Ecesis

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Guest Editor: Ashley Zavagno *WRA, Inc.,* **and Brian Bartell** *Prunuske Chatham*

Process-Based Restoration

1 **The Science of Letting Nature Do the Work**

8 **Beaver and Process-Based Restoration Build Momentum in California!**

11 **Butte Sink Mitigation Bank: Adapting a Process-based Based Restoration Approach to Mitigation Banking**

16 **Rewilding the Carmel River at Rancho Cañada**

19 **Low-Tech Process-Based Meadow Restoration in the Kern Plateau-Golden Trout Wilderness**

Plus

2 **SERCAL 2023 Call for Abstracts — Cultivating Connections**

6 **Opening Plenaries**

23 **Leadership Team & Supporting Members**

24 **Amplifying New Voices**

Managing Editor: Julie St John

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The Science of Letting Nature Do the Work *by Damion Ciotti[1]*

Process-based restoration (PBR) is an invitation to nature to take a substantial role in a restoration project. Instead of engineered blueprints and heavy construction techniques used to build discrete areas of habitat, we remove human constraints (e.g. infrastructure) and open space and connectivity, allowing natural processes to do the work. Nature's work involves complex interactions of floods, sediment, vegetation, and wildlife. Restoring what Aldo Leopold referred to as the "land's capacity for self-renewal" is the basis to PBR. For the U.S. Fish and Wildlife Service, this allows us to restore more complex and biodiverse habitat and work at larger landscape-scale by employing nature to do a greater share of the restoration work.

Doty Ravine Creek in the Sierra Foothills is a demonstration site of this approach. Like many Sierra streams, it was degraded by a century of levee infrastructure, agriculture, grazing, and dredge mining. Instead of measuring project success by what habitat we could build with heavy machinery, we asked how can we employ

continued next page

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Above: **A beaver dam analog (BDA) built during the pilot project in Casa Vieja Meadow.** *Photo courtesy Nick Bouwes.* See page 19 for article: *Low-Tech Process-Based Meadow Restoration in the Kern Plateau-Golden Trout Wilderness.*

Photo by Monte Kawahara, BLM

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A full pool beaver dam provides complex habitat and reduces flow capacity in the degraded incised channel. *Photo courtesy Damion Ciotti.*

The Science of Letting Nature Do the Work *continued*

nature and invest minimum effort? Fortunately, the landowner, Placer Land Trust, was equally excited and willing to experiment. We did a few actions to assist nature, including hand-placed wood structures to help existing beaver reinforce their dams so they wouldn't blow out in the incised channel (4 to 9 feet deep). Heavy machinery construction was limited to breaching agricultural levees and providing offstream livestock watering. This removed the human controls that prevented channel migration and wetland development.

In four years, the site went from an incised, degraded channel and dry floodplain to a 60-acre complex of anabranching channels and wetlands providing migratory bird, salmon, and steelhead habitat. We provided nature with space to do the work and evolve itself. Beaver jumpstarted the process early on by raising the water level in the incised channel to something resembling an infinity pool. Their operation converted the floodplain from star thistle and blackberry to sedges, cottonwood and willow sprouts, increasing the roughness coefficient by a magnitude in preparation for coming floods. That winter, the channel "woke up" after a 1-½ century-long slumber and migrated across the floodplain, forming new channels and depositing sediment like a farmer's plow preparing new seedbeds for riparian vegetation. The beaver were no longer confined to the incised channel and built large dam complexes, creating expansive wetlands and new stream channels that provide refuge for fish and storage of water, sediment, and carbon. The site took a new and ever-changing form created by nature, under present day climate and environmental conditions, validating its long-term sustainability and resilience.

> There is potential for expansion of the restoration economy with professionals skilled with their hands and an eye for working with and mimicking natural stream processes.

The Beaver Teacher

There were key lessons about habitat restoration design and how we use space, energy, and materials efficiently and adaptively with a restoration project. Beaver seem focused on two primary objectives: 1) Increasing vegetation production, and 2) Maintaining a connected water system of ponds and channels for protection and transport of materials. For example, nature achieved full floodplain connectivity in year two after filling less than 15% of the incised channel with sediment. Beaver only filled the channel where they absolutely needed to. Floodplain connections occurred incrementally and at four locations with beaver and beaver dam analogues (BDAs). My past projects required moving tens of thousands of cubic yards of rock and soil to fill incised

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The Science of Letting Nature Do the Work *continued*

channels and stabilize floodplains. Beaver achieved this in part by "filling the channel with sunlight" and growing a dense jungle of willow, bulrush, and other vegetation, diminishing the incised channel's flow capacity. They also had no need for imported largewood and rock to stabilize their construction, and simply grew vegetation onsite to provide resistance to intense winter flood shear stresses. Traditionally, we invested heavily in fossil fuel to import rock and harden our projects. Are there applied engineering lessons to be learned from beaver that may increase our quality, efficiency, pace, and scale of restoration?

I realized our search for stability in restoration design was yielding extreme inefficiency. Force-fitting projects into the ecosystem not only overlooks opportunities to use natural process but requires additional fossil fuel and soil disturbance to resist nature's forces of change. The Doty Ravine project cost the USFWS $58,000 for levee-breaching and construction of BDAs. Had we used conventional restoration techniques, this project would have cost upwards of $400,000 for implementation of standard channel-fill and stream channel construction practices that would require moving and importing tens of thousands of

Beaver work with stream energy to farm the valley bottom increasing vegetation production and storage of fine sediment, water and carbon. *Photo courtesy Matt Hamman.*

cubic yards of soil and rock material. This cost savings is only secondary however, compared to avoiding disturbance to existing salmon habitat and Native American cultural resources that would have been prerequisite. Standard actions would involve channel dewatering, clearing of riparian vegetation, scraping and regrading soil, and importing of fill and rock to harden or stabilize newly constructed habitat. These actions also presented risks of introducing invasive species. In the end, we would have succeeded in constructing something new, but would it be as dynamic, biodiverse, and resilient as the habitat we allowed nature to build?

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New anabranching channels and islands form across the floodplain as beaver dams and vegetation clog the old incised stream channel. *Photo courtesy Damion Ciotti*

The Science of Letting Nature Do the Work *continued*

Similar successes across the West raise the question of why this approach is not more common? Academics argued for a process-based approach for decades, suggesting the fundamental goal of *espace de liberté*, or making room for the river to do the work. While this concept took off in Europe, the U.S. followed the path of channel engineering whereby the practitioner speculates the form a stream reach should take and then precedes to construct that form. While suitable for certain streams with limited space, energy, or sediment, its misapplication has diminished nature's seat at the restoration table. The practice of mimicking and working with beaver however, has revived the idea of PBR by engaging a new generation of practitioners with practical tools in ecological engineering. As a result, we are seeing practitioners and programs shifting away from investments in heavy-handed construction of stream, meadow, and wetland habitat in order to invest in the short- and long-term benefits of PBR and working with nature to heal itself.

While we are passionate about PBR, we are also pragmatists. There are no panaceas. There are only degrees to which natural process and nature can be employed to do the work if human constraints cannot be addressed. For example, stream reaches below major dams that block sediment supply, urban areas with restricted lateral space, or heavily mined areas may require construction and channel engineering techniques. We still need heavy machinery for modifying infrastructure such as ditches, levees, and roads. However, many streams are suitable for a process-based approach including delicate meadow ecosystems and small streams where infrastructure can be modified and we can mimic beaver and natural wood-loading process.

Process-based restoration remains a largely untapped opportunity to increase the pace, scale, and quality of stream restoration. Simply relocating nuisance beaver to key restoration sites would be a powerful tool with demonstrated value of nearly a half million dollars for one Sierra project alone. There is potential for expansion of the restoration economy with professionals skilled with their hands and an eye for working with and mimicking natural stream processes. Integration of stream restoration and fire management is opportunity to use wood deemed waste to feed streams devoid of wood structure. These efforts will also help move the restoration community to net carbon storage in the coming decade by relying more on nature's power and reducing unnecessary construction and fossil fuel use. The greatest challenge to PBR implementation is finding the will to relinquish some controls to nature as we develop a project. We will develop sustainable projects once we accept the restoration end goal is dynamic and we are in a partnership with nature to get there.

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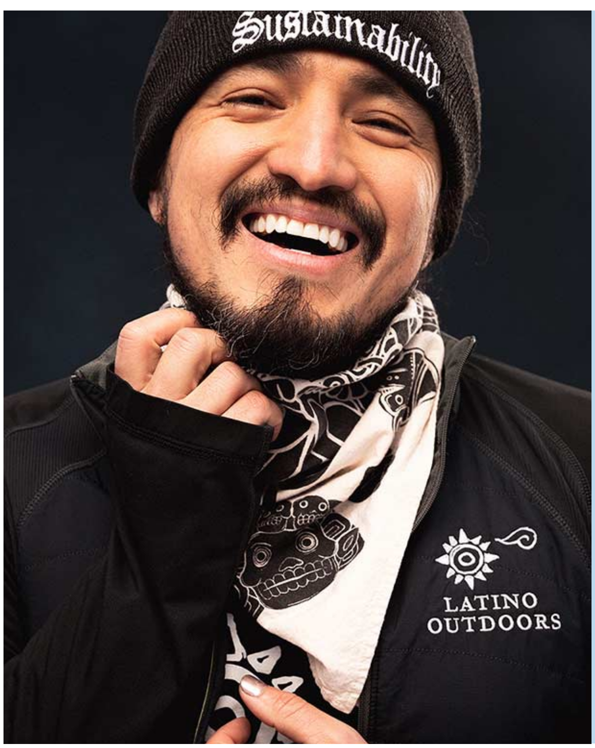
For more information on this topic see "Design Criteria for Process-based Restoration of Fluvial Systems" **https://academic.oup.com/bioscience/article/71/8/831/6307424**.

Thursday Evening Opening Plenaries

April 13 at the Davis Veterans Memorial Theatre

Dr. Earyn McGee

Dr. Earyn McGee received her BS in Biology from Howard University and a MS and PhD in Natural Resources from the University of Arizona. Dr. McGee is passionate about field research, herpetology, and social justice. This is reflected in her research which focuses on how drought affects lizards in arid environments and also how to increase the representation of African American women in natural resources careers. She is a NSF Bridge to Doctorate Fellow and a NSF GRFP Fellow. She has served her community as a Doris Duke Conservation Scholars graduate mentor, the Co-chair of her department's Inclusive Excellence committee, and as a science communicator. You can find her on Twitter and Instagram at **@Afro_Herper** where she runs a popular social media game called #**FindThatLizard**. Every week she sends out a photo of a lizard camouflaged in its natural environment to her 47k+ followers on Twitter and almost 20k followers on Instagram. Players then have four hours to **#FindThatLizard** before the location is revealed. Earyn uses this game as an opportunity to teach people about lizards and help them build a greater appreciation for these cool animals. Dr. McGee was also one of the co-organizers for the 2020 social media phenomena **#BlackBirdersWeek**. She has been recognized for her efforts as a Forbes 30 under 30 lister in 2020. In the fall of 2019 Dr. McGee was named an AAAS IF/THEN STEM Ambassador. As a part of this program, she has been able to share her work with a national audience. Including inside *Marie Claire* magazine, on Goldieblox's *Fast Forward Girl*s, and soon an episode on CBS's *Mission Unstoppable*. Dr. McGee and the other 124 Ambassadors have been honored with life sized statues as part of the **#IfThenSheCan** — The Exhibit program. She spent the summer of 2020 working for the *Las Vegas Review Journal* as an AAAS Mass Media Fellow. Her greatest accomplishment in this program was having her work was featured on the front page of the newspaper. One day Dr. McGee hopes to host a natural history TV show to teach people about animals and showcase Black, Indigenous, and other People of Color doing important conservation work.



José G. González

José G. González is the Founder of Latino Outdoors and Co-Founder of the Outdoorist Oath. He is a professional educator with training in the fields of education and conservation while engaging in different artistic endeavors with art and messaging—often exploring the intersection of the environment and culture. As a Partner in the Avarna Group and through his own consulting, his work focuses on Equity & Inclusion frameworks and practices in the environmental, outdoor, and conservation fields. He is also an illustrator and science communicator.

He received his B.A at the University of California, Davis, and his M.S at the University of Michigan School of Natural Resources & Environment. His teaching coursework was at the Bilingual, Multicultural, Education Department at Sacramento State.

He serves as a Trustee for the National Outdoor Leadership School, a Trustee for the National Recreation Foundation, and Outdoor Industry Association Board Director, among other such leadership volunteer roles.

You can connect with him on social media **@JoseBilingue**. Puns welcomed.

Friday Morning Opening Plenaries

April 14 at the Davis Veterans Memorial Theatre

Nailah Pope-Harden

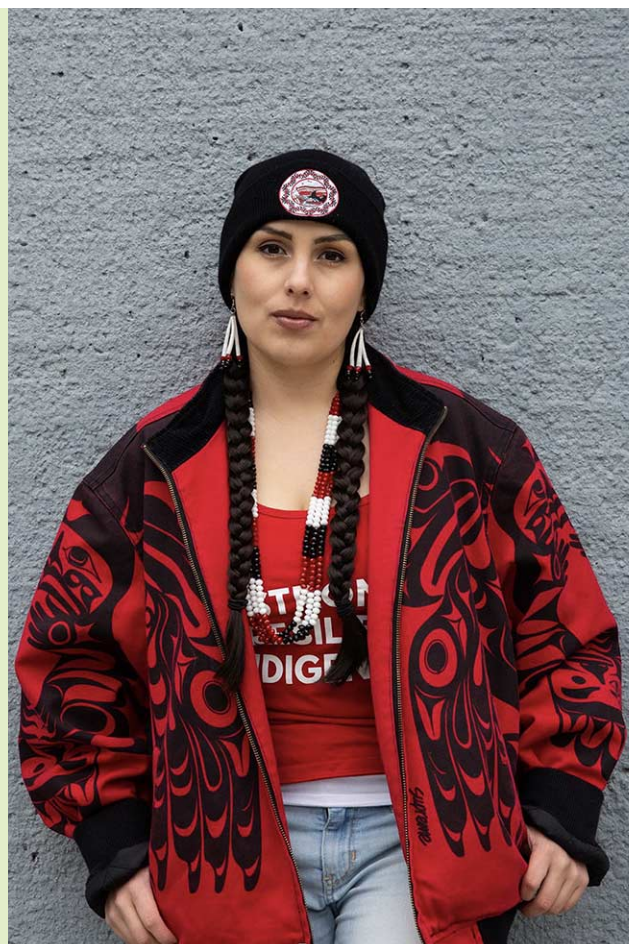
Nailah (nah-EE-lah) is the Executive Director of ClimatePlan. In her role at ClimatePlan, she is responsible for expanding the network presence, cultivating new members, and ensuring the mission and vision of the organization are being carried out. She comes to this position with years of community organizing and coalitions building experience that spans neighborhood, regional, state, and national social justice campaigns. The through-line in Nailah's personal and professional life is always ensuring her son has a healthy, safe, loving environment and future. She does this by building community everywhere she goes, learning from those around her, and being open to (transformative) change. Nailah is located in Sacramento. **nailah@climateplanca.org**.

Nailah first came into SERCAL's radar when we heard about the Morrison Creek Revitalization Project and watched her presentation, *Equity is Not Salt; We Need to Add Spice*. From there, we hired her to conduct a series of DEI workshops for the Board of Directors, and she presented during our SERCAL 2021 session on Diversity, Equity, and Inclusion. Needless to say, we are huge fans of Nailah!

Brook M Thompson

Brook Thompson (She/Her/They) is a Yurok and Karuk Native from Northern California. Growing up she lived and fished on the same land that her ancestors have been on since time immemorial. Brook fights for water and Native American rights through public speaking, academic research, and frontline activism. She has been an intern for the City of Portland's Bureau of Environmental Services, the Senate Committee on Indian Affairs in D.C., the California State Water Resource Control Board Office of Information Management, Save California Salmon, and currently works as a Restoration Engineer for the Yurok Tribe's fisheries Design and Construction Program. In 2017 Brook was awarded the American Indian Graduate Center's Undergraduate student of the year and in 2020 she won Unity's 25 Under 25 award, and in 2022 was accepted into the Water Solution Network. Brook is a graduate of Portland State University with a Bachelor of Science in civil engineering with a minor in political science and a master's in environmental engineering at Stanford University and is now attending UC Santa Cruz for a Ph.D. in environmental studies where she studies how Indigenous Knowledge can be better implemented to into California water policy. Thompson's goal is to bring together water rights and Native American knowledge through engineering, public policy, and social action.

You can find her at **BrookMThompson.com** or on Instagram at **brook_m_thompson**.



North American beavers (*Castor canadensis*) can create beneficial aquatic habitat in many watersheds across California, including this urban stream in the city of Napa. *Photo: Rusty Cohn, Napa Beavers*

Beaver and Process-Based Restoration Build Momentum in California!

by Hannah Wilton[1], Kate Lundquist[2], and Brock Dolman[3]

Over the past few months, beavers have captured the media's attention and garnered widespread support amongst California leaders as the next best "climate-solving hero." Indeed, a growing body of research shows that this keystone species can help increase water storage, provide habitat for other species, sequester carbon, and even create natural fire breaks. As the state faces persistent drought, wildfires, and other climate change woes, many are turning to beaver as a "nature-based solution" that could help mitigate our biodiversity and climate crisis.

Despite their recent recognition, beavers haven't always been regarded with such respect. During European colonization, the fur trade devastated their once-abundant populations across North America. Native *Castor canadensis* were trapped and hunted out of California until, by the early 1900s, there were only an estimated 1,000 left in the state. Though it is no longer legal to recreationally trap beaver in California, up until now, beaver have been perceived

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Beaver and Process-Based Restoration *continued*

Participants of the Fall 2022 "Build Like a Beaver" training led by members of the Cal PBR Network build instream structures to mimic beaver in Yellow Creek. The training was held on two adjacent Plumas County properties stewarded by the Maidu Summit Consortium, California Department of Fish and Wildlife, Feather River Land Trust and the US Forest Service. For more info go to www.CalPBR.org/training. *Photo: Carrie Monahan, The Sierra Fund*

and managed as a nuisance — they block culverts and irrigation ditches, cause flooding, and cut down trees that people want standing. Landowners still maintain the right to depredate (kill) beavers causing damage.

The historic and ongoing removal of beaver, paired with the concurrent genocide of Indigenous land stewards as well as other legacy impacts (mining, logging, overgrazing), has greatly altered the health of watersheds across California. In 1923, the California Division of Fish & Game (now California Department of Fish & Wildlife) launched an extensive translocation program to repopulate streams and rivers with this helpful ecological engineer. However, since this program ended in 1950, California has not had a dedicated program to restore beaver despite successful efforts in other western states over the past two decades. The loss of keystone beaver along with the removal of large riparian wood and floodplain disconnection have effectively starved California streams of structural complexity and ecological function.

In the words of the California Process-Based Restoration Network, process-based restoration (PBR) is "partnering with nature to recover degraded river and stream catchments by removing impediments to physical and biological processes and harnessing the system's fluvial and biological energy to do most of the restoration 'work.'" Partnering with beavers as process restoration agents, or mimicking their dam-building behavior, are great examples of low-tech, cost-effective PBR techniques that can support watershed restoration at the scale and pace necessary to combat the climate crisis. However, many communities in California have not been aware of these restoration solutions and the ecosystem services beaver provide.

In partnership with many restoration professionals, the Occidental Arts & Ecology Center's (OAEC) WATER Institute has been advocating for the inclusion of beaver in our watershed restoration efforts for the past two decades. A critical step in building support for beaver restoration was to update and expand our collective understanding of where beavers are native within California. OAEC co-authored peer-reviewed papers documenting evidence that redefined beaver's historical range pre-European settlement, and further legitimized the call to protect and restore this native species.

A growing body of research shows that this keystone species can help increase water storage, provide habitat for other species, sequester carbon, and even create natural fire breaks.

In 2012, OAEC formally launched a Bring Back the Beaver Campaign to continue educating key stakeholder communities on the benefits of beaver and process-based restoration, while bringing attention to demonstration projects that highlight the efficacy of these practices. We've also been advocating on beaver's behalf at the policy level, partnering with other conservation NGOs and rewilding organizations to help federal and state agencies rethink how we can manage this species to enhance our restoration and climate goals.

There are many ways to restore beaver. For example, where beavers are already present but causing problems, we can prioritize co-existence solutions like flow control devices, tree cages, fence protection, or OAEC's Beaver Back Saver Device. These non-lethal measures can help mitigate conflict, while keeping beavers *in situ* to continue providing enormous benefits to our watersheds.

Restoration practitioners can also enhance existing beaver habitat through various strategies, such as planned grazing regimes or riparian fencing to reduce grazing competition. Adding structural complexity to a system with hand-built instream structures, like beaver dam

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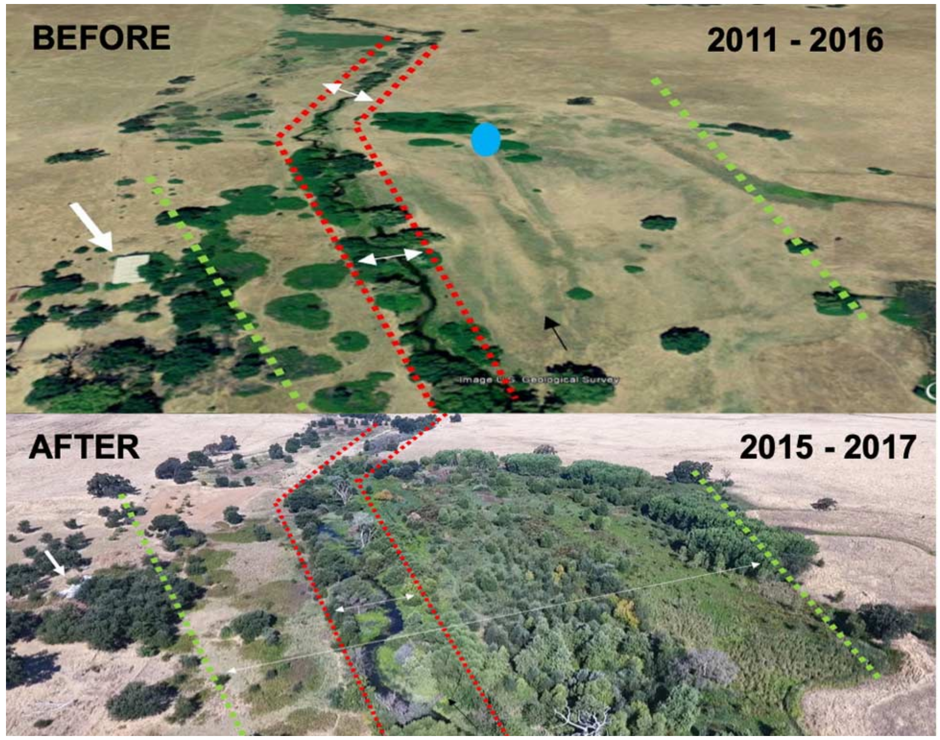
Beaver and Process-Based Restoration *continued*

analogues (BDAs) and post-assisted log structures (PALS), can have a similar effect and even encourage beavers to return to places they have yet to repopulate. In environments that aren't suitable for beaver, we can honor their ecological genius and mimic dam-building activity through process-based treatments and, where appropriate, relocate them to their former range. Holistic approaches to beaver restoration are outlined in OAEC's *Beaver in California: Creating a Culture of Stewardship, the Beaver Restoration Guidebook, and the Low-Tech Process Based Restoration for Riverscapes Design Manual,* which also offer helpful tools for planning through to implementation.



The Placer Land Trust's riparian restoration project at Doty Ravine Preserve near Lincoln, CA is a great example of how learning to live and actively partner with beaver can help achieve many restoration goals at a fraction of the cost of mainstream restoration techniques. By reinforcing the beaver dams, adding more channel spanning structures and giving the beaver more access to the floodplain by breaching two levees, project partners were able to increase the wetted width of a stream by 1,000% in less than 5 years. *Images: Damion Ciotti, US Fish and Wildlife Service*

Those interested in learning more about how to integrate these techniques can learn from the work of the recently formed California Process-Based Network**.** The WATER Institute and other members of the network have partnered with dozens of land owners and managers, NGOs, tribes, communities, and agencies to model these strategies across the state. Our collaborations, as well as other case studies from across the arid West, have revealed incredible results. We've seen overgrazed, dry, and eroding river systems transform back into green biodiverse oases, the rapid regrowth of riparian vegetation in meadows and wetlands, and imperiled species take refuge in beaver habitat. Cities have adopted co-existence strategies and embraced their beaver neighbors, while transportation and water agencies have installed innovative solutions to mitigate flooding issues while preserving beaver habitat. These pilots have played a key role in building momentum across California by offering stakeholders tangible experiences of beaver and process-based restoration and an ability to see the landscape effects unfold over time.

Last year, the WATER Institute, in consultation with Jennifer Fearing of Fearless Advocacy, coordinated a massive show of multi-stakeholder support with more than 100 conservation, agricultural, business, and tribal partners to ensure beaver and process-based restoration would not be left out of the statewide climate conversation. As a result, both were included in the California Natural Resources Agency's (CNRA) Natural and Working Lands Climate Smart Strategy as key nature-based solutions.

This momentum ultimately culminated in the California State Legislature approving the Governor's June budget proposal that provides funding to the California Department of Fish and Wildlife (CDFW) to launch a new statewide Beaver Restoration Program to guide the restoration and management of the species. CDFW's new program will fund five permanent staff members to develop a Beaver Management Plan and carry out a full suite of restoration practices including co-existence and relocation. The significance of this moment was recognized by major media outlets including, *The New York Times*, the *Los Angeles Times*, the *San Francisco Chronicle*, *The Globe and Mail*, and *Mother Jones*.

For OAEC and the many other organizations that have worked for decades to shift the narrative on beavers and remove obstacles to restoration, the species' newly acclaimed recognition represents a major "watershed" moment in California. With a renewed commitment from our state agencies and increases in state funding and regulatory efficiency through the Cutting the Green Tape Initiative, California is poised to increase the pace and extent of ecological restoration at a scale heretofore unseen.

Flooded rice fields of the Butte Sink Mitigation Bank North Unit. *Photo courtesy Stewart DesMeules.*

Butte Sink Mitigation Bank: Adapting a Process-based Based Restoration Approach to Mitigation Banking

by Brian Bartell[1] and Ashley Zavagno[2]

Process-based restoration, particularly in riverscapes, has had increasing evidence in the past several years to support its efficacy and efficiency as a restoration approach (Beechie *et al.* 2010, Sear *et al.* 2006, Ciotti *et al.* 2021, Wheaton *et al.* 2019). It has been lauded as a way of improving ecological uplift of restoration projects, increasing project resiliency, reducing implementation costs, increasing the pace and scale of restoration, and reducing the carbon footprint of restoration implementation (*ibid*). While the potential benefits are numerous, this approach has encountered obstacles that limit more widespread adoption, including regulatory policies and anthropogenic constraints. Once such example is in the policies governing mitigation banks.

Mitigation banks restore and conserve aquatic resources and/or special-status species habitats with the intent of selling the ecological value of the restoration/conservation as mitigation credits to various permittees impacting similar resources in the region. They have been cited as a way to increase the pace and scale of restoration by incentivizing the investment of private capital into restoration and consolidating mitigation efforts into larger, more ecologically valuable projects. Policies governing the entitlement, implementation, monitoring, and management of mitigation banks, however, have presented challenges to utilizing process-based restoration approaches.

Mitigation banks in California require that credits be calculated to the hundredth of an acre and classified, based on the type of resource being restored and the anticipated ecological uplift. This level of precision in classification, size, and location of restored resources can be challenging to match with a process-based restoration approach since this approach typically favors dynamism and is less focused on achieving specific community types and habitat elements. Additionally, performance monitoring required by mitigation banks typically lasts anywhere from five to ten years and must demonstrate "success" within that timeframe for the majority of credits to be released. Some processes may take longer to re-establish the desired

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Butte Sink Mitigation Bank *continued*

habitat type or may be more difficult to measure or quantify, which is why mitigation banks often resort to form-based performance standards and designs. Furthermore, mitigation banks are typically restricted to implementing all restoration actions within one to two consecutive years resulting in a "one and done" approach. This approach limits restoration practitioners' ability to implement actions over time or adaptively manage sites, as most actions taken after the initial restoration effort result in a delay in credit releases and an extension of the performance monitoring timeline.

While the aforementioned policies present challenges to utilizing process-based restoration approaches in mitigation banking, the Butte Sink Mitigation Bank offers an example of how elements of a process-based restoration approach can be integrated into a mitigation bank. Butte Sink Mitigation Bank may also offer insights into how a process-based restoration approach can be utilized in other constrained settings.

The Butte Sink Mitigation Bank lies sixty miles north of Sacramento, near the center of the Sacramento River's portion of California's great Central Valley lies in area known as the Butte Sink. Located west of the Sutter Buttes, the area is said to have historically been a network of sloughs, channels, cutoff oxbows, and floodplain wetlands that encompassed nearly a quarter of a million acres. In wet years, the flows of the Sacramento River and Butte Creek would join and turn the area into a vast inland lake.

Today, the area is a patchwork of agricultural fields, densely forested wetlands, sloughs, and managed wetlands which is the center of California's rice-growing industry. The hydrology of the sink has been highly altered, and a vast web of irrigation canals and drainage ditches now allow humans to manage the water to support agriculture and a network of waterfowl hunting clubs and wildlife refuge units. As the Sacramento River was "tamed" with levees, a system of weirs and bypasses was created to manage floodwaters. The Tisdale and Colusa weirs now divert flood flows from the Sacramento River into the Butte Sink, before draining out through the Sutter Bypass at the south end of the sink.

The Butte Sink Mitigation Bank is uniquely situated at the outlet of the Colusa Weir and along Butte Creek. Butte Creek has the largest wild run of spring-run chinook salmon (*Oncorhynchus tshawytscha*) of any of the Sacramento's tributaries, and winter-run chinook can enter the site during high flows from the Colusa weir or from Tisdale Weir via Butte Creek. The majority of the approximately 310-acre Butte Sink Mitigation Bank property is currently in rice production during the growing season and managed for waterfowl hunting

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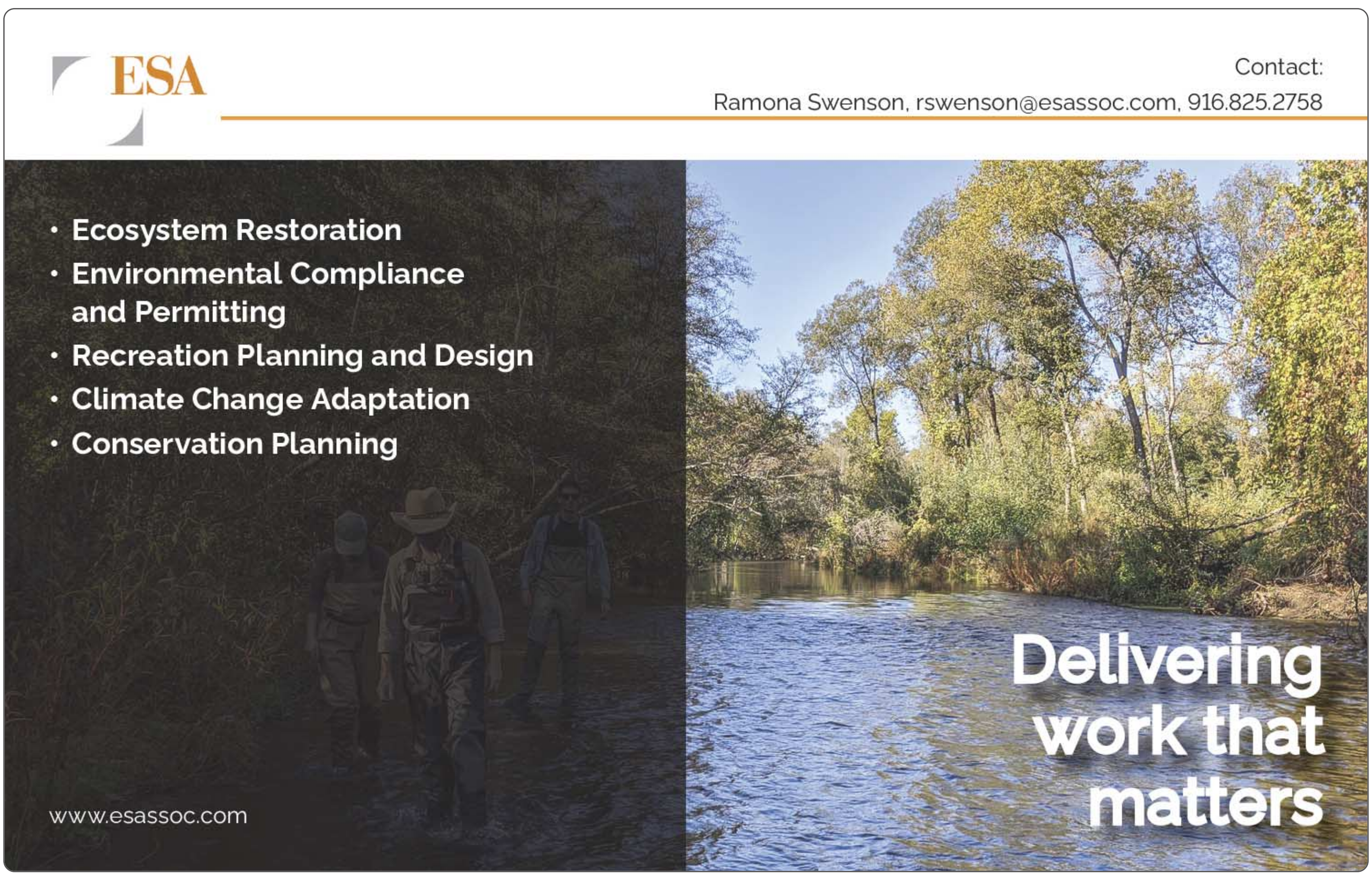

Butte Creek reach adjacent to the Butte Sink Mitigation Bank.

Butte Sink Mitigation Bank *continued*

during the winter months. The site's location at the southernmost reach of the Butte Sink and the outlet of Colusa Weir leads to saturated or flooded conditions that can last into the growing season and prevent the planting of rice. These conditions which limit the utility of the site for rice production are ideal for the restoration of forested floodplains and juvenile salmonid-rearing habitat. This led to the landowner embarking on the entitlement of a mitigation bank on the property with the help of WRA, Inc. and Mitchell Chadwick.

The main goal of the bank is to restore a natural floodplain wetland mosaic that provides substantial ecological functions including juvenile salmonid-rearing habitat which provides abundant food, cover from predators, and velocity refugia. Early in the bank entitlement process, however, the regulatory agencies expressed concern about traditional floodplain enhancement features like side channels, alcoves, and depressional wetlands in an area that experiences frequent flooding. The concerns revolved around stranding of salmonids and the long-term viability of form-based constructed features on the floodplain. The design team and fisheries biologists conducted outreach with staff from the Trinity River program and the University of California at Davis Center for Watershed Sciences to help guide the design to create a project that maximizes habitat for salmonids, minimizes the risk of stranding, and allows for a resilient design that will continue to provide the desired habitat in perpetuity with minimal long-term maintenance. It quickly became apparent that a traditional form-based design, typical in mitigation bank design, would not be suitable for this unique setting, and that design which allowed for the development of natural floodplain features would be the best approach.

Butte Sink Mitigation Bank offers an example of how elements of a process-based restoration approach can be integrated into a mitigation bank.

Based on the guidance from the regulatory agencies and technical experts, the design team developed a design that would allow for the restoration of natural processes. The team focused on removing or reducing anthropogenic constraints on the site by reducing the elevation of the levees along Butte Creek, removing plugs in the agricultural ditches draining the site, relocating the Highline Canal that supplies irrigation to the greater area, improving the hydrologic connections between the floodplain and Butte Creek, and ceasing agricultural production onsite.

In addition to the general mitigation bank policies and considerations described above, any design considered needed to allow for continued access to the duck club just outside of the bank

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Butte Sink Mitigation Bank *continued*

property, allow irrigation waters from the Highline Canal to reach adjacent properties, and maintain the current flood conveyance capacity of the Colusa Bypass. Because of these considerations, significant hydraulic modeling was completed to demonstrate both anticipated ecological uplift and adherence to design constraints. This level of effort may be more than would be required in a less constrained system utilizing a low-tech process-based approach.

Two-dimensional hydraulic modeling was used to demonstrate the improved hydrology created by the design, and to help determine the appropriate sizing of connections between the floodplain and Butte Creek. The hydraulic modeling of the existing conditions showed that minimal grading would be required near the northern end of the site adjacent to Butte Creek in order to greatly increase the hydrologic connection between Butte Creek and the site. In addition, discharge data from the Colusa Weir indicates that the Bank property receives water from the weir in 90% of years (DWR 2010). Design iterations focused on increasing the period of floodplain inundation while allowing for receding flows to occur concurrently with receding flows in Butte Creek. Near the south end of the site, the team designed outlets that will allow for the site to drain naturally, allowing for juveniles to safely make their way back into Butte Creek and side channels as flood flows recede.

Currently, the rice production areas of the site are made up of a series of flat-bottomed cells separated by small earthen berms. The design calls for removing

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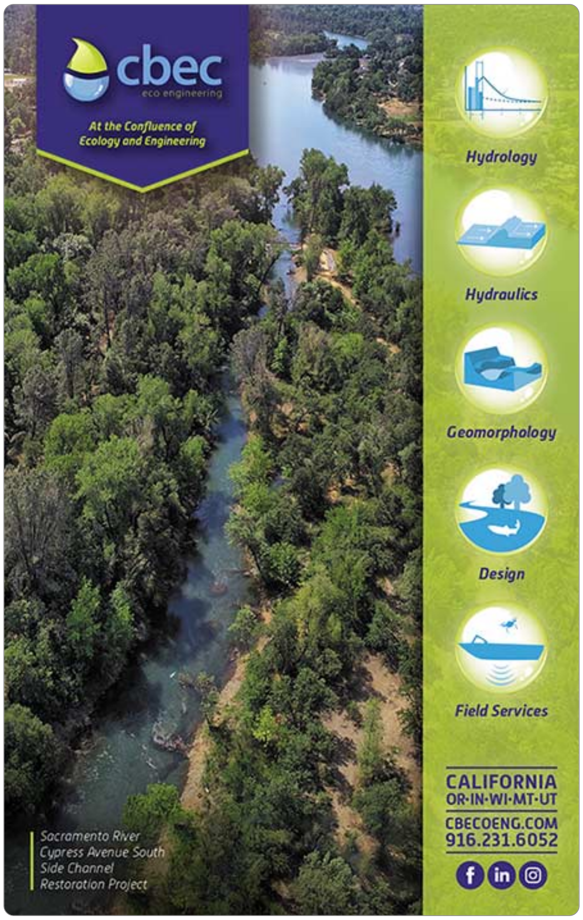

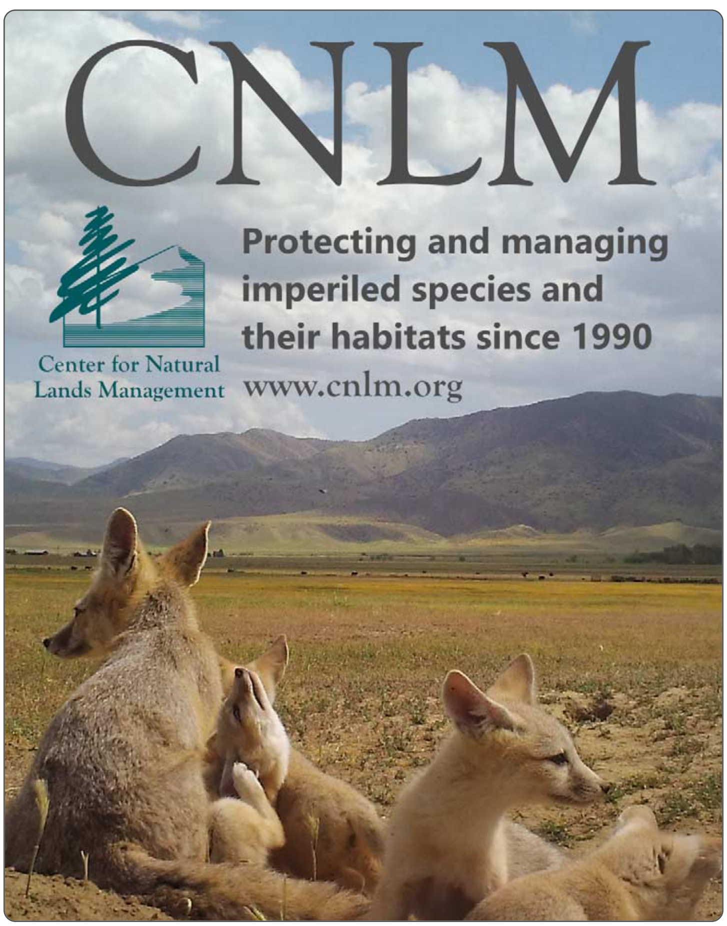

Butte Sink Mitigation Bank

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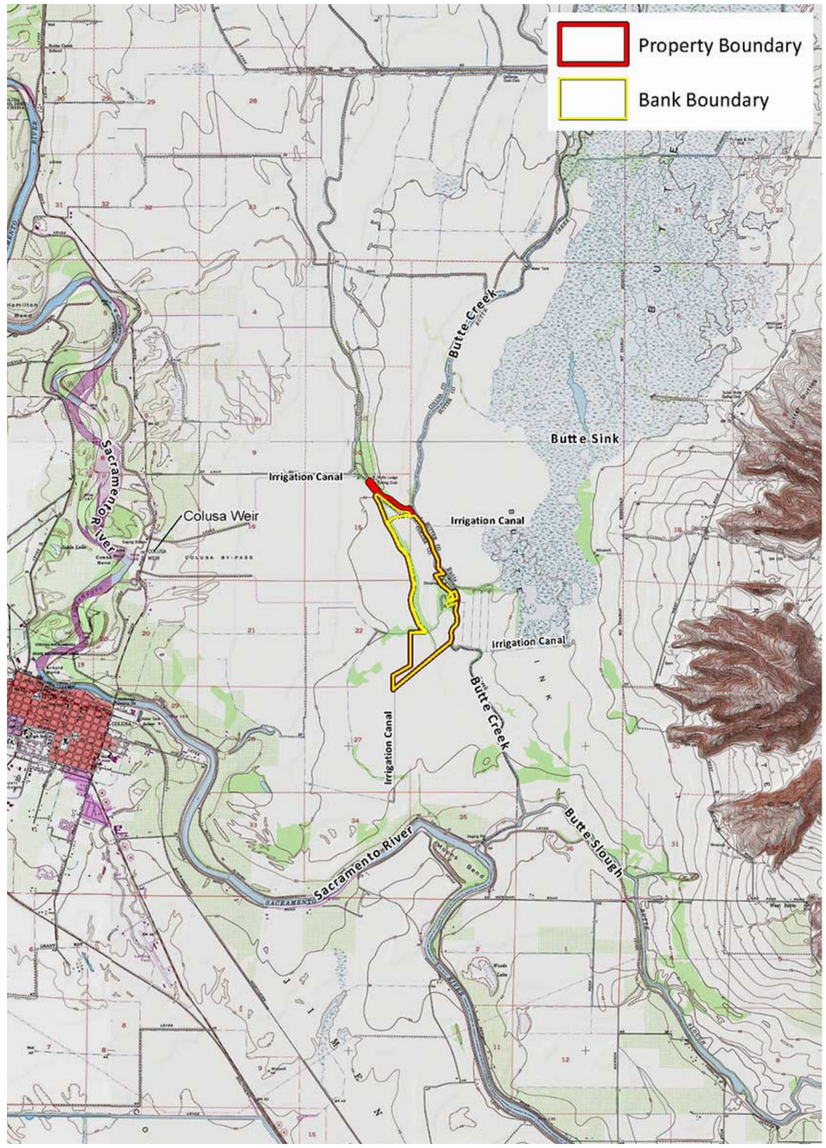
some of these features and allowing others to remain with small notches to provide short-term increase in the residence time of water on the floodplain. Based on information provided by the landowner from decades of experience farming the site, in years with high flows, these features are often washed away. It is anticipated that as vegetation matures, the roughness of the natural vegetation will replace the site's man-made microtopography as the main driver in extending the hydroperiod of water retention on the site to meet the goal of improving the habitat for juvenile salmonids. Other design elements include removing culverts and temporary dams and ditch plugs to allow for unimpeded flows through the site.

Approximately 30 percent of the site will be planted with a mix of wetland trees and shrubs. Remaining areas will be allowed to recruit naturally. While natural recruitment would have likely revegetated the site entirely without planting due to the surrounding native vegetation and substantial hydrology, planting a portion of the site will help the bank revegetate more quickly, which will help meet performance standards. It is anticipated that planting will be implemented using agricultural style row planting techniques that are cost-effective and allow the site to self-sort over time to match micro conditions. The project team had hoped to implement a phased revegetation approach within planted areas to mimic natural succession (e.g. planting understory species after canopy development of initially planted species), however, the mitigation policies described above limits the ability to do additional plantings after our initial installation.

To help kickstart woody debris recruitment, debris racks made of partially buried wooden posts will be installed on the floodplain in primary flow paths to help trap woody debris. Much like the residual rice berms, it is anticipated that over time the natural roughness from developing vegetation and the falling of trees onsite will support wood debris recruitment over time.

Construction is planned for the summer of 2024 pending all regulatory agency approvals. A significant benefit of mitigation banks is the extensive performance monitoring conducted, which allows restoration practitioners to learn from decisions made. Monitoring at the Butte Sink Mitigation Bank will include hydrologic, vegetative, structural diversity, and fish monitoring, which will provide valuable data assessing the efficacy of project as a whole and the process-based design elements utilized. These data could help inform the use of a process-based approach in future projects that have similar site constraints and illustrate where compromise can occur without sacrificing ecological function.



Butte Sink Mitigation Bank Location.

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The Carmel River floodlplain at Rancho Cañada, viewed from the trail to Inspiration Point in Palo Corona Regional Park.

Rewilding the Carmel River at Rancho Cañada

by Ben Snyder[1] *All images courtesy the author.*

A warming winter sun rises over the Carmel River valley at what will become Rancho de la Cañada, chasing away the remnants of clouds and fog following last night's downpour. The year is 1602, and Spanish explorers have yet to arrive on the central California coast. Hundreds of Rumsen Ohlone people call the valley home, nourished by a fantastical abundance of Steelhead trout, dozens of species of waterfowl, deer, elk, acorns, berries, and nuts. They fashion small boats for themselves from tule reeds, and weave ornate baskets, headdresses, and jewelry from Santa Barbara sedge and sandbar willow, as they and their ancestors have done for thousands of years. The lower valley is densely vegetated with willows, cottonwoods, and alders. A cacophony of bird calls and chorus of frog calls fills air. The Carmel River is overflowing its low banks and spreading out onto its broad floodplain, eroding sand and gravel bars, creating new pools, glides, and riffles; uprooting trees, activating remnant scour channels, and renewing a thriving mosaic of aquatic, riparian, and upland habitats.

This is the vision of the Carmel River that I have in my mind, as I sit down at my computer here in Oakland, a couple hours' drive north of what is now known as Rancho Cañada. I have a two-dimensional hydrodynamic model of the Carmel River open on my desktop, showing spatial distributions of depth, velocity, and shear stress in the river for scenarios ranging from next-to-nothing summer baseflows to a so-called 500-year flood. The model output helps us to make refinements to the design, making sure that the objectives will be met.

My colleagues and I are working alongside a 25-member strong technical advisory committee (TAC) to develop a process-based design for this reach. All members of the design team and the TAC bring the wisdom gained from our previous experience in river restoration. Although we all have different perspectives and some of us represent different stakeholders, there is unanimous support for process-based design at Rancho Cañada. Many of us of learned the hard way that prescriptive, inflexible, overly-engineered approaches that force a river into a particular behavior tend not be sustainable.

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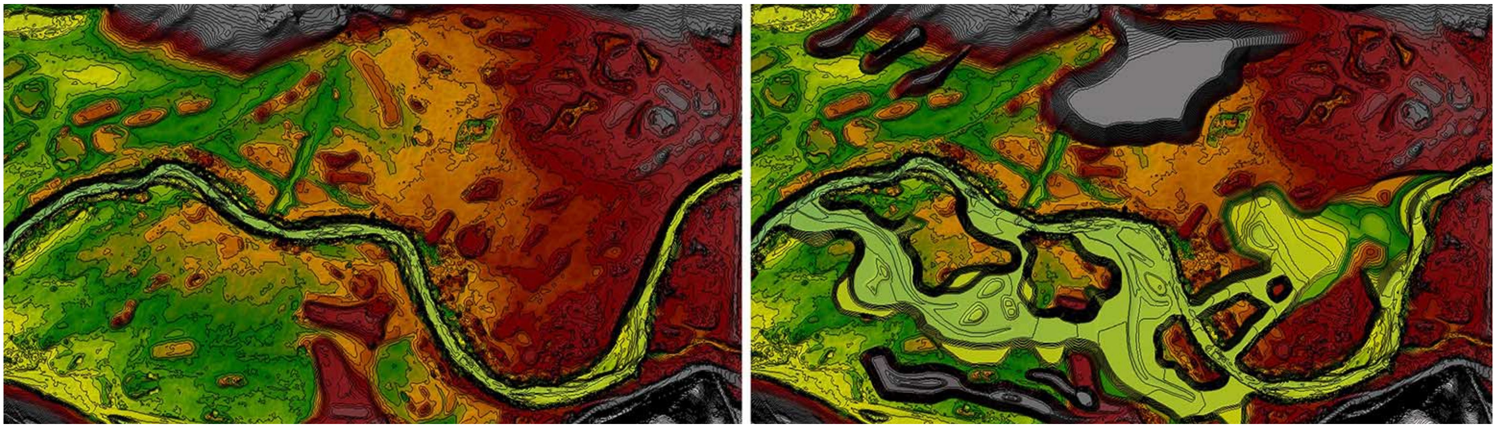

Comparison of terrains for existing conditions (left) and 65% design (right), showing broad new floodplains, backwater channels, and alcoves.

Rewilding the Carmel River at Rancho Cañada *continued*

We are united by this vision of a reach of the Carmel River that can be wild, once again.

Mexican and European settlers largely tamed the Carmel River here, despite intermittent periods of devastating floods and droughts, eventually establishing large swaths of wheat fields and cattle ranching. With a watershed area of over 200 square miles—the Santa Lucia mountains rising abruptly from the coast—winter storms have caused the Carmel to flood its banks many times over the past century. The natural banks are made largely of sand, and riprap was placed all along the banks to keep valuable farmland from washing away. The farmland was eventually developed into the scenic Rancho Cañada golf course, with periodic placement of riprap on the banks to keep the river in its historic alignment. The river reclaimed a large portion of the floodplain in February 1998, when a 50-year flood hit. Hundreds of truckloads of landslide debris were trucked in from Big Sur. The fairways, sand traps, and putting greens were all painstakingly rebuilt — the mighty Carmel was pushed back into its place, boulders up to five feet in diameter lining the bank where it had once made its escape.

> Steelhead love to congregate behind big boulders, so we will give them plenty of spots to do that, in the channel and out on the new floodplain.

Being unable to erode its banks and move from side to side, much of the energy of the river has been forced into the bed, leading it to incise far below the floodplain. The model I see today is showing me that, based on historic flow records, there's less than a 20% chance of the river activating the floodplain in any given year. Rather than the rich mosaic of self-renewal and thriving biodiversity that existed long ago, this reach of the river has become an efficient flume-like conveyance of water and sediment.

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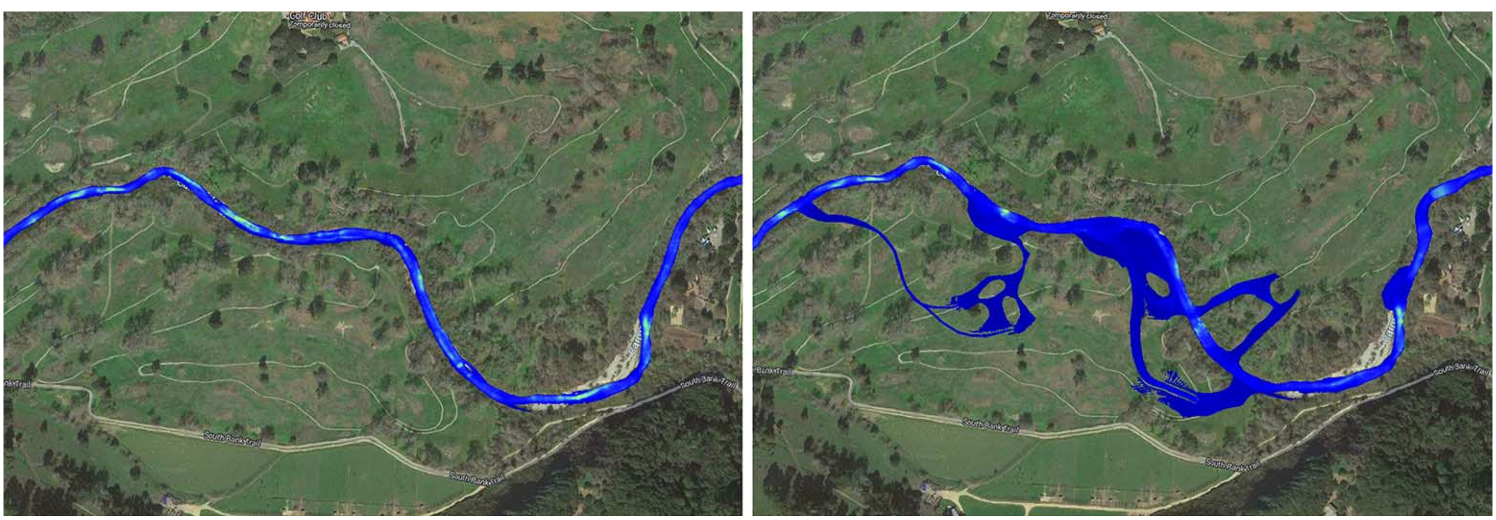

Comparison of modeled velocity for a 200 cfs (winter baseflow) discharge for existing conditions (left) and 65% design (right) for Rancho Cañada reach of the Carmel River.

Rewilding the Carmel River at Rancho Cañada *continued*

We are in a unique position of being able to give this reach of river much of its life back. The design approach championed by the technical advisory committee is essentially a valley reset: creating a blank canvas for the valley morphology at a new and much lower elevation. Channel meander modeling helped us to define a broad channel migration zone where the floodplains will be lowered to below the winter baseflow water surface profile. A series of riffles, planted with willow trenches, will help to back water up in the main river channel and push it out into the new floodplains.

One approach the team considered was to simply remove the riprap that's been placed along the banks, and let the river do the work of creating its new morphology and floodplain. The Rancho Cañada design team and stakeholders agreed that we should take the opportunity to make an immediate and dramatic improvement to this reach of the Carmel River by investing in floodplain grading and re-shaping of upland areas, rather than waiting and hoping for the right series of storms and channel-forming events to re-shape the river. Also, excavating a floodplain nearly as wide as the predicted channel migration zone will allow recreational features — public access trails and boardwalks — to be implemented alongside the new habitats, ensuring that Rancho Cañada remains a treasured resource that is accessible to the public.

All the riprap that has been dumped along the banks in the past will be carefully excavated to limit disturbance of existing riparian vegetation as much as possible. Some of the riprap will be re-purposed on-site for habitat features and riffles. Steelhead love to congregate behind big boulders, so we will give them plenty of spots to do that, in the channel and out on the new floodplain. The new floodplain will be activated by flows of about 120 cfs, which is less than the winter baseflow. Large wood structures and beaver dam analogues will be added to the floodplains to improve cover, increase ponding, and create habitat complexity. The floodplains will be planted with a carefully curated palette of native emergent wetland, riparian, and upland species. The planting palette will include Santa Barbara sedge and sandbar willow to help sustain the culture of the Rumsen Ohlone people.

Over time, the river will carve new meanders out into the floodplain, naturally rejuvenating the ecosystem with a steady supply of water, nutrients and large wood from the watershed. We may not be able to reclaim all the richness and abundance of resources that once existed here, but we will create a new and sustainable space for the Carmel River that will be truly wild, once again.

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Field crew installing low-tech structures at Casa Vieja pilot project in 2021. *Photo courtesy Nick Bouwes.*

Low-Tech Process-Based Meadow Restoration in the Kern Plateau-Golden Trout Wilderness

by Nick Bouwes[1], Jessica Strickland[2], and Sabra Purdy[3]

Montane meadows are characterized by low gradient valleys with fine sediments, shallow water table, and soils of high carbon and nitrogen dominated by herbaceous plant species. Meadows provide several important ecosystem services and critical habitat for several species of flora and fauna, including California golden trout and Mountain yellow-legged frogs. They support lush grasses and sedges that are important to grazing animals. Properly functioning meadows store water during the wet seasons and slowly release water during the dry season,s providing important increases in baseflow for downstream uses. They slow flows which keep sediment and nutrients up in the headwaters that could otherwise overwhelm systems downstream. Meadow are also highly resilient to drought, floods, and fires affecting the entire watershed. Additionally, the ability of meadows to sequester carbon is on par with, or higher than, tropical rainforests (Reed *et al.* 2020).

A legacy of land uses has resulted in the ubiquitous degradation of meadows throughout the world. An estimated 70% of meadows in the Sierra Nevada have been heavily impacted (Hunsaker *et al.* 2015) by legacy and/or contemporary grazing, timber harvest, road construction, channelization, and the near extirpation of beaver. Channel incision is a common result of these activities, as the loss of vegetation, bank trampling, and trailing concentrates flows on denuded surfaces, creating gullies that down-cut rapidly. These gullies can exceed 10' in depth and are effective at draining meadows, reducing water storage, and lowering water tables out of reach of hydric and mesic plant species that are quickly replaced by upland xeric species such as sagebrush. This results in vastly reduced wet meadow areas — the disconnected floodplain is no longer accessible

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at most flows with an associated loss of critical floodplain processes. As rich organic soils and peat dry, meadows release a tremendous amount of carbon, making them sources rather than carbon sinks. This transition into a new, drier state be can very difficult to reverse naturally even if all the stressors are removed. Thus, active restoration is required if we are to regain the benefits meadows provide.

The Kern Plateau-Golden Trout Wilderness Meadow Restoration Project is a large-scale meadow restoration effort being undertaken by a diverse partnership including Trout Unlimited and other NGOs, the Inyo National Forest USFS, consulting stream-meadow restoration practitioners, engineers, geomorphologists, and ecologists, through a grant awarded by California Department of Fish & Wildlife. The goal of the project is to restore natural hydrological, biological, and geomorphic processes — the design includes building structures in over 18 miles of stream will affect about 190 acres of riparian meadows in 15 meadow complexes, increasing resilience and ecosystem services, and improving aquatic, riparian, and floodplain habitats.

Restoration of Kern Plateau meadows will rely largely on Low-Tech Process-Based Restoration (LTPBR) techniques (Wheaton *et al.* 2019) that have become increasing popular in stream restoration. LTPBR practices utilize simple, cost-effective, hand-built structures that mimic beaver dams (i.e., beaver dam analogues, or BDAs), wood accumulations (i.e., post-assisted log structures, or PALS), and sedge mats (i.e., sedge plugs). These structures are meant to promote channel aggradation, raise water surface and water table elevations, reconnect the floodplain, and increase the recruitment of sedges and other riparian plants. Ultimately, a reconnected floodplain and restored meadow would be sustained by the restored riparian plant community, who roots provide the binding organic matrix that can resist downcutting. If beaver occupy the project area either passively or through a relocation program, then the restoration could be greatly accelerated.

Unlike more traditional practices that rely on engineered designs and heavy construction equipment (e.g., excavators) to impose channel and floodplain restoration objectives, LTPBR reduces design and implementation costs and allows natural stream processes to do much of the restoration "work." This minimizes economic and ecological risks making the LTPBR approach capable of scaling to meadow degradation over large spatial extents and in wilderness areas off limits to mechanized equipment and transportation.

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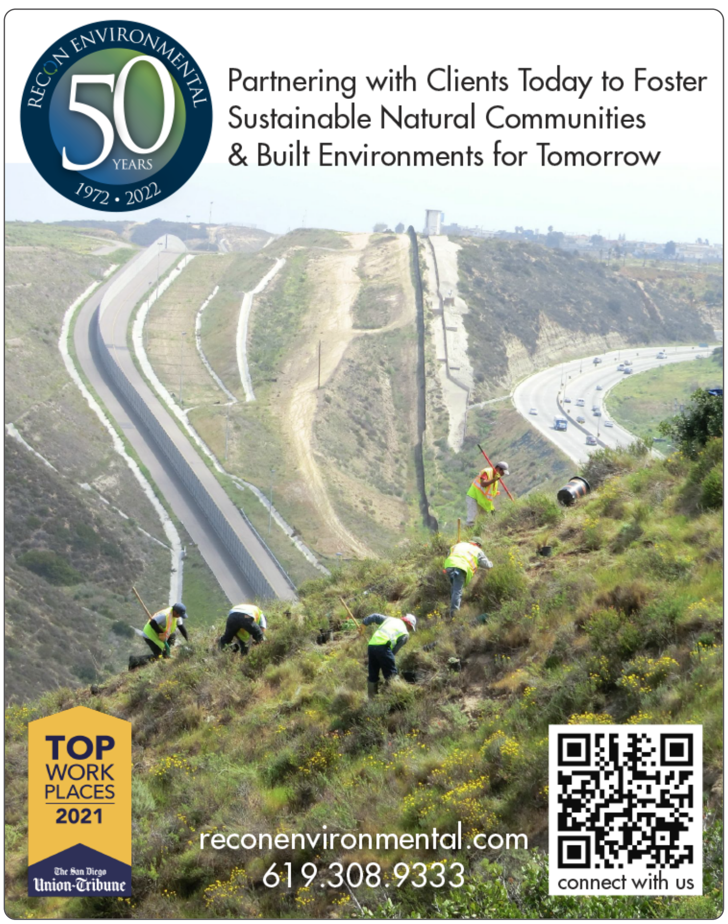

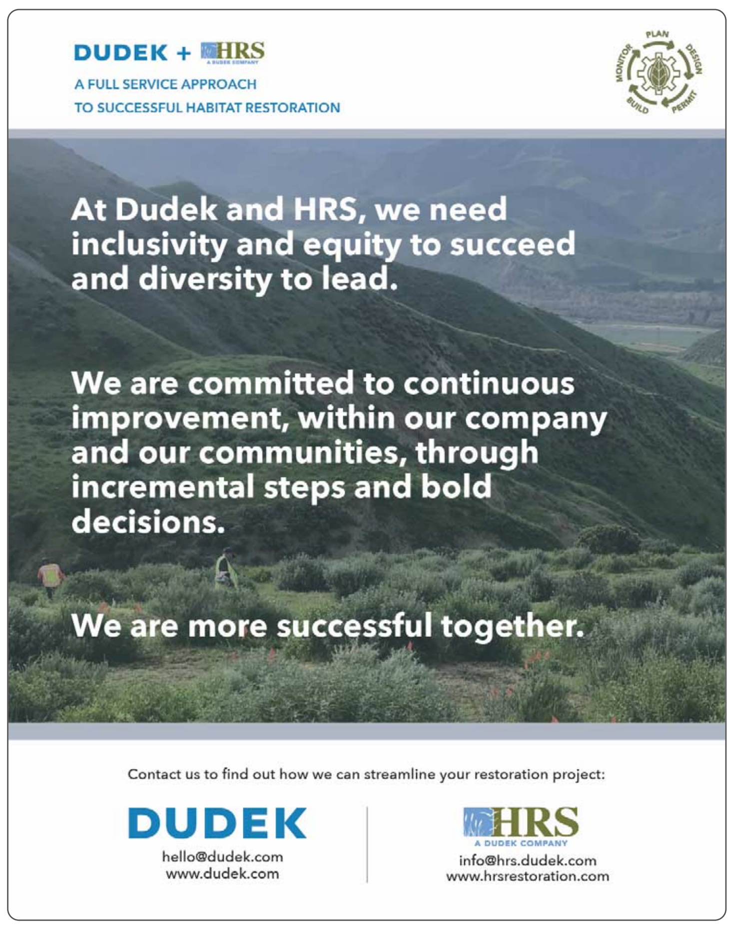

Low-Tech Process-Based Meadow Restoration

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Although similar techniques were initiated over a century ago in Sierra Nevada meadows to halt erosion and aggrade incised channels (Kraebel and Pillsbury 1934), current examples of large meadows LTPBR designs are not common in California. Skepticism still exists whether these techniques are robust enough to achieve ecological benefits in meadow ecosystems. Thus, extensive monitoring within an adaptive management framework will be used in this precedent-setting restoration project to increase our understanding of how to work with natural meadow processes and whether we can achieve large-scale success with this simple and affordable approach.

Stakeholder tour at Horseshoe Meadow pilot project, 2022. *Photo courtesy Jessica Strickland.*

An added layer of complexity is that the Project meadow sites are almost entirely located on land managed by the U.S. Forest Service, and many are within designated Wilderness Areas. Public lands are often multi-use working landscapes, which can be challenging for restoration practitioners. Public lands user groups, such as grazing permittees, off-highway vehicle users, fisherman, hikers, etc., all have interests which can be instinctually viewed as noncomplementary. Welcoming transparency and curiosity around how individual user groups value meadow resources sets a foundation based in equality and understanding. In setting that foundation, implementing small-scale pilot demonstration areas has been an integral component of this project. Not only do these demonstration areas aid in understanding how proposed restoration techniques behave in a particular environment, but they also offer a platform for collaborative discussion and knowledge-sharing. Additionally, they create a space, *in situ*, for state and federal permitting agencies to increase their understanding of how LTPBR activities impact the local environment during and immediately post-construction. As LTPBR techniques become increasingly popular and California continues to drive forth in its initiative to streamline permitting, pilot projects can advance conversations early in the planning process for large landscape-level projects such as this.

In the fall of 2021, a pilot was implemented in one of the project meadows, where different types of structures were built in a designated wilderness setting. The site was revisited the following summer and has provided a valuable learning experience to inform a second pilot implemented in the fall of 2022. Trout Unlimited, U.S. Forest Service, state agency regulators, restoration practitioners, and the grazing permittees were able to observe the structure construction live. The onsite meeting led to valuable discussions about the goals, objectives, and approaches with overall support for the project.

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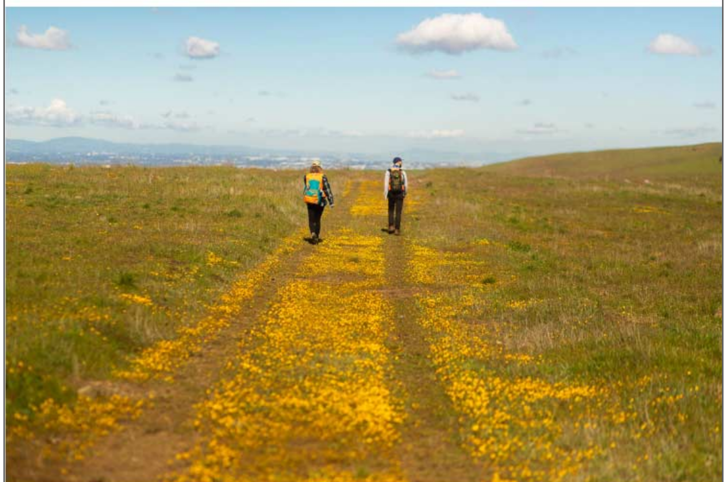

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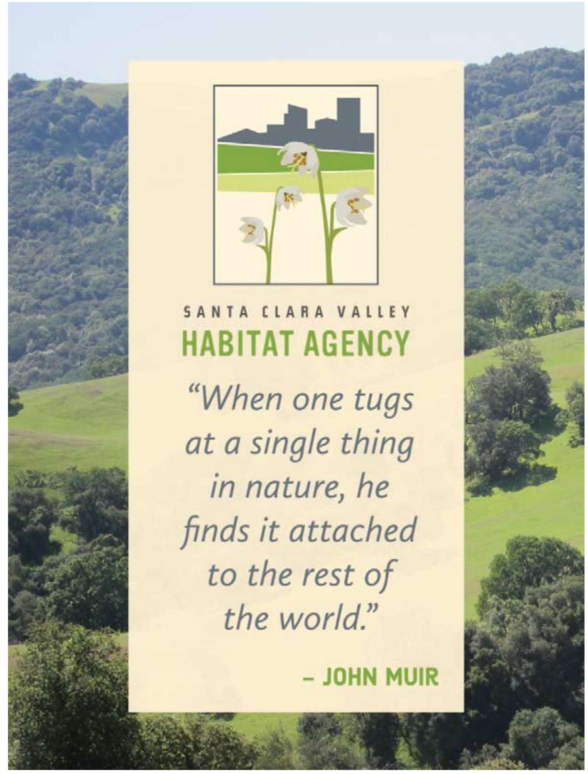

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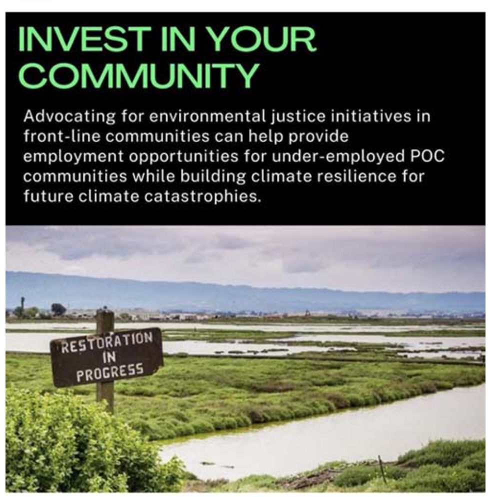

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