DECISION SUPPORT FOR REGIONAL ADVANCE MITIGATION PLANNING

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ABSTRACT

Mitigating impacts of transportation projects uses avoidance, minimization, and compensation or offsite mitigation actions. This project developed a technical approach to address offsite mitigation which has often occurred during project execution, adjacent to the project, and in small, unsustainable, and ineffective actions. More recently, advance mitigation has been advocated to consider all projects in a long range transportation plan and identify the pool of mitigation sites that should be conserved for use and implemented in advance of projects. The expected benefits of this approach are streamlined transportation projects and more effective and efficient conservation through placement of mitigation projects in more desirable and sustainable locations.

The Pikes Peak Area Council of Governments developed an initial Integrated Regional Mitigation Plan that quantified the expected impacts to a large number of species habitats and ecosystem types from the approximately 200 projects in the Long Range Transportation Plan. A multi-factor process was then used to select the pool of sites that could provide the necessary mitigation for a set of "mitigation targets" (those features such as habitats to be mitigated) and these were weighted with the presence of non-target but high priority biodiversity, other values such as ecosystem services, and locational importance such as proximity to existing conservation lands. The resulting geospatial database supports regional planning and can be used by project and mitigation partners to identify the mitigation needs of individual transportation projects, identify candidate locations for offsite mitigation, and prioritize a set of sites for field verification and other investigations into project suitability.

INTRODUCTION

Mitigation for transportation project impacts on natural resources has typically been planned and executed on a project-by-project basis, often resulting in small, unsustainable, and ineffective mitigation (1, 2). In the document *Eco-logical: an Ecosystem Approach to Developing Infrastructure Projects* (3) the case was made for proactive planning for mitigation in advance of transportation projects and this concept was further developed and formalized in the technical guide to Eco-logical (4). Expenditures for mitigating infrastructure projects represent one of the largest sources of conservation funding in the U.S., therefore it is critical that those funds are used to achieve effective conservation (5). Some states have institutionalized the advanced mitigation approach and there are several examples from smaller jurisdictions (6,7) but the practice is still in development with lessons yet to be learned (7). This paper focuses on the technical methodology to support regional advanced mitigation. We built upon the work by Huber et al. (8) who described a pilot project to develop a Regional Advanced Mitigation Plan that could identify opportunity areas for mitigating a collection of transportation project impacts over a multi-county region. That work, along with some additional guides and studies (4, 9, 10) informed a project (completed in 2015) that sought to create an Integrated Regional Mitigation Plan (IRMP) that could mitigate the cumulative impacts on biodiversity from the set of transportation projects in a Long Range Transportation Plan. The intended result is a decision support tool (DST) that can link any project to candidate areas capable of providing the necessary mitigation and rank these areas by other factors such as supplemental benefits (e.g., ecosystem services), site condition, cost, etc.

This project was conducted for the region of the Pikes Peak Area Council of Governments (PPACG) which is the designated Metropolitan Planning Organization (MPO) for the Colorado Springs (Colorado, USA) Urbanized Area. This region has a mix of dense urban, suburban, and exurban development, extensive farm and grazing lands, and undeveloped public land. It includes over 600,000 people within its 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 Long Range Transportation Plan (LRTP) and transportation improvement program to determine investment priorities for billions of dollars in federal, state, and local funds. Mitigation is a key component of PPACG's transportation activities and comprises up to 50% of some projects.

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 (11, Sec. 1508.20).

Compensatory mitigation may be accomplished by restoration, creation, enhancement, or protection of other occurrences of the impacted resource (12). 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.

While the complete methods and DST developed for the IRMP are capable of supporting all levels of mitigation, the IRMP assumes that avoidance and minimization have already been implemented to the degree feasible and is therefore focused on compensating for unavoidable impacts to resources. The intent of applying the IRMP is to ensure that there is no overall loss of those resources in the area of interest. Compensatory mitigation often involves a requirement for more area to be mitigated than was impacted; such as a ratio of 3:1 (9). Further, in an IRMP, 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 (9). By applying 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 DST, rather than a single map. It identifies mitigation opportunity areas capable of providing the type and quantity of mitigation anticipated through cumulative effects assessment of transportation projects identified in the LRTP. 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 (13), while an IRMP seeks to identify ample opportunities and support selection for the best 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 attractive to 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 and support development of mitigation banks as the preferred long-term approach.

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.

METHODS

While producing an Integrated Regional Mitigation Plan is a recommended approach to mitigation, very few actual implementations have occurred and published methods are sparse. Methods described here were informed by a summary study (10), a case study (8), and a guide (9). The methods are fairly linear, understanding that some parts can be conducted in parallel and many parts are conducted iteratively to achieve desired outcomes, often by revisiting previous steps. Note that these steps have considerable parallels with those of the Integrated Ecological Framework (e.g., see 4).

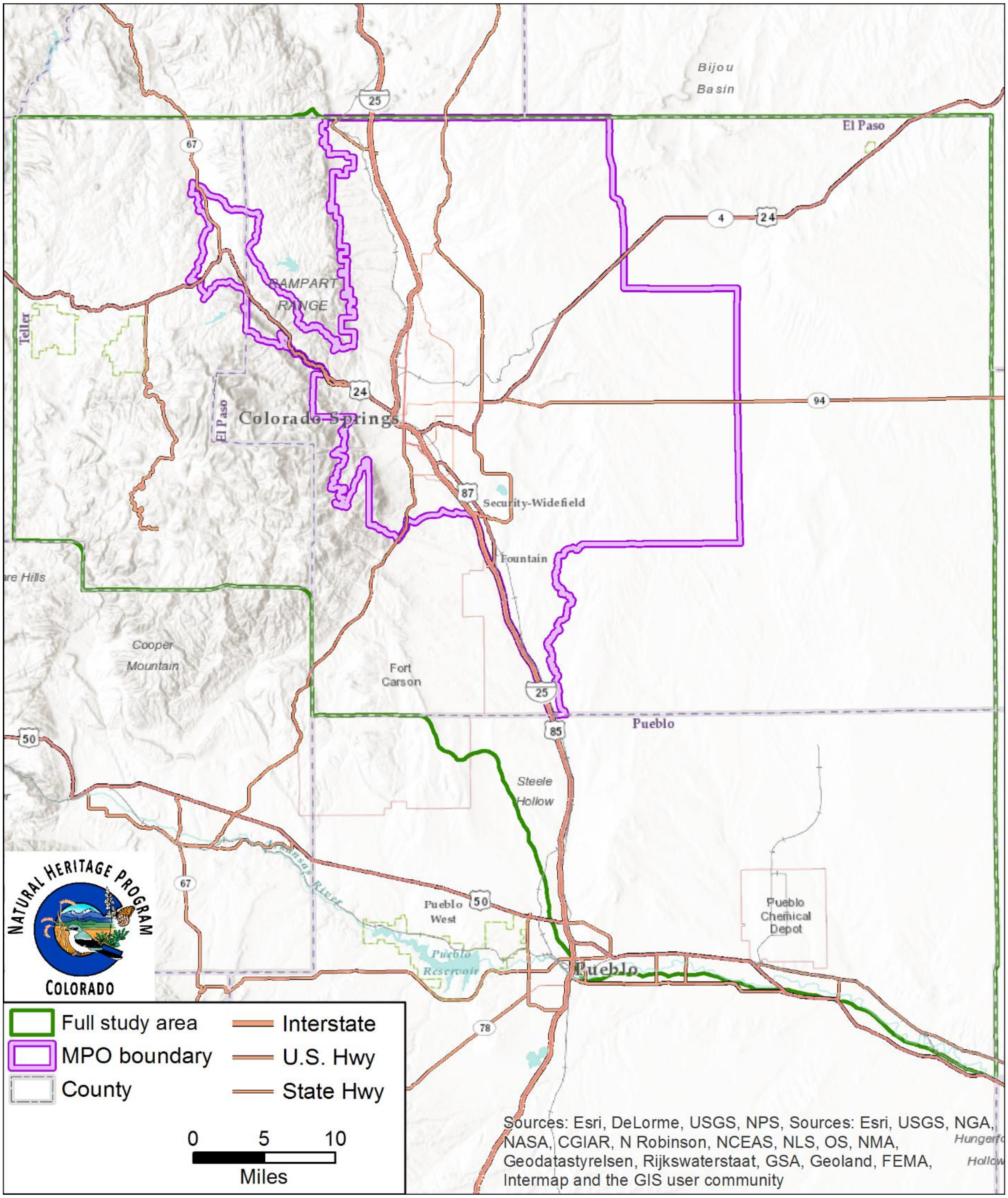
Development of the PPACG IRMP consisted of six basic steps:

1. Define the region of analysis.
2. Identify biological resources to be considered in the plan.
3. Determine mitigation needs.
4. Identify a suite of potential mitigation sites.
5. Develop a method for prioritizing among multiple mitigation sites.
6. Build a decision support system that can be accessed by the implementation parties and easily updated as new information becomes available.

This is a complex process, the highlights of which are presented in this section. However, for detailed methodology, please see the full report delivered to PPACG (14).

Region of Analysis

A novel component of this project was the use of two different regional boundaries (Figure 1). For the purpose of identifying conservation elements and calculating transportation project impacts (= mitigation needs), the jurisdictional boundary within which the impacts occur (PPACG MPO boundary) was used. To identify the suite of potential mitigation sites represented by the IRMP, a larger 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 than might be found in the more developed MPO region. This is the preference of the resource and regulatory agencies that advised PPACG on this project. PPACG is able to transfer funds through the state DOT to accommodate mitigation outside their jurisdiction.



149 **FIGURE 1 Analysis regions used in developing the Integrated Regional Mitigation Plan.**

150 **Identification of Mitigation Needs**

Conservation Elements & Mitigation Targets

Selection of mitigation targets typically begins with "regulated" conservation elements (e.g., species listed as Threatened or Endangered under the Endangered Species Act; wetlands protected under the Clean Water Act). In practice, requirements or negotiations between resource/regulatory agencies and transportation agencies may request mitigation beyond these elements to include a broader set of resources. In their land use planning efforts, PPACG strives to conserve or minimize impact to conservation elements (species, plant communities, and ecological systems) beyond those elements that they are required by law to protect. To identify conservation elements that could potentially be impacted by PPACG activities, a preliminary list was developed through queries of the Colorado Natural Heritage Program's (CNHP's) Element Occurrence and Potential Conservation Areas (PCAs) data for sensitive species and natural communities documented within the study area. Some species not tracked by CNHP but considered important by the PPACG's Advisory Committee were added. These include big game species that are not only economically important species, but are also of significant highway safety concern because of the potential for collisions.

To aid in determining which of the conservation elements warranted inclusion in the IRMP, the elements were sorted 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"), which include 34 species, several "potential conservation areas" or PCAs designated by CNHP, and a large number of habitat and ecosystem types. 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. Conservation elements in bins 4 and 5, together with other factors, were considered additional values (i.e., extra points) to be used in ranking and selecting from among multiple potential mitigation sites.

TABLE 1 Conservation element status bin definitions

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 (SCGN) 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 (including big game species), and any other areas considered to be important for mitigation or restoration

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 a conservation element from the area. The buffers, determined in consultation with the 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. These distances were based on typical distances that equipment travel during road repair/improvements versus new road construction. Projects that do not have significant spatial extent (e.g., planning, traffic, and safety studies, alterations to bus routes or vanpools), or those whose impacts would be confined to existing infrastructure (e.g., repaving, bus stop improvements) were not considered in the impact analysis.

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 (15), designated Critical Habitat (16, 17), NWI mapping (18), and Colorado Parks and Wildlife Species Activity Maps (19). Not all targets have current, high-quality data that are publicly available; meaning that there can be both false positive impact results (impact shown where a mitigation target no longer exists) or false negatives (target exists but no occurrence has been mapped).

To assist in focusing attention on priority mitigation needs, each transportation project was ranked according to the significance of its impact. In consultation with the Advisory Committee, impact weights were created based on relative weighting of the targets (based on Bin), the number of targets impacted, and the size of the impact, calculated as:

$$A \times \sum_{i=1}^{3} (W_i Q P_i) + (W_i C N_i)$$

where: A = Actual impact acres for a project

W*i* = Weight assigned to Bin *i* (Bin 1; 0.65, Bin 2; 0.25, Bin 3; 0.10)

Q = Relative weight assigned to area impacted vs. number of targets (0.95)

P*i* = Proportion of impact acres in Bin *i*

C = Relative weight assigned to number of targets impacted vs. area (0.05)

N*i* = Number of targets impacted in Bin *i*

Raw impact scores were then relativized to a scale of 0 to 100 by dividing each score by the highest raw score, and classified into four categories: 0 = no impact, >0-5 = low impact, >5-

20 = moderate impact, and >20 = high impact. Project impact levels (Figure 3) 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.

Identifying and Prioritizing Potential Mitigation Sites

The primary focus of our analysis was the identification of sites where impacts to mitigation targets can be mitigated with the greatest effect, considering the overall land use trends in the PPACG region. The process and tool is designed to be dynamic such that if the list of transportation projects we evaluated were to change, the calculation of mitigation acres needed for each target could be refreshed.

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 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 (not available for this project). The identified and prioritized sites become part of the IRMP database. The following sections describe the technical methods for these steps.

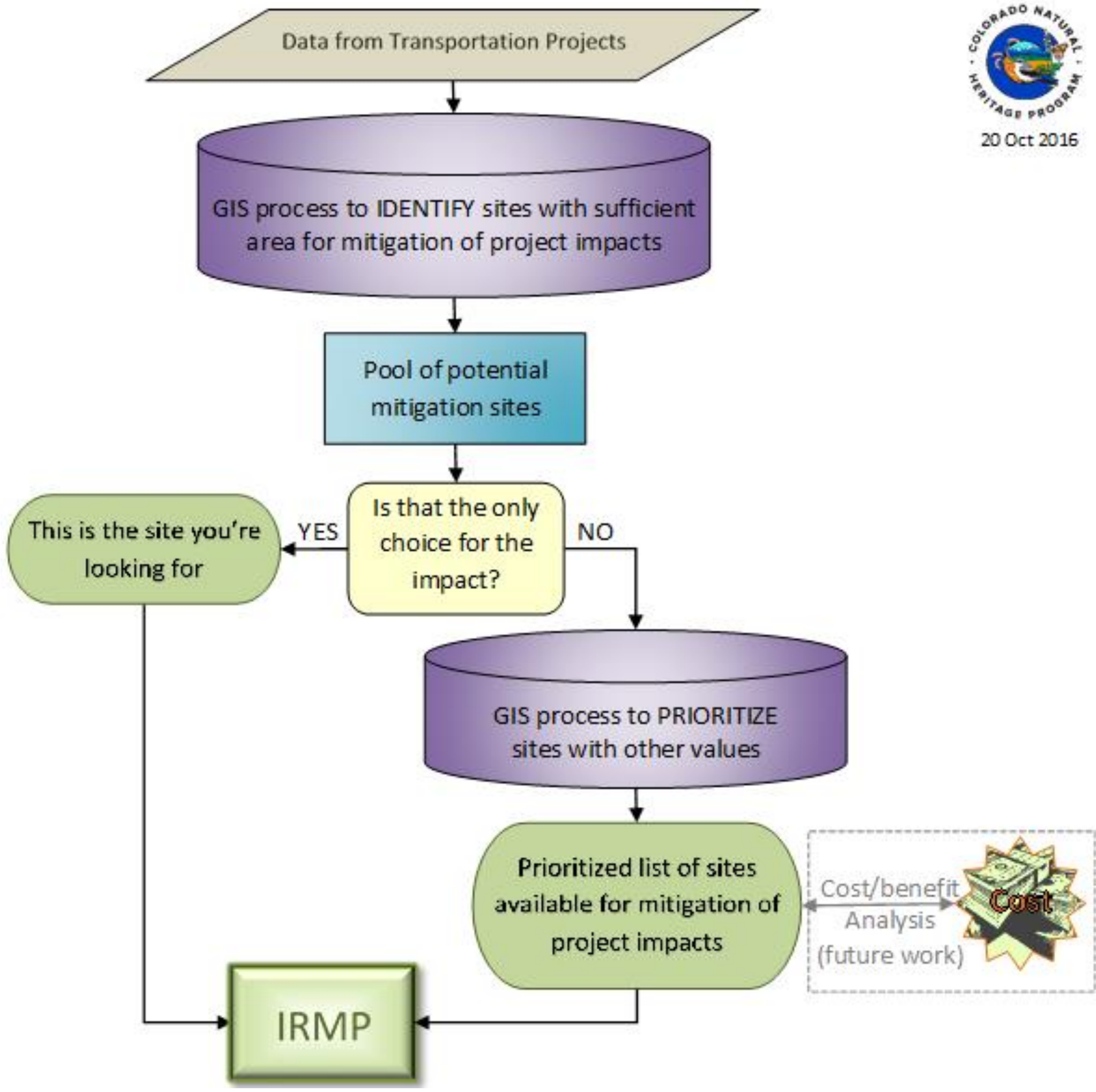


FIGURE 2 Mitigation site identification and prioritization process.

Identifying Potential Mitigation Sites

Selection of potential mitigation sites involves identifying sites that contain occurrences of the mitigation targets in sufficient acreage (in aggregate) to offset all of the calculated impact acres multiplied by a defined mitigation ratio. We selected Public Land Survey System (PLSS) ~640 acre Sections for Planning/Site Units because they were used in previous related studies in the region and they correspond well to land ownership patterns and comply with CNHP data security requirements for rare and imperiled species. 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 reasoning that the 3:1 ratio for regulated features is typical (8) and that the other bins would likely have lesser to no additional mitigation requirements. Increasing the ratios further can help guard against previously noted problems of loss of Planning Units before mitigation is needed or commission errors when the targets are not actually in the sites. However, with rare and imperiled species, inadequate numbers of known occurrences to accommodate larger ratios can become challenging to implement.

To identify potential mitigation sites, a custom program (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. If acreage is insufficient, the script searches the surrounding Planning Units to determine if a combination of adjacent units 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 mitigating impacts to the target. A site visit would be required to confirm target presence, evaluate the on-the-ground configuration of target acreage, and habitat quality.

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), several factors can be used to prioritize among them to limit the number that must be further investigated and verified. These factors can include the cost of site acquisition, cost of the mitigation action (e.g., restoration, ongoing management), the presence of other values in addition to the mitigation target(s), and the value of the site for enhancing the size of, or providing buffer to existing conservation areas, and enhancing or maintaining connectivity among conservation areas.

In the present project, data on acquisition cost was not available and the scale of the planning units and inability to predict what specific mitigation actions would be needed precluded using the cost factors. The added value factors 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. These added value factors are also often of primary interest to organizations that may become critical implementation partners in mitigation projects through shared funding, workload, and ongoing stewardship.

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 2.

TABLE 2 Inputs for site prioritization

Site Prioritization	Scoring	AHP Weight(1)
Other Bin 1-3 targets present	% acreage within Planning Unit	0.56
Bin 4-5 targets present	% acreage within Planning Unit	0.22
Intact shortgrass habitat present	% acreage within Planning Unit	0.04
Fire/flood restoration potential	% acreage within Planning Unit	0.04
In 100-year floodplain	% acreage within Planning Unit	0.04
Prairie-dog suitable habitat	% acreage within Planning Unit	0.04
Forest health management opportunity	% acreage within Planning Unit	0.04
Terrestrial / Aquatic connectivity	High / Low / None	
Included in other regional plan	Yes / No	
Adjacent to protected area	Yes / No	
Cultural site(2)	Yes / No	

1 See text for definition
2 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 overall weighting scheme was selected to strongly favor the presence of other Bin 1-3 targets (that were not the mitigation targets), moderately emphasize Bin 4-5 targets, and then weight additional factors, both quantitative and qualitative, equally. The added-value factors that could be calculated as acreage were ranked in a series of pair-wise comparisons to develop relative priorities and numerical weights for each factor, using a publicly available Analytical Hierarchy Process (AHP) Excel template calculator (20). The calculator computed weights via eigenvector analysis. Planning Unit acreage proportions were calculated in ArcGIS 10.2 (21) for each of the seven spatial factors present in a unit. Another custom program (Python script) was used to apply the weights from the spreadsheet calculator (Table 2) to the calculated proportions, which were averaged to produce the weighted average sub-score (AvgAcreScore). Scores for four qualitative added-value factors (Table3) were added to site priority ranks by converting presence/absence or ordinal levels to an index score, which were also applied in the script and averaged as a second sub-score (AvgQualScore). The two sub-scores were combined into an overall weighted average (PriorityIndex) using the formula:

PriorityIndex = (AvgAcreScore)*0.636 + (AvgQualScore)*0.364

If a Planning Unit was the only available site for mitigation, its added-value score defaulted to 1 indicating that it is “irreplaceable” in systematic conservation planning terminology (13) and plan goals cannot be achieved without it.

TABLE 3 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
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 time of the study, so all scores defaulted to “No”.

RESULTS

Targets and Project Impacts

There are 200 planned transportation projects for which physical disturbance was predicted. Of these, 52 were projected to impact mitigation targets. Of the 137 mitigation targets present within the MPO boundary, 34 could be impacted by one or more transportation projects according to our analysis. No target was impacted by more than three transportation projects. Because PPACG desires to integrate 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 were provided to PPACG to allow planners to identify targets and acres impacted by individual transportation projects.

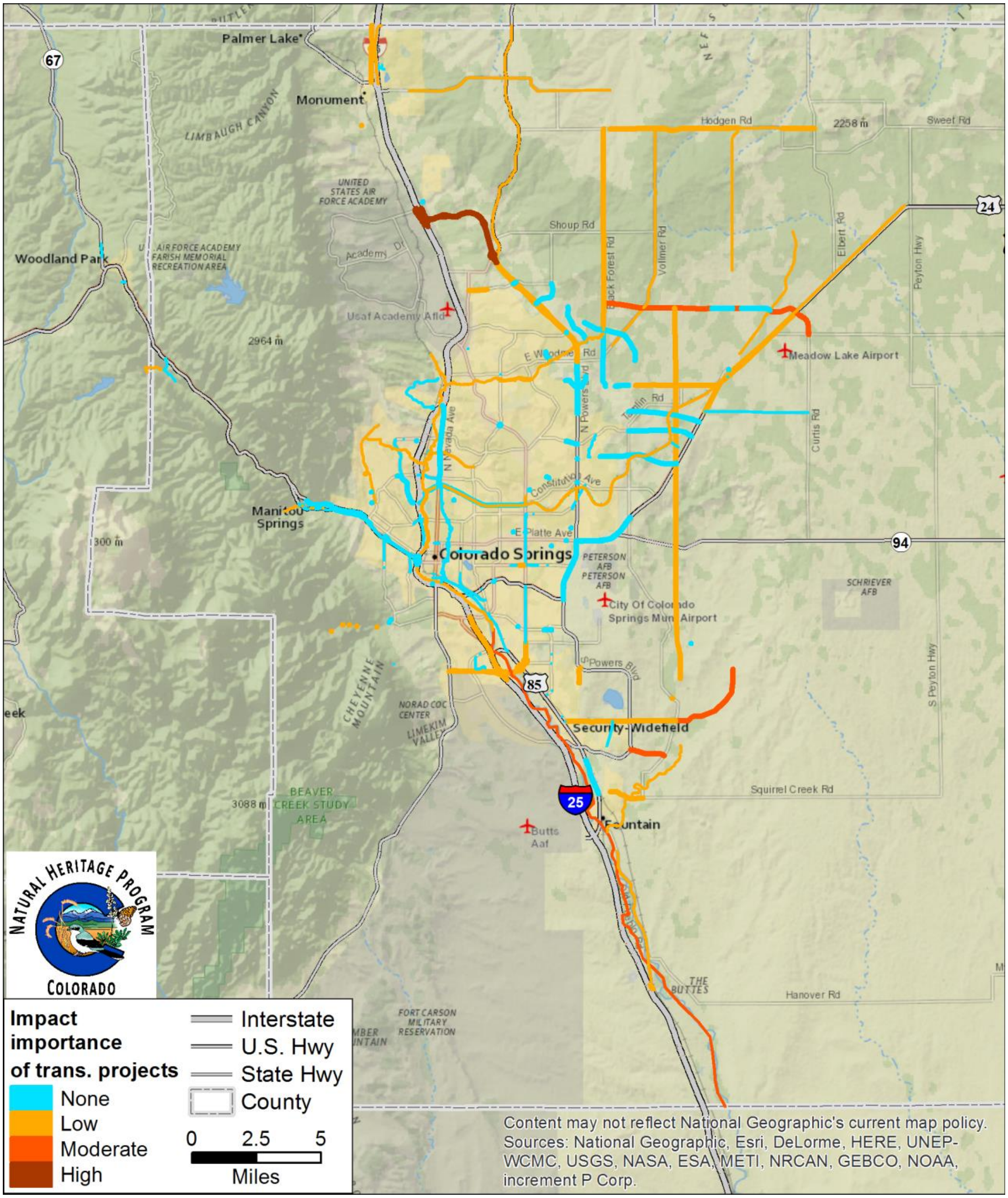


FIGURE 3 Impact importance of planned transportation projects based on number and type of conservation elements mapped within the projects' buffers.

Potential Mitigation Sites

The identification of potential mitigation sites resulted in the inclusion of 1,950 Planning Units or Planning Unit combinations in the geodatabase. Added-value scores for sites 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 4.

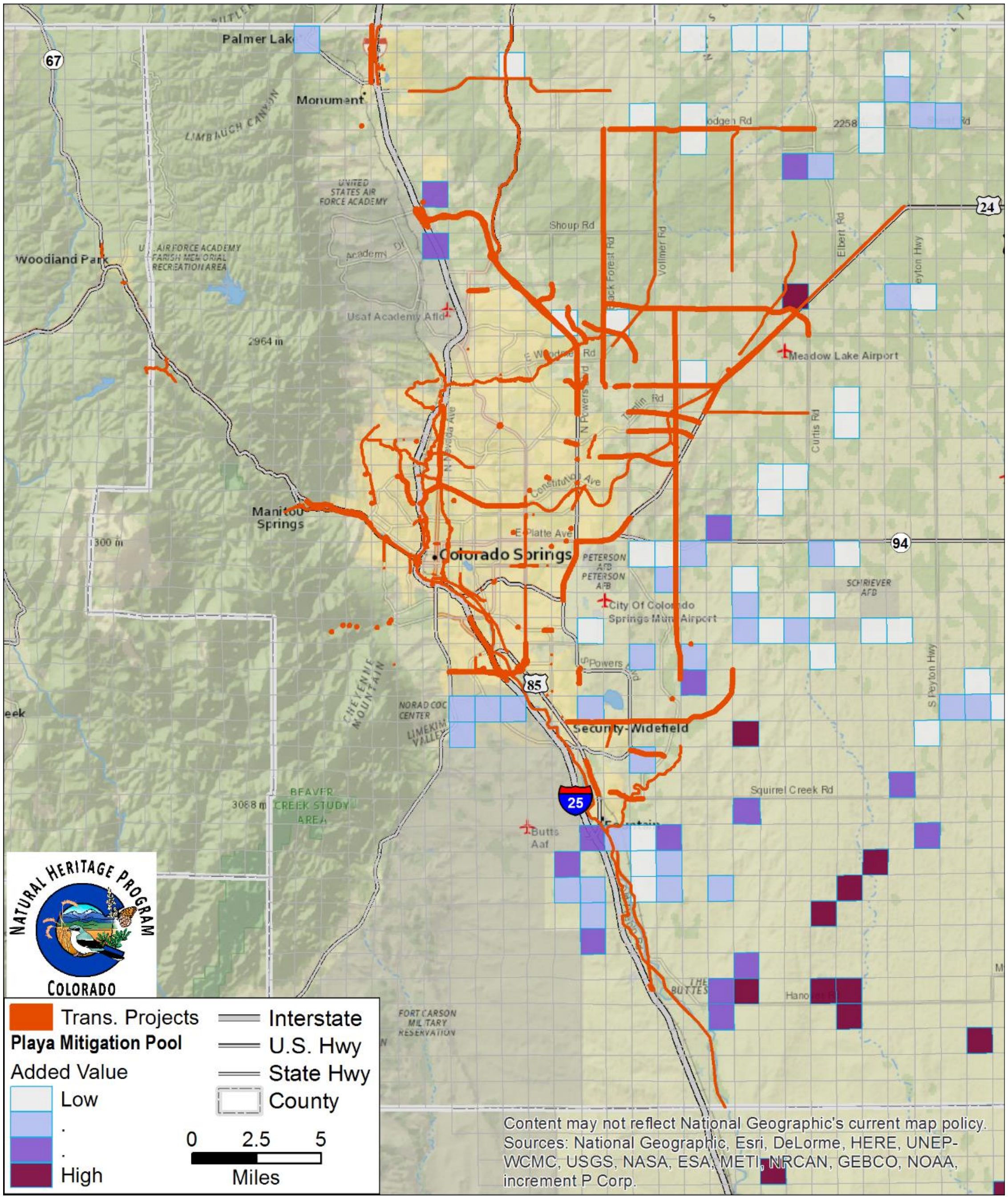


FIGURE 4 Example of identified and prioritized potential mitigation site locations for the playa habitat mitigation target (a Bin 3 target). Square mile sections shaded from white to

red contain the playa habitat mitigation target, colors of shading correspond to additive value factors present.

Application of the IRMP

The data, methods, and analyses results described above have been developed to assist PPACG in improving conservation outcomes by implementing a comprehensive mitigation program. As of this writing, the database has not be applied yet so the following describes the intended application.

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 DST 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 to correct omission and commission errors (and then incorporate these corrections into the database).
2. Confirm the desired compensatory mitigation ratios for the affected mitigation target(s) in consultation with resource/regulatory agencies.
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 and more sustainable patches and occurrences of the mitigation targets are 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 dropped from consideration as impractical to restore (if severely degraded). Existing data for the mitigation targets were insufficient 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.

As of this writing, a searchable geodatabase of the IRMP has been provided to PPACG. Ease of access and collaborative use of the IRMP is important for successful application by the many partners so PPACG is investigating integration of the geodatabase in a Google Earth portal. The ultimate vision for such a portal would allow partners (project proponents, engineers, resource agency staff, etc.) to select a 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 could 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 for others) and updating the database with new data, including field verification data.

CONCLUSIONS

Mainstreaming regional advanced mitigation planning is still in relatively early development within the transportation planning discipline. This project explored and developed technical methods and tools for quantifying resource impacts, selecting mitigation targets, and identifying and prioritizing a suite of sites capable of fulfilling offsite mitigation needs. This work has stimulated plans for an integrated toolkit that can automate much of the processes described, something that is needed to make this practice more accessible to transportation planners and mitigation partners and serve the dynamic needs of transportation project implementation.

Limitations

This IRMP is based on statewide and regional datasets of varying age, accuracy, and precision. In addition, some components of mitigation planning that are acknowledged to be important were not available for inclusion in this IRMP such as parcel cost. The DST is intended to be dynamic and updatable with new data and assumptions. With respect to the cost component in our framework, the cost-to-benefit analysis was kept separate from the prioritization analysis to maintain clarity in prioritizing potential mitigation sites from an ecological standpoint. Areas of known or predicted urban development, such as those in the future land use scenarios (e.g., PPACG's Small Area Forecast and Accelerated Trend scenarios) 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 to non-conflict areas. Such detailed incorporation of development scenarios or similar information into the process could steer mitigation away from areas of high future development value/threat and, preferably, steer development away from high-value conservation areas.

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