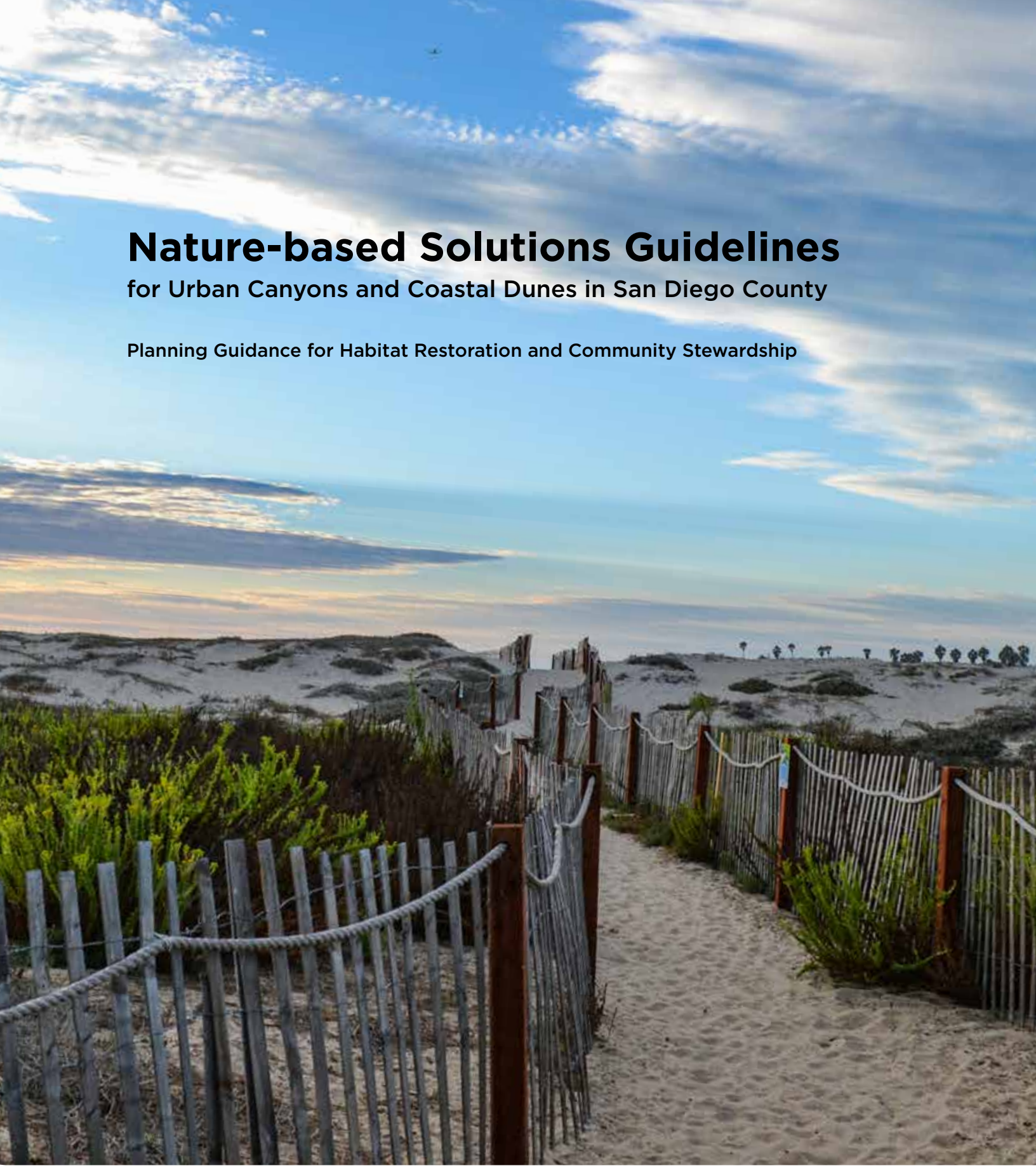
Nature-based Solutions Guidelines

for Urban Canyons and Coastal Dunes in San Diego County

Planning Guidance for Habitat Restoration and Community Stewardship



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National Fish and Wildlife Foundation (NFWF)

This project was funded through the
NFWF National Coastal Resilience Fund
under Grant ID 0318.25.083755

SUGGESTED CITATION:

Lang, F., Gorman, K., Galleher, L., et al. (2026). Nature-based Solutions Guidelines for Urban Canyons and Coastal Dunes in San Diego County: Planning Guidance for Habitat Restoration and Community Stewardship. San Diego Natural History Museum, San Diego, California.

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Introduction

San Diego County's coast and urbanized watersheds are increasingly vulnerable to climate change impacts like sea level rise, flooding, erosion, wildfires, habitat loss, and changing species distributions. These challenges threaten natural ecosystems, critical infrastructure, private property, public health, and regional economic stability[1,2]. Along San Diego's coastline, nine cities, seven military installations, state parks, marine protected areas, transportation routes, power infrastructure, and coastal communities all face mounting climate-related risks. Countywide, up to $2.6 billion in commercial assets are at risk from rising tides, while severe storms continue to expose the region's social and ecological vulnerabilities.

Invasive and non-native vegetation poses a growing challenge in San Diego County's varied ecosystems. Many invasive plants not only compete directly with natives for space and nutrients but also increase fire frequency. This leads to a cycle that hinders the recovery of native plants, destabilizes soils, and speeds up erosion[3]. In San Diego's urban canyons, degraded vegetation communities and channelized storm flows amplify downstream flood risks in nearby neighborhoods[4-6]. In coastal areas, invasive plants can disrupt sand movement and reduce the shoreline's natural ability to buffer wave energy and flooding[7].

Recent extreme weather events have demonstrated the consequences of these combined pressures. During the January 22, 2024 storm event, San Diego recorded some of the highest rainfall levels ever, causing severe flooding in parts of the Chollas Creek watershed. Floodwaters led to fatalities, displaced residents, and damaged hundreds of homes, disproportionately affecting underserved communities with limited flood protection resources. Meanwhile, the ongoing loss and degradation of coastal habitats have heightened exposure to storm surge and rising sea levels. In fact, since the mid 19th century, more than half of California's coastal dunes have been lost to development and erosion, with more densely populated areas like Southern California experiencing losses up to 95%[7]. These issues underscore the urgent need for strategies that protect, restore, and sustainably manage ecosystems while also supporting community wellbeing[1,8-11].



Nature-based Solutions and Coastal Resilience

Addressing today's interconnected environmental and social challenges requires interdisciplinary approaches that recognize the relationship between ecological systems and the communities that depend on them[12]. Projects that focus on ecological outcomes without fully integrating the necessary social, economic, and community dimensions may struggle to succeed in the short-term or achieve long-term sustainability[12-14]. Nature-based Solutions (NbS) aim to fill this gap by concurrently supporting ecosystem health, climate resilience, and human wellbeing[15].

Since 2008, academic literature exploring NbS in different contexts has framed the concept in various models[16]. One way NbS can be understood through three distinct lenses: actions that protect and restore ecosystems, processes that drive ecological and social improvement, and the resulting *physical features* on the landscape. Within this framework, one example of a primary NbS process is habitat enhancement. It represents the synergistic result of technical habitat restoration coupled with sustained community support, elevating both habitat potential and ecosystem services, and implies long-term stewardship of natural systems. While models and frameworks vary across the literature, all NbS actions and processes must be intentionally designed to yield overall resilience for both human and natural environments[17].



In California, NbS are increasingly seen as a critical component of conservation planning. For example, Executive Order N-82-20 called for expanding NbS across California to support the state's climate change goals. It also launched the statewide 30x30 initiative, which seeks to conserve 30 percent of California's lands and coastal waters by 2030 while advancing biodiversity protection, climate resilience, and equitable access to nature. Together, these efforts promote landscape-scale conservation that utilizes the enhancement of natural processes and systems to deliver multiple co-benefits. Sea level rise, coastal storm surge, erosion, drought, extreme heat, and wildfires are not isolated stressors; they interact across watersheds, bioregions, and communities, necessitating proactive and holistic planning approaches[18,19].

Enhancing coastal resilience is especially pertinent in Southern California, where communities face a unique mix of threats due to their proximity to the ocean and increasingly hot, dry inland conditions. In San Diego County, urban canyons and coastal dunes are well-suited to serve as regional NbS by providing habitat for native and endangered species while also protecting adjacent communities and infrastructure[2]. For example, restoring coastal dunes can improve habitat quality while also reducing wave impacts and buffering against flooding[20]. Similarly, canyon restoration can support biodiversity while slowing stormwater flows, stabilizing soil, moderating urban heat, and minimizing wildfire risks[4,5]. Traditional "hard armoring" approaches such as seawalls, riprap, and concrete channels are increasingly

CASE STUDY Local Dune

Cardiff State Beach Living Shoreline Project

The Cardiff State Beach Living Shoreline Project (Project) is located at the south end of the City of Encinitas, within the community of Cardiff-by-the-Sea. The Project is an innovative "Green-infrastructure and Nature-based Solutions (NbS)" project, featuring 2,900 linear feet of reconstructed dunes with engineered revetment, cobble, native dune vegetation, recreational trail, reconfigured on-street parking, green cycle-track bike lane improvement, emergency access and staging area, educational placard signage, and Americans with Disabilities Act (ADA) improvements with Mobi-mat beach access. Winner of the 2020, American Shore and Beach Preservation Association (ASBPA) national award, the project involved the replacement of existing cobble rock and failing riprap along an extensive Coast Highway 101 reach, with engineered revetment and natural dune structure. The Project was grant funded by the California State Coastal Conservancy, Ocean Protection Council, U.S. Fish and Wildlife Service, and San Diego Association of Governments. It is managed by the City of Encinitas and California State Parks, in partnership with Nature Collective, University of California Los Angeles and Scripps Institution of Oceanography.

The Project is located within the City of Encinitas's jurisdiction, both City of Encinitas and California State Parks ownership and the California Coastal Commission's Original Permit Jurisdiction. Additionally, it is adjacent to two Marine Protected Areas (MPAs) known as the Swamis Marine Conservation Area (SMCA) to the west and the San Elijo Lagoon Marine Conservation Area and Ecological Reserve to the east.

This Project was needed to address the frequent flooding and erosion of South Coast Highway 101 due to inadequate protection, the prominence of a cobble beach that reduced suitable habitat and beach use area, and dangerous beach accessways. The aim was to protect South Coast Highway 101 from damage, reduce the vulnerability of this flooding, create coastal dune habitat, create a pedestrian path and bike lane adjacent to the dune's linear length, and beneficially reuse sand from the San Elijo Lagoon annual dredging operations and other opportunistic beach sand projects to maintain the project long-term.

Provided by Todd Mierau, Coastal Zone Program Administrator for City of Encinitas



Cardiff State Beach before installation of Living Shoreline



Cardiff State Beach after installation of Living Shoreline

recognized as costly and ineffective solutions. While these approaches may provide short-term protection, they can accelerate erosion, degrade habitat, disconnect natural sediment processes, and reduce public access and ecological function over time[21]. In contrast, NbS work in tandem with natural systems to increase coastal resilience.

Since NbS operates at the intersection of ecological science and community interests, projects require balancing multiple goals that may sometimes conflict[22]. Scientific recommendations aimed at maximizing ecological outcomes might clash with immediate community needs, access issues, or risk-reduction priorities. Conversely, projects designed primarily around human use or hazard reduction might not yield the highest ecological value. An effective NbS approach acknowledges these tradeoffs and strives for integrated, lasting solutions.

As climate conditions continue to change, conservation efforts must anticipate future risks and adapt to evolving challenges. By aligning habitat restoration with public engagement and community goals, NbS can create landscapes that are ecologically functional, socially relevant, accessible, and adaptable in the face of climate change[12]. The following section outlines the scope and goals of these guidelines and how they aim to support the implementation of NbS throughout San Diego County's urban canyons and coastal dunes.

Purpose and Scope of the Guidelines

These guidelines aim to synthesize existing information related to dune and canyon NbS in San Diego County. The information presented is sourced from regional technical reports, scientific literature, site visits, and technical stakeholder interviews. The primary goal is to translate this information into clear, actionable guidance for planners, practitioners, and community stakeholders on topics such as site selection, permitting, project timelines, materials, and community engagement. Because this document is intended as a capacity-building tool, the text primarily focuses on early-stage planning considerations and decision-making frameworks rather than detailed restoration protocols or implementation methods, which are more commonly found in habitat management guidelines. Additionally, the document suggests numerous other resources for further reading and more in-depth exploration.

These guidelines are intended primarily for small-scale NbS projects, generally less than five acres in size. Larger projects often involve additional complexities related to engineering, grading, sediment management, permitting, and regulatory review that fall beyond the scope of this document. Similarly, projects that interact with aquatic ecosystems, such as wetlands, estuaries, or streambeds, typically require more extensive permitting and compliance processes and are therefore not addressed here, although the recommendations presented may still be applicable across different habitat types.

This document's emphasis on canyons and dunes directly relates to their ecological importance and urban accessibility. Urban canyons and coastal dunes are some of San Diego's most valuable yet increasingly threatened natural systems. Historically, these landscapes provided essential ecological services, including flood attenuation, sediment retention, erosion control, wildfire protection, groundwater recharge, biodiversity support, and protection from coastal storm surge and wave action. However, decades of development, habitat fragmentation, altered hydrology, invasive species, and fire disturbances have severely compromised their resilience and ecological function.

The recommendations presented in these guidelines emphasize an equity-first approach[23] to climate adaptation. Historically, planning processes have been shaped by systems rooted in decades of structural inequities, with communities often deliberately excluded from meaningful participation in decision-making. Furthermore, low-income communities, communities of color, and Indigenous communities have been some of the most adversely impacted by climate change, as well as other environmental burdens such as air and water pollution and limited access to parks and green space[24 - 27]. This has contributed to a lack of trust in the public agencies responsible for land use and resource management decisions. Rebuilding that trust requires intentional, long-term engagement and authentic opportunities for community representation throughout the planning process[1,23]. This document attempts to highlight ways in which project leaders can design inclusive planning processes that are responsive to community needs and consistently elevate local knowledge, perspectives, and priorities.

As a trusted local nonprofit with more than 150 years of experience in biodiversity research, environmental science, and community engagement, the San Diego Natural History Museum (The Nat) plays an important role in promoting collaborative, science-based conservation solutions across the region. By combining rigorous scientific research, regional biodiversity expertise, and a longstanding commitment to public education, The Nat is uniquely positioned to provide practical guidance for stewarding San Diego's canyon and dune ecosystems within the NbS framework. These guidelines were created by The Nat in collaboration with many nonprofit, government, and community-based partners to deliver lasting benefits to the communities that depend on these landscapes.





Phase 1: Project Planning

Project Leadership

Early in the planning process, stakeholders should identify the individual or organization best positioned to guide project direction, establish priorities, coordinate partners, secure funding, and oversee implementation. While large conservation or land management organizations often serve in this role, they are not always the most effective choice. In many cases, community-based organizations or local stewardship groups may be better suited because of their deep understanding of local needs, concerns, and access considerations[28].

Project leadership should be viewed as a long-term commitment that extends beyond project implementation to include ongoing maintenance, monitoring, and adaptive management. Leaders should help define clear roles and responsibilities for all partners, ensuring that each participant contributes according to their expertise and capacity, and that partners are compensated fairly for their participation. Guidance on identifying and engaging specialized implementation and scientific partners is described in subsequent sections.

Selecting a Site Location

Picking an appropriate site is the foundation of a successful NbS project. Project leaders should begin by identifying existing regional conservation efforts and clearly defining project goals and objectives, then determining where restoration can best advance those priorities.

A typical site selection workflow includes:

1. Define project objectives
2. Compile regional conservation and planning datasets
3. Identify candidate restoration sites
4. Evaluate ecological suitability
5. Assess community benefits and equity
6. Review land ownership
7. Screen permitting constraints
8. Prioritize sites based on project goals

Throughout this workflow, project leaders typically evaluate a combination of geospatial datasets. While specific layers will vary depending on project objectives, common examples include:

Natural Resources

- Protected areas
- Wildlife corridors
- Species observations
- Vegetation communities
- Watersheds and wetlands
- Soils and topography

Climate risk

- Flood hazard zones
- Wildfire history and severity
- Heat exposure
- Erosion susceptibility

Community and Built Environment

- Parcels & land ownership
- Parks and trails
- Roads and transportation networks
- Utilities
- Socioeconomic demographics
- Public Access
- Population density

Depending on project objectives, the relative importance of each consideration may vary. For example, if the main goal of a project is to provide biodiversity benefits, leaders can use historical data on rare or threatened species observations in combination with geospatial data to identify undeveloped or underutilized land that could be restored or enhanced to support species recruitment. A sample resource for geospatial data-based site selection based on biodiversity benefits is included in *Appendix A*.

Priorities of a project vary and should be taken into consideration when selecting a site. For example, if the main project goal is protecting urban infrastructure, project leaders might need to navigate tradeoffs involving wildlife habitat and public access. For instance, when asked about coastal dune implementation and planning, technical stakeholders consistently highlighted balancing social and ecological criteria as a key challenge[29]. While coastal dunes can help shield frontline communities from sea level rise and storm surge[1,7,21], they may also limit public access points to beaches or obstruct ocean views. Additionally, some endangered species are sensitive to changes in natural or built structures, like the California Least Tern (*Sternula antillarum browni*), which relies on open, sparsely vegetated coastal areas with clear sightlines to detect predators and support successful nest colonization[30].

These competing needs underscore the inherent complexity of site selection for NbS projects and highlight the importance of interdisciplinary planning approaches that balance ecological function, species conservation, community benefit, and long-term feasibility. A description of possible site selection considerations follows below.

Existing Restoration and Planning Efforts

Existing restoration efforts, planning frameworks, and mapping tools can help guide site selection and collaboration. For example, the NatureServe Map of Biodiversity Importance (MoBI)[31] is a high-resolution mapping tool that combines decades of field observations, species occurrence records, and predictive habitat modeling to identify priority areas for conserving at-risk species across the U.S. At the state level, CA Nature provides an interactive geospatial data platform that compiles data on biodiversity, climate vulnerability, protected areas, and public access to track progress toward California's 30x30 goals[19]. Its Conservation Opportunities Modeler allows users to identify priority areas based on ecological value, resilience, and equity considerations under different planning scenarios.



California Least Tern (*Sternula antillarum browni*) in coastal habitat. Photo by Barbara Swanson.

Table 1 – Regional Planning and Mapping Resources

RESOURCE	GEOGRAPHIC SCALE	PRIMARY PURPOSE	INFORMATION AVAILABLE	POTENTIAL APPLICATIONS
NatureServe Map of Biodiversity Importance (MoBI)	National	At-risk biodiversity	Species and modeled importance	Initial biodiversity screening
CA Nature	Statewide	Conservation opportunities and progress	Biodiversity, resilience, access	Scenario-based prioritization
San Diego 30x30	Regional	Local conservation coordination	Projects and opportunities	Identify partners and project alignment
Multiple Species Conservation Program (MSCP), Vernal Pool Habitat Conservation Plan & Multi-Habitat Planning Area (MHPA)	Regional	Habitat preservation and conservation	Preserve core biological areas and corridors	Regulatory and habitat context
Management and Monitoring Strategic Plan (MSP) Roadmap	Regional	Management prioritization	Conservation priorities based on habitat restoration and threat reduction	Identify regional priorities
Regional Priority Plan	Regional	Wildfire mitigation and community protection	Priority wildfire mitigation projects	Align projects with fire-resilient management
Climate Resilient SD	City	Climate adaptation	Vulnerabilities and strategies	Align with City planning
Coastal Resilience Master Plan	City	Coastal adaptation	Priority sites and NbS concepts	Align with active or planned coastal projects
San Diego Regional Climate Collaborative Plan Tracker	Regional	Regional planning database	Climate-related plans	Find relevant existing plans

While these tools provide valuable context, conservation decisions are often strengthened by a more localized approach. San Diego 30x30 translates statewide goals into a place-based framework by mapping local conservation projects across the county[32]. This information can be used to screen for existing or planned restoration initiatives and partners, helping ensure that new NbS projects align with broader conservation strategies. The San Diego Region Coastal Resilience Roadmap was developed by the San Diego Regional Climate Collaborative (SDRCC) to facilitate accelerated action for coastal resilience projects and investments that prioritize benefits to underserved communities in the region. Through analysis of existing planning efforts, surveys, focus groups, and dialogues, the roadmap sets forth a set of principles and associated actions focused on achieving multi-benefit outcomes for San Diego's ecological systems, economies, and people[1].

At the regional scale, the San Diego Multiple Species Conservation Program (MSCP) provides the backbone for landscape-scale conservation planning. The MSCP is designed to protect large, intact blocks of habitat and suites of species through a coordinated preserve system. Developed through a partnership between the Cities of San Diego, Chula Vista, San Diego County and state and federal wildlife agencies, the MSCP establishes a long-term strategy for conserving biodiversity across jurisdictional boundaries[33]. Central to the MSCP is the Multi-Habitat Planning Area (MHPA), a connected network of core habitat areas and wildlife corridors designed to support MSCP covered species while allowing for compatible land use[34]. The MSCP is part of California's broader Natural Community Conservation Planning (NCCP)[35] program, which emphasizes ecosystem-scale planning.

The Management and Monitoring Strategic Plan (MSP) Roadmap, developed by the San Diego Management and Monitoring Program (SDMMP), provides an implementation framework for MSCP and NCCP lands. The MSP Roadmap translates broad conservation goals into measurable, spatially explicit priorities by identifying where habitat restoration, species management, and threat reduction efforts will be most effective[36]. In this way, the MSCP and NCCP establish the conserved landscape and regulatory structure, while the MSP Roadmap helps coordinate and prioritize on-the-ground conservation actions within that system.

Local planning efforts are augmented through resilience and risk reduction strategies. The San Diego Regional Priority Plan (RPP), led by the Resource Conservation District of Greater San Diego County in partnership with the Fire Safe Council of San Diego County, helps identify, prioritize, and advance projects that reduce wildfire risk[37]. The City of San Diego's Climate Resilient SD Plan complements these efforts by integrating climate adaptation into broader city and regional planning processes. Developed in part to meet the requirements of California Senate Bill 379, which requires local governments to incorporate climate adaptation and resiliency strategies into General Plans, Climate Resilient SD emphasizes cross-jurisdictional coordination and regional collaboration, including with the San Diego Association of Governments (SANDAG)[38]. The City of San Diego's Coastal Resilience Master Plan (CRMP) further identifies priority actions to address sea level rise, coastal flooding, and erosion through a portfolio of NbS strategies, including habitat restoration and green infrastructure[39]. Aligning NbS projects with the CRMP, RPP, and Climate Resilient SD can help ensure consistency with regional resilience goals.

While these resources provide a useful starting point, it is not an exhaustive inventory of all planning frameworks across San Diego, and navigating the full range of existing resource management plans can be overwhelming. In response, SDRCC developed the San Diego Regional Plan Tracker, a living geospatial database of climate-related plans that serves as a comprehensive, streamlined resource for planners and practitioners in San Diego and beyond[40].

Landscape Connectivity and Unique Ecosystem Attributes

Habitat fragmentation and connectivity barriers should also be considered, such as roads, development, trails, and other built features. Project sites that are adjacent to or connected with existing natural habitats can provide greater value by supporting wildlife movement, facilitating genetic exchange, and improving long-term resilience[41].

Connectivity mapping tools, such as the California Department of Fish and Wildlife (CDFW) Terrestrial Habitat Connectivity Mapping tool, can help identify wildlife corridors, habitat linkages, and barrier locations where restoration may strengthen ecological continuity[42]. While the Connectivity tool specifically maps wildlife movement corridors, the CDFW Areas of Conservation Emphasis (ACE) tool allows users to view connectivity in relation to biological value and climate resilience. In addition, the San Diego State University Institute for Ecological Monitoring and Management Climate Resilient Connectivity for California's South Coast Ecoregion model provides regional linkage maps that integrate multispecies connectivity and projected climate change to identify landscapes most likely to support biodiversity persistence under future conditions. These complementary tools can help prioritize restoration, land protection, and habitat enhancement efforts across the region[43]. Broader connectivity initiatives, such as the Wildlands Network, further emphasize the importance of protecting and restoring connected landscapes[44].

Findings from The Nat's Healthy Canyons Initiative underscore the importance of connected habitats in the San Diego region. Surveys across 19 urban canyon systems documented a diverse wildlife community spanning highly urbanized fragments and larger, more contiguous natural areas. Composition varied across this gradient, with several chaparral-associated species more frequently documented in larger canyons and connected open spaces, while smaller and more isolated canyons tended to support a higher proportion of urban-adapted and non-native species. These results highlight the need for stepping-stone habitat patches, linear movement corridors, and open space networks for supporting wildlife movement across urban landscapes[45].

Site selection should also account for unique features and system attributes that may be especially vulnerable to climate change or development. For example, chaparral and coastal sage scrub habitats with steep slopes, riparian corridors, and habitat transition zones may face heightened exposure to wildfire, drought, erosion, and flooding. The Climate Science Alliance, in collaboration with a team of ecologists and climatologists, developed the San Diego County Ecosystems Assessment as part of California's Fourth Climate Change Assessment to evaluate how changing temperature, precipitation patterns, fire regimes, and land-use pressures are expected to affect the region. The report provides a science-based foundation for understanding regional ecosystem vulnerability[46].

Environmentally Sensitive Habitat Areas (ESHA), as defined under the California Coastal Act, further reflect this emphasis on system vulnerability by identifying habitats that are rare or especially valuable for their ecological function[47]. In Southern California,

coastal habitats are commonly threatened by “coastal squeeze”, in which urban development patterns prevent marshes, wetlands, and dunes from migrating inland with sea level rise[48]. The Coastal Quest Sea Level Rise Vulnerability Assessments show how sea level rise threatens beaches, infrastructure, and natural resources along the San Diego coast[49].

NbS planning efforts in San Diego increasingly recognize dune conservation as a priority strategy that can provide both ecological and shoreline protection functions[39]. Protecting remnant dunes, restoring degraded systems, and reconnecting dunes with adjacent habitats can support sediment transport and connectivity across the coastal zone. The California Dune Science Network (CDSN) provides a suite of planning and technical resources specific to coastal dune ecosystems. The CDSN dune inventory, vulnerability assessments, and restoration frameworks can help prioritize locations for dune conservation. Considering ecosystem vulnerability, wildlife movement corridors, and areas supporting sensitive or uniquely adapted species can strengthen site selection for NbS projects in dunes and other ecosystems throughout San Diego[7,50].

Understanding Land Ownership and Permitting Requirements

The site-level considerations described above can help identify where habitat restoration is most impactful, but moving toward implementation requires a clear understanding of land ownership and the regulatory authorities that govern each site. In San Diego County, parcel maps and online geospatial data tools provide a practical way to identify property boundaries and responsible agencies. For example, the SanGIS interactive map allows users to search for a location, view parcel boundaries, and access information such as parcel numbers, jurisdictional boundaries, and planning layers. Additional county or city mapping tools can be used to confirm ownership, zoning, or regulatory overlays[51]. Once ownership is identified, project leaders can determine which agency or entity has authority over the site and what approvals may be required.



Project partners visiting coastal dunes in Camp Pendleton. Collaborative site visits help identify project priorities, site-specific constraints, and potential for Nature-based Solutions strategies. Photo by Frances Lang.

Yet many county or city mapping tools have important limitations in how they represent land ownership. Parcel-based geospatial data systems use contemporary land ownership systems and often do not reflect Indigenous sovereignty, ongoing Tribal stewardship, or the historical processes of land dispossession that shaped present-day property boundaries. Platforms such as Native Land Digital’s interactive map illustrate Indigenous traditional territories, languages, and treaty areas[52]. Reviewing this information during the planning phase can help project leaders comprehend that present-day landscapes sit within overlapping systems of stewardship and governance.

In San Diego, successful NbS projects depend on collaboration between multiple stakeholders, including Tribal nations, city departments, resource agencies, community organizations, and private landowners. The iterative process of addressing concerns from these diverse groups can enhance feasibility, improve outcomes, and strengthen overall project design[23]. Permitting should therefore be viewed as both a regulatory requirement and a relationship-building exercise, helping to align project goals with regional priorities while creating a stronger foundation for community engagement.

Permitting as a Core Project Challenge

Permitting is viewed as one of the most significant challenges facing NbS projects, particularly in highly regulated coastal and urban ecosystems. Interviews with agency staff and local organizations show that many groups, especially those without prior experience or dedicated permitting specialists, struggle to determine which permits are required and which actions may trigger regulatory review. Even in cases where projects may qualify for exemptions, technical environmental studies may still be required to satisfy permitting requirements and support regulatory determinations. Overlapping jurisdictions can make it difficult to identify the appropriate regulatory authority, and frequent changes to laws and regulations make it challenging to stay current. The process can also impose financial and scheduling burdens, as long approval times increase project costs. Understanding permitting pathways, timelines, and responsibilities is therefore critical to successful implementation[29,53,54].

Permitting timelines for habitat restoration projects can vary widely, ranging from a few months for small, low-impact efforts to several years for more complex projects involving multiple agencies and sensitive resources[29,53]. For this reason, it is essential to account for permitting early in project planning and build realistic timelines that reflect potential regulatory complexity. Early coordination with city departments, state agencies, and federal regulators can help clarify expectations and identify potential timing concerns.

The City of San Diego, as the primary landowner of many urban canyon sites, can support projects through permitting guidance, infrastructure coordination, and integration with existing management plans. For coastal dune projects, coordination with California State Parks is important, as the department manages many of California’s beaches and can help ensure that restoration activities align with site-specific adaptation plans[29]. Because sediment supply is fundamental to dune formation, dune restoration requires access to a dedicated and sustainable sand source, which may require involvement from additional state or federal agencies.

Successful permitting depends on clear communication with landowners, public works departments, planning staff, and resource managers. Projects that engage agencies early and frame restoration as a shared, multi-benefit effort are more likely



Community members and environmental practitioners participating in restoration activities at Swan Canyon, San Diego. These coordinated efforts illustrate the importance of planning and regulatory considerations in urban green spaces. Photos by Kayla Gorman.

to move efficiently through the review process and gain long-term support[29,53]. However, not all communities feel an equal level of trust and cooperation with public agencies; therefore, establishing authentic lines of communication requires ample time, transparency, and effort on the part of both project leaders and local decision-makers[23].

Streamlining Restoration Permitting

Since the late 1990s, California has steadily advanced a more streamlined, programmatic approach to permitting environmental restoration projects. This has involved moving from county-level programs and pathways for small projects toward statewide general orders, programmatic biological opinions, California Environmental Quality Act (CEQA) exemptions, and restoration management permits that can accommodate projects across a broad range of scales, without imposing fixed acreage or linear-footage eligibility limits. Actions by agencies such as CDFW, the State Water Resources Control Board (SWRCB), California Coastal Commission (CCC), U.S. Fish & Wildlife Service (USFWS), and National Marine Fisheries Service have clarified permitting pathways and created more predictable regulatory frameworks.

California's Cutting the Green Tape initiative was created in 2019 to address the types of permitting barriers that often slow habitat restoration and NbS projects. Led by the California Natural Resources Agency (CNRA), in partnership with the California Landscape Stewardship Network, the initiative focuses on making environmental permitting faster, more straightforward, and more cost-effective[55]. Its goal is to increase the pace and scale of restoration needed to meet California's biodiversity and climate targets by making regulatory processes more efficient. According to the CNRA, the Cutting the Green Tape initiative has supported more than 500 projects to date, including contributing to the restoration of nearly 300,000 acres of habitat, improved connectivity across 5.5 million acres of land, and enhancement of more than 700 miles of stream corridor across California[56].

Two key tools in CDFW's Cutting the Green Tape program are the Statutory Exemption for Restoration Projects (SERP) under CEQA, and the Restoration Management Permit (RMP). Qualifying projects can proceed under these streamlined pathways when they meet defined eligibility requirements. Projects that impact surface water, coastal waters, or groundwater may apply to enroll under the SWRCB Statewide Restoration General Order. For qualifying restoration projects that are five acres or less in size, the CEQA Categorical Exemption 15333 – Small Habitat Restoration Projects provides the simplest CEQA compliance pathway. Projects in the Coastal Zone that require a Coastal Development Permit may qualify for a waiver from the CCC if the proposed work will enhance the coastal environment and avoid adverse impacts. Collectively, this shift toward "cutting the green tape" has made it easier to implement NbS at the local level, allowing projects across San Diego County to move more efficiently from design to implementation while still meeting environmental protection goals[57].

While some streamlined permits are well suited for projects with limited ground disturbance and minimal risk to sensitive resources, the Cutting the Green Tape initiative was specifically developed to make it easier to implement larger, more ecologically meaningful restoration projects, including those in environmentally sensitive habitats. Rather than encouraging project proponents to avoid these areas, the Cutting the Green Tape initiative seeks to reduce regulatory barriers so that restoration practitioners can undertake projects of sufficient scale and complexity to address significant environmental challenges. Programmatic pathways such as SERP and RMP are designed to facilitate restoration projects at landscape scales, including projects spanning hundreds or even thousands of acres. Although regulatory compliance may still be simpler for projects located outside jurisdictional waters or critical habitat, project leaders should recognize that many expedited pathways were intentionally established to support ambitious restoration efforts in the very habitats where ecological benefits can be greatest.

Permitting and Regulatory Planning Tools

The Accelerating Restoration website and its Essential Permitting Guide were created to support practitioners navigating complex regulatory processes. Developed by Sustainable Conservation, the site organizes regulatory information into clear, user-friendly webpages that explain which permits may apply, which agencies are involved, and how projects can qualify for accelerated or programmatic approvals. The Essential Permitting Guide summarizes major federal, state, and regional permits and their eligibility requirements and benefits in a single reference table, with links to learn more about each pathway. Website users can browse regulatory pathways by agency, making it easier to identify likely permitting routes for restoration projects. By consolidating information from multiple agencies into one platform, the site reduces uncertainty and helps project teams plan their permitting strategies early[58].

In parallel, the USFWS Information for Planning and Consultation (IPaC) platform provides an additional early-stage screening tool for identifying federally listed species, critical habitat, and other environmental constraints that may affect project design and permitting pathways. IPaC allows users to generate automated species and habitat reports for a given project location, helping teams anticipate regulatory requirements under the federal Endangered Species Act and related protections[59]. Further information about methods for identifying threatened, endangered, or rare species is discussed in subsequent sections.

CASE STUDY Local Canyon

The Manzanita Greening and Canyon Health Project

The Manzanita Greening and Canyon Health Project is a streambed and riparian enhancement project within the underserved community of City Heights in an urban-embedded Open Space canyon and drainage area. Like many urban canyons in San Diego, Manzanita Canyon is conserved as part of the City of San Diego's Multiple Species Conservation Program, but it is also an important utility corridor functioning as part of the City's stormwater system with overhead power lines and undergrounded sewer infrastructure. This project is a pilot for streambed bioengineering techniques, providing an object lesson in design, permitting, and implementation of these NbS under an array of constraints found in San Diego's urban settings. These include but are not limited to complex and overlapping regulations, logistical challenges on the public and private interface, and engineering for climate-driven changes in storm intensity/duration/frequency.

As streambed bioengineering techniques are relatively novel for application in San Diego's ephemeral streambeds, there is not a clear permitting pathway at the City for riparian restoration that involves wetland grading. Streambed bioengineering is a habitat restoration methodology that involves temporary grading impacts in wetlands for the purpose of wetland expansion, stabilization, and functional uplift. At the City, wetland grading is considered a permanent construction impact requiring mitigation, triggering a Site Development Permit. Further, all grading projects require a construction-oriented engineering review, triggering a Grading/Right of Way (ROW) Permit. This disconnect between grading-triggered construction permitting pathways and restoration through streambed engineering was partially resolved for this project by utilizing the State of California's Cutting the Green Tape program spearheaded by CDFW, including achieving a Statutory Exemption for Restoration Projects (SERP) and a Restoration Management Permit (RMP). With SERP, RMP, and by achieving conformance with the CA Water Quality Control Board's Statewide Restoration General Order (SRGO)—an accelerated restoration permitting process for water quality certification and water discharge requirements—the City was convinced to forego the Site Development Permit for a Right of Entry Permit (ROE). A ROE is the generalized City permit typically used for restoration projects that do not involve wetland grading. In the end, the City permits for this project included an unusual combination of ROE (restoration) with a Grading/ROW (construction).

Clearly, designing and permitting streambed bioengineering projects with this dual permit combination is not scalable due to the time and cost the process incurs. Canyonlands is currently working with City officials to structure a streamlined program for stream and river enhancement and restoration projects that will standardize streambed bioengineering and alignment with Cutting the Green Tape processes for faster and more cost-effective planning and permitting at the local level, based on the lessons learned in this project. The Manzanita Greening and Canyon Health Project broke ground in Fall of 2026 and provides a living example of NbS applied for streambed stabilization, expansion of the floodplain, localized flood mitigation, water quality improvement, local air quality improvement, reduced heat island effects, and expansion of riparian forest for habitat and drought-resilient carbon sequestration.

Provided by Clayton Tschudy, Executive Director of San Diego Canyonlands



Photo courtesy of San Diego Canyonlands, Condor Visual Media

Permitting at the Local Level

While state and federal permitting processes often follow standardized regulatory frameworks, local permitting can vary by jurisdiction. A permit needed for access to San Diego City owned land is a Right of Entry Permit (ROE). While the ROE does not specifically allow for habitat restoration or enhancement actions, it is the first step to gaining legal access to these properties. However, there are ways to strategically utilize a ROE within preexisting restoration projects to streamline permitting processes. For areas within the Multiple Habitat Planning Area (MHPA), these types of activities (invasive species removal, habitat restoration, trail maintenance, sensitive species surveys, etc.) have been studied and analyzed as part of the MSCP Environmental Impact Report (EIR). It is the substantial conformance with the MSCP EIR that provides the environmental clearance to complete these types of approved actions within the MHPA. Outside of the MHPA there is no such approved action from a city EIR, and each activity must be studied, and potential impacts need to be permitted through a CEQA exemption. The ROE is not a permit to authorize any activity, it merely provides an organization with legal access and rights to conduct a project. The Project description and Project scope will determine the proposed direct and indirect impacts, and those impacts will need to be analyzed to determine if they meet the threshold that would require permitting, mitigation, and restoration. The ROE permit is part of this process because that is the vehicle that provides the discretionary action for CEQA approval[53].

For example, a project is proposed to take place with volunteers to remove invasive species, but the project has the potential to impact 0.15 acres of environmentally sensitive lands within the MHPA. The MSCP EIR covers the areas within the MHPA and the activity of removing the invasives substantially conforms with the EIR, so the invasive removal and restoration would be covered under the EIR and would not require any permitting. However, if the project proposed to create an access path through 0.15 acres of maritime succulent scrub, the project would be required to go through a site development permit process and mitigate for those impacts. The ROE itself does not waive those requirements, they would exist whether or not an ROE was issued. The ROE is a great way to have outside groups legally have access rights to City or County property but that permit is separate from any other permit requirements that may be required as a result of potential project impacts. Depending on site location, ROE permits for county and city properties are typically managed by individual departments, such as the Planning and Land Use Department, Storm Water Division, or Parks and Recreation Department[60].

While the ROE process can provide a streamlined permitting pathway for some spaces, it still requires clear project planning and interdepartmental coordination. While an ROE is a useful tool for advancing NbS projects, it does not take the place of state and federal permitting requirements, so an RMP, CDP, or other permits may still be necessary, depending on site location and planned activities.

Identifying Specialized Implementation and Scientific Partners

In addition to collaborating with local landowners and regulatory agencies, project leaders should explore partnerships with organizations holding specific technical, scientific, implementation, and community expertise. Community-based organizations such as San Diego Canyonlands, Earth Discovery Institute, Nature Collective, and The San Diego River Park Foundation bring

extensive experience in habitat restoration, volunteer mobilization, and environmental education. These organizations possess deep site-specific knowledge, established relationships with local communities, and practical experience navigating permitting, access, and site maintenance needs. Nonprofit organizations also serve as trusted messengers and can bring adaptive, creative approaches to implementation. In addition to streamlining efforts, these collaborations can strengthen community trust and participation, which are critical to the long-term success of NbS projects.

Scientific partners play an important role in informing restoration design through expertise in plant taxonomy, native plant selection and placement, soil and sediment dynamics, and data collection methods. Because The Nat has conducted long-term, multitaxon biodiversity surveys within San Diego's urban canyon systems, generating valuable ecological baseline data, the organization is well-equipped to provide scientific and technical leadership for canyon NbS projects. Additional scientific support may include habitat assessments, genetic testing, and environmental DNA (eDNA) monitoring to better understand ecosystem conditions and track project outcomes over time.

For coastal projects, expertise in littoral cells and sand movement dynamics is often necessary. Agencies such as the U.S. Geological Survey can provide technical support for understanding long-term coastal change. The U.S. Army Corps of Engineers can provide technical expertise related to beach nourishment efforts, which may require complex analyses of sand grain size, quality, and contamination.

Consistent training and communication among partners are critical to avoiding unintended impacts. For example, brush management crews responsible for removing highly flammable materials such as dry grasses, leaves, and twigs may not always be trained to distinguish native from invasive vegetation. As a result, they may inadvertently remove ecologically important native species or leave highly invasive plants that continue to degrade habitat conditions. For example, Western Coastal Wattle (*Acacia cyclops*) is native to Australia but is frequently mistaken for California chaparral because of its drought tolerance and bright yellow flowers. These aggressive trees, which are now widespread throughout San Diego's canyons, displace native flora, alter soil chemistry, and disrupt local ecosystems. They are also very difficult to control once established[61]. Project leaders may need to contract with an offsite nursery to propagate native plants for restoration, but seeds should still be collected from the project site whenever possible to preserve local genetic integrity.

Depending on the site, advanced expertise may be required for invasive species eradication, as well as wildlife translocation, predator management, Indigenous fire stewardship, public engagement, and cultural land management practices. Site-specific planting and restoration decisions should always be informed by qualified restoration ecologists to improve plant survival and avoid ineffective or unsustainable practices that ultimately waste resources[29,53,54]. Establishing clear protocols, roles, and expectations across all participating organizations before work begins can help ensure NbS projects are implemented effectively and in accordance with ecological and community priorities.

Community Engagement Strategy and Relationship Building

In any project, effective community engagement requires early, sustained, and intentional public outreach[23]. Research on collaborative coastal resilience highlights the importance of robust social networks, knowledge exchange, and trusted relationships that evolve over time[62]. For this reason, community engagement should begin at the outset of planning and be treated as a foundational component of NbS project design rather than a rushed, procedural step during permitting or final review[23].

Key best practices include:

- Begin engagement early in the planning process
- Maintain transparency with consistent communication
- Offer multiple opportunities for participation, including workshops, site visits, and surveys
- Remove barriers to participation with services like translation, transportation, and childcare
- Co-design projects with community members and tribal partners
- Incorporate indigenous knowledge through respectful, reciprocal, and long-term partnerships
- Continue engagement after implementation through adaptive management

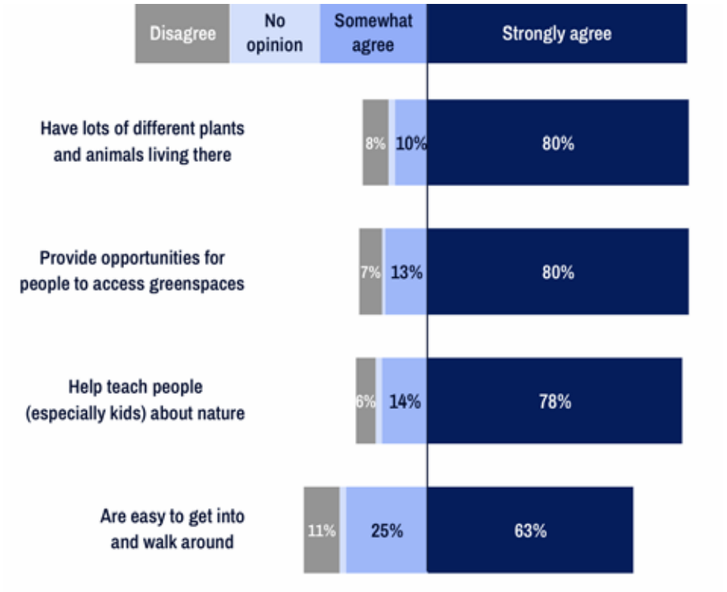
Engagement strategies should be structured to support equitable participation, particularly in communities that have historically been underserved by environmental investments[24-26]. This includes improving meeting accessibility, providing translation services, offering alternative scheduling options, and facilitating transportation and childcare services. Rather than assuming community members will self-identify, project leaders should proactively design multiple entry points for participation, including workshops, site walks, advisory groups, informal listening sessions, and surveys[23]. For example, a collaboration between The Nat's Healthy Canyons Initiative and the Canyon and Dune Resilience Project, launched a survey where community members across San Diego County were asked about their perceptions and values related to their local urban canyon systems. The results demonstrate strong support for restoration activities that prioritize biodiversity, environmental education, and access[63]. Questions and tools that were utilized for the survey are included in *Appendix B*.

A central component of effective engagement is co-design, where community members and Tribal partners are involved in shaping project goals, priorities, and management decisions. This includes integrating Indigenous knowledge systems and respecting cultural landscapes, archaeological resources, and place-based histories[64,65]. Engagement with Tribal partners should be grounded in reciprocal, long-term relationships rather than the extraction of Indigenous knowledge to inform a single project, as extractive approaches reinforce historical patterns of colonization. It is also important to acknowledge that projects may be experienced differently across communities. For instance, restoration efforts may enhance ecological function but restrict access to areas used for recreation, subsistence, or cultural practices[23]. Projects may alter off-leash dog areas, shift surfing conditions, or result in various other changes that affect site use. As a result, not all stakeholders will view every project positively. Surfacing these perspectives early, and engaging in open dialogue about potential tradeoffs, are important aspects of the co-design process.

Listening to community knowledge provides critical insight into lived experience. Residents may identify informal access points, erosion hotspots, or safety concerns that are not reflected in geospatial data layers or technical datasets[63]. Similarly, adaptation strategies such as beach nourishment, which are generally viewed by restoration practitioners as beneficial, may be perceived by the public as excessively

CANYON PRIORITIES

Community priorities for San Diego's urban canyon systems based on responses to The Nat's Healthy Canyons Initiative community survey.





San Diego Natural History Museum 2026. San Diego Canyon Greenspaces: Community Survey Report. Prepared by J. Sickler Consulting.

expensive and ultimately unsustainable, costing millions of dollars per year depending on the site[29]. Climate adaptation benefits should be communicated in clear, accessible terms, and framed alongside the cost of inaction, such as loss of high-value infrastructure. Project leaders should also recognize that certain terms may carry unintended negative connotations; for example, using "community-led relocation" rather than "managed retreat" may better communicate the collaborative nature of relocating infrastructure in response to sea level rise. Timing engagement to align with community priorities is also useful; for example, hosting (indoor) educational workshops on the topic of extreme heat during the summer, when climate realities are most salient.

Community engagement should be embedded throughout the project lifecycle, from planning and co-design to implementation, long-term management, and stewardship. By fostering relationships grounded in mutual learning, respect, and sustained collaboration, project leaders can build lasting partnerships that strengthen both ecological resilience and community wellbeing[23].

Phase 2: Site Assessment and Project Design

Understanding the Local Environment

Following the planning phase, the next step in developing an effective NbS project is gaining a detailed understanding of the site itself. Establishing baseline conditions is critical for supporting long-term habitat performance and feasibility, reducing unintended impacts, and ensuring that restoration strategies are appropriately tailored to the landscape[66,67].

A thorough assessment should begin with an evaluation of physical site conditions, including topography, elevation, and erosion risk. In San Diego's canyon and coastal environments, steep slopes, unstable soils, and variable terrain can significantly influence restoration outcomes. Understanding site hydrology is also important, including drainage patterns, inundation frequency, and groundwater dynamics. Watershed-scale assessments can help project leaders map drainage areas and evaluate upstream runoff and other potential stressors[68]. Water also profoundly shapes vegetation distribution, particularly in riparian corridors and low-lying areas. In coastal environments, project planning must account for wave action, tidal influence, sediment transport, and bluff erosion[7]. These processes continuously shape beaches and dunes and can affect the longevity and resilience of restoration efforts.

Documenting existing plant communities and habitat types is a key step in understanding ecological conditions. This may include chaparral, coastal sage scrub, riparian habitat, grasslands, wetlands, beaches, or dune systems. Microclimate conditions, which can be distinctive to a very small area (e.g., within a few meters), should also be evaluated. Factors such as temperature, solar exposure, coastal fog, and wind patterns can vary dramatically across short distances in San Diego landscapes. North- and south-facing slopes, for example, often support different vegetation communities due to variances in moisture retention and heat exposure. This can influence species composition and habitat resilience under future climate scenarios. Effective restoration planning should consider these site-specific characteristics as well as broader ecological connectivity, such as wildlife movement corridors, pollinator pathways, and opportunities for genetic exchange[29,53,54]. A sample Site Assessment & Monitoring Survey can be found in *Appendix C*.

Soil conditions are another essential component of site assessment. The U.S. Department of Agriculture's SoilWeb online database provides detailed soil survey information, including soil type, texture, depth, hydrologic properties, and other characteristics that can inform project planning. Soil compaction, salinity, contamination, and nutrient composition can all influence plant establishment and ecosystem health[69]. In some habitats, biological soil crusts (biocrusts) are important ecological features that should be protected. Biocrusts are thin living layers composed of fungi, lichens, mosses, cyanobacteria, and algae that form on the surface of the ground. They can help stabilize soils, retain moisture, and resist invasion by nonnative plants. It is a common misconception that restored habitats should be densely planted and lack bare ground; in fact, bare patches of soil naturally occur in undisturbed habitats and are important to







Top left: Quino Checkerspot Butterfly (*Euphydryas editha quino*), a federally endangered butterfly native to southern California. Photo by John Martin under Permit TE-108507.

Top right & bottom: California Dotseed Plantain (*Plantago erecta*), an important larval host plant for the Quino Checkerspot Butterfly. Photo by Jon Rebman.

the survival of many species[53,54]. In Southern California, the federally endangered Quino Checkerspot Butterfly (*Euphydryas editha quino*) requires bare ground for basking and supporting the growth of the butterfly's primary host plant, California Dotseed Plantain (*Plantago erecta*).

Understanding historic land use can further clarify existing conditions. Previous grading, agriculture, off-road vehicle use, fire history, or informal trail networks may continue to influence site conditions and ecological processes well into the future. Historical context can also shape permitting pathways and regulatory considerations[66]. For example, the CCC considers coastal dunes to be ESHA regardless of their current condition, reinforcing the importance of both historic and existing ecological value. In addition, adjacent development, roads, utilities, stormwater infrastructure, and emergency access requirements may limit available restoration space or require creative design solutions. Understanding these constraints allows project teams to identify realistic solutions and incorporate necessary buffer or transitional zones to ensure compatibility with surrounding communities.

Understanding Ecological and Social Challenges

Beyond understanding physical site conditions, project leaders should also develop an understanding of the specific ecological and social challenges influencing the project area. Evaluating the pressures, stressors, and disturbances affecting a site helps form a clearer picture of restoration needs and strategies[23-26]. Successful NbS projects must account for interconnected factors such as climate impacts, disturbance regimes, human activities, public access, and safety.

Identifying Ecological Stressors and Restoration Challenges

A key step in NbS planning is identifying the primary stressors limiting habitat function and resilience. In many coastal and urban ecosystems, invasive species are among the most persistent challenges. Non-native plants and trees can outcompete native vegetation, alter habitat structure, increase fire risk, and reduce biodiversity. Addressing invasive species requires significant investment in long-term management, including targeted removal, ongoing monitoring, and biosecurity measures designed to prevent reinfestation and spread[29,53].

Restoration decisions rarely involve simple solutions, and interventions designed to address one factor may create additional challenges. For example, while herbicide can be used to control invasive vegetation, it introduces risks to surrounding waterways, non-target species, and human health[53]. Because of the potential for unintended impacts, herbicide use should generally be limited to highly persistent weeds for which hand removal has been proven ineffective (e.g., invasive grasses like Hybrid False Brome, *Brachypodium hybridum*).

Additionally, some invasive plants may provide temporary soil stabilization or



Hybrid False Brome (*Brachypodium hybridum*), an invasive annual grass affecting native plant communities. Photo by Jon Rebman.

erosion control, so removal strategies should be carefully timed and paired with native plant establishment. It is important to recognize these complexities and develop adaptive management approaches to balance immediate restoration needs with long-term ecosystem health.

Climate-related vulnerabilities are another critical consideration. Increasing temperatures, drought, changing precipitation patterns, and more frequent or intense wildfires can substantially alter site conditions[8,9]. Understanding disturbance regimes is especially important in fire-prone habitat types like Southern California's chaparral, coastal sage scrub, and grassland communities. Repeated, high-severity fires can prevent native plants from recovering, allowing fast-growing non-native grasses to dominate and further increase future fire risk. While severe wildfires can cause ecological damage, low-intensity fires can provide important ecosystem benefits such as reducing the accumulation of fine fuel loads (dry grasses, leaves, sticks, and bark that are especially susceptible to combustion) and supporting nutrient cycling[37].

Several resources exist to support project leaders in conducting initial site assessments and identifying both current and future

ecological stressors, such as aerial imagery, vegetation mapping, biodiversity surveys, and local literature archives. Many of these resources are available through The Nat's Research Library, San Diego Conservation Planning Hub, and other regional data platforms[70,71]. For example, coastal flooding due to sea level rise and storm projections can be explored through the Coastal Storm Modeling System (CoSMoS) for Southern California[72]. The California Fire Science Consortium maintains a collection of research briefs, technical reports, articles, and tools focused on wildfire ecology, prescribed fire, fuels management, and climate resilience. Engaging technical specialists, including landscape ecologists and restoration practitioners, can further strengthen understanding. Site walkthroughs with local experts are often invaluable for identifying subtle ecological patterns, disturbance indicators, and restoration opportunities that may not be visible through desktop analysis alone[29,53].

Human use patterns can also affect habitat quality. Recreational activities, informal trails and access points, and unsheltered settlements can contribute to erosion, vegetation loss, and wildlife disturbance. Understanding how people interact with a site allows project teams to design NbS interventions that balance ecological protection with community access. For example, project leaders at the Cardiff State Beach Living Shoreline site in San Diego County incorporated design considerations such as placing Beach Bur (*Ambrosia chamissonis*) on the street-facing side of dune systems to subtly discourage visitors from crossing over the dunes and encourage them to use designated access points near existing parking areas[29]. These types of design choices can help reduce habitat disturbance while supporting positive community experiences and managing public access.

Integrating Community Needs and Equity Considerations

Understanding social conditions is especially important because NbS projects occur within lived landscapes. Project teams should consider who uses the site, who has historically been excluded, who stands to benefit from improvements, and who may experience limitations[12]. Incorporating these perspectives helps ensure that NbS projects support both ecosystem resilience and community wellbeing, including respecting the social functions that make natural places meaningful to local communities. For example, a critical component of coastal NbS projects is the need to maintain sufficient "towel space" for public recreation, gathering, or relaxation on sandy beaches[29]. The best way to gather authentic, real-world community input is through direct engagement with residents and site users.

Coastal dune ecosystems illustrate why successful NbS projects require balancing ecological goals with community needs. From a purely ecological perspective, the greatest restoration benefit comes from minimizing or eliminating human disturbance. In practice, however, completely restricting public access is not feasible, may undermine public support, and can create inequitable outcomes by limiting access to open space. NbS recognize that healthy ecosystems and thriving communities are interconnected. As a result, project planning should intentionally seek solutions that protect and restore ecological function while accommodating appropriate public access, recreation, education, and other community priorities. This integrated approach may require scientists, restoration practitioners, and land managers who are accustomed to prioritizing ecological outcomes to broaden their planning process by incorporating community values alongside ecological objectives from the outset[73].

NbS projects require navigating complex ecological, social, and management approaches using the best available data. Tools such as the California Environmental Protection Agency's CalEnviroScreen and related environmental justice mapping resources can help identify communities experiencing disproportionate environmental burdens and inform more inclusive decision-making[74]. The Vulnerable Communities Platform shows how wildfire, extreme heat, flooding, sea level rise, and drought are expected to affect California communities[75]. Additional resources, such as the California Healthy Places Index[76] and Parks for All Californians frameworks, can provide insight into community conditions, access to green space, and public health needs. However, because statewide screening tools may not fully capture local conditions or community priorities, project leaders should supplement them with site-specific data, community knowledge, and direct engagement to ensure equitable planning decisions. For example, the San Diego Heat Risk Explorer is an interactive map that helps identify how communities are most affected by heat waves specifically in San Diego County[77].

Identifying Threatened, Endangered, or Rare Species

Understanding the species currently present at a site, as well as those historically documented, is a critical step in developing effective NbS projects.

Biodiversity data helps project leaders identify conservation priorities and design restoration strategies that support existing species. Data gaps can limit management decisions by making it difficult to fully characterize species distributions, habitat use, and movements.

Key sources for biodiversity data include The Nat's collection of animal atlases, which provide comprehensive details on



Short-tailed Whipscorpion (*Hubbardia pentapeltis*, Order *Schizomida*), a cryptic soil-dwelling arachnid. Photo by Tobias Hays.

the distribution, abundance, and long-term change of wildlife species in San Diego County[78]. The Consortium of California Herbaria (CCH2 Portal) is the primary resource for sharing data about California's herbaria collections[79]. Observations from community science platforms and biodiversity databases, such as the Global Biodiversity Information Facility and iNaturalist, can also provide valuable information. When combined with long-term monitoring efforts and expert-led biological inventories, such as those conducted through The Nat's Healthy Canyons Initiative, these datasets can be used to track species occurrences, habitat associations, and seasonal use patterns over time[45]. Additionally, *Appendix D* includes a sample Plant Palette of Lost and Rare plants in San Diego County.



Least Bell's Vireo (*Vireo bellii pusillus*) in riparian habitat. Photo by Alexandra Houston.

The presence of federally or state-listed species, special-status species, and sensitive or unique plant communities can substantially influence project goals, design, and permitting requirements.



Coastal California Gnatcatcher (*Polioptila californica californica*) in coastal sage scrub habitat. Photo by Alexandra Houston.

The USFWS Environmental Conservation Online System (ECOS) documents federal listing status, critical habitat designations, and recovery planning information[80]. At the state level, CDFW maintains lists of California's threatened and endangered plant and animal species, as well as an inventory of the status and locations of rare plants and animals[81].



California Adder's Tongue (*Ophioglossum californicum*), a native fern of coastal sage scrub openings. Photo by Jon Rebman

When evaluating species of conservation concern, it is important to consider their full range of habitat needs and life stages, such as breeding, nesting, and foraging. A species may depend on multiple habitats or specific landscape conditions, which requires an ecosystem-scale approach[29,53,54]. For example, the Western Spadefoot (*Spea hammondii*), a species of toad classified as a Species of Special Concern by CDFW and currently under review for federal listing, spends the majority of its life burrowing underground but relies on seasonal ponds for breeding.



Western Burrowing Owl (*Athene cunicularia hypugaea*) occupying open grassland habitat. Photo from San Diego Zoo Wildlife Alliance.



Western Spadefoot (*Spea hammondii*), a California amphibian associated with seasonal wetlands and vernal pools. Photo by Adam G. Clause under CDFW Permit SCP S-183440004-19131-001.

In Southern California, more than 80% of its habitat has been lost to development. For species like the western spadefoot, protecting only one portion of its habitat is unlikely to support long-term survival[82]. Similarly, the Western Burrowing Owl (*Athene cunicularia hypugaea*) is a California Species of Special Concern but not federally listed, which creates management challenges because the species occurs broadly across developed and undeveloped landscapes.

Protecting habitat for widespread species can create tension with competing land uses, because avoidance measures may be difficult to achieve. Similar challenges can occur with listed butterfly species that depend on very specific host plants and habitat conditions.

Table 2 – Common Species and Natural-Community Conservation Classifications



CLASSIFICATION	APPLIES TO	WHAT IT MEANS	REGULATORY SIGNIFICANCE	PRIMARY SOURCE
Federally Endangered	Plants and animals	The species is in danger of extinction throughout all or a significant portion of its range.	Formally protected under the federal Endangered Species Act. Projects involving the species or its habitat may require federal consultation, avoidance measures, or permits.	U.S. Fish and Wildlife Service or the National Marine Fisheries Services
Federally Threatened	Plants and animals	The species is likely to become endangered within the foreseeable future throughout all or a significant portion of its range.	Formally protected under the federal Endangered Species Act, although applicable protections may differ by species.	U.S. Fish and Wildlife Service or the National Marine Fisheries Service
State Endangered	Plants and animals	The species is in danger of extinction in California.	Formally protected under the California Endangered Species Act.	California Fish and Game Commission and the California Department of Fish and Wildlife
State Threatened	Plants and animals	The species is likely to become endangered in California without protection or management.	Formally protected under the California Endangered Species Act.	California Fish and Game Commission and the California Department of Fish and Wildlife
California Species of Special Concern	Native animals	A species, subspecies, or distinct population of conservation concern because of declining populations, restricted distribution, significant threats, or other indicators of vulnerability.	Not formally listed under California Endangered Species Act. However, the designation is frequently considered during CEQA review and conservation planning.	California Department of Fish and Wildlife
California Rare Plant Rank	Plants and lichens	A scientific ranking describing rarity, distribution, threat, or the need for additional information.	A California Rare Plant Rank (CRPR) is not itself a state or federal listing. Nevertheless, rare plants (especially CRPR 1 and 2 taxa) may require evaluation under CEQA and can influence project design.	California Native Plant Society and California Department of Fish and Wildlife
Fully Protected	Certain fish, amphibians, reptiles, birds, and mammals	A California classification originally created for animals that were rare or at risk of extinction. Many are also listed as threatened or endangered.	Carries separate protections under California law. Project teams should consult CDFW regarding any activity that could affect a Fully Protected species.	CDFW
Special-Status Species	Plants and animals	An umbrella term commonly used for species receiving legal protection, agency recognition, scientific rarity rankings, or other conservation attention.	Not a single formal designation and does not establish one uniform level of protection.	Multiple agencies and conservation programs
Sensitive Natural Community	Vegetation communities (rather than individual species)	A natural community considered rare or vulnerable based on its global or state rarity rank or other available evidence.	May influence CEQA analysis.	Vegetation Classification and Mapping Program and California Natural Diversity Database

Notes: A single species may hold multiple classifications simultaneously. Classification systems and individual species statuses change over time; project teams should verify current information through official federal and state sources and consult qualified biologists.

Selecting focal, indicator, or obligate species can provide a useful framework for guiding NbS project design. Focal species are species whose habitat requirements represent broader ecosystem needs. Indicator species can provide insight into ecosystem conditions, while obligate species can highlight the importance of maintaining specific habitat characteristics. Local conservation frameworks, such as the MSCP, demonstrate how species and habitat needs can be used to guide conservation planning by prioritizing species with the greatest risk and focusing efforts on habitats that support the highest number of at-risk species[33]. Because species requirements can be extremely complex, projects should always involve qualified biologists or wildlife experts when identifying focal or special status species and incorporating their needs into project design.



Torrey Pine (*Pinus torreyana*), one of the rarest pine species in North America. Photos by Jon Rebman.

Climate change adds additional complexity. Some species are dependent on narrow geographic, elevation, or climatic conditions and have a limited ability to adapt. Microclimate-dependent species, such as those that rely on cooler conditions at higher elevations or coastal fog-dependent vegetation communities like the Torrey Pine (*Pinus torreyana* subsp. *torreyana*), may become increasingly vulnerable as temperatures increase and ecosystems shift[83].



Mountain Yellow-legged Frog (*Rana muscosa*), a federally endangered amphibian of mountain streams. Photo by Brad Hollingsworth.

For example, the Mountain Yellow-Legged Frog (*Rana muscosa*) is a critically endangered species that has been extirpated from San Diego County and is historically found only in high-elevation alpine locations in Southern California.

Its geographic range is restricted to cold, perennial streams, and it cannot easily survive in warmer habitats. As temperatures rise, high-elevation species have limited opportunities to shift their range upward[54]. When possible, NbS projects should consider whether restoration actions can support future climate resilience, not just current habitat conditions, by accounting for species' long-term habitat needs.

Species interactions can also influence planning decisions. Species assemblages, or "suites", are groupings that collectively represent a target habitat type. For example, the Coastal Cactus Wren (*Campylorhynchus brunneicapillus sandiegensis*), a California Species of Special Concern, depends on mature cactus patches that provide nesting structure and native plants that support the insect communities the wren relies on for food.

At the El Monte Ecological Preserve in San Diego County, restoration efforts led by Earth Discovery Institute that created cactus scrub habitat as well as native vegetation supporting arthropod prey successfully



Coastal Cactus Wren (*Campylorhynchus brunneicapillus sandiegensis*) utilizing cactus scrub habitat. Photo by Alexandra Houston.

led to the establishment of a new breeding territory for Coastal Cactus Wrens[84].

Conversely, restoring habitat for one species may unintentionally create conditions that negatively affect another. For example, adding trees or structures that provide perching areas for raptors may benefit some species while increasing predation pressure on others[54]. In some cases, maintaining existing site conditions may even be more beneficial than intensive restoration. Leaving areas of bare ground, retaining organic matter, and avoiding unnecessary grooming or over-planting can support ground-dwelling species and maintain habitat complexity. Understanding these nuanced relationships can help ensure that restoration strategies support broader ecosystem function rather than focusing on a single isolated species[54]. CDFW's California Wildlife Habitat Relationships System, which provides modeled habitat suitability and species-habitat association information, can be a useful tool for learning about species linkages that occur within the state[85].

Plant Identification and Selection

Selecting appropriate plant species is one of the most important steps in designing effective restoration-based NbS, specifically in the canyons and dunes of San Diego County.



California Adolphia (*Adolphia californica*), a rare shrub native to southern California. Photo by Jon Rebman.

Plant choices should be aligned with the reference ecosystem, habitat type, plant community, specific conditions of the site, and projected changes in temperature, drought frequency, wildfire patterns, and coastal processes. Rather than applying a generalized plant palette across a region, project leaders should identify the native plant communities that historically occurred at the site and select species that are appropriate for the specific site, landscape position, and microhabitat conditions[54]. Accurate plant identification and taxonomy, the science of identifying and classifying organisms, provides the foundation for this process. Many native plants in San Diego County can be difficult to distinguish because closely related species may appear nearly identical while having very different habitat preferences, distributions, and conservation needs. For example, the rare San Diego Goldenstar (*Bloomeria clevelandii*) and the Common Goldenstar (*Bloomeria crocea* var. *crocea*) are visually similar but occur in different ecological contexts. Similarly, Barberry-leaf Goldenbush



San Diego Goldenstar (*Bloomeria clevelandii*), a rare native wildflower that closely resembles the common goldenstar but occupies different ecological settings. Photo by Jon Rebman.



Common Goldenstar (*Bloomeria crocea var. crocea*), a widespread native wildflower. Photo by Jon Rebman.

(*Hazardia berberidis*), a species restricted primarily to Baja California can be confused with the locally native Southern Sawtooth Goldenbush (*Hazardia squarrosa* var. *grindelioides*). Without careful identification, restoration projects may unintentionally introduce species that are not appropriate for local ecosystems.

Accurate identification is also critical for invasive species management. Many invasive plants are easiest to control when detected early, and misidentifications can delay management actions or result in resources being directed toward the wrong species. For example, in grasses the invasive Giant Reed (*Arundo donax*) has been confused with the native Giant Wild-Rye (*Leymus condensatus*). Understanding which plants are present, both native and non-native, helps project leaders evaluate existing conditions and design restoration strategies that support long-term ecosystem function.

Selecting Plants Based on Site Conditions and Ecological Function

Native plants and vegetation communities are adapted to particular combinations



Wart-stem Ceanothus (*Ceanothus verrucosus*), a rare shrub associated with coastal sage scrub. Photo by Jon Rebman.

of soils, moisture regimes, elevation, exposure, slope, disturbance patterns, and climate conditions. Matching plants to these conditions increases the likelihood of successful establishment and helps maintain ecological relationships among plants, wildlife, and other organisms[54].

Consider the functional role each species provides, including:

• **Erosion control and slope stabilization:** Species selected for steep slopes or disturbed areas should provide soil retention, root structure, and resilience to drought and disturbance. For example, California



California Buckwheat (*Eriogonum fasciculatum*), a foundational shrub supporting native pollinators. Photo by Jon Rebman.



Red Sand Verbena (*Abronia maritima*), a native coastal dune wildflower. Photo by Jon Rebman.



Beach Saltbush (*Atriplex leucophylla*), a native shrub adapted to coastal dune environments. Photo by Jon Rebman.



Beach Bur (*Ambrosia chamissonis*), a native coastal dune shrub that stabilizes sandy soils. Photo by Jon Rebman.

Buckwheat (*Eriogonum fasciculatum*) is well adapted to steep canyon slopes and provides important habitat value for insects and other wildlife. For dune systems, Red Sand Verbena (*Abronia maritima*), Beach Saltbush (*Atriplex leucophylla*), and Beach Bur (*Ambrosia chamissonis*) help trap and form mounds of sand.

• **Structural diversity:** Restoration designs should incorporate vegetation that reflects the natural structural complexity of the target ecosystem and supports a broad range of species. In some canyon ecosystems, this may include groundcovers, herbaceous species, shrubs, and canopy-forming trees, while naturally open habitats such as grasslands and vernal pools require a different structural approach.

• **Successional stage:** Early-successional "pioneer" species may be important for quickly establishing vegetation in disturbed areas, while later-successional species help achieve mature habitat structure over time.

Importance of Hyperlocal Plant Sourcing

Projects should prioritize locally sourced native plant material. Plants from nearby populations are often better adapted to local soils, climate conditions, and ecological pressures and help maintain the genetic integrity of native populations. Using local seed sources also reduces the risk of



California Poppy (*Eschscholzia californica*), California's state flower and an important native pollinator plant. Photo by Jon Rebman.

introducing plants that are not native to the area[86]. Community involvement can support local seed collection efforts. For example, volunteers may assist with collecting seed from locally occurring wildflower populations, such as California Poppy (*Eschscholzia californica*) and lupine species (*Lupinus* spp.), for use in restoration projects.

Climate-resilient designs may incorporate drought-tolerant, salt-tolerant, and fire-adapted species, but these should still be sourced from appropriate local populations whenever possible. Selecting plants for future resilience does not mean simply choosing the most tolerant species available. The goal is to maintain ecological integrity by supporting native species that are adapted to local conditions and can continue providing habitat functions under changing climate conditions[54].

Matching Plants to Microhabitats

Even within the same habitat type, conditions can vary significantly across a site[54]. Species should be placed where they naturally occur and where they are most likely to persist under future environmental conditions. For example, San Diego Marsh-Elder (*Iva hayesiana*) is naturally associated with canyon bottoms, riparian areas, and wetter microhabitats.



San Diego Marsh Elder (*Iva hayesiana*), a native shrub associated with coastal wetlands and marsh margins. Photo by Jon Rebman.

Planting this species on dry slopes or outside its natural range may reduce establishment success, particularly during prolonged drought conditions, and may not provide wildlife benefits if the species that rely on it are not present in those locations. Similarly, Narrowleaf Milkweed (*Asclepias fascicularis*), an essential host plant for the Western Monarch Butterfly (*Danaus plexippus*), is unlikely to persist on exposed, dry slopes and is better suited to lower canyon areas.



Narrowleaf Milkweed (*Asclepias fascicularis*), a native milkweed that supports monarch butterflies. Photo by Jon Rebman.



Western Monarch Butterfly (*Danaus plexippus*) caterpillar, the larval stage of this declining migratory pollinator on the narrowleaf milkweed (*Asclepias fascicularis*). Photo by Neal Kramer · Copyright © 2007 Neal Kramer.

Additionally, planting milkweed close to the coast may hinder monarch conservation efforts. In naturally occurring inland areas of San Diego, native milkweed will go dormant in the winter, which encourages monarch butterflies to migrate. However, if planted too close to the coast (e.g., within five miles), the plants are unlikely to go dormant when they should, which can disrupt monarch migration patterns and decrease the survival rate of the caterpillars[87]. Coastal projects can instead prioritize nectar-producing plants that support adult butterflies and limit milkweed placement to appropriate inland breeding areas.

Planting decisions should also consider interactions among closely related species. For example, White Sage (*Salvia apiana*) and Black Sage (*Salvia mellifera*) typically occupy slightly different microhabitats in natural ecosystems.

When planted together outside their natural distributions, they may hybridize and potentially alter local genetic patterns[54]. When possible, restoration should avoid creating conditions that encourage unnecessary hybridization between closely related native species.



White Sage (*Salvia apiana*), a native shrub characteristic of coastal sage scrub communities. Photo by Jon Rebman.



Black Sage (*Salvia mellifera*), a dominant shrub within coastal sage scrub ecosystems. Photo by Jon Rebman.

Cultural and Community Considerations

Plant selection should also recognize that plants have ecological, cultural, and social meanings that vary among communities. Species names, traditional uses, and relationships with plants differ across cultures, and no single interpretation applies universally[88,89]. For example, many southwestern indigenous groups used different parts of California Buckwheat, *Eriogonum fasciculatum*, for a variety of medicinal purposes. Engaging local communities and incorporating diverse knowledge systems can strengthen restoration planning and ensure that NbS projects reflect both ecological and community values as intended.

Resources for Plant Identification and Selection

Several resources exist to support accurate plant identification, restoration planning, and appropriate species selection:

- The California Native Plant Society, Calscape, and Xerces Society provide information on native plant species, distributions, conservation status, and plant selection recommendations that support pollinators and other biodiversity.

- The California Invasive Plant Council supports identification and management of invasive plant species, including information on invasive plant distributions, ecological impacts, best management practices, and species prioritization for restoration projects.

- Local botanical surveys, habitat assessments, and herbarium records (such as from the Checklist of the Vascular Plants of San Diego County, the San Diego County Plant Atlas website, and the CCH2 Portal) can help identify appropriate reference conditions and locally adapted plant material.

Ultimately, plant selection is not simply a matter of choosing native species from a list. Effective NbS projects require understanding the ecological relationships that shape plant communities and also how humans will use and impact the site continuously over time[54].



Phase 3: Implementation and Long-Term Stewardship

Site Preparation and Timing

As project leaders move toward the implementation stage, site preparation becomes the predominant focus. Thoroughly preparing a site helps ensure that restoration activities occur safely, efficiently, and with minimal impacts to sensitive habitats and species. Common activities include designing native plant palettes, planning equipment and crew access routes, identifying staging areas, and flagging environmentally sensitive areas or exclusion zones. More complex projects may require feasibility studies, engineering review, or agency safety office approval, particularly when public access or infrastructure are involved. Determining a realistic project size and timeline helps ensure that implementation activities remain feasible over time.

Site preparation should account for seasonal and ecological patterns that influence both project success and environmental compliance. Rainfall, storm cycles, drought conditions, and extreme heat periods can all impact restoration outcomes, site accessibility, and public safety. In coastal environments, understanding tide cycles is imperative for scheduling field activities, which may need to occur during low tides. Planning on-the-ground work outside of sensitive periods, such as breeding seasons, migration periods, and flowering windows can reduce impacts to wildlife and minimize permitting constraints. For example, least tern nesting season in San Diego typically occurs between April through August, which limits restoration opportunities near nesting habitat (site monitoring and assessment activities can be prioritized during these times instead)[29,53,54].



Flagging used to mark survey locations and sensitive resources during rare plant surveys and restoration planning. Photo by Frances Lang.



Two California Least Terns (*Sternula antillarum browni*) on coastal nesting habitat. Photo by Barbara Swanson.

Similar constraints apply for other types of wildlife, which can occasionally create situations where avoiding impacts to one species may overlap with seasonal restrictions for another. These considerations reinforce the importance of establishing clear project goals and maintaining coordination with biologists, permitting agencies, and land managers throughout project implementation.

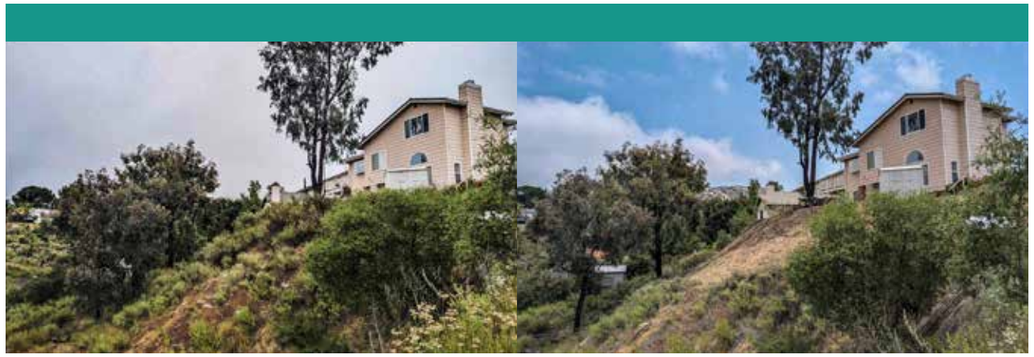
Seasonal conditions should likewise inform planting schedules. Installing native plants during the rainy season from fall through spring can increase survival, support root establishment, and reduce the need for supplemental irrigation90. Implementing planting activities in phases can also yield numerous benefits. Rather than disturbing an entire site at once, phased planting can maintain refuge areas for wildlife, improve erosion control, and allow lessons learned during early implementation to inform subsequent phases. Site preparation should also extend beyond native plant installation to include the steps necessary for successful establishment. Early maintenance is often one of the strongest predictors of long-term restoration success and can substantially reduce plant mortality[29,53,54].

A clear maintenance plan should identify partner responsibilities, schedules, and resources for irrigation, weed control, replacement planting, and routine inspections. Project teams should minimize the use of plastic-based materials whenever practical and develop a plan for the timely removal of temporary installation materials to prevent them from becoming litter or degrading habitat quality. Planting flags, nursery containers, protective tubes, shims, temporary fencing, and other construction materials should be collected and properly disposed of once they are no longer needed. Removal schedules should be incorporated into project planning and post-installation inspections. Project timelines should also include flexibility to accommodate regulatory and community feedback, evolving partner needs, unforeseen site conditions, and climate-related disruptions such as storms, flooding, or prolonged drought.

Community Action and Neighborhood Participation

As with other parts of NbS project implementation, community involvement and neighborhood participation can be extremely complex, yet imperative to success[23,29,53]. Creating opportunities for outdoor learning, community science, interpretive signage, and volunteer stewardship helps build a sense of ownership while increasing awareness of climate risk as well as the potential value of restored sites. Community members who understand the purpose and benefits of restoration are more likely to support ongoing management efforts.

Public programs benefit from clearly defined roles, expectations, and field behavior guidelines. Participants should receive basic training to protect sensitive habitats during restoration and maintenance activities, including staying within designated work areas, cleaning equipment and field gear to reduce the spread of invasive species, and safely performing restoration tasks. For example, volunteers conducting litter cleanups should be trained to recognize native vegetation and avoid trampling plants or disturbing wildlife. Established training protocols can also be used to teach participants how to collect observational data and make valuable contributions to site monitoring. Tools such as iNaturalist can be used to document plant and wildlife



San Diego County home before and after defensible space treatment. Photo from Fire Safe Council of San Diego County.

occurrences, and CoastSnap enables community members to photograph shorelines to help track coastal change and sea level rise over time.

Community science can help address important biodiversity data gaps by complementing technical monitoring conducted by restoration practitioners and scientists. Across the 19 urban canyons surveyed in San Diego through the Healthy Canyons Initiative, researchers documented thousands of new plant and wildlife records, demonstrating that many urban natural areas remain incompletely characterized. Community science observations can help identify remnant populations, document opportunities for recruitment from surrounding habitats, and establish ecological baselines that inform future monitoring and adaptive management[45].

Neighborhood stewardship extends beyond organized volunteer events and includes everyday actions by adjacent residents and property owners. In fact, management practices along the urban edge can substantially influence restoration outcomes. Reducing excessive nighttime lighting and noise, keeping pets out of sensitive areas, minimizing bird strike hazards, and using native landscaping can all improve habitat quality and support ecosystem resilience[53,54]. The City of San Diego's Landscape Standards prohibit several highly invasive plant species including Pampas Grass (*Cortaderia selloana*) and Castor Bean (*Ricinus communis*) from certain areas and require their eradication where they occur. In sites adjacent to sensitive habitats, including canyons and other open spaces, the city emphasizes the use of native plants to reduce the risk of invasive species spreading into natural areas[91].

As restoration succeeds, residents may encounter native wildlife that is sometimes misunderstood, such as rodents, snakes, and other species that naturally occupy healthy ecosystems. Community education can help promote safe coexistence, including practical measures such as discouraging rodent attractants in surrounding yards and installing appropriate snake exclusion fencing where necessary. Residents can also contribute to restoration efforts by partnering with local institutions to host camera traps or acoustic recorders on their properties, helping monitor wildlife activity and improve understanding of habitat connectivity[54].

Projects located within the Wildland-Urban Interface require additional emphasis on wildfire resilience. NbS project planning should consider defensible space, fuel management, and emergency access in addition to ecosystem function. Tree maintenance also plays an important role in reducing wildfire risk. Regular removal of dead limbs, pruning to reduce ladder fuels, and maintaining healthy, structurally sound trees can improve fire resilience without removing mature native trees that provide valuable wildlife habitat. Project leaders should coordinate closely with fire agencies, land managers, and property owners to ensure that habitat restoration, tree maintenance, and brush management practices are compatible with local fire regulations. Because wildfire regulations, defensible space recommendations, and building codes are periodically updated, project leaders should consult the California Department of Forestry and Fire Protection (CAL FIRE), regional Fire Safe Councils, Firewise communities, or local fire departments for the most current regulatory requirements and guidance. NbS project leaders should incorporate this information into community outreach and education efforts to help residents understand how wildfire preparedness and habitat conservation can be achieved together[37].

Monitoring and Adaptive Management

Adaptive management approaches are essential throughout all phases of project planning and implementation, and NbS projects are not complete when implementation ends. Long-term success depends on sustained monitoring, maintenance, and a willingness to adapt as conditions change. Establishing a clear plan for monitoring and adaptive management helps ensure that project investments continue to provide ecological and community benefits into the future.

NbS projects benefit from clearly defined roles, responsibilities, and funding sources for post-implementation activities. Identifying who is responsible for collecting data, evaluating results, maintaining infrastructure, managing vegetation, and implementing corrective actions helps prevent gaps in stewardship after initial restoration activities are complete. Because ecological outcomes often take years to fully emerge, monitoring and maintenance should be viewed as essential components of the project rather than optional follow-up activities.

Monitoring programs should establish measurable success criteria that directly reflect the original project objectives. To accurately evaluate project effectiveness, pre-project baseline mapping should use the same protocols that will be applied during post-project monitoring to ensure that results are directly comparable over time. Increasing native biodiversity is often one of the most meaningful and easily communicated measures of success, providing a useful indicator of overall ecosystem recovery. Other metrics may include native plant survival, vegetation cover, invasive species abundance, wildlife or community use, or other project-specific indicators. Monitoring should also consider ecological conditions beyond the immediate project footprint, including surrounding habitat that may influence overall resilience (e.g., a 1,500-foot buffer area). Whenever appropriate, monitoring protocols should be coordinated with the SDMMP to promote consistency across projects and contribute to regional datasets. For MSCP covered species, project leaders must ensure that all applicable Conditions of Coverage are addressed as part of their monitoring objectives.

Monitoring should also include identifying issues that require immediate attention. Irrigation failures, erosion, or the appearance of invasive species can often be corrected if detected quickly. Early detection and rapid response are particularly important for highly invasive plants, which are significantly easier and less costly to eradicate before they become established. Successful

Table 3 – Monitoring Metrics

Project Goal	What to Monitor	Example Indicators	Recommended Methods	Suggested Frequency	Adaptive Management Response
Healthy native vegetation	Plant establishment and condition	Survival of installed plants, canopy cover, evidence of natural recruitment, plant vigor	Permanent vegetation plots, photo points, GPS mapping	Quarterly during first year, then annually	Replace failed plantings, adjust irrigation, modify species selection or planting methods
Invasive species control	Invasive plant abundance	Percent cover, density, new infestations, invasive seedlings emerging from the seed bank	Field surveys, GPS mapping, drone or aerial imagery (where appropriate)	Seasonal (especially after winter rains)	Rapid removal of new infestations; modify treatment methods if invasives continue to spread
Biodiversity	Wildlife and plant response	Native species richness, presence of focal species, pollinator activity, habitat structure	Biological surveys, camera traps, acoustic monitoring, iNaturalist/ community science observations	Annually or seasonally, depending on target species	Modify habitat features, planting palette, or maintenance practices if objectives are not being met
Erosion mitigation	Soil stability	New erosion features, exposed roots, sediment movement, slope stability, dune morphology (where applicable)	Photo monitoring, erosion pins, drone imagery, field inspections following storms	After major storm events and annually	Install additional erosion-control measures or revegetate unstable areas
Community access	Human use patterns	Informal trails, trampling, litter, vandalism, unauthorized access, condition of interpretive signage	Field inspections, visitor observations, community reporting, surveys	Quarterly or after major volunteer events	Improve fencing, signage, trail design, or outreach to reduce impacts
Evaluate overall project success	Progress toward project objectives	Achievement of goals established during project planning	Compare monitoring results against baseline conditions and project objectives	Every 3-5 years	Update restoration strategies, maintenance plans, and future project phases through adaptive management

restoration requires a long-term commitment to invasive plant management. In some cases, three to five years of consistent treatment is needed to sufficiently reduce the seed bank and prevent reinfestation. Likewise, many restoration projects require irrigation for at least five years to support successful establishment of native vegetation. Ongoing maintenance should also address vandalism, damaged materials, and other disturbances, as neglected sites can quickly become reinvaded by invasive species and ultimately perform worse than conditions prior to restoration.

Adaptive management recognizes that restoration is an ongoing learning process rather than a fixed sequence of actions. Project teams should design management plans with enough flexibility to respond to changing environmental conditions, evolving community needs, new scientific information, or unexpected outcomes. Project outcomes should be evaluated at regular intervals (e.g., twice per year) and used to refine maintenance practices, adjust restoration techniques, or inform future phases of implementation. Additionally, project teams should establish clear pathways for data sharing and reporting. Sharing outcomes with regional conservation partnerships, community members, land managers, and habitat monitoring programs strengthens collective understanding of restoration effectiveness, supports future planning efforts, and helps build a more collaborative network of NbS practitioners across San Diego County.

Conclusion

NbS are most effective when they are approached as an integrated process that connects site design, local priorities, ecological conditions, and long-term stewardship. The decisions made during the earliest stages of planning can influence project feasibility, community support, permitting pathways, and future maintenance requirements, making thoughtful preparation essential to success. Lasting outcomes also depend on strong coordination among technical experts, community partners, land managers, and regional monitoring efforts, with resources such as The Nat's Conservation Planning Hub helping to strengthen collaboration and share knowledge across projects.

While comprehensive planning, funding, and data can strengthen restoration efforts, waiting for perfect information or ideal conditions can delay meaningful progress. Project leaders should be prepared to make informed decisions using the best available science and local knowledge and adapt as new information emerges. Even modest, strategic actions, such as removing invasive vegetation, protecting existing habitat, or improving site stewardship, can produce substantial benefits and create momentum for larger projects over time.

These recommendations are intended to support an equity-first approach to NbS that is practical, informed, and responsive to the unique ecological and community context of each project. By embracing adaptive management, learning from diverse perspectives and lived experience, and engaging communities early and often, NbS practitioners can help create healthier landscapes, more resilient communities, and a legacy of stewardship for generations of San Diegans to come.



Appendices

Appendix A

Biodiversity-focused Site Selection Methodology

1. Project Boundary Delineation

The first step in any geospatial site selection process is to define a project boundary that reflects the goals of the project while aligning with recognizable landscape features whenever possible.

Project boundaries may be based on ecological, jurisdictional, watershed, or community planning objectives. Whenever feasible, boundaries should follow recognizable physical or infrastructure features rather than arbitrary polygons, creating an analysis area that better reflects real-world landscape conditions.

Examples of boundary features include:

- Coastlines or shorelines
- Watershed boundaries
- Major roadways or highways
- Rivers or creek corridors
- Municipal or jurisdictional boundaries
- Conservation planning boundaries
- Buffers surrounding priority project areas

2. Identification of Undeveloped and Underutilized Land

To identify and screen potential Nature-based Solutions opportunities within the project boundary, project teams can combine high-resolution satellite imagery with land cover and impervious surface datasets.

- National Land Cover Database (NLCD) Fractional Impervious Surface data are particularly useful because they classify land based on the proportion of impervious (paved or built) surface within 30-meter pixels. This layer is effective for identifying small or fragmented green spaces embedded within developed landscapes.
- One example symbology is shown below:
- **0–1% impervious surface:** Entirely natural surfaces
- **2–19% impervious surface:** Predominantly natural or semi-natural cover
- **20–49% impervious surface:** Mixed natural and developed land

This graduated symbology emphasizes areas with substantial natural or semi-natural cover while also highlighting mixed-use or lightly developed parcels that may represent opportunities for restoration, habitat enhancement, or expansion of public access.

Additional datasets commonly used during this stage include:

- Recent aerial imagery (e.g., NAIP)
- Digital Elevation Models (DEMs)
- Existing vegetation or habitat maps
- Hydrology datasets
- Existing protected lands
- Local planning layers

Together, these datasets provide an initial inventory of candidate restoration opportunities for further evaluation.

3. Preliminary Site Screening and Digitization

Areas identified through land cover analysis should be manually reviewed to assess their preliminary suitability for Nature-based Solutions implementation. At this early stage, feasibility should focus primarily on identifying restoration opportunities and potential public access rather than detailed design, ownership, or regulatory constraints.

Key screening criteria may include:

- Presence of possible access from a public street or right-of-way
- Existing native habitat or opportunities for habitat restoration
- Opportunities to improve habitat connectivity
- Potential for public access or recreation
- Areas lacking existing management or restoration
- Existing degradation, invasive species, erosion, or other restoration needs

Existing parks, preserves, or open spaces should not automatically be excluded from consideration, as many may present meaningful opportunities for habitat enhancement, restoration, improved public access, or expansion into adjacent undeveloped land.

Each qualifying area can be digitized manually as a polygon in GIS software (e.g., ArcGIS Pro) and stored as a candidate project site.

For each site, it is useful to record:

- Site name
- Preliminary habitat type
- Potential access points
- Existing site conditions
- Restoration opportunities
- Constraints or notable observations

This step produces an inventory of candidate sites for further ecological and feasibility analysis.

4. Parcel Overlay and Ownership Assessment

To better understand land ownership and refine feasibility assessments, candidate site polygons should be overlaid with parcel datasets containing ownership information. Parcel data are available through many local and regional agencies and can help distinguish publicly owned lands from privately owned properties requiring additional coordination.

Using spatial selection tools (e.g., Select By Location in ArcGIS Pro), parcels intersecting each candidate site can be identified and reviewed individually to determine existing land use and ownership.

Parcels may be categorized as follows:

- Publicly owned vacant or undeveloped parcels: High-priority candidates that may present opportunities for restoration, habitat enhancement, or expanded public access.
- Privately owned vacant or undeveloped parcels: Potential candidates that may require partnership, acquisition, easements, negotiated access, or other coordination prior to implementation.

Ownership screening helps distinguish near-term opportunities from longer-term or more complex projects. Depending on project objectives, additional considerations may include existing conservation easements, land management authority, zoning, utility corridors, and other regulatory or operational constraints.

5. Integration of Conservation Considerations

To incorporate ecological value into the site selection process, project teams should evaluate biodiversity using species occurrence data, habitat information, and regional conservation priorities.

Species occurrence data may be obtained from sources such as the Global Biodiversity Information Facility (GBIF), iNaturalist, museum collections, local biological inventories, or other regional datasets. The ArcGIS Living Atlas Download Species Occurrence Points (GBIF) geoprocessing tool provides one example of an efficient method for retrieving georeferenced observations from GBIF, including research-grade iNaturalist observations, museum records, and academic datasets.

Species occurrence queries should be limited to spatial and temporal parameters appropriate for the project. For example, project teams may limit observations to the project boundary and recent decades to better represent current conditions.

To ensure consistency and avoid data gaps, GBIF records may be queried at the species level, as community science observations do not always reliably distinguish between subspecies. In cases where subspecies distinctions are important, occurrence records should be reviewed individually, considering record location, habitat associations, known subspecies distributions, and available photographic evidence.

Focal Special-Status Species

Project teams should identify focal species that represent the habitats, restoration objectives, or conservation priorities relevant to the project area. Rather than serving solely as target species, these organisms can function as indicators of habitat quality and ecological condition.

For example, projects occurring within coastal sage scrub may evaluate species closely associated with that habitat, while dune restoration projects may focus on dune-dependent plants and wildlife. Similarly, riparian, wetland, or marsh restoration projects may prioritize species indicative of those ecosystems.

The occurrence of focal species within candidate sites can help identify areas that already support high-quality habitat or present important opportunities for habitat protection and restoration.

Habitat-indicator Species

Certain species are closely associated with specific habitat types and can serve as indicators of habitat integrity.

For example, species strongly associated with coastal sage scrub, cactus scrub, riparian woodland, salt marsh, or dune systems may indicate relatively intact habitat capable of supporting broader ecological communities. Likewise, the absence of these species from otherwise suitable habitat may suggest degradation or fragmentation that could benefit from restoration.

Project teams should select habitat indicator species that best reflect local ecological conditions and project objectives.

Regional Conservation Priorities

Regional conservation planning documents and habitat conservation plans provide valuable context for biodiversity assessments.

Where available, project teams should consider evaluating species covered under regional conservation programs or other locally available conservation initiatives. These datasets can help identify opportunities to complement existing conservation efforts while supporting landscape-scale habitat connectivity.

6. Compiling Site Information

Using candidate site polygons, parcel information, habitat data, and biodiversity observations, project teams should compile a standardized set of site attributes to support comparison among candidate sites.

Examples of commonly recorded attributes include:

General Site Information

- Site name
- Site acreage
- Existing land use
- Habitat type
- Project type
- Existing site conditions
- Site notes

Biodiversity

- Presence of focal species
- List of documented special-status species
- Presence of habitat indicator species
- Other documented species of conservation interest
- Vegetation communities
- Habitat connectivity

Feasibility

- Public access opportunities
- Existing access constraints
- Vacant or undeveloped parcels
- Public versus private ownership
- Existing management authority
- Opportunities for restoration or enhancement

Acreage values may be calculated directly from candidate site polygons using GIS geometry tools. Habitat classifications should represent a generalized description of the dominant ecological conditions present at each site.

Examples include:

- Coastal sage scrub
- Chaparral
- Cactus scrub
- Riparian
- Creek corridor
- Salt marsh
- Dune habitat
- Grassland
- Disturbed or weedy habitat
- Managed landscape
- Turf or recreational fields

Similarly, project type should reflect the primary restoration opportunity represented by the site.

Example project types include:

- Habitat Creation: Areas where native habitat is absent or highly degraded, presenting opportunities for invasive species removal, revegetation, or large-scale habitat establishment.
- Habitat Enhancement: Areas where native habitat is already present but may benefit from invasive species management, supplemental planting, erosion control, or other actions that improve habitat quality and ecological function.
- Habitat Protection: Areas supporting relatively intact habitat where management focuses on long-term protection, stewardship, or preventing future degradation.
- Public Access Improvements: Areas where habitat is largely intact but opportunities exist to improve community access through trail development, viewpoints, interpretive infrastructure, or other low-impact recreational improvements.



Community Survey Resources
Canvassing with The Nat

Best Practices

A key strategy for reaching the public in specific areas (adjacent to canyons) is to distribute paper flyers directly to homes. Although the response rate is often low, this technique reaches members of the public in our target areas who may not be our usual participants/members. Below are some tips for staying safe and moving efficiently through a neighborhood.

Before Going Out in the Field:

1. Be prepared to work outside (hat, walking shoes, layers, sunscreen, water, snacks, backpack, etc.).
2. Wear a branded shirt and/or name tag clearly showing your affiliation with the museum.
3. Wear a brightly colored safety vest (provided).
4. Bring business cards for yourself or your supervisor.
5. Accessible volunteer/staff phone list. Know who to contact if you have questions/difficulties.
6. Determine where you are going and what route you will be taking (this may be assigned by your supervisor). Bring a pencil/pen to track your route.
7. Check the weather before you go. Reschedule if it's raining.

Flyer Distribution:

1. Work in pairs. Each person can distribute to one side of the street, making sure to stay in sight of each other.
2. Everyone should have a cell phone (minimum one cell phone per pair).
3. Track your route on the map, marking where you have walked as you traverse the route. It may be helpful to pin your starting location.
4. Do not ring doorbells.
5. Flyers can be left on doorsteps or porches. Place one edge of the flyer under a doormat to keep it from blowing away. Do not open gates to enter a yard, leave a rolled-up flyer on the gate/fence.
6. Do not leave flyers if a "No Trespassing" or "No Soliciting" sign is posted.
7. Avoid dogs (another good reason to never open a gate).
8. If the residents are in the yard or someone is on the street, smile and introduce yourself. Aim for friendly, brief encounters. Be sure to begin by letting folks know you are from the San Diego Natural History Museum, so they know you're not soliciting for donations/business/politics. In-person encounters are one of the best ways to recruit.
9. Never approach a house that makes you feel uncomfortable.

Community Survey Resources
Canyons Survey Canvassing

Main Talking Points

- The Nat invites adults in San Diego to take part in a brief research survey about community values and needs around local urban greenspaces.
- Your responses will help generate data that guide future greenspace activities based on community needs.
- The survey is voluntary.
- It will take 10–20 minutes.
- Your answers are anonymous.

More in-depth objectives of survey (if asked):

- The San Diego Natural History Museum (SDNHM) has several ongoing initiatives focused on fostering deeper connections between local communities and these urban greenspaces and understanding how to improve these greenspaces for wildlife and people.
- The objective of this survey is to better understand perceptions, concerns, barriers to access, and needs of communities in San Diego related to their local urban greenspaces.
- The findings are intended to inform ongoing and future projects at SDNHM as well as broader countywide initiatives.

Main talking points about Manzanita Canyon Project from Canyonlands (if asked):

Using state-provided grant funds, Manzanita Canyon is being restored to reestablish natural stream functions and enhance wildlife habitat.

- Some project goals include: (1) Build drought- and flood-tolerant canyons, (2) Improve stormwater management and water quality, (3) Preserve public access and trail compatibility, (4) Restore native plants and wildlife habitat, (5) Protect urban infrastructure.
- You can expect occasional construction noise and temporary changes to walking paths. These activities support long-term benefits, including the planting of native trees and shrubs and lasting improvements to the creek and overall neighborhood environment.

Appendix B
Canyons Survey

This survey will ask questions about your experience, thoughts, and opinions about the canyon greenspaces in San Diego. We are interested in all residents' opinions!

We ask that only adults (18 or older) complete the survey. Please only fill it out one time.

All responses are anonymous. We will not be able to associate a response with your name, email address, or other identifying information.

Participation is your choice. You can skip any questions you prefer not to answer.

Questions? Contact our team at mthompson@sdnhm.org.

Survey Questions

1. What is your current zip code?

_____

Many of San Diego's natural greenspaces (open areas with natural vegetation) are canyons.

For the purposes of this survey, when we refer to a canyon, we are only referring to canyon greenspaces.

2. Is there a canyon greenspace within a 10-minute walk of your home?

- ☐ Yes
- ☐ No
- ☐ I'm not sure

If you answered yes to the previous question:

3. Do you know where to go if you want to access the canyon greenspace nearest to your home?

- ☐ Yes, the canyon has public access, and I know exactly how to get in
- ☐ Yes, the canyon has public access, and I think I know how to get in
- ☐ No, the canyon has public access, but I don't know how to get in
- ☐ The canyon near me is not open or easily navigable by the public
- ☐ The canyon near me is on private property, so I cannot get in

4. How often do you visit or travel through local canyons?

- ☐ Once a week or more
- ☐ Monthly
- ☐ A few times a year
- ☐ About once a year
- ☐ Once every few years
- ☐ It's been a long time
- ☐ I've never been in a local canyon

5. How beneficial do you feel it is to live near a canyon?

- ☐ Not at all beneficial
- ☐ A little beneficial
- ☐ Somewhat beneficial
- ☐ Very beneficial
- ☐ Extremely beneficial

You can skip this next question if you have never visited a canyon:

6. Thinking about yourself and your family, which of these are reasons you like to visit canyons in the area?

[check all that apply to you]

- ☐ Recreation (walking, biking, dog walking, running)
- ☐ Spending time with family or friends
- ☐ Physical or mental health benefits
- ☐ Being in nature; spotting wildlife or plants
- ☐ No cost to visit
- ☐ Useful route or shortcut to get from place to place
- ☐ Being outdoors; getting fresh air
- ☐ Cultural connection to specific places
- ☐ Some other reason:

_____

7. I think it is important that San Diego's canyons...

	Strongly disagree	Slightly disagree	Slightly agree	Strongly agree	No opinion
Have lots of different plants and animals living there					
Provide opportunities for people to access greenspaces					
Are easy to get into and walk around					
Help teach people (especially kids) about nature					

8. To what extent do you think San Diego's canyons contribute to...

	Not at all	A little	Somewhat	Very much	Extremely
Reducing flooding					
Increasing fire risk					
Improving air quality					
Reducing urban heat					

9. How much is each of the following a barrier or concern that keeps you from visiting local canyons?

	Not a barrier	Slight barrier	Major barrier
Poorly maintained areas			
Accessibility due to mobility or related issues			
Concerns about personal safety			
Don't know how to enter			
Lack of restrooms, shade, and/or seating			
Exposure to plants and wildlife			
Cost (e.g., parking and entrance fees)			
Feeling unwelcome or unsure if access is allowed			

10. If you could make changes to improve San Diego's canyons, what would they be?

The San Diego Natural History Museum is working with communities, scientists, and officials on plans to restore local canyons and dunes.

Are you interested in learning more about joining a team to help develop a restoration plan?

▯ Yes ▯ No

Thank you for taking the time to complete this survey!

Appendix C

Example Site Assessment & Monitoring Survey

The following survey provides an example of a generalized field data collection form that can be adapted to support a wide range of Nature-based Solutions projects. Standardized surveys help ensure that restoration outcomes are documented consistently.

Project Information

Project Name:

Project ID (optional):

Survey Date:

Start Time:

End Time:

Observer(s):

Organization:

Site Information

Site Name:

Survey Location (GPS or Map):

Habitat Type

▯ Coastal Dune

▯ Coastal Sage Scrub

▯ Riparian

▯ Wetland

▯ Grassland

▯ Chaparral

▯ Forest/Woodland

▯ Other: _____

Site Conditions

Overall Site Condition

▯ Excellent

▯ Good

▯ Fair

▯ Poor

Dominant Vegetation Community:

Evidence of Disturbance

▯ None

▯ Invasive Species

▯ Erosion

▯ Trash

▯ Unauthorized Trails

▯ Fire Damage

▯ Flood Damage

▯ Grazing

▯ Other

Vegetation Assessment

Estimated Native Vegetation Cover (%):

Estimated Non-native Vegetation Cover (%):

Dominant Native Species:

Dominant Invasive Species:

Evidence of Natural Recruitment?

☐ Yes ☐ No

If yes, describe:

Special-status Species Observed?

☐ Yes ☐ No

If yes:

Species:

Location:

Behavior:

Habitat Features

Present?

☐ Standing Water

☐ Nesting Habitat

☐ Burrows

☐ Rock Outcrops

☐ Dead Wood

☐ Pollinator Resources

☐ Wildlife Corridors

☐ Sensitive Plant Populations

Other:

Wildlife Observations

Species Observed

Species	Number	Notes

Restoration Monitoring

Native plant survival (%):

Estimated invasive cover (%):

Signs of erosion?

☐ None

☐ Minor

☐ Moderate

☐ Severe

Infrastructure functioning as intended?

☐ Yes ☐ No

Maintenance Needed?

☐ None

☐ Minor

☐ Moderate

☐ Major

Describe:

Photo Documentation

Photo 1

Photo 2

Photo 3

Photo 4

Location

GPS Coordinates OR Map Attachment:

Additional Comments

Follow-up Recommendations

☐ Continue monitoring

☐ Invasive species treatment

☐ Supplemental planting

☐ Repair erosion control

☐ Improve public access

☐ Additional biological surveys

☐ No action needed

Other:

Appendix D

Sample Plant Palettes: Lost and Rare Plants

The following species are examples of rare or lost native plants that meet one or more of the following criteria: (1) taxonomic issues, (2) exist in historic specimen collections but have not been documented recently, or (3) species that are becoming extremely rare in our region. These species are associated with San Diego County's coastal dune or canyon ecosystems, which often warrant special consideration during restoration planning. While some of these species may be protected at the state or federal level, not all species on the list are. Project managers should consider the specialized habitat requirements, limited distributions, and sensitivities of the plants listed. Because these species are susceptible to habitat disturbance, their presence should be considered a valuable indicator of ecosystem health. Identifying and protecting these species can help support long-term ecosystem function.

Coastal dunes

Aphyllon parishii subsp. *brachylobum* (Orobanchaceae) Beach/Short-Lobe Broom-Rape, *Astragalus tener* var. *titi* (Fabaceae) Coastal Dune Milkvetch, *Calystegia soldanella* (Convolvulaceae) Seashore Morning-Glory, *Chaenactis glabriuscula* var. *orcuttiana* (Asteraceae) Orcutt's Pincushion, *Lupinus pallidus* (Fabaceae) Baja California Sand Lupine, N*emacaulis denudata* var. *gracilis* (Polygonaceae) Slender Woolly-Heads



Dune Milkvetch (*Astragalus tener* var. *titi*), an extremely rare native legume associated with coastal habitats. Photo by Jon Rebman.

Canyons

Aphyllon parishii subsp. *parishii* (Orobanchaceae) Parish's Broom-Rape , *Fritillaria biflora* var. *biflora* (Liliaceae) Chocolate Lily, *Leptosyne californica* (Asteraceae) California Coreopsis, *Mahonia* aff. *pinnata* (Berberidaceae) Shiny-Leaf Barberry, *Physalis* aff. *greenei* (Solanaceae) Greene's Ground-Cherry, *Sphenopholis interrupta* subsp. *californica* (Poaceae) Baja California Oatgrass.

Glossary

1. Adaptive Management
A structured, iterative approach to management that uses monitoring results and new information to evaluate project performance and adjust actions over time.

2. Baseline Conditions
The ecological, physical, and social characteristics of a site before project implementation. Baseline conditions provide the reference point for project design, monitoring, and evaluating project success.

3. Beach Nourishment
The placement of compatible sand on beaches to reduce erosion, increase recreational beach width, and improve coastal resilience.

4. Biosecurity
Measures that prevent the introduction, spread, or establishment of invasive species, pests, pathogens, or other biological threats that could negatively affect native ecosystems.

5. Capacity-building
Developing the knowledge, skills, partnerships, and resources needed by organizations and communities to effectively plan and implement projects.

6. Climate Adaptation
Actions that help ecosystems and communities prepare for and respond to current or anticipated climate impacts, including extreme heat, wildfire, flooding, drought, and sea level rise.

7. Coastal Resilience
The ability of coastal ecosystems and communities to prepare for, withstand, and recover from hazards such as sea level rise, erosion, flooding, and extreme weather.

8. Conservation Planning
A science-based process for identifying, prioritizing, and managing lands or waters to enhance ecosystem function and support long-term resilience.

9. Ecosystem Services
The benefits people receive from healthy ecosystems, including flood reduction, water filtration, recreation, and improvements to human health and well-being.

10. Habitat Restoration
The process of improving degraded ecosystems by reestablishing ecological processes and habitat conditions that support healthy natural communities.

11. Indigenous Fire Stewardship
The intentional use of cultural burning and other traditional land stewardship practices by Indigenous communities to meet cultural objectives, maintain ecosystem health, and reduce wildfire risk.

12. Nature-based Solutions (NbS)
Actions that protect, restore, or sustainably manage natural and working landscapes to address societal challenges while providing benefits for biodiversity, climate resilience, and human well-being.

13. Taxonomy
The scientific classification and identification of organisms. Accurate taxonomy is essential for documenting biodiversity, identifying species of conservation concern, and restoration planning.

14. Urban Infrastructure
Human-built features within developed areas including roads, buildings, stormwater systems, utilities, and transportation networks.

15. Wildland-Urban Interface (WUI)
The area where human development meets wildland (or natural vegetation), creating unique challenges for wildfire risk, land management, emergency response, and restoration planning.

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