APPENDIX 2: DEMONSTRATION OF AN INTEGRATED WATERSHED ASSESSMENT USING THE LEVEL 1-2-3 MONITORING FRAMEWORK

Demonstration of an Integrated Watershed Assessment Using the Level 1-2-3 Monitoring Framework

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ABSTRACT

The San Gabriel River watershed was selected to demonstrate how the level 1-2-3 monitoring framework could be used to assess wetland condition. This watershed historically supported 19,000 ha of wetland habitats, of which 2,500 ha remain. An analysis of land use within the watershed revealed that the watershed is roughly divided between natural and urban land cover types and is comprised of 27% impervious surfaces. Over 5,000 acres of contemporary wetlands and riparian habitat were mapped in the San Gabriel River watershed using the National Wetlands Inventory, augmented with hydrogeomorphic (HGM) modifiers (Level 1). Ambient condition, determined via probabilistic sampling, showed distinct differences between the upper, lower, and mainstem portions of the watershed using the California Rapid Assessment Method (CRAM), an Index of Biotic Integrity, water chemistry, and toxicity tests as indicators (Level 2). The upper watershed had the highest overall riverine wetland condition based on all indicators assessed; heavy metal contamination is highest in lower watershed portions of the watershed because there areas are dominated by storm drain discharge; nutrients are highest in the river's mainstem where treated wastewater is the dominant source of discharge. Riverine wetland condition at specific project sites was evaluated via CRAM (Level 2) and intensive sampling, using the same indicators as the Level 2 assessment, was conducted at a number of targeted sites (Level 3). Results from the project and targeted sites revealed similar patterns in habitat condition, water chemistry, toxicity, and biotic integrity as observed in the ambient survey, with sites in the upper watershed receiving the highest values for all metrics assessed. The resultant evaluation provided a multimetric evaluation of wetland extent and ambient condition, while providing a context to interpret condition at project sites and to identify priority needs for future analysis.

INTRODUCTION

Effective wetland management depends on a holistic understanding of watershed condition (Reinhardt *et al*. 2007; Thomas and Lamb 2005). Unfortunately, most current watershed monitoring and assessment is based on singular objectives (e.g. regulatory compliance) or single indicators (e.g. benthic macroinvertebrates), therefore a comprehensive perspective of wetland condition is frequently not possible. For example, historical wetland loss and degradation are often cited as rationale for management actions (e.g. wetland acquisition, restoration, and creation), but information on historical impacts is often limited to estimates of change in area over a specific point in time and data on changes in habitat condition are lacking (see Bedford and Preston 1988). Likewise, wetland monitoring often focuses on specific projects or sites, but information on overall ambient condition, necessary to supply the ecological context for project-based assessments, is not available (Fenessey *et al*. 2007; Brooks *et al*. 2006). Ultimately, resource managers need to integrate data at both the ambient and site-specific level to make the most informed management decisions.

Recognizing this, a new paradigm for wetland management has emerged in the United States that moves beyond the single dimension and toward a more integrated assessment of wetland resources that incorporates multiple scales of assessment. The model for this is the U.S. Environmental Protection Agency's (USEPA) Level 1-2-3 framework and its ten basic elements of a monitoring and assessment program (USEPA 2006). Level 1 evaluates wetland extent and distribution; Level 2 assesses regional condition; and Level 3 entails site-specific evaluation. This framework has gained popularity as a management tool because it will better enable USEPA and the States to determine whether their programs meet the prerequisites of Section 305b of the Clean Water Act (CWA).

In California, a number of assessment tools associated with Level 1-2-3 framework as proposed by the USEPA have been developed. These tools include standardized wetland and riparian mapping methodologies, tools to assess stressors on wetlands at a landscape scale, the California Rapid Assessment Method (CRAM) for wetlands, and standardized, Level-3 monitoring protocols. Implementation of the monitoring toolkit within the Level 1-2-3 framework provides the means for a cost-effective, comprehensive assessment of ambient extent and condition of aquatic resources and beneficial uses. The application of these tools is intended to provide data to agencies and the general public on wetlands and riparian areas that are appropriate at the specified level of monitoring and applicable at the state, region, or watershed scale to inform management actions and prioritize recovery efforts. Stein *et al.* (2007a) provide a complete review of the Level 1-2-3 framework for wetland monitoring and assessment and discuss how it can be integrated in the context of state and federal wetland programs in California.

Watersheds provide a good organizational template for application of the Level 1-2-3 toolkit at the state or regional scale. Because their monitoring often involves multiple entities with variations in data collection and assessment methods, watersheds provide opportunities to integrate multiple objectives in a coordinated way that leverages funding among a broad range of assessment efforts while concurrently tracking ambient conditions and the performance of wetland projects among disparate programs and policies. Although the benefits of applying these tools in programmatic watershed monitoring are recognized, there are relatively few examples of actual implementation (e.g. Wardrop *et al.* 2007). Therefore, demonstration projects are needed as examples of real-world applications of this framework. In addition, demonstrations provide the empirical basis for determining how to most effectively integrate multiple layers of data into the watershed assessment process and can help guide future refinement of the process.

In this paper, we present a demonstration of the Level 1-2-3 assessment framework and associated wetland monitoring tools in the San Gabriel River watershed (Los Angeles Co., California). Our specific objectives were to (1) provide a foundation for how to incorporate wetland status and trends assessment into routine watershed monitoring; and (2) demonstrate the utility of CRAM as a rapid assessment tool for regional ambient and project monitoring. This information is intended to be used for prioritizing management and restoration activities, providing context for project and/or site-specific monitoring, and identifying possible causal relationships of wetland condition.

METHODS

Study Area

The San Gabriel River watershed is approximately 689 mi^2 ($1,785 km^2$) and is the third largest coastal catchment in Los Angeles County, California. The basin is bound by the San Gabriel Mountains to the north, the San Bernardino Mountains to the east, the watershed divide with the Los Angeles River to the west, and the Pacific Ocean to the south. The headwaters originate at 444 m the San Gabriel Mountains and the main channel flows for 60 km through the heavily urbanized San Gabriel Valley and Los Angeles basin before terminating at the Pacific Ocean in San Pedro Bay (Figure 1).

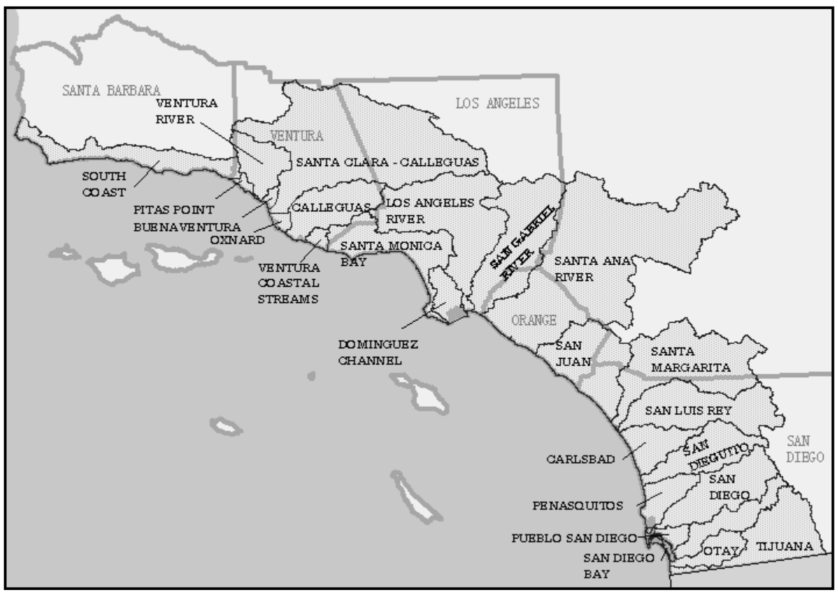

Figure 1. Location of the San Gabriel River watershed in relation to the other coastal watersheds of southern California.

Like many urbanized watersheds, wetlands and riparian areas in the San Gabriel River basin have been severely impacted by development and other forms of anthropogenic disturbance. Because there are multiple stakeholders working together within this watershed to coordinate monitoring efforts, the San Gabriel River offered a unique opportunity to apply the Level 1-2-3 framework at the watershed scale. Land use within the watershed is roughly divided between natural land cover and commercial, residential, and industrial uses. The upper third portion of the watershed in the San Gabriel Mountains remains relatively undeveloped, although the river has been modified with a series of flood control and water conservation dams. Most of this portion of the watershed is located on National Forest lands and the vegetation consists of extensive areas of undisturbed riparian, chaparral, and woodland habitats (Stephenson and Calcarone 1989). Further downstream, towards the middle of the watershed in the San Gabriel Valley, are large spreading grounds utilized for groundwater recharge. Most of the river's main stem and tributaries located in the San Gabriel valley and Los Angeles basin were confined within concrete channels for flood control during the 1950s, but the bottom of the main channel was left unlined to promote infiltration of floodwaters released from upstream dams. The net effect of land use disparities, impoundments, and water diversions is that there is little or no hydrologic connectivity between the upper and lower portions of the watershed.

Level 1: Landscape Assessment

Documenting Historical Wetland Loss

The San Gabriel River and its floodplain was the subject of an in-depth historical ecology and landscape study (Stein *et al*. 2007b). Analysis focused on the San Gabriel River floodplain (circa 1870) from the base of the San Gabriel Mountains to the boundary with the historic San Gabriel/Los Angeles River estuary. Primary historical data sources included Mexican land grant sketches (for former Mexican territories), US General Land Office maps, irrigation maps, topographic maps and soil surveys, and aerial photographs. Secondary data sources included oral histories, essays, ground photographs, and field notes. The concordance between these multiple data sources allowed conclusions based on the collective "weight of evidence" to support inferences about historical condition in the San Gabriel River watershed.

Once assembled, these data sources were digitized, georeferenced, and overlaid in GIS to produce historical wetland polygons that were later classified using current wetland inventory data to facilitate comparison with contemporary conditions. The resulting maps were then compared to contemporary wetland maps to assess wetland loss and type conversion. Historical herbaria records and bird observations were used to confirm the results of the GIS analysis and provided further insight into the composition of historical wetland communities of the watershed. See Stein *et al*. (2007b) for a complete discussion of the methods that were used to assess historical wetland loss in the San Gabriel River watershed.

Wetland/Riparian Habitat Inventory and Mapping

Established federal and state standards as defined by the National Wetlands Inventory (NWI) and the California Statewide Wetlands Inventory were used to map the wetlands and drainage networks in the San Gabriel River watershed (see Dark *et al*., 2006). Draft mapping standards developed for the State of California under the consideration of the Riparian Habitat Joint Venture were used to map riparian areas (Collins et al. 2007b). The California Statewide Wetlands Inventory is the primary wetland inventory for the State and is used to update the NWI of the USFWS and the NHD of the USGS.

The process of inventorying wetlands, riparian areas, and drainage networks in the San Gabriel River watershed began with the creation of an ArcGIS 9.0 geodatabase containing base digital aerial imagery and collateral data within the study area. Baseline imagery consisted of 1-m resolution color infrared United States Geological Survey (USGS) digital orthophoto quads (DOQs) from year 2000 or later. Collateral data sources included old NWI wetland maps where available, 10-meter digital elevation models (DEMs), quadrangle boundaries of the area to be mapped, land use data (SCAG 2000), pre-existing National Hydrography Data (USGS. 2004), hydric soils data (NRCS 2005), and USGS topographic maps (1:24,000).

Classification of wetland habitats followed the standard guidelines of the USFWS's method for "Classification of Wetlands and Deepwater Habitats" (Cowardin et al. 1979), augmented with hydrogeomorphic (HGM) modifiers (Brinson 1993; Sutula *et al.* 2004). The Cowardin classification of wetlands is a hierarchical classification process with systems (Marine, Estuarine, Riverine, Lacustrine and Palustrine subsystems (includes deepwater habitats), and more detailed classes, subclasses and dominance types. HGM describes the landscape position and local geomorphic context of wetland and riparian habitat. HGM classifications are applied after the Cowardin classifications are applied via an automated process. This layer is overlaid onto the classified NWI wetlands, then a post-classification is performed by translating the NWI classification and it's geomorphic location into the HGM classification. See Dark *et al*. 2006 for a detailed description of the methods used to map and classify wetlands in the San Gabriel River watershed.

Assessment of Landscape Stressors on Wetlands and Riparian Areas

Land use maps for the San Gabriel River watershed were produced using three types of data: vegetation type, percent impervious surface, and population density distribution. These maps were used to visually depict land cover in the watershed as well as for context in the assessment stressors that potentially influence riverine wetland condition within at the landscape-scale. The land cover maps were generated from the National Land Cover Database (NLCD 2001). Percent impervious surface was based on land cover imagery with values representing the percent of impervious surface within each cell of the raster image (30 x 30 m). The population data was generated from Topologically Integrated Geographic Encoding and Referencing System (TIGER) census data.

Using the procedure described by Brown and Vivas (2005), a Landscape Development Index (LDI) was developed for the San Gabriel River watershed using three sources of land use data: USGS derived percent impervious surface, NLCD, and regional data from the Southern California Association of Governments (SCAG). LDI and impervious surface values were derived for each CRAM dataset using the following input scales: buffer (100 and 200m), upstream (500 and 1000 m with a 100 m lateral buffer), and at the level of the watershed. All calculations were prepared in a Geographic Information System. Derived LDI values were then compared with overall CRAM index scores to serve as an indicator of riverine wetland condition for various portions of the watershed.

Level 2: Rapid Assessment of Riverine Wetland Condition

Ambient Watershed Assessment with CRAM

In the San Gabriel River watershed, Level 2 monitoring was demonstrated with a probabilistic survey of ambient riverine and associated riparian wetland condition using CRAM (Collins *et al.* 2007a). One hundred points were probabalisticly selected using the sample frame developed as part of the Level 1 assessment. The sample draw was weighted by proportion of watershed area to ensure adequate distribution of sites throughout the three main portions of the watershed: upper watershed above Morris Dam, lower watershed (tributaries entering the river below Morris Dam), and the mainstem river below Whittier Narrows. Thirty sites were assesssed over a six-week period during the spring and summer of 2005. Potential sites were rejected if they could not be legally or safely accessed or did not contain surface flow for a sufficient time to allow collection of the Level 3 indicators (typically through late June). If a site was rejected it was replaced with the next sequential site from the sample draw. Additional sites from the probabilistic sample draw will be included in subsequent year's surveys. Data were summarized and analyzed using histograms and cumulative frequency distributions (CDFs).

Project Assessment with CRAM

CRAM was used to evaluate the riverine wetland and associated riparian habitat condition at ten project sites distributed throughout the San Gabriel River watershed. The ten sites were identified and selected based on input from various public agencies operating within the watershed and represented a range of project types (i.e. restoration, enhancement, mitigation) in various stages of progress (planned, on-going, or completed projects). Assessment areas were determined using the recommended guidelines for riverine wetlands provided in Collins *et.al* (2007a). In all cases, both sides of the stream channel were assessed with CRAM. Data were summarized using a cumulative frequency distribution (CDF).

The 2005 ambient survey was used as context to interpret the CRAM metric scores at the individual project sites. In addition, the CRAM stressor checklists were used to determine the types and number of stressors that could influence CRAM index and attribute scores at the various project sites. This information provided a means to identify site-specific management needs that potentially merit further analysis.

Level 3: Intensive Site Assessment

Level-3 monitoring was conducted at the same probabalistically selected sites included in the Level 2 ambient survey. In addition, Level-3 sampling was conducted at 12 targeted locations that included key confluence points and unique areas of special habitat value within the watershed (LASGWC 2006). Level-3 monitoring was based on the "triad" approach and included bioassessment (and its associated suite of physical habitat measurements), aquatic toxicity, and water column chemistry. This triad of data provided insight into a variety of perspectives on conditions at a site and an opportunity to assess any apparent linkages between observed levels of chemicals of concern, toxicity, and/or changes to physical habitat, and impacts on the instream aquatic community.

Field protocols and assessment procedures followed the draft Surface Water Ambient Monitoring Program (SWAMP) protocols based on existing California Department of Fish and Game protocols (Harrington 1995; 1999; 2002; 2003) and the USEPA's Western Environmental Monitoring Assessment Program (EMAP). Bioassessment included the manual collection of composite benthic macroinvertebrate samples using a D-shaped kick net at each of the monitoring locations. Water chemistry included the manual collection of grab water samples using specified container types as defined in the SWAMP protocols. Water column toxicity, sampling included the manual collection of grab water samples using a one gallon wide mouth carboy at each of the monitoring locations. See Johnson (2007) for a complete description of the laboratory and field methods used.

Benthic macroinvertebrates collected from each site were identified to the lowest specified taxonomic level, and then biological metrics including diversity, average tolerance scores, relative abundance of aquatic macroinvertebrate species among distinct FFG categories (e.g., predators, grazers), and others were calculated. Next, the multi-metric Southern California IBI was calculated for each site (Ode *et al*. 2005). The IBI score derived for each site allows the water quality conditions found there to be compared against reference site conditions in southern California. Scores below 39 (on a scale of 100) represent "poor" conditions. Also, bioassessment sampling included a measure of the instream physical habitat (PHAB) originally developed by the USEPA and modified by SWAMP for use in California. This method focuses on the habitat conditions found in the streambed and along the banks.

The data collected at ambient and targeted sites were summarized and analyzed using cumulative frequency distributions (CDFs) and box and whisker plots. The CDFs illustrate the distribution of values from 0-100 percent for various indicators measured. The box and whisker plots show the median and range of the different indicators measured. In addition to comparing mean concentrations of the constituents sampled at individual sites, CDFs were used to compare data from targeted and permit-mandated stations to the ambient condition for the watershed as established by the random sites. Analysis of variance (ANOVA) was used to determine whether the patterns observed in the ambient survey were statistically significant.

RESULTS

Level 1 – Landscape Assessment

Historical Wetland Loss and Conversion

Approximately 19,000 ha of wetlands and riparian habitat historically existed in the lower San Gabriel River floodplain. The southern floodplain supported the broadest diversity of wetland types. Two depressional wetland types (alkali meadow and wet meadows) and one riverine wetland type (alluvial scrub shrub) dominated the historic landscape. Vast expanses of saltgrass (*Distichlis* spp.) dominated alkali meadows were most common along the tidal fringe of the lower floodplain, seasonal wet meadows were most dominant in the Whittier Narrows area, and alluvial scrub shrub was most common in the upper floodplain. Since the late 1800s, 86 percent (15,500 ha) of all wetlands have been lost due to urbanization of the region and associated hydrologic alterations. The study area currently supports about 2,500 ha of wetlands.

Based on relative changes in Cowardin wetland area since historic times, palustrine wetlands (i.e. seasonal and perennial wetlands, alkali meadows, and small ponds) have been the most impacted over time, with an approximate 94% reduction in area. As indicated, the greatest losses for this wetland class have been observed in the southern floodplain and tidal fringe areas. Another palustrine wetland type heavily impacted since the 1870s was a series of seeps and springs along the foothills of the San Gabriel Mountains; most of these wetlands have been extirpated from the contemporary landscape. The distribution of historical wetland by HGM class shows a similar pattern, with over 11,000 ha of depressional wetlands in the tidal fringe and an over 2,200 ha of fluvial wetlands in the upper floodplain as the predominant wetland types. Approximately 100 ha seep/spring/slope wetlands are thought to have existed historically within the watershed.

Riverine systems have also undergone extensive loss (approximately 75% of the historical riverine wetland area) and modification since the 1870s. The greatest proportional loss of riverine wetlands has occurred in the upper floodplain and the Whittier Narrows area (near the center of the watershed). There has also been a dramatic shift in the wetland profile of the San Gabriel River watershed, with lacustrine wetland acreage having dramatically increased in the watershed since historic times. There was little evidence that these systems were present in the historic landscape.

Contemporary Wetland Inventory and Mapping

A total of 5,395 ha of wetland habitat were mapped in mountain, foothill, and valley areas of the San Gabriel River Watershed (Dark *et al*., 2006). Almost all of the wetlands mapped in the San Gabriel Valley exhibit some form of anthropogenic impact. Based on total wetland acreage by Cowardin class, the vast majority of wetlands in the San Gabriel River watershed is comprised of riverine (2286 ha) and palustrine wetlands (2053 ha). Estuarine wetlands represent the smallest proportion of the total wetland acreage in the watershed and are exclusively located on the coastal terrace.

A summary of wetlands by hydrodgeomorphic (HGM) category indicates that fluvial systems (including both riverine wetlands and some palustrine wetlands confined to a channel) are the dominant wetland types in the San Gabriel River watershed. Most of these wetlands are found to canyon areas, with smaller amounts in valley areas. Lakes and depressional wetlands are also present on the landscape and represent approximately 20% of all wetlands within the watershed. Slope, seep, and spring wetlands are among the least common wetland class within the watershed representing only 1% of the total wetland area.

Eleven subwatersheds were identified in the San Gabriel River drainage. The Upper Canyon and Upper San Gabriel subwatersheds have most of the riverine and palustrine wetlands, which represented the largest wetland categories using the Cowardin classification system. The Alamitos Bay subwatershed contained the majority of estuarine wetlands, while the Lower San Gabriel subwatershed contained the greatest diversity of wetlands within each of the Cowardin systems represented in the area.

Land Use and Landscape Stressors

Significant, negative correlations were observed between CRAM scores (overall and attribute level) and the intensity of surrounding landscape using all land use data sets and at all scales of at which the analysis was conducted. This relationship was strongest with the National Landcover Data and percent impervious cover layers.

Land use in the San Gabriel River watershed is roughly divided between natural (47.1%) and urban-residential (52.3%) land use types, with less than 1% devoted to agricultural purposes. Development, as reflected by percent impervious surface, is concentrated in the southern portion of the watershed, primarily the lower elevation areas of the San Gabriel Valley and Los Angeles basin. These areas are dominated by a mix of urban/residential development and have correspondingly high percentage of impervious surfaces. In contrast, the entire northern portion of the watershed within the San Gabriel Mountains/Angeles National Forest and the portion in the Puente-Chino Hills are covered by forest, shrubland, or woodland and are characterized by low percent impervious surface.

Land cover is mirrored by the population density data for the San Gabriel River watershed. The basin can essentially be divided into two broad segments: the upper third of the watershed, primarily the portion within the Angeles National Forest, with less than 100 people/mi^2, and the remaining two-thirds, within the San Gabriel Valley and lower Los Angeles basin, with much higher population densities. The western half of the San Gabriel Valley and most of the Los Angeles basin have population densities in excess of 6,000 people/mi^2, and the Puente-Chino Hills and eastern half of the San Gabriel Valley have intermediate population densities that fall between the extremes of the northern and southern portions of the watershed.

Level 2 – Rapid Assessment

San Gabriel River Ambient Watershed Assessment with CRAM

The results of the 2005 ambient assessment of riverine wetland condition documented a broad range of condition in terms of overall integrity of riverine wetland and associated riparian habitats in the upper, mainstream, and lower portions of the San Gabriel River watershed. Although conclusions about differences between these three subregions are preliminary because of the limited number of sites available for each subregion, the 30 probabilistically selected sites enabled statistically valid information to be generated about the condition watershed as a whole.

In 2005, CRAM scores ranged from 35 (with the minimum score possible of 25) to 91 (out of a maximum possible score of 100). Overall CRAM scores varied by a site’s location within the watershed and illustrate clear patterns between its upper (undeveloped) portions and lower (developed) portions in terms of habitat condition. The upper watershed, which is comprised of mostly natural streams, has the highest mean CRAM score. The mainstem of the river, which is predominantly channelized, had the lowest mean CRAM scores (approximately half the mean score as the upper watershed). The lower watershed, which is comprised of a mix of semi-natural and channelized systems, had intermediate scores that were comparable to mean values for the overall watershed condition.

Assessment of Project Sites with CRAM

Overall CRAM index scores for the ten project sites assessed in the San Gabriel River watershed ranged from 58 to 83. Similar to the results of the ambient assessment, projects located in the least developed portions of the watershed had the highest overall CRAM scores and those in the most developed portions of the watershed had the lowest overall CRAM scores. The project planned at Cattle Canyon had the highest overall CRAM index score (83), follwed by the Oak Canyon site (82). Cattle Canyon is an unregulated tributary of the San Gabriel River located in the San Gabriel Mountains and the Angeles National Forest whereas the Oak Canyon site is located in a 58 acre natural park in the Anaheim Hills. The project at the El Dorado Nature Center received the lowest CRAM score and was located in one of the most developed portions of the watershed. The other project sites all received comparable overall CRAM index scores, ranging from 57 to 66. The project sites that were located in close physical proximity to one another at the Whittier Narrows received very similar overall CRAM index scores. There were no apparent trends in CRAM scores among sites based on project type or status.

Although some sites scored similarly for overall CRAM index scores, raw attribute scores differed. For example, Cattle Canyon, the highest scoring site based on overall index scores, received high attribute scores for the buffer/landscape and hydrology attributes, but scored lower than Oak Canyon for physical and biotic structure. In general, sites located in the most developed portions of the watershed (e.g. Lemon Creek) scored lowest for the buffer/landscape connectivity attribute. Three of the five most common stressors at all sites were related to the hydrology attribute (non-point source discharges, flow obstructions, and flow diversions).

Level 3 – Intensive Site Assessment

Metals and Nutrients

Comparison of data collected for a suite of general constituents, metals, and nutrients from the three subregions of random sites indicates differences in water chemistry based on watershed position. For all constituents sampled, the lowest concentrations were found in the upper watershed. For metals (except zinc) and organic carbon, the highest levels were observed in the lower watershed, as shown in the representative pattern for total copper. Zinc concentrations were generally highest in the river's mainstem. For nutrients, the highest levels were along the mainstem of the San Gabriel River, as shown in the representative pattern for nitrate + nitrite. Little toxicity was observed during the ambient assessment. Only 2 of the 30 random sites sampled (7% of total samples) exhibited toxicity. Both samples were from the lower watershed. These findings are consistent with other studies (Schiff et al. 2006).

In general the mean values for general constituents, metals, and nutrients measured at the targeted sites were comparable to the random sites with a few notable exceptions. Chloride and orthophosphate levels were substantially lower at the targeted sites than at the random sites. In contrast, total iron was higher at the targeted sites.

Benthic Macroinvertebrates

The cluster analysis of species data from the 2005 random watershed sites identifies groupings of sites that were similar in terms of composition and ecological groupings of the benthic community based on the location in the watershed. Benthic macroinvertebrate IBI scores also differ based on watershed position. IBI scores from site group 1, sites located in the lower, most developed portion of the watershed, had the lowest overall IBI scores. Site groups 3 and 4 are sites located in the upper watershed and had the highest IBI scores. Site group 2 contains a mix of lower watershed and mainstem sites.

Differences among the major portions of the watershed are also apparent when species in the three subsets of the watershed are combined into ecological groupings. The upper watershed contains larger proportions of collectors / filterers, shredders, and predators. The lower watershed and mainstem communities contain more generalist feeders, and are dominated by collectors/gatherers, with the lower watershed community having a slightly larger proportion of collectors / gatherers than the mainstem. Based on taxonomic evaluation, the lower watershed includes a number of species that rarely occur at either the mainstem or upper watershed sites, and tended to be the most tolerant to habitat degradation. Targeted sites had IBI scores that span the full range of scores observed in the random sites, but a similar trend, with upper watershed targeted sites tending to group with upper watershed random sites, was observed in the cluster analysis for these sites.

DISCUSSION

We used the San Gabriel River as a template to demonstrate how various levels of monitoring data can be collected, analyzed, and interpreted to provide a robust, integrative assessment of wetland condition at the watershed-scale. Level 1 outputs include base maps and inventories that are fundamental to all assessment efforts, in part because they serve as sample frames for Level 2 and Level 3 assessments. Programmatic Level 1 products include updates of state and federal maps and inventories, plus evaluation of no-net-loss policies. Level 1 output, in conjunction with Level 2 and Level 3 results, can provide the information needed for the State to report on the condition of its wetlands pursuant to Section 305b of the Clean Water Act. Monitoring under a variety of state programs, including NPDES, CWA 401 Certification and Waste Discharge Requirements, and the Streambed Alteration (1600) Permits under the state's Fish and Game Code can be coordinated to minimize redundancies, maximize comparability of data, and maximize the geographic coverage of the data. A coordinated approach using standardized tools for data collection and information management can minimize the aggregate costs for multiple programs while improving public access to monitoring and assessment results. Whether Level 2 or Level 3 methods are used to collect data will depend on case-specific circumstances. However, the efficacy of using the less expensive Level 2 methods should be carefully considered before Level 3 methods are employed. In many cases, Level 2 methods can be used augment the Level 3 assessments of specific wetland functions or aspects of condition to provide more robust evaluations of overall functional capacity or health at little additional cost.

Level-1 assessments are used to develop watershed landscape profiles and can incorporate data on current and historic wetland extent and distribution. Landscape profiles not only characterize the range of wetland and riparian resources at the regional or landscape scale, they can help foster novel ideas on how wetlands function in the landscape and innovation in how these resources are managed (Kentula 2007). For example, mapping wetlands using Cowardin classification and HGM provides information on a wetland's vegetative characteristics and water regime, as well as its functionality and geomorphic context. For example, because of the prevalence of fluvial systems in the San Gabriel River watershed, conservation efforts that strive to preserve, maintain, or restore natural hydrology, such as improvements in the design and functioning of flow-through treatment wetlands and the removal of barriers to natural streamflow (e.g. fish barrier removal projects), can contribute signifcantly to improving overall wetland functioning in this watershed. Understanding these processes is an extremely important part of the decision-making process for wetland recovery, protection, and land use planning. Wetlands that have been modified and have lost much of their natural functionality are typically good candidates at which to target restoration efforts (Dark *et al*. 2006).

Geomorphic information can also be useful for prioritizing management activities and identifying unique aspects of specific regions within a watershed to be targeted for habitat preservation, restoration and enhancement. For example, the landscape profile for the San Gabriel River revealed that the lower portion of this watershed contains the greatest diversity of Cowardin wetland types and that most of the riverine wetlands are located canyon areas in the upper watershed. Therefore, restoration activities in the lower watershed, especially those that target multiple wetland types, provide value by contributing to maintain overall wetland resource diversity in the watershed. Likewise, restoration projects located in areas adjacent to mountain and foothill canyons in the upper watershed would be of particular benefit to riverine wetlands.

Coupling current wetland mapping with an understanding of historic wetland habitat further strengthens the understanding of how to prioritize recovery efforts in a region or watershed. For example, the mapping of historical wetland habitats in the San Gabriel watershed identified particular wetland areas within the lower portion of the watershed with significant potential for restoration (see Stein *et al*. 2007b). The historical data also increased the functional understanding of present day wetland system processes and their relationship to land use and wetland type conversion. Historical mapping in the San Gabriel River watershed revealed that the loss of fluvial palustrine wetlands since the 1870s is associated with an increase in lacustrine wetland acreage over time. Other studies have reported losses of palustrine wetlands due to conversion into lacustrine deepwater habitat from other regions of the United States (Syphard and Garcia 2001).

Multiple tiers of monitoring data can be used to make inferences on the causal relationships of wetland condition in a watershed. For example, level 1 landscape assessment data can occasionally provide insight to corroborate data from Level-2 rapid assessments and Level 2-tools provide the context in which to interpret Level 3 data. In the San Gabriel River watershed, the percent impervious surface was a useful

Level-1 landscape-scale indicator of overall riverine wetland condition, showing a negative correlation with wetland condition scores as measured by CRAM. Similarly, a Level-2 metric, such as a CRAM index score, can be a good surrogate in the absence of intensive, level-3 data. A comparison of benthic macroinvertebrate (Level-3) and CRAM indices (Level-2) for the San Gabriel River watershed reveals a positive relationship between benthic macroinvertebrate communities (as measured by IBI) and habitat condition (as measure by CRAM) across streams in this watershed (Figure 2). This positive relationship suggests that biotic integrity (as indicated by the benthic macroinvertebrate community) is higher at sites with more intact wetland and riparian communities. This type of analysis also illustrates how the coarser CRAM assessment and the finer scale benthic macroinvertebrate data complement each other to provide a more refined understanding of factors that affect wetland condition.

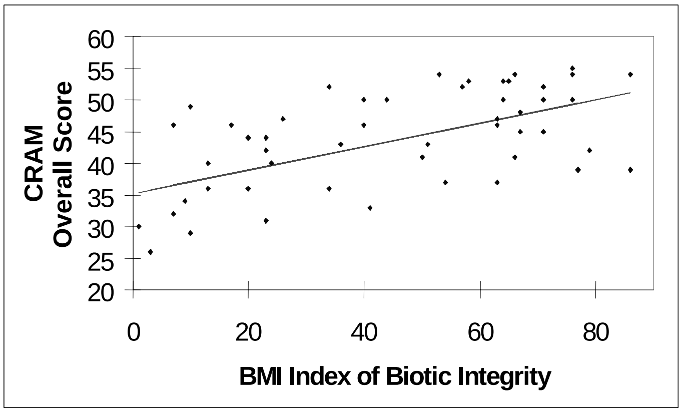

Figure 2. Scatter plot and linear regression between overall CRAM scores and IBI scores from the 2005 ambient survey of riverine wetland condition in the San Gabriel River watershed.

Information from Level 1-2-3 studies can also be used to identify disparities in water quality within a watershed, determine potential future regulatory action, and help address management questions that are most relevant to resource managers and the public. For example, a comparison Level 3 data from the San Gabriel River watershed indicates differences in water chemistry, heavy metal concentration, and nutrient loads among three subregions based on watershed position and suggests that metals are highest in the lower watershed that is dominated by storm drain discharge, whereas nutrients are highest in the river's main stem where treated wastewater is the dominant discharge. The information from Level 1 (landscape) and Level 2 (condition) studies corroborate that watershed position is an important determinant of overall water quality in this watershed. In addition, the positive correlation between CRAM-benthic macroinvertebrate IBI scores provides an increased "weight of evidence" to indicate that biotic integrity is strongly dependent on habitat condition. The interrelationship among metrics used at various levels of monitoring can also suggest redundancies between various tools and potential efficiencies that might be achieved by consolidating measurement approaches. In addition, because trends in aquatic chemistry and IBI scores were detected at targeted sites, this type of Level 3 analysis can be important for identifying targeted sites with anomalous conditions that warrant further examination.

Information on the effectiveness of extensive public investments in wetland and riparian resource conservation is typically not available because efforts are not coordinated and the condition of wetlands and riparian habitat is not monitored systematically. By applying a hybrid sampling design that integrates probability-based surveys, rapid assessment methods (Level-2) and intensive (Level-3) sampling at fixed sites, wetland status and trends assessment can be successfully incorporated into traditional water quality and biological monitoring programs to provide a more robust assessment of the ambient condition of aquatic resources and beneficial uses. For example, prior application of the 1-2-3 framework in the San Gabriel River watershed, most monitoring was permit-mandated and focused primarily around point sources. A watershed-wide probability-based survey that incorporated CRAM and level 3 monitoring protocols provided a cost-effective means of integrating routine water quality, ambient, and disparate, site-specific monitoring data The results of an ambient assessment of this watershed with CRAM indicated that riverine wetlands in the upper, lower, and main stem of the San Gabriel River watershed exhibit a broad range of riverine wetland conditions. This relationship is supported by the water chemistry and bioassessment data (Level-3) collected in the watershed at both the ambient and targeted sampling sites. This information can be used to link assessment of wetland condition with more traditional water-quality monitoring and bioassessment to formulate management actions.

Rapid assessment methods also provide a cost-effective means to collect the Level-2 data that is necessary to provide the context for monitoring activities conducted at the project or site-specific scale. One of the advantages of using a commonly applied rapid assessment tool such as CRAM is the ability to compare scores from a site of interest to other sites or groups of sites. The combination of these can be used to provide assessments of status and trends of wetland and riparian beneficial uses. Level 2 assessments of ambient condition provide the interpretive power and deeper contextual understanding for the Level 3 data collected at specific sites in the watershed. Wetland resource managers commonly want to know how a particular wetland site compares to other sites in the region, what their monitoring data represents, and whether there is a management issue of concern at a specific site. Without an understanding of ambient condition provided through Level-2 assessments, Level-3 data have much less contextual basis on which to base management decisions.

It is important to acknowledge that any conclusions on watershed condition based on an ambient assessment will vary based on the indicator used in the monitoring. Although water chemistry data can indicate “good” water quality based on the standard used, the overall biology of the ecosystem may be in “poor” condition if viewed in the context of physical habitat indicators (such as CRAM scores). For example, resource managers may be interested in determining the percent of stream miles that are “impaired”. Using the San Gabriel River as an example, had this assessment relied only on total copper concentrations as an indicator of condition, less than 20 percent of stream miles impaired based on standards for copper (Figure 3). If based on toxicity standards, this percentage would be even lower because almost no aquatic toxicity was observed in the watershed. If viewed in the context of biological condition, as indicated by bioassessment data (IBI) or CRAM scores, conclusions about the percent of stream miles impaired would be much higher. This discrepancy indicates that assessments based on water chemistry versus those that measure overall habitat condition provide different types of information. Therefore, conclusions regarding the causes of impairment need to consider the nature of the indicator in order to guide the best management course of action.

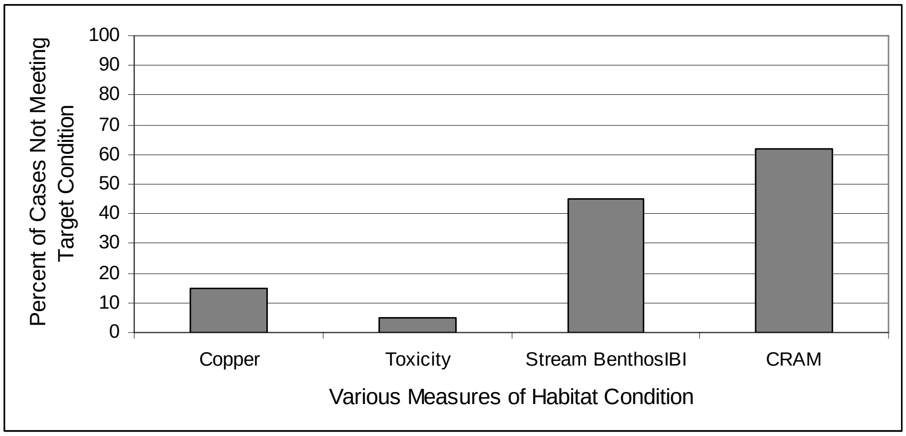

Figure 3: Indicators used in the San Gabriel River watershed to assess riverine-riparian condition relative to different environmental policies and programs. For CRAM, the minimum acceptable condition was assumed to be represented by the 25th percentile of index scores based on the statewide ambient survey.

The San Gabriel River watershed provided the template to illustrate the merits of using various levels of data (i.e. wetland resource extent/distribution, ecological condition, and intensive site-specific monitoring) to provide a complete assessment of overall watershed condition. In addition, integrative assessments provide the means to show how information generated from Level 1 landscape scale and Level 2 rapid assessments can be used to interpret and/or supplement more intensive, Level 3 data. A monitoring program based on the 1-2-3 assessment framework can be used to guide wetland restoration, provide data on regional wetland condition, and verify the effectiveness of management approaches and/or regulatory actions. Incorporation of this overall framework into agency wetland monitoring programs provides a valuable opportunity to evaluate the effectiveness of public investment in conservation and restoration of these resources.

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