SFEI AQUATIC SCIENCE CENTER

NUMBER 725
SEP 2014

Creating Landscape Profiles of Aquatic Resource Abundance, Diversity and Condition

An Interactive, Web-based Data Analysis Tool that Supports California's Wetland and Riparian Area Monitoring Plan (WRAMP)

Funded by:
EPA-REG9-WP Grant # CD-00T54701-3

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THIS REPORT SHOULD BE CITED AS:

Lowe, S., A. Robinson, P. Frontiera, K. Cayce, and J. Collins (2014). Creating Landscape Profiles of Aquatic Resource Abundance, Diversity and Condition: An Interactive, Web-based Data Analysis Tool that Supports California's Wetland and Riparian Area Monitoring Program (WRAMP). Report prepared for and funded by EPA-REG9-WP Grant # CD-00T54701-3. San Francisco Estuary Institute & Aquatic Science Center, Richmond, CA. Contribution #725

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INTRODUCTION

The processes that affect wetland functions and ecological condition occur at multiple scales. Wetlands are influenced by their location in the landscape and the proximity, extent and ecological condition of surrounding aquatic resources. The hydroperiod and sediment dynamics within wetlands are often affected by larger, regional processes. Beneficial uses of a wetland such as fisheries protection and wildlife support, depend on the abundance, diversity, and ecological conditions of aquatic resources both inside and outside wetlands at a broad landscape scale.

In recognition of the importance of regional processes and functions, wetland managers need to have easier 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.

The EcoAtlas website was developed by the San Francisco Estuary Institute/ Aquatic Science Center through other Federal funding and hosts the Landscape Profile Tool (funded by EPA Grant # CD-00T54701-3). EcoAtlas hosts the California Aquatic Resources Inventory (CARI) an interactive map of the most current efforts to develop detailed maps of the extent of wetlands and streams across California. Through various funding sources mapping efforts have intensified the level of detail in the Bay Area, Tahoe, the Santa Rosa Plain, and parts of Southern California. Those detailed maps have been incorporated into NWI and NHD maps and made available through EcoAtlas. EcoAtlas also includes 1) compensatory mitigation project maps and information and 2) results of rapid assessments of wetland ecological condition (using the California Rapid Assessment Method for Wetlands (CRAM)) from field surveys conducted across the State and hosted on the CRAM website. EcoAtlas, CRAM, and the Project Tracking web-services were developed with support from State and the U.S.EPA in support of the Wetland and Riparian Area Monitoring Program (WRAMP[1]). WRAMP and the online tools that are being developed under the program, not only support the State Water Board's development of a Wetland and Riparian Area Protection Policy (WRAPP), but to also provide a necessary 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, have access to landscape level summaries of aquatic resource extent, mitigation projects, and ecological conditions of the wetlands within a user defined area. This access to information will allow managers to evaluate wetland extent and restoration progress in a landscape context which

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

may avoid authorizing actions that cumulatively degrade the abundance, diversity, and conditions of aquatic resources within a landscape or watershed.

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:

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 (WRAMP)[2], 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 (WRAPP) in 2012[3]. 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. The landscape profile tool is part of a larger suite of interrelated tools and resources developed to support WRAMP and the WRAPP.

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

[3] 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

The Landscape Profile tool is part of the California EcoAtlas, which provides free public access to information about the quantity and quality of California wetlands. EcoAtlas (www.ecoatlas.org) is the user-interface for WRAMP. Ecoatlas is a data and information management and delivery system with tools designed to support selected environmental regulatory and planning decisions. EcoAtlas contains the most current aquatic resources maps for the state, restoration and mitigation project information, summary tools, and environmental data. The Landscape Profile tool enables integration of information in EcoAtlas characterize the abundance, diversity, and condition of aquatic resources in the landscape context. EcoAtlas and its associated tools allow users to explore or summarize data in different ways depending on user needs, and it includes data collected in a manner that supports current state wetland policy. These tools can be used to create a picture of aquatic resources in a selected landscape by integrating stream and wetland maps, restoration information, and monitoring results with land use, transportation, and other information important to the state's wetlands.

The California Environmental Data Exchange Network (CEDEN; www.ceden.org) is a data management system for environmental data related to surface water bodies in California. By consolidating data in a central location, CEDEN facilitates easy access to statewide monitoring data for managers, scientists, citizen groups, and the public. EcoAltlas has the ability to display water quality and contaminant data from CEDEN and (at the time of this report) showcases water and sediment toxicity data from CEDEN.

The State Wetland Portal (www.mywaterquality.ca.gov) provides the public with answers to important questions about California wetlands, including "What is the extent of wetlands?" and "How healthy are our wetlands?" Data from EcoAtlas and CEDEN are used to answer these questions. The landscape profile tool allows users to explore wetland data for specific, user-defined area and as a result, provides less explanation and interpretation for the summary report. However, these reporting and summary tools rely on the same datasets and complement one another.

THE LANDSCAPE PROFILE TOOL AND ITS INTENDED USES

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 summaries of wetland data for watersheds or user-defined areas. The purpose of EcoAtlas and the Landscape Profile Tool is to make recent maps and other data about aquatic resource extent and condition accessible to managers and decision-makers in a form that is immediately usable so that it can support decision making. The tool will not make 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.

There are two levels of questions that the Landscape Profile Tool supports: regional questions regarding the ambient conditions within a landscape and local questions about the effects of a particular 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.

As the Landscape Profile Tool is further developed it must remain flexible in order to meet the needs of the different agencies and user communities. Government programs and other organizations will inherently be interested in using the Tool 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).

DEVELOPMENT OF THE LANDSCAPE PROFILE TOOL

The Landscape Profile tool was developed with regular input from regulators, managers and technical science advisors to ensure that would be easy to use and provided relevant information for aquatic resource managers. An advisory group of local and national experts was convened at the initial phase of the project to (1) review the initial design of the tool relative to its intended uses; (2) recommend the kinds of input data, metrics derived from these data, and the summary outputs of the profiles for the intended uses; and (3) identify other potential uses of the tool and recommend directions for its development. This inclusive development approach allowed for flexible and efficient development of the Landscape Profile Tool.

Landscape metrics to be summarized by the Landscape Profile Tool were compiled and internally vetted for ecological and hydrological significance before being further vetted and reviewed by the technical advisory group. Criteria for determining metrics and features to include in the profile included the level effort, data availability, and prioritized need. A long list of metrics related to wetland extent and ecological condition, land use, restoration activity, and ecological value were considered (see Appendix). Some of the metrics not included in this first iteration of the current Landscape Profile Tool may be added in future versions as funding and resources allow (see Next Steps).

In later stages of the tool development, web-enabled demonstrations were held to acquire feedback from agency staff and potential users on the Landscape Profile Tool, and the EcoAtlas website in general. The Tool was also presented and vetted with the CWMW. These demonstrations provided valuable feedback on the content, functionality and utility of the

Landscape Profile Tool that was then used to make improvements. Demonstrations were held every 4-6 weeks between Oct 2012 and the release of EcoAtlas in July 2013.

Throughout the development process careful consideration was given to the options available for delineating the area of interest for which the Landscape Profile would be generated. This area of interest can be a watershed, small project area, administrative boundary, or any user defined area (polygon). Current delineation options include 1) a dynamically defined watershed drawn upstream from a user-selected 'pour point', 2) a user-defined area of interest that is drawn using the on-line tools, and 3) a pre-defined, administrative or watershed boundary, such as a county or USGS watershed or basin codes (HUCs) (Table 1).

The first of these options uses the StreamStats tool, developed through a cooperative effort of the USGS and ESRI, Inc (streamstats.usgs.gov). USGS StreamStats allows users to define a topographic watershed by defining a pour point. One downside of the tool is that StreamStats, as currently developed, is particularly subject to error in flat or highly developed areas, and watersheds delineated via StreamStats should be checked for accuracy by the user.

The second delineation option allows users to draw their own area of interest by hand, using the online drawing tool. This option supports users interested in non-watershed based area or a watershed area that StreamStats does not properly delineate.

User can also generate profiles for the following pre-defined administrative or watershed areas: Congressional Districts, counties, and three USGS hydrologic watershed types (HUC8, HUC10, and HUC12). Congressional Districts are based on the 2011 boundaries.

A user can download, upload, and/or change the shape of a selected profile area. Any area that was created in the Landscape Profile Tool can be downloaded as a KML file, which can later be opened in Google Earth. And, any area of interest (polygon) from an ESRI shape file or a KML/KMZ can be uploaded to the Landscape Profile Tool in order to generate a profile summary. One can also edit and adjust the shape of a profile area that is already created. These customizing features make the tool more flexible, and easier to use.

Table 1. Delineation options allow the user to define the landscape area of interest in several different ways.

Delineation Option	Description
Topographic Basin	A dynamically defined watershed delineation drawn upstream of a user-selected pour point, based on the USGS Stream Stats service.
User defined polygon	Area of interest that is drawn using on-line tools and can be a watershed or non-watershed polygon
Pre-defined polygon	Widely used administrative and watershed boundaries: Counties, Congressional Districts, and Hydrologic Regions (HUC8, HUC10, and HUC12).
Download polygon	Users can download a polygon that they created as a KML file that can then be opened in Google Earth.
Upload polygon	Users can upload a polygon using a ESRI shape file or KML/KMZ.

LANDSCAPE PROFILE TOOL CONTENT

Aquatic Resources

The aquatic resources summary given by the Landscape Profile Tool provides the total acreage of different wetland types within the user-defined landscape. Wetlands are grouped by tidal influence. For both tidal and non-tidal wetlands the tool provides the relative percent Classifications of different wetlands follow CARI standards.

CARI is a standardized statewide map of wetlands in California compiled from multiple data sources, including the National Wetland Inventory (USFWS) and National Hydrography Dataset (USGS). These datasets are used to produce seamless coverage of the abundance and distribution of wetlands in the state. The Landscape Profile Tool clips a user defined area or watershed and summarizes the aquatic resources within the shape area in acres. Pie charts are used to show percentages of each wetland type. Streams are classified as drainage features. Drainage features include channels, large ditches and sloughs, but do not include storm drains. The Landscape Profile Tool displays total linear extent for drainage features within the user define area.

The diversity, extent, and position of wetlands in a landscape determine the beneficial uses they support. Different wetland types support different species and vary in the degree to which they support other wetland services such as groundwater recharge, carbon sequestration, or nutrient cycling. The position of wetlands within a landscape can influence the impact and success of restoration projects within a region. Results from the Landscape Profile Tool can help inform managers on the degree to which restoration or construction will change the wetland composition of the landscape.

The mapped aquatic resources available through EcoAtlas and CARI cannot be used for jurisdictional delineations, but rather they are a first-cut at identifying the potential absence or presence of aquatic resources in a specific area for planning, permitting (providing context), and sampling (developing study designs). Local intensifications of CARI data exist for certain areas, providing a higher resolution of aquatic resource data (e.g. the Bay Area Aquatic Resources Inventory and Tahoe Aquatic Resources Inventory). The uneven density of map data across the state must be considered when interpreting the landscape profile summaries.

Historical Aquatic Resources (Wetland extent)

The EcoAtlas maps of Historical Aquatic Resources combines 12 separate historical ecology research projects, conducted by SFEI-ASC, and spanning from 1998 to 2013. For each research project, an array of heterogeneous data source s was compiled and analyzed in order to map the historical landscape in GIS. These research projects developed maps of habitat extents prior to Euro-American settlements using spatial data sources including historical maps, surveys, and aerial photos and non-spatial sources such as early explorers' journals, travelers' accounts, and newspaper articles.

Historical ecology data can provide insight into how landscapes maintain ecological functions and can help to identify restoration opportunities and constraints within an area. The goal of the historical ecology mapping projects which provided this data was to inform habitat restoration, watershed management, flood protection, and local education. More information on the individual research projects that contributed to this dataset, including biobliographic references, methodology and published reports can be found on the SFEI website (http://www.sfei.org/HE-Projects).

As with modern aquatic resources, historical aquatic resources are reported as the overall extent of habitats (in acres) with pie charts to show percentages and total linear extent for drainage features. However, the historical data also includes terrestrial habitat features such as grasslands, oak woodland and chaparral. Historical data is available for a limited set of locations only.

Wetland Projects

The wetland Projects page in EcoAtlas contains information on wetland creation and restoration projects (mostly compensatory mitigation projects) in the San Francisco Bay Area, the Central Coast, the South Coast and the Tahoe area. Wetland project information may be available for other areas in the future. In the San Francisco Bay Area, project information is required to be added to EcoAtlas for all new 401 certified projects as part of the permitting process. The Projects page on EcoAtlas allows a project manager to submit reports, maps, and other project

information to an existing project or complete an online form to add new projects and submit a KML of the project extent. The submissions are periodically screened by the EcoAtlas service team to make sure they are authentic and then added to EcoAtlas.

The Landscape Profile Tool draws from the wetland Projects database in EcoAtlas to list projects located within the selected area of interest. Within the Landscape Profiles summary report the user can see the project type, project area, and number of CRAM sites within the project boundaries. The "Project Details" option in the web report directs the user to the project information page. The project information page provides details on the size, construction status, county, contacts, and planned activity of the project. In addition, some projects have loaded up supporting documents and materials such as monitoring reports, permits, and photos related to the restoration effort. These additional materials are stored on the project's file repository within EcoAtlas and project leads can add documents at any time.

Information about existing wetland projects within an area can facilitate communication among resource managers and aid in considering the cumulative impacts from multiple projects in an area. Although the wetland projects database is frequently updated, the list of projects in an area may not be comprehensive. At this time only the San Francisco Bay Regional Water Quality Control Board requires all permitees to enter their projects into EcoAtlas.

Wetland Condition Assessments Using the California Rapid Assessment Method (CRAM)

Rapid assessments provide standardized, cost-effective tools for land use planning and project evaluation. The score from a rapid assessment indicates where a wetland falls on the continuum ranging from best achievable ecological condition (or least-impacted condition) to highly-degraded. CRAM was developed as a rapid assessment method for all wetland types across California. CRAM provides a measure of the extent to which wetland area is providing the services and functions that a fully functioning wetland provides. Degraded wetland systems would be expected to have low overall CRAM scores for a portion or all the wetland assessed. Rapid assessment methods are especially helpful as an initial screening tool for identifying areas where more intensive monitoring may be warranted.

CRAM is a field-based assessment of a pre-measured wetland area (about 1 HA in size). The resulting overall ecological condition score is a multi-metric index based on four main attributes with underlying metrics and sub-metrics related to wetland condition. The four attributes include: landscape context, hydrology, physical structure and biotic structure. The maximum possible Overall CRAM Score represents the best condition that is likely to be achieved for the type of wetland being assessed. The Overall CRAM Score for a wetland therefore indicates condition relative to the best achievable condition for that wetland type in California.

Correct interpretation of CRAM scores requires consideration of the context for conducting the CRAM assessment, whether it was part of an ambient survey or project assessment. "Ambient" CRAM assessments are usually part of a larger survey to assess ambient wetland condition within a specific study area. "Project" CRAM assessments are used to identify the initial range in ecological condition within a restoration project for which an action is proposed or to monitor restoration success over time. CRAM scores should only be interpreted to the area they were designed to assess, as they will not necessarily reflect conditions for the whole Landscape Profile tool user-defined area. However, one can compare site specific assessments to probability survey results with in the area if they exist. The Santa Clara Valley Water District has conducted several ambient watershed surveys of streams within Santa Clara County since 2010 for the specific purpose of understanding the extent of the wetland resources and overall ecological condition of streams within their District. The District has adopted a 1-2-3 framwork to ecological monitoring and assessment outlined in their Ecological Monitoring & Assessment Framework Technical Plan[4].

Species of Special Concern- California Natural Diversity Database (CNDDB)

The Landscape Profile tool uses CNDDB QuickView, the non-subscription, publically available version of the California Natural Diversity Database[5] to report on the status and locations of rare plants and animals in California. CNDDB is a collection of wildlife sighting data that constitute the most complete set of information available on the State's declining and/or vulnerable taxa. Data are available at the 7.5' Quadrangle and County level only. All special status species from quadrangles that overlap with the defined landscape are reported, although the species reported may not necessarily inhabit the area of overlap. Including CNDDB data in the landscape profile highlights species of concern that may be in the area and can be used as a starting point for further investigation into protected species in the region.

CNDDB is not an exhaustive and comprehensive inventory of all rare species and natural communities statewide. CNDDB concentrates its work on areas with active Natural Community Conservation Plans or Habitat Conservation Plans, as well as high priority areas identified by the California Department of Fish and Wildlife and other biologists. No inference can be made regarding lands that have not been surveyed, and it is never appropriate to conclude that an area contains no rare taxa based on the CNDDB data.

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[4] http://www.valleywater.org/Services/HealthyCreeksandEcoSystems.aspx

[5] www.dfg.ca.gov/biogeodata/cnddb/mapsanddata.asp

Land Use and Development (Census and Land Use)

Development can have profound effects on the condition of wetlands within a landscape, particularly with regard to hydrological modification, and therefore basic measures of urbanization and human influence are included in the landscape profile using land cover and census data.

The Landscape Profile Tool includes information about the extent and relative percentages of six types of developed land: low, medium, high density development, developed open space, crops and pasture. The information is derived from the National Land Cover Database 2011 (NLCD 2011). NLCD 2011 is the most recent product created by the Multi-Resolution Land Characteristics (MRLC) Consortium. The NLCD 2011 is a map of land cover classified into a 16 class land cover classification scheme that has been applied consistently across the United States at a spatial resolution of 30 meters. This dataset was developed using unsupervised spectral image classification of the Landsat Enhanced Thematic Mapper+ (ETM+) circa 2006 satellite imagery. For more information about NLCD 2011 and MRLC, go to: http://www.mrlc.gov/nlcd2011.php

The Landscape Profile includes information about the population and languages spoken in the profiled area based on the latest census by the U.S. Census Bureau. The census data is a product of the Fire and Resource Assessment Program (FRAP) at CAL FIRE. FRAP acquired the original census data from the US Department of Commerce, US Census Bureau, Geography Division and, using methods recommended by the Bureau, developed a GIS layer of population and housing counts by census block. FRAP further refined the analysis of population density on habitable lands reported in this layer.

The census blocks not exactly match the boundaries of a user defined profile area. Therefore the Tool adjusts the census data based on the proportions of census blocks within the user define area. Information about languages spoken within the profile is included to support environmental outreach and education.

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 1). 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.

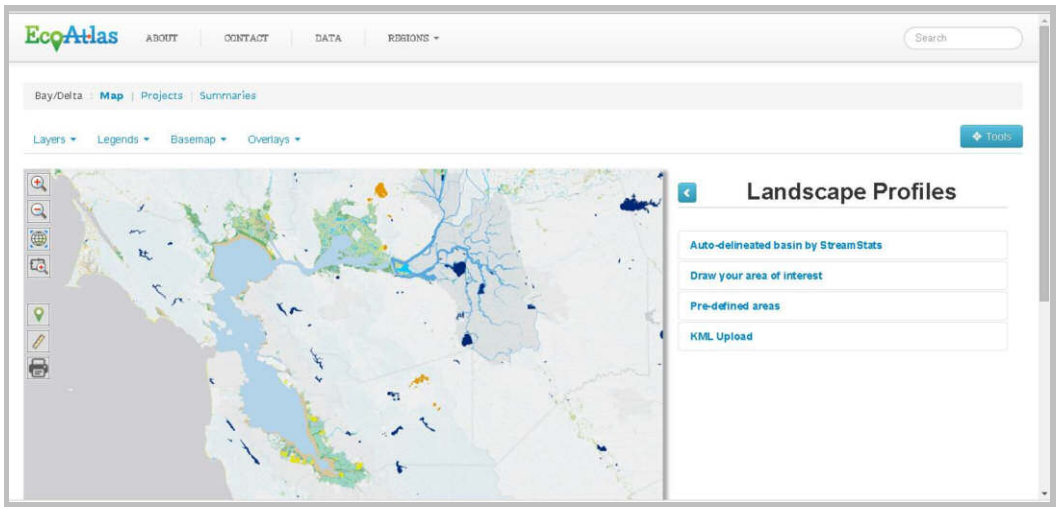

Figure 1. Screenshot of EcoAtlas and the Landscape Profile Tool's webpage.

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 2). 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-defined 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.

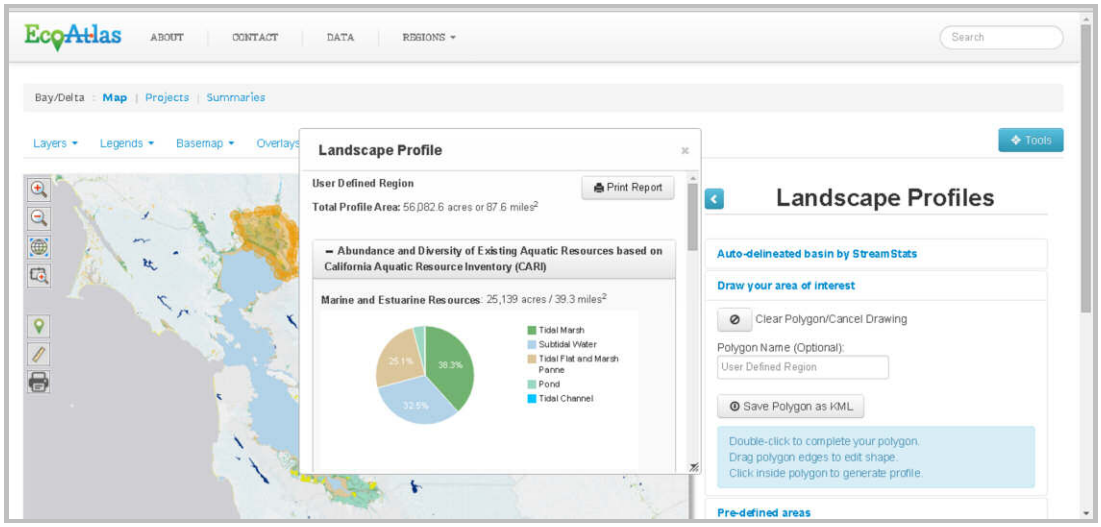

Figure 2. Screenshot of the Landscape Profile "pop-up" summary.

For wetland restoration projects and CRAM assessments the user has the option to "drill down" to get additional information (Figure 3).

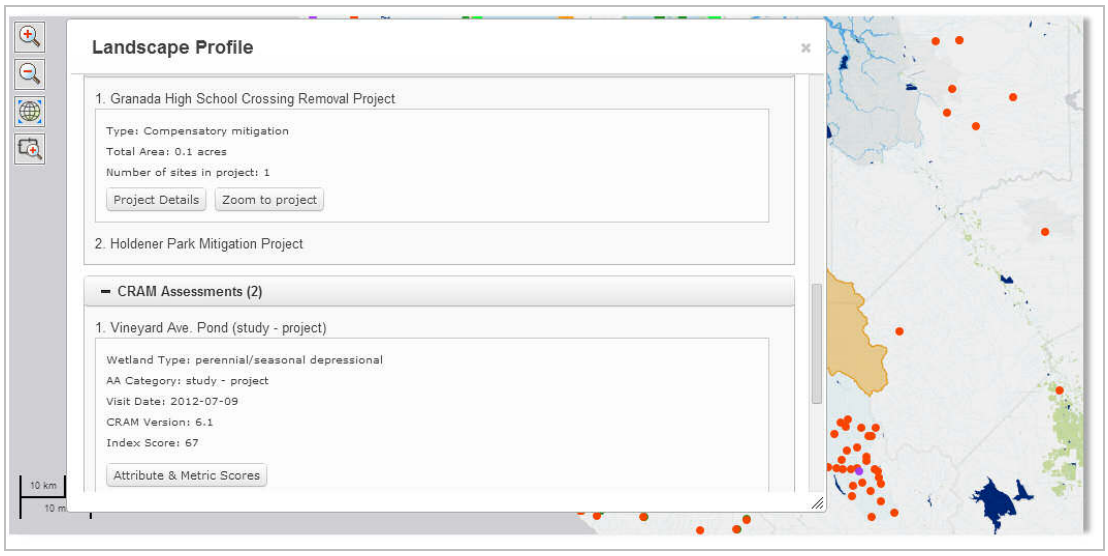

Figure 3. Screenshot of a wetland project and CRAM assessment where the user can further "drill-down" to additional project details and/or documents, zoom to a map of the project area, or further access CRAM scores for a specific ecological condition assessment within a user-define, profiled area.

The downloadable Landscape Profile PDF report includes additional background explanations about what the Tool summarizes (Figure 4). 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).

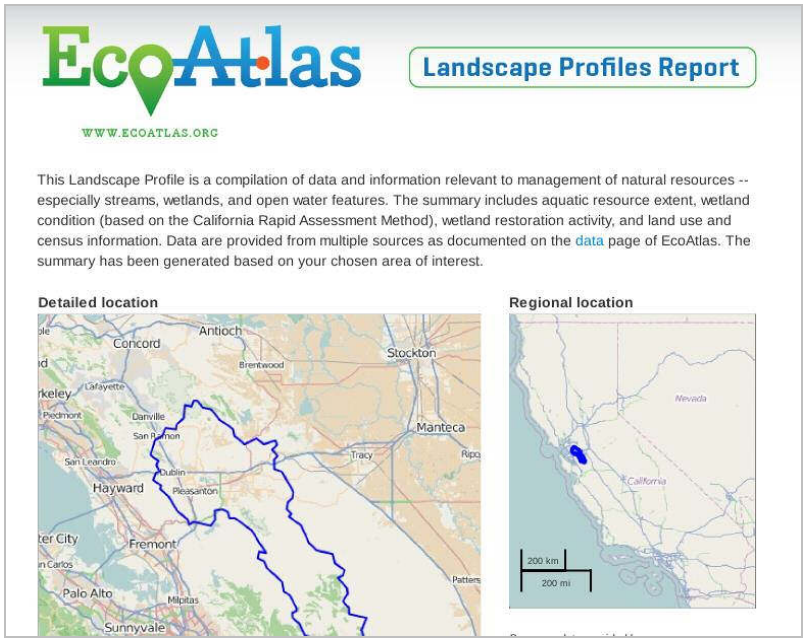

Figure 4. Screenshot of part of the first page of the Landscape Profile Tool's PDF report showing the user defined area and regional location map.

TOOL PLATFORM

The Landscape Profile tool and EcoAtlas are built almost exclusively with free and open source software (FOSS). Non-FOSS components are indicated below with an (*). EcoAtlas and the Landscape Profile tool are powered by an Apache 2 web server that resides on an Ubunto 12.04 linux server. Landscape Profile data local to the EcoAtlas server are stored in a PostgresSQL 9.1.10 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 2.01 extension to the database (http://postgis.net) enables the geospatial queries that produce the landscape profile tool results.

The Landscape Profile Tool web map engine is MapServer 6.4.1 (mapserver.org). MapServer retrieves geographic data from the PostgreSQL/PostGIS database 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 2.11 (openlayers.org), a free and open source JavaScript web mapping library. Other components of the user interface include the JavaScript libraries jQuery.js 1.8.16, bootstrap.js 2.1.1 and Chosen.js 0.9.8., 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 0.9.6 (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 8 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

The landscape profile tool is not a static tool, and additional functionality can be added as warranted. High priority changes to the Landscape Profile tool include: 1) better alignment with the needs of mitigation planning and tracking agencies, 2) additional context for interpreting CRAM scores, and 3) adding new landscape summary metrics, including estimates of riparian extent and ecological connectivity.

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:

1. grouping Ambient CRAM scores into a cumulative distribution function plot of the range of scores for a region. Once could then compare a site to the regional range of ambient scores and determine if the site falls within the low, medium or high range of condition scores;

2. linking Project scores to additional information about the restoration projects, such as the type and/or age of the project; and

3. interpolating limited CRAM scores to say something about the overall ecological condition of the specific wetland type in a watershed for areas where ambient surveys have not been done.

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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APPENDIX

List of all the Landscape metrics initially considered by the technical advisory team for inclusion in the landscape profile tool. Metrics that were not included but have not been rejected may be added in later versions of the tool. Metrics were prioritized on the basis of the data available, the computational intensiveness, and the ecological and hydrological relevance.

Metrics Considered		Status
Wetland Distribution and Abundance Metrics	Total area by wetland type	Included
	Total length of Channel	Included
	Number of wetland types in watershed	Included
	Total count by wetland type	Not included
	Patch size distribution	Not included
	Total length of natural vs unnatural Channel	Not included
	Total length by channel order	Not included
	Total area of riparian	Not included
	Length of stream by width class	Not included
	Length of riparian width class by channel order	Not included
	Total riparian area for non-linear wetlands	Not included
	Bifurcation ratio of natural channels	Rejected
	Channel Density	Rejected
Wetland Landscape Ecology Connectivity Metrics	Edge-to-area ratio of polygonal wetland patches by type	Not included
	Nearest neigbor distances	Not included
Wetland Condition Metrics	CRAM scores and project information	Included
	Display associated project information including project name, contact info, CRAM version, study boundary	Included
	Restoration and mitigation projects	Included
	Land Use	Included
Wetland Project Summary	Census	Included
	Historical land use composition (if data are available)	Included
Other Summaries	CNDDB	Included
	Vegetation cover	Not included
	Bedrock geology	Not included
	Precipitation	Not included
	Length of natural channel order by slope	Not included
	Valley width or percent of area of valley floor	Not included
	geomorphic flood plain width	Not included
	Linear connectivity of creek features (breaks in riparian)	Not included
	LID site suitability layer	Not included
	LID recommendations based on watershed characteristics	Not included
	Existing LID projects (LID tracker)	Not included
	Mainstream elevation profile	Not included
	Level 3 data	Not included
	Monitoring Inventory	Not included
	TMDL/303d listing	Not included
	Bathymetry	Not included
	Statewide parcel layer	Not included
	Basin slope distribution	Rejected
	Soils - ranked by permeability	Rejected