

California's Experience with Dunes and Coastal Resilience: A Synthesis Report of the 2021 Coastal Dunes for Resilience Workshop



Morro Strands State Beach, Morro Bay, California
Photo by Nick Sadrpour



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Acknowledgements:

This workshop and summary report would not have been possible without the support of the Honda Marine Science Foundation and the contributions of valuable insight, perspectives, and case studies by numerous coastal resource managers, academics, coastal engineers, restoration ecologists, dune education and interpreters, and coastal agencies and funders.

Suggested citation:

Engeman L, Shabo C, Sadrpour N, Hubbard D, Johnston K, Grubbs M. California's Experience with Dunes and Coastal Resilience: A Synthesis of the 2021 Coastal Dunes for Resilience Workshop. *California Sea Grant Publication #*_ March 2022.



Cardiff State Beach, San Diego, CA

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East Depression Beach, UC Santa Barbara
Photo by Laura Engeman

Introduction

The California Dune Science Network (Network) is a collaborative effort to expand understanding of coastal dunes and their role in building a resilient, transitional, and adaptive coast for future generations. In 2021, the Network documented at least nineteen sites in California where coastal dunes were in planning stages or had already been restored or constructed to increase resilience. The Network acknowledges that this list may be incomplete and welcomes suggestions for additional dune sites and resources.

In an effort to foster knowledge-sharing across these sites and disseminate information and lessons learned, the Network hosted a virtual *Coastal Dunes for Resilience Workshop* on December 8th and 9th, 2021. The workshop featured recent dune research, information about nature-based dune and resilience projects, and collaborative learning opportunities at California's pilot project and natural dune sites. It also engaged diverse perspectives on coastal resource stewardship, public access, and culturally inclusive climate adaptation approaches and how these play a role in the success of coastal dune resilience efforts.

The workshop also provided an avenue for exploring the appetite for scientific knowledge and collaboration for advancing dune resilience best practices in California. Participation demonstrated that there was significant interest in this topic. Attendees included 144 participants who engaged in the workshop across the two days, and they represented a wide range of expertise including scientists, coastal managers, planners, engineers, educators, policy experts, students, and interested members of the public (see Appendix I). Many of these participants expressed a strong desire for additional learning and discussion sessions on project planning, permitting and designing, implementation, and monitoring practices.

The following is a summary of the four major themes that arose from the *Coastal Dunes for Resilience Workshop*. This synthesis is intended to provide ideas for maximizing pilot projects going forward and for establishing best practices for effective implementation of coastal resilience strategies along our coastlines.

Workshop Themes

Theme 1: There is more than one approach to designing dunes for resilience

A common remark heard at the 2021 Workshop is that there is no one-size-fits-all approach when designing dunes for resilience or implementing projects. Coastal dunes and beaches are dynamic systems constantly in a state of change with varied management practices; therefore,

they vary in shape, size, and composition over time and seasons. The physical form and features of coastal dunes are also highly dependent on coastal processes at the site, accommodation space, exposure to natural hazards and forcing (e.g., waves, winds, tides), land use constraints, and exposure to human disturbance. Due to these factors as well as site-specific stakeholder interests and management practices, coastal dune resilience cannot be achieved through a uniform design. Planning must instead represent the most effective approach given site conditions for improving the ability of the dune ecosystem to hold up under climate stressors (e.g., waves, high waters) and maintain itself over time, including naturally rebuilding after being disturbed.

Despite this no-one-size-fits-all dilemma, it is recognized that the health of dune ecosystems universally relies upon a strong interconnection of geomorphological, aeolian, and biotic processes. In other words, a healthy dune system is highly dependent on sufficient sand and sediment supply, strong winds to promote sediment transport, and vegetation that traps sand and allows it to accumulate over time. Interruption of these processes, whether through human interaction and urbanization or disturbance events, can negatively impact the size and shape of the dune geomorphology or vegetation patterns and hinder the system's ability to provide buffering from flooding and wave-driven erosion, as well as other ecosystem services.

Several workshop panelists also emphasized that an important component of dune resilience success is not just to restore abiotic and biotic features, but also processes, including allowing the system to move and adapt. The long-term success of coastal dunes, especially in the face of sea-level rise, depends on the ability for this naturally dynamic environment to migrate and fluctuate, and recover from storm events. Whereas each coastal site may have different expectations for long-term dune sustainability, no coastal site is static. Dune designs should consider how they will adapt to natural variability inherent in a coastal system and future shoreline conditions. In areas where space is adequate for accommodating natural migration, restoration of a functional dune system may have time to prove its resilience and ability to adapt long-term. Conversely, in sites where coastal squeeze provides limited beach width and limited migration, sediment nourishment, maintenance, and land use transition strategies may be critical to dune resilience and recovery.

The extent to which dune design should mimic or reference existing or historic dune systems is an additional challenge noted by several attendees. For much of California's coastline, natural processes and features have been significantly altered. With more stressors expected on coastal ecosystems in the future, it is important to acknowledge and work within this shifting baseline. Often there are also very limited or no examples of existing dune systems to reference or substantial differences between the project location and nearby dunes. Therefore, a reference

or sentinel site can, and should be more than just the nearest dune system. Workshop participants agreed there was a need to broaden the definition and revisit the purpose for identifying reference sites. Reference sites can provide a variety of dune design and planting strategies, insight into evaluation techniques to measure system response and recovery performance, and a greater understanding of the variability across dune systems especially in the context of changing climatic stressors.

Theme 2: First define the goal for resilience and then select the dunes approach

While the general definition of nature-based adaptation solutions can be to provide benefits for coastal and community resilience, workshop participants emphasized that it is important to clearly define and prioritize the primary purpose(s) of the project and align the dune resilience approach with those goals. For example, if the primary purpose is to provide coastal protection for an asset or infrastructure, the design is likely to prioritize vegetation and materials that best support sand stabilization over habitat benefits to shore birds. Attempting to achieve multiple and equally prioritized restoration and coastal protection goals can compromise the overall design effectiveness for particular objectives, complicate permitting and monitoring requirements, and confuse public expectations for the project. Multi-benefit projects, however, can also garner more public support as they can provide solutions that address the concerns of a wider group of stakeholders. Several workshop participants suggested that developing a dune resilience typology or categories for approaches would be useful to support the development of best practices and techniques and facilitate permitting and designing of projects. These categories of approaches can also help to define how success will be measured in terms of ecosystem services, flood protection, and operation and maintenance over time.

The following are three suggestions for distinct coastal resilience goals and the strategies that are generally used to achieve these targets. Some of these strategies can be used for more than one goal, but the design or approach often differs depending on the performance expectation.

1. Goal is to restore existing coastal dune ecosystems to enhance their ability to withstand and recover from current and future stressors and disturbances.

This goal is directed at the long-term conservation of remaining California dune ecosystems and the species that depend on them, so strategies are focused on active restoration of dune function and processes. Activities may need to be implemented ongoing or periodically depending on the system's ability to recover and restore itself (e.g., adaptive management actions).

There are several case studies that highlight various efforts to control and remove invasive plant species and re-establish native dune vegetation to mirror a more naturally sloped system with greater sand distribution and sand accumulation over time. As seen in several California dune sites, invasive plants (e.g., iceplant and/or European beachgrass) impact dune systems by forming dense, monotypic mats that slow sand movement and change sand deposition, leading to more steeply sloped foredunes and backdunes. This change in dune structure inhibits the natural migration of the dunes and can contribute to more severe erosion during storms. Several research studies within the Humboldt Bay National Wildlife Refuge are experimenting with these techniques to maintain a healthy balance of foredune erosion and accretion during restoration.

Other case studies featured strategies using materials such as wooden shims, woody debris, natural wrack, crimped straw, or hay bales to trap sand and assist dune recovery. These strategies are often complimented by efforts to reduce human disturbances or redirect recreational use through fencing, boardwalks, and walkways. Workshop participants also discussed that in areas of increasing urbanization and coastline development, these approaches will not be viable in the long-term without land use transitions or inland migration strategies.

2. Goal is to improve coastal protection against flooding and erosion using dune forms and features.

Where the primary goal for dunes is providing coastal defense against flooding and erosion, there is a greater focus on creating dunes that can prevent wave overtopping or mitigate erosion during storm conditions. These dunes may be hybrid structures and include maintenance strategies (e.g., cobble berms) designed specifically to maintain a certain level of protection or coastal defense. Workshop participants noted that “hybrid” projects (that use combinations of natural and built infrastructure) may require more expensive and labor-intensive maintenance to sustain the expected level of coastal protection performance.

A hybrid approach was used at Cardiff State Beach in Encinitas and results from this project were presented at the workshop. These dunes were artificially created using material from a nearby lagoon restoration project. The dunes were designed to provide improved protection for a section of Pacific Coast Highway that was experiencing beach erosion and road undercutting. This project, while not a permanent solution to the increasing flooding experienced in that area, has held off major storms over the last few years and has allowed for continuous road service.

Another example discussed was the Surfer’s Point project in Ventura that employed innovative engineering approaches that worked with the natural processes at this location. In Phase 1 of

the project, an eroding parking lot and collapsing bike path were relocated inland, and material was brought in to re-engineer the shoreline into a more natural cobble beach topped by vegetated dunes. So far, the project has successfully withstood strong El Niño storms in 2015 and 2016 and has enhanced beach habitat, protected the new multi-modal recreational path, and continued to provide ample public access to the beach.

3. Goal is to establish or re-establish dunes and native vegetation in coastal landscapes that have been heavily modified to increase beach sand retention and resilience, coastal biodiversity, and protection from sea-level rise.

The last goal seeks to preserve beaches by passively establishing dunes that help to retain sand and reduce erosion during hazard events or prolong resilience to sea-level rise by removing existing disturbances. In this case, the establishment of dunes is a strategy for improving the resilience of beaches and their ecosystems where very little to no coastal dunes currently exist.

An example of this approach is Santa Monica Beach. In Los Angeles, many of the beaches have been nourished and are managed with daily activities such as mechanized raking and re-grading, or grooming. This continuous flattening of the beach increases its vulnerability to erosion and flooding by reducing the site's ability to retain sand through natural processes or vegetated dunes. The Santa Monica pilot project demonstrated that a low-impact and low-cost strategy of installing sand fences and seeding native dune plants could gradually accumulate sand over time and enhance the beach topographic features and general profile, including the establishment of small dune hummocks.

Theme 3: The importance of socio-cultural perceptions to dune project success

In the workshop, many panelists and participants commented that socio-cultural perceptions of beaches and dunes play a significant role in designing and implementing coastal dune projects. Coastal dune projects must include meaningful engagement that seeks community expertise before the start of a project. Workshop participants emphasized that creating and investing in relationships on the ground are needed to support a dune resilience project and ensure community buy-in for the project's expectations including social, economic, and cultural benefits. Socio-cultural connections and values for coastal resources, including ancestral and current linkages to the coast by indigenous populations, are also important to how coastal dune projects design access and interactions with the site.

Many participants expressed a need to address perceptions on how beaches look today compared to their historic profiles and then how the shoreline will continue to change into the future. A few provided examples where removal of invasive species faced opposition because

the beachgrass was considered more aesthetically pleasing than the native alternative. Others mentioned that restoring dunes could be seen as limiting access to economically valuable, and culturally important, public spaces. Starting with pilot projects and demonstrating ways to balance resilience with continued enjoyment of beaches and coastal resources was viewed as an important pathway to shifting perceptions and building community support for a new “vision” of the beach and coast.

Currently most dune projects have not conducted pre- and post-project surveys to determine how the community perceived the project and its success. However, in retrospect many workshop attendees acknowledged that gathering this information should be a priority and that it would be valuable to better understand how the community and visitors interact with the restored resource to target messaging for project updates, maintenance requirements, or additional adaptive management efforts. Evaluating both public perceptions and economic benefits would also serve to build best practices and overall support for replication or implementation in other areas along the coast.

Theme 4: Evaluating resilience designs and developing best practices requires a new approach to monitoring

Dune resilience pilot projects can be useful for evaluating the viability of resilience strategies, optimizing dune resilience designs, and developing best practices. However, this requires monitoring not only how the dunes grow and sustain themselves in typical dynamic beach conditions, but how the system responds and recovers from disturbance and extreme and regularly occurring storm events. Workshop participants expressed that this approach to monitoring and evaluation is a critical component to understanding whether a resilience approach is working and refining techniques. They also noted that collaborative funding and capacity are going to be needed to achieve this.

There are two important aspects to monitoring that participants felt should be modified and improved upon with the support of a network-wide focused discussion and statewide partnerships. The first is that while site-level monitoring is needed (and usually required by permitting) to assess how a dune approach was performing, there is an equally important need for tracking shoreline conditions at other beach areas within the region. This regional context provides important information on underlying conditions in the littoral cell and nearshore system including natural variability that may be impacting the success of the dune project. Regional reference site monitoring (sometimes included in project requirements) is also determined to be useful for comparing how the dune project holds up in extreme conditions versus other beach or dune areas. However, the burden of undertaking regional monitoring by

a single project is too expensive and challenging, therefore this could and should be a collaborative effort across the region (and state) because it can serve multiple sites.

This leads to the second important monitoring theme heard by workshop participants - that there is a need for developing a strategic framework that supports data sharing, more standardization of monitoring metrics, and expanded capacity to track and evaluate sites beyond just the first five years (often the requirements associated with permits). Many participants noted that similar monitoring frameworks have been developed for assessing wetland conditions and management changes and are now used statewide. Also, hazard events that provide the best “tests” for evaluating the dune design response and recovery often do not occur that frequently, so longer-term monitoring partnerships are needed to truly evaluate resilience strategies and build best practices. This may be possible through strategic consortiums of academic, community and government entities where capacity is leveraged across regions and sites serve as “living laboratories” to expand collective expertise and knowledge in this new field of coastal management. These consortiums can also serve as workforce development and educational centers providing community members and youth with opportunities to engage and help steward our coastal areas for the future.

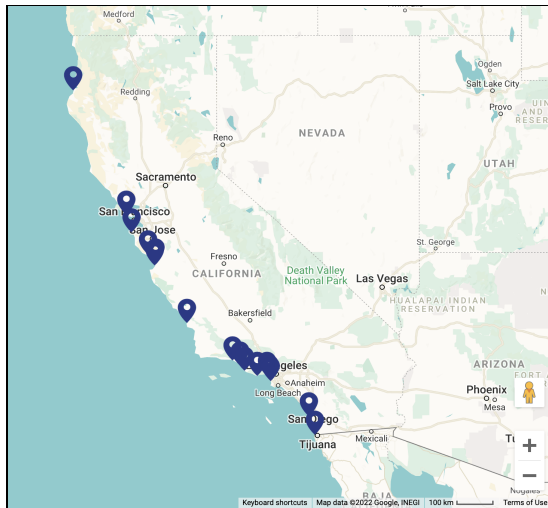
Looking Forward

The *Coastal Dunes for Resiliency Workshop* provided an initial opportunity for ideas and strategies to be shared amongst the many practitioners working in the coastal resilience space. The workshop highlighted common challenges, needs, and four emerging themes for implementing coastal dunes for resilience in California: (1) there is no one-size-fits-all approach to designing dunes for resilience, (2) defining resilience goals and expectations are key to selecting an effective dunes approach, (3) importance of socio-cultural engagement and perceptions in dune project success, and (4) evaluating project and shoreline resilience is key to optimizing project designs and developing best practices.

These initial recommendations will allow for further conversations on how to evaluate strategies and move forward in a more unified and efficient way to meet the needs of our coastal communities and ecosystems. The Network will continue to build its base of knowledge and contribute to best practices that make sense for the California landscape. Further workshops should dig into the details of how to effectively design dune resilience projects and monitoring and management strategies, while meeting the changing and unique needs of beach users and coastal community members and infrastructure impacted by sea-level rise. The Network wants to thank attendees for their participation and interest and encourages all to visit <https://www.resilientcoastlines.com> for more information and to continue to engage.

Appendix I: Details of the Coastal Dunes for Resilience Workshop- December 8 and 9, 2021

The California Dune Science Network was created to expand understanding of coastal dunes and their role in building a resilient, transitional, and adaptive coast for future generations. The network seeks to advance “collective expertise,” build best practices and research priorities to help guide policy and investments, share and enhance access to results and monitoring data for research and learning, and provide educational resources for students, stakeholders to learn about and engage in dune resilience efforts.

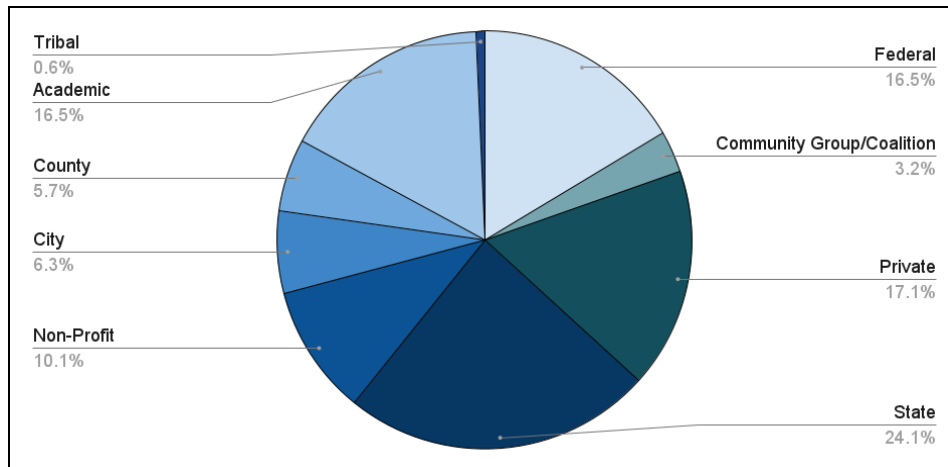


Across California, there are currently 11 projects implemented that utilize coastal dunes for resiliency with eight others in various stages of planning. Additionally, many other communities have included dunes in their coastal resilience planning documents as a viable option to explore.

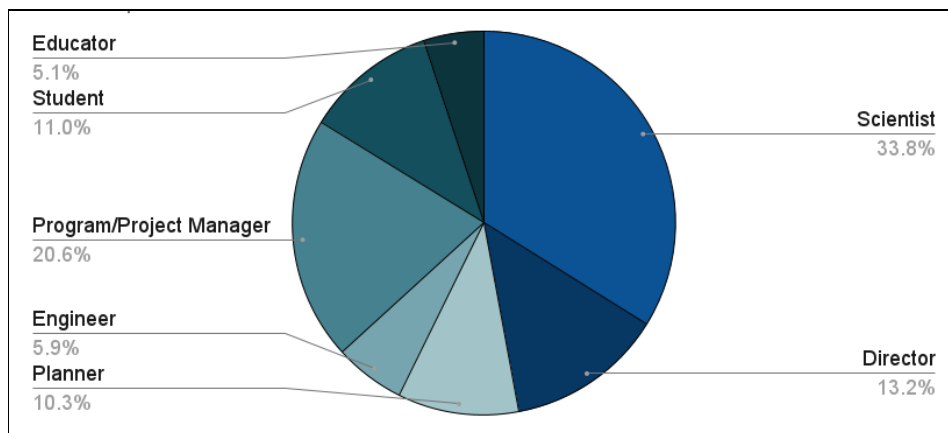
In an effort to learn from these early experimental projects and advance dune resilience best practices and scientific knowledge in California, the California Dune Science Network hosted a Coastal Dunes for Resiliency Workshop on December 8th and 9th, 2021. The Workshop featured lessons learned from recent dune research and nature-based projects,

identified collaborative learning opportunities at California's pilot project and natural dune sites, and engaged diverse perspectives on coastal resource stewardship, public access, and culturally inclusive climate adaptation approaches. As part of the Workshop, video case studies were submitted and these along with small group discussions also highlighted topics that could use further exploration to grow expertise and success in this newer field of coastal resource management in the face of climate change. These topics included how to align project design approaches, goals and monitoring; social, economic, and cultural considerations and potential co-benefits; ways to leverage pilot projects for evaluating techniques and resilience effectiveness; and expanding understanding of the various dune restoration and engineering approaches used to enhance coastal resilience.

The Workshop was promoted through a wide range of networks to attract and build ongoing coordination and cooperation between academics, scientists, planners, permitting agencies, local, regional, state, and federal agencies who are interested and/or involved in utilizing coastal dunes for resilience in California and beyond. Over the two days of the workshop, a total of 144 practitioners attended and participated. The majority of participants represented state (24.1%) and federal agencies (16.1%), the private sector (17.1%), and academic institutions (16.5%). The remaining participants joined from city and county departments (12%), non-profit institutions (10.1%), community organizations and coalitions (3.2%), and tribes (0.6%).



Efforts were made to invite representatives from many sectors and there were scientists, program and project managers and directors, planners, engineers, educators, and students joining the conversation each day. Participants brought a wide range of experience and knowledge of dune resilience. Some were directly involved in project design and monitoring and others were coastal managers or students interested in learning about this nature-based approach.



As one participant reflected, the Workshop fostered a “mix of those in policy, consulting, science, and outreach...*(providing)* the opportunity to network and talk with a diverse range of dune enthusiasts and professionals from across all of California.” Another participant expressed appreciation that “we didn’t just talk hard science *(such as)* dune engineering, but also full picture project challenges like community and public relation issues and potential solutions.”

For more information on the Workshop agenda, goals, and partners or to watch the workshop recordings and video case studies, please visit <https://www.resilientcoastlines.com>.

Project Specific Resources:

ESA. Surfer's Pt. Shore Enhancement Project: 2016-2017 Monitoring Report. 2018.
<https://www.resilientcoastlines.com/post/surfer-s-pt-monitoring-results-2015-2017>

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For additional resources- visit the [Coastal Dune Network's Literature Hub](#).