

**Pikes Peak Area Council of  
Governments'  
Regional Transportation Plan:  
Integrated Regional Mitigation Plan**



July 2015

*CNHP's mission is to preserve the natural diversity of life by contributing the essential scientific foundation that leads to lasting conservation of Colorado's biological wealth.*

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# Pikes Peak Area Council of Governments' Regional Transportation Plan: Integrated Regional Mitigation Plan

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## INTRODUCTION

The Pikes Peak Area Council of Governments (PPACG) is the designated Metropolitan Planning Organization (MPO) for the Colorado Springs Urbanized Area, which consists of over 600,000 people and includes two counties and seven municipalities. PPACG's mission is to provide a forum for local governments to discuss issues that cross jurisdictional boundaries, identify shared opportunities and challenges, and develop collaborative strategies for action. As the MPO, PPACG must maintain a regional transportation plan and transportation improvement program to determine investment priorities for billions of dollars in federal, state, and local funds.

One goal of PPACG's transportation planning process is to better account for the needs and desires of agencies that impact, or are impacted by, transportation investments. Thus, as part of its Regional Transportation Plan for the Pikes Peak region, PPACG developed an Integrated Regional Mitigation Plan (IRMP). To assist in this effort, PPACG was awarded a grant from the Federal Highway Administration's Strategic Highway Research Program (SHRP2) Lead Adopter Incentive Implementation Assistance program. The objective of this funding program is to help local governments implement Eco-Logical (Brown 2006) and the subsequent technical guide expressed in the Integrated Ecological Framework (Crist et al. 2014), which was developed and tested under previous SHRP2 studies (SHRP C06 and C18, respectively, described below). It is hoped that this IRMP will create a paradigm shift away from the traditional planning process, in which transportation mitigation has not included cooperation with other agencies. The IRMP will help guide and support PPCAG's mitigation planning efforts by fostering cooperation and collaboration early in transportation improvements, and by providing more comprehensive information to aid decision-making.

The Colorado Natural Heritage Program (CNHP) and NatureServe supported PPACG in development of the IRMP by providing technical analysis and planning assistance, as described in the following sections of this report. Specifically, this work utilized Steps 1-5 of the Integrated Ecological Framework (Crist et al. 2014). All phases of the work were conducted in collaboration with PPACG's SHRP2 Advisory Committee.

### Physical Context

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The PPACG area is located at the juncture of Colorado's eastern plains and the Southern Rocky Mountains; the region is known for its cool summer weather, high number of clear, sunny days, and relatively dry climate. The area's meteorological classification is alpine desert, with about 250 days of sunshine per year. Physiographically, the Pikes Peak metropolitan planning area is characterized by gently sloping plains to the east and mountain ranges and basins to the west. The planning area lies entirely to the east of the Continental Divide. Fountain Creek on the west, and Black Squirrel Creek to the east are tributaries of the Arkansas River, and form the primary watersheds of the area, while streams along the northern boundary drain towards the South Platte River. Although Precambrian Pikes Peak granite forms the core of the mountainous areas, bedrock throughout much of the planning area is overlain by more recent alluvial (carried by water) and aeolian

(windblown) material. Mountain soils are normally rocky and shallow, except in areas where groundwater discharges or slope wetlands occur. Along drainages, both in the mountains and on the plains, wetland plant communities occur on alluvial soils. Of the nearly 200 soils found within the region, only two have been identified as hydric soils with the potential for floodplain mitigation. More information on the natural setting of the Pikes Peak region can be found in Chapter 2 of the Regional Transportation Plan.

## Previous Planning Efforts

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### **SHRP C06**

The SHRP2 Capacity program was initiated by the National Academy of Science's Transportation Research Board (TRB) to develop approaches and tools for systematically integrating environmental, economic, and community requirements into the analysis, planning, and design of new highway capacity. As part of this work, specifically under the SHRP2 C06 project, NatureServe and its partners developed the nine-step Integrated Ecological Framework (IEF, Crist et al. 2014) for integrating transportation and conservation planning. The framework was designed to improve incorporation of regulated and non-regulated resources, such as wetlands, water quality, endangered species, wildlife, habitats, and cultural resources early in transportation planning processes. The ultimate goal of implementing the IEF is to obtain early agreement on resources to avoid conflicts and delays during transportation improvements, as well as more effective and sustainable mitigation strategies.

### **SHRP C18**

In 2011, PPACG published a revision of its Moving Forward Regional Transportation Plan. This revision process included an analysis of ecological impacts of various development scenarios within the PPACG planning region, using components of the SHRP2 C06 Integrated Ecological Framework. Supported by a second TRB grant under the SHRP C18 program, PPACG collaborated with the Colorado Natural Heritage Program and NatureServe to evaluate impacts to a select suite of species and ecological systems from various future land use scenarios. Results of the SHRP2 C18 analysis helped to guide development of PPACG's preferred future development scenario – the Small Area Forecast scenario (CNHP and NatureServe 2011). For the analysis presented in this report, impacts from the Small Area Forecast and Accelerated Trend scenarios were re-calculated using updated versions of both scenarios as well as updated conservation element distribution data.

## **OVERVIEW OF MITIGATION AND THE IRMP**

Mitigation is generally understood as comprising the steps of avoidance of impacts by relocating or deferring impacting projects, minimizing impacts through project design and implementation measures, and compensating for unavoidable impacts through offsite actions (CEQ Sec. 1508.20). While the overall project products and decision support system can support all levels of mitigation, the IRMP is focused on compensating for unavoidable impacts to a resource by a variety of methods, with the intent of ensuring that there is no overall loss of those resources in the area of

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interest. Compensatory mitigation may be accomplished by restoration, creation, enhancement, or protection of other occurrences of the impacted resource (Compensatory Mitigation for Losses of Aquatic Resources, 40 CFR Part 230 Subpart J and 33 CFR Part 332). Restoration may be defined as the process of returning a population or habitat to a condition (including composition, structure, and process) that is as good as, or better than, it was prior to the disturbance. For example, a restoration of a burned forest may be appropriate mitigation for transportation impacts to an unburned forest nearby. Compensatory mitigation usually involves a requirement for more area to be mitigated than was impacted; mitigation ratios of 3:1 are typical (Huber et al. 2010). Further, in an IRMP (or RAMP—Regional Advanced Mitigation Plan as it is called in Huber et al. [2010]), it will be necessary to identify even more candidate areas than required for mitigation because not all areas will actually be available, cost effective, or contain the features of interest when further investigated. By developing the IRMP fewer areas will need to be investigated for each project's mitigation needs, potentially more effective and sustainable mitigation projects will be conducted, and local governments and other infrastructure developers will be aware of sites potentially needed for future mitigation so those sites can be preserved in the interim.

The IRMP is best understood as a spatial database, rather than a single map, that identifies mitigation opportunity areas capable of providing the type and quantity of mitigation anticipated through cumulative effects assessment of transportation projects identified in the regional transportation plan. It is not a fixed solution that aims to be implemented as-is (like a conservation plan), but rather provides a spatial database with attributes that are useful for developing advance mitigation projects linked to individual transportation projects as they are implemented. This is a key difference (between conservation and mitigation plans), in that conservation plans attempt to reach a set of conservation goals with minimum cost and/or area, while an IRMP seeks to identify ample opportunities and support the selection for mitigation sites as transportation projects are implemented. That said, IRMPs should complement conservation plans and direct mitigation projects to areas identified in conservation plans and give weight to such areas whenever possible. Coupling mitigation projects to conservation plans is what makes mitigation projects more effective and sustainable as well as attract implementation partners. Acquisition and implementation cost can be additional factors in identifying or ranking the suite of potential mitigation sites in an IRMP to help guide choices when multiple site options exist.

Developing an IRMP uses current, accepted, and best practices to direct mitigation opportunities to areas that can provide viable/sustainable mitigation and, where appropriate, incorporate other ecosystem services to maximize public benefits. Though not directly addressed in this IRMP, it can also support “out of kind” mitigation such that “needier” natural resources/biodiversity components (hereon called “conservation elements”) such as ecosystems, habitats (inclusive of wetlands), species occurrences, etc., may be considered higher priority for receiving mitigation action when more common conservation elements are impacted by transportation projects. The IRMP provides a larger amount of compensation opportunity than calculated cumulative impacts from transportation projects in order to provide flexibility in locations owing to uncertainty about compensation ratios, ability to acquire any particular tract of land for mitigation, large differences in acquisition costs, and so on.

# METHODS

This section describes the methods used to generate the IRMP. Resources that are considered mitigation targets in this analysis are primarily biological (species, natural plant communities, conservation sites, etc.), but additional factors such as the presence of cultural sites, or inclusion in a regional conservation plan, are taken into account as well.

## Region of Analysis

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Two regions of analysis were used to develop the IRMP (Figure 1). For the purpose of identifying conservation elements and calculating transportation project impacts (= mitigation needs), the PPACG MPO was used. To identify the suite of potential mitigation site represented by the IRMP, a larger regional boundary (“full study area” in Figure 1) was used to account for areas outside of the MPO boundary that could be more appropriate for receiving compensatory mitigation credits. “More appropriate” is defined as providing larger, more intact, and more sustainable occurrences of the mitigation targets. The regional boundary includes the entirety of the Fountain and Chico Creek watersheds, all of adjacent Teller County, and northern Pueblo County to Highway 50.

## Identification of Mitigation Needs

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### Conservation Elements & Mitigation Targets

In their land use planning efforts, PPACG strives to conserve or minimize impact to conservation elements (species, plant communities, and ecological systems) beyond those resources that they are required by law to protect (e.g., species listed as Threatened or Endangered under the Endangered Species Act; wetlands protected under the Clean Water Act). To identify conservation elements that could potentially be impacted by PPACG activities, a preliminary list was developed through queries of CNHP’s Element Occurrence<sup>1</sup> and Potential Conservation Areas (PCAs)<sup>2</sup> data for sensitive species and natural communities documented within the study area. Some species not

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<sup>1</sup>A mapped occurrence of a species or ecological community (element) using standard mapping methods developed by NatureServe and the network of natural heritage member programs.

<http://www.natureserve.org/prodServices/heritagemethodology.jsp>

<sup>2</sup> CNHP’s best estimate of the primary area required to support the long-term survival of targeted species or natural communities. For additional detail, see [http://www.cnhp.colostate.edu/download/gis/pca\\_reports.asp](http://www.cnhp.colostate.edu/download/gis/pca_reports.asp).

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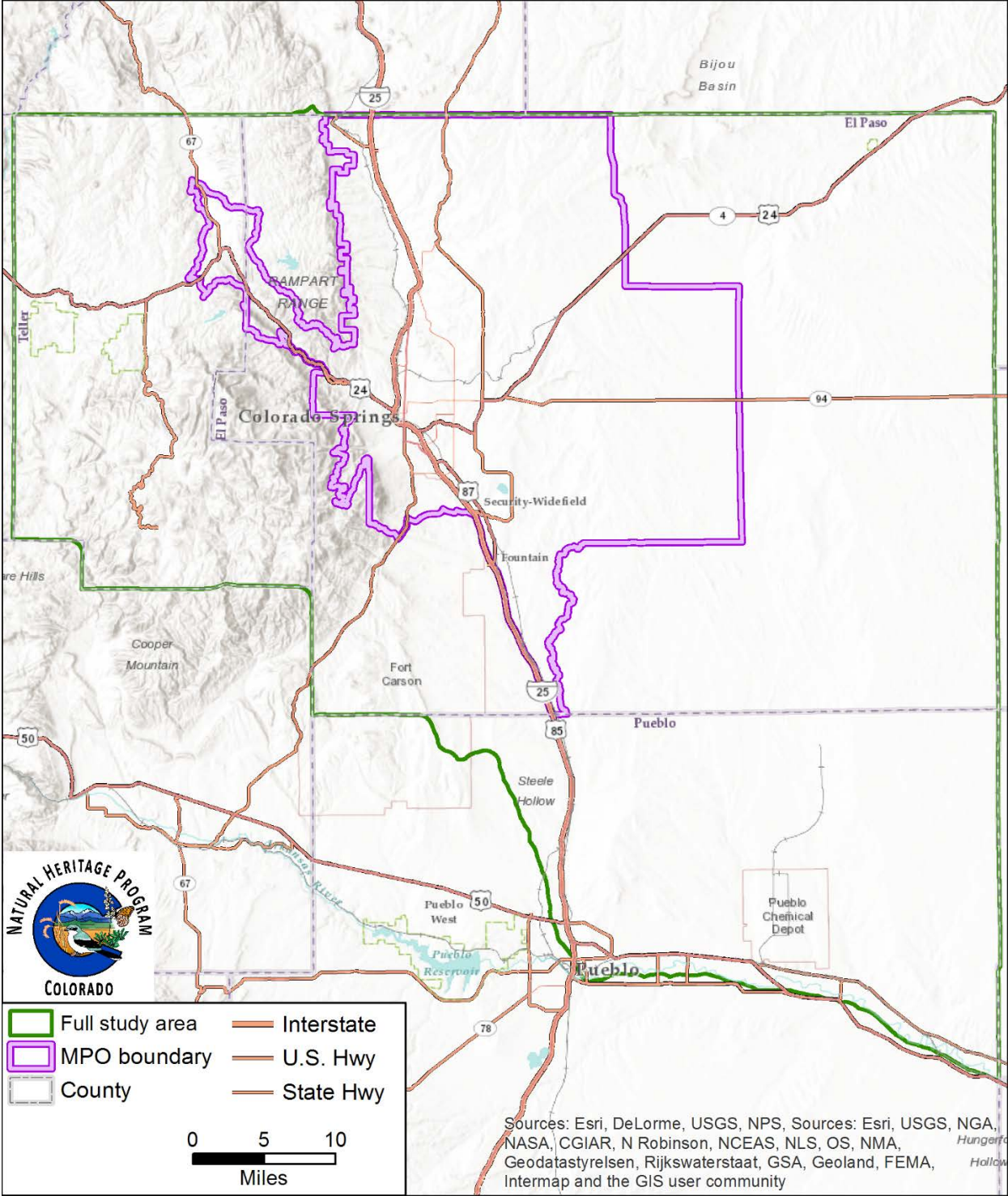


Figure 1. Analysis regions used in developing the IRMP.

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tracked by CNHP but considered important by the SHRP2 Advisory Committee were added. These include big game species that are not only economically important species, but also significant highway safety issues.

Wetland and riparian areas mapped from the National Wetland Inventory (NWI) were also added at the suggestion of the SHRP2 Advisory Committee, with the understanding that there is no way to tell from the NWI data if any given area mapped as a wetland is a regulated wetland as defined by the Clean Water Act. For the purposes of this analysis, the NWI dataset was filtered so that only those polygons representing wetland and riparian areas that are not wholly artificial were used. This allowed us to include, for instance, some man-made or impounded wetlands, but not water treatment areas or evaporation ponds. NWI wetland and riparian areas are identified in this document and the supporting data by their classification code according to Cowardin et al. 1979.

To aid in determining which of the conservation elements warranted inclusion in the IRMP, we sorted the elements into five status classes (which we referred to as “bins”), reflecting their degree of conservation concern and other considerations (Table 1). The Advisory Committee recommended that PPACG commit to mitigating impacts to conservation elements in bins 1-3 (referred to hereafter as “mitigation targets;” Table 2). Documented occurrences of these elements were used to calculate potential impacts from transportation projects, and to map potential mitigation sites, as described in the following sections of this report. Conservation elements in bins 4 and 5 (Table 3), together with other factors, were considered additional values (i.e., extra credit) to be used in selecting from among multiple potential mitigation sites.

**Table 1. Conservation element status bin definitions.** See Attachment A1 for definitions of NatureServe/CNHP conservation status ranks and CNHP biodiversity status ranks.

Bin	Description
1	Federally Listed & Candidate Species
2	Species or natural communities ranked as Critically Imperiled range-wide (G1) by NatureServe and CNHP OR Tier 1 Species of Greatest Conservation Need (SGCN) as defined by Colorado Parks & Wildlife’s State Wildlife Action Plan OR Potential Conservation Areas ranked as having outstanding biodiversity significance (B1) by CNHP
3	Species or natural communities ranked as Imperiled range-wide (G2) OR Tier 2 SGCN as defined by Colorado Parks & Wildlife OR Potential Conservation Areas ranked as having very high biodiversity significance (B2) OR Wetland/Riparian
4	Species or natural communities ranked as Vulnerable range-wide (G3) (100 or fewer known occurrences) AND/OR Critically Imperiled - Imperiled in Colorado (S1 or S2)
5	Remaining targets from original list, and any other areas considered to be important for mitigation or restoration

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**Table 2. Mitigation targets (conservation elements in bins 1-3).** Targets in bold are potentially impacted by planned transportation projects (also shown in Table 9). Elements are sorted first by bin, then by taxonomic group (species, communities, and PCAs). Within groups, plants are alphabetical by scientific name; all other targets are alphabetical by common name. Species marked with an asterisk (\*) have the majority of their known occurrences within the PPACG regional study area.

Group	Common Name	Scientific Name / Wetland Code	Data Source
<b>Bin 1 - Federally Listed &amp; Candidate Species</b>			
Birds	Mexican Spotted Owl	<i>Strix occidentalis lucida</i> EOs	CNHP 2015a
	<b>Mexican Spotted Owl Critical Habitat</b>	<b><i>Strix occidentalis lucida</i> Critical Habitat</b>	USFWS 2004
Fish	<b>Arkansas Darter</b>	<b><i>Etheostoma cragini</i></b>	CNHP 2015a
	Greenback Cutthroat Trout	<i>Oncorhynchus clarkii stomias</i>	CNHP 2015a
Mammals	<b>Gunnison's Prairie Dog - Montane Population</b>	<b><i>Cynomys gunnisoni</i> pop. 1</b>	CNHP 2015a
	<b>Preble's Meadow Jumping Mouse</b>	<b><i>Zapus hudsonius preblei</i> EOs</b>	CNHP 2015a
	<b>Preble's Meadow Jumping Mouse Critical Habitat</b>	<b><i>Zapus hudsonius preblei</i> Critical Habitat</b>	USFWS 2010
<b>Bin 2 - Critically Imperiled Range-wide OR Tier 1 SGCN OR B1 PCAs</b>			
Amphibians	Northern Leopard Frog	<i>Lithobates pipiens</i>	CNHP 2015a
Birds	Brown-capped Rosy-finch	<i>Leucosticte australis</i>	CNHP 2015a
	<b>Golden Eagle</b>	<b><i>Aquila chrysaetos</i></b>	CNHP 2015a
	Greater Sandhill Crane	<i>Grus canadensis tabida</i>	CNHP 2015a
	<b>Mountain Plover</b>	<b><i>Charadrius montanus</i></b>	CNHP 2015a
Fish	Southern Redbelly Dace	<i>Phoxinus erythrogaster</i>	CNHP 2015a
Mammals	Fringed Myotis	<i>Myotis thysanodes</i>	CNHP 2015a
	<b>Townsend's Big-eared Bat Subsp</b>	<b><i>Corynorhinus townsendii pallescens</i></b>	CNHP 2015a
Reptiles	Colorado Checkered Whiptail	<i>Aspidoscelis neotesselata</i>	CNHP 2015a
Vascular Plants	<b>Golden Columbine</b>	<b><i>Aquilegia chrysantha</i> var. <i>rydbergii</i>*</b>	CNHP 2015a
	Pikes Peak Spring Parsley	<i>Oreoxis humilis</i>	CNHP 2015a
Wetlands	Playa Grassland	<i>Pascopyrum smithii</i> - <i>Eleocharis</i> spp. Herbaceous Vegetation	CNHP 2015a
PCAs	Pikes Peak PCA		CNHP 2015a
	Rare Plants of the Chalk Barrens PCA		CNHP 2015a
<b>Bin 3 - Imperiled Range-wide OR Tier 2 SGCN OR B2 PCAs OR Wetland/Riparian</b>			
Amphibians	Couch's Spadefoot	<i>Scaphiopus couchii</i>	CNHP 2015a
	Plains Leopard Frog	<i>Lithobates blairi</i>	CNHP 2015a
Birds	American Peregrine Falcon	<i>Falco peregrinus anatum</i>	CNHP 2015a
	<b>Bald Eagle</b>	<b><i>Haliaeetus leucocephalus</i></b>	
	Ferruginous Hawk	<i>Buteo regalis</i>	
	Lewis's Woodpecker	<i>Melanerpes lewis</i>	
	Long-billed Curlew	<i>Numenius americanus</i>	
	McCown's Longspur	<i>Calcarius mccownii</i>	
	Northern Goshawk	<i>Accipiter gentilis</i>	

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Group	Common Name	Scientific Name / Wetland Code	Data Source
Insects	Colorado Blue	<i>Euphilotes rita coloradensis</i>	CNHP 2015a
	Hops Feeding Azure	<i>Celastrina humulus</i>	CNHP 2015a
	Moss's Elfin	<i>Callophrys mossii schryveri</i>	CNHP 2015a
	Rhesus Skipper	<i>Polites rhesus</i>	CNHP 2015a
	Simius Roadside Skipper	<i>Amblyscirtes simius</i>	CNHP 2015a
Mammals	<b>Bighorn Sheep</b>	<b><i>Ovis canadensis</i></b>	CPW 2014
	<b>Black-tailed Prairie Dog</b>	<b><i>Cynomys ludovicianus</i></b>	CNHP 2015a
	<b>Swift Fox</b>	<b><i>Vulpes velox</i></b>	CNHP 2015a
Vascular Plants	Dwarf Milkweed	<i>Asclepias uncialis</i> ssp. <i>uncialis</i>	CNHP 2015a
	Front Range Milkvetch	<i>Astragalus sparsiflorus</i> *	CNHP 2015a
	Golden Blazing Star	<i>Nuttallia chrysantha</i>	CNHP 2015a
	James' Telesonix	<i>Telesonix jamesii</i>	CNHP 2015a
	Narrowleaf Grapefern	<i>Botrychium lineare</i> *	CNHP 2015a
	Porter Feathergrass	<i>Ptilagrostis porteri</i>	CNHP 2015a
	Pueblo Goldenweed	<i>Oonopsis</i> sp. 1	CNHP 2015a
	Round-leaf Rour-o'clock	<i>Oxybaphus rotundifolius</i>	CNHP 2015a
Upland Plant Communities	Upper Montane Woodlands	<i>Pinus aristata</i> / <i>Trifolium dasyphyllum</i> Woodland	CNHP 2015a
	<b>Xeric Tallgrass Prairie</b>	<b><i>Andropogon gerardii</i> - <i>Sporobolus heterolepis</i> Western Foothills Herbaceous Vegetation</b>	CNHP 2015a
Riparian	Coyote Willow/Mesic Graminoid	<i>Salix exigua</i> / Mesic Graminoids Shrubland	CNHP 2015a
	Foothills Riparian Shrubland	<i>Betula occidentalis</i> / <i>Maianthemum stellatum</i> Shrubland	CNHP 2015a
	Forested Riparian	PFO/USA	USFWS 1975-1999
	Forested Riparian	PFOAH	USFWS 1975-1999
	Forested Riparian	PFOB	USFWS 1975-1999
	Forested Riparian	PFOC	USFWS 1975-1999
	Forested Riparian	PFOJ	USFWS 1975-1999
	<b>Forested Riparian - Temporarily Flooded</b>	<b>PFOA</b>	USFWS 1975-1999
	Forested Riparian with Emergent - Temporarily Flooded	PFO/EMA	USFWS 1975-1999
	<b>Forested Riparian with Scrub/Shrub</b>	<b>PFO/SSA</b>	USFWS 1975-1999
	Forested Riparian with Scrub/Shrub	PFO/SSJ	USFWS 1975-1999
	<b>Forested Riparian, Impounded - Temporarily Flooded</b>	<b>PFOAh</b>	USFWS 1975-1999
	Lower Montane Riparian Forest	<i>Pseudotsuga menziesii</i> / <i>Cornus sericea</i> Woodland	CNHP 2015a
<b>Montane Riparian Forest</b>	<b><i>Pseudotsuga menziesii</i> / <i>Betula occidentalis</i> Woodland</b>	CNHP 2015a	
Montane Riparian Shrubland	<i>Alnus incana</i> / Mesic Graminoids Shrubland	CNHP 2015a	

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Group	Common Name	Scientific Name / Wetland Code	Data Source
	Montane Riparian Willow Carr	PSS/EMA	USFWS 1975-1999
	Montane Willow Carr	PSSC	USFWS 1975-1999
	Montane Willow Carr	<i>Salix monticola</i> / <i>Calamagrostis canadensis</i> Shrubland	CNHP 2015a
	Montane Willow Carr	<i>Salix bebbiana</i> Shrubland	CNHP 2015a
	Narrowleaf Cottonwood Riparian Forest	<i>Populus angustifolia</i> / <i>Salix exigua</i> Woodland	CNHP 2015a
	Narrowleaf Cottonwood/Common Chokecherry	<i>Populus angustifolia</i> / <i>Prunus virginiana</i> Woodland	CNHP 2015a
	Plains Cottonwood / Alkali Sacaton	<i>Populus deltoides</i> / <i>Sporobolus airoides</i> Forest	CNHP 2015a
	Plains Cottonwood Riparian Woodland	<i>Populus deltoides</i> - ( <i>Salix amygdaloides</i> ) / <i>Salix (exigua, interior)</i> Woodland	CNHP 2015a
	Shrub Riparian	PSS/EMC	USFWS 1975-1999
	Shrub Riparian	PSS/EMKA	USFWS 1975-1999
	Shrub Riparian	PSS/USA	USFWS 1975-1999
	Shrub Riparian	PSSAh	USFWS 1975-1999
	Shrub Riparian	PSSBb	USFWS 1975-1999
	Shrub Riparian	PSSCb	USFWS 1975-1999
	Shrub Riparian	PSSCh	USFWS 1975-1999
	Shrub Riparian	PSSCH	USFWS 1975-1999
	Shrub Riparian	PSSJ	USFWS 1975-1999
	<b>Shrub Riparian - Seasonally Flooded</b>	<b>PSSC</b>	USFWS 1975-1999
	<b>Shrub Riparian - Temporarily Flooded</b>	<b>PSSA</b>	USFWS 1975-1999
	<b>Shrub Riparian with Emergent Vegetation</b>	<b>PSS/EMA</b>	USFWS 1975-1999
	Subalpine Riparian Willow Carr	<i>Salix planifolia</i> / <i>Carex aquatilis</i> Shrubland	CNHP 2015a
	Subalpine Riparian/Wetland Carr	PSSA	USFWS 1975-1999
	Thinleaf Alder-Red-osier Dogwood Riparian Shrubland	<i>Alnus incana</i> / <i>Cornus sericea</i> Shrubland	CNHP 2015a
Wetlands	Buffalograss Playa	<i>Buchloe dactyloides</i> - <i>Ratibida tagetes</i> - <i>Ambrosia linearis</i> Herbaceous Vegetation	CNHP 2015a
	Bulrush	<i>Schoenoplectus pungens</i> Herbaceous Vegetation	CNHP 2015a
	Clustered Sedge Wetland	PEMB	USFWS 1975-1999
	Emergent Wetland	PEM/USA	USFWS 1975-1999
	Emergent Wetland	PEMAh	USFWS 1975-1999
	Emergent Wetland	PEMAx	USFWS 1975-1999
	Emergent Wetland	PEMBb	USFWS 1975-1999
	Emergent Wetland	PEMCb	USFWS 1975-1999
	Emergent Wetland	PEMF	USFWS 1975-1999

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Group	Common Name	Scientific Name / Wetland Code	Data Source
	Emergent Wetland	PEMFb	USFWS 1975-1999
	Emergent Wetland	PEMFh	USFWS 1975-1999
	Emergent Wetland	PEMFx	USFWS 1975-1999
	Emergent Wetland	PEMJ	USFWS 1975-1999
	Emergent Wetland	PEMKa	USFWS 1975-1999
	Emergent Wetland	PEMKC	USFWS 1975-1999
	Emergent Wetland	PEMKx	USFWS 1975-1999
	Emergent Wetland	PEM	USFWS 1975-1999
	<b>Emergent Wetland - Saturated</b>	<b>PEMB</b>	USFWS 1975-1999
	<b>Emergent Wetland - Seasonally Flooded</b>	<b>PEMC</b>	USFWS 1975-1999
	<b>Emergent Wetland - Temporarily Flooded</b>	<b>PEMA</b>	USFWS 1975-1999
	<b>Emergent Wetland, Impounded - Seasonally Flooded</b>	<b>PEMCh</b>	USFWS 1975-1999
	<b>Emergent wetland, Man-made - Seasonally Flooded</b>	<b>PEMCx</b>	USFWS 1975-1999
	Great Plains Marsh	<i>Schoenoplectus acutus</i> - <i>Typha latifolia</i> - ( <i>Schoenoplectus tabernaemontani</i> ) Sandhills Herbaceous Vegetation	CNHP 2015a
	Mosaic of Wetland Graminoid Communities	<i>Juncus balticus</i> , <i>Schoenoplectus pungens</i> , <i>Distichlis spicata</i> , and <i>Carex</i> sp. Herbaceous Vegetation	CNHP 2015a
	Other Wetland	Pf	USFWS 1975-1999
	<b>Playa</b>	<b>Playa</b>	
	<b>Pond – Semi-permanently Flooded</b>	<b>PABF</b>	USFWS 1975-1999
	Pond Wetland	PABFb	USFWS 1975-1999
	Pond Wetland	PABFx	USFWS 1975-1999
	Pond Wetland	PABG	USFWS 1975-1999
	Pond Wetland	PABGb	USFWS 1975-1999
	<b>Pond, Impounded - Intermittently Exposed</b>	<b>PABGh</b>	USFWS 1975-1999
	<b>Pond, Impounded – Semi-permanently Flooded</b>	<b>PABFh</b>	USFWS 1975-1999
	<b>Pond, Man-made</b>	<b>PABKx</b>	USFWS 1975-1999
	Prairie Slough Grass	<i>Spartina pectinata</i> Western Herbaceous Vegetation	CNHP 2015a
	Saline Bottomland Shrublands	<i>Sarcobatus vermiculatus</i> / <i>Sporobolus airoides</i> Sparse Vegetation	CNHP 2015a
	Shrub Riparian	PSSB	USFWS 1975-1999
	Shrub Riparian	PSSBh	USFWS 1975-1999
	Western Slope Marsh	<i>Phragmites australis</i> Western North America Temperate Semi-natural Herbaceous Vegetation	CNHP 2015a

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Group	Common Name	Scientific Name / Wetland Code	Data Source
	Wet Meadows	PEMC	USFWS 1975-1999
PCAs	Aiken Canyon PCA		CNHP 2015a
	Cascade Creek East PCA		CNHP 2015a
	<b>Cheyenne Canyon PCA</b>		CNHP 2015a
	Chico Basin Shortgrass Prairie PCA		CNHP 2015a
	<b>Judge Orr Road PCA</b>		CNHP 2015a
	<b>Monument Creek PCA</b>		CNHP 2015a
	Schriever Playas PCA		CNHP 2015a
	Severy Creek PCA		CNHP 2015a
	Signal Rock Sandhills PCA		CNHP 2015a
	South Slope PCA		CNHP 2015a

**Table 3. Conservation elements in bins 4 and 5.** Elements are sorted first by bin, then by taxonomic group (species, communities, and PCAs). Within groups, plants are alphabetical by scientific name; all other targets are alphabetical by common name.

Group	Common Name	Scientific Name	Data Source
<b>Bin 4 - Species or natural communities ranked as Vulnerable range-wide (G3) (100 or fewer known occurrences) AND/OR Critically Imperiled - Imperiled in Colorado (S1 or S2).</b>			
Vascular plants	<b>Plains ragweed</b>	<i>Ambrosia linearis</i>	CNHP 2015a
	<b>Rocky Mountain columbine</b>	<i>Aquilegia saximontana</i>	CNHP 2015a
	<b>Hall's milkweed</b>	<i>Asclepias hallii</i>	CNHP 2015a
	<b>Barneby's fever-few</b>	<i>Bolophyta tetraneuris</i>	CNHP 2015a
	<b>Reflected moonwort</b>	<i>Botrychium echo</i>	CNHP 2015a
	<b>Crawe sedge</b>	<i>Carex crawei*</i>	CNHP 2015a
	<b>A sedge</b>	<b><i>Carex oreocharis</i></b>	<b>CNHP 2015a</b>
	<b>Eaton's lip fern</b>	<i>Cheilanthes eatonii</i>	CNHP 2015a
	<b>Sandhill goosefoot</b>	<i>Chenopodium cycloides</i>	CNHP 2015a
	<b>Birdbill day-flower</b>	<i>Commelina dianthifolia*</i>	CNHP 2015a
	<b>Frostweed</b>	<i>Crocotum bicknellii*</i>	CNHP 2015a
	<b>Slender cottongrass</b>	<i>Eriophorum gracile</i>	CNHP 2015a
	<b>Richardson alum-root</b>	<i>Heuchera richardsonii*</i>	CNHP 2015a
	<b>Yellow stargrass</b>	<i>Hypoxis hirsuta*</i>	CNHP 2015a
	<b>Small-headed rush</b>	<i>Juncus brachycephalus*</i>	CNHP 2015a
	<b>Alpine bluebells</b>	<i>Mertensia alpina</i>	CNHP 2015a
	<b>Jeweled blazingstar</b>	<i>Nuttallia speciosa</i>	CNHP 2015a
	<b>Arkansas Valley evening primrose</b>	<i>Oenothera harringtonii</i>	CNHP 2015a
	<b>Rocky Mountain phacelia</b>	<i>Phacelia denticulata</i>	CNHP 2015a
	<b>Rocky Mountain bladderpod</b>	<i>Physaria calcicola</i>	CNHP 2015a
	<b>Rydberg twinpod</b>	<i>Physaria vitulifera</i>	CNHP 2015a

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Group	Common Name	Scientific Name	Data Source
	<b>Southern Rocky Mountain cinquefoil</b>	<i>Potentilla ambigens*</i>	CNHP 2015a
	<b>Prairie goldenrod</b>	<i>Unamia alba*</i>	CNHP 2015a
	<b>Plains ironweed</b>	<i>Vernonia marginata*</i>	CNHP 2015a
Upland Plant Communities	Dry Alpine Meadows	<i>Kobresia myosuroides - Carex rupestris</i> var. <i>drummondiana</i> Herbaceous Vegetation	CNHP 2015a
	Foothills Ponderosa Pine Savannas	<i>Pinus ponderosa / Schizachyrium scoparium</i> Woodland	CNHP 2015a
	Foothills Ponderosa Pine Savannas	<i>Pinus ponderosa / Carex inops</i> ssp. <i>heliophila</i> Woodland	CNHP 2015a
	Great Plains Mixed Grass Prairie	<i>Hesperostipa neomexicana</i> Herbaceous Vegetation	CNHP 2015a
	Great Plains Mixed Grass Prairies (Sandstone/Gravel Breaks)	<i>Schizachyrium scoparium - Bouteloua curtipendula</i> Western Great Plains Herbaceous Vegetation	CNHP 2015a
	Great Plains Salt Meadows	<i>Sporobolus airoides</i> Southern Plains Herbaceous Vegetation	CNHP 2015a
	Lower Montane Forests	<i>Corylus cornuta</i> Shrubland [Provisional]	CNHP 2015a
	Mixed Mountain Shrublands	<i>Quercus gambelii - Cercocarpus montanus / (Carex geyeri)</i> Shrubland	CNHP 2015a
	Montane Grasslands	<i>Danthonia parryi</i> Herbaceous Vegetation	CNHP 2015a
	Northern Sandhill Prairie	<i>Artemisia filifolia / Andropogon hallii</i> Shrubland	CNHP 2015a
	Shortgrass Prairie	<i>Bouteloua gracilis - Pleuraphis jamesii</i> Herbaceous Vegetation	CNHP 2015a
	Vine-mesquite Herbaceous Vegetation	<i>Panicum obtusum</i> Herbaceous Vegetation	CNHP 2015a
<b>Bin 5 - Remaining targets from original list, and any other areas considered to be important for mitigation or restoration</b>			
Birds	Ovenbird	<i>Seiurus aurocapilla</i>	CNHP 2015a
Mammals	American Black Bear	<i>Ursus americanus</i>	CPW 2014
	Elk	<i>Cervus canadensis</i>	CPW 2014
	Mountain Lion	<i>Puma concolor</i>	CPW 2014
	Mule Deer	<i>Odocoileus hemionus</i>	CPW 2014
	Pronghorn	<i>Antilocapra americana</i>	CPW 2014
	White-tailed Deer	<i>Odocoileus virginianus</i>	CPW 2014
Vascular Plants	Dwarf wild indigo	<i>Amorpha nana*</i>	CNHP 2015a
	Western moonwort	<i>Botrychium hesperium</i>	CNHP 2015a
	Mingan's moonwort	<i>Botrychium minganense</i>	CNHP 2015a
	Mud sedge	<i>Carex limosa</i>	CNHP 2015a
	American yellow lady's-slipper	<i>Cypripedium calceolus</i> ssp. <i>parviflorum*</i>	CNHP 2015a
	Longstem water-wort	<i>Elatine triandra</i>	CNHP 2015a
	Gay-feather	<i>Liatris ligulistylis*</i>	CNHP 2015a
	American currant	<i>Ribes americanum*</i>	CNHP 2015a
	Lesser bladderwort	<i>Utricularia minor</i>	CNHP 2015a

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Group	Common Name	Scientific Name	Data Source	
	Prairie violet	<i>Viola pedatifida*</i>	CNHP 2015a	
Upland Plant Communities	Alpine Meadows	<i>Carex rupestris</i> - <i>Geum rossii</i> Herbaceous Vegetation	CNHP 2015a	
	Foothills Ponderosa Pine Scrub Woodlands	<i>Pinus ponderosa</i> / <i>Quercus gambelii</i> Woodland	CNHP 2015a	
	Great Plains Shortgrass Prairie	<i>Pascopyrum smithii</i> - <i>Bouteloua gracilis</i> Herbaceous Vegetation	CNHP 2015a	
	James' Seaheath/Galleta-Blue Grama Shrubland	<i>Frankenia jamesii</i> / <i>Hilaria jamesii</i> - ( <i>Bouteloua gracilis</i> ) Shrubland	CNHP 2015a	
	Mesic Oak Thickets	<i>Quercus gambelii</i> / <i>Carex inops</i> Shrubland	CNHP 2015a	
	Mesic Tallgrass Prairie	<i>Andropogon gerardii</i> - <i>Calamovilfa longifolia</i> Herbaceous Vegetation	CNHP 2015a	
	Mixed Mountain Shrublands	<i>Cercocarpus montanus</i> / <i>Muhlenbergia montana</i> Shrubland	CNHP 2015a	
	Montane Grasslands	<i>Stipa comata</i> - <i>Bouteloua gracilis</i> Herbaceous Vegetation	CNHP 2015a	
	Salt Meadows	<i>Distichlis spicata</i> Herbaceous Vegetation	CNHP 2015a	
	Shortgrass Prairie	<i>Opuntia imbricata</i> Shrubland	CNHP 2015a	
	Snowberry Shrubland	<i>Symphoricarpos occidentalis</i> Shrubland	CNHP 2015a	
	PCAs	Air Force Academy Oak Foothills PCA		CNHP 2015a
		Almagre Mountain		CNHP 2015a
Blue Mountain to Phantom Canyon PCA			CNHP 2015a	
Blue Springs PCA			CNHP 2015a	
Bohart Playas PCA			CNHP 2015a	
Catamount Creek PCA			CNHP 2015a	
Cave of the Winds PCA			CNHP 2015a	
Central Arkansas Playas PCA			CNHP 2015a	
Cheyenne Mountain PCA			CNHP 2015a	
Chico Creek PCA			CNHP 2015a	
Colorado Springs Airport PCA			CNHP 2015a	
Crystola PCA			CNHP 2015a	
Crystola Creek at Aqueduct PCA			CNHP 2015a	
Farish Recreation Area PCA			CNHP 2015a	
Fountain and Jimmy Camp Creeks PCA			CNHP 2015a	
Fountain Creek PCA			CNHP 2015a	
Fountain Creek Springs at Pinon PCA			CNHP 2015a	
Halfway Picnic Ground PCA			CNHP 2015a	
Hanover Road PCA			CNHP 2015a	
La Foret PCA			CNHP 2015a	
Midway Prairie PCA		CNHP 2015a		
Monument Southeast PCA		CNHP 2015a		
Pine Drive PCA		CNHP 2015a		
Pineries at Black Forest PCA		CNHP 2015a		

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Group	Common Name	Scientific Name	Data Source
	Sand Creek Ridge PCA		CNHP 2015a
	South Catamount Creek PCA		CNHP 2015a
	Table Rock PCA		CNHP 2015a
	The Craggs PCA		CNHP 2015a
	Upper Crystola Creek PCA		CNHP 2015a
	West Kiowa Creek at Elbert PCA		CNHP 2015a
	White Gulch PCA		CNHP 2015a

### Calculating Impacts from Transportation Projects

Information about planned transportation projects was supplied in GIS vector data format by PPACG, and included buffers within which project impacts were assumed to have the effect of essentially removing the conservation value of the area. The buffers, determined in consultation with the SHRP2 Advisory Committee, were defined as 100 feet from the edge of right of way (ROW) for updated/improved transportation projects, and 360 feet from ROW for new transportation projects (Figure 3). Projects that do not have significant spatial extent (e.g., planning, traffic, and safety studies, alterations to bus routes or van pools), or those whose impacts would be confined to existing infrastructure (e.g., repaving, bus stop improvements) were not considered in the impact analysis or the IRMP.

The buffered transportation projects were intersected with the best available spatial distribution data for mitigation targets, and the impacted acreage summed. Distribution data included mapped locations of element occurrences and PCAs (CNHP 2015a), designated Critical Habitat (USFWS 2004 and 2010), NWI mapping (USFWS 1975-1999), and CPW's Species Activity Maps (CPW 2014). Spatial data used to represent the distribution of mitigation targets are listed, by element, in Tables 2 and 3. Note that not all targets have current, high-quality data that are publicly available. In particular, we were not able to obtain complete data for some fish species, the most current mapping of black-tailed prairie dog colonies, or locations of cultural sites.

### Process for Identifying and Prioritizing Potential Mitigation Sites

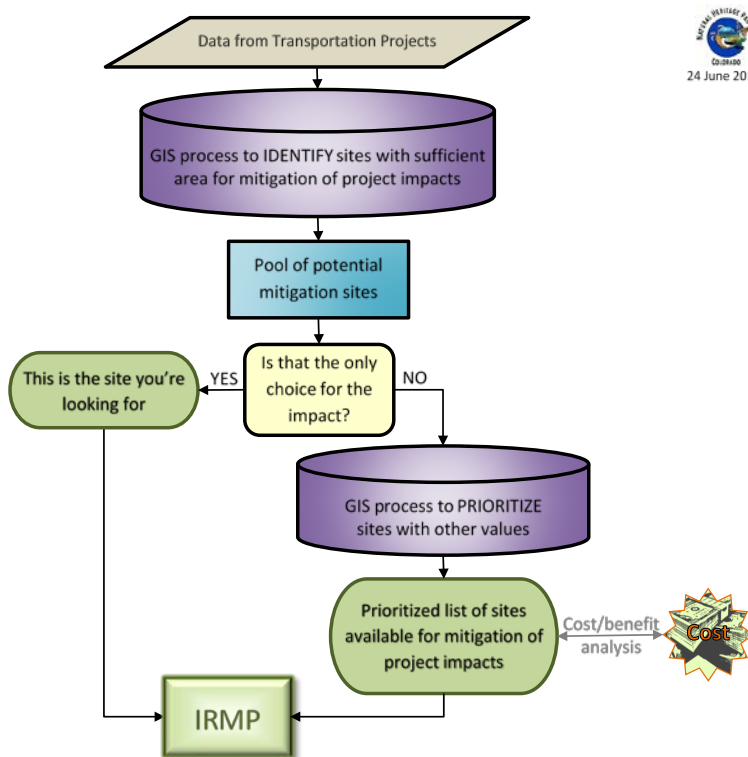
The primary focus of our analysis is the identification of targets that are likely to be impacted by planned transportation projects within the MPO boundary, and the compilation of information about where these impacts can be mitigated with the greatest effect, considering the overall land use trends in the PPACG region.

To identify and prioritize potential mitigation and/or restoration sites, we used a two-step process (Figure 2). The first step examines the full study area in a GIS analysis, and identifies one or more sites that have sufficient acreage to mitigate for impacts to each specific target. If there is only a single site available, no prioritization is needed. If more than one site is identified, the pool of potential mitigation sites is prioritized by applying weights for "added-value" factors. A cost-to-benefit analysis could then be performed on the prioritized site list, if adequate cost information is available. The identified and prioritized sites become part of the IRMP database. The following

sections describe the technical methods for completing these steps. Inputs for the first step are listed in Table 4.

**Table 4. Data sources for identification of potential mitigation sites.**

Part 1. Site Identification	Format	Source(s)
Planning Units	Vector digital data	PLSS (BLM 2011)
Table identifying bin 1-3 targets by Planning Unit	Table	Mapped locations of element occurrences and PCAs (CNHP 2015a), critical habitat (USFWS 2004 and 2010), NWI mapping (USFWS 1975-1999), Species Activity Maps (CPW 2014).
Table summarizing impacted targets	Table	Transportation project data (PPACG 2015)



**Figure 2. Mitigation site identification and prioritization process.**

**Technical Methods for Identifying Potential Mitigation Sites**

To facilitate this spatial analysis, the area within the regional study area was divided into Planning Units derived from Public Land Survey System sections (typically 640 acres in extent). These units were retained from previous work under SHRP2 C18, and were chosen because of their overall correlation with land ownership patterns, and because of their generally uniform size.

Selection of potential mitigation sites involves identifying sites that contain occurrences of the mitigation targets in sufficient acreage to offset all of the calculated impact acres multiplied by a defined mitigation ratio. For this analysis, we applied mitigation ratios of 3:1 for Bin 1 targets, 2:1 for Bin 2 targets, and 1:1 for Bin 3 targets.

To identify potential mitigation sites, a custom Python script was written that loops through the impacted mitigation target spatial data, determining how much acreage is impacted, and then finding all Planning Units with that target present. For Planning Units with the target present, the script determines if there is sufficient acreage for mitigation, or, if acreage is insufficient, is the Planning Unit part of a larger combination of adjacent units that can meet the mitigation acreage requirement. Results are written to an output table that identifies all Planning Units or adjacent Planning Unit combinations that have sufficient acreage for mitigation of impacts to the target. A site visit would be required to evaluate the on-the-ground configuration of target acreage, as well as its quality. It should be noted that in the case of certain targets such as PCAs, all Planning Units identified as containing potential mitigation acreage will be part of the PCA itself.

### **Prioritizing Among Multiple Potential Mitigation Sites**

The identification process described above selects all available potential mitigation sites. Where more than one potential mitigation site is available to offset impacts to any given target(s), the value of mitigation projects can be increased by preserving or enhancing other values in addition to the mitigation target(s). These can include conservation of other non-target conservation/cultural elements, and conservation/enhancement of ecosystems services such as hydrologic function (when not the direct mitigation target), recreational values (when compatible with the mitigation targets), visual amenities, and so on. Characterizing the value of a particular site with regard to factors other than required mitigation targets in the IRMP assists prioritization among candidate sites and can also provide additional benefits. The added-value process highlights the importance of such places, either for mitigation purposes, or in and of themselves. These priority places may include conservation elements not considered in the IRMP directly, and so act similarly to inclusion of ecosystem services by identifying other values that can be provided if the area is conserved/restored. Further, other organizations may likely be interested in collaborating to achieve conservation in these locations that contain values of interest to them. A prioritized pool of mitigation sites will also help optimize field verification efforts to select the final mitigation site(s).

### ***Tools for Site Prioritization***

We considered three alternative methods (described briefly below) for prioritizing potential mitigation sites. Pros and cons of each method considered are summarized in Table 5.

#### ***Marxan optimization***

Marxan is a decision support software program for conservation planning and reserve system design (Ball et. al, 2009). Marxan helps planners identify geographic areas to protect and manage for species and ecological systems. It does this by maximizing cost-benefit ratios to identify an optimal reserve design to achieve specific conservation goals. Goals are expressed as number of element occurrences, percent of area, or both. How "cost" is defined depends on the project objectives and available data. Cost can be actual financial value of land, or a more abstract indicator such as current or proposed levels of human development (i.e., that would serve as a proxy for the

desirability and practicality of implementing a conservation project in a particular area). The output of a Marxan analysis is an optimized set of sites that meet the specified goals.

**Multi-criteria decision analysis (MCDA) methods**

MCDA includes a large number of methods for the problems of choice, ranking, or sorting (Roy 2005). Criteria used in decision making are weighted, ranked, or sorted according to a variety of schema, typically through pairwise comparisons, and the analysis produces an overall relative weighting that accounts for the relative contribution (value) of each input criteria.

The Analytic Hierarchy Process (AHP; Saaty 1987, 1990) is a typical and widely used MCDA method that integrates well with spatial data. The decision or objective (in this instance, which mitigation site is best) is broken into a hierarchy of criteria (added-value factors) and alternatives (available mitigation sites). Alternative weightings for both qualitative and quantitative criteria can be accepted from different sources (e.g. stakeholders), or compiled as a series of value judgments according to stated goals and objectives. The added-value weights can be thought of as the benefits of each potential site over and above its qualifications in relation to the original mitigation target. These benefits can be compared with costs of each site, when and if this information is available.

**Bayesian network**

Bayesian networks (BN) are graphical models consisting of nodes and connecting arcs where the nodes represent variables (discrete or continuous) and arcs represent directional connections between them. Relationships between connected nodes are specified as conditional probability distributions; the entire network models a process of reasoning about the probability of effects when our information is less than certain. BN are typically constructed by first developing a conceptual model of the variable relationships (an influence diagram), and then identifying the probabilistic relationships between the variables (Marcot et al. 2006). In prioritization methods, BN appear to be most useful in illuminating the effects of various factors within a decision making process - for instance, the consequences of a particular management action on the outcome for a desired characteristic of a managed area.

**Table 5. Comparison of prioritization methods for potential mitigation sites.**

Method	Pros	Cons
Marxan	<ul style="list-style-type: none"> <li>• GIS analysis</li> <li>• Freely available software</li> <li>• Good for identifying a complete portfolio of sites that includes cost-benefit factor</li> </ul>	<ul style="list-style-type: none"> <li>• Requires explicit goal statements, and ideally, good cost data</li> <li>• Produces optimized set, not priority-ranked list, so that goals are not achieved unless complete portfolio is used</li> </ul>
AHP	<ul style="list-style-type: none"> <li>• GIS compatible</li> <li>• Easy-to-use software calculator available</li> <li>• Produces clear rankings</li> <li>• Able to incorporate qualitative and quantitative criteria</li> <li>• Can incorporate input from multiple users, with measure of consistency</li> </ul>	<ul style="list-style-type: none"> <li>• Requires expert judgments or collaborative input that are somewhat subjective</li> <li>• Some maneuvering needed to combine non-raster value factors</li> </ul>
BN	<ul style="list-style-type: none"> <li>• Able to incorporate qualitative and quantitative criteria</li> </ul>	<ul style="list-style-type: none"> <li>• Difficult to parameterize for this project without loss of information - continuous variables require discretization</li> </ul>

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Method	Pros	Cons
	<ul style="list-style-type: none"> <li>Depicts explicit relationship between variables</li> <li>Can incorporate uncertainty</li> <li>Free software versions available</li> </ul>	<ul style="list-style-type: none"> <li>Integration with GIS may be complex</li> <li>Steep learning curve</li> </ul>

The conceptual model (Figure 2) made it clear that Marxan was not an ideal method for the process; although a group of sites could be identified through this technique, there was no appropriate prioritization method. The ability of Bayes Networks to incorporate uncertainty was attractive, however, the prioritization requirements of our project introduced a level of complexity that was greater than that recommended for this technique (Marcot et al. 2006). We therefore selected a mixed model that incorporates a MCDA technique (AHP) in addition to rule-based spatial data processing. Although not directly used in the process, a Bayes Network was used to conceptualize the index scoring for qualitative added-value factors.

### ***Technical Methods for Added-value Prioritization of Potential Mitigation Sites***

In consultation with the SHRP2 Advisory Committee, we identified 11 added values that could be considered in this analysis, based on availability of spatial data to represent them. Factors included in the added-value prioritization for this IRMP are listed in Table 6.

**Table 6. Inputs for site prioritization.**

Part 2. Site Prioritization	Scoring	Data Source
Other Bin 1-3 targets present	% acreage within Planning Unit	Mapped locations of element occurrences and PCAs (CNHP 2015a), critical habitat (USFWS 2004 and 2010), NWI mapping (USFWS 1975-1999).
Bin 4-5 targets present	% acreage within Planning Unit	Mapped locations of targets (CNHP 2015a).
Intact shortgrass present	% acreage within Planning Unit	Patches of >=1000 acres, extracted from shortgrass patches of Rondeau et al. (2011)
Fire/flood restoration potential	% acreage within Planning Unit	Fire perimeters (Black forest and Waldo Canyon) - National Interagency Fire Center 2012-2014. No flood data available.
Is in 100-year floodplain	% acreage within Planning Unit	FEMA (2015), TNC 2009, El Paso (2006)
Prairie-dog suitable habitat	% acreage within Planning Unit	CNHP Suitable habitat models for Gunnison prairie-dog (2012) and Black-footed ferret (2015)
Forest health management opportunity	% acreage within Planning Unit	Tree mortality – compiled from USFS Forest Health Protection annual forest health aerial survey data 2008 - 2014
Terrestrial / Aquatic connectivity	High / Low / None	<ul style="list-style-type: none"> <li>Terrestrial: Colorado Parks and Wildlife Species Activity Mapping Data (CPW 2014) migration corridors and portions of large predator human conflict areas</li> <li>Aquatic: TNC Freshwater Measures database (TNC 2012) – extract of good quality, long uninterrupted stretches</li> </ul>
Included in other regional plan	Yes / No	<ul style="list-style-type: none"> <li>TNC ecoregional portfolios for Central Shortgrass Prairie (Neely et al. 2006) and Southern Rocky Mountain (Neely et al. 2001) ecoregions</li> <li>Western Association of Fish and Wildlife Agencies Crucial Habitat Data Set for Colorado, Updated 2015.</li> </ul>

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		<ul style="list-style-type: none"> <li>• CDOT PMJM conservation properties in Northern El Paso County (CDOT 2014)</li> <li>• Green Infrastructure plan map (PPACG 2011)</li> </ul>
Adjacent to protected area	Yes / No	COMaP v9 (Lavender et al. 2011) extract of public and private protected lands
Cultural site	Yes / No	No data available*

\*The project team was unable to locate a suitable dataset for cultural sites; this factor was left as a placeholder in the prioritization process.

The added-value factors that could be calculated as acreage (Table 7) were ranked in a series of pair-wise comparisons to develop relative priorities and numerical weights for each factor, using a publicly available AHP Excel template calculator (Goepel 2013). The calculator computed weights via eigenvector analysis. Planning Unit acreage proportions were calculated in ArcGIS 10.2 (ESRI 2014) for each of the seven spatial factors present in a unit. A custom Python script was used to apply the weights from the spreadsheet calculator (Table 7) to the calculated proportions. Scores for four qualitative added-value factors (Table 8) were added to site priority ranks by converting presence/absence or ordinal levels to an index score, which were also applied in the script. The two scores (acreage and qualitative) were combined as a weighted average using the formula:

$$\text{PriorityIndex} = (\text{AvgAcreScore}) * 0.636 + (\text{AvgQualScore}) * 0.364$$

The overall weighting scheme was selected to strongly favor the presence of other Bin 1-3 targets, moderately emphasize Bin 4-5 targets, and then weight additional factors, both quantitative and qualitative, equally. If a Planning Unit was the only available site for mitigation, its added-value score defaulted to 1.

**Table 7. Weights for quantitative added-value factor scoring.**

Factor	Weight (normalized principle eigenvector)	Rank
Presence of targets in Bins 1-3	56.03%	1
Presence of targets in Bins 4-5	22.15%	2
Intact shortgrass	4.36%	3
Suitable habitat for prairie dogs	4.36%	3
Fire or flood restoration potential	4.36%	3
Forest health opportunity	4.36%	3
In 100-year floodplain	4.36%	3

**Table 8. Qualitative added-value factor index scoring.**

Adjacent to Protected Area	Cultural Site*	Present in other Plan	Connectivity	Qualitative Index Score
Yes	Yes	Yes	High	1
Yes	Yes	Yes	Low	0.875
Yes	Yes	Yes	None	0.75
Yes	Yes	No	High	0.75

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Adjacent to Protected Area	Cultural Site*	Present in other Plan	Connectivity	Qualitative Index Score
Yes	Yes	No	Low	0.625
Yes	Yes	No	None	0.5
Yes	No	Yes	High	0.75
Yes	No	Yes	Low	0.625
Yes	No	Yes	None	0.5
Yes	No	No	High	0.5
Yes	No	No	Low	0.375
Yes	No	No	None	0.25
No	Yes	Yes	High	0.75
No	Yes	Yes	Low	0.625
No	Yes	Yes	None	0.5
No	Yes	No	High	0.5
No	Yes	No	Low	0.375
No	Yes	No	None	0.25
No	No	Yes	High	0.5
No	No	Yes	Low	0.375
No	No	Yes	None	0.25
No	No	No	High	0.25
No	No	No	Low	0.125
No	No	No	None	0

\*No data available at this time, so all scores defaulted to "No".

## RESULTS

### Targets and Project Impacts

There were 200 planned transportation projects for which physical disturbance was predicted. Of these, 52 were projected to impact mitigation targets. Of the 137 mitigation targets (Table 2) present within the MPO boundary, 34 could be impacted by one or more transportation projects according to our analysis (Table 9). No target was impacted by more than three transportation projects (Figure 3).

To assist in focusing attention on priority mitigation needs, each transportation project was ranked according to the significance of its impact (Table 10, Figure 3). Raw impact scores were relativized to a scale of 0 to 100 by dividing each score by the high score, and classified into four categories: 0 = no impact, >0-5 = low impact, >5-20 = moderate impact, and >20 = high impact. Project impact levels (Figures 3 and 4; Table 9) highlight the location of projects with the most significant impacts, and can be used to identify in advance areas that may require additional planning effort. Because PPACG's focus was on integrating impacts from, and mitigation for, the full suite of proposed transportation projects, the IRMP geodatabase focuses on identifying a pool of potential mitigation areas based on the total number of acres impacted for each target across all transportation projects. Supporting tabular data are included to allow planners to identify targets and acres impacted by individual transportation projects.

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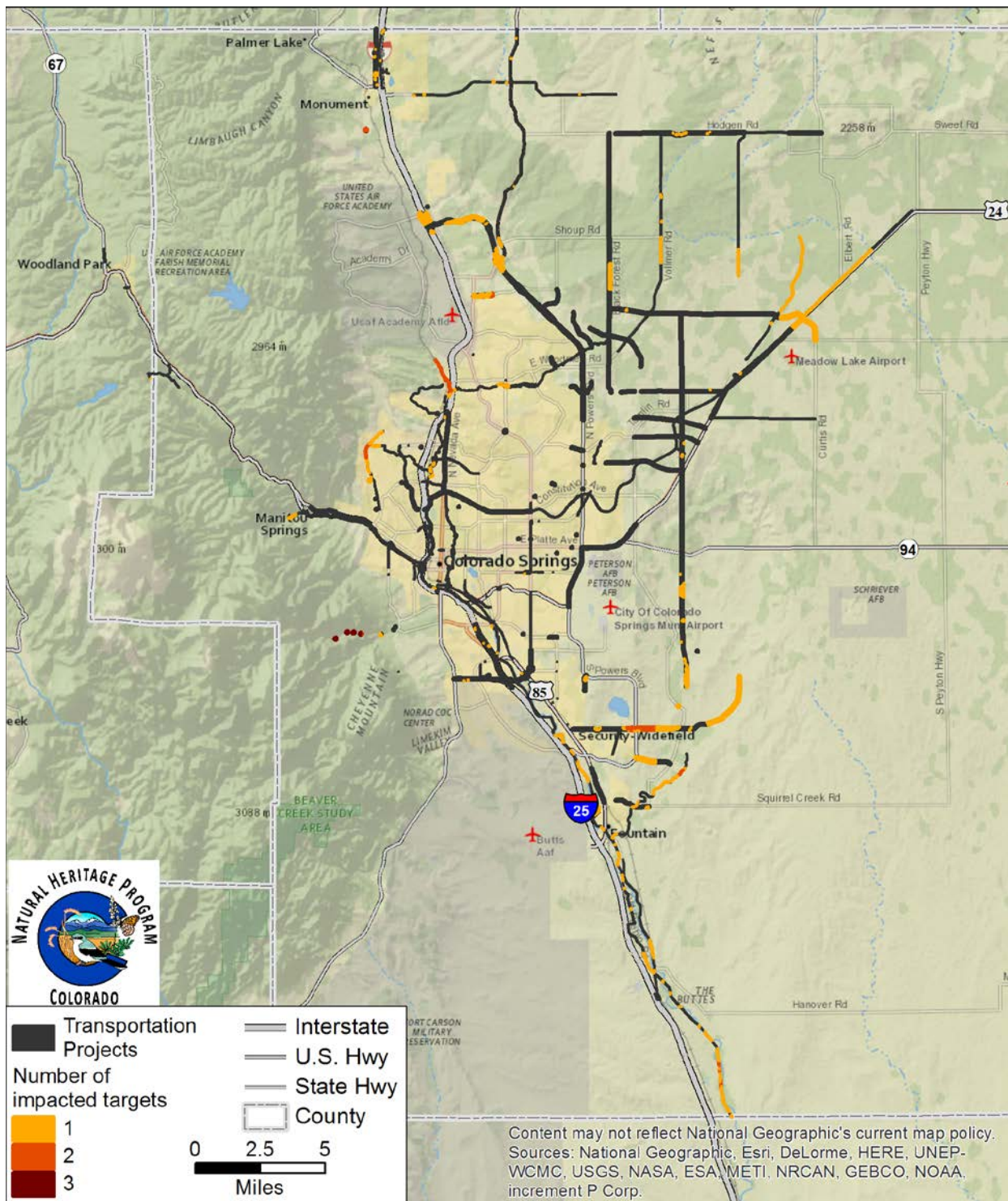


Figure 3. Locations of transportation projects that impact bin 1-3 targets. No transportation projects impacted more than three targets.

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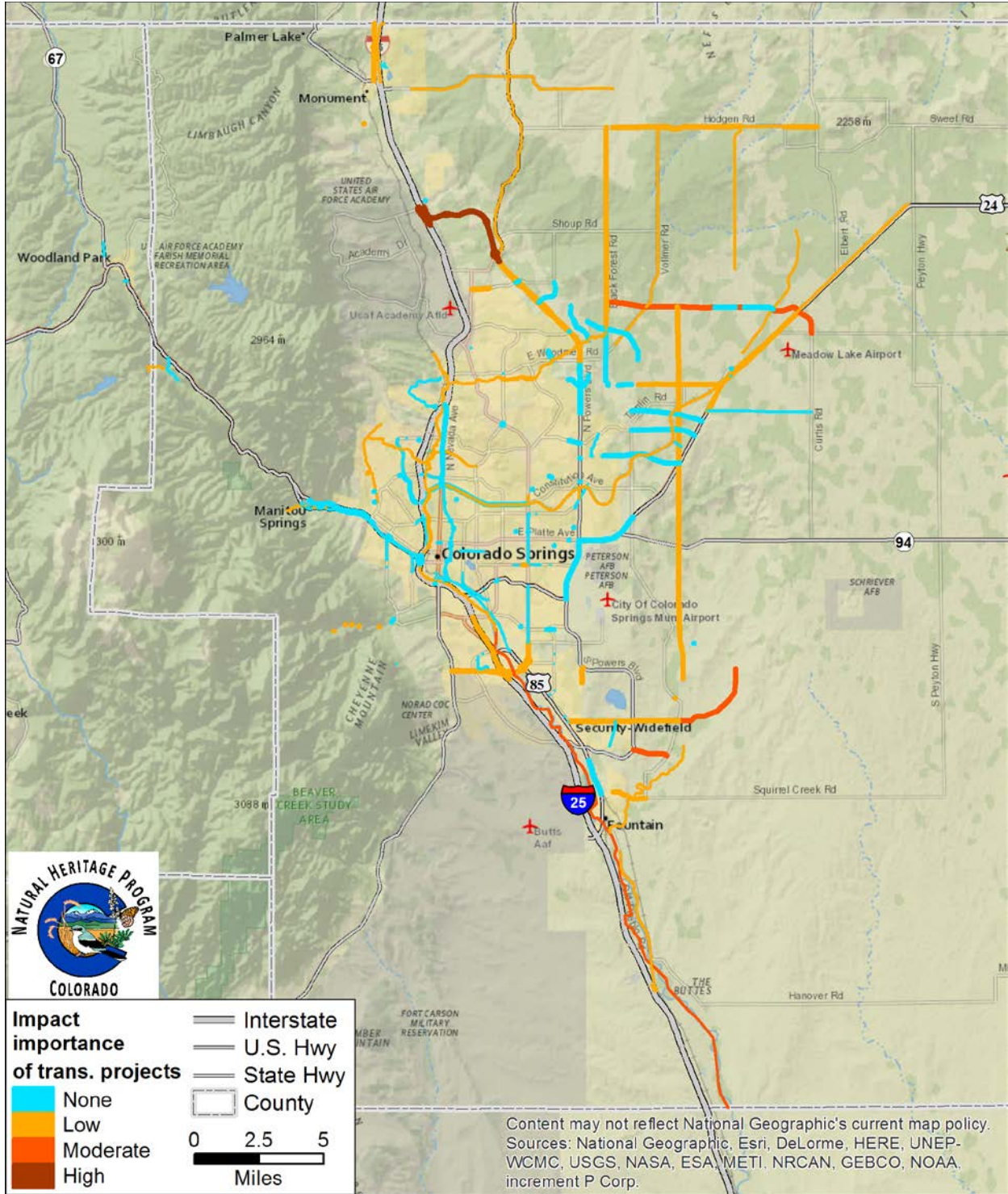


Figure 4. Impact importance by location for projected transportation projects. Impact colors in this map are also shown in Table 10.

## Potential Mitigation Sites

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The identification of potential mitigation sites resulted in the inclusion of 1,950 Planning Units or Planning Unit combinations in the geodatabase. The number of potential mitigation sites available for each impacted target are summarized in Table 11. There was one instance in which only a single unit was available for mitigation of an impacted target. This target is the seasonally flooded, man-made emergent wetland (highlighted in yellow in Table 11); the only planning unit available with sufficient acreage for mitigation is the same unit where the target is impacted. For this particular target, it may be acceptable to mitigate with a combination of isolated small sites (i.e., sites that were too small to have been included in the IRMP as stand-alone potential mitigation areas). It should be noted that this Planning Unit was also in the potential site pool of several other impacted targets.

Added-value scores for sites other than the single instance example ranged from 0.072 to 0.815. Due to the lack of data for the presence of cultural sites, the theoretical possible high score was reduced from 1.0 to approximately 0.98. It is unlikely that a site could ever realize a perfect added-value score, due to the inherently mutually exclusive nature of some factors (for instance, suitable prairie dog habitat is typically not in the 100-year floodplain).

An example of the identification and prioritization results for a single target is shown in Figure 5.

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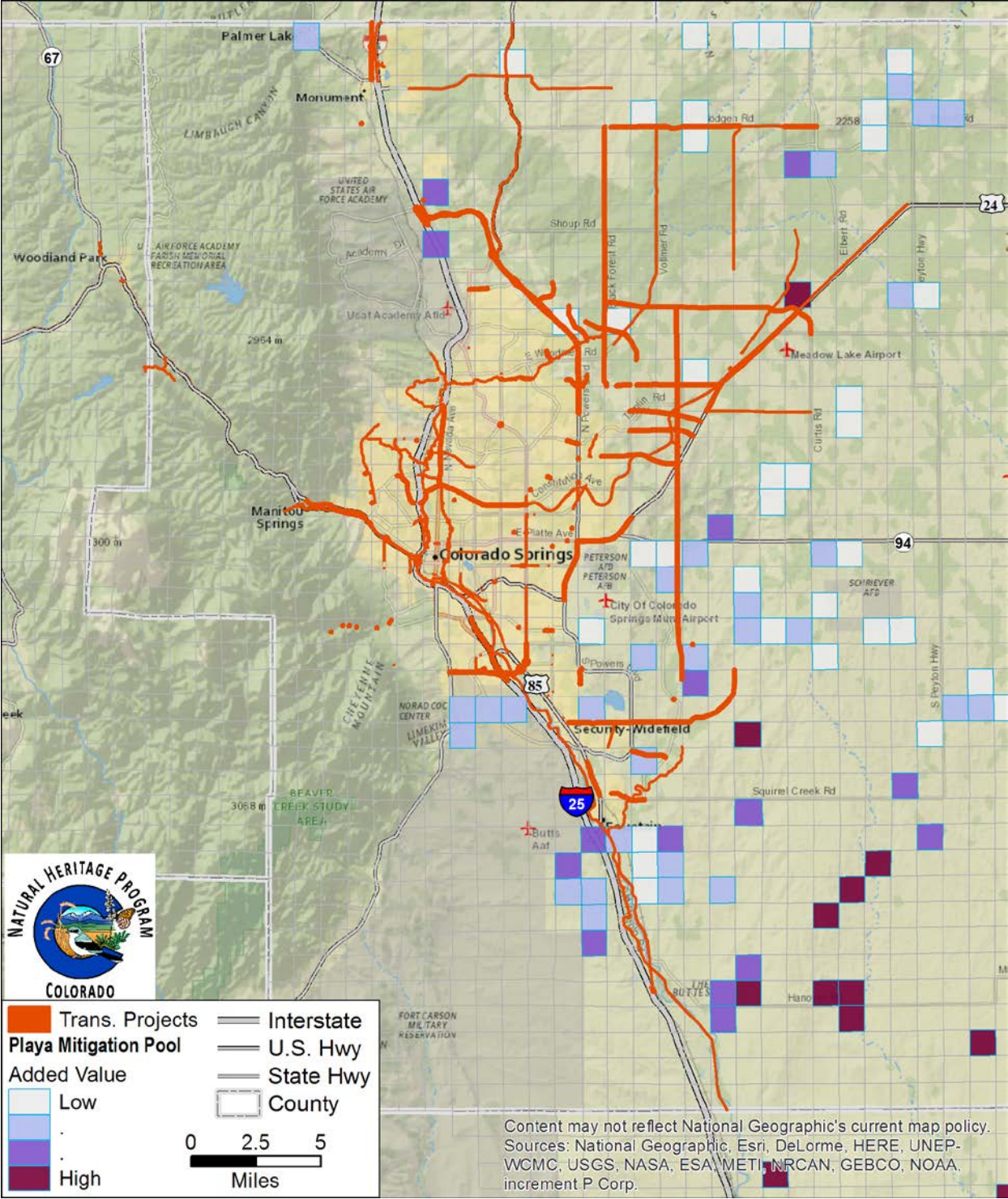


Figure 5. Example of identified and prioritized potential mitigation site locations for the Playa habitat mitigation target.

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**Table 9. Bin 1-3 targets that are impacted by planned transportation projects. Targets are sorted by bin, then by percent impact, from largest to smallest.**

Common Name	Scientific Name or Wetland Code	Total Acres	Impacted Acres	Percent Impacted
<b>Bin 1 - Federally Listed &amp; Candidate Species</b>				
Preble's Meadow Jumping Mouse	<i>Zapus hudsonius preblei</i> EOs	333.6	22.3	<b>6.7%</b>
Preble's Meadow Jumping Mouse Critical Habitat	<i>Zapus hudsonius preblei</i> Critical Habitat	3,372.0	156.5	<b>4.6%</b>
Arkansas Darter	<i>Etheostoma cragini</i>	501.2	22.5	<b>4.5%</b>
Gunnison's Prairie Dog - Montane Population	<i>Cynomys gunnisoni</i> pop. 1	1,180.1	7.9	<b>&lt;1%</b>
Mexican Spotted Owl Critical Habitat	<i>Strix occidentalis lucida</i> Critical Habitat	132,907.5	48.1	<b>&lt;1%</b>
<b>Bin 2 - Critically Imperiled Range-wide OR Tier 1 SGCN OR B1 PCAs</b>				
Townsend's Big-eared Bat Subsp.	<i>Corynorhinus townsendii pallescens</i>	4,004.3	41.3	<b>1.0%</b>
Golden Eagle	<i>Aquila chrysaetos</i>	9,548.9	93.5	<b>1.0%</b>
Golden Columbine	<i>Aquilegia chrysantha</i> var. <i>rydbergii</i>	878.8	0.8	<b>&lt;1%</b>
Mountain Plover	<i>Charadrius montanus</i>	20,745.4	0.2	<b>&lt;1%</b>
<b>Bin 3 - Imperiled Range-wide OR Tier 2 SGCN OR B2 PCAs OR Wetland/Riparian</b>				
Emergent Wetland, Man-made - Seasonally Flooded	PEMCx	25.7	4.2	<b>16.5%</b>
Pond, Impounded - Intermittently Exposed	PABGh	35.6	3.8	<b>10.7%</b>
Forested Riparian with Scrub/Shrub	PFO/SSA	559.4	54.5	<b>9.7%</b>
Montane Riparian Forest	<i>Pseudotsuga menziesii</i> / <i>Betula occidentalis</i> Woodland	588.6	31.6	<b>5.4%</b>
Bald Eagle	<i>Haliaeetus leucocephalus</i>	1,143.2	52.3	<b>4.6%</b>
Monument Creek PCA		13,142.5	477.3	<b>3.6%</b>
Pond – Semi-permanently Flooded	PABF	14.3	0.5	<b>3.2%</b>
Emergent Wetland, Impounded - Seasonally Flooded	PEMCh	218.2	5.9	<b>2.7%</b>
Xeric Tallgrass Prairie	<i>Andropogon gerardii</i> - <i>Sporobolus heterolepis</i> Western Foothills Herbaceous Vegetation	3,801.2	102.5	<b>2.7%</b>
Pond, Impounded – Semi-permanently Flooded	PABFh	424.9	10.1	<b>2.4%</b>
Judge Orr Road PCA		25,625.8	420.7	<b>1.6%</b>
Black-tailed Prairie Dog	<i>Cynomys ludovicianus</i>	15,983.1	183.2	<b>1.1%</b>
Emergent Wetland - Seasonally Flooded	PEMC	3,571.2	17.9	<b>&lt;1%</b>

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Common Name	Scientific Name or Wetland Code	Total Acres	Impacted Acres	Percent Impacted
Forested Riparian - Temporarily Flooded	PFOA	3,733.5	11.3	<1%
Cheyenne Canyon PCA		18,165.3	41.5	<1%
Emergent Wetland - Temporarily Flooded	PEMA	2,296.5	4.0	<1%
Forested Riparian, Impounded - Temporarily Flooded	PFOAh	4.6	0.01	<1%
Shrub Riparian with Emergent Vegetation	PSS/EMA	140.3	0.2	<1%
Emergent Wetland - Saturated	PEMB	285.9	0.2	<1%
Swift Fox	<i>Vulpes velox</i>	659,333.4	470.6	<1%
Shrub Riparian - Temporarily Flooded	PSSA	5,048.8	1.3	<1%
Bighorn Sheep	<i>Ovis canadensis</i>	62,264.9	11.8	<1%
Playa	Playa	1,183.4	0.2	<1%
Shrub Riparian - Seasonally Flooded	PSSC	2,842.3	0.3	<1%
Pond, Man-made	PABKx	135.2	0.01	<1%

**Table 10. Relative impact ranks of transportation projects, alphabetically by project name. Warmer colors (orange to red) indicate higher relative impact, blue indicates no impact.**

Project Name	% Target Ac in Bin1	% Target Ac in Bin2	% Target Ac in Bin3	Impact Importance
Academy Blvd. widening: Drennan Rd to Hwy 115	0%	0%	100%	0.0
Black Forest Road Improvements: Woodmen Rd. to Hodgen Rd.	0%	0%	100%	4.5
Briargate Pkwy./Stapleton Rd. Connection	0%	0%	100%	17.3
Eastonville Rd. South Improvements: Meridian Ranch Rd. to Londonderry Dr.	0%	0%	100%	1.1
Fontaine Blvd. Improvements: Easy St. to Marksheffel Rd.	0%	0.1%	100%	16.7
Fountain Creek Regional Trail (#16) Construction	11%	0%	89%	19.0
Fountain Creek Trail Bridge Repair	100%	0%	0%	0.1
Historic Bridges Repair and Restoration	100%	0%	0%	1.3
Hodgen Rd. Improvements: Black Forest Rd. to Meridian Rd. and from Eastonville Rd. to Elbert Rd.	0%	0%	100%	0.4
Hwy 105 Improvements: Lake Woodmoor Dr. to SH 83	20%	0%	80%	0.3

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Project Name	% Target Ac in Bin1	% Target Ac in Bin2	% Target Ac in Bin3	Impact Importance
I-25 Widening: S. Academy Blvd. to Circle Dr./Lake Ave. Interchange	0%	0%	100%	0.2
Jimmy Camp Creek Trail Construction	2%	0%	98%	4.3
Powers Blvd. (SH 21) Widening: Woodmen Rd. to SH 83	28%	0%	72%	14.7
Ruxton Ave. Pedestrian and Drainage Improvements	100%	0%	0%	5.4
SH 83 Traffic/Safety Improvements	39%	0%	61%	5.4
Squirrel Creek Rd. Extension (Phases 2 and 3)	17%	0%	83%	1.2
Union Blvd. over Cottonwood Creek Bridge Replacement	48%	0%	52%	1.7
US 24 East Widening: Garrett Rd. to Stapleton Rd.	0%	0%	100%	4.7
Vollmer Road Improvements: Cowpoke Rd. to Hodgen Rd.	0%	0%	100%	1.2
Banning Lewis Pkwy.	4%	0%	96%	11.3
Fontaine Blvd Extension	0.4%	0%	100%	20.9
Black Forest Rd.: Old Ranch Rd. to Research Blvd.	0%	0%	100%	0.3
Dublin Blvd. Extension: Vista del Pico Blvd. to US 24	0%	0%	100%	0.0
30th St. Corridor Improvements	0%	95%	5%	9.4
Airport Rd. Over Spring Cr. Bridge Replacement	0%	0%	100%	0.0
Gateway Rd. Over Camp Creek Bridge Replacement	0%	0%	100%	0.9
Marksheffel Rd. Over Jimmy Camp Creek Replacement	0%	0%	100%	0.9
Old Ranch Rd. Improvements: Voyager Pkwy. to Kettle Creek	21%	0%	79%	11.5
Pikes Peak Greenway Corridor Improvements Phase II	45%	0%	55%	16.2
Powers Blvd. (SH 21) Extension: I-25 to SH 83 Phase I	15%	0%	85%	51.4
S. Cheyenne Canyon Rd. 1 Over Cheyenne Creek Bridge Replacement	0%	0%	100%	0.4
Cottonwood Trail Corridor Improvements	36%	0%	64%	4.4
Pikes Peak Greenway Corridor Improvements Phase I	45%	0%	55%	16.2
Rock Island Trail Corridor Improvements Phase I	0%	0%	100%	9.9
Sinton Trail Corridor Improvements	0%	96%	4%	2.4
Templeton Gap Trail Corridor Improvements	0%	0%	100%	0.1
Beacon Lite Rd.: Hwy 105 to County Line Rd.	0%	0%	100%	0.5
Black Forest Rd.: Research Pkwy. to Wildridge Rd.	0%	0%	100%	1.5
Eastonville Rd.: Mclaughlin Rd. to Latigo Blvd.	0%	0%	100%	7.3

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Project Name	% Target Ac in Bin1	% Target Ac in Bin2	% Target Ac in Bin3	Impact Importance
Fontaine Blvd.: Grinnell St. to Powers Blvd.	0%	0%	100%	0.9
Grinnell Blvd.: Bradley Rd. to Powers Blvd.	0%	0%	100%	0.6
Hodgen Rd.: Black Forest Rd. to Eastonville Rd.	0%	0%	100%	0.1
Meridian Rd.: Rex Rd. to Hodgen Rd.	0%	0%	100%	2.4
Mesa Ridge Pkwy. Improvements: Powers Blvd. to Marksheffel Rd.	0%	100%	0%	17.1
Monument Hill Rd.: County Line Rd. to Woodmoor Dr.	0%	0%	100%	0.1
Old Pueblo Rd.: Link Rd. to I-25	1%	0%	99%	1.6
S. Academy Blvd.: I-25 to Bradley Rd. Ramps	0%	0%	100%	0.0
Vollmer Rd. Improvements: Briargate Pkwy. to Burgess Rd.	0%	0%	100%	0.0
Belvedere Ave. Widening Phase I	0%	0%	100%	0.0
Belvedere Ave. Widening Phase II	0%	0%	100%	0.0
Arnold Ave. Bridge Replacement	57%	0%	43%	3.8
Cheyenne Canyon Rd. Bridge Replacements	35%	1%	64%	10.5

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**Table 11. Mitigation site summary. Table is sorted by target bin level, then by number of potential sites, from least to most.** Yellow highlighting indicates that only a single unit was available for mitigation; the only unit available with sufficient acreage for mitigation is the same unit where the impact occurs.

Common Name	Scientific Name or Wetland Code	Number of Potential Mitigation Sites Available	Added Value Range	
			Min	Max
<b>Bin 1 - Federally Listed &amp; Candidate Species</b>				
Arkansas Darter	<i>Etheostoma cragini</i>	2	0.342	0.357
Preble's Meadow Jumping Mouse	<i>Zapus hudsonius preblei</i> EOs	2	0.363	0.398
Preble's Meadow Jumping Mouse Critical Habitat	<i>Zapus hudsonius preblei</i> Critical Habitat	7	0.288	0.424
Gunnison's Prairie Dog - Montane Population	<i>Cynomys gunnisoni</i> pop. 1	18	0.207	0.767
Mexican Spotted Owl Critical Habitat	<i>Strix occidentalis lucida</i> Critical Habitat	221	0.075	0.737
<b>Bin 2 - Critically Imperiled Range-wide OR Tier 1 SGCN OR B1 PCAs</b>				
Townsend's Big-eared Bat Subsp.	<i>Corynorhinus townsendii pallescens</i>	11	0.164	0.564
Golden Columbine	<i>Aquilegia chrysantha</i> var. <i>rydbergii</i>	11	0.382	0.672
Golden Eagle	<i>Aquila chrysaetos</i>	18	0.187	0.634
Mountain Plover	<i>Charadrius montanus</i>	125	0.231	0.722
<b>Bin 3 - Imperiled Range-wide OR Tier 2 SGCN OR B2 PCAs OR Wetland/Riparian</b>				
Emergent Wetland, Man-made - Seasonally Flooded	PEMCx	1	1.000	1.000
Pond, Impounded - Intermittently Exposed	PABGh	3	0.153	0.284
Montane Riparian Forest	<i>Pseudotsuga menziesii</i> / <i>Betula occidentalis</i> Woodland	3	0.395	0.616
Forested Riparian with Scrub/Shrub	PFO/SSA	4	0.391	0.449
Bald Eagle	<i>Haliaeetus leucocephalus</i>	6	0.257	0.404
Forested Riparian, Impounded - Temporarily Flooded	PFOAh	6	0.258	0.380
Monument Creek PCA		11	0.311	0.419
Pond – Semi-permanently Flooded	PABF	11	0.132	0.449
Xeric Tallgrass Prairie	<i>Andropogon gerardii</i> - <i>Sporobolus heterolepis</i> Western Foothills Herbaceous Vegetation	11	0.179	0.322

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Common Name	Scientific Name or Wetland Code	Number of Potential Mitigation Sites Available	Added Value Range	
			Min	Max
Pond, Man-made	PABKx	12	0.276	0.377
Emergent Wetland, Impounded - Seasonally Flooded	PEMCh	18	0.090	0.407
Shrub Riparian with Emergent Vegetation	PSS/EMA	20	0.103	0.549
Pond, Impounded – Semi-permanently Flooded	PABFh	27	0.127	0.512
Judge Orr Road PCA		32	0.095	0.402
Cheyenne Canyon PCA		34	0.202	0.737
Black-tailed Prairie Dog	<i>Cynomys ludovicianus</i>	36	0.216	0.627
Forested Riparian - Temporarily Flooded	PFOA	51	0.078	0.437
Emergent Wetland - Saturated	PEMB	79	0.143	0.753
Emergent Wetland - Seasonally Flooded	PEMC	97	0.108	0.485
Bighorn Sheep	<i>Ovis canadensis</i>	136	0.126	0.731
Shrub Riparian - Temporarily Flooded	PSSA	170	0.077	0.682
Emergent Wetland - Temporarily Flooded	PEMA	173	0.102	0.689
Playa	Playa	218	0.084	0.815
Shrub Riparian - Seasonally Flooded	PSSC	333	0.072	0.677
Swift Fox	<i>Vulpes velox</i>	891	0.050	0.792

## APPLICATION OF THE IRMP

The data, methods, and analysis results described above have been developed to assist PPACG in improving conservation outcomes by implementing a comprehensive mitigation program. The resulting IRMP should not be seen as a single static map of opportunities, because a large number of factors contribute to developing mitigation projects to address individual transportation project mitigation requirements. Integrating the many factors into a single scoring/weighting procedure would reduce the complexity of the product, but would also obscure important overriding factors and trade-offs in site selection decisions. Instead, the IRMP should be viewed as a spatial database of information that informs this purpose.

The basic steps to apply this information are:

1. When a transportation project is funded, the expected impacts are confirmed. This can range from accessing the original impact calculations from the IRMP or recalculating the impacts if any of the input information has changed. In addition, on-the-ground site assessments are highly recommended.
2. Confirm the desired compensatory mitigation ratios for the affected mitigation target(s).
3. Use the IRMP database to search for locations that can provide the necessary mitigation; this may require more than one site to provide the necessary mitigation for all targets. Adjacent sites or those that contribute to larger more sustainable patches and occurrences of the mitigation targets would be preferable.
4. Compare available sites to identify highest priority or most appropriate candidate sites, using factors that identify additional values including restoration and management potential, connectivity, intact habitats, the presence of additional targets, and status in regional plans.

Another factor to consider in the evaluation of potential mitigation sites is the current condition of the site. Areas in good condition may be highly desirable for conservation easements or other protection mechanisms, whereas areas in degraded condition could either be prioritized for restoration (if moderately degraded), or avoided as impractical to restore (if severely degraded). Existing data for the mitigation targets weren't sufficient to allow inclusion of condition as a factor in the development of the IRMP. However, GIS modeling can offer a suitable surrogate for this concept, at least from a high-level perspective. To illustrate this, we overlaid CNHP's Landscape Disturbance Index model (CNHP 2015b) on the Planning Units. The average landscape condition score, translated into the categories "Excellent", "Good", "Fair", and "Poor" (representing approximate quartiles) was calculated for each Planning Unit and added to that layer's attribute table in the IRMP. Once a suite of potential mitigation sites has been identified and prioritized, this condition attribute can be used along with other available, relevant information to help focus further decision-making. Of course, on-the-ground condition should always be evaluated before making final prioritization decisions.

At this stage of the process, all of the data and products for the IRMP have been assembled, but development of a system for convenient and effective access to the information is still needed. PPACG had been developing a secure Google Earth site that could conceptually fill the need,

pending resolution of data security issues with partners permitted to use the site. The technical need is for an internet-based portal that can allow partners (project proponents, engineers, resource agency staff, etc.) to select the proposed transportation project, identify the available mitigation sites associated with that project's impacts, query and investigate attributes of those sites, and then rank the sites and generate a series of maps and reports. This information can then be used to conduct further investigation, including field verification of the site attributes to inform final site selection and mitigation project design. Further, the system should be amenable to attributing sites as "used" for mitigation so they are no longer available (or not available for certain targets but possibly others) and updating the database with new data, including field verification data.

## Limitations

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### Data

This IRMP is based on statewide and regional datasets of varying age, accuracy, and precision. Its contents and the results of our analyses are only as good as these input data and the assumptions behind the calculations and parameters used. In addition, some components of mitigation planning that are acknowledged to be important were not available for inclusion in this IRMP. Data gaps include the following:

- Spatial representations of potential or restorable habitat (e.g., instances of wetlands that have been converted to farmland). Development of such data would require modeling with expert review or comprehensive field mapping.
- Parcel cost/value – this information may be available for purchase through the Assessor's Office, but was not obtainable for this IRMP. Also, real estate values are highly volatile. Modeling (such as hedonic modeling) may be suitable and use of relative scales from low to high might be appropriate to prioritize among mitigation sites for further investigation vs using exact dollar figures.
- Ecosystem services – some services may be appropriate for mapping or modeling (e.g., groundwater recharge, carbon sequestration, flood regulation), but existing data were not available.
- Cultural values – these data, when they exist, are often proprietary and sensitive, and therefore not generally available for public uses at a regional scale.
- Absence of data documenting the presence of conservation elements does not necessarily mean that no conservation elements are present.

With respect to the cost component, to maintain clarity in prioritizing potential mitigation sites from an ecological standpoint, the cost-to-benefit analysis was kept separate from the prioritization analysis. Areas of known or predicted urban development, such as those in the future land use scenarios (e.g., Small Area Forecast and Accelerated Trend) could be incorporated into a cost analysis step of the IRMP (lower right in Figure 1). Two pathways can result: Areas of likely development that coincide with a portion of a target's mitigation pool can either be 1) avoided as not a practical option for mitigation or 2) the area preserved and the proposed urban development relocated. Such detailed incorporation of development scenarios or similar information into the process could steer mitigation away from areas of high future development threat. However, the

most useful cost-benefit analysis would incorporate more precise information about actual real estate values for sites of interest. This information is generally highly variable over time, and was not available for inclusion in this iteration of the IRMP.

Finally, new datasets are constantly being developed in a variety of statewide conservation and planning efforts; incorporating these data as they become available are likely to improve outcomes. There is no single formula for choosing a mitigation site – many considerations could come into play, depending on specific circumstances and the number of options available.

### **Methods**

Very few examples of IRMPs exist and thus little real-world implementation has thus occurred for evaluation. However, the methods used in this process incorporate other relevant and proven processes. Some of the limitations in the methods include:

- The use of the PLSS 640 acre sections was a balanced choice for a regional mitigation plan, but will naturally contain a considerable amount of area not needed for mitigation projects (especially for small patch conservation elements). Smaller site units can also help target field verification but data security issues precluded use of smaller sites for public use.
- While CNHP strives to have the most comprehensive database of significant biological resources as possible, not all areas of the state have been surveyed, nor can we claim that all significant secondary sources of data have been included in this dataset.
- Information portrayed in these datasets are graphic representations of phenomena that are difficult to reduce to two dimensions. Species distributions and populations are fluid, the concept of natural communities is an abstract simplification, and all natural systems are dynamic and ever-changing.
- The use of spatial data and GIS software allows a level of granular precision that does not reflect the scale at which the data were created or collected, and the data used here were gathered at a variety of scales. Software applications allow calculating acreages to 16 decimal places, or zooming in to scales of 1:1, but neither action is consistent with the scale of the data, and discrepancies when using high resolutions should be expected.
- The main assumption throughout this process is that the underlying data sources are current and accurate enough to be meaningful in relative comparisons only. Because of the potential for errors in omission and commission in the datasets used, it is important to remember that these data should be used for initial planning only, and all initial decisions confirmed with field surveys and/or stakeholder consultation.

Particular choices made throughout the process are amenable to updates and changes. For example, smaller site units could be used to better target candidate sites for small-patch conservation elements, if the input data scales can support it.

### **IRMP Access and Implementation**

As described in the section above, a system for access and implementation is not yet available and was beyond the scope for the IRMP team to develop. In the near term, this IRMP exists as a geodatabase that can be used internally by PPACG, but is not directly accessible by others.

## **Follow-on Steps in Mitigation Project Development**

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Once a set of appropriate mitigation sites has been identified, follow up actions may include:

- Confirmation that the sites are still available and not developed.
- Site visits to confirm presence of mitigation targets and other values.
- Discussion of collaborative conservation work with other interested parties (e.g., those that have identified the site as a conservation priority).
- Cost analysis, including investigation into current land values, landowner willingness, and other relevant factors.
- Determination of the potential for “out of kind” mitigation, if desired.

Out-of-kind mitigation could shift mitigation from more common conservation elements to those that are needier. This strategy should be implemented by applying systematic conservation planning to set quantitative retention goals for all of the conservation elements of interest. This IRMP is not a complete conservation plan, but provides valuable inputs that can feed into a comprehensive plan.

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# Attachment A1: Colorado Natural Heritage Program Methodology

## Species and Plant Association Element Occurrence Mapping

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CNHP is the state's primary comprehensive biological diversity data center, gathering information and field observations to help develop statewide conservation priorities. The multi-disciplinary team of scientists, planners, and information managers at CNHP gathers comprehensive information on the rare, threatened, and endangered species and significant plant communities of Colorado. Life history, status, and locational data are incorporated into a continually updated data system. Data maintained in the CNHP's database are an integral part of ongoing research at Colorado State University and reflect the observations of many scientists, institutions and our current state of knowledge. These data are acquired from various sources, with vary levels of accuracy, and are continually being updated and revised. Sources include published and unpublished literature, museum and herbaria labels, and field surveys conducted by knowledgeable naturalists, experts, agency personnel, and our own staff of botanists, ecologists, and zoologists.

All Natural Heritage Programs house data about imperiled species and plant associations and are implementing use of the Biodiversity Tracking and Conservation System (BIOTICS) developed by NatureServe. This database includes taxonomic group, global and state rarity ranks, federal and state legal status, observation source, observation date, county, township, range, watershed, and other relevant facts and observations. BIOTICS also has a GIS mapping program component for digitizing and mapping occurrences of rare plants, animals, and plant communities. These rare species and plant communities are referred to as "elements of natural diversity" or simply "elements."

Concentrating on site-specific data for each element enables CNHP to evaluate the significance of each location for the conservation of biological diversity in Colorado and in the nation. By using species imperilment ranks and quality ratings for each location, priorities can be established to guide conservation action. A continually updated locational database and priority-setting system such as that maintained by CNHP provides an effective, proactive land-planning tool.

To assist in biological diversity conservation efforts, CNHP scientists strive to answer questions like the following:

- What species and ecological communities exist in the area of interest?
- Which are at greatest risk of extinction or are otherwise significant from a conservation perspective?
- What are their biological and ecological characteristics, and where are these priority species or communities found?
- What is the species' condition at these locations, and what processes or activities are sustaining or threatening them?
- Where are the most important sites to protect?

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- What actions are needed for the protection of those sites and the significant elements of biological diversity they contain?
- How can we measure our progress toward conservation goals?

### The Natural Heritage Ranking System

Key to the functioning of Natural Heritage Programs is the concept of setting priorities for gathering information and conducting inventories. The cornerstone of Natural Heritage inventories is the use of a ranking system to achieve the twin objectives of effectiveness and efficiency.

To determine the status of species within Colorado, CNHP gathers information on plants, animals and plant communities. Each of these elements of natural diversity is assigned a rank that indicates its relative degree of imperilment on a five-point scale (for example, 1 = extremely rare/imperiled, 5 = abundant/secure). The primary criterion for ranking elements is the number of occurrences (in other words, the number of known distinct localities or populations). These distinct populations are known as Element Occurrence (EOs). Several other factors are used to assign ranks including size of the geographic range, the number of individuals, the trends in both population and distribution, identifiable threats and the number of protected occurrences.

Element imperilment ranks are assigned both in terms of the element's degree of imperilment within Colorado (its State-rank or S-rank) and the element's imperilment over its entire range (its Global-rank or G-rank). Taken together, these two ranks indicate the degree of imperilment of an element (Table 1). CNHP actively collects, maps and electronically processes specific occurrence information for animal and plant species considered extremely imperiled to vulnerable in the state (S1 - S3). Several factors, such as rarity, evolutionary distinctiveness and endemism (specificity of habitat requirements), contribute to the conservation priority of each species. Certain species are “watch listed,” meaning that specific occurrence data are collected and periodically analyzed to determine whether more active tracking is warranted.

**Table 1. Natural Heritage Program Status Ranks and Definitions**

Definition of Natural Heritage Imperilment Ranks.	
G/S1	Critically imperiled globally/state because of rarity (5 or fewer occurrences in the world/state; or 1,000 or fewer individuals), or because some factor of its biology makes it especially vulnerable to extinction.
G/S2	Imperiled globally/state because of rarity (6 to 20 occurrences, or 1,000 to 3,000 individuals), or because other factors demonstrably make it very vulnerable to extinction throughout its range.
G/S3	Vulnerable through its range or found locally in a restricted range (21 to 100 occurrences, or 3,000 to 10,000 individuals).
G/S4	Apparently secure globally/state, though it may be quite rare in parts of its range, especially at the periphery. Usually more than 100 occurrences and 10,000 individuals.
G/S5	Demonstrably secure globally/state, though it may be quite rare in parts of its range, especially at the periphery.
G/SX	Presumed extinct globally, or extirpated within the state.
G/S#?	Indicates uncertainty about an assigned global or state rank.
G/SU	Unable to assign rank due to lack of available information.
GQ	Indicates uncertainty about taxonomic status.
G/SH	Historically known, but usually not verified for an extended period of time.

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G#T#	Trinomial rank (T) is used for subspecies or varieties. These taxa are ranked on the same criteria as G1-G5.
G/SNR	Not yet ranked.
S#B	Refers to the breeding season imperilment of elements that are not residents.
S#N	Refers to the migratory or winter season imperilment of elements that are not residents.
SNA	Not Applicable. A conservation status rank is not applicable because the species is not a suitable target for conservation activities.
SZN	Migrant whose occurrences are too irregular, transitory, and/or dispersed to be reliably identified, mapped, and protected.
SR	Reported to occur in the state but unverified.
S?	Unranked. Some evidence that species may be imperiled, but awaiting formal rarity ranking.

This single rank system works readily for all species except those that are migratory. Those animals that migrate may spend only a portion of their life cycles within the state. In these cases, it is necessary to distinguish between breeding, non-breeding and resident species. As noted in Table 3, ranks followed by a "B," for example S1B, indicate that the rank applies only to the status of breeding occurrences. Similarly, ranks followed by an "N," for example S4N, refer to non-breeding status, typically during migration and winter. Elements without this notation are believed to be year-round residents within the state.

Natural Heritage imperilment ranks should not be interpreted as legal designations. Although most species protected under state or federal endangered species laws are extremely rare, not all rare species receive legal protection. Legal status is designated by the U.S. Fish and Wildlife Service under the Endangered Species Act or the Colorado Division of Wildlife under Colorado Statutes 33-2-105 Article 2. In addition, the U.S. Forest Service recognizes some species as "Sensitive," as does the Bureau of Land Management.

### **Element Occurrences and their Ranking**

Actual locations of elements, whether they are single organisms, populations, or plant communities are referred to as element occurrences. The element occurrence is considered the most fundamental unit of conservation interest and is at the heart of the Natural Heritage Methodology. To prioritize element occurrences for a given species, an element occurrence rank (EO-Rank) is assigned according to the ecological quality of the occurrences whenever sufficient information is available. This ranking system is designed to indicate which occurrences are the healthiest and ecologically the most viable, thus focusing conservation efforts where they will be most successful. The EO-Rank is based on three factors:

Size – a measure of the area or abundance of the element’s occurrence. Takes into account factors such as area of occupancy, population abundance, population density, population fluctuation and minimum dynamic area (which is the area needed to ensure survival or re-establishment of an element after natural disturbance).

Condition/Quality – an integrated measure of the composition, structure and biotic interactions that characterize the occurrence. This includes measures such as reproduction, age structure, biological composition (such as the presence of exotic versus native species), structure (for

example, canopy, understory and ground cover in a forest community) and biotic interactions (such as levels of competition, predation and disease).

Landscape Context – an integrated measure of two factors: the dominant environmental regimes and processes that establish and maintain the element and connectivity. Dominant environmental regimes and processes include herbivory, hydrologic and water chemistry regimes (surface and groundwater), geomorphic processes, climatic regimes (temperature and precipitation), fire regimes and many kinds of natural disturbances. Connectivity includes such factors as a species having access to habitats and resources needed for life cycle completion, fragmentation of ecological communities and systems and the ability of the species to respond to environmental change through dispersal, migration, or re-colonization.

Each of these factors is rated on a scale of A through D, with A representing an excellent rank or D representing a poor rank. These ranks for each factor are then averaged to determine an appropriate EO-Rank for the occurrence. If not enough information is available to rank an element occurrence, an EO-Rank of E is assigned. EO-Ranks and their definitions are summarized in Table 2.

**Table 2. Element occurrence ranks and their definitions.**

Rank - Definition	
A	Excellent viability.
B	Good viability
C	Fair viability.
D	Poor viability.
H	Historic: known from historical record, but not verified for an extended period of time.
X	Extirpated: extinct within the state.
E	Extant: the occurrence does exist but not enough information is available to rank.
F	Failed to find: the occurrence could not be relocated.

**Potential Conservation Areas (PCAs)**

CNHP designs Potential Conservation Areas (PCAs) to protect element occurrences of rare plants, animals and plant communities. These PCAs focus on capturing the ecological processes that are necessary to support the continued existence of a particular element occurrence of natural heritage significance. PCAs may include a single occurrence of a rare element, or a suite of rare element occurrences or significant features. PCAs are ranked according to their biodiversity significance (Table 3).

The goal of delineating PCAs is to identify a land area that can provide the habitat and ecological needs upon which a particular element or suite of elements (rare plants, animals and plant communities) depends upon for their continued existence. Best available knowledge of each species’ life history is used in conjunction with information about topographic, geomorphic and hydrologic features, vegetative cover, and current and potential land uses to delineate PCA boundaries. These boundaries do not confer any regulatory protection of the site, nor do they automatically recommend exclusion of all activity.

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The PCA boundaries represent the best professional estimate of the primary area supporting the long-term survival of the targeted species or plant communities and are presented for planning purposes. They delineate ecologically sensitive areas where land-use practices should be carefully planned and managed to ensure that activities are compatible with protection of natural heritage resources and sensitive species. Please note that these boundaries are based primarily on CNHP's understanding of the ecological systems. A thorough analysis of the human context and potential stresses was not conducted. All land within the conservation planning boundary should be considered an integral part of a complex economic, social and ecological landscape that requires wise land-use planning at all levels to achieve sustainability.

**Table 3. Natural Heritage Program biological diversity significance ranks and their definitions.**

Rank - Definition	
B1	<p><u>Outstanding Significance (indispensable):</u>                      only known occurrence of an element                      A-ranked occurrence of a G1 element (or at least C-ranked if best available occurrence)                      concentration of A- or B-ranked occurrences of G1 or G2 elements (four or more G1 or G2 elements)</p>
B2	<p><u>Very High Significance:</u>                      B- or C-ranked occurrence of a G1 element                      A- or B-ranked occurrence of a G2 element                      One of the most outstanding (for example, among the five best) occurrences range wide (at least A- or B-ranked) of a G3 element.                      Concentration of A- or B-ranked G3 elements (four or more)                      Concentration of C-ranked G2 elements (four or more)</p>
B3	<p><u>High Significance:</u>                      C-ranked occurrence of a G2 element                      A- or B-ranked occurrence of a G3 element                      D-ranked occurrence of a G1 element (if best available occurrence)                      Up to five of the best occurrences of a G4 or G5 community (at least A- or B-ranked) in an ecoregion (requires consultation with other experts)</p>
B4	<p><u>Moderate Significance:</u>                      Other A- or B-ranked occurrences of a G4 or G5 community                      C-ranked occurrence of a G3 element                      A- or B-ranked occurrence of a G4 or G5 S1 species (or at least C-ranked if it is the only state, provincial, national, or ecoregional occurrence)                      Concentration of A- or B-ranked occurrences of G4 or G5 N1-N2, S1-S2 elements (four or more)                      D-ranked occurrence of a G2 element                      At least C-ranked occurrence of a disjunct G4 or G5 element                      Concentration of excellent or good occurrences (A- or B-ranked) of G4 S1 or G5 S1 elements (four or more)</p>
B5	<p><u>General or State-wide Biological Diversity Significance:</u> good or marginal occurrence of common community types and globally secure S1 or S2 species.</p>