

Making the most of action on climate

by Bob Miller and Doug Wilson

As storms intensify and sea levels rise, competition for scarce public resources to deal with climate change will likely increase. How will we decide where to best spend those resources? Marin County is currently engaged in implementing its Climate Action Plan (CAP), as are all of the towns and cities in the county, to help meet greenhouse gas (GHG) reduction targets that are not already state- or market-driven. These plans list local sources of GHG emissions and possible actions to reduce or offset, i.e., mitigate, them. The county's CAP also includes strategies to adapt to the effects of climate change, notably sea level rise.

These plans have many similarities, but also some differences: not all Marin municipalities have shorelines, and only the County has significant agricultural lands. Sharing of ideas and results among jurisdictions nonetheless makes good sense, and ultimately the more unified Marin's response, the more effective it is likely to be - locally and globally. But in Marin each CAP contains longer lists of possible actions than can realistically be funded or acted upon in the near future.

How do we make choices among many possible actions and projects? Not only are funds limited, but in many cases our knowledge about the cost-effectiveness of projects also is limited. Climate change is not a new phenomenon, but

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Ocean Acidification: The "other CO2 problem"



Acidification is complicated by upwelling of deep waters along the California Coast such as offshore Point Reyes National Seashore.

Judy Betz

In tackling the causes and consequences of global climate change, it is tempting to focus on what is most visible, like the shrinking Arctic icecap, or where sea levels are likely to reach along the Marin shoreline. While these are vitally important, other less obvious effects of climate change are occurring in our oceans as atmospheric concentrations of carbon dioxide (CO₂) attain unprecedented levels and average temperatures worldwide seawater reach historic highs. Oceans occupy 70 percent of the earth's surface and contain 97 percent of the earth's water. About 30 percent of the CO₂ released by burning fossil fuels is absorbed into the ocean. How this is affecting ocean chemistry and marine ecosystems is not immediately apparent to most of us, but ocean acidification (OA) is rapidly earning its reputation as the "evil twin of global warming."

At MCL's March 23 Water Speaker Series meeting, Dr. Karina Nielsen, Director of the Romberg Tiburon Center (RTC), addressed MCL members and the public. In the span of an hour, she outlined the basic chemistry of carbon in the ocean, how the carbon cycle has been deviating from historic norms due to rising CO₂ concentrations and global

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A Message from the President

We live in a time when we must face difficult questions about our relationship to the land and to the sea. The choices we make today will impact generations to come and planning for the future is not really about us anymore.



Though climate change is a human issue, it's not just a human issue. The ongoing effects of climate change are a threat to endangered ecosystems across the planet and a strain on all.

It's critical that populations of species are given time to adapt to changing conditions. That's where conservation comes in. Public

lands are essential. The greening of urban, natural, and working lands all contributes to greenhouse gas reductions--an important mitigation strategy. However, ongoing conservation requires clear and sustained focus, vigilance, and resolve in maintaining protections. There can be no backsliding on protections.

The past is not the future. Unlike those in Washington who threaten rollbacks of environmental protections, we understand that the days of unconscious and unabated use of resources are over. As a community and as a region we increasingly understand our connections to the land and sea, the limits they require of us, and our necessity to live within those.

California is the sixth largest economy in the world. As such, California's actions

have far-reaching impacts. Climate change projects in the state can create models that are used by others and can become part of a larger American conservation story. Recent MCL Annual Dinner keynote speaker and past state legislator, Fran Pavley, through her work on AB32 and SB32, have shown us that.

Investing in solutions that have the greatest positive impacts, implementing environmental protections with oversight and enforcement, creating incentives, and transparent reporting are all required. Please join Ken Alex, Director of California's Office of Research and Planning, at MCL's Business-Environment Breakfast on May 19, to hear about California's investment in climate change mitigation.

Updates on Marin's public lands

This has been a spectacular spring for Marin's open spaces and parklands. It has also been an unusually busy time for the agencies that manage these lands: storms have taken their toll in downed trees, slides, and other damage to roads and trails. Plans and new projects are in various stages of design and public review. Some projects are essentially "shovel ready," waiting for the end of nesting season and other conditions that limit the construction timelines. Among current activities are the following.

Managing vegetation on the County's open space preserves

Late last year, after an eight-year planning process, the Marin County Open Space District Board of Directors agreed to "accept" a Vegetation and Biodiversity Management Plan, but not to certify its EIR. (See [MCL Newsletter January-February 2017](#)) Controversy over including herbicides as one of several tools in the County's Integrated Pest Management (IPM) "toolbox" for controlling weeds on open space preserves threatened to

derail the management program. The Board asked for greater emphasis on working toward zero herbicide use on the preserves, and they asked for greater public engagement.

This spring, staff has developed an ambitious work program for 2017-2018 that lists 85 projects targeting about two dozen invasive plant species on 30 preserves. Fourteen projects are on Ring Mountain Preserve alone. The majority of projects qualify as "maintenance" - treating infestations that can be controlled by "organic" methods, i.e., by repeated hand pulling supplemented with power tools, or in limited cases, by goat grazing or propane flaming, and in very small areas, covering plants with plastic. In 17 projects, however, the plan recommends strategic use of "conventional products," i.e., selected herbicides. Most of these are in fuel breaks that must be kept clear of broom thickets



Volunteers tackle an infestation of broom.

Marin County Parks

for fire safety. In two wetland areas, species like invasive Spartina and pepperweed have proved to be resistant to other methods of control. On Ring Mountain, the primary rationale for strategic use of herbicide is to contain non-native weeds that threaten to spread into rare plant populations.

Although the Open Space District's progress toward zero herbicide use is commendable, the District must pursue that goal with a clear understanding of

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Public lands *from page 2*

what is practically achievable and when. A practical goal is to manage each project that warrants some use of herbicide to reach an eventual zero – a point where other methods can take over, and/or the threat of further invasion is eliminated. That would spell success, but sometimes this takes years of persistent effort. Therefore, as long as any of the District's preserves require attention, the tool box door should not permanently close on herbicides as one tool. In addition, every year new invasive plants find their way into the Bay Area, such as the arrival of Japanese knotweed considered one of the world's 100 worst invasive species and now taking hold in some Marin waterways. How to control such invaders continues to challenge public land managers. MCL will be monitoring the effectiveness of the District's program.

worked through 18 preserves in Regions 1, 2, and 3, District staff are focusing now on the six preserves that make up Region 4 in North Marin. Novato is fortunate in its abundance of open space preserves. Novato counts ten preserves within easy reach of its scattered neighborhoods, six of them in Region 4.

Mount Burdell, the largest preserve in the Open Space District at 1,627 acres, is also the fifth tallest of Marin's hills and mountains (1,558 ft.).



Mount Burdell trails will be the next focus of the RTMP.



Japanese knotweed is a recent threat to marin waterways.

The mountain hosts rare plant species on serpentine soils, and areas of native grasses and wildflowers persist despite a past history of over grazing. In spring, the broad grasslands are a mass of wildflowers. Six species of oaks, plus possible hybrids, also make this preserve botanically unique. The preserve also offers a network of popular roads and trails for hikers, bikers, and equestrians. Numerous informal "social" trails have been created over the years by local residents, mountain bikers, or others. These will be a particular focus of discussion: which trails should be kept open as foot paths or improved eventually for shared use and which should be decommissioned to reduce habitat fragmentation and prevent damage to sensitive plants. Other issues to expect at the workshop: mountain bikers asking for more access to currently restricted foot

and equestrian trails and local residents wanting favorite social trails to remain open.

Other preserves in Region 4 offer an unusual variety of ecosystems, among them: Rush Creek and Bahia, with extensive adjacent tidal salt marsh, a large non-tidal marsh, and a rare (for Marin) blue oak woodland; Deer Island, surrounded by diked historic former tidelands and the Novato Creek floodplain; Indian Tree, with unexpected giant redwoods and huckleberry at the 1,440-ft. crest after a long, largely forested ascent; Little Mountain preserve, tucked between North Marin Water District lands and Stafford Lake and O'Hair Park; and the smallest preserve in Region 4 – Verissimo Hills. The latter two offer more local recreation.

The Open Space District will hold a public workshop on May 13 at the Margaret Todd Senior Center from 1:00 – 3:00. At that time staff will provide draft maps of the preserves, showing

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Road and Trail Management Plan moves north

Two years after rolling out the long-studied plan for managing the roads and trails in the County's Open Space District preserves, the painstaking process of designating which roads and trails to include in the "system" continues. Having

Events

Seniors Walking

Under a Measure A Community Grant Program, MCL is hosting five Senior Walks into Conservation History this winter and spring. At this date, groups had visited Bothin Marsh, Deer Island, and Ring Mountain Open Space Preserves. A Walk around Cemetery Marsh in the Rush Creek Preserve is planned for May 25, and the concluding Walk will be a 1 ½-mile walk

around the popular Lake Lagunitas, in the MMWD watershed, on June 29. Transportation is provided, departing from Mill Valley Community Center and Smith Ranch Road Park & Ride. Reservations are required.

Call 415-485-6257, or reserve on line at mclevents.eventbrite.com

May 25: Rush Creek Preserve

June 29: Lake Lagunitas



Nona Dennis leads a group of walkers around Deer Island on March 30, 2017.

Kirsten Nolan

MCL Director Profile

Bob Miller, San Rafael



photo courtesy of Bob Miller

Bob Miller joined MCL's Board in 2016, following his retirement in 2015 as a professor of health economics on the faculty of UC San Francisco. Among other work during his 25 years at UCSF, he analyzed and compared managed care with non-managed care health plan performance related to utilization, quality, and service. His papers on health information technology costs, benefits, barriers/facilitators and financing included estimates of the cost of electronic health records that were incorporated into a \$30 billion federally-funded incentive program designed to accelerate adoption of health information technology by physicians and hospitals. Bob currently is a member of the Investment Advisory Committee for a UnitedHealth care

loan program that helps health care providers serving disadvantaged patients to access California's tax-exempt municipal bond market.

As a member of last year's Environmental Forum of Marin's Master Class, Bob analyzed the economics of carbon sequestration in Marin rangelands. At MCL, he is continuing to examine carbon-sequestration costs, benefits, barriers and facilitators, to further understanding of the comparative cost-effectiveness of greenhouse gas (GHG) mitigation alternatives. Bob is also a hiker and enjoys birding. He received his PhD in economics from the University of Michigan.

Events

Business-Environment Breakfast, Friday, May 19, 7:30–9:00 a.m., McInnis Park Clubhouse

Ken Alex, Director of the Office of Planning and Research, to speak

The closest analog that California has to a statewide land use and planning agency is the Office of Planning and Research (OPR). Unknown to most of the public, OPR resides within the Governor's office and has the basic charge of planning for California's growth and environment. MCL is looking forward to welcoming Ken Alex at its Business-Environment Breakfast on Friday, May 19. It will be an opportunity to learn more about the agency and to hear about current activities from OPR's longest tenured director (17 years).



Ken Alex

As the Director of OPR, Ken Alex serves as Senior Policy Advisor to Governor Jerry Brown on a wide range of land use and climate-related policy issues. He also chairs the State's Strategic Growth Council, which comprises the Secretaries of Food and Agriculture, Cal EPA, Natural Resources, State Transportation, Health and Human Services, and Business, Consumer Services, and Housing, plus three public members. During his tenure as director, Ken has led a broad effort to modernize land use planning through greater transparency; easier access and local application through

mapping tools, templates, and streamlined permits; reduced barriers to in-fill development; promotion of transit oriented development; protection of agricultural land and open space; recognition of water constraints; and updated general plan and CEQA guidelines.

Before joining the Governor's Office, Ken was the Assistant Attorney General heading the environment section of the California Attorney General's Office, and the co-head of the Office's global warming unit. From 2000 to 2006, Ken led the California Attorney General's energy task force, investigating price and supply issues related to California's energy crisis. California Lawyer named Ken an "Attorney of the Year" in 2004 for his work in energy law. In 2007, he received the American Bar Association's award for Distinguished Achievement in Environmental Law and Policy for global warming work. Ken is a graduate of Harvard Law School and holds a B.A. in political theory from the University of California at Santa Cruz.

OPR – some background

OPR was created by statute in 1970 during the Reagan administration. It is part of the Governor's office and serves the Governor and his cabinet as staff for long-range planning and research. It also oversees environmental policy and the California Environmental Quality Act (CEQA), which was enacted the same year. This included reporting to the legislature every four years. In 1973, OPR published the Environmental Goals and Policy Report (updated in 1978, 1983, and revised in 2003). The report's broad goal was to "articulate the state's policies on growth and development while preserving environmental quality."

The agency has evolved over time, subject to the priorities of the sitting governor. During the first administration of Governor

Jerry Brown (1975 – 1983), OPR was at the center of groundbreaking research, land use and growth policies that influenced the state's direction for decades to come. That period was followed by 16 years of Republican governors and four years of a Democrat who weren't enthusiastic about government supervision of state land use.

In 2008, during Republican Arnold Schwarzenegger's tenure as governor, the Strategic Growth Council (SGC) was created with the charge to better coordinate the activities of state agencies, provide local governments with data and information, and to facilitate collaboration over a wide range of state concerns, including environment, natural resources, air and water quality, energy, transportation, economic development, public health, water conservation, and equity and communities. The centerpiece was a bond-funded grant program to assist in the development of sustainable communities. Promoting sustainable communities and meeting the goals of AB 32 (including the SB 32 extension) have been ongoing priorities of the council. As Chair of the SGC and Director of the OPR, Ken is strategically positioned to influence California's future.

Ticket price includes full breakfast buffet.:

\$15 MCL Members

\$20 Non-members

Pre-registration required by May 16.

Register online at

mclbb_kenalex@eventbrite.com

or call 415-485-6257

Marin Conservation League Business Member Profile



THE OUTDOOR ART CLUB

By Arlin Weinberger

MCL is proud to have the Outdoor Art Club of Mill Valley as one of its long-standing Business Members. Associations between the two organizations reach back into 20th century history and reveal a deep shared commitment to conservation, in both cases initiated by women.

For the Outdoor Art Club, it started in 1902 with women on a walk in Mill Valley - that was the beginning of this 115-year-old organization. The group had come upon some workmen cutting down redwood trees near Litton Square. They were aghast and decided that they should form an organization to preserve the beauty of Mill Valley.

Founded by 35 civic-minded women, the Outdoor Art Club has a long history of conservation and preservation, starting with "Clearance Days" in 1902 when 53 school children cleared debris around the Old Mill. It soon became apparent that the new organization needed a home, and funds were raised to buy four parcels in Mill Valley and build a clubhouse. Bernard Maybeck designed the building (his fee was \$165.37) and it was completed in 1904. In 1978 it was designated as a Registered Historical Landmark. The membership is now over 400

women and the Club undertakes projects through its various sections, including Civics and Conservation, Community Service and Cultural Arts.

In its early days the Club initiated such projects as working with children to cut down caterpillar infestations (by paying children to collect jars full of caterpillars). Later, moving to bigger projects, the Club led a successful drive to save vegetation along the hiking trails of Mount Tamalpais and convinced the Marin County Board of Supervisors to take responsibility for policing fire trails.

The Club's conservation efforts have not been limited to Mill Valley. Through the years they have joined with other conservation organizations to purchase land for Audubon Canyon Ranch (ACR) (1962); plant seedling pines in over 30 acres of El Dorado

National Forest (a long term project); conserve the Corte Madera tidelands (1965); work with MCL and ACR to preserve Kent Island in Bolinas Lagoon (1967); save the Butterfly Trees of Muir Beach (1972-73); and, again collaborating with MCL and others, work to purchase land in the Northridge area of Mt. Tam, leading to establishment of the Marin County Open Space District in 1972. The Club spearheaded the drive to purchase important railroad acreage above Mill Valley (1976). They also were the sole Mill Valley sponsors of the California Historic Resources Inventory (1977).

The Outdoor Art Club has had another interesting connection with MCL. Grace Wellman, born in 1904 in the historic "Flinn House" in Mill Valley and whose mother was a founder of the Club, carried her family's conservation tradition forward and served for several notable decades on the MCL board, including a term as president. She received MCL's Green Award in 1982.

MCL commends the long commitment of Mill Valley's Outdoor Art Club to conservation and its contributions to the environmental quality of Marin County and greatly appreciates its support as a Business Member!



Under construction.

Courtesy of The Outdoor Art Club



Promoting Safe Trails in Marin

Going out for a hike or jog or a bike ride next weekend? Or for a ride on your horse? Whether you're on foot, hooves, or wheels, "Slow and Say 'Hello'" when you pass fellow travelers. MCL joins Marin Horse Council and Marin County Bicycle Coalition in urging you to travel safely, respect plants and wildlife, enjoy your experience, and leave a legacy of wildlands for future generations to appreciate. safetrailsmarin.org

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which trails are recommended for adoption as system trails and which social trails might be slated for decommissioning. Maps will also show sensitive resources to be avoided.

Redwood Creek Watershed and Muir Woods National Monument

The National Park Service (NPS) has a number of projects in various stages of review, both within Muir Woods National Monument and along Muir Woods Road, now renamed "Frank Valley Road" from west of the concrete bridge. (See "Restoring a Watershed...", MCL Newsletter November–December 2016, for an overview of projects.). The public recently received status updates for two of the projects, discussed below.

County Public Works staff joined NPS personnel in April to report progress to the Board of Supervisors on tasks listed in the NPS-County MOU signed in 2014. The MOU outlines a seven-year program aimed at reducing and eventually eliminating parking along Muir Woods/Frank Valley Road and relieving traffic congestion. The core of the plan is NPS' Vehicle Reservation System for visitors to the Monument,

scheduled to launch in early 2018. The planning for this system is complicated, with little precedent in the Park Service for guidance. In the meantime, the County and Park Service have worked closely to reduce parking on the road shoulder adjoining

traffic, as it is intended to do, congestion and parking along the road toward Muir Beach will be unavoidable. Traffic woes for local residents have been exacerbated by this winter's closure of Shoreline Highway, with no relief expected until repairs are completed.



Under the MOU, parking eventually will be eliminated from the roadside.

Fog City Secrets

On a separate note, NPS recently circulated an Environmental Assessment (EA) for the Salmon Enhancement and Bridge Replacement Project, whose primary objective is to restore high quality habitat for juvenile Coho salmon inside

Redwood Creek by installing bollards and enforcing parking restrictions. The NPS also has hired parking attendants to assist drivers during peak visitation periods.

Residents of Muir Beach, who must deal with Muir Woods' visitor traffic, are justifiably frustrated by the glacial pace of the "improvements." Indeed, until a reservation system begins to even out peak

Muir Woods. At a public meeting in April, NPS environmental staff explained the three-part project to 1) remove many of the large boulders that were installed to stabilize creek banks by the California Conservation Corps in the 1930s, to restore a more natural stream processes; 2) strategically place large woody debris, like already-fallen trees, in the creek to create pools and refuge for juvenile fish; and 3) replace four aging bridges that cross the creek and connect trails with upgraded new structures. These tasks are complicated by the extraordinary sensitivity of the resources that must be protected during construction, while, at the same time, accommodating a continuing stream of visitors. Projects will be phased over several construction seasons. Portions of the creek will be temporarily dewatered during the low flow season, and staging areas will be established at Alice Eastwood Camp at one end, and the entry Plaza at the other. The EA contains details and is available on line at <https://parkplanning.nps.gov/projectHome.cfm?projectId=62983> Comments on the EA are due by May 18, 2017.



The Salmon Enhancement Project would remove many large boulders that stabilize the banks of Redwood Creek.

Nature Note

California names a state lichen

How did we miss such an important event? On January 1, 2016, the “lace lichen” (*Ramalina menziesii*), a remarkable organism that festoons branches in many of Marin’s coastal woodlands and evergreen forests, became the California State Lichen. Like our state bird, the California quail; or state rock, serpentinite; state flower, California poppy; or state grass, purple needle grass – the lace lichen joins 16 other such symbols of California’s geo-ecological diversity. More than 1,900 species of lichen are known in the state, 1,200 of them in Marin County. Lace lichen stands out as one of Marin’s iconic species, a clear signal of the coastal fog belt.

Assembly Bill 1528, authorizing the designation, was sponsored in 2015 by Assembly Member Marc Levine and sailed through the legislature. But the real work must be credited to the California Lichen Society, who launched the campaign in 2011 and sparked Levine’s interest. Among local members of that society, Clint Tellner of Novato was enthusiastic over the success: “It’s certainly a first for California!” California is the only state to recognize a lichen as a state symbol.

The subject of endless fascination in their seemingly infinite configurations and colors on trees, rocks, desert soils, and other substrates, lichens give real meaning to the term “biodiversity.” The lace lichen is simply one of the more conspicuous members of this diverse group of organisms. Often confused with “Spanish moss” (no relation) or “old man’s beard” (a different species of lichen), the lace lichen is found throughout coastal California, extending inland as much as 130 miles wherever a valley through the hills draws in wind bearing coastal fog. This broad distribution was one of the reasons lace lichen was such an obvious candidate for state designation – that, and the ease of recognition even by those not well acquainted with lichens, and because of its unique beauty!

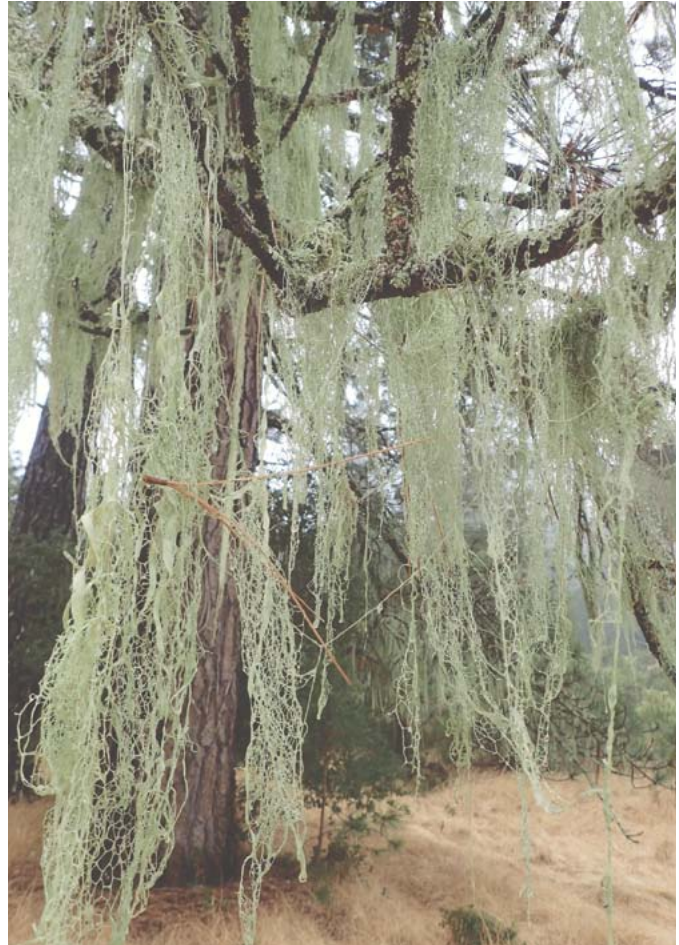
This shouldn’t diminish appreciation

for the other 1,199 species of lichens in Marin, however – half a dozen different species can crowd onto one short branch of an oak, or dozens of multi-colored “crustose” lichens may cover the surface of a rock.

A three-part organism

For 150 years, scientists have known that lichens consist of a relationship between a fungus and a green alga or a blue-green alga (cyanobacterium) that form a symbiotic union. The fungus provides the “home” or structural support, absorbs moisture from rain and fog, takes up nitrogen from the air, and traps dust particles, which yield other nutrients; and the alga provides the necessary chemical energy (sugars) derived through photosynthesis. Last year, researchers made a new discovery: lichens also contain a single-celled yeast that apparently produces chemicals that help lichens ward off predators and repel microbes. This explains, in part, why scientists have been unable to synthesize lichens in the laboratory, even when combining species that have been partnering successfully in nature for 400 million years!

Although omnipresent, lichens’ importance in ecosystems can be easily overlooked. They are ecosystem pioneers, slowly breaking down rock to initiate soil



J. Maughn flickr creative commons

Lace lichen may be found in clumps like “Spanish Moss” but can be clearly identified by its lace like structure.

development. Animals use lichens for food, nesting material, and camouflage. Humans have used lichens for millennia as dyes and medicines. Lace lichen, in particular, has a long history of use for baby diapers and other sanitary purposes.

And now lichens, known for their sensitivity to air pollution and climate, have a contemporary job. When asked “Why name a lichen?” Marc Levine responded: “They are biological indicators of both air quality and climate change around the world.”

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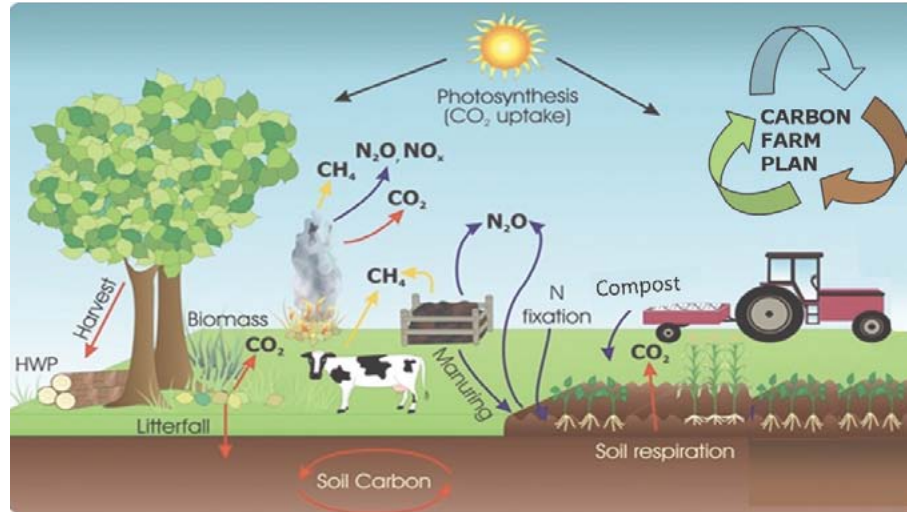
detailed knowledge is, and responses will doubtless lead us into new territory, with intended and unintended consequences, and sometimes ancillary benefits beyond those related to climate.

Here we propose a set of criteria in the form of questions that might be asked in deciding where and how to spend public funds on projects to mitigate greenhouse gas emissions.

1. Is the project price or cost to society "reasonable" compared to other ways of mitigating greenhouse gases? The most commonly used cost metric to compare GHG mitigation efforts is dollars per metric ton of carbon dioxide equivalent (\$/tCO₂e) not put into, or removed from, the atmosphere. Carbon dioxide is not the only GHG pollutant (there are also methane and many others), but it is by far the largest. Thus we measure all GHG pollutants by comparing them with CO₂. Society's cost for each mitigation activity includes financial costs less benefits. The cost to society is what counts, regardless of who pays, private or public. Non-financial benefits and costs (including for public health, safety, environment) must also be considered.

Like any other purchase, the lower the social cost or price paid per tCO₂e reduced, the greater the "bang for the buck"—the better the value for the money spent. Some mitigation projects—like switching to LED lighting or some types of large-scale solar installations—can generate savings over time (rather than incur costs), but in many cases some price or net cost must be paid.

What's a "reasonable" price to pay per ton of CO₂ equivalent reduced? The Environmental Protection Agency (EPA) estimated that in 2007 each ton of CO₂e cost society about \$44 in today's dollars (although other estimates are far higher), so any mitigation activity costing less than \$44 could be seen as a net saving to society as a whole. Alternatively, some large oil companies, in costing out long-range investment projects, anticipate government-levied carbon taxes of \$40–\$80 per ton CO₂e emitted, which is consistent



Intergovernmental Panel on Climate Change (IPCC)

Carbon sequestration on rangeland is a "best practice" strategy.

with the EPA's estimate. Currently, many GHG reduction opportunities appear to be in or below that price range. Paying for a project with a high price per ton CO₂e reduced, such as California's bullet train project, may well have value—but for reasons other than reducing greenhouse gases.

2. Is the public policy exemplary—a "best practice" policy that helps develop technologies like carbon storage or methane capture, or that other jurisdictions could copy and spread? Marin accounts for less than 1/200th of one percent of global greenhouse gases, so Marin's primary contribution to reducing global warming should be fostering innovation in mitigation techniques or public policies that might serve as models for others outside of Marin.

3. Is the potential impact large enough to be worthwhile? Since public programs incur staff time costs to administer them, projects with greater GHG reduction impact likely will have lower administrative costs per tCO₂e reduced.

4. Will the market solve the problem without additional public policy? In some mitigation areas, like large-scale wind and solar, continually falling costs due to competition, technology developments and economies of large-scale production may argue for waiting, letting even lower market prices create mitigation incentives without public spending.

5. Does the mitigation project, such as a ground-based solar array, maintain or enhance existing biological diversity or in any way compromise it? Reducing greenhouse gases has real value, but projects should not harm existing ecosystems.

6. Can outside grant money pay for part of the cost? Too often the availability of "free" outside grant money determines which projects get funded, regardless of other criteria. If the cost to society of a mitigation project is high—and outside grants cover the costs—that project may have value, but not much for reducing greenhouse gases.

At least two other considerations also are important:

Spending on "municipal" versus "community" greenhouse gas mitigation

Most CAPs separate their inventories of GHG emissions into those associated with governmental activities ("municipal") and those associated with "community" activities and facilities, like transportation or residential and commercial building energy. To date Marin jurisdictions have mostly funded projects that reduce their own operations' GHGs. According to unincorporated Marin's Climate Action Plan, however, County operations ("municipal") account for only three percent of its overall GHG emissions, while the "community" accounts for 97 percent. In most cities, that

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Ocean Acidification from page 1

temperature levels, the mounting evidence of how these shifts are affecting coastal ecosystems, the progress of recent research into the known and unknown biological effects of ocean acidification (OA), and the importance of linking research findings to policy and legislative action. The RTC, which Dr. Nielsen heads, is one of a number of research institutions along the Pacific Coast, from San Diego to British Columbia, that are conducting critical research into the phenomenon of OA and its ecological effects.

The mechanisms of acidification

Acidification of ocean waters is not a new topic. Carbon chemistry in ocean water has been understood since the late 18th century, but scientists have been tracking ocean pH for only a few decades, and research into related coastal ecology is even more recent. (pH is the log scale measure of the alkaline [basic] and acidic properties of water, with 7 being neutral.) In a brief "Carbon--Oceans 101" tutorial, Dr. Nielsen explained that CO₂ from the atmosphere reacts with seawater to form a weak carbonic acid. With increased CO₂ uptake, however, some of the "extra" carbonic acid molecules react with water to yield bicarbonate, thus binding up carbonate ions needed to build shells and skeletons, and freeing a hydrogen ion to increase acidity, i.e., lower the pH.

The ocean as a sponge for CO₂

The ocean acts as a sponge for excess atmospheric CO₂, but not without a cost. As concentrations of CO₂ have risen in the past 200+ years since the industrial revolution, surface ocean pH is estimated to have decreased from 8.2 to 8.1 on a log scale, representing an increase in acidity of almost 30 percent. Acid levels differ widely across the earth's oceans, varying with temperature and depth and many other factors, but in combination



With increased ocean acidity, it takes more energy to form shells.

with other biogeochemical changes in the ocean, acidification could undermine the functioning of entire marine and coastal ecosystems, threatening food security for millions, and causing other untold social and economic disruption. More alarming is the rate of ongoing acidification, projected to increase by about 150 percent by 2100 if we continue to emit CO₂ at the current rate. This rate of OA has not been experienced for at least 400,000 years and could continue for hundreds of years to come. (UK Ocean Acidification Research Programme, 2015)

Upwelling complicates the picture

Acidification is especially complicated along western coastlines such as the California Coast, where surface waters, deflected away from the coastline by northwesterly winds during the summer, are replaced by upwelling of deep, cold waters. During the process of upwelling, waters that have been isolated from surface waters for sometimes hundreds or thousands of years become nutrient rich as they pick up the breakdown products of accumulated organic matter along the ocean bottom, but they also acquire higher acidity and lower oxygen concentrations. In surface waters, the nutrients stimulate

primary production (phytoplankton, sea grasses, marine algae) and attract a feeding frenzy of marine creatures, but the acidic and low oxygen (hypoxic) chemistry may have deleterious consequences for many marine organisms. The interplay of these properties makes the coastal ecosystems on the Pacific continental shelf a particularly interesting and important area for research on changing ocean chemistry. Conditions are not static. Dr. Nielsen pointed out that there are dynamic "hot spots" along the southern Oregon and northern California coast where conditions vary with seasons and the amount of upwelling.

Relationship to biology

Once considered a benefit, the capacity of oceans to remove CO₂ from the atmosphere is now revealing a significant ecological downside, with particularly negative consequences for organisms that rely on carbonate ions to build shells and skeletons. These organisms span the food chain, from pteropods (tiny marine snails that are a key marine food source), to more recognizable filter-feeding bivalves, such as oysters, mussels, and clams here, or coral reefs in the tropics. With increased

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acidity, it takes more energy to form shell structure; once formed, shells may be thinner and therefore more vulnerable to corrosion or predators. The death of coral reefs is already alarming the public worldwide as ocean waters warm and the coral structures dissolve.

Winners and losers?

Not all organisms respond in the same way. There may be a few winners as well as losers as acidification continues. A NOAA-supported study projects that Dungeness crab and some commercial finfish species living on the sea floor may decline in future years due to negative effects on their shelled prey, while other marine organisms, including zooplankton, seabirds, marine mammals, and fish that live in the water column, may be less affected, although their dependence on vulnerable organisms at the base of the food web needs further study. Dr. Nielsen said the native Olympia oyster, currently being cultivated in a pilot program to build a "living shore" in San Francisco Bay that is resilient to sea level rise, appears to be doing somewhat better than the commercially grown Pacific oyster. In 2013, a MCL audience heard Terry Sawyer, marine biologist and co-owner of Hog Island Oyster Company in Tomales Bay, report that larval and juvenile stages of oyster development in his oyster beds are particularly vulnerable to acidic water. The company is working closely with researchers at U.C. Davis' Bodega Marine Laboratory to better understand how OA might affect oysters in the future.

Connecting science and policy: what can we do?

If there is any good news, it is that research institutions are collaborating on a regional scale and are also working with local and state governments to promote management strategies that will conserve the greatest number of shell fish (and other) species. Prompted in part by findings of a

panel of scientists from along the length of the Pacific Coast of North America and convened by the Ocean Science Trust on behalf of the Ocean Protection Council, the California legislature passed S.B. 1363 last year, signed by the Governor in September, which establishes the Ocean Acidification and Hypoxia Reduction Program. The bill calls for state agencies to coordinate on a variety of measures that protect habitats in the coastal ecosystem and to promote cultivation of eelgrass ("seagrass") in the shallow submerged zone. Eelgrass can help to oxygenate shallow coastal waters and also sequester carbon.

While governments can take some actions to forestall the damage, their actions depend on continuing study of ecological effects and development of adaptive solutions in a field where, although the chemistry of OA is very well understood, the ecological unknowns outweigh the knowns. Accelerating OA science will expand the management options that are available; inaction now will reduce options and impose higher costs later. Through actions to protect coastal ecosystems from other stressors, such as controlling pollutants from entering the ocean from the land, we buy time for ecosystems, leaving organisms with more energy to cope with exposure to acidification while we continue working together to mitigate OA's root cause. Ultimately, the only long-term solution is to reduce the build-up of CO₂ emissions in the atmosphere. Dr. Nielsen closed her remarks with an eloquent plea for political support for research and science training programs that are threatened by federal budget cuts.

Climate *from page 9*

proportion is similar. So projects confined to the municipal realm will necessarily have limited value. While funding a switch to MCE's "Deep Green" option for public buildings may meet "reasonable" cost criteria, programs like the County's Green Commute program apparently do not (at over \$300/tCO₂e).

Jurisdictions have tended to focus on "municipal" GHG mitigation for various reasons: lack of a constituency or administrative champion for community programs, absence of a budget line item for community efforts, limited control over outcomes that depend on persuasion or incentives, and challenges in measuring the true impact (how much was due to the program versus what would have happened anyway?). These challenges might be addressed in a structured process which would include major stakeholders from the community, tasked with finding innovative, cost-effective, mitigation projects.

Spending on "adaptation" versus "mitigation"

The Marin BayWAVE Project report will increase community awareness of Marin's vulnerabilities to sea level rise and to increasingly strong storms along the Bay, as the C-SMART Assessment has done on the Pacific Coast (See MCL Newsletters November–December 2015; January–February 2017). While understanding of such vulnerabilities is crucial, demand for public spending to protect Marin's assets and possibly lives could overwhelm spending on mitigation—unless Marin assumes responsibility for being a leader in GHG mitigation innovation and policy.

MCL will be discussing these and other considerations and criteria for cost-effective action on climate in [monthly meetings of the Climate Action Working Group](#) and welcomes input from other organizations and individuals.

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**Issue Committee Meeting Schedule
(subject to change—check website)**

Land Use and Transportation:

1st Wed. of the month, 9:00 AM—11:00 AM

Parks and Open Space:

2nd Thurs. of the month, 3:00—5:00 PM

Invasive Plant Subcommittee of POS:

3rd Wed. of the month, 3:00—5:00 PM

Climate Action Working Group: 3rd Fri. of the month, 9:00 AM—11:00 AM

Agricultural Land Use: meets quarterly; Water and Watersheds, North Marin Unit: Check website for times and locations

Marin Conservation League was founded in 1934 to preserve, protect and enhance Marin County's natural assets. MCL is a non-profit 501(c)3 organization. All contributions and memberships are tax-deductible to the extent allowed by law.

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