PATHWAYS TO 30X30 CALIFORNIA

Appendix D

CONSERVING CALIFORNIA:
ADVANCING SCIENCE IN SUPPORT OF 30X30

AN APPENDIX TO THE *PATHWAYS TO 30X30 STRATEGY DOCUMENT* DEVELOPED BY THE CALIFORNIA BIODIVERSITY NETWORK

APRIL 22, 2022

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Executive Summary

The California Biodiversity Network (CBN) is composed of academic institutions, NGOs, government agencies, and private entities with expertise in conservation science and practice. This report serves as an appendix to California's Pathways to 30x30 Strategy, outlining research and information priorities that will advance California's 30x30 key objectives: biodiversity conservation, access to nature, and climate resilience. The report was compiled by the CBN Steering Committee with extensive input from more than 400 participants in four topical Roundtables and an Equity Forum.

The goal of this report is threefold: (1) to highlight research priorities that can translate into actionable science needed to ensure the success of 30x30; (2) to guide investments by philanthropic foundations and agencies that will enhance conservation planning and effective stewardship to advance biodiversity conservation; and (3) to lay the foundation for enhanced cooperation and collaboration across public, private, and tribal organizations in support of conservation and stewardship.

We provide this guidance with the recognition that since time immemorial, Indigenous peoples have upheld traditional responsibilities to steward the lands and waters of their homelands. The CBN respects and honors the relationships, knowledge, and traditions that connect Indigenous peoples to their homelands, and the essential role of tribal and equitable partnerships shaping the future of conservation and stewardship in California.

Biodiversity comprises all aspects of ecosystems and communities of species, including the genetics, physical characteristics, and behavior of plants, animals, and microbes, their distributions in space and time, and their interactions with each other and their abiotic environment. From the coast to the mountains, valleys, and deserts, California is known as a biodiversity hot spot. Biodiversity knowledge is captured in a wide range of physical and digital resources, including natural history museums, academic research, public agency records, and community science projects. The Department of Fish and Wildlife hosts essential biodiversity databases and other resources which have been integrated into the CA Nature tool, which supports 30x30 conservation planning.

California is recognized for its history of conservation successes, including excellent local, regional, and state parks systems and outstanding units of the US National Park Service. In the time since European colonization, economic development, agriculture, and urbanization have led to extensive land use change and loss of natural habitats and biodiversity. These threats are now exacerbated by the increasing pace of climate change, which is impacting all ecosystems across the state. Many unique habitats, plants, and animals remain under threat. California's commitment to 30x30 provides a unique opportunity to enhance conservation while improving access for all Californians and advancing nature-based solutions that improve resilience in the face of climate change.

The research recommendations in this report are organized under five headers:

Equity Forum: Successful implementation of the California 30x30 initiative will hinge on a deeper understanding, acknowledgement, and actions to address historical injustice and issues of social equity. Research recommendations address four key topics:

- The importance of access to nature for human health and quality of life
- Restitution for historical displacement, redlining, forced removal, and other loss of lands and associated cultural values
- Approaches to reduce displacement arising from establishment of parks and ecological restoration (i.e., "green gentrification")
- Questions about how to diversify the professional and public contributions to conservation, incorporate traditional ecological knowledge, and ensure that knowledge contributed by diverse communities leverages multiple benefits resulting from conservation and restoration actions.

Systematic Conservation Planning Roundtable: Implementing the California 30x30 initiative will require conservation planning strategies that guide resource investments to the highest priority areas for biodiversity conservation and restoration, climate resilience, and ecosystem carbon storage, and that increase equitable access to open space. Research recommendations in support of these goals focus on three overarching topics:

- Improving mapping of conservation lands and establishing conservation objectives and targets based on best available biodiversity data and established conservation planning principles
- Evaluating existing planning efforts, partnerships, and networks to improve implementation plans for 30x30 efforts
- Developing tools and training to ensure that a wide range of users can access decision-support resources and incorporate new information as it becomes available to enhance conservation planning and implementation

Biodiversity Informatics and Community Science Roundtable: Biodiversity priorities outlined in California's Pathways to 30x30 strategy document depend on biodiversity data and informatics—data on which plants, animals, and ecosystems are found where, and the ability to interpret and share those data to support strategic conservation planning. Research priorities to enhance this knowledge and its availability to inform conservation planning fall under five topics:

- Capturing data about newly discovered and poorly characterized biodiversity
- Enhancing and expanding species occurrence and observation data
- Integrating landscape-level environmental and biodiversity data
- Expanding community science programs to scale observational data and improve integration with other data
- Advancing data synthesis and modeling

Biodiversity-Climate Sentinel Site Network Roundtable: Sentinel Sites are conserved areas where in-depth data are gathered and the resulting analyses are used to inform programs and policies affecting larger geographic areas and partners. Building a statewide network of climate-biodiversity Sentinel Sites provides

an opportunity to apply a sustained, standardized measurement strategy linking climate and biodiversity over time. California has an array of field stations and reserves that provide the opportunity to build an exceptional Sentinel Site network. Priorities to advance this goal fall under four headings:

- Building the social and institutional network
- Standardizing field data collection and management across the Sentinel Site Network
- Designing a representative station network for the state
- Generating metrics for conservation and opportunities for engagement

Stewardship Roundtable: Success of the 30x30 initiative requires a commitment to stewardship and community engagement across the diversity of California's landscapes. Approaches to stewardship should maintain and enhance natural processes (e.g., water cycles, fire regimes, food webs) to advance ecosystem resilience and adaptation to changes, allowing biological diversity to persist and form new associations over time, and support human health, access, and enjoyment in an equitable and just manner. Research recommendations to enhance stewardship in California fall under eight themes:

- Education, workforce training and community-centered stewardship
- Open space in urban areas and increasing access for Indigenous communities
- Restoration, healthy soils, and regenerative ecosystems
- Freshwater conservation
- Fire, fuels, and forest management
- Invasive species
- Ecocultural species studies
- Planning and policy research

Conclusion

Advancing biodiversity knowledge and the scientific foundations of conservation planning, stewardship, and long-term environmental monitoring is essential for successful implementation of the California 30x30 initiative. The CBN Roundtables and Equity Forum will continue to provide a forum for collaboration in support of collective action, and CBN will serve as a key contributor to California's 30x30 Partnership. Advancing the three goals of biodiversity conservation, climate resilience, and access to nature, with a commitment to equitable participation in decision making, can establish California as a model for successful implementation of the global commitment to 30x30.

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Introduction

The California Biodiversity Network (CBN) developed this Appendix to provide an overview of existing science supporting statewide conservation efforts in California and to summarize critical research and information gaps that need to be filled to guide the overall success of 30x30 goals and objectives moving forward.

The CBN is composed of academic institutions, NGOs, government agencies, and private entities with expertise in conservation science and practice. The Network Steering Committee has organized four Roundtables tasked with the following themes: Systematic Conservation Planning, Biodiversity Informatics and Community Science, Climate-Biodiversity Sentinel Sites, and Stewardship. An Equity Forum was organized to surface priorities related to equity and inclusion in participation, decision making, and implementation. The CBN will be a key member of California's 30x30 Partnership supporting CNRA's implementation of the California 30x30 initiative.

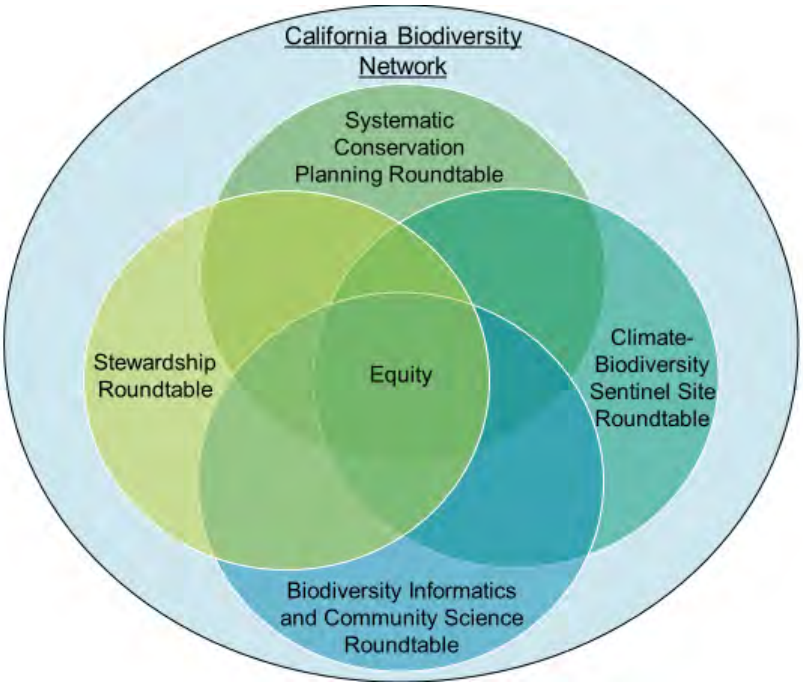

Fig. 1. Organization of the California Biodiversity Network. The network is overseen by a Steering Committee, which includes the chairs of the Roundtables.

In alignment with a global movement to conserve the world's biodiversity, California's 30x30 initiative aims to conserve 30% of California's land and coastal waters by 2030. California has committed to advancing three objectives: protecting California's unique and rich biodiversity, enhancing access to nature for all Californians, and advancing nature-based solutions that increase resilience for nature and people in the face of climate change.

Acknowledging that conservation decision making, and the benefits of conservation itself, have historically been concentrated in relatively small sectors of society, California seeks a fundamental change in approach that is inclusive and equitable and includes strong partnerships with California's Native American community. Success for 30x30 requires a deeper and more meaningful investment in understanding the disparity in access to natural spaces by communities of color for their multiple benefits including cultural practices, community fabric, and physical/mental health. Historical practices of displacement, redlining, and forced removal and current programs that result in gentrification and displacement require research, analysis, and identification of successful new models of design and implementation based on the best research, data, and public engagement.

This appendix focuses on research and information needs in the social and natural sciences to advance these objectives. Our emphasis is on climate-smart biodiversity, conservation and stewardship of terrestrial, freshwater, estuarine, and coastal ecosystems. We identify key linkages to equity and access to frame nature-based solutions that cut across CBN focus areas. For open water marine conservation science priorities, we point readers to the work of the Ocean Protection Council conducted in support of 30x30 (Pathways to 30x30 Appendix E).

Information needs, syntheses and research priorities identified in this report were developed through a process of stakeholder engagement that included a survey distributed to CBN's network of scientific and stewardship representatives and five subsequent Roundtable and Equity Forum workshops held between October 2021 and February 2022. As of February 2022, more than 400 participants have provided survey input, engaged in Roundtable workshops, or contributed to the review process informing this Appendix.

In this Appendix, the Steering Committee presents priorities identified by the diverse participants engaged in the CBN Roundtables and workshops. The following sections consist of a synthesis of highlighted topics organized by Roundtable focus areas and a detailed list of recommended research, planning, and implementation actions supporting these priority topics.

This Appendix and the recommended actions serve three purposes. First, they provide students, researchers, agency scientists, and others with priority research projects for actionable science needed to ensure the success of 30x30. Second, they offer a guide to philanthropic foundations and agencies for investing in conservation planning, data collection and mobilization, and research on effective stewardship that can advance biodiversity conservation in a period of rapid change. And lastly, they lay the foundation for enhanced cooperation and collaboration across public, private, and tribal organizations for knowledge integration, synthesis, and application of the best available science in support of conservation and stewardship.

We provide this guidance with the recognition that since time immemorial, Indigenous peoples in what is now known as California have upheld traditional responsibilities to steward the lands and waters through kinship systems and reciprocity and remain committed to the stewardship of their homelands. This

stewardship has shaped the genetic, species, and ecological diversity that is found in California today.

The CBN respects and honors the relationships, knowledge, and traditions that connect Indigenous peoples to their homelands, and acknowledges that the colonial practices, exclusions, erasures, and barriers to stewardship—including forced removal from their lands of many Indigenous peoples in this state—has hindered their conservation actions, resulting in many of the issues we are tackling today and with this document. Recognizing the inherent relationship between biodiversity and Indigenous cultures, we seek to embrace ecocultural equality as a central tenet of biodiversity conservation and stewardship.

Our Current Knowledgebase

Collecting and Interpreting Biodiversity Data

Existing biodiversity information is derived from many sources, including field surveys, long-term population studies, physical and digital collections, species locations observations and records, remote sensing, genetic sequences, and associated abiotic and ecological data. These data can span many ecological scales, from the individual to the species, community, and ecosystems. Different types of data are suited to addressing different questions. Here we describe specific strengths and limitations of different data types for guiding conservation planning, including the realization of goals outlined in the Pathways to 30x30 strategy document.

Biodiversity data spans all aspects of species distributions in space and time, the physical and genetic characteristics of organisms, and their interactions with the biotic and abiotic environment. Conservation planning uses observed occurrences and modeled suitability to construct species, natural community, and vegetation system data which are commonly derived from the following data classes:

- Specimen-based data on species occurrences in space and time accompanied by a physical record, often housed in museums, usable for further types of diversity data collection such as genomic information and phenotypic traits.
- Sampling of entire communities using bulk samples of organisms in a given area (e.g., of arthropods or soil organisms) or eDNA (from flowers, leaves, soil, water, etc.)
- Field observations, including biotic surveys, wildlife tracking, photographs, and sound recordings. These data types are massively scalable through community science.
- Remotely sensed data using light, laser, radar, electrical resistivity or other sensors, based on ground, drone, airborne, or satellite platforms, to map land

cover, vegetation, and species distributions and measure aspects of land and water condition.

- Functional, demographic, and life history data, including responses to experimental perturbations, that assist in projection of current and future distributions, and species responses to land use, global change, and other disturbances.
- Synthetic or model-derived data, especially models of current and projected species distributions based on occurrence data and associated environmental data "covariates" (indicators of suitable climate and/or viable habitat).

These data types each have various strengths and challenges. Taken together they are important to assess how biodiversity varies across multiple ecological and spatial scales and how this variation can be integrated to inform conservation planning. Scales of biodiversity variability that need to be considered include:

- Genetic variation within and among populations – critical for considering evolutionary potential and constraints, populations at risk of extinction, potential for species range shifts, etc.
- Species richness, community composition, structure, and dynamics across sites – important for understanding biodiversity patterns and differential responses of species to environmental change, guiding conservation of habitats, ecosystems, and communities of interacting species, etc.
- Habitat distributions and ecosystem structure and function across landscapes – critical for conserving wildlife habitat, understanding relative vulnerability of systems in relation to land use change, disturbance, and climate change, and supporting climate resilience and contributions of natural and working lands to climate solutions.

Accompanying biophysical and land use data, including topography, soils, lithology, subsurface hydrology, grazing history, fire history, agricultural and residential development, etc. are important for interpreting biodiversity patterns, guiding large landscape conservation, planning for climate change impacts, assessing impacts of large disturbances, planning for climate resilience, and the deployment of nature-based solutions.

The California Department of Fish and Wildlife maintains an array of biodiversity resources and databases listed below, which informs conservation planning by California's Natural Resource Agency. These materials are now integrated into the new CA Nature tool designed to support the 30x30 planning process.

Available state-supported resources include:

- Biogeographic Information and Observation System (BIOS)
- CA Natural Diversity Database (CNDDB)
- Areas of Conservation Emphasis (ACE)
- California Wildlife Habitat Relationships (CWHR)
- Vegetation Classification and Mapping Program (VegCAMP)

- Landscape Conservation Planning resources (CDFW Planning)
- Threatened and Endangered Species List (CESA)
- California EcoAtlas
- California Aquatic Resource Inventory (CARI)

Biodiversity occurrences and observations are captured in the resources above, as well as databases maintained by museums, academic research units, NGOs, community science organizations, local and federal agencies, and aggregated global portals (e.g., GBIF). Occurrence and observation databases and vegetation community data also inform species range models and inferences, special status designations, and species richness estimates as used in the ACE tool (e.g., to identify areas of greatest diversity, etc.). Integration of additional data from BIOS into the ACE data system is needed to leverage the full catalog, notably for freshwater, marine, and plant biodiversity.

Biodiversity data are central to conservation planning: one of the biggest present challenges is that only a small portion of data collected by diverse agencies and individuals are aggregated into statewide databases. So, while California possesses one of the world's most sophisticated knowledge bases for conservation, significant opportunities remain to integrate other existing data sources and collect new data to fill major gaps, particularly around population status and trends that could provide early warnings on potential extinction hazards.

The CBN's recommendations for augmenting datasets and developing explicit tools to leverage existing and emerging datasets are discussed further below.

Climate-Smart Conservation and Stewardship

Successful conservation investments in the 21st century must now anticipate the potential impacts of climate change as part of framing "climate-smart" conservation and stewardship strategies. The US National Park Service has introduced and embraced the Resist-Accept-Direct (RAD) framework to develop management strategies in the face of climate change. While this framework has not been formally adopted as part of California's 30x30 initiative, it provides a valuable starting point for discussions about conservation objectives and actions. The research recommendations provided throughout this document are designed to support decision making in the face of dynamic changes underway in the state's natural ecosystems.

California's plan to conserve 30 percent of its lands and coastal waters by 2030 requires a shared understanding of and commitment to the complex, science-based, and community-driven practices of stewardship, as they are expressed across the diversity of California's landscapes. Stewardship of biodiversity should maintain and enhance natural processes (e.g., water cycles, fire regimes, food webs) to enhance ecosystem resilience, allow biological diversity to persist and form new associations over time, and support human health, access, and enjoyment in an equitable and just manner. Indigenous stewardship combined with western science offers a way to enhance natural processes and promotes productive, sustainable, resilient, and just social-ecological systems.

In a recent review, McLaughlin et al.[1] provide an up-to-date summary of conservation and management strategies addressing the impacts of climate change. The most frequent recommendations in the literature in the past decade are protection and restoration of ecosystem function, enhanced connectivity, management for climate refugia, mitigation of non-climate threats, enhanced monitoring, assisted migration, cross-scale management, and management for genetic or phenotypic diversity, followed by a descending list of other actions. Importantly, many of these recommendations address immediate threats as well as long-term climate change impacts, offering "no-regrets" options for current action.

Shifts in suitable habitat due to climate change and related effects may cause species to persist in only small fractions of their original range, and/or expand into previously unoccupied areas. Areas buffered from climate change impacts may represent important *in situ* refugia, at least in the short term. Understanding how species' functional and demographic characteristics interact with climate change and other disturbances to influence potential range shifts is a critical priority. Changes in geographic distribution may require a reconsideration of what it means for a species to be considered native in a particular location, and what it means to be exotic or invasive.

Topographic heterogeneity is a key factor that can enhance the potential for local species' persistence, as it enables small-scale movements for some species to provide access to suitable microclimates retained within their current range. On the other hand, some areas such as groundwater dependent ecosystems, cool coastal climates, and higher mountain elevations may be especially important as refugia for species that need to move out of their current range to survive. These locations could become *ex situ* refugia, where protection now is critical to conserve suitable habitat for displaced species in the future.

Successful conservation of California's water-limited Mediterranean-climate ecosystems in the context of projected increases in aridity will be enhanced by science and data collection at the watershed scale. Particular attention should be given to hydrologic connectivity and understanding environmental flows from headwaters to estuaries. It is also critical to identify key river corridors essential for fish and wildlife movement and that also serve as climate refugia for native species, many of which remain vitally important to tribal communities. Riverine ecological restoration research can help prioritize barriers to remove, reconnecting rivers to their floodplains, restoring hydrographs to promote native organisms, and restoring groundwater-surface water interactions.

In the context of climate change, effective approaches to conservation biology require even more interdisciplinary collaboration, including strong partnerships and collaborations with ecological, conservation, earth sciences, engineering, agricultural, forestry, and social science research communities. There is increasing recognition of the importance of social sciences to frame effective and equitable

[1] McLaughlin, B. C., Skikne, S. A., Beller, E., Blakey, R. V., Olliff-Yang, R. L., Morueta-Holme, N., Heller, N. E., Brown, B. J., Zavaleta, E. S. In revision. Conservation strategies for the climate crisis: an update on three decades of biodiversity management recommendations from science. Biological Conservation, 268: 109497

implementation strategies aimed at preventing habitat conversion in estuaries, grasslands, shrublands, desert vegetation, and woodlands of California in an era of rapid social and environmental change.

Academic, NGO, and agency researchers have conducted a wide array of systematic conservation studies in California, covering specific taxa, regions, or conservation targets. A partial listing can be found in a web table developed by CBN, and a variety of the regional regulatory plans (HCCPs, NCPs, etc.) can be found in the Pathways to 30x30 Appendix F.

Opportunities to Fill 30x30 Research and Knowledge Gaps

This section highlights key research and information priorities identified by CBN Roundtables to guide the implementation of California's 30x30 initiative. Roundtable participants contributed specific recommended actions, which are organized into focus areas under each topic. Additional information about the Roundtable events, participants, and workshop outcomes are available on the CBN website.

Equity Forum

Successful implementation of the California 30x30 initiative will hinge on a deeper understanding, acknowledgement, and actions to address equity, environmental justice, green gentrification, cultural practices, land loss, and Indigenous stewardship. Point Blue Conservation Science partnered with CBN to host an equity forum, which included the participation of representatives from academia, community-based organizations and other NGOs, governmental agencies, and land management practitioners from across California.

Three major themes were identified and explored by participants in a virtual forum: (1) the recognition that the lack of access to nature has direct impacts on health and life expectancy (2) that Indigenous people as well as other people of color have been subjected to displacement, redlining, and removal from their traditional and owned lands, often in the name of conservation and (3) that the mere action of creating parks in urban areas often results in the economic and demographic displacement of communities of color. An open discussion about other themes related to equity was also held, bringing forth additional recommendations for research, data analysis, and modeling.

A greater investment in research into the issues of equity, environmental justice, social and behavioral science, public health impacts and the correlation between historic conservation efforts and the impacts on people of color will inform the 30x30 decision makers and significantly improve the outcomes.

Human Health and Life Expectancy

Mental and physical health impacts from limited or no access to parks and open space results in diminished life expectancy. Summary research recommendations:

- Synthesize existing research to advance knowledge on the disproportionate decreases in life expectancy in communities of color with limited or no access to nature.
- Build new mapping data layers related to public health and equitable access.
- Map distributional inequities in variations to access to nature.
- Research systemic barriers to operationalizing equity in the conservation and environmental industries, including community-based organizations.
- Research state budget appropriation, allocation, and investment into issues around equity to seek performance metrics on outcomes.
- Model successful standards that leverage multiple benefits beyond typical education and language translations for equitable access to nature.
- Conduct research into cultural misconceptions about BIPOC and their relationship to nature and the outdoors.
- Examine new models to career pathways in the environmental industry for marginalized communities of color to resolve existing barriers and social injustice; for example, wildfire crews are drawn from California's incarcerated populations but are not eligible for the job once released.

Loss of Land and Control

Restitution for historical practices of displacement, redlining, and forced removal. Summary research recommendations:

- Research the historical progression of large-scale conservation in California to document land loss and displacement.
- Engage Indigenous people to map their traditional territories and lands.
- Research the current easement language used by land trusts for expansion to allow more Indigenous cultural practices.
- Study the necessary capacity building (legal, financial, technical management expertise, human resources, long-term sustainability) for Indigenous communities to take back lands.
- Study more effective models for conservation groups and land trusts that go beyond the standard DEI approach.
- Research barriers to Indigenous stewardship that are baked into conservation tools and institutional frameworks.
- Research Native land trusts (there are at least eight in CA) to learn about the opportunities and challenges they have encountered and how they are working through those.

Green Gentrification and Displacement

Displacement from park development and ecological restoration of open spaces. Summary research recommendations:

- Study a model as a requirement for the allocation of public subsidies for park development, preservation, and restoration of open space that prevents the displacement of communities of color in proximity to the site and embeds social equity outcomes.
- When planning investments to improve access to parks and other open space, invest research into who is using the existing access and who uses the access after improvement.
- Research how to prevent displacement and gentrification resulting from investment in waterway improvements.
- Research successful models of community engagement, with a specific focus on communities of color, in conservation, access and park design and develop a set of best practices.
- Research the most effective models of "technical assistance" often provided to communities that lack capacity to engage or lead conservation and access planning efforts.
- Test the hypothesis that open space signage in multiple languages increases park use by non-English speaking populations.
- Study effective and successful community engagement techniques for their ability to be used to train and educate local, state, federal and NGO organizations to be more effective.
- Research the reasons why awareness and concern for the environment by communities of color are not translating into greater diversity in environmental, conservation and natural resources workforce, including academia.
- Research effectiveness of various youth conservation programs in their long-term impact on career paths and workforce diversity.
- Research the "minimum critical funding" for new parks to be effectively maintained and managed to meet their conservation and access objectives.
- Research cultural and Indigenous use of plants that can be used to develop stewardship connections to parks and open space.

Open Forum

General discussion on other topical areas as defined by the participants. Summary research recommendations:

- Research how to diversify the science fields as well as the people conducting the science.
- Study better ways to integrate Traditional Ecological Knowledge (TEK) with western science.
- Study how to both generalize TEK and also incorporate distinct views from the different Californian Indigenous cultures.
- Identify successful models from around the world of integrating TEK with western science to achieve conservation outcomes.
- Study how "different ways of knowing" can affect restoration goals and outcomes.
- Research the negative results of restoration outcomes for lessons learned.

- Study how to better integrate demographic information into community science efforts.
- Make sure that community science data and results are reported back and available to the communities that provided input.
- Research the different health outcomes from variations on access to nature.
- Develop methodology to monitor and measure desired equity outcomes.
- Develop new models where human elements are incorporated into natural systems.

Systematic Conservation Planning Roundtable

Implementing 30x30 will require conservation planning strategies that guide resource investments to the highest priority areas for biodiversity conservation and restoration, climate resilience, and ecosystem carbon storage, and that increase equitable access to open space. Because the overall objectives of the Executive Order are ambitious and varied, it is critical that this conservation planning approach seeks synergies, and minimizes trade-offs, across objectives. For example, meeting the three major goals of the initiative (biodiversity conservation, equitable access, and nature-based solutions) will require planning tools that evaluate opportunities to meet multiple objectives. Developing an analytical toolset to support such a prioritization will take time with iterative updates based on participant feedback. This should happen in parallel with ongoing implementation. Building such tools is essential if 30x30 is to be implemented in a transparent, inclusive, and science-informed way.

Understanding how ecosystems have responded to historical land use, resource extraction, and non-anthropogenic stressors is foundational to developing models that can support decision making under future changes. Detecting and where possible, attributing, the response of biodiversity to historical changes is a critical and overlooked area of research. Integrating biodiversity, land ownership, and management data with models that represent major drivers of change (e.g., future development, climate impacts) can provide a solid foundation for ongoing implementation of California's 30x30 initiative. Data access and visualization tools (including CA Nature) that give users the ability to run scenarios and see how a proposed conservation action will contribute to regional and statewide targets will be essential and will enhance public stakeholder participation. Such functionality was critical to the Marine Life Protection Act stakeholder planning. For 30x30, additional socioeconomic, land tenure and management, bio-cultural, biodiversity and environmental data will need to be incorporated over the long term to identify opportunities that enhance multiple goals.

A priority-setting and adaptive management framework for the biodiversity objectives for 30x30 is represented in Figure 2. The approach is part of a sequential cycle as each step builds on the last. Overall, it is iterative and can be adaptive as new information emerges about biodiversity, threats, and conservation or restoration opportunities. It adapts the steps of the more formal systematic

conservation planning approach used commonly in academic conservation planning.

It is important to recognize that prioritizing the landscape for strategic implementation of 30x30 does not mean mapping an exclusive set of priority areas or activities. Planning can often be flexible about where to meet objectives especially for wide-ranging species and habitats. This section, and related specific recommendations listed in the final section, highlight key data sources and existing plans and studies that can inform all four steps in the framework. Notably, these steps also overlap with opportunities discussed in both the Stewardship and Sentinel Sites Roundtables.

While the key questions highlighted in each step in Figure 2 must be answered analytically with expertise from multiple scientific disciplines (e.g., conservation biology, landscape ecology, resource economics) using models built on the best available data, the process of conducting these steps requires input and interpretation from a range of stakeholders. Priority stakeholder perspectives include communities that have been historically excluded or disenfranchised from land conservation, those affected by proposed actions (or the lack of action), particularly communities most likely to experience impacts from environmental degradation and climate change. Integrating the perspectives of Indigenous Californians is especially important given the unique and complementary value of many aspects of traditional ecological knowledge.

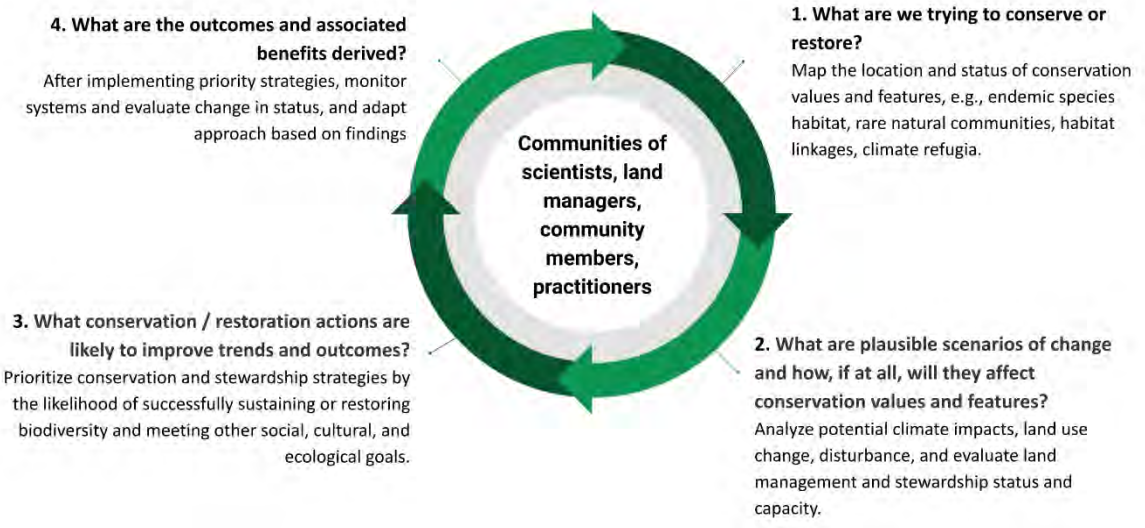

Figure 2. An iterative cycle to guide conservation planning and adaptive management for Climate-Biodiversity Resilience in California.

Recommendations provided in the final section focus on tools to strategically inform conservation planning and to collect supplementary data for evaluating the outcomes of 30x30 investments.

Clarify Primary Objectives
Establishing primary objectives of 30x30 efforts as distinct from secondary or collateral benefits will be necessary to design an efficient planning framework. Such objectives could be qualitative such as: "design connected public and private conservation lands networks that capture irreplaceable taxa and are representative of all ecosystem types" or they could have quantifiable targets of what types and amounts of biodiversity to prioritize. Such quantifiable metrics enable use of a variety of conservation tools for optimization and trade-off analysis to evaluate how well planned and implemented actions support 30x30 objectives.

Leverage Existing Efforts and Partnerships
Many successful land use and conservation planning efforts around the state have relied on local and regional partnerships and networks. Recommendations under this focus area will support leveraging past efforts and existing data, and designing inclusive, collaborative development of regionally specific conservation objectives.

Design with Flexibility to Incorporate New Information
Designing conservation planning approaches and tools that can incorporate new biodiversity science and data, strategic opportunities, and stressors will be critical for 30x30 implementation. Building on the foundation of ACE and other available data is critical for this effort. Yet, additional paths for priority data to be integrated in the CA Nature tool are needed, beyond those provided by the current ACE methodology. For example, data should be summarized in additional ways, not just by watershed or hexagon (e.g., wetlands or fine-scale habitat features). Also, assigning ordinal scores to represent relative priority value may not be suitable for different prioritization methods or across regional scales. Recommendations below pertaining to this focus area provide a roadmap for integrating existing and new data as it becomes available.

Specific Recommendations of the Systematic Conservation Planning Roundtable

Refine Conservation Lands Data and Establish Primary Objectives

- Refine the mapping of places that meet the definition of 30x30 Conservation Areas for California's initiative beyond lands that meet the USGS Gap status 1 and 2 definition, such as relevant conservation easements, protected working lands, and administratively protected land.
- Establish a systematic data base of areas that would fit the IUCN definition of "Other effective area-based conservation measures (OECM)". These will contribute to ecosystem function and biodiversity conservation and form a third class of area intermediate between protected and non-protected.
- Establish primary objectives and associated performance metrics for at least the biodiversity conservation portion of 30x30 planning. Where appropriate, develop regional conservation and restoration targets for species and communities based on levels of irreplaceability, endemism, phylogenetic metrics, level of representation in conserved lands, and risk of loss due to stressors.

Leverage Existing Efforts and Partnerships

- Evaluate existing voluntary partnerships and networks as possible convening bodies to develop regional 30x30 recommendations or implementation plans.
- Evaluate existing studies, plans, and assessments available publicly (see web table and those listed in Pathways to 30x30 Appendix F) for suitability and integrate into the CA Nature tool where appropriate. Develop a publicly accessible data management system to track and integrate existing conservation plans and analyses for inclusion in CA Nature.
- Convene a data and conservation planning stakeholder group to evaluate suitability of data and acquire and mobilize data from existing and emerging efforts for CA Nature using transparent criteria.

Incorporate New Information

- Specify an inclusive process in the design of decision support modules of CA Nature to elicit and incorporate input from stakeholders and experts (including from Sentinel Sites) about conservation planning, land management, and data analyses.
- Provide training and support for all users to be able to access and effectively use functions of CA Nature and other decision support tools.
- Develop tools that can adapt to changing conditions. Integrate Sentinel Site, remote sensing, and modeled data to enhance projections of relevant and plausible scenarios of future land use, biodiversity condition, or climate change.
- Apply existing research on the risk of loss or degradation of biodiversity due to the following drivers (at a minimum): invasive species, development, agricultural intensification, climate change effects, and disturbances.
- Track and incorporate ecological and species data outside of California state boundaries since climate change is shifting species ranges and vegetation biomes.

Biodiversity Informatics and Community Science Roundtable

Biodiversity priorities outlined in California's Pathways to 30x30 strategy document depend on biodiversity data and informatics—data on which plants, animals, fungi, microbes, and ecosystems occur where, and the ability to interpret and share those data to support the strategic conservation planning described above. New approaches to engaging community scientists in growing biodiversity data in every dimension provide an opportunity to use informatics to integrate across various biodiversity, land ownership and management data sources, along with threats or drivers of biodiversity change, to guide resource management and investment decisions.

As described in the Introduction, many data resources are currently available and incorporated into existing conservation planning frameworks to varying extents.

Many other resources exist but are not easily accessible or yet integrated into conservation planning. Still other types of data are within our grasp but need further investment to both collect and develop theoretical frameworks and methodologies for their strategic integration into conservation planning.

Here we describe how biodiversity informatics and community science can fill important information gaps to realize the successful implementation of 30x30 investments. In the final section, we recommend specific actions for each of the focus areas discussed here.

Capturing Data About Newly Discovered and Previously Uncharacterized Biodiversity

Setting conservation priorities relies on the ability to assess the distribution of biological diversity (including genetic, ecological, and species diversity) and to understand the composition of ecological communities and ecosystems in a landscape. Sometimes conservation planning uses ecosystems as coarse-filter surrogates where species diversity is poorly characterized. Therefore, an understanding of how species and ecological communities behave in these ecosystems and the patterns of diversity at different scales should be a priority for investigation. Recommended actions in this category focus on how to capture data on poorly characterized or understood taxonomic groups, ecosystem types, and ecological processes.

Enhancing and Expanding Species Occurrence and Observation Data

Even for known species, occurrence data remain broadly lacking across many taxa, habitats, localities, and through time. This is particularly important to identify natural communities and species most at risk. Species occurrence mapping and data capture should continue and be expanded. This could partially be addressed by integrating diverse data sources (e.g., museum collections, community science observations) and modernizing existing data systems and explicitly accounting for data collection methodology-specific biases. Recommendations under this category speak to strategic, collaborative approaches to closing these data gaps.

Landscape-Level Environmental and Biodiversity Data

We are poised to collect landscape-level data that will allow us to both infer existing biodiversity patterns and make projections of biodiversity change under varying scenarios of anthropogenic impacts and climate change. Leveraging remote sensing tools and analytical methods will be critical for these goals. The recommendations below under this topic speak to opportunities to build bridges across different ecological scales, to integrate evolutionary considerations, and to inform large landscape conservation strategies.

Community Science Data

An increasingly large proportion of our knowledge on the distribution of biodiversity in California is the result of observations contributed through community science. More than 60% of all species occurrence records and six of the top ten datasets in the Global Biodiversity Information Facility (GBIF) are crowd-sourced from hundreds of thousands of volunteers (for example, eBird, iNaturalist). Supporting community

science is also a method for fostering connection to nature for California residents and visitors. Direct experiences in nature are vital for developing affinity for and emotional connection to the natural world. Biodiversity-focused community science provides an opportunity for participants to slow down, be curious, and engage with nature. Success in this effort requires a deeper and more meaningful investment in understanding the benefits of culturally competent, or better yet, humble, community science models that integrate California's demographical profile today and in the future. Social science research will enhance the value of Community Science programs and their contribution to the success of 30x30, as outlined below.

Data Synthesis and Modeling

The collection and dissemination of empirical data empowers researchers to create much needed synthetic or modeled distribution information, as in Species Distribution Models (SDMs). These synthetic data leverage empirical data to make inferences across data-poor areas and under future climate scenarios. Credible hypotheses that can fill in knowledge gaps can then help to direct scarce resources by pinpointing these areas for empirical data collection. This process creates an iterative and adaptive feedback loop of continuing knowledge acquisition. This priority is but one within the broader context of data synthesis across species, community, environmental, and genomic data types. The recommendation here is to partner with the Systematic Conservation Planning and Sentinel Site Roundtables to identify strategies to fill data gaps central to improving priority Species Distribution Models.

Specific Recommendations of the Biodiversity Informatics and Community Science Roundtable

Sample and Map Undiscovered and Uncharacterized Biodiversity

- Prioritize biodiversity surveys and research beyond threatened and endangered species to include:
    - Species that are lesser-known, cryptic, often overlooked, and critical to ecosystem health due to abundance or diversity, e.g., marine, freshwater, and soil invertebrates, insects, and other arthropods, as well as fungi and seaweed
    - Multi-species characterization of biodiversity in freshwater, brackish, and marine habitats
    - Migratory species
    - Taxa of ecocultural importance in underrepresented areas, such as the Central Valley, tribal lands, urban areas, and private lands
- Improve the availability of genetic and genomic datasets which can help reveal cryptic species diversity, community composition and structure, biological interactions, population level gene flow, genetic variation, and spatial genetic structure to inform conservation.
- Provide resources to tribes, scientists, and nonprofit organizations to conduct long-term biodiversity surveys and comprehensive genetic assessments, including through specimen collection.

- Partner with tribes on biodiversity collecting and conservation needs that honor their expertise and data sovereignty standards, policies, and conforming data management systems.
- Support specimen-based baseline surveys for lands acquired or restored with public funding (as land trusts often do for their acquisitions and easement monitoring).

Enhancing and Expanding Species Occurrence Data

- Compile a complete specimen-based occurrence map for all of California by investing in a Golden State All Taxa Biodiversity Initiative (ATBI) that is representative of regional differences across the state.
- Improve infrastructure available for scientists and nonprofit organizations to openly share data.
- Advance and expand biodiversity monitoring on private and public lands through targeted specimen collection efforts, bioblitzes, and community science campaigns.
- Support museums, universities, agencies, and others in digitizing specimens, democratizing occurrence datasets, and improve data availability through open access databases.
- Contribute resources, including staffing, to existing programs such as CNDDB to develop and modernize systems, improve efficiencies, and provide relevant, up-to-date information through timely data integration and user support.
- Continue to collect, calibrate, and assess "absence" data and maintain current "presence" data, by partnering with diverse stakeholders to best estimate uncertainty.
- Study federal and state permitting requirements for research and data collection as potential impediments to biodiversity conservation including facilitating access for data collection on government lands.
- Track changes in species and habitat distribution and abundance over time and potential causal factors.

Landscape-level Environmental and Biodiversity Data

- Complete a statewide fine-scale vegetation map for California to National Vegetation Classification System (NVCS) and Survey of California Vegetation (SCV) standards as described by VegCAMP and other federal/state vegetation data and programs (also endorsed by Stewardship Roundtable) to support conservation planning, land management, and species distribution modeling.
- Enhance the distribution and availability of vertebrate and invertebrate species data, community level data, including GPS, acoustic, eDNA, and camera trap data.
- Improve the availability of geomorphic data, including soil data.
- Systematically collect climate, environmental, and biodiversity data on, and model potential for, climate change refugia, including soil moisture modeling to address future increases in climatic water deficit.

- Inventory and regularly monitor biotic and environmental dynamics at multiple scales, including landscapes, to better understand correlates of biodiversity and change.
- Assess the effectiveness of current and potential remote sensing technology that can be used statewide to monitor climate effects on biodiversity.

Strengthening Community Science

- To improve and enhance the biodiversity information in CA Nature, support the meaningful integration of data from iNaturalist, eBird, and other sources, and support the institutions that run community science programs to engage people in the collection of these verifiable observational data.
- Use and support the continued development of quality assurance and quality control methods to address the spatial and temporal biases in community sourced data.
- Support the development of methods and systems to integrate community science data with specimen collection and other streams of data collection throughout the state.
- Study environmental and climate education and service effort outcomes, including community science, to identify best practices including cultural humility and long-term engagement of volunteers.
- Support continued social science and human dimensions research on the influence of community science on the participants and investigate and encourage use of outcomes to improve data quality and increase levels of engagement, especially of BIPOC communities (also endorsed by the Stewardship Roundtable).
- Encourage participatory research through improved usability of existing mobile and online applications for crowd-sourced data acquisition.
- Use and work to improve statistical approaches to weight contributed data based on estimates of reliability to better use community science data for species distributions and conservation research.
- Use community science to help land management agencies balance the demand for recreation with stewardship goals.

Data Synthesis and Modeling

- Support and expand innovative data compilation, analyses, and modeling that integrate many sources of species occurrence and observation data to build Species Distribution Models and other synthetic data products.

Climate-Biodiversity Sentinel Site Roundtable

Building a statewide network of climate-biodiversity Sentinel Sites provides an opportunity to apply a sustained, standardized measurement strategy linking climate and biodiversity over time. Sentinel Sites are conserved areas from which in-depth data are gathered and the resulting analyses are used to inform programs and policies affecting a larger geographic area and partners. They consist of a variety

of field stations situated on public and private reserve lands dedicated to long-term environmental, climatic, and biological data collection. Data collected include intensive (high-frequency, multivariate) long-term measurements. Ideally, Sentinel Sites represent the full range of ecosystems subjected to a shared set of stressors such as climate change, habitat decline, isolation, fragmentation, or pollution. The first step will be to aggregate existing data to establish "a baseline" against which ecological change may be measured at a variety of scales.

For example, NOAA has launched a Sentinel Site network in our nation's estuaries to monitor the impacts of sea level rise using a consistent approach to facilitate accurate tracking for multiple local applications and comparison across regions. With significant planning, it is also possible to utilize Sentinel Site data to estimate the impact of threats or stressors including climate change, human disturbance, or alternatively, the benefits of stewardship and restoration, on biodiversity and other aspects of ecological condition. Here we explore the benefits of forging a multi-jurisdictional Sentinel Site network for California across terrestrial, freshwater aquatic/wetland, estuarine and near coastal habitats, and what it will take to get us there.

The proposed Sentinel Site Network will help address issues key to other Roundtables, including Systematic Conservation Planning, Informatics and Community Science, and Stewardship such as the following:

- Impacts of drought, fire, and hydrological variability on biodiversity and ecosystem services
- Regions or habitats where climate change is causing the greatest threat to biodiversity
- Regions or habitats where species are in decline or recovery
- Locations where acquisition and/or restoration activities will likely achieve the most effective results
- Species response to management/stewardship/restoration activities
- Habitat restoration and species recovery tracked against targeted conservation goals

Current members of the Climate-Biodiversity Sentinel Site Roundtable include but are not limited to the UC Natural Reserve System, CDFW Wildlife Areas and Ecological Reserves, Point Blue Conservation Science, The Nature Conservancy's Dangermond Preserve and the new Point Conception Institute, UC Santa Barbara's Regional Ecosystem Services Observation Network-RESON, Jasper Ridge Biological Preserve, CSU field stations and preserves, Pepperwood, the National Ecological Observation Network (NEON), Long Term Ecological Research (LTER) projects, and others. US National Parks in California have hosted a range of long-term research and are important partners moving forward.

Multi-disciplinary benefits of such a network identified by Roundtable members include the following:

- Standardizing measurements at the site scale to allow data comparisons and aggregation

- Supporting landscape-scale inferences via the ability to combine multiple standardized datasets
- Creating statewide opportunities for coupled *in situ* measurements of climate and biodiversity parameters
- Applying empirical data to response evaluation and trend forecasting
- Improving model forecasts of climate effects and other stressors on biodiversity
- Improving data management efficiency and expanded data access via utilization of shared platforms for analysis
- Creating a transparent process for evaluating indicators relevant to management and conservation investments

With recent advances in technology and a rekindled commitment to collaboration across jurisdictions, we can now envision and build a network that effectively fills biodiversity data gaps in the context of climate stressors and other covariates and integrates the knowledge and findings of diverse practitioners across the state of California into an aggregated whole.

While it is tempting to tackle spatial-sensor design challenges right away, the critical starting point is defining an inclusive multi-jurisdictional institutional framework for this effort under the umbrella of CBN and 30x30. Besides the scientific community, this institutional foundation needs to include decision makers (e.g., land managers, policymakers) to ensure desired outcomes are aligned with practical applications. Therefore, land managers and other decision makers are a critical part of the team throughout the process from start to finish.

Members of the California Biodiversity Network's Sentinel Site Roundtable are collaborating to realize this vision by creating a real-time observation network capable of responding to priority questions and filling data gaps that bridge disciplines and geographies, described in relevant section of the Priority Information and Research Directions that closes this document.

Related recommendations collectively define a process for building a Sentinel Site network to both plan and evaluate the outcomes of 30x30 investments. Specific recommended actions are summarized by theme below.

Building the Social And Institutional Network

Building the Sentinel Site network will entail securing convening resources to recruit a fully representative set of managers and researchers engaged at private, local, state, tribal, and federal field stations and other long-term monitoring sites to expand the map of current sites and refine needs for strategic additions of Sentinel Sites. Engagement of researchers, conservation practitioners, and community members will be essential for supporting the sensor network, developing network governance, and ensuring from the start that the design process incorporates a mechanism for translating data to relevant indicators for policymakers.

Standardizing Field Data Collection and Management Methods Across the Sentinel Site Network

To effectively integrate monitoring and research data across the Sentinel Site Network, recommendations under this focus area include optimizing remote sensing tools, leveraging automatic sensors for biological data collection, and effective and efficient data management, analysis, and integration for both physical and biological data.

Designing a Representative Station Network for the State

In the highly diverse ecosystems of California, determining the signal of a stressor like climate change against the noise of natural variability demands consistent, long-term datasets. Examples of these kinds of datasets are long-term Wildlife Picture Index monitoring programs (e.g., Pepperwood established a standardized dataset capturing the impact of megafires on wildlife that is now being applied regionally: this data collection commenced five years before the advent of megafire events, before there was a specific fire-related hypothesis to be tested). Our collective challenge today is thus to anticipate future data collection needs to better understand our contemporary period of rapid environmental change. Recommended actions summarized below lay out a sequential set of steps to build on the current network and fill information gaps based on habitats, climate space, development pressures, etc.

Generating Metrics for Conservation and Opportunities for Engagement

The California Climate-Biodiversity Sentinel Site Network Roundtable will work closely with the other CBN Roundtables, including Systematic Conservation Planning, Biodiversity Informatics and Community Science, and Stewardship to design a coordinated system for data collection, integration, and analysis. This empirical knowledge base can be designed to regularly update ACE and CA Nature to continually improve the quality and quantity of data relevant to the adaptive management of California's biodiversity.

Specific Recommendations of the Sentinel Site Roundtable

Building a Social and Institutional Network

- Build a multi-jurisdictional, statewide Sentinel Site monitoring network.
- Determine the key elements of a network including backbone organization, shared goals, and metrics of success.
- Determine what kinds of indicators can inform CA Nature and decision makers about enduring science questions, acquisition priorities, stewardship, regulatory actions, and more.

Standardizing Field Data Collection and Management

- Generate standardized climate and biodiversity measurement protocols for utilization at each Sentinel Site.
- Advance opportunities to leverage advances in automated biological data collection (cameras, acoustic, other) and remote sensing (multiple scales).

- Create metrics for tracking climate adaptation, stewardship, and connectivity objectives, initiatives, and project outcomes.
- Leverage existing (for example, UC's Dendra.Science, BIOS and CA Nature, Conservation International's Wildlife Insights) and create new data management platforms to efficiently curate and analyze climate and biodiversity data streams and research access.

Designing a Representative Station Network

- Enlarge the network with new members.
- Collectively determine priorities for siting new stations on the landscape.
- Develop informatics approaches that can be applied to scale results from sentinel sites to support adaptive conservation planning tools (ACE and others).
- Identify spatial gaps (e.g., habitat, climate type) not covered by the current Sentinel Site collaborative.

Generating Metrics for Conservation and Opportunities for Engagement

- Determine how Sentinel Site data can effectively serve as a real-time change detection/recovery tracking system, including early detection of extinction risk and novel invaders.
- Utilize data to adaptively manage stewardship strategies and measure stewardship outcomes.
- Determine how Sentinel Sites can attract more diverse research participants and benefit environmental justice communities.

Stewardship Roundtable

Stewardship comes in many forms and cuts across many cultural, geographic, and disciplinary boundaries. A multitude of perspectives, including those of historically marginalized groups (e.g., Native American, Black, Latinx, Asian, LGBTQIA+), can enhance our collective stewardship efforts for positive conservation outcomes. Multicultural leadership and approaches to stewardship will benefit California's diverse communities. Attention to societal diversity as a means to secure biodiversity, as well as access and climate resilience, requires more time and investment to build relationships than is typical in the design, funding cycles, and implementation of many projects. To advance broader social objectives, our efforts must uplift Indigenous leadership and people from historically marginalized backgrounds to advance community capacity and resilience.

Maintaining the significant ecological value of California's working lands requires attention to livelihoods that depend on these lands as well as support for conservation-focused stewardship. We need working lands to be biologically diverse, thereby maintaining habitat for some species while facilitating dispersal and climate change adaptation for others. Stewardship can help working lands be more resilient to extreme weather events, such as wildfire, floods, droughts, and pest and disease outbreaks (which are becoming more frequent with climate change) and is also necessary to ensure the production of food, forage, and timber is sustained over the

long run. Clear guidelines, certification opportunities, and land care community led movements are needed to consider working lands as working for conservation.

Here we first summarize key stewardship themes and then list priority actions to fill information gaps and advance stewardship science that were identified by researchers and practitioners. Sixty-seven participants completed our survey covering information from about 84 projects. Additionally, 38 Roundtable members were involved in online paired interviews, thematic and regional; and additional members of the Stewardship Roundtable provided input to the final recommendations. Participants represented all nine regions of California, worked in a diversity of landcover types, and were from a variety of backgrounds and organizations.

Key Stewardship Themes

Education, Workforce Training, and Community-Centered Stewardship

Advancing knowledge and building capacity to conduct the stewardship needed to protect California's ecosystems is challenging. To meet the challenge, we need to support land stewards, uplift opportunities for Indigenous leadership and employment, and engage the public in stewardship in an equitable way. The proposed actions will equip communities and support workforce training programs that can advance community-scale stewardship and ecological monitoring efforts, which will also create jobs and improve inclusivity across the environmental workplace.

Open Space in Urban Areas and Increasing Access for Indigenous Communities

The state's protected open space provides important opportunities for people to connect with nature which is vital for human well-being and stewardship. Increased access to open space for people living in the urban core and providing Indigenous people access to steward sacred places and ecocultural species are critical steps toward sovereignty and justice. Additional recommendations to advance research and science in this area can be found in the Equity Forum section of this report.

Restoration, Healthy Soils, and Moving Toward Regenerative Ecosystems

We must pursue innovative approaches to restoration, advancing ecosystem stewardship, and accelerating carbon sequestration. Adapting to climate change and the uncertainty it brings requires a shift from maintaining historical conditions toward restoring ecosystem processes, managing functional adaptation, and identifying pathways to resilience. This approach can begin with Resilience Action Planning exemplified by one constructed for Florida's coral reef, where climate change and other threats are addressed through interventions and restoration for ecosystem recovery. The proposed research agenda below is focused on measuring mapping and monitoring to enhance ecosystems and conserve soils (their biota and climate mitigation and resilience value) and offers ways to make this information available to advance the practice.

Freshwater Conservation
Freshwater is the lifeblood of Mediterranean-climate ecosystems, and stewardship is essential to maintain and recover natural flow regimes, riparian habitats, and permanent and seasonal wetlands. Actions that increase hydrologic connectivity to advance recharge and environmental flows may require the removal of non-functioning dams and other barriers and protection of natural sinks and floodplains. In uplands, sustaining vegetation mosaics and cover is key to protecting both temperature and discharge in drought-stressed rivers. Cultural burning practices across forest, shrub and wetland ecosystems can also support improved stream flow conditions.

Fire, Fuels, and Forest Management
Fire is a natural process and is a central tool that Indigenous Californians use to the advantage of many ecosystems and their own livelihoods. Traditional burning produces a variety of species and plant age classes that provide food, medicine, and materials. The disruption of traditional Indigenous burning practices has created vulnerabilities to many ecosystems. While for more than 100 years, US legal systems prevented Indigenous use of fire and regulated it almost out of existence, Indigenous stewardship is now recognized as a critical dimension of forest stewardship. A critical action is for Indigenous people who have traditional knowledge to be able to revitalize the use of fire today and share these approaches to enhance biodiversity, as well as a lower risk of loss of homes and livelihoods in our communities.

Invasive Species
Invasive species have transformed California's ecosystems, impacted agriculture productivity, and in many cases have become a permanent part of California's diversity and ecological dynamics. Invasive species management involves prevention, early detection, eradication, and control. Only through monitoring biodiversity is early detection of invasive species possible; and impact monitoring is needed to assess the effectiveness of eradication efforts, which often require ongoing stewardship to achieve long-term control.

Species and Ecocultural Studies
Information gaps on species and ecocultural taxa and their habitat needs limit our ability to conserve biodiversity across California. In addition to extending habitat protection for biodiverse woodlands, shrublands, and grasslands under 30x30, we need to pay particular attention to stewarding desert species that are highly vulnerable to climate change and face pressures from industrial-scale solar, recreation, and extraction.

Planning and Policy Research
Research on environmental policy, land use planning, and the consequences for biodiversity protection is needed to identify opportunities and barriers to conservation. Investigation opportunities and constraints on conservation and stewardship based on governance and economic factors need to receive the same level of attention as applied research in the natural sciences. This includes

opportunities for private landowners to formulate and implement landscape-scale conservation and coordinate stewardship across ownerships.

Specific Recommendations of the Stewardship Roundtable

Education, Workforce Training, and Community-Centered Stewardship

- Investigate barriers and opportunities to advance stewardship corps and workforce education programs for Indigenous communities and young adults from underserved communities as pathways to conservation science and stewardship jobs.
- Study outcomes of workforce programs for the participants' identity, self-efficacy, agency, and career paths.
- Research the history of local environmental and justice movements, including motivations to participate and what fosters long-term engagement.
- Study natural and climate friendly design, construction, and rehabilitation building materials including those with low embodied carbon and improve permitting to facilitate their use.
- Connect conservation scientists and practitioners so they can co-design research for adaptive management to bridge the gap between research and practice to improve stewardship.

Open Space in Urban Areas and Increasing Access for Indigenous Communities

- Examine opportunities for urban green spaces (e.g., open lots, cemeteries, playgrounds) to conserve biodiversity through diversified plantings and natural landscaping.
- Map cumulative recreation use on and off trails that have high visitation rates, with a focus on Habitat Conservation Plans (HCP), Natural Community Conservation Plans (NCCP), and other areas essential for endangered species protections; conduct complementary studies of impacts of recreation on these species and the ecosystems they rely on.
- Research recreation activity type and carrying capacity compatibility with biodiversity conservation objectives within specific habitat types.
- Study methods for augmenting urban biodiversity, improving landscape ecology, and reducing urban heat islands.
- Support social research on the local networks of practitioners and institutions that implement place-based stewardship.
- Map relative use of open spaces and areas where access to open space needs to be augmented to improve equity.
- Conduct research in partnership with local organizations to identify ways to improve access to open space for people of color and remove barriers and provide capacity for Indigenous people to access and steward ecocultural areas.

Additional recommendations to advance research and science in this area can be found in the Equity Forum section of this report.

Restoration, Healthy Soils, and Regenerative Ecosystems

- Develop a statewide interactive database and explorer mapping tool for restoration projects with performance metrics, information on restoration outcomes (including failures), and best practices by ecoregion and habitat type including information on priorities for assisted migration.
- Develop interactive explorer tools to choose species, tree densities, genetics, and other appropriate parameters to foster climate-resilient restoration outcomes.
- Develop standardized monitoring protocols for different ecosystem types, soil health (e.g., nitrogen deposition, below-ground diversity), and focal organisms to detect threats and stressors and enable comparison across sites.
- Track and examine impacts of plant species translocations and ways to simplify permitting for translocations and experiments needed to conserve listed species.
- Examine responses of native grasses and forbs to compost application in rangelands designed to improve carbon sequestration and moisture holding capacity.
- Investigate opportunities and barriers private landowners face to steward biodiversity and sequester carbon and recommend effective instruments to overcome implementation gaps.
- Identify areas that should be restored for overall watershed health in addition to high priority areas for protection.
- Support community monitoring for early detection of potential invasive species and diseases (i.e., new arrivals rapidly expanding their range); changes in flowering timing, seed set, and other lifecycle events in relation to environmental cues; community re-photography of historic photo points; and community supervision of monitoring instruments.
- Map areas suitable for livestock grazing into the future and examine alternative approaches to grazing for controlling invasive grasses and rangeland health in areas where livestock will no longer be economically viable.
- Measure carbon sequestration, soil moisture, and forage availability at sites converted from predominantly invasive grasses and forbs to a higher percent of native annuals and perennials.
- Measure and map levels of nitrogen deposition on California's ecosystems, a necessary step to protect native forbs.
- Measure and add estimates of soil health to soil maps related to below-ground diversity (faunal, bacterial, and fungal) to guide protection of these soils and restoration of degraded soils.
- Survey public attitudes toward restoration and provide best practices for building a common community vision for successful project implementation.
- Study historical ecology, including species accounts, focused on former wetlands to provide guidance for restoration.

Freshwater Conservation

- Examine ways to increase hydrologic connectivity to promote recharge and environmental flows (e.g., removal of non-functioning dams and barriers, protection of natural sinks and floodplains).
- Determine the flow requirements to prevent cyanobacterial overgrowths and other aquatic invasive species that impact waterways.
- Examine how lithology, vegetation, and land use affect groundwater recharge, surface flows, and erosion.
- Assess strategies to sustain vegetation mosaics and cover to protect temperature and discharge in rivers.
- Map and monitor surface and ground water levels to aid recovery of historic water sources in the desert.
- Develop daily surface flow models based on real-time surface water flows and integrate into a publicly available decision support tool.
- Examine how land management (e.g., cultural burning practices) across forest, shrub, and wetland ecosystems can improve stream flow conditions.
- Create an interactive explorer mapping tool with spatially explicit water budget information including stream flow across dry, average, and wet years, storage capacity for existing reservoirs, managed releases, and effects of water withdrawal and storage on downstream flow.
- Create an interactive tool to explore three-dimensional transient groundwater flow models and tools to help optimize recharge and plan groundwater use.
- Develop an interactive mapping tool with information on aquatic invasive species, pollutants, and their concentrations, including nutrients, pesticides, pharmaceuticals, and other chemical contaminants.
- Research stewardship needs for wetlands to retain below-ground carbon storage and reduce methane emissions.
- Study the chronology of rock pool animal communities and their associations with hydro-period and water temperature data.
- Synthesize research on retention of live and large wood in streams for habitat enhancement and extend this information to land stewards.
- Improve understanding of current and likely future fog patterns and how coastal microclimates and fog reliant communities respond to changes in fog timing and extent.
- Prioritize aquatic species conservation in relation to cultural subsistence, and to address equity and justice relative to Sustainable Groundwater Management Act (SGMA) implementation.
- Quantify how lithology, forest thinning and other vegetation management, and land use affect groundwater recharge, surface flows, and erosion—especially excessive loading of finer sediments into channels.
- Develop multi-variable metrics to identify where to develop new green infrastructure and access as sea level rise occurs along the coast and bays to adapt to sea level rise.
- Study watershed-scale restoration and conservation efforts that encompass entire river networks that rely on ecosystem management

including beaver reintroduction and other approaches to recover natural river processes across the catchment area.

Fire, Fuels, and Forest Management

- Monitor invasive species as well as threatened, endangered, and sensitive animal and plant species responses post-fire.
- Develop an interactive explorer mapping tool with fire history information and include atmospheric interactions into fire modeling to better predict fire behavior and its ecological effects in light of climate change.
- Improve documentation of Indigenous management of California ecosystems using fire and including Indigenous people in the management of these ecosystems.
- Assess health outcomes for human communities disproportionately impacted by smoke and other air quality impacts.
- Investigate differential impacts of fuel treatments on fire behavior under mild versus severe fire weather conditions.
- Examine the influence of the seasonal timing of controlled burns on biodiversity including species reproduction, movement, and the food web.
- Investigate how forest thinning influences microclimate, soil moisture, and future fire patterns.
- Study use of fire and grazing for post-fire management to prevent invasive species and community homogenization.
- Quantify and refine carbon sequestration and emissions associated with ecosystems where prescribed burning is a tool for stewardship.
- Study under what environmental conditions reforestation should be implemented after high-severity fire.
- Map habitat types vulnerable to global change, including catastrophic fire, that are underrepresented in existing conservation areas.

Additional recommendations to advance research and science in this area can be found in the Equity Forum section of this report.

Invasive Species

- Map and model locations of invasive species, including expert knowledge and community science efforts, including a focus on early detection of leading edges of invasion. This should include transportation corridors, underpasses, culverts, bridges, and waterways.
- Investigate invasive species biology including seed viability and response to control measures.
- Research disease interactions between non-native and native species (e.g., bees).
- Identify and prioritize opportunities to permanently eradicate invasive species from offshore islands, isolated freshwater bodies, and isolated mainland terrestrial populations.
- Identify a blacklist of invasive species to keep out of the state, preapprove effective tools to eradicate them, and an adequate funding source such that if found via early detection, they can be immediately eradicated.

Ecocultural Species Studies and Information

- Expand and streamline use of monitoring technologies statewide, such as ground-based sensors, eDNA, and community science efforts.
- Assess gaps in protection from habitat conversion and extend protections, particularly within woodlands, shrublands, and grasslands.
- Investigate long-term wildlife corridor efficacy and function.
- Map mitigation lands and identify ways to advance mitigation to contribute to protected lands networks and connectivity.
- Work with Indigenous knowledge-bearers, while honoring data sovereignty, to identify culturally important species and assess stewardship access by Indigenous people and threats by global change.
- Identify ways to prioritize protection of desert ecosystems as they face pressures from industrial-scale solar development, recreation, and extraction.
- Create maps of landforms to readily identify watershed features including urban areas and deserts.
- Survey biodiversity, carbon sequestration, and water regulation on working lands.
- Investigate stewardship activities that best support conservation goals.
- Monitor stewardship activities across conservation areas and their influence on community composition, carbon sequestration, hydrology/soil moisture, and food webs.
- Model habitat suitability under different climate scenarios at finer spatial scales that can be used to consider assisted migration and other stewardship options.
- Measure climate change effects on soil seed banks, germination, phenology, seed set, and below-ground processes to inform species and habitat movement and management.
- Investigate variation in plasticity and other adaptive traits for widespread species at risk from climate change.
- Support bioenergetics modeling to understand habitat needs for desired populations.

Planning and Policy Research

- Research barriers to habitat protection in underrepresented regions and policies that effectively protect critical habitat from land use conversion and biodiversity hotspots.
- Research ways to expand protection with private landowners and managers to formulate and implement cross-boundary plans for coordinated stewardship within specific locales and across ownerships (e.g., Coordinated Resource Management and Planning).
- Research the diversity of incentive programs including those employed in other states and countries to motivate private landowners to steward biodiversity and sequester carbon.

- Document case studies and working models of cross-jurisdictional authorities as working models capable of increasing stewardship actions at a landscape scale.
- Study the ecological review of working conifer forests under the Forest Practices Act and its effectiveness for ensuring working forests are also advancing conservation goals.
- Compare conservation benefits provided under the Forest Practice Act for conifer habitat types with the application of CEQA for other habitat types such as woodlands and shrublands to advance working lands for conservation.
- Create shared understanding and templates for stewardship costs to improve budgeting and realistic planning.
- Study effectiveness of mitigation banks, conservation easements, and other private land conservation instruments.

Conclusion

Advancing biodiversity knowledge and the scientific foundations of conservation planning, stewardship, and long-term environmental monitoring is essential for successful implementation of the California 30x30 initiative. The CBN will continue to provide a forum for collaboration and serve as a key contributor to California's 30x30 Partnership throughout its implementation. With this contribution the CBN provides a focus for essential near- and long-term actions, identifying linkages among regional and statewide conservation plans or mandates, developing support for new activities, expanding equitable and diverse collaborations, and clarifying how insights gained from these activities will be made available to practitioners. Advancing the three goals of biodiversity conservation, climate resilience, and access to nature, with a commitment to equitable participation, will make California a model for successful implementation of the global commitment to 30x30.

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