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Task 6:
Enhancements to EcoAtlas' CRAM analysis tools: Habitat Development Curves and Ecoregional Cumulative Distribution Function plots (CDFs)

Two new web-based wetland project analysis features for the California Rapid Assessment Method (CRAM)

Introduction

The latest version of the California EcoAtlas website was released in July 2013 by the San Francisco Estuary Institute (SFEI). It is a free, public interactive service to provide access to information about the abundance, diversity, distribution and condition of wetlands throughout California. It is designed to serve a broad and diverse audience – ranging from policy makers to regulators to researchers to the general public -- who share a common set of questions: "Where are our state's wetlands and how are they doing?" By integrating a diversity of data sources, using interactive maps, charts, and reports, EcoAtlas facilitates the integration of this information at various scales to achieve a watershed scale view. At its core, the functionality of EcoAtlas is map-based so that a user can aggregate information based on either a predefined (i.e. USGS hydrologic unit, watershed, or regional area) or user defined area using the online map-based drawing tools. The content of EcoAtlas includes three main types of information:

1. Graphical Information System (GIS) and remote-sensing data - to assess the distribution, diversity and abundance of wetlands
2. Wetland rapid assessment data - the overall condition of wetlands based on field collected data using the California Rapid Assessment Method (CRAM)
3. Intensive site assessment data – field collected data that provides higher resolution of information on the condition of wetlands in an assessment area. Information can include site-specific measures (such as toxicity or indices of biological integrity) or intensive wetland project monitoring reports.

The California Aquatic Resources Inventory (CARI) is the base layer on the interactive map. CARI is a GIS dataset of wetlands and streams across California, hosting the most detailed data sources whenever possible. CARI allows its users to determine the location and classification of the state's aquatic resources. EcoAtlas also hosts field-collected wetland condition assessments, based on CRAM; wetland project extents and information (via the EcoAtlas base layer and the Project Tracker link), and an interactive Landscape Profile Tool (LP tool), which lets a user summarize these data within a user-defined area.

EcoAtlas, CRAM, and the Project Tracking tools were developed over the course of several years, under the guidance of the California Wetlands Monitoring Workgroup, with support from State and the U.S.EPA projects in support of the Wetland and Riparian Area Monitoring Program (WRAMP[1]). WRAMP tools developed and hosted on EcoAtlas not only support the State Water Board's development of a Wetland and Riparian Area Protection Policy (WRAPP), but provide a degree of standardization necessary for future assessments of the extent and condition of California's wetland resources.

With these web-based tools, environmental managers, scientists and the public can step back from the minutiae of individual restoration projects or stream characterizations to view broader landscape-level summaries. These reports capture aquatic resource extent, salient mitigation projects, and the ecological condition of the wetlands within a user-defined area. This access to information will allow environmental managers to evaluate wetland extent and restoration progress in a landscape context which may avoid authorizing actions that cumulatively degrade the abundance, diversity, and conditions of aquatic resources within a landscape or watershed.

In recognition of the importance of regional processes and functions, wetland managers must have ready access to information about the extent and condition of wetlands in the context of the surrounding landscape to better evaluate the performance of compensatory mitigation projects within its regional context. To that purpose, habitat development curves (HDCs) and regional cumulative distribution function plots (CDFs) have been developed for wetlands using CRAM data. Projects that use CRAM to monitor ecological condition of their wetlands can compare their project scores to the expected HDC and/or the ecoregional CDF using the LP tool on EcoAtlas.

Caltrans provided funding to SFEI to enhance EcoAtlas' analytical tools to allow users to compare project assessments to HDCs for estuarine and depressional wetlands, and both project and non-project assessments to the ecoregional Riverine CDF for 6 regions across the state.

EcoAtlas is gaining recognition as a valuable tool for dependably compiling and delivering critical information about wetlands and related management and regulatory activities to multiple agencies in the service of their programs. It has passed the proof-of-concept stage of development and is moving toward early implementation, especially for project planning and tracking through the CA Habitat Joint Ventures, the Delta Conservancy, and the 401/WDR Program of the State Water Resources Control Board (SWRCB). Interest within the Habitat conservation Planning (HCP)/Natural Community Conservation Planning (NCCP) community and 404 Program is growing. Many local agencies and special districts around the state are also showing keen interest.

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[1] http://www.mywaterquality.ca.gov/monitoring_council/wetland_workgroup/docs/2010/tenetsprogram.pdf

Background and Regulatory Context

State Senate Bill 1070 instigated the establishment of the California Water Quality Monitoring Council (Monitoring Council) and requires the State Boards, departments and offices within the California Environmental Protection Agency (Cal/EPA) and the California Natural Resources Agency to integrate and coordinate their water quality and related ecosystem monitoring, assessment, and reporting. The California Wetlands Monitoring Workgroup (CWMW) is one of many workgroups that supports the Monitoring Council. The CWMW's mission is to improve the monitoring and assessment of wetland and riparian resources by developing a comprehensive wetland monitoring plan for California and increasing coordination and cooperation among local, state, and federal agencies, tribes, and non-governmental organizations.

CWMW evolved from a statewide steering committee originally formed to coordinate among agencies and advise on the development, implementation and routine use of standardized wetland and riparian monitoring and assessment tools. The assessment toolkit, standardized statewide, addresses the three tiered framework advocated by USEPA in their Elements Paper[2]:

Level 1-- habitat inventory and landscape tools,
Level 2-- rapid, field-based assessments of condition, and
Level 3-- intensive measures of condition and functions.

One of the first accomplishments of the CWMW was the publication of the Tenets of a State Wetland and Riparian Monitoring Plan[3] (WRAMP), which outlines a standardized approach for implementing the USEPA Level 1-2-3 framework for wetland monitoring and assessment in California. WRAMP was endorsed by the California Wetlands Monitoring Council (CWMW) in 2010 and adopted in the first phase of the State Water Quality Control Board's development of the Wetland and Riparian Area Protection Policy[4] (WRAPP) in 2012. WRAPP recognizes the tools developed under WRAMP as approved methods for tracking trends in wetland extent and condition in order to assess the performance of wetland, stream and riparian protection policies, programs, and projects. EcoAtlas and its associated analysis tools are part of a larger suite of interrelated tools and resources developed to support WRAMP and the WRAPP.

EcoAtlas and its Intended Uses

The purpose of EcoAtlas and its associated analysis tools is to make recent maps, wetland project information, ecological condition assessments, and other landscape based data about aquatic resource extent and condition accessible to managers, scientists, and the public in a form that is immediately usable so that it can support decision making. The tool will not make

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[2] http://www.cramwetlands.org/sites/default/files/Wetland_Elements_Final.pdf; https://www.epa.gov/sites/production/files/2015-10/documents/2009_03_10_wetlands_initiative_cef_full.pdf

[3] http://www.mywaterquality.ca.gov/monitoring_council/wetland_workgroup/docs/2010/tenetsprogram.pdf

[4] Phase I: "Water Quality Control Policy for Wetland Area Protection and Dredge and Fill Permitting" http://www.waterboards.ca.gov/water_issues/programs/cwa401/docs/wrapp/policy_draft.pdf

decisions (e.g. determine mitigation ratios, determine the best location for restoration projects), but rather will provide landscape based information to support users in making such decisions. The Landscape Profile Tool was developed to support a landscape approach to mitigation planning for aquatic resources. It is likely, however, that this tool will help other environmental programs and projects requiring data management, access, and summaries of wetland data for watersheds or user-defined areas.

There are two levels of questions that EcoAtlas supports: regional questions regarding the ambient conditions within a landscape and local questions about the effects of a particular wetland project on a watershed or landscape. Regional questions include: “Where are our wetlands and what is their condition?”. Local questions include: “How is a particular project affecting a watershed?”. Currently, a “project” is defined as an on-the-ground activity requiring a 401 Certification or Wastewater Discharge Order (WDO). This definition will eventually be expanded to include other regulatory and management activities.

The new HDC and ecoregional CDF analysis features in EcoAtlas begin to address the second question. A user can compare the project condition to the expected habitat development curves and also compare it to the condition of wetlands (of the same wetland type) at the ecoregional scale. At this time HDCs and CDFs for all wetland types do not exist either because there isn’t enough CRAM data to support their development (as in the case of CDFs) or because they have not been developed (HDCs). Caltrans funded SFEI to develop the capability to display these project evaluation analysis features in EcoAtlas so that as HDCs for other wetland types become available they can be more easily added to EcoAtlas. The same for the ecoregional CDFs.

As EcoAtlas and its online tools are further developed they must remain flexible in order to meet the needs of different agencies and user communities. Government programs and other organizations will inherently be interested in using the tools for evaluating areas of different scales, different datasets, and different levels of precision, depending on the questions being asked. EcoAtlas incorporates local and statewide data with an uneven density of information. It is important that users understand the limitations of these data when interpreting the information provided. Descriptions of the data used are provided on the EcoAtlas website (see the ‘Data’ link at the top navigation bar).

CRAM Ecoregional Cumulative Distribution Function Plots

A cumulative distribution function (CDF) of CRAM scores describes the probability that a specific percentage of the assessments in a defined area will have a value less than or equal to a specific CRAM score. A separate CDF is developed for each wetland type. CDFs can be developed for any geographic extent, from projects to watersheds, regions and statewide. CRAM CDFs on EcoAtlas are being developed for California ecoregions. An ecoregional CRAM CDF can be used to compare different areas of one wetland type to each other and the whole ecoregion.

CRAM data from either the statewide Perennial Stream Assessment Program5 (PSA) or the Southern California Stormwater Monitoring Coalition Program6 (SMC – south coast ecoregion only) collected between 2008 and 2013 were used to generate CDFs for 6 ecoregions. Those monitoring programs use spatially balanced random sampling designs to monitor the ecological condition of perennial streams in California. Since 2008, both programs began to assess the overall ecological condition of perennial streams using CRAM, and those data were used to develop the ecoregional CDFs in the Landscape Profile Tool of EcoAtlas. Ecoregional CDFs will be developed for other ecoregions and wetland types as the necessary data become available.

The spatially balanced probabilistic sampling designs of the PSA and SMC assign sample weights to individual assessments representing a portion of the streams within the sampled stream population, making it possible to develop CRAM CDF plots that estimate the proportion of perennial streams within an ecoregion for any CRAM score. For example, in the Index Score CDF plot for the Bay/Delta Ecoregion in Figure 1 (below), 50% of the perennial streams within the region have a CRAM score of ≤ 69 (reading across horizontally on the y-axis and up vertically to the Index Score on the x-axis). Mitigation projects in streams that have CRAM scores can be compared to the ecoregional Riverine CDF to evaluate the ecological condition of the streams in the project area compare to the rest of the ecoregion.

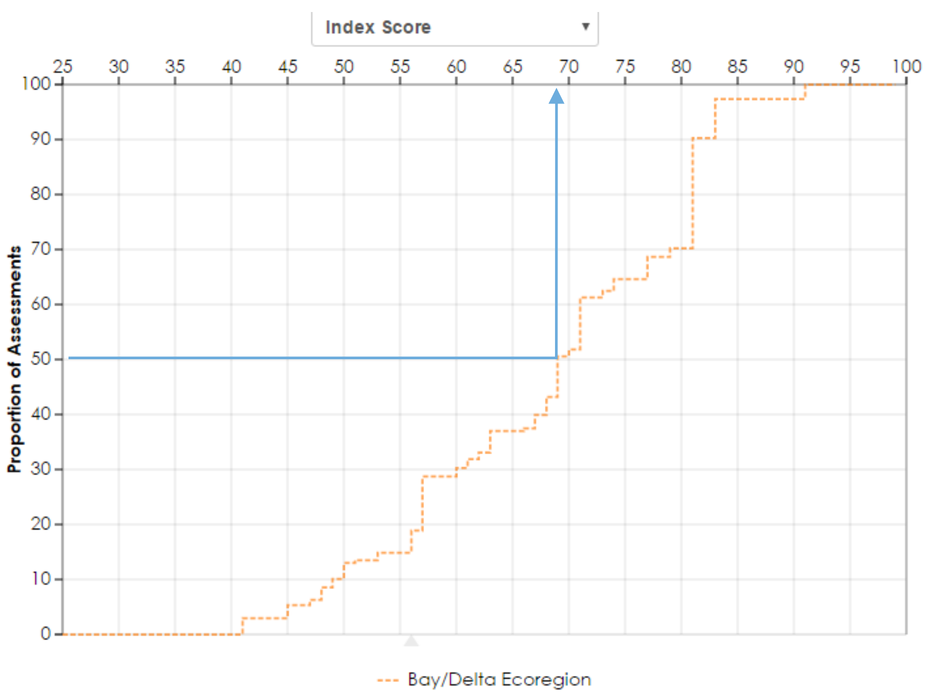

Figure 1. Example CRAM Index score CDF plot for the Bay/Delta Ecoregion.
Data source – PSA (2008-2013).

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5 http://www.waterboards.ca.gov/water_issues/programs/swamp/bioassessment/statewide_program.shtml

6 5-year Regional Stream Survey Report (SCCWRP #844)

Habitat Development Curves

HDCs for Estuarine and Depressional wetlands have been developed based on available CRAM data from across the state. Wetland projects that have associated CRAM assessments (that are designated as publicly viewable) can visually compare their scores to the HDC for the same wetland type.

HDCs are used to determine the developmental status and trajectory of on-the-ground projects to create, restore, or enhance California wetland and stream habitats. Each HDC was developed from a subset of pre-existing statewide CRAM assessments of habitat condition for wetlands of different ages of each wetland type that, in aggregate, represent the full spectrum of habitat development. The estuarine HDC was drafted in 2014 (SFEI, 2014[7]), while the depressional HDC was developed under this Caltrans project, and is reported on in the Task 3 memo. Figure 2 shows a screenshot of the HDC for estuarine wetlands with overlaid CRAM assessments from one wetland creation project that was assessed within only a few years of project completion.

For each HDC, reference condition is represented by areas of a habitat that consistently get very high CRAM scores, have not been subject to disruptive management practices, and exist within landscapes that are protected and managed for their natural conditions. The horizontal lines intersecting the top of an HDC represent the mean CRAM score and standard deviation of scores for qualifying reference areas.

The age of a project is estimated as the elapsed time (in years) between the groundwork end date for the project and the date of the CRAM assessment. The minimum age of a non-project area, including any natural reference area, is estimated from all available local information, including historical maps and imagery, historical written accounts, and place-specific scientific studies of habitat development.

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[7] Developmental Trajectory for California Tidal Marsh Restoration and Mitigation Projects (SFEI, 2014) http://www.sfei.org/documents/developmental-trajectory-california-tidal-marsh-restoration-and-mitigation-projects

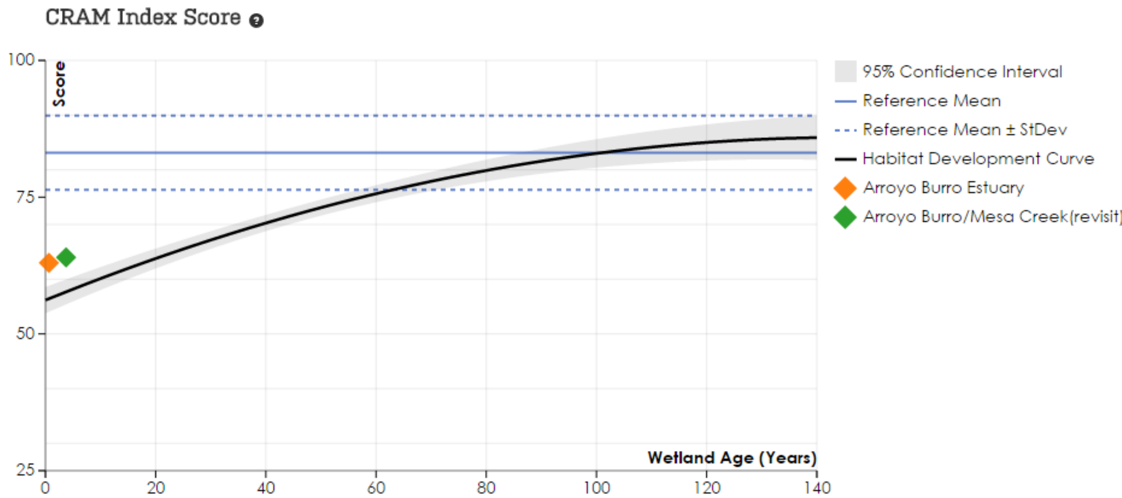


Figure 2. Screenshot of the Habitat Development Curve (HDC) comparing two estuarine CRAM assessments within the Arroyo Burro Estuary wetland creation project to the estuarine HDC and reference condition range.

A HDC can be used to address the following questions:

A. ***At what time in the future will the area of assessed habitat achieve the reference condition or other milestones in habitat development?*** The HDC can answer this question if the CRAM score for the assessed area is within the confidence interval of the HDC. The answer is the time in years along the HDC between the current age of the assessed area and the future date corresponding to the intersection of the HDC and the reference condition or other milestone.
B. ***Is the area of assessed habitat likely to develop faster, slower, or at the same pace as most other areas of the same habitat type?*** The habitat area is likely to develop faster, slower, or at the same pace if the CRAM score for the area is above, below, or within the confidence interval of the HDC, respectively.
C. ***What can be done to improve the condition of the habitat area or to increase its rate of development?*** HDCs by themselves cannot answer this question. Possible answers can be inferred by the following analysis that involves HDCs:
    1. Examine the HDC for each of the four CRAM Attributes;
    2. Identify the Attribute(s) scoring below the HDC;
    3. For any low-scoring Attribute, examine the component Metric Scores (note: the Metric Scores for any public CRAM assessment in the CRAM database can be obtained through EcoAtlas);
    4. Assume the low score of an Attribute is due to its low-scoring Metric(s);
    5. Consider modifying the design or management of the habitat area in ways that will sustainably increase its score(s) for the low-scoring Metric(s).

Landscape Profile Tool User Interface

The Landscape Profile Tool is embedded in the EcoAtlas website (www.ecoatlas.org). The Tool can be accessed through the "Map" viewer of EcoAtlas by clicking on the "Tools" button above the map (Figure 3). Once the Landscape Profile Tool has been selected, users are prompted to choose one of four options for delineating the geographic area of interest: 1) use StreamStats, 2) draw your own polygon, 3) choose from pre-defined regions, or 4) upload your own KML file.

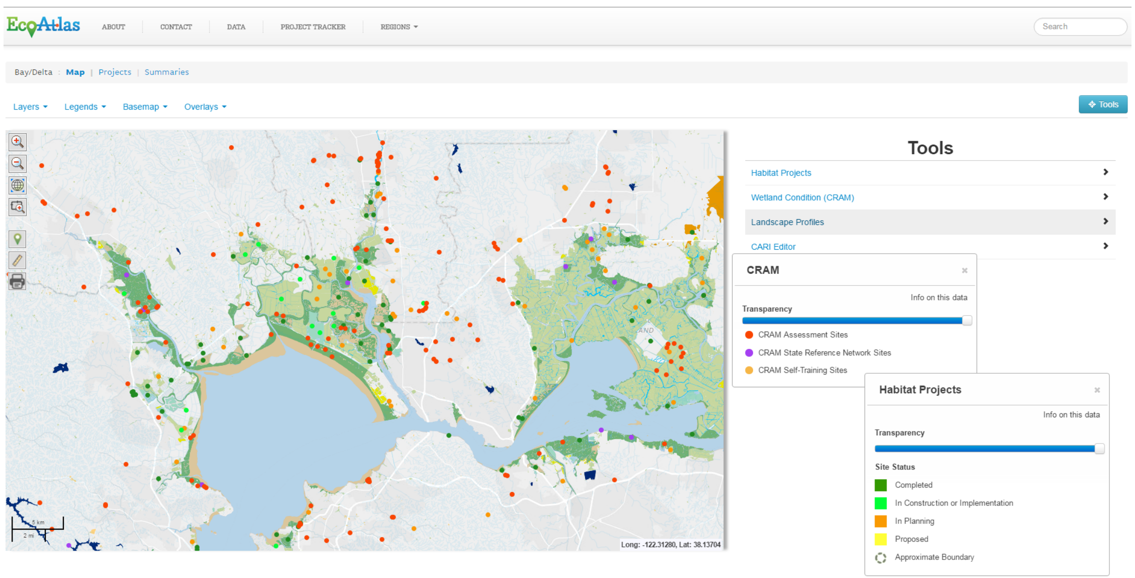


Figure 3. Screenshot of EcoAtlas and the Landscape Profile Tool's webpage.

Once the area of interest has been selected (or drawn), the user clicks on the new polygon and a web-based 'pop-up' summary report of the Landscape Profile is generated (Figure 4). The user can scroll through the summary profile online or print a copy of the report by clicking on the "Print Report" button at the top of the pop-up.

The Landscape Profile includes the total area of the user-selected area and summary charts and tables of the abundance and diversity of the current aquatic resources within the area, the extent of types of historical habitats (if available), overall wetland condition (based on CRAM), a list of wetland projects, species of special concern, estimates of population and spoken languages, and land use and development information.

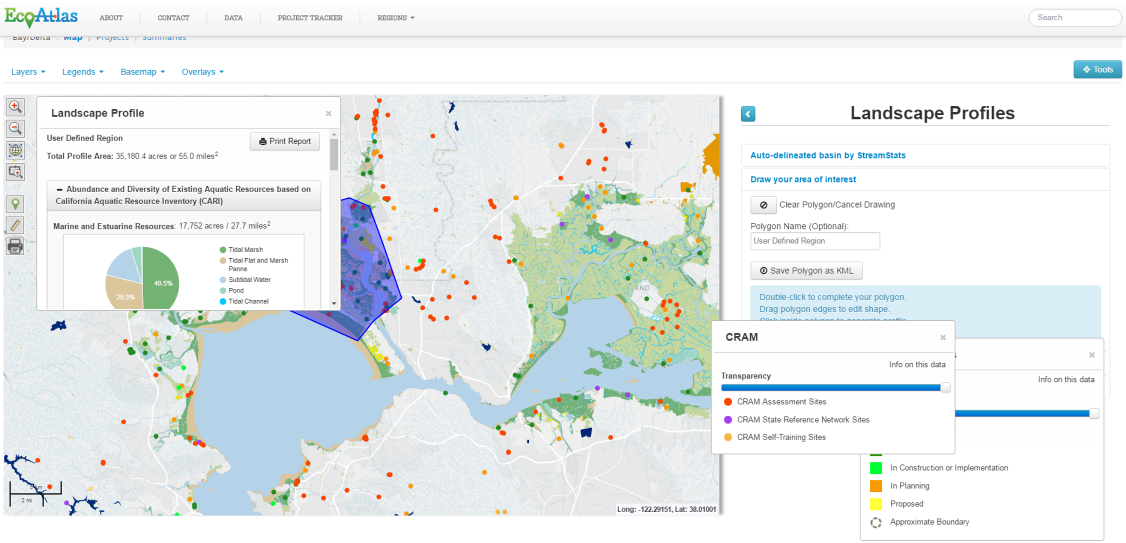


Figure 4. Screenshot of the Landscape Profile "pop-up" summary.

For wetland restoration projects and CRAM assessments the user has the option to "drill down" to get additional information (Figure 5), and also click on the Project Details button to access all the available project information and documentation that has been uploaded to the Project Tracker (Figure 6). The user can also zoom to the project on the EcoAtlas basemap.

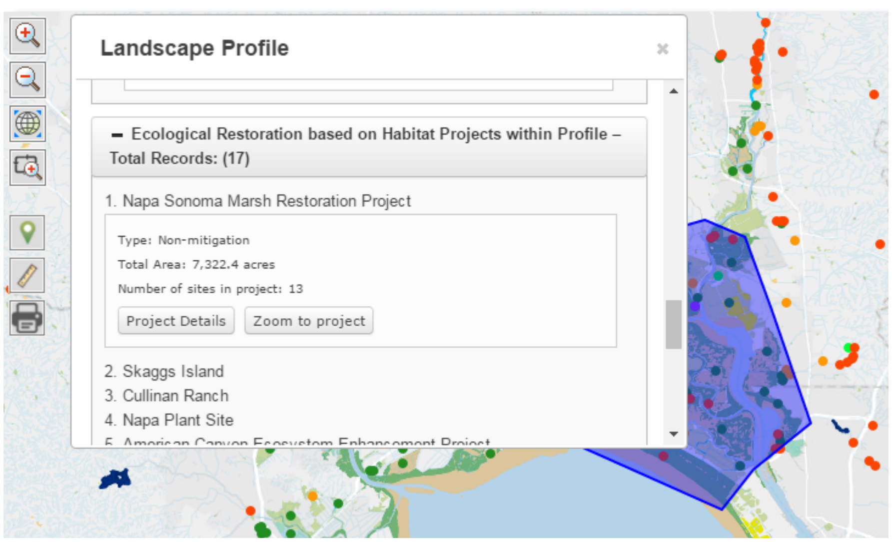
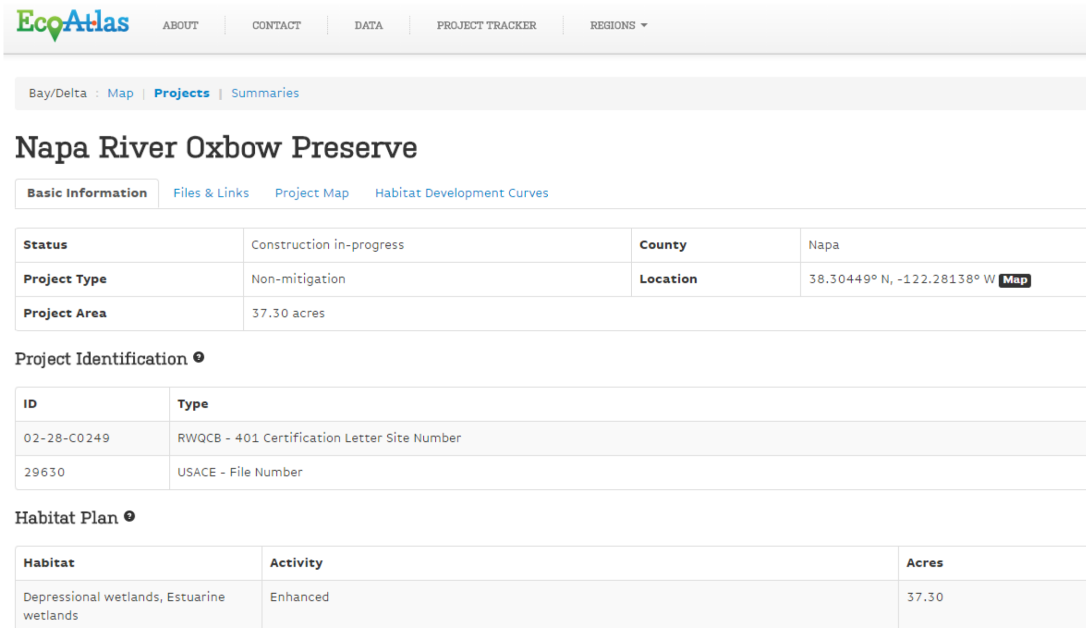


Figure 5. Screenshot of a wetland project and CRAM assessment where the user can further "drill-down" to additional project details and/or documents, zoom to a map of the project area, or further access CRAM scores for a specific ecological condition assessment within a user-define, profiled area.



EcoAtlas ABOUT CONTACT DATA PROJECT TRACKER REGIONS

Bay/Delta : Map | Projects | Summaries

Napa River Oxbow Preserve

Basic Information | Files & Links | Project Map | Habitat Development Curves

Status	Construction in-progress	**County**	Napa
Project Type	Non-mitigation	**Location**	38.30449° N, -122.28138° W Map
Project Area	37.30 acres		

Project Identification

ID	Type
02-28-C0249	RWQCB - 401 Certification Letter Site Number
29630	USACE - File Number

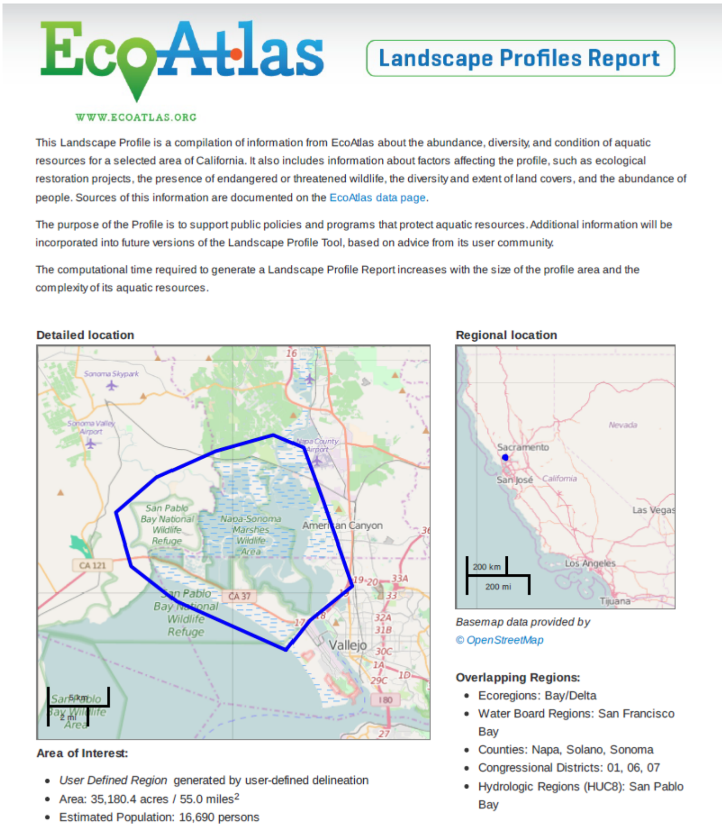
Habitat Plan

Habitat	Activity	Acres
Depressional wetlands, Estuarine wetlands	Enhanced	37.30

Figure 6. Screenshot of a single project’s “Basic Information” page accessed by clicking the Project Details button from within the pop-up of the LP tool, or from the “Projects” link at the top of the web-page (once a user has zoomed to a specific region).

Scrolling to down to the Aquatic Resource Condition based on CRAM section of the profile, the user can “drill-down” to the list of the CRAM site names and interactively get more site specific information, and can click a button to view the CRAM scores depicted on the ecoregional CDF (if you have selected an area that include riverine or depressional wetlands that have been assessed using CRAM).

The downloadable Landscape Profile PDF report (available from the Print Report button at the top of the pop-up) includes additional background explanations about what the Tool summarizes (Figure 7). It includes a map of the user defined area of interest and its general location within the state, the total acreage of the profiled area, population, name/s of the Regional Water Quality Control Board (Water Board Regions), Congressional District, and USGS hydrologic regions. However, the pdf report does not contain CNDDB data or the detailed information on individual restoration project or CRAM assessments that are in the online pop-up view. Instructional videos are available on EcoAtlas to guide users through the website, and through the Landscape Profile Tool in particular (http://www.ecoatlas.org/about).


EcoAtlas Landscape Profiles Report

WWW.ECOATLAS.ORG

This Landscape Profile is a compilation of information from EcoAtlas about the abundance, diversity, and condition of aquatic resources for a selected area of California. It also includes information about factors affecting the profile, such as ecological restoration projects, the presence of endangered or threatened wildlife, the diversity and extent of land covers, and the abundance of people. Sources of this information are documented on the EcoAtlas data page.

The purpose of the Profile is to support public policies and programs that protect aquatic resources. Additional information will be incorporated into future versions of the Landscape Profile Tool, based on advice from its user community.

The computational time required to generate a Landscape Profile Report increases with the size of the profile area and the complexity of its aquatic resources.

Detailed location

Regional location

Basemap data provided by © OpenStreetMap

Area of Interest:

- *User Defined Region* generated by user-defined delineation
- Area: 35,180.4 acres / 55.0 miles²
- Estimated Population: 16,690 persons

Overlapping Regions:

- Ecoregions: Bay/Delta
- Water Board Regions: San Francisco Bay
- Counties: Napa, Solano, Sonoma
- Congressional Districts: 01, 06, 07
- Hydrologic Regions (HUC8): San Pablo Bay

Figure 7. Screenshot of part of the first page of the Landscape Profile Tool's downloadable PDF report showing the user defined area and regional location map.

EcoAtlas Platform

The Landscape Profile Tool and EcoAtlas are built almost exclusively with free and open-source software (FOSS), using broadly adopted software standards. Non-FOSS components are indicated below with an (*). EcoAtlas and the Landscape Profile Tool are powered by an Apache web server that resides on an Ubuntu Linux server. Landscape Profile data local to the EcoAtlas server are stored in a PostgresSQL database server. Non-local data accessible in the Landscape profile tool include: (1) remote ESRI*, Google* and OpenStreetMap basemaps; (2) the USGS StreamStats basin data; and (3) the CA DFG CNDDB QuickView data. The PostGIS extension to the database (http://postgis.net) enables the geospatial queries that produce the Landscape Profile Tool results.

The LP Tool web map engine is MapServer 6.4.1 (mapserver.org). MapServer retrieves geographic data from the PostgreSQL/PostGIS database and renders these data on the EcoAtlas web map and in the Landscape Profile report maps. This process is based on the Open Geospatial Consortium's (OGC) Web Map Server Implementation Specification 1.1.1, an open and standard protocol. For some of the profiled datasets MapCache 1.2.1 is used in conjunction with MapServer to provide quick rendering of mapped images, or tiles.

The Landscape Profile Tool and EcoAtlas user interface, eg the web site, is primarily built on OpenLayers (openlayers.org), a free and open source JavaScript web mapping library. Other components of the user interface include the JavaScript libraries jQuery.js, bootstrap.js and Chosen.js, as well as Adobe Typekit. Additionally SFEI created custom graphic elements, icons, and images to increase the usability and appeal of the site. The Landscape Profile Tool PDF report is rendered using the tool wkhtmltopdf (wkhtmltopdf.org). Interactions between the user interface and the backend components are handled via AJAX and PHP.

Browser compatibility

EcoAtlas and the Landscape Profile Tool are designed to be compatible with the four major web browsers - Internet Explorer, Chrome, FireFox and Safari. We test extensively on Internet Explorer versions 9 and above as well as the most recent releases of the three other browsers. That said, the operation and appearance of the tool may differ slightly in the different browsers. We encourage users to report browser related issues so that we may investigate and address any functional inconsistencies.

Next steps

EcoAtlas and its data analysis tools continue to be improved and developed, and additional functionality can be added as warranted.

Additional functionality to support future on-line mitigation permitting and tracking might include analysis of the site suitability of potential mitigation sites, or creation of "future" profiles. These future profiles would include expected mitigation results (abundance, type, and condition of wetlands), which would facilitate comparisons of current and future profiles, or comparison of alternative plans.

Additional CRAM reporting might include providing context for interpreting site specific CRAM results. Possibilities include:

- Further developing the ecoregional CDF plots based on existing, ambient statewide CRAM assessments by selecting a subset of available data to create a spatially balanced random sample of CRAM scores for all wetland types that have adequate spatial coverage of the wetland resources.
- Currently riparian metrics are not included in EcoAtlas or the Landscape Profile Tool. However, a riparian buffer estimation tool has been developed by SFEI-ASC, which may be integrated into EcoAtlas in the future. This tool estimates riparian extent on the basis of mapped hillslope and vegetation characteristics. Riparian habitat is very important to wetland function, particularly for streams where riparian habitats contribute to physical structure, temperature regulation, and wildlife support in and around streams. Future riparian metrics that could be included in the Landscape Profile Tool are riparian area by wetland type and riparian width for riverine wetlands.
- Ecological connectivity of aquatic resources is an important consideration for landscape planning and wildlife management. Including habitat connectivity metrics in the landscape profile would be particularly valuable for supporting Habitat Conservation Planning and Natural Community Conservation Planning. Development of such metrics is tricky because typical measures of fragmentation (e.g. patch size distribution, nearest neighbor distance, edge to area ratio) depend on identification of wetland patches, which is generally species specific. The ecological connectivity tool will likely need to be developed on a species-by-species basis.

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