San Francisco Estuary Partnership

ESTUARY NEWS

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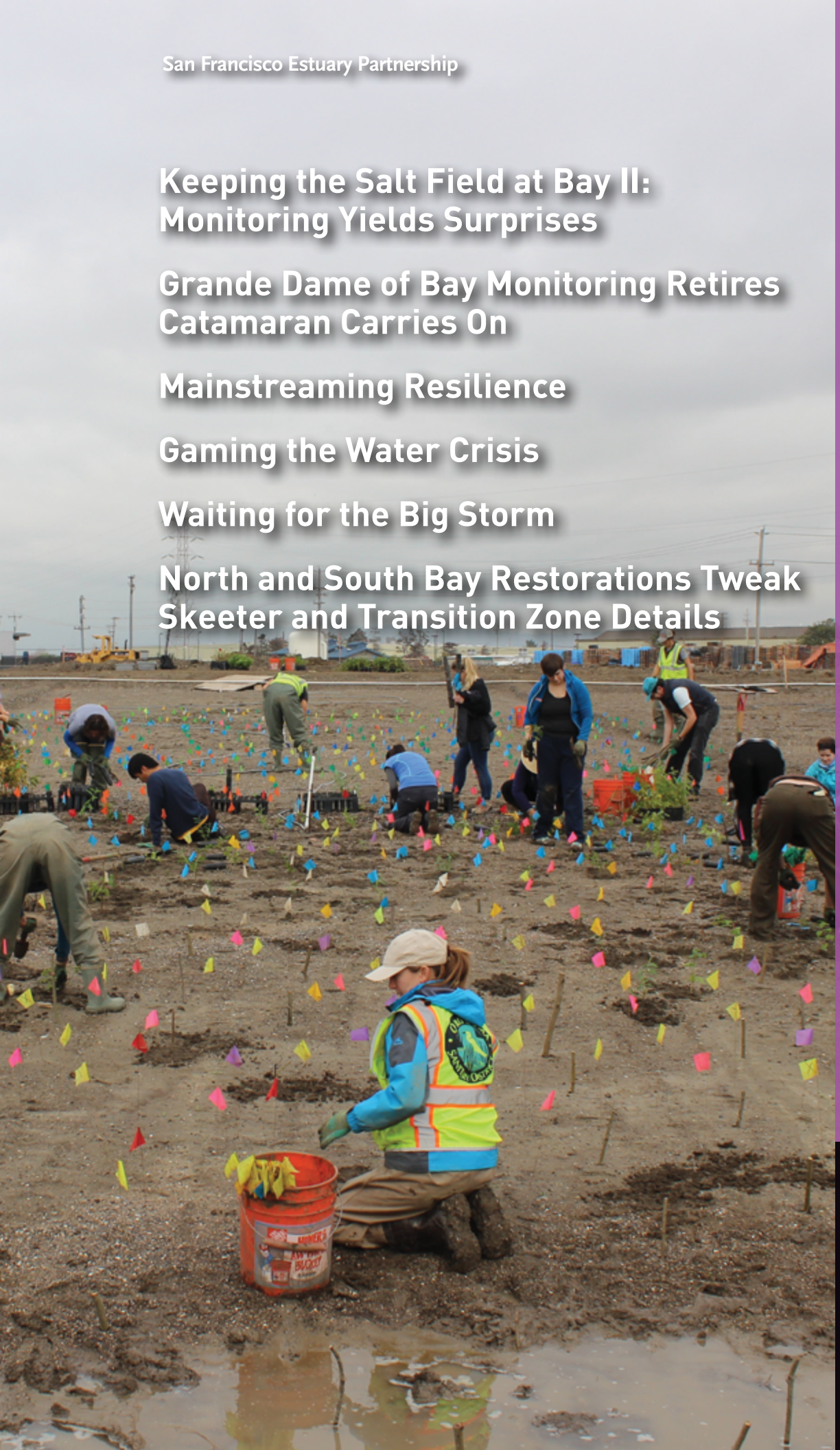

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OPINION

Vote for Bay Beauty & Safety

KATHLEEN M. WONG
SCIENCE WRITER

As the icecaps melt and the seas rise, the Bay Area and its densely populated communities face a momentous choice.

In one scenario, it could carry on as usual, adding incrementally to the muddy necklace of wetlands that ring its shores. In due time, this option could commit our region's cities to erect ugly walls between themselves and the Bay. These shoreline barriers would be every bit as engineered and pricey as Hoover Dam.

In an alternative scenario, we citizens could vote to approve a $12 per parcel tax this June 7. On the ballot in all nine Bay Area counties, Measure AA for a Clean and Healthy Bay would not only provide comparable protection against flooding but also result in a healthier Bay with a softer, spongier shore. Administered by the San Francisco Bay Restoration Authority, a regional government agency established to enhance the Bay's wetlands and wildlife habitat, the funds would raise more than $500 million over 20 years. Make no mistake—without Bay wetland restoration on this scale, no amount of high-dollar engineering will be enough to protect the doorsteps of Delta residents and Google from the ocean in tomorrow's warming world.

When the late Sylvia McLaughlin helped launch Save the Bay in 1960, infill had reduced the acreage of the Bay by nearly 240 square miles, marsh birds languished for lack of habitat, and urban development, diking, and salt pond construction had decimated tidal wetlands by more than 85 percent.

In the intervening decades, environmental organizations have made tremendous progress adding to these remnant acres of historic wetland. With backhoes and pipes spewing dredge spoils, people have learned to reconnect salt ponds to estuary waters, raise subsided hayfields above the tides, and repopulate marshes with rare wetland plants.


Photo: Rick Lewis

This work has transformed the Bay from a place to avoid into a treasured destination for swimming, birding, and hiking. The Carquinez Strait, the wetlands just west of the new Niners stadium, and the formerly polluted Emeryville mudflats draw picnickers and bikers to enjoy darting flocks of sanderlings and breezes fresh from the Pacific.

Even so, the tally of tidal wetland acres now stands at just 44,000. Raising that number to 100,000 acres, as recommended in the *Baylands Ecosystem Habitats Goals Report* of 1999, will be the measure's prime directive. That's because wetlands are not only critical for declining regional species, they're also key to keeping Bay Area shorelines dry and buffering us from big storms.

The enlarged marshes will attract scores of wildlife, from the pickleweed-dependent salt marsh harvest mouse to the gawky, squawky Ridgway's rail. Broad, gradual levees on the landward side of the marshes will offer upland habitat for wildlife looking to shelter in storms. Expanded trail networks through the new wetlands will let residents experience the muddy glory of it all.

A Bay once hemmed in by more than 20 municipal trash dumps also will have far less pollution floating through it. Garbage interceptors will be installed along waterways to trap much of the detritus that so often collects on urban shores.

To make this greener Bay come true, we must act today. Newly established wetlands will need decades to accumulate enough fine sediments to stay above water level. Plenty of restoration projects, ranging from Oakley to Palo Alto, are planned, ready to go, and await only funding.

Evidence of the value of wetlands surrounds us—in the form of stunning views from atop Mission Peak, avocet chicks toddling off nests at Hayward Regional Shoreline, and the silver shine of fishes pulled from Bay piers. Grow that vision for the future, and vote for Measure AA.

NORTH BAY

Watershed Pow Wow
April 22

The mid-March spate of storms hit the North Bay hard, and water managers throughout the region watched closely to see how newly restored creek channels, flood plains, and wetlands would respond, and how fast reservoirs would fill up. Improving the region's ability to forecast and respond to major storm events will be one topic discussed at an April 22nd conference in Napa sponsored by the North Bay Watershed Association. Other timely topics include the latest on new projects and plans for water recycling; funding tips for shoreline restoration projects that benefit flood management along with habitat improvement; and state groundwater rules. Keynote speakers include State Senator Lois Wolk and Assemblymember Marc Levine. A wine reception will top off the one-day conference at the Embassy Suites Hotel in downtown Napa. Details and registration information: www.nbwatershed.org

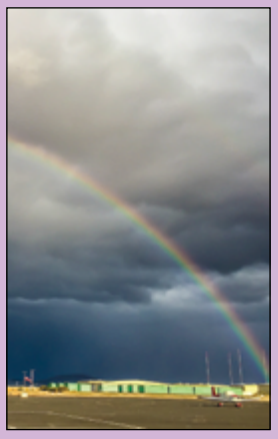
Photo: Bird's Eye View

HYDRODYNAMICS

Keeping the Salt Field at Bay II

After four of California's driest years on record, the rain we've gotten this winter is hardly a drought buster. But it's still a relief. Just a year ago, our "wet" season was so dry that state water officials panicked.

Major reservoirs were drawn way down, and record-low snowpack would limit replenishment to a trickle. Water managers worried about the hot, dry months. Would reservoirs still hold enough for freshwater releases to keep saltwater from pushing deep into the Sacramento-San Joaquin Delta, contaminating water supplies to cities and farms? So they built a barrier to block salt instead.

Late last spring, when all hope of snow was gone, the state Department of Water Resources (DWR) dropped 150,000 tons of rock across the West False River in the heart of the Delta. Salt barriers are not new. The state first built them in the Delta during the mid-1970s drought — two in 1976 and six in 1977 — and came close again two years ago. "We thought about installing a drought barrier in 2014 but then it rained," says Eli Ateljevich, a water quality modeler with DWR. "2015 was more urgent. It was full of unpleasant surprises, like even when it rained not much was getting into reservoirs."

While barriers are nothing new in the Delta, last year's approach was. Rather than the multiple barriers used before, modeling suggested that a single obstruction would be less disruptive to fish habitat while still being enough to protect water supplies. With all the waterways that thread the Delta, it may come as a surprise that blocking just one could keep the salt at bay. But the West False River is effectively all that stands between the tides and the pumps at the southern end of the Delta. "It's the biggest, most direct channel for getting salt down toward the pumps," Ateljevich says. "Other routes are smaller, more meandering."

West False River is the entrance to Frank's Tract, a flooded island in the middle of the Delta that looks like a lake. "During drought, salt starts moving in and laps its way up to Frank's Tract, and then the vigor of the tides injects it in," Ateljevich says. And from there, it's just about as close to a straight shot south as you get in the Delta — and water can take several routes. "Once salt makes it to Frank's Tract, there's no way to control it and keep it away from the pumps," he adds. "The drought barrier was an insurance policy."

One that we needed, it turned out. In the summer of 2015, salt levels just west of the barrier climbed as high as Ateljevich has seen since they've been intensively monitored. But inside Frank's Tract, salt levels held steady and even dropped a bit. "Salt would have been just shy of twice as high without the drought barrier," he says. "I'd give it an A+ for preventing salinity intrusion." That said, he says there's room for improvement: "I'd have liked the water to get fresher faster." One way to make that happen in the future would be to get the barrier in before the salt intrudes so far into the Delta.

DWR reports that by keeping salt out of Frank's Tract, the barrier helped us keep about 29 billion gallons in upstream reservoirs, instead of releasing it to flush out the Delta and keep the water drinkable and fit for farming. This much-needed water helped stretch supplies for people and fish until the next rains.

The barrier also provided a deeper look into the inner workings of the Delta. "We don't often do these kinds of grand experiments on water flow and the ecosystem," says Sam Harader, a manager with the Delta Stewardship Council's Delta Science Program. So he and other Delta experts put their heads together to brainstorm likely impacts of the barrier. Then the program funded studies to see what actually happened.

Questions included whether altered flows would affect phytoplankton growth, and whether the barrier would restrict zooplankton — which the endangered Delta smelt (*Hypomesus transpacificus*) and other fish eat

continued to back page

False River emergency salinity barrier. Photo: Bird's Eye View

COORDINATION

Do the Pieces Fit?

Reporter John Hart previews his assignment for ESTUARY

This summer, the San Francisco Estuary Partnership publishes its new *Comprehensive Conservation and Management Plan* (CCMP) for the Bay-Delta Estuary. That word "comprehensive" stakes quite a claim.

Photo: Rick Lewis

If the CCMP is the closest thing we have to a master vision for the future of these waters in the era of climate change, it is also just one in swarm of plans and planning efforts purporting to shape that future. How do they all get along?

How does the CCMP fit in with the *Bay Area Integrated Regional Water Management Plan* or the *Bay-Delta Water Quality Control Plan*? Does it mesh with the *Bay Plan* and the *Delta Plan*, not to mention the *Delta Land and Resource Management Plan*? Is it on the same page with *Plan Bay Area* and California EcoRestore? What about California WaterFix and the *California Water Action Plan*? For the non-initiate, the contours of the cause can disappear in a cloud of organizations and acronyms and abstractly titled calls to action.

Are these people talking to one another? Do their ideas add up to one way forward, or tug in opposing directions? Do the pieces fit?

Some fit quite well, in fact. Some distinctly don't. And some, perhaps compatible, have yet to be measured against one another.

On assignment from *Estuary News*, I am delving into these matters for a longer piece to be published online.

In the process of my research, however, I have already encountered the profound divide that still separates efforts concerning the Lower Estuary — otherwise known as San Francisco Bay — and those relating to the Upper Estuary — otherwise known as the Sacramento-San Joaquin River Delta. (The Suisun Bay region, in between, is a zone of institutional overlap.) The Estuary Project covers all three, and the forthcoming CCMP says more than its predecessors did about Delta matters. Still, the 34-member CCMP Implementation Committee is heavily weighted toward "downstream" interests. Planners in both regions acknowledge the need to work together more closely. I'll attempt to ascertain how well they are doing.

In the Lower Estuary, the years since launching of the Estuary Project have brought remarkable results. The first CCMP, in 1993, called for vast wetland restorations around the lower bays; a series of follow-on reports spelled out the science and the details. The San Francisco Bay Joint Venture, created in 1995 and funded by the Fish and Wildlife Service since 2001, has taken the lead in making restorations happen. Another consortium of agencies cleared the way for the use of dredge mud in building up subsided wetland soils. Now, with the job about half done, attention turns to the challenge of sea level rise and the integration of wetlands into a regional system of flood control and water recycling. A new focus on watersheds intersects with local government land use planning. There are new pieces needing to fit.

In the Upper Estuary, the road to coordination began later, one might say in 1992, with the creation of the Delta Protection Commission; in 1994, with the hope-filled launch of CALFED; or in 2009, when the Delta Reform Act set up the Delta Stewardship Council and the Delta Conservancy.

As I explore the interaction of these agencies, one thing is already clear: coordination is hard upstream because fundamental decisions involving statewide interests here have yet to be made. While the Council and Commission have certain authorities, especially in land use, neither has much power over the Delta's uneasy role as the hub of the state's water plumbing. The rules here are written by the likes of the Department of Water Resources, the State Water Resources Control Board, and often the courts.

Thus one huge factor in the estuary's future — the supply of fresh water from inland rivers, the very thing that makes this an estuary, not a bay — is out of reach of the new *Comprehensive Conservation and Management Plan*. Clarity here must wait for the State Water Board, which has just embarked on the long-delayed revision of its *Bay Delta Water Quality Control Plan*. The board has already confirmed that the ecosystem needs much more water than it is getting. Now comes the fateful balancing of needs that will yield the actual rules. Concerning this enormous factor in the future of the estuary, the Estuary Partnership can only educate and advise.

Read the results of my investigation into how all Bay and Delta initiatives overlap and integrate, or not, online no later than March 31 at www.sfestuary.org/estuary-news

F A S H I O N

Mainstreaming Resilience

Whatever the "perturbation" coming our way — a flood, a drought, a weed or Donald Trump — our recovery, in the aftermath, depends on something ecologists call resilience. It's a term everyone is pasting onto their management initiatives these days — resilient landscapes, resilient shorelines, resilient water supplies, neighborhoods, infrastructure... But what exactly does it mean, and how is it different from other fashionable buzzwords that have galvanized Californians into thinking about the future?

"It's not a replacement for the still very valid goals of 'restoration' and 'ecosystem health,'" says Marilyn Latta of the State Coastal Conservancy's Living Shorelines Project. "It's about [visualizing] those concepts through the lens of climate change." From this perspective, she says, resilient refers to natural habitats being as strong and robust as possible (in terms of ecosystem structure, functions, and services) as soon as possible in order to best withstand stressors such as changing temperatures, freshwater regimes, and sea level rise over the long term.

"Like adaptive management, it's become somewhat of a holy grail: manage systems for resilience and they'll be able to absorb all the stresses we throw their way," adds John Wiens, a member of the Delta Stewardship Council's Independent Science Board. "What's not obvious is how one should go about enhancing the resilience of a system, except perhaps by fostering diversity or not putting all one's eggs in one basket. Sounds good, but the devil is in the details."

Even after half a dozen interviews and numerous papers explored to write this story, the details on the actual characteristics of resilience are still fuzzy. The fuzziness is both a strength (in terms of universal appeal and application to everything from hedge funds to emergency preparedness) and a weakness (in terms of the lack of a way to measure it scientifically, not to mention some ambiguity about the desirability of any status quo we are trying to make resilient, such as the current Delta).

Officially, definitions of resiliency range from the social — the capacity of individuals, communities and systems to survive, adapt and grow in the face of stress or shocks — to the ecological — the amount of disturbance an ecosystem can withstand without changing self-organized processes and structures.

Unofficially, it's touched on by this water conservation fable from the US Geological Survey's Jim Cloern: "Trying to be a good citizen, I replaced my back lawn with artificial turf. After it was installed, the blades stood tall and from a distance kind of looked like grass. After a year of my lab racing across the plastic grass the blades are bent over, matted down, and I don't know how to get them to stand upright again. Artificial turf is not resilient because it doesn't return to its original state after a perturbation (her name is Bella)."

"The whole notion that a system can bend but not break is comforting," says Wiens. In a new book called *Ecological Challenges and Conservation Conundrums*, out this April, he uses real grass in bigger patches than Cloern's backyard as an example: "A grassland that is moderately grazed may change in some details of species composition and nutrient cycling, but if grazing is stopped it can return, in time, to something approximating its basic function and structure ... Grazed too heavily, however, the system may be so degraded that it cannot recover — a threshold has been passed and the system moves to an alternative state, such as a shrubland or barren desert. Its resilience has been exhausted."

"If you think about resilience as how well systems can absorb and recover from impacts, you can actually use that criteria across all kinds of sectors," says Maggie Wenger, a climate planner with the San Francisco Bay Conservation and Development Commission's Adapting to Rising Tides Project. "Whether I'm thinking about a marsh or a park or a human community or a highway, resilience is a [useful planning] bar."

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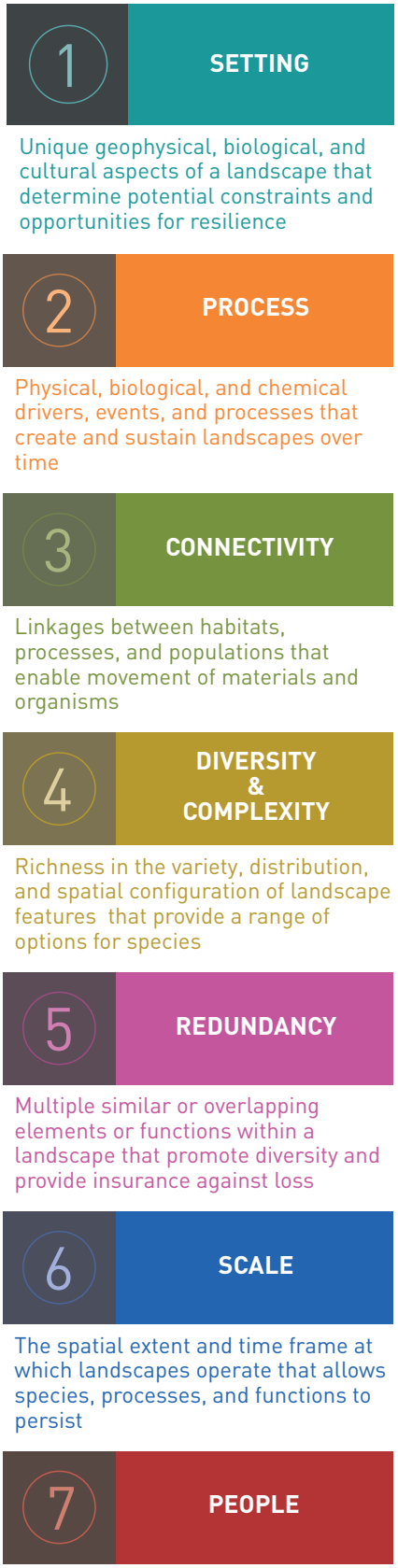
Seven Resilience Principles



Resilience principals described in the Landscape Resilience Framework. SFEI, 2015. Graphic: Ruth Askevold

MONITORING

Bay Belle Retires, Catamaran Carries On

Side by side at a Redwood City marina, two vessels await their very different destinies. The Research Vessel *Polaris*, a classy 96-foot yacht, was built in 1927 as a pleasure craft for a Los Angeles tycoon. Beyond a few streaks of rust, her age isn't showing. After a series of owners, she spent decades as the workhorse of the US Geological Survey's San Francisco Bay science program, carrying researchers on transects across the Bay and into the Delta. Much of what we know about how the Estuary works—the effects of freshwater flows, sediment pulses, pollutants and pollution controls, invasive species and changing food webs—comes from sampling done from the ***Polaris***. Recently enrolled in the National Register of Historic Places, the boat was retired last year when repairing her many leaks got too costly. She will be sold at auction. Meanwhile her successor floats next to her in the Redwood City marina. The USGS rechristened this 67-foot aluminum catamaran the *RV David H Peterson* for the late oceanographer. Once she's refitted and the *Polaris*' equipment transferred over, the *Peterson* will carry Bay science into the future, extending the dataset that is a legacy of the ***Polaris***.

The *Polaris* was custom-built for attorney and financier Lee Allen Phillips in 1927, originally christened *Pasada Mañana* ("Get Around to It Tomorrow"). The Wilmington Boat Works used oak timbers, Douglas-fir planking, teak for the decks, mahogany finish for the cabins.

As executive vice president of Pacific Mutual Life Insurance, Phillips had a hand in the construction of the Biltmore Hotel in Los Angeles, and the draining of the Cienega wetlands. As president of California Delta Farms, he oversaw the conversion of over 100,000 Delta acres to agriculture, including the Jones and Rindge Tracts and King, Bacon, and Bouldin Islands, collaborating with George Shima, a Japanese immigrant known as the Potato King. Much of the acreage was leased to Chinese- and Japanese-born farmers. Phillips took the *Pasada Mañana* into the Delta to inspect his properties and on duck-hunting trips, and to sea after marlin and swordfish off Catalina Island. She was also a "floating hotel" for visiting VIPs like Winston Churchill and Herbert Hoover.

After Phillips' death in 1938, his widow sold the *Pasada Mañana* to oil executive John Grant. The Army acquired the vessel during World War II to move troops around Puget Sound. A postwar owner, Alaska Charters, rechristened her the *Polaris* before selling her to Ken Bechtel in 1959. Bechtel donated her to the University of California. Byron Richards, her long-time skipper with USGS, was told that every time she left UC's Richmond berth, "something broke." In 1966 UC sold the vessel to the USGS for $4000, and she became part of the agency's Pacific-Alaska Marine Geology Program.

Monitoring instruments lowered into the Bay at 36 Bay-Delta stations from the Polaris.

The *Polaris* took her first Bay cruise in the late 1970s, initially for marine geologist David McCulloch's seismic studies, then branching into water quality work. "It's amazing how little we knew about the Bay in the late 60s," says biologist James Cloern, who heads the USGS water quality sampling program. "Fundamental discoveries were made from the *Polaris* that couldn't be made any other way; some were used to shape environmental policies." Aboard the *Polaris*, young oceanographers from the University of Washington —John Conomos, Fred Nichols, Bill Broenkow, and Dave Peterson — launched the modern era of Bay science.

Back then, there were questions about the condition and health of the Bay that not everyone wanted answered. Officials in Sacramento tried to shut the nascent program down; one reportedly cautioned that water was a political issue, not a scientific one. Some federal agencies were also hostile. "They warned us against pursuing the research, threatened our jobs," recalls Conomos, now retired. USGS director William Pecora was not intimidated. "Our agency didn't back down," says Conomos. "They supported us completely and we kept our funding."

Early on, the *Polaris* had some old-school skippers who didn't always see eye-to-eye with the scientists. Then Byron Richards, who grew up on the Bay ("My younger brother and I lived on the water") and graduated from the California Maritime Academy, got the job in 1980. "Byron was a gift from God, the heart and soul of the *Polaris* and the field data collection program," says Conomos. Cloern calls him "a treasure to work with." For Tara Schraga, lead scientist for the water-quality cruises, Richards was "a stellar captain who cared deeply about the program, always fixing, fabricating, and making sure we got the science done." Richards insists *Polaris* engineers Jim Robello and Scott Conard deserve credit for the program's success as well.

Richards found "a lot of stuff jury-rigged," he recalls. He helped put the *Polaris* to rights and restored something of her former glory, stripping 13 coats of paint from the salon, down to the original mahogany: "The Army had painted it white; later somebody painted it baby-shit yellow, then green like the cells in San Quentin."


Photo: Francis Parchaso

He discovered a unique prohibition-era feature in the mid-80s: two copper tanks behind a false wall in the main cabin. Chris Morrison, Phillip's grandson, confirmed that there had been spigots on the after bulkhead for the cocktail hour.

The *Polaris* has carried generations of scientists. David Schoellhamer, a sediment specialist, visited her "as a little kid" when his father Jack managed the marine geology program. Cloern first saw her on a PBS "Nova" episode when he was in graduate school. "I thought, 'What a great job,'" he remembers. "Six months later I was working with the USGS scientists." He and others later brought their own PhD candidates and post-docs on board.

The cruising routine evolved as new equipment became available. Leaving Redwood City, the *Polaris* would visit 36 stations along an 80-nautical-mile transect from Alviso to Rio Vista to sample water quality, at first with a sump pump to on-board instruments, later with sophisticated conductivity, temperature, and depth sensors dropped over the side. A new group of scientists would come aboard at Rio Vista and collect clams and other benthic organisms from the mud on the return voyage. A 17-foot Boston Whaler was deployed for shallow-water work. Sometimes the *Polaris* returned to her first owner's old Delta stomping grounds, up the Sacramento and Cosumnes rivers.

The data they collected was used to shape the X2 standard (for an indicator of the North Bay's salinity gradient) and California's marine invasive species act, and will influence the pending chlorophyll standard. "Measurements before and after urban sewage treatment programs were in place document successes of the Clean Water Act," says Cloern. "From *Polaris* data, we've learned a lot about how invasive species like the Asian clam have affected San Francisco Bay, and how oscillations of climate systems have caused big changes in the Bay's biological community."

"This may be the longest-running continuous monitoring program in the US," Schraga says. "Every single data point we've ever collected is available online," Cloern adds. "The site gets half a million users a year from 73 different countries."

It wasn't all routine sampling. Francis Parchaso, who runs the benthic sampling program, remembers a squall in San Pablo Bay with wind-driven waves breaking over the boat, and being stuck on a sandbar in Three Mile Slough waiting for a tidal assist. Schraga recalls dodging floating trees during the 1998 El Niño. The *Polaris*, for all her splendid qualities, had a tendency to roll. Leaving Redwood City, Richards once warned: "If there's anything you don't want, leave it on the counter."

After 29 years as master of the *Polaris*, Richards retired in 2009, and Joel Fritsch, another Maritime Academy graduate, took the helm. He was accustomed to huge dredge ships: "She handled a lot differently. She was built for luxury, not for maneuverability." He did his best to keep her floating but "water was coming in at all the seams."

The *Polaris* made her last cruise in May 2015 as the oldest working vessel in federal service. She'll be sold at auction, with online bidding. Assistant branch chief Deborah Stoliker says the purchaser will be legally required to maintain the boat's historic character.

The *David H Peterson*, built in 2000, is a former Alaskan state police patrol craft. Stoliker anticipates that the refit for the vessel will be completed within the next six months, with the work done locally. There's no crane, so she can't carry the smaller Boston Whaler like the *Polaris* did. All of the *Polaris*' scientific equipment will be transferred to the *Peterson*, and an Imaging Flow CytoBot will be added for monitoring phytoplankton. The scientists have a wish list for new gear, and hope it matches the agency's budget. Stoliker promises the new boat "will be able to do everything we could do on the *Polaris*, but more efficiently." Fritsch, who has taken the *Peterson* out for sea trials, calls her "a nice-handling, good solid boat that will bring USGS into the future and be able to adapt to changing science."

Cloern stresses the need for local support to keep a research boat on the Bay: "It's not the mandate of USGS to do this work, it's individual scientists' research programs. We need local and state funding to keep it going. It's unimaginable to think about stopping." **JE**

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See extended story online www.sfestuary.org/estuary-news

POLLUTION

Waiting for the Big One

If and when El Niño decides to dump a big storm on the Bay Area—even at 2:00 am on a Saturday night — SFEI's Lester McKee and Alicia Gilbreath and their team are ready to pull on their parkas and dash out to take water samples.

Last September, stakeholders in the Regional Monitoring Program decided they would be remiss if they did not try to measure some high priority pollutants during an El Niño year. "With plenty of data for normal years, it was important to get data from a more extreme year," says Phil Trowbridge, the RMP manager, adding that months of planning enabled them to focus on three things — mercury, PCBs and sediment — in three places — under the Golden Gate Bridge and the South Bay's Dumbarton Bridge and at the mouth of the Guadalupe River. "There are lots of cool things to measure, but we wanted the results to be valuable for making management decisions." But at press time they were still waiting for a heavy enough storm to move these contaminants around the Bay.

"Most legacy pollutants in the Bay tend to be associated with sediment," says Trowbridge, meaning they often attach to particles of sand, silt and mud.

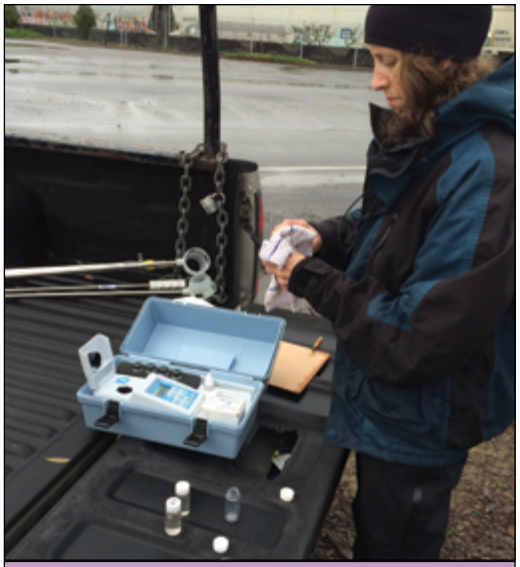
The storm event the researchers are waiting for is different for each monitoring area. At the Golden Gate, they are hoping for outflow from the Delta of a minimum of 225,000 cubic feet per second (cfs), as well as spikes in sediment at the upstream boundary of the Bay determined by USGS sensors. At the other locations, they are hoping for a storm that occurs shortly after about 10 inches of rain have fallen and saturated the watershed. At the Dumbarton Bridge that would mean around 3,500 cfs, and at the Guadalupe 6,000 cfs or more.

SFEI's Lester McKee, who designed the sampling protocol for the Guadalupe, wants to find out whether the extensive work to reduce mercury loads from the watershed — with its legacy of mining — has worked. "We want to measure when the watershed's really in action," he explains. Researchers will use a crane and winch system to drop sample bottles into the mouth of the river from a bridge, and sample for a couple of days during high flows when concentrations will likely be at their peak. "We hope to see the beginning of a downward trend in mercury loads from this watershed," says McKee.

At the Dumbarton Bridge, a USGS team will go out in a boat during the storm and take samples across the entire span. They will take manual measurements of flow, derive a vertical velocity profile, and measure sediment in the water column. They will then use all of that data to calibrate a stationary instrument called an acoustic Doppler current profiler (ADCP) in the deepest part of the channel that collects data every 15 minutes, and derive a sediment flux for the entire Dumbarton cross-section.

At the Golden Gate, where the water 300 meters deep (making it impossible to station an instrument in the water column), USGS researchers will sail back and forth taking measurements with the ADCP and bottles. The data will be used to compute fluxes of sediment over a few tidal cycles as a sediment plume from upstream passes through the Bay.

"This is critical information for improving our understanding of the Bay's sediment and pollutant budgets and for supporting future management and policy," says McKee. One policy that could benefit from the new dataset, if it ever does rain, is the region's total load target for PCBs (TMDL) scheduled for review in a few years. Another policy now being questioned is the one that permits dredged sediment to be dumped in the ocean offshore.



SFEI's Jennifer Hunt out during a storm completing measurements of turbidity in stormwater. Photo: SFEI

The researchers are excited, meanwhile, by the fact that the plan enables them to respond quickly. "It really illustrates some of the strengths of the RMP," says Trowbridge. "It can be pretty adaptive."

The San Francisco Estuary Partnership was also pretty adaptive, working quickly with EPA to reallocate funds to the RMP so that the El Niño monitoring could roll.

As for that big one everyone is waiting for? Golden Gate Weather Service's Jan Null says he still thinks it will happen. But he also says people have lots of "mixed conceptions" about El Niño. "The media portrays it as always accompanied by huge downpours with houses falling off of cliffs, but it comes in lots of flavors, and we only halfway understand it," he says. Many other factors affect El Niño, including fluctuations in temperature between the ocean and atmosphere, as well as ocean oscillations occurring across decades. "It's the warmest it has ever been — a record setting event as far as overall strength — but it's skewed slightly to the west," says Null. "We're not sure what influence that has on the jet stream and the weather."

For her part, Gilbreath hopes a big storm happens soon; her boots and gear are stacked at her front door, ready for action. "It's invigorating to be out there in the rain and wind," she says. "The hardest part is the sleep deprivation, especially when you're working on something fairly meticulous [through the night]. You cannot contaminate any samples. You have to be really focused." **LOV**

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After press time in early March, the first biggish storm arrived but not enough to mobilize all sampling efforts. SFEI crews did spend the first weekend out sampling past midnight however, and were hoping the second storm on the following weekend would meet parameters for Guadalupe and Dumbarton sampling.

RESTORATION

Skeeters Undone

We used to blame malaria and other diseases on miasmas, mysterious vapors emanating from swamps and marshes. Once the role of marsh-breeding mosquitoes in disease transmission was established, draining their habitat became a public-health imperative. Mussolini did it, and was praised even in non-Fascist circles, although his Pontine Marshes reclamation scheme is now recognized as a human and environmental disaster. That's not an option in the 21st-century Bay Area, where "no net loss of wetlands" is a conservation axiom. Teaming up to deal with a mosquito problem, the US Fish & Wildlife Service, the Marin-Sonoma Mosquito and Vector Control District, and Audubon California had a better idea. They've replumbed a dysfunctional marsh near the mouth of Sonoma Creek, eliminating a mosquito hotspot while enhancing habitat for endangered wildlife and bolstering a wetland's resilience against sea level rise.

The 400-acre Sonoma Creek Marsh is a centennial marsh, one of a class of marshes formed within the last century—in this case, beginning in the 1960s. After the original wetlands had been diked and drained for farming, sediment blasted loose by hydraulic gold mining in the Sierra settled between the dike and the Bay. "As sediment slowed down, the Bay side started growing vertically, forming a berm," explains wildlife biologist Meg Marriott of USFWS, whose agency manages the marsh as part of the San Pablo Bay National Wildlife Refuge. "There's a lower area in the middle. When big storm events push water over the bayside berm, it can't get out. It ponds, stagnates, and breeds mosquitoes."

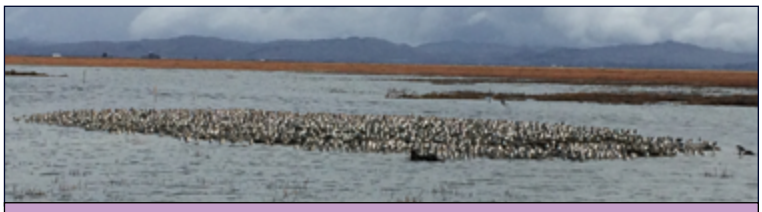
The marsh is too young to have evolved the branching channel system and tidal flushing of healthy wetlands. Plants will grow there, but there are dead zones where standing water drowns them. Mosquitoes of four species, including two of the genus Aedes, breed in the marsh. Although no mosquito-borne cases have been confirmed in the United States, Aedes aegypti mosquitoes are known carriers of the Zika virus in Brazil and elsewhere. For over 10 years, the Vector Control District has treated the marsh with what in pest control parlance are called larvicides and pupacides; they can't use adulticides because of their potential danger to wildlife.

"In the Bay Area, most mosquito control districts are pretty progressive," says consulting environmental scientist Stuart Seigel, who was lead restoration designer for the project and guided it through the permitting process. "They've all had pressure over the years on the use of pesticides."

The Marin-Sonoma district, which had previously made small adjustments to the marsh's drainage pattern, pitched the enhancement project to the refuge and put up the initial $90,000 for design work. Audubon California, fresh from assisting the Refuge in a similar but smaller-scale (65-acre) restoration at Lower Tubbs Island, signed on to manage the new project. "We started the permitting process in 2011 and didn't wind up getting everything until 2014," Marriott recalls. "It was a doozy."

The design called for a mile-long channel through the middle of the marsh; marsh mounds as high-tide refugia for wildlife; and a gently sloping transition ramp on the landward side, also intended to help marsh-dwelling birds and mammals escape extreme tides. The ramp was a sticking point for the permitting agencies, since its construction covered 10 acres of existing (although degraded) marsh. With a reduced footprint, it was approved as an experimental or demonstration element—a precedent-setting decision. "It's a temporary loss of wetlands, but with sea level rise it will be regained over the next twenty or thirty years," Siegel says.

Once greenlighted, construction of the channel, ramp, and mounds in a narrow window between the end of the breeding season for the endangered Ridgway's rail and the start of the salmon and steelhead migration was completed in four months. Siegel calls it "a very challenging project to construct," requiring a temporary roadway out into the marsh: "Engineer Melissa Carter and the contractor Hanford ARC were effective in setting goals and developing an appropriate strategy." The team "had to move thousands of pounds of mud in a flooded habitat," says Audubon restoration project manager Courtney Gutman. "They did a fabulous job."



New marsh mounds in old mosquito habitat. Photo: FWS

"It was like magic," says Marriott. "The channel started draining that basin off. We have regular tidal flushing twice a day."

Migratory shorebirds responded immediately to the new channel and marsh mounds. A flock of 3000 sandpipers dropped in toward the end of construction; Gutman says the construction workers stopped their vehicles to watch them twist and turn through the air, spooked by a cruising northern harrier. It's hoped that endangered rails and mice, as well as songbird species of special concern, will thrive in the replumbed wetland. Wildlife use will be monitored for the next 20 years.

The transition ramp, built at a 40-to-1 slope to allow wildlife to get up and out when the tide rises, will be hydroseeded with native grasses. Then other plants grown by young volunteers in the Students and Teachers Restoring a Wetland (STRAW) program at the refuge's nursery will be added. In addition to its habitat function, the ramp will buffer property owned by the Vallejo Sanitation District on the landward side, currently leased for hay farming, against extreme tides. **JE**

Project visible with binoculars from a pullout where Highway 37 crosses Sonoma Creek.

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TRANSITIONS

Selective Sowing

While hills ringing the Bay are still emerald and velvety in their springtime splendor, local restorationists are racing to get new plants in the ground. The last two years (at least) have been hard on plantings that don't rely on supplemental water. That's why some projects that are concerned with establishing native plant footholds have been taking advantage of the recent wet weather window.

"Typically in a year we plant about 20,000 to 30,000 plants. This year we're shooting for 100,000," says Save the Bay Habitat Restoration Director, Donna Ball. The bulk of those plants, about 70,000, are being planted at the Oro Loma Horizontal Levee Project (see cover photo) on the Hayward Shoreline. But Save the Bay volunteers are also planting gum plant, saltgrass, alkali heath, and creeping rye, and others species to help complete the restoration efforts on Bair Island.

The restoration of Bair Island — 3,000 acres in the Don Edwards San Francisco Bay National Wildlife Refuge along the Redwood City coastline — has been underway for more than a decade, led by the U.S. Fish and Wildlife Service and a coalition of conservation organizations. This year, to put the finishing touches on the project, land managers at the refuge partnered with Save the Bay and the San Francisco Bay Bird Observatory (SFBBO) to replant recently reconstructed transition zones. These critical habitat areas lie between the salt-water marsh and drier uplands.

Save the Bay is working with young plants that volunteers raised in nurseries run by the organization, while SFBBO is working on seeding new sections of the transition zone. "Because of the drought, we want plants that can really tolerate tough conditions, such as alkali heath and salt grass. We will continue to install plants adapted to survive at the site," Ball says.

"Both of those efforts are happening in small sections of the site this year," says Joy Albertson, the Supervisory Wildlife Biologist for the refuge. "Then we'll move on down the levee and complete the process in the next five years."

In a lot of ways, Bair Island's history encapsulates the pressures faced by many San Francisco Bay marshlands. In the 1920s, owner Fred Bair drained the island for farming. In the 1940s, a salt company bought and divided it into three sections for evaporation ponds—Inner, Middle, and Outer Bair Islands. By the 1970s, the land has been sold again, this time to Mobil Oil. The city approved the company's plans to build a massive bayside housing, retail, and office complex named South Shores.

Local residents organized and partnered with conservation agencies to put a stop to the plans, and over the next decades looked for a way to preserve the island permanently. They succeeded: the Peninsula Open Space Trust purchased the land for $15 million in the late 1990s and transferred control to the national wildlife refuge.

Massive restoration work began in 2008 with the addition of dredging material and upland fill to Inner Bair Island, restoring the marsh to its historic plain elevation. Another part of the project involved building a pedestrian bridge connecting the mainland with Inner Bair, which opened in 2013. More recently, in December 2015, managers breached the levee surrounding Inner Bair.

"The tides will bring in enough seed to begin the restoration of the tidal areas, so it's not necessary to plant pickleweed and cordgrass," Albertson says. "But with the transition zones, there's no place nearby for those seeds to come from, so if the area is not planted then it will be overtaken by weeds."

Albertson and her colleagues at the refuge will monitor how the marsh is filling in over the next few years using aerial photographs. Once there is enough viable habitat, then they will start monitoring for Ridgway rails and salt marsh harvest mouse, both endangered species that are present in adjacent marshes. "It's expected that both species, once there are a few acres of contiguous marsh habitat nearby, will come back," Albertson says. **DM**

Photos: USFWS & Save the Bay

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CLIMATE CHANGE

Fun in the Drought

Raise the topic of water in California, and fingers start pointing fast. Residents have little sympathy for those in other parts of the state, and even less for officials charged with keeping faucets flowing.

Think you can do a better job of solving the Golden State's water dilemmas? Try playing California Water Crisis, a new board game by Bay Area graphic designer and public policy wonk Alfred Twu. The game lets players walk a mile in the shoes of a water manager from Northern California, Southern California, or the Central Valley. Along the way you'll gain a new understanding of how the economic priorities, social values, and environmental constraints endemic to each region set the stage for uncomfortable tradeoffs.

Each round of the game is equivalent to a water year. In winter, a roll of the dice establishes how much water falls. Then each region receives its water allocations based on water rights. Players then supply their towns, farms, and/or reservoirs, and can even pump groundwater if their water allotment falls short. They collect taxes based on the number of farms and cities present, and can use those funds to raise public opinion or improvements such as desalination plants that will guarantee them more water in successive years.

As in real life, winning hinges solely on public approval ratings, not how many farms or ecosystems are kept functioning and watered.

Game touches are thoughtful and dilemmas feel uncomfortably true to life. Low value rolls of the dice send the game into multiyear megadrought mode. Groundwater is free until levels drop below a given depth. Public approval drops in Northern California for losing farms, Southern California for failing to build more cities, and the Central Valley for groundwater pumping.

For variety, the game can also be played in the historic past, when reservoirs and the Central Valley Project were nonexistent, as well as the future, when all regions must cooperate to survive, with the rules adjusted accordingly. **KMW**

The California Water Crisis Game is available online at www.californiarailmap.com/cawater where game pieces and the game board can be printed out at home, and selected game stores.

Shedding Heat Needle by Needle

If forests are the lungs of the planet and trees sequester carbon, reforestation should be an effective way to mitigate global warming. Or maybe not. Scientists with France's Laboratoire des Sciences du Climat et de l'Environnement, led by Kim Naudts, have concluded that it depends on what kinds of trees are planted. Their study, recently published in *Science*, notes that "two and a half centuries of forest management in Europe have not cooled the climate," in

Afsoon Razavi

part because from about 1850 on, deciduous broadleaf trees like oaks and beeches were replaced by evergreen conifers like Scots pine and Norway spruce. Changing the species structure of the continent's forests reduced the amount of water released by leaves, decreasing the atmosphere's ability to shed heat. The change also altered the reflective properties of the canopy. The take-home message: forest management as a climate tool risks failure "unless it is recognized that not all forestry contributes to climate change mitigation."

USGS physical scientist Alicia Torregrosa, who studies the effect of fog in coastal forests, calls that conclusion plausible. "It's so easy to forget that the water cycle is very active at every interface of the soil-plant-air system, " she says, adding that the new study "has a lot of relevance for California, especially now that there is an active community of land stewards that are responding to myriad climate change impacts that affect forests. " Although California may not have experienced the same kind of species replacement as Europe, the timber-management plans in effect here share the production-oriented approach that has ruled European forestry. "What would it look like if we took a whole-system approach to forestry practices?" she asks. **JE**

RESILIENCY
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Last year a San Francisco Estuary Institute team led by Erin Beller made what is widely viewed as the first successful attempt to defuzz resilience in a project funded by Google. They convened a strong national science panel to vet the working definitions and applied the tenets to a watershed-wide vision of ecological resilience in relation to infrastructure and land use in the South Bay, according to coastal ecologist Peter Baye.

The resulting 2015 *Landscape Resilience Framework*, which was then applied in a *Silicon Valley Vision*, revolves around seven specific elements (see p.5). "A couple years ago, our real estate team realized we needed the guidance of the region's best ecological resilience scientists to develop a roadmap for our physical presence in the Bay Area," says Google's Audrey Davenport. "We consider ourselves a customer of this emerging science."

However fuzzy and buzzy, resilience does invite us squint a little farther and deeper into the future. "It draws attention to the reality that there are limits to how much alteration or change a system can take before it becomes something else," writes Wiens.

Read this story's in-depth, extended version: www.sfestuary.org/estuary-news

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San Francisco Bay and the Sacramento-San Joaquin River Delta comprise one of 28 "estuaries of national significance" recognized in the federal Clean Water Act. The San Francisco Estuary Partnership, a National Estuary Program, is partially funded by annual appropriations from Congress. The Partnership's mandate is to protect, restore, and enhance water quality and habitat in the Estuary. To accomplish this, the Partnership brings together resource agencies, non-profits, citizens, and scientists committed to the long-term health and preservation of this invaluable public resource. Our staff manages or oversees more than 50 projects ranging from supporting research into key water quality concerns to managing initiatives that prevent pollution, restore wetlands, or protect against the changes anticipated from climate change in our region. We have published *Estuary News* since 1993.

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COVER PHOTO *Spring planting at Oro Loma Horizontal Levee project.* Photo: Save the Bay

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SALT FIELD

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— from reaching the western Delta. Researchers also wondered if the difference in salt levels on either side of the barrier would affect which species of invasive clam lives where: the overbite clam (*Corbula amurensis*) thrives in brackish water while the Asian clam (*Corbicula fluminea*) does not.

"Part of the challenge, and really it's a nearly impossible task, is teasing out the effects of the drought barrier from those of the drought," Harader says. "Flows were already greatly reduced with or without the barrier." The researchers are still crunching the numbers to see what it all means.

The Delta Science Program also funded a U.S. Geological Survey (USGS) study that gave snapshots of water quality in the Delta. "We'll be able to link water quality data with biological data on algae, plankton and fish," says USGS hydrologist Bryan Downing, who led the study.

While zooming along at 20 miles per hour, the boat used for the study sucked up water samples and pumped them through waterproof case-clad instruments, which took measurements every second. "It's a great system," Downing says. "We can cover lots of the Delta in real time, which is important because the Delta is tidal so water there is in nearly constant motion." A given "parcel" of water can move miles across the Delta in six hours.

Besides confirming that the salt barrier worked, the study yielded a surprise. A set of findings pointed to troubles in the San Joaquin River-Stockton Deep Water Ship Channel, which links Disappointment Slough in the central Delta at the eastern edge near Stockton.

USGS scientists, Dr. Judy Drexler, Dr. Tamara Kraus and Bryan Downing (left to right) collecting water samples for laboratory analysis. The field verification instrument, a YSI model EXO, was used to measure in situ water quality parameters, necessary for the laboratory analyses and as a verification for the high speed mapping system. Photo: USGS

One trouble was a huge increase in chlorophyll, which is a proxy for algae. And high algae can cause low oxygen, which is bad for fish and other aquatic life. A second trouble was that nitrogen levels tripled in the shipping channel, which makes sense because lots of nutrients can mean lots of algae. Completing the triple whammy, flows appeared to stagnate in the shipping channel. "Water seems to just sit there," Downing says. "This part of the survey had a huge wow factor — we didn't realize how extensive it was." (*See online story graphics.*)

Six months after the salt barrier went in, the state took it out and ended the grand experiment in the Delta. The barrier was massive at 750 feet across and 120 feet wide at the base, and deconstruction — crane bucket by crane bucket — took nearly 10 weeks during the fall of 2015. We probably won't need a salt barrier this year because recent rains have begun to refill our reservoirs. But all that rock is sitting in Rio Vista, ready for the next time we need it to keep salt at bay. **RM**

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