California RAMP MARXAN Tool

California Regional Advance Mitigation Planning (RAMP) uses GIS to estimate habitat-specific "footprints" (impacts) of multiple planned government infrastructure projects (e.g., roads). Based on this information and compiled regional conservation goals termed a greenprint, RAMP then uses MARXAN landscape analysis software to identify a portfolio of land parcels that could cost-effectively be acquired to meet compensatory mitigation obligations in advance of the projected impacts. The MARXAN prioritization process used by RAMP can offer financial and ecological benefits over the more typical project-by-project approach to planning compensatory mitigation projects used by government agencies. RAMP's method is also readily transferable to any other state due to the fact that all state DOTs have transportation planning documents that can be used to estimate infrastructure footprints in advance. Financial and ecological gains are particularly possible for states DOTs with complete or nearly complete control over their own funding and that could readily implement advance mitigation planning.

OVERVIEW

Lead developers: California Department of Transportation (Caltrans), California Department of Water Resources (DWR), California Department of Fish and Game (CDFG), U.S. Army Corps of Engineers Sacramento District (Corps), U.S. Environmental Protection Agency (EPA), U.S. Fish and Wildlife Service (FWS), NOAA National Marine Fisheries Service (NMFS), and the University of California-Davis (UC-Davis).[1]

Year developed: 2007.[1]

Geographic area: RAMP priorities are primarily identified at the ecoregional scale in the California Central Valley where Caltrans and DWR have overlapping infrastructure projects. However, the Caltrans Statewide Advance Mitigation Initiative (SAMI) aims to partner with the Federal Highway Administration (FHWA) to obtain federal funding to expand RAMP's methods to a statewide advance mitigation program.[1]

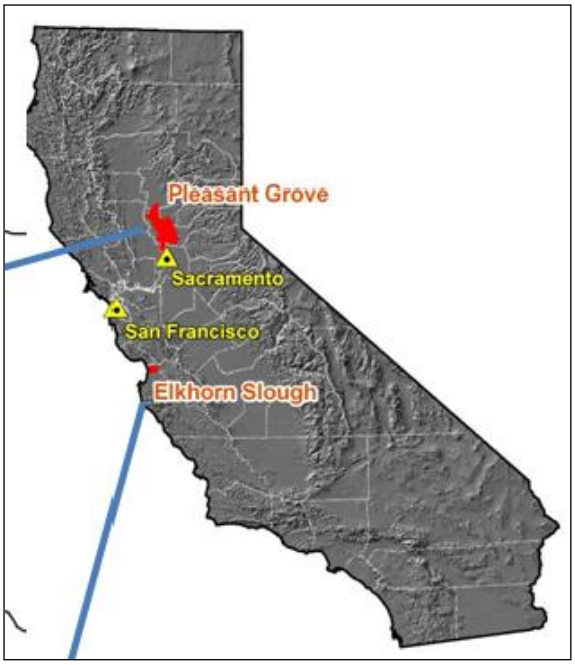

Figure 1. RAMP's MARXAN approach was used to determine priority areas for habitat and aquatic resource compensatory mitigation for the Pleasant Grove and Elkhorn Slough watersheds in Thorne et al. (2009). Used with permission of the University of California-Davis

Resource types: RAMP identifies parcel portfolios for mitigation based on habitat goals and impacts specific to each region. For example, Thorne et al. (2009) identifies 15 habitat types to serve as conservation targets for mitigation in the Elkhorn Slough watershed, six of which are aquatic resource types: mudflat, salt marsh, saltwater, freshwater, freshwater wetlands, and riparian.[1]

Updated: 5/7/2012

Restoration/conservation: RAMP identifies priorities for aquatic resource restoration (reestablishment and rehabilitation), creation, enhancement, preservation/protection, and acquisition without preservation/protection (e.g., fee simple acquisition).[1]

Stakeholders: Government agencies (namely Caltrans) as well as the general public in areas of agency impacts and compensatory mitigation activities.[1]

Current status: RAMP's MARXAN method was peer-reviewed with the publication of Thorne et al. (2009) and Caltrans is currently in the process of implementing RAMP advance mitigation projects. Caltrans is rolling out RAMP and SAMI (the funding mechanism for advance mitigation projects) carefully to ensure that the mitigation programs are inclusive of stakeholder concerns.[1]

PRIORITIZATION ANALYSIS

Determination of input factors/weightings: The Caltrans MARXAN greenprint analysis incorporates conservation targets defined by multiple stakeholders. For the Thorne et al. (2009) analysis of the Elkhorn Slough watershed, RAMP consulted with the Elkhorn Slough Foundation to identify habitat types and extents (i.e., weightings) that local stakeholders considered to be ecologically desirable for protection (e.g., 30% freshwater wetlands). RAMP then used these target habitat percentages as inputs in the MARXAN reserve selection algorithm. In another example, through an analysis of impacts to different habitat types, RAMP determines the required extent of habitat that would need to be mitigated based on typical mitigation ratios for each habitat type. These habitat extents serve as inputs for the MARXAN greenprint analysis.[2]

Landscape prioritization tool(s):

Road impact footprint analysis: Thorne et al. (2009) applied appropriate buffer distances to spatial data on the location of funded road construction projects to identify the area impacted by each road project. Caltrans biologists defined these buffers to reflect the spatial extent of impact for each road classification so that, for example, road widening projects impacted a 30.5m buffer while passing lane projects impacted a 10m buffer. RAMP extended this "footprint" an additional 250m and overlaid the resulting area with habitat maps to calculate the proportion of each habitat type located in the proximity of each project. For each project, RAMP then multiplied this proportion by the project's footprint area to estimate the total area of each habitat type impacted by each project and summed these totals across all projects in the study region. The total habitat area projected to be impacted throughout the region was then multiplied by anticipated mitigation ratios for each habitat type to identify Caltrans' mitigation needs.[2]

Prioritization objectives assessed:

- Future impacts

Table 1. The RAMP team calculated habitat impacts due to funded road construction projects by drawing from the factors and data sources listed below.

Factor used in analysis	Data source(s)
Location of funded road	Caltrans

construction projects	
Buffer area reflecting the impact area of each road classification	Caltrans biologists
Habitat maps	N/A
Mitigation ratios commonly applied for each habitat type	Caltrans biologists

MARXAN greenprint analysis: Thorne et al. (2009) used the MARXAN landscape optimization algorithm to identify a portfolio of habitat restoration and protection sites to serve as compensatory mitigation in advance of future road infrastructure impacts. As applied by Caltrans, the MARXAN optimization procedure uses GIS spatial data inputs for stakeholder conservation values, location of parcels within wildlife corridors, and parcel costs[3] to identify a cluster of parcels ("regional greenprint") that provides maximum benefits in terms of some factors (e.g., achievement of stakeholder habitat values) while minimize the costs of others (e.g., parcel cost). Caltrans incorporates habitat mitigation needs derived based on its analysis of the expected habitat "footprint" of anticipated infrastructure impacts to establish a final mitigation portfolio. In practice, priority parcels identified using this method will be used to guide the acquisition of land in order to satisfy Caltrans' compensatory mitigation obligations.[1]

Throughout this process, the UC-Davis RAMP research team was the primary decisionmaker for internal model settings and weightings of the MARXAN model (e.g., boundary length modifiers). Government agencies, non-profit organizations, and academic institutions contribute data used by the MARXAN model to identify a regional conservation design.[2]

Prioritization objectives assessed:

- Habitat quality
- Cost-effectiveness

Table 2. Factors and associated data sources used by the RAMP MARXAN analysis to calculate a conservation value for each parcel.

Factor used in analysis	**Data source(s)**
Land-cover map	High-resolution vector map (<1 ha) from aerial photography developed for the study by the Elkhorn Slough Foundation (ESF and Scharffenberger, 2002); 2002 100m raster land cover map obtained from the California Department of Forestry and Fire Protection
Land-ownership parcel boundaries	Monterey County and San Benito County
Parcel cost data	Monterey County and San Benito County
Existing conservation lands	Elkhorn Slough Foundation and Statewide Public and Conservation Trust Lands data set (California Resources Agency 2007)
Caltrans road construction projects	Statewide Caltrans data set
Threatened & endangered species known locations	California Department of Fish and Game (CDFG) database (CDFG 2007)
Wildlife corridors	Huber et al. 2008
Modeled species distributions	Hollander (unpublished data)

Refinement of landscape priorities: Mitigation areas identified in the landscape prioritization MARXAN analysis will be field verified with the California Rapid Assessment Method (CRAM) or intensively collected data, as appropriate in particular areas of California, to select final mitigation sites. CRAM assessments are field-based evaluations of four attributes of wetland condition – landscape context, hydrology, physical structure, and biotic structure – that produce an overall score that can be used to prioritize mitigation sites. Although Caltrans has not yet identified specific intensive field assessment methods, it does intend to evaluate mitigation sites identified by the MARXAN tool using such techniques where appropriate. Depending on species offset assessment requirements, these might include species protocol surveys developed by FWS or CDFG. For instance, if eradication of invasive species is a mitigation objective, then intensive vegetation assessments might be used.[1]

Prioritization products: RAMP greenprints and mitigation portfolios are publicly available as static maps.[1]

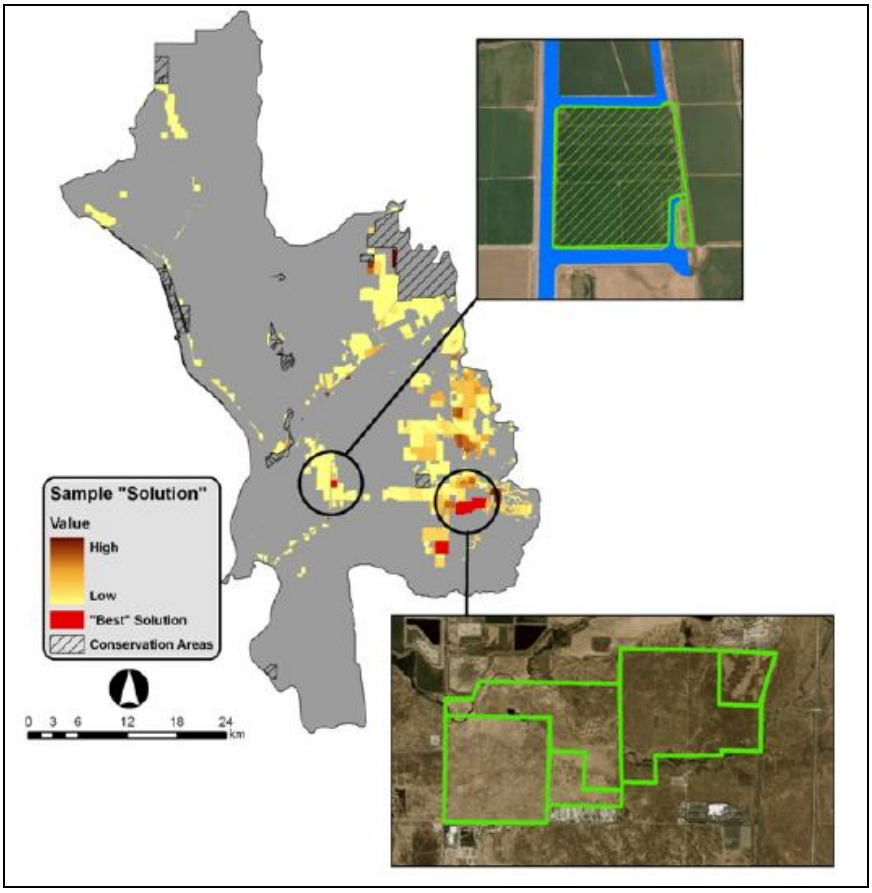

Figure 2. RAMP applies MARXAN to identify priority parcels for mitigation of agency infrastructure projects. In the above map, dark brown colored parcels represent those most likely to meet Caltrans' mitigation need, while red parcels are "best" solutions that meet mitigation needs at low cost. Used with permission of California Department of Transportation (Caltrans).

IMPLEMENTATION

Updated: 5/7/2012

Regulatory/non-regulatory programs:

- Section 404 compensatory wetland and stream mitigation.[1]
  - Watershed approach: If the scale of analysis used by the RAMP MARXAN approach is set at the watershed level – as was the case in Thorne et al. (2009) – the tool can be applied to support a watershed approach to compensatory mitigation. Watershed-specific conservation targets and spatial data can be used by the MARXAN tool to identify portfolios of mitigation parcels where aquatic resource restoration or conservation would best meet watershed needs.[1]
  - Mitigation banking site selection:
    - Bankers have an incentive to use prioritized sites because there is low uncertainty that credits generated by these sites will sell. Caltrans and DWR are committed to purchasing mitigation credits generated by bankers at sites that they have already determined to be suitable.[1]
    - Expedited approval: Since infrastructure, resource, and regulatory agencies are involved in the mitigation planning process from the beginning, mitigation bankers constructing banks in priority locations receive expedited approval.[1]
    - Higher credit generation: Because mitigation banks in priority locations satisfy the conservation needs of RAMP and are in place in advance of impacts, these banks could potentially receive more credits.[1]
- Endangered or threatened species compensatory mitigation (e.g., giant garter snake).[1]
- California Environmental Quality Act (CEQA).[1]
- National Historic Preservation Act.[1]
- Identification of specific privately-owned parcels that should be acquired to meet conservation goals.[1]

Transferability:

- RAMP's MARXAN technique is readily transferable to any other state because all state DOTs have transportation planning documents that can be used to estimate infrastructure footprints in advance. From this information, any state can then plan mitigation sites by determining suitable greenprints following the method applied by RAMP.[1]
- Compared to its application in California, where funding for transportation projects can be difficult to obtain, RAMP's approach may be highly effective in states with DOTs that have complete or nearly complete control over their transportation funding (e.g., North Carolina). These states in particular stand to gain both financially and ecologically from implementing RAMP's MARXAN prioritization method as part of an advance mitigation planning framework.[1]

Data gaps:

- Comprehensive data on the location of rare and endangered species (individual plants and animals and communities) could be obtained through improvements to the California Natural Diversity Database (CNDDB).[1]
- Data on projected ecological impacts from DWR water infrastructure development to support more holistic consideration of future impacts.[1]
- National Wetlands Inventory (NWI) wetlands and stream location and coverage maps are flawed in parts of California.[1]

Updated: 5/7/2012

- Location data for jurisdictional waters are needed from the Corps, FWS, and CDFG.[1]

Barriers:

- CDFG is understaffed and has experienced substantial staff turnover, which complicates dedicating adequate resources to these mitigation-planning efforts.[1]
- Securing sufficient funding for RAMP and SAMI efforts has been difficult.[1]
- Property rights concerns have also been raised, since part of the RAMP assessment process analyzes the availability of particular parcels; however, Caltrans plans to address these concerns with its public outreach program.[1]
- Looking toward the future, sufficient funding and staffing were identified as potential barriers to implementation of advance mitigation projects.[1]

Future goals:

- Within the next five years, Caltrans aims to initiate compensatory mitigation for impacts that are expected in the subsequent 5-10 years, so that these advance mitigation projects will have already achieved performance standards prior to infrastructure impacts.[1]

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[1] Interview on 8/4/2011 with Jim Thorne, Andrea Williams, and Rebecca Loefller.
[2] Thorne JH, Huber PR, Girvetz EH, Quinn J, and McCoy MC. 2009. Integration of regional mitigation assessment and conservation planning. Ecology and Society 14(1): 47
[3] In one of its study watersheds, Caltrans RAMP estimated parcel cost for all land parcels within the watershed based on parcel cost data for two counties by developing a function relating parcel cost and size.