EVALUATE COLORADO'S ACEA METHODOLOGY AS A MECHANISM FOR CUMULATIVE IMPACTS ASSESSMENT IN REGIONAL TRANSPORTATION PLANS

Requested by:

American Association of State Highway
and Transportation Officials (AASHTO)

Standing Committee on the Environment

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Acronyms

ACEA	Area-wide Cumulative Effects Assessment
AASHTO	American Association of State Highway and Transportation
Officials	
CDOW	Colorado Division of Wildlife
CEQ	Council on Environmental Quality
CNHP	Colorado Natural Heritage Program
COG	Council of Governments
CVS	Conservation Value Summaries
CWCS	Comprehensive Wildlife Conservation Strategy
DOT	Department of Transportation
DRCOG	Denver Regional Council of Governments
EJ	Environmental Justice
EO	Executive Order
EST	Environmental Screening Tool
ETDM	Efficient Transportation Decision Making
HHS	Health and Human Services
TMDL	Total Maximum Daily Load
FHWA	Federal Highway Administration
GI	Green Infrastructure
GIS	Geographic Information System
IBA	Important Bird Areas
LRTP	Long-range Transportation Plan
MPO	Metropolitan Planning Organization
NEPA	National Environmental Policy Act
NCHRP	National Cooperative Highway Research Program
NGO	Non-governmental Organization
PACOG	Pueblo Area Council of Governments
PCA	Potential Conservation Areas
PEL	Planning and Environmental Linkages

PPACG	Pikes Peak Area Council of Governments
SAFETEA-LU	The Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy For Users
SHRP	Strategic Highway Research Program
SME	Subject Matter Expert
SWAP	State Wildlife Action Plan
TIP	Transportation Improvement Program
TNC	The Nature Conservancy
TRB	Transportation Research Board
UCD	University of Colorado at Denver
UTPS	Urban Transportation Planning System

1 Introduction

Departments of Transportation (DOTs) are frequently confronted with the challenge of performing meaningful and efficient environmental analysis acceptable to the resource agencies involved, so that environmental information can inform and support decision-making at appropriate points in the transportation planning and project development process. There are many resources to assist planning organizations in navigating the environmental analysis process in all phases of project planning and delivery and meeting respective regulatory requirements. Nevertheless, many agencies still struggle with incorporating environmental considerations in transportation plans, in part because they lack the appropriate tools.

1.1 Key Regulatory Drivers

The National Environmental Policy Act (NEPA) directs Federal agencies to examine the consequences of their proposed activities on the human and natural environment. Consequences include the direct and observable effects, indirect effects and the cumulative effects of past, present, and reasonably foreseeable future actions that may be vague and not easily recognized. Cumulative effects include changes to air quality, water quality, biological resources, historic resources, community resources, and much more.

A comprehensive cumulative effects analysis provides the big picture information decision-makers need to balance transportation decisions against the ultimate environmental consequences. On a project-by-project basis, the effects of an individual project may be minor but the combined effects of multiple activities over time can be significant. Thus, the cumulative impact analysis can be pivotal to the decision-making process, particularly in respect to long-term transportation planning.

Transportation planning involves identifying current and projected future transportation problems and needs at the statewide and metropolitan levels and developing a transportation plan covering 20 or more years. The planning process also includes estimating the impact of recommended future improvements to the transportation system on cultural and natural environmental resources. Planning actions are not considered a Federal action subject to review under NEPA and are typically conducted in the design phase for individual projects. However, there are many decisions made in the planning process that provide a foundation for the NEPA analysis, and when conducted and documented consistent with NEPA procedures, can be accepted and carried through to the NEPA process in project design. The planning process, with its broad scope, offers an appropriate venue for assessing the cumulative impacts of a plan and program (Emerson and Hoeffner 2006). Incorporating natural and human environmental considerations in planning may result in process efficiencies and higher quality mitigation in project delivery.

In 2005, Congress enacted the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) that further emphasized the need to integrate environmental issues with metropolitan planning. Section 6001 of SAFETEA-LU requires that the transportation planning process provide for development of a safe and efficient transportation system with consideration of actions and strategies that protect and enhance the environment, and improve the quality of life. In developing the long-range plan, Section 6001 §134 states:

> *A long-range transportation plan shall include a discussion of types of potential environmental mitigation activities and potential areas to carry out these activities, including activities that may have the greatest potential to restore and maintain the environmental functions affected by the plan.*

Further:

> *The discussion shall be developed in consultation with Federal, State, and tribal wildlife, land management, and regulatory agencies.*

The discussion of mitigation in a long-range plan is fundamentally different from a discussion of mitigation in a NEPA document. In planning, the mitigation strategies and activities are "intended to be regional in scope, and may not necessarily address potential project-level impacts" (23 CFR Part 450 §104). However, as with NEPA, impacts include those to both the human and natural environment.

At the state level, nearly all states have environmental laws, regulations and/or policies that require the transportation planning process include consideration of environmental and social effects; some states have gone a step further and developed environmental performance measures to aid in the decision making process (Amekudzi and Meyer 2005). For example, the Colorado DOT (CDOT) requires the 20-year transportation plan include expected environmental, social, and economic impacts of the recommended transportation network, including an objective evaluation of a full range of alternatives in order to balance transportation needs and environmental needs in a safe and efficient manner [43-1-1103(1)(d) C.R.S.]. Similarly, Virginia DOT's 20-year Statewide Transportation Plan establishes goals, objectives, and priorities to meet federal planning requirements. The Plan promotes economic development and environmental quality, among other things, and includes quantifiable measures to achieve the goals and objectives. The Transportation Board then considers the results to evaluate and select projects for the Six-Year Improvement Program [Code 33.1.23.03].

California's Transportation System Performance Measures Report identifies performance measures to aid in the decision making process, including environmental quality, equity, and economic well-being. The Maryland Transportation Performance Act requires MDOT to apply environmental performance measures to the Maryland Transportation Plan. With assistance from an advisory committee, MDOT developed a set of measureable, meaningful and manageable indicators (Amekudzi and Meyer 2005).

1.2 Background

In 2005, CDOT initiated six major corridor transportation projects within the Denver metropolitan planning region. Each project had the potential to affect the same natural and cultural resources in the region and CDOT considered individual cumulative effects evaluations in the region as redundant and a waste of limited resources. Within this context, CDOT initiated the *Area-wide Coordinated Cumulative Effects Assessment* (ACEA) (Mueller et al 2008). The purpose of the study was to evaluate the technical feasibility of conducting a meaningful cumulative impacts analysis on a regional scale for multiple transportation projects in the 20-year long-range transportation plan (LRTP) and other development related to additional growth and land use changes.

The ACEA study attempted to determine whether a regional accounting of resources is feasible considering the availability of data and other resources and, if so, whether a regional accounting would be useful to NEPA practitioners, planners and decision makers. The study concluded that geographic information system (GIS) data is generally adequate for most resources to support an area-wide cumulative effects assessment (Mueller et al 2008). However, the methodology and tools used for the CDOT study stopped short of providing the information a decision maker needs to understand the significance of cumulative impacts from a proposed transportation network on the potential for any given resource to maintain long-term productivity or sustain itself. Ultimately, CDOT determined the ACEA study did not provide them a practical and implementable approach for conducting a meaningful analysis for cumulative effects on a regional basis.

Nevertheless, DOTs have a continued interest in alternative approaches to the development of a range of tools that can help staff incorporate environmental factors in the LRTP. To help decision makers balance transportation decisions and environmental impacts and make informed decisions, they need to be able to distinguish the location of sensitive resources and other environmental issues, quantify impacts to help determine significance, identify alternatives to avoid or reduce environmental impacts, and plan broad mitigation strategies. It is anticipated that, if feasible, this would lead to project efficiencies and improved environmental stewardship through project development and implementation.

1.3 Research Objective and Approach

The objective of this study, NCHRP 25-25/54, *Evaluate Colorado's ACEA Methodology as a Mechanism for Cumulative Impacts Assessment in Regional Transportation Plans,* was to develop a strategy to identify and apply natural and cultural resource metrics to a regional transportation plan, similar to an air quality conformity analysis, such that decision makers would have a meaningful tool to determine the significance of the cumulative effects of a transportation network on a given resource within the planning region. This research builds on the lessons learned in the CDOT study to develop an alternative and flexible approach for conducting a region-wide cumulative effects analysis. In consultation with the NCHRP Panel, four representative cultural and ecological resources were selected to conduct a cumulative effects analysis on the long-range plans for three metropolitan planning organizations (MPO). The research consisted of the following tasks.

1.3.1 Review of the Colorado ACEA Methodology

Phase I of the ACEA, conducted by Muller et al. (2008) used GIS tools to assess the direct, indirect and cumulative effects from a hypothetical project and compared the impacts to a regional accounting from multiple transportation projects in a metropolitan area on a regional scale. Through a series of seven workshops held within the Denver

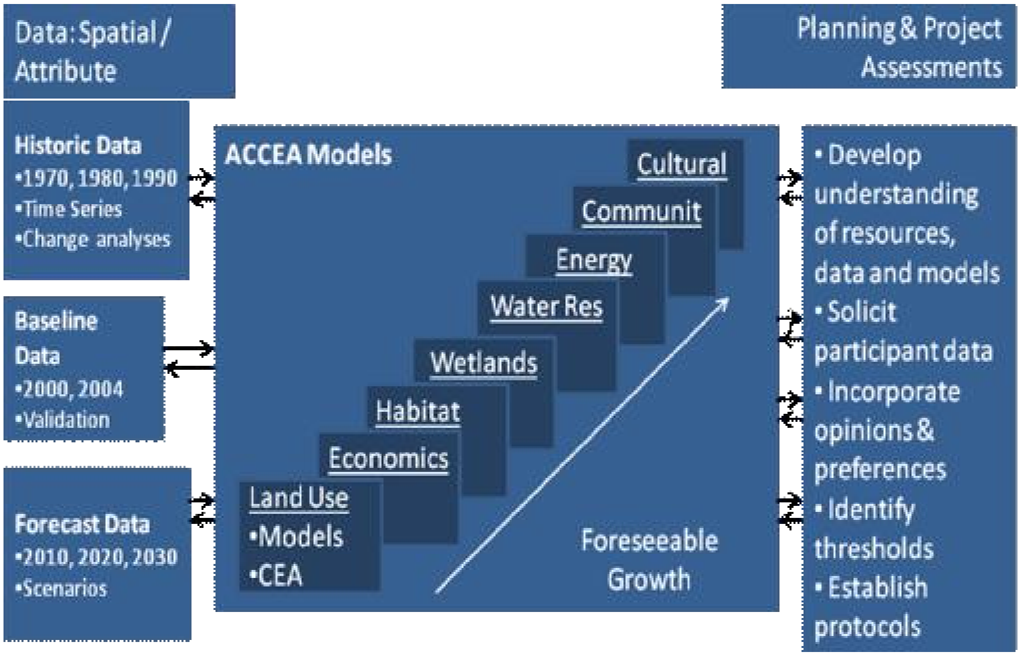
Regional Council of Governments (DRCOG) planning area, input was provided by experts in transportation, environmental, planning and other interest groups. Resources of concern and metrics to measure resource impacts were identified during the workshops but no attempt was made to prioritize the list of resources or their metrics. Workshop attendees could not agree upon threshold levels for the metrics without a clear statutory or administrative guidance, but did agree on thresholds for metrics that did: endangered species (no take or current condition) and wetlands (no net loss). Four demonstration models were conducted using spatial data:

- An Urban Growth Model—to assess impacts of planned growth
- Induced Growth Model—to assess impacts of unplanned growth related to new road corridors
- Impervious Surface Model—to assess impacts on stormwater movement with increased growth
- Suitable Habitat Models—to project likely habitat for the black-tailed prairie dog and Preble's meadow jumping mouse within the study area

Impact results were reported for each model individually; no cumulative result was calculated. These were presented in tabular form, and showed the amount of acres impacted at regional, local, and project specific scales. The authors wanted to determine the significance of changes, however, no thresholds /levels of significance were agreed upon at the expert workshops. Additionally, in the absence of thresholds, there was no attempt to compare the cumulative effects with appropriate national, regional, state or community goals to determine whether there were significant impacts.

This initial phase successfully demonstrated the power of GIS technology, but fell short of providing a clear framework to conduct future cumulative effects analyses. The ACEA Phase I workflow shows data inputs, models, expert review and input, but no clear process nor direction for decision making (Figure 1.1). The main limitation of this approach is the lack of additive cumulative assessment of the model results.

Figure 1.1 Phase I ACEA Work Flow Diagram



(from Muller et al 2008)

1.3.2 Current Project Selection of Representative MPOs

Three MPOs with different levels of staffing were used to demonstrate and evaluate a revised framework and toolkit in order to assess capacity issues for using various tools to conduct a cumulative effects analysis. To simplify data collection for this study, the three MPOs selected are all in Colorado and include a well staffed and large district, DRCOG; the medium-staffed, medium-sized area of the Pikes Peak Area Council of Governments (PPACG) (Colorado Springs and eastern towns); and the small Pueblo Area Council of Governments (PACOG) with a very limited staff. Although the three pilot MPOs are in Colorado, the methodologies, techniques and tools are transferable to MPOs nationwide; however, specific metrics and thresholds will vary by region and should be determined in consultation with the MPO, DOT, resource agencies, and other appropriate stakeholders.

1.3.3 Selection of Resource Areas for Analysis

This study focuses on four key community and ecological areas of interest: biological resources, priority conservation areas, low income and minority populations, and public recreational resources. Metrics (specific resources) were identified for each resource area and indicators were developed for three levels of risk (low, medium and high risk to long-term viability) under cumulative impacts when legal thresholds do not exist. Section 2 discusses the metrics and indicators selected for this research and the workflow model for the cumulative impacts assessment.

1.3.4 Assessment of Available Tools

Cumulative effects analyses inherently require spatial analyses and modeling to calculate and predict changes to distribution and condition of resources. While standard GIS platforms can be used to conduct virtually any spatial analyses, the application of specialized tools has the potential to streamline the process and standardize approaches. Section 3 describes the suite of tools used for this study and provides a few examples of other tools that could be used for conducting a regional cumulative effects analysis.

1.3.5 Application of Metrics to Regional Transportation Plans

The selected metrics and indicators were applied to the long-range transportation plans of the three representative MPOs and the results are presented in Section 4.

1.3.6 Focus Group

The methodology and initial results of the cumulative effects analysis were presented to a focus group of representatives from various resource agencies, MPOs, and CDOT in a series of three webinars. The focus group provided feedback on the approach and tools, recommendations for improvement and their overall opinions on the usability and value of a region-wide cumulative effects analysis. A summary of the feedback from the focus group is presented in Section 5.

1.4 Study Limitations

Due to the limited scope of this study, the temporal and spatial boundaries are not necessarily consistent with NEPA requirements. For this study, only present and potential future impacts were considered; past effects to cultural and natural resources were not included due to the time and resources needed to locate historical data. In reality, the accumulative effect of all past actions, or the baseline condition, may be adequate. In other instances, the scoping process may reveal past actions that would be useful and relevant for decision makers to make a reasoned choice among alternatives. It is also noted that spatial boundaries are not the same as political boundaries and vary by resource. However, for purposes of this study, the spatial boundaries were considered to be the same as the geographic boundary of the respective MPOs. This approach was considered adequate since the primary purpose of this study was to identify a methodology and a range of tools that can be used by MPOs with diverse capabilities to conduct a region-wide analysis rather than to conduct a NEPA analysis.

2 Region-wide Cumulative Assessment Work Flow

A regional cumulative impact assessment workflow describes the flow of information from source inputs (GIS maps, expert knowledge, stakeholder input, etc.) through analytical functions to produce the outputs used for decision making. The workflow used for this study provides a relatively simple but highly robust and flexible approach to conducting regional cumulative impact assessment and the consequent development of alternatives and mitigations. The workflow is modeled on some of the core concepts of systematic conservation planning (Margules & Pressey, 2000) and the use of spatial decision support tools that automate a great deal of the technical GIS work necessary to carry it out (Sarkar et al., 2006). Maintaining a scientifically-defensible and robust process does raise the bar in terms of data, subject matter expertise, and spatial analyses. Further information on tools is presented in Section 3 of this report.

The workflow is presented in terms of diagrams that depict the flow of information from source inputs to outputs utilized in decision making. It is important to emphasize that the workflow and supporting toolkit are decision ***support*** systems, not decision making systems so the results require review and judgment in terms of how they should affect decision making. General recommendations for metrics and indicators are followed by an overall workflow. The overall workflow is subdivided into submodels and their interactions. Additional detailed views of each submodel are also provided.

2.1 Metrics and Indicators

From here on metrics and indicators are described in terms of resources and retention goals. We define resources as those features that are to be assessed for effects and metrics as both the unit of measurement and the threshold to determine significance of effects.

2.1.1 Resource Selection

Resource selection is conducted primarily by considering legal requirements and stakeholder/citizen values in the planning region. Specific methods for resource selection can include:

- Identifying what specific resources are required to be assessed/conserved by law such as wetlands and endangered species
- Consulting with resource agency and key partner organizations to identify their priorities and objectives that extend beyond legal requirements
- Engaging other key stakeholder groups to identify their priorities and objectives
- Conducting civic engagement/community visioning to include public values in specific resources or locations

2.1.2 Ecological Indicators

For ecological values, this study draws on key recommendations from the field of systematic conservation planning. Key features of this approach include:

- Applying the coarse filter-fine filter approach (Noss 1987, Hunter 1991): The main idea of the coarse filter is that by conserving representative examples of all the ecological communities of a given region, the vast majority of species can also be conserved. The explicit assumption is that communities can serve as a surrogate or coarse filter for conserving the majority of species of a region. But some species, such as rare or wide-ranging ones, are either not predictably associated with communities and ecosystems or range across many ecosystems. These species may pass through the coarse filter and require a more focused fine-filter approach, such as those that commonly occur under endangered species programs. The original coarse filter-fine filter metaphor was straightforward: if a set of reserves contains representative examples of all the various community types in a given region it should protect viable populations of most species. For the remaining species, those that fall through the pores of the coarse filter, a series of fine filters protection strategies are needed (Noss 1987, Hunter 1991). Protecting ecological communities, therefore, complements saving rare species.

- Applying quantitative retention goals: this concept uses either a single quantity or range of quantities of spatial goals (number of acres or number of occurrences/populations) to drive the development of conservation plans (Groves 2003). The use of quantitative goals helps determine the gap in goal achievement in existing conservation reserves and amount of additional conservation required as well as to quantify the impact of actions that will remove area or occurrences of habitat. Retention goal setting is further described in Section 2.1.4.

- Irreplaceability: this concept calculates how irreplaceable or required a site is to meet stated quantitative retention goals (Groves 2003). For example, if a site contains a resource feature with a retention goal of 100%, its irreplaceability score is 100% meaning that it must be in a land use compatible with retention of that feature. This concept can be used to help prioritize resources (those with higher goals have higher priority) as well as places and is particularly useful in evaluating tradeoffs between two conflicting uses of a site.

- Complementarity: this concept is used to help identify efficient sets of sites for meeting resource retention goals by identifying which sites can provide the most goal achievement across resources in addition to sites already "conserved" (Groves 2003).

A large number of conservation plans have been developed using scientifically defensible approaches. Therefore, it is suggested that these plans be included after vetting how they were developed and determining their suitability to the project purposes and context. Not all conservation plans accommodate all important ecological resources and thus a combination of plans plus inclusion of individual resources not included or inadequately represented in plans is suggested. Examples of such plans with their emphases and source information include:

- **State Wildlife Action Plans,** technically know as comprehensive wildlife conservation strategy (CWCS)**s** are required by every state to ensure conservation programs funded by SWG are designed for maximum benefits to nongame wildlife. These proactive plans examine the health of wildlife, identify priority species, and prescribe actions to conserve wildlife and vital habitat before they become more rare and more costly to protect. These reports contain information on the distribution and abundance of species of wildlife, the locations and relative condition of key habitats; prioritize species and key habitats; identify issues that adversely affect prioritized species and their habitats; and identify conservation actions necessary to conserve them. These data layers can be very useful for bringing in map representation of prioritized species and their habitats into the planning area. (Colorado Division of Wildlife (CDOW) 2006).

- **The Nature Conservancy Ecoregional Assessments and Conservation Action Plans** are intended to represent biodiversity conservation priority areas by applying systematic conservation planning. Ecoregional Assessments have been done throughout the U.S. but are often conducted over vast areas and may produce plans that are too coarse in scale for direct spatial application to LRTPs. However, a great deal of valuable work in terms of identifying resources and retention goals will have been produced and source input data of appropriate scale likely will have been gathered. Conservation Action Plans are typically conducted at local landscape scales appropriate for application to LRTPs but they have not been developed systematically across the U.S. and thus are much less available (Neely et al 2006).

- **Natural Heritage Program Conservation Sites** identify areas where there is a concentration of species and habitats of concern. These are often at a fine scale and can complement broader planning approaches. Natural Heritage Programs provide information on the distribution of potential conservation areas (PCAs) to public and private agencies and individuals for environmental review, proprietary land management, resource planning, biological and ecological research and general scientific reference. A PCA represents the best estimate of the primary area supporting the long-term survival of targeted species, subspecies and natural communities. PCAs are land units that have been identified as important to the continued existence of ecological processes that support one or a suite of rare or significant features. Also, a) they are often based on desk-top scientific references and need ground-verification; b) they are based on biological and physical factors and do not account for land owner-ship and political concerns; c) they are useful for land-use planning and conservation strategies but do not carry any legal meaning or in any way represent an attempt to regulate or limit the use of private property. PCAs constitute a hypothetical area required to ensure the continued existence of the targeted biodiversity resources (Colorado Natural Heritage Program 2009).

- **Audubon Important Bird Areas (IBA)** are vital to birds and other biodiversity. IBAs are sites that provide essential habitat for one or more species of birds, and include sites for breeding, wintering, and/or migrating birds. They may be a few acres or thousands of acres, but are usually discrete sites that stand out from the surrounding landscape. IBAs may include public or private lands. Criteria can include support of: species of conservation concern (e.g. threatened and endangered species), restricted-range species (species vulnerable because they are not widely distributed), species that are vulnerable because their populations are concentrated in one general habitat type or biome, and/or species (or groups of species such as waterfowl or shorebirds) that are vulnerable because they occur at high densities due to their congregatory behavior (Audubon Society 2009).

- **Other regional conservation plans**: some additional organizations have also produced systematic conservation plans for particular regions such as those of the Wildlands Project (e.g., Yellowstone to Yukon initiative) or Southern Rockies Ecosystem Project. (see http://www.y2y.net/home.aspx ; http://www.restoretherockies.org/)

- **Local land trusts** often lack the capacity to conduct systematic conservation planning, however, examples exist of such planning conducted at local scales. Additionally, land trusts may have considerable expertise in the biodiversity (and other resources of conservation interest) of the region and may be important implementation partners. (see http://www.landtrustalliance.org/home-page)

2.1.3 Cultural Indictors

Cultural indicators present a unique challenge in that they are additive resources. That is, the absolute numbers of these resources increase as time passes; whereas other resources tend to decline. For example, properties that are eligible for the historic register may exist today and are not a protected resource, but during the implementation of a 20+ long-range plan, will become a resource that must be considered.

2.1.3.1 Environmental Justice

For Environmental Justice (EJ) issues, this study refers to Executive Order (EO) 12898, “Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations and FHWA Order 6640.233 “FHWA Actions to Address Environmental Justice in Minority Populations and Low-Income Populations. The EO requires federal agencies to identify and address disproportionately high and adverse human health and environmental effects of their programs on low income and minority populations to achieve environmental justice. While EJ concerns are most often raised during project development, the most appropriate time to ensure compliance with the Orders is in the planning process.

Minority refers to persons who are Black (having origins in any of the black racial group of Africa or African Americans); Hispanic (of Mexican, Puerto Rican, Cuban, Central or South American, or other Spanish culture or origin, regardless of race); Asian American (having origins in any of the original peoples of the Far East, Southeast Asia, the Indian subcontinent, or the Pacific Islands; or Native American Indian and Alaskan (having origins in any of the original people of North America maintaining cultural identification through tribal affiliation or community recognition) (USDOT n. d.).

Low–income refers to a person whose household income (or in the case of a community or group, whose median household income) is at or below the U.S. Department of Health and Human Services (HHS) poverty guidelines (USDOT n. d.). As of 2009, the HHS guideline for a family of four is approximately $25,000 (US Census 2009).

The census is the best source of information on concentrations of low-income and minority populations, although the information can be somewhat dated. Other Federal, tribal, state, and local health, environmental, and economic agencies may also have useful demographic information (CEQ 1997).

2.1.3.2 Section 4(f) Property

The intent of Section 4(f) of the US Department of Transportation Act of 1966, as amended (49 U.S.C. 303 (c)) and FHWA regulations at 23 CFR Part 774 is to avoid the use of any significant publically owned parks, recreation areas, wildlife and waterfowl refuges and historic sites unless there is no feasible and prudent alternative to the use of such land. In order to demonstrate that there is no feasible and prudent alternative to the use of 4(f) land, location alternatives and design shifts that totally avoid the 4(f) land and all possible planning to minimize harm must be well documented and supported. The long-range planning process is an appropriate place to begin to identify these resources and consider alternatives to avoid 4(f) resources. At the project level design phase it can become much more difficult to develop avoidance alternatives or minimize impacts.

For purposes of this study, the MPOs provided information on the location of public parks and bike paths or “green infrastructure”. (Due to the limited scope, this study did not attempt to gather data for wildlife refuges or historic sites.) MPOs do not necessarily have information on the location of all types of 4(f) properties and in practice, additional information could be obtained from the State DOT, local entities, federal and state wildlife protection agencies, the National Park Service, the Advisory Council on Historic Preservation, the State Historic Preservation Officer, the US Forest Service, the Bureau of Land Management, and other land management agencies, as appropriate.

2.1.4 Retention Goal Setting

Setting quantitative goals for retaining resources are a key part of systematic conservation planning and are recommended in this approach to regional cumulative effects assessment to determine when levels of significance[1] of effects have been reached. The following is a brief summary of the subject from Chapter 6 “How much is Enough? Setting Goals for Conservation Targets” by Craig Groves (2003).

Setting goals for conservation serves four useful purposes. First, goals allow an evaluation of how effective a proposed plan will be in retaining resources at levels believed to be necessary to achieve their long term viability within the region/project area. Second, setting explicit goals enables planners and managers to better understand and account for the tradeoffs that often must be made in trying to sustain human

[1] The use of the word significant here is not the same as the definition of significant in the CEQ regulations 40 C.F.R §1508.27.

communities, ecological communities, and species. Most decision makers are routinely placed in such positions by laws and policies that require them to make these sorts of tradeoffs. Third, goals will help planners realize how many conservation areas are needed at regional and local scales and may underline how important a particular conservation area may be. Fourth, goals are quantifiable and document a desired vision of future scenarios by stakeholders, the general public and resource agencies as well as planners.

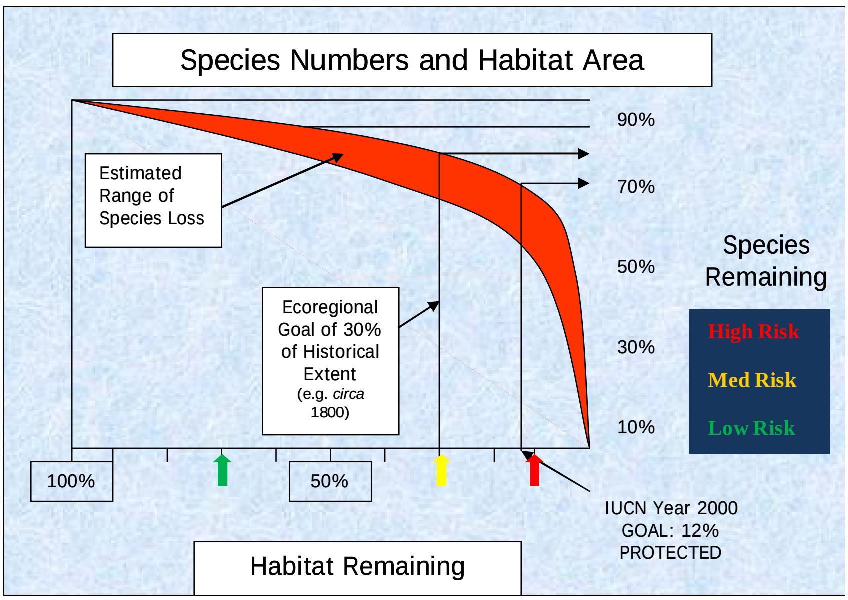
The primary purpose of setting goals is to estimate the effort that will be necessary to sustain resources well into the future. "Sustain" does not mean keeping populations at minimal levels that may not be ecologically functional (Groom and Coppolillo 2001). How much is really enough? What proportion of an ecosystem needs to be conserved in compatible land uses to ensure that the ecological processes remain intact and that the native species composition and structure are maintained into the future? A similar thought process would apply to cultural resources although there may be greater emphasis on avoidance of the resource. These are among the most difficult questions for planners, biologists and managers to answer and some of the most discomforting. Although principles of conservation biology and ecology offer guidance to address these questions, our knowledge of the life history requirements of most species is too incomplete to provide definitive answers. The assumption behind the goal-setting process is that the conservation of multiple examples of each resource across its range of distribution will help "capture" its ecological and genetic variability.

The overarching goal or vision is to identify priority areas that, if properly managed, would conserve biodiversity. To achieve that vision, stakeholders need to set resource-specific goals. Biologists and planners need to be careful to not confuse goals with values. Scientists often give credence to goals by referring to them as "scientifically defensible" of "justifiable". Goals and objectives are justified not in references to science but in references to values—the things people care about. Scientific thinking helps inform how to go about achieving goals.

In most situations, planners need the flexibility to meet the needs of many stakeholders in any given region. Figure 2.1 shows the relationship between the percentage of habitat loss and the percentage of the number of species likely to be remaining after that habitat loss. Curves like these (based on Dobson 1996, modified from Comer 2005 and Comer 2001) are used to predict the number of species that will go extinct in a region from habitat loss. The two curves represent results primarily from studies on ocean islands (lower curve) contrasted with studies on terrestrial "habitat islands" (upper curve). Interpreted cautiously, these curves suggest that conservation goals for communities or ecosystems in continental situations that attempt to conserve 30-40% of historical extent of habitat are likely to conserve 65-80% of the species that occur within them. The green, yellow and red arrows illustrate Low, Medium and High Risk Goals, respectively. A Green, or low risk, goal of 70%, for example, has a lower risk of losing species (or a higher likely hood of retaining more species) than goal of retaining only 10 or 12% of a community or ecosystem.

In the examples that follow, planners established three different retention goals, ranging from 10 to 90% and examined the alternative results. Figure 2.1 presents an example of alternative "low, medium, and high" risk retention goals as it generates less conflict with other uses. Conversely, a "low risk" goal carries a low risk of losing biodiversity but requires more area and thus more tradeoffs with other uses to achieve the goals. With modern GIS applications, planners can fairly easily examine these different scenarios. Ease of analysis, however, does little to alleviate the problem that in many regions, especially metropolitan areas, indigenous species populations, natural vegetative cover, and naturally flowing streams have been so extensively altered that flexibility in selecting areas to protect, let alone setting and meeting goals for preservation, may be a moot point.

Figure 2.1 Goal Setting Based On Species-Area Curve



Guidelines for Setting Goals

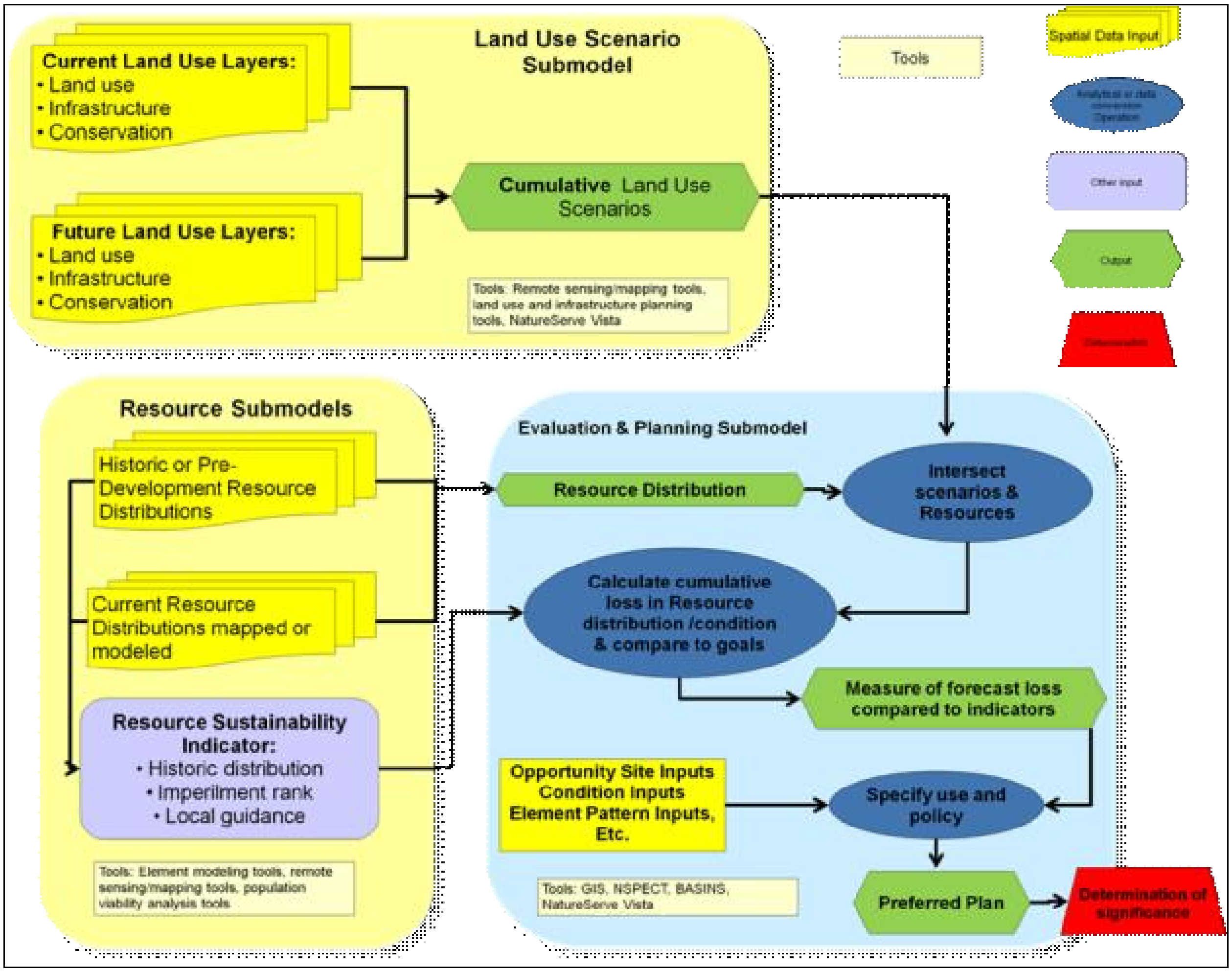
- Use recommendations from literature, recovery plans, and experts.
- Use results from species-area relationships (Figure 2) for communities and ecosystems.
- Use history as a guide to the past and future — it is helpful to have some understanding of the historic extent of ecosystems. If only 30% of historic values remain, then a goal to retain all that is left can be presumed justifiable.
- Use Alternative Goals to explore potential optional scenarios — maps of alternate scenarios can be a powerful tool to illustrate future options.
- Observe the Precautionary Principle -- Anticipate the demise and degradation of biodiversity and act accordingly with prudence, especially in the face of

uncertainty. Set retention goals with safety margins, especially when little is known about certain species or ecosystems.

2.2 Cumulative Impact Assessment Model

The cumulative impact assessment model is a combination of described methods supported by graphic workflow diagrams. Figure 2.2 illustrates the general cumulative impact assessment model and identifies the more detailed submodels for the various components. The model begins with the Land Use Scenario Submodel that generates the scenarios used to evaluate cumulative effects. The Resource Submodels generate information about the spatial distribution, retention requirements, and sustainability indicators (retention goals). The Evaluation and Planning Submodel combines the scenarios and resource information to calculate cumulative effects and support either alternative plan development or mitigation identification. The cumulative effects are measured against defined indicators at which point stakeholders and decision-makers can make a determination of significance of the environmental impacts. In this final stage, an informed decision can be made about the indicators using metrics produced in the process and changes can be made to plan alternatives to create more compatible plans or mitigation to plan impacts can be identified.

Figure 2.2 General Cumulative Impact Assessment Model

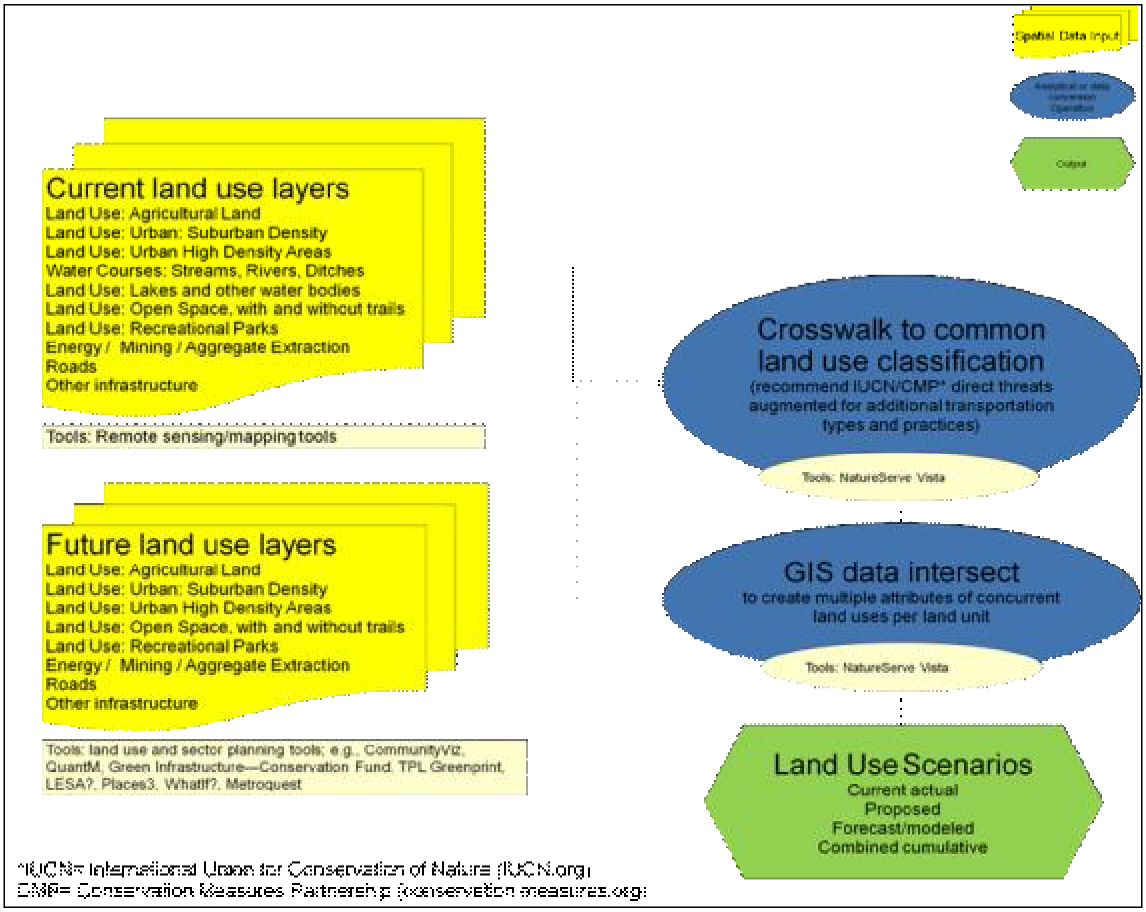


2.2.1 Cumulative Scenario Mapping

A cumulative scenario analysis describes physical factors (land uses, management practices, natural disturbances, etc.) occurring or planned or predicted to occur on the land, in the water, or in the air. Typically, separate scenarios are built that describe current actual factors, allowed factors under current policies, proposed factors, or expected factors under market and or ecological/climate trend models. Long-range Transportation or Corridor Plans are represented as "proposed" scenarios but would be inclusive of current factors and may also include trends (e.g., in urban growth but also other disturbances that would add cumulative effects).

A scenario incorporates as many factors that affect the resources as can be reasonably mapped and assessed for effects on resources. During this step, defining the scope, time frame, and geographical limit of the study is important to identify appropriate factors as inputs to scenario mapping. Many of the factors included in Figure 2.3 are common examples of land use and land policy layers which are used in cumulative scenario mapping. The inputs may include additional map layers depending on the nature and scope of the project. A multi-disciplinary team can help establish which layers are most important to include in the study.

Figure 2.3 Cumulative Scenario Mapping Workflow



Many of the map layers listed in Figure 2.3 are becoming increasingly available online through state, regional, county or city GIS clearinghouses. Future land use layers can be extracted from 20 or 30 year comprehensive plans or vision assessments. If this data is difficult or impossible to obtain, tools can be used to spatially model future urban growth based on spatial trends or more complex object-based models. Not uncommonly, remotely sensed data, such as Landsat satellite imagery is used to map prior growth and supports future scenario modeling.

Scenario input layers often originate from various sources so it is important to crosswalk them to a common classification inclusive of all factors used in the assessment. This step will support gathering expert knowledge on the responses of each resource to each factor which then facilitates rapid cumulative assessment of any proposed scenario. This approach recognizes the individual responses resources have to each factor; for example, a new road overpass may actually improve wildlife species connectivity but may impact a recreation area or low income or minority populations. Additional tips for creating a common factors classification are:

- Good classifications are simple and intuitive; an audience of professionals should be able to clearly understand why certain types were included and what they represent. A consistent approach to classifying will aid this process immensely.
- The common factors classification should be hierarchical and nest more specific types within more general types and represent a gradient of intensity of the factor where applicable.
- The classification should allow new factors to be incorporated as they are identified or changed depending on expert input.

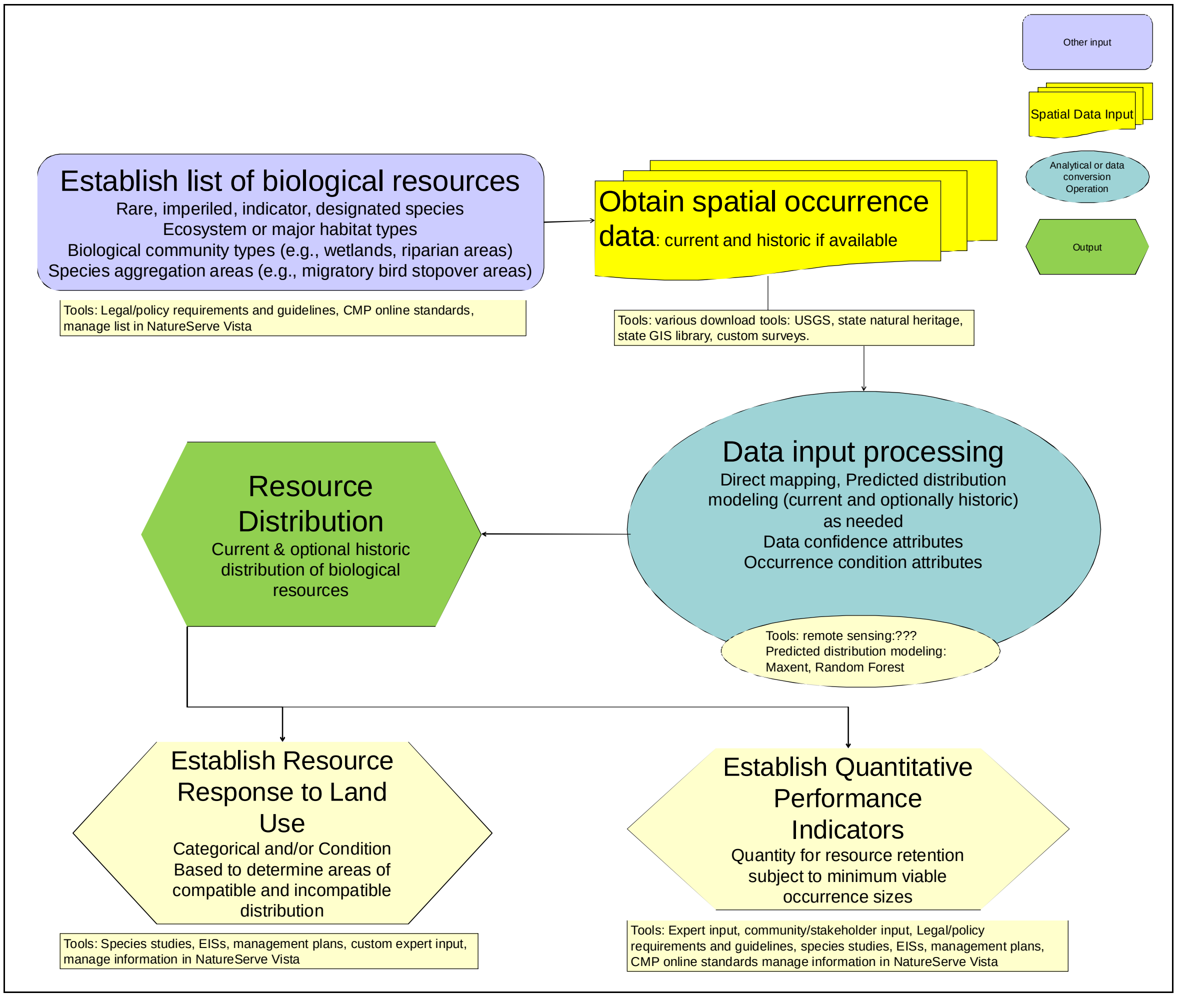
The GIS data intersect requires the user to input factors in terms of physical uses/phenomena and optionally land policy information. Land policy describes the mechanism by which a use/phenomena occurs or restricts other uses such as by zoning, legislative acts or even natural processes such as plant community succession. This attribute can be useful to understand the risk that a seeming natural open space use may be converted to development in the future. Land policy also assists in the GIS process of determining whether overlapping input layers represent concurrent land uses or if one layer takes precedence and “dominates” other layers -- federal law will take precedence over state law, etc. Often, an area will have multiple plans which guide or restrict actions.

The outputs of this process are different scenarios. An initial or baseline scenario may simply reflect what land uses and land policies are currently in effect. Adding future land use and land policy data will create forecast or proposed scenarios.

2.2.2 Biological Process Submodel

Figure 2.4 depicts the biological process submodel. Establishing a list of biological resources is the first step towards creating a database of biological resources -- ecosystems, habitats, and species that need to be considered when evaluating cumulative effects. Obtaining these resources has become much easier in the last 20 years. Many of these resources are available online from state natural heritage programs, Division of Wildlife, and the US Fish and Wildlife Service, among others. Historic occurrence data, when available, is used for considering effects against an earlier set of baseline conditions. This type of data can also inform planners about possible opportunities for mitigation through restoration of habitat. Biological data can be incorporated into a GIS as vector or raster data. It is noted, however, that climate change predictions are expected to result in sometimes dramatic shifts in species and habitat distributions and (though it is not explicitly addressed in this process model) incorporating climate change effects for adaptation planning as part of this process is encouraged.

Figure 2.4 Biological Processes Workflow



Certain species may be of high concern but have limited occurrence data. Habitat models have been developed to predict the distribution of a species. Predictive distribution maps are critical to planning for calculating expected effects on distributions and avoiding surprises of finding species during project EISs that should have been addressed during LRTPs. Specialized programs such as Maxent and Random Forests can model the predicted species distributions but should be used with expert guidance and input.

The initial outputs are resource distribution maps for the biological resources of the study area. Several important steps remain to finalize the outputs. First, the biological response to factors needs to be established. The fundamental assumption is that biological resources will respond to changing conditions on the ground. This response can be categorical (beneficial, neutral, negative). A condition model can be used to set a degree of impact on a numerical scale for a biological resource or group of resources. In addition, a distance effect can be added to account also for offsite impacts such as noise, light, microclimate effects, and water pollution. A condition model can save time by allowing the user to group large numbers of biological resources together (for example, songbirds or amphibians) and assign a common impact value and characterize how much of a buffer these resources need in order to persist. Information about how a biological resource responds to a factor can be obtained from a variety of sources: environmental impact statements, game management plans, individual species studies, and most productively through direct expert input in this process.

The final step in the biological resource submodel is the establishment of quantitative performance indicators as explained in Section 2.1.4. This step is critical to quantifying and assessing cumulative effects of land use change. This input numerically defines the amount of a biological resource necessary to maintain a viable population or a functioning ecosystem. While for legally-protected resources there may be established thresholds; for other resources the indicator can be provided by expert input or a combined process with community or stakeholder input.

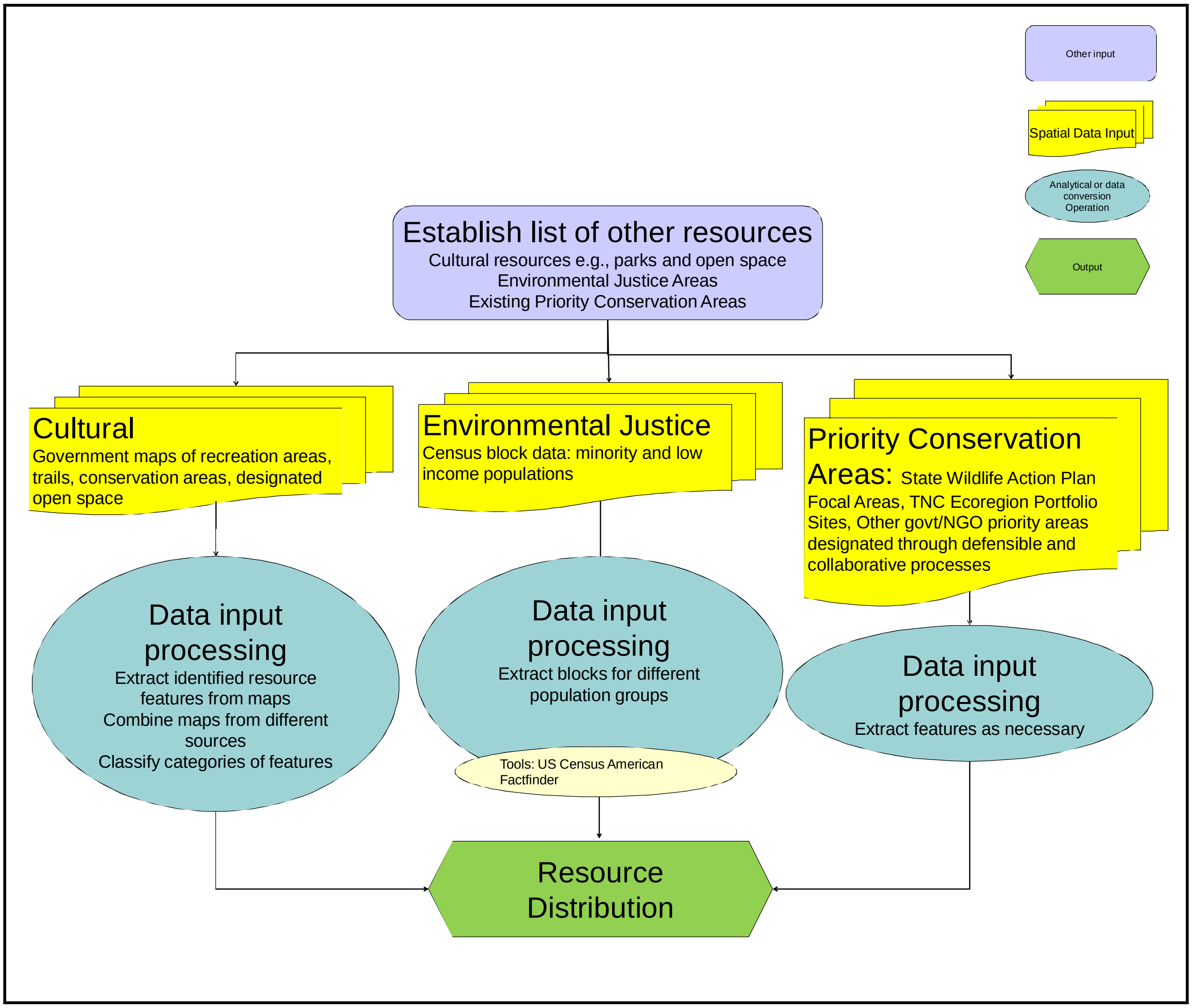
2.2.3 Cultural, Environmental and Priority Conservation Areas Submodels

Just as the cumulative effect on biological resources is important to monitor and evaluate, it is as important to evaluate the effects on the human environment including impacts to low income/minority communities, green infrastructure (parks, greenways, designated open space), priority conservation areas and others. The process of integrating this information is similar to that of biological resources and is depicted in Figure 2.5. Initially, a decision making process defines a set of resources that will be included in the cumulative effects analysis. This set of resources is then reviewed against the availability of spatial data that can represent them. In recent years, much of this information has become more accessible online through state and local government GIS data clearinghouses. The US Census offers an easy online tool, the American Factfinder (http://factfinder.census.gov/home/saff/main.html?_lang=en) for downloading income and minority information usually at the census block level.

At the forefront of priority conservation areas are focal areas defined by State Wildlife Action Plans (SWAPs) (also known as CWCS) and those produced by non-government organizations (NGOs) such as The Nature Conservancy (TNC) Ecoregion Assessments and Conservation Action Plans, Audubon IBAs, and local NGOs and other state and federal agencies with specific resource management responsibilities. SWAPs have been defined by biologists to hold a host of sensitive, at-risk or federally listed species. The State Division of Wildlife will also designate critical areas for big game species: winter ranges, calving grounds or other important habitats. While big game are rarely at-risk species, their presence in proposed transportation project areas have severe safety considerations as well as considerable value to citizens, sportsmen and women, and local economies.

All of this information can be incorporated into a GIS platform and mapped to reveal the independent and combined resource distributions.

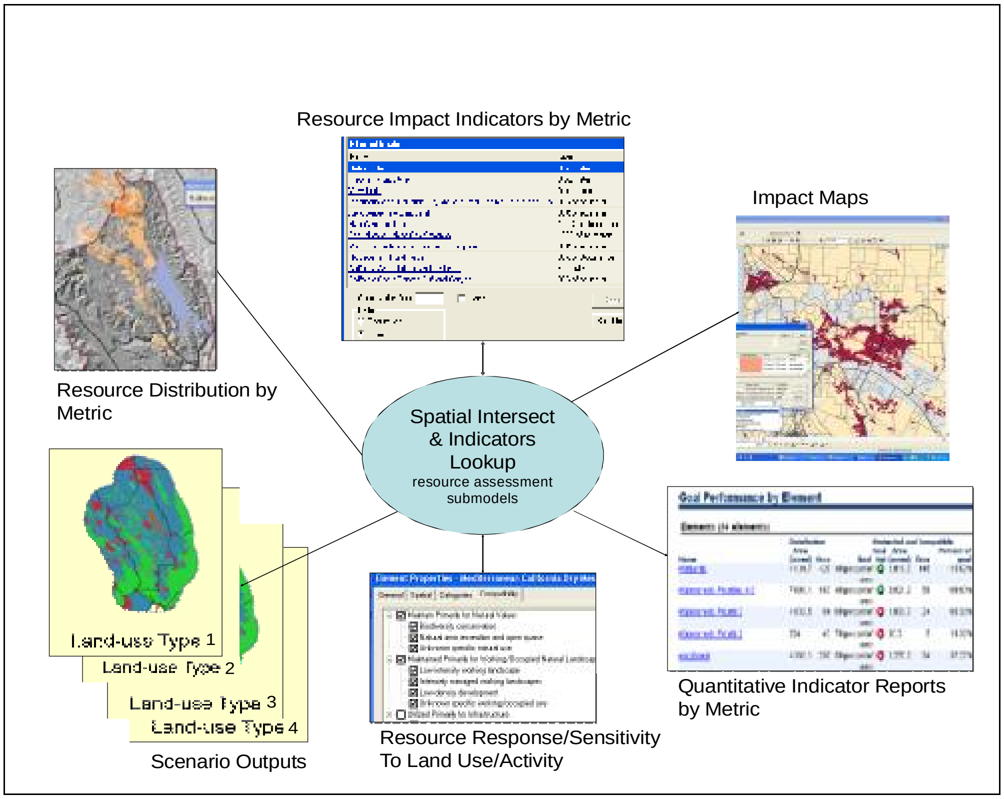
Figure 2.5 Resource Data Workflow: Cultural, Environmental Justice, Priority Conservation Areas



2.2.4 Scenario Evaluation and Outputs

Figure 2.6 illustrates the process of quantifying and evaluating the cumulative effects by comparing resources to scenarios and assessing effects against resource responses and sustainability requirements. It also depicts the outputs that can be produced from a comprehensive cumulative effects analysis. The metrics and indicators entail three levels of significance: low, medium, and high risk.

Figure 2.6 Scenario Evaluation of Cumulative Effects



The model intersects resource distribution maps with scenario maps of cumulative factors. Each resulting combination of resources and factors is first assessed for resource response to determine if that area of intersection is compatible with resource sustainability or not. Next, aggregated areas of compatible resource are compared to a minimum required occurrence size input and if that threshold is met, the area is summed to determine if the overall indicator is met. Results are output in both tabular report form and map graphics. Specific outputs are detailed here:

Scenario Performance by Resource: Reports resource indicator performance for each evaluated scenario according to percent of indicator achieved and quantity of resource remaining. Resources not meeting the indicator threshold are flagged.

Scenario Conflicts Map: Depicts areas of the map containing resources that failed to meet retention goals (indicator threshold) and are incompatible with the scenario factors (e.g., land use) at those locations. Conflict areas are colored in an increasingly darker gradient to indicate number of resource conflicts at those locations.

Resource Impact Maps: Intersecting incompatible factors with resource data will produce maps for each resource illustrating areas where impacts are occurring or could occur given a particular scenario.

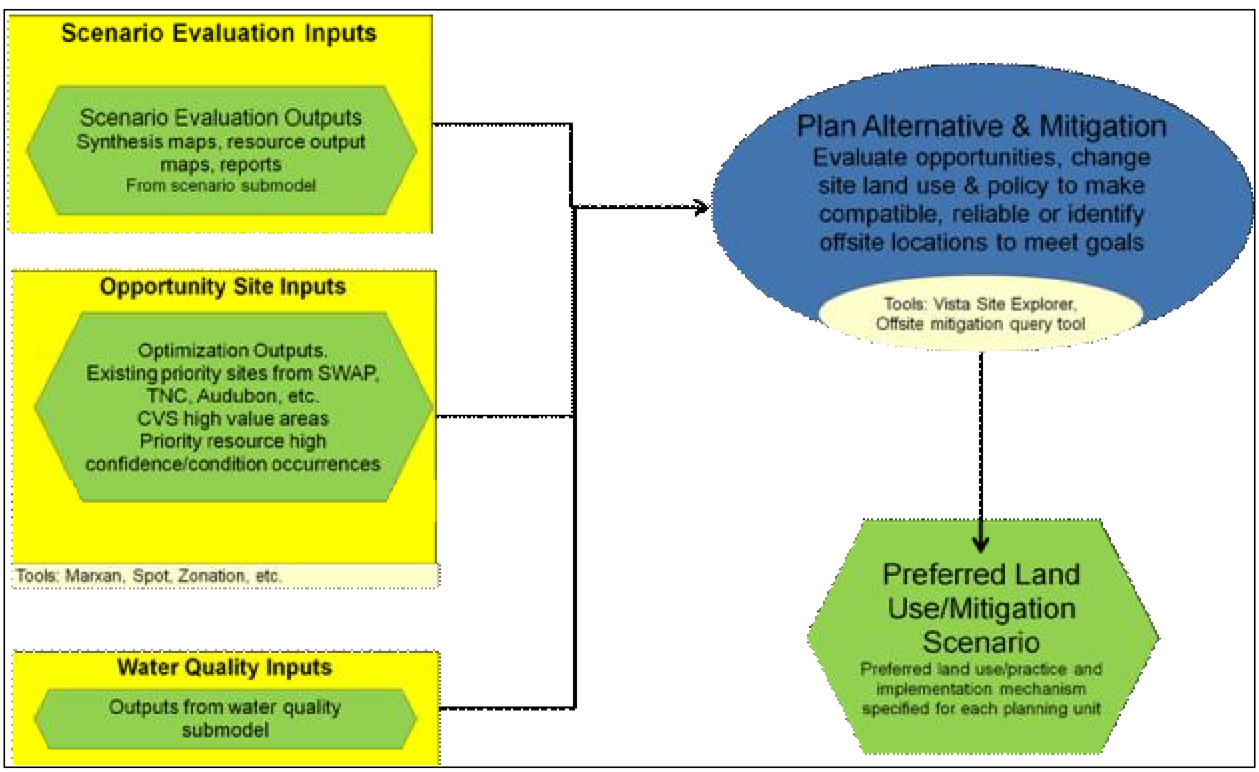
Quantitative Indicator Reports by Resource: The report provides detailed statistical and map outputs for each resource as it performed under each scenario.

These outputs are then used by planners, resource subject matter experts (SMEs), and decision makers to determine if impacts are sufficiently significant to reject a plan option or if modifications could be made to create an acceptable plan either through creating a new alternative or mitigating impacts (see section 2.2.4.1 for alternative plan and mitigation workflow).

2.2.4.1 Plan Alternative Development and Mitigation Submodel

Once cumulative effects and significance of impacts are understood, this workflow (see Figure 2.7) assists the planner (in combination with resource experts) in developing alternatives to the LRTP or identifying specific mitigation needs and opportunities. In section 2.2.4 the planners, SMEs, and decision makers would have determined what course of action to take: accept or reject a plan alternative, modify an alternative, or mitigate an alternative. A modification course suggests that impacts could be avoided by changing the land use/transportation features of conflicting sites to compatible uses and relocating (if necessary) those uses to locations that would not cause conflicts. A mitigation course suggests that some land use/transportation features cannot be changed or relocated and impacts occur. This workflow would address the process of identifying offsite locations and methods to achieve resource retention goals.

Figure 2.7 Plan Alternative and Mitigation Workflow



2.3 Key Differences with ACEA Study

- The ACEA 2008 study addressed individual biological resources and for demonstration purposes used predictive habitat modeling for two mammal species. The explicit use of existing conservation priority maps and assessing those for how well they cover the resources of interest and whether they are at an appropriate level of precision for the type and scale of the assessment is suggested. The results of that analysis can identify if and which individual resources (e.g., species and ecosystems) may need to be added to the assessment and then what data source or predictive models may be available or needed.
- The 2008 ACEA study recommended expert workshops to develop levels of significance, however, workshop attendees were unable to agree on such levels for resources without legal status. Expert involvement is needed along with other processes for setting levels of significance such as using a range or flexible assignment of levels assigned by different levels of risk, for example 10%, 50%, 80% retention goals, and exploring the results of each with decision makers and stakeholders.
- The ACEA study used manual GIS analyses but reported just tabular final impact data at three scales, and those effects were not cumulatively assessed. The use of GIS spatial decision support tools is suggested to increase efficiency and ease of adoption by non-GIS experts and to combine present and future scenario factors to obtain true cumulative effects assessment.

3 Tools

After completing the process models (see Section1.3.2) a broad survey was conducted for additional tools that could address parts of the workflow. The results from the survey are listed in Table 3.1. The demonstration toolkit used for this study is described in Section 3.1.

Table 3.1 List of Tools Reviewed and Their Primary Functions

Tool Name	Primary functionalities	Similar functionality
ArcGIS	Core platform, spatial data preparation & analysis, visualizations‡	IDRISI* GRASS GIS* MapWindows*
NatureServe Vista	Conservation planning, decision-support, visualizations‡	ArcGIS (through customization) C-Plan* TPL Greenprinting*
N-SPECT	Non-point source and erosion water quality monitoring and comparison	BASINS SWAT*
CommunityViz	Land-use planning, decision-support, civic engagement, visualizations‡	MetroQuest PLACE³S Index* WhatIf?*
TransCAD	Transportation planning and data management for existing networks, visualizations‡	ArcGIS transportation data modeler
QuantM	Route optimization for new transportation infrastructure: roads, railroads	ArcGIS (through customization)

Land Change Modeler	Modeling land-use change, conservation planning	ArcGIS (through customization)
Green Infrastructure	Civic engagement method with GIS support	TPL Greenprinting*
MetroQuest	Web-based civic engagement, decision-support, visualizations‡	CommunityViz Places3* Index* WhatIf?*
American Factfinder	Source data acquisition	Unknown
Google Earth	Visualizations‡	ArcExplorer*
BASINS	Watershed planning, water-quality assessment, data acquisition	N-SPECT SWAT*
Marxan	Conservation site optimization	SPOT* Zonation*
PLACE³S	Civic engagement method with GIS support	CommunityViz Index* Metroquest WhatIf?*
ETDM (Florida DOT)	Web based civic engagement, decision-support, visualizations‡	PEL
PEL (Colorado DOT)	Web-based tool supporting better decision-making regarding community, economic and environmental goals.	ETDM

* Tool not covered in the present tool survey
‡ Visualizations: Supports more than one method to create visual material: maps, tables, simulated landscapes, etc
NOTE: The Transportation Research Board of the National Academies, the National Research Council, the Federal Highway Administration, the American Association of State Highway and Transportation Officials, and the individual states participating in the National Cooperative Highway Research Program do not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the object of this report. This list was drawn based on the experience of the research team based on their knowledge at the time of this research. Any omissions are not intentional.

3.1 Toolkit

The primary toolkit used for this study is a suite of four software tools which can operate in conjunction with one another. Each has a specific strength: ESRI ArcGIS 9 serves as the platform for the other three tools as well as can provide considerable additional spatial analytical power to fill gaps not provided by other tools. NatureServe Vista is a decision-support tool for incorporating resource information, especially biodiversity, to define systematic conservation goals and alternate scenarios. CommunityViz supports community planning, its strengths lie in intuitive 3-D visualizations and analysis of different development scenarios. N-SPECT is a tool developed by the NOAA Coastal Services Center to predict locations in a watershed contributing runoff, sediment, nutrients, and toxins; the load of those contributions; and the load and concentration of where they accumulate in streams and rivers. ESRI and CommunitViz require commercial licenses and NatureServe Vista and N-SPECT are offered as free downloads.

All tools offer the user the ability to incorporate and develop present and future scenarios, allowing for different ideas to be analyzed and shared with stakeholders and other audiences. Scenarios also facilitate the creation of quantitative goals to be estimated and set.

4 Application of Metrics to Regional Transportation Plans

This section describes the generic requirements to implement the workflow in terms of staff skills, information technology capacity, and access to SMEs; it is followed by a description of specific actions to demonstrate the workflow in the three pilot MPOs.

4.1 Capacity Needed to Implement the Workflow

Note that the proposed workflow is scalable to some degree depending on available capacity and resources. The following describes a "middle-of-the-road" level of capacity.

4.1.1 Staff Skills and Organization

Resource agencies, NGO partners, and SMEs: staff need to be able to:

- Identify the existing plans that provide cultural or biological areas of interest and meet the criteria for the MPO.
- Determine which resources are not sufficiently represented by existing information and require separate treatment.
- Determine the sustainability requirements of the resources (minimum size of occurrences, regional retention goal(s), connectivity or other configuration requirements, etc.
- Determine the response of the resources to the factors to be represented in LRTP scenarios.
- Ability to use software tools necessary/desired for gathering and inputting information into the system to be used for cumulative assessment.

MPOs & planning partners: staff need to be able to:

- Gather spatial information for scenario inputs (current baseline land use, infrastructure, conservation, etc.) and integrate it into scenarios.
- Model expected trend in growth and development to develop future trend scenarios and subsequent transportation needs under different assumptions (e.g., business as usual vs. transit-oriented development).
- Apply tools to conduct the intersection of scenarios with resources to quantify cumulative effects (this step optionally could be done by the resource agencies or other resource partners).
- Apply tools to develop alternative scenarios that reduce or mitigate impacts (this component best done in partnership with resource SMEs).

It will be critical as in any project to organize the people contributing to the process. It is suggested that the players throughout the state establish clear, uniform structures for conducting this work so it becomes routine and does not have to be created each time. Having working groups associated with the different types of resources, scenarios, and planning has proven a useful way to structure project teams.

4.1.2 Information Technology Capacity

Under the proposed workflow and toolkit it is assumed that both resource agency and MPO staff would apply the same tools or other tools with similar IT requirements. Therefore, the IT requirements are quite modest and comprised of:

- Desktop computer: a CPU with a capacity of 1.0 GHz or greater with a Windows operating platform.
- At a minimum, hard drive storage should have 100 GB, not including the Microsoft .NET framework 2.0.
- Broadband internet access of at least 256 Kbit/s but preferably 768 Kbit/s is very helpful in order to quickly download and upload large files.
- Commercial software (in addition to proposed decision support tools including:
    - Microsoft Access
    - ESRI ArcGIS 9.x (compatible with desired DSTs) with Spatial Analyst
- A convenient and secure online document sharing site such as Sharepoint would be helpful to facilitate exchange of data and group development of documents.

4.2 Data Sources

The amount and availability of data necessary to successfully address the cumulative effects has improved tremendously in the last 10 years. All data used for the three MPO analyses was obtained free of charge with minimal effort. The data from the Colorado Division of (Wildlife) DOW and the US Census was downloaded from the internet. Data from the Colorado Natural Heritage Program (CNHP) and the MPOs was requested by telephone and delivered via ftp site.

A sample of between 15 and 20 features or resources were selected to include in the demonstration projects. A complete list of the resources used for each area is included in Appendix A, figures 5-7. The sample datasets included six focal resources: ecological systems, rare/imperiled species, cultural/recreational features, low-income and minority populations, priority conservation areas, and floodplains.

Below we list the sources of data that were used in this project:

- **Colorado Natural Heritage Program**: Prioritized species and ecosystems, priority conservation areas

- **Councils of Government: Denver Regional, Pikes Peak Area, Pueblo Area**. These organizations provided the fundamental baseline and future scenario data in terms of present land cover and estimated future urban land cover. The COGs also provided key layers reflecting the important local cultural features: parks, greenways, bike and hiking paths. In many instances the locations of important local features were included as well: military bases and local government/utility infrastructure. The COGs also provided floodplain data which would have been expensive to obtain otherwise from FEMA.

- **Colorado Division of Wildlife**: Key habitat areas prioritized by CDOW

- **US Census**: Census block groups of low-income households and areas of high-minority populations

- **NatureServe:** Information at hand complemented the CNHP prioritized ecosystems and DOW habitat areas with selected land cover areas to better identify wetlands and riparian areas.

4.3 Tools

There is no "supertool" capable of conducting all computerized analyses necessary for regional cumulative impact assessment; therefore, the use of a "toolkit" approach that combines multiple tools to support an information workflow is suggested. Our toolkit consists of NatureServe Vista on the ArcGIS 9.x platform with Spatial Analyst. Complementary tools to this core toolkit are CommunityViz (for developing trend models of urban development and iterating with Vista to develop land use plans), N-SPECT (estimating and comparing impacts to aquatic resources) and QuantM (fine tuning planned transportation corridors and optimizing alternatives). However, as noted in Section 3, using a different combination of tools could produce similar results. For example, IDRISI with Land Change Modeler could be a comparable toolkit for several core functions.

The toolkit was used to conduct the following:

- Represent the resources to retain, restore, promote, or legally required to assess
- Incorporate expert knowledge (provided by our in-house ecologist) on the resource viability requirements and responses to scenario factors
- Define a variety of scenarios and evaluate their ability to support retention goals/determine threshold of significance performance
- Explore sites and create alternatives (mitigation) for sites to promote goal achievement

Over time the toolkit is also designed to dynamically monitor effects of changes in policy or conditions and adapt plans accordingly.

4.4 Metrics and Indicators

In order to build on the research done for the ACEA study, this analysis focused on four key community and ecological areas of interest (hereon referred to as "resource areas"). Representative metrics (specific resources) were identified for each area and indicators developed for three levels of risk (low, medium, and high risk to long-term viability) under cumulative effects when legal thresholds do not exist. A low-risk indicator is likely to sustain the resources but is also likely to have many land use conflicts, while a high-risk indicator is less likely to sustain the resources but have fewer conflicts. The three-level indicator approach can reveal for decision makers the approximate level of indicator needed to maintain viable and socially-acceptable levels of resource distribution for the long-term.

4.4.1 Resource Areas

Biodiversity includes native wildlife habitat expressed as ecological systems, wetlands (including riparian areas), individual plant communities (more specific components of broad habitat/ecological systems), and rare and threatened plant, animal and fish species. The approach used here was consistent with the "Coarse Filter/Fine Filter" concept described in Section 2.1.1. The Coarse Filter resources included broad habitats that are unique, mapped and well described. Whether they cover large areas of the landscape, such as shortgrass prairies, or narrow floodplains along a creek, these habitats include many other species that that may not be listed specifically. The "Fine Filter" resources were represented by species and plant communities when specific locational data was available. This assessment used the ecological systems (natural habitats), and rare or imperiled species shown in Table 4.1 that occurred within or in close proximity to the future urban growth and new proposed roads.

Table 4.1 Coarse and Fine Filter Biodiversity Resources Used in the Three Demonstration Study Areas

Study Area	DRCOG	El Paso	Pueblo
Biodiversity Type	name	name	name
Ecosystem	Ponderosa Pine	Ponderosa Pine	Ponderosa Pine
Ecosystem		Pinyon Juniper Woodland	
Ecosystem	Gamble Oak - Mt Mahogany Scrub	Gamble Oak - Mt Mahogany Scrub	
Ecosystem	Sagebrush	Sagebrush	Sagebrush
Ecosystem	Foothill Shrubland		
Ecosystem	Foothill and Piedmont Prairie	Foothills-Piedmont Prairie	
Ecosystem	Shortgrass Prairie	Shortgrass Priairie	
Ecosystem	Sand Dune Complex	Sand Dune Complex	Sand Dune Complex
Ecosystem	Shrubby Wetlands	Shrubby Wetlands	Shrubby Wetlands
Ecosystem	Floodplains	Floodplains	Floodplains
Species	Schryvers elfin (butterfly)	Black Tailed Prairie Dog	Black Tailed Prairie Dog
Species	Mottled Duskywing (Butterfly)	Gunnison's Prairie Dog	Colorado Checkered Whiptail (lizard)
Species	Plains Sharp-Tailed Grouse	Golden Columbine	Rocky Mt Bladderpod (wildflower)
Species	Bell's Twinpod (Wildflower)	Arkansas Darter (fish)	Arkansas Valley Evening Primrose

			(wildfower)

Following are metrics and indicators for the three levels of retention.

Indicators for Low Risk Plan may include:

- No loss of any regulated wetland
- No loss of non-jursidictional wetland or riparian habitats
- No confinements, encroachment or constriction of natural floodplains or drainages
- No more than 10% of the historic ranges of upland habitats are impacted
- 100% of known G1-G3 species are not impacted

Indicators for Medium Risk Plan may include:

- Up to 25% loss of any regulated wetland
- Up to 25% loss of non-jursidictional wetland or riparian habitats
- Up to 30% confinements, encroachment or constriction of natural floodplains or drainages
- No more than 30% of the historic ranges of upland habitats are impacted
- 80% of known G1-G3 species are not impacted

Indicators for High Risk Plan may include:

- Up to 50% loss of any regulated wetland
- Up to 25% loss of non-jursidictional wetland or riparian habitats
- Up to 50% confinements, encroachment or constriction of natural floodplains or drainages
- No more than 70% of the historic ranges of upland habitats are impacted
- 50% of known G1-G3 species are not impacted

Priority Conservation Areas consist of mapped areas indentified through science-based, collaborative, and reviewed processes but are not yet officially designated for conservation. These include Ecoregion Portfolio Sites identified through a comprehensive conservation planning process for the Central Shortgrass Prairie and the Southern Rocky Mountain Ecoregions by TNC of Colorado and NatureServe. These are ecoregion-wide assessments of biodiversity, its current status, and threats. A suite of areas were identified as the most important sites required to protect biodiversity and to maintain healthy functioning ecosystems and species populations in perpetuity. Smaller scale Potential Conservation Areas (PCAs) identified by the Colorado Natural Heritage Program were also included. In the DRCOG area, there were over 100 PCAs identified by the Heritage program. In the El Paso area, two PCA's were used, and in the Pueblo area, none were employed for the demonstration.

Indicators for Low Risk Plan may include:

- No impacts, encroachments or loss of hydrologic functioning to any of the identified sites
- Where required, connectivity and wildlife movement is maintained unimpeded between sites

Indicators for Medium Risk Plan may include:

- Impacts, encroachments or loss of hydrologic functioning to 20% of the identified sites
- Connectivity and wildlife movement is lost between sites by 20-40%

Indicators for High Risk Plan may include:

- Impacts, encroachments or loss of hydrologic functioning to 80% of the identified sites
- Connectivity and wildlife movement is lost between sites by 60-80%

Environmental Justice populations include the location of low income and minority, elderly and other vulnerable neighborhoods. The pilot evaluation used US Tiger data census blocks extracted to contain high proportions of minority (blocks with >50% minority ethnicity) and low income (blocks with average annual income < $25,000) populations.

Indicators for Low Risk Plan may include:

- No fragmentation of community cohesion by roads
- Increased business and economic opportunities

Indicators for Medium Risk Plan may include:

- Intrusion of new road(s) on up to 3% of a low-income or minority community
- Limited increase in business and economic opportunities

Indicators for High Risk Plan may include:

- Intrusion of new road(s) on greater than 3% of a low-income or minority community
- Little to no increase in business and economic opportunities

Green Infrastructure (public recreational resources) included established ball parks, picnic areas, soccer fields, bike paths, and other green corridors designed for recreational/ public use. The pilot evaluation used currently mapped locations of established parks and bike paths as available for the pilot sites.

Indicators for Low Risk Plan may include:

- No impacts or loss to established bike paths and parks
- Impact allowable only where unavoidable

Indicators for Medium Risk Plan may include:

- Impacts or loss up to 30% of established bike paths and parks
- Impact allowable only where unavoidable

Indicators for High Risk Plan may include:

- Impacts or loss up to 50% of established bike paths and parks
- Impact allowable only where unavoidable

The cultural resources used for this study are shown in Table 4.2.

Table 4.2 Cultural Resources Used In Demonstration Study

Cultural Resources		
DRCOG	**El Paso**	**Pueblo**
Environmental Justice - Minority	Environmental Justice - Minority	Environmental Justice - Minority
Environmental Justice - Poverty	Environmental Justice - Poverty	Environmental Justice - Poverty
Mountain backdrop preservation areas		
Urban parks	Parks	Pueblo west parks
Bike paths	Bike paths and trails	Pueblo parks
Open Space and Parks		Lake Pueblo Park

4.5 Results

4.5.1 Demonstration Areas

This section focuses on the results of the proposed cumulative effects analysis in the three demonstration project sites, the metropolitan planning regions of the Denver Region (DRCOG), Pikes Peak Area (PPACG) and Pueblo Area (PACOG).

At 3,608 square miles, DRCOG was the largest area examined. Current land use was brought in from a map released in 2008 at the parcel level to conduct municipal level analysis. Every parcel in the region is designated one of five development types: urban, semi-urban, semi-rural, rural and undevelopable (the latter typically representing local, state or federal lands or areas restricting development due to steep gradient, etc)**.** DRCOG projected future land use by using the 2035 urban growth boundary assuming all parcels would be converted to urban or undevelopable land use (future planned parks, for example).

PPACG includes Park and Teller Counties as well as the city governments but the analysis region focused on El Paso County. This created a project area of 2,130 square miles. This decision was based on availability of data and to focus on the effects of new roads and development in the I-25 corridor: Monument, Colorado Springs, and Fountain. PPACG provided a current and 2035 land-use and transportation layers. A second future scenario for Transit Oriented Development developed in 2007 for El Paso County was developed in the toolkit software, CommunityViz.

PACOG consisted of Pueblo County, containing an area of 2,398 square miles. Present scenarios were assembled from various land-use layers and the future scenarios from the 2035 LRTP (which included land-use).

4.5.2 Inputs and Outputs in the Cumulative Effects Analysis Process

- Scenarios: This project simplified the process of developing the present and future development scenarios compared to the ACEA approach. Rather than rely on historical data, compile multiple plans and policies, and model future development, the Councils of Governments (COGs) current land-use maps and 2035 plans were used to create baseline and future scenarios. These plans are already produced by the COGs and represent the "best guess" of urban and transportation expansion. Land use/management data was translated into "standard" land use categories.

- Assessing the road network effects: One key assessment is the direct effects of the expansion of the road networks on resources. Road networks were provided by all COGs for developing the scenarios. These were incorporated into the other land use layers by using the lane width and buffering roads according to the CDOT Design Guide (Colorado DOT 2005). In future scenarios, road networks are expanded through addition of new roads widening of existing roads to accommodate projected increase in capacity needs. These buffers ranged from 120 ft for a two lane highway to 300 ft for a six lane highway. These reflect the recommended widths that include lanes, shoulders, medians, and sideslopes. These distances are more reflective of newer or rural cross sectional roadways and likely overestimate the width of existing urban roads.

- Obtaining resource data: The wide variety of resources were all available from existing data sources. Many of these resources are subject to considerable expert scrutiny and/or represent cultural/recreational priorities established at the local or regional level. An example of the former is species element occurrences created by the CNHP. These sites represent the most accurate species locations available. An example of a cultural/recreational priority is the Mountain Backdrop Preservation Zone in DRCOG. The result of using these data sources is that much of the prioritization and scrutiny is completed by those parties who have the expertise or legal authority to designate these resources. Appendix A, figures 5-7 have complete lists of the resources used in each MPO. Resources can be graphically displayed individually or overlaid and combined in Conservation Value Summaries (CVS), which in this example sum the combined number of resources in each pixel across the landscape. A CVS can be useful in readily identifying high value areas that should be avoided for intensive uses at the start of a planning process. The resources were divided and categorized into cultural and ecological groups and separate CVSs created for each group.

- Documenting resource responses: Resource responses to factors in the scenarios are combined with spatial analyses to calculate cumulative impacts and map conflict zones. A resource response describes how the resource is expected to fair when the scenario factor (e.g., urbanization) falls on the resource. The toolkit used for this study supports both categorical responses (e.g., negative, neutral, beneficial) and more detailed and precision models of how scenario factors affect the condition of the resource both on and off site. The simpler categorical response assigned a negative response of most resources to transportation networks and most urban growth factors. For this demonstration project, these response assignments were based on general "rules-of-thumb" and expert judgment rather than rigorous testing or modeling. In Vista, resource responses to scenario factors can be fine-tuned as necessary and documented as to source and reasoning.

- Calculating cumulative effects: Scenario Evaluation is the process of comparing resources to the scenarios and then viewing the results against the sets of pre-determined resource retention goals. Goals are defined for each resource and express the percentage of the resource that must be viable after comparison with the scenario. Scenario evaluations were rerun for each of the different significance/risk levels in order to compare goal attainment/significance of impacts across scenarios.

    - The products of a Scenario Evaluation are a report and several visualization layers that can be used in the decision-making process. The report summarizes, in total and by category, the performance of the scenario in terms of the number and percentage of resources that met conservation goals. The report also provides a detailed comparison of individual resources against the scenario: their original distribution, and the amount/percentage that was retained in areas with compatible land use, both with and without adequate protection (reliable policies). The raster layers generated by the Scenario Evaluation identify areas in the planning region where opportunities to improve performance against goals exist. The first layer identifies compatibility conflicts - locations where resources with unmet goals due to incompatibility of land use are concentrated. The second summary layer shows protection policy conflicts - areas where resources are compatible with land use, but policies may be unreliable or unknown to assure retention. In addition, a set of separate maps is generated, one per resource, which distinguishes between areas of incompatibility, compatibility without protection, and compatibility with protection for that resource.

- Evaluating site-level performance: We used the Vista Site Explorer on a PCA in DRCOG and PPACG to produce detailed information on effects to sites (polygons of planning, management, or ownership units) for both baseline and future land-use scenarios. In this case we generated a regular grid of sites but one could readily use Transportation Analysis Zones, private property parcels, etc.). The Site Explorer produces a site report that assists in determining how well the site is performing in meeting its resource retention goals and if not, to give a relative sense of the importance of the site for mitigation to better meet the goals with changes to the scenario factors. Specifically in this case, Site Explorer provided an inventory of scenario factors and resources within the PCA, the number and percentage of occurrences that are compatible and protected (i.e., areas with compatible land uses along with policy types that will reliably ensure that the actual land uses will be no more intensive than the uses indicated), and the achievement of resource retention goals within the site and across the planning region.

- Developing alternatives/mitigating impacts: In addition to data on the PCAs and resources that occur, the Site Explorer was employed to develop and save an alternative (e.g., mitigation) scenario specifying more compatible land uses to achieve conservation of the PCA. This provides a critical feedback loop for transportation planners, allowing them to develop alternate scenarios that meet the goals and can be shared with stakeholders and decision-makers for further input. The toolkit is setup to allow transportation planners to intelligently make these mitigation/conservation decisions without direct assistance of other SMEs but review by SMEs of alternative plans and mitigations prior to their adoption is encouraged.

4.5.3 Potential Shortcomings

4.5.3.1 Inadequacy for All Resource Categories and Scenario Factors

This toolkit was specifically developed for biodiversity assessment and conservation planning though it has proven useful for many other resources. However, it may not adequately address all resource types (it cannot readily account for many socioeconomic concerns for example). Nor is it likely to readily incorporate all types of on and offsite impacts. For this reason the toolkit approach is suggested where specialty tools can be integrated as needed.

4.5.3.2 Identifying Causes of Impacts

This toolkit is adept for cumulative impact assessment and when examining sites can assist users in determining the primary factors causing impacts. However, it currently does not provide region-wide reporting to identify or rank the scenario factors causing impacts. This may be possible to conduct using Site Explorer over the entire region (treat the region as a single site) but this has not been tested.

4.5.3.3 Spatial Precision

This toolkit transforms data to a raster format and therefore some spatial resolution is lost, especially for small and linear features. A good example of this is the impact that widened roads would have on narrow stream corridors or bike paths. As a road is widened its impact on a bike path may not be adequately calculated or the reverse could occur- as features are buffered out, impact may be overestimated as linear features are generalized into pixels. This problem can be addressed by:

- Use a finer resolution raster cell to more precisely represent small or linear features but for large regional areas this would significantly increase computer processing time.

- CommunityViz uses vector analyses so would likely be better at calculating effects to linear features. However, given the size of the region, the processing time may also be quite lengthy.

5 Focus Group

A focus group of SMEs provided feedback on the preliminary results of the cumulative effects analysis. The group included representatives from each of the three pilot MPOs, the Colorado Department of Public Health and Environment, the US Fish and Wildlife Service, the US Environmental Protection Agency, and the Colorado Department of Transportation. Many of these experts had previously participated in CDOT's ACEA study.

A PowerPoint presentation was given in a series of three one-and-one-half hour webinars to demonstrate the tools and present the preliminary results of applying the selected metrics to the long-range plans for each of the three MPOs. The presentation discussion included the background of the ACEA study, a comparison of the methodologies and differences between the ACEA study and this NCHRP 25-25-(54) study, the general cumulative impact assessment model, indicators for high, medium and low risks to the resources, and a live demonstration of the approaches and tools used to determine cumulative impacts. Following the demonstration the webinar participants provided comments to identify missing information and make suggestions for process improvements. In a follow up email, they were also encouraged to provide any additional afterthoughts via phone or reply email. No follow-up comments or suggestions were received.

5.1 Focus Group Feedback

Feedback from the focus group was primarily in the form of brief questions, minor comments or issues beyond the scope of this study. Most participants indicated support for the concept. In general, MPOs liked the format because impacts can be generally quantified. The tools can be used to help the public and agencies visualize the general location of impacts and potential mitigation or conservation areas as well as understand the tradeoffs between alternatives. The resource agencies had concerns about how the resource data will be kept current, the adequacy of the data, and whether the agency's input early in the planning process would be given due consideration. The agencies also recognized the value of this process for conservation planning.

Questions and comments related to the MPOs included:

- Liked the potential for the tools to quantify impacts
- Need to compare TDM scenarios and increased density along a corridor
- What training will be needed to use the tools?
- When working with spatial data, need to be mindful of the definition of "urban" – it also includes what is built and areas of planned growth
- What is the benefit for the MPO of doing region-wide cumulative effects analysis?

- How relevant will this be with reauthorization of the next transportation bill in five months?
- MPO resources (funding) are declining and MPO urban population limits may be increased with the next transportation bill meaning the MPOs will have to do more with less. Rural transportation regions are already struggling with undependable federal funding.
- If the MPO had normal funding and staffing, this type of regional cumulative effects analysis would be at the top of the to-do list; it would be easy and feasible to integrate with existing systems.
- This process may provide a tool more palatable to local officials. It is a better format to be able to show one layer of resources at a time.
- This would add a more formal level of analysis.
- Liked the comparison (of this approach) to the CDOT ACEA approach
- Showing a conflict between resources and land use on private land may be interpreted by a landowner as a taking causing unnecessary concern.
- If the resource data is available from the COGs, why aren't they using it?
- <u>Questions and Comments Related to the Environmental Resource Agencies included:</u>
- The Nature Conservancy Ecoregion Assessment results are very coarse for this scale of assessment and leave out areas of interest versus priority plans detailed for green infrastructure program.
- This tool can help with conservation planning.
- Need to consider:
- Time to collect data
- Data availability
- Constraints to obtaining data
- Conservation areas
- How valuable will this (tool) be if the data is limited or spotty?
- The tools should be able to show how to identify quality mitigation areas.
- How current is the data?
- Identify tools for resources not addressed in this study, e.g., water quality and air quality.

- Where does data come from for wetlands? Need to compare wetlands mapping with DOW priority habitat.
- How is data adequacy determined?
- How is use of mitigation banks considered?
- Biological resources need to include critical habitat and recovery areas.
- This tool would be useful for review of EISs.
- When sensitive areas are identified by the regulatory agencies, will long-range plan alternatives avoid significant impacts? What role will politics play?
- Resource agencies may find it difficult to consider a high-level, region-wide analysis as opposed to evaluation of project level details.
- Can this tool be used to assess affects to climate change as a result of a long-range plan?

<u>General comments and questions included:</u>

- CDOT is currently working on a linking planning and NEPA tool; developing a resource mapping component is the next step.
- This study is not comparable to the Planning and Environmental Linking tool CDOT is working on which will be used for early identification of issues.
- Need to provide the same relative amount of data/analysis for each resource.
- The best use for this tool would be for land use planning for local planners.
- The cumulative effects analysis needs to be repeatable and documentable to use in planning and NEPA.
- How are the designations “high”, “medium” and “low” determined and by whom?
- Who would maintain the database and make sure that the data were constantly updated and reliable?
- Would like to see thresholds for significant impacts at the local level.

Setting levels of significance for non-regulated resources will remain a challenge but not insurmountable technically or scientifically. The ACEA study attempted to identify thresholds for significant impacts for those resources without a regulatory threshold but it proved to be very controversial. Not surprisingly, no agreement was reached between the Federal Highway Administration and the resource agencies. This study attempted to overcome the issue by using “risk indicators” rather than fixed numerical thresholds. As explained above and in the webinar, the level of significance would have to be determined on a region by region basis with the input of federal and state resource agencies, public input and local governments at the time the long-range plan is developed.

Another commonly expressed concern is data management - data storage, keeping the data current, and adequacy of the data for conducting the analysis. While it would be ideal if all the necessary resource data could be maintained in one location with a standardized process for keeping the data up to date, this is not feasible for most agencies. However, this need not preclude the cumulative effects analysis. As described in Section 4.2, obtaining data from resource specific agencies, NGOs and other SMEs who regularly maintain their data sources is a reasonable and feasible alternative.

5.2 How Feedback was used to Modify/Enhance Final Results

Transportation agency (MPO, DOT) participants provided few specific recommendations to modify the final results. Some participants indicated their lack of previous conceptualization of how to move resource cumulative impact assessment upstream from project EISs to the LRTP phase (largely the impetus for this study and the Strategic Highway Research Program (SHRP) C06 studies). This process will continue as NatureServe and partners extend this work in SHRP CO6B and gain national review of these recommendations. A few of the comments were outside the purview of this study such as addressing climate change and or the role of politics on the long-range plan. Most of the comments regarding tools and data have been addressed throughout this document. However, some comments that were actionable for this study, included:

5.2.1 Recommendation to Describe and Demonstrate How the Workflow Can Accommodate Offsite Mitigation

A workflow component and demonstration aspect was added to illustrate two approaches for different situations:

- In the case where a proposed scenario feature impacts resources outside of a conservation priority area (but are the targets of conservation in a conservation priority area), then mitigation can be applied to help conserve the resources within the conservation priority area.
- In the case where a proposed scenario feature impacts a conservation priority area, then the area could be expanded in another part or a new priority area could be identified and implemented whichever is more practical. The expanded or new portions would need to contain the same resources of conservation concern that would be impacted.

Additionally, Eco-Logical (Brown 2006) allows for out-of-kind mitigation where it can be shown to offer greater ecological benefits than in-kind mitigation. In this case, the results of the scenario evaluation and the irreplaceability concept described in 2.1.2 can be used to identify other resources with higher conservation need. Areas of those resources at risk can then be targeted for mitigation (conservation) attention.

5.2.2 Recommendation to Explicitly Describe How the Process and Toolkit Can Comparatively Evaluate Alternative LRTP Scenarios

This capability already exists in the process model and toolkit but it was more explicit. The process and toolkit can evaluate any number of alternative scenarios and the user can readily compare the map and quantitative results. Further, the user could then refine individual alternatives using the toolkit or create hybrids among alternatives.

6 The NEPA Nexus

As described in Section 1.2 of this report, the objective of this research was to identify a range of tools that can be used by MPOs with various staffing capacities to conduct a meaningful region-wide cumulative effects analysis on the LRTP. The development of tools and methods with which to conduct such an analysis can help MPOs and DOTs meet the SAFETEA-LU requirements for integrating environmental values in the planning process and may provide a range of associated benefits for the transportation planning agencies as well as resource agencies and other stakeholders during project design and permitting.

6.1 Use of Planning Decisions to Simplify the NEPA Process

Planning and NEPA have comparable requirements to utilize public involvement and resource agency collaboration to identify alternatives and their environmental effects, and yet, despite decades of statutory emphasis on coordinating transportation planning and NEPA, there remains a disconnect between the two processes in practice. Typically, the NEPA process is not initiated until the project level analysis which can lead to "the development of information that is more appropriately developed in the planning process, resulting in duplication of work and delays in transportation improvements" (23 CFR Part 450, Appendix A).

While a NEPA analysis is not required for the long range planning process there are benefits to linking the two processes for both the environment and efficiencies in project delivery. Planning studies and decisions may be relied upon in the NEPA process when it can be demonstrated that agency coordination and public involvement during planning were carried out and adequately documented in a form that meets the standards established by NEPA regulations and FHWA guidance. Planning decisions that may be used in the project NEPA analysis include such things as the purpose and need statement, preliminary screening of alternatives and elimination of unreasonable alternatives, and preliminary identification of environmental impacts and mitigation.

A planning-level analysis does not need to rise to the level of detail required in the NEPA process but it "needs to be accurate and up-to-date, and adequately support recommended improvements in the statewide metropolitan LRTP" (23 CFR Part 450, Appendix A). Amekudzi and Meyer (2005) succinctly explain the requirements for utilizing planning decisions in the project level NEPA analysis. The planning documents must:

- *Be sufficiently detailed to reveal the trade-offs between different alternatives*
- *Be based on current data (e.g., data from the most recent Census) or be updated by additional information*
- *Be based on reasonable assumptions that are clearly stated*

- *Rely on analytical methods and modeling techniques that are reliable, defensible, and reasonably current*

The long-range plan must discuss “potential areas” where mitigation may occur and “types” of mitigation activities to address the environmental impacts of the proposed transportation network. It is not necessary to develop specific mitigation measures for individual projects but the plan must include approaches for mitigating impacts such as wetland mitigation, avoidance of habitat fragmentation, and preservation of habitat for endangered species (AASHTO 2008).

In the planning process environmental issues are considered on a broad scale, not at the level of detail expected in project design. The planning process provides an opportunity to engage federal, state and local resource agencies, the public and planners that can lead to mitigation strategies that are more economical, that use an ecosystem approach, are more effective from an environmental stewardship perspective than traditional project-specific mitigation measures and support multiple goals (transportation, environmental, and community (23 CFR part 450 Appendix A). This could include a discussion of specific geographic areas such as Section (4f) properties, existing conservation areas, sensitive wildlife habitat, or concentrations of low-income and minority populations where public agencies are seeking to protect or restore cultural or natural values and resources. This could also include a discussion of types of areas – for example, by listing the characteristics that are associated with desirable mitigation sites (AASHTO 2008).

The robust use of remote sensing, GIS, or other geospatial decision support tools along with the cumulative effects assessment workflow described in this study, can significantly help transportation agencies evaluate natural and cultural resource issues in planning to make informed decisions that will help them balance transportation needs and environmental impacts. These tools can be used to document the impact analysis and provide support for the decisions made and can be used to repeat the analysis in the environmental review process so that decisions made during planning stick in project design. Conducting some analysis at the planning stage can reduce duplication of work, leading to reductions in costs and time requirements, thus moving through the project development process faster and with fewer issues. Agencies may be able to develop more environmentally sensitive transportation projects, avoid costly delays due to unexpected disagreements late in a project's development, support resource agency conservation efforts, and improve relationships among project stakeholders (FHWA n.d.).

7 Conclusion

Inherent in the requirements of this study was that the approach be tested and evaluated in three different size/capacity MPOs to determine capacity limitations of its implementation. Because NatureServe (rather than an MPO) conducted the actual workflow and tool use it was not possible to directly evaluate how capacity would affect process and/or toolkit adoption. However, through the review by the MPOs and resource agencies, and previous experience with different capacity users, some evaluation of capacity implications and recommendations were appropriate. This section provides an analysis of the differences in capacity among the three pilot MPOs and implications and suggestions for implementing the proposed workflow. It is emphasized, however, that the primary burden in carrying out the proposed workflow is on the resource agencies, partner NGOs, and various subject matter experts that would be required to develop the key information inputs. The technical requirements are actually quite low as described earlier.

7.1.1 MPO Capacity

There are considerable differences in the number of staff and technical capability among the three MPOs;

- Pueblo Area COG (small MPO) is made up of seven governmental entities. It has two full time employees, the MPO coordinator and the senior transportation planner. It has several part time employees who provide additional support. Discussions with MPO staff indicate that funding is a major limitation; however, it receives technical, computational and logistical support from the Pueblo County government and Pueblo City Government. Its primary focus is on transportation planning.
- Pikes Peak Area COG (mid-size MPO) consists of 15 government entities. It has 30 employees spanning seven distinct focal areas. There are six employees dedicated to transportation planning, including a director, three planners and several technicians. The MPO has sufficient resources to support its staff with revenue from its member government entities as well as project funding.
- Denver Regional COG (large MPO) is composed of nine county or city/county entities and 48 municipalities for a total of 57 participating local governments. It has approximately 90 staff with 6 focal areas.

PPACG and DRCOG have considerable GIS expertise and did not indicate technical capacity concerns. PACOG, the lowest capacity reviewer indicated that while they saw the process and toolkit as potentially very useful, they currently do not have in-house capacity to implement it.

7.1.2 Implications

As noted in Section 4.1, the requirements for implementing the workflow and toolkit are somewhat scalable. That said, the workflow as detailed cannot be accomplished without involvement by resource agencies and/or NGOs that can provide 1) key resource data, and 2) expertise in using resource data and conducting conservation/mitigation planning.

While the larger MPOs are likely to have the capacity and expertise to set up and maintain these partnerships it will be very challenging for low capacity MPOs to do the same. In addition, the NCHRP 25-25 (32) report Linking Environmental Resource and Transportation Planning (Cambridge Systematics, Inc. 2008), cited that transportation organizations recognize the importance of high quality data, conservation planning expertise, and the resources needed to ensure participation by natural resource agencies in the transportation planning process but "Resource agencies often reported that they had insufficient staff to actively participate in interagency planning."

The recent development of State Wildlife Action Plans (SWAPs) has provided an opportunity for many resource agencies to participate in systematic planning so this may be a venue for transportation planners to engage natural resource agencies and NGOs. But it is important to note that the SWAPs did not use a consistent approach nationwide, and may not be consistent with the workflow presented here (e.g., lacked use of quantitative retention goals, only covered terrestrial animals (Stein and Gravuer 2008) or were subcontracted out to others thus not building capacity within the agency.

7.1.3 Suggestions for Implementing the Workflow

This workflow represents an appropriate level of rigor and robustness for conducting regional cumulative impact assessments, identify mitigation strategies for decision makers, meet SAFETEA-LU requirements and inform the NEPA process. Suggestions for implementing the workflow as described are followed by suggestions for a reduced approach.

- The simplest way for low capacity MPOs and resource agencies to implement the workflow is to secure the necessary outside assistance to fill gaps in skills and capacity. NGO and academic partners often have both the skills and motivation to provide such services in addition to many private consulting firms.

- There are great efficiencies to be had by streamlining the delivery of resource agency input into the planning process that can overcome what must appear as a torrent of requests for project level input. Given that wildlife resources, for example, tend to be similar over larger regions than MPOs, the resource SMEs could be tapped once to provide information to numerous planning activities. It would be helpful for natural resource and transportation agencies to identify existing interagency groups and plug planning activities into those existing interagency dialogs. Thus, the ability to consolidate resource agency engagement across MPOs would make the involvement of resource agencies and NGOs in planning much more likely and efficient, and thereby addressing many of the needs identified as being critical to a successful planning process. While developing specific recommendations for this streamlining is beyond the scope of this study, SHRP C06A is addressing some of these issues.

- Where NGOs have developed conservation priority maps, they are logical partners to provide information to properly assess and apply those maps. Where current priority maps are lacking or inadequate for LRTP purposes, these organizations can act as SMEs to identify resources and retention goals along with additional necessary inputs.

- A single computer/lab can be used to conduct all technical work and input of SMEs gathered either through distribution of an input spreadsheet distributed to SMEs or SMEs can be convened in a workshop (as per the ACEA study). Thus, this need not be a long burdensome process nor require a large IT capability to gather and integrate the necessary information.

- In cases where the MPO lacks any capacity to implement the proposed spatial analyses workflow, it is possible to use a significantly scaled back process which can rely on SME involvement or be automated through a statewide system. The process in its most minimal form would entail overlaying (graphically with hard copies or through a GIS) proposed LRTP alternatives with the State Wildlife Action Plan and or other spatial conservation priority maps for the resources of interest. Areas of potential conflict would be identified and SMEs would identify resources that might be impacted and make an expert judgment about the significance of the impact and options for mitigation.

    - Colorado's Planning and Environmental Linkages (PEL) Tool, while not adequate for a cumulative effects analysis, would be useful for all MPOs in terms of providing a basic checklist of issues (environmental, cultural, etc) that should be reviewed in greater detail earlier in the transportation planning process. The PEL tool is designed for corridor planning and to facilitate the interaction between MPOs and DOTs with resource agency personnel. When finished, the tool will be free and accessible as a web-based interface. However, the PEL tool will not quantify many of the key impacts from transportation and therefore is not an adequate substitute for a cumulative effects analysis.

    - The approach used in this study is similar to that provided by Florida's ETDM online system for project evaluation. Therefore, states could replicate this capability which would contain all of the necessary resource layers and the overlay capability. The only technical requirement then for the MPO would be to provide their LRTP to the state system for assessment.

This alternative approach would accomplish the rudimentary need for comparing the LRTP to the resources but falls far short of the recommended framework in terms of ability to quantify cumulative effects and to support a full cycle of LRTP option development, assessment, selection, and implementation.

- The lack of capacity by resource agencies can somewhat be mitigated by involvement of science-based NGOs like The Nature Conservancy but in the long run, more capacity for resource agencies to routinely engage with transportation planning activities will be required as has been identified and acknowledged elsewhere. This will require internal capacity building and training in methods and tools.

7.2 Data Availability

A region wide cumulative effects analysis of the LRTP appears tractable for most MPOs and partners in terms of data availability and spatial analyses. For the four resource areas considered in this study, data was readily available from the MPOs and resource agencies in a GIS format. For the most part, the availability of the ecological data used in this study is typical nationwide. For the cultural resources that were represented by data from the MPOs there may be more or less data depending on several factors. The data MPO's have at hand varies from agency to agency and additional resource data may be scattered among different agencies. Most agencies will readily provide the data, particularly for biological resources.

7.3 Process Efficiencies

It is not practical or necessary to analyze every potential effect of a LRTP on the human and natural environment and it is important to keep the larger purpose of the analysis in context when selecting resources for evaluation. When deciding which resources to evaluate for a region-wide long range plan one only needs to focus on those issues that are truly meaningful to the evaluation and the decision at hand. There are many other metrics that could be used beyond the sample used for this study.

Equipped with information provided by the suggested workflow and told, DOTs will have an opportunity to develop alternatives to minimize or avoid impacts, and evaluate the tradeoffs before time and resources are spent analyzing and designing an alternative in project development. It is also possible for a broad spectrum of mitigation strategies to be identified to address multiple needs for both the DOTs and the resource agencies. Consideration of mitigation at an ecosystem approach in the planning process can provide an opportunity to identify "best –value" mitigation in a watershed or ecosystem and result in more effective and efficient planning process that, with adequate documentation, can be adopted for use in the NEPA process. "Thoughtful consideration of environmental needs during the planning process can shorten the environmental review process. Moreover, it can lead to better program and project decision, for both transportation and the environment" (AASHTO 2008).

Finally, as was CDOT's objective with the ACEA, environmental assessments and environmental impact statements prepared for projects within the same region can refer to the region-wide cumulative effects analysis to eliminate redundant analyses and streamline the NEPA analysis and agency reviews.

8 Future Research

The work presented in this report represents many years of methods and tools development by a large number of organizations. The work to refine and expand on this approach will continue under the TRB SHRP C06B grant currently underway and available approximately late 2010. That grant will support further development of this framework and toolkit as well as integration of federal regulatory requirements and a crediting and assurances component. Specific research areas identified in the current project that may or may not be addressed by SHRP C06B include:

1. Further assessment and testing of components to address environmental justice and water quality assessment
2. Further development and testing of components to facilitate alternative LRTP development
3. Identifying mitigation needs, and identifying mitigation receiving areas and the assurances and crediting components of doing so.
4. Investigating how centralized online systems could provide equivalent capability especially in areas typically weak for online tools such as use of local or security-limited data and supporting iterative alternatives development.

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Appendix A: Screenshots from Vista Demonstration

Figure A.1 2006 Baseline Scenario - DRCOG

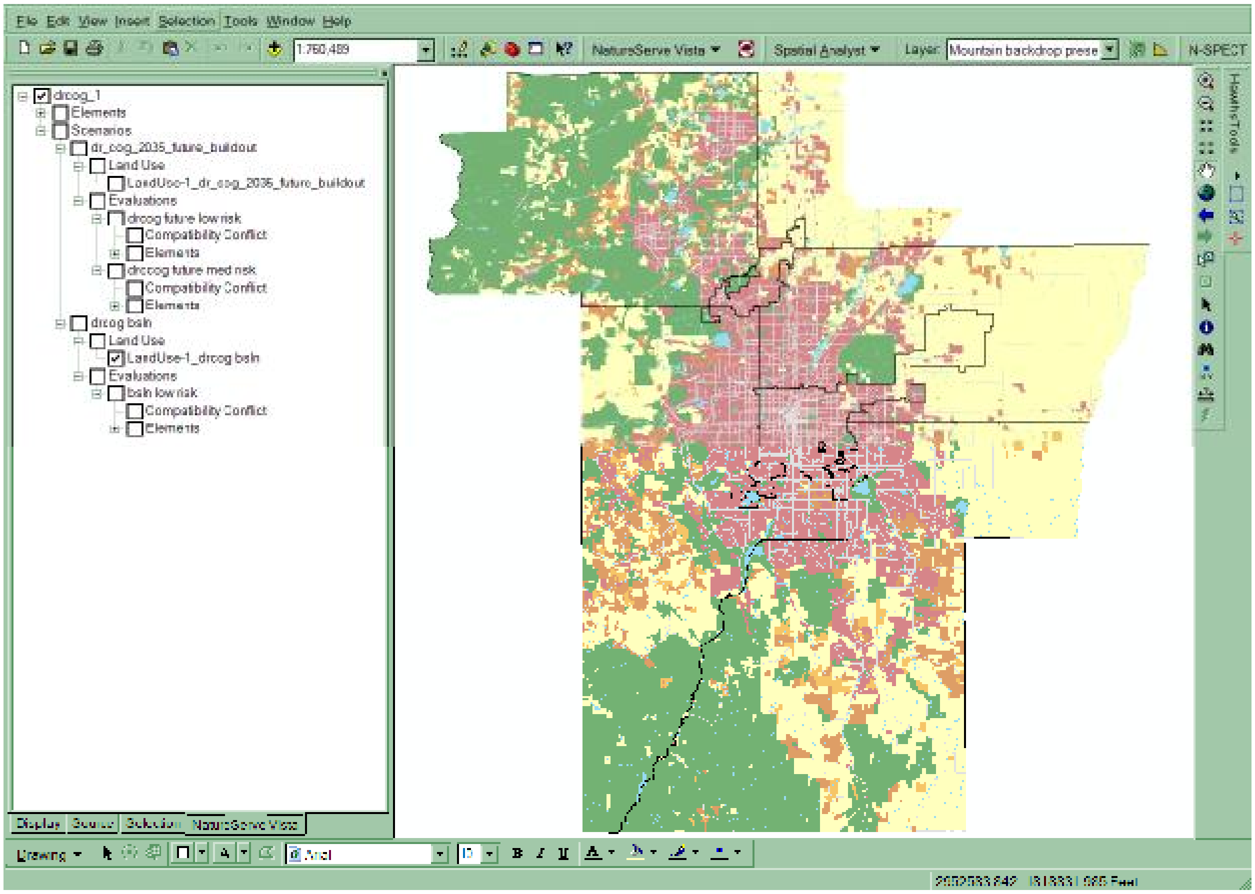


Figure A.2 2035 Future Trend Scenario - DRCOG

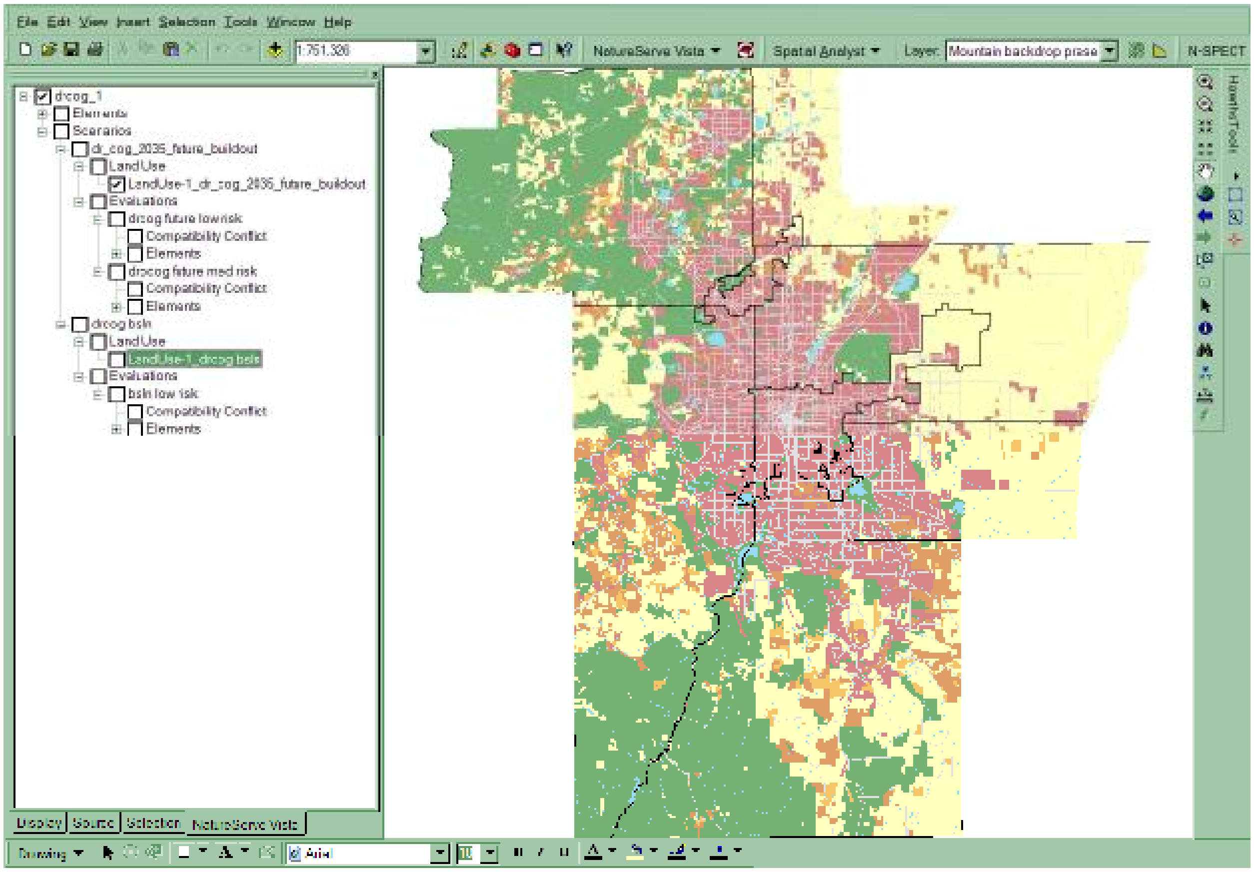


Figure A.3 2006 Baseline Scenario Zoom-In: Northeast DRCOG

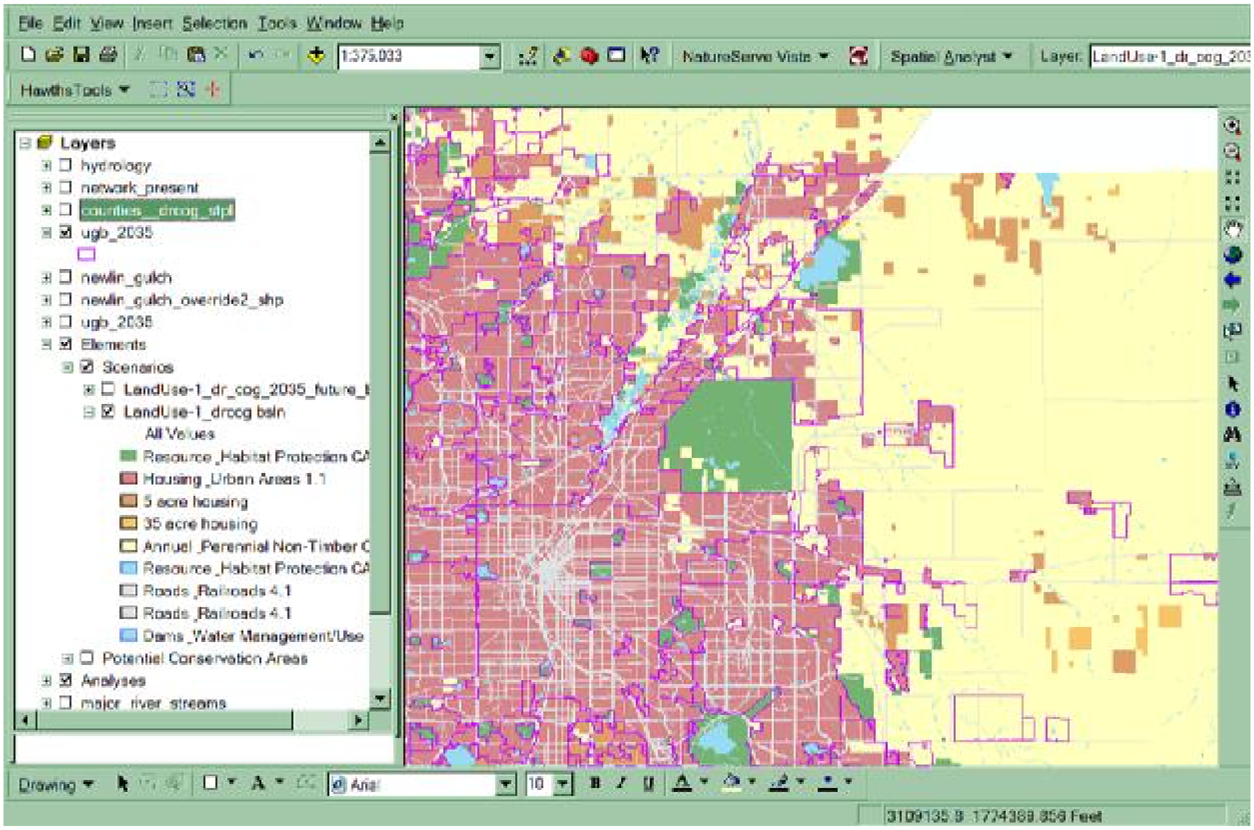


Figure A.4 Trending Future Scenario Zoom-in - Northwestern DRCOG

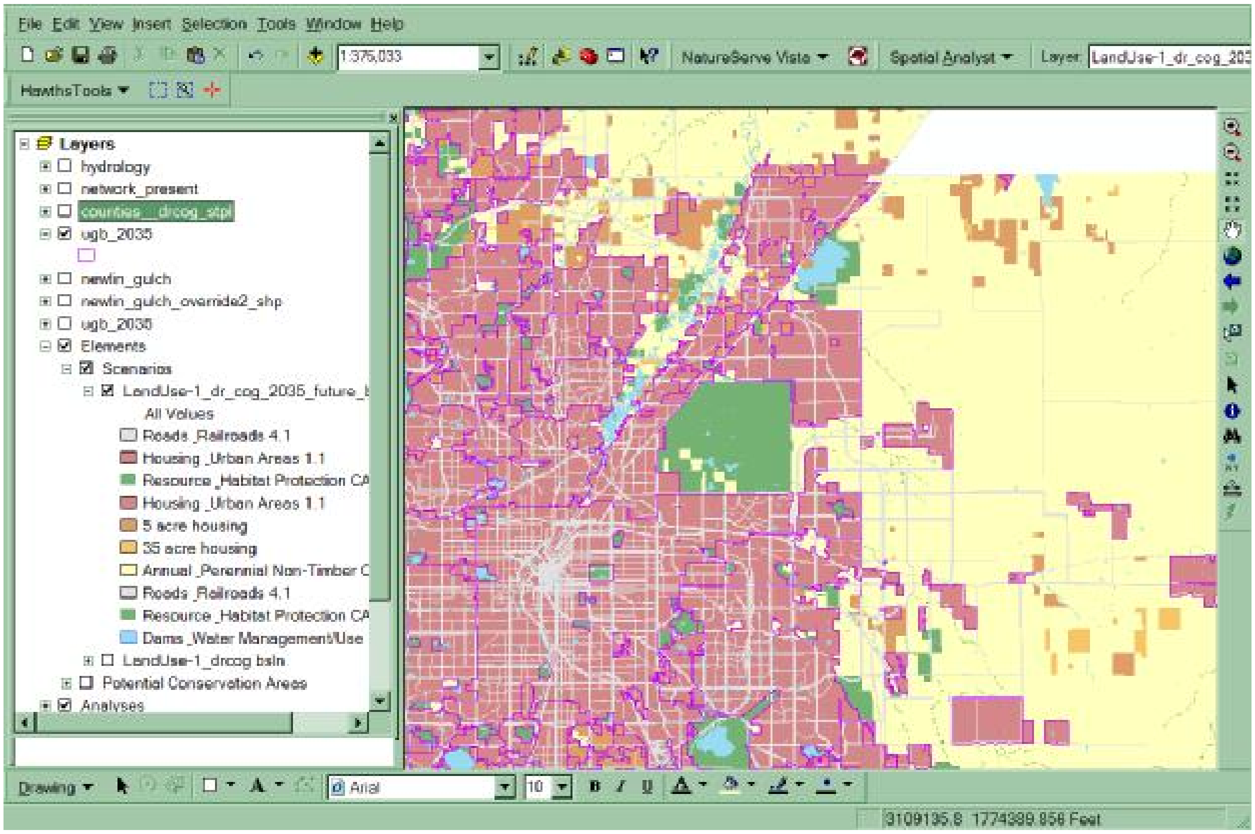
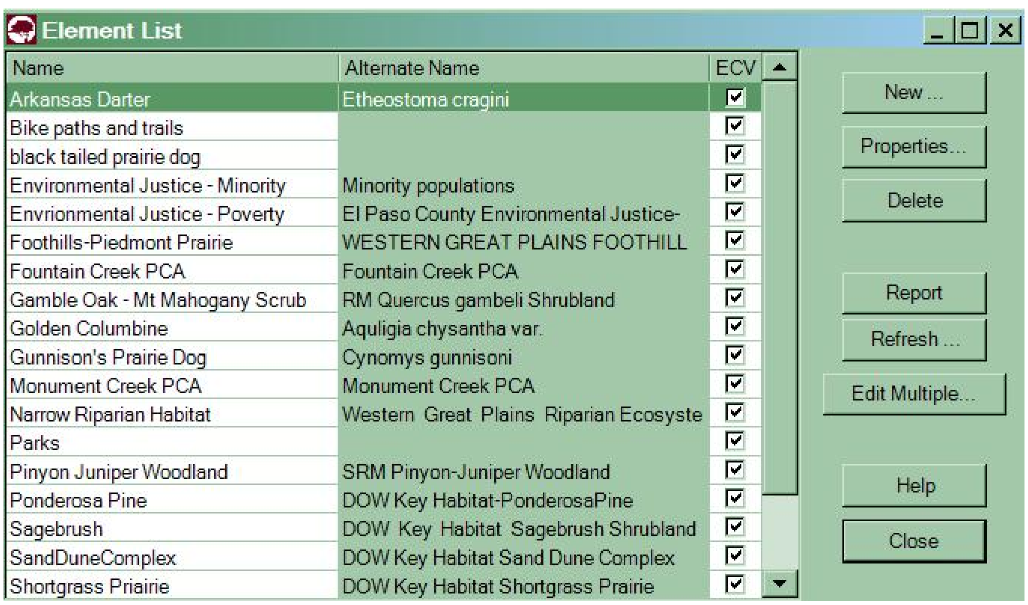


Figure A.5 DRCOG Resource List

Name	Alternate Name	ECV
Bell's Twinpod	Physaria bellii	☑
Bike paths		☑
Floodplains		☑
Foothill and Piedmont Grassland	Western Great Plains Foothill and Piedmont Grassland	☑
Foothill shrubland	Rocky Mountain Lower Montane-Foothill Shrubland	☑
Gambels Oak Shrubland	Rocky Mountain Gambel Oak-Mixed Montane Shrubland	☑
High percent minority areas		☑
High percent poverty areas		☑
Mottled Duskywing	Erynnis martialis	☑
Mountain backdrop preservation areas		☑
open_space_and_parks		☑
Plains Sharp-Tailed Grouse	Tympanuchus phasianellus jamesi	☑
Ponderosa Pine	Ponderosa Pine DOW State Key Habitat	☑
Potential Conservation Areas		☑
Sagebrush	Sagebrush DOW State Key Habitat	☑
Sand Dune Complex_Shrub	Sand Dune Complex_Shrub DOW State Key Habitat	☑
Shortgrass Prairie	Shortgrass Prairie DOW Key Habitat	☑
Shrub-dominated Wetlands	Shrub dominated Wetlands DOW state key habitat	☑
shryvers_elfin	Callophrys mossii schryveri	☑
urban parks		☑

Figure A.6 PPACG Resource List



Name	Alternate Name	ECV
Arkansas Darter	Etheostoma cragini	☑
Bike paths and trails		☑
black tailed prairie dog		☑
Environmental Justice - Minority	Minority populations	☑
Envrionmental Justice - Poverty	El Paso County Environmental Justice-	☑
Foothills-Piedmont Prairie	WESTERN GREAT PLAINS FOOTHILL	☑
Fountain Creek PCA	Fountain Creek PCA	☑
Gamble Oak - Mt Mahogany Scrub	RM Quercus gambeli Shrubland	☑
Golden Columbine	Aquligia chysantha var.	☑
Gunnison's Prairie Dog	Cynomys gunnisoni	☑
Monument Creek PCA	Monument Creek PCA	☑
Narrow Riparian Habitat	Western Great Plains Riparian Ecosyste	☑
Parks		☑
Pinyon Juniper Woodland	SRM Pinyon-Juniper Woodland	☑
Ponderosa Pine	DOW Key Habitat-PonderosaPine	☑
Sagebrush	DOW Key Habitat Sagebrush Shrubland	☑
SandDuneComplex	DOW Key Habitat Sand Dune Complex	☑
Shortgrass Priairie	DOW Key Habitat Shortgrass Prairie	☑

Figure A.7 PACOG Resource List

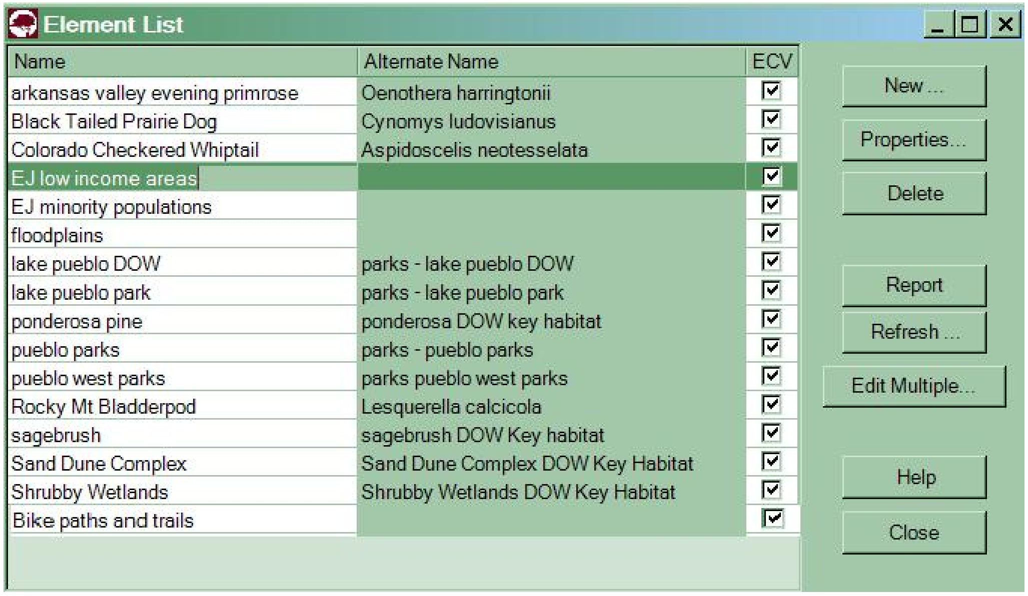


Figure A.8 Sample Resource Input Window

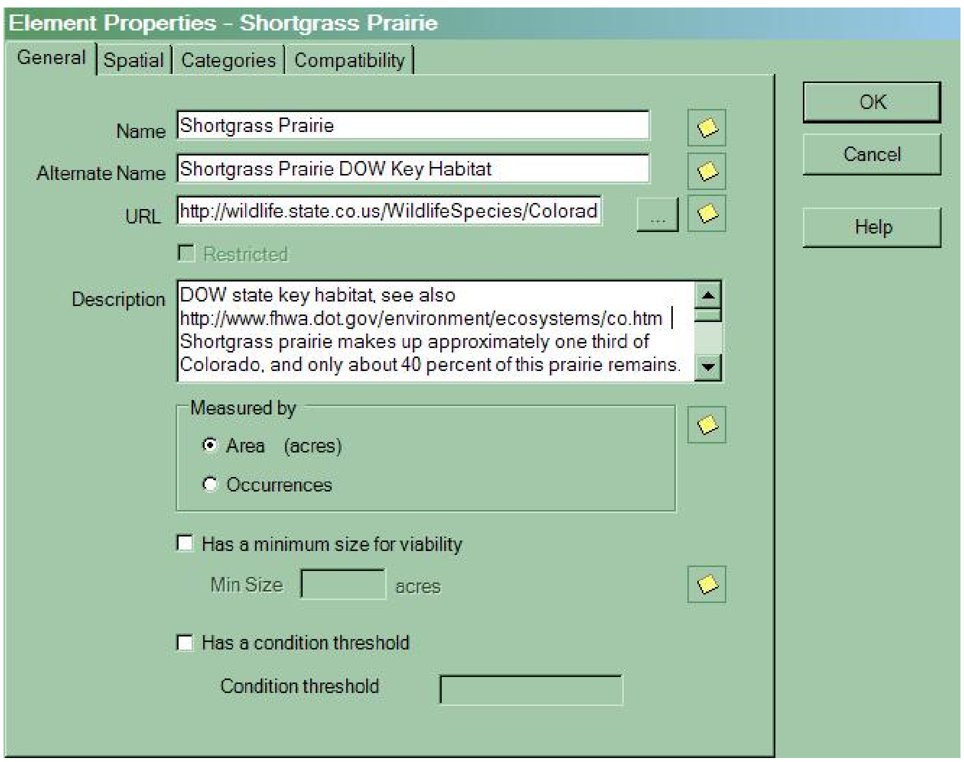


Figure A.9 Baseline Scenario with Environmental Justice

Minority areas displayed in purple.

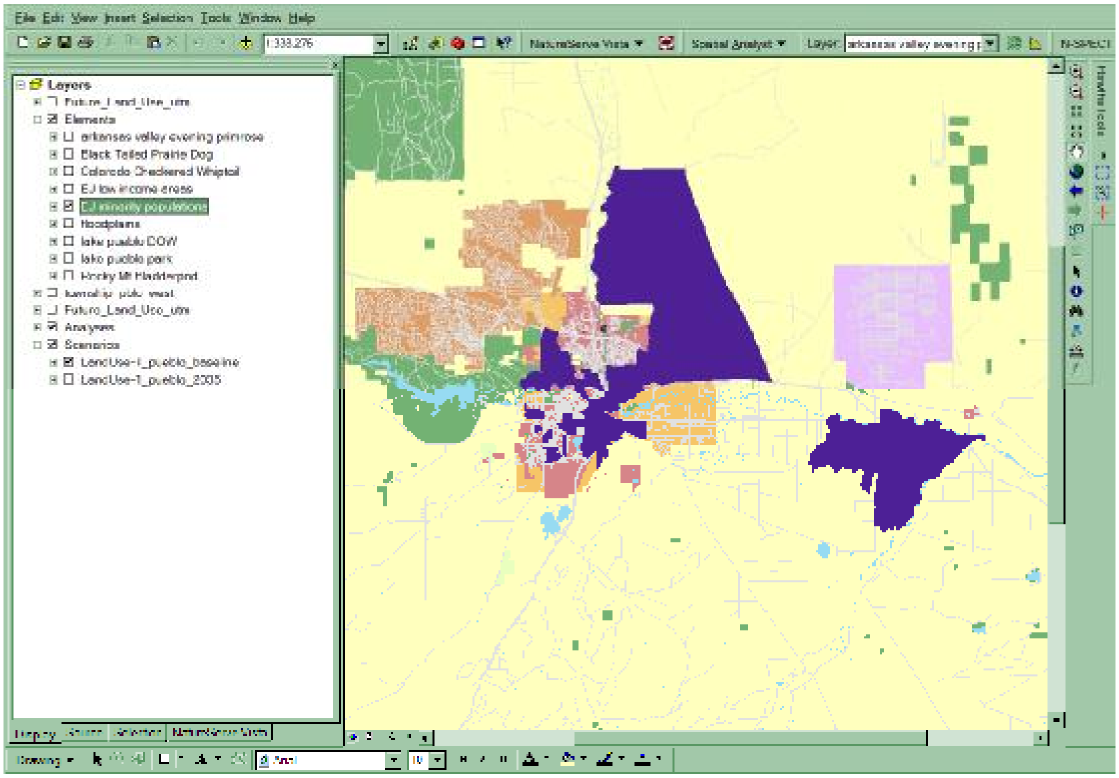


Figure A.10 Conservation Value Summary

Biological resource occurrences, ecological systems and floodplains.

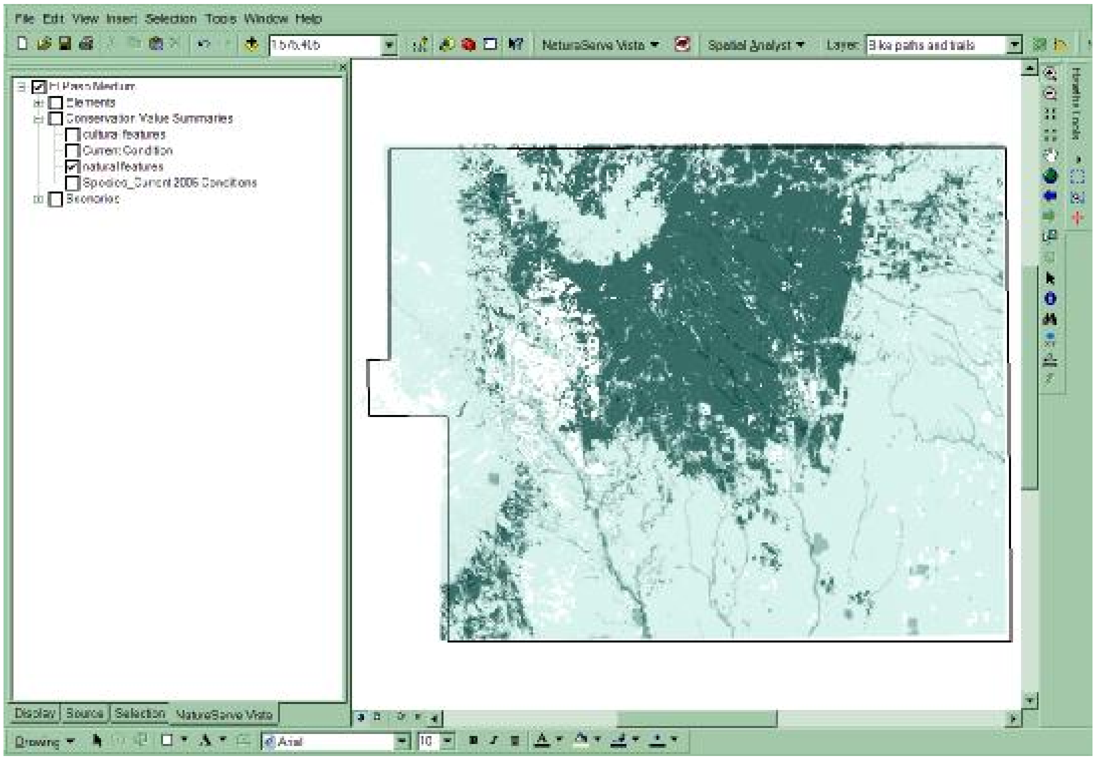


Figure A.11 Conservation Value Summary

Cultural features, Environmental Justice Areas and Priority Conservation Areas

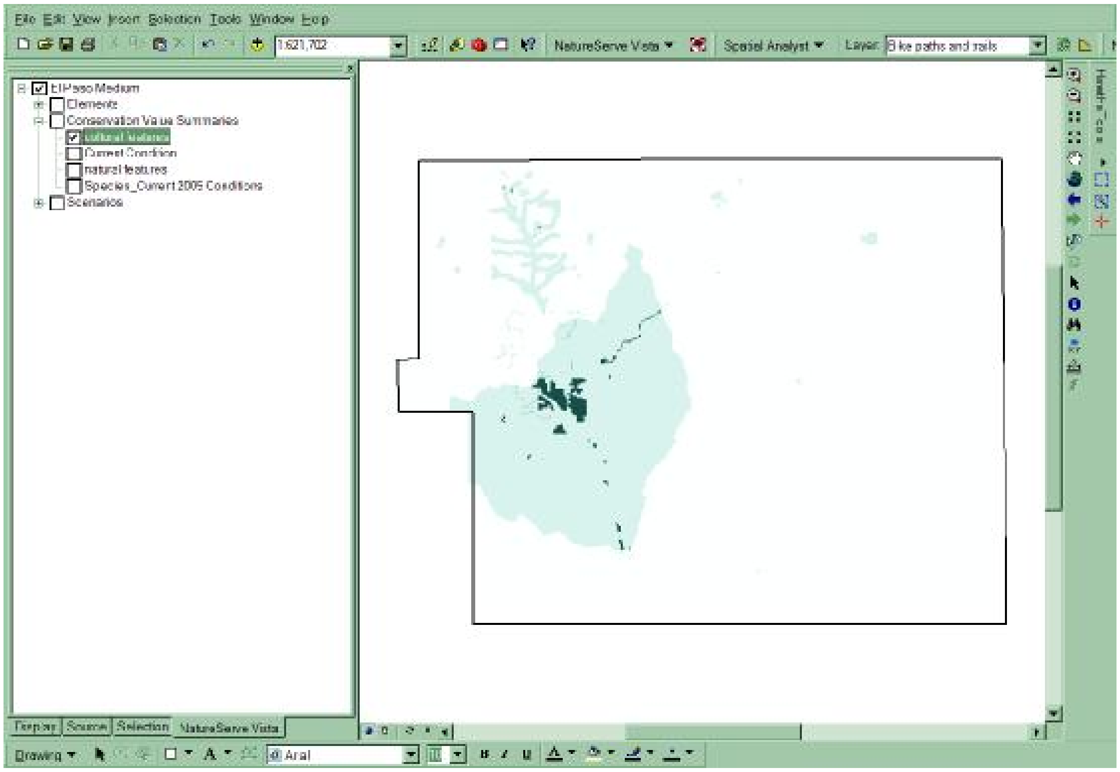


Figure A.12 Baseline Scenario Evaluation - PPACG

Tan areas contain resources that either have no conflicts with the scenario's land use or their goals have been met somewhere else in the project area. Areas displayed in shades of red have resources that have not met their goals under the scenario and are in conflict with the land use at those locations. Darker red shades are those areas where a high number of resources included in the evaluation coincide with areas of incompatible land use.

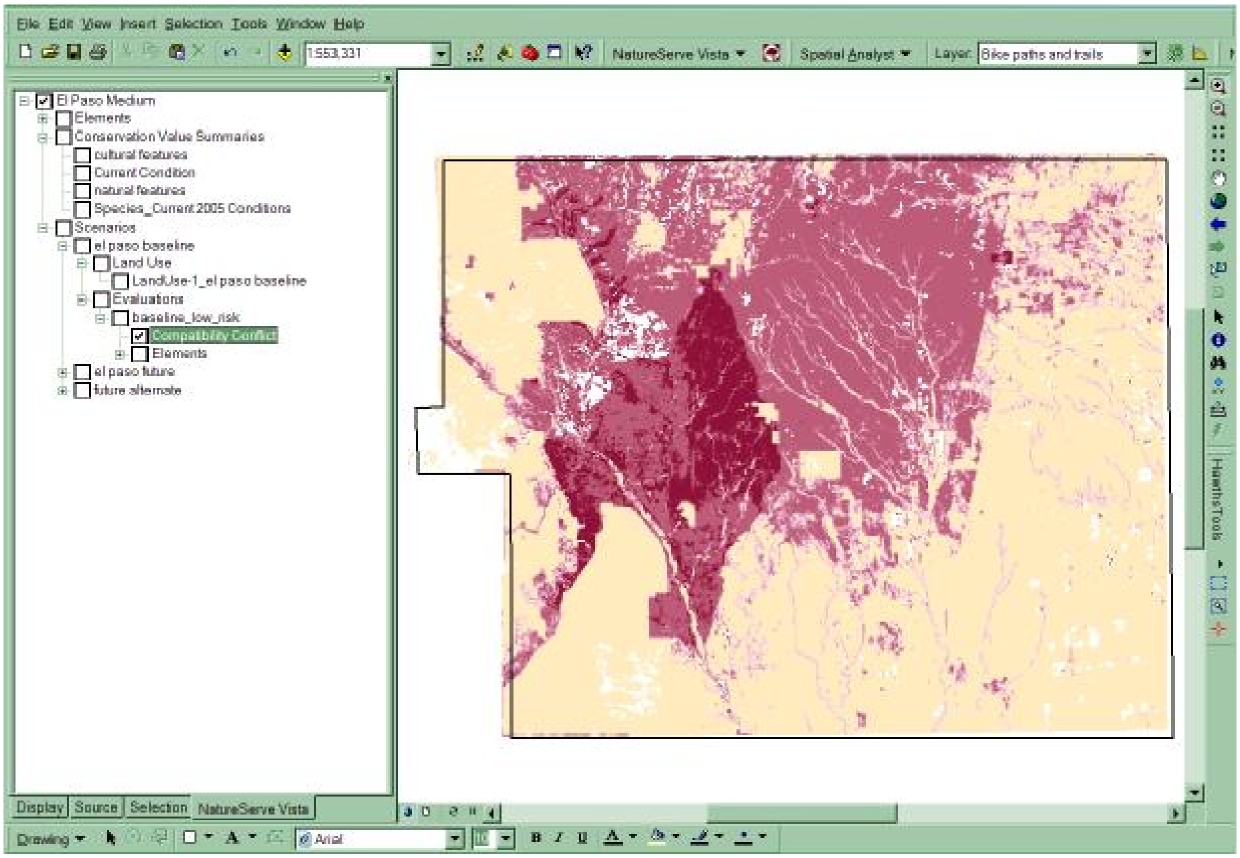


Figure A.13 Zoom-in Scenario Evaluation - Baseline DRCOG

Tan areas contain resources that either have no conflicts with the scenario's land use or their goals have been met somewhere else in the project area. Areas displayed in shades of red have resources that have not met their goals under the scenario and are in conflict with the land use at those locations. Darker red shades are those areas where a high number of resources included in the evaluation coincide with areas of incompatible land use.

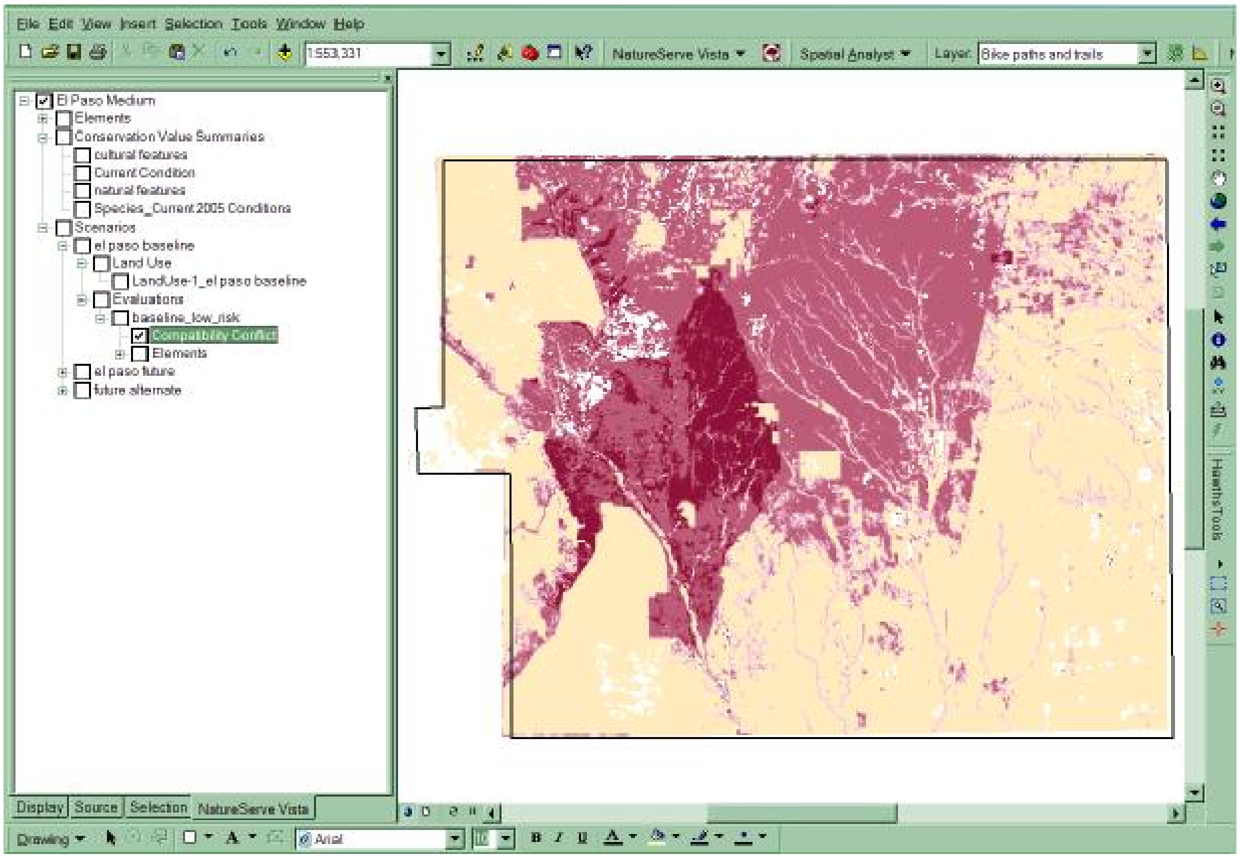


Figure A.14 Sample Scenario Evaluation Report

Notice the six categories of resources, goal levels, and the goal attainment status for each resource.

Summary

Name	Protected and Compatible Goal Met For	Protected and Compatible Goal Unmet For	Compatible Goal Met For	Compatible Goal Unmet For
element occurrences (4 elements)			2 elements (50%)	2 elements (50%)
ecological systems (8 elements)			7 elements (87.5%)	1 elements (12.5%)
pca (1 elements)			1 elements (100%)	0 elements (0%)
floodplains (1 elements)			0 elements (0%)	1 elements (100%)
environmental justice (2 elements)			1 elements (50%)	1 elements (50%)
green infrastructure (4 elements)			4 elements (100%)	0 elements (0%)

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Details

element occurrences (4 elements)

Name	Distribution Area (acres)	Distribution Occs	Distribution Avg Condition	Compatible Goal	Goal Met	Compatible Area (acres)	Compatible Occs	Compatible Avg Condition	Percent of goal
Plains Sharp-Tailed Grouse	71,668	17	NaN	80 percent of area		62,561	17	NaN	109.12%
Mottled Duskywing	220,933	16	NaN	80 percent of area		96,922	16	NaN	54.84%
Bell's Twinpod	2,303	9	NaN	80 percent of area		2,010	9	NaN	109.1%
shrivers elfin	250,424	18	NaN	80 percent of area		172,793	18	NaN	86.25%

ecological systems (8 elements)

Name	Distribution Area (acres)	Distribution Occs	Distribution Avg Condition	Compatible Goal	Goal Met	Compatible Area (acres)	Compatible Occs	Compatible Avg Condition	Percent of goal
Foothill and Piedmont Grassland	155,965	10670	NaN	70 percent of area		124,362	7940	NaN	113.91%
Foothill shrubland	39,980	5382	NaN	70 percent of area		33,319	4296	NaN	119.06%
Ponderosa Pine	378,027	10281	NaN	70 percent of area		318,271	8442	NaN	120.28%
Gambels Oak Shrubland	98,044	5593	NaN	70 percent of area		77,589	4454	NaN	113.05%
Shrub-dominated Wetlands	62,563	12322	NaN	70 percent of area		38,940	7253	NaN	88.92%
Shortgrass Prairie	88,261	6666	NaN	70 percent of area		69,670	4700	NaN	112.77%
Sand Dune Complex Shrub	2,441	672	NaN	70 percent of area		1,861	508	NaN	108.91%
Sagebrush	1,032	328	NaN	70 percent of area		860	269	NaN	119.05%

pca (1 elements)

Name	Distribution Area (acres)	Distribution Occs	Distribution Avg Condition	Compatible Goal	Goal Met	Compatible Area (acres)	Compatible Occs	Compatible Avg Condition	Percent of goal
Potential Conservation Areas	232,948	115	NaN	70 percent of area		197,483	113	NaN	121.11%

floodplains (1 elements)

Name	Distribution Area (acres)	Distribution Occs	Distribution Avg Condition	Compatible Goal	Goal Met	Compatible Area (acres)	Compatible Occs	Compatible Avg Condition	Percent of goal
Floodplains	185,146	1249	NaN	70 percent of area		128,132	1220	NaN	98.87%

environmental justice (2 elements)

Name	Distribution Area (acres)	Distribution Occs	Distribution Avg Condition	Compatible Goal	Goal Met	Compatible Area (acres)	Compatible Occs	Compatible Avg Condition	Percent of goal
High percent minority areas	85,628	264	NaN	70 percent of area		68,233	264	NaN	113.84%
High percent poverty areas	13,002	85	NaN	70 percent of area		6,997	82	NaN	76.88%

green infrastructure (4 elements)

Name	Distribution Area (acres)	Distribution Occs	Distribution Avg Condition	Compatible Goal	Goal Met	Compatible Area (acres)	Compatible Occs	Compatible Avg Condition	Percent of goal
open space and parks	771,190	4	NaN	70 percent of area		754,825	4	NaN	139.83%
Bike paths	11,488	1	NaN	70 percent of area		9,411.75	1	NaN	117.04%

Figure A.15 Using Site Explorer – PPACG

The baseline scenario is in the background and the purple outline designates a Priority Conservation Area which is prime habitat for a threatened mouse species. In the baseline scenario, several areas (grid cells in red) present compatible land uses with the PCA.

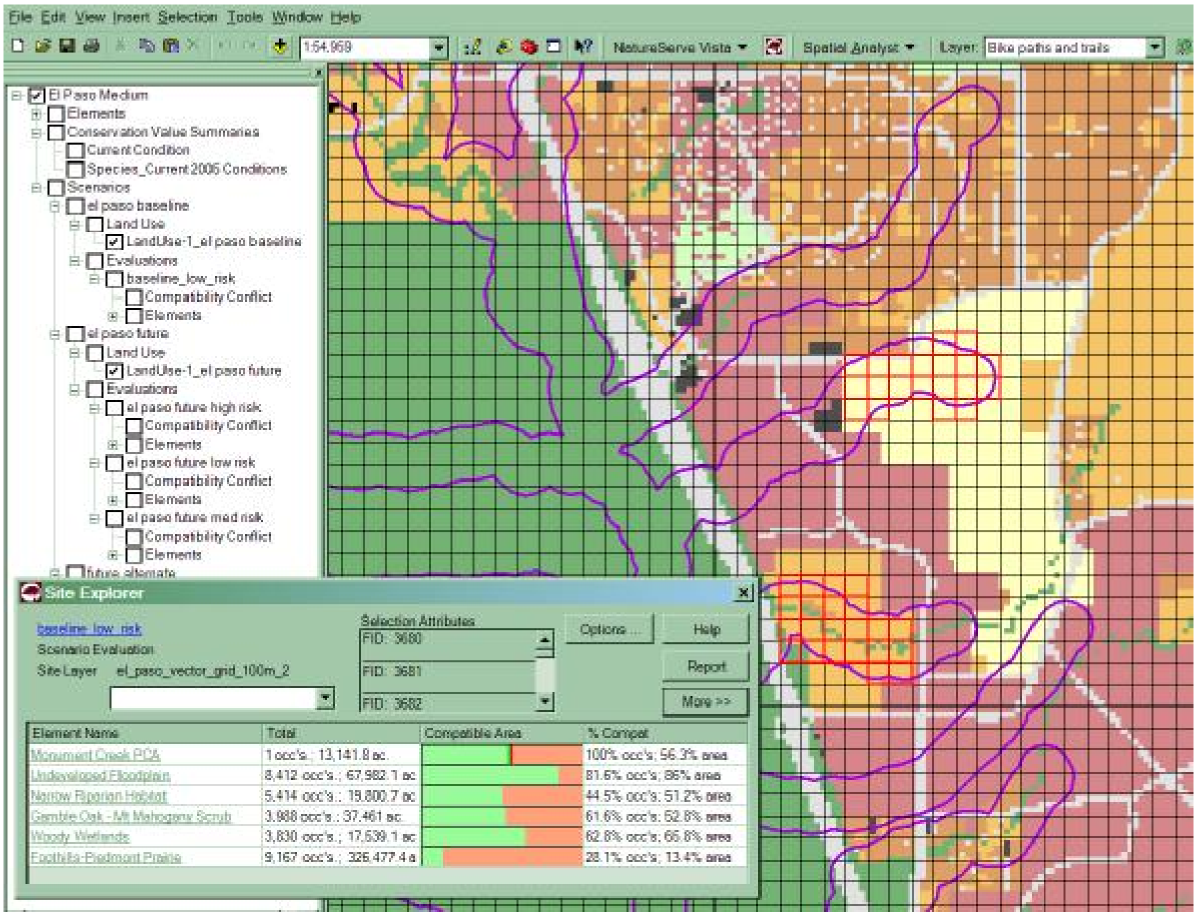

Figure A.16 Using Site Explorer – PPACG

The future scenario shows an increased road network and expanding urbanization in the PCA, furthering the resource from its goal attainment.

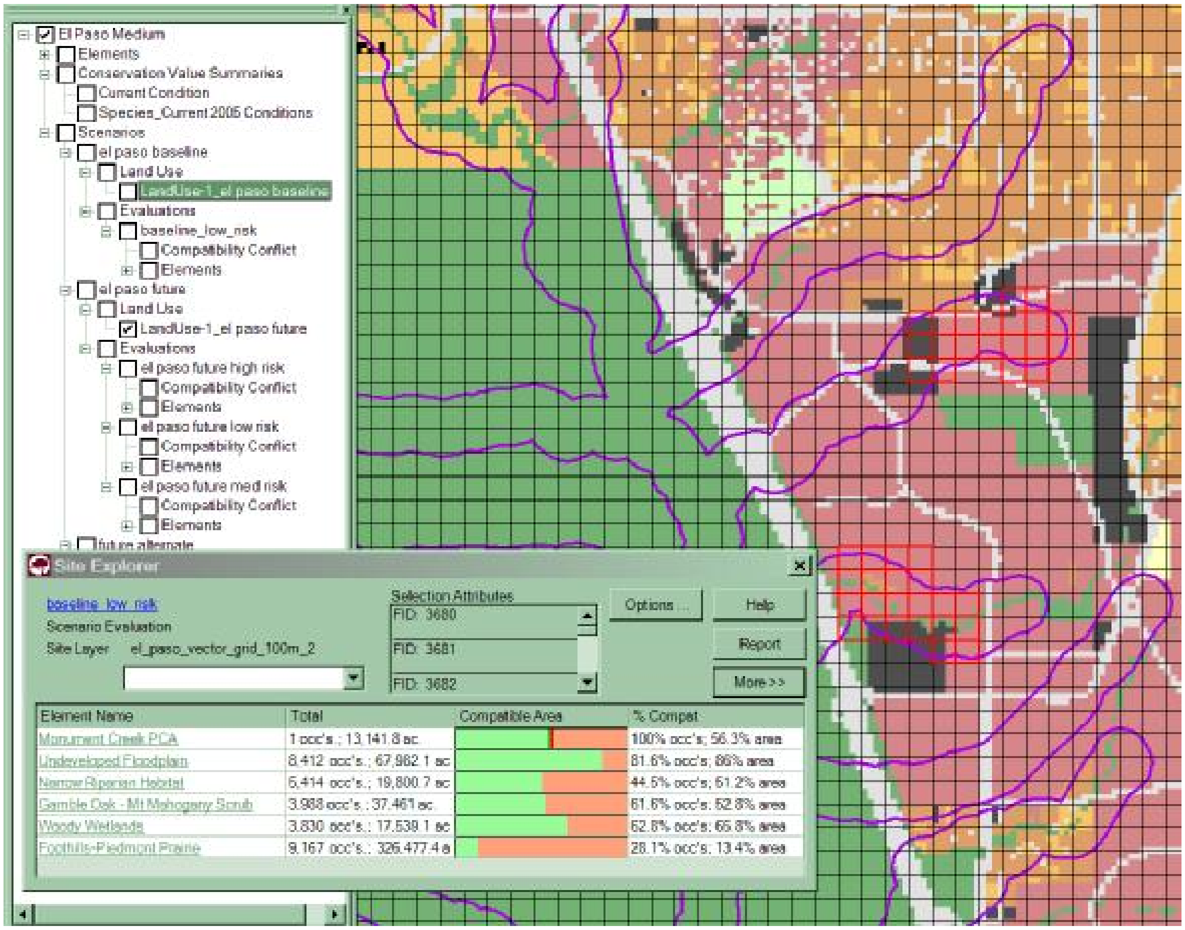

Figure A.17 Using Site Explorer – PPACG

The baseline scenario evaluation indicates there are more areas with compatible land uses within the PCA (areas within the green grids (selected with the Site Explorer)).

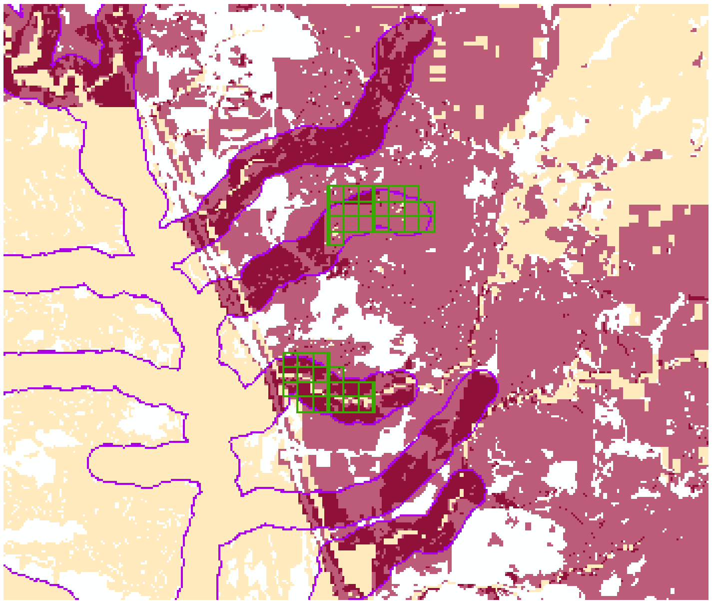

Figure A.18 Using Site Explorer – PPACG

The future scenario evaluation indicates that there are areas where more compatible land uses exist within the PCA (areas within the green grids (selected with the Site Explorer)).

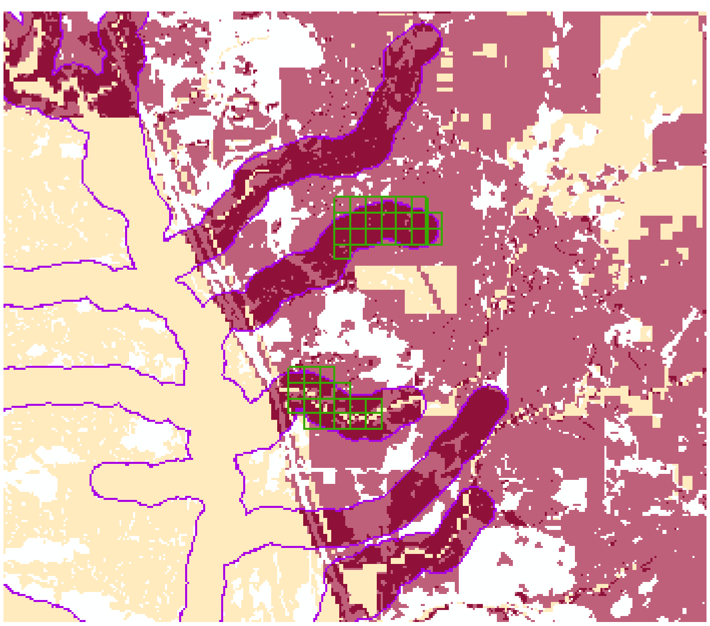

Figure A.19 Using Site Explorer to Create Mitigation Scenarios – PPACG

Using the Site Explorer to create an alternate scenario, the selected grid cells were converted to a compatible land use adding 656 acres to the PCA, helping it to attain its conservation goal.