges from 0–1, with 0 having little or no socio-economic value, and 1 having considerable socioeconomic value, scored thus: 0 = 0, 1 = 0.33, 2 = 0.66, and 3+ = 1.

The five categories of scores are summed and defined as the landscape species Aggregate Score. Species with the highest scores were considered most suitable for consideration among the suite of landscape species.

The final selection of species was based on both the aggregate score and the types of the Ecological Systems used, as noted above. The species with the highest aggregate score was selected first, followed by the species with the next highest score, which also has the least overlap in Ecological Systems (coarse filter vegetation communities) used. The process continued until all of the ecological systems were accounted for among the suite of selected landscape species. Coppolillo *et al*. (2004) suggest that we begin with 10 – 25 species, and ultimately select 4 – 6 landscape species. In our approach, we began with 25 – 30 species, with the intent to select no more than 10. Our candidate species were drawn from the species lists in the State Wildlife Action Plans and from the list of modeled vertebrates in the SWReGAP final report (Prior-Magee et al. 2007).

We found that this approach was not very suitable for the selection of aquatic species, unless they were treated separately. We opted to simplify the process and hand select likely vulnerable candidates representing the major types of aquatic ecological systems in the ecoregion. In addition, we found that riparian areas were not well represented in the final suite of selected species. We then selected a riparian obligate with the widest distribution and highest aggregate score and added it to the suite of landscape species.

5.4.1.3 Final Landscape-species Conservation Element Selections

The objective of the landscape-species selection process was to iteratively identify a small suite of species that collectively utilize all ecological systems in the ecoregion (Table 2). The full list of candidate species selected for evaluation with scores is shown in Appendix (2). The effect of the cumulative additions of species (X-axis) on the number of Ecological Systems (Y-axis) and selected threats (Y-axis) or disturbances is shown in Figure 8.

Table 2. Category and aggregate scores for selected Colorado Plateau landscape species.

SPECIES	AREA	HETEROGENEITY	VULNERABILITY	FUNCTIONALITY	SOCIO-ECONOMIC SIGNIFICANCE	SPECIES SCORE
Mountain lion	1.00	0.77	0.25	0.50	1.00	3.52
American peregrine falcon	1.00	0.57	0.75	0.50	0.40	3.22
Big free-tailed bat	1.00	0.69	0.75	0.00	0.40	2.84
Desert Bighorn sheep	0.75	0.42	0.50	0.50	0.60	2.77
Bobcat	1.00	0.55	0.00	0.50	0.60	2.65
Kit fox	0.50	0.36	0.50	1.00	0.20	2.56
Burrowing owl	0.25	0.34	0.50	1.00	0.40	2.49
Yellow-breasted chat	0.00	0.12	0.25	0.00	0.20	0.57
Razorback sucker	0.00	0.00	1.00	0.00	0.60	1.60
Colorado River cutthroat	0.00	0.00	0.50	0.00	0.40	0.90

5.5.1 Desired Species Conservation Elements

5.5.1.1 Introduction

A list of desired species conservation elements was provided by the AMT in the Statement of Work for this REA. We included these species as candidates in the landscape species selection process. If an AMT species was not selected for the limited suite of landscape species conservation elements, it was reassigned as a "desired" species conservation element. These elements will be treated and reported on separately in the REA final report summaries.

5.5.1.2 Final Desired Species Conservation Element Selections

For the Colorado Plateau, we will treat wild horses and burros as desired conservation elements. The species that will be treated as desired species conservation elements in this REA are shown in Table 3:

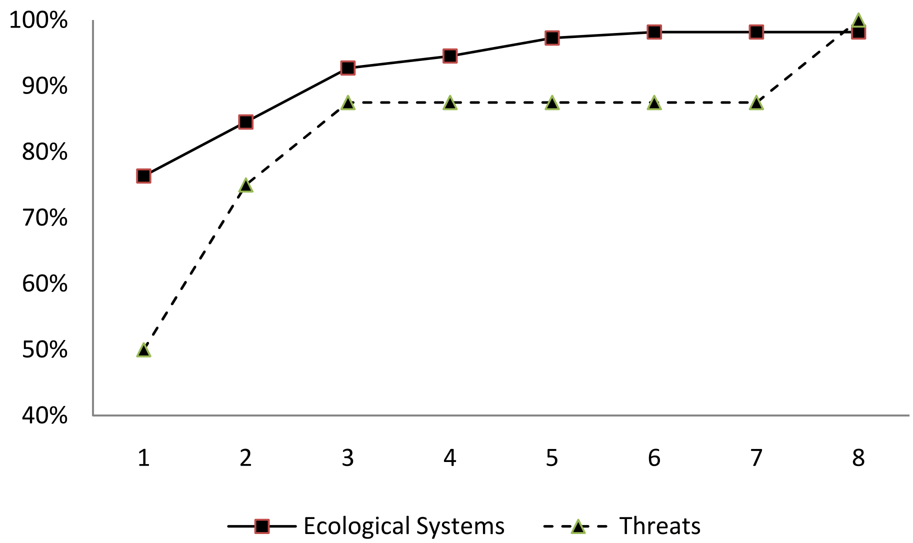

Figure 8. Cumulative numbers of Ecological Systems required and major threats encountered by the selected suite of terrestrial landscape species (Y-axis) as species were added to the suite (X-axis) for the Colorado Plateau. After Coppolillo, 2003.

5.6.1 Sites of Conservation Concern as Conservation Elements

5.6.1.1 Introduction

Vegetation, terrestrial, and aquatic species can move through space and time in response to agents of change, including climate change. Terrestrial and aquatic sites of conservation concern cannot, therefore they represent a particular challenge for management planning, and must be managed in *situ*. In all likelihood, many sites will lose the functionality for which they were designated as a result of interactions between climate change and other change agents such as fire and invasive species. In this REA, we will assess current and forecasted threats to a defined set of sites from a range of agents of change.

Table 3. Desired Species Conservation Elements for the Colorado Plateau Ecoregion evaluated using a modified version of the Coppolillo *et al*. (2004) approach (see text for details). Those that were selected as landscape species are denoted with an asterisk.

SPECIES	AREA	HETEROGENEITY	VULNERABILITY	FUNCTIONALITY	SOCIO-ECONOMIC SIGNIFICANCE	SPECIES SCORE
Golden eagle	1.00	0.45	0.25	0.50	0.60	2.80
Desert Bighorn sheep*	0.75	0.42	0.50	0.50	0.60	2.77
Gunnison sage-grouse	1.00	0.09	1.00	0.00	0.60	2.69
Kit fox*	0.50	0.36	0.50	1.00	0.20	2.56
Burrowing owl*	0.25	0.34	0.50	1.00	0.40	2.49
Gunnison's prairie dog	0.00	0.19	0.50	1.00	0.60	2.29
White-tailed prairie dog	0.00	0.12	0.50	1.00	0.60	2.22
Black-footed ferret	0.00	0.12	1.00	0.50	0.60	2.22
Greater sage-grouse	1.00	0.09	0.50	0.00	0.60	2.19
Mule deer	0.25	1.00	0.00	0.50	0.40	2.15
Mexican spotted owl	0.25	0.11	0.75	0.50	0.40	2.01
Pronghorn	1.00	0.16	0.25	0.00	0.40	1.81

5.6.1.2 Final Sites of Conservation Concern Selections

The list of sites of conservation concern which are selected are listed in Table 4. The Dynamac team suggested that the AMT consider adding an additional biodiversity indicator. We proposed that we summarize all available location data of species of concern (Federally Listed T, E, candidate species, and State Ranked G1 – G3 species in a couple of ways: by occurrence at the 5th level HUC landscape reporting unit and within a coarse grid with a resolution of 50x50 km. We would summarize this generalized diversity of species of conservation concern within various landscape reporting units (5th level HUCs and Level IV ecoregions). We intend to ensure that species are drawn from State Wildlife Action Plans and occur in at least 5% of the ecoregion in this evaluation to capture a different picture of species richness at the ecoregion scale.
Resolution: The AMT accepted this additional biodiversity conservation element and recommended that we complete one or two CEs (plant and animal) for this modeling exercise.

5.7.1 Ecosystem Functions and Services as Conservation Elements

5.7.1.1 Final Functions and Services of Conservation Concern Selections

Ecological functions and services of conservation concern selected for this REA are listed in Table 5. Soil stability was suggested during the first workshop as an important conservation element. Forage was later added as a conservation element associated with livestock grazing.

The Dynamac team proposed the inclusion of reference sites identified in EPAs EMAP-West project. These sites, representing discrete reaches and their upstream catchments, were identified in a probabilistic sampling of all streams in 12 western states (Stoddard et al. 2005). Selections of the highest quality sites sampled were selected on the basis of watershed-level disturbance and in-stream conditions identified during field reconnaissance & sampling. These sites, along with highly disturbed sites, were used to develop and calibrate indicators of biological integrity and expectations of least-disturbed condition within the waters of each ecoregion. The least-disturbed sites represent ecoregion-level reference conditions, which have intrinsic value as both aquatic and terrestrial conservation elements. We may be able to highlight the watersheds in which they are found. Alternately, we can identify all sampled watersheds, and qualitatively rank them according to the indicators of biological integrity associated with the sampled reach.

Resolution: The group accepted Dynamac's suggestion to add the EPA reference site database to the list of aquatic sites of high biodiversity.

Table 4. Sites of Conservation Concern Conservation Elements selected for the Colorado Plateau Ecoregion.

SITE CLASSES	RESOLUTION
Terrestrial Sites of High Biodiversity:	
TNC portfolio sites	ACCEPTED
NatureServe/Natural Heritage sites	ACCEPTED
Important bird areas (Audubon)	ACCEPTED
Areas recognized by Partners-In-Flight	ACCEPTED
Areas recognized by State Wildlife Action Plans	ACCEPTED
Terrestrial Sites of High Ecological and/or Cultural Value:	
Historic and Nationally Designated Trails	ACCEPTED
Wilderness Areas	ACCEPTED
Wilderness Study Areas	ACCEPTED
Historic Districts	ACCEPTED
National Wildlife Refuges	ACCEPTED
Monuments	ACCEPTED
National and State Parks	ACCEPTED
NCAs	ACCEPTED
ACECs	ACCEPTED
Forest Service Research Natural Areas	ACCEPTED
State Wildlife Management Areas	ACCEPTED
Suitable Wild and Scenic Rivers	ACCEPTED
Designated Recreation Management Areas	ACCEPTED
Sensitive Receptors with respect to air quality and smoke impacts	ACCEPTED
Aquatic Sites of High Biodiversity:	
TNC portfolio sites	ACCEPTED
NatureServe/Natural Heritage sites	ACCEPTED
Areas recognized by State Wildlife Action Plans	ACCEPTED
EMAP-West Reference Sites	**Proposed:** ACCEPTED

Table 5. Functions and Services of Conservation Concern as Conservation Elements selected for the Colorado Plateau Ecoregion.

SITE CLASSES	RESOLUTION
Terrestrial Functions of High Ecological Value:	
Soil stability	**Recommended** by USGS: ACCEPTED
Forage	**Recommended** by AMT
Surface and Subsurface Water Availability:	
Aquatic systems of streams, lakes, ponds, etc.	ACCEPTED
Springs/seeps/wetlands	ACCEPTED
Riparian areas	ACCEPTED
High quality and impaired waters	ACCEPTED
Groundwater protection zones, sole source aquifers	ACCEPTED

6. Change Agents

6.1 Introduction

The purpose of the REA is to assess the current condition of ecoregional natural resources, and to predict future condition at several time horizons. Condition or status of resources will be assessed with respect to threats posed by anthropogenic disturbances or change agents. Natural disturbance agents and cycles influence population dynamics and the status of species as an assumed backdrop to stresses imposed by anthropogenic disturbance. We have broken down these threats into general categories, including upland habitat loss (semi-permanent and permanent), riparian habitat loss, aquatic habitat loss, terrestrial habitat fragmentation, aquatic habitat fragmentation, upland habitat disturbance (transient habitat loss, stresses), riparian habitat disturbance, aquatic habitat disturbance, direct take, bioaccumulation of toxins. We chose to characterize threats first, and then assign change agents to the threat categories. The specific change agents responsible are less important that understanding the threats that they pose to the condition of vulnerable resources. The same change agent may represent a threat to one organism and a benefit to another. We have identified a set of key change agents that represent a threat to vulnerable resources in this ecoregion. We have included those identified by the AMT in the Statement of Work, as well as an additional change agent that was recommended and has been accepted following AMT review.

6.2 Final Selection of Change Agents

Table 6. Change agents selected for the Colorado Plateau Ecoregion.

CHANGE AGENTS	RESOLUTION
Wildland Fire	ACCEPTED
Invasive Species	ACCEPTED
Land and Resource Use	ACCEPTED
Urban and Roads Development	ACCEPTED
Oil, Gas, and Mining Development	ACCEPTED
Renewable Energy Development (i.e., solar, wind, geothermal, including transmission corridors)	ACCEPTED
Agriculture	ASSUMED by Dynamac
Livestock grazing (proposed by Dynamac)	**Resolution:** ACCEPTED by the AMT, but recommended inclusion of separate change agents for wild horses, burros, and wildlife.
Wild horse and burro grazing (proposed by AMT)	ACCEPTED
Wildlife grazing (proposed by AMT)	ACCEPTED
Groundwater and Surface Water Extraction, Development, and Transportation	ACCEPTED
Recreational Uses	ACCEPTED
Pollution (Air Quality)	ACCEPTED
Climate change	ACCEPTED

7. REA Output Products

The REA process is to develop a comprehensive picture of the current status and projected changes of important ecological resources, functions, and services during the next 50 years. The final products of this process will be prepared to be relevant to future analyses of Cumulative Impacts (NEPA) and Currently Affected Environment for RMPs. Several different approaches will be used in concert to characterize potential changes to these key ecological resources under near-term and long-term time scenarios. These projections will be prepared to inform decisions on proposed land use allocations and the potential cumulative impacts associated with these proposed allocations. One additional objective is to help identify both on- and off-site opportunities for mitigating potential impacts of land use allocation changes.

REA output products are the primary outputs of ecoregional analysis; they are used to summarize landscape status and potential for change for tabulation and display. Output products may be generated for any specific conservation element or change agent. Output products for specific conservation elements and change agents will be characterized in two categories: status products and potential for change products.

STATUS PRODUCTS

- Status is characterized by attributes and indicators for:
  - Size (e.g., magnitude, proportion, density),
  - Condition (i.e., quality),
  - Landscape Context (i.e., relationship to surrounding landscape), and
  - Trend (i.e., current change with no additional [i.e., future] change agent forcing.)

POTENTIAL FOR CHANGE PRODUCTS

- Potential for change is characterized by attributes and indicators for:
  - Direction of change (i.e., increasing/decreasing),
  - Magnitude or scope of change,
  - Likelihood of change, and
  - Certainty of change.

REPORTING UNITS OF MEASURE

Categorical information depicting attributes is used to tabulate and display REA output products. Although actual numerical measurements and/or model outputs may be available for some conservation elements/change agents, thresholds are set to categorize all data into standard reporting categories. During review of the Draft Memorandum, a comment was made regarding units of measure. There was concern that the labels might be misleading, and that a clear understanding is needed for the condition status as related to the each conservation element. This was a very good point, and it relates back to the discussion of development of indicators of biological integrity (Section 4.1). It will be extremely important to base condition of conservation elements on a standardized measure away from some point of reference. No two organisms respond in the same way to a specific disturbance or stress.

- Categorical information is the primary information type tabulated and displayed (on maps) for the output products of ecological integrity, status, and potential for change.
- Categories are established by setting thresholds delineating the acceptable range of variation for attributes/indicators.
- Descriptive attribute/indicator categories include (but are not limited to):
  - Poor – Fair – Good – Very Good – Unknown – None/NA
  - Low/none – Moderate – High – Very High – Unknown
  - Present – Absent – Unknown

The descriptive categories are intended to facilitate presentation of complex findings in a simplified manner. Operational definitions for categories will be provided to aid in interpretation and future comparisons.

8. SUMMARY

The selections of management questions, conservation elements, and change agents described in this memorandum represent the end product of several review processes. We were provided with a set of core questions, conservation elements, and change agents by the AMT. The final selection represents a constructive and iterative process involving AMT guidance, clarifications, feedback at the first workshop, and peer review. The selection of questions, conservation elements, and change agents during this step of the REA were meant to represent desired information regarding present and future status of resources within this ecoregion. We fully anticipate that there will be further refinement of questions and possible attrition as we proceed through the next several stages of this process. Attrition may be related to data gaps or lack of appropriate approaches, methods, or tools needed to answer questions within the time frame of the REA. The next stage will involve identification and evaluation of data required to address each management question. Following that will be an assessment of approaches, methods, and tools required to address these questions.

During the first stage of this REA, our objective was to characterize the major ecological components of the ecoregion, the threats or stressors to those components, and the change agents responsible for those threats or stresses. We constructed a simplified model of the general relationships between these elements, reviewed the management questions provided by the AMT, revised or suggested additional questions, identified the important agents of change within the ecoregion, and selected a suite of conservation elements upon which to base our assessment of natural resource conditions within the ecoregion. We identified a set of coarse-filter Ecological Systems and a list of landscape species to assess condition of the landscape with respect to specific habitat and life history needs. Some conservation elements must be managed in place, such as sites of ecological value. We identified a suite of sites to evaluate. Many of these sites may lose the reason for their establishment as a result of disturbance associated with climate change. We also selected a set of desired species, those which were identified by the AMT, but which did not make it on to the landscape species list. These will be the evaluated in a separate set of assessments. Lastly, we identified a set of major agents of change which represent a range of threats to resources of conservation concern. Collectively, the assessments will provide a means to establish baseline condition for a suite of important resources in the Colorado Plateau ecoregion. This baseline condition will be used to characterize the potential trends in resource condition in the coming years, both in the near-term as a consequence of development activities and the spread of invasive species, and in the long-term, as a result of climate change.

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APPENDIX 1. Coarse-Filter Ecological System Selections

Coarse Filter Ecological System Conservation Elements for the Colorado Plateau (*note: ecoregion inclusions are included*).

FOREST & WOODLAND CLASSES (31.2%)		
Percent of Ecoregion	Code	Ecological System
3.13%	S023	Rocky Mountain Aspen Forest and Woodland
0.01%	S024	Rocky Mountain Bigtooth Maple Ravine Woodland
0.00%	S025	Rocky Mountain Subalpine-Montane Limber-Bristlecone Pine Woodland
1.50%	S028	Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland
0.66%	S030	Rocky Mountain Subalpine Mesic Spruce-Fir Forest and Woodland
0.47%	S031	Rocky Mountain Lodgepole Pine Forest
0.85%	S032	Rocky Mountain Montane Dry-Mesic Mixed Conifer Forest and Woodland
0.61%	S034	Rocky Mountain Montane Mesic Mixed Conifer Forest and Woodland
2.55%	S036	Rocky Mountain Ponderosa Pine Woodland
0.01%	S038	Southern Rocky Mountain Pinyon-Juniper Woodland
20.39%	S039	Colorado Plateau Pinyon-Juniper Woodland
0.35%	S040	Great Basin Pinyon-Juniper Woodland
0.67%	S042	Inter-Mountain West Aspen-Mixed Conifer Forest and Woodland Complex

Coarse Filter Ecological System Conservation Elements for the Colorado Plateau (*note: ecoregion inclusions are included*). (continued…)

SHROUB / SCRUB CLASSES (37.3%)		
Percent of Ecoregion	Code	Ecological System
0.04%	S043	Rocky Mountain Alpine Dwarf-Shrubland
2.03%	S045	Inter-Mountain Basins Mat Saltbush Shrubland
4.49%	S046	Rocky Mountain Gambel Oak-Mixed Montane Shrubland
0.66%	S047	Rocky Mountain Lower Montane-Foothill Shrubland
0.02%	S050	Inter-Mountain Basins Mountain Mahogany Woodland and Shrubland
6.34%	S052	Colorado Plateau Pinyon-Juniper Shrubland
9.14%	S054	Inter-Mountain Basins Big Sagebrush Shrubland
0.00%	S055	Great Basin Xeric Mixed Sagebrush Shrubland
0.68%	S056	Colorado Plateau Mixed Low Sagebrush Shrubland
0.19%	S057	Mogollon Chaparral
6.32%	S059	Colorado Plateau Blackbrush-Mormon-tea Shrubland
0.13%	S060	Mojave Mid-Elevation Mixed Desert Scrub
5.37%	S065	Inter-Mountain Basins Mixed Salt Desert Scrub
0.23%	S069	Sonora-Mojave Creosotebush-White Bursage Desert Scrub
0.00%	S070	Sonora-Mojave Mixed Salt Desert Scrub
0.01%	S128	Wyoming Basins Low Sagebrush Shrubland
1.06%	S136	Southern Colorado Plateau Sand Shrubland

Coarse Filter Ecological System Conservation Elements for the Colorado Plateau (*note: ecoregion inclusions are included*). (continued…)

GRASSLANDS (9.1%)		
Percent of Ecoregion	Code	Ecological System
0.15%	S081	Rocky Mountain Dry Tundra
0.35%	S083	Rocky Mountain Subalpine Mesic Meadow
0.26%	S085	Southern Rocky Mountain Montane-Subalpine Grassland
1.71%	S090	Inter-Mountain Basins Semi-Desert Grassland
3.91%	S071	Inter-Mountain Basins Montane Sagebrush Steppe
0.13%	S075	Inter-Mountain Basins Juniper Savanna
0.00%	S078	Inter-Mountain Basins Big Sagebrush Steppe
2.57%	S079	Inter-Mountain Basins Semi-Desert Shrub Steppe

WOODY WETLAND & RIPARIAN CLASSES (2.4%)		
Percent of Ecoregion	Code	Ecological System
0.00%	S014	Inter-Mountain Basins Wash
0.00%	S020	North American Warm Desert Wash
0.11%	S091	Rocky Mountain Subalpine-Montane Riparian Shrubland
0.00%	S092	Rocky Mountain Subalpine-Montane Riparian Woodland
0.49%	S093	Rocky Mountain Lower Montane Riparian Woodland and Shrubland
0.00%	S094	North American Warm Desert Lower Montane Riparian Woodland and Shrubland
1.79%	S096	Inter-Mountain Basins Greasewood Flat
0.01%	S097	North American Warm Desert Riparian Woodland and Shrubland
0.00%	S098	North American Warm Desert Riparian Mesquite Bosque
0.00%	S118	Great Basin Foothill and Lower Montane Riparian Woodland and Shrubland

EMERGENT HERBACEOUS WETLAND CLASSES (0.2%)		
Percent of Ecoregion	Code	Ecological System
0.01%	S100	North American Arid West Emergent Marsh
0.20%	S102	Rocky Mountain Alpine-Montane Wet Meadow

Coarse Filter Ecological System Conservation Elements for the Colorado Plateau (ecoregion inclusions are included). (continued…)

SPARSELY VEGETATED / BARREN CLASSES (13.8%)		
Percent of Ecoregion	Code	Ecological System
0.00%	S001	North American Alpine Ice Field
0.35%	S002	Rocky Mountain Alpine Bedrock and Scree
0.09%	S004	Rocky Mountain Alpine Fell-Field
0.61%	S006	Rocky Mountain Cliff and Canyon
0.00%	S009	Inter-Mountain Basins Cliff and Canyon
10.55%	S010	Colorado Plateau Mixed Bedrock Canyon and Tableland
1.17%	S011	Inter-Mountain Basins Shale Badland
0.86%	S012	Inter-Mountain Basins Active and Stabilized Dune
0.08%	S013	Inter-Mountain Basins Volcanic Rock and Cinder Land
0.02%	S016	North American Warm Desert Bedrock Cliff and Outcrop
0.01%	S019	North American Warm Desert Volcanic Rockland
0.05%	N31	Barren Lands, Non-specific
0.00%	S015	Inter-Mountain Basins Playa
0.00%	S022	North American Warm Desert Playa

OPEN WATER (0.7%)		
Percent of ecoregion	Code	Ecological System
0.71%	N11	Open Water

CRYPTOGAMIC CRUST		
Cryptogamic crust	NA	Ecological system (proposed and accepted)

Classes adapted from:

Lowry, J. H, Jr., R. D. Ramsey, K. Boykin, D. Bradford, P. Comer, S. Falzarano, W. Kepner, J. Kirby, L. Langs, J. Prior-Magee, G. Manis, L. O’Brien, T. Sajwaj, K. A. Thomas, W. Rieth, S. Schrader, D. Schrupp, K. Schulz, B. Thompson, C. Velasquez, C. Wallace, E. Waller and B. Wolk. 2005. *Southwest Regional Gap Analysis Project: Final Report on Land Cover Mapping Methods*, RS/GIS Laboratory, Utah State University, Logan, Utah.

APPENDIX 2. Candidate Landscape Species Selections and Scores

SPECIES	SCIENTIFIC NAME	AREA	HETEROGENEITY	VULNERABILITY	FUNCTIONALITY	SOCIO-ECONOMIC SIGNIFICANCE	SPECIES SCORE
Mountain lion	*Puma concolor*	1.00	0.77	0.25	0.50	1.00	3.52
American peregrine falcon	*Falco peregrinus*	1.00	0.57	0.75	0.50	0.40	3.22
Big free-tailed bat	*Nyctinomops macrotis*	1.00	0.69	0.75	0.00	0.40	2.84
Golden eagle	*Aquila chrysaetos*	1.00	0.45	0.25	0.50	0.60	2.80
Bighorn sheep	*Ovis canadensis*	0.75	0.42	0.50	0.50	0.60	2.77
Gunnison sage-grouse	*Centrocercus minimus*	1.00	0.09	1.00	0.00	0.60	2.69
Bobcat	*Lynx rufus*	1.00	0.55	0.00	0.50	0.60	2.65
Kit fox	*Vulpes macrotis*	0.50	0.36	0.50	1.00	0.20	2.56
Burrowing owl	*Athene cunicularia*	0.25	0.34	0.50	1.00	0.40	2.49
Gunnison's prairie dog	*Cynomys gunnisoni*	0.00	0.19	0.50	1.00	0.60	2.29
White-tailed prairie dog	*Cynomys leucurus*	0.00	0.12	0.50	1.00	0.60	2.22
Black-footed ferret	*Mustela nigripes*	0.00	0.12	1.00	0.50	0.60	2.22
Greater sage-grouse	*Centrocercus urophasianus*	1.00	0.09	0.50	0.00	0.60	2.19
Mule deer	*Odocoileus hemionus*	0.25	1.00	0.00	0.50	0.40	2.15
Pinyon jay	*Gymnorhinus cyanocephalus*	0.25	0.22	0.25	1.00	0.40	2.12
Mexican spotted owl	*Strix occidentalis lucida*	0.25	0.11	0.75	0.50	0.40	2.01
Pronghorn	*Antilocapra americana*	1.00	0.16	0.25	0.00	0.40	1.81
Southwestern willow flycatcher	*Empidonax traillii extimus*	0.00	0.12	1.00	0.00	0.60	1.72
Razorback sucker	*Xyrauchen texanus*	0.00	0.00	1.00	0.00	0.60	1.60
Canyon treefrog	*Hyla arenicolor*	0.00	0.00	0.50	0.50	0.20	1.20
Arizona toad	*Bufo microscaphus*	0.00	0.04	0.75	0.00	0.40	1.19
White-tailed jackrabbit	*Lepus townsendii*	0.00	0.17	0.25	0.50	0.20	1.12
Sage sparrow	*Amphispiza belli*	0.00	0.41	0.50	0.00	0.20	1.11

APPENDIX 2. Candidate Landscape Species Selections and Scores (continued)

SPECIES	SCIENTIFIC NAME	AREA	HETEROGENEITY	VULNERABILITY	FUNCTIONALITY	SOCIO-ECONOMIC SIGNIFICANCE	SPECIES SCORE
Olive-sided flycatcher	*Contopus cooperi*	0.00	0.22	0.50	0.00	0.20	0.92
Colorado River cutthroat	*Oncorhynchus clarkii pleuriticus*	0.00	0.00	0.50	0.00	0.40	0.90
Northern leopard frog	*Rana pipiens*	0.00	0.10	0.50	0.00	0.20	0.80
Black-throated sparrow	*Amphispiza bilineata*	0.00	0.23	0.25	0.00	0.20	0.68
Yellow-breasted chat	*Icteria virens*	0.00	0.12	0.25	0.00	0.20	0.57
Sage thrasher	*Oreoscoptes montanus*	0.00	0.36	0.00	0.00	0.20	0.56
Juniper titmouse	*Baeolophus ridgwayi*	0.00	0.17	0.00	0.00	0.20	0.37

APPENDIX 3. The Relationship Between Threats (Stressors) and Change Agents

THREATS	CHANGE AGENTS
Upland habitat loss	Wildland fire (increased ignition frequency, increased severity, decreased frequency due to suppression), invasive species displacement of native vegetation (cheatgrass), land use change (urban, low-density residential, roads, infrastructure (e.g., powerlines), energy development, agriculture, timber harvest, overgrazing, etc..
Riparian habitat loss	Wildland fire, invasive species displacement of native vegetation(tamarisk), land use change (urban, low-density residential, roads, infrastructure (e.g., powerlines), energy development, agriculture, timber harvest, overgrazing, etc..
Aquatic habitat loss	Removal of riparian vegetation, channelization, water diversions, dams, water withdrawls, sedimentation, non-point source pollution, changes in flow, temperature, and sediment regimes, fragmentation of natural movements (culverts, low head dams), etc..
Terrestrial habitat fragmentation	Increased road density, agriculture, development, OHV use, logging, chaining, unnatural changes in characteristic disturbance regimes through fire suppression, increased fire frequency, etc..
Aquatic habitat fragmentation	Removal of riparian vegetation, channelization, water diversions, dams, water withdrawls, sedimentation, changes in flow, temperature, and sediment regimes, fragmentation of natural movements (culverts, low head dams), etc..
Upland habitat disturbance	Proximity to human infrastructure (urban, development, agriculture, roads, powerlines, etc.), and human land use activities (OHV use, livestock grazing, etc.), invasive species encroachment
Riparian habitat disturbance	Proximity to human infrastructure (urban, development, agriculture, roads, powerlines, etc.), and human land use activities (OHV use, livestock grazing, hunting, fishing, firewood removal, etc.), receipt of NPS pollution from activities associated with adjacent human-changed landcover/land use.
Aquatic habitat disturbance	Pollutants from human activities (point source & non-point source), changes in characteristic thermal, flow, sediment, O2, and sediment regimes. Boating, fishing, invasive aquatics (plant, animal)
Direct take	Hunting, fishing, trapping, poisoning, road kill, dam turbine kill, wind generator kill.
Bioaccumulation of toxins	Pollutants from a range of sources concentrating up trophic levels, causing mortality, reproductive failure, etc.