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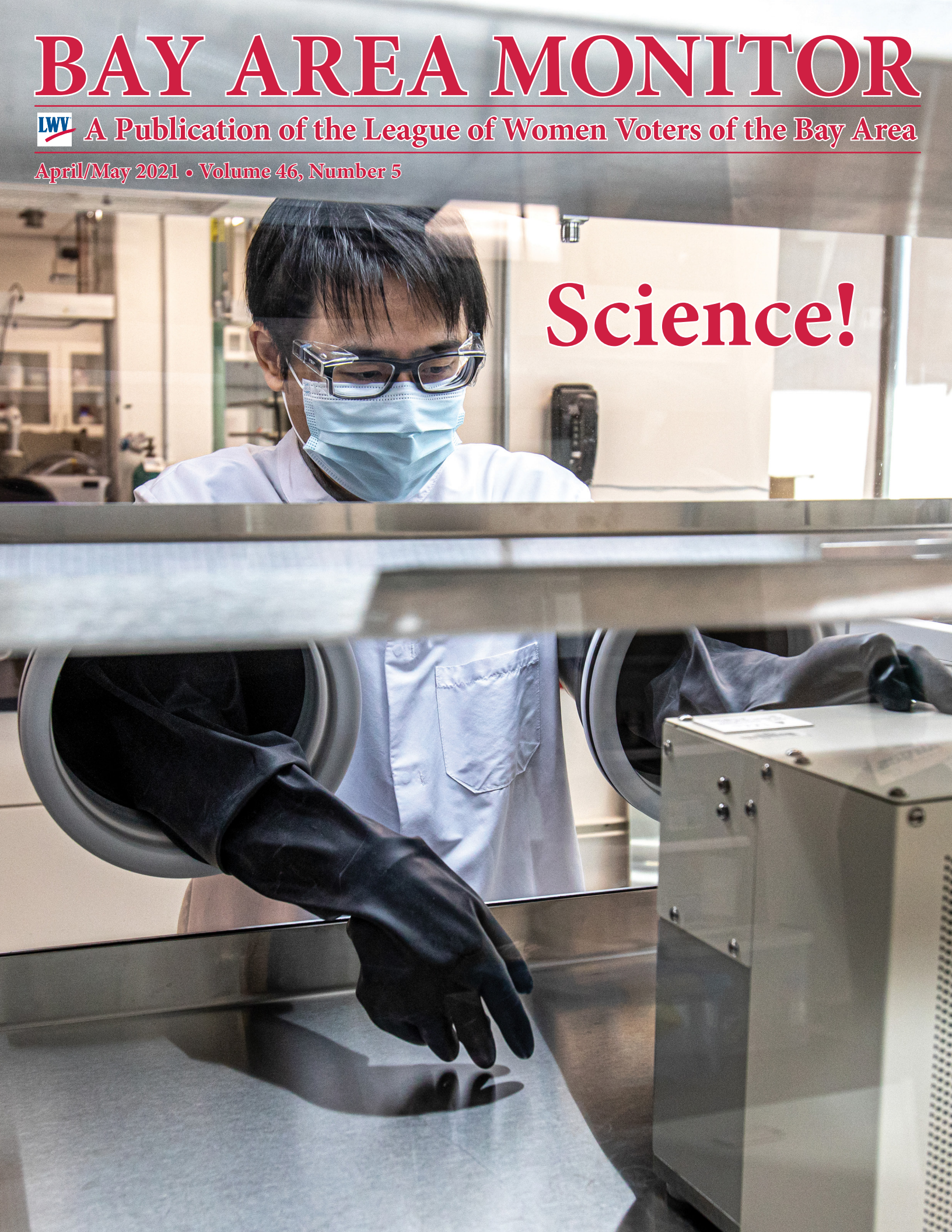

Science!

Getting Experimental

The *Monitor* has always been a publication with a scientific orientation. After all, the League launched it in 1975 to address air pollution, a problem that calls for systematic study, measurement, and expertise, not to mention usage of terms such as "oxides of nitrogen" and "hydrochlorofluorocarbons." Cutting through tricky lingo in attempting to convey technical information that shapes government policy has been a *Monitor* mainstay ever since.

Our current edition exemplifies this effort, with all articles focusing on scientific research in some capacity. We start off with a look at academic investigations into power sources for electric vehicles. In her article on this subject, Cecily O'Connor pays particularly close attention to work being done at the Department of Energy's SLAC National Accelerator Laboratory, an institution featured on our front cover in Jacqueline Orrell's photo of Stephen Dongmin Kang demonstrating how he uses a modular glovebox workstation at Menlo Park's Arrillaga Science Center. The Stanford postdoctoral researcher is part of an investigative team led by William Chueh, whose work with batteries should help reduce the carbon footprint of our energy usage.

Robin Meadows follows with a look at a new study on the unintended consequences of building seawalls along the shoreline of San Francisco Bay to combat sea-level rise, demonstrating how policymakers will need to take such research into account in coordinating an effective and equitable regional response to this threat. After that, Leslie Stewart begins her article by citing recent findings that fine particulate matter in wildfire smoke is up to ten times as hazardous to human health than similarly sized particles from other sources; she then explains how pollution regulators and their partners are seeking innovative methods to reduce the availability of fuel for the wildfires that have become so prevalent in our part of the country. Finally, Aleta George highlights the research of one woman attempting to protect one bird species as an example of the kind of effort required for all of us to protect all species. Aleta also graces our back cover, searching the skies for feathered friends over Suisun City's Rush Ranch.

As important as scientific inquiry may be for its own sake, its application to solving real-world problems is what the *Monitor* strives to illuminate. Ultimately, we want to reveal how science can spur positive change in our communities. Moreover, in the spirit of the League, we also want to showcase ways that you can contribute to that positive change.

The Next Edition of the *Monitor* Will Be Our Last in Print

Read Future Coverage Online at bayareamonitor.org

As we announced in our previous edition, we will discontinue printing the *Bay Area Monitor* in the coming fiscal year, ending our 46-year run of offering a paper copy of the publication. The League of Women Voters of the Bay Area regrets the fact that we are bringing this era to a close, but the cost of maintaining a physical presence in your mailbox is simply too much for us to bear.

We intend to continue covering the region with our unique brand of reporting to keep you in the loop about issues related to transportation, land use, air quality, water, and open space across the Bay Area and beyond. In order to stay connected with our coverage, please sign up for email announcements at bayareamonitor.org/subscribe.

With science, this can be a tall order — not everyone has access to a modular glovebox workstation. While the *Monitor* aspires to provide information you can act on, that goal can be a little harder to accomplish when we're covering cutting-edge research. It's a delicate challenge, and one of a few that I invite you to consider with me at LWV Berkeley-Albany-Emeryville's April 12 Environmental Concerns online meeting at 7:30, when I'll be discussing how the media can empower people to take action in support of the environment. (Visit lwvbae.org for details.)

Of course, the media can use a little support itself. On that note, thank you to our readers who have recently donated to the *Monitor*: Jane Bergen, Linda Craig, Sally Francis, Robert Jenkins, Liza Loeffler, James Murray, and Deborah O'Brien. Your donations will help us complete our transition to an online-only publication this summer.

But before that happens, we'll be back in your mailbox one last time in June. See you then.

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Academic Research Gives a Tune-up to Electric Vehicle Market

By Cecily O'Connor

California has repeatedly strengthened its commitment to reducing greenhouse gas emissions. It wants to have five million electric vehicles (EVs) on the road by 2030 and it will ban sales of new gas-powered cars and trucks by 2035.

At the heart of these moving targets is a significant statewide policy effort to fight climate change and reduce air pollution. But a lot of energy lies in avenues of EV innovation, especially on the academic research path. Universities in the Bay Area and beyond are exploring technologies that contribute to goals necessary for mass EV adoption: reduced vehicle cost and charging time, as well as increased battery range and storage.

Bruis van Vlijmen demonstrates how he works inside a battery informatics lab as part of the SLAC National Accelerator Laboratory's research efforts. photo by Jacqueline Orrell/SLAC National Accelerator Laboratory

On March 8, Stanford University scientists announced a breakthrough toward achieving these goals: they had applied machine learning to accelerate the design of new batteries and enhance their use. Published in *Nature Materials*, their study is part of a collaboration between Stanford, the Massachusetts Institute of Technology, the Toyota Research Institute, and the Department of Energy's SLAC National Accelerator Laboratory.

"Ten years ago, I selected batteries as a research area where I saw promise," said William Chueh, an investigator with SLAC who led the study. "I started working on batteries because I thought electrification would be a key step to de-carbonization, but I also took time to understand the underlying scientific challenges."

He boiled those problems down to a need to design new chemistries for the battery, and also accelerate the pace of research and development. Chueh's research could affect other battery-powered devices like cell phones, but the *Bay Area Monitor*'s interview with the Stanford professor centered on EVs.

To be fair, the EV market has a ways to go before its products are as ubiquitous as cell phones. It's a space where innovation is happening, but growth requires meeting other challenges.

For example, California is the largest U.S. market for electric cars. But sales represent a small portion of new passenger vehicle purchases overall and buying power isn't evenly distributed. Many consumers need subsidies to cover the EV cost and incentivize them to shift out of traditional cars, according to Oakland's nonprofit Greenlining Institute, which provides an equity toolkit to help make cars accessible to underserved communities.

Supporting adoption is essential. Transportation accounts for more than 50 percent of California's greenhouse gas emissions, which contribute to climate change impacts like extreme weather, poor air quality, increased wildfires, and rising sea levels.

When California announced the 2035 phase-out date for gas-powered vehicles in September — a climate-pledge car manufacturers like General Motors and Volvo have since separately committed to as well — it provided added motivation to scientists engaged in ongoing research.

Chueh and his colleagues began a while ago by learning the rules for designing better batteries, the process of which forms the basis of Stanford and SLAC's more recent research, he said.

First, they figured out how to observe what they typically can't set eyes on: how lithium moves inside the battery as it functions. Stanford and SLAC researchers used X-rays to understand how electrode particles release stored lithium ions during battery charging, essentially making a movie of

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what's occurring inside, Chueh said. Research facilities such as Lawrence Berkeley National Laboratory's Advanced Light Source assisted with this effort.

Second, they used that data, along with mathematical models and equations that describe the chemistry and physics of the process, in scientific machine-learning algorithms.

Applying those two data points, they realized some particles release a lot of ions immediately and quickly, while others release ions slowly or not at all. This imbalanced pattern stresses the battery, which limits its lifetime. Stanford and SLAC's discovery has the potential to improve battery cost, storage capacity, and durability for EVs.

Meanwhile, other academics have been studying new energy sources that could power EVs and help take the stress off the electrical grid. In January, a research team at California State University, Long Beach published a study that paints a picture of alternative EV charging. The team explored the potential to find new renewable energy sources when cars are driving under a freeway overpass. The research was funded by San Jose's Mineta Transportation Institute. "We cannot rely only on one system or another system" for power generation, said Hamid Rahai, co-author of the study. "It has to be a combination."

Using computer simulations, Rahai and his team examined the wind load on bridge columns under a 405 Freeway overpass in Long Beach and calculated the wind energy generated when a small passenger van or SUV drives past the supports. Their calculations show it's possible to create significant renewable electric power with a zero-carbon footprint, compared to power plants relying on fuel to generate electricity. But what's the right approach to capture wind energy? Rahai explained one option is a diaphragm. It's part of an electronic system that oscillates and generates a current that can be captured, regulated by electronic circuitry, and made available for public use in various applications.

Or the system could rely on a vertical axis wind turbine to grab wind energy for local power generation. But this option requires continuous wind, which could be a limitation.

Rahai said it's also possible to place diaphragm panels in optimal locations on the bridge, which could be networked to create power. A similar approach could be used for the vertical axis wind turbines along several overpasses for significant power generation, too.

Coincidently, in a separate effort, Stanford professor Shanhui Fan is working on wireless transmission of power to EVs as they drive on highways. He built a wireless charging system that could be scaled to transmit the tens or hundreds of kilowatts of electricity that an EV would need. However, it could be a while before wireless chargers are driven into highways.

EVs will contribute to the need to grow energy supplies, although it won't be "anything extreme or out of the ability of planners to take into account," said Alan Jenn, assistant director at the Institute of Transportation Studies at the University of California, Davis.

About 320,000 EVs are registered in Pacific Gas & Electric's service area, representing roughly one in every five EVs in the nation, according to the utility.

But the amount of stress an EV places on the grid could depend more on when drivers charge, Jenn said. For example, charging around 6 p.m. is a peak demand time while overnight charging is generally less burdensome to the distribution system.

California's 2018 total energy consumption is second-highest in the nation, but fourth-lowest per capita due to its climate and energy efficiency programs, according to the U.S. Energy Information Administration.

"We've had pretty good policy about the grid getting cleaner and adopting EVs," Jenn said. "There isn't really anything yet about charging behavior and promoting cleaner, more sustainable ways of charging. That's a big policy opportunity in the future."

Forthcoming research could inform new policies. Jenn said he is currently contributing to a California Environmental Protection Agency research effort on decarbonizing transportation by 2045. His part is exploring EV charging at specific times. That report will be released later this year.

Cecily O'Connor covers transportation for the Monitor.

Regional Planning for Sea-Level Rise Is Key to Environmental Justice

By Robin Meadows

Seawalls like this one on the San Francisco shoreline (photographed in 2016) receive a great deal of impact from waves. New research suggests that such structures create a bounce-back effect, amplifying tides elsewhere along the bay. photo by Dave R/Flickr

As shoreline communities in the San Francisco Bay Area scramble to prepare for rising seas, they should also be mindful that protecting themselves could worsen flooding elsewhere. This is because seawalls can reflect and amplify tides. "Decisions in one location could affect hazards in another," said environmental engineer Michelle Hummel, who began studying the bay while at UC Berkeley and is now at the University of Texas at Arlington. Her latest research reveals that building seawalls along relatively small sections of shore could raise water levels enough to have far reaching effects, even all the way across the bay.

"It was pretty surprising," Hummel said of her findings, which she and co-author Mark Stacey of UC Berkeley reported in the February 2021 issue of the journal *JGR Oceans*. "We had seen it for seawalls at the county level but didn't expect small-scale projects to have bay-wide impacts."

Hummel and Stacey combined a model of tides in the San Francisco Bay with projections for sea-level rise, and found that seawalls could amplify the tide by up to four inches. "That might not seem like a lot — but if you also have a king tide, storm surge, or high wind, that could extend the amount of flooding," Hummel explained.

Seawalls' effects on water level varied with the landscape of the shoreline. The impact was minimal along the steep bluffs of headlands, which dominate the shore in Marin County, San Francisco, Point Richmond, and the Carquinez Strait that runs between Contra Costa and Solano counties. This makes sense, Hummel pointed out, because a bluff is much like a seawall, so building seawalls along headlands wouldn't do much to change the way water behaves in the bay.

But building seawalls in other places could, especially in the wide alluvial valleys where rivers flow into the bay. "Wide alluvial valleys have more area for storing water, so protecting and cutting them off from the bay would mean higher water levels in the bay," Hummel says. The impact of seawalls on water levels was most pronounced in the alluvial valleys where the Napa and Petaluma rivers join San Pablo Bay, and where Coyote Creek joins the South Bay. "Seawalls there can cause cross-bay interactions," she continued,

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Regional Planning for Sea-Level Rise (from page 5)

"especially at the Napa River, where protections can increase water levels as far away as the South Bay." In other words, when incoming tides hit a seawall at one end of the bay, they can bounce back and ultimately make the water higher at the other end.

These findings add urgency to Bay Adapt, a new effort to coordinate protections against rising tides in the bay. "We need to act more regionally," said project leader Jessica Fain, who directs planning at the San Francisco Bay Conservation and Development Commission (BCDC). "It can't be city by city — one city shouldn't make flooding in another one worse." Launched in 2020, Bay Adapt aims to facilitate consensus on a regional vision for sea-level rise preparation in the bay. "Then local plans can be consistent with the whole," Fain said. Other advantages of a common vision include technical assistance for local planners, who are often spread thin, as well as advocating with a more unified voice for resources from the state.

Fain acknowledges that finding a common voice for the hundreds of diverse stakeholders in Bay Adapt — from elected officials to business interests to environmental groups to community organizations — is an ambitious goal. But she's inspired by a similar effort at the tip of Florida, where four counties joined forces a decade ago to coordinate on climate change. If they can do it there, surely we can do it here too.

Indeed, California is beginning to move in this direction. In a 2020 report called *What Threat Does Sea-Level Rise Pose to California?*, the Legislative Analyst's Office said regional coordination on sea-level rise preparation should be one of our priorities as a state, and held up Bay Adapt as an example. In addition, last year State Senator Toni Atkins of San Diego introduced Senate Bill 1, which calls for more cooperation in coastal planning and development.

Here in the Bay Area, hot-button issues for reaching consensus on sea-level rise adaptation include whether to require regional planning or to encourage it with incentives, a choice that Fain refers to as the stick versus the carrot. Moreover, sea-level rise preparations are much farther along in some parts of the Bay Area than in others, raising environmental justice and equity issues. "We don't want to hold back early movers but we also want to think long term," Fain said. "We want to support vulnerable communities."

One of the most vulnerable is East Palo Alto. This low-lying city of about 30,000 is on the edge of the bay in San Mateo County, which is predominantly white and among the top ten wealthiest counties nationwide. In contrast, East Palo Alto is far more diverse, with mostly people of color — Latinx, Black, Asian, and Pacific Islander — and far less affluent, with 13 percent in poverty.

East Palo Alto sits right between two of the earliest sea-level rise adaptation projects in the Bay Area. Just 12 miles to the north, construction has begun to raise the levee that runs all along the water side of Foster City, a town of 34,000. The project is funded by Measure P, a $90 million bond Foster City voters overwhelmingly passed in 2018, and is scheduled for completion in 2023.

And just 13 miles to the south of East Palo Alto, plans are well underway to build a new levee in Alviso, a San Jose neighborhood at the tip of the South Bay. The project, which will also restore tidal marsh, is estimated at nearly $200 million. Funding to date includes a federal contribution of $80 million, and local contributions of about $60 million from Measure AA, the 2016 Bay Area-wide parcel tax, as well as $17 million from Santa Clara County's Measure S, a 2020 parcel tax. Construction on the Alviso levee project is expected to begin this year and completion is scheduled for 2028.

There's no doubt that Foster City and Alviso both need to bolster their levees against sea-level rise. But, as environmental engineer Hummel's work shows, such unilateral actions could come at the cost of harming unprotected communities like East Palo Alto. "The Bay Area needs a cohesive plan for equity, instead of letting everyone do their own thing," Hummel said.

BCDC's Bay Adapt helps give East Palo Alto and other vulnerable communities a voice at the regional level. "We're

at the forefront of sea-level rise," said Julio Garcia, who is program director for Nuestra Casa, an East Palo Alto community organization dedicated in part to environmental justice. "In about twenty years, a lot of our community will flood."

Garcia is also part of Bay Adapt's 32-member Leadership Advisory Group and, after years of outside planners and engineers parachuting in to East Palo Alto with top-down fixes, he welcomes the move toward including local residents in decision making from the outset. "We live right here — we know where it floods and what will be good for our community," he said. "Maybe we don't want to see a barrier like a seawall, maybe we want a more natural barrier like restored marshland."

Putting local people at the heart of making decisions that affect them will promote trust and buy-in when it comes to sea-level rise adaptation. "Creating true partnerships with communities is a step up from just coming in and being experts," Garcia said. "It will be great for everybody to have a common plan to tackle these issues."

Robin Meadows covers water for the Monitor.

A Burning Issue: Reducing Both Wildfire Fuel and Carbon Emissions

By Leslie Stewart

Where there's smoke, there's fire, goes the old saying — and Northern California has learned that where there are wildfires, there is smoke, sometimes blankets of irritating, unhealthy smoke. A recent study in the journal *Nature Communications* concluded that tiny particles in wildfire smoke are up to 10 times as hazardous to human health as similar particles from other sources. In addition to smoke, wildfires have economic and human impacts, and also add massive carbon emissions to the atmosphere, exacerbating climate change in a vicious cycle which may lead to additional wildfires. In our efforts to dampen their size and frequency, reducing the fuel they depend on is proving increasingly critical.

An aerial view of wildfires in Sonoma County on October 14, 2017. photo by Army National Guard Capt. Will Martin/Flickr

Although wildfires that devastate developed areas also burn structures and possessions, vegetation and trees are their primary fuel; this is why a key strategy in stopping wildfires is to create "defensible space" by clearing vegetation around homes or establishing firebreaks in wooded areas. Removing "biomass" — living and dead trees and underbrush — is therefore a focal point of wildfire prevention and suppression. Handling that biomass is a challenge; burning it adds to carbon emissions, while other options may leave it as fuel for future fires.

Another problematic category of biomass related to wildfires is "salvage trees," trees killed by fire that need to be removed for safety or fuel reduction. Fred Euphrat, a retired forester now teaching at Santa Rosa Junior College, owns 400 acres that were impacted by fire, and he is now selling fire-damaged trees to the county's remaining lumber mill. Marketability of salvage timber is limited by how quickly it can be harvested, as well as how easy it is to cut and transport. Euphrat quoted a

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timber industry motto, "Every time you move a piece of wood you double its price." Even chipping is a problem, depending on the location and condition of the logs.

Currently, there are a few basic ways to remove biomass from potential wildfire locations. You can clear undergrowth while leaving trees (a "shaded firebreak"), you can totally clear both trees and brush, or you can selectively thin out the trees. However, cutting and clearing simply leave biomass in a different form: logs and slash (limbs, treetops, and other woody debris). Although logs may be removed and sold, slash and brush have no value. As Northern Sonoma County Air Pollution Control District Executive Officer Robert Bamford put it, "How do you get rid of all this stuff?"

In the 1980s, a number of bio-energy plants were permitted to burn biomass to create energy. As energy alternatives evolved, these plants became uneconomical; they were also opposed by environmental groups, which maintained that their emissions created pollution and greenhouse gases. Today there are only a few remaining in the state.

In urban areas, biomass from clearing and thinning is often turned into landscaping wood chips, which break down faster but also release their carbon more quickly as they decompose. In more rural areas, mills may produce chips for bio-energy or paper, but chipping is often not economical because of the difficulty and expense of transporting the material from remote locations to a chipper.

Leaving woody debris to decay naturally sequesters the carbon, but flammable material remains on the forest floor. The most common method of dealing with forest waste from clearing and thinning is still to create multiple slash piles in open areas. These are then burned when air pollution regulations permit, resulting in local smoke impacts and the release of as much carbon as if they had burned in a wildfire. "Slash piles are traditional," the U.S. Forest Service's Debbie Page-Dumroese told a recent Redwood Forest Foundation Initiative workshop, "but the smoke and particulates have become untenable — we have to do better."

Controlled or prescribed burning — deliberately setting fires in a specified area under carefully monitored conditions — can also thin and clear vegetation by removing the lighter fuels that will burn quickly, while sparing the larger trees from prolonged heat which would kill them. This practice was used for centuries by Native American tribes to manage forested areas, and tribes are now taking a significant role in its revival by modern forestry.

Prescribed burns have their own drawbacks. They must be done under permits that strictly specify conditions; they may be cancelled if the weather isn't right, and they create smoke which may affect air quality unless humidity brings particulates down to earth quickly. In addition, the condition of many forested areas makes controlled burns dangerously unpredictable without prior programs of manually thinning and clearing, because years of fire suppression have overloaded these areas with flammable biomass. "Prescribed burns are not possible in overgrown forests," said Clarke Stevenson of the firm California Law Empowering Renewable Energy. He asserted that "fires are crucial to long-term forest management, but they can't be done now."

To confront the challenges of handling biomass, policymakers and land managers are exploring new options. In one intriguing example, North Bay entrepreneurs may help develop innovative methods through the Sonoma BioBiz competition, sponsored by the Northern Sonoma County Air Pollution Control District, in partnership with the Bay Area Air Quality Management District, CalFire, and many local agencies and organizations. The broad coalition of sponsors indicates the range of interest; in addition to air quality impacts, major county industries are affected by loss of timber and smoke-tainted wine grapes, while fire damage and destruction of viewsheds can affect property values.

The Brentwood Public Library is one of several Bay Area construction projects to use mass lumber, which is cost-effective and has a low carbon footprint. photo courtesy Contra Costa County Library

Competition organizers are not expecting a proposal for a bio-energy plant that simply burns wood chips to create energy. Their website (*biomass.biz*) provides some starter ideas: several types of controlled combustion to create synthetic fuels and biochar; "mass lumber" for construction projects; and using wood from salvage trees.

Controlled combustion processes include pyrolysis, gasification, and biochar production. Pyrolysis and gasification capture the gases created as the biomass burns to create a synthetic bio-oil or syngas that can be burned for heat or energy. Both release less carbon and emit fewer pollutants than open burning or bio-energy plants.

Biochar kilns use the gases that are emitted during combustion as additional fuel in a low-oxygen combustion process. Biochar has a number of commercial applications when produced in bulk, or smaller quantities can be returned to the forest floor, as charred wood from a forest fire would be. It captures up to 50 percent of the carbon from biomass, making it an excellent way to sequester carbon long-term.

Unlike larger facilities that require the biomass be transported to them, biochar kilns come in a variety of sizes suitable for smaller-scale operations closer to the biomass source. A truck-mounted biochar kiln is currently operating on the Richardson Ranch in northwestern Sonoma County. A recent virtual workshop hosted by the Redwood Forest Foundation Initiative showed how portable kilns are being used in Mendocino County to create biochar from biomass generated from firebreaks and stream restoration projects. The workshop also showcased a grant-funded demonstration project conducted by the Sonoma County Ecology Center that uses similar kilns. The Ecology Center's project manager Raymond Baltar predicted during the workshop, "Burning low-value biomass in the forest will continue."

Other more novel uses for biomass include mass lumber, which is growing in popularity as a construction option. These laminated wood products are being used in Bay Area projects, including the Brentwood Public Library and the Microsoft campus expansion in Silicon Valley. California recently amended building codes to allow buildings of up to 18 stories to be built using mass lumber rather than requiring steel and concrete, significantly reducing their cost and carbon footprints. An affordable housing project in San Jose using mass lumber will start construction in 2022.

Wood from fire-damaged trees may require special processing, but is now being used by cabinet makers and musical instrument builders. Both mass lumber and salvaged wood products lock up carbon because the wood is not being burned or otherwise destroyed.

An informal survey of landscapers and tree-trimmers in 2013 in Sonoma County indicated that much of their waste material went to landfills, sequestering the carbon, but it could be diverted to other biomass uses. Fire prevention activities such as clearing defensible space around homes in the wildland-urban interface, or clearing trees away from power lines, also create woody biomass. Much of the agricultural waste generated by vineyards is potential fuel for biochar or other biomass combustion.

Better biomass management can transform woody waste material from a headache into an asset. In addition to avoiding wildfires and preventing smoke and carbon emissions, innovative approaches to biomass as a resource may play a significant role in a more resilient region.

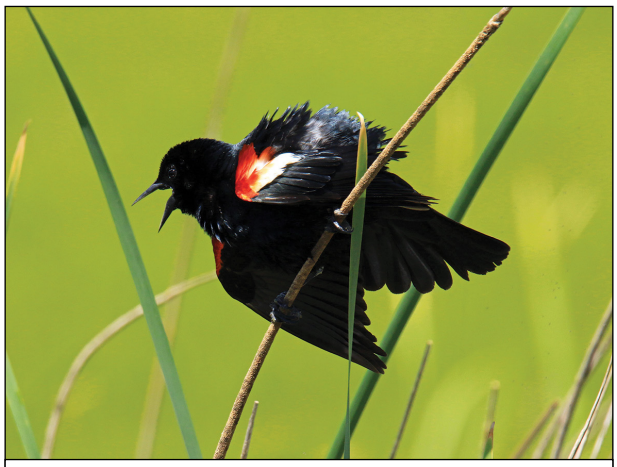
Leslie Stewart covers air quality and energy for the Monitor.

Take These Broken Wings

By Aleta George

A study published in the journal *Science* in 2019 found that bird populations in North America have taken a nosedive in the last 50 years. By crunching data from citizen scientist counts and surveys, scientists found that there are three billion fewer birds than there were in 1970.

One species that has taken a heavy hit is the tricolored blackbird, whose population has plummeted from several million in the mid-19th century to less than 180,000 today, according to Audubon California. In response to the population crash, a band of individuals and conservation organizations are finding creative ways to bring this bird back from the brink. Their efforts to protect this one species serve as an example of the collaboration and ingenuity needed to address the overall loss of bird populations in the Western Hemisphere, especially with the advent of climate change.



Tricolored blackbirds can be identified by the white stripe at the base of the male's otherwise red epaulet. photo by Tom Muehleisen

Sometimes one person's actions can make a difference. After several years of recording the songs and calls of breeding tricolored blackbirds in Solano County, volunteer Wendy Schackwitz is driving the length of California in her RV to place AudioMoth sound recorders in breeding colonies of tricolored blackbirds, named for the jaunty white stripe at the base of the male's scarlet epaulet. Trikes, as they are fondly called, are closely related to the more common red-winged blackbird, but unlike red-winged blackbirds, they are almost strictly a California bird. Also unlike the red-winged variety, trikes are colonial nesters, the largest in North America. "It's their one claim to fame," said Schackwitz.

Schackwitz's interest in tricoloreds began in 2016 when Solano Land Trust asked her to monitor a breeding colony near a restored pond at Rush Ranch, a 2,070-acre open space preserve in Suisun City. Schackwitz, a retired geneticist who was then the president of Napa-Solano Audubon, observed two rounds of nesting that year. But even with weekly visits, she wanted to know more about the birds.

The following year she applied for a small grant to pursue an idea inspired by Soundscapes to Landscapes, a project that studies bird diversity across landscapes through bioacoustics and modeling. She wondered what she could learn about the breeding colony at Rush Ranch if she dedicated her bioacoustics monitoring to that one species. Could a map of their sounds inform her about the breeding timing of the birds?

She recorded the birds at Rush Ranch during the 2017 breeding season. With lots of rain, a full pond, and juicy bugs for the birds to eat, it was a good year for the trikes. At the height of the season, she counted 2,000 birds (high for Bay Area colonies, but not for San Joaquin Valley colonies that can number in the tens of thousands). With thousands of hours of recordings, she created a sonogram, a picture of sound in graph form. By matching the sounds to observations made on site visits, she was able to link specific sounds to behaviors. She chose three vocalizations on which to focus: the male song, which meant courting; the female song, which meant nesting; and the end of the female song, which meant hatching of the chicks. With this information, she was able to determine the exact number of nesting attempts, and the dates the babies hatched, information that in the future could be of potential use to farmers and conservation groups in the San Joaquin Valley.

California's Central Valley was once a giant wetland where tricolored blackbirds and other birds and wildlife found suitable habitat for breeding and feeding, and as the wetlands were being swallowed by cities and farms, the trikes adjusted. They found alternative nesting habitat in introduced Himalayan blackberry thickets and grainfields of triticale, grown as feed by dairy farmers. The problem with their adaptation is that the time to harvest the triticale is synchronous to the breeding cycle of tricolored blackbirds.

The blackbirds were being slaughtered during harvest, and with the majority of the population breeding in Central Valley grainfields, something had to be done. Audubon California biologists knocked on farmers' doors to inform them of the problem, but it wasn't enough. "The farmers want to respect the birds, but they are also trying to make a living," said project manager Xerónimo Castañeda. "[We] needed a more concerted and organized effort to educate the producers on why they needed to protect the birds, and we needed resources to help."

In collaboration with Western United Dairies, Dairy Cares, the

California Farm Bureau Federation, the California Department of Fish & Wildlife, and the U.S. Department of Fish & Wildlife, Audubon California applied for and received a grant from the USDA Natural Resources Conservation Service. With that funding in place since 2014, they have educated dairy farmers about the problem, and compensated them for delaying their harvests until the baby birds fledge and the colonies leave the area.

"It has become a real-time, rapid response action," said Castañeda. Once a colony lands to breed, Castañeda contacts the ag partners, who call the dairy farmers. "It's been a huge success, and in 2020 we protected pretty much 100 percent of the colonies that we found on dairy fields." The largest colony last year had about 25,000 birds.

"Whether it's drinking a glass of milk or eating some nice cheese, that milk could have come from one of the dairies that is participating in our program," adds Castañeda, who said the program costs, at minimum, $500,000 a year.

After her first year of recording, Schackwitz expanded her efforts and for two years placed recorders at several other sites in Solano County, which still supports several small breeding colonies in natural habitats. This year she invested $5,000 of her own money on new equipment, and with data obtained from eBird — an online bird-sightings database — is tracking colonies up and down California. She had hoped to place 40 to 50 recorders, but the logistics have proven challenging. Many of the breeding sites are on private property, and gaining permission is often a process that takes time.

With an introduction from Castañeda, Schackwitz will place a recorder on at least one San Joaquin Valley dairy farm this year. "I'm excited to learn more about the timing of [the birds'] nesting and when they are on the landscape," said Castañeda, who conducts site visits of breeding colonies once or twice a week. The recordings will provide near continuous data. "Hopefully, the data will provide more precision in when the birds will be out of the fields so that the farmers can return to their work."

Another potential site in the Bay Area where Schackwitz may place a recorder is in Santa Clara County, but she won't know until April when a site visit confirms that the birds have returned to the same site. In Santa Clara County, there are three to four small breeding colonies of tricolored blackbirds, though the number of birds and number of sites were once much larger. "They liked those wetland valley floors with cattails, which Santa Clara Valley used to have," said wildlife biologist Ryan Phillips, who in 2014 conducted the first survey of trikes in that county.

All but one of the extant breeding colonies are on private land, and not protected. The one public site that has had a breeding colony in the past is in Cañada de los Osos Ecological Reserve, owned and managed by the California Department of Fish & Wildlife. The Santa Clara Valley Habitat Agency is planning to improve the habitat of a 14-acre pond to entice trikes. Improving habitat for the blackbirds will also make it more habitable for red-legged frogs and western pond turtles. The cost of the project is unknown as it's still in the planning stage.

Wendy Schackwitz recorded the songs of tricolored blackbirds at Rush Ranch. photo by Aleta George

Phillips and others are thinking even bigger. "In my opinion, Coyote Valley could be the stronghold in the region for tricolored blackbirds," he said, citing the restoration potential of natural protected lands. Restoring habitat is not a guarantee that blackbirds will come, however. In addition to suitable breeding habitat, the birds need to forage for their young in the vicinity of their colonies, which adds another layer of complications. The decline in insect populations from insecticides and herbicides is a significant factor in the birds' survival. Climate change is another issue. According to a 2019 report by Audubon, *Survival by Degrees*, at least one-third of the tricolored range will be lost as the climate shifts.

The tricolored blackbird is one bird among many that has had to adapt to our world, and efforts to save it illustrate the complexities and costs required to protect a species from going extinct. Castañeda gleans hope from the Audubon California program. "We like to share this story as a kind of champion because it has brought together all these different stakeholders to move towards the common goal of protecting this iconic species that can't be found anywhere else in the world."

Aleta George covers open space for the Monitor.

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