CALIFORNIA LANDSCAPE CONSERVATION COOPERATIVE

PROGRESS REPORT
9 TALES OF CHANGE

CREATING SCIENCE-BASED TOOLS FOR ON-THE-GROUND CLIMATE CHANGE PLANNING AND ADAPTATION....

It's been the hottest year on record, and California's long past questioning the science on climate change and hell bent on developing electric cars, building bullet trains, trading carbon, and designing the habitats of the future, both human and wild. Perhaps it's because we've always inhabited a continental crust primed for sudden shifts of ground. Perhaps it's that we've never had enough water and we've always had too many cars. Or maybe it's that we're still a frontier state where people go to stretch their legs and imaginations. Whatever it is, we're not running from the idea that temperatures may rise by 5-10 degrees Fahrenheit by 2100, and sea level by more than five feet. Extreme weather and changes in ocean ecosystems are already with us. By the time a child born today has a midlife crisis, it could be too hot to work outside on a summer day in Sacramento, and thousands of acres of San Francisco Bay wildlife habitats could be on the verge of drowning.

"Climate change is real, it's now, and it can't be ignored. It has to be integrated into land and resource management decision-making as soon as possible. If managers stay stuck in the day-to-day, they could really miss the boat as far being prepared, and conducting actions now that are going to set them up for success in the future," says Rebecca Fris of the California Landscape Conservation Cooperative.

In 2010, the Department of the Interior set up California's Landscape Conservation Cooperative, one of 22 similar collaborative efforts nationwide. Its purpose is to get good science on how climate change may impact California's diverse landscapes into the hands of those managing parks, preserves, natural areas and rare habitats on the ground. Its official boundaries stretch from northern Mexico up to Bodega Bay, as well as into the heart of the Central Valley, and along the spine of the Sierra.

California's landscapes are already populated with hundreds of initiatives to address changing temperatures, rising sea levels, and the increasing frequency of floods and fires in the Golden State, and the Cal LCC is not trying to reinvent the wheel. It doesn't fund projects that move dirt, grow organizations, build infrastructure, or revolve around single species or properties, says Fris. Instead it looks for projects connecting climate concerns across big landscapes encompassing many jurisdictions and ecosystems, projects such as those described in the pages that follow.

Inside, you'll read about two cutting edge computer modeling projects in the San Francisco Bay Area which seek to predict the future of the region's tidal marshes – first in the path of rising sea levels. One takes a big landscape view of the region, and the other ground truths predictions of sea level rise impacts on 12 historic marshes (see p. 3 and p. 6). Used together, they've given local shoreline managers a clearer sense of how to adapt to their rapidly changing environment. On page 8, you'll read about research elsewhere in California to map wildlife migrations in the Sierra in response to changing conditions, grapple with shrinking rangelands across the state, and sustain sensitive chaparral plants in Southern California threatened by the increasing intensity of fires. The story on page 11 details four telling case studies of how to apply climate smart principles

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CA LCC

Continued from cover story

and plan for resilience on the ground. Progress reports, data layers, and on-line planning tools coming out of all this Cal LCC-funded research are being collected on California's Climate Commons (see below).

Of course, the Cal LCC has done much more in the past three years than what's highlighted in these pages. In the San Francisco Bay region, it's worked especially hard to collaborate on, and to support, existing initiatives like the Bay Area Ecosystems Climate Change Consortium and the San Francisco Bay Joint Venture, and helped fund their high priority projects including a climate change update of the 1999 regional restoration bible (aka the *Bayland Ecosystem Habitat Goals*). It has organized workshops on how to do vulnerability assessments. And in 2011, it put more than fifty scientists, local agency staffers, and shoreline landowners in the same room for a week for an exercise in structured decision-making around specific resource management planning questions.

These are only a few examples drawn from 25 projects supported by the Cal LCC with over $2.5 million since 2010. Add in partner contributions, and more than $6.5 million has been invested in preparing for California's hotter, wetter, and more fiery future.

According to Debra Schlafman, coordinator of California's LCC, "Ever since the turn of the century, natural resource management has meant looking in the past, or restoring to some past, fairly stable, state. We're trying to change that fundamental process so we can look to the future, which is more uncertain, and provide assistance with how to make decisions and set priorities."

California Landscape Conservation Cooperative
www.californialcc.org

DAYLIGHTING CLIMATE DATA

BY SUSAN K. MOFFAT

You're a land manager trying to figure out how soon sea level rise will put your bayfront hiking trail underwater. Or you're an agricultural planner researching what kind of crops a particular plot will support in the future, given climate-driven changes in rainfall. Where do you turn for information?

The California Climate Commons aims to be the go-to library, data repository, and on-line forum for planners, land managers, and scientists who need up-to-date climate change data and analysis. "We want to make the information easy to navigate, transparent, and responsive to changing needs," says Deanne DiPietro, project lead for the Commons, which is based at PRBO Conservation Science's Petaluma offices. As shelves groan with new research reports and servers swell with terabytes of data on everything from groundwater movement to bird distribution, the need for someone to organize the research, put it in context, and make it available in formats data users need has become increasingly obvious. So the California Landscape Conservation Cooperative (Cal LCC) in mid-2011 booted up the Commons.

While scientists will find this information hub useful, it's aimed primarily at practitioners who need to make on-the-ground decisions about land acquisition, restoration design, and regulatory policy changes. The creators of the Commons hope it will become a digital watering hole where information and analysis gets exchanged among researchers and land managers so that it actually shapes decisionmaking. As a funder of climate research, the Cal LCC wants to make sure that its investments in science get as widely used as possible.

Data manager Deanne DiPietro demonstrates the resources and tools hosted by the California Climate Commons. Photo: Susan K. Moffat

DiPietro and the rest of the five-person team who spend time managing the Climate Commons don't just organize and index datasets and reports. They write guides to explain issues of data scale and resolution, and detail the differences among climate models. The Commons also hosts data sets — providing the physical server and architecture for storing and disseminating information. In other words, it provides the virtual shelfspace for information, as well as the card catalog and reference librarians.

DiPietro says that the more data users participate in uploading data and discussing technical issues on the site's forums, the more valuable the Commons will become. "We hope to build a community of practice, and the library is just one piece," she says.

Tom Robinson, a planner at the Sonoma County Agricultural Preservation and Open Space District, used information from the Commons to help recommend sites for preservation that will provide the greatest ecosystem benefits, given expected changes in the climate. He needed to get a sense of what the habitat, precipitation, and groundwater conditions on certain parcels, and in the region, are now—and what they are likely to be in fifty years.

Through the Commons, Robinson was able to get this information from the California Basin Characterization Model, which was created by Lorraine and Alan Flint of the U.S. Geological Survey and published by the California Energy Commission. Now, anyone with an Internet connection can access the data and find historic patterns as well as projections from four future climate scenarios.

Robinson says that "breaking down research silos" is what is exciting about the Commons. By meeting up in the ether, researchers and practitioners can collaborate more effectively to make good decisions on the ground.

Climate Commons
http://climate.calcommons.org

PARTNERS: Cal LCC, PRBO, UC Davis Information Center for the Environment

12 MARSHES AT THE END OF A HOCKEY STICK

BY ARIEL RUBISSOW OKAMOTO

'The hockey stick' is what scientists call the trajectory of accelerating sea level rise projected to flood many of San Francisco Bay's tidal marshes by early next century. The uptick — the bend in the stick where so much ice melts that ocean waters suddenly warm and swell — occurs between 2060 and 2080 for many Bay marshes according to new US Geological Survey models. The models are the first of their kind to combine extremely precise measurements of the elevations of 12 bay marshes, with variables such as sediment build up, vegetation coverage, and sea level rise. The result is a carefully-crafted methodology for projecting how your marsh will change decade-by-decade that is now out in print, on the web, and in video.

"It's not going to happen overnight," says Don Brubaker, manager of the San Pablo Bay National Wildlife Refuge. "It's going to creep up on you, where you once had pickleweed you're going to have mudflat, and eventually shallow open water. Whether that happens on my watch, maybe, maybe not, but in the meantime we're going to have a window where we need to farm as many endangered harvest mice and clapper rails as we can, while it's still good habitat. After that, maybe we'll have some other restoration techniques to try that no one thought possible before," he says.

"People want to do something about climate change, in a positive way, but a lot of the information is global scale, very broad and large. We're trying to make it local and actionable," says wildlife biologist John Takekawa, part of the USGS team that studied the 12 marshes in depth.

Below: China Camp State Park

The methodology used by the USGS team offers a new scale of sea level rise projecting that is highly site specific. "We go out and tromp around the marsh, we take elevation readings and map vegetation, and we monitor water levels and collect sediment. And then we put that all into our models and talk about what's going to happen up until 2100," says Karen Thorne, a USGS ecologist with computer modeling skills who teamed with Takekawa on the project.

In particular, the team used recent advances in technology — Real Time Kinematic GPS — to survey marsh elevations to the centimeter level of accuracy. "Many areas at the edge of San Francisco Bay have very shallow gradients, so there's not a lot of difference between those areas and the level of the water," says Takekawa.

It took three years of painstaking work involving 7,437 elevation points, 11 transects, 3,303 vegetation plots, and thousands of cross-eyed hours at the computer, among other things, to develop the methodology. But by combining all the field data and sea level rise scenarios into sophisticated computer models, the team has been able to predict how 12 of the region's most established wetlands may evolve from pickleweed- to cordgrass-dominated marshes, and later into mudflat and subtidal habitats, and when, decade by decade (see chart p. 4).

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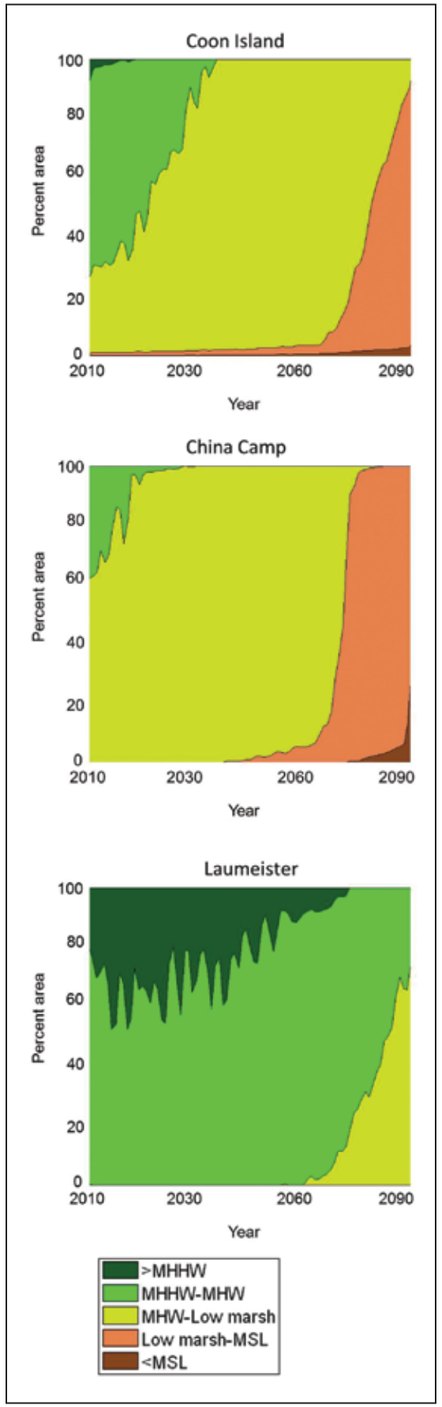


These figures depict habitat change to 2100, with increasing marsh loss after 2050 (the bend in the hockey stick projection for rapidly rising sea level). The colors represent habitat types at each marsh site. MSL represents mudflat habitat, MSL-Low marsh is the Spartina zone, low marsh to MHW is pickleweed habitat, MHW to MHHW is the upper marsh area with MHHW is the upper marsh transition zone. Source: USGS, 2012.

Continued from page 3

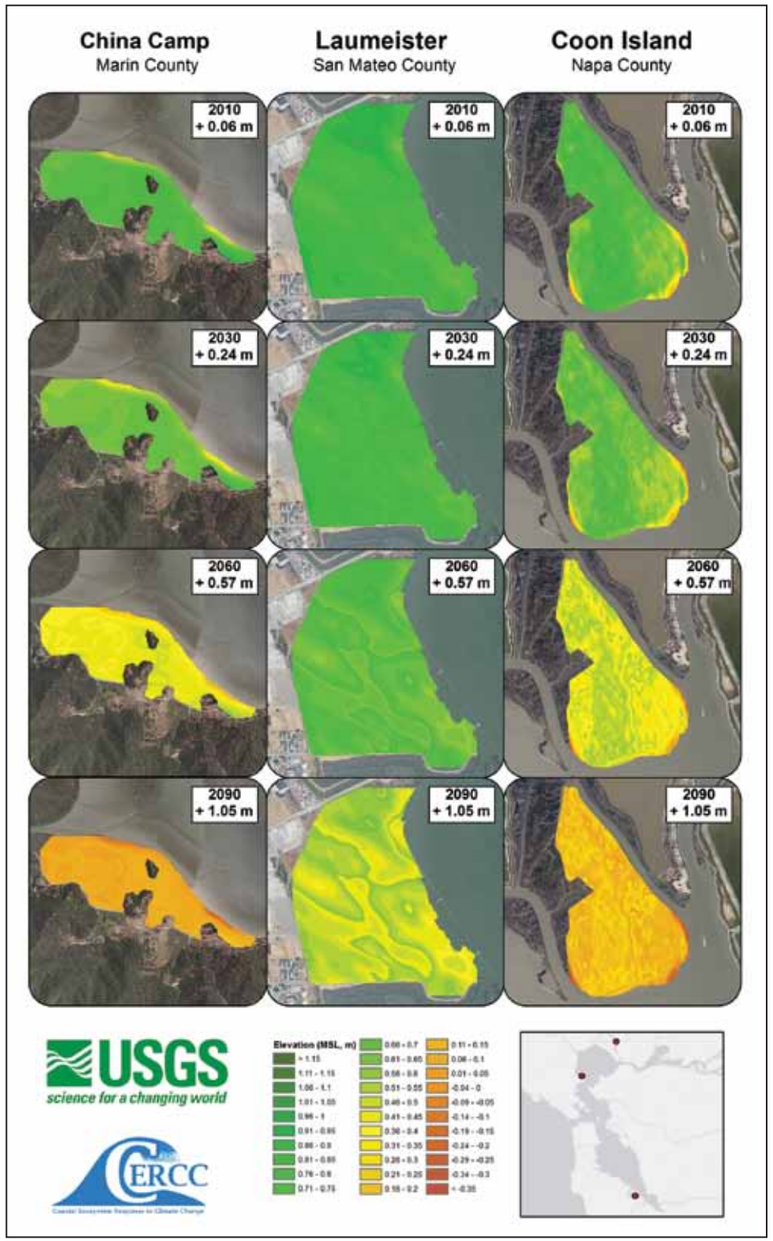
The study's results can be found on the web and in the USGS 2012 open-file *Final Report for Sea-Level Rise Response Modeling for San Francisco Bay Estuary Tidal Marshes*. According to the results, almost all of the marshes in the North Bay, including China Camp in Marin County, and sites along the Petaluma River, could flood completely by 2080-2100, after the bend in the hockey stick when sea level rise accelerates.

South Bay marshes could do better. "The difference has less to do with age and more to do with geography, where they are in the Bay," explains Thorne. "Marshes in the North Bay didn't keep up as long as marshes in the South Bay largely because sediment accretion rates are different." Marshes naturally keep pace with sea level rise by trapping sediment and accumulating organic matter, at least until the water level starts rising faster than they can build up. This set of models is particularly detailed because of localized accretion data collected in the San Pablo Bay Wildlife Refuge by the USGS team, and backed up by earlier work in other marshes led by University of San Francisco wetland ecologist John Callaway.

According to the team's future projections, the South Bay's Laumeister Marsh may survive longest, while Marin County's Corte Madera marsh may be the first to go under. Laumeister turns out to be in a good spot to collect sediment, whereas Corte Madera had further to go to keep up, because it has the lowest starting elevation of the 12.

"Knowing the elevations helps us predict when changes in water level will become a problem for species trying to survive in these fringe habitats," says Takekawa. "They live on the edge of the Bay and the edge of existence, in the zone where water meets land and where habitats change quite a bit. So when a climate change occurs that, from an evolutionary perspective is relatively rapid, it's likely wildlife populations will change too. They can't adapt that fast."

The good news is that all 12 marshes were able to keep pace for the next four or five decades. "We encourage people to look at this as a positive period, when you can boost your resources, and try to keep them very healthy. That way when the rapid sea level rise comes, your adjustment is from a base of strength, rather than from fragmented, weak populations across a landscape that have no chance of surviving," says Takekawa.



This window of opportunity has shoreline managers already looking at the ups and downs of the North and South Bay results to see what opportunities they may present for stronger adaptive management. While the North Bay has lower sediment accumulation rates, for example, it has more open space behind marshes where wetlands could migrate inland and stay viable – so opening up avenues for tidal influence further inland may be important. And while South Bay marshes may build up more easily, and have a bigger sediment supply, most border big levees with houses and urban areas on the other side – leaving them little room to migrate inland. So managers there are considering innovative types of setback levees and ways to help marshes grow in place.

Matt Ferner, who coordinates research for the National Estuarine Research Reserves at Marin's China Camp and Solano's Rush Ranch, has been given mandates to address climate change but hasn't had the money or the computer modeling expertise to do much. "It was a breath of fresh air to have the USGS scientists come in and do the RTK surveys, think carefully about the habitats, monitor the water levels, and develop this really nice report that has explicit predictions we can turn to," he says.

Ferner compared the predictions for China Camp with detailed maps of the reserve, and with projections from two other sea level rise modeling efforts — one done by PRBO conservation science (see p. 6) and one done by U.C. Berkeley doctoral student Lisa Schile. "I was relieved that these models agreed on where the most sensitive and most dynamic areas are at China Camp," he says. "Using these tools, I looked for the places where we have the most diverse plant communities, and where change was predicted to occur quickly because of steeper elevation gradients, or because of dynamic features in the vegetation. The comparison enabled me to lay out our transects across the marsh for long-term monitoring, so we can see if actual changes in the marsh match up with predicted changes."

Ferner says the model predictions also helped him move a key project to the front burner, namely the restoration of two brackish marshes cut off from the bayfront marsh by North San Pedro Road. "If there's any chance of China Camp marshes surviving accelerated sea level rise, it's going to be by transgressing up slope, but with the road in the way that's not going to happen," he says. "The report helped us get our brackish marsh restoration project top priority status with state parks."

On the 17,000 + acres of the San Pablo Bay Wildlife Refuge, Brubaker has also been shifting his management perspective based on the USGS findings. He talks about what he calls "restoration on the fly," a happy euphemism for "adaptive management." He points out that over a big, complicated, three-year restoration project like the one he has underway at Cullinan Ranch, "later and greater" climate change modeling information can come in during construction, and you've got to be ready to make adjustments.

"Models are a great tool, but when it comes down to doing stuff on the ground, it may be just a matter of let's just push this up a little higher with the dozer, or, as we cut away this levee, let's smooth out the leftover material into an extra island, or stockpile it on site for later levee-raising. Or let's cut this channel in a slightly different direction in case of a storm surge. We want to build in a certain amount of resiliency, because errors in those models could be just a matter of centimeters, and 2-3 centimeters could put your high tide refugia underwater all the time. Then you'd wonder why, when you had the dozers and excavators out, you hadn't added a few more scoopfuls of dirt," he says.

Giselle Block, a biologist who works for the U.S. Fish & Wildlife Service's Inventory and Monitoring Program, says response from refuge managers like Brubaker has been very positive all along the West Coast. Indeed, with support from the California Landscape Conservation Cooperative (Cal LCC), the USGS model is now being applied in the Tijuana Slough refuge on the California-Mexico border, and at the Seal Beach Refuge on Anaheim Bay. California's neighboring LCC pitched in to take the model north to Humboldt Bay, and USGS Climate Science Centers are supporting work in coastal marshes in Oregon and Washington. "This is not something refuge staff or budgets could get done by themselves. They're getting assistance in areas that take quite a lot of expertise," says Block. "This work not only informs what we do on individual refuges, but also informs at a regional level, and at a higher leadership level. Few refuge managers could make the kind of changes we need alone," says Block.

No wonder Thorne's phone has been ringing more since the report came out, and many of the calls aren't local. Indeed Thorne recently got a call from Ferner's boss in Washington, who wants to encourage similar collaborations between scientists, research reserves and LCCs across the country.

"We've found that rather than just saying that everything's going to be gone or different by 2100, which can be paralyzing, it makes more sense to talk in decades. People almost always circle back to shorter-term goals and strategies. They aren't ready to give up, they want the wildlife to stick around," says Thorne.

12 Marsh Results, USGS
www. werc.usgs.gov/sfbayslr

PARTNERS: USGS, USFWS, Cal LCC

CLIMATE-MINDED WEEDING

BY JOE EATON

Invasive plant and animal species may benefit from climate change, finding altered habitats more hospitable. With Cal LCC support, the California Invasive Plant Council (Cal-IPC) is prioritizing landscape-level responses to invasive plants. Cal-IPC has been working to implement regional strategies based on CalWeedMapper, an online decision-support tool with statewide maps for 200 invasives showing future spread projections under midcentury climate conditions. The first region to begin on-the-ground implementation has been the Central Sierra.

"It's not rocket science," says Cal-IPC's Doug Johnson. "But the tool is able to evaluate invasive plant species over a large territory, and then put it into a digestible form so managers can draw conclusions about regional management options ranging from eradication to containment to surveillance."

Cal-IPC's regional prioritization work using CalWeedMapper fills the gap left by the defunding of the California Department of Food and Agriculture's weed control program. "There's consensus that controlling invasive species is a no-regrets action that can be taken immediately to help native species adapt to climate change," says Johnson. "This landscape-level approach makes sure that we're getting the most conservation impact with limited funding."

CaWeedmapper
http://calweedmapper.calflora.org

California Invasive Plant Council
www.cal-ipc.org

MARSH BIRDS SQUEEZED

BY LISA OWENS VIANI

The Estuary's rarest and most unusual birds—those that skulk and flit through pickleweed, cordgrass, and gumplant, their buzzy trills and rattles often the only clue to their presence—are in trouble, having lost much of the tidal marsh habitat that used to fringe San Francisco Bay. Their future may be even grimmer as sea level rises and the climate changes, say scientists, based on recent Estuary-wide modeling done by PRBO Conservation Science. And while the birds are threatened on one side by rising water, predators lurk on the other side of the marsh in the uplands the birds need as a refuge.

The future of the Estuary's tidal marshes—and tidal marsh birds—will depend a lot on mud. If sea level rises and marshes do not keep pace by collecting sediment and building up ("accreting"), habitat will likely be inundated for the endangered California clapper rail and threatened California black rail, as well as for several California species of concern: three tidal marsh song sparrow subspecies and the San Francisco common yellowthroat. Can't birds just fly away and nest and forage elsewhere? Not tidal marsh obligates, says PRBO's Julian Wood. "These birds live their entire lives—and have evolved to adapt to—this harsh environment with high salinities. If this habitat is gone, these birds will be gone as well."

With support from the California Landscape Conservation Cooperative (Cal LCC), the Coastal Conservancy, and others, PRBO's Sam Veloz and partners took a look at what the future may bring for tidal marshes and tidal marsh birds. They modeled marsh accretion using two sea level rise scenarios: high and low sediment input, and high and low organic accumulation. These are the two ways marshes build up naturally, by collecting sediment from mudflats, bay waters, and runoff, and by growing plants that decompose and leave new layers of organic matter. Modeling by federal and state scientists suggests that the bay's sediment supply is slowly decreasing, but some parts of the bay are more sediment rich than others. Organic accumulation assumptions depended on salinity and followed previous modeling by PRBO's Diana Stralberg.

Albany shore and fringe marsh. Photo : Drew Kerr

"We found that tidal marsh sustainability over 100 years was very sensitive to the sediment scenario used but not to organic accumulation," says Veloz. Veloz then used the high and low sediment models—and PRBO's long-term studies of tidal marsh birds—to try to figure out how the four tidal marsh dependent birds, plus the more common marsh wren, will respond to changes in marsh elevation—a proxy for nesting and foraging habitat—and salinity.

"The worst case scenario [high sea level rise, low input of marsh-building sediment], shows declines for all of those species, even the marsh wren," says Veloz. "Most of them trend down to 100 percent loss. Clapper rail, interestingly, does the 'best,' but they're starting from such a low number."

Song sparrows, of which there are three endemic subspecies in bayland habitats around the Estuary, fared poorly. "If we assume high sea level rise, under low sediment, we project a 50-100 percent decline in the Estuary's song sparrow population," says Veloz. But under high sediment conditions, the population could increase slightly—at least initially. "You see the dramatic effect of sediment. Given the same sea level rise scenario, you could have a sustaining population or a really declining population."

Common yellowthroats and marsh wrens showed a greater sensitivity to changes in salinity. These species are more abundant in brackish marshes with taller vegetation like tules and bulrushes, which grow where salinity is lower, as in Suisun Bay. But if those marshes flood and become more saline, that habitat could disappear.

Resource managers can visit PRBO's Climate Smart Planning Tools where maps based on the various modeled scenarios demonstrate how sea level rise could affect tidal marsh and birds around the Bay over the next 100 years. The tool is also designed to assist funders in deciding on whether to fund specific projects. "We want people to use the tool to see how their site responds to different scenarios,'" says Veloz. He urges people to look at a range of possibilities, not just pick one scenario. "Even if you pick a scenario that doesn't turn out to be true, you're still better off than ignoring the future in terms of providing tidal marsh habitat for birds."

Veloz says his other message for managers who are planning restoration projects is to think about resilience. "All of the restoration projects we're engaging in are valuable to tidal marsh birds, but some projects are more resilient to all of the different scenarios we modeled. If you're in a high sediment area, your project is more likely to be sustainable, but regardless, birds do better if we do restoration than if we don't." In other words, even if a project might be under water in 100 years, the habitat it provides in the meantime will help boost bird populations along the way.

One resilient site seems to be Sonoma Baylands. "That one comes out really well because it's in a high sediment area plus is such a large restoration project and includes areas that are now upland. It's also at a higher elevation and has more capacity to allow the marsh to transgress in the future. So there's a lot of adaptive capacity in the project," says Veloz.

Restoration sites that are less resilient—where there is less sediment coming in and building up—may need to be managed more adaptively, he points out. "If we get high sea level rise rates, we might need to bring in sediment. Or if you're starting now, you might want to engineer higher elevations and allow for transgression as sea level rises." The bottom line? Start planning now, and have a plan in place, suggests Veloz.

Losses of nesting, roosting, and foraging habitat aren't the only possible problems looming for tidal marsh birds. Predators, changes in temperature and precipitation, and extreme tides pose additional challenges. To assess these and other potential risks, PRBO's Nadav Nur developed population-dynamic models of the long-term viability of black rail, clapper rail, common yellowthroat, and song sparrow populations. In a closer look at song sparrows, PRBO scientists analyzed 11 years of data collected from 7 different marsh sites and 3,000 nesting attempts, and developed a more complex population-dynamic model incorporating the sea level rise and climate change scenarios from Veloz's model, and the same assumptions of sedimentation and organic matter accumulation. In addition, Nur's modeling drew on projections for future temperature, precipitation, and extreme tides.

When they analyzed the 11 years of song sparrow nesting data, "The magnitude of failure due to flooding surprised us," says Nur. In some years as many as 55 percent of nests had failed. Nur and his colleagues then analyzed the species' reproductive success in relation to projected changes in temperature, precipitation, and extreme tides. The higher the extreme tides, the lower nest success was.

Nur says that overall rates of nest failure due to predation and flooding are currently too high to allow for song sparrow populations to be stable or to grow. "Any additional nest failure will tip the balance between population stability and decline," says Nur—even one additional extreme high tide in 10 years is sufficient to affect song sparrow population trends. He adds that while most people think of the "king tides" as being a winter phenomenon, tides can also be quite high during the spring — just when song sparrows are nesting.

The problem is that tidal marsh birds face two devils, says Nur: nest predators and flooding. If tides get too high, nests will flood. But if birds choose to build nests higher in the vegetation, the nests will be more conspicuous and accessible, becoming as Veloz puts it, a "predator buffet."

managers and getting their feedback, as well as making presentations at meetings and conferences. "Eventually what we'd like to see is as people use the tool, to put their info up on the web site. When new people come, they can see how others have used it," says Veloz.

The next step is for PRBO to overlay its bird demographic model onto the sea level rise maps so that managers can see both changes to the marsh and potential changes to bird populations at the same time.

Marsh wren (left), San Francisco common yellowthroat (center) and tidal marsh song sparrow (right). The latter two species frequently nest in the bright yellow gum plant that lines tidal marsh channels. Gumplant grows taller than other marsh plants, and the birds can conceal their nests in leaves up above the high tide level. The clapper rail sometimes nests in the open marsh plain in clumps of Spartina or in dense pickleweed. Black rails prefer to nest in tall, dense vegetation, especially alkali bulrush. Black rail nests are so well concealed that you can be standing right over them and not even see them. Photos: Jerry Ting

Changes in precipitation will also affect song sparrows, Nur found. "The models showed the wetter and cooler the breeding season, the longer the breeding season; yet nest survival is lower. Conversely, during breeding season when conditions are expected to be drier and warmer, nest survival will increase, but the breeding season will shorten, and the number of breeding attempts will decrease."

The news from the models is not completely discouraging. They also showed that short-term (20-year long) management actions could help the populations of all four tidal marsh obligate birds recover or at least arrest their decline. Actions could include removing or reducing predator populations—or possibly more importantly, removing predator access to marshes.

PRBO has been getting the word out about its online Climate Smart Planning Tools by showing them to resource

Says PRBO's Ellie Cohen, "Birds are great indicators of what's happening in the world around us. Everybody's been asking us what can we do differently today to address climate change. These new tools allow managers to see a range of possible future scenarios so they can make better decisions today. Support from the Cal LCC and Coastal Conservancy helped us to take these tools to a new level, not only to communicate different potential future scenarios but also to prioritize restoration sites across multiple scenarios so we can reduce the impacts of climate change and secure more healthy ecosystems in an ever changing world."

PRBO Climate Smart Planning Tool
http://data.prbo.org/apps/sfbslr/

PRBO Population Dynamics Models
http://data.prbo.org/apps/sfbslr/demography

PARTNERS: PRBO, Cal SCC, Cal LCC

CALIFORNIA'S WILDLIFE REACTS TO CHANGING CLIMATE

BY SUSAN SULEIMAN

Nearly a century ago, Joseph Grinnell, the first director of the Museum of Vertebrate Zoology at the University of California, and a man who spent 38 years on a definitive list of the state's birds, was aware that his painstaking notes might be all that remained of many of the species he chronicled.

"The India ink and paper of permanent quality will mean that our notes will be accessible 200 years from now," he wrote to the museum's founding patron, Annie Montague Alexander. Grinnell added, by way of explanation: "We are in the newest part of the new world where the population will be immense in fifty years at most."

As prescient as Grinnell was when he assembled his early ecological map of California, he didn't foresee climate change. Climate change is already affecting wildlife from Lassen Peak to Mount Whitney, the same places Grinnell conducted field research to build the museum's collection of California species. Rather than engaging in the basic science that Grinnell pioneered, scientists today are using cutting-edge technology to fashion plausible scenarios that can help land managers include climate change in their decision-making. It's a bit like preparing for war. But instead of a map with pins indicating troop movements, they are putting together a new biological map, tracking the movements of birds and mammals as they adapt to rising temperatures and see-sawing rainfall. Since 2009, key pieces of this strategic map have been falling into place with the help of collaborative initiatives and support from the California Landscape Conservation Cooperative (Cal LCC).

As Hurricane Sandy revealed, the climate war is everywhere. But the American West has been affected more dramatically than most places. From 2002 to 2007, the average temperature increase in the western U.S. was 70 percent greater than the world average. Scientists studying California are observing an increase in rain versus snow, and earlier budding of plants. (More rain might sound good to perpetually water-starved California, but without storage, the most tangible effects are likely to be flooding and mudslides.) Fires also are becoming more frequent and severe.

In other words, climate change isn't a distant possibility. It's here.

"One way to think about it is this: when people were debating about whether climate change was happening, a lot of the plants and animals had figured it out," says Steve Beissinger, a professor of Conservation Biology at UC Berkeley.

Ten years ago, Beissinger and a team of scientists undertook an historic task: re-surveying the landscape where Grinnell and his colleagues tracked California's birds and mammals. Between 2002 and 2007, they used Grinnell's colorfully annotated maps as they tromped around Yosemite, Lassen and Kings Canyon National Parks, and Southern California's White Mountains.

In Yosemite, the researchers noted that about half of the small mammal species had remained in place. Others, such as the pinyon mouse, had migrated uphill, seeking cooler temperatures. This wasn't entirely surprising: minimum temperatures in the central Sierra had warmed by 5-6 degrees Fahrenheit since Grinnell's surveys. But it wasn't always clear why species reacted differently. As they resurveyed other parts of the state, the picture only grew more complicated.

"Sometimes two species in the same genus might have different patterns," Beissinger says. "One might be moving uphill and another not at all. When we started looking at birds, we saw some species moving up, as we expected with climate warming, but others were moving down. And the same species was doing one thing in the Sierra and another in Lassen."

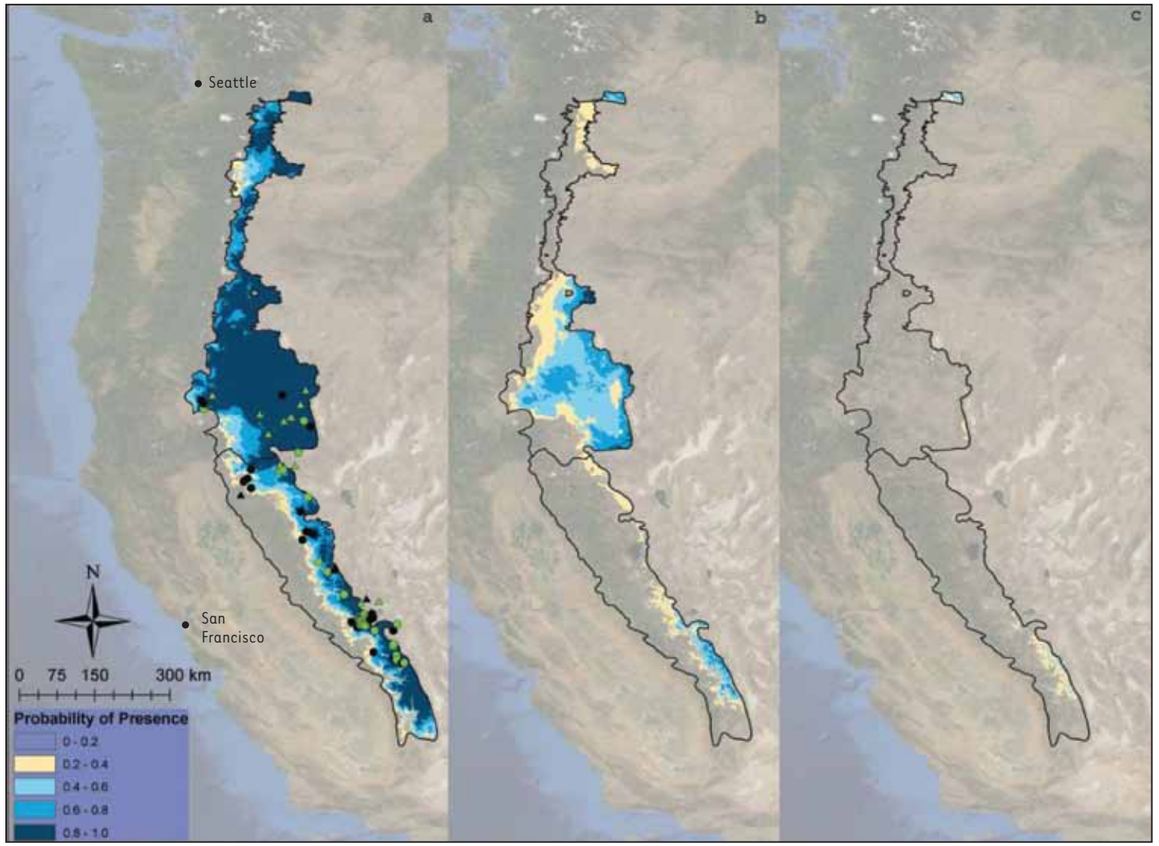
"We began to get a sense of how climate change is different in different places and how it is different for different species," says Beissinger.

The two main variables are temperature and precipitation, but California's mountain ranges seemed to be experiencing many permutations of those two, according to Beissinger. While Yosemite was warming, Lassen was growing cooler and rainier. The southern Sierra were warming, and experiencing the same amount of rain or getting drier. Plants and animals were all over the map, too, with some reacting to temperature, while others responded to precipitation.

"With montane species, there's a push and pull; warmer temperatures push species upslope to stay in the same climate, since temperate decreases with altitude. But increased rain pulls them downslope, because rainfall generally increases with elevation," he says.

Climate change gets even more complicated when you consider the conundrums faced by land managers. That's where the new map being constructed by scientists becomes not just an interesting set of observations but also something of practical use.

"With a changing climate, you're likely to have new species coming in," Beissinger says. "You might think, 'Wow, this could increase the biodiversity in my reserve!' That could be true, for a period of time. But it will be a species colonizing at the warming end of their geographic range. For species at the cool edge of their range, or for an endangered



Belding's ground squirrel, **Urocitellus beldingi**, *species distribution model results projecting (a) current distribution from historical presences and absences, (b) future distribution from less severe climate change scenario and (c) future distribution from more severe future scenario.*
Source: Morelli et al. 2012 Proceedings of the Royal Society B.

species, you could have a whole lot of problems. In addition, exotic species and new diseases from locations with warmer climates are showing up."

One thing became clear after Beissinger finished his study: land managers needed to plan, and do it quickly. Like the rest of the country, many of California's parks, forests, and wildlife refuges had been established back in Grinnell's day, when scientists didn't understand landscape-level conservation. Scenic vistas, so-called "rocks and ice" were protected, but lowland habitat needed for migrating species was often left open to development. As climate change forced species from their customary niches, scientists felt they had to move quickly to update California's biological map. It wouldn't be possible to save everything, but prioritizing areas essential to wildlife could help buffer the impacts of climate change.

In California, researchers had the advantage of the state's tradition of valuing its landscape, which included a wealth of scientific research, and of land managers accustomed to collaborative decision-making. For example, post-doctoral researcher Toni Lyn Morelli would never have known that the Belding's ground squirrel was disappearing from the Sierra without access to Grinnell's exhaustive research. Grinnell had studied this common squirrel, also called the sage rat, pot gut or picket pin, in 1918. With funding from the National Science Foundation and later the Cal LCC, Morelli, under the direction of principal researchers Craig Moritz and Steve Beissinger, decided to study the squirrel because small mammals can be bellwethers of climate change, reacting to both temperature and precipitation.

"I went back to every site I could find," Morelli says. "I brought along female undergraduates on backpacking trips through Yosemite. Some of them had never been hiking before, and it was a great experience for them. And then our data surprised everyone."

When the results came, Morelli's research showed that while heads of state were arguing in Kyoto, Copenhagen, and Durban, Belding's ground squirrels had disappeared from 42 percent of the sites where Grinnell and his team saw them.

Morelli and another post-doctoral researcher, Sean Maher, drilled down to causes and solutions. The Belding's ground squirrels live in meadows, where cooler air pools, providing a buffer from climate change. But these oases are

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fragile, and many were disappearing. Their research is now being used to help land managers identify these climate refugia for protection.

Belding's ground squirrel, aka sage rat, pot gut or picket pin. Photo: Toni Morelli

While Morelli and others update and collect information about specific species in specific places, others are weaving together that information in the larger map of the region. The Cal LCC provided support for Jason Kreitler, a research geographer with the U.S. Geological Survey (USGS), to develop an overall map that will help land managers incorporate climate change scenarios into management of wildlife corridors. Kreitler has developed algorithims that apply general circulation models of the earth's oceans and atmosphere to the specific topography of California. He's fine-tuning and coordinating climate change modeling with scientific knowledge of wildlife behavior. Because his mapping stretches across jurisdictions, he's found himself communicating with all kinds of agency personnel.

"People are doing this kind of climate science in different parts of the country, but in the Bay Area people are used to working collaboratively, and tackling issues without waiting for the federal government. So the response of managers has been: 'Great! Tell me what I can do.' With the Cal LCC involved, there's an incentive for interaction with different agencies, state land managers, the forest service, everyone," Kreitler says.

"Everyone" includes people who farm or run cattle ranches. Another Cal LCC-funded project is sketching out possible futures for California's shrinking rangelands. Sixteen million of the state's more than one billion acres are grazed, and much of this land provides habitat for wildlife as well as domestic animals. Kristin Byrd of the USGS is working with a multi-disciplinary team looking at both climate and development patterns in the Central Valley and its surroundings. Byrd says that the most likely scenario is that higher temperatures will, in the aggregate, reduce water availability for pasture and wildlife. The researchers are identifying water and wildlife "hotspots" and assessing their vulnerability, information that can be used not only by wildlife agencies but also for land-use planning.

In a panoramic view, how does this emerging map of 21st century California look?

"Landscapes are really lumpy out there, in terms of what will happen to them, climate-wise," says Steve Beissinger. "Some species will adapt. Others will move, which increases the importance of connectivity. And others may disappear if we don't find ways to sustain them. What did that great social critic and songwriter Tom Lehrer say? 'Be prepared. It's the Boy Scout marching song.' "

California Climate Commons
http://climate.calcommons.org/
Grinnell Resurvey Project
http://mvz.berkeley.edu/Grinnell/

Partners: UC Berkeley, USGS, Cal LCC

THE TRIPLE THREAT

BY JOE EATON

Climate change doesn't act alone. Resource managers must address its interaction with other forces, such as habitat loss and altered fire regimes. Case in point: San Diego County's chaparral, where sensitive plant and animal species were being displaced by urban development and stressed by more frequent fires before climate change was on anyone's radar.

In another Cal LCC project, UC Riverside biologist Helen Regan is developing a management decision tool for that triple threat. Her team looked at three shrubs: Tecate cypress (*Hesperocyparis forbesii*), a California near-endemic and the only host of a rare butterfly, Thorne's hairstreak (*Mitoura thornei*); wart-stem ceanothus (*Ceanothus verrucosus*), also endemic; and the more widespread desert ceanothus (*C. greggii.*) None are listed as endangered or threatened; but the cypress and *C. verrucosus* are covered by the San Diego Multiple Species Conservation Plan.

A wildland fire in mixed chaparral moving downslope in San Diego, California. Photo: Richard W. Halsey

All three plants require fire for their seeds to germinate. "But fires in quick succession can be a threat," says Regan. With a fire- return interval of less than 20 years, they can't produce enough seeds to persist. (Unlike some relatives, the two ceanothus species don't resprout after fires.)

The project used two climate models, one predicting drier and warmer conditions, the other wetter and warmer, along with species distribution and urban growth models. Results: "Suitable habitat is projected to decline in most cases, but frequent fire is a much more serious threat than loss of habitat with climate change." Regan plans to include the threatened California gnatcatcher (*Polioptila californica*), a coastal sage-scrub bird, and the big-eared woodrat (*Neotoma macrotis*) in the next phase of her study.

Her US Fish and Wildlife Service collaborators "want a scientifically defensible method for investigating the potential of different types of management action under the threats of climate change, urban growth, and altered fire regimes," she says. "They're interested in how the science can inform managers."

CLIMATE SMART HOW TO?

BY ARIEL RUBISSOW OKAMOTO

If anyone could be called a cheerleader for climate change preparation in the San Francisco Bay Area, it might be Ellie Cohen. Listening to her speak at a November 2012 Climate Smart workshop for regional professionals, it was hard not to imagine red hot poms-poms twirling above her head. Her sense of positive purpose, her call for constructive work, is as enlivening as looking at climate models is deadly. But there are more like her. Cohen is part of a diverse group of Bay Area professionals that meets quarterly to discuss what information land, water and wildlife managers need to plan ahead, and how scientists can better provide it. This Bay Area Ecosystems Climate Change Consortium (BAECCC), formed in 2009, collaborated with The Nature Conservancy and the California Landscape Conservation Cooperative to put on the workshop where Cohen made her pitch for action.

"To prevent total climate chaos, we have to engage in both mitigation and adaptation, whether you're a city planner or a governor or a parks director or the President," said Cohen, who heads up PRBO Conservation Science. "Conserving ecosystems is just as important as reducing greenhouse gas emissions. We need to collaborate and coordinate from the ocean to the Sierra, break down the silos in the way we do our work, and share information openly across organizations and communities."

Cohen was one of 12 speakers who acquainted the 130 attendees at the Oakland workshop with the climate changes projected for the Bay Area, and what we might do about them. First, the USGS's Tom Suchanek gave an overview of west coast trends in precipitation, temperature, wave surges, storm frequencies and sea level rise. USGS projects a 3-6 degree centigrade rise in temperature for Northern California, and 45-165 cm (16-65-inch) rise in sea level by 2100. "Wave surges are going to increase in magnitude and frequency. How many 100-year storms are we going to start seeing every year?" he asked. Part of being prepared is to do a vulnerability assessment, and the next speaker, The Nature Conservancy's Kirk Klausmeyer, explained how to do one. If you can figure out where on your property vulnerability is low and where high, you can take informed actions to minimize threats and enhance resilience, he said.

In the next section of the workshop, land managers described what steps they had taken to make their restoration or acquisition or development projects "Climate Smart" – a new term adopted from the National Wildlife Federation by workshop organizers. As one speaker commented, "We called it 'resilience' a couple weeks ago."

First, the National Park Service's Carolyn Shoulders described restoration work at the mouth of Redwood Creek at Muir Beach, on Marin County's ocean coast. The work involved realigning the creek channel to follow its more natural course and to fully connect the creek with its floodplain, rebuilding a pedestrian bridge over the new floodplain, and expanding a tidal lagoon. In summer 2013, the visitor parking lot that has dammed the system for decades will also be relocated. "Visitor access is still important, but needed to be accommodated without compromising ecosystem function," she said. "The hallmark of the project is that it allows natural floodplain processes and creek migration, and it's no surprise that the benefits of opening up the flood plain will increase with sea level rise. We removed obstacles so the landscape can adapt as it may."

Next, The Nature Conservancy's Sasha Gennet described a strategic assessment they conducted of how Mt. Hamilton's open spaces south of San Jose would adapt to climate change. Though the assessment suggested this landscape might be relatively climate resilient, connectivity of wildlife habitats emerged as a real concern. "The mountain could become an island, it's very threatened by development spreading south from Silicon Valley," said Gennet. As a result, the Conservancy took a broader, more regional look at habitat connectivity and ended up identifying one unassuming, degraded stretch of riparian habitat in the Pajaro Creek watershed "as a small but mighty piece of the connectivity puzzle," she said. "It was a challenge to convince our funders that this 167 acres of farmland was a linchpin property, and that acquiring and preserving it should be the highest conservation priority in the Bay Area," she said. She described plans for restoring some riparian habitat on the linchpin property, and returning other areas to farming or grazing uses. "Increasing the pace and scale of protection and restoration in the face of climate change is important, but stewardship is incredibly expensive and forever. We have to engage private landowners, including the farming community, in adaptation," she said.

Next, the Sonoma Land Trust's Julian Meisler identified three climate change challenges for his 2300-acre shoreline restoration site at Sears Point: designing a marsh that wouldn't go underwater with sea level rise; providing refuge for endangered wildlife from extreme events (such as a combination king tide and storm); and anticipating what level of protection was necessary for the adjacent railroad and highway infrastructure. "Highway 37 is completely in harm's way, it sits at or below sea level, and we need to be careful we don't worsen the condition," he said. To address some of these challenges, the project includes a big levee complete with setbacks and stockpiles of sediment stored in place so it can be used later to raise the levee as needed. In closing, Meisler said the smartest, most resilient, restoration actions work under multiple climate change scenarios, and that an even bigger challenge may the strings and deadlines attached to many restoration grants.

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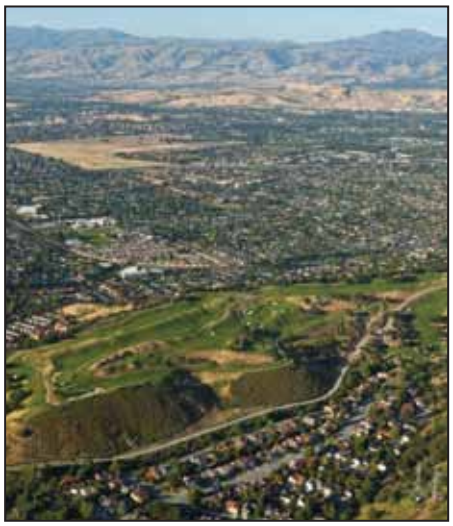
The next speaker, John Parodi who manages PRBO's STRAW program, called climate change in restoration "a game changer." Parodi described a recent experiment in which he modified the planting palette and lay out for a stream-side restoration project in Marin County with climate change in mind: "We added redundancy to our design, we wanted to make sure if one piece of the project failed another would be there to take it's place." To do this experiment in coastal Marin County, he and 282 students and 82 parents did a traditional and a climate smart restoration side-by-side, so STRAW can compare results in the decades ahead. In the climate smart plot, they planted twice the number of species and also at a higher density, for example, and also included some atypical species based on projected changes in precipitation. "We tried to end-run it and get rock-star plants that could handle both extremes," he said.

After these case studies in how to adapt on the ground, the final hours of the workshop were spent on some key tools and information for managers now brewing in various computer models and labs around the Bay Area. David Ackerly from UC Berkeley described the Terrestrial Biodiversity Climate Change Collaborative, and work to downscale models of global climate shifts to the local and watershed level. The models project a sharp rise in summer temperatures, but less of a change in winter months. "The entire Bay Area is going to shift to a new climate, it will be more like Santa Barbara in San Francisco," he said. He urged land managers to confront the possibility that rock star species like blue oaks might not be the showpiece of their properties in the future. "If your focus is a piece of parkland, you won't be able to move the land, and your favorite species may disappear," he said.

The workshop closed with descriptions of several powerful climate change planning tools under development. Stuart Weiss of the Creekside Center for Earth Observation described watershed change projections for 18-acre grids developed by USGS's Alan and Lorrie Flint, which model 100 futures over 10 Bay Area counties. Combining some of their modeling with data on soil storage, recharge, runoff and other factors, he and others have been developing tools to assess what he calls an area's "climatic water deficit" (dry season intensity and stress). After Weiss, Ryan Branciforte described the Bay Area Open Space Council's efforts to enhance the Conservation Lands Network Explorer with a new feature that will allow users to access projections of climate change. "We're trying to customize the tool to show you what your city, your county, might look like in the future," he said. Indeed the many modeling tools that have rapidly been developed over the past few years for the Bay Area, along with other planning resources and research results, are well organized



View looking east toward Mt. Hamilton, with development encroaching across the Santa Clara Valley floor. Just south lie the farms and ranches of the Upper Pajaro Valley, where conservation and restoration could not only protect farming but enable animals to move between big blocks of core habitat in the mountains, and adapt to climate change. Photo: William K Matthias

and presented on-line on the California Climate Commons, explained the final speaker, Deanne DePietro.

After the workshop, several participants commented on its usefulness. Erin Chappell, from the state's Department of Water Resources, whose job it is to bring one of the largest water agencies in world, as well as numerous local water agencies, up to speed on climate change, said: "Most people can understand the climate change concept, but when it comes time to design your water supply or flood control or restoration project, it's not so clear what it should look like. These climate smart principles interest me because they provide a link from theory to practice, and the case studies make the concepts more tangible," she says. She points out that most water planning is based on past hydrologic records that can no longer be counted on to indicate the future. "It's a big transition in thinking for many agencies, not just our agency. Having these examples is very useful."

Another participant, a San Mateo County planner, felt the case studies could come in handy as a reference when he reviews permit applications for park and open space projects. "It's difficult for the public and politicians to understand things like vulnerability and adaptation, so hearing about specific projects like moving the Muir Beach parking lot to enhance natural drainage, and how the planners got the public on board, was intriguing," said San Mateo's Matt Seubert.

In the end, Cohen reiterated some of the climate smart principles BAECCC is promoting. "We have to have a future focus, and imagine beyond the science that's there today. Going forward, we're going to have more and more uncertainty because our environment is changing at an accelerated speed. So don't wait for your boss to tell you, or your government to tell you, what to do. The time to test and experiment is now."

Workshop Presentations & Links:
http://climate.calcommons.org
http://baeccc.org
www.bayarealands.org/explorer/

Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future, National Research Council, 2012
http://dels.nas.edu/Report/Level-Rise-Coasts/13389

Workshop Case Studies & Climate Smart Principles Packet:
www.sfestuary.org/estuary-news/

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