Colorado Plateau

Rapid Ecoregional Assessment

Final Workplan I-4-a

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1 INTRODUCTION

1.1 Rapid Ecological Assessment (REA) Approach

Rapid Ecological Assessments (REAs) are a product of the BLM's evolution toward a landscape approach to land management. The broad regional extent of the landscape approach addresses issues that transcend administrative boundaries, such as renewable energy development, the spread of invasive species, and projected climate change. Using the landscape approach, the BLM hopes to integrate available scientific data and information from BLM field offices, other federal and state agencies, and public stakeholders to develop shared responses and collaborative management efforts across administrative boundaries. The data collected for the REAs will comprise a baseline from which to evaluate the results of adaptive management.

A central purpose of the Colorado Plateau Rapid Ecological Assessment is to document the current status of selected ecological resources (conservation elements) at the ecoregional scale and to investigate how this status may change over several future time horizons. REA assessments are expected to identify areas with high ecological integrity and elements of high biological and ecological value—conservation areas, biological hotspots, and wildlife corridors—to provide a better understanding of key ecosystem processes and potential impacts of future changes. REAs do not involve original research, but they use existing data, modeling, and GIS analyses to answer a broad range of management questions. REAs are timely in supporting planning, management, and mitigation strategies for impacts anticipated from various climate change scenarios. Intensive data collection required to conduct an REA will also reveal knowledge gaps and highlight areas for future ecosystem monitoring and research.

1.2 Overview of Rapid Ecological Assessment Workplan

The REA Workplan provides guidance and plans workflow for Phase II, the assessment and reporting phase of the REA. Three tasks that were prerequisite to the development of this REA Workplan comprised Phase I: Task 1) the selection of management questions and conservation elements; Task 2) the collection and evaluation of data layers necessary to conduct the assessment; and Task 3) the recommended approach to analyses, i.e., methods, models, and tools.

The Workplan begins with an overview of Tasks 1–3 and the major decisions and resolutions reached by the Assessment Management Team (AMT), USGS peer reviewers, and participants at the first three workshops. The Task 1–3 overview documents the group's acceptance of final management questions, conservation elements, and change agents to be assessed (Appendices 1–9) in addition to general modeling approaches. Sections 2.4.6–2.4.9 summarize sections of Memo 3 that were added to the final version. We included these sections in the workplan to provide an opportunity for discussion and comment during Workshop 4.

The second portion of the Workplan focuses on the workflow, timelines, and products to be produced in Phase II. We discuss workflow and timelines (Section 3) with the aid of 2 Gantt charts and present a rolling review process for reviewers to comment on output products. Project tracking tables (Section 2.3 and Appendix 10) provides a listing of datasets, models and methods, and output products related to and addressing each management question.

2 REA PHASE I TASKS COMPLETED

2.1 Review of Task I-1: Management Questions and Conservation Elements

The full Colorado Plateau Task 1 Memorandum I-1-c may be found at the BLM Programs Rapid Ecoregional Assessments website: http://www.blm.gov/wo/st/en/prog/more/climatechange/reas.html.

2.1.1 Task 1 Objectives

The objectives of the first task of the REA were to identify the subjects of the assessment, develop a basic ecoregional model, and produce a finalized list of ecoregion-specific management questions. The REA will assess the current status and future condition of the ecoregion's natural resources 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., soil stability) of regional significance in major ecosystems and habitats across the level III ecoregion. This limited collection of conservation elements represents all renewable resources and values within the ecoregion and serves as a surrogate 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- or least-disturbed *reference condition* and thus depart from a state of ecological or biological integrity (Frey 1977, Karr and Dudley 1981).

2.1.2 REA Reporting Units

The REA will be conducted within the boundaries of the Colorado Plateau ecoregion and a perimeter 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 ecoregions and to avoid problems associated with "edge effects" during GIS analyses.

Assessment data will be summarized and displayed in landscape reporting units. Reporting units organize data into categories to reveal meaningful patterns. Two landscape reporting units—30m pixels for raster data and 5th level hydrologic units (HUCs)—were identified in the REA Statement of Work (SOW). The Dynamac team suggested several other reporting units:

- Omernik Level IV ecoregions, a finer resolution subdivision of the level III Colorado Plateau ecoregion (Omernik 1995).
- Major aquifer boundaries.
- A unit that represents the resolution of the 15 km climate data that will be used in the REA.

Resolution: The AMT and the group at Workshop 1 (August 9, 2010) accepted the five reporting units. However, in the months that followed the status of the reporting units evolved. Most of the groundwater questions have been removed from the list of management questions making the use of major aquifer boundaries as reporting units unnecessary. In addition the climate modeling will be done at a finer resolution of 4 km.

2.1.3 Ecoregional Conceptual Model

Conceptual models help to visualize the factors that affect, both positively and negatively, the current and future condition of resources of conservation concern and to define the relationships between conservation elements and associated change agents. The expression of known relationships in conceptual models forms the basis for the development of management questions and the selection of associated data layers and analyses. The basic ecoregional conceptual model (Appendix 1) serves as the source for more detailed conceptual sub-models that accompany the data needs assessment and the methods modules in subsequent task memos 2 and 3. The basic ecoregional conceptual model portrays the ecoregion under the influence of natural drivers (representing a condition of ecological integrity) and anthropogenic stressors and associated change agents (representing the gradient of human disturbances) affecting Colorado Plateau landscapes and biota.

2.1.4 Management Questions

The AMT provided a list of core management questions in the SOW to guide the assessment process. Part of the challenge of this first REA was to gauge the time and resource requirements needed to address the full complement of management questions. The Dynamac team evaluated each question to determine whether they could be feasibly answered during the short timeframe of the REA. We examined each question and determined the type of data required and the probable approaches and methods that could be used. Participants at Workshop 1 (August 2010) helped to refine or delete various management questions and agreed to a revised set of management questions.

However, throughout the period of Tasks 1–3, the Dynamac team and others questioned the ability to answer various management questions because of their complexity (e.g., groundwater questions), redundancy, imprecise wording, or a suspected lack of data or approaches to fit within the constraints of a rapid assessment. In mid-January 2011, USGS peer reviewers met to evaluate the wording and feasibility of the full set of management questions.

Resolution: Following USGS review and discussion by the AMT, USGS, and Dynamac staff, a number of management questions were modified or deleted, reducing the original number (about 57) to 44 management questions (March 17, 2011, Appendix 2).

2.1.5 Conservation Elements

At Workshop 1, the debate over the initial selection of wildlife species conservation elements centered on the selection process itself, the rationale for inclusion of vulnerable species, and the mixing of vulnerable species and species managed for game. BLM guidance after the workshop suggested that conservation elements include 1) Ecological Systems (vegetation communities) as coarse filters; 2) sensitive species representing fine filters (presented as a richness map and described as species diversity hotspots under the category of sites of terrestrial conservation concern below); 3) a selection of dominant plant species from the top eight classes of vegetation communities; 4) a selection of up to a dozen landscape wildlife species; and 5) a set of desired species (the initial list of species of concern presented in the SOW) identified by the AMT. In addition, a range of terrestrial and aquatic sites and ecological services and functions (such as soil stability) were included as conservation elements.

Coarse Filter Conservation Elements. Coarse filter conservation elements represent characteristic vegetation assemblages occurring within the ecoregion. For this REA, the Dynamac team chose to use the vegetation types defined in the SW ReGAP project (Prior-Magee et al. 2007). We elected to include all Ecological Systems present in the ecoregion to serve as coarse filters, rather than solely those occupying a large fraction of the landscape, since some of the smaller vegetation classes have importance as habitat disproportionate to their area (Appendix 3). 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.

Dynamac proposed that the AMT add an additional conservation element that provides critical ecosystem functionality in arid regions, cryptogamic or biological soil crusts. Soil crust is a useful indicator of arid ecoregion condition. This important component of arid 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.

Resolution: After Workshop 1, participants agreed to include biological soil crust as a conservation element pending the acquisition of data. Following Workshop 3 (January 2011), USGS proposed modeling soil crust in the Colorado Plateau ecoregion; BLM accepted, and the Dynamac team provided more complete SSURGO soil data coverage to USGS (Matt Bowker) to facilitate the crust modeling.

Fine Filter Species and Dominant Plant Species Conservation Elements. A species richness map for special status species will capture fine-filter special status species by 5th level HUC (see Biodiversity, page 5). In addition, several of the wildlife species conservation elements can serve as fine filters because they have conservation status. Following Workshop 1, the AMT suggested that Dynamac identify a dominant plant species associated with each of the principle Ecological Systems in the Colorado Plateau because no plant species had been identified as conservation elements and because individual plant species are often used in climate change modeling. The Dynamac team will characterize the current distribution of these species and their vulnerability to change agents, including predicted vulnerability associated with climate change. To select the plant species, we identified dominant overstory species and selected a single species from each Ecological System. Eight species represent 66.5% of the landscape in the Colorado Plateau ecoregion (Appendix 4).

Wildlife Species Conservation Elements: Landscape Species and Desired Species. Following Workshop 1, the AMT recommended using the approach of Coppolillo et al. (2004) for the selection of wildlife species conservation elements. The AMT requested that we include the core desired species that they had identified in the initial SOW in the list of candidate species to be screened as landscape species. The Dynamac team used the basic structure of the Coppolillo approach and redefined some of the component scoring procedures (see Memo1, Section 5.4.1.2 for scoring criteria). We then selected a set of 25–30 species from the State Wildlife Action Plan lists and the SW ReGAP list, as well as the core species identified in the SOW by the AMT, and proceeded to score each species.

Resolution: Following Workshop 1, the AMT recommended an alternate approach (Coppolillo et al. 2004) for the selection of landscape wildlife species. The Dynamac team used the Coppolillo approach (Coppolillo et al. 2004) to screen a selection of candidate species (Appendix 2, Memo 1) and select a final group of landscape species (Appendix 5 this document).

Those core species identified by the AMT in the Statement of Work for this REA that failed to score high enough to be selected in the landscape species screening were reserved as *desired species conservation elements* (Appendix 6) to be reported on separately in the REA final report summaries. We will also treat wild horses and burros as desired species conservation elements. Both core and desired species will be used for summary status assessment.

Participants in the REA process continued to suggest additional wildlife species of unrepresented taxa or habitats throughout Tasks 1, 2, and 3. AMT guidance during and following Workshop 2 (October 27 and 28, 2010) indicated that wildlife species conservation elements may be considered for inclusion throughout the Pre-Assessment phase. USGS review comments following Workshop 2 suggested that species selection should focus on identifying species that are vulnerable to change agents. The Dynamac team agreed that the selection of disturbance-sensitive species will provide the best representation of status and condition at the ecoregional level with respect to habitat alteration, displacement, and human stressors.

Resolution: At Workshop 2, the AMT and workshop participants agreed to delete the bobcat and kit fox from the list of core wildlife species and to add the flannelmouth sucker (*Catostomus latipinnis*), a representative of mid-elevation streams, and the ferruginous hawk (*Buteo regalis),* a sensitive raptor and associate species of prairie dog towns (one of the Colorado Plateau REA major species assemblages).

Sites of Conservation Concern. All of the terrestrial and aquatic sites of conservation concern initially proposed by the AMT were accepted at Workshop 1 (Appendix 7). Dynamac will assess current and forecasted threats to the sites of conservation concern from a range of change agents.

The Dynamac team also proposed the inclusion of reference sites identified in the Environmental Protection Agency's EMAP-West stream survey (conducted 2000–2004, Stoddard et al. 2005). The least-disturbed sites represent ecoregion-level reference conditions, which have intrinsic value as both aquatic and terrestrial conservation elements. We will qualitatively rank the sampled watersheds according to the indicators of biological integrity associated with the sampled reach. The AMT and workshop participants accepted Dynamac's suggestion to add the EPA reference site database to the list of aquatic sites of conservation concern.

Resolution: Following Workshop 2 (October 2010), Natural Heritage sites and sites noted in State Wildlife Action Plans were deleted from the list of Sites of Conservation Concern because of a lack of mappable data.

Biodiversity. To address ecoregional biodiversity, the AMT indicated that Dynamac will receive G1–G2 species plus threatened and endangered species occurrence data generalized to the level of the 5^{th} level hydrologic units (HUCs), one of the landscape reporting units specified in the REA Statement of Work. The BLM acquired this generalized species-of-concern richness-summary map layer from NatureServe representing data available from State Natural Heritage Programs. We have the option of organizing subsets of these data in different ways to include biodiversity hotspots and endemics. The BLM accepted this coarse expression of the species data because of the prohibitive costs associated with acquiring spatially-explicit occurrence data as well as concerns about mapping detailed occurrences for vulnerable species.

Resolution: BLM received the species richness map from NatureServe in late March, 2011.

Ecosystem Functions and Services as Conservation Elements. Ecological functions and services of conservation concern include surface and ground waters and riparian zones (Appendix 8). Soil stability was suggested as an additional terrestrial function at the first workshop. Forage was recommended by the AMT and added as a conservation element.

Resolution: 1.) Soil stability was accepted as a conservation element at the first workshop. 2.) Following Workshop 3 (January 24 and 25, 2011), the AMT reduced the number of management questions related to forage to one related to the effects of climate change on forage resources.

Change Agents. An assessment of the status of conservation elements must be conducted with reference to both natural and anthropogenic disturbance factors. The concept of reference condition subsumes natural disturbance dynamics and the full range of potential natural successional trajectories and states. Human disturbances represent the change agents of interest in the REA process, although the same change agent may represent a threat to one organism and a benefit to another. The Dynamac team 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, grazing, for AMT consideration (Appendix 9). After group discussion at the first workshop and subsequent AMT direction, grazing was accepted as a change agent if it included grazing by all herbivores, i.e., wildlife, wild horses and burros, and livestock.

Resolution: After Workshop 3, BLM deferred several management questions related to grazing and directed the contractor to limit the grazing management questions to vulnerability of HMAs and allotments (or sub-allotments, if possible) to the effect of change agents (especially climate change).

2.1.6 Literature Cited

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2.2 Review of Task I-2: Data Identification and Evaluation

The full Colorado Plateau Task 2 Memorandum I-2-c, Data Identification and Evaluation (with all of the conceptual models and data needs, data evaluation, and data gaps tables included) is located at the BLM Programs Rapid Ecoregional Assessments website:
http://www.blm.gov/wo/st/en/prog/more/climatechange/reas.html .

2.2.1 Task 2 Objectives

The objectives of Task 2 were to identify, evaluate, and ultimately recommend datasets required to assess the current status of the collection of ecological systems, species, sites, and ecological function and service conservation elements selected during Task 1and to forecast changes in status of these elements at two future time horizons: 2020 and 2060.

In this second stage of the REA process, the Dynamac team conducted a data needs assessment, located and identified extant data layers from a variety of sources for consideration, identified data gaps, and solicited additional data layers from Workshop 2 participants (October 27 and 28, 2010). Data acquisition and evaluation is an ongoing and iterative process; the results of Workshop 2 and the accompanying memo marked the beginning of a data identification process that will continue throughout Work Plan preparation and beyond. Additional data may be found or offered or additional data needs may arise with the inspection and approval of approaches and methods during Tasks 3 and 4 as well as during the review process.

2.2.2 Data Needs Assessment

To identify general data needs to address specific management questions, the Dynamac team grouped management questions into subject classes. Using a conceptual model of conservation elements, change agents, and influential processes as a guide, we identified data layers needed to address each question within the management question group. A tentative analysis approach was linked to each management question to provide a rationale for the related data needs assessment. We organized the results of the data needs assessment into sets of tables for each group of related management questions.

2.2.3 Conceptual Models (Memo 2, Section 3.2, Data Needs by Management Question Group)

The focus of Task 2 was data and data acquisition; the conceptual models illustrate the mechanisms and relationships that assisted Dynamac staff in the data needs evaluation. The conceptual models presented in Task 2 are stressor models illustrating the mechanisms and pathways of the sources of stress and the key, typical, or known responses of ecosystem attributes (conservation elements). The Dynamac team planned to approach the conceptual models with a strategy of increasing detail and documentation with each iteration of the Pre-Assessment from the broad scale basic ecoregion model developed during Task 1 to the detailed models that accompany the modeling and mapping approaches in Task 3. The conceptual models developed for Task 2 are at an intermediate level of detail and resolution and they pertain to classes of management questions.

2.2.4 Data Identification and Evaluation

Data identification and evaluation is a continuation of the process that began with the review and evaluation of the lists of management questions provided by the AMT during Task 1. The object of the data evaluation stage is to match potential data layers with identified data needs and to assess the utility of the datasets to map key attributes of conservation elements and address classes of management questions.

The linear nature of tasks and deliverables complicated the data search, since the needed data is largely dependent on the methods to be used, and the methods were not identified until Task I-3. The large number of acquired datasets to evaluate delayed the selection of a final set of useful data layers to address the groups of management questions. Including the required and recommended datasets listed by BLM, several hundred candidate data layers were acquired before Workshop 2. The SOW called for each dataset to be evaluated according to 11 quality criteria listed in the Data Management Plan (for example, criteria such as spatial accuracy, thematic accuracy, and precision) and given a confidence score to aid in choosing the optimum data layer in each thematic class. During the data evaluation process, the Dynamac team also noted major data gaps in a series of tables to help focus the discussion for Workshop 2 participants. Some of these gaps have been filled since Workshop 2.

Resolution: About 70 data layers were acquired from or by suggestion of workshop participants following Workshop 2. We are still receiving data on a regular basis. In this workplan, we have taken the data organization another step further to begin to assign the data layers to particular management questions and associated individual modeling approaches.

Resolution: On March 31, 2011, the Dynamac team delivered an Access database to BLM that organized the data acquired up to Workshop 2 (October 18, 2010) and that is queryable by management question.

Resolution: Because almost 400 data layers were sought and acquired by the Dynamac team before Workshop 2, it became apparent that completion of the data identification and evaluation step was not realistic within the time and level-of-effort constraints inherent in the REA process. As a result, the AMT agreed to extend the data identification and evaluation stage through Task 3 and 4 of the REA and to delay the formal evaluation of data layers until they were formally accepted for each modeling effort. Memo I-2-c therefore represents a status report of data evaluations conducted through 18 October, 2010. During Task 3, BLM Data Management suggested that the datasets may be evaluated using a narrative justification to expedite the evaluation process.

Data Evaluation Discussion Following Workshop 4. At Workshop 4 (April 21, 2011), the Dynamac team presented the results of a revised narrative data evaluation that inserted a narrative statement for each of the 11 data quality criteria. BLM Data Management accepted the revised approach, however, the Dynamac team felt that it was no faster than the original approach suspended in October 2010. The Dynamac team and BLM agreed to a further revision of the process during discussions following Workshop 4 that requires a narrative explanation only for criteria that express limitations in a particular dataset. All agreed that this approach would relay the necessary information on data layer limitations and allow maximum efficiency to evaluate several hundred data layers.

Data Quality Discussion Presented at Workshop 4. The Dynamac team presented an example of a state line effect between Utah and Colorado in mule deer distribution data. Participants debated how such data issues should be handled in a rapid assessment that will produce hundreds of models and maps. Would the lines be revised on a case-by-case basis through discussion with experts or would a statement of uncertainty be enough to warn the user?

Resolution: Participants at Workshop 4 settled on a three-step approach to similar data-related mapping issues: 1.) try to resolve the issue with expert input and revision of map polygons: 2.) flag the area to indicate those portions of the map that are acceptable and those that are suspect; 3.) use the SW ReGAP model (that tends to be an overestimate).

2.3 Overview of Work Effort: Project Tracking Tables

The Project Tracking Tables (Appendix 10) provide an overview of the modeling effort for Phase II of the REA and track the components and output products. The tables are organized by management questions as well as by conservation element and change agent. The project tracking tables include:

- Listing of all management questions;
- Processing status;
- Conceptual models used for each conservation element and change agent;
- List and sources of datasets to be used to address various management questions
- Modeling tools;
- Process model to address each management question; and
- Output products for each management question

The tables are presented here with the review of Task 3, Methods, Models and Tools, because the tables record and display examples of the conservation elements covered in Memo 3. They also serve as examples of the data tables that will be updated regularly on the Data Basin review website as various management questions are addressed and models completed during the Rolling Review process (discussed in Sections 3.1 and 3.2).

2.4 Review of Task I-3: Methods, Models, and Tools

2.4.1 Task 3 Objectives

During Tasks 1 and 2, the Dynamac team, the BLM, and workshop participants refined management questions, selected conservation elements, and collected hundreds of candidate data layers. Task 3, Models, Methods, and Tools, focuses on the models and analysis methods required to address groups of management questions and conservation elements.

The first objective of Task I-3 was to develop an overarching organizational approach for making status and condition assessments. When assembled, this higher-order logic model will integrate the attributes and indicators derived from lower-order models of specific conservation elements to assess biotic and landscape condition (Sections 2.4.3 and 2.4.7). In Memo 3 we also presented examples of approaches to various classes of conservation elements in separate sections, or methods modules that included background text, conceptual models, and geoprocessing models developed to address specific sets of management questions.

2.4.2 Conceptual Models and Process Models

The REA process has emphasized conceptual models. Before Task 3, the Dynamac team produced a basic ecoregion model and intermediate-scale conceptual models of classes of management questions. In Task 3, detailed conceptual models accompany each example methods module to relate individual conservation elements with specific groups of associated management questions and lists of attributes and indicators necessary to assess the status and condition of conservation elements. The conceptual models created for individual conservation elements thus assist in developing geoprocessing methods and deriving metrics for inclusion in the higher-order ecological condition and status assessments. Literature citations and text support the linkages within the conceptual model and explain the use of the model to depict current status and potential for change.

Conceptual models help guide our understanding and thinking about how a conservation element interacts with the world. Through this understanding, more meaningful process models can be generated. Process models represent a schematic description of the methods and tools used to address a management question or to generate a metric for use in status assessments and an index of ecological condition—they are not intended to address every aspect of the conceptual model. A description of the required data and parameters are also included. We describe various types of process models used at different levels of organization of REA components. In theory, a separate process model could be created for each combination of management question, conservation element, or change agent.

2.4.3 Methods and Tools

Each modeling approach presented in Memo 3 (methods modules in Sections 4 and 6), for groups of management questions or individual conservation elements, specifies the method of analysis to address a specific set of management questions for a specific conservation element and one or more change agents. The process models described above (Section 2.4.2) summarize the methods. For efficiency, we grouped sets of similar management questions related to an individual conservation element and proposed an approach addressing the pertinent set of questions. In each case, the methods modules provide a rationale for method selection as well as the selection of appropriate datasets for each group of management questions or conservation elements.

In Memo 3 and at Workshop 3, the Dynamac team presented a number of tools ranging from software to pre-existing process models. MaxEnt, FRAGSTATS, and MAPSS were all described as contributing to the final deliverable. Finally, we featured the Ecosystem Management Decision Support (EMDS®) system, in concert with NetWeaver® software, that we proposed using to develop a logic model for integrating the various components of the REA into a comprehensive assessment of ecoregion condition.

Resolution: After Workshop 3 (January 24 and 25, 2011), the BLM evaluated the use of the EMDS decision support tool and NetWeaver software and decided that it was not acceptable for multiple reasons (Appendix 11), including that the modeling software was not easily transferable to the BLM Field Office level; in the agency's view it would require too much training and additional software purchase (Netweaver would have to be purchased if the agency wished to manipulate the logic models at a future date). BLM asked that the Dynamac team approach the assessment using only Model Builder or Python as tools. The Dynamac team remains concerned that using only Model Builder will limit our ability to address all aspects of the assessment in a timely manner, particularly the more complex issues of ecological condition and impacts of the change agents on conservation elements. We decided to explore using EMDS in addition to Model Builder/Python for some aspects of the Workplan, particularly to facilitate the synthesis of individual elements into higher-order ecological condition and potential-for-change outputs and also to assist reviewer understanding of more complex data and model relationships.

2.4.4 Species Habitat Models

The most appropriate species habitat modeling method used to answer some of the management questions depends on the data available for species occurrence locations as well as for environmental predictors. Throughout Task 3, the Dynamac team sought existing models for various species and several new models were proposed by BLM and USGS (cheatgrass, soil crust). Where quality models do not currently exist, we proposed various potential methods for addressing this issue.

Resolution: At Workshop 3, the group decided that the Dynamac team will approach species habitat modeling in the following order of preference: 1) existing high quality models that cover the full ecoregional extent or that can be readily be extended from a portion of the assessment region to cover the desired areal extent; 2) a modeling approach such as MaxEnt (or related software) if occurrence data are available, and 3) SW ReGAP models if both existing models and occurrence data are lacking.

2.4.5 Output Products to Show Status and Potential for Change

The application of methods and tools will result in a collection of output products: textual, tabular, and spatial. Ecoregional assessment analyses will cover conservation elements and change agents relative to their current status and potential for future change. According to the SOW, "…current status is the existing state or cumulative condition that has resulted from all past changes imposed upon the prior historical condition. Status is characterized by attributes and indicators for size, condition, landscape context, and trend." Describing status for various conservation elements and resource values assumes that specific characteristics of a resource can be identified and mapped. Through spatial modeling, the Dynamac Team will assess the current status of each of the conservation elements described above in Task 1.

We will assess for each conservation element individually and for all conservation elements collectively, potential change due to fire, development, invasive species, and climate change. Potential for change predicts how status may change in the future; potential for change consists of attributes and indicators for direction, magnitude, likelihood, and certainty of change. Products displaying potential-for-change help clarify how current evidence of cumulative impacts may be projected into the future and help identify potential trade-offs, alternatives, and mitigation strategies for BLM planning purposes. Another REA product of interest to BLM is the location of areas with high potential for renewable energy development. Current and potential development data layers will be combined with mapped results for the various conservation elements to obtain spatially explicit information on the elements that may be affected by various renewable energy development forecasts.

Conceptual models guide the development of analytical process models that provide specific map-based outputs directed at answering the stated management questions as well as overarching topics such as mapping overall ecological condition. Specific output products will include:

(1) Status – Conservation Values (biological/ecological values + landscape values + ecosystem service values)
(2) Status – Ecological Integrity (biological values + landscape values)
(3) Status – Biological and Ecological Values
(4) Status – Landscape Values
(5) Status – Ecosystem Services Values
(6) Status – Wildlife Species Conservation Elements (from the pre-selected suite of core and desired species)

(7) Status – All species (richness and endemism metrics)
(8) Status – Change agents (locations and magnitude)
(9) Future – Change agents (locations and magnitude)
(10) Vulnerability – Conservation Values
(11) Vulnerability – Ecological Integrity
(12) Vulnerability – Biological and Ecological Values
(13) Vulnerability – Landscape Values
(14) Vulnerability – Ecosystem Services Values
(15) Vulnerability – Wildlife Species Conservation Elements (from the pre-selected suite of core and desired species)

The original source data, models, and results, including all appropriate metadata, will be provided according to the specifications listed in the REA Statement of Work and Data Management Plan and also (with permission) on Data Basin for broader public dissemination. Summary tables and descriptions of the findings will also be part of the final assessment report.

2.4.6 Summarizing Uncertainty

Uncertainty is an important topic within spatial modeling, especially when dealing with complex ecological systems and complex issues such as climate change. There are various sources of uncertainty—lack of ecological knowledge, uneven or flawed input data, poor assumptions, and algorithmic errors—and a number of ways that uncertainty may be presented cartographically. For the REA process, we expect that many potential errors and areas of uncertainty will be identified during the rolling review. This expert review process will help validate model outputs and provide context or important qualifiers for interpreting the results. Reviewers of the various conceptual models, process models, and their outputs will assess whether the results produce ecologically meaningful information. When we generate statistical models (e.g. species habitat suitability models) for various components of the REA, we will also produce various numeric measures of uncertainty. For climate change questions, we propose to create a climate change uncertainty layer based on density of meteorological stations, terrain complexity, and abundance of water bodies (lakes and permanent streams).

Resolution: Workshop 4 participants discussed the issue of uncertainty and viewed an example of a state line effect between merged data from two states. We settled on a three-step approach to similar data-related mapping issues: 1.) try to resolve the issue with expert input and revision of map polygons: 2.) flag the area to indicate those portions of the map that are acceptable and those that are suspect; 3.) use the SW ReGAP model (that tends to be an overestimate).

2.4.7 Attributes and Indicators

Ecological attributes are traits or factors that are necessary to maintaining a fully functioning species population, assemblage, community, or ecosystem. Ecological attributes for each conservation element correspond to size, condition, and landscape context, and the list of attributes may include biological characteristics, ecological processes, environmental regimes, and aspects of landscape structure. Ecological attributes describe characteristics that limit a conservation element's spatial extent, create temporal variability, or illustrate an element's resilience or sensitivity to disturbance (Unnasch et al. 2009). On a species level, they are traits that are necessary for species survival and long-term viability.

Indicators are measurable aspects of ecological attributes. Indicators quantify (as much as possible) habitat characteristics, the magnitude and degree of exposure to disturbance factors or stressors, and the subsequent response to stressors (Mouat et al. 1992). Thus, a good indicator is not just measurable, but sensitive and responsive to a full gradient of disturbance (Noss 1990). In the REAs, attributes and indicators are key elements used to answer management questions, parameterize models, and help explain the expected range in status and condition of individual conservation elements. Ideally, indicators should be tested and calibrated along the gradient of disturbance (Karr and Chu 1997); however, this is not possible in the context of a rapid ecoregional assessment, the results of which will be a more qualitative assessment of status and vulnerabilities than an assessment based on empirical data.

The attributes and indicators that are actually used in the REA for modeling purposes will be a subset of those that may be proposed generally for a conservation element (discussed at Workshop 3, see master attribute and indicator table, Appendix 12); the final attributes and indicators must be those for which data is available to build appropriate models that produce spatially-explicit results. For example, we might use attributes and indicators related to climate, soil, beetle distribution, and fire regimes as ranges of optimal environmental response in MaxEnt modeling for the conservation element pinyon pine. For an animal species like razorback sucker, appropriate indicators include length of free-flowing rivers, size of reservoirs, water temperature, presence of nonnative, invasive fishes, and alteration of natural flow regime.

2.4.8 Operational Reference Condition

In recent decades, reference condition has been conceptualized in terms of ecosystem structure and function for individual sites, groups of sites, or prescribed areas and described in terms of expectations relative to a concept of historic or presettlement land cover, water quality, or species' distribution and richness. For the REA, we are faced with defining reference condition spatially at an ecoregional scale. We are limited by available spatial data and challenged by having to define reference condition over a continuous land surface.

Vegetation community is a key element for estimating reference conditions for conservation elements; vegetative cover serves as habitat and provides a means to estimate the status of species that are dependent on those habitats. To conduct the REA and expect to estimate condition based on departure from reference or estimate of presettlement condition, it is necessary to have a dataset that is continuous across the entire ecoregion and that expresses both current vegetation and (modeled) reference condition.

Although there was some discussion and debate at each workshop about the use of LANDFIRE or SW ReGAP for mapping vegetation (see Section 2.4.9), the only dataset that is available over the entire region that attempts to map reference condition is the LANDFIRE Biophysical Settings (BpS) dataset (www.landfire.gov); it depicts the vegetation communities that may have been dominant on the landscape prior to Euro-American settlement and thus provides the best available representation of vegetation community reference conditions. All vegetation communities are described in terms of NatureServe's Ecological Systems classification and are mapped using a combination of vegetation plot data, biophysical gradients, vegetation dynamics models, and other information as available. The BpS units are coupled with reference condition vegetation dynamics models, which describe the primary succession classes (e.g., post-fire vegetation, old growth forest) and their state-transition probabilities, including rates of fire, which would most likely have occurred under pre-settlement conditions. These probabilities are integrated to estimate the proportion of each BpS unit that would be occupied by each succession class averaged across *time and space*. **Note**: These values are averages and *do not* express ranges of variability (HRV) nor can the locations of the BpS be used to express a spatial range of variability or patch characteristics.

It is also important to note that the BpS units describe a spatially-dynamic mosaic of succession classes over time as the landscape experiences disturbances, such as fire, and vegetation succession in the absence of disturbance. Thus care must be exercised when comparing these reference vegetation conditions to current vegetation conditions, which represent a single point-in-time estimate of vegetation communities on the landscape. Typically, this comparison is performed by aggregating current vegetation type and structure into the succession classes defined for the Biophysical Settings on which those combinations fall or additional states that represent conditions that would not have occurred under reference condition dynamics (e.g., invasive vegetation types). The percent of a BpS occupied by each succession class and uncharacteristic condition is then calculated within an appropriate landscape summary unit (e.g., 5th level HUC or 4th level ecological region) and compared to the percentages of those succession classes that would have been expected under reference conditions.

Resolution: The Dynamac team will employ LANDFIRE BpS to represent reference condition. During a discussion among BLM and USGS staff and REA contractors at a summary assessment webinar on April 15, 2011, the group agreed that 1) vegetation cover serves as habitat and provides a means to estimate the status of species that are dependent on those habitats; 2) it was outside the scope of the REAs to establish reference condition for individual species; and 3) LANDFIRE Bps was the only dataset that is available over the entire region that attempts to map reference condition. REA participants are well-aware of the limitations of LANDFIRE, particularly in arid regions like the Sonoran Desert; however, the need for a spatial, continuous estimate of reference condition and for consistency among ecoregions allowed few choices.

2.4.9 Ecological Integrity Assessment

Note: BLM guidance for ecological condition and summary status assessments is ongoing. The draft workplan (Task I-4-a) was delivered April 13, 2011. BLM and USGS held a webinar and subsequent ecological integrity and summary assessment discussions on April 15, May 6, and May 11, 2011. On May 6, a workgroup of BLM, USGS, and 3 of the contractors agreed on the term Index of Ecological Integrity.

2.4.9.1 Chronology of ecological integrity debate and discussion.

Memo 1, Workshop 1 (August 2011). The Dynamac team presented at Workshop 1that

- Development of landscape-level indicators of ecological integrity based on the responses of conservation elements to disturbance was a research effort and beyond the scope of a rapid assessment
- The term ecological integrity implied a more rigorous and defensible product (based on empirical data and calibration of metrics) than the qualitative product that would be produced in a rapid assessment and that ecological status or condition might be a better name than ecological integrity.
- There were few existing examples in the literature of terrestrial indices of ecological integrity
- In the absence of a collection of minimally- or least-disturbed reference sites to serve as a model against which to compare the condition of disturbed sites, progress on an assessment of ecological condition depended on our ability to spatially depict reference condition as a continuous surface across the landscape
- Once an operational reference condition was determined, the relative departure in landscape condition away from the reference condition would serve as a qualitative measure of resource status for the purpose of the REA.

The group at Workshop 1 acknowledged that the ecological integrity issue required further discussion and guidance.

Memo 2, Workshop 2 (October 2010). There was little discussion of ecological integrity at Workshop 2. BLM noted that they were working with USGS on guidance in time for Workshop 3 in January 2011. Throughout the fourth quarter, the Dynamac team continued planning their REA approach to ecological condition assessment and submitted comments to BLM in December 2010 on the BLM/USGS ecological integrity guidance document.

Memo 3, Workshop 3 (January 2011). Karl Ford presented BLM's guidance for ecological integrity at Workshop 3. Karl noted that BLM, Dynamac, and other contractors had differing opinions about some aspects of the index methodology, but he was hopeful that the divergent ideas would be integrated so that the REAs would show consistency among ecoregions.

Other discussions at Workshop 3 centered on how field managers and BLM Field Office staff would use ecological integrity information: some felt that ecological integrity information may not be as useful to field offices as information on individual conservation elements and that the REA's highest use might be accumulating and mapping data. The rest of the ecological integrity discussion at Workshop 3 involved Dynamac's concept of how ecological integrity would be represented in the decision support tool (EMDS) logic trees.

2.4.9.2 Approach for Ecological Condition Assessment

Conceptually, overall ecological integrity consists of two major components—*biological and ecological values* and *landscape values*. The logic trees presented at Workshop 3 showed that the lower-order components of each of the aggregated values were arrays of individual conservation elements and the attributes and indicators critical to their status and condition. As part of the ecological integrity assessment, lower-order components of biological and ecological values and landscape values from both the terrestrial and aquatic domains will be aggregated into a meaningful framework for evaluating likely impacts from the various change agents.

The landscape (or waterscape) is the stage on which biological and ecological processes take place; the landscape values component of ecological integrity assessment incorporates directly measurable attributes of overall landscape or waterscape condition. Terrestrial factors such as the amount of native habitat converted to other land uses, road density, and invasive species cover provide quantifiable descriptors of a departure from reference condition. Companion aquatic disturbance factors might include degree of water management (dams and diversions), riparian habitat alteration, and water quality. When combined, these terrestrial and aquatic factors create an overall relative landscape value and give users the information they need to understand the degree of naturalness of each analytical unit (regions, grid cells, or HUCs) and their spatial configuration.

The other component of ecological integrity assessment, biological and ecological value, is more challenging to assess. The Dynamac team intends to evaluate the list of conservation elements (many of them species) both separately and collectively as part of the ecological integrity assessment for each REA. However, when evaluating species collectively across a region, measures of species richness must be used with care. Vertebrate species richness may be naturally higher at middle elevations (McCain 2003, McCain 2007) or in warmer river and stream systems (Mebane et al. 2003, Hughes et al. 2004). However, species numbers also increase with moderate disturbance (Odum et al. 1979, Odum 1985), and this factor is of more importance for ecological integrity assessment. Areas with high species endemism or high species richness may be important from a conservation or management perspective, but it does not follow that they must possess better ecological condition. Ecosystem condition can decline as species diversity (even native species diversity) increases (Scott and Helfman 2001). Areas with high species endemism or high species richness should be evaluated separately from ecological integrity and identified by aggregating species data across a region (as BLM has done for the Colorado Plateau and Sonoran REAs by acquiring the richness-function data from NatureServe that will enumerate and display G1 and G2 species and threatened and endangered species by 5th level HUC).

Resolution: Participants at a Summary Assessment Webinar held April 15, 2011 agreed that we would use vegetation communities and habitat as a surrogate to evaluate reference condition for species and avoid attempting to establish regional expectations for individual species (numbers and distribution).

In summary, we propose using an aggregation of biological and ecological values and landscape values to evaluate ecoregion ecological integrity. These spatially explicit evaluations will be based primarily on comparison of a predetermined reference condition with measures of direct anthropogenic disturbance and inferred qualitative levels of impact on the suite of species selected. During the assessment process, we will estimate qualitatively the deviation of the present-day habitat of each conservation element from a modeled representation of reference condition (Section 2.4.8) and identify the change agents that contribute to that deviation from reference condition. This qualitative departure from reference condition will define a gradient of ecological condition at a relatively coarse scale—that of the ecoregion as well as the other landscape reporting units—and be expressed as a simple index.

Workshop 3 Resolution: The Dynamac team proposed using EMDS software to conduct this and other portions of the assessment, but as mentioned earlier, output from this specific software was not acceptable to BLM. We plan to explore using EMDS to help address ecological integrity and then attempt to replicate the logic and operations in the Model Builder or Python domain. We doubt this parallel approach would be affordable to apply to the full modeling effort, but we feel it can provide useful insights to this particular issue especially. The logic model generated using EMDS will also help reviewers understand the major tenets of this important concept better than the approved alternatives.

2.4.10 Current Vegetation Conditions: Use of SW ReGAP and LANDFIRE

A recurrent theme during Tasks 1–3 was the choice between the major vegetation data layers, SW ReGAP and LANDFIRE. Each had advocates and each framework had advantages in particular circumstances: SW ReGAP was supposedly more accurate and LANDFIRE more appropriate for fire-related questions. Two options considered at Workshop 2 were 1) to use SW ReGAP for all vegetation questions and LANDFIRE for fire-related questions with the risk of having incomparable results or 2) to perform a cross-walk between SW ReGAP and LANDFIRE. The crosswalk required rewriting the code for LANDFIRE using biophysical information from SW ReGAP and was judged too time-consuming.

Resolution: In the final version of Memo 3 (Section 5.3.2.2) the Dynamac team proposed using both frameworks where appropriate and integrating them into a common layer when necessary. Since LANDFIRE BpS is necessary to estimate reference condition, the use of LANDFIRE EVT to estimate current vegetation condition will minimizes errors of comparison. Furthermore, a LANDFIRE EVT update is expected by June with more timely data than SW ReGAP. However, to determine potential errors and uncertainties in the LANDFIRE EVT, we will overlay it on the SW ReGAP land cover dataset and note areas of significantly different vegetation communities. Where significant differences exist between LANDFIRE EVT and SW ReGAP, these areas will be evaluated to determine a) if any differences would affect the distribution of the conservation element and b) if those differences are related to recent disturbances not captured by SW ReGAP. Where SW ReGAP is deemed to better capture current vegetation in these areas of high difference, the LANDFIRE EVT will be corrected using SW ReGAP.

For example, after comparison with SW ReGAP, LANDFIRE may be used alone or integrated with SW ReGAP, depending on the species of interest. Fine-scale differences in annotation between frameworks are less important for species that are habitat generalists, with mapped distributions covering large areas of the ecoregion; thus, using LANDFIRE BpS and EVT is more appropriate for habitat generalists. We are more likely to integrate the SW ReGAP and LANDFIRE frameworks when modeling species that are habitat specialists, when accuracy and detail in landscape character are more important.

2.4.11 Data Basin for Data Management and Product Review

The Dynamac team proposed to use Data Basin (www.databasin.org) as the overall data management and decision support system for integrating the different components of this REA. The Conservation Biology Institute (CBI) developed Data Basin in partnership with the foundation community and Esri (originally Environmental Systems Research Institute). Data Basin is a web-based mapping system that connects users to conservation spatial datasets, numerous mapping and analytical tools, and scientific expertise. Individuals and institutions can explore and download thousands of conservation spatial datasets, upload their own datasets, connect to other external data sources, and produce customized maps that can be easily shared. This web-based data sharing system will allow easy uploading, integration, and management of the numerous datasets needed to implement the BLM REA modeling and analytical processes. It provides private group work spaces and easy-to-use commenting tools.

The Dynamac team proposed to use Data Basin as the location for data storage, product delivery, and review. A more detailed discussion of the review procedure follows in Section 3.2.

Resolution: BLM approved the use of Data Basin on 3-1-11.

2.4.12 Literature Cited

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3 TIMELINES AND ROLLING REVIEW

3.1 Timelines and Deliverables

This Workplan marks the transition between REA Phase 1 and Phase 2; it represents a summary of accomplishments in Phase 1 and an overview of the milestones that remain. The Gantt chart pictured below (Table 1) shows the workflow and timelines for the portion of the REA following Task 3 and extending from March 2011 to February 2012. It begins with Phase 1, Task 4 Draft and Final Workplans and displays the rest of the REA process (Phase 2) through January 2012. The deliverable schedule (Table 2) lists the deliverable dates for the remainder of Phase I and all of Phase II. Details of the timelines from the Gantt chart follow:

- Lines 3 and 4, Draft and Final Workplan:
  The Dynamac team delivered the draft workplan on April 13 and the final on May 13, 2011.

- Line 5, Input Data Uploaded for Review and Comment:
  The timeline for this task (Input Data Uploaded) extends through the months of April and May to mark the data loading to Data Basin. MDA completed an Access database on March 31 that organized all data layers received up to Workshop 2 (October and November 2010). Once the data is organized into folders on Data Basin, all data received after Workshop 2 will be incorporated and the Access database updated for all data layers to be used in REA analyses.

- Line 6, Processing of Draft Datasets
  The processing of draft datasets accompanies data loading to Data Basin. Staff at CBI have begun regenerating data layers as needed (e.g., clipping, edgematching) and documenting each activity as the layers are loaded to Data Basin. As data layers are processed and assigned to various conservation elements, they are documented in the Project Tracking Tables (Section 2.3, Appendix 10) that are posted to Data Basin to allow ongoing review and approval of data layers.

- Line 7, Draft Datasets Uploaded for Review and Comment
  This task is related to Phase II, Task 1 with deliverable dates of June 25 for the Sonoran Desert and June 28 for the Colorado Plateau. The rolling review process (described below) alters this deliverable somewhat in that the rolling review will have begun in early May and will be continuing throughout the summer until late August. The Dynamac team intends to honor the June deliverable by submitting the data layers associated with the Process Tracking Tables that have been generated and listed by the end of June along with metadata and narrative data layer evaluations. There may be a limited number of datasets, either late-arriving or not yet processed for analyses and scheduled later in the rolling review, that will not be included in this late June deliverable but added thereafter. The Statement of Work lists this deliverable as due 60 days after the final Workplan; we will deliver it 38 days after the final Workplan to put the deliverable dates back on schedule.

- Lines 7–12, Data, Process Models, Model Output, and Draft Information Documents.
  All the tasks listed on lines 7–12 pertain to components of the Rolling Review process that will continue from early May throughout the summer until late August, two weeks before Workshop 5 (Presentation of Preliminary Information Documents) in mid-September.

  The AMT and Workshop 3 participants agreed to the Rolling Review process in principle at Workshop 3 (January 24 and 25, 2011) and to a more detailed proposal on a conference call 3-29-11.

  The Rolling Review allows the Dynamac team to start 2 months early on Phase II, Task 2, the modeling and analysis phase. Datasets, process models, model output, and any companion documents will be loaded on Data Basin for review. We will start in late April on the modeling instead of waiting until late June when the data compilation (Phase II, Task 1) would have been completed according to the SOW. The rolling review allows this task to start early and continue over several months to spread out the review and approval process; it gives us a more reasonable timeframe to complete as many of the proposed components of the REA as possible. In this way, the review and approval of data layers, modeling and analyses, and final products can occur as each product, or group of products, is completed and loaded on Data Basin, rather than approving all data, all models, and all output products in large batches on sequential hard deliverable dates. The approach is mutually beneficial to the Dynamac team and BLM, USGS, and state agency reviewers. Section 3.2 below describes the rolling review process and Data Basin group participation in greater detail.

- Lines 13–15, Ecoregional Assessment Report Draft Materials Uploaded, Draft and Final Ecoregional Assessment Report.
  The companion documents produced over the summer months and accompanying the model output products will be compiled to create the draft and final Assessment Report. Draft materials will be presented at Workshop 5 in mid-September and the Draft Assessment Report submitted by November 25, 2011. The Dynamac team will deliver the final REA Assessment Report on January 4, 2012.

Note: All deadlines are subject to alteration through technical direction or mutual agreement with BLM and the AMT.

3.2 Rolling Review Process on Data Basin

The Dynamac team will establish a closed group in Data Basin where we will post spatial datasets for each ecoregion as well as draft sets of models as they are completed. Eight folders will be organized by species conservation elements, terrestrial and aquatic resources, change agents (wildfire, invasive species, development, and climate change), and ecological condition. Each folder will contain subfolders allowing topical experts to easily find categories of interest and focus their efforts to specific areas of expertise. A designated BLM group administrator will manage the groups and approve access to prospective users. Reviewers will have easy access to the group and receive instructions and tools for conducting their review.

We developed a preliminary schedule for posting groups of products on Data Basin (Table 3), showing the estimated timeline for the tasks associated with addressing the various management questions and production of deliverables. Lists of management questions have been sorted by level of difficulty or complexity (A, B, C; Appendix 13). The first group of entries in Table 3 shows the general order of addressing the A, B, and C management questions. Almost half of the management questions are rather straightforward *what/where* mapping questions (marked A on the list). We can start these maps immediately and post groups of them on Data Basin every week or two beginning in late May. Those questions in the B and C categories are more complex and time-consuming. They will be started early, but may require more data preparation and analysis before posting on Data Basin later in June through August.

At the time of Workshop 4, BLM presented a list of topical review leaders and potential reviewers for each of the eight category folders. CBI will notify the review leads when products (data inputs, concept and process models, and draft results) are ready for review. All datasets and a map for review will be provided within each folder. Team leaders will notify reviewers of the deadline for comments. Reviewers will be directed to a profile description page for the map for review where they will be able to download any attachments (e.g. model diagrams, methods, etc.). They will then be directed to open the live map and to select "Add Comments" where they will be asked to answer a series of questions in a customized comment window. Users will also be given simple instructions on how to provide comments about a specific location on the map itself. All comments will be saved automatically. At the end of the review period, the review leader will simply open the reviewed map again, aggregate the comments, and make a final recommendation to the AMT (Approval, Accepted with revision, Rejected). The AMT will make the final decision and notify the Dynamac team. This process will continue until all aspects of the project have been reviewed.

At any point during the duration of the project, review leaders can request that CBI provide a special tutorial or webinar review session to expedite the review process.

The rest of Table 3 is devoted to estimated timelines of specific Data Basin tasks: species modeling, ecological integrity, and analysis of the change agents. The final entries in Table 3 pertain to final product deliverables.

In addition to completing the list of deliverables outlined in the SOW (Table 2), we propose to provide all of the input spatial datasets and final model results as published galleries in Data Basin for access by the BLM and the rest of the Data Basin community (as permitted by data sharing agreements). This will allow the entire body of work to be easily accessible to users via the Internet without the need to acquire GIS software.

REA Workflow (Jan 2011- Feb 2012)	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb
1. Workshops														
2. Data Basin Review Site Up														
3. Draft Work Plan														
4. Completed Work Plan														
5. Input Data Uploaded														
6. Processing of Draft Datasets														
7. Draft Datasets Uploaded for Review & Comment														
8. Process Models Uploaded for Review, Comment														
9. Approved Data-Methods-Tools Folders in DataBasin														
10. Model Output Review														
11. Draft Information Documents Uploaded for Review														
12. Draft Status, Potential Change Datasets Uploaded														
13. Ecoregional Assessment Report Materials Uploaded														
14. Draft Assessment Report														
15. Final Assessment Report														

Table 1. Gantt chart showing timelines and workflow for REA products. Deliverable dates shown as red bars above and in text below:

Line 3: Draft Workplan: Due April 13, both ecoregions. Comment period 7 days, and Line 4: final Workplan May 18, 2011.
Line 5: Input Data Uploaded: Access database delivered April 1, 2011; Data Basin loading beginning 4-11 and ongoing throughout rolling review.
Line 6: Processing draft datasets: Ongoing
Line 7: Draft datasets uploaded for review and comment: Phase II, Task 1, Draft datasets June 25 Sonoran and June 28 COPL.
Lines 7, 8, 9, 10, 11, and 12: Rolling review on Data Basin. Line 11: Draft Information Documents uploaded for Workshop September 13th week.
Line 12: Draft output products on Data Basin available for comment until October 21, 2011.
Line 14: Draft Assessment Report: November 25; Line 15: Final Assessment Report January 4, 2012.

Table 2. REA Deliverable Schedule. If a single date is shown, it is an average date for both ecoregions. Separate dates are shown for each ecoregion if known.

PHASE I PRE-ASSESSMENT	
Task/Deliverable	**Scheduled Completion/Delivery**
Task 4	**Prepare REA Workplan**
Draft REAWP (I-4-a)	April 13, 2011
AMT Workshop 4	April 21, 2011
Workshop summary (I-4-b)	April 26, 2011
BLM comments to Contractor	April 28, 2011
Final REAWP (I-4-c)	May 15, 2011 (Phase II Task 1 60 days following I-4-c)
BLM approval review	May 20, 2011
PHASE II ASSESSMENT	
Task/Deliverable	**Scheduled Completion/Delivery**
Task 1	**Compile and Generate Source Datasets**
Draft datasets (II-1-a) and metadata (II-1-b)	Sonoran June 25, 2011 CO Plat. June 28, 2011
BLM approval review	Sonoran June 30, 2011 CO Plat. July 3, 2011
Task 2	**Conduct Analyses and Generate Findings**
Preliminary information documents (II-2-a)	September 1, 2011
AMT Workshop 5	September 13, 2011
Workshop summary (II-2-b)	September 18, 2011
BLM comments to Contractor	September 25, 2011
Draft status & potential change datasets (II-2-c)	October 21, 2011
BLM approval review	October 26, 2011
Task 3	**Prepare Rapid Ecoregional Assessment Documents**
Draft REA documents (II-3-a)	November 25, 2011
AMT Workshop 6	December 5, 2011
Workshop summary (II-3-b)	December 10, 2011
BLM comments to Contractor	December 21, 2011
Final REA documents (II-3-c) & datasets (II-3-d)	January 4, 2012
BLM comments to Contractor	January 18, 2012
All final deliverables delivered	January 29, 2012
BLM final REA approval review	February 8, 2012

Table 3. Detailed Rolling Review Timeline showing the uploading and review time segments for various classes of model output products.

REA Workflow (April 2011- Feb 2012)	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb
Management Questions											
Sequence A questions											
Sequence B questions											
Sequence C questions											
Data Basin											
Create groups within Data Basin											
Upload initial datasets											
Maintain group space and manage review process											
Maintain datasets on Data Basin											
Produce galleries for final products											
Species habitat modeling											
Current and Historic Distribution											
Species connectivity											
Ecological Integrity Modeling											
Data Assembly and Model Construction											
EMDS / Model Builder Testing											
FRAGSTATS											
Construction of Draft Ecological Integrity Model											
Final assembly of integrity model											
Climate Change Modeling											
Downscaling 15km to 4km											
Create climate change prediction surfaces											
MAPSS modeling											
Evaluate conservation element sensitivity using CCVI											
Create uncertainty surface											

Table 3 (Continued). Detailed Rolling Review Timeline

REA Workflow (April 2011- Feb 2012)	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb
Land and Resource Use-Development Modeling											
Planned development											
Conflicts with CEs											
Wildfire											
Recent fires											
Potential fire regime change; effects on CEs											
Restoration potential											
Invasive Species Modeling											
Current distribution mapping											
Potential encroachment modeling											
Restoration potential											
Production of Final Products											
Aggregating all components											
Generate report materials											

APPENDICES

APPENDIX 1. Basic Ecoregional Conceptual Model

The basic ecoregion conceptual model serves as the source for more detailed conceptual sub-models that accompany Task 2 and Task 3. In the basic ecoregional conceptual model for the Colorado Plateau (Figure 1), boxes represent conservation elements, ovals represent classes of change agents, and arrows represent the direct and indirect effects (threats, stresses, or positive change) on ecosystem components, including conservation elements. The conceptual model portrays the ecoregion under natural conditions (representing ecological integrity) and under the influence of anthropogenic stressors (represented by red arrows) and associated change agents.

Regional climatic conditions represent the dominant natural change agent in the basic ecoregion conceptual model (Figure 1). Secondary natural regional change agents in the Colorado Plateau 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. The overlay of human activities, expressed as anthropogenic change agents and change agent subclasses, are shown as yellow ovals on the conceptual model. The oval marked *land and resource use* covers major human activities such as urban and industrial development, surface and groundwater extraction, recreation, agriculture, and grazing. The red arrows mark the interactions of human activities with other model components.

Four representative natural vegetation coarse-filter classes—arid basin shrublands, semi-arid sage, riparian communities, and upland pinyon-juniper woodland— 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 aggregations of the coarse filter conservation element classes covering more than 1 or 2% of the ecoregion area (SW ReGAP, Prior-Magee et al. 2007). 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 2002, Housman et al. 2006). Wildlife occurrence and abundance is dependent on interactions with all the abiotic factors (such as climate, fire regime, and water availability) and the vegetation classes (representing major habitats).

References Cited

Belnap, J. 2002. Impacts of off-road vehicles on nitrogen cycles in biological soil crusts; resistance in different U.S. deserts. *Journal of Arid Environments* 52(2):155–165.

Housman, D.C., H.H. Powers, A.D. Collins, and J. Belnap. 2006. Carbon and nitrogen fixation differ between successional stages of biological soil crusts in the Colorado Plateau and Chihuahuan Desert. *Journal of Arid Environments* 66(4):620–634.

Prior-Magee, J.S., K.G. Boykin, D.F. Bradford, W.G. Kepner, J.H. Lowry, D.L. Schrupp, K.A. Thomas, and B.C. Thompson (eds.). 2007. Southwest Regional Gap Analysis Project final report. U.S. Geological Survey, Gap Analysis Program, Moscow, Idaho.

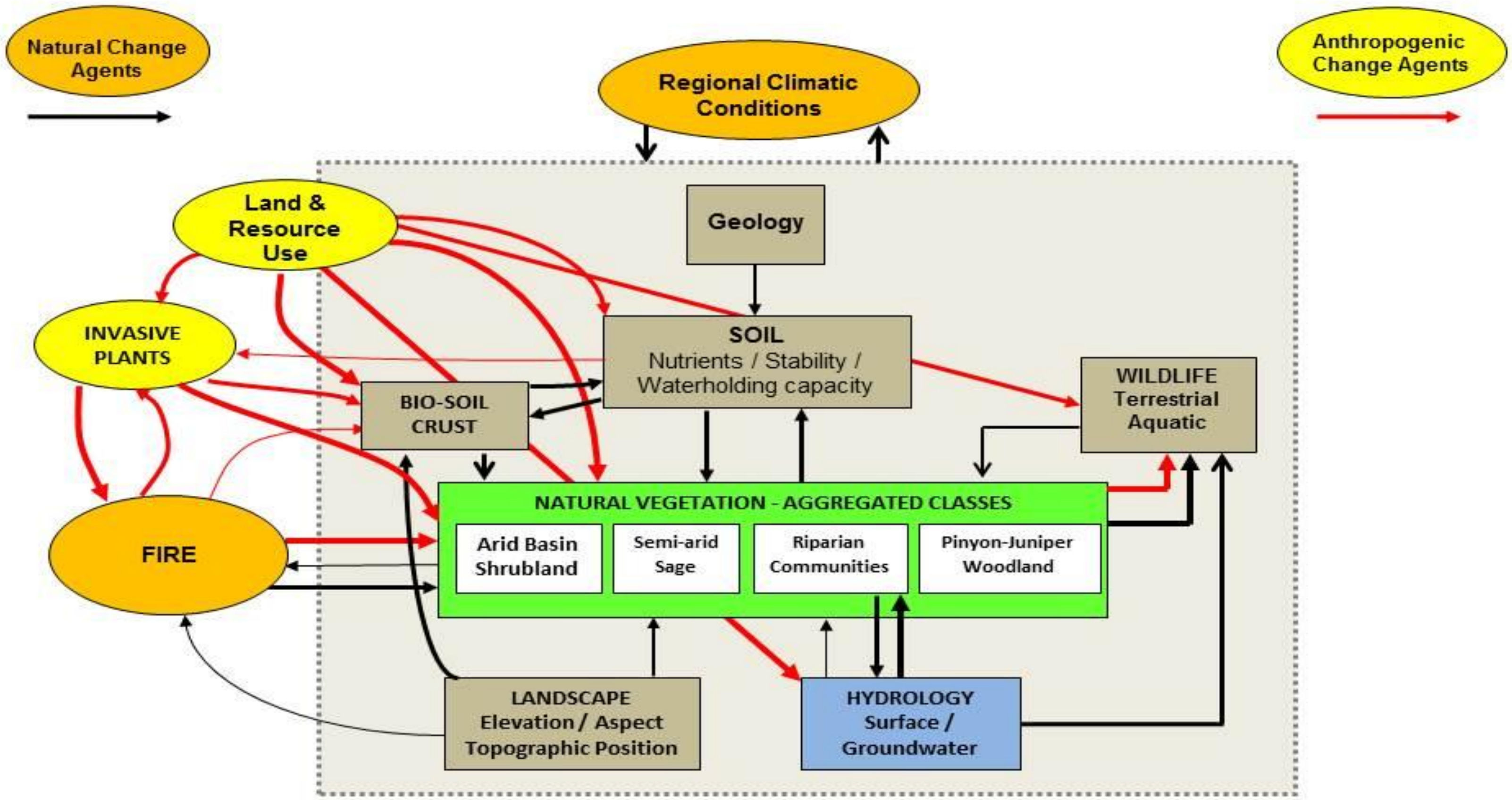

Figure 1. Basic ecoregion conceptual model for the Colorado Plateau Ecoregion, with both natural and anthropogenic change agents shown.

APPENDIX 2. Final AMT-Approved Colorado Plateau REA Management Questions 3-17-11: **TOTAL 45**

A. SOILS, BIOLOGICAL CRUSTS, AND FORAGE MANAGEMENT

1. Where are soils susceptible to wind and water erosion?
2. Where are sensitive soils (including saline, sodic, gypsiferous, shallow, low water holding capacity)?
3. Which HMAs and allotments may experience significant effects from change agents including climate change?
4. Where are soils that have potential to have cryptogamic soil crusts?
5. What/where is the potential for future change to the cryptogamic crusts?
6. Where are hotspots producing fugitive dust that may contribute to accelerated snow melt in the Colorado Plateau?

B. SURFACE AND GROUNDWATER MANAGEMENT QUESTIONS

1. Where are lotic and lentic surface waterbodies and livestock and wildlife watering tanks and artificial water bodies?
2. Where are perennial streams and stream reaches?
3. What are seasonal discharge maxima and minima for the Colorado River and major tributaries at gaging stations?
4. Where are the alluvial aquifers and their recharge areas (if known)?
5. What is the condition of these various aquatic systems defined by PFC?
6. Where are aquatic systems listed on 303d for water quality or have low macroinvertebrate diversity?
7. What is the location/distribution of these aquatic biodiversity sites?
8. Where are the areas of high and low groundwater potential?

C. ECOLOGICAL SYSTEMS MANAGEMENT QUESTIONS

1. Where are existing vegetative communities?
2. Where are vegetative communities vulnerable to change agents in the future?
3. What change agents have affected existing vegetation communities?

D. SPECIES CONSERVATION ELEMENT MANAGEMENT QUESTIONS

1. What is the most current distribution of available occupied habitat (and historic occupied habitat if available), seasonal and breeding habitat, and movement corridors (as applicable)?
2. What areas known to have been surveyed and what areas have not known to have been surveyed (i.e., data gap locations)?
3. Where are potential habitat restoration areas?
4. Where are potential areas to restore connectivity?
5. What is the location/distribution of terrestrial biodiversity sites?
6. What aquatic and terrestrial species CEs and high biodiversity sites and movement corridors are vulnerable to change agents in the near term horizon, 2020 (development,

fire, invasive species) and a long-term change horizon, 2060 (climate change)? Where are these species and sites located?

7. Where are HMAs located?

E. WILDFIRE MANAGEMENT QUESTIONS

1. Where are the areas that have been changed by wildfire between 1999 and 2009?
2. Where are the areas with potential to change from wildfire?
3. Where are the Fire Regime Condition Classifications?
4. Where is fire adverse to ecological communities, features, and resources of concern?

F. INVASIVE SPECIES MANAGEMENT QUESTIONS

1. Where are areas dominated by tamarisk and cheatgrass, and where are quagga and zebra mussel and Asiatic clam present?
2. Where are the areas of potential future encroachment from this invasive species?
3. Where are areas of suitable biophysical setting (precipitation/soils, etc.) with restoration potential?

G. FUTURE DEVELOPMENT MANAGEMENT QUESTIONS

1. Where are areas of planned development (e.g., plans of operation, urban growth, transmission corridors, governmental planning)?
2. Where are areas of potential development (e.g., under lease), including renewable energy sites and transmission corridors and where are potential conflicts with CEs?

H. RESOURCE USE MANAGEMENT QUESTIONS

1. Where are high-use recreation sites, developments, roads, infrastructure or areas of intensive recreation use located (including boating)?
2. Where are areas of concentrated recreation travel (OHV and other travel) located?
3. Where are permitted areas of intensive recreation use (permit issued)?
4. Where are allotments and type of allotment?
5. Where are the areas of potential woody biomass for energy utilization?

I. AIR QUALITY MANAGEMENT QUESTIONS

1. Where are the viewsheds adjacent to scenic conservation areas?
2. Where are the viewsheds most vulnerable to change agents?
3. Where are the designated non-attainment areas and Class I PSD areas?

J. CLIMATE CHANGE MANAGEMENT QUESTIONS

1. Where/how will the distribution of dominant native plant and invasive species be vulnerable to or have potential to change from climate change in 2060?
2. Where are areas of potential for fragmentation as a result of climate change in 2060?
3. Where are areas of species (conservation elements) distribution change between 2010 and 2060?
4. Where are aquatic/riparian areas with potential to change from climate change?

APPENDIX 3. Coarse Filter Ecological Systems of the Colorado Plateau.

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

APPENDIX 3 (Continued). Coarse Filter Ecological Systems of the Colorado Plateau.

SHRUB / 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

APPENDIX 3 (Continued). Coarse Filter Ecological Systems of the Colorado Plateau.

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

APPENDIX 3 (Continued). Coarse Filter Ecological Systems of the Colorado Plateau.

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

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

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 4. Plant Species Representative of Major Ecological Systems.

ECOLOGICAL SYSTEM	% OF ECOREGION	REPRESENTATIVE SPECIES	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 wyomingensis*
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%		

APPENDIX 5. Final Selection of Landscape Species for the Colorado Plateau Ecoregion identified using a modified version of the Coppolillo *et al*. (2004) approach (see Appendix 2, Memo 1 for candidate 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

APPENDIX 6. Desired Species Conservation Elements for the Colorado Plateau Ecoregion.

SPECIES	AREA	HETEROGENEITY	VULNERABILITY	FUNCTIONALITY	SOCIO-ECONOMIC SIGNIFICANCE	SPECIES SCORE
Golden eagle	1.00	0.45	0.25	0.50	0.60	2.80
Gunnison sage-grouse	1.00	0.09	1.00	0.00	0.60	2.69
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
Flannelmouth sucker	----	----	----	-----	-----	-----
Ferruginous hawk	----	----	----	-----	-----	-----

APPENDIX 7. Sites of Conservation Concern Selected for the Colorado Plateau Ecoregion.

Terrestrial Sites of High Biodiversity:

- TNC portfolio sites
- Important bird areas (Audubon)
- Areas recognized by Partners-In-Flight

Terrestrial Sites of High Ecological and/or Cultural Value:

- Historic and Nationally Designated Trails
- Wilderness Areas
- Wilderness Study Areas
- Historic Districts
- National Wildlife Refuges
- Monuments
- National and State Parks
- NCAs
- ACECs
- Forest Service Research Natural Areas
- State Wildlife Management Areas
- Suitable Wild and Scenic Rivers
- Designated Recreation Management Areas
- Sensitive Air Quality and Smoke Impact Receptors

Aquatic Sites of High Biodiversity:

- TNC portfolio sites
- EMAP-West Reference Sites

APPENDIX 8. Ecosystem Functions and Services of Conservation Concern Selected for the Colorado Plateau Ecoregion.

Terrestrial Functions of High Ecological Value:

- Soil stability
- Forage

Surface and Subsurface Water Availability:

- Aquatic systems of streams, lakes, ponds, etc.
- Springs/seeps/wetlands
- Riparian areas
- High quality and impaired waters
- Groundwater protection zones, sole source aquifers

APPENDIX 9. Change Agents Selected for the Colorado Plateau Ecoregion.

CHANGE AGENTS

- Wildland Fire
- Invasive Species
- Land and Resource Use
  - Urban and Roads Development
  - Oil, Gas, and Mining Development
  - Renewable Energy Development (i.e., solar, wind, geothermal, including transmission corridors)
  - Agriculture
  - Livestock, wild horse and burro, and wildlife grazing
  - Groundwater and Surface Water Extraction, Development, and Transportation
  - Recreational Uses
  - Pollution (Air Quality)
- Climate change

APPENDIX 10. Project Tracking Tables for the Colorado Plateau Ecoregion.

NOTE: Datasets are listed in table format by Management Questions for 3 Change Agents, wildfire and 2 invasive species, and wildlife species conservation elements listed in Appendices 5 and 6 (double-click the icon to open each table). The numbers for Management Questions (MQs) in Column B in each spreadsheet match the numbering system of the management questions in Appendix 2. Conceptual models (Column D) and process models (Column H) are linked to PowerPoint slides, double-click to open. Conceptual models and process models may still be revised between submission of these workplans and the rolling review of individual elements. Dataset IDs are examples and not the actual IDs—permanent dataset ID numbers are forthcoming in the Access database that will be updated for the final workplan in May and for the late June data deliverable—but "dummy" ID numbers are provided as an example. Data contained herein represent all datasets proposed for use in modules submitted in Memo 3. Additional tables with datasets will be compiled as other modules are developed and expanded and included as part of the Rolling Review process.

Table 10-1 Change Agent – Wildlfire.

Matrix Table CP Wildfire.xlsx

Table 10-2. Change Agent – Invasive Species, Tamarisk.

Matrix Table CP Tamarisk.xlsx

Table 10-3. Change Agent – Invasive Species, Cheatgrass.

Matrix Table CP Cheatgrass.xlsx

Table 10-4. Burrowing Owl.

Matrix Table CP Burrowing Owl.xlsx

Table 10-5 Pinyon Pine.

Matrix Table CP Pinyon Pine.xlsx

Table 10-6. Golden Eagle.

Matrix Table CP-SD Golden Eagle.xlsx

Table 10-7 Razorback Sucker.

Matrix Table CP Razorback Sucker.xls

Table 10-8 American Peregrine Falcon

COP CE-PM American Peregrine Falcon data

Table 10-9 Big Free-tailed Bat

COP CE-PM Big
Freetailed Bat datase

Table 10-10 Black-footed Ferret

COP CE-PM
Blackfooted Ferret da

Table 10-11 Ferruginous Hawk

COP CE-PM
Ferruginous Hawk dat

Table 10-12 Flannelmouth Sucker

COP CE-PM
Flannelmouth Sucker

Table 10-13 Greater Sage Grouse

COP CE-PM Greater
Sage Grouse dataset

Table 10-14 Gunnison's Prairie Dog

COP CE-PM
Gunnisons Prairie Dog

Table 10-15 Gunnison's Sage Grouse

COP CE-PM
Gunnisons Sage Grou

Table 10-16 Mexican Spotted Owl

COP CE-PM Mexican
Spotted Owl datasets

Table 10-17 White-tailed Prairie Dog

COP CE-PM
Whitetailed Prairie Do

Table 10-18 Yellow-breasted Chat

COP CE-PM
Yellowbreasted chat

Table 10-19 Mountain Lion

COP CE-PM Mountain
Lion datasets.xlsx

Table 10-20 Mule Deer

COP CE-PM Mule
Deer datasets.xlsx

APPENDIX 11. BLM Decision on EMDS (March 1, 2011).

This memo documents the status and review of the Dynamac proposal to use EMDS and Data Basin to support Rapid Ecoregional Assessments. Each product review is summarized below. This review was conducted by the NOC Data Management Team. BLM 'Findings' and 'Recommendations' were approved by the Colorado Plateau and Sonoran Assessment Management Teams.

EMDS

- ***Issue #1 – Dependency on SQL Server Express***: In BLM's testing of EMDS 4.1, we found we needed to load SQL Server Express 2008 in order for the software to run. SQL Server Express has been denied by Configuration Management to be loaded on BLM desktops. The developer of EMDS stated to James Strittholt (CBI) that EMDS is not using SQL Server Express in the current version. Subsequent testing by BLM found that there still is a dependency and the software cannot be installed without SQL Server Express 2008.

- ***Issue #2 – Cost of 3rd Party Software***: There are two software packages which provide additional tools to EMDS. CDP is the decision support extension and NetWeaver provides the logic modeling framework. Neither software package is required for EMDS, a free ArcGIS extension, to run. Combined these two software packages would cost approximately $1300 per license. NetWeaver is approximate $500. NetWeaver would only need to be purchased if BLM wanted/needed to modify the EMDS logic models. Given that BLM does intend to use products (data and models) from the assessments to support refinement of analyses during our step-down phase, we will need to modify EMDS models. BLM does not want to have to purchase NetWeaver for all the potential step-down projects.

- ***Issue #3 – ArcGIS 10 Compatibility***: BLM is preparing to roll-out ArcGIS 10 to all desktops in the very near future. The REA SOW calls for ArcGIS 9.3.x compatibility. Currently EMDS does not run in ArcGIS 10, but a new version is coming out soon. BLM does not see this as an issue.

- ***Issue #4 – Comparable products between ecoregions***: It is the desire to have products coming out of the assessments that are at least comparable between ecoregions. EMDS creates a *possible* situation where BLM will have incompatible products region-to-region.

- ***Issue #5 – Pre-summarized input datasets***: As stated by James Strittholt, "EMDS does not run against the various input datasets live. Processing would take too long. The input data are used and summarized by analytical unit." The SOW does require attributes and indicators to be delivered at native analysis resolutions. The Status deliverables are the only products that should be aggregated to some predefined higher lever analysis unit (referred to in the SOW as Landscape Reporting Unit). BLM wants to provide the full detail available in the data to help interpret Status results.

- ***Issue #6 – System Maintenance***: The ESRI suite of products is the standard GIS not only in the BLM but the entire Department of Interior. Maintaining an additional set of software nationally will require increased staff time to ensure system integrity. This additional time was not planned for as part of the REAs.

- ***Issue #7 – Training/Tech Transfer***: Several BLM users of EMDS (primarily on the Fire side of the house) have expressed concern over the steep learning curve required by EMDS. BLM's GIS user base is comfortable working in the ArcGIS environment and has the training to develop and modify ArcGIS models. However, adding an additional layer of complexity by adding EMDS to the mix was not the original plan for the REAs. Concern over requiring field and state office personnel to learn a new software package as part of these assessments has come from the level of a State Director.

- ***Issue #8 – Statement of Work***: The SOW specifically states that all modeling that is performed in the ArcGIS environment would require contractors to deliver ArcGIS ModelBuilder files or ArcGIS Toolboxes. ArcGIS-compatible python scripts that are linked to a Toolbox are also acceptable deliverables. Isolated exceptions to this requirement are allowed if the modeling is done outside of the ArcGIS environment. MaxEnt is an example of this situation.

- ***BLM Finding*** – BLM will not install EMDS on its network for the reasons described above.

- ***Recommendation*** – If Dynamac/CBI teams want to use EMDS the primary requirement will be to deliver ArcGIS models for all work done in EMDS.

APPENDIX 12. Attribute and Indicator Table for Major Conservation Elements of the Colorado Plateau.

Conservation Element	Key Ecological Attribute	Indicator	Indicator Rating				Citation
			Poor	Fair	Good	Very Good	
Mountain Lion	prey	ungulate density	low	medium	high	very high	Julander and Jeffrey (1964)
Mountain Lion	habitat	cover & terrain	very dense or open cover	-	-	rugged terrain with mixed cover	Riley (1998)
Mountain Lion	habitat degradation	human development	high human development	moderate human development	low human development	no human development	Van Dyke et al. (1986)
Peregrine Falcon	actively breeding peregrine falcons	Number of active nests	1 breeding pair (3 year running average)	2 - 4 breeding pairs (3 year running average)	5 -10 breeding pairs (3 year running average)	10 breeding pairs (3 year running average)	
Peregrine Falcon	breeding habitats	distance from human disturbance			>1km		GBBO
Peregrine Falcon	breeding habitats	cliff height	<12m		200+ meters		GBBO
Ferruginous Hawk	abundance of main prey	jackrabbit density	<10 per sq km	10-30 per sq km	30-50 per sq km	>50 per sq km	Howard and Wolfe (1976)
Ferruginous Hawk	habitat suitability	size of contiguous cropland	>16 ha	8-16 ha	1-8 ha	none	Jasikoff (1982)
Ferruginous Hawk	habitat degradation	livestock density	present in large number	present in moderate numbers	present in small numbers	absent	Olendorff (1993)

Conservation Element	Key Ecological Attribute	Indicator	Indicator Rating				Citation
			Poor	Fair	Good	Very Good	
Big Free-tailed Bat	habitat	plant community	other	montane conifer or mixed forest	temperate woodland	lowland riparian, desert shrub	Milner et al. (1990), Oliver (2000)
Big Free-tailed Bat	habitat	roosts	other	tree cavities	buildings, caves	rock crevices in cliffs	Milner et al. (1990)
Big Free-tailed Bat	habitat	elevation	>9,200 ft	7,550-9,200 ft	5,900-7,550 ft	<5,900 ft	Milner et al. (1990), Oliver (2000)
Desert Bighorn Sheep	habitat	distance to perennial water	>3.2 km		< 3.2 km		Smith et al. 1991, Turner et al. 2004
Desert Bighorn Sheep	winter range	snowpack depth	> 25 cm		< 25 cm		Smith et al. 1991
Desert Bighorn Sheep	summer range	area	< 227 km2		> 227 km2		Zeigenfuss et al. 2000
Yellow-breasted Chat	population size & dynamics	Abundance	0 -0.31 birds/ha	0.31 -0.62 birds/ha	0.62 -0.93 birds/ha	>0.93 birds/ha	Golet 2011
Yellow-breasted Chat	population size & dynamics	Shrub density	Low			High	
Yellow-breasted Chat	Habitat	Elevation			<1600m		
Golden Eagle	habitat loss or degradation	urban development	present	--	minimal	absent	Kochert and Steenhof (2002)
Golden Eagle	habitat degradation	livestock grazing and agricultural development	existing or planned	--	--	absent	Beecham and Kochert (1975)

Conservation Element	Key Ecological Attribute	Indicator	Indicator Rating				Citation
			Poor	Fair	Good	Very Good	
Golden Eagle	habitat degradation	fire	>40,000 ha of shrublands burned	--	burned territory with adjacent vacant unburned territory	unburned territories	Kochert et al. (1999)
Golden Eagle	habitat degradation	mining and energy development	present	--	--	absent	Phillips and Beske (1984)
Golden Eagle	habitat	vegetation	disturbed areas, grasslands, agriculture			shrubland	Marzluff et al. (1997), Peterson (1988)
Golden Eagle	habitat nest sites	topography	--	--	--	cliffs within 7 km of shrubland	Menkens and Anderson (1987), McGrady et al. (2002), Cooperrider et al. (1986)
Golden Eagle	mortality	infrastructure (roads, power lines, wind turbines	--	--	--	infrastructure absent	Franson et al. (1995)
Golden Eagle	illness/mortality	poisoning from pesticides and other toxins	high levels of contaminants	--	--	low/no contaminants	Craig and Craig (1998), Franson et al. (1995), Harmata and Restani (1995), Kramer and Redig (1997), Pattee et al. (1990)
Golden Eagle	mortality	shooting	Occurs	--	--	doesn't occur	Beans (1996)
Golden Eagle	population	surveys					Good et al. (2004)

Conservation Element	Key Ecological Attribute	Indicator	Indicator Rating				Citation
			Poor	Fair	Good	Very Good	
Gunnison Sage Grouse	habitat	plant communities	developed	agricultural fields	grasslands	sagebrush, riparian, wet meadows	Lupis (2005)
Gunnison Sage Grouse	habitat degradation	sagebrush loss from leks	<0.6 mi of active lek	0.6-4.0 mi from active lek	4.0-6.0 mi from active lek	none in vicinity	GSRSC (2005)
Gunnison Sage Grouse	disturbance	development footprint	<0.6 mi of active lek	0.6-4.0 mi from active lek	>4.0 mi from active lek	none in vicinity	GSRSC (2005)
Greater Sage Grouse	general habitat	cover type	cultivated fields	scrub-willow; sagebrush savannas	small sagebrush; forb rish mosaics	tall sagebrush	Schroeder et al. (1999) Connelly et al. (2004)
Greater Sage Grouse	habitat	invasive conifers (e.g. junipers)	abundant and encroaching	present but not encroaching	few and not encroaching	absent	Connelly et al. (2000)
Greater Sage Grouse	nest sites	mean sagebrush canopy cover	<15% or >38%	15-23%	23-30%	30-38%	Connelly et al. (2000)
Gunnison's Prairie Dog	forage	available foods	shrubs	insects	forbs	grasses	Shalaway and Slobodchikoff (1988)
Gunnison's Prairie Dog	habitat	elevation	<4,500 ft or >11,000 ft	4,500-5,000 ft or 10,000-11,000 ft	5,000-6,000 ft or 8,500-10,000 ft	6,000-8,500 ft	Longhurst (1944), Pizzimenti and Hoffman (1973)
Gunnison's Prairie Dog	habitat	slope	>15%	5-15%	2-5%	0-2%	Fitzgerald and Lechleitner (1974)
White-tailed Prairie Dog	habitat	elevation	<4,160 ft or >9,630 ft	8,525 - 9,630 ft	7,640 - 8,525 ft	4,160 - 7,640 ft	Utah Natural Heritage Program
White-tailed Prairie Dog	habitat	slope	>10 degrees	5-10 degrees	0-5 degrees	0 degrees	Collins and Lichvar (1986)

Conservation Element	Key Ecological Attribute	Indicator	Indicator Rating				Citation
			Poor	Fair	Good	Very Good	
White-tailed Prairie Dog	habitat	max vegetation height	>92 cm	62-92 cm	31-62 cm	<31 cm	Collins and Lichvar (1986)
Black-footed Ferret	prey	prarie dog density	<3.63 per ha	3.63-5 per ha	5-7 per ha	>7 per ha	Houston et al. (1986), Biggins et al. (1993)
Black-footed Ferret	prey	total area of prairie dog colonies	<800 ha	800-1,900 ha	1,900-3,000 ha	>3,000 ha	Houston et al. (1986), Biggins et al. (1993)
Black-footed Ferret	dispersal	prairie dog inter-colony distance	>4.3 km	3.2-4.3 km	2.1-3.2 km	<2.1 km	Minta and Clark (1989)
Mule Deer	habitat degradation	distance from wells	<2.7 km	-	-	>3.7 km	Sawyer et al. (2006)
Mule Deer	habitat degradation	distance from roads	>200m	-	-	>500 m	
Mexican Spotted Owl	habitat	forest type	spruce-fir, pinyon-juniper, low elevation riparian	ponderosa pine, gambel oak, AZ cypress	Madrean pine-oak, evergreen oak, high elevation riparian	mixed-conifer (Douglas-fir and/or white fir)	Ganey and Balda (1989), Ganey and Dick (1995)
Mexican Spotted Owl	habitat	canopy closure	<55%	55-67%	68-80%	>80%	Ganey and Balda (1989), Ganey and Dick (1995)
Mexican Spotted Owl	habitat	physiography	-	-	mountain slopes	narrow, steep-walled deep canyons below 2,300 ft	Ganey and Balda (1989), Ganey and Dick (1995)
Pronghorn	habitat	distance to water	>6.5 km	4.5-6.5 km	4.5-1.5 km	<1.5 km	Yoakum et al. (1996)
Pronghorn	movement	barriers	abundant	common	few	none	Jaeger and Fahrig (2004)

Conservation Element	Key Ecological Attribute	Indicator	Indicator Rating				Citation
			Poor	Fair	Good	Very Good	
Pronghorn	habitat	diet	woody vegetation	single food type - grass or shrub	somewhat mixed food type	well-mixed food - forbs, grass, and shrubs	Yoakum et al. (1996), Martinka (1967)
Burrowing Owl	thermal biology	elevation	>9,000 ft	7,500-9,000 ft	5,500-7,500 ft	<5,500 ft	Utah NHP (2007)
Burrowing Owl	mortality	proximity to roads	<0.5 mi	0.5-1.0 mi	1.0-1.5 mi	>1.5 mi	Haug et al. (1993)
Burrowing Owl	habitat	aridity/openness of habitat	other	golf courses, fairgrounds, some ag land		dry, open short-grass prairies and steppes	Haug et al. (1993)
Flannelmouth Sucker	habitat	summer water temperature	<10 degrees C or >30 degrees C	10-17.5 degrees C or 29-30 degrees C	17.5-25 degrees C or 27-29 degrees C	25-27 degrees C	Bezzerides and Bestgen (2002)
Flannelmouth Sucker	habitat	water depth	<0.5 m or >2.5m	0.5-1.0 m or 2.0-2.5 m	1.5-2.0 m	1.0-1.5 m	Beyers et al. (2001)
Flannelmouth Sucker	dispersal	unblocked linear extent	<1.6 km	1.6-10 km	10-20 km	>20 km	Bezzerides and Bestgen (2002)
Colorado River Cutthroat	habitat	avg max water temperature	<4 degrees C or >20 degrees C	4-6.5 degrees C or 19-20 degrees C	6.5-12 degrees C or 14-19 degrees C	12-14 degrees C	Binns and Eiserman (1979), Hickman and Raliegh (1982)
Colorado River Cutthroat	habitat	avg min dissolved oxygen	<6.3 mg/L	6.3-7.2 mg/L	7.2-9 mg/L	>9 mg/L	Hickman and Raliegh (1982)
Colorado River Cutthroat	flow regime	avg daily base flow	<25%	25-37.5%	37.5-50%	>50%	Binns and Eiserman (1979), Hickman and Raliegh (1982)

Conservation Element	Key Ecological Attribute	Indicator	Indicator Rating				Citation
			Poor	Fair	Good	Very Good	
Razorback Sucker	habitat	water body	irrigation canals	small rivers, reservoirs	medium rivers	large rivers	Valdez et al. (2002)
Razorback Sucker	breeding habitat	river feature	rapids, riffles	slow runs, eddies	pools, off-channel flooded pits	backwaters	Osmundson et al. (1995)
Razorback Sucker	habitat	summer water temperature	>29 degrees C or <12 degrees C	26.9-29 degrees C or 12-17.5 degrees C	24.8-26.9 degrees C or 17.5-22.9 degrees C	22.9-24.8 degrees C	Buckley and Pimentel (1983)
Razorback sucker	spawning and nursery habitat	substrate	mud, silt, fines, sediment	—	coarse sand	cobble, gravel	Valdez et al. (2002) and sources cited therein
Razorback sucker	survival of eggs, larvae, and, fry (i.e., recruitment)	nonnative fishes*	present	—	—	absent	Minckley et al. (1991), Valdez et al. (2002), and others
Plant Species							
Pinyon Pine	habitat	elevation	<1400 m	---	1400 m - 2700 m	2100 m - 2400 m	Cronquist (1972)
Pinyon Pine	mortality	fire return interval	<100 years		100 to 300 years	>300 years	Keeley (1981)
Pinyon Pine	Climate	precipitation	<102 mm		102 mm - 520 mm		Ffolliott (1974)
Pinyon pine	Climate	Temperature	18° C > , < 24° C				Anderson (2002)
Pinyon pine	Climate	Frost free days	>120		<120		Ronco (1990)

APPENDIX 13. Sequence for Addressing Colorado Plateau REA Management Questions: See Section 3.2, Table 3 for A, B, C timelines

	A. SOILS, BIOLOGICAL CRUSTS, AND FORAGE MANAGEMENT	
B	1.	Where are soils susceptible to wind and water erosion?
A	2.	Where are sensitive soils (including saline, sodic, gypsiferous, shallow, low water holding capacity)?
C	3.	Which HMAs and allotments may experience significant effects from change agents including climate change?
C	4.	Where are soils that have potential to have cryptogamic soil crusts?
C	5.	What/where is the potential for future change to the cryptogamic crusts?
B	6.	Where are hotspots producing fugitive dust that may contribute to accelerated snow melt in the Colorado Plateau?
	B. SURFACE AND GROUNDWATER MANAGEMENT QUESTIONS	
A	1.	Where are lotic and lentic surface waterbodies and livestock and wildlife watering tanks and artificial water bodies?
A	2.	Where are perennial streams and stream reaches?
A	3.	What are seasonal discharge maxima and minima for the Colorado River and major tributaries at gaging stations?
A	4.	Where are the alluvial aquifers and their recharge areas (if known)?
??	5.	What is the condition of these various aquatic systems defined by PFC?
A	6.	Where are the aquatic systems listed on 303(d) with degraded water quality or low macroinvertebrate diversity?
A	7.	What is the location/distribution of these aquatic biodiversity sites?
A	8.	Where are the areas of high and low groundwater potential?
	C. ECOLOGICAL SYSTEMS MANAGEMENT QUESTIONS	
A	1.	Where are existing vegetative communities?
C	2.	Where are vegetative communities vulnerable to change agents in the future?
C	3.	What change agents have affected existing vegetation communities?
	D. SPECIES CONSERVATION ELEMENT MANAGEMENT QUESTIONS	
A/B	1.	What is the most current distribution of available occupied habitat (and historic occupied habitat if available), seasonal and breeding habitat, and movement corridors (as applicable)?
A/B	2.	What areas known to have been surveyed and what areas have not known to have been surveyed (i.e., data gap locations)?
B	3.	Where are potential habitat restoration areas?
B	4.	Where are potential areas to restore connectivity?
A	5.	What is the location/distribution of terrestrial biodiversity sites?
C	6.	What aquatic and terrestrial species CEs and high biodiversity sites and movement corridors are vulnerable to change agents in the near term horizon, 2020 (development, fire, invasive species) and a long-term change horizon, 2060 (climate change)? Where are these species and sites located?
A	7.	Where are HMAs located?

	E.	**WILDFIRE MANAGEMENT QUESTIONS**
A	1.	Where are the areas that have been changed by wildfire between 1999 and 2009?
A	2.	Where are the areas with potential to change from wildfire?
A	3.	Where are the Fire Regime Condition Classifications?
B/C	4.	Where is fire adverse to ecological communities, features, and resources of concern?
	F.	**INVASIVE SPECIES MANAGEMENT QUESTIONS**
A/B	1.	Where are areas dominated by tamarisk and cheatgrass, and where are quagga and zebra mussel and Asiatic clam present?
B/C	2.	Where are the areas of potential future encroachment from this invasive species?
B/C	3.	Where are areas of suitable biophysical setting (precipitation/soils, etc.) with restoration potential?
	G.	**FUTURE DEVELOPMENT MANAGEMENT QUESTIONS**
A	1.	Where are areas of planned development (e.g., plans of operation, urban growth, transmission corridors, governmental planning)?
B/C	2.	Where are areas of potential development (e.g., under lease), including renewable energy sites and transmission corridors and where are potential conflicts with CEs?
	H.	**RESOURCE USE MANAGEMENT QUESTIONS**
A	1.	Where are high-use recreation sites, developments, roads, infrastructure or areas of intensive recreation use located (including boating)?
A	2.	Where are areas of concentrated recreation travel (OHV and other travel) located?
A	3.	Where are permitted areas of intensive recreation use (permit issued)?
A	4.	Where are allotments and type of allotment?
B	5.	Where are the areas of potential woody biomass for energy utilization?
	I.	**AIR QUALITY MANAGEMENT QUESTIONS**
B/C	1.	Where are the viewsheds adjacent to scenic conservation areas?
B/C	2.	Where are the viewsheds most vulnerable to change agents?
A	3.	Where are the designated non-attainment areas and Class I PSD areas?
	J.	**CLIMATE CHANGE MANAGEMENT QUESTIONS**
B/C	1.	Where/how will the distribution of dominant native plant and invasive species be vulnerable to or have potential to change from climate change in 2060?
B/C	2.	Where are areas of potential for fragmentation as a result of climate change in 2060?
C	3.	Where are areas of species conservation elements distribution change between 2010 and 2060?
C	4.	Where are aquatic/riparian areas with potential to change from climate change?