URBAN COAST

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URBAN COAST

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WELCOME

ABOUT URBAN COAST

This multidisciplinary journal is a product of the Center for Santa Monica Bay Studies, a partnership of Loyola Marymount University's Seaver College of Science and Engineering and The Bay Foundation. *Urban Coast* fulfills the Center's goal of providing a much-needed forum to highlight research that informs the most pressing issues of our day and policies that affect the condition of urban coastal resources.

Urban Coast is a forum for researchers, agencies, advocacy groups, and other science and policy leaders to engage in constructive discussion and information exchange on issues that are pertinent to our coastal environments. In this way, we find common ground and highlight the robust science, analysis, and assessment needed to catalyze good policy, design, and management measures.

THE CENTER FOR SANTA MONICA BAY STUDIES

The Center for Santa Monica Bay Studies is a program of the Seaver College of Science and Engineering at Loyola Marymount University and The Bay Foundation. The mission of the Center is to engage in multidisciplinary research on environmental and social issues affecting Santa Monica Bay and its watershed, and to contribute to policies and actions that improve the environmental condition of the Bay. Visit www.santamonicabay.org.

SUBMISSIONS

The *Urban Coast* is a peer-reviewed publication. Feature articles are generally between 4,000 and 6,000 words, while short submissions are between 1,000 and 3,000. Submissions are accepted for all four sections of the journal, including Perspectives with essays and editorials that review current conditions or policies; Research & Policy features articles on scientific or policy studies; Case Studies are detailed project reports with implications for the urban coastal environment; and Notes & Abstracts include short descriptions of research, policy, and events relevant to our urban coastal environment. Submissions for the Notes & Abstracts section are between 250 and 500 words, and should be an abstract or a short summary about your innovative environmental research, technical study, restoration project, BMP or LID implementation, or other projects. All submissions should be written according to the standards of the Chicago Manual of Style, 16th Edition. References should be placed at the end of the document. Tables and images should be separated from the text. Images should be provided in .tif format, not exceeding a width of five inches and a resolution of 600 dpi (a width of 3,000 pixels). Include the article's title; the author's name, phone number and email address; and a two-sentence biographical statement. Article submissions should include a 250-word abstract. Submissions will be accepted on a rolling basis. Feel free to contact us by email to discuss your ideas. Please send manuscripts as .doc attachments via email to: guangyu.wang@waterboards.ca.gov.

We welcome submissions for science and policy topics pertinent to the urban coastal environment. Some topics for consideration include: Habitat Preservation and Restoration, Stormwater Issues, Aerial Deposition, Water Conservation/Independence/Quality, Rapid Indicators, BMP Effectiveness, Emerging Contaminants, Low Impact Development, Climate Change, Sustainability, Invasive Species, Resource Management, Environmental Justice, and other pertinent coastal science and policy topics.

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Who Will Pay to Clean up Stormwater?

Los Angeles has been grappling with the problem of cleaning up urban runoff for decades. The Clean Water Act is over 40 years old and requires that we meet water quality standards set by the state and federal Environmental Protection Agencies. Besides that, we are a region that understands the need for clean water in a very real way: too little water, or too dirty water, and our economy and quality of life decline, and fast.

As water management evolved in Los Angeles, we set up what could be called a dis-integrated governance structure for water. We treat drinking water, stormwater, and wastewater as if they are separate, unconnected resources or liabilities. We import drinking water from far away, then clean it very well and dump it into Santa Monica Bay, at great expense. The tab is mostly picked up by the public, who pay for drinking water as well as a monthly charge from their city or county for sewage treatment. At the same time, we direct the rainwater that falls onto our streets and roof tops into storm drains and directly out to sea, laden with trash, oil, heavy metals and other contaminants. This imposes another cost, when dirty water and trash cause beach closures or discourage beach and ocean use. Now, we are under ever-greater pressure from the State Water Resources Control Board to clean up our stormwater. This is also a golden opportunity for us to do a better job of managing water overall: water is water, and LA needs to do a better job of stewarding rainwater as a valuable resource rather than a regulatory liability.

The first step is to put in place a sustainable source of funding for managing our local water. We know a lot about how to do it, and we can answer outstanding questions about which technologies work best and where, but we will need funding to make it happen. Relying on continued bond measures to build treatment facilities is not acceptable – bond funding can be used only for capital projects, meaning there is no money available to pay for the ongoing operations and maintenance, and that just doesn't work. In addition, most people agree that the best solutions are integrated solutions, i.e. they solve more than one problem at once, so that stormwater can be captured, cleaned and stored for use by building a park or other green space in a neighborhood that needs it. A dedicated funding stream for stormwater cleanup could be crafted to require this kind of multi-benefit solution to our pressing water resource problems.

A property-based fee for stormwater is the fairest way to pay for management of the resource. Property owners have the greatest control over what happens to the water that falls on their land, and could be rewarded with discounts or rebates for making simple, on-site improvements that clean or infiltrate stormwater. Those who choose not to improve will pay, and the funds can be used for collective solutions like parks or underground treatment facilities that will benefit everyone who lives in or visits the Los Angeles region. What are we waiting for?

Shelley L. Luce, Executive Director
The Bay Foundation

PHOTO: LARRY BRAMBLES

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Editor's Note

I would like to take this opportunity to thank all those involved with *Urban Coast*: Dr. Shelley Luce for her resolve and leadership in establishing this unique and much-needed forum for discussing diverse issues of coastal environments; Julie Du Brow for her perseverance and punctuality in navigating through the publication process; members of the advisory boards of *Urban Coast* and the Center for Santa Monica Bay Studies, as well as all the reviewers of the manuscripts, whose input were indispensible in ensuring the high quality of this publication. Last but not least, my great appreciation to all the authors – this journal would not be possible without your contribution. Thank you.

Guangyu Wang, Ph.D
Staff Scientist, Santa Monica Bay Restoration Commission

PHOTO: LIA PROTOPAPADAKIS

SURFERS ENJOY LAST FEW WAVES AS SUN SETS AT DOCKWEILER BEACH.

Letter from the Editor

Being an editor of a serious journal is never easy, even for someone with years of experience. So for a first-time editor like me, it did not take long to find out how difficult this job really is, to say the least. The Urban Coast makes the job of its editor even harder by its unconventional approach - unlike most scientific or technical journals where the editor's primary responsibility is to ensure that the experiments, the findings, and the conclusions are scientifically sound (which we do, as well), Urban Coast wants its authors and readers to engage in "constructive discussion and information exchange." In other words, we want people to offer different perspectives, especially new ideas and even provocative opinions.

This was what on our minds when our Editorial Board came up the theme of 'Los Angeles River revitalization' for this issue because we have observed so many conflicting visions playing out in that watershed, both historically and at present. However, we came up short in achieving this objective with the three articles we published in this issue. By all means, these are all excellent articles by authors well-vested in LA River-related issues. They also described and represented well the roles and contributions of three key stakeholders (federal, state, and private) in the river's revitalization process. We just wished that they could spice up the rhetoric and give readers more of a sense of the conflict and contrast. Instead, they individually showed more harmony than acrimony. But at the end, we have no regret because we see that together these articles sent a compelling message that breaking the institutional barriers and collaboration across the board is what made the progress possible. This is fascinating, instructive, and should happen at every urban rivers watershed!

We also wished that the articles could keep up with the latest happening in that watershed, which is moving at an ever faster pace. Around the time that this issue is printed, the Army Corps of Engineering has just released their preferred alternatives developed under its Los Angeles River ecosystem restoration study. There are news coverage, commentaries, speeches, and even rallies related to this event around the region as we speak. Yes, we know we are a bit behind, as are most periodic journals. On the other hand, we are glad that things are moving forward and fast, and we take this as another vivid testimony of the success achieved through the collaborative efforts featured in these articles.

As in previous issues, besides the focused discussion on the theme of Los Angeles River revitalization, we offer opinions, original research, and case studies related to a wide range of issues. We also debut a new book review section, thanks to Melina Watts for her wonderful idea and contribution. We have articles about restoring wetlands (again!), protecting streams, greening highly urbanized areas, and changing people's behaviors. There may not seem to be a common thread to connect these diverse topics. But it nevertheless reflects perfectly the diverse nature of our watersheds. Eventually all these pieces of the puzzle will fall into the right place to show a perfect picture of our common vision.

Enjoy your reading!

Guangyu Wang, Ph.D
Deputy Director and Sr. Scientist,
Santa Monica Bay Restoration Commission


PHOTO: LIA PROTOPAPADAKIS

PERSPECTIVES

Urban Coast invites researchers, agencies, advocacy groups, and other science and policy leaders to engage in constructive discussion and information exchange on issues that are pertinent to our coastal environments. In this way, we can find common ground and highlight the robust science, analysis, and assessment needed to catalyze good policy, design, and management measures. The Perspectives section includes essays and editorials that review and analyze current conditions and policies. In this issue, the featured discussion focuses on urban wetland restoration and revitalization of the Los Angeles River, and includes viewpoints from many parties of interest.

PHOTO: GERICK BERGSMA 2010 MARINE PHOTOBANK

FIGURE 2. The Ballona Wetland at sunset, looking southwest over the salt pan of Area B. PHOTO: COURTESY OF THE BAY FOUNDATION

ACHIEVABLE RESTORATION TARGETS FOR URBAN WETLANDS

JOY B. ZEDLER

Abstract

Many of the earth's most altered ecosystems are urban wetlands, owing to their positions low in their watersheds. The most highly altered urban wetlands occur downstream from large developed areas with extensive hardscaping (impervious streets, roofs, driveways, and sidewalks). Compared to historical conditions, watersheds with substantial hardscaping discharge water in larger pulses of greater velocity than historically, and the water carries more contaminants. Moreover, since hydrological conditions are critical to the type and composition of wetlands, all downstream ecosystem components will be altered, creating novel hydroperiods and geomorphology, novel soils, and assemblages of plants and animals that are without analogs in natural ecosystems. Such is the case for the Ballona Wetlands (Fig. 1), whose hydrological conditions are highly modified and whose biota include native and nonnative species in new combinations.

FIG. 1. Aerial photo of the Ballona Wetland. This "diamond in the rough" is dissected by a flood control channel, bounded on the north by Marina del Rey and encroached upon by urban Los Angeles. Potential for restoration to make it "shine" involves minor to major interventions to increase the influence of ocean tides. PHOTO: COURTESY OF THE BAY FOUNDATION

Can restorationists turn back the clock? Not entirely (Seastedt et al. 2008). It is unrealistic to imagine that restoration activities could eliminate—or even compensate for—the many environmental stressors in urban wetlands or that restorationists could replace the full complement of species that once inhabited such ecosystems. At the other extreme, it seems unwise to allow environmental impacts to continue to degrade highly valued places such as the Ballona Wetland. Rather than pursing futile efforts to turn back the clock, restorationists could choose to acknowledge the many irreversible attributes of humanized watersheds and adapt restoration targets to landscape change. Here, I consider landscape change to encompass a broad spectrum of human effects—some direct, such as hardscaping, and some indirect, such as climate change.

An early book promoting urban wetland restoration in New Jersey suggests a similar approach. Casagrande (1997, page 254) stated that "Wetland restoration in urban areas is, in effect, restoration of human habitat." This acknowledges the role of people in setting restoration targets and the need to accommodate the human needs, for example, for education, recreation, and esthetic appreciation. However, he was not envisioning an amusement or water park, nor was he advocating endless efforts toward some historical ideal. Rather, he suggested dual goals such that "Urban wetland restoration can restore the ecosystem to a condition that maximizes human benefits while minimizing inputs of energy." He proceeded to advise readers on how to achieve that ambitious outcome: "By restoring ecological processes suited to the climate, topography, geology, and hydrological context of the restoration site." His next sentence was ahead of its time: "Such restoration does not require exact duplication of an historic landscape." In the process of "landscape-change adaption," restorationists can aim to achieve selected ecosystem services, including biodiversity support (Table 1), but they cannot expect to duplicate historical conditions.

TYPE OF SERVICES (MEA 2005)	EXAMPLES
Cultural Services	Esthetics: Breaks in urban landscapes Inspiration: Positive feelings, imagery for art Recreation: Birds to watch, trails to hike Education, research opportunities
Supporting Services	Supporting biodiversity Produce "food" for wildlife, microbes
Regulatory Services	Improving water quality Abating flooding Storing carbon
Provisioning Services	Producing fibers for crafts Growing plants that sustain gene pool

TABLE 1. Wetland ecosystem services (functions valued by people) that might be conserved, restored and sustained in the Ballona Wetlands. The four types of services follow the terminology of the Millennium Ecosystem Assessment (MEA 2005).

There is little virtue in insisting on setting targets that cannot be reached. It makes sense, however, to work to conserve and restore ecosystem services provided by urban wetlands. An earlier paper discussed the tradeoff inherent in urban wetland restoration (Callaway and Zedler 2004). On the positive side, the opportunities are greater, both for improving lands and for benefiting people. At the same time, the challenges are greater and the outcomes less certain because of the many interacting environmental factors and the uncertainties of human behavior (Table 2).

Three salt marsh restoration projects in San Diego County, California, illustrate several reasons to restore and sustain biodiversity, even if all species cannot be recovered:

1. Famosa Slough (37 ac) is just south of San Diego's Mission Bay Aquatic Park (http://www.famosaslough.org/map.htm). This wetland is hardly a duplicate of its condition in the early 1900s, when it was an extension of Mission Marsh downstream from a freely flowing San Diego River. Yet the urbanized Famosa Slough still serves local residents and visitors. After years of citizen efforts, the City of San Diego purchased Famosa Slough and then removed trees and homeless camps, treated inflowing runoff, and recontoured landfills. Meanwhile, volunteers created trails, removed exotic weeds, planted native species, and encouraged interpretive signage. The highly modified site attracts diverse birds, provides opportunities for wildlife appreciation and photography, and improves the quality of urban runoff.

2. Sweetwater Marsh on the east side of San Diego Bay is trapped behind acres of dredge spoil deposits. It is part of a National Wildlife Refuge, supports four endangered species and attracts local outreach programs for schools and the public (USFWS 2006). Citizens were instrumental in getting federal agencies to mitigate damages caused by freeway and flood-control construction projects. Some of the dredge spoil was excavated to create tidal channels and salt marsh; other fill was removed to create salt marsh islands. Moreover, two native plants —salt marsh bird's beak (*Cordylanthus maritimus* ssp. *maritimus*) and Pacific cordgrass (*Spartina foliosa*)—were planted to recover endangered populations: to provide nesting habitat for the endangered light-footed clapper rail (*Rallus longirostris levipes*). A visitor center on Gunpowder Point attracts school groups and the public.

3. Tijuana Estuary is downstream from a 1750-square-mile watershed that is mostly within Mexico, where slopes are greatly modified and soils are highly erodible. Tons of sediment moved downstream into the salt marsh with flooding during the stormy phase of the Pacific Decadal Oscillation (1978 to present). However, the estuary still supports many sensitive plants and animals, of which three are on the federal list of endangered species. These are the California least tern (Sterna antillarum browni), light-footed clapper rail, and salt marsh bird's beak. Also abundant at Tijuana Estuary is the state-endangered Belding's Savannah sparrow (Passerculus

+	More people will be served
	Recreation for bird and plant watchers Esthetic enjoyment by artists, photographers Stress reduction related to open space
-	More wastes need to be processed
	Nutrients from lawns and runoff Contaminants from streets Carbon dioxide from people, vehicles, and engines
-	Habitats are more isolated
	Insufficient dispersal Disturbed edges Lower diversity of species, genotypes
-	Exotic species will likely invade
	Human dispersal Excess runoff, lowered salinity Disturbance
-	Altered hydrologic and sediment dynamic
	More fresh surface water inflow Less fresh groundwater discharge due to groundwater pumping Poor water circulation due to roads, berms More sediment inflows due to construction upstream
-	Loss of transition from marsh to upland due to urban fill and steep banks
	Loss of high-tide refuges for mobile species, such as clapper rails Loss of bee habitat and reduced pollination of rare annual plants Loss of sensitive transition species such as box thorn (Lycium californicum) Loss of box thorn services, such as bird perching and nesting, small mammal cover and runways; natural "fences" provided by its spines and dense canopy (James and Zedler 2000).

TABLE 2. A major benefit (+) and many constraints (-) involved in restoring urban wetlands, relative to rural wetlands with less-altered watersheds (from Callaway and Zedler 2004).

sandwichensis beldingi). This site has multiple designations: National Estuarine Research Reserve, Ramsar Wetland of International Importance, State Park, and County Park. It attracts visitors and supports research and education for all ages.

When I moved to Southern California in 1969, all three of the above coastal wetlands were more degraded and more threatened by neglect and misuse than they are today. A few key citizen leaders and many who followed their leads transformed each of these "diamonds in the rough" into cultural and ecological amenities. Jim and Barbara Peugh led (and still lead) efforts at Famosa Slough; Joan Jackson was a key player in augmenting mitigation efforts at Sweetwater Marsh, and Mike and Patricia McCoy were critical in keeping Tijuana Estuary from becoming a marina. In every case, local residents helped to persuade public agencies to work toward restoration, and they sought science-based approaches to conserve and restore wetland biodiversity and related ecosystem services (before that term was in use).

The Ballona Wetland is also a diamond in the rough; it has many values in its present degraded condition and it has the potential to "shine," that is, achieve realistic restoration targets. How might it be restored to a "condition that maximizes human benefits while minimizing inputs of energy…by restoring ecological processes suited to the climate, topography, geology, and hydrological context," as Casagrande (1997) suggested? How can it be sustainable into a novel future, given all the constraints of an urban wetland (Table 2)? Once we acknowledge that we cannot turn back the clock, either for the watershed or the site, we can focus on accommodating landscape changes, even though we cannot predict details of future environmental conditions, including human behavior.

To meet the challenge of setting goals for an unknown future, I recommend establishing an adaptive restoration process that allows restorationists to distinguish achievable and unachievable targets based on field experimentation (Zedler and Callaway 2003; Zedler 2005). Adaptive restoration begins by establishing a restoration task force that is empowered to plan and implement restoration using field experimentation and related monitoring. The process is iterative and long term; it is based on obtaining data through long-term monitoring of both the site as a whole and experimental plots, interpreting the results, communicating the findings to a broad range of stakeholders, distinguishing achievable and unachievable targets, and adjusting targets accordingly. In planning experiments, it is important to aim high, that is, to set potential targets that might be achievable, then establish long-term field experiments to test alternative actions (Table 3).

Scenic views and photogenic species provide cultural services at the Ballona Wetland (Table 1), although there will always be some disagreement about which attributes are beautiful and which are impaired. Both the positive and negative descriptors (beauty, impaired) involve subjective judgments, and it is unlikely that all of the people will be pleased all of the time and in all places. I suggest that stakeholders agree on some basics, however, to the effect that native species are preferable to non-natives, and regionally rare species could be promoted for establishment even if there is no historical record of their occurrence at Ballona Wetlands. Examples are Pacific cordgrass, salt marsh bird's beak, box thorn (*Lycium californicum*), and tidewater goby (*Eucyclogobius newberryi*).

It is difficult to specify the ecosystem services that are restorable, and there might be disagreement about the services that should be restored first. Still, the public should know about the high value of ecosystem services that wetlands provide, despite their small global area. According to Costanza et al. (1997), tidal marshes provide services worth $9,990/ha/yr, mostly for "waste treatment," and estuaries provide services worth $22,832/ha/yr, mostly for nutrient cycling (Costanza et al. 1997). Of the many wetland services, N removal is especially valuable (Jordan et al. 2011).

EXAMPLES OF POTENTIAL TARGETS	POTENTIAL EXPERIMENTS WOULD TEST:
Establish some of the region's valued species (bird's beak? cordgrass? box thorn? tidewater goby?)	Alternative methods for introducing each species Alternative places and times to introduce each species
Detoxify soil contaminants	Alternative soil amendments Alternative plantings
Jumpstart creek formation	Ability of creating small vs. large channel mouths to catalyze creeks to form dendritic systems
Test the ability of habitat/nesting islands to enhance native bird populations	Islands of varied size and shape, if intertidal areas are suitable for a large experiment

TABLE 3. Some potential targets for the Ballona Wetland and ways to test if and how they can be achieved.

Restoring downstream urban wetlands is challenging, partly because of current landscape changes and partly because we have to anticipate unknown future conditions. We can rarely be certain which targets are achievable. However, adaptive restoration can distinguish the unachievable and achievable targets, and at the same time, identify the more effective methods for progressing toward project goals (Table 4). For example, if diverse vegetation does not appear to be achievable, it might still be possible to create microsites that support species that might otherwise fail to establish. In one experiment at Tijuana Estuary, we flattened a tidal plain and unknowingly prevented it from sustaining annual pickleweed (*Salicornia bigelovii*). Years later, the persistence of this plant in shallow pools nearby suggested its chief competitor, the perennial pickleweed, has a strong advantage except in the more waterlogged soils. Subsequent experimentation indicated that the annual can be sustained where ~5 cm of tidal water is retained at low tide (Varty and Zedler 2008). Additional research would be helpful in determining where complete dominance by perennial pickleweed can be avoided and more diverse vegetation is achieved.

Diversity should be most readily achieved where multiple habitats are provided in close proximity. Bird's beak can grow in disturbed high intertidal marsh, but as an annual plant, it needs ground-nesting bees to pollinate its flowers so seeds can perpetuate it. Thus, it did not thrive when seeded to a small island that was fully submerged at high tide at Sweetwater Marsh, but did reestablish where supra-tidal ground was present nearby. In another example, clapper rails need low marsh for nesting, marsh plains for foraging, and high marsh and transitions to upland for high-tide refuges in midwinter. These birds, including eggs and chicks, are vulnerable to both terrestrial and aerial predators in all locations, so dense vegetation is needed in the wetland-upland transition (to avoid dogs, cats), as well as tall cordgrass in the low marsh (to be less visible to raptors).

It is difficult to restore rare and endangered species in Southern California, in part because there are few coastal wetlands that are fully tidal, and in part because habitats are smaller than they were historically. Adapting to landscape change in the restoration of rare species would thus require a shift from strictly adhering to historical sites to including other sites where their habitat can be restored. Because the exact conditions of each restoration site cannot be predicted or even measured in great detail, I suggest aiming for heterogeneous topography, to include areas of supra-tidal land, the full range of tidally influenced wetlands, and complex tidal creek networks. Even exaggerated excavations can be beneficial, as at Tijuana Estuary's Model Marsh, because some degree of erosion and sedimentation are certain to occur. The Model Marsh might owe its shallow tidal creek networks to the excavation of deep channels early on (Wallace et al. 2005). There is ample room for more geomorphological research. For example, a large field experiment could test the need to over-excavate creeks in the Ballona Wetland. Questions that are amenable to experimentation are: Which

WETLAND	TARGETS REACHED	TARGETS RULED OUT	REFERENCES
San Diego Bay: Sweetwater marsh	Least tern foraging habitat (channels with fish) Salt marsh bird's beak established from seed	Nesting habitat for light-footed clapper rails could not be sustained due to sandy dredge-spoil substrate that could not accumulate nitrogen	Zedler 1993, Langis et al. 1991, Boyer and Zedler 1999, Williams and Zedler 1999, Parsons and Zedler 1997
Tijuana Estuary: Tidal Linkage	Native salt marsh can be established on tidal plain	Diverse plantings are not sustainable where conditions allow strong dominance by pickleweed	Callaway et al. 2003, Zedler and West 2008, Doherty et al. 2011
Tijuana Estuary: Model Marsh	Annual pickleweed can establish and persist in shallow (5 cm) pools	Diverse salt marsh not sustainable with sedimentation	Varty and Zedler 2008
Tijuana Estuary: Model Marsh	Fish use tidal creeks as habitat and corridors to the marsh plain where they feed in tidal pools	Large, deep channels are not sustainable far inland from the ocean mouth where sedimentation exceeds erosion	Larkin et al. 2009, Wallace et al. 2005

TABLE 4. Examples of adaptive restoration. In each case, experiments ruled out unachievable targets and helped managers to accept achievable alternatives.

environmental damages are reversible? Which ecological targets are achievable? Which plant species are most easily established and most readily sustained and most functional? What role can islands play, and which island sizes, shapes, and edge:core ratios are most effective in providing ecosystem services, including biodiversity support? Where will irrigation be needed? Where might pollinators be limiting to annual plant populations?

In restoration, practitioners should not expect to achieve all aims. Restoring habitat for endangered species is tough, and restoring sustainable populations of endangered species is tougher. No effort that I have been involved in avoided surprises, and the surprises led to expectations such as the following: Weather can be helpful (rain after planting) or fatal (tides add seawater; drought during low tides can cause mortality). Sedimentation and erosion will occur (despite heroic efforts to trap sediments upstream or position excavation sites where they will not fill in). Nutrient-rich conditions can enhance cordgrass growth (at low levels) or cause annual pickleweed to outgrow it (with prolonged use of fertilizer; Boyer and Zedler 1999). Algal blooms can smother seedlings (direct effect) and attract coots that trample young plantings (indirect effect). We can use a variety of attributes to track restoration progress, but each can follow a unique trajectory (Zedler and Callaway 1999). Greater understanding comes from tracking multiple ecosystem responses.
Returning to Casagrande (1997), I agree that "Wetland restoration in urban areas is, in effect, restoration of human habitat." The Ballona Wetland will always be a human habitat—it is a rare coastal open space in an urban landscape. I am uncertain about the claim that "Urban wetland restoration can restore the ecosystem to a condition that maximizes human benefits while minimizing inputs of energy." It is not clear how we can both maximize human benefits and minimize inputs of energy in the Ballona Wetland. Many of the restorable services are cultural and valued differently by those who appreciate the Ballona Wetland as is and those who see a more fully tidal future—in one of the last places where such a transformation is possible. Scientists can advise on how and why to sustain one or the other, but only the stakeholders can decide whether or not to fight for one or the other scenario or to work toward a compromise. I agree that we should proceed "by restoring ecological processes suited to the climate, topography, geology, and hydrological context of the restoration site." The site is suited for restoration to a fully tidal estuary. The initial investment will be large, but so will the rewards, especially if biodiversity and services become sustainable with minimal energy input. I agree that "such restoration does not require exact duplication of an historic landscape." Even if we could duplicate historical conditions, not all would agree on a time period or specific state to mimic. Ecosystems are too dynamic to specify exact outcomes or to expect any state achieved in the short term to be sustained into a novel future.

Today's urban wetlands are diamonds in the rough that can become tomorrow's shining jewels (Fig. 2). We all need to work together to make Ballona Wetlands and other Southern California wetlands shine—brilliantly!

Joy B. Zedler is Aldo Leopold Chair of Restoration Ecology, Botany Department and Arboretum, University of Wisconsin—Madison.

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FIGURE 1: Hidden L.A.
PHOTO: DIGITALLY REPRODUCED BY THE USC DIGITAL ARCHIVE ©2004, CALIFORNIA HISTORICAL SOCIETY: TICOR/PIERCE, CHS-2040

LOS ANGELES RIVER 3.0: CHANGING THE COURSE OF LOS ANGELES

OMAR BROWNSON & EMILY MARSH

Introduction

The Los Angeles (LA) River is a disruptive force that has changed the face of the city since its beginnings. The river has gone through multiple iterations as a critical source of fresh water, an infrastructure project for controlling flooding, and now a public resource for a sustainable city. Once disguised, the LA River is now being openly enjoyed by the public, from kayaking, cycling, and horseback riding to bike-in movie screenings. This renewed attention to the river is driving major investment. In summer 2013, the LA River Revitalization Corporation broke ground on the first philanthropically funded bridge in LA. The landmark La Kretz Crossing connects East and West Los Angeles, linking the newly expanded North Atwater Park to 4,200-acre Griffith Park via a bicycle, pedestrian, and equestrian structure. With spectacular views of the LA River, the surrounding parks, and downtown Los Angeles, the cable-stayed bridge will announce the river's rebirth.

All the good that is happening reflects tremendous changes in attitudes toward the river that date back to the beginning of Los Angeles. In 1781, the fresh water of the Los Angeles River attracted the forty-four settlers known as "Los Pobladores" who planted the seeds of a city. The river was lush and green, and a central place for residents to work and play. In the 1940s, to protect against flooding and to support the infrastructure needed to grow a city with roads and rail, the U.S. Army Corps of Engineers channelized the river into what we see today. Now, through a series of public–private partnerships, Los Angeles has an opportunity to create the longest urban greenway in the country. An LA River Greenway will transform LA. For too long, Angelenos have been stuck in a concrete landscape—frustrated that the only river they know is one of cars and cement. Every world-class city has defining public spaces—this is ours. It can be thought of as a linear Central Park—a grand public space that will redefine how we connect with Los Angeles. That is what the LA Greenway is truly about: connectivity. The LA Greenway will connect LA communities fragmented by major roads, connect Angelenos to their environment, and connect Angelenos to one another. Imagine a place, tracing from the San Fernando Valley, through the heart of downtown Los Angeles, and out through Long Beach Port, where kids can play, families can picnic, people can gather, and restored nature can flourish.

Transforming the Los Angeles River means turning what has historically been seen as a liability into an innovative civic and environmental asset, linking the Santa Monica Mountains to the Pacific Ocean. We have a real opportunity to create the city where we want to live. We can enhance the quality of life in a city hungry for green space and strengthen communities by restoring the LA River to a vibrant green corridor that people from throughout the country will want to visit and enjoy. The LA River Greenway will be the single greatest transformation of Los Angeles in the twenty-first century. It's not often that you can make an impact at this scale, along the full fifty-one miles of the river pathway.

An LA River Greenway will transform LA. …Every world-class city has defining public spaces—this is ours. It can be thought of as a linear Central Park— a grand public space that will redefine how we connect with Los Angeles.

Looking ahead, we need to strengthen the leadership and planning to work collaboratively across sectors and jurisdictions to be effective stewards of the Los Angeles River. We need to move more river-related projects from concept to construction. We need to make the vision for the LA River tangible for the public, and highlight our project's inevitability. Building from the City's LA River Revitalization Master Plan (2007) and the County's LA River Master Plan (1996), the LA River Revitalization Corporation aims to create a broad coalition of public, private, and philanthropic interests to support a common agenda based on the Greenway 2020 campaign.

The Los Angeles River Revitalization Corporation (RRC) is an entrepreneurial nonprofit venture responsible for catalyzing responsible real estate and related community development along the Los Angeles River. Founded in October 2009, the RRC was incorporated as an independent nonprofit by the mayor and City Council to act nimbly and quickly to implement the LA River Revitalization Master Plan. This Master Plan is a twenty-five-year blueprint for transforming the thirty-two-mile stretch of the LA River that flows through the City of Los Angeles. The LA River is at the heart of our vision to create new way of living in Los Angeles—the Greenway.

Los Angeles's once sprawling landscapes of orchards, river banks, and beaches inspired millions to seek the opportunity-laden Western frontier. The river, snaking from the San Gabriel Mountains to the Pacific Ocean, and 852 square miles of watershed served as a foundational resource that supported the quickly growing agricultural settlement. As Los Angeles grew into the West's largest economic powerhouse, the river's floods and shifting alluvial plains wreaked havoc on the factories and transportation yards that were built along the river's edges, posing a direct threat to the city's continued economic success. Thus, the river and its watershed were understood as a high-risk liability that needed to be controlled, resulting in concrete channelization in the 1930s. The transformation of the river from a rich, riparian landscape to a cement thoroughfare turned LA's once treasured life source into a piece of inaccessible infrastructure. Decades later, forgotten and ignored by the city's inhabitants, the now barren river channel, except for a few soft-bottom stretches, serves as a reminder of the river's reputation as a liability while continuously limiting natural habitats, the provision of green space and recreational opportunities, and the overall connectivity of Los Angeles's inhabitants.

In the past, cities and development were considered the antithesis of nature. More recently, however, nature and the city have been reframed as being intrinsically bound together; cities are created not through the destruction of nature but through the processing of nature from its organic state to its constructed state. Indeed, "Nature plays a complex triple role in urban development" as a resource input, as a location in space, and as a shell for our emotional and physical existence (Hall and Pfeiffer 2000, 104). In the creation and development of Los Angeles, the Los Angeles River has played each role. In each role (as a resource input, a location in space, and a shell), the river has been defined by the historical, environmental, social, and political contexts of Los Angeles itself. Today, efforts to revitalize the LA River and its tributaries offer a transformative opportunity to again redefine the river as all three roles at once.

Recent environmental efforts seek to revitalize the river's riparian ecological habitats and repurpose the river as an opportunity for parks, recreation, and community development. Through these revitalization efforts, river advocates are redefining the LA River not as a resource, a location, or an emotional and physical shell, but instead as a way to chart a new course to creating a healthier and vibrant Los Angeles, competitive and relevant to the needs of the twenty-first century. However, one of the core challenges facing these revitalization efforts is in reorienting the existing urban framework that defines the river as a single-purpose flood control mechanism toward a framework that defines the river as a multipurpose asset, ranging from parks and bike paths to opportunities for community and economic development. Further, the LA River provides critical environmental services to the greater Los Angeles watershed that are extremely valuable, in dollars and otherwise. With some of the river's natural functions restored, such as infiltrating rainwater, carrying stormwater, and providing habitat, the river's value as an asset will increase immensely.

To champion the river's multipurpose, asset-oriented framework, continued leadership and planning are needed to bring together the various environmental and greening agendas across local, county, state, and federal interests. The RRC's challenge is to articulate how the river fits into each department's silos and then challenge the departments to work together, including across jurisdictions, to more effectively implement river restoration and responsible land use projects. The RRC seeks to explore how the river's revitalization can be streamlined with appropriate governance that creates more opportunities for habitat restoration, community involvement, economic development, and urban entrepreneurship.

This article explores the governance challenges and legislative opportunities facing the LA River's revitalization. In first examining the river's history, the article provides a contextual framework for the river as a natural resource and infrastructure. The next section will detail the different government bodies that have jurisdiction over the river and how these governance structures pose governance challenges and increased revitalization opportunities. Finally, the article offers examples of legislation that would help further the stewardship of the LA River, its watershed, and its revitalization efforts. These examples are prime opportunities for policy to set the groundwork for enhanced urban river revitalization efforts while championing the river's reputation as Los Angeles's newest, oldest asset. Indeed, the LA River can become a symbol of LA's renewal as the river serves as an opportunity to reimagine nature, and community, in the city (Gottlieb 2007).

A Brief History of the LA River in Three Parts

The LA River 1.0: A Natural Resource

The Los Angeles River's history can be organized into three phases: first, its original natural state (Figure 1); second, its cement mechanized state; and, now, an opportunity for ecological and urban revitalization. The RRC has termed these three phases River 1.0, River 2.0, and, currently, River 3.0, with 3.0 offering a hybrid of the river's characteristics as it existed during the 1.0 and 2.0 phases.

When settlers first moved to the Los Angeles basin, they built orchards and towns along the river's banks. The river served as the backbone of the new city's economic success. LA County became the number one agricultural county in the United States until the 1950s. As much as the city depended on the river, however, its course was erratic with constant directional changes (Gottlieb 2007, 108). At the onset of the twentieth century, the city began to rapidly industrialize, serving as the West Coast's largest port. During this time:

> the LA River began to lose some of its visual appeal as anchoring the region's attractive landscape. Instead it came to be seen as a barrier for existing and future residential and industrial development along its path, owing to the propensity to carry rapidly flowing flood waters during the occasional but fierce storms that periodically occurred. (Gottlieb 2007, 139)

Along with the floods, focus on the LA River began to change with the construction of the LA aqueduct and the availability of LA's first imported water supply: The river was no longer an integral source of water for the city (Gottlieb 2007, 140). After two intense, destructive floods in 1934 and 1938, the city earned federal funding to finally control the river's ongoing flood risks. Since "Land-use planning is key to a locality's prosperity, demography and success" (Pinectl 2003, 981), the decision to channelize the river was key to Los Angeles's continued prosperity.

FIGURE 2: The concrete bed of the LA River. PHOTO: EDWIN BECKENBACH

The LA River 2.0: Mechanized Infrastructure

Plans to channelize the LA River were developed in the 1930s and implemented during the '40s and '50s by the Works Progress Commission (Artz 2012a; Armstrong 2012). When the Army Corps of Engineers was commissioned for the project, they were challenged to find the most effective way to provide flood control: "As the Army Corps of Engineers has often reminded its critics, Los Angeles, sited in an alluvial plain at the foot of a rugged, rapidly eroding mountain range, has the worst flood and debris problems of any major city in the Northern Hemisphere" (Davis 1999, 69). The resulting channelization design provided an effective and, indeed, elegant means of quickly conveying water from the San Gabriel Mountains to the ocean (Figure 2). The river was straightened, widened, and reinforced into a fifty-one-mile cement flood control channel, thus allowing millions of people to settle within the river's historic flood plain (Artz 2012a).

Although this strategy solved Los Angeles's flood problems, it also "[entombed] the natural river into a concrete straightjacket – effectively destroying the riparian landscape" (Davis 1999, 69). Predictably, the channelization of the river redefined the urban landscape: "Areas surrounding the river became fenced off, a forbidden territory that effectively [belonged] to the engineering agencies" (Gottlieb 2007, 141). At the time, however, the involved parties, including the city and the Army Corps of Engineers, did not necessarily understand that building this massive piece of infrastructure would damage the environment forever and set in motion this disconnect between people and nature (Armstrong 2012). In the decades following the channelization, the river became increasingly divorced from its natural origins. Since the river exists as

FIGURE 3: A view of an integrated social and environmental Greenway north of present-day downtown. PHOTO: PORT A+U

a concrete flood channel rather than a river, communities and houses along the edge have literally turned their backs to the river, viewing it as a liability and an eyesore.

LA River 3.0: Paradise Unpaved

River 3.0 is just beginning. Technology has advanced in the sixty years wherein we can maintain flood control capacity, while we restore some of the river's natural functions and bring the city back to the river once again. River 3.0, as envisioned in the city's Los Angeles River Revitalization Master Plan (LARRMP), will transform the river channel from its single-use purpose as a flood control mechanism to a multi-benefit asset for ecological restoration, greening and recreation, and community development (Figure 3). Just as the city rationalized channelizing the river to protect local prosperity and success in the 1930s, the LARRMP's river-focused land-use planning is also key to the city's "prosperity, demography, and success." Restoring some of the river's natural functions will not only provide immense ecological benefits to the river and its watershed but will also provide economic and social value: "Parks and open space, clean air, and attractive waterways are visible components of attractive urban regions, and should be added to the understanding of how localities promote economic development in a competitive globalized world" (Pinectl 2003, 982). The LARRMP links economic development, community revitalization, and habitat restoration strategies to create a more holistic urban river revitalization approach. The river's environmental, social, and economic impacts do not exist in silos: They are intrinsically integrated in its construction. As more and more revitalization projects take place along the LA River, the connectivity of the environmental, social, and economic impacts must be continuously considered and understood.

The evolution of the LA River from a natural resource to a concrete channel to, next, an urban greenway reflects the changing needs of the city and its inhabitants. Today, the LARRMP is a symbol of the city's urban regeneration efforts, offering a new framework for understanding urban LA and the important role of urban rivers in sustainable urban ecosystems. As Carey McWilliams wrote fifty years ago:

> Los Angeles is a 'land of magical improvisation,' a characteristic that . . . can be extended to such extraordinary initiatives such as efforts to re-envision the Los Angeles River as the centerpiece of building community and reimagining nature in the city. (Gottlieb 2007, 6)

Former Los Angeles Mayor Villagrosa refers to the river's restoration efforts as "un-paving paradise" (Armstrong 2012). Although restoration efforts have been powered by the desire to "undo the continuous loss of urban nature (Gottlieb 2007, 51), the LA River's revitalization is not simply about bringing nature back to the city; it's about directing the course of the city to be relevant and competitive for the next fifty years.

Challenges of Jurisdiction and Single-Purpose Agendas

Although the LA River was originally solely under the jurisdiction of Los Angeles County and the Army Corps of Engineers, today the river is controlled by multiple governance scales, including city, county, state, and federal. Because the river is not under a single jurisdiction, it is especially important that the river is considered in the environmental and greening agendas of each governing layer. At the city level, for example, decisions regarding the river require the involvement of multiple departments, including the Bureau of Engineering, Bureau of Sanitation, Department of City Planning, and Department of Parks and Recreation. Rather than excluding the river from the departments' agendas, as was often the case, the river's revitalization provides an opportunity for different departments to develop cohesive strategies that streamline processes relating to the river's revitalization projects. Before the ways in which governance structures and policies can facilitate revitalization are explored, the current multi-scalar (and multipurpose) projects that are taking place along the LA River, their limitations, and opportunities must be understood.

Federal and City: The Army Corps of Engineers' LA River Ecosystem Restoration Feasibility Study

The U.S. Army Corps of Engineers' LA River Ecosystem Restoration (ARBOR) Study is investigating opportunities to restore the critical natural and cultural heritage resource that is the LA River, which flows through historically disadvantaged communities and underserved neighborhoods of Los Angeles (Figure 4). The seven-year, $9.7 million study will lead to the restoration of two thousand acres of habitat along eleven miles of the river from downtown to Griffith Park, to revitalize and create a functional, connected watershed that will provide a more diverse ecological system across the region.

The project will provide an economic boost to the area, increasing property values in the vicinity of the study area and improving the quality of life for residents of Los Angeles. Many of the historically disadvantaged communities along the river do not have access to open space resources and have high unemployment rates. The project will provide an opportunity to rectify this environmental injustice.

Although the LARRMP advocates for projects that provide restoration and recreation, the Army Corps of Engineers is assigned to provide habitat restoration and endangered species protection, with limits on the percentage of the study that can be used in recreational development. However, the ARBOR Study is bringing much needed local and federal attention to the LA River and its potential future redevelopment. Indeed, part of the challenge for the

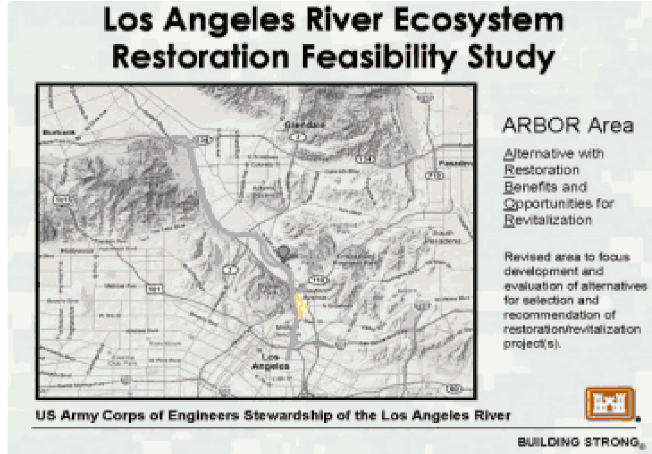

FIGURE 4: A map of the Army Corps of Engineers' ARBOR area.
PHOTO: ARMY CORPS OF ENGINEERS

Army Corps of Engineers' ARBOR project team is to make a case to show that "urban ecosystem restoration has a place in the Corps' restoration initiative" (Artz 2012b). If the ARBOR Study becomes a federally supported project, then the LA River will directly benefit while the importance of urban river restoration is elevated as whole.

At the local level, the RRC plays an integral role in building political, stakeholder, and community support for the river's ecological restoration. In linking the river's environmental restoration to local communities and opportunities for economic development, the ARBOR Study becomes more than just a habitat restoration project. The study is a means of paving the way for increased activity and investment in the river's overall revitalization.

Federal: Urban Waters Federal Partnership

The LA River Watershed has been chosen for the Urban Waters Federal Partnership's first phase pilot program, which is focused on communities. The Partnership, which consists of thirteen federal agencies including, the U.S. Environmental Protection Agency (EPA), Department of the Interior, and Department of Energy, seeks to "revitalize urban waters and the communities that surround them, transforming overlooked assets into treasured centerpieces and drivers of urban renewal" (Urban Waters Federal Partnership 2011b, 1), with a particular aim to improve urban water areas in blighted communities. Similar to the RRC's local efforts, the Partnership asks government agencies to break down their program silos to pursue a collective effort that will "reverse past neglect, energize existing programs, and engage new partners" (Urban Waters Federal Partnership 2011b, 1). In many ways, the Partnership serves as a federal-level model of what the RRC aims to achieve at the local level. By creating opportunities for agencies, departments, and organizations to work across programs toward the same revitalization goals, the overall long-term benefits will be more effective for all participants.

The LA River Watershed was one of seven locations chosen for the First Phase Pilot Program. Similar to the objectives of the

Transforming the Los Angeles River means turning what has historically been seen as a liability into an innovative civic and environmental asset, linking the Santa Monica Mountains to the Pacific Ocean.

LARRMP, the LA River Watershed's project will enhance flood protection, improve water quality through green infrastructure, facilitate safe public access, and revitalize riparian ecosystems (Urban Waters Federal Partnership 2011a). In addition to the federal partners, the local project will also partner with state agencies (such as State Coastal Conservancy and Mountains Recreation and Conservation Authority), local government agencies (including the City of Los Angeles and the Los Angeles County Flood Control District), and nongovernmental organizations (including the RRC, LA Conservation Corps, and Friends of Los Angeles River [FoLAR]). These multi-scalar partnerships will be working together to complete a multitude of projects, feasibility studies, and outreach programs over the next two years. Most importantly, "The Partnership helps . . . coalesce local leaders around issues of national importance which, in turn, helps encourage practical grassroots projects that are better coordinated and implemented more efficiently given limited resources" (Urban Waters Federal Partnership 2011a). Here the RRC's efforts to elevate the conversation about the LA River watersheds become important. In articulating how the river and its wider watershed relate to different projects, agencies, and organizations, multi-scalar organizations can work across program areas to make the LA River a leader in the national urban waters revitalization effort.

Federal: America's Great Outdoors Initiative

In 2010, President Obama launched America's Great Outdoors (AGO) Initiative to develop local agendas for conservation and recreation. Similar to the Urban Waters Federal Partnership, the AGO is working to make the federal government a better partner with states and local communities while encouraging local, grassroots conservation and restoration initiatives. In the AGO's fifty-state report, which outlines some of the country's most promising opportunities to reconnect communities with nature, two California projects were highlighted. One was recreational efforts for the LA River (U.S. Department of the Interior 2011). As a result, the Department of the Interior (DOI), which has led this initiative, will work with its key bureaus (including the National Park Service and the Bureau of Land Management) to make resources available to support the goals of the LARRMP, especially for river revitalization efforts and building recreational trails along the river's edge. This groundbreaking federal initiative encourages partnerships to occur from the ground-up and highlights the importance of local knowledge as it relates to urban conservation issues. In this vein, there's a distinct opportunity for local LA organizations to leverage their energy and resources to instigate river revitalization partnerships and projects.

State: Senate Bill 1201

Most recently, and perhaps most importantly, California passed Senate Bill 1201 in 2012 as a result of the advocacy group Friends of the Los Angeles River who championed greater access to the LA River. After decades of the flood channels being closed to the public, the bill legalizes access to the soft-bottom sections of the LA River by reclassifying natural-bottom flood channels as natural rivers, which is necessary to release local agencies from liability for harm that occurs in flood channels. SB 1201 also created the Los Angeles River Interagency Access Council, which will coordinate state and local agencies in providing public access and developing safety policies for the LA River. Although SB 1201 occurred later in the LA River's revitalization timeline, the passing of the legislation indicates that restoration and recreational efforts can actually take place in that relevant projects can ensure access to previously inaccessible areas.

County: LA County's Sediment Management Strategic Plan

The County's role is primarily focused on flood control and environmental management of the LA River. In 1996, the County developed the Los Angeles River Master Plan, which outlines a system of greenway trails and parks along the entire river and through several cities (Armstrong 2012). Because the LA County Flood Control District manages the LA River as a flood control mechanism, along with the Army Corps of Engineers, the Flood Control District's activities and projects, such as the County Master Plan, are often more closely oriented toward flood control efforts while the LARRMP focuses on reconnecting communities to the river. The Flood Control District manages a system of dams, reservoirs, debris basins, and other drainage infrastructure, which reduces the risk of floods but simultaneously results in highly unnatural sediment transport in the river itself. LA County's Department of Public Works recently created the Sediment Management Strategic Plan to provide direction on how to handle new challenges of sediment management and how to pursue other management alternatives that can reduce the negative environmental impacts. Although the Strategic Plan is a living document that still primarily focuses on flood risk management and water conservation, the plan is a unique opportunity for the County to pursue more environmentally focused flood management activities. Such activities could include opportunities for more natural sediment control and reduced vegetation removal to increase the river's natural habitat and aesthetic qualities. Through the Sediment Management Strategic Plan and other similar projects, the County will play a key role in shifting perception of the river from a single-function flood control channel to a multi-benefit river with ecological value.

LA City: Community Specific Plans and Tributary Protection

The City of Los Angeles is the champion and steward of the LA River revitalization efforts. In various partnership and management roles, the City's LA River Project team, housed in the Bureau of Engineering, serves as a focal point for facilitating revitalization and restoration efforts. In a partnership role, the City is the "public entity helping to implement [the LARRMP] and [is] the local sponsor of the Army Corps of Engineers' LA River Revitalization Feasibility Study" (Armstrong 2012). In a management role, the City oversees the development and eventual implementation of the River Improvement Overlay (RIO) District, which outlines specific land zoning rules that will reorient communities and plant palettes toward revitalizing the river's riparian landscapes. Community planning areas and community specific plans, such as the Cornfield Arroyo Seco Specific Plan, are areas where the city is developing plans to reorient communities toward the river while leveraging the environmental and recreational benefits. Such activities will prove critical as components of the LARRMP are implemented and if the Army Corps of Engineers' feasibility study becomes a funded project. Further, the City protects the tributary streams that feed into the river to prevent past mistakes related to the river's channelization.

Re-Framing the LA River

In establishing the LA River as multipurpose asset, the most influential task will be to insert the river into key urban conversations to better lead and coordinate the river's transformation into a great urban greenway. Although the river in recent history has been framed as a piece of mechanized infrastructure, protecting LA's population from harm, the LARRMP has outlined a path to restore some of the river's natural qualities while reconnecting communities and the city of Los Angeles as a whole to the broader watershed. Indeed, "Part of the power of the efforts to restore or at least modify the LA River's current state as a concrete channel has been the power of nostalgia, the desire to undo the continuous loss of urban nature" (Gottlieb 2007, 51). The LARRMP's environmental restoration, recreational development, and community revitalization projects provide an opportunity for the river to be built anew. If the river is reestablished as a resource, an asset, and an actual place, then the river can effectively change the course of LA.

Although the previously outlined projects and partners have incited key, influential efforts to revitalize the LA River, the challenge is elevating river restoration conversations at the local level. Conveying the plan to the public continues to be difficult. Moreover, there is "still widespread lack of awareness of the LA River, that it exists at all" (Armstrong 2012). Although public awareness is important, the attention of policy and legislation could lead to key changes that will streamline and encourage revitalization efforts from several perspectives. Further, in the river's current form, the LA River is, quite literally, a piece of infrastructure. To repurpose a piece of infrastructure, there must be attention from the highest levels of government. Although federal involvement thus far (such as the Army Corps of Engineers' Feasibility Study and the Urban Watersheds Federal Partnership) has initiated this attention, an ecosystem of policy and legislation must be built to support and continue these efforts. Although grassroots organizations, such as FoLAR, have advocated for the river's revitalization since the 1980s and many local organizations and public entities have successfully implemented pocket parks, river trails, and more, these organizations are limited when it comes to affecting infrastructure. At the moment, neither local organizations nor government agencies have the means to build multimillion-dollar, multi-jurisdiction projects. As the LA River illustrates, urban river revitalization:

> raises a series of questions about how environmental management is being incorporated into urban governance in different urban contexts, not least in terms of how local territorial structures associated with ecological modernization are situated in relation to those concerned with promoting urban development, managing territorial redistribution and the like. (While, Jonas, and Gibbs 2004, 549–50)

Articulating the LA River: A Series of Vignettes

This section explores examples of how the river's profile could be elevated in the agendas of different government departments and agencies. More importantly, elevating the river's profile as an asset, a benefit, and a place across multiple agendas can further reduce programmatic silos and invite enhanced cross-governmental partnerships. The first examples examine how current policy or legislation could be modified to streamline revitalization and restoration efforts. The next set of examples explores potential measures of which, if they're put forth, the river should be a focal point. These vignettes articulate examples of how organizations can and should begin to think about the river in a multipurpose, asset-based framework.

LA County Storm Water Pollution Measure

LA County's Storm Water Pollution measure from the Los Angeles County Flood Control District, which was recently deferred from being placed on the ballot, proposed placing a levy on all property owners within the district. The parcel fee would have raised an estimated $290 million per year to help cities and the County mitigate water quality issues stemming from polluted stormwater and urban runoff. Although tight budgets were of significant concern for public agencies residing within the flood control district, a different approach to the measure might have elicited a different response. For example, if the river's restoration goals, as outlined in the LARRMP, Proposition 84, and the Feasibility Study, had been included as one of the main reasons for the Storm Water Pollution Measure, then the flood control communities may have had a better vision of the benefits of mitigating water quality issues. The parcel fee might have been considered more than an additional property cost but instead would have been part of the larger, transformational effort behind re-imaging the river and the future of Los Angeles. The Storm Water Pollution Measure would provide much needed eco-services for treating the river's polluted, potentially hazardous, stormwater runoff. Given the recent passing of SB 1201, which allows public access to the natural bottom portions of the flood channel, the proposed stormwater treatments are especially important. However, because the measure did not promote the broader environmental and health benefits of revitalizing the river as a whole, the measure's long-term benefits failed to capture the public's imagination.

LA River Greenway 2020

Imagine a fifty-one-mile continuous greenway from Canoga Park in the Valley to Long Beach. More than twenty-six miles of paths already exist. The LA River Greenway 2020 campaign aims to close the gap on the remaining twenty-four miles to create one of the largest urban greenways in the country. The RRC seeks to build a shared vision and partnership with leaders from public agencies, design, nonprofits, and philanthropy communities to collaborate, integrate planning, and raise public and private resources. Access to and along the river is the catalyst to activate this great public resource. The Greenway is more than an environmental project. It is critical to connecting the divided and expansive Los Angeles metropolis, linking together fourteen cities and the diverse communities that span the river's length. The LA River Greenway is key to anchoring a permanent, regional non-motorized transportation corridor in Los Angeles County. Greenway 2020 would not only provide Angelenos safe routes for commuting to work but would also create more access to open space and recreation for the underserved neighborhoods along the River. A continuous bike path would fundamentally transform the way Angelenos relate to the river and move across the region. In addition to non-motorized transit opportunities, the Greenway opens opportunities for increased public transit, as one third of all Metro stops are within one mile of the river.

Key projects to extend this LA River Greenway are in motion. As part of the Evolution project, NBC/Universal will extend the existing seven-mile greenway to Lankershim by 2016. The RRC will work to extend the Greenway from Lankershim along the river to Balboa Park and then to Warner Center to complete the river's westward leg. Concurrently, the RRC will work to bridge the gap between the end of the existing Elysian Valley bike path at the north edge of downtown and the City of Vernon, where the existing river path resumes and travels the remaining 16.8 miles to the ocean.

Momentum for the LA Greenway has been building. Legislative bill AB735 was recently introduced in Sacramento by Representative Jimmy Gomez to champion greenways statewide. Mentioning the LA River by name, this initiative is part of a broader Greenway 2020 campaign to build support. Greenway 2020 captures the imagination of the public. It continues to engage key public agencies. The RRC has been central to the effort to make the case for the LA River as a leading civic priority.

To leverage the resources and funds required to accomplish LA River Greenway 2020, Los Angeles will need to work in partnership. Revitalizing the LA River will be the single greatest transformation of Los Angeles in the twenty-first century. The RRC will lead the charge and create the essential public, private and philanthropic partnerships this project needs to succeed.

> With some of the river's natural functions restored, such as infiltrating rainwater, carrying stormwater, and providing habitat, the river's value as an asset will increase immensely.

Conclusion

The Los Angeles River is an integral part of the history of Los Angeles. Once forgotten, the river is now being reimagined as the heart of a more sustainable city. The LA River is an idea whose time has come. The revitalization of the LA River will be a key test of the feasibility of public–private partnerships to pave the way toward tangible change. An ambitious vision, the revitalization is an indicator of the public values of the Los Angeles, and the extent to which the city can come together to shape its urban landscape. The LA River will be a continuous fifty-one-mile greenway that creates open space, connectivity, and economic revitalization from the Valley to Long Beach.

The public sector is increasingly coming together to advance river transformation. Acting as a hub to cut across jurisdictions, the LA River Revitalization Corporation is working to create healthy, vibrant communities, enhanced green infrastructure, and better recreational facilities. River revitalization will happen; the policy and projects are already in motion. A range of city, state, and federal initiatives—described above—have created the enabling context for the LA River to thrive. The only question remaining is how long river renewal will take. One thing is clear. A restored LA River will be a centerpiece of Los Angeles—to identify the city with a sustainable future. We will transform the Los Angeles River, and, in turn, positively affect the lives and opportunities for all Angelenos.

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FIGURE 4: Kayakers on the Los Angeles River in the Sepulveda Basin, 2011.
PHOTO: DEREK LAZO

REVITALIZED RIVERS AND VIBRANT COMMUNITIES: THE PROMISE IN LOS ANGELES

NANCY L. C. STEELE, MIKE ANTOS, & PAULINE LOUIE

Abstract

The coastal draining rivers of Los Angeles County are engineered and managed for two primary purposes: reducing the risk of flooding and retaining mountain rainfall for water supply. All other benefits of the rivers, or ecosystem services, have been reduced or eliminated. Changing and enlarging the priorities for the urban rivers of Los Angeles requires full implementation of a new paradigm, based on a watershed approach and requiring the coordinated, collaborative efforts of many local, state, and federal organizations and agencies. In Los Angeles, a new partnership with multiple agencies of the federal government is providing assistance. Led by the U.S. Environmental Protection Agency (EPA), the Urban Waters Federal Partnership (UWFP) is an umbrella for broad, cross-sector coordination and implementation of a region-wide watershed approach. To achieve a restored river and revitalized communities in Los Angeles, the organization and agency partners of the UWFP need to strengthen the existing collaborative network to effectively coordinate and carry out the work of facilitating, supporting technology and communication, collecting and reporting data, and handling logistical and administrative details. The UWFP is among the newest additions to a chorus of adaptive management efforts related to the Los Angeles River watershed. Success will require smart, watershed-wide, collective impact planning and investment to achieve the vision. In this way can the Los Angeles River reclaim its multiple benefits and serve as a vital resource for communities.

Introduction

Today, the coastal-draining rivers of Los Angeles County are engineered and managed for two primary purposes: reducing the risk of flooding and retaining mountain rainfall for the water supply. The ecosystem services provided by rivers, primarily supplying water, growing fish, serving as a conduit for transportation, recreational

FIGURE 1: Map of the Los Angeles River watershed. CREDIT: COUNCIL FOR WATERSHED HEALTH

opportunities, cycling nutrients, transporting sediment, filtering pollutants, and others (U.S. Geological Survey 2007), were reduced in the Los Angeles system over the past century to one service—supplying water, primarily sourced from mountain rainfall.

How can the communities adjacent to rivers, and part of the river watersheds, reclaim the multiple benefits from those rivers so they are a resource for communities? What has happened in Los Angeles has happened to rivers across the country. The stories are the same; only the details are different. Changing and enlarging the priorities for the urban rivers of Los Angeles require full realization of the paradigm of watershed management. Although it took two agencies, one local and one federal, working for most of the twentieth century to engineer a flood control system from the rivers, the future system requires the collaborative efforts of many local, state, and federal organizations and agencies.

The federal commitment to "be at the table" on a working level is a rare opportunity for the local stakeholders who have long been involved with river restoration and revitalization.

A watershed approach is widely accepted as the most effective framework for addressing water resource challenges (U.S. Environmental Protection Agency [EPA] 2012a). Working with the landscape and its natural processes, a watershed approach relies on sound science, receives input from multiple stakeholders, and integrates multiple programs to strategically address priorities and resolve challenges. The watershed approach integrates scientific research and engineering in a management process that requires the consent and support of the public. Thus, the decision-making cycle includes not only planning, implementing, monitoring, assessing, and adjusting but also providing feedback to and from the public (Alcamo and Bennett 2003). The question remains: How do you fully implement a watershed approach in a system of agencies, cities, and organizations, each with its own authorities, jurisdictions, and missions?

In Los Angeles, a new partnership with multiple agencies of the federal government is providing some answers to this question. Led by the U.S. EPA, the Urban Waters Federal Partnership is an umbrella for broad, cross-sector coordination and implementation of a region-wide watershed approach. The Partnership was formed as an acknowledgement that large-scale change requires commitment from key agencies and organizations from different sectors working together on a common agenda.

Traditional Navigable Waters

On July 6, 2010, the EPA issued a ruling that the entire fifty-one-mile Los Angeles River is "traditional navigable waters" of the United States (U.S. EPA 2010a) (Figure 1). The EPA decision clarified the legal status of the river under the Clean Water Act and overturned an earlier decision by the U.S. Army Corps of Engineers to designate only 3.75 miles in two reaches as "traditional navigable waters."

The decision by the Army Corps of Engineers, issued two years earlier in March 2008, was met with protests by advocates for the river. Removal of Clean Water Act protection from most of the river was seen as a setback after decades of work to change the perception of the river as nothing more than an open urban storm drain. Seven environmental groups responded to the March decision with a joint letter of protest to the EPA. Over three days at the end of July 2008, a small group of twelve people committed an act of civil disobedience when they navigated the length of the LA River in canoes and kayaks in the Los Angeles River Expedition, seeking to show that the river was navigable by small craft (de Turenne 2008).

Two days after the EPA issued its ruling, Administrator Lisa Jackson stood on the banks of Compton Creek, a tributary of the river, and stated:

> A clean, vibrant L.A. River system can help revitalize struggling communities, promoting growth and jobs for residents of Los Angeles. We want the L.A. River to demonstrate how urban waterways across the country can serve as assets in building stronger neighborhoods, attracting new businesses and creating new jobs. (U.S. EPA 2010b)

The founder of Friends of the Los Angeles River, poet and writer Lewis MacAdams, exulted in the implications of the decision. "This is an important day, one we've been working toward for years," said MacAdams. "It is a day when the EPA has essentially redefined the L.A. River and its values. In other words, starting today, a flood control channel is only one of its many characteristics" (Sahagun 2010).

The EPA based its decision on historic use and current navigation and recreational uses of the river. Although the evaluation was based in science and engineering, the conclusion is an important political milestone in the cultural history of the river and its relationship to the communities through which the river flows. The decision also set the stage for more federal involvement in the region, a mirror of the process that brought us the current river.

Taming the River, Conserving Water

Many great cities have developed alongside rivers in order to use them as a supply and a drain, for commerce and for recreation. Los Angeles is no exception; because of the region's semiarid climate, settlements for thousands of years relied upon the perennial mild flows (MacDonald 2007) near the confluence of the Los Angeles River and the Arroyo Seco and stayed clear of the vast areas of the region that would become flooded during winter rains.

The earliest European who recorded his impression of the Los Angeles River was Father Juan Crespi during the Portolá Expedition of 1769 from San Diego to Monterey. Crespi described a "good sized, full flowing river" near present-day downtown in August, the middle of the dry season (Gumprecht 1999). The earliest settlements by the Spanish were placed near water supplies, including the agricultural settlement that became Los Angeles (Wagner 1935). Some one hundred years later, the river would still be described as a "willow-lined stream" by none other than William Mulholland, famed chief engineer of the Los Angeles Department of Water and Power (Carle 2000).

A series of major storms causing great loss of life and property from the 1880s through the 1930s coincided with rapid development of the Los Angeles region, as the population grew more than ten times (LA Almanac 2012). New residents often did not appreciate or were not told about the potential hazards of winter storms, seeing instead an arid landscape free of water (Davis 1998). Thus, the floodplains were settled. After a particularly damaging flood in 1914, the Los Angeles County Flood Control District (LACFCD) was created by an act of the California legislature in 1915 (Gumprecht 1999). The new district was empowered to provide flood protection, water conservation, and recreation and aesthetic enhancement, through assessments on property owners and bonds. The first LACFCD project involved installing check dams and debris basins along the foothills of the San Gabriel Mountains.

In 1935, after several more disastrous floods pointed to the need for urgent action, President Roosevelt authorized Works Project Administration funding, allocated to the U.S. Army Corps of Engineers, to complete a flood control and water conservation system for the Los Angeles region. Many millions of dollars and thirty-five years later, the Los Angeles County Drainage Area Project, the largest public works project west of the Mississippi River, undertaken by the Army Corps of Engineers in partnership with the LACFCD, was officially completed (Gumprecht 1999). It is fortunate that the plans for the rebuilt river system included detaining and conserving rainfall in the mountains; otherwise, the river would in truth have become nothing more than a single-purpose storm channel.

The first director of the LACFCD, James W. Reagan, advocated for a system of mountain dams and reservoirs, not to store water for direct use as a water supply but for gradual release for percolation into aquifers tapped by wells:

> Very little consideration is being given by the sub-dividers to the providing of the county in the near future with an adequate and vitally necessary supply of water. . . The depletion of the underground water supply in Los Angeles County is extremely alarming. The present plan of running this very much needed floodwater away to the sea as quickly as possible . . . should be discontinued as quickly as possible. (Reagan 1924)

The landscape of Los Angeles, before urbanization, could capture 95 percent of most storms (Los Angeles & San Gabriel Rivers Watershed Council [LASGRWC] 2010a). Rain would fall on the vegetated slopes and sink in or flow toward the highly porous soils of the valleys and coastal plain. Water that did not otherwise

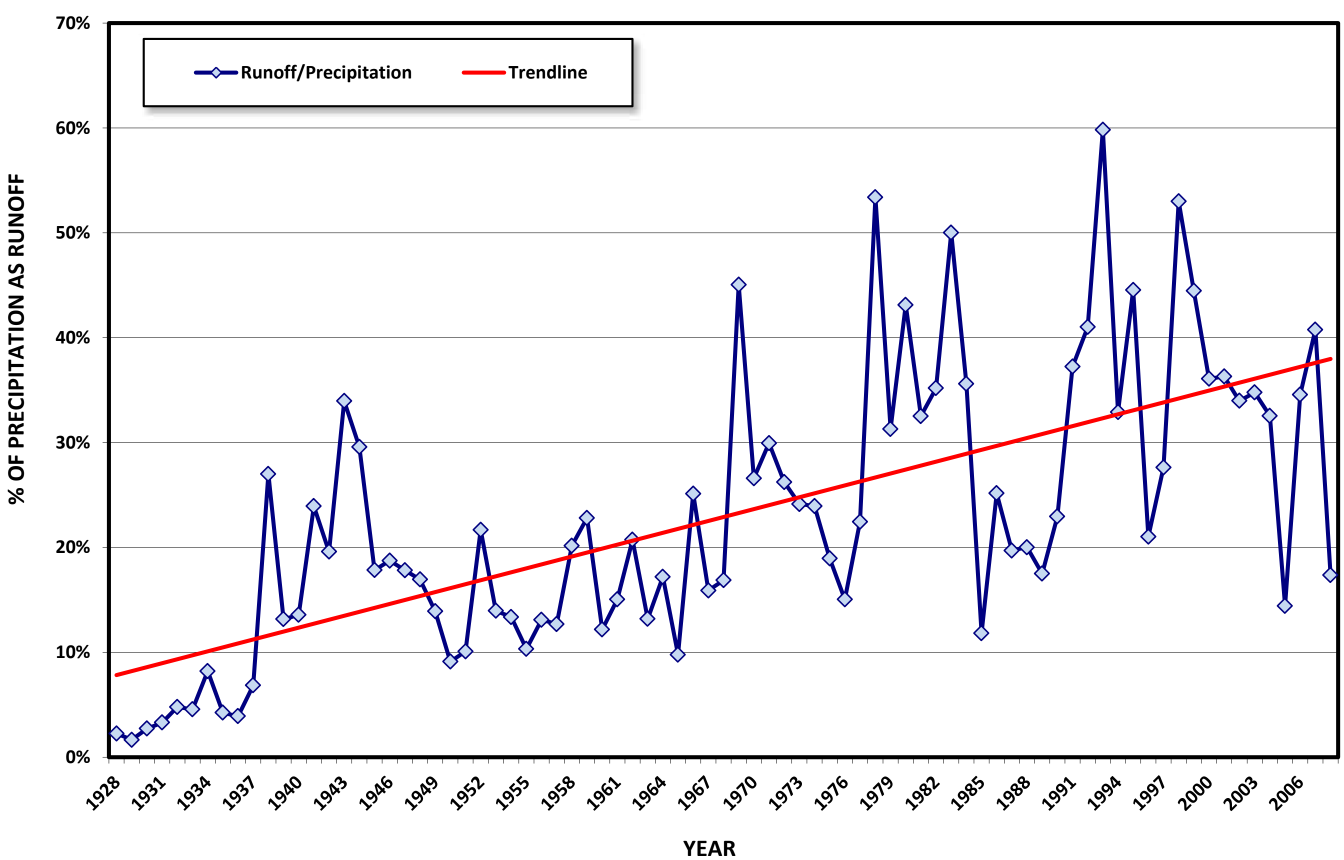

FIGURE 2: Ratio of annual runoff to annual precipitation in Los Angeles (1928–2008). DATA SOURCES: LOS ANGELES CIVIC CENTER PRECIPITATION, WESTERN REGIONAL CLIMATE CENTER; LOS ANGELES RIVER FIRESTONE BLVD. STREAM GAGE, COUNTY OF LOS ANGELES DEPARTMENT OF PUBLIC WORKS.

evaporate or transpire from the leaves of plants would fill the deep aquifers contained in coarse sediment washed off the mountains. Plentiful groundwater would rise to the surface in the Glendale Narrows, providing year-round flows for this reach of the river.

The rivers would rage in only the largest storms or wettest of winters. The Los Angeles River could reportedly increase its flow 3,000 percent in one day, rivaling the Colorado River for discharge volumes (Davis 1998). Today, mountain and foothill dams restrain much of the flow during winter storms. Urban hardscape also increases runoff and reduces infiltration of stormwater. As a result, only about 60 percent of the rain soaks into the ground today; the rest is directed to the ocean (Figure 2).

Nevertheless, groundwater remains an important source of water supply for the Los Angeles region, providing about 40 percent of the total. Recharge of captured mountain runoff using spreading basins is by far the largest component of active recharge (Metropolitan Water District of Southern California 2007). Although the details may not have been clear to the engineers of the early twentieth century, they knew that groundwater was an essential supply to a growing population in a region with few perennial streams.

In addition to the challenge of taming the river and conserving the water, many other water-related problems confront the Los Angeles region. Climate change reduces the reliability of the water supply system. The rivers are polluted by urban runoff, and the resemblance to natural rivers is gone. The amount of native vegetation and wildlife continues to decline with development and too frequent wildfires that convert chaparral to non-native grasses. Urban communities have too few parks and little access to wide open spaces. A watershed approach is necessary as it benefits communities and ecosystems by using a systems approach to solving these problems simultaneously.

Revitalizing Communities and Waterways: Urban Waters Federal Partnership

Almost one year after the EPA's ruling on the navigability of the river, the Los Angeles River was selected as one of seven pilot watersheds for implementation of the Urban Waters Federal Partnership (UWFP) with the vision that "urban waterways across the country can serve as assets in building stronger neighborhoods, attracting new businesses and creating new jobs" (U.S. EPA 2010b). On June 24, 2011, eleven federal agencies signed a statement of principles to launch the Urban Waters Federal Partnership with the stated goal of restoring urban waterways and revitalizing communities throughout the United States. The Los Angeles River is joined by the Anacostia (Washington, DC, and Maryland), Patapsco (Baltimore), Bronx and Harlem River (New York), South Platte River (Denver), Lake Pontchartrain (New Orleans), and the northwest Indiana area (U.S. EPA 2011). The partnership has since grown to thirteen federal agencies and added eleven new waterways (U.S. EPA 2013a).

The Urban Waters Federal Partnership is aimed at reconnecting urban communities with their waterways, particularly communities that are overburdened or economically distressed. The vision is of transforming "overlooked assets into treasured centerpieces and drivers of urban renewal" (U.S. EPA 2013b). The Partnership improves coordination among federal agencies and collaborates with community-led revitalization efforts to improve the nation's water systems and promote their economic, environmental, and social benefits. Specifically, the program:

- Break(s) down federal program silos to promote more efficient and effective use of federal resources through better coordination and targeting of federal investments.
- Recognize(s) and build(s) on local efforts and leadership, by engaging and serving community partners.
- Work(s) with local officials and effective community-based organizations to leverage area resources and stimulate local economies to create local jobs.
- Learn(s) from early and visible victories to fuel long-term action.

This notion of reconnection is echoed through many of the Obama administration's programs and initiatives, with activities designed to complement several others in objective and scope to several others. The 21st Century Strategy for America's Great Outdoors (AGO) detailed by President Obama in April 2010 was one of the first efforts by the administration to line up federal support behind the doctrine of multi-benefit engagement of natural resources. In its implementation, AGO has opened a number of pathways for projects that promote coexistence of conservation and recreation ideals.

With a more specific scope to urban waterways, the Urban Waters Federal Partnership has expanded the AGO vision to using restoration and stewardship of rivers and watersheds to catalyze other benefits, such as health, education and recreation, economic development, and smart land use planning, to fulfill additional community priorities.

Recognizing that accomplishing these goals in urbanized and built-out places often presents competing visions with existing infrastructure and development, the Urban Waters Federal Partnership work has strategically leveraged the federal Partnership for Sustainable Communities (U.S. EPA 2013a). The Partnership for Sustainable Communities is a significant cooperation between the U.S. Department of Transportation, the U.S. Department of Housing and Urban Development, and the Environmental Protection Agency that has aligned regional planning, transportation investment, and environmental stewardship. One project, described below (Northeast Los Angeles Riverfront Collaborative), received a Challenge Grant from the U.S. Department of Housing and Department (HUD) to identify economic and recreational benefit opportunities along the Glendale Narrows stretch of the river in northeast Los Angeles, which has allowed the participating agencies to engage the larger effort through direct programmatic support.

Participating Partners

Federal Agency Partners

Army Corps of Engineers
Department of Agriculture, Forest Service
Department of Commerce, Economic Development Administration
Department of Commerce National Weather Service
Department of the Interior
Department of the Interior, Fish and Wildlife Service
Department of the Interior National Park Service
Department of the Interior U.S. Bureau of Reclamation
Department of the Interior U.S. Geological Survey
Department of Housing and Urban Development
Department of Transportation
Environmental Protection Agency

Non-Federal Partners

Arroyo Seco Foundation
California State Parks
City of Glendale
City of Long Beach
City of Los Angeles
Council for Watershed Health
Friends of the Los Angeles River
Gateway Cities Council of Governments
Los Angeles County Bicycle Coalition
Los Angeles Conservation Corps
Los Angeles County Public Works/Flood Control District
Los Angeles Regional Water Quality Control Board
Los Angeles River Revitalization Corps
Los Angeles Unified School District
Mountains Recreation and Conservation Authority
San Gabriel and Lower Los Angeles Rivers and Mountains Conservancy
Santa Monica Mountains Conservancy
State Coastal Conservancy
The River Project
TreePeople
Trust for Public Land
Urban Rivers Institute
Urban Semillas

FIGURE 3: Los Angeles Urban Waters Federal Partnership (box).

Los Angeles UWFP

The Los Angeles UWFP established in 2011 is led by the U.S. EPA and is joined by nine other federal agencies and twenty local organizations (Figure 3). The Partnership enjoys high levels of participation by federal partners and local stakeholders, all of whom view the Urban Waters Federal Partnership as an opportunity to elevate the profile of river revitalization work to one that will draw high-level attention and necessary resources. Despite the federal austerity measures, throughout 2013 federal partners continued to meet and identify efficiencies toward achieving joint goals. This follows the Obama administration's charge to build cross-agency collaboration to address local priorities—a charge that can be successful in LA River revitalization because of the number of federal agencies that have complementary activities in the same geography.

The Urban Waters Federal Partnership provides a mechanism for the agency staff to engage with each other and to embed collaboration into their operations. The federal commitment to "be at the table" on a working level is a rare opportunity for the local stakeholders who have long been involved with river restoration and revitalization. Regulatory and coordination issues that may have dogged local sponsors for years are directly being received and tracked by staff, and information for addressing local issues is being sought throughout the national Urban Waters Federal Partnership network. Furthermore, partners seeking resources for revitalization projects have been given an extra boost as these activities are prioritized by the Partnership.

In addition to supporting the mission and vision of the Urban Waters Federal Partnership, the Los Angeles partners identified the following specific goals:

- Restore ecosystem functions
- Balance revitalization with flood avoidance to ensure public safety
- Reduce reliance on imported water supplies
- Foster sustainable stewardship.

Outreach to engage cities downstream of the City of Los Angeles expanded the reach of the Los Angeles UWFP. An updated work plan, in progress in 2013, will address additional priorities, such as increased open space and parks, public health, and safe access to bikeways.

The following describes projects and activities that were the focus of the Los Angeles UWFP in 2011–2013.

LA River Ecosystem Restoration Feasibility Study

The LA River Ecosystem Restoration Feasibility Study by the U.S. Army Corps of Engineers was started in 2006 with a fifty/fifty cost share partnership between U.S. Army Corps of Engineers and the City of Los Angeles. The study is investigating the feasibility of restoring a more natural riparian ecosystem along a ten-mile stretch of the river from near Griffith Park to downtown Los Angeles (U.S. Army Corps of Engineers 2012).

The alternatives for restoring the ecosystem include plans that incorporate a suite of habitat types along and within the Los Angeles River, such as wetlands, riparian areas, pool/riffle complexes, and riparian buffers, as well as appropriate recreation features (e.g., trails, signage). The Partnership identified completion of the ARBOR[1]

1 Nicknamed for the U.S. Army Corps of Engineers' LA River Ecosystem Restoration Study—an acronym for "Alternative with Restoration Benefits and Opportunities for Revitalization."

study as the highest priority and critical to the success of overall revitalization goals.

Numerous projects along the LA River have been proposed to create pocket parks, improve habitat, increase recreation trails, and retain stormwater runoff, but without implementation of the ARBOR study, these efforts would have difficulty linking up and fully realizing their restoration and revitalization potential. Nevertheless, completion of the study was once uncertain due to a sizeable shortfall in federal funding. However, in September 2012, fashion manufacturer Miss Me, Inc. donated nearly $1 million to Friends of the Los Angeles River (FoLAR), an LA UWFP member, which in turn provided these resources to the City of Los Angeles to support the study. With this generous gift, progress moved quickly (FoLAR 2012), and the U.S. Army Corps of Engineers report is due out for comment in September 2013.

Enhancing Recreational Opportunities

Compared to the twenty-five largest metropolitan areas in the U.S. in 2000, Los Angeles ranked seventeenth in city land devoted to parks and lags all other large cities on the West Coast (Loukaitou-Sideris 2006). Many of the ongoing LA UWFP activities include expanding the opportunities for recreational activities for the approximately nine million residents of the Los Angeles River Watershed. One means for facilitating recreation in this watershed is via the AGO Initiative. In November 2011, the U.S. Department of Interior released its "America's Great Outdoors: Fifty State Report," which identified the combined Los Angeles and San Gabriel River Trail systems as one of two priorities in the State of California.

The National Park Service (NPS) is the lead federal agency for facilitating this AGO priority and supports several high-profile projects associated with these trails. NPS, Mountains Recreation and Conservation Authority, The River Project, LA River Expeditions, Friends of the Los Angeles River, Urban Semillas, and other partners worked with the Los Angeles Conservation Corps (LACC) and the U.S. Army Corps of Engineers in the Paddle the LA River program (2013) (Figure 4). Over the first two years, more than 2,000 people, including urban school children, kayaked or canoed a two-mile stretch of the river within the Sepulveda Basin Recreation Area and Flood Control Basin from Memorial Day to Labor Day. In the first year of operation, tickets sold out within minutes, and the public buzz brought significant visibility to the restoration of the river.

In 2013, the program was extended to the Glendale Narrows section of the river; data are still out on how many kayaked this section, which was open for anyone with a kayak and a paddle. Unfortunately, the U.S. Army Corps of Engineers was unable to process the permit for the Sepulveda Basin Recreation Area for 2013. The goal for 2014 is for both areas to be open to the public for summer recreation and programs.

Los Angeles Urban Waters Ambassador

The Los Angeles UWFP welcomed its Urban Waters ambassador in summer 2012. This full-time federal position is staffed by an employee of the U.S. Department of Housing and Urban Development but funded by the U.S. Environmental Protection Agency for a two-year term. The ambassador is hosted by a nongovernmental organization (NGO), the Council for Watershed Health, and serves as coordinator, facilitator, and reporter of local watershed revitalization efforts, providing support in strategic planning and project execution. Beginning with summer 2013 and extending through spring 2014, the Council for Watershed Health hosted an Ann C. Rosenfield graduate fellow from the UCLA Luskin School of Public Affairs who worked with the ambassador and the Council for Watershed Health to extend the work of the Partnership.

Monitoring and Communicating Conditions of Watershed Health

Understanding status and trends in watershed condition over the long-term is a critical aspect of effective watershed management. Assessment of progress in environmental management founded on investigation and reporting is crucial especially because activities and programs occur over numerous agencies and organizations, and results are not always immediately apparent. The Council for Watershed Health is working with the U.S. EPA and members of the LA UWFP to develop a framework with which to describe status and trends with indicators of environmental, social, and economic health for the Los Angeles River watershed.

Ultimately, a regular periodic report card that effectively communicates with policy makers and the public will become an ongoing part of the management system of the Los Angeles watershed. The report card, which requires as-yet unidentified long-term support, will be a tool widely communicated to agencies, corporations, elected officials, and members of the public to stimulate discussion and promote improvement in conditions. In this way, we can focus limited resources on what is working and adapt management plans to compound the effects of well-coordinated actions. This work follows on the Council for Watershed Health's 2010 pilot investigation of the health of the Arroyo Seco watershed, a tributary of the Los Angeles River (LASGRWC 2011).

Additional Related Projects and Programs

South Los Angeles Wetlands Park

In February 2012, the City of Los Angeles held its grand opening for the new South LA Wetlands Park, built on a former railcar and bus maintenance yard in a densely populated neighborhood sorely in need of green space. In this neighborhood, residential streets coexist with warehouses, mechanics shops, and scrap yards. The new park replaces one of these industrial areas with constructed wetlands to naturally treat stormwater before it is discharged into the Los Angeles River. By diverting water from storm drains and allowing it

FIGURE 5: Northeast Los Angeles River Collaborative (NELA RC) Project study area. CREDIT: CREATED FOR THE CITY OF LOS ANGELES BY TIERRA WEST ADVISORS, INC.

to flow through wetlands, the project can treat up to 680,000 gallons of stormwater per day (LA Stormwater 2012).

The Los Angeles Department of Public Works Bureaus of Sanitation and Engineering collaborated with the Department of Recreation and Parks to design and construct South Los Angeles Wetlands Park. The City Council approved $8.1 million in Proposition O General Bond funding to develop and construct the wetlands, and additional funds were provided by the Collection System Settlement Agreement, Propositions 50, 12, 40, and K, the Metropolitan Transit Authority, and a U.S. EPA Brownfields Grant (LA Stormwater 2012).

Northeast Los Angeles Riverfront Collaborative

The Northeast Los Angeles Riverfront Collaborate (NELA RC) builds on the growing momentum for river revitalization to re-vision the Los Angeles River as a focal point for the communities of Atwater Village, Cypress Park, Elysian Valley, Glassell Park, and Lincoln Heights (Figure 5). Funded by a $2.25 million community challenge planning grant from the Federal HUD-DOT-EPA Partnership for Sustainable Communities, the collaborative is engaging community residents through kiosks and postcards, and online at www.mylariver.org. NELA RC has three objectives:

- Engage the community in identifying a NELA Riverfront District,
- Create a comprehensive implementation strategy for community revitalization and reinvestment, and
- Create a model of engagement and public media to foster civic participation in the revitalization of communities.

The NELA Riverfront Collaborative will produce its first report by spring 2014 (NELA RC 2013).

Regional Watershed Monitoring

The Los Angeles River Watershed Monitoring Program (LARWMP) is designed to answer five specific questions of interest to a broad range of stakeholders within the watershed (LASGRWC 2010b):

- What is the environmental health of streams in the watershed?
- Are the conditions at areas of unique importance getting better or worse?
- Are receiving waters near discharges meeting water quality objectives?
- Are local fish safe to eat?
- Is it safe to swim?

The LARWMP was developed during 2007 by a group of stakeholders representing major National Pollution Discharge Elimination System (NPDES) permittees, regulatory and management agencies, and conservation groups. The objectives of the program are to increase awareness of the importance of issues at the watershed scale and to improve the coordination and integration of monitoring efforts for compliance and ambient conditions. The program focuses on improving understanding of

- Compliance with receiving water objectives
- Trends in surface water quality
- Impacts on beneficial uses
- Health of the biological community
- Data needs for modeling contaminants of concern

The resulting program is a multi-level monitoring framework that combines probabilistic and targeted sampling for water quality, toxicity, bio-assessment, and habitat condition (Figure 6). Patterned after a similar program implemented for the San Gabriel River, the LARWMP incorporates local and site-specific issues within a broader watershed-scale perspective. The LARWMP is implemented through a collaborative effort led by the Council for Watershed Health, in cooperation with the cities of Burbank and Los Angeles, the Los Angeles County Department of Public Works, the Los Angeles Regional Water Quality Control Board, the U.S. EPA, and other stakeholders.

The field protocols and assessment procedures follow California's Surface Water Ambient Monitoring Program (SWAMP). Results of the ambient assessment are shared through the California

FIGURE 6: Water quality sampling in the Los Angeles River watershed. PHOTO: AQUATIC BIOASSAY CONSULTING INC

Environmental Data Exchange Network, and annual reports are posted on the Council's website. In late 2013, the results and conclusions compiled from the first five years of monitoring will be issued in a State of the Los Angeles River Watershed report and conference.

Elmer Avenue Neighborhood Retrofit Project

The Elmer Avenue Neighborhood Retrofit Project demonstrates the transformation of conventional paved landscapes with various best management practices and strategies, on public and private property, to improve water quality, increase water supply, and enhance communities with new green spaces (Belden et al. 2012). Working with residents and numerous local, state, and federal stakeholders, the City of Los Angeles and the Council for Watershed Health completed construction in June 2010 of the first phase project, a one-block "clean water street" that manages runoff from forty upstream acres of residential landscape.

An extensive monitoring program is under way, seeking to answer questions ranging from the amount of water captured and infiltrated to the ability of residents to manage the improvements. Phase 2, the creation of a green, walkable Paseo that captures and infiltrates runoff from an additional twenty acres, was completed in 2012 with funding by multiple agencies: the California Strategic Growth Council, Santa Monica Mountains Conservancy, the Los Angeles Department of Water & Power, and City of Los Angeles Proposition O (Figure 7).

A third phase, funded through the City of Los Angeles Proposition O, completed in 2013, will extend the life of project benefits and capture additional water that monitoring had found was bypassing the project. Elements of the project, including monitoring, continue to be funded by federal partner Department of the Interior Bureau of Reclamation and others.

Achieving Lasting Change

The movement to revitalize the Los Angeles River, begun in the 1980s, has grown to encompass the watershed and even the metropolitan region beyond. In addition to the examples described, the U.S. EPA designated Los Angeles as a green infrastructure partner, one of ten cities nationwide. The U.S. EPA technical assistance program awarded a grant to the Council for Watershed Health to evaluate state and regional regulatory drivers that influence the costs and benefits of green infrastructure. The result is a report that identifies green infrastructure opportunities and barriers in greater Los Angeles, including a checklist for local governments (U.S. EPA and Council for Watershed Health 2013).

The question remains, what does success look like? At the community level, the Northeast Los Angeles Riverfront Collaborative uses open-ended questions, asking community members, "I want my river to be…." (NELA RC 2013). Indicators, quantitative measures of ecological health, including water quality compliance, are necessary to provide answers of a different sort (Wicks et al. 2010). Both are required to link communities to rivers.

The UWFP links community revitalization with river restoration, as does the vision of the Council for Watershed Health (2011) and numerous other watershed and river restoration organizations. Thus, the goal of restoring the river is inextricably linked with, in the words of EPA Administrator Lisa Jackson, "building stronger neighborhoods, attracting new businesses and creating new jobs" (U.S. EPA 2010b).

Although the Los Angeles community has worked for decades to bring about this equation, involvement of federal agencies is providing the catalyst. Bringing together the group of federal agencies with local agencies, cities, and organizations is taking the watershed approach to a new scale by providing additional inputs of technical assistance and funding. Whether the effort operating under the UWFP umbrella will succeed in the long term, however, has yet to be determined. The remainder of this paper provides a discussion of the conditions necessary for successful large-scale social sector change (Kania and Kramer 2011).

FIGURE 7: Elmer Avenue Paseo on December 12, 2012.
PHOTO: NANCY L. C. STEELE

To ensure that all partners are working toward the same outcome and reduce the possibility of working at cross-purposes, a **common agenda** and shared vision for change must be established. In December 2011, the LA UWFP group members adopted a work plan, bringing local specificity to the vision and objectives of the UWFP. Partners supported the Los Angeles River Ecosystem Restoration Feasibility Study as the highest priority, and some of the partners took affirmative actions to ensure political and financial support.

It is equally important that the group agreed to a mechanism for measuring and reporting success. A **shared measurement system** that reflects the overall goals of the partnership has yet to be identified. The project to develop indicators of watershed health should be recognized as an essential component of a successful LA UWFP.

Most of the partners are involved in one or more of the projects identified in the work plan along with reinforcing projects and projects not yet added to the work plan. These **mutually reinforcing activities** illustrate two necessary conditions: that each participant (1) undertakes projects at which it excels and (2) coordinates its activities and projects with the group vision. Each participant needs to be clear about its role and the activities it will undertake to support the partnership. Otherwise, overlapping visions and poor communication about activities could end up sabotaging the trust this condition requires.

As a corollary to the prior condition, **continuous communication** among partners is required to develop and maintain trust and ensure focus remains on the agreed-upon vision. Participants need to believe their own interests will be treated fairly and decisions made based on objective evidence. In addition to communications and meetings, another way to accomplish this condition is through collaborative projects and advocacy for priorities.

Finally, achieving successful collective impact requires a **backbone support organization** with dedicated staff that can plan, manage, and support the initiative. For the first two years of the LA UWFP, the EPA has provided support staff in the ambassador position. Moving forward, the group should determine how it will continue the Partnership if future funding is not available to continue to support dedicated staff.

To achieve a restored river and revitalized communities in Los Angeles, the organization and agency partners need to strengthen the existing collaborative network to effectively coordinate and carry out the work of facilitation, technology and communication support, data collection and reporting, and logistical and administrative details. The network must be able track and report on how individual partner efforts are contributing to the success of the whole at the same time that partners work collectively on a common vision.

The UWFP is among the newest additions to a chorus of adaptive management efforts related to the Los Angeles River watershed.

Success will require smart, watershed-wide, collective impact planning and investment to achieve the vision. Only in this way can the Los Angeles River reclaim its multiple benefits and serve as a vital resource for communities.

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PHOTO: LIA PROTOPAPADAKIS

URBAN RIVER RESTORATION IN LOS ANGELES: THE COLLABORATIVE ROLE OF CALIFORNIA'S STATE CONSERVANCIES

MARC BEYELER AND ELENA EGER

Abstract

This article explores an important aspect of the history and structure of urban river restoration in Los Angeles, California, focused on the pivotal role and support of four California state conservancies to materially aid grassroots, local and regional public partners, and other state and federal agencies in effective urban river restoration. Over two decades, these four state public Conservancies became essential partners in complex community-government collaborative urban river conservation and restoration efforts. We examine select experiences of the four conservancies over this time to offer some important lessons for modeling best practices to increase river restoration and conservation outcomes and to address a range of connected, landscape-level resilience and sustainability needs. We conclude that while the state conservancies' contributions have been, and continue to be, critical to successful river conservation and restoration, more research is needed to gain a better understanding of their effectiveness in terms of the following: 1. Advancing the implementation of ecosystem-based river management and restoration; 2. building interdisciplinary technical and scientific capacity; and 3. synthesizing and communicating technical and scientific knowledge to policymakers, managers, and community stakeholders.

Introduction

The past decades brought a remarkable increase in river and watershed restoration in California, including urban river conservation in urban Los Angeles. Increasing attention to integrating natural resources protection and public recreation and use has spurred important changes in many different governmental and nongovernmental contributions, resulting in better coordinated and integrated public organizational capacities. Limitations in the effectiveness of traditional structures and forms of government organization in California to timely or adequately address complex, natural resource and environmental management needs, including landscape-scale urban river restoration, have led to the development of new public programs, new organizational forms, and new agencies to coordinate and manage resource protection and river restoration in California. These public organizational innovations include important "boundary-spanning organizations," among them, a suite of California state public conservancies.

California State Public Conservancies

California has ten conservancies established by legislation[1] to supplement its traditional state natural resource and public recreation agencies and help to protect regional resources of statewide significance. California conservancies are intended to act as creative problem-solving, cross-agency, collaborative, and environmentally integrative agencies to both facilitate the implementation and increase the extent of natural resource protection, including river restoration in California. The conservancies balance and integrate the often-conflicting goals of resource protection and public use. All are independent agencies within the California Natural Resources Agency, and are governed separately by independent bodies. All of the conservancies are non-regulatory, collaborative, state-local partnerships.

Each conservancy is charged with acquiring, restoring and protecting natural resource land in specified geographical regions of the state in order to advance certain statewide resource and conservation goals. Importantly, each conservancy emphasizes efforts to protect a particular "place," such as the California Coast, the Sierra Nevada Mountains, Lake Tahoe, the San Joaquin River and Delta, the Coachella Mountains, the Santa Monica Mountains, the Baldwin Hills, the San Gabriel/Los Angeles River, and the San Diego River.

Each conservancy is authorized to work with cooperating local and regional agencies, as well as other state agencies, to complete overall conservation and public access plans and help coordinate implementation for the jurisdictional areas the conservancy covers, including urban river conservation, enhancement, and restoration. Each conservancy has specific statutory powers and responsibilities, and all the conservancies are authorized to acquire and manage lands and to make grants to other agencies or nonprofit organizations. Most of the conservancies have goals that include public access and recreation.

While there is a state conservancy model in California, there is not simply one type of state conservancy. The structure of governance,

1970–79	1980–89	1990–1999[3]	2000–2009
State Coastal Conservancy (SCC) (1976)	Santa Monica Mountains Conservancy (SMMC) (1980)	San Joaquin River Conservancy (SJRC) (1995)	Baldwin Hills Conservancy-(BHS) (2000)
	California Tahoe Conservancy-CTC (1984)	Coachella Valley Mountains Conservancy (CVMC) (1996)	San Diego River Conservancy (SDRC) (2002)
		San Gabriel and Lower Los Angeles Rivers and Mountains Conservancy (RMC) (1999)	Sierra Nevada Conservancy (SNC) (2004)
			Sacramento-San Joaquin River Delta Conservancy (SSJRDC) (2009)

TABLE 1. California Conservancies formation history.

each conservancy's statutory authorities, and sources of financial and funding support are specific to each conservancy.

Within the concept and model of the state conservancy in California, each is individual and particular, if not unique.[2] Table 1 shows the historical development of state conservancies in California and the increasing pace in creating new Conservancies in the past two decades.

The conservancies do not have land use authority and cannot supersede any local jurisdictional authority.[4] The area under the jurisdictions of each of these conservancies varies from just two square miles to 1,100 miles along the coast, to over 25 million acres in the Sierra. The conservancies share many common goals, objectives, and practices and several of the conservancies cooperate and coordinate in cross-jurisdictional projects. The important common features include the following:

1 State Coastal Conservancy: Public Resources Code (PRC) sections 31000 et seq; Santa Monica Mountains Conservancy: PRC sections 33000 et seq; Sierra Nevada Conservancy: PRC sections 33300 et seq; San Diego River Conservancy: PRC sections 32630 et seq; San Joaquin River Conservancy: PRC sections 32500 et seq; Rivers and Mountains Conservancy: PRC sections 32600 et seq; Baldwin Hills Conservancy: PRC sections 32550 et seq; Coachella Valley and Mountains Conservancy: PRC section 33500; Delta Conservancy: PRC section 32300; and the California Tahoe Conservancy: Government Code sections 66905 et seq.

2 See Appendix B: Comparison of California's state conservancies.

3 In 1998, the San Francisco Bay Program was established within the State Coastal Conservancy (SFBP/SCC, 2012).

4 The Sierra Nevada Conservancy may not acquire a fee interest in real property by purchase. See California Public Resources Code section 33347 (a).

1. Shared and transparent governance;
2. Multiple objectives;
3. Common collaborative practices;
4. Shared common characteristics; and
5. Integrated resource and ecosystem-based management (EMB) planning.

1. Shared and Transparent Governance: Conservancies' governing bodies employ a collaborative state-local policy and approval structure to promote better integration of statewide, regional, and local priorities. Each conservancy has public members included in its voting membership.

2. Multiple Objectives: Conservancies' programs and projects address multifaceted objectives, including conserving, enhancing, restoring, and preserving ecosystems, habitats and species, focused on desert, wetland, riverine, riparian, forest and watershed resources; preserving agricultural lands and working landscapes; improving public access and recreational opportunities; preserving open space; resolving resource and land use disputes; providing neutral broker forum and function; providing technical professional and financial assistance; and linking statewide priorities with regional and local priorities.

3. Common Collaborative Practices: Conservancies model many common collaborative practices, including: relying on public-private-community partnerships (community land trusts and nongovernmental organizations [NGOs]); supporting conservation efforts with integrated technical and financial resources; creatively using demonstration projects; serving as policy and practice initiator and tester; and acting as experimenter and early adopter, including supporting innovative projects to establish "proof of concept."

4. Shared Common Characteristics: Conservancies share many common characteristics, including an emphasis on voluntary, community-based action; use of plans as templates for achieving implementation goals; and utilization of a place-based, unique state-local structure. To date, although provided for some conservancies, eminent domain is never used. Conservancies share many funding and financing similarities, including the use of a diverse array of special funds, comprising regulatory penalties and a reliance on general obligation bond funds; limited use of state general funds; and strong leverage of local and federal funds.

5. Integrated Resource and Ecosystem-Based Management: Conservancies have pursued integrated resource protection programs, including habitat restoration focused on wetland/riparian/watershed enhancement and restoration; community-level prioritization and implementation; integrated coastal/marine-land/sea connection; and climate adaptation and mitigation.

All of the conservancies are founded on an explicit understanding that resource conservation program success is built on the collaborative efforts of state, regional, and local agencies and stakeholders, including representation from the public. Additionally, as the number of conservancies multiplied, increased recognition of the "place-based" nature of successful community-level river and watershed restoration results in strong local representation on each conservancy governing body.

Even though the State Coastal Conservancy does not have "local" representation, per se, it does have a majority of public members among its seven designated members. Over the past four decades, many of these public members regularly "expressed" local desires and priorities in their votes on project and program approvals. All of the other conservancies have combined "state" and "local" memberships, in addition to significant public membership. The state members include constitutional, statutory, and representatives of state agencies, and most include representation from the California Natural Resources Agency and the California Department of Finance. The local representatives are chosen from local government representatives.

Table 2 below shows the distribution of membership by category for the four Conservancies located and/or active in urban river restoration in Los Angeles (see Appendix B: California Conservancies' Governance). The different points of view, with important and numerous members of the public represented, broadens the sense of participation and ownership and genuine involvement and level of control over decision-making and implementation priorities.

Urban River Restoration in California, Southern California, and Los Angeles

For thirty years, California state government resource policy, protection, and restoration efforts were focused on urban river restoration, including importantly, river restoration in Southern California. A crucial element of these statewide efforts is the "River Parkways" program, which addresses river and stream and adjacent riparian areas, most often planned for a complex set of scenic, natural, open space, and recreational uses, and often encompassing

MEMBERSHIP	SCC	SMMC	RMC	BHC
Total	7	12	20	15
Voting	7	9	13	9
State	3	2	3	3
Local	-	3	9	1
Public	4	3	1	5
Federal	-	1	-	-
Tribal	-	-	-	-
Non-Voting	-	3	7	6
Legislative	6	6	-	-
Other	-	26	-	-

TABLE 2. Los Angeles Conservancies' governance.

ecological restoration, flood management, water quality, and riverfront revitalization benefits.

California has been fertile ground for river and watershed restoration for over the past three decades (Kondolf 2007), and efforts in the state are among the most numerous and most advanced in the United States (Kondolf 2007; Bernhardt 2005, 2007; AWWA, 2012). California is home to multiple state-funded restoration programs evolved from diverse legislative mandates, ballot initiatives, and citizen-sponsored programs (McGinness 2005). Programmatic goals include watershed-based resource restoration addressing wetlands, streams, water quality, ecosystems, and habitat.

River restoration, watershed and water supply planning and implementation efforts were simultaneously developed within separate programs, although there have been increased coordination and integration in policy and program initiatives over the past decade, particularly with the development of Integrated Regional Water Management Plan (IRWMP). Most recently, the increasing integration of river and watershed restoration efforts and the adoption of ecosystem-based management (EBM) approaches have resulted in increased collaborative and coordinated efforts. Collaborative efforts at coastal urban river restoration, including wetland and watershed restoration, though growing in number and significance, remain an experiment in public policy in California.

These collaborative initiatives seek to build voluntary cooperation between often-competing and adversarial stakeholders in order to promote more effective long-term coastal resource protection. While there is no agreement on the outcomes and effectiveness of collaborative, "voluntary," and/or "incentives-based" initiatives, including river and watershed planning (Mazmanian and Kraft 2009), there is growing case study evidence of the positive outcomes associated with collaborative wetland, river, and watershed efforts. In the past decade, these types of coordinated, community-based efforts have continued to grow in importance, particularly within Southern California and Los Angeles (Jenkin 2005; IRWMP 2007).

In coastal Southern California, including the Los Angeles basin, there are many different efforts at river and watershed planning and implementation under way (SCWRP 2012). These efforts are long term, in some cases going back three decades, focused on the restoration and revitalization of the Los Angeles River and its tributaries, the adjacent San Gabriel River and its tributaries—both draining to San Pedro Bay, and watersheds, creeks and streams draining into Santa Monica Bay.

Los Angeles is and has been a fierce battleground over water quality, supply, pollution, and protection, including so-called "pollution wars," that is, fights over polluted urban runoff, total maximum daily loads (TMDLs) of pollutants and the Clean Water Act, and coastal water quality and safe beaches in Santa Monica Bay. Increasingly, Los Angeles is cited as a national model for developing innovative successful program approaches to address these resource problems.

FIGURE. 1. Los Angeles Basin region.

Since the 1980s, mounting community-based and multilevel government efforts have emerged to plan for natural resource, river, and watershed restoration of the Los Angeles River. These efforts were led by a number of neighborhood, community, and stakeholder groups, such as the Friends of the River (FoLAR), North East Trees (NET), and many community and neighborhood-level groups (Gottlieb 2005; Coast and Ocean, 2001).

The Los Angeles River flows for fifty-one miles, draining from the San Gabriel Mountains and from the north side of the Santa Monica Mountains and Hollywood Hills, south to the Pacific Ocean in Long Beach, encompassing a watershed area of 824 square miles, about 20% of the total land area in Los Angeles County (Fig. 1). Jurisdiction for the Los Angeles River corridor is fragmented among a dozen cities, including the City of Los Angeles, the County of Los Angeles, and the federal US Army Corps of Engineers, making coordinated and integrated restoration and revitalization for the river and watershed, a complex, complicated, and time-consuming effort.

The communities bordering the river represent some of the densest urban communities in the county, and these communities lack recreation, parks, and green space (Wolch 2002; Trust for Public Land 2002).

In 2010, the population density for the dozen cities lining the river ranged from a low of 8,000 people per square mile in the City of Los Angeles to more than 23,000 residents per square mile in one of the smallest jurisdictions, the City of Maywood. In six of these communities, population density along the river exceeds 10,000 residents per square mile.

The modern battle over the future of the Los Angeles River began in the 1980s as the county and the US Army Corps of Engineers pursued modern flood control improvements, while citizens and stakeholders began to ask, "Why not re-envision the LA River as an

PROJECT NAME	ACQ.	PLANNING	DESIGN & DEVELOP.	IMP., CONST., RESTORATION	TOTAL FUNDS*
Confluence Park (Arroyo Seco)	X (2003)	X (Project Plan–2002)	X	X	$7.7 M
Elysian Valley–Marsh St. Park	X (2006)	X	X	X	$5.288 M
Tijunga Wash		X	X	X	$7 M

**Numbers represent minimum amounts, as totals reported may omit some authorized funding.*

TABLE 3. Select SMMC-supported Los Angeles River parkway projects.

actual river?" This conflict of visions and the controversy over the future of the LA River has now been widely documented (Gottlieb 2002; Kibel 2007).

By the end of the '80s, these growing calls for action to rethink the "beneficial uses" of the river and for restoring the river and its damaged natural resources was heeded by the public owners of the Los Angeles River. In 1990, Los Angeles Mayor Tom Bradley established a Los Angeles River Task Force to "articulate a vision for the future of the river." The Task Force established a broad set of goals for the river along with three initial demonstration projects to kick start river restoration and revitalization.

In 1991, the County Board of Supervisors initiated the Los Angeles River Master Plan. The County Master Plan included input from the river corridor cities, in addition to representation from citizen groups and stakeholders, as well as state and federal agencies. These two efforts took place at the same time that growing calls for watershed planning were being registered nationally, echoing at the state level and the local level in Los Angeles.

Many of the past and current Los Angeles River restoration projects involve conservancies as key restoration partners. There are four California state conservancies active in urban river restoration in Los Angeles: the California State Coastal Conservancy (SCC), the Santa Monica Mountains Conservancy (SMMC), the San Gabriel-Lower Los Angeles Rivers and Mountains Conservancy (RMC), and the Baldwin Hills Conservancy (BHC). Three of these (excepting the BHC) are active on the Los Angeles River. Three of these conservancies are located in Los Angeles, and the fourth, the SCC, operates its statewide and regional programs from Oakland.

The three state conservancies active in the Los Angeles River watershed have partnered with sub-state, regional, and local agencies to implement river and watershed plans and projects in urban Los Angeles. The LA River and its watershed have received a great deal of social investment from the conservancies' efforts and participation; this has accelerated in the recent decade, fueled in part by the technical and financial resources of the conservancies and spurred by several general obligation bond acts.

What did these conservancies contribute to the LA River and watershed restoration partnership efforts? Over the past three decades, these conservancies funded and supported major planning and implementation projects towards Los Angeles River restoration and revitalization. Since the early 1990s, the SMMC has been assisting in development and implementation of the Los Angeles River Parkway, and in the past fifteen years, working with the RMC on coordinating overall efforts and integrating collective efforts on the Los Angeles and San Gabriel Rivers and watersheds.[5] These efforts were augmented by the efforts of the SCC in supporting key initiatives focused on wetlands, public access, and urban parks development.[6]

Many tangible accomplishments, projects, and multiple project benefits resulted from these combined efforts and a select listing of project accomplishments for the Los Angeles River undertaken, funded, and/or completed by the SMMC are included in Tables 3 and 4. A great deal of the SMMC's efforts focused on the Upper Los Angeles River watershed and on the "heart" of the Los Angeles River at its confluence with the Arroyo Seco River. The SMMC's key planning implementation and management partner is the Mountains Recreation and Conservation Authority (MRCA), established in 1985, under the state's Joint Powers Act between the SMMC, the Conejo Recreation and Parks District, and the Rancho Simi Recreation and Park District.

Because each conservancy is specific to the geography and political culture and structure of the locality, among the four conservancies active in Los Angeles, there are several important differences in the operations and results of each.

5 Common Ground, jointly adopted by the SMMC and the RMC in 2001, is a watershed and open-space plan for the San Gabriel and Los Angeles Rivers.

6 The SCC and the SMMC jointly developed and operate under a JPA for projects within the Los Angeles River watershed along the Arroyo Seco River.

PLAN/PROJECT	DATE	CONSERVANCIES	PARTNERS
Los Angeles River Park and Recreation Area Study	1990–93	SCC; SMMC	California Legislature-SB 1920: 1990
AIA LA River Report	1990–94	SCC	California Legislature-SB 1920: 1990
Los Angeles River Watershed Plan/Task Force	1996	SCC; SMMC	LA County Dept. of Public Works; US Army Corps of Engineers
Common Ground from the Mountains to the Sea	2001	SMMC; RMC	California Resources Agency
Elysian Valley Greenway/ Gateway Parks	1995–2010	SMMC/MRCA	Trust for Public Land; Northwest Trees; City of Los Angeles
LA River Center		SMMC/MRCA	
River Wetlands Study	2001	SCC	
Lower Los Angeles River Restoration FA	2002	SCC	City of Long Beach
Arroyo Seco Watershed Restoration FA	2002	SCC	Northeast Trees (NET)/Arroyo Seco Fdn
Taylor Yard Feasibility Study	2002	SCC	Coalition for a State Park at Taylor Yard; CA State Parks
Cornfield		SMMC	CA State Parks; City of LA
LA River Revitalization Plan	2004	SCC	City of Los Angeles
Maywood Riverfront Park	1995–2008	SCC; SMMC/MRCA	Trust for Public Land
Los Angeles River Urban Wildlife Refuge	2007	SMMC	
DeForest/Dominguez Gap Wetlands	2007	SCC; RMC	LA County; City of Long Beach

TABLE 4. Select Conservancy-supported Los Angeles River projects.

The SMMC has developed strong local partnerships to own, develop, manage, and steward, protected and public use lands.

The SMMC partnered with the MRCA focuses much attention on river parkway planning and development on the Los Angeles River and within the river watershed. Creating fifty-one miles of continuous river parkway and greenbelt along the LA River to implement the County's LA River Master Plan is one of the six strategic objectives of the SMMC. SMMC has a small governing board for efficiency but it is backed by a large advisory board, which maintains deep community connections to maximize SMMC's community support and participation. While SMMC staffing has remained small, its grant support and financial investments for planning, development, and project staff at the MRCA has leveraged significant accomplishments.

The RMC has a much different governing board, larger and more specifically representative of municipal level governments, and operates under a very specific plan approval process. The RMC has remained a small staff organization, establishing select partnerships to carry out projects, such as the Los Cerritos Joint Power Authority (JPA), established with the Cities of Long Beach and Seal Beach and the SCC, to acquire, design, and implement wetland restoration activities at the mouth of the San Gabriel River.

The SCC always has relied on partnership-oriented, community-based ecosystem planning, technical assistance, and funding approach in its activities along and to the coast, and similarly in its river parkway activities in Los Angeles. The SCC's river parkway activities in Los Angeles are closely coordinated with the other conservancies and local stakeholders, and it has established several formal partnerships with the other Los Angeles conservancies through multiple JPAs, MOUs, and other joint efforts, including coordinated acquisition agreements.

Since the 1980s, the SCC has been involved in several key planning and implementation projects along the LA River. At the specific request of the State Legislature (Senate Bill 1920 in 1990), the SCC prepared a plan that included an assessment of the river's potential for enhancement for public recreation and habitat. The SCC also funded the preparation of a report by the American Institute of Architects analyzing the major issues, opportunities, and constraints involved in a large-scale river restoration. The SCC manages and coordinates the Southern California Wetlands Recovery Project

(SCWRP) and acts as the SCWRP's staff to coordinate coastal wetland and watershed projects, including riverine and riparian habitat restoration efforts. The Work Program for the SCWRP prioritizes important river restoration and enhancement projects on the River (SCWRP, 2012).

Table 4 includes a select list of some of the major river restoration planning and implementation projects in Los Angeles involving one or more of the California Conservancies. Several major planning initiatives for the Los Angeles River involve one or more of the state conservancies in a variety of roles, including funder, sponsor, project manager, and so on.

Successful efforts concerning river restoration in Los Angeles rely on a number of innovative public and private partnerships, in many cases materially aided by one or more of the state conservancies. For some of these partnerships, one or more of the conservancies played a key early adopter or early facilitator role in sustaining or propelling river restoration efforts. The conservancies' practices and programs recognize the need to build more cooperative and collaborative social network-based governance and management structures to facilitate natural resource restoration.

CONSERVANCY	PUBLIC PARTNERSHIPS	COMMUNITY PARTNERSHIPS
Santa Monica Mountains (1980)	Mountains Recreation and Conservation Authority-MRCA (JPA-1985); Baldwin Hills Regional Conservation Authority (JPA-1999)	San Gabriel and Los Angeles Rivers Watershed Council
State Coastal (1976)	Los Angeles River Watershed Task Force (1996); Los Angeles River Interagency Agreement (2004)	Los Angeles County, DPW; CA State Parks; Los Angeles and San Gabriel Rivers Watershed Council
San Gabriel & Lower Los Angeles Rivers & Mountains (1999)	Los Cerritos Wetlands JPA (2006)	State Coastal Conservancy; Los Angeles and San Gabriel Rivers Watershed Council; Habitat and Science Advisory Panel (2004)

TABLE 5. Los Angeles River restoration partnerships.

Table 5 shows the interrelationships between the conservancies and several different public and community partners and partnerships focused on the Los Angeles River. Collaborative planning and project development has been a signature "business" practice for these state conservancies. Several enduring state-local governmental partnerships were created, including the MRCA; the Los Cerritos Wetlands Joint Powers Agency (LCWA) and the San Gabriel and Los Angeles Rivers Watershed Council (now renamed the Council for Watershed Health).

Conclusion

This exploration of the collaborative history of conservancies' efforts related to Los Angeles River restoration offers some important lessons learned for modeling best practices in the future to improve conservation outcomes and to address a range of connected conservation resilience and sustainability needs. This article has substantiated many project and program accomplishments associated with the conservancies' contributions to river restoration as part of larger collaborative ensembles and community partnerships. Indeed, conservancies play critical and essential roles in river restoration in Los Angeles.

Like many other, if not most river restoration efforts, however, evaluation of outcomes resulting from this history of programs, agencies, and governmental and community activities still must be fully and adequately developed and analyzed. Monitoring and evaluation of environmental and resource condition change resulting from four decades of river restoration in California is severely lacking (Kondolf 2005). Analysis and evaluation of any specific impacts or outcomes resulting from institutional innovations, including from the experience and operations of the state conservancies, is still lacking.

Additional analysis and research is needed on the performance of innovative boundary organizations, such as the California conservancies. Actual performance results measured against a broad array of criteria are needed, importantly including information regarding transparency and the levels, types, and effects of public participation. More analysis of social, management, or decision-making conditions must be undertaken to support successful integrated river and watershed restoration. Many of the coordinated and collaborative efforts where the conservancies played a pivotal role in Los Angeles River restoration now are at least three decades old and need to be analyzed against a range of "success" measures. Further evaluation of the social capital component of river and watershed-based ecosystem management efforts is necessary to more fully understand best management practices.

Meeting these information and analysis needs requires more research at the interface of multiple social science disciplines, including sociology, psychology, and economics and law; various design disciplines; and multiple natural science disciplines, including hydrology, geomorphology, natural resource ecology, engineering, and hydro-ecology.

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Appendix A.: California Conservancies Funding and Staffing

Most of the monies appropriated for Conservancies' operations and programs have traditionally been from sources other than the State General Fund. The majority of state funding for the conservancies comes from special funds, including the Environmental License Plate Fund, and a continuing series of Resource Bond acts. The table below (A-1) lists the state conservancies and the enacted (i.e., "adopted") budget for fiscal years 2007–8 through 2012–13.

During the past five years, the bulk of funding has come from voter-approved general obligation bond acts, the Environmental License Plate Fund (ELPF), and a diverse range of special funds. From 2000 to 2006, California voters passed five major open space, water supply, flood control, and coastal protection bond acts, totaling more than twelve billion dollars. Little to no general fund revenues have been devoted to either the operational or programmatic needs of the conservancies. Importantly, the last significant conservation bond act in California was passed in 2006, and since then, no new bond acts have made it to the ballot.

The amount of bond act funding in the past decade, was unprecedented in California in the past fifty years, and is unlikely to be duplicated in the short-term or near-term future in the state. Recent trends, which show a flat to declining financial resources to the state conservancies, are likely to continue into the near-turn and foreseeable future. Reduced financial resources from state sources are likely to continue for LA-based Conservancies.

Recent funding levels for each of these Conservancies are shown below (Fig. A-1).

Conservancy	07-08	08-09	09-10	10-11	11-12	12-13
Baldwin Hills	3,490	502	3,622	577	568	561
California Tahoe	45,512	12,703	6,655	6,453	7,182	5,441
Coachella	11,878	11,890	7,177	5,833	443	359
Delta	-	-	-	829	963	846
San Diego	299	333	340	322	320	327
Rivers & Mtns	38,834	9,220	13,161	1,174	8,438	1,484
San Joaquin	456	498	651	646	636	636
SMMC	18,312	21,250	9,878	5,269	2,534	5,200
Sierra Nevada	21,404	21,536	20,202	4,777	4,664	4,654
State Coastal	132,940	126,394	118,594	52,492	14,472	33,630

TABLE A-1. California Conservancies' total state funding by fiscal year: 2007–2012. SOURCE: CALIFORNIA STATE BUDGETS: CALIFORNIA DEPARTMENT OF FINANCE.

Another measure of conservancies' resources lies in the authorized number of budgeted personnel in each of the conservancies. The chart below shows the approved number of staff for each of the four conservancies active in Los Angeles (Table A-2). In the case of the Santa Monica Mountains Conservancy, however, it should be noted that a great part of its work is done through its JPA partnership, the Mountains Recreation and Conservation Authority (MRCA), where the bulk of program and administrative staff are located. As can be seen below, staffing for the three Los Angeles Conservancies is flat (or slightly declining) for each of the individual conservancies. As mentioned above, in the case of the SMMC, many of its programs and activities are carried out through its JPA partnership in the MRCA.

Significantly, the RMC has suffered a substantial decline in authorized personnel from 9 in 2007 to 5 1/2 in 2012. The overall fiscal trend of limited, flat, and restricted funding from state resources is likely to continue in California for the foreseeable future. Each conservancy is currently developing or increasing support from diverse funding sources. Multi-year financial planning has become an essential element of conservancy strategic planning.[7]

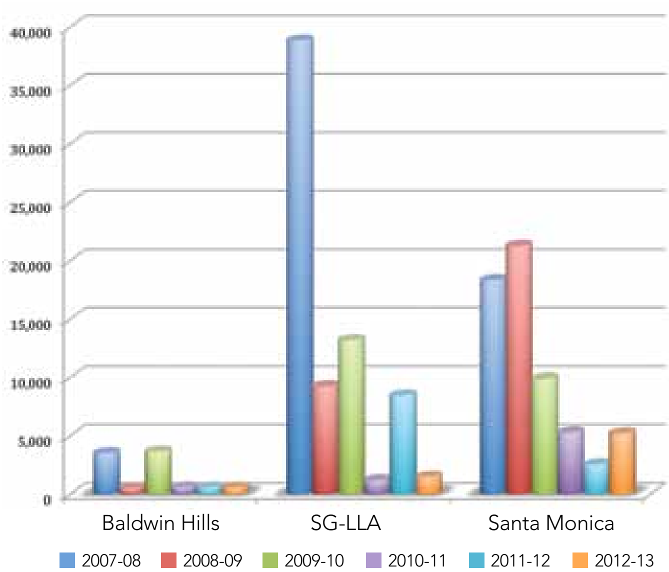

FIGURE A-1. Los Angeles Consverancies funding: 2007-2012.

Conservancy	07-08	08-09	09-10	10-11	11-12	12-13
Baldwin Hills	3	4	4	3.9	3.9	4
Rivers & Mtns	9	9	7	6.5	6.5	5.5
SM Mtns	5.2	5.2	5.2	5.2	5	5

TABLE A-2. Los Angeles Conservancies' total state personnel.

7 The Coastal Conservancy approved its first 10-year funding plan in 2013 (SCC, 2013).

Appendix B. California Conservancies Governing Board Membership

CCC=California Coastal Commission; SLC=State Lands Commission; UC=University of California; WCB=Wildlife Conservation Board; DFW=Department of Fish and Wildlife; SLT-South Lake Tahoe; BOS=Board of Supervisors; SMMNRA=Santa Monica Mountains Recreation Area; BLM=Bureau of Land Management; USFS=United States Forest Service; SDRWQCB=San Diego Regional Water Quality Control Board; SA=State Assembly; SS=State Senate.

GOV TYPE	SCC[8]	SMMC[3]	CTC[4]	SJRC[5]	CVMC[6]	RMC[7]	BHC[8]	SDRC[9]	SNC[10]	SSJRDC[11]	GSR[12]
Total Membership	7	12	8	15	21	20	15	13	16	13	
Voting	7	9	7	15	21	13	9	11	13	11	
State	3	2	2	6	6	3	3	3	2	2	1.0
CRNA (10)	Secretary	Secretary	Secretary	Secretary	Secretary	Secretary	Secretary	Secretary	Secretary	Secretary	1.0
DOF (9)	Director		Director	Director	Director	Director	Director	Director	Director	Director	.9
CDPR (8)		Angeles District		Director	Director	Director	Director	Director	Director	Director	.8
Other	CCC			SLC, WCB, DFW	UC, WCB, DFW						.3
Public	4	3	2	3	3	1	5	5	5	4	1.0
Gov	2	1	2	3	1	1	3	3	3	2	1.0
Assembly Speaker	1	1			1		1-LA Co.	1	1	1	.7
Senate Rules Cmte	1	1			1		1-LA Co.	1	1	1	.7
Local		3	3	6	8	9	1 (3)	3	6	5	.9
County		2- LA; Ventura	2-El Dorado; Placer	2-Fresno; Madera	1-Riverside	1-LA Co BOS	1 (3)-LA Co. DPR; see public above	1-San Diego-2nd Dist. BOS	6-1 from Cos. BOS of each sub-region	5-Cos. BOS	.9
City			1-SLT		7	3 COG; 2 LCC					.3
City, Mayor		1-LA City Mayor		2-Fresno; Madera				SD			.3
City- CC								CD6			.1
Spec Dist				2-Fresno; Madera		3 Water					.2
Federal		1-SMMNRA			BLM; NPS; USFS						.2
Tribal					1-Agua Caliente						.1
Non-Voting		3	1			7	6	2	3	2	.7
Ex-Officio		SCC, CCC, USFS	USFS			USACOE, USFS, LACo DPW, OCo PFRD, SGRW, CDPR, WCB	CalEPA, SCC, SLC, Gov. appt., SMMC, CC DPR	WCB; SDRWQCB	NPS; BLM; USFS	SA and SS	.7
Legislative Oversight	6:3-SA; 3-SS	6: 3-SA; 3-SS									.2
Advisors		26-Adv Cmte								10-Advisors	.2

8 California State Coastal Conservancy

9 Santa Monica Mountains Conservancy

10 California Tahoe Conservancy

11 San Joaquin River Conservancy

12 Coachilla Valley Mountains Conservancy

13 San Gabriel and Lower Los Angeles Rivers and Mountains Conservancy

14 Baldwin Hills Conservancy

15 San Diego River Conservancy

16 Sierra Nevada Conservancy, SNC

17 Sacramento-San Joaquin Rivers Delta Conservancy

18 "Governance Strength Rating" (GSR): Frequency of Governance Type included in Conservancy Governing Board Membership.

RESEARCH & POLICY

Urban Coast highlights research that informs the most pressing issues of our day and policies that affect the condition of urban coastal resources. The Research & Policy section features articles on scientific or policy studies of the environmental and social issues that impact and influence our coastal environments. Additionally, this section discusses the efforts to apply the findings of these multidisciplinary studies in order to improve watershed and coastal management actions and policies.

PHOTO: JOHN HOLLENBECK

PHOTO: BOB GODFREY

REDUCING HUMAN CONSUMPTION OF "DO NOT CONSUME" FISH FROM THE PALOS VERDES SHELF USING COMMUNITY-BASED SOCIAL MARKETING TECHNIQUES

NAMJU CHO, ON BEHALF OF THE FISH CONTAMINATION EDUCATION COLLABORATIVE

Abstract

The Angler Outreach Program was conducted in Southern California near the Palos Verdes Shelf (PVS) Superfund Site that applied a community-based social marketing (CBSM) model to ensure anglers were aware of a revised fish advisory and did not consume fish species included in the advisory. The program incorporated the following steps: (1) formative research that includes identifying a target audience, target behaviors, and motivators and barriers associated with the target behavior, (2) pilot testing, (3) intervention, and (4) evaluation. Work was done as part of the Fish Contamination Education Collaborative (FCEC), a United States Environmental Protection Agency (USEPA)-supported partnership of stakeholders that was established in response to the human health risks posed by the contaminated sediments along the PVS. A tip card was developed to inform anglers about which fish have been deemed "Do Not Consume" (DNC) and consumption guidelines for other fish. We (the FCEC) then surveyed anglers about their awareness of DNC fish and post-catch behavior, including whether they typically eat (DNC) fish they catch, and compared results between those who had received outreach and those who had not. Based on 870 survey responses, we found that a smaller proportion of anglers who received outreach consumed DNC fish they had caught and a larger proportion of anglers who received outreach were aware of DNC fish contamination compared with anglers who had not received outreach.

Background

The Palos Verdes Shelf (PVS) Superfund Site is located within the Southern California Bight, an area of the coastal Pacific Ocean between Point Conception and San Diego, California. It is an 88 square kilometer area of sediment on the continental shelf and slope off the coast of the Palos Verdes Peninsula, Los Angeles County, California (USEPA 2009). For nearly 40 years, the pesticide dichloro-diphenyl-trichloroethane (DDT) and the electric insulator polychlorinated biphenyl (PCB) were discharged from several industrial sources into the sewers and were released into the waters of the PVS. The DDTs and PCBs mixed with the suspended solids in the discharge flowing out of the sewer outfalls and settled to the ocean floor to form a large sediment deposit. It was estimated that at one time, more than 1,000 metric tons of DDTs were discharged, with approximately 100 tons settling on the surface sediment that covered the large expanse of ocean floor at the PVS (USEPA 2009).

Organisms inhabiting the site accumulate both DDTs and PCBs, leading to contamination of fish and other animals through the food chain. As a result, the largest threat to human health is the consumption of contaminated fish within the red zone, which indicates the areas with the highest concentration of DDTs and PCBs.

Fish caught in the red zone (Fig. 1), as defined by the California Environmental Protection Agency's Office of Environmental Health Hazard Assessment (OEHHA), are at the highest risk for contamination; this is particularly the case with white croaker. White croaker caught within the PVS contain higher levels of DDTs and PCBs compared to other fish species due to white croaker's bottom-feeding behavior and depth and habitat preferences. This is important to know in light of the fact that white croaker is the third most commonly caught fish in Los Angeles County, with a high consumption rate relative to the catch rate (Allen et al. 1996). The first fish advisory issued by the OEHHA included only white croaker.

In June 2009, the OEHHA published an advisory report entitled "Health Advisory and Safe Eating Guidelines for Fish from Coastal Areas of Southern California: Ventura Harbor to San Mateo Point" (California Environmental Protection Agency Office of Environmental Health Hazard Assessment 2009). The advisory was based on the analysis of tissue samples from locally caught fish to determine the concentrations of PCBs, DDTs, and their metabolites, chlordane, dieldrin, and mercury. The results

FIG. 1. Map of red and yellow zones for fish caught from Ventura Harbor to San Mateo Point CREDIT: OFFICE OF ENVIRONMENTAL HEALTH HAZARD ASSESSMENT WWW.OEHHA.CA.GOV/FISH.HTML

of this analysis prompted the OEHHA to add four fish species to the "Do Not Consume" (DNC) fish advisory list: topsmelt, barred sand bass, barracuda, and black croaker. Prior to the release of the 2009 advisory, *white croaker* (aka kingfish, tomcod) was the only species listed as a DNC fish off the Los Angeles and Orange County coasts.

The risks associated with consuming DDT- and PCB-contaminated fish such as white croaker include reproductive impairment, neurological damage, increased risk of cancer, and liver damage. Immediate exposure to (i.e., ingestion of) these contaminants in fish does not produce instant health effects; however, prolonged exposure leads to a buildup of these contaminants within the body, and consequently, increased probability of health risks. The magnitude of the health effects associated with consuming contaminated fish depend on a few factors, including: the chemical concentration within the fish; frequency of consumption; fish preparation methods; and individual consumer characteristics such as age, gender, life style and health history.

This article represents the efforts of FCEC's Angler Outreach Program, of which Heal the Bay and Cabrillo Marine Aquarium are major contributors. The Angler Outreach Program seeks to effectively communicate to pier and shoreline anglers in Los Angeles and Orange County ways they can reduce their exposure to contaminated fish, yet maximize the benefits of healthy fish consumption. A key component of this strategy was to develop and implement an The Angler Outreach Program using the community-based social marketing (CBSM) model proposed by McKenzie-Mohr (2000, 2002; McKenzie-Mohr and Smith 1999; Oskamp and Schultz 2006; Schultz and Tabanico 2008). The Messaging Work Group, an advisory branch of the FCEC and made up of partners that include the Santa Monica Bay Restoration Commission and other governmental and nongovernmental entities, also provided input and expertise.

The focal point of the Angler Outreach Program is a "leave-behind" material—a tip card—that summarizes the main points of the advisory that outreach workers convey. To ensure the tip card resonated with the target audience, we pilot tested the material with anglers before finalizing the tip card and applying it broadly throughout all targeted piers. We received invaluable feedback that helped us revise the tip card that included information on which fish should not be consumed and which fish can be consumed in moderation and cooked a certain way.

This project differed from previous public health campaigns utilizing a social marketing framework in three ways: (1) it included pilot testing to ensure the outreach tactics were effective and only after were broadly applied, (2) it had an evaluation component, and (3) a group of anglers who did not receive outreach served as a control group that was compared with anglers who received outreach. The evaluation measured awareness levels among the target audience and post-catch behavior, including consumption patterns of caught DNC fish and whether they usually share caught DNC fish with family/friends.

While the CBSM approach has proven effective in promoting conservation behaviors, there has been scant research applying the strategy to reduce both public health and environmental risks faced by consumers. Social marketing helps to address social issues by applying and reinterpreting traditional marketing concepts (Andreasen 1995; Neiger et al. 2001; Walsh et al. 1993). Unfortunately, many social marketing programs overemphasize passive forms of communication (such as flyers or signs) that focus solely on awareness of the issues.

The CBSM aims to promote behavior change within a target population by focusing outreach efforts on specific behaviors, and working at the community level through direct contact with individuals (McKenzie-Mohr and Smith 1999; Schultz 2002; Schultz and Tabanico 2008). The model is used to create an effective message before implementing an intervention by identifying the motivators and barriers to changing behavior within a target population that will also inform how best to disseminate the message (Alcalay and Bell 2001; Neiger et al. 2001; Walsh et al. 1993). As a result, CBSM principles are well suited to translate complex scientific messages and behavior change strategies into effective outreach programs and communication campaigns (Lefebvre and Flora 1988, 300).

Approach and Methods

Public outreach programs can be difficult to evaluate without significant resources, and more often than not, may be ineffective in terms of changing behavior. This is why the FCEC tried to apply the principles of social marketing to improve public health conditions—following the successful case studies over the last 30 years (De Gruchy and Copel 2008; Harvey 2000; Lefebvre and Flora 1988; Reger et al. 1998; Rothschild 2000; Walsh et al. 1993), and more recently, studies to foster sustainable environmental behaviors (Andreasen 1995). For example, Reger et al. (1998) acknowledged the limited impact of previous community-based health promotion programs and instituted new approaches. By targeting specific community group members at risk, implementing a media campaign, and using a non-intervention control comparison group, Reger et al. (1998) were able to observe significant behavior change in the community intervention group using post-intervention self-reports. Similar procedures were utilized in an effort to design an effectual community-based health intervention program. Goodman (1998) identified five major evaluation principles for community-based promotion programs: program theory, instruments tailored to the members of the community, evaluation that involves qualitative and quantitative responses, incorporates social ecology and social system concepts, and involves local stakeholders in meaningful ways. The current program applied these principles in an effort to improve evaluation integrity.

McKenzie-Mohr (2005) identified seven steps for community-based observation in accordance with social marketing principles: clarifying the objective of the survey, listing items to be measured, writing the survey, performing a pilot, selecting a sample,

FIG. 2. Front of the original tip card.

FIG. 3. Back of the original tip card.

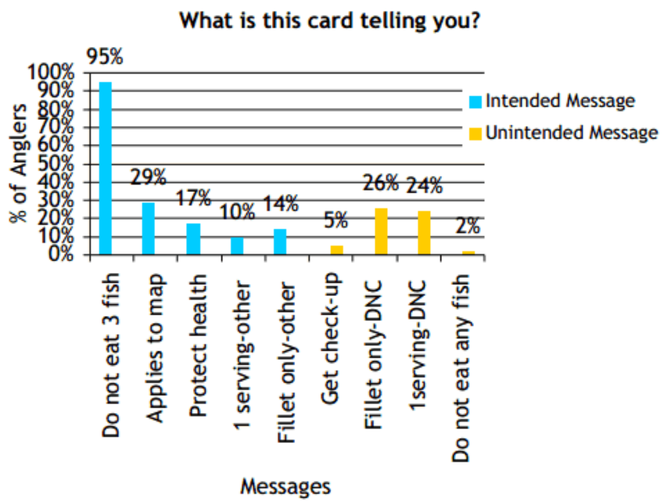

FIG. 4. Most prominent messages from the tip card.

conducting the survey, and analyzing the data. The CBSM model we applied to our Angler Outreach Program emphasizes person-to-person channels of communication and outlines the following steps, a concise version of McKenzie-Mohr's (2005) survey steps and expansion upon follow-up of the data: (1) formative research that includes identifying a target audience, target behaviors, and motivators and barriers associated with the target behavior, (2) pilot testing, (3) intervention, and (4) evaluation. The program also included a control group that helped us compare results between anglers who received outreach and those who had not.

1. Formative Research

In conducting formative research, we learned from pier anglers that a big motivator was protecting the health of their children and a lack of awareness around DNC fish was a major barrier to avoiding DNC fish consumption. This formative research involved conducting a baseline evaluation at local sites and surveying anglers. We learned this from their responses to the following question: "What would motivate someone like you to throw a contaminated fish…back in the ocean?" Their children's health was one of the top responses.

We developed a tip card to inform anglers about the advisory and applied the stated motivator into the content development by featuring a doctor with a child to depict the idea of protecting their families' health. The tip card was originally a postcard-sized, double-faced card that featured an area map and three DNC fish on one side and information on how to eat other non-DNC fish on the other side (see Fig. 2 and 3).

2. Pilot Testing

The tip card was piloted with the assistance of our FCEC outreach partners in October–November 2009. Forty-one surveys were collected across the following nine piers: Belmont, Rainbow Harbor, Seal Beach, Cabrillo, Hermosa, Redondo, Venice, Pier J, and Santa Monica pier.

When shown the original tip card, 95% of the anglers who responded cited avoiding the consumption of contaminated fish as the most prominent message. In addition to identifying intended messages (i.e., do not eat contaminated fish, information applies to defined area, protect the health of your family), a large number of anglers also cited unintended message points (i.e., get a check-up at the doctor, avoid consuming fish altogether; and only eat the skinless fillet once a week of all fish in general, including DNC fish). Less than 15% of anglers understood that the preparation message points related to "all other fish." Anglers could not separate the advice from the back of the card from the front of the card because there was no logical visual distinction between these two sets of advice. As a result, anglers were faced with a seemingly contradictory set of guidelines: Do not eat these three fish, but if you do, only eat the skinless fillet once a week (Fig. 4).

Four anglers (or 10% of those surveyed) indicated they were illiterate. We took this finding into consideration when revising the tip card's content, layout, and design.

Results of the tip card pilot testing indicated that several elements of the material needed to be modified. With input from FCEC's group of partners, the recommended modifications were as follows:

- Simplify/reduce text:
  - Ten percent of surveyed anglers were found to be illiterate. This finding prompted us to reduce text throughout the material and increase the use of visual images.
- Focus on the use of visual images:
  - Use symbols like green checkmarks to indicate a recommended behavior (i.e., skinless fish fillet consumption/ serving size).
  - Fourteen percent of anglers recommended that DNC fish should be individually crossed out.
  - Nine percent of anglers recommended using real images for the serving size section.
- Remove doctor/child image and replace with angler/family image:
  - Fifty-five percent of anglers thought that this image meant to visit the doctor for a checkup. Anglers suggested we include an image of an angler with his or her family to increase the relevancy of the material and message points.
- Increase relevancy/usefulness of card:
  - Make the card smaller/foldable so that anglers can easily carry the material, such as a small pocket handbook.
  - Include fish that anglers can consume, perhaps along with legal size limits.
  - Include a ruler at the bottom of the material.
- Redesign structure and layout of the back of the card:
  - Less than 15% of surveyed anglers understood that the preparation message points presented on the back of the card related to "all other fish." Anglers could not separate the advice from the back of the card from the front of the card because there was no logical visual distinction between these two sets of advice.

- A potential solution to this problem might be to make a visual connection between the preparation guidelines and "all other fish." Preparation advice could be presented alongside a visual list of safe fish that anglers can eat. Therefore, one side or panel of the material would focus on DNC fish and another would focus on featured safe fish and accompanying preparation/consumption guidelines.
- Include a phone number in addition to the website address:
  - Twenty-two percent of surveyed anglers noted that they did not have Internet access or own a computer.

We revised the tip card (Fig. 5 and 6) based on findings of the pilot test and recommendations of Heal the Bay (which came up with an initial revised concept) and the Messaging Work Group.

3. Intervention and Implementation: Angler Outreach

After synthesizing the lessons learned from the pilot testing, we revised the tip card and expanded the FCEC outreach activity by increasing the number of field teams and time in the field through the Angler Outreach Program. Heal the Bay and Cabrillo Marine Aquarium reviewed the tip card with anglers 2–3 days a week over the course of approximately a year. They conducted outreach to more than 8,873 individuals across nine piers: Santa Monica Pier, Venice Beach Pier, Redondo Beach Pier, Hermosa Beach Pier, Cabrillo Pier, Belmont Pier, Rainbow Harbor, Pier J, and Seal Beach Pier. The Angler Outreach team handed a copy of the tip card to anglers after reviewing the content with them.

FIG. 5. Front of the revised tip card.

FIG. 6. Back of the revised tip card.

4. Evaluation

We designed a survey that was administered by Heal the Bay and Cabrillo Marine Aquarium. Prior to beginning the survey, surveyors assessed eligibility criteria. To prevent over-surveying of our target population, anglers were eligible if they indicated they had not previously been surveyed by an outreach worker in the past month. We assessed "typical" post-catch behavior with DNC fish caught and awareness of DNC fish, comparing data between anglers who received outreach with those who had not. The control group was defined as anglers who did not receive subsequent outreach.

It is important to note that we conservatively consider outreach in general as a potential influence on DNC fish awareness and post-catch behavior. This is because the overall angler-outreach program has been carried out since 2001 when the program was operating under a different advisory. When considering whether or not anglers had received outreach, it is not possible to distinguish whether they received outreach based on the old or new advisory. Therefore, we conservatively consider outreach in general as a potential influence on specific behaviors and awareness levels.

A total of 870 anglers responded to the survey with a largely male sample (95%). Approximately 15% of the sample reported that they had received outreach. The remainder of the surveyed population represented the control group of anglers who had not received outreach.

Findings

The survey assessed the following between anglers who had received outreach and those who had not: self-reported typical post-catch behavior with caught DNC fish (eating it or giving it to friends/family), and awareness of DNC fish contamination.

Typical post-catch behavior of DNC fish by outreach status

We examined post-catch behavior of all DNC species□ plus mackerel, which was included as a discriminant (non-DNC fish) item□ by outreach status (defined as having reviewed a tip card or not). Across all DNC species, the positive finding was that a smaller proportion of anglers who received outreach (2–8%) reported usually eating fish relative to anglers who had not received outreach (7–22%; Fig. 7). However, the opposite pattern was observed for giving fish to friends/family: Across all DNC species, greater proportions of anglers who had received outreach (11–14%) reported usually giving fish to friends/family relative to anglers who had not received outreach (7–8%; Fig. 8). The Angler Outreach Program has since incorporated this finding into its outreach efforts, that is, placing an emphasis on not giving DNC fish they catch to friends/family in addition to not eating them.

DNC fish contamination awareness by outreach status

Irrespective of outreach status, the majority of anglers were aware of DNC species contamination. Across DNC species, however, larger proportions of anglers who received outreach were aware of contamination compared to those who had not received outreach.

Our outreach team asked anglers if they had heard anything about each of the five DNC fish species being contaminated. For all DNC fish, a larger proportion of anglers who received outreach reported being aware of contamination relative to anglers who had not received outreach (Fig. 9). Note that a larger proportion of anglers who had received outreach reported that shark□ another discriminant□ was contaminated, relative to anglers who had not received outreach, though sharks tend to have high levels of mercury in other areas. This may point to the need for more specificity in distinguishing between DNC and non-DNC species during outreach sessions. On a more positive note, however, for the other safe (non-DNC) fish, mackerel, a smaller proportion of

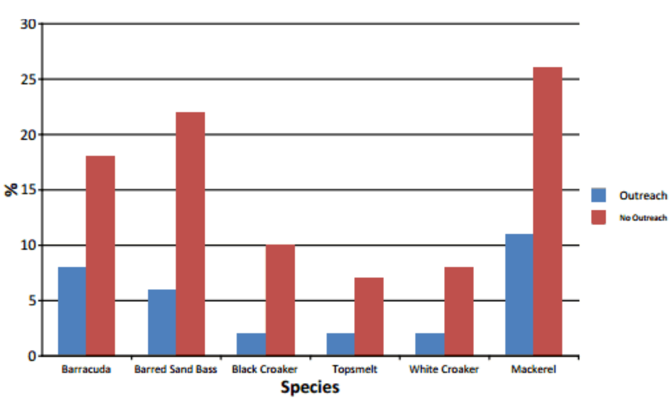

FIG. 7. Proportion of anglers who reported usually eating caught fish, by outreach status (noutreach=61-65, nno outreach=409-436).

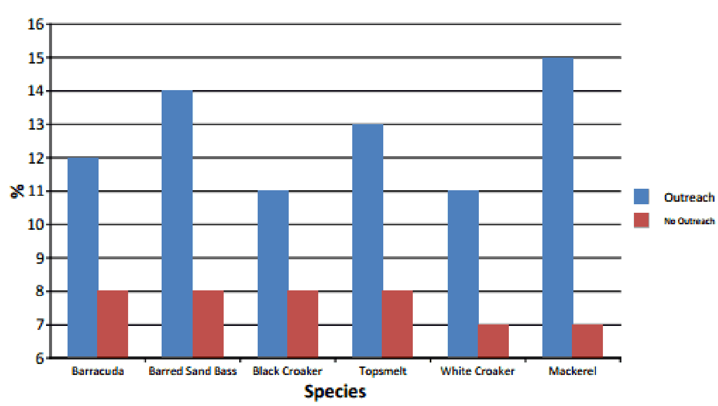

FIG. 8. Proportion of anglers who reported usually giving caught fish to family/friends, by outreach status (noutreach=61-65, nno outreach=409-436).

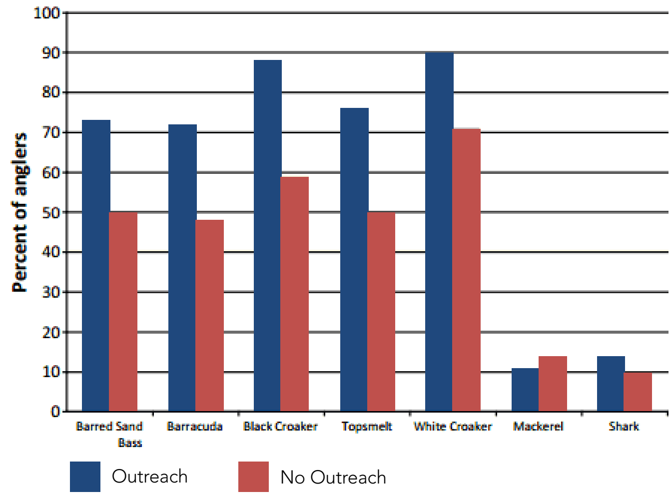

FIG. 9. Awareness of contamination of DNC and non-DNC fish, by outreach status (noutreach=112-114, nno outreach=647-664).

anglers who had received outreach reported it to be contaminated relative to anglers who had not received outreach, consistent with anglers being able to distinguish between DNC and non-DNC species. Future outreach efforts should continue to assess anglers' ability to discriminate between information provided about DNC versus non-DNC species (i.e., shark or mackerel).

Summary of typical post-catch behavior and DNC fish awareness by outreach status

Results comparing our control group with the group of anglers who received outreach were encouraging. We found that a smaller proportion of anglers who received outreach reported typically eating DNC fish they caught relative to anglers who had not received outreach. However, a higher proportion of anglers who received outreach reported giving caught DNC fish to friends/family compared with anglers who had not received outreach. On a positive note, a higher proportion of anglers who received outreach reported being aware of DNC fish contamination across species compared with anglers who had not received outreach.

Limitations

The findings in this article should be considered in light of several limitations. First, most of the data were obtained via self-report, which is subject to a number of known biases. Second, survey administration methods may not have been consistent across surveyors. Survey administrators collected data but did not employ a standard data collection monitoring protocol. Another limitation is that outreach results may not be solely attributed to the revised outreach material (i.e., tip card). It is possible that anglers who reported receiving the outreach actually received the initial OEHHA advisory prior to the updated advisory and dissemination of the new tip card. Anglers reported whether they had received outreach, but they could have been exposed to information about DNC fish that was not part of the information delivered by outreach workers and/or administered as part of the FCEC program. Finally, inferential statistical tests were not conducted. In future years, we recommend conducting inferential tests using data collected according to protocol.

Conclusions

The current Angler Outreach Program yielded several interesting results by applying the community-based social marketing model. The program was shown to be effective by observing significantly different results from a non-outreach comparison group. A smaller proportion of anglers who received outreach reported usually eating DNC fish that are contaminated relative to anglers who had not received outreach, although the outreach group also reported usually giving DNC fish to friends/family more often than the non-outreach group. The outreach group was also shown to be more aware of contaminated fish than those who did not receive the outreach, though the majority of anglers in both groups were aware of contaminated fish.

The implications of this study show that the CBSM model can be successfully applied towards changing the behaviors of the target population (PVS anglers). The current project was unique in utilizing social marketing principles to include pilot testing, incorporating an evaluation component, and using a control group that did not receive outreach. Incorporating a tip card that had been pilot tested by the target audience as part of an outreach program can be effective in similar community environments, as it involves more dynamic communication and goes beyond passive marketing. Future outreach programs can continue to apply the CBSM model with success and build off of the lessons learned from the current study.

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IMPACT OF DEVELOPMENT ON AQUATIC BENTHIC MACROINVERTEBRATE COMMUNITIES IN THE SANTA MONICA MOUNTAINS OF SOUTHERN CALIFORNIA

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Abstract

Urban runoff due to development poses one of the greatest threats to the health of riparian and ocean ecosystems today. Past studies of urbanized watersheds have found that increased urbanization leads to impaired biological diversity in streams. This study assesses the impact of urbanization on aquatic benthic macroinvertebrates in the Santa Monica Mountains watersheds. We calculated the percent of developed area and percent of impervious area at monitoring sites based on geographic information system (GIS) mapping to quantify development in the region. We assessed the relationship between development and benthic macroinvertebrate communities, using the multi-metric Index of Biological Integrity (IBI) score given out of 0–100. At our fifteen sites, the average IBI scores ranged from 13 to 76, percent developed area ranged from 0.2% to 33.1%, and percent impervious area ranged from 2.1% to 21.2%. We found significant negative relationships between percent developed and impervious area and IBI score. Taking into account year and season sampled, as well as field protocol used, both percent developed area and percent impervious area explained a large amount of the variation in IBI scores (62% and 64%, respectively). We identified levels of 8.8% developed area and 6.6% impervious area, where sites with development over these levels showed biological impairments based on the regulatory threshold (IBI score of 39). This research shows that even low levels of urbanization and development impact biological health in streams, indicating a need to reduce impervious surface impacts through low-impact development (LID) and curb further development in the Santa Monica Mountains and Malibu Creek Watershed.

Introduction

The world's rapidly growing population and economy has led to the extensive urbanization of once natural watersheds. Urbanization and development have been shown to cause negative impacts to both water quality and the biota of streams, through loss or alteration of habitat, as well as through urban runoff and pollution (Jones and Clark 1987; Lenat and Crawford 1994; Weaver and Garman 1994; Basnyat et al. 1999; Paul and Meyer 2001; Brabec et al. 2002; Hatt et al. 2004; Miltner et al. 2004; Walsh et al. 2005). Developed areas often have significant impervious surface area, including roads, parking lots, and commercial and residential buildings, which impede water from infiltrating directly into the ground and lead to higher and faster runoff volumes, and subsequently affect the hydrology, chemistry, channel morphology, and biological health of aquatic ecosystems (Paul and Meyer 2001; Center for Watershed Protection 2003). Urban runoff also often contains trash and debris, bacteria, sediments, nutrients, metals, toxic chemicals, and other pollutants, which can adversely affect the quality of the receiving waters, associated biota, and public health. Previous studies have documented negative ecological impacts at levels of 10% or more impervious cover (Schueler 1994); biological impacts to aquatic vertebrate communities were seen at 8% or greater urbanization in the Santa Monica Mountains of Southern California (Riley et al. 2005). Other studies have found impacts to streams at even lower levels of development and imperviousness (Walsh et al. 2007; King et al. 2011).

Direct measurements of biological communities such as plants, invertebrates, fish, and microbial organisms are well accepted as effective indicators of stream health (Harrington and Born 2000). Combined with measurements of watershed characteristics such as land use practices, physical features of in-stream habitat, and water chemistry, biological assessment (bioassessment) provides information about the health status of a waterbody through the presence and abundance of different organisms and can be an effective tool for long-term trend monitoring of watershed condition (Davis and Simon 1995; Karr 1998; Karr and Yoder 2004). The results of the assessment can also be compared to a biological standard to quantify the health of the waterbody in question (US EPA 2012). Benthic macroinvertebrate (BMI) monitoring is a widely used method of stream bioassessment. BMIs are critical to the health of stream systems, as they are a significant food source for other aquatic and terrestrial animals. They are ubiquitous, relatively stationary, and their high species diversity allows for a spectrum of responses to environmental stresses (Rosenberg and Resh 1993; Merritt and Cummins 1996). Individual BMI species vary in sensitivity to environmental stressors, such as low dissolved oxygen, temperatures elevated above natural background, sedimentation, scouring, invasive species, nutrient loading, and chemical pollution (Resh and Jackson 1993), making BMIs very useful in identifying the cause of stream habitat impairment. Previous studies have also found that BMIs are sensitive to development and imperviousness in a drainage basin. In watersheds of high impervious surface area, the BMI community tends to be dominated by pollution tolerant species (Paul and Meyer 2001). BMI diversity and abundance has also been shown to decline with increases in urbanization and impervious surface cover at levels of 5–15% (May et al. 1997; Paul and Meyer 2001; Morse et al. 2003). Declines in stream macroinvertebrates were also found at impervious cover as low as 0.5–2% (King et al. 2011) and sensitive benthic macroinvertebrates were rare at sites with greater than 4% imperviousness (Walsh et al. 2007).

The Santa Monica Mountains of Southern California are located in close proximity to highly urbanized Los Angeles. Despite this proximity to one of the largest urban areas in the world, much of the study area remains undeveloped, offering the opportunity to study the impacts of urbanization on relatively natural stream ecosystems. At 109 square miles, the Malibu Creek Watershed is the second largest watershed draining to the Santa Monica Bay. Over 75% of the Malibu Creek Watershed is undeveloped, with several small cities and rural residential communities located within its reaches. The highly visited, world-famous Surfrider Beach is located at the terminus of the watershed. Protecting water quality and biological resources in the Malibu Creek Watershed is paramount for preserving the treasured natural resources and allowing safe recreational use of the Santa Monica Bay.

The purpose of this study was to assess the impact of urbanization on the condition of aquatic benthic macroinvertebrate communities in the Malibu Creek Watershed. We measured urbanization as both amount of area developed and amount of impervious area and looked for a relationship between urbanization and BMI assemblages using the common metric, Index of Biological Integrity (IBI) score. As previously described, benthic macroinvertebrates are known to be sensitive to urbanization and we sought to confirm this pattern on a local watershed-scale level. Although similar impacts have been shown elsewhere, documenting it for a specific area and on a local scale is important and useful for land use planners and management agencies in the Santa Monica Mountains. The study further examined the level of urbanization or imperviousness that corresponds to the established regulatory limits (IBI score of 39). Determining levels of urbanization and imperviousness that cause ecological impacts will help guide the development and implementation of new management policies and practices. For instance, the impact level could serve as a cap for future development, as well as an impervious surface reduction goal for redevelopment projects through the implementation of low impact development (LID).

Methods

Site Description

The Malibu Creek watershed is located in Southern California's Santa Monica Mountains, just north of the City of Malibu, Los Angeles County. It contains both urban/residential development and undeveloped parklands within the Santa Monica Mountain National Recreation Area. The drainage network includes Malibu Creek and its tributaries, Cold, Las Virgenes, Medea, Cheeseboro, Stokes, and Triunfo Creeks. Other nearby, less-developed watersheds in the Santa Monica Mountains include Arroyo Sequit, Lachusa,

Sample Location	Site[a]	Number of Samples	Average IBI Score	SD IBI Score	Average IBI Category	Percent Developed Area	Percent Impervious Area
Upper Cold Creek	H3	14	76	8.8	Good	1.46	2.47
Cheeseboro Creek	H6	7	51	10.3	Fair	0.23	2.07
Upper Las Virgenes Creek	H9	9	41	10.3	Fair	1.16	2.36
Solstice Creek	H14	11	67	10.7	Good	2.32	2.76
Lachusa Creek	H18	10	56	18.6	Fair	5.29	4.07
Arroyo Sequit Creek	H19	11	66	6.9	Good	3.06	2.89
Mid-Cold Creek	M11	10	51	8.3	Fair	10.50	5.36
Mid-Malibu Creek, upstream	M12	13	22	9.1	Poor	26.87	14.06
Mid-Las Virgenes Creek	M13	10	19	7.2	Very Poor	12.92	8.64
Mid-Malibu Creek, downstream	M15	12	25	10.9	Poor	22.38	12.07
Outlet Malibu Creek	O1	13	23	7.8	Poor	21.61	11.72
Outlet Cold Creek	02	11	39	16.3	Poor	11.89	6.13
Outlet Las Virgenes Creek	O5	12	26	8.6	Poor	14.72	9.24
Medea Creek	O7	11	19	7.8	Very Poor	33.09	21.24
Triunfo Creek	017	9	13	8.3	Very Poor	29.94	13.20

[a] H= high-quality site, M = middle site, O= outlet site

TABLE 1. Monitoring locations, numbers of samples, average Index of Biological Integrity (IBI) score, standard deviation of IBI scores, category of average IBI score, and percent developed area and percent impervious area upstream of monitoring sites in the Santa Monica Mountains.

and Solstice Creeks. Flow is naturally intermittent in some stream reaches due to the prevailing Mediterranean-type climate, with hot dry summers and winter rainfall. However, import of water into the basin for urban uses over many years has shifted the flow regime in some streams from intermittent to perennial, primarily caused by dry-weather runoff, wastewater treatment plant discharges, and regulatory flow requirements. Other hydrological alterations within the watershed include roadway stream crossings, horse ranches, field spraying of treated wastewater effluent in the Las Virgenes Creek sub-basin, and the construction of Rindge Dam in lower Malibu Creek.

Field Sampling

The field sampling was conducted by Heal the Bay's Stream Team. The Stream Team program was initiated in 1998 and uses field crews comprising skilled professional staff and trained volunteers to conduct watershed monitoring. We conducted benthic macroinvertebrate assessments at fifteen sites between 2000 and 2011 (Table 1). All sites are within the Santa Monica Bay Watershed; twelve sites are within in the Malibu Creek subwatershed and three sites are outside the Malibu Creek watershed (see Figure 1 for sampling locations). Sites were grouped into categories of high-quality sites, middle watershed sites, and outlet sites (Table 1). These sites were selected to provide a gradient of urbanization so that we could test the relationship between urbanization or imperviousness and the condition of biological communities. High-quality sites were selected at minimally developed areas in the watershed; waters at these sites are just downstream from protected open space with some hiking uses and minimal paved areas. Our criteria for high-quality sites are not based on the same criteria and are less stringent than those used in the State's Reference Condition Management Program (RCMP), as our sites were selected prior to the development of the RCMP and the Surface Water Ambient Monitoring Program (SWAMP) protocols. Middle sites are located in the mid-watershed and were selected to detect where stream degradation may occur in each tributary, as well as the gradient of impacts that might occur between the upper and lower stretches of individual streams. Outlet sites were selected at the outlets of tributaries and most are directly downstream of residential or commercial development and/or stream alterations such as culverts and concrete banks.

Bi-annual samples were collected between 2000 and 2004 during spring and fall. In 2005, sites were sampled once in the winter and between 2006 and 2011, sites were sampled once a year in the spring. In 2004 and 2007, bioassessment monitoring was not performed.

Between 2000 and 2003, BMI samples were collected using the California Stream Bioassessment Procedure (CSBPs) for non-point source assessments (Harrington 1996). With this method, three riffles in each monitoring reach were randomly chosen and one sample was collected in the top third of each. Starting with the lowermost riffle, the benthos within a 1 ft^2 area was disturbed upstream of a 1 ft wide, 0.5 mm mesh D-frame kick-net. Three locations along the transect representing the richest habitats were

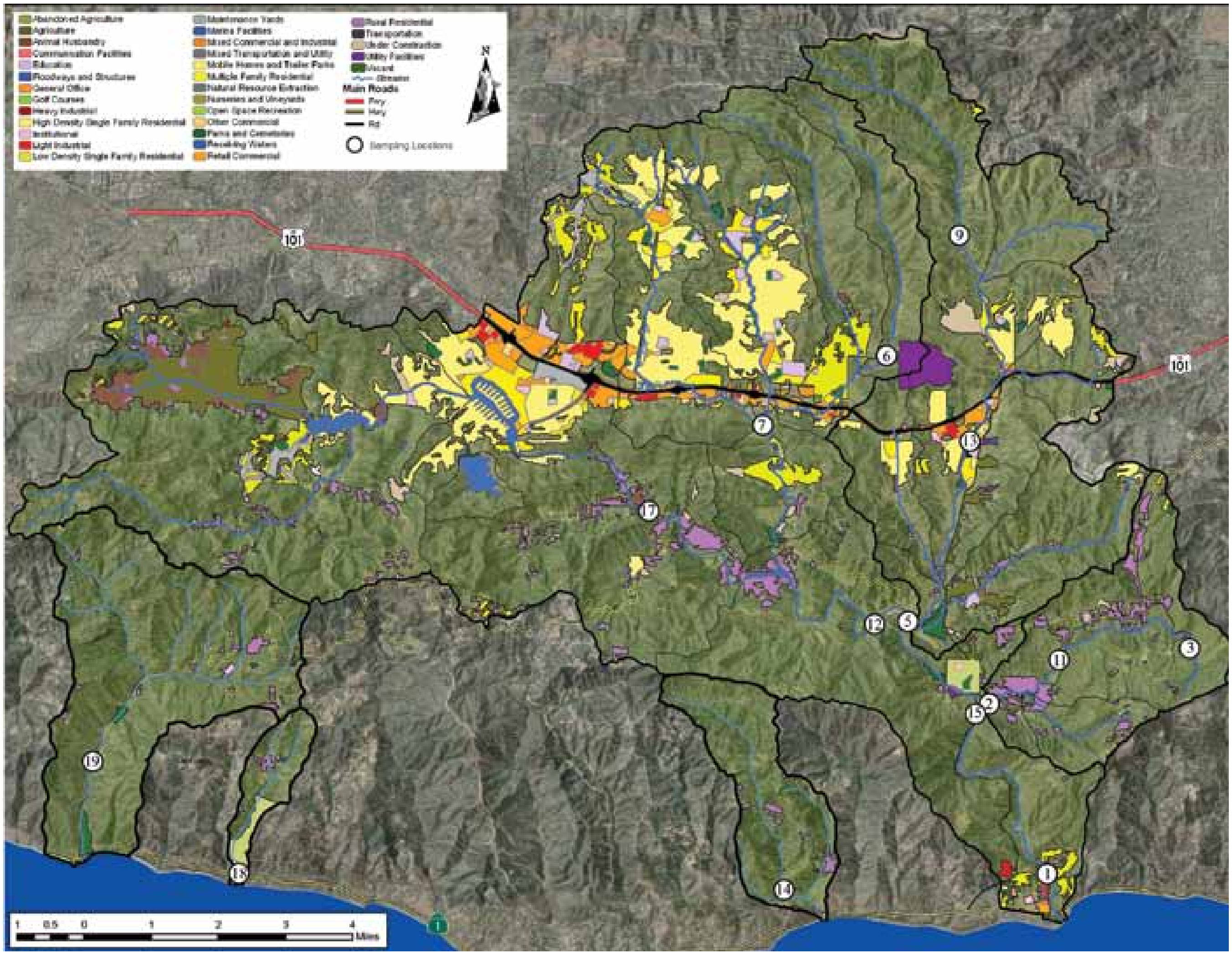

FIG. 1. Land use in the Malibu Creek Watershed and surrounding watersheds. Land uses in the Malibu Creek Watershed and adjacent watersheds based on SCAG (2001) data and aerial photos. Heal the Bay monitoring locations are designated by white circles with numbered site locations.

sampled and combined into a composite sample (representing a 3 ft^2 area). Sampling of the benthos was performed manually by rubbing cobble and boulder substrates in front of the net followed by "kicking" the upper layers of substrate to dislodge any invertebrates remaining in the substrates. The duration of sampling ranged from 60 to 120 seconds, depending on the amount of boulder and cobble-sized substrates that required rubbing by hand; more and larger substrates required more time to process. This procedure was repeated for the three riffles and maintained as three separate samples for the reach. The three samples were transferred into a 500 ml wide-mouth plastic jar containing approximately 200 ml of 95% ethanol.

In 2005 through 2007, sampling was conducted using the US EPA targeted riffle composite (TRC) procedure (Peck et al. 2004), which was adapted by the SWAMP and described in Ode (2007). With this procedure, a 1 ft2 of riffle area of the benthos was disturbed using the method previously described for the CSBP. Eight samples were taken from eight different riffles if available or by collecting more than one sample per reach if fewer than eight riffles were available. The locations in the riffles were randomly chosen using a number from 1 to 10 representing 10% increments upstream from the bottom of the riffle and from the right wetted bank. The eight collections from the riffles were composited and transferred into a 500 ml wide-mouth plastic jar containing approximately 200 ml of 95% ethanol.

Starting in 2008, sampling was conducted by using the Reach Wide Benthos (RWB) procedure also described in Ode (2007). With this procedure, 11 transects are established equidistant (15 m) along a 150 foot reach. Starting with lowermost transect and on the right side (25% distance from right bank), a 1 ft^2 area of the benthos

Land Use Category	Impervious Factor (IF)
Abandoned Agriculture	0.060
Agriculture	0.060
Animal Husbandry	0.060
Communication Facilities	0.750
Education	0.750
Floodways and Structures	0.000
General Office	0.850
Golf Courses	0.060
Heavy Industrial	0.800
High-Density Single Family Residential	0.600
Institutional	0.750
Light Industrial	0.750
Low-Density Single Family Residential	0.400
Maintenance Yards	0.750
Marina Facilities	0.750
Mixed Commercial and Industrial	0.800
Mixed Transportation and Utility	0.750
Mobile Homes and Trailer Parks	0.417
Multiple Family Residential	0.600
Natural Resource Extraction	0.750
Nurseries and Vineyards	0.060
Open Space Recreation	0.030
Other Commercial	0.850
Parks and Cemeteries	0.100
Receiving Waters	0.000
Retail Commercial	0.850
Rural Residential	0.350
Transportation	0.750
Under Construction	0.060
Utility Facilities	0.750
Vacant	0.019

TABLE 2. Impervious factors (IF) for land use categories in the Malibu Creek Watershed used to calculate percent impervious area.

was disturbed using the method previously describe for the CSBP. After securing the BMIs in the net or sample jar, the next transect upstream was sampled in the center (50% distance for the right bank) in the same manner and then the next transect was sampled on the left (75% distance from the right bank). This pattern was continued until all 11 transects were sampled (representing 11 ft^2). The 11 collections from the transects were composited and transferred into a 500 ml wide-mouth plastic jar containing approximately 200 ml of 95% ethanol. To compare different field protocols, duplicate samples using both techniques were collected at a site in 2008 when we switched from riffle-based BMI collection (CSBP and TRC) to a multi-habitat method (RWB).

Laboratory Analysis

The BMI samples were processed by Sustainable Land Stewardship International Institute (SLSII) in Sacramento or Chico, California. Each sample was rinsed through a No. 35 standard testing sieve (0.5 mm brass mesh) and transferred into a tray marked with twenty 25 cm2 grids. All sample material was removed from one randomly selected grid at a time and placed in a petri dish for inspection under a stereomicroscope. All invertebrates from the grid were separated from the surrounding detritus and transferred to vials containing 70% ethanol and 5% glycerol.

In 2000 through 2006, this process was continued until 300 organisms were removed from each sample and starting in 2008, this process was continued until 500 organisms were removed from one composite sample per site. The material left from the processed grids was transferred into a jar with 70% ethanol and labeled as “remnant” material. Any remaining unprocessed sample from the tray was transferred back to the original sample container with 70% ethanol and archived. BMIs were then identified to the Southwest Association of Freshwater Invertebrate Taxonomists (SAFIT) Standard Taxonomic Effort (STE) Level 1 (Richards and Rogers 2006). A taxonomic list of all BMIs identified from the samples was used to calculate and summarize the aquatic macroinvertebrate community–based metric values.

Data Analysis

The IBI score for each site was calculated based on the methods in Ode et al. (2005). Briefly, the southern California IBI assigns an overall site score from 0 to 100 through a multi-metric, multivariate technique based on seven metrics: EPT taxa richness (Ephemeroptera [mayflies], Plecoptera [stoneflies], and Trichoptera [caddisflies]), Coleoptera (beetle) richness, predator richness, percent of individuals in specific feeding groups (collector-filterers + collector-gatherers), percent pollution intolerant individuals, percent non-insect taxa, and percent pollution-tolerant taxa. Within the southern California (SoCal) IBI, scores are divided into the following five categories to assess biotic condition: “excellent” (81–100), “good” (61–80), “fair” (41–60), “poor” (21–40), and “very poor” (0–20). Values of 39 or lower depict a biologically impaired waterbody with poor or very poor biotic condition (Ode et al. 2005). The State Water Resources Control Board uses this score to designate waterbodies as impaired for macroinvertebrate communities in the 303(d) List of Impaired Waters. The SoCal IBI has different scoring methods for different ecoregions in southern coastal California; our sites all fall within Omernik Ecoregion 6 and were scored accordingly (Ode et al. 2005).

BMI Sample Calibration and Re-verification

To use the SoCal IBI, specific biological metrics had to be calculated based on 500 organisms. Since the version of the CSBP used in 2000 through 2003 required the collection of three samples from which a subsample of 300 organisms per sample were counted, there were 900 organisms in total identified for each site (according

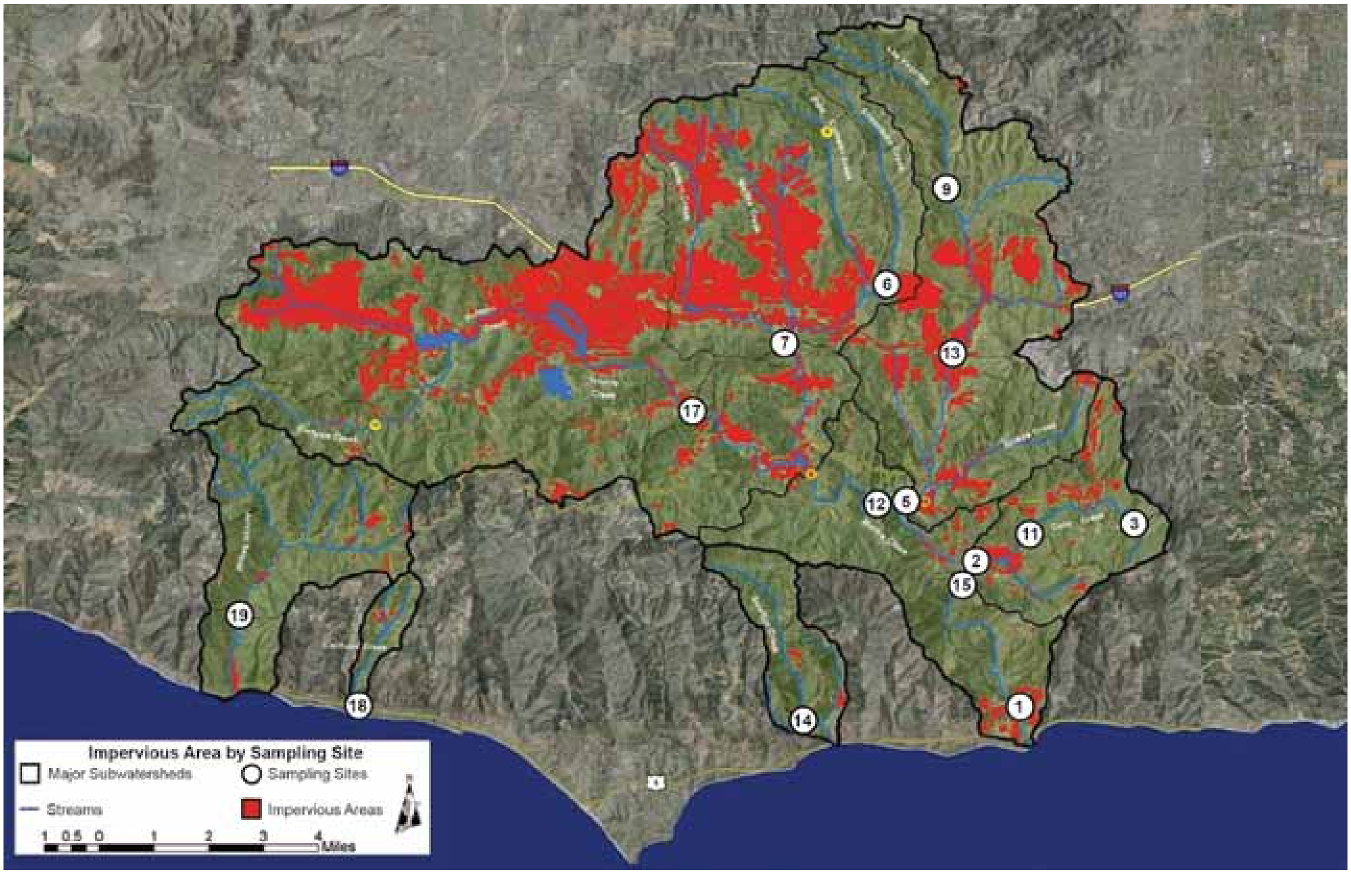

FIG. 2. Impervious area in the Malibu Creek Watershed and surrounding watersheds. Impervious area (shown in red) in the Malibu Creek Watershed and adjacent watersheds based on SCAG (2001) data and impervious factors (Table 2). Heal the Bay monitoring locations are designated by white circles with numbered site locations.

to the CSBP laboratory processing). A Monte Carlo simulation model developed by DFG was used by SLSII staff to reduce the 900 identified organism count from the 2000 through the 2003 samples to 500. The 2005 through 2010 BMI samples were collected using the SWAMP Bioassessment Procedure (Ode 2007), and therefore no conversion or use of the Monte-Carlo procedure was necessary.

Land Use: Development and Imperviousness

We analyzed land use maps to determine the extent of urbanization as measured by the percent developed area and percent impervious area. Land use data was obtained from the 2001 Southern California Association of Governments (SCAG) and aerial photographs for Los Angeles County (2002) and Ventura County (2003). We reclassified the SCAG data using the Anderson classification system (Anderson et al. 1976) and created two additional land use categories: Parks and Cemeteries and Abandoned Agriculture. Abandoned Agriculture is generally placed into the Vacant Land use category; however, our analysis of aerial photographs indicated that runoff from Abandoned Agriculture will act more like runoff from existing Agriculture than Vacant Land. The Parks and Cemeteries category included the following SCAG land use categories: Cemeteries, Other Open Space and Recreation, Undeveloped Local Parks and Recreation, Developed Local Parks and Recreation, and Developed Regional Parks and Recreation.

After reclassification, we calculated the amount of development upstream of monitoring sites. We calculated percent developed area as the amount of land that was not classified as Vacant or Open Space Recreation divided by the total amount of land upstream of a given site. Further, the SCAG land use data were evaluated to determine how much of a given land use category would result in runoff. Each land use category was assigned an impervious factor (IF) or a number representing what percentage of the land use results in runoff (Table 2). The IFs were derived from the Los Angeles County Department of Public Works (2006) and Ackerman et al. (2003). Animal Husbandry has no specific documentation by Los Angeles County Department of Public Works (2006) or Ackerman et al. (2003). We assigned an impervious factor of 6% to it, which is the same designation used by Ackerman et al. (2003) for Agriculture, Nurseries, and Vineyards. The Golf Course and Under Construction land uses were also considered to have 6% impervious cover, as they are more similar to irrigated agriculture than to unmanaged open space. The IF was multiplied by the acres of each specific land use, these values were totaled for all land-uses upstream of each site, and divided by the total amount of land to determine the percent impervious area that drains into each monitoring location. This calculation may not provide a complete picture of runoff in the watershed because it does not distinguish between those surfaces that are directly connected to the storm drain network versus those surfaces that drain into pervious areas. Further, percent developed area and impervious area for each site were assumed to be constant over time because land use data is only available approximately every five years. On the other hand, there has been relatively little new development over the time period of our study.

Statistical Analyses

To examine the relationship between development and biological community, we performed multiple regression analyses in R (R Development Core Team 2011). We assessed the statistical relationship between percent development (developed area and percent impervious area) and IBI score. Percent developed area and percent impervious area were log transformed for normality. We included possible confounding factors of year, season, and field protocol through multiple regression analyses. We also examined bivariate plots of just IBI score and percent developed area and IBI score and percent impervious area to determine the level of development that corresponds to the regulatory impaired IBI score of 39. We determined the best fit trendlines for the bivariate relationships through simple regression analyses.

Results

Upstream percent development ranged from less than 1% to over 33% at the monitoring sites, while percent impervious area ranged from approximately 2% to over 21% (Table 1). High-quality sites had the lowest percent developed and impervious area; all high-quality sites had less than 6% development upstream and less than 5% impervious area (Table 1). In contrast, middle and outlet sites all had over 10% developed area upstream and over 5% impervious area (Table 1). Development and imperviousness in general occur in the upper watershed, along the 101 Ventura Freeway corridor (Fig. 1 and 2). Land uses in developed areas are primarily high-density single family residential, multiple-family residential, and mixed commercial and industrial (Figure 1). In the middle watershed, there is less development and impervious area overall, with the primary developed land use in that area being rural residential (Fig. 1 and 2). However, middle watershed sites still had moderate levels of development and imperviousness as upstream of these sites includes the more developed areas in the upper watershed. At the terminus of the Malibu Creek Watershed, development and imperviousness also increase somewhat as the Creek flows through the city of Malibu right before reaching Malibu Lagoon and Santa Monica Bay (Fig. 1 and 2).

To assess whether the results would vary due to the use of different field sampling protocols, we qualitatively compared the IBI scores as well as the individual metrics that comprise the IBI score for one site that was sampled in 2008 using both the riffle based method (CSBP and TRC) and the multi-habitat method (RWB). We found no major difference in IBI score obtained using the two types of SWAMP sampling procedure (RWB vs. TRC) and no notable differences at the individual metric level. The duplicate samples collected using the two sampling procedures produced IBI scores with a difference of 3 points, which is lower than the average difference found for all duplicate samples in other years.

On average, high-quality sites had much higher IBI scores than middle and outlet sites (Table 1). The average IBI score at high-quality sites was 60, in the "fair" range, while average IBI scores at middle and outlet sites fell in the "poor" range, with scores of 29 and 24 respectively (Table 1). Moreover, we found that both percent developed area and percent impervious area were significant predictors of IBI score, taking year, protocol, and season into account (Table 3). The confounding variables (year, protocol, and season), on their own, were not significant predictors of IBI score. Percent impervious area (log transformed), year, protocol, and season explained 71% of the variation in IBI scores. Percent developed area (log transformed), year, protocol, and season explained 68% of the variation in IBI scores.

When we examined the bivariate relationship between IBI score and percent developed area, we found that percent developed area was a significant predictor of IBI score ($p<0.0001$) and explained 61.9% of the variation in IBI score (Figure 3a). A logarithmic trendline was the best fit for the relationship between percent developed area and IBI score (Figure 3a). The trendline had an IBI score of 39 (impairment) when percent developed area was equal to 8.8%. No sites with greater than 4% developed area had average IBI scores above 60, in the good range and above (Table 1).

IBI scores decreased dramatically as the impervious area above each site increased (Fig. 3b). We found that a logarithmic trendline was the best fit line for the bivariate relationship between percent impervious area and IBI score. Percent impervious area was a significant predictor of IBI score ($p<0.0001$) and explained 64.1% of the variation in IBI scores. The trendline had an IBI score of 39 (impairment) when percent impervious area was equal to 6.6%. No sites with greater than 3% impervious area had average IBI scores above 60, in the good range and above (Table 1).

Discussion

We found a clear and significant negative relationship between development and biological communities of benthic macroinvertebrates in the waterways of the Santa Monica Mountains. IBI scores decreased dramatically with increasing percent developed area and impervious area. Based on the regression lines, sites with over 8.8% developed upstream area or over 6.6% impervious upstream area would be classified as impaired based on having an IBI score of 39 or lower. These results are somewhat surprising, as previous studies have identified ecological impacts at higher levels of impermeability—habitat degradation in areas with 10% or more

Independent Variable	Coefficient	Std. Error	t-value	p-value
Model 1				
Log(Impervious area)	-25.54	1.35	-18.94	<0.001
Year	-2.03	1.06	-1.91	0.06
Protocol – reach wide benthos	7.26	8.75	0.83	0.41
Protocol – targeted riffle composite	-2.90	5.76	-0.50	0.61
Season – spring	-3.12	2.71	-1.15	0.25
Season – winter	-4.91	5.46	-0.90	0.37
R^2 adjusted = 0.71				
Model 2				
Log(Developed area)	-15.92	0.90	-17.71	<0.001
Year	-1.87	1.11	-1.69	0.09
Protocol – reach wide benthos	6.05	9.16	0.66	0.51
Protocol – targeted riffle composite	-3.44	6.03	-0.57	0.57
Season – spring	-2.41	2.84	-0.85	0.40
Season – winter	-4.54	5.72	-0.79	0.43
R^2 adjusted = 0.68				

TABLE 3. Multiple regression analysis of percent development (percent impervious area and developed area) and IBI score. Confounding factors include year, field protocol, and season.

impervious cover (Schueler 1994), and biological impacts to aquatic vertebrate communities in areas of 8% or greater urbanization in the Santa Monica Mountains (Riley et al. 2005). Studies in Washington and Maryland have demonstrated measurable decreases in BMI diversity and abundance in response to an increase in urbanization, correlated with impervious surface areas of 10–20% (Klein 1979; Paul and Meyer 2001). On the other hand, the identification of impacts at low levels of urbanization is not without precedence. A study in Maine found that impairment occurs at a similar level to our observation; they found degradation of the insect community-structure with a percent total impervious area greater that 6% (Morse et al. 2003). Other studies have documented even lower levels at which negative impacts occur (Walsh et al. 2007; King et al. 2011), including one study that found impacts at levels of impervious cover under 1% (King et al. 2011). Nevertheless, additional analysis, especially one that incorporates additional local data, would be a useful way to test the robustness of our findings. One readily available source of the data is from bioassessment monitoring conducted by the Stormwater Monitoring Coalition (SMC), a group of Southern California stormwater regulators and management agencies. It would be valuable to add or compare their data on BMI and urbanization to our data including testing whether a logarithmic regression continues to be the best fit for the bivariate relationships and to assess whether an IBI score of 39 (impaired) still corresponds to an impervious level of 6.6%.

Percent developed and impervious area account for 68% and 71% of the variation in IBI scores, respectively, taking year, protocol, and season into account. Consequently, it is critical that the amount of development and impervious cover throughout the watershed be reduced and modified to improve the biotic condition of streams. Though the Malibu Creek Watershed is nearly 80% open space, the density of impermeable area throughout the watershed has a profound effect on biological integrity. Low impact development (LID) is a means to decrease runoff and increase permeability in developed areas. We recommend that local municipalities in the Malibu Creek Watershed incorporate LID measures into new development and redevelopment to reduce impervious cover and the impacts associated with it in their planning with a subwatershed target of less than 3% effective impervious area. Widespread implementation of LID systems in developed areas of the Malibu Creek Watershed would help increase water to soil infiltration and reduce impacts of impervious area, thus improving habitat and water quality throughout the watershed. Additionally, implementation and enforcement of new and existing water quality regulations would help improve biotic condition. These and other improvements should be seriously considered to benefit aquatic life and the overall biological health of the Malibu Creek Watershed. Progress is already being made towards these LID goals with the adoption of the recent Los Angeles County municipal stormwater permit and other local ordinances; however additional attention is needed on redevelopement.

In order to better understand how impervious area impacts the benthic macroinvertebrate community, we suggest conducting more site-specific research to examine density of impermeable

FIG 3.a

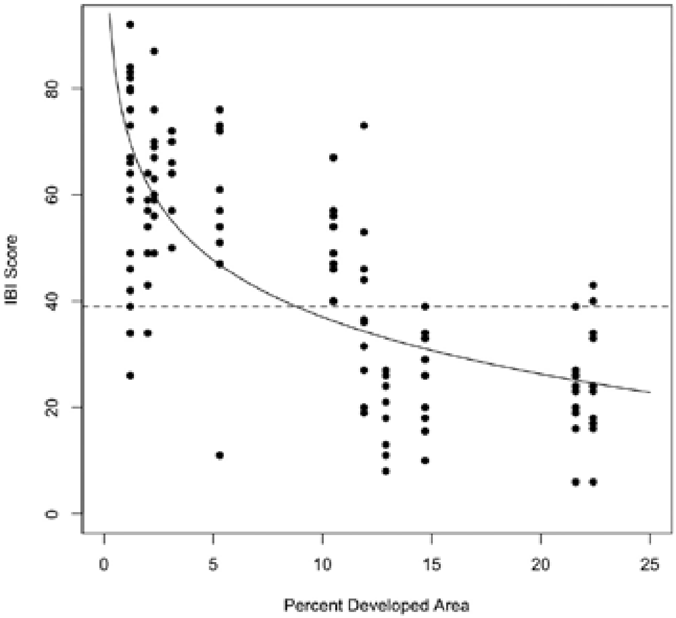

FIG 3.b

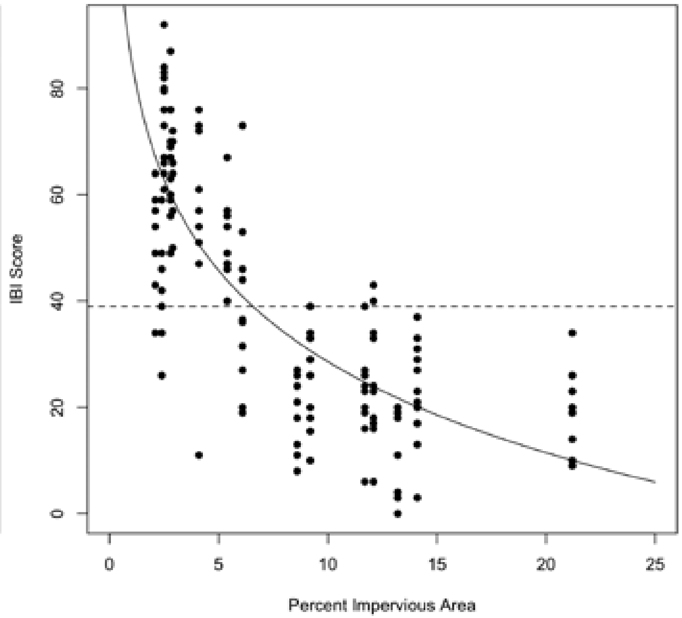

FIG. 3. Bivariate relationship between development and average IBI score. Bivariate relationship between percent developed area and average IBI score (a) and percent impervious area and average IBI score (b). The solid lines are the best fit trendlines and the dashed lines show the IBI score, which indicates impairment (39). A score of 39 or lower indicates biological impairment. IBI score decreased with increasing developed and impervious area. When examined in a simple regression, percent developed area was a significant predictor of IBI score ($p<0.0001$, $R2=0.619$). Percent impervious area was also a significant predictor of IBI score ($p<0.0001$, $R2=0.641$). The best fit trendlines crossed the regulatory threshold of biological impairment (IBI score of 39) at 8.8% developed area (a) and 6.6% impervious area (b).

area in specific places and its impact on IBI scores. Looking at impacts on a smaller scale may help to determine which component of urbanization has the greatest effect on a certain region. In addition, effective impervious area (EIA), which considers only the impervious surface that is directly connected from the drainage catchment to the streambed (US EPA 2012) is considered a better way to quantify impervious surface area and should be used as indicator of the effects of urbanization. Hatt et al. (2004) found that increased EIA has a more dramatic effect on water chemistry and stream morphology. Further, examining impervious cover at different scales would be useful to determine at which scale (local, catchment, or watershed) impervious cover is most important.

In addition to better quantifying impervious area and investigating how specific development patterns affect stream biota, it is important to examine the causal factors that negatively impact biota. From the results of this study, it is clear that urbanization and development negatively impact aquatic macroinvertebrates in the Malibu Creek Watershed. However, we do not know which stressor and the proportional impacts of each stressor causing degradation. It is reasonable to assume that increased runoff from development is the main culprit, as it both alters the flow regime of, adds pollution loading to, and alters the physical and chemical habitat of streams. However, there may be other factors that are also important to the physical, chemical, and biological health of streams. Previous studies have found that physical habitat is an important predictor of stream biota and benthic macroinvertebrate health (Maddock 1999; Nerbonne and Vondracek 2001). For example, studies have shown that benthic macroinvertebrates are negatively affected by the percent of fines (stream substrate) and embeddedness of stream substrate (Nerbonne and Vondracek 2001; Kaller and Hartman 2004). Examining additional landscape factors beyond impervious area would be beneficial; for example, road density and vegetation condition in the riparian zone may also be important. To tease out relative impacts of these parameters, further causal assessment needs to be performed and more water quality and habitat parameters should be included in the analyses. Heal the Bay's Stream Team currently collect water quality and physical habitat data in the watershed. A logical next step is to incorporate the data collected from this effort into the analysis to determine which parameters also exhibit strong correlations with IBI scores in addition to development.

Identifying the specific factors of urbanization that are negatively impacting stream biota will allow managers and policy makers to target their recommendations and actions to improve biological health streams in the watershed. Consequently, it is critical that the amount of development and impervious cover throughout the watershed be limited and reduced through the incorporation of LID measures into new development and redevelopment by local municipalities in the Malibu Creek Watershed, and they should do so with a subwatershed target of less than 3% effective impervious area.

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PHOTO: KARINAJOHNSTON

CLIMATE CHANGE IMPLICATIONS FOR THE BALLONA WETLANDS RESTORATION

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Abstract

Low-lying coastal wetlands are particularly vulnerable to sea level change and other potential impacts of climate change. Parties responsible for restoration and long-term management of these coastal wetlands need to understand the potential extent of these impacts and plan adaptation strategies accordingly. Using the Ballona Wetlands as a case study, this research explored a new approach to integrating climatic and hydrological models for studying the impacts of sea level rise and extreme rainfall patterns, the two changes most likely to result from climate change. Under this study, multiple models were applied to simulate the impacts of various sea level and precipitation scenarios to two wetland restoration alternatives under development. In total, a suite of 36 model simulations are performed to investigate the inundation impacts of either single sea level rise (SLR) or precipitation event, or combination of various scenarios.

The results of the study demonstrate that in the event of SLR, habitats restored according to either alternative will experience various levels of impacts. However, a restoration alternative that can accommodate the transgression of habitats upslope may provide more sustainability and support more diverse marsh habitats in the long term. The study results also validate one of the widely held assumptions that tidal wetlands in Southern California, including the Ballona Wetlands Ecological Reserve (BWER), are inherently highly vulnerable to SLR because they typically exist within a very narrow elevation range set primarily by the tidal frame (high and low tides), which is approximately 2 m in the region. The results of this investigation may help in planning coastal wetlands restoration projects in the future. Finally, the study demonstrates that the integrated modeling approach is feasible and can be applied to assessing the impacts of climate change on other coastal wetlands habitats.

Introduction

There is growing and increasingly firm evidence that more emission of anthropogenic greenhouse gas is causing the global average surface air and ocean temperatures to increase. As the climate warms, sea level rises due to melting of land-based ice and thermal expansion of oceans and seas. Global temperature rise may also result in many other potential impacts including, but are not limited to higher storm surge and more occurrence of extreme precipitation events—both flood and drought.

Low-lying coastal regions such as wetlands are particularly vulnerable to the impacts of climate change, especially to sea level rise and changing precipitation characteristics. Tidal wetlands exist within a narrow range of elevations, set primarily by tidal frame (Zedler and Cox 1985; Silvestri et al., 2005). A small change in the tidal frame due to sea level rise would result in the movement of the vertical distribution of tidal habitats, depending on the physical condition gradients (Kirwan et al., 2010). Furthermore, it may be very difficult for coastal wetlands in Southern California to adapt to sea level rise through transgression of habitats to higher elevation under existing conditions due to urbanization of the surrounding land and hydrological modifications to the system. For these reasons, it is very important for restoration planners and resource managers to understand the extent of these impacts and develop and implement adaptation strategies accordingly. Ideally, the adaptation measures can be built in early on during the restoration planning stage.

The Ballona Wetlands provide a good location for a case study on the potential impacts of climate change. The Ballona Wetlands are one of the last remaining major coastal wetlands in Southern California. The upstream watershed is one of the most developed regions in the United States, with urbanized areas accounting for approximately 80% of the 130-square-mile watershed (Fig. 1).

FIG. 1. Map of the Ballona Creek Watershed. Figure courtesy of PWA (2006).

Development in and around the historical Ballona Wetlands has caused changes in hydrology and altered the size and function of the native habitats in several ways, including change in land surface elevation and permeability as a result of the deposits of fill from the construction of Marina Del Rey, construction of highways and railroads, change in tidal exchange patterns due to construction of levees and culverts, and conversion of marsh to agricultural fields.

In 2004, the State of California took title to approximately 600 acres of the remaining Ballona Wetlands (Fig. 2) and created the Ballona Wetlands Ecological Reserve (BWER). The state is working with stakeholders to plan the restoration of the BWER, with the goal of "restoring, enhancing, and creating estuarine habitat and processes in the Ballona ecosystem to support a natural range of habitats and functions, especially as related to estuarine dependent plants and animals," among other things (PWA 2006). In order to achieve this goal, the Ballona Wetlands Restoration Project initiated by the state stressed in its plan the importance of "restoring inherent ecological processes, improving sustainability and resiliency to adapt to climate change and other environmental changes" (BWRP 2012). A better understanding of the potential impacts of climate change on the Ballona Creek Watershed and Wetlands will help to accomplish this objective.

Analysis of climate change impacts at the concept design and feasibility analysis stage of restoration, as in the case of BWER, is more advantageous, as restoration alternatives can be refined to be more adaptive to the impacts of climate change before proceeding to formal review. The purpose of this study is to analyze the potential climate change impacts to habitats in the BWER under different restoration alternatives. The study was conducted by applying various climate change scenarios, primarily sea level rise and changes in precipitation, to the hydrologic conditions in the watershed and hydraulic conditions of the wetlands. Model simulations were conducted to predict changes in tidal heights and area of inundation under two restoration alternatives. The potential changes in the type and acreage of habitats within the BWER due to changes in the period, depth and frequency of tidal inundation were also investigated.

Methodology

Modeled Sea Level Rise and Precipitation Change Scenarios

While there are many potential impacts of climate change globally, this study focuses on the implications of potential changes in sea level and precipitation. These are two of the major impacts of climate change to which low-lying coastal regions such as wetlands are particularly vulnerable. For the impacts of sea level rise, several projections were researched and compared, including the IPCC (2007) projections and more recent studies by Kerr (2009) and Vermeer and Rahmstorf (2009). The state of California is currently using projections from 101 to 140 cm by 2100 (CO-CAT, 2010), based on Vermeer and Rahmstorf (2009); this takes into account the rapid changes resulting from ice sheet breaks and is considered

FIG. 2. Existing Ballona Wetlands Area. Figure courtesy of PWA (2008).

more realistic. For these reasons, scenarios applying California's projections (100 and 140 cm) are applied in this study.

Unlike sea level, changes in precipitation are more evident in frequency and magnitude of extreme precipitation events than the changes in mean precipitation. Changes also result from climate patterns such as El Nino–Southern Oscillation (ENSO) and northern and southern hemisphere annual modes. There have been a number of studies of these changes since 1970 in the western United States and Southern California (e.g., Karl and Knight 1998; Madsen and Figdor 2007; Pryor et al. 2009; Mass et al. 2010; Higgins et al. 2007; Karl et al. 2009). According to these studies, even if there is no change in mean precipitation, the frequency of heavy precipitation events and incidence of drought have both increased, and will continue to increase in many areas, including Southern California (IPCC 2007). On the other hand, modeling studies of extreme precipitation changes under future conditions in Southern California demonstrate conflicting results (e.g., Bell et al. 2004; Diffenbaugh et al. 2005; Kim 2005), and all modelers have emphasized the high level of uncertainty in their projections for the Southern California region. Given these uncertainties, a suite of hypothetic precipitation scenarios ranging from a 25% decrease to a 25% increase in extreme precipitation are used in this study.

Modeled Wetland Restoration Plan Alternatives

The study applies and integrates multiple models under various climate change scenarios to two potential wetland restoration plans for the BWER. Through the restoration planning process, planners considered various design alternatives for the BWER, ranging from minor changes to the existing conditions to major earth moving and creation of a sinuous creek channel and unrestricted tidal flows to the wetland. For this study, we modeled impacts to a design known as Alternative 5, and a revised version of Alternative 5, known as the Revised Alternative. Alternative 5 (Alt5) involves removing the Ballona Creek flood control levees and excavating fill alongside the creek to allow it to meander through its floodplain and restore a large contiguous salt marsh plain (Fig. 3a). Revised Alternative 5 (or RevAlt5) accommodates some existing infrastructure constraints at the site, and includes a continuous slope from subtidal through upland habitats to allow the migration of habitats in the event of sea level rise. In RevAlt5, the channel meanders less than in Alt5, and the existing flood control levees remain in place in the far eastern (upstream) portion of the site (Fig. 3b). Note that these alternatives examined by this study are the original Alt5 from 2008 and RevAlt5 from 2009. They are not the alternatives from the Environmental Impact Reporting process; those have not been finalized, and these are only two of the graphic options that have been in development.

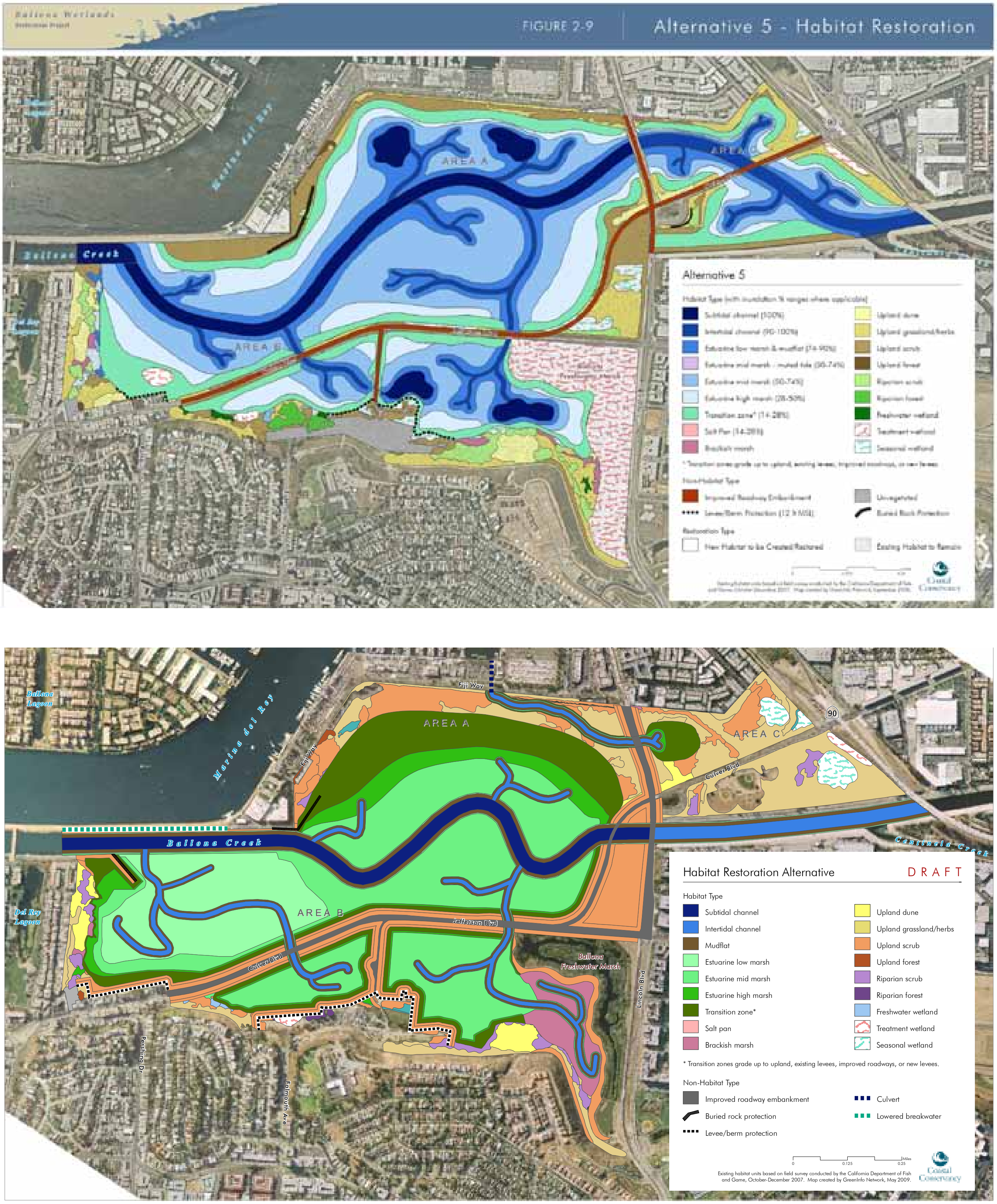

FIG. 3. Maps of wetlands for the 2008 restoration Alternative 5 (Alt5) (a) and the revised restoration Alternative 5 (RevAlt5) (b).

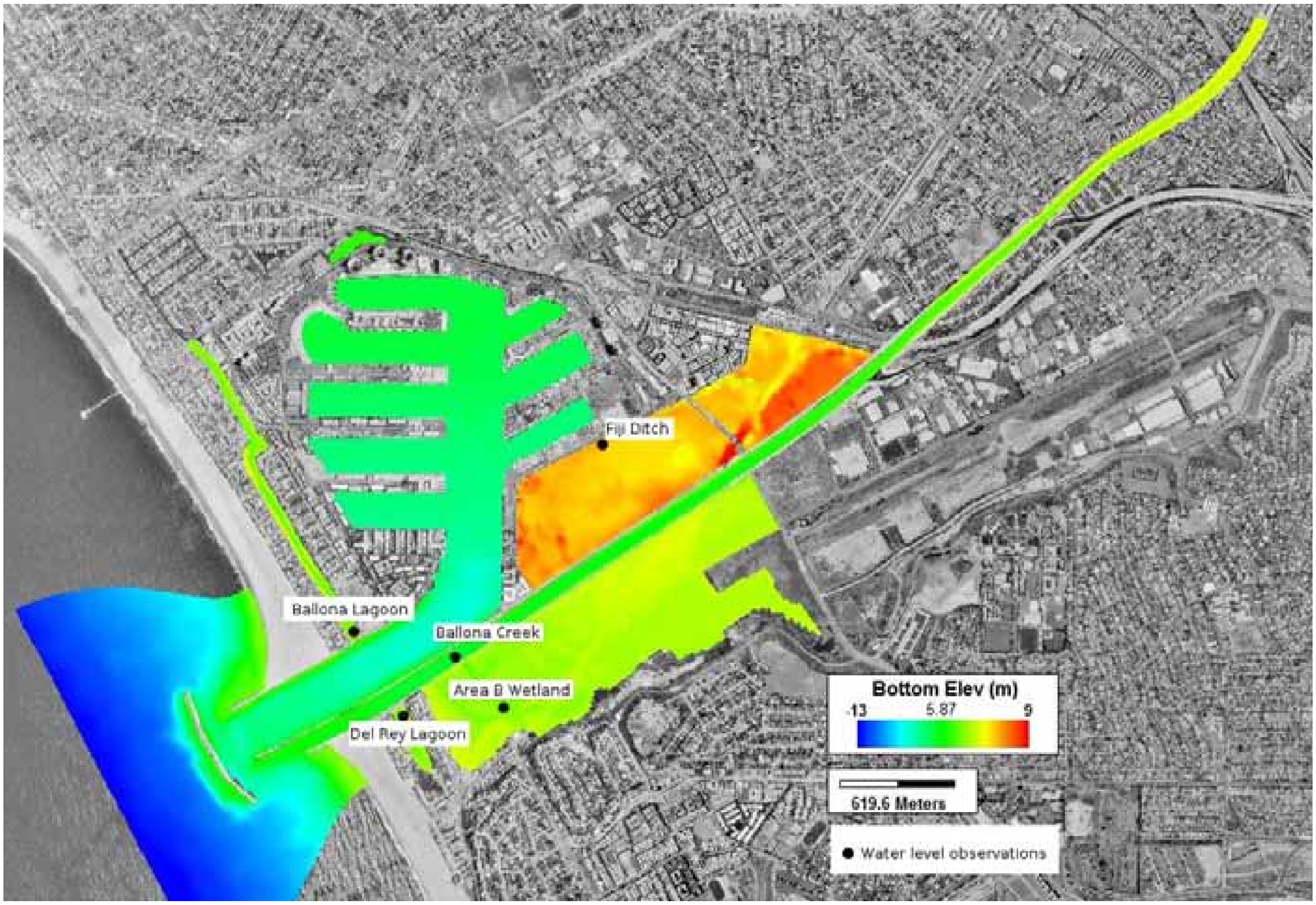

FIG. 4. EFDC model extent for Alternative 0. Figure courtesy of PWA (2008).

Hydrological Modeling

The primary models applied in this study are the Environmental Fluid Dynamics Code (EFDC) for simulating the hydrologic processes in the wetlands and the Hydrologic Engineering Center Hydrologic Modeling System (HEC-HMS) for simulating the primary hydrologic processes of the watershed (excluding the wetlands). The EFDC is a state-of-the-science hydrodynamic model that can be used to simulate aquatic systems in one, two, and three dimensions (Hamrick 1992; Tetra Tech. 2002). The model includes the primary physical processes important to the Ballona Wetland system, including unsteady tidal flow, boundary wetting and drying, and hydraulic control structures, and has been extensively applied and calibrated over the BWER (PWA, 2008). In this study, the model has been configured to predict two-dimensional depth-averaged flow. Overall, depending on the scenario (Alt0 [existing condition], Alt5, and RevAlt5), the model domain has approximately 43,000 grid cells (Fig. 4–5) and verification experiments using the Alt0 configuration accurately predicted water levels, typically within 5 cm of observations, over a two-week period (PWA 2008).

HEC-HMS is a modeling system used to represent the watershed rainfall-runoff process. This study implements a HEC-HMS beta configuration of the Ballona Creek Watershed developed and calibrated by the Los Angeles district of the Army Corps of Engineers (USACE 2012). The model domain decomposed the Ballona Creek watershed into 42 sub-basins and the major watershed characteristics incorporated as model elements include basin roughness ("n") values, baseflow, rainfall data, soil loss rate, S-graph, channel routing, and model calibration. The model parameters are estimated through field investigation of the watershed according to the guidelines described in the USACE Ballona Creek Ecosystem Restoration Feasibility Study (USACE, 2012), and the models were calibrated using data from a rain gage located in the watershed and flow gage in the creek. Various flood scenarios based on the 100-year precipitation event were simulated and used as input for the upstream boundary of the EFDC model.

Tidal and Flood Simulation

To simulate the hydrologic conditions of the wetlands, the time-varying boundary conditions required by EFDC were set in the form of tidal heights for the ocean and discharge from the watershed generated by HEC-HMS. Two sets of simulations were conducted. The first, referred to as *tidal,* requires only time-varying tidal boundary conditions from the ocean. The second set, referred to as *flood,* requires time-varying boundary conditions from both the ocean and watershed. Each set of the above experiments was applied under various sea level rise (SLR) and/or extreme precipitation conditions to the two wetland restoration alternatives.

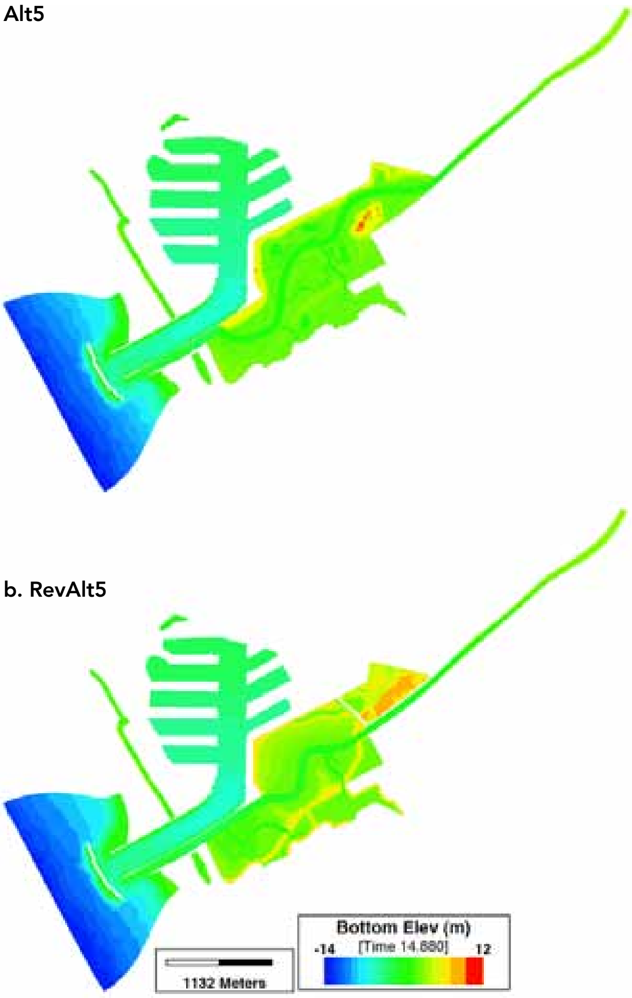

FIG. 5. Maps of EFDC bottom elevation for the restoration Alternative 5 (Alt5) (a) and revised restoration alternative 5 (RevAlt5) (b).

Scenario	Tidal Boundary Conditions	Sea Level Rise (cm)	Precipitation Event Boundary Conditions
Alternative 5	July 11–30 (No Flood): 6 simulations (3 for each alternative)	0	No Flood
Revised Alternative 5	July 6, Peak at Flood: 30 simulations (15 for each alternative)	100	100 yr - 25%
		140	100 yr - 10%
			100 yr
			100 yr + 10%
			100 yr + 25%

TABLE 1. List of scenarios and ocean and upstream boundary conditions. Note that each boundary condition is run under each scenario.

In the tidal simulation set, the role of tidal cycles alone on the wetland hydrology is investigated for the two restoration alternatives. Runoff generated from precipitation is assumed to be negligible. The tidal heights are specified for a representative spring-neap cycle from July 11 to July 30, 2006. Water surface elevations and inundation levels at current sea level conditions are compared to those at 100 and 140 cm of SLR. In total, there are six simulations: one for each of three SLR scenarios for each of the two restoration alternatives.

In the second simulation set, referred to as flood, both the role of tidal cycles and the role of extreme flooding on wetland inundation levels are considered. The output storm flow hydrographs simulated by HEC-HMS, based on the precipitation input, provide the Ballona Creek discharge into the BWER. Five scenarios based on the 100-year precipitation event are simulated using the HEC-HMS modeling system: The 100-year precipitation, which is considered the baseline event, and the 100 year with decreases and increases of 10% and 25%. The resulting hydrographs are applied as input to EFDC at Sawtelle, Sepulveda Channel, and Centinela Channel for each of the two restoration alternatives. In EFDC, the ocean boundary condition is forced by a typical 1.5-day tidal cycle with zero, 100, and 140 cm SLR. The peak of the hydrograph is timed such that it coincides with the higher high tide peak so that maximum wetland inundation occurs. In summary, a suite of 36 flood simulations were performed, as shown in Table 1.

Results

Impacts of Sea Level Rise—Tidal Simulations

This experiment investigated the impacts of SLR only on the two proposed restoration alternatives through tidal simulations. Input tidal levels varied from approximately -0.2 to 2.1 m, 0.8 to 3.1 m, and 1.2 to 3.5 m in the simulations with no SLR, SLR of 100 cm, and SLR of 140 cm, respectively. The EFDC model output suggests that with no SLR, the inundation areas with Alt5 ranged from 0.45 km^2 (19% of the wetland area) to 1.71 km^2 (74%), with a mean inundation area of 0.81 km^2 (35%; Fig. 6a,b, 7a,b, and Table 2). In contrast, the wet-dry active range with RevAlt5 was comparatively smaller, with inundation areas ranging from 0.32 km^2 (14%) to 0.65 km^2 (29%) and a mean area of 0.41 km2 (18%; Fig. 6c,d, 7c,d and Table 2). Note that these numbers were likely to be higher, since lower and higher tides, as well as storm surges occurring throughout the year, were not considered in the simulations.

In the event of SLR, the modeling output suggests that higher tides and subsequent higher water levels in the BWER will occur (Fig. 6 and 7). For Alt5, the wet-dry active range remained similar to the no SLR scenario (1.30 km^2 or 56%), while the mean inundation area substantially increased to 1.55 km2 (67%)—an increase of 0.74 km^2 (32%) with 100 cm of SLR and an additional increase to 1.76 km^2 (76%) with 140 cm of SLR. For RevAlt5, in contrast, with 100 cm of SLR, the wet-dry active range increased to 0.92 km^2 (41%), while the mean inundation area increased to 1.35 km^2 (59%). These numbers further increased with 140 cm of SLR to a wet-dry active range of 0.99 km^2 (43%) and mean inundation area of 1.63 km^2 (71%). The

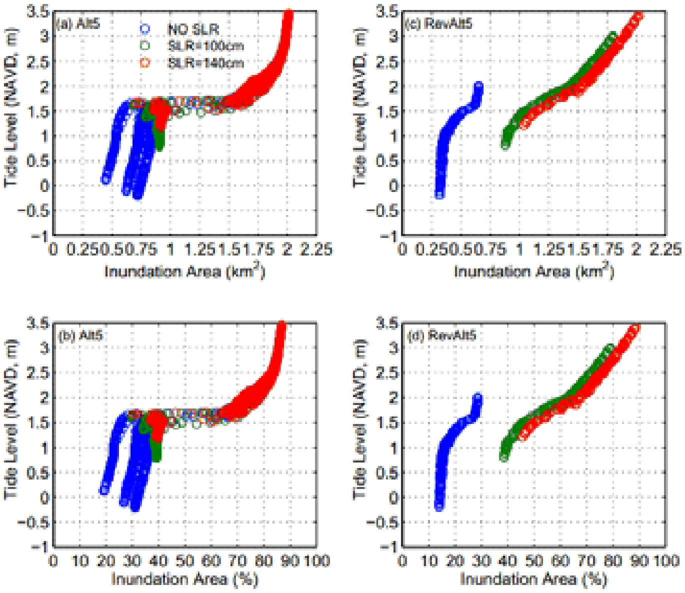

FIG. 6. Tidal simulations: Wet area versus tide level for no sea level rise (blue), 100 cm sea level rise (green), and 140 cm sea level rise (red) for both restoration alternatives; (a) Alt5 inundation area in km², (b) Alt5 inundation area in percent, (c) RevAlt5 inundation area in km², and (d) RevAlt5 inundation area in percent.

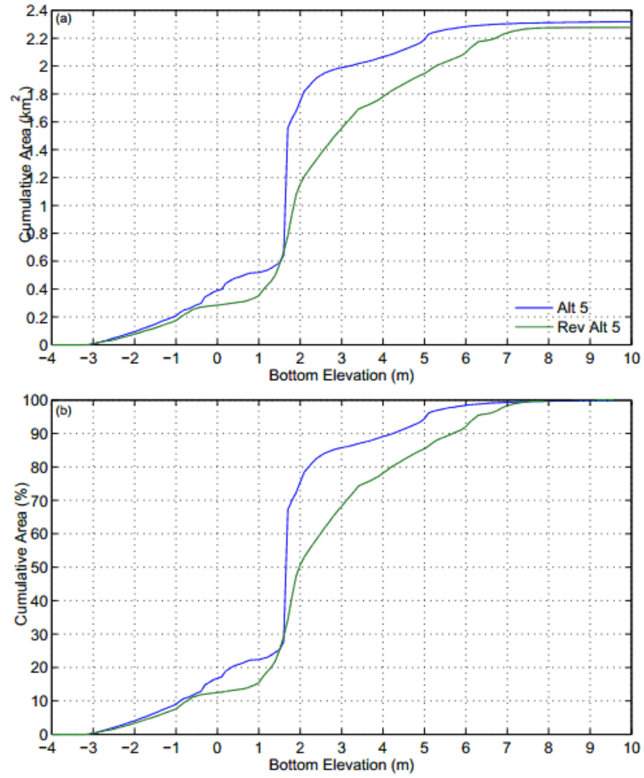

FIG. 8. Cumulative wetland area as a function of bottom elevation.

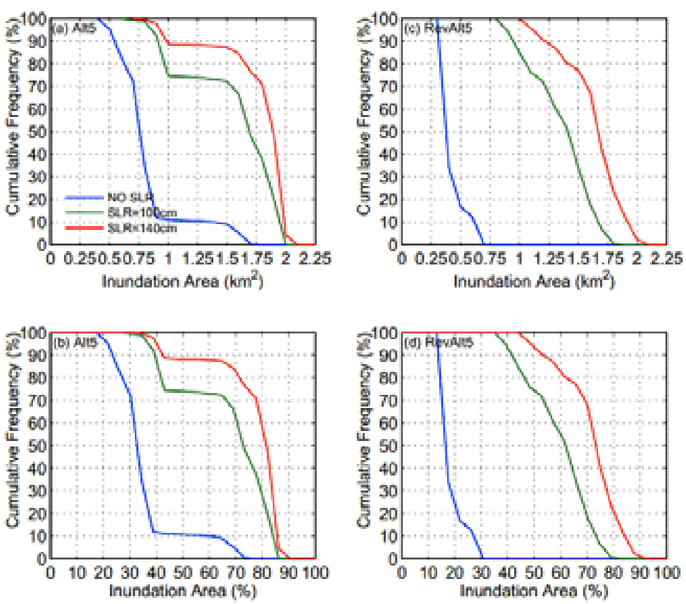

FIG. 7. Tidal simulations: Inundation area cumulative frequency for no SLR (blue), 1.0 m SLR (green), and 1.4 m SLR (red); (a) Alt5 inundation area in km², (b) Alt5 inundation area in percent, (c) RevAlt5 inundation area km², and (d) RevAlt5 inundation area in percent.

large shift in mean inundation levels with SLR is largely determined by the bottom elevation of the wetlands. In Alt5, 0.91 km² (29%) of the wetland area lay in the 1.6 to 1.7 m elevation zone (Fig. 8). Both the 100 and 140 cm SLR projections resulted in a shift in mean inundation levels to above the 1.6 to 1.7 m elevation range (comparing Fig. 6 and 8). On the other hand, the more gradual shift in RevAlt5 elevation zones (Fig. 8) tends to result in less change in inundation area and an increased resilience to SLR.

Impacts of Changes in Precipitation Event Magnitude—Flood Simulations

Flood hydrographs modeled by HEC-HMS for both restoration alternatives show that the impacts of 10% and 25% decreases and increases to the 100-year precipitation event in general resulted in a disproportionally smaller or larger volume of flood discharge entering the wetlands. For example, the 10% and 25% reductions in the 100-year precipitation event resulted in 14% and 36% reductions in watershed flood discharge entering the wetlands, reducing the flood return periods to approximately 50 and 10 years, respectively. Similarly, 10% and 25% increases in the 100-year precipitation resulted in 14% and 35% increases in watershed discharge, which are comparable to approximately the 200-year event and the greater than 500-year event, respectively. These results suggest that nonlinearities inherent in the system such as those related to infiltration processes in the watershed amplify the response of storm flow to changes in precipitation. In addition, they imply that

	Alternative 5 – Tidal						Revised Alternative 5 – Tidal					
	No SLR		SLR = 100 cm		SLR = 140 cm		No SLR		SLR = 100 cm		SLR = 140 cm	
	km²	%	km²	%	km²	%	km²	%	km²	%	km²	%
Mean	0.81	35%	1.55	67%	1.76	76%	0.41	18%	1.35	59%	1.63	71%
Minimum	0.45	19%	0.68	29%	0.70	30%	0.32	14%	0.88	39%	1.04	45%
Maximum	1.71	74%	1.99	86%	2.01	87%	0.65	29%	1.80	79%	2.02	89%
Range	1.26	55%	1.30	56%	1.31	57%	0.34	15%	0.92	41%	0.99	43%

TABLE 2. Mean, minimum, and maximum inundation area (km2) according to the alternative and SLR scenario.

	Maximum Inundated Area Alternative 5 – Flood Simulations									
	T=100yr-25%		T=100yr-10%		T=100yr		T=100yr+10%		T=100yr+25%	
	km²	%	km²	%	km²	%	km²	%	km²	%
No SLR	1.16	50%	1.44	62%	1.64	71%	1.83	79%	1.92	83%
SLR=100 cm	1.90	82%	1.93	83%	1.95	84%	1.97	85%	1.99	86%
SLR=140 cm	1.97	85%	1.98	85%	1.99	86%	2.00	86%	2.03	87%
	Maximum Inundated Area Revised Alternative 5 – Flood Simulations									
	T=100yr-25%		T=100yr-10%		T=100yr		T=100yr+10%		T=100yr+25%	
	km²	%	km²	%	km²	%	km²	%	km²	%
No SLR	1.74	76%	1.86	81%	1.93	85%	2.00	88%	2.04	90%
SLR=100 cm	1.98	87%	2.03	89%	2.05	90%	2.06	90%	2.07	91%
SLR=140 cm	2.04	90%	2.06	90%	2.06	91%	2.07	91%	2.08	91%

TABLE 3. Flood simulation—Maximum inundation area in km2 and % for each of the flood with and without SLR simulations. Upper table is for Alt5 and lower is for RevAlt5.

small changes in future precipitation may result in large changes in watershed response.

For Alt5 with the baseline flood event (T=100 years), the maximum BWER inundation area modeled by EFDC was 1.64 km² (71%; Fig. 9 and Table 3). Locations near developed areas were inundated during this event, such as at Jefferson Blvd and Lincoln Blvd (Fig. 9a). For such a large storm, however, some amount of flooding is generally expected. The maximum wetland inundation area varied from 1.16 km² (50%) to 1.44 km² (62%) under the 25% and 10% reduction scenarios, respectively. Under the 10% and 25% increase scenarios, maximum inundations levels were 1.83 km2 (79%) and 1.92 km² (83%), respectively (Fig. 9 and Table 3). In these scenarios, much of the area near the bluffs along the southern boundary of the BWER were also flooded (Fig. 9d,e).

For RevAlt5, maximum inundation area were 1.93 km² (85%) for the baseline flood simulation (T=100yr; Fig. 10 and Table 3). Although the far eastern portion of the BWER and the area south of the creek levees appeared to be inundated as a result of the flood, they were actually inundated due to the initial water elevations being set to the tidal levels (Fig. 10). On the other hand, changes in the 100-year precipitation and associated flood event for RevAlt5 resulted in a range of maximum inundation areas considerably smaller than the Alt5 simulations (1.74 to 2.04 km2 for T=100yr-25% or 76 to 90% for T=100yr+25%), similar to the tidal simulations (Fig. 10 and Table 3), suggesting a greater resilience to flooding.

Combined Impacts of Sea Level Rise and Changes in Precipitation Event Magnitude

In these model simulations the combined impacts of sea level rise and changes in the precipitation event magnitude for both restoration alternatives were analyzed. Specifically, sea level rise conditions were applied to the tidal cycle with the various changes in flood frequency, as is done in the tidal simulations. First, the simulation was analyzed for both restoration alternatives when SLR was considered with no change in the 100-year precipitation event magnitude. The result shows that significant wetland inundation occurred at approximately day 6.2—well before any significant flood entered the wetlands from the watershed (Fig. 11). This inundation

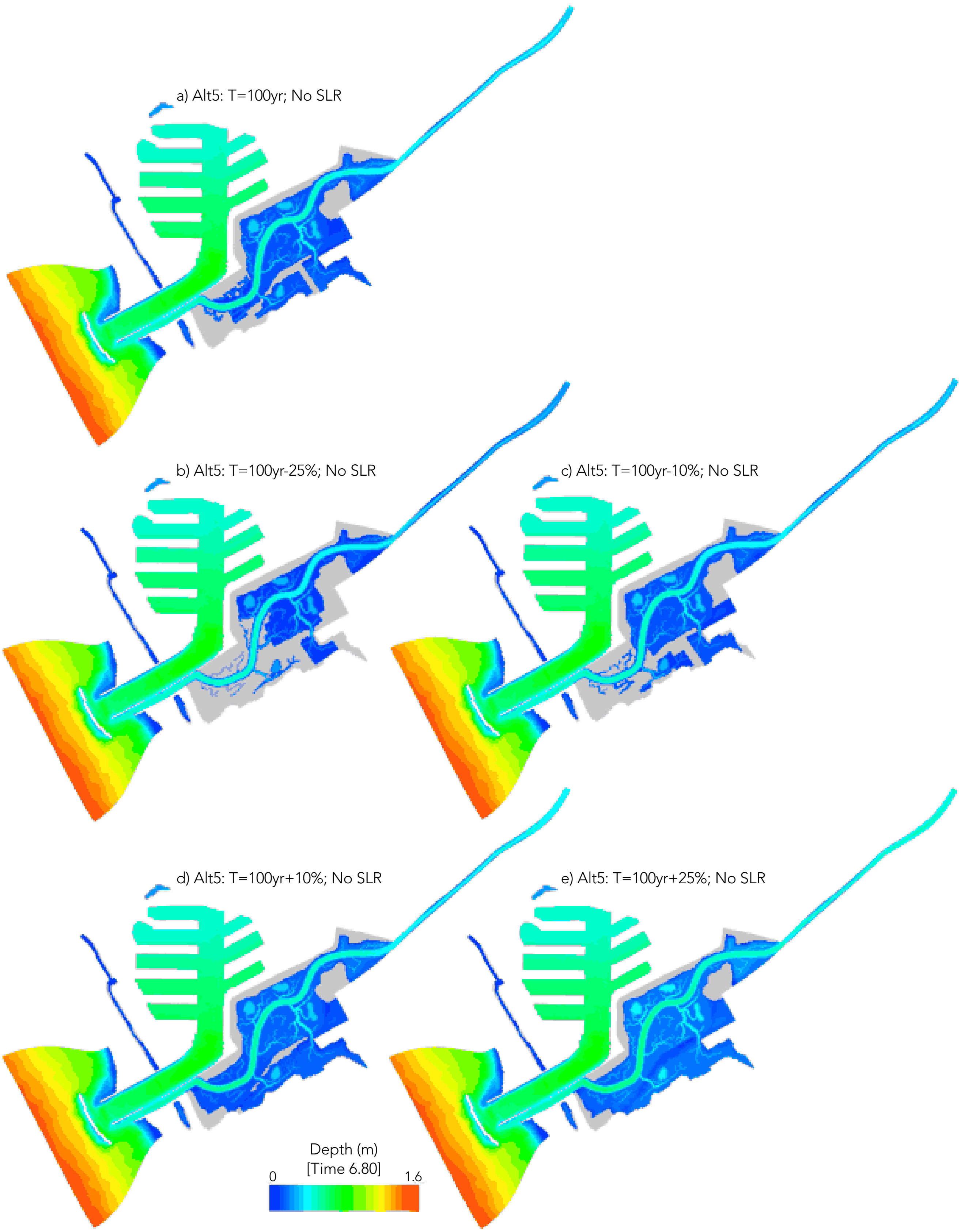

FIG. 9. Flood Simulations: Alt5 – Water depths (m) at maximum inundation (time = 6.80) for the 100-year precipitation event; a) T=100 yr, b) T=100 yr - 25%, c) T=100 yr - 10%, d) T=100 yr +10%, and e) T=100 yr +25%.

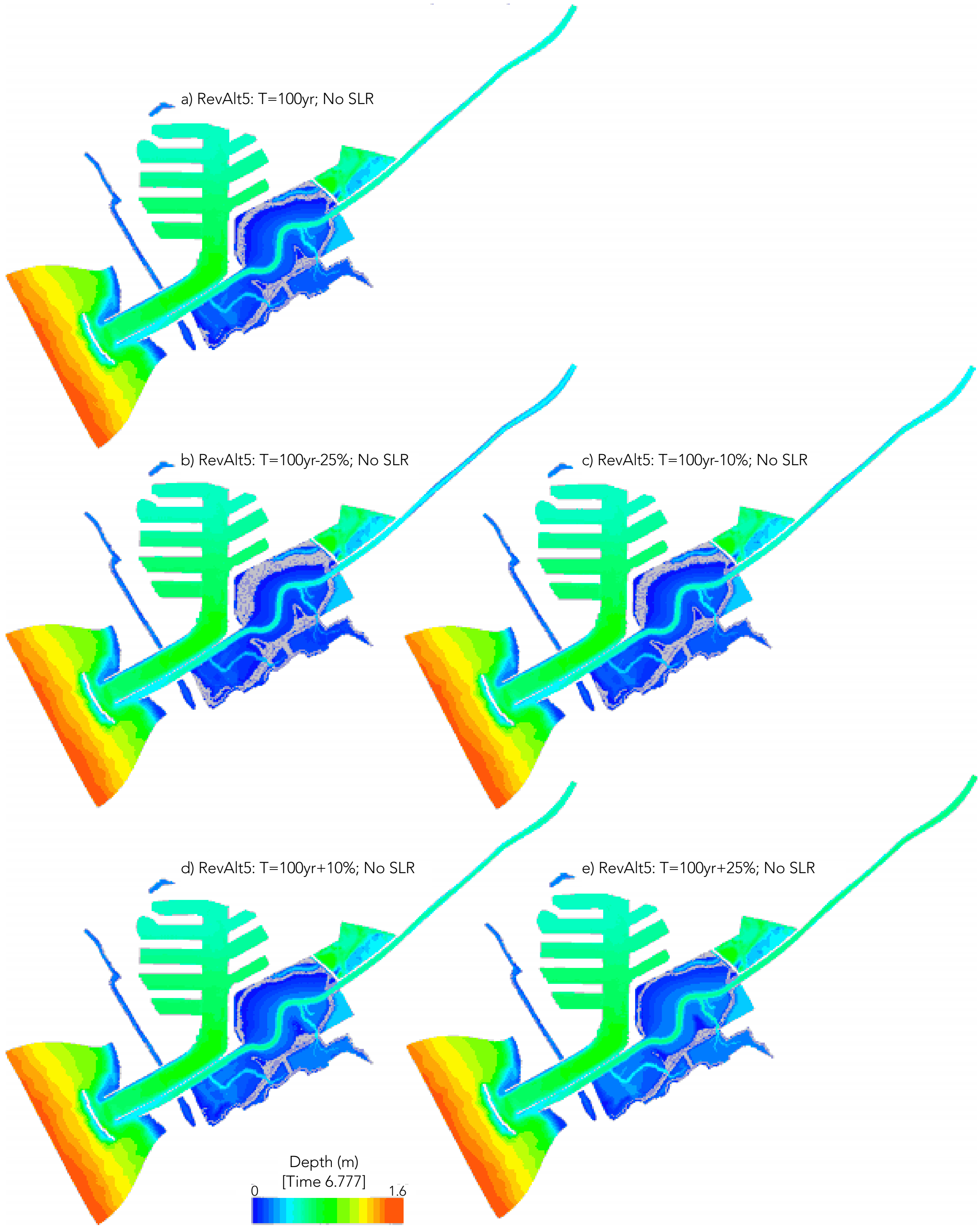

FIG. 10. Flood simulations: RevAlt5 – Water depths (m) at maximum inundation (time = 6.777) for the 100-year precipitation event; a) T=100 yr, b) T=100 yr - 25%, c) T=100 yr - 10%, d) T=100 yr +10%, and e) T=100 yr +25%.

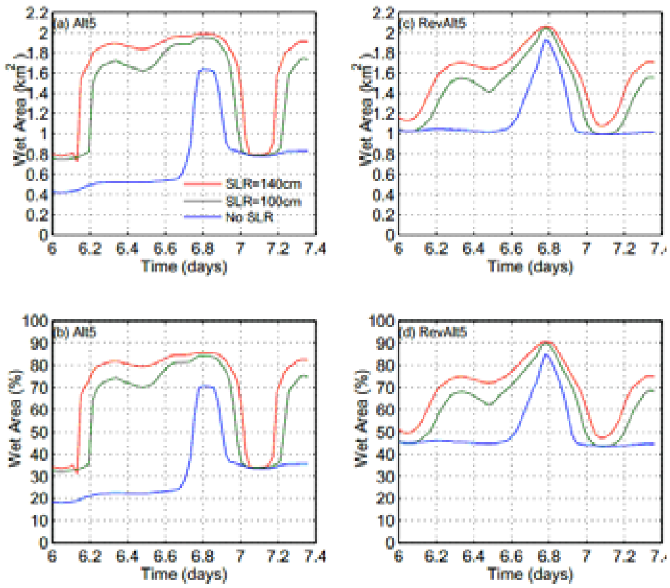

FIG. 11. Flood simulations with SLR: Wet area versus time resulting from the 100-yr precipitation event for the three sea level rise scenarios for Restoration Alternative 5 and Revised Alternative 5. Notice that the tidal cycle in these simulations is timed such that its peak occurs at the flood hydrograph peak at approximately day 6.8. In addition, the flood discharge completely subsides at approximately day 7.1.

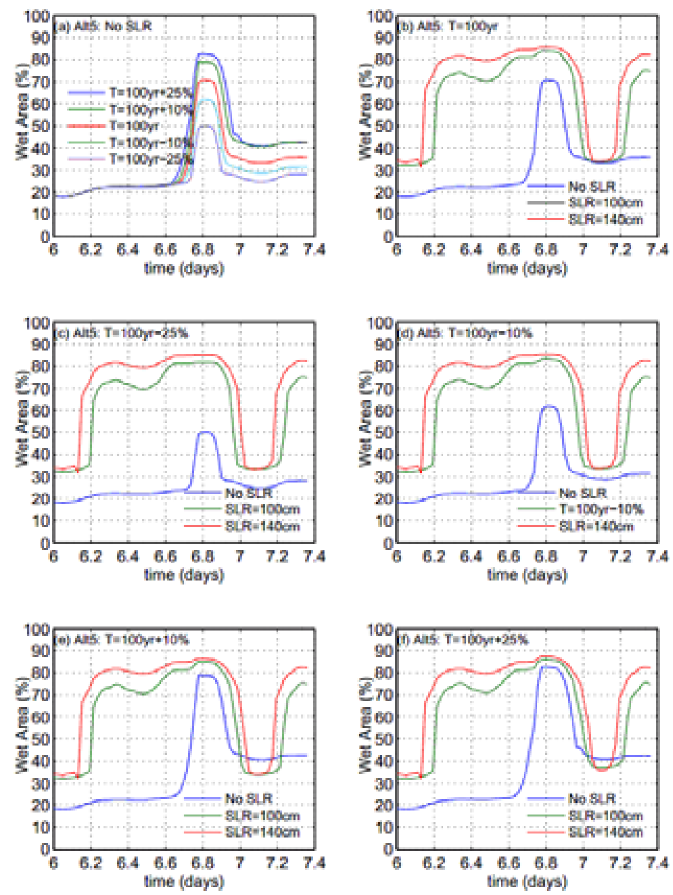

FIG. 12. Flood simulations with SLR: Wet area versus time for the five flood scenarios for Restoration Alternative 5.

persisted at nearly the same level until the flood and higher high tide occurred. Furthermore, another inundation peak occurred at approximately day 7.3 after the watershed flood discharge had completely subsided (Fig. 11). This peak coincided with the lower high tide of day 7 on the following day. In short, SLR dominated the response of wetland inundation to flooding, particularly with the Alt5 scenario. RevAlt5 displayed a similar but weaker response despite starting at a higher water level.

When considering the combination of SLR with changes in extreme precipitation event magnitude for Alt5, the wetland inundation levels remained similar regardless of the change in precipitation event magnitude (Fig. 12). Even with the 25% reduction scenario resulting 36% decrease in discharge, the wetland inundations levels remained at 80% until the higher high tide droped at day 7.0. This result is similar for RevAlt5 (Fig. 13).

Impacts of Sea Level Rise on Habitat Conditions

Types of estuarine habitats within the existing BWER include sub-tidal and intertidal channels, mudflats, salt flats, low marsh, marsh plain (or mid marsh), high marsh, high marsh transition zone, and brackish marsh. Although multiple factors contribute to the types and acreages of habitats within the BWER, the period, depth, and frequency of tidal inundation is considered a major factor (Warren and Nierling 1993; Donnelly and Bertness 2001; Greer and Stow 2003; Watson and Byrne 2009), and subjects most to the impacts of climate changes. For these reasons, we used the modeled changes to the hydrology and hydraulics of the wetlands discussed above to predict the changes in habitat distribution and acreage under the two restoration alternatives. Because, as discussed above, increased precipitation has very little effect on the hydrology of the system when sea level rise is included in the scenario, we reasonably assumed that the migration of wetland habitats is largely driven by SLR, and considered the implications of increased sea level only in this analysis. In addition, change in elevation instead of inundation frequency was used to predict the effects of SLR on habitat distribution and acreage in this analysis. Previous EFDC modeling on habitat areas have shown that elevation can provide a surrogate for inundation frequency as the results based on either are in general comparable.

All major types of estuarine habitats within the existing BWER listed above were investigated. Both Alternative 5 and the Revised

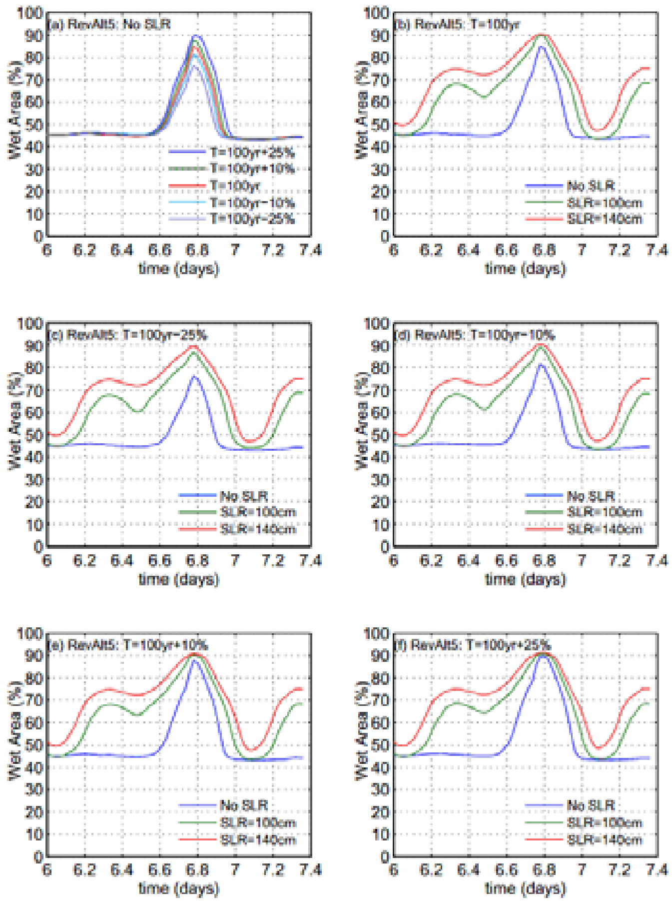

FIG. 13. Flood simulations with SLR: Wet area versus time for the five flood scenarios for Revised Restoration Alternative 5.

Alternative (Fig. 3) are expected to yield the same habitat types as currently exist in the BWER, but with conditions more representative of a natural wetland with reduced impacts from urban development. Figure 14 displays the effects of SLR on the habitat distributions under Alt5. With current SL conditions, restoration Alternative 5 supported a large mid salt marsh plain (1.1 km^2) typical of Southern California coastal wetlands. However, with SLR, this middle marsh habitat transitioned to mudflat habitat (1.31 km^2 with 1.0 m SLR, and 1.38 km^2 with 1.4 m SLR) assuming static conditions of other physical influences such as scour or sedimentation. The transition from a vegetated middle marsh wetland system to a mudflat-dominated system will cause dramatic shift in the species supported. For example, there may be a significant loss of Belding's savannah sparrow habitat with SLR due to the bird's dependency on marsh habitat for breeding.

Habitat distributions were investigated for the revised restoration alternative using similar methods to Alt5. RevAlt5 modified the previous Alt5 and included a continuous slope throughout the marsh habitat that extends into the transitional and upland habitats. This minor change may provide significant benefits, including extending the persistence of intertidal marsh habitats based on the ability of those habitat types to transgress up the margins of the marsh. The modeled prediction on the habitat distributions shows that RevAlt5 may provide such benefit. Under RevAlt5 and with current SL conditions, the revised restoration alternative supported a range of vegetated marsh habitat (0.86 km^2). With SLR, this alternative also shifted toward a mudflat dominated system (0.86 km^2 with 1.0 m SLR, and 0.91 km^2 with 1.4 m SLR). However, the revised alternative continued to support a significant area of diverse marsh habitats (0.41 km^2 with 1.0 m SLR, and 0.31 km^2 with 1.4 m SLR) (Fig. 15).

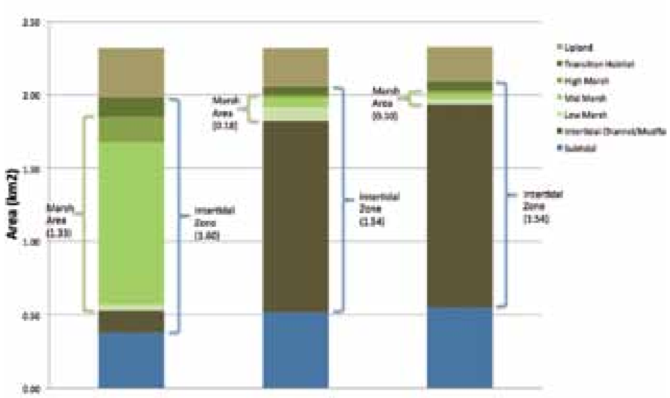

FIG. 14. Restoration Alternative 5 habitat area with current SL and 1.0 m and 1.4 m SLR.

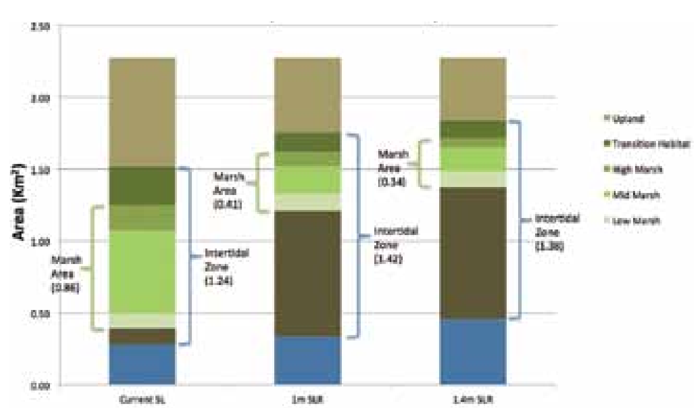

FIG. 15. Revised Restoration Alternative 5 habitat area with current SL and 1.0 m and 1.4 m SLR.

Discussion

This study used hydrological and hydraulic modeling to investigate the impacts of SLR and changes of precipitation event magnitude on two restoration alternatives being developed for the BWER. The results demonstrate that in the event of SLR (with SLR estimates of 1.0 m and 1.4 m in the year 2100), habitats restored according to either alternative will experience various levels of impacts. On the other hand, when SLR is included in the scenario, changes in precipitation event magnitudes have little effect on the hydrology of the system for both alternatives.

The results of the study also demonstrate that a restoration alternative that can accommodate the transgression of habitats upslope may provide more sustainability in the long term. The steep, then flat, then steep system of Alt5 is well designed to accommodate current sea level conditions. However, it is not resilient to SLR impacts because the wetlands remain largely inundated even at lower tides under SLR scenarios. In contrast, RevAlt5 is more resilient to SLR because more of the wetlands experiences both dry and wet conditions under the SLR scenarios. In future restoration planning for coastal habitats, it may be useful to model the impacts of sea level rise on designs that provide flat marsh areas on a stepped, rather than continuously sloped, gradient. Incremental steps of marsh at various elevations may maintain larger areas of a given marsh habitat as sea levels rise.

The results of this study validate one of the widely-held assumptions that tidal wetlands in Southern California, including the BWER, are inherently highly vulnerable to SLR because they typically exist within a very narrow elevation range set primarily by the tidal frame (high and low tides), which is approximately 2 m in the region. A small change in the tidal frame due to SLR would result in migration of the vertically distributed tidal habitats. Meanwhile, it should be noted that the response of tidal wetlands to SLR also depends on many other factors that were not investigated under this study. One of the key factors is the availability of space for the transgression of wetland habitats to higher elevations. Another is sediment supply to the wetland and the associated rate of wetland accretion. If sediment is readily available, vertical accretion may keep pace with SLR and the spatial distribution of tidal habitats may not change significantly. If sediment supply is low, as in the urbanized Ballona Creek, accretion rates may be slower than SLR and habitats would transgress landward, if there is space for them to do so. The restriction on tidal flow caused by the existing tide gates in the creek levee should also be further investigated because these gates prevent full high tide from entering the wetlands and therefore further limit the ability of the wetlands to respond to the SLR. Finally, further studies may need to consider the effect of ponding water on habitat distributions because ponding may become more frequent and persistent, and ponds may become larger and deeper as sea levels rise.

This study also investigated the impacts of climate change on the habitat structure and function in coastal wetlands, mainly as a result of increased inundation frequency due to SLR. This is important as previous research in other regions such as the San Francisco Estuary wetlands and the New England salt marshes suggests that wide-scale vegetation change is already occurring due to sea level rise (Donnelly and Bertness 2001; Watson and Byrne 2009). The results indicate that with SLR, such changes could also occur in BWER, to various degrees under different restoration alternatives. However, these results are still preliminary and limited to general habitat type only. In the future, an investigation of the species supported by these habitats and the potential change in species composition and diversity could be developed from the SLR projections.

Modeling System Constraints and Considerations for Further Application

In this study, a suite of simulations using both a watershed rainfall-runoff model (HEC-HMS) and a wetlands model (EFDC) were performed to investigate the potential impacts of climate change on two BWER restoration alternatives. While considerable and reliable information is provided from this suite of simulations, the results are preliminary, and several improvements can be made.

First, although extensive work has gone into calibrating the model for the Ballona Watershed and simulated hydrographs resulting from the 100-year precipitation event (and other return periods) match observations remarkably well, the configuration is still in a testing phase, and improved model parameters in a new model configuration expected to be released by ACOE in the near future will hopefully better represent the rainfall-runoff processes of the watershed. For the tidal simulations in this study, the EFDC configuration and calibration did not include processes for infiltration, evapotranspiration, and direct precipitation falling onto the wetlands. These, particularly direct precipitation, may be an important component of a wetland water budget and should be considered in similar studies in the future. An ideal next step would be a yearlong set of simulations that include these parameters and is associated with a large El Nino event that generated considerable precipitation and stormflow into the wetlands. Furthermore, additional experiments with a larger extended domain and/or flux boundaries should be performed in the future to address the potential inundation of areas in the surrounding community and to test the robustness of a revised RevAlt5. Finally, additional experiments should be designed to investigate the scenario of a large storm event coinciding with storm surge, which is rather typical and which impacts may be underestimated in this study.

In summary, this study explored a new approach to integrate climatic and hydrological models, and demonstrated its applicability in assessing the impacts of climate change on coastal wetland habitats. The applicability of this new modeling tool may be more important than the results of analysis on the two restoration alternatives. Since at the time of this paper's publication the Ballona Wetland restoration planning process is still ongoing, and restoration alternatives are still evolving, new model runs for the updated restoration alternatives may provide more representative and reliable assessment of the climate change impacts.

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CASE STUDIES

Urban Coast includes detailed project reports regarding the various efforts to improve the condition of our coastal environments. The Case Studies section focuses on specific projects implemented to protect and manage coastal resources while also involving and educating the public. Understanding the specifics of particular projects, the successes, and the lessons learned informs and provides implications for future efforts.

PHOTO: THE BAY FOUNDATION

URBAN GREENING: A RESIDENTIAL LEARNING LAB

ISABELLE DUVIVIER & LINDA JASSIM

Abstract

Working locally can transform a street, a neighborhood, and even a whole city. Architect Isabelle Duvivier was inspired to push the limits by creating Los Angeles County's "greenest home" when she transformed a dilapidated 100-year-old house. The house resides in a long-established, low-income neighborhood on Brooks Avenue in Venice, California. Her solution was holistic. Every part of the house from building materials to energy and water use was examined for maximum efficiency. What resulted was a Leadership in Energy and Environmental Design (LEED) Platinum house and a 2012 Outstanding Home Award from the United States Green Building Council (USGBC). Experimental opportunities such as greywater applications, 95% native plants, collection cisterns for irrigation, net-zero energy, and material reuse were investigated and used. One hundred percent of storm water was collected on site, including runoff from an adjacent property. One of the project's most notable achievements was controlling how and where water was distributed and reused. The gardens were designed to create a haven for local wildlife, a spot for orchards, farming, and a distribution center to provide produce to neighbors. The heat island effect was reduced through landscaping and minimizing the hardscape. The house and garden acts as a laboratory for "sustainable" gardening. Duvivier even boosts educational signage about green building throughout the property. Looking into the future, Duvivier is designing a sustainable neighborhood plan by reimaging the streets and alleyways as part of a broader green infrastructure network that will include permeable paving, street trees, and play areas.

Introduction

Sustainable Goals

Isabelle Duvivier, a local California architect wanted to make a big difference in environmental practices in her community when she purchased a dilapidated house on Brooks Avenue in Venice in a low-income neighborhood. She went about renovating the 100-year-old house from top to bottom, inside and out with experimental and scientific fervor. The goal was to reduce the impact of the house

FIG. 1A. The original 100-year-old house before the transformation.

FIG. 1B. The original home was remodeled and the second story addition includes the master suite.

and garden on the environment through intelligent design choices related to water, energy, and material use. To achieve this goal, every part of the Brooks residence, a 1,700 square foot remodel and addition to a 1912 Craftsman Cottage, was examined and designed to be as green and energy efficient as possible using the most current technologies and experimental opportunities available. The natural environment was also incorporated by creating a habitat for birds, bees, and butterflies, along with educational opportunities for friends, clients, and neighbors. The result was a Leadership in Energy and Environmental Design (LEED) Platinum dwelling that was recently honored by the United States Green Building Council (USGBC) with a 2012 Outstanding Home Award. The award recognizes innovative multi- and single-family projects that have demonstrated leadership in the residential green building marketplace. The house has also become a personal learning laboratory and a means to experiment with new technologies.

Adaptive Reuse in a Historical Neighborhood

Rather than tear down the 100-year-old house in which generations have lived (Fig. 1a), Duvivier remodeled and modernized her craftsman house, keeping the integrity of the bungalow streetscape (Fig. 1b). Integration into this high-density, low-income neighborhood was important. The sailing form of the new second story harmoniously blends with the existing house while respecting the architectural history and scale of this traditional beach neighborhood. A vegetable garden was created in the south-facing front yard to encourage casual discussion around the sharing of food. Giving food to neighbors became a common practice. Whenever possible, Duvivier hired local workers to decrease commutes and infuse revenue and jobs into the local economy.

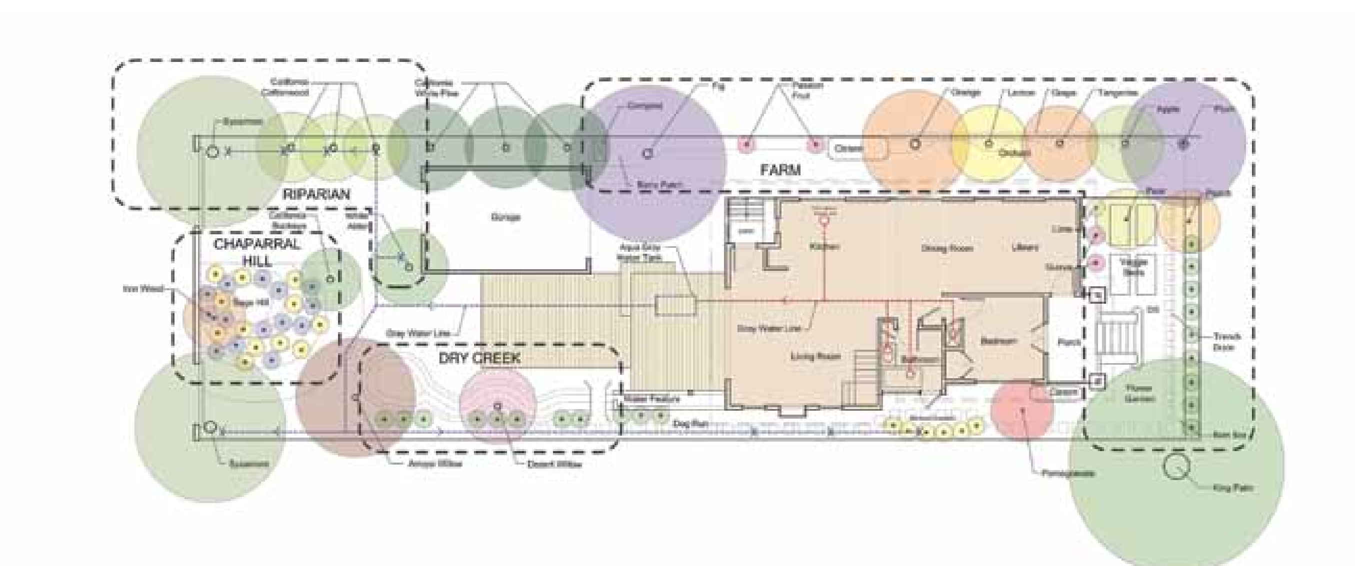

FIG. 2. Site plan showing zoning for water use and associated plant communities' locations.

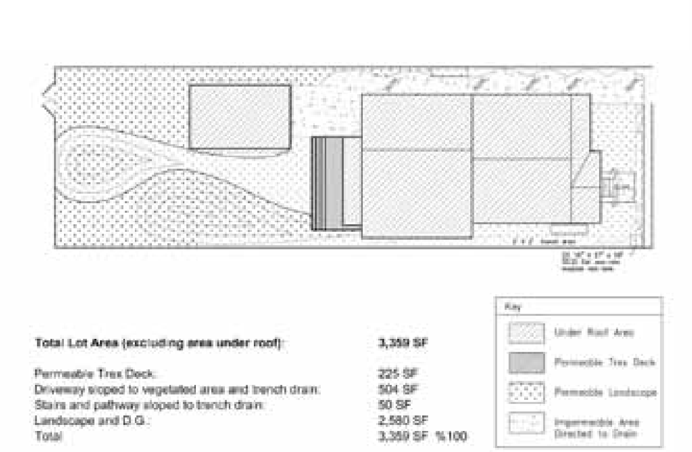

FIG. 3. Site plan for permeable surfaces and runoff flow direction. Measures were taken to infiltrate onsite and offsite runoff, such as the installation of trench drains, EcoRain boxes, and swales, the removal of concrete, and the use of Trex decking.

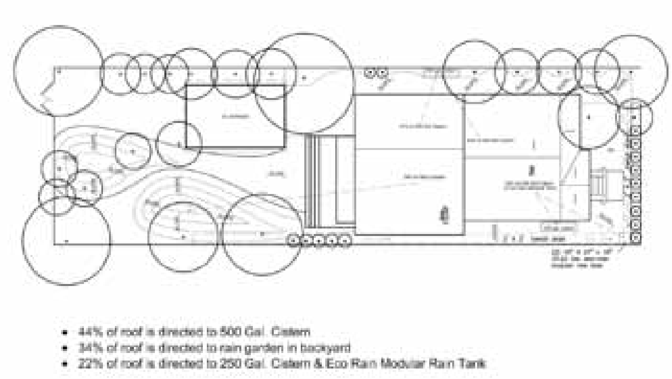

FIG. 4. Site plan for roof runoff collection. All roof runoff is directed either to a cistern or to the rain garden.

Water Management and Conservation

An overall site plan was developed early on, zoning the garden into different types of habitats, water requirements, roof runoff opportunities, and indoor water availability (Fig. 2). The entire site is designed to either allow water to permeate into the ground naturally (Fig. 3) or to be collected for reuse later (Fig. 4). The goal was to increase the efficiency of storm water/greywater reuse, introduce elements of beauty into water delivery systems, and provide habitat diversity without the need for imported water. The principals of low impact development (LID) were used even though at the time of the permitting of this project, these City of LA requirements were not yet in place.

Offsite water sources

Water sources include seasonal offsite runoff from an adjacent neighbor and the rear alley that drains four immediately adjacent, impermeable, high-density housing projects. Another water source includes all project seasonal roof runoff. Finally, the last water source is the frequently flowing greywater from the ultra–low flow interior bathroom fixtures.

Infiltration devices installed on site

Due to the site topography and the compacted soils, in the past, rainfall would be directed toward the house, and due to the elevation change, would end up collecting under the house. To eliminate this problem, the site was modestly re-graded to direct water away from the house (Fig. 5a). It should be noted that although the site was re-graded, no soil left the site in order to reduce the waste impacts. Instead, a small hill was created, specifically a landscape feature later


FIG. 5A. The site needed to be modestly re-graded to move runoff away from the house. No soil left the site. The excess soil was used to create a berm, which later became Sage Hill.
FIG. 5B. Sage Hill in the back yard is a main feature of the landscaping and was created from excess soil after re-grading the site for better surface water management.


FIG. 6A. Percolation trench during construction showing filter fabric and gravel.
FIG. 6B. Percolation trench during a rain event before it was filled with gravel and landscaped.

FIG. 7. The original driveway was retained for bike riding and skating but 4′ of it was removed for better infiltration and to plant the fruit trees and perennials.

coined Sage Hill (Fig. 5b). A gravel-filled trench drain and several Eco-Rain boxes were installed along the west and front property lines to direct water away from the house toward the front of the property where it could be infiltrated (Fig. 6a and b). On the rear east side of the property, a swale was created and planted with trees. On the front east side, the concrete from the original driveway was cut out and vegetated with fruit trees and perennial herbs. (Fig. 7) These measures were taking to infiltrate onsite and offsite surface runoff.

In order to infiltrate runoff from a portion of the building, an 850-gallon rain garden was installed in the rear yard to collect runoff from 34% of the roof area. This rain garden is landscaped with California native plants, which enjoy seasonal drenching (Fig. 8a–d). There is also a lovely waterwheel sculpture and fountain that slows the water down and makes an artful statement before the water disappears into the garden (Fig. 13a and b). Trex decking and decomposed granite (DG) were used to allow for infiltration on outdoor walking and entertaining surfaces.

Water collections—Cisterns, first-flush diverter

Two cisterns were installed that together collect 800 gallons of rainwater. These cisterns collect the 66% of the roof runoff that the rain garden does not infiltrate. One cistern waters the fruit orchard using a manually operated gravity-feed drip irrigation system (Fig. 9). The other serves as a seasonal fish habitat and a flower garden. Both cisterns and their accessories (first-flush diverter, rain chains, and downspouts) are artful and positioned for functionality and visibility.

A first-flush diverter was created that would be prominently displayed and oversized (Fig. 10). This device is placed on the downspout to divert the first several gallons of rainwater away from the collection container, to overflow into the adjacent vegetation. The initial water is dirty from roof pollution, bird droppings, and other loose matter. The design works in such a way that heavier material will drop straight down into the diverter instead of the cistern. The standard ones available are uninteresting and often made of vinyl. A beautiful custom-built device was created that is integrated into the downspout and cistern collection area. It is highly visible so as to be used as an educational example, showing how it works to all who visit the site.

The second cistern collects less water, only 300 gal., than the other but it is a living laboratory for the little people who live in the house (Fig. 11a). While it is used to water a small flower garden at the front west corner of the property, it provides learning opportunities and requires much on-going experimentation (Fig. 11b). It is an open-air cistern that provides habitat for fish, plants, and insects.

Making water visible—Rain chains and waterwheel

One of the goals of this project was to make water visible by creating and displaying artfully made beautiful water accessories, such as custom-made ornamental rain chains (Fig. 12a and b) and a waterwheel (Fig. 13a and b), in addition to the cisterns. This was seen as an important part of the site design to promote dialogue and an understanding of hydrology and watershed management.

Greywater

A greywater recycling system is connected to most fixtures in the house except the kitchen sink, dishwasher, and toilets. The water flows into a Hydotech Aqua2use tank that instantly pumps the water in a 1” pipe into the garden (Fig. 14a and b). Water flows out directly into the garden and is never stored in the tank. There is an overflow to the sewer in case of a malfunction, as well as a valve that can turn the whole greywater system off.

As previously stated, the site is organized by location of water sources, both rainwater and greywater. It is a not a good green building practice to introduce water close to the house. Irrigation and moisture near the base of a house will encourage mold, rotten wood, and termites, and has the potential to undermine the foundation. Deciding where to use greywater requires careful consideration. Not only do you want the plants to be away from the house, but you need to choose plants that like the appropriate water regimen.

There are approximately seven native riparian trees that are regularly irrigated by the greywater system (Fig. 15a). Each tree is surrounded by a 1’ deep by 3’ mulch field and has an adjustable valve to adjust water levels (Fig. 15b). The tree species include the following: *Populus fremontii* (cottonwoods), *Alnus rhombifolia* (white alder), *Platanus racemosa* (California sycamore), and *Salix lasiolepis* (arroyo willow), plus five nonnative varieties of banana located in the banana crescent at the end of the greywater line.

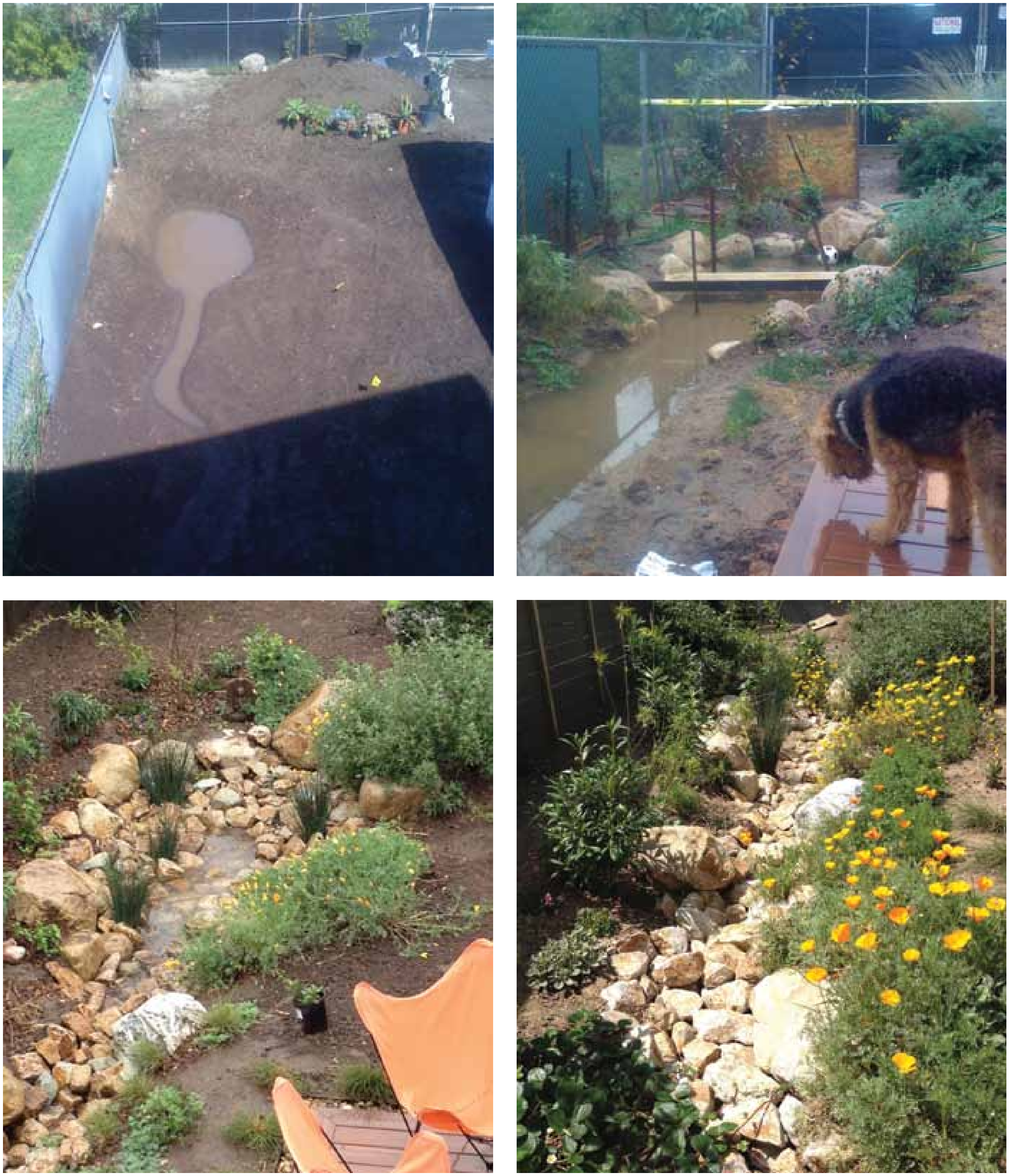

FIG. 8A. Rain garden under construction.
FIG. 8B. Rain garden under construction after a big rain event with some preliminary landscaping.
FIG. 8C. Rain garden, first winter.
FIG. 8D. Rain garden, first summer.

FIG. 9. A 500 gal. stainless steel cistern and overflow diverter positioned in a prominent location on the site to encourage discussion.

FIG. 10. The first-flush diverter collects the first rain and heavy matter to reduce pollutants in the cistern.

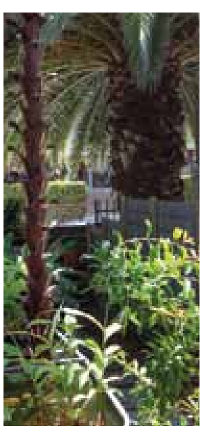

FIG. 11A. A 300 gal. open cistern and decorative downspout collect water for irrigation and outdoor play.
FIG. 11B. The open cistern is used to water the small flower garden, which is under an enormous, beautiful palm toward the front of the property.

FIG. 12A. An important part of the site design was to create beautiful water features to start dialogues and foster awareness about local water opportunities and constraints.

FIG. 12B. Rain chains were custom made by a sheet metal subcontractor that had a flare for the ornate.

FIG. 13A. The waterwheel is part of the storm runoff system, but also an artistic device used to draw attention to the rain and fog drip alike.
FIG. 13B. In the backyard, roof runoff from rain passes over a waterwheel into a fountain and overflows into a vegetated swale, which collects up to 850 gallons.

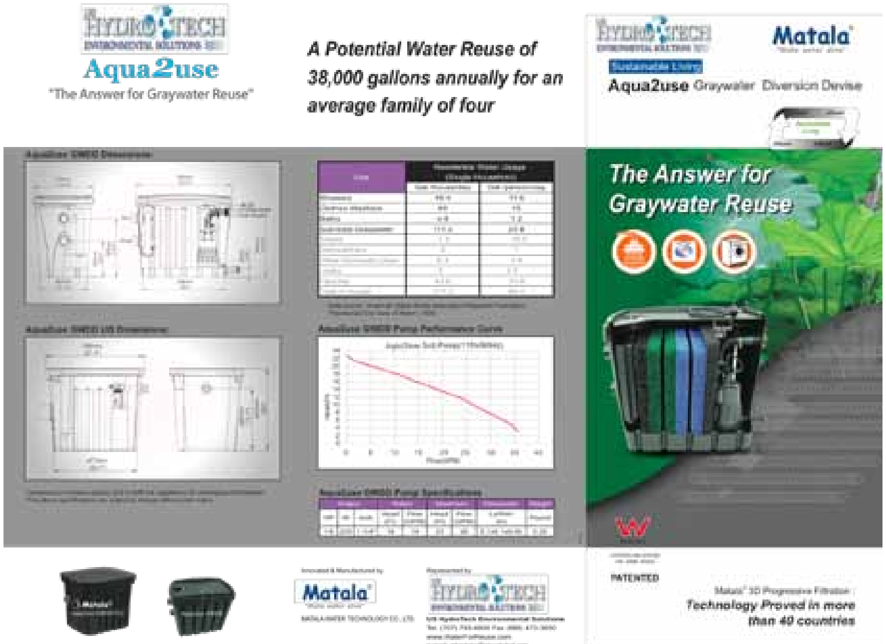

FIG. 14A. The Hydotech Aqua2use system instantly pumps greywater into the garden.
FIG. 14B. The greywater tank before hookup to the sewage system.

FIG. 15A. Twenty-three trees have been planted on site for erosion control, to reduce the heat island effect, and to provide habitat and food for the residents and critters. Seven of the trees are irrigated several times daily by the greywater system.

FIG. 15B. The greywater valve at each tree is very wide to allow particles to flow without clogging the pipe.

FIG. 16A. The vegetable garden is located in the front yard for easy access, to promote dialogue with neighbors, and for the sharing of food.
FIG. 16B. The veggie garden is the only garden that requires regular hand watering.

FIG. 17. A tree house made with recycled wood lath and palettes, next to a young fig tree and the berry patch.

Habitat

Plant communities found on the property are native chaparral, riparian shrubs/trees, a fruit orchard, a berry patch, a banana crescent, and a vegetable garden. The backyard is a formalized version of the natural world where native plants are aesthetically pleasing and serve a function—conserving water and providing sustenance for native organisms. One cistern collects rainwater used to irrigate the fruit orchard and the other is an open-air cistern with a habitat for fish that subsequently irrigates the cut-flower garden. There is a vegetable garden in the front yard that encourages discussions with neighbors about growing organic food while building community spirit and sharing food (Fig. 16a and b) At the top of the driveway, next to the garage, concrete was removed to build a tree house (more like a lifeguard tower; see Fig. 17). Next to the tree house, a fig tree was planted with berry vines under it, so one day the tree house might actually have a tree in and/or near it. In the backyard is a rain garden that fills seasonally with over 850 gallons of rainwater (Fig. 8c-d). Ninety-one percent of the plants on the entire property are native plants that are drought tolerant and thus rarely need to be watered. These plants also provide a critical habitat for native fauna and insects that exotic plants do not (Fig. 18a and b).

There are approximately 106 species of butterflies in Los Angeles. Eighty-five of those species require native plants to survive, based on centuries of co-existence and species interactions. The same is true for birds and insects. To attract these native organisms, a wide variety of native species was planted. These include five types of *Salvia* and *Ceanothus;* three varieties of *Ribes;* several types of *Dudleyas, Heucheras, Mimulus;* and shrubs and trees such as *Lyonothamnus floribundus, Prunus ilicifolia, Carpenteria californica;* and wild flowers.

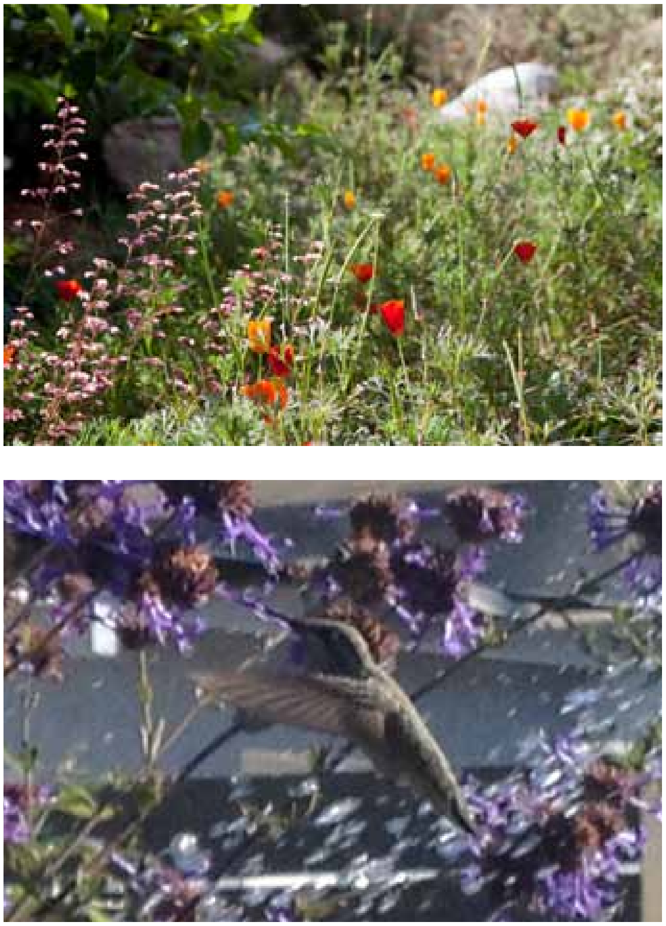

FIG. 18A AND B. All the vegetation in the backyard is California native. The plants attract native critters, are low maintenance, and require little water once established.

FIG. 19. Repurposed stair treads, book shelves and hand rail—wood is from the interior studs of the house.

FIG. 20. Recycled concrete countertops and repurposed Douglas fir cabinets.

Special species that were planted include *Comarostaphylis diversifolia* and *Aristolochia californica*.

Nonnative species planted for food and source food for the bees are housed in an onsite top-bar beehive. These plants include apple, plum, peach, and citrus fruit trees, borage, rosemary, many perennial herbs, and vegetables.

Team collaboration between many subcontractors was essential to the creation of an efficient water distribution system inside and outside of the home. The plumber, in tandem with the greywater engineer, contractor, and landscaper, developed an intelligent greywater distribution and overflow system, which was fine-tuned to accommodate overall landscape and specific plant requirements and flow rates.

A sheet metal subcontractor and artist collaborated with the cistern company, landscaper, and drip irrigation professional to develop a water delivery system for many different water sources. Through collaboration, the team managed to tap the expertise of each individual, resulting in a better project and educating all the team members as the work progressed.

The Building

Energy Performance

To improve energy performance, this passive solar house has a lot of natural lighting, carefully placed windows, solar tubes, and skylights, as well as natural ventilation so that there is no need for air conditioning. Combined with high-efficiency appliances and Energy Star lighting (95% LED lights), the result is a home that is 53% more efficient than Title 24, the State of California's Energy Requirements. There is a 4 kW solar array that produces a power surplus ten months of the year.

One of the most important aspects of the green design is called QII or Quality Insulation Installation, which is a technique of properly insulating a home, thereby improving overall energy performance. This technique was used on the house, and is a requirement of all LEED-certified building, as well as Energy Star homes. It is a very

House Areas	Material	Low Emissions	Local Production
Exterior siding	Recycled content fiber cement		
Wood floor	Reused existing Doug Fir floors	X	X
Wood floor	New floor from locally demoed house	X	X
Framing	Reused existing on 80% of house		
Cement	30% fly ash		X
Interior paint	Low/no VOC		
Patio	Trex - made from recycled durable material		
Counter	Recycled concrete		X
Door jam	Made from existing 2 x 4s		X
Sealant		X	
Roofing	Asphalt shingles made locally		X
Insulation	Recycled content	X	
Shelving	Reused existing	X	
Cabinets	Made from old Doug fir	X	X
Tiles	Recycled content		
Aggregate	Local source		X

TABLE 1. List of materials used for the interior of the house

effective way to reduce leakage by avoiding the loss of air space within the fiber or smashing insulation around pipes and electrical conduits. As a result, the insulative quality of the insulation is increased. It is easy to do by a trained professional and needs to be verified by an accredited third-party green building expert known as a HERZ rater.

Materials for the Interior of the House

Materials were used in an ultra-efficient manner to reduce the need for source material and minimize waste. The stair treads, doorjambs, and bookshelves are made from laminated 100-year-old 2x4's reclaimed wood from the few walls that were removed (Table 1 and Fig. 19). The existing Douglas fir floors were restored. In order to reduce material sent off to a landfill, the old cellulose insulation was composted on site and no soil was removed from the property. In the backyard, re-grading the site to divert water away from the house created Sage Hill (Fig. 5b). High recycled-content products were selected, including the exterior siding, bathroom tiles, concrete countertops (Fig. 20), insulation, and the foundation. In total, 76 percent of construction waste was reused instead of going to the landfill.

Observations

After two years, we made the following observations.

Overall

- No rainwater has left the site since the BMPs were implemented. Additionally, runoff from the neighbor's property and some runoff from the alley and sidewalk are also absorbed.
- Grading has successfully eliminated water from collecting at the base of the house or under the house.
- Native vegetation has attracted a wide diversity of bird and butterfly species and created a great habitat for the bee population on site.

Rain garden

- The vegetated swale/rain garden has absorbed 100% of all its share of the runoff.
- Storm events that produce more than 1 ½ inches of precipitation or multiple events over the course of a couple of days create a small pond that persists for one to two days before being absorbed into the soil.

Cisterns

- While the two cisterns often overflow (into the infiltration trench drain) after the third consecutive storm event, the large rainwater cistern is empty by mid-summer when used bi-weekly to irrigate the fruit trees. The site could have used bigger cisterns, but due to space constraints, a larger above grade one was not possible. To install an underground cistern, it would have been necessary to install a pump, which due to maintenance and longevity was less desirable. The current gravity-fed irrigation system works well.

Greywater

- There is much more irrigation water available due to the greywater system than was first expected and planted for. Sycamore, willows, cottonwoods, and alders were planted at about 3–4 feet tall and after two years, they have grown to 18 to 23 feet tall due to the constant irrigation from the greywater.

FIG. 21. The plan calls for creating a street tree network to absorb air pollutants and provide shade; paving changes to increase permeability and slow traffic; and widening sidewalks to accommodate pedestrian-oriented activities.

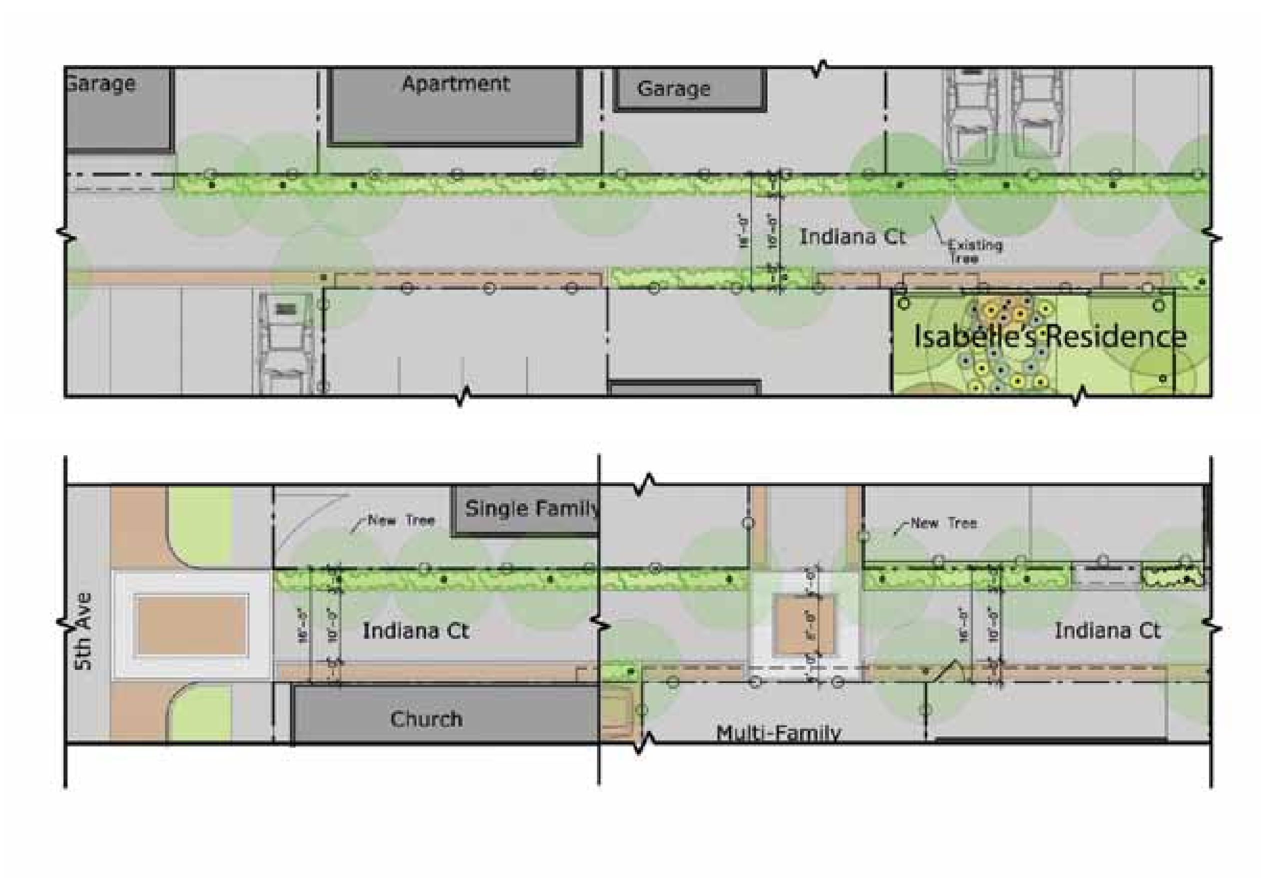

FIG. 22. The plan includes improvements such as landscaping, tree planting, permeable paving, and creating places for basketball playing, cycling, and other outdoor, kid-friendly activities.

- Additional riparian plants and the banana crescent were added to the system to use up some of the abundant water.
- Several of the finest filters from the greywater tank were removed to allow passage of coarser material.

Next Steps

With the house and garden now complete, Duvivier is looking beyond this site toward the entire neighborhood. With a group of neighbors, she plans to grow green infrastructure into the surrounding neighborhood, alleys, and street networks. She has drawn up preliminary plans to start a conversation about this with the neighbors and policymakers. This predominantly multi-family, low-income, mixed-race neighborhood is extremely park poor. There are many neighborhood children who have neither front nor backyards, and consequently a lot of activities, such as soccer, basketball, and bike riding take place in the alleys. Most apartment buildings have no views, little landscaping, and are completely impermeable, creating a river of water in the alleys during rain events. To make matters much worse, this neighborhood is under the Santa Monica Airport's flight path, dumping pollutants from the planes onto the community.

Duvivier's long-term plan is to obtain funding to create a network of green alleys that will be designed for permeability, capturing storm water, landscaping, trees, and play spaces for the community. Along Brooks Avenue, the plan calls for creating a street tree network to absorb air pollutants and provide shade; paving changes to increase permeability and slow traffic; and widening sidewalks to accommodate this pedestrian-oriented neighborhood (Fig. 21). In the alleyways, the plan includes improvements such as landscaping, tree planting, permeable paving, and creating places for basketball playing, cycling and other outdoor, kid-friendly activities (Fig. 22).

LEED Platinum—Leadership in the Built Environment

The Leadership in Energy and Environmental Design (LEED) rating consists of a suite of rating systems for the design, construction, and operation of high-performance green buildings, homes, and neighborhoods. The Brooks Residence received the highest rating, which is a Platinum LEED. A total of 109 points ranks this home within the top ten LEED-rated homes in California and the top twenty-five LEED-rated homes in the US. Both on the inside and the outside of the Brooks Residence, the architect Isabelle Duvivier demonstrates leadership by expanding the conversation on green building techniques and water reuse.

Team

Architect/Project Manager: Isabelle Duvivier, AIA, LEED AP, Duvivier Architects
Project Team: Loren Perry, Tina Hovsepian
Green Rater: Walker Wells, Director, Green Urbanism Program for Global Green USA
General Contractor: Rick Arreola, Arreola Construction
Plumbing: Best Buy Plumbing, Inc.
Cisterns: California Water Storage/California Rainwater Tanks
Gutters, Rain Chain, Waterwheel: Larry Strickland from Sheet Metal Specialists
Greywater: Scott Hey Tank LA
Cabinets: Clark Davis
Counters: Aggregate Art
Structural Engineer: David Lau
QII Insulation: Allied Insulation
Tiles: Epoxy Green
HVAC: Patrick Modugno
Solar Panels: Martifer Solar
Plant specialist: Jettscape
Tree House Builder: Karl Braunz
Deck Builder: Richard Draut
Windows: Marvin Integrity
Photography: Augusta Quirk, Isabelle Duvivier

Isabelle Duvivier is a licensed and LEED-certified architect in the state of California. She received her master's degree in Architecture from the University of California at Berkeley in 1992.

Linda Jassim received her Master's Degree in Landscape Architecture from the University of Southern California in 2005. She works as a designer and writer in the architecture and landscape architecture fields.

FIG. 1. View of the Madrona Marsh Preserve in late spring.

MADRONA MARSH RESTORATION AND ENHANCEMENT PROJECT: PRESERVING THE LAST FRESHWATER MARSH IN LOS ANGELES COUNTY

TRACY DRAKE, JOHN DETTLE, AND ABIGAIL KENT

Abstract

The Madrona Marsh Preserve in the City of Torrance is the last vernal marsh in the South Bay area of Los Angeles County and is an environmentally sensitive area and valuable habitat for a variety of birds, insects, mammals, and plant species. Once sought out to be a condominium development, the City along with the Friends of Madrona Marsh saved the habitat through an agreement with the developer to donate the marsh and surrounding properties. Over the years, a decline in the quality of water entering the marsh has caused concern over the health of the marsh habitat. The goal of the Madrona Marsh Restoration and Enhancement Program is to improve water quality in the vernal marsh and to improve conditions for the wetland habitat. This paper presents and discusses the centerpiece of the Restoration and Enhancement Program—a storm water treatment project to provide clean water supply to the wetlands. The design, construction, and performance of the treatment facilities, and particularly the challenges of designing a nutrient removal treatment system to treat urban runoff and storm water from a large detention basin used to supplement water in the Madrona Marsh, are highlighted.

Background

Madrona Marsh Preserve (Fig. 1) is located in the South Coast City of Torrance and is the last remaining vernal marsh in Los Angeles County. A vernal marsh is a depression or standing body of water flooded by runoff water from the surrounding area. Madrona Marsh fits in the category, as it is wet during winter and spring when it is fed by rain events, and dry by the end of summer until the following rainy season. This particular marsh was created when the Palos

Verdes Peninsula was geologically uplifted and the natural drainage to the ocean was halted.

The Madrona Marsh Preserve is a former oil and gas recovery site. In the 1920s, the land was used for oil development (Friends of Madrona Marsh, 2012). Then, in the 1970s, it was sought out as a condominium development, but the City of Torrance along with the Friends of Madrona Marsh saved the delicate habitat by forming an agreement with the developer, which resulted in the City purchasing the most critical 54 acres, including the 20 acre seasonal marsh, and designated it a nature preserve in perpetuity.

Upon acquiring the land, the City hired a professional naturalist to institute programs for restoring the preserve. Dedicated to the enhancement of the preserve's four beneficial uses—shelter, water, food, and space—a comprehensive restoration program was implemented. From the beginning, improving water quality entering the marsh was deemed the single most important component of the program. The goal is to deliver water to the vernal marsh that is as clean as when the marsh received it from mountains and rivers, not urban runoff, and is in good quality to support return of the plants back into the natural seasonal growth pattern.

Prior to restoration, a large detention basin (sump; Fig. 2) located at the southeast corner of the preserve received untreated runoff via two large storm outfalls. This water is then distributed to the marsh through two pumps without any type of filtration or treatment (Fig. 2). Under normal conditions, wetlands are nature's best filtering system, but the situation in Madrona Marsh was anything but normal. The main concern was high phosphate concentrations found in the water entering the marsh, which was causing rapid algal growth, leading to oxygen depletion—a condition otherwise known as eutrophication. With funding and

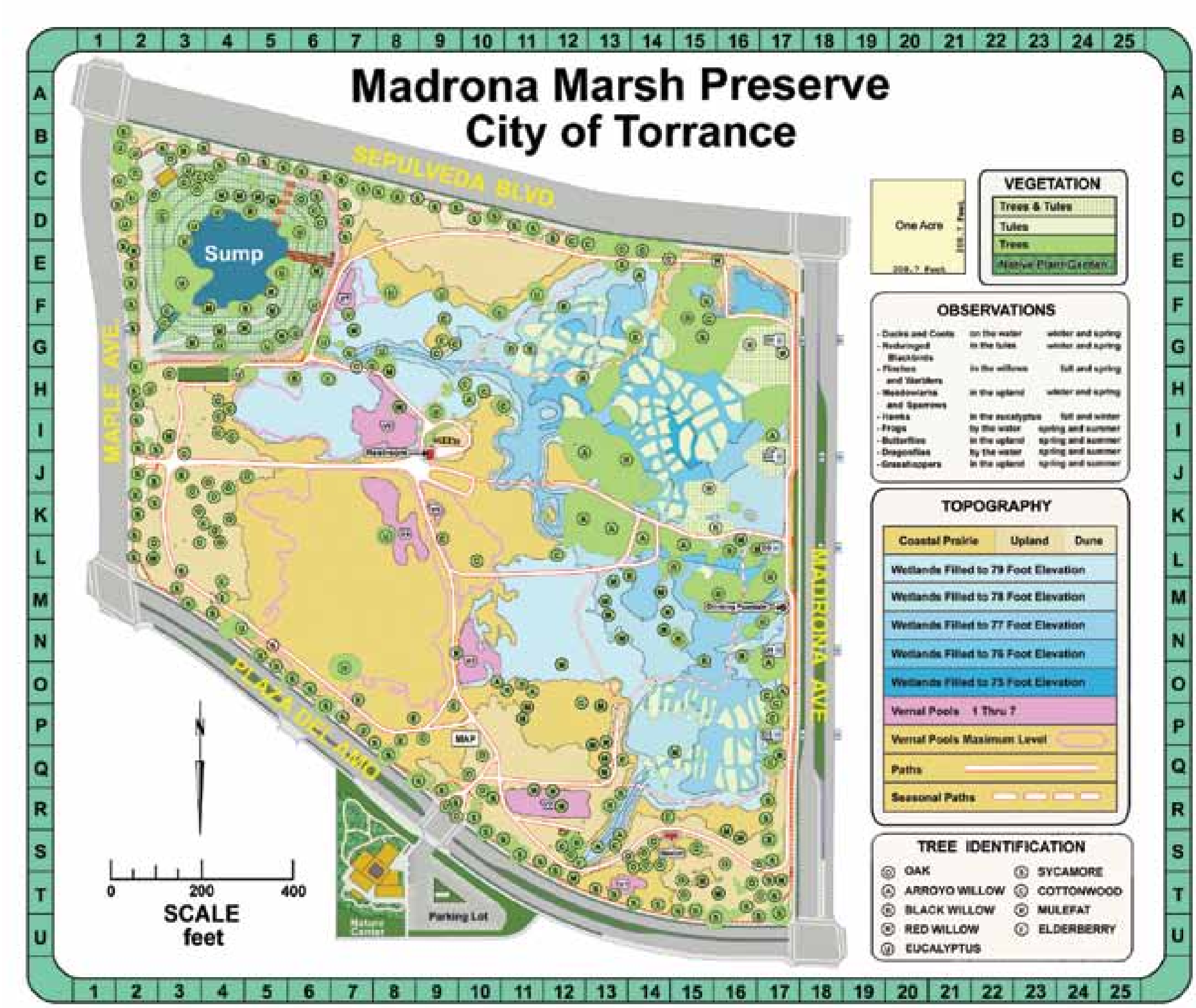

FIG. 2. Madrona Marsh site map. The detention basin (sump) is located at the upper-left corner of the map.

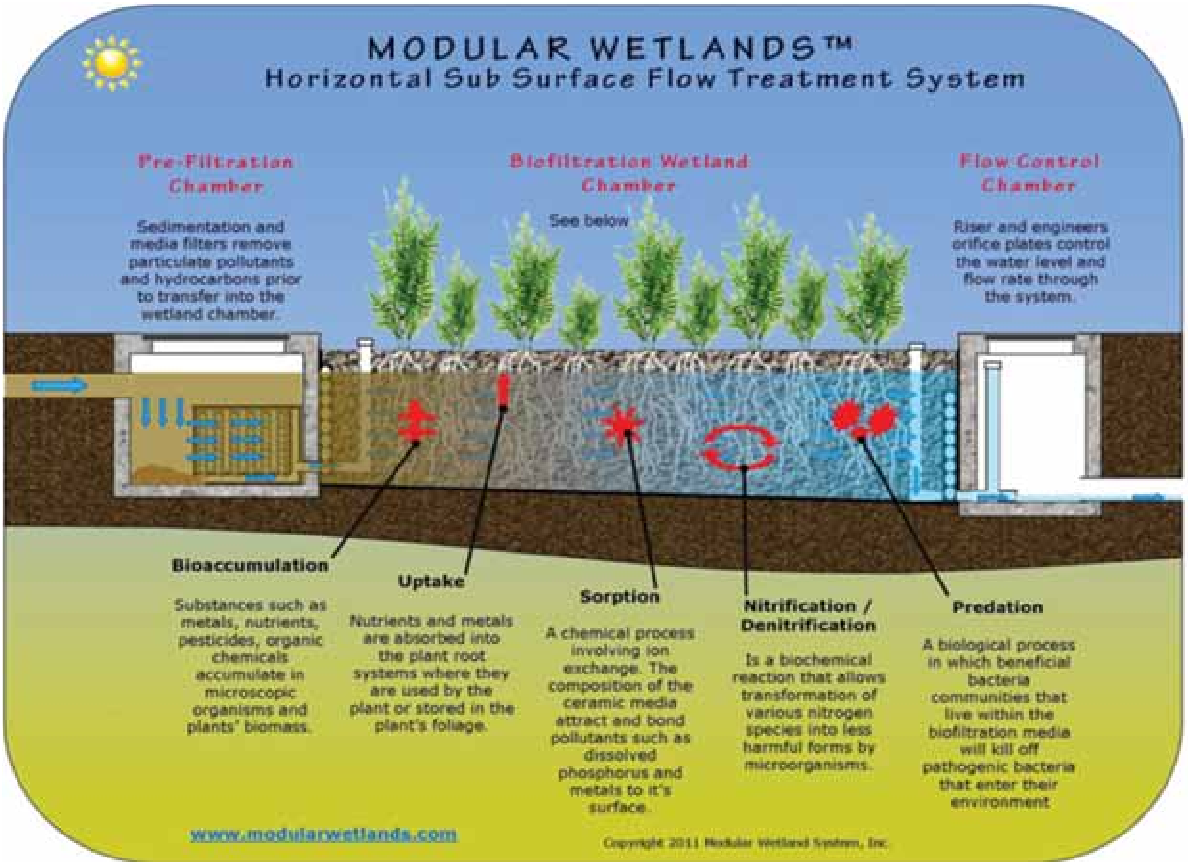

FIG. 3. Modular wetlands horizontal subsurface flow treatment system.

Contaminant	Influent (mg/L)	Effluent (mg/L)	Reduction %
Phosphorus	0.17	ND	*
Dissolved Phosphorus	0.11	ND	*
Chromium	0.0022	ND	*
Copper	0.0088	0.0036	59%
Lead	0.0011	ND	*
Nickel	0.0024	ND	*
Zinc	0.056	ND	*
Dissolved Copper	0.0068	0.0029	57%
Dissolved Zinc	0.047	ND	*
Total Nitrogen	1.1	0.6	45%
Total Kjeldahl Nitrogen	0.75	ND	*
Total Suspended Solids	13	ND	*
COD	29	ND	*
BOD	4.8	2	58%
Turbidity	5.8	1.1	81%

ND = Non Detectable * Indicates High Removal

TABLE 1. Contaminant concentrations in influent and effluent samples collected in April 2012.

FIG. 4. Dropping of the precast box during construction of the WetlandMod system.

FIG. 5. Construction of the riprap waterfall into the wetland basin.

support from the Santa Monica Bay Restoration Commission and the California Coastal Conservancy, the City began researching alternative sources of water, as well as methods to reduce nutrients in the basin before the water was pumped to the marsh.

Among potential sources, potable and recycled water were first explored, but were found to be unsuitable. Portable water was too expensive to transport to the site and its high chlorine count was also a concern. The nutrient levels in recycled water were also deemed too high for the wetlands. The focus then shifted to the collection and delivery of urban runoff flow into the wetlands from surrounding areas. The main challenge of such an option is that the selected method must rely solely on urban runoff and rain to maintain the hydraulic conditions needed for preserving and protecting this isolated wetland. There also must be a treatment process, most likely in the form of filtration, built into this option. Without filtration, the increased phosphates and other nutrients will reduce the viability of the marsh, causing the plants to grow too much and die too early, as observed over the past few years by Madrona Marsh Preserve personnel. The effect of this was a reduction of viable habitat and an increase of maintenance required to have vital open-water areas in the wetlands.

Ideally, the restoration program would like to see runoff treatment achieved on site and through uptake of nutrients and other pollutants by wetland vegetation. To further evaluate the need for and feasibility of natural runoff treatment, the restoration program assessed the quality of the existing runoff entering the detention basin through weekly monitoring of a suite of water quality parameters including nitrate, phosphate, turbidity, and color. Through examination of the monitoring data, a few things became evident. First, the phosphate and nitrate loads in the runoff from the surrounding area entering the detention basin were indeed above a level that could cause a serious decline in water quality and degradation in the quality of wetland habitat. Second, the runoff entering the detention basin was dynamic in nature; influent concentration levels of the above parameters changed from week-to-week and sometimes day-to-day. This means that any treatment methods, including bioremediation through the use of wetland vegetations, must be able to deal with flow fluctuation.

The Modular Wetland System

To select an effective treatment method, the City of Torrance paired up with Modular Wetland Systems (WetlandMod or MWS). The two entities joined efforts to brainstorm and design a feasible filtration system and decided on the WetlandMod, a self-contained treatment train including a pretreatment chamber and a horizontal flow biofiltration system (Fig. 3). The treatment train is built into a modular pre-cast concrete structure that incorporates capture, screening, hydrodynamic separation, advanced media filtration, and biofiltration. The biofiltration process replicates natural processes to remove a variety of pollutants from storm water runoff, including fine total suspended solids (TSS), bacteria, oils and grease, heavy metals, and harmful nutrients like nitrate and phosphorus. To adapt the system to the Madrona Marsh project site, the design team tweaked its original module to incorporate a much larger scale wetland bed to treat various flow volumes from the detention basin for use in the vernal marsh.

Construction of the WetlandMod began in October 2011. This included dropping a 22' precast box that houses a pretreatment chamber and media cartridges (Fig. 4). Contractors excavated a 107' x 37' x 3.7' area for the filtration media bed. The clean soil from the excavation was used on site to restore access roads. The wetland media (lightweight ceramic sorptive media) filled the bed and wetland-specific vegetation was planted. Vetiver grass was chosen for its noninvasive yet vigorous root system, drought tolerance,

FIG. 6. Curb grate installed at a catch basin opening in the drainage area.

FIG. 7. Post construction of the Modular Wetland System site.

and pollutant removal capabilities, including removal of dissolved nutrients and heavy metals. The project also included removal of a limited number of trees to allow for increased sunlight and UV disinfection at the basin inlet, and construction of a 150 foot long riprap waterfall from the flow control vault at the top of the site down to the wetland basin (Fig. 5). A small precast flow control vault was dropped at the end of the media bed to direct water down the riprap waterfall back into the basin. In addition to construction within the Madrona Marsh property, numerous retractable curb grates were installed throughout the 241 acre drainage area to prevent trash, foliage, and other pollutants from entering the basin (Fig. 6). In February 2012, after all construction was completed, the pumps were turned on and began filtering water from the basin via the newly constructed filtration system.

Post restoration, the basin continued to receive runoff via two large storm outfalls (Fig. 7). The basin now contains three pumps: Two pumps deliver treated water into the vernal marsh, while the third sends it into the WetlandMod, where water flows through a proprietary media that removes high levels of TSS, hydrocarbons, particulate heavy metals, and nutrients. Reducing particulates in the pre-treatment chamber minimizes pollutant loading and prevents clogging in the media bed. Water is then distributed through a manifold, creating an even flow of water across the media bed. Treated water is diverted back into the basin using a riprap waterfall that oxygenates the water. The pumps run water into the WetlandMod system 24 hours a day. This system is specifically designed to treat continuous low flows, but with inconsistent flow volumes. Native Vetiver grass was planted because it has proven effective at removing pollutants while exposed to inconsistent water and even drought situations (Vetiver Network International). An irrigation system in the media bed allows the grass to survive when treatment through the WetlandMod system is not needed.

Results

The WetlandMod system treats up to 40,000 gallons per day and remove an array of pollutants with a combination of best management practices (BMPs): The media filtration and biofiltration remove nutrients and heavy metals, the riprap waterfall oxygenates the water, tree removal provides UV disinfections, inlet filters remove oil and grease, and curb guards prevents trash from entering the basin. This multi-BMP approach has produced immediate improvement on water quality in the marsh. Samples collected and tested within 24 hours following initial filtration have shown 37% nitrate reduction, over 50% phosphate reduction, and 87% turbidity reduction. The influent water color was a murky, yellow-brown, while the effluent water is colorless.

In April 2012, samples were collected and tested again, showing improved results (Table 1): Nitrogen levels reduced further along with turbidity, and total and dissolved phosphorous became non-detectable. Dissolved metals also showed additional reductions with some even non-detectable. Once again, the effluent water was colorless. Results are expected to continue to improve as the sump water circulates through the WetlandMod system 24 hours a day and after Vetiver grass root systems establish within the wetland media bed.

Besides test data showing improvement in water quality, construction of this project has exhibited many other positive effects. It was evident that running water from the flow control vault down the riprap waterfall into the basin created a wonderful bathing area for birds. During spring migration, it was not uncommon to see over 150 cedar waxwings perched in the trees near the waterfall, preening after having bathed. Hummingbirds seem to prefer the outflow pipe and can be seen there any time of the day. Clean water creates a healthy habitat for all. Other benefits include reduced amounts of trash observed in the basin after rain events, greater public awareness of the impact of storm water pollution on nature, and most importantly, no algae blooms in the vernal marsh.

Staff at Madrona Marsh will continue to monitor the system on a monthly basis to ensure nutrient levels are low. Project benefits include keeping the City of Torrance in compliance with and exceeding water quality regulations. Most importantly, it is the first time in decades the vernal marsh of the preserve is receiving clean, high-quality water.

About the Friends

The Friends of Madrona Marsh (FOMM) is a non-profit organization dedicated to preserving and restoring the Madrona Marsh. The Friends have been the backbone of the Madrona Marsh Preserve for the last thirty years. They are involved in creating, sponsoring, and conducting various activities to promote the preservation and restoration of the marsh, as well as service to the Nature Center. Members of FOMM and volunteers also assist in tours and projects by Torrance Parks and Recreation.

Tracy Drake is the Manager and Naturalist for the Madrona Marsh Preserve and Nature Center. She is in charge of the overall management of the Nature Center and Preserve, including all educational, research and outreach programs. She is also in charge of the Preserve's maintenance activities including irrigation, mowing and tree-trimming, and non-native plant removal and replacement.

John Dettle is the Engineering Manager of the Public Works Department, City of Torrance, and was the lead engineer on the Madrona Marsh Restoration and Enhancement Project.

Abigail Kent is the Marketing Director for the Modular Wetland Systems and oversees the marketing efforts for several environmental companies. Part of her time is spent researching and writing about innovative project designs implemented to enhance water quality.

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City of Torrance. 2011. "Madrona Marsh Nature Center: Map of the Madrona Marsh." http://www.torranceca.gov/Parks/6642.htm.

Friends of Madrona Marsh. 2012. "Explore the Marsh." http://www.friendsofmadronamarsh.com/explore.html.

Vetiver Network International. "Contaminated Water and Land." http://www.vetiver.org/g/contaminated_water.htm

ENVIRONMENTAL NOTES & ABSTRACTS

Urban Coast contains summaries of submitted research and policy as well as abstracts from current literature. This section brings together innovative policy developments, environmental research, technical studies, and monitoring and project implementation to keep our readers abreast of the latest thinking about environmental issues and solutions. This collection of notes and abstracts reflects the latest developments in urban coastal research and policy and shares knowledge of how the vast array of techniques and tools available are being applied in urban coastal regions. We encourage our readers to learn more about any or all of the work highlighted in this section.

We welcome suggestions for abstracts to include in this section as well as submittals. Please direct correspondence to gwang@waterboards.ca.gov.

PHOTO: FLICKR – THE COMMONS

PHOTO: JOHN HOLLENBECK

POLICY

Towards a Social–Ecological Resilience Framework for Coastal Planning. Lloyd, M. G., Peel, D., and Duck, R.W. 2013. *Land Use Policy* 30(1): 925–33.

Abstract

It is increasingly recognized that designing and implementing adaptive land management and development policies for the coastal zone requires an interdisciplinary and integrated approach. Yet integrative thinking and action often remain problematic due to the competing interests and ambitions involved in coastal zone planning and management and the legacy of established development on the coast. This paper presents a developmental timeline to critically consider institutional responses to coastal development and seeks to locate contemporary challenges, such as climate change, in the context of a new environmental determinism. The argument is put forward that securing a shared understanding of development conditions and risks needs to be predicated on creating more robust conditions for interaction and fostering a sounder appreciation of the inter-dependencies of natural processes and governance. The concept of resilience is critically explored in order to consider a normative analytical framework for facilitating social learning and developing a reciprocal understanding of social–ecological dynamics that offers a spectrum of resilience options. This is illustrated in the context of coastal geomorphological processes and Process-Defined Management Units.

Coastal and Ocean Science-Based Decision-Making in the Gulf of California: Lessons and Opportunities for Improvement. Lowell, S. M., T. C. Hoffmann, M. McGrath, G. Brazil, and S. L. Thomas. 2012. *Coastal Management* 40(6): 557–76.

Abstract

The Gulf of California hosts astounding biodiversity that supports numerous economic activities in the region. These activities, and emerging threats, are placing pressure on the region's ecosystems. Government and civil society are working to address threats through several conservation and management mechanisms. Nevertheless, the use and incorporation of scientific information—a key component for creating effective and durable management—are still deficient. This article presents science integration and discusses the findings of a study that assesses the regional landscape, existing institutional arrangements, and capacity for using science to inform policy and management decisions. The article also explores the current use of science within fisheries policy and management and the capacity of the National Network of Information and Research of Fisheries and Aquaculture (RENIIPA) and the State Fisheries and Aquaculture Councils, two mechanisms in the region. Finally, the article shares lessons learned and offers recommendations on how the region can strengthen science-based decision-making. Results indicate

that although some actors in the Gulf of California are producing relevant science, the capacity of intermediary groups connecting producers with users of science, or mechanisms in place to ensure that science is being used in decision-making processes, varies. Moreover, despite having a well-developed landscape of producers, intermediaries, and mechanisms in place for fisheries management in the region, effective science integration is not occurring.

Buy Coal! A Case for Supply-Side Environmental Policy. Bard Harstad. 2012. *Journal of Political Economy* 120(1): 77–115.

Abstract

Free-riding is at the core of environmental problems. If a climate coalition reduces its emissions, world prices change, and nonparticipants typically emit more; they may also extract the dirtiest type of fossil fuel and invest too little in green technology. The coalition's second-best policy distorts trade and is not time consistent. However, suppose that the countries can trade the rights to exploit fossil-fuel deposits: As soon as the market clears, these problems vanish, and the first-best is implemented. In short, the coalition's best policy is to simply buy foreign deposits and conserve them.

Near-Term Priorities for the Science, Policy and Practice of Coastal and Marine Spatial Planning (CMSP). Halpern, B. S., J. Diamond, S. Gaines, S. Gelcich, M. Gleason, S. Jennings, S. Lester, A. Mace, L. McCook, K. Mcleod, N. Napoli, K. Rawson, J. Rice, A. Rosenberg, M. Ruckelshaus, B. Saier, P. Sandifer, A. Scholz, and A. Zivian. 2012. *Marine Policy* 36(1): 198–205.

Abstract

There is currently a rare opportunity to inform emerging efforts to implement coastal and marine spatial planning (CMSP) in the United States, Europe, and elsewhere around the world. In particular, the newly formed U.S. National Ocean Council is developing a strategic action plan for CMSP over the next eighteen to twenty-four months. To identify priority needs for significantly advancing CMSP, a group of experts in the science, policy, and practice of CMSP developed recommendations for (1) process development, (2) communication and engagement efforts, (3) tradeoff and valuation analyses, and (4) decision support. Some of these priorities are supported by existing activities in the United States and elsewhere. Others have yet to be addressed and merit immediate attention.

Facilitating Ecological Enhancement of Coastal Infrastructure: The Role of Policy, People and Planning. Naylor, L.A., M. A. Coombes, O. Venn, S. D. Roast, and R. C. Thompson. 2012. *Environmental Science & Policy* 22(1): 36–46.

Abstract

Urbanization is recognized as a major pressure on coastal biodiversity. Increasing risks of flooding and erosion associated with future climate change indicate that new hard infrastructure will have to continue to be built—and existing structures upgraded—in areas of high social and economic value. Ecological enhancement involves undertaking management interventions at the design stage to improve the ecological potential of these structures, or to improve the ecological value of existing structures. Although scientific research into ecological enhancement methods and designs is growing, discussion of the non-science drivers and mechanisms by which ecological enhancements can be successfully implemented in coastal infrastructure projects has been limited.

We explore the science–policy–practice interfaces of the ecological enhancement of hard coastal structures from three perspectives. First, we outline the growing number of European and United Kingdom policies and legislative instruments that are increasing the need to consider ecological enhancement in coastal developments. These serve as a facilitative tool for making enhancement projects happen, constituting a significant 'policy push' for research and application in this area. Second, we examine the role of people in influencing the uptake of ecological enhancements. The critical role of "knowledge brokers" and the need for effective and sustained collaboration between a range of groups and individuals to get research approved operational trials off the ground is discussed. Third, we examine where in the typical planning, design, and build process current enhancement projects have been embedded, serving to illustrate how the science can be used in practice.

Long-term Corporate Climate Change Targets: What Could They Deliver? Gouldson, A., and R. Sullivan. 2013. *Environmental Science & Policy* 27(1): 1–10.

Abstract

Driven by the rising cost of energy, stakeholder pressure, and the expectation that governments will continue to implement policy measures directed at reducing greenhouse gas emissions, an increasing number of companies have set targets to reduce their greenhouse gas emissions. These commitments raise two important questions. The first is whether they can be considered—individually or collectively—an appropriate response to the threat presented by climate change. The second is whether they are dependable; that is, can policy makers and other stakeholders can rely on companies to deliver on the commitments that they have made?

This article examines these two questions using the case of the United Kingdom (UK) supermarket sector to illustrate and explain the issues at stake and, more generally, to examine the contribution that these types of voluntary commitments can make to wider public policy goals on climate change. The reasons for focusing on the UK supermarket sector are that the companies in this sector are some of the largest retailers in the world, they are significant emitters (their direct emissions account for 0.9% of UK carbon emissions, and some indications suggest that their indirect emissions account for ten times as much), and they are less heavily regulated that other sectors with comparable carbon footprints.

The article concludes that the targets being set voluntarily by companies in this sector align with, or may even exceed, the climate change policy goals being set by national governments. Moreover, the article concludes that the companies' targets are plausible and have a reasonably high likelihood of being delivered if energy prices remain high and if the companies can sustain recent rates of improvement. However, the article also cautions against relying on these types of voluntary commitments, noting that their scope is limited (i.e., most targets relate to companies' direct rather than indirect emissions), and that the inconsistencies and opacities in company reporting on performance and outcomes make it extremely difficult for stakeholders to have confidence that the targets set have actually been delivered.

POLLUTION

Linking Chemical Contamination to Biological Effects in Coastal Pollution Monitoring. Beiras, R., I. Durán, S. Parra, M. B. Urrutia, V. Besada, J. Bellas, L. Viñas, P. Sánchez-Marín, A. González-Quijano, M. A. Franco, Ó. Nieto, and J. J. González. 2011. *Ecotoxicology* 21(1): 9–17.

Abstract

To establish the connection between pollutant levels and their harmful effects on living resources, coastal monitoring programs have incorporated biological tools, such as the scope for growth (SFG) in marine mussels and benthic macrofauna community indices. Although the relation between oxygen-depleting anthropogenic inputs and the alteration of benthic communities is well described, the effects of chemical pollutants are unknown because they are not expected to favor any particular taxa. In this study, the combined efforts of five research teams involved in the investigative monitoring of marine pollution allowed the generation of a multiyear data set for Ría de Vigo (northwest Iberian Peninsula). Multivariate analysis of these data allowed the identification of the chemical-matrix combinations responsible for most of the variability among sites and the construction of a chemical pollution index (CPI) that significantly ($P < 0.01$) correlated with biological effects at the individual and community levels. We report a consistent reduction in the physiological fitness of local populations of mussels as chemical pollution increases. The energy balance was more sensitive to pollution than individual physiological rates, but the reduction in the SFG was primarily due to significantly decreased clearance rates. We also found a decrease in benthic macrofauna diversity as chemical pollution increased. This diversity reduction resulted not from altered evenness, as the classic paradigm might suggest, but from a loss of species richness.

Concentrations and Annual Fluxes of Sediment-Associated Chemical Constituents from Conterminous US Coastal Rivers Using Bed Sediment Data. Horowitz, A. J., V. C. Stephens, K. A. Elrick, and J. J. Smith. 2012. *Hydrological Processes* 26(7): 1090–14.

Abstract

Coastal rivers represent a significant pathway for delivering natural and anthropogenic sediment-associated chemical constituents to the Atlantic, Pacific, and Gulf of Mexico coasts of the conterminous United States. This study entails an accounting segment using published average annual suspended sediment fluxes with published sediment-associated chemical constituent concentrations for (1) baseline, (2) land-use distributions, (3) population density, and (4) worldwide means to estimate concentrations and annual fluxes for trace and major elements and total phosphorus, total organic and inorganic carbon, total nitrogen, and sulfur, for one hundred thirty-one coastal river basins. In addition, this study entails a sampling and subsequent chemical analysis segment that provides a level of "ground truth" for the calculated values, as well as generating baselines for sediment-associated concentrations and fluxes against which future changes can be evaluated.

Currently, between 260 and 270 Mt of suspended sediment are discharged annually from the conterminous United States; about 69% is discharged from Gulf rivers ($n = 36$), about 24% from Pacific rivers ($n = 42$), and about 7% from Atlantic rivers ($n = 54$). Elevated sediment-associated chemical concentrations relative to baseline levels occur in the reverse order of sediment discharges: Atlantic rivers (49%) > Pacific rivers (40%) > Gulf rivers (23%). Elevated trace element concentrations (e.g., copper [Cu], mercury [Hg], lead [Pb], zinc [Zn]) frequently occur in association with present/former industrial areas and/or urban centers, particularly along the northeast Atlantic coast. Elevated carbon and nutrient concentrations occur along the Atlantic and Gulf coasts but are dominated by rivers in the urban Northeast and by Southeastern and Gulf coast (Florida) blackwater streams. Elevated calcium (Ca), mercury (Mg), potassium (K), and sodium (Na) distributions tend to reflect local petrology, whereas elevated titanium (Ti), sulfur (S), iron (Fe), and aluminum (Al) concentrations are ubiquitous, possibly because they have substantial natural as well as anthropogenic sources. Almost all the elevated sediment-associated chemical concentrations found in conterminous U.S. coastal rivers are lower than worldwide averages.

The Challenge of Choosing Environmental Indicators of Anthropogenic Impacts in Estuaries. Daffor, K. A., S. L. Simpson, B. P. Kelaher, G. F. Clark, V. Komyakova, C. K. C. Wong, and E. L. Johnston. 2012. *Environmental Pollution* 163:207–17.

Abstract

Ecological assessments over large spatial scales require that anthropogenic impacts be distinguishable above natural variation, and that monitoring tools are implemented to maximize impact detection and minimize cost. For three heavily modified and four relatively pristine estuaries (disturbance category), chemical indicators (metals and polycyclic aromatic hydrocarbons [PAHs]) of anthropogenic stress were measured in benthic sediments, suspended sediments, and deployed oysters, together with other environmental variables. These were compared with infaunal and hard-substrate invertebrate communities. Univariate analyses were useful for comparing contaminant loads between different monitoring tools and identified the strongest relationships between benthic and suspended sediments. However, multivariate analyses were necessary to distinguish ecological response to anthropogenic stressors from environmental "noise" over a large spatial scale and to identify sites that were being impacted by contaminants. These analyses provide evidence that suspended sediments are a useful alternative monitoring tool for detecting potential anthropogenic impacts on benthic (infaunal and hard-substrate) communities.

The Use of Benthic Macroinvertebrates to Establish a Benchmark for Evaluating the Environmental Quality of Microtidal, Temperate Southern Hemisphere Estuaries. Tweedley, J. R., R. M. Warwick, F. J. Valesini, M. E. Platell, and I. C. Potter. 2012. *Marine Pollution Bulletin* 64(6): 1210–21.

Abstract

Establishment of a benchmark against which deleterious changes to an estuary can be evaluated requires validating that it has not been subjected to detrimental anthropogenic perturbations and then identifying the biological features that indicate a pristine condition and can thus be used as indicators for detecting and monitoring departures from the natural state. The characteristics of the benthic macroinvertebrate fauna of an essentially pristine, seasonally open estuary in Western Australia (Broke Inlet) have been determined and compared with those previously recorded for a nearby eutrophic, seasonally open estuary (Wilson Inlet). Density was far lower in Broke than Wilson. Compositions differed radically at all taxonomic levels, with polychaetes contributing less, and crustaceans more, to the abundance in Broke. Average taxonomic distinctness was greater for Broke than Wilson and sixteen other temperate southern hemisphere estuaries, whereas the reverse was true for variation in taxonomic distinctness, emphasizing that Broke Inlet is pristine.

Source Characterization and Spatio-temporal Evolution of the Metal Pollution in the Sediments of the Basque Estuaries (Bay of Biscay). Legorburu, I., J. G. Rodriguez, A. Borja, I. Menchaca, O. Solaun, V. Valencia, I. Galparsoro, and J. Larreta. 2013. *Marine Pollution Bulletin* 66(1–2): 25–38.

Abstract

According to Water Framework Directive requirements, Member States must identify and analyze effects derived from human pressures in aquatic systems. As different kind of pressures can impact water bodies at different scales, analyses of spatio-temporal evolution of water bodies becomes essential to understand ecosystem responses. In this investigation, an analysis of spatio-temporal evolution of sedimentary metal pollution (cadmium [Cd], chromium [Cr], copper [Cu], mercury [Hg], nickel [Ni], lead [Pb], zinc [Zn]) in twelve Basque estuaries (Bay of Biscay) is presented. Data collected in extensive sampling surveys are the basis for the geographic information system (GIS)-based statistical approach used. The implementation of pollution abatement measures is reflected in a long-term decontamination process, mostly evident in estuaries with the highest historical sediment pollution levels. Spatial evolution is determined by either naturally occurring or human-driven processes. Such spatial processes are more obviously being reflected in estuaries with lower historical sediment pollution levels.

MONITORING

Sediment Fluxes from California Coastal Rivers: The Influences of Climate, Geology, and Topography. Andrews, E. D., and R. C. Antweiler. 2012. *Journal of Geology* 120(4): 349–66.

Abstract

The influences of geologic and climatic factors on erosion and sedimentation processes in rivers draining the western flank of the California Coast Range are assessed. Annual suspended, bedload, and total sediment fluxes were determined for sixteen river basins that have hydrologic records covering all or most of the period from 1950 to 2006 and have been relatively unaffected by flow storage, regulation, and depletion, which alter the downstream movement of water and sediment. The occurrence of relatively large annual sediment fluxes are strongly influenced by the El Niño – Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO). The frequency of relatively large annual sediment fluxes decreases from north to south during La Niña phases and increases from north to south during El Niño phases. The influence of ENSO is modulated over a period of decades by the PDO, such that relatively large annual sediment fluxes are more frequent during a La Niña phase in conjunction with a cool PDO and during an El Niño phase

in conjunction with a warm PDO. Values of mean annual sediment flux, Sf, were regressed against basin and climatic characteristics. Basin area, bedrock erodibility, basin relief, and precipitation explain 87 percent of the variation in Sf from the sixteen river basins. Bedrock erodibility is the most significant characteristic influencing Sf. Basin relief is a superior predictor of Sf compared with basin slope. Sf is nearly proportional to basin area and increases with increasing precipitation. For a given percentage change, basin relief has a 2.3-fold greater effect on Sf than a similar change in precipitation. The estimated natural Sf from all California coastal river Sf for the period 1950–2006 would have been approximately 85 million tons without flow storage, regulation, and depletion; the actual Sf has been approximately 50 million tons, because of the effects of flow storage, regulation, and depletion.

Long-term Monitoring of Heavy Metals in Chilean Coastal Sediments in the Eastern South Pacific Ocean. Chandía, C., and M. Salamanca. 2012. *Marine Pollution Bulletin* 64(10): 2254–60.

Abstract

Concentrations of seven metals (aluminum [Al], cadmium [Cd], copper [Cu], iron [Fe], lead [Pb], nickel [Ni], zinc [Zn]) were determined in 256 surface sediment samples, collected between May 2006 and November 2009, from fifteen stations at the mouth of the Itata River and its adjacent marine zone (central-southern Chile) as part of an environmental monitoring program. The objectives of the work were to (i) establish baseline metal concentrations in the sediments of the area and (ii) identify tendencies in the spatial and temporal distribution of the metals in these marine sediments. Concentrations were highest in the north zone of the Itata River mouth (stations E2C, E13C) for all the metals and at the stations farthest offshore from the mouth (E4, E6) for copper (Cu), iron (Fe), lead (Pb), and nickel (Ni). The ranges in those concentrations were lower than those reported in other studies performed along the Chilean coast and lower than those observed in most other coastal systems around the world. Based on results of the indices used (geoaccumulation index, enrichment factor), the coastal sediments were not measurably elevated above natural levels.

Will Coastal Wetlands Continue to Sequester Carbon in Response to an Increase in Global Sea level?: a Case Study of the Rapidly Subsiding Mississippi River Deltaic Plain. R. D. DeLaune, and J. R. White. 2012. *Climatic Change* 110(1–2): 297–314.

Abstract

The highly visible coastal phenomenon of wetland loss in coastal Louisiana (LA) was examined through the prism of carbon accumulation and loss. Carbon storage or sequestration in rapidly subsiding LA coastal marsh soils was based on vertical marsh accretion and aerial change data. Marshes sequester a significant amount of carbon through vertical accretion; however, large amounts of carbon previously sequestered in the soil profile is lost through annual deterioration of these coastal marshes. Hurricanes, such as Katrina and Rita, have triggered instantaneous large carbon losses of sequestered soil carbon through the destruction of large areas of marsh. This analysis shows proposed coastal restoration efforts will not be sufficient to restore carbon losses by storms and marsh deterioration. Further, we have estimated the economic benefit of carbon sequestration for coastal wetland restoration efforts. Results show that LA coastal marshes may not serve as a net sink of carbon. These results may serve as a predictor of the impact of future predictions of increasing global sea level rise on carbon sequestration for other coastal regions.

An Integrative Management Protocol for Connecting Human Priorities with Ecosystem Health in the Neponset River Estuary. Frashure, K. M., R. E. Bowen, and R. F. Chen. 2012. *Ocean and Coastal Management* 69(1): 255–64.

Abstract

Environmental scientists currently lack a common and unifying approach to equitably connect human activities with ecosystem health assessments. To enhance ecosystem health, our historical way of thinking about ecosystem monitoring needs to include a vital connection between the benefits of ecosystems and users' well-being. To date, much emphasis has been placed on environmental indicators (e.g. pH, salinity, dissolved oxygen), and not as much on socio-economic indicators (e.g., environmental clean-up costs, dollars lost from beach closures, number of public access points), ones that the public can understand more easily, and therefore value, and this bias toward environmental indicators may influence their decisions. Given that each ecosystem has unique physical characteristics and that monitoring objectives may vary, a common set of indicators is not necessarily suitable to all systems. Rather, a common protocol for indicator selection is more appropriate as it can be applied across political jurisdictions and a diverse set of ecosystems. To investigate the value of environmental and socio-economic indicators in coastal urban ecosystems, we have applied a methodology to identify management goals and to select indicators specific to an urban estuarine ecosystem, the Neponset River Estuary. In our study, we identified the stakeholder community who had significant management interests in order to specify and rank management goals. A panel of experts was convened to select and rank essential environmental and socio-economic indicators according to how well they measured success in achieving the largest number of more important management goals. A post-survey evaluation was administered among the stakeholder community and panel of experts in order to evaluate the protocol's applicability, effectiveness, and potential for implementation. This protocol resulted in a ranked set of environmental and socio-economic indicators that were equally assessed against a common set of management goals identified by the stakeholder community from the Neponset River Estuary.

Taxonomic Sufficiency of Polychaete Taxocenes for Estuary Monitoring. Soares-Gomes, A., C. L. T. Mendes, M. Tavares, and L. Santi. 2012. *Ecological Indicators* 15(1): 149–56.

Abstract

The polychaetes assemblage structure was used to investigate taxonomic sufficiency in a heavily polluted tropical bay. Species abundance was aggregated into progressively higher taxa matrices (genus, family, order) and was analyzed using univariate and multivariate techniques. Polychaetes distribution in Guanabara Bay (GB) was in accordance with a pollution gradient, probably ruled by the organic enrichment, consequent effects of hypoxia and altered redox conditions coupled with prevailing patterns of circulation. Within the sectors of GB, an increasing gradient in species richness and occurrence was observed, ranging from the azoic and impoverished stations in the inner sector to a well-structured community in terms of species composition and abundance inhabiting the outer sector. Multivariate statistical analysis showed similar results when species were aggregated into genera and families, while greater difference occurred at coarser taxonomic identification (order). The literature about taxonomic sufficiency has demonstrated that faunal patterns at different taxonomic levels tend to become similar with increased pollution. In GB, an analysis carried out solely at family level is perfectly adequate to describe the environmental gradient, considered a useful tool for a quick environmental assessment.

RESTORATION

A Comparative Review of Recovery Processes in Rivers, Lakes, Estuarine and Coastal Waters. Verdonschot, P. F. M., B. M. Spears, C. K. Feld, S. Brucet, H. Keizer-Vlek, A. Borja, M. Elliott, M. Kernan, and R. K. Johnson. 2012. *Hydrobiologia.* doi:0.1007/s10750-012-1294-7.

Abstract

The European Water Framework Directive aims to improve ecological status within river basins. This requires knowledge of responses of aquatic assemblages to recovery processes that occur after measures have been taken to reduce major stressors. A systematic literature review comparatively assesses recovery measures across the four major water categories. The main drivers of degradation stem primarily from human population growth and increases in land use and water use changes. These drivers and pressures are the same in all four water categories: rivers, lakes, and transitional and coastal waters. Few studies provide evidence of how ecological knowledge might enhance restoration success. Other major bottlenecks are the lack of data, effects mostly occur only in short-term and at local scale, the organism group(s) selected to assess recovery does not always provide the most appropriate response, the time lags of recovery are highly variable, and most restoration projects incorporate restoration of abiotic conditions and do not include abiotic extremes and biological processes. Restoration ecology is just emerging as a field in aquatic ecology and is a site, time, and organism group-specific activity. It is therefore difficult to generalize. Despite the many studies, only few provide evidence of how ecological knowledge might enhance restoration success.

Assessment of the Subtidal Macrobenthic Community Functioning of a Temperate Estuary following Environmental Restoration. Verissimo H, J. Bremner, J. Patricio, P. van der Linden, and J. C. Marques. 2012. *Ecological Indicators* 23(1): 312–22.

Abstract

Biological Traits Analysis (BTA) is a recently proposed method for addressing ecological functioning based on traits exhibited by members of biological assemblages. This multi-trait approach was applied to the soft-bottom subtidal macrobenthic communities of the Mondego estuary (Portugal), aiming to assess its functioning following a management measure implemented in this system. In particular, the response of benthic assemblages to restoration efforts was investigated over a five-year period, testing for temporal differences before and after management, in order to assess the effectiveness of this recovery action.

BTA revealed to be a useful approach providing valuable information on the functioning of the subtidal benthic communities. Overall, results suggested that there have been some changes in the ecosystem over the study period, although the success of the management measure at the benthic functional level revealed unclear. The climatic variability experienced in the estuary over the monitoring period seemed to have played a significant role in masking the potential effects of restoration. Furthermore, evidence suggested a possible persistence in the benthic functioning despite the occurrence of shifts in taxonomic composition, assured by the potential ability of different species with a similar set of traits to perform similar roles in the ecosystem.

To best of our knowledge, this study constituted one of the first attempts to investigate the effects of a management measure in an estuary by means of Biological Traits Analysis. Thus, it can thus be useful as a guideline for further management actions in the Mondego estuary extendable to other poikilohaline estuaries as well, and to provide insights on the BTA application to this type of ecosystems.

Biotic and Abiotic Controls on Sediment Aggregation and Consolidation: Implications for Geochemical Fluxes and Coastal Restoration. Land, L. E., A. S. Kolker, and R. P. Gambrell. 2012. *Marine Environmental Research* 79(1): 100–10.

Abstract

This study examined the influence of particle size and organic matter on aggregation and compaction of three hydraulically dredged sediments from coastal Louisiana (clay, silt loam, sandy loam) saturated under a range of salinity regimes (1 and 5 PSU, 5 and 10 PSU, and 15 and 25 PSU) for four time periods (1, 8, 16, and 26 weeks). Particle sizes were determined using a laser diffraction particle size analyzer, which allowed us to develop high-resolution results indicating changes in aggregate size across a spectrum of experimental conditions. The sediments with greater organic matter content exhibited approximately 60% aggregation, as indicated by fewer aggregates in the clay size fraction, and subsequently more aggregates in the sand size fraction, when organic matter remained in the sediment. Additionally, the sandy sediment compacted more than the organic sediments in the first sixteen weeks. These findings suggest that sediments with greater clay and organic matter content behave as larger particles and may undergo particle rearrangement and compaction over longer time scales than sandy sediments with low organic matter. For coastal wetland restoration, models should include the effect of organic matter on particle aggregation to understand sediment dynamics over geologic time.

A Methodology for the Classification of Estuary Restoration Areas: A Management Tool. Jimenez, M., S. Castanedo, R. Medina, and P. Camus. 2012. *Ocean & Coastal Management* 69(1): 231–42.

Abstract

Planning the recovery of estuarine areas represents a major challenge for environmental managers, who must find a balance between the desired environmental restoration, understood as the return to natural conditions, and the different socioeconomic uses currently borne by the estuaries. This work presents a methodology for optimizing decision-making in accordance with the objectives that might arise in projects for the hydrodynamic restoration of estuaries. Socioeconomic issues are not considered in this study. The new approach is based on a classification of the zones to be restored according to characteristics representing their hydrodynamic performance and the possible morphodynamic effects of the restoration on the rest of the estuary. To achieve this, the four following parameters were chosen: (1) changes in tidal prism induced by restoration of that zone ($\Delta\Omega$), (2) the distance between the concession and the estuary inlet (L), (3) the tidal wave phase lag (□), and (4) the flood potential of the restoration area (I). The classification combines self-organizing maps (SOM) and the K-means algorithm. The methodology was applied in a total of 139 areas (concessions) on ten estuaries along the entire coast of Cantabria (northern Spain) where a Spanish Ministry of the Environment Recuperation Plan is under way. The results classify the 139 areas of restoration into five clusters. Empirical relationships were used to estimate the effects the restoration of each cluster may have on the estuary's various morphodynamic elements (cross-sectional area of the estuary mouth, area of tidal flats, volume of tidal channels, and volume of the ebb tidal delta), giving managers an overall view of the potential effects of the restoration in each zone and providing a basis on which to plan these actions.

URBAN RIVERS

Some Simple tools for Communicating the Biophysical Condition of Urban Rivers to Support Decision Making in Relation to River Restoration. Shuker, L., A. M. Gurnell, and M. Raco. 2012. *Urban Ecosystems* 15:389–408.

Abstract

This paper illustrates a set of simple tools that may be used to assess and communicate the biophysical condition of river and riparian habitat in urban catchments. The tools are based upon information collected using the Urban River Survey (URS), a habitat survey designed for application to 500 m stretches of urban river corridor, and comprise (i) a series of aggregate indices, (ii) three classifications relating to the materials, habitat, and vegetation characteristics of urban river stretches, which contribute to an overall score, the Stretch Habitat Quality Index (SHQI), and (iii) two environmental gradients that define a URS matrix of engineering:habitat associations. This toolkit may be used to gather and exchange knowledge about urban river habitat quality to a wide range of specialist or nontechnical stakeholders and local community members. It may be used to provide information at the catchment and reach scales to support stakeholder discussions and decision making relating to initial site selection for restoration works, to post project appraisal, and to track changes in river character across space and through time. Example applications of the tools are provided using URS surveys undertaken on tributaries of the River Thames within London in comparison with an archive of previous surveys from three other urban river systems. These tools are being validated in London as part of a larger interdisciplinary research project that is testing the suitability of this type of approach in the context of the London Rivers Action Plan, Water Framework Directive, and urban green space regeneration.

Rediscovering the Value of Urban Rivers (Review). Everard, M., and H. L. Moggridge. 2012. *Urban Ecosystems* 15:293–314.

Abstract

Rivers commonly serve as defining, founding features of human settlements, yet urbanization has degraded them, often to the extent that they no longer provide the services to society from which the settlements developed. Urban river restoration has expanded in recent years, and part of this can be attributed to the increased recognition of the interconnected benefits that restored ecosystems can provide to society. This paper reviews the impact of urbanization on rivers and the ecosystem services that they provide, and explores the ecosystem approach to restoration. Techniques and tools for the practical application of the ecosystem services approach in conservation are considered, with reference to case studies. There is a need to internalize ecosystem service insights into pragmatic, transparent, and readily used and understood planning tools, based on the capacities of a range of ecosystem services in river corridors. This is necessary if we are to avoid the continued erosion of critical resources such as rivers, rediscovering their multiple values to society, and to accelerate the translation of these sustainability concepts into applied tools.

Riparian Habitat Assessment Tool for Lebanese rivers (RiHAT): Case Study Ibrahim River. Abboud, M., J. Makhzoumi, C. Clubbe, R. Zurayk, S. Jury, and S. N. Talhouk. 2012. *BioRisk* 7:99–116.

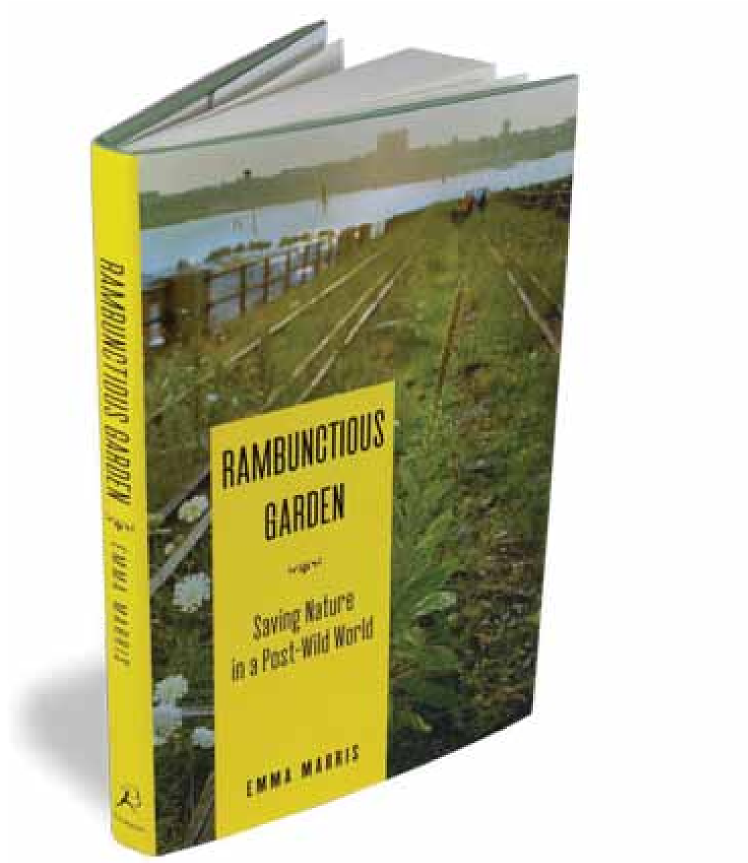
Abstract

Biodiversity conservation in Lebanon ought to be guided by practical assessment tools in order to promote conservation efforts amid destructive and profit-driven urban and industrial expansion. The challenge for national conservation scientists, however, is to develop such tools while reconciling between scientific "rigor" and pressing national realities. Those include rapid habitat loss, limited human and financial resources, and the fact that biodiversity is a low national priority compared to other social, political, and economic issues. It is in this context that we propose a rapid management strategy guide based on a habitat assessment tool for riparian ecosystems (which are typically threatened in Lebanon). The proposed riparian habitat assessment tool (RiHAT) consists of a habitat condition index based on twelve indicators grouped under two attributes, floristic and landscape.

BOOK REVIEW

RAMBUNCTIOUS GARDEN: SAVING NATURE IN A POST-WILD WORLD

BY EMMA MARRIS
REVIEW BY MELINA SEMPILL WATTS



Ms. Marris so enjoys attacking sacred cows that she is disparaging of past icons such as Thoreau, while promoting newer leaders, such as Douglas Kent, who suggests a lawn in Southern California would be better paved over. This kind of scattershot approach to a huge array of ecological concerns makes for troubling reading: Effective environmental restoration is our best hope for the future, not a parlor game.

This book could have been a great review of the wildly disparate strands of endeavor in the field of ecological restoration and environmental science; instead, the book chaotically advocates for some of these practices and ideas over others. Despite the glowing reviews on the back book cover, long-time reporter for *Nature* Ms. Marris is in danger of falling into this dire category of public writing practiced by junior film critics who mistake being scathing for being brilliant. Talking smack about Thoreau, Grinnell, and the Leopold Report, each a keystone to subsequent conservation efforts, just seems adolescent.

Reflecting on environmental change over epochs and on the increasing knowledge we have about human impacts on nature in every era, Ms. Marris questions the concept of ecological baselines, and then questions current approaches to environmental restoration and even the value of the effort itself.

On the plus side, Ms. Marris is an advocate for the idea that nature is everywhere, even the sidewalks of New York City and has covered a number of interrelated stories that are going to change how science is done in years to come. Thus, *Rambunctious Garden* is best seen as a launching pad for the release into the public/academic wild of new biological vocabulary.

Things you need to know from *Rambunctious Garden:*

Rewilding: Dave Foreman in the mid-1990s suggested recreating damaged or obliterated ecosystems by the use of **proxy species** to replace extinct species, such as using Heck cattle as stand-ins for Aurochs. **Pleistocene rewilding:** "In 2004 thirteen scientists and conservationists, including Paul Martin, Michael Soulé, and David Foreman met at broadcasting mogul Ted Turner's ranch in New Mexico to discuss the idea of bringing proxies of extinct megafauna back to North America." This means elephants, lions, and cheetahs.

Novel Ecosystems

To quote Ms. Marris: "Novel ecosystems are defined by anthropogenic change but are not under active human management. Some were intentionally altered by people . . . Others were never systematically altered but have been changed by humans from a distance, by the encroachment of introduced species, by climate change, by extinctions, and by a grab bag of other forces . . . novel ecosystems are now more common than intact ecosystems." In *Ecological Monographs,* novel ecosystem advocate Ariel Lugo, found the understory in plantations in Puerto Rico were "richer in species, had greater aboveground biomass, and used nutrients more efficiently than the native understories."

Worth further exploration: Erle Ellis has mapped out **anthropogenic biomes** that show cities, agriculture, suburbia, and natural biomes, creating reality-based assessments of current natural systems, including novel ecosystems. Marris says he finds: "75 percent of the world's ice-free land "showed evidence of alteration as a result of human residence and land use."16 Twenty percent of the world's ice-free land is cropland; a third is rangeland. Just 22 percent shows no sign of human."

Marris says that Hawaiian scientist Mascaro "realized that as an ecologist … he had to let go of the values he had picked up during his training about "good" and "bad" species and ecosystem "health" or "proper functioning." She says: "What he saw, suddenly, was that without this value system in place, his "novel" ecosystems and "native" ecosystems were virtually indistinguishable."

Marris posits: "More than sickly ecosystems nursed by park rangers, novel ecosystems are really wild, self-willed land with lots of evolutionary potential." As someone who lives next to Malibu State Park and who walks through abandoned city lots to see what is growing there, this statement just sounds horrendously off.

Assisted migration: The idea is to resist the devastation of climate change by moving species to cooler locations. Do we move out current species to make room for incoming species? Would this promote additional invasive species? While scientists debate the ethics, the impacts, the practicality, or lack thereof, to this approach, Marris introduces Connie Barlow, who has been replanting *Torreya taxifolia,* or Florida torreya, outside its historic range on private property. Meanwhile, foresters in British Columbia lead by forester Greg O'Neill are conducting a decades-long experiment in moving species to provide trees with a better shot at survival in the face of climate change—and to help a billion-dollar business to continue. With two hundred million seedlings planted annually, Sally Aitken, University of British Columbia in Vancouver, asserts: "Reforestation is one of the only ways that you could accomplish assisted migration on a large scale."

Researchers find that gardening is resulting **in unintentional assisted migration on a large scale.**

In her own chapter, "Learning to Love Exotic Species," Marris asks: *"What happens to the concept of 'invasive species' if you fold humanity back into nature and consider us just another way species move around, along with migration and ocean currents? Presto change-o, it disappears."*

Although this approach allows for a creative exploration of positive interactions between incoming species and native species, this cheerful reinterpretation of reality negates the impacts of cats, rats, snakes, and goats on islands, of anacondas on Florida, of lionfish on the Atlantic seaboard. She admits that lakes and islands are subject to horrific effects by invasive species but in general supports the **reckless invader hypothesis,** which posits that after eighty years or so, ecosystems integrate invaders and things fall back into balance. Really?

Land-sparing Strategy

While noting the integration of nature-preservation with farming in Europe and efforts by Natural Resources Conservation Service/ Resource Conservation Districts for conservation strategies on farming land, she pushes the concept of land-sparing strategy, which posits that it is better to do intensive conventional and factory farming and leave open space natural when possible, rather than focusing on working landscapes. Again, really?

Designer Ecosystems

Arguably designer ecosystems are as old as human settlements in the Amazon, where tribal peoples created "black lands" or *terra preta do Indio,* from trash heaps, broken pottery, and charred forest, to grow food plants in richer soils.

Creek, stream, and river restoration experts are more comfortable with designer ecosystems because hydrological systems change over time. An intriguing example of this is the Duwamish River Cleanup Coalition, which is creating an "eco-industrial vision" for the river.

More radical versions of designer ecosystems are promoted by René Dubos. Marris says, "Dubos envisioned a flourishing world covered in managed nature designed to support humans and other species."

Island Civilization

Marris describes: "Historian Roderick Nash, in the epilogue to his seminal survey of American attitudes toward wilderness, sketches out a similar future. He calls it the 'garden scenario' in which 'human control of nature' is both 'total' and 'beneficent.' He continues: 'The fertility of the soil is well maintained; carefully managed rivers flow clean and pure.'" This becomes: "the 'Island Civilization' alternative, wherein humans retreat to very dense cities, voluntarily limit their own population, and let the rest of the planet run wild."

Marris promotes her concept, **rambunctious gardening,** which posits that since all of nature is influenced by people, we may as well choose to define it by proactive interface. Her intermittent willingness to jettison many restoration and preservation goals while she laments shrinking biodiversity is maddening, but the book is worth reading for exposure to new ideas.

Melina Sempill Watts is the Santa Monica Mountains Watersheds Coordinator with the Resource Conservation District of the Santa Monica Mountains.

PHOTO: DYLAN MCDANIEL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