

California Biodiversity Network Stewardship Roundtable Research Needs Report

Introduction

California's plan to protect 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. Approaches should maintain and enhance natural processes (e.g. water cycles, fire, 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 offers a way to enhance natural processes and promotes productive, sustainable, resilient, and just social-ecological systems.

Since time immemorial, the Indigenous peoples in what is now known as California upheld traditional responsibilities to steward the lands and waters. Based upon kinship systems and reciprocal relationships, Indigenous peoples remain committed to the stewardship of their aboriginal homelands. This stewardship has shaped the genetic, species, and ecological diversity that is found in California today. The CBN Stewardship Roundtable respects and honors the relationships, knowledge, and traditions that connect Indigenous peoples to their homelands, and also acknowledges the history of exclusion of and erasure of many Indigenous peoples in this state and their legacies of conservation. Recognizing the inherent relationship between biodiversity and Indigenous cultures, we embrace equity and justice as central principles of biodiversity conservation and stewardship.

Stewardship comes in many forms. Considering a multitude of perspectives, including those of marginalized groups (e.g., Black, Latinx, Asian, LGBTQIA+), can aid our collective conservation efforts. We recognize the need to seek multicultural leadership and approaches to stewardship in a way that benefits California's diverse communities. This requires more time to build relationships than has typically been built into grants. To advance broader social objectives, our efforts must uplift Indigenous leadership and people from historically marginalized backgrounds to advance community capacity and resilience.

We are facing the fastest rates of climate change ever recorded, and the trajectory of California's ecosystems is highly uncertain. To address this challenge, we must dispel notions of static natural areas and commit to actively stewarding our lands and waters through changing stressors and political realities. This will require a dedicated and significant funding stream to develop and scale-up stewardship activities, research, and ecological monitoring. This roundtable report identifies priority information and research needs to advance stewardship of California's natural areas. In particular, the importance of Indigenous led stewardship, freshwater conservation, and conserving biodiversity on working lands needs to be elevated as part of 30x30.

While California's seasonal pattern of rainfall during the winter and dry summers is predictable, the amount of precipitation we receive each year is more unpredictable than any other part of the United States. Wide variability in annual streamflow is common, leading to uncertain surface water availability for flora, fauna, and human use. Climate scientists are forecasting higher variability and more extreme rainfall and drought events. Indigenous knowledge holders recall the history of exposed areas across major riverbeds and adaptation to dry periods. Cultural burning can be used in some areas to improve river flow and habitat conditions.

An integrated approach to terrestrial-freshwater conservation under 30x30 will require planning and implementation at the watershed scale. Particular attention should be given to hydrologic connectivity by protecting environmental flows from headwaters to estuaries and the maintenance of 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 ecosystems should be enhanced by removing barriers to flow, reconnecting rivers to their floodplains, restoring hydrographs to promote native organisms, and restoring groundwater-surface water interactions.

Indigenous people tended California's ecosystems in a way that sustainably produced a variety of food, medicine and materials for their use for thousands of years. Biodiversity conservation and ecosystem functions such as water filtration and storage, carbon sequestration, and clean air depends upon both protected and working lands. Working lands include landscapes that support resource use and conservation values; these include rangelands, forestlands, urban open spaces, and are roughly equally divided between public and private holdings. California will continue to lose biodiversity if we do not advance stewardship of working lands because protected areas are influenced by surrounding landscapes and the species that occupy them. Furthermore, climate change is forcing relocation of many species, often into areas that are unprotected for all or part of their life cycle.

Maintaining the value of California's working lands requires we attend to livelihoods that depend on these lands as well as support 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.

In sum, in addition to extending environmental protection under 30x30, we need to support land stewards, uplift Indigenous opportunities for leadership and employment, and engage the public in stewardship in an equitable way.

Priority information and research gaps from expert opinion through a participatory process

Fundamental to the success of stewardship actions is the need for both western and Indigenous science, along with sustained funding, public participation, and knowledge sharing and comprehensive data collection and monitoring. We observed widespread interest in pulling together existing data sets and making them more accessible. Collecting missing data is equally important and there is strong interest in supporting researchers to work with land and water managers especially from those in the non-profit and local government sectors stewarding lands without researchers on staff. We bring the following stewardship activities into focus because of their importance in stewarding California's ecosystems given future environmental change.

The following information and research priorities were identified from surveys and workshop participation from CBN participants interested in and practicing stewardship in California's lands and waters. 67 participants completed our survey, including information about 84 projects. Additionally, 38 participants were involved in paired interviews, action group discussions, and regional discussions. Participants were located across the state and represented all 9 regions of California (Fig. 1), working with a diversity of landcover types (Fig 2). Participants were from a variety of backgrounds and organizations, and included tribal members, landowners and land managers, as well as individuals from academic, nonprofit, and government agencies. While this is a small sample of the stewards in California, this report emphasizes a wide range of near-term research and information needs as well as training, extension, and policy revisions in support of stewardship. Most of these priorities span more than one ecosystem, and all reflect the participatory process described above. However, the list is not exhaustive and there will need to be a continued effort to engage a diverse group of stewards to drive this work.

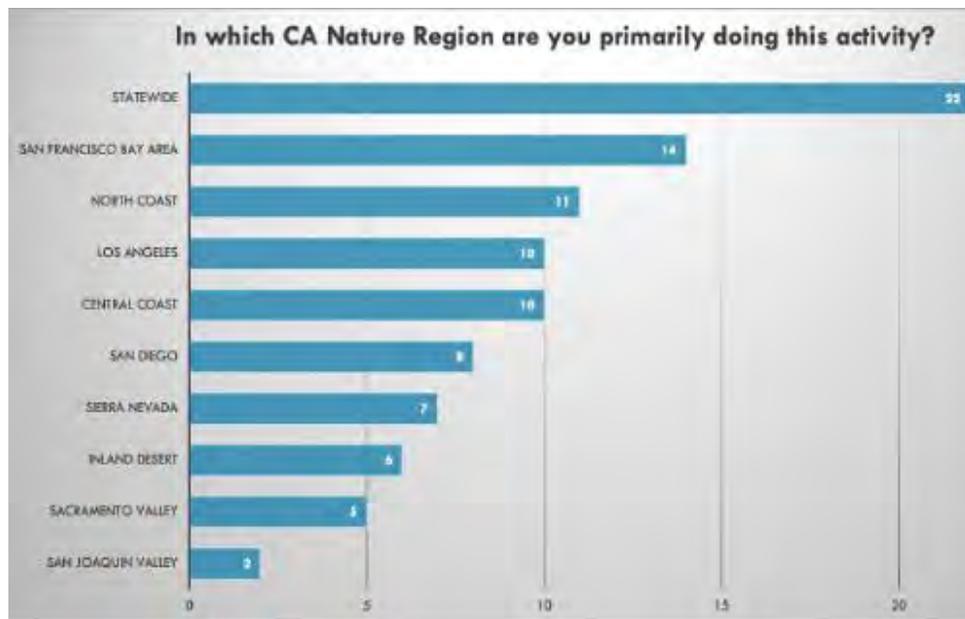


Figure 1. Regional representation from the survey data

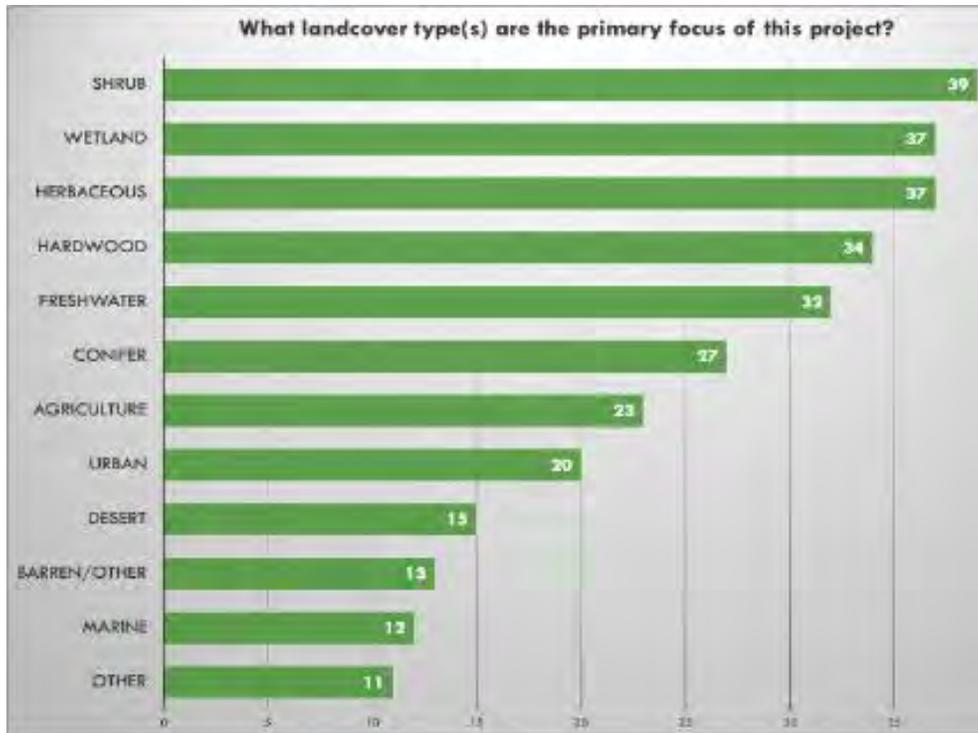


Figure 2. Landcover representation from the survey data

A. Education, Workforce Training and Community-Centered Stewardship

Education, workforce training and public service are essential to building public support and engagement in stewardship activities and climate change solutions. Moreover, workforce development is needed to scale-up the work to meet numerous stewardship objectives, and also create jobs to support rural economies in a sustainable way. The goal is to equip communities and support workforce training programs that can advance community-scale stewardship efforts which will also improve equity and inclusivity across the environmental workplace. Integrating a local workforce will help to sustain stewardship and meet monitoring objectives over the long-term.

Priority information and program implementation

- Uplift traditional ecological knowledge, deepen Indigenous opportunities for building stronger interconnection and interdependence with nature, connect culture to landscape, and promote local partnerships to improve access for Indigenous-led stewardship.
- Create a grants program and other ways to advance stewardship corps and workforce education programs for Indigenous communities and to serve young adults from underserved communities as a pipeline to stewardship jobs.
- Incentivize teacher training in environmental and climate education.
- Invest in communities of practice among scientists and practitioners (e.g. California Biodiversity Network) so they can support one another, co-design

research and best practices that can be extended to others and improve stewardship overall.

- Provide incentives for local conservation organizations to engage the public in stewardship, if they are not involved the lands listed as conserved will only be temporarily protected.
- Explore ways for the public to appreciate urban ecology as well as places outside of where they live that provide crucial habitat for California's biodiversity such as deserts, the eastern Sierra and the Klamath mountains.
- Use video, animation and other accessible media to share positive stewardship stories.
- Engage small-parcel landowners in land care and learning about sustainable land management practices, including ways to maintain appropriate grazing levels (including for horses), enhance riparian vegetation and woody debris, control invasive species, manage pests, and minimize movement barriers such as fencing.
- Collect and disseminate stewardship stories spanning different regional protected and working lands networks.

Priority research directions

- Study outcomes from environmental and climate education and service efforts, including community science, to identify best practices including cultural competency and how to keep volunteers engaged.
- Research local environmental and justice movements, including motivations to participate and what fosters long-term engagement, and assess interventions that strengthen these movements.
- Research on the influence of community science on the participants and research outcomes to improve levels of engagement and data quality.
- Study natural building materials with low embodied carbon and improve permitting to facilitate their use.
- Encourage participatory research through improved usability of existing mobile and online applications for crowdsourced data acquisition and new statistical approaches to weight-contributed data based on estimates of reliability to better use community science data for species distributions and conservation research.

B. Open space in an urban context

The state's protected open space provides important opportunities for people to connect with nature which is vital for human well-being and stewardship. At the same time, finding an appropriate balance between biodiversity conservation and outdoor recreation is complicated, especially since impacts vary among species and recreation activities. Access to open space is not afforded to all residents, especially those in the urban core. At the same time urban green spaces provide an opportunity to conserve biodiversity through diversified plantings and natural landscaping across open lots, cemeteries, and playgrounds. Increased access to open space for people living in the urban core and providing Indigenous people

access to steward sacred places and ecocultural species is a necessary step toward sovereignty and justice. More science-based information to help solve these dilemmas as well as improve equity around public access to open space and enhance urban green spaces.

Priority information and program implementation

- Maps of cumulative recreation use on and off trails with a focus on HCP, NCCP and other areas essential for endangered species protections that have high visitation rates; with complimentary studies of impacts of recreation on these species.
- Maps of relative use of open spaces and areas where access to open space needs to be augmented to improve equity.
- Expand youth and adult programming focused on local natural areas and their stewardship, including engaging with private landowners.
- Work with local organizations to improve access to open space for BIPOC people and remove barriers and provide capacity for Indigenous people to access and steward ecocultural areas.
- Improve recreation infrastructure including trailheads and limit use of informal trails to improve the visitor experience and offer informal education on ecocultural areas, environmental protection, and climate change.
- Financial incentives/support for farmers, ranchers, and farmworkers to retain their lands and/or conduct necessary stewardship activities in an equitable way that supports BIPOC individuals and communities.
- Advance stewardship that improves environmental health in agricultural settings for workers and the entire community of life.
- Fund partnership with tribes and Native communities to access and steward sacred areas and ecocultural resources.

Priority research and implementation directions

- Participatory research to help communities and park agencies balance the demand for recreation with stewardship goals.
- Study methods for augmenting urban biodiversity, improving landscape ecology, and reducing urban heat islands.
- Social research on the local networks of practitioners and institutions that implement place-based stewardship.
- What nature-based recreational opportunities are most valued by specific underserved communities and developing a plan to access.

C. Restoration, healthy soils and moving toward regenerative ecosystems

Given increased rates of change and the resulting widespread existence of novel communities, we must adopt and pursue innovative approaches to restoring and advancing ecosystem stewardship. Adapting to climate change and the increased uncertainty it brings, the focus should shift from maintaining historical conditions toward restoring ecosystem processes, managing dynamics and identifying and creating pathways to resilience.

Priority information and program implementation

- Interactive database and explorer mapping tool for restoration projects with performance metrics, information on restoration failures (did not produce desired results); start with publicly funded efforts and partner with NGOs to collate existing data.
- Publicly accessible database that provides information and best management practices for implementing successful restoration techniques, including weed control, by habitat type and specific to each ecoregion.
- Fine scale mapping of areas with a high proportion of native grasses and forbs which requires expert opinion and ground truthing, to guide protection of these habitats and associated seed sources.
- Extension information for how to select and grow local native plant species and if and when to source genetic stock from areas where future climate analogs exist to adapt to climate change.
- Identify areas that should be restored for overall watershed health in addition to high priority areas for protection.
- Measure and map levels of nitrogen deposition on California's ecosystems.
- 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.
- Long-term data sets that rest with agency scientists and others need to be more readily accessible to researchers through a digital cataloging effort, ideally combining and leveraging existing data sources and portals (e.g., Dryad). These include but are not limited to water quality, fish and wildlife surveys, and vegetation monitoring.
- Community monitoring of early detection of new arrivals and diseases; changes in flowering timing, seed set, and other life-cycle events in relation to environmental cues; community rephotography of historic photo points; and community supervision of monitoring instruments.
- Develop standardized monitoring protocols for different ecosystem types, soil health, and focal organisms to detect threats and stressors and enable comparison of outcomes of management interventions across sites.

Priority research directions

- What makes for regenerative grazing regimes including the use of native herbivores?
- How are native grasses and forbs responding to compost application in rangelands designed to improve carbon sequestration and moisture holding capacity?
- Needs assessment to determine the best way to structure incentive programs to motivate private landowners to steward biodiversity and sequester carbon.
- Tools that provide a standard estimate of carbon capture given changes in herbaceous cover and composition.

- Track and examine impacts of plant species translocations and simplify permitting for translocations and experiments needed to conserve listed species.
- Measure variation in plasticity and other adaptive traits for widespread species at risk from climate change.
- 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.
- Examine public attitudes to restoration and provide guidance for building a common community vision for successful project implementation.
- What mixture of management tools including fire, grazing, and herbicides can best control rangeland invasive species such as barbed goatgrass, medusahead?
- Examine the benefits and costs of passive restoration methods compared to expensive and intensive approaches.
- Invest in the geographic expansion of existing species distribution data sets to provide fuller coverage across the state.
- Study disturbance regimes and successional dynamics in nonstationary environments, including identification of leading and trailing edges of existing ecosystems and emergence of novel ecosystems.

D. Freshwater conservation

Freshwater is the lifeblood of Mediterranean-climate ecosystems, and stewardship is essential to maintain and recover natural flow regimes, riparian habitats and wetlands. Increasing hydrologic connectivity to advance recharge and environmental flows often requires 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.

Priority information and program implementation

- 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; as well as opportunity to estimate water withdrawal and storage on downstream flow. Start with coastal rivers with highly distributed water management and this will help improve flow regimes for salmonid recovery.
- Interactive tool to explore three-dimensional transient ground-water flow models and tools to help optimize recharge and plan groundwater use –

this would help determine how plans emerging from SGMA (Sustainable Groundwater Management Act) will influence wetlands.

- Interactive mapping tool with information on aquatic invasive species, pollutants and their concentrations, including nutrients, pesticides, pharmaceuticals, and other chemical contaminants.
- Examine stewardship needs for wetlands to retain below ground carbon storage and reduce methane emissions.
- Access to real-time surface water flows.

Priority research directions

- How does lithology, vegetation, and land use affect groundwater recharge, surface flows, and erosion -- especially excessive loading of finer sediments into channels?
- Study of the chronology of rock pool animal communities and their association with detailed hydroperiod and water temperature data on under-surveyed private lands.
- Recover and monitor historic water sources in the desert.
- How does forest thinning change groundwater distribution and vadose zone (between groundwater and land surface) moisture regimes?
- How does land use in the headwaters affect that natural storage and transport of water especially belowground?
- What are the flow requirements to prevent cyanobacterial overgrowths for impacted rivers?
- Investigate the importance of retaining live and large wood in stream 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.
- Aquatic species conservation prioritization in relations to cultural subsistence, and to address equity and justice relative to SGMA implementation.

E. Fire, fuels & forest management

Fire is a natural process and is a primary 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. For more than 100 years, US legal systems have prevented Indigenous use of fire and regulated it almost out of existence. It is crucial that Indigenous people who have traditional knowledge be able to revitalize the use of fire today and share these approaches to enhance biodiversity. Further, the disruption of Indigenous burning practices has created vulnerabilities to many ecosystems where frequent and seasonally timed fires can be used to create stability and enhanced habitat conditions as well as a lower risk of loss of homes and livelihoods in our communities.

Priority information and program implementation

- Advance prescribed fire planning and support through collaborative design, education, and advocacy.
- Foster prescribed fire practices based on Indigenous leadership and provide insurance options to reduce liability.
- Monitoring invasive species response post-fire focused on informing weed control implementation.
- Monitoring threatened, endangered and sensitive animal and plant species response post-fire.
- Interactive explorer mapping tool with fire history information.
- Interactive explorer tools to choose climate-smart species, healthy tree density, and genetics for restoration.
- Identify communities with knowledge, partnerships, and capacity to steward with fire to support, conduct participatory research, and extend the practice to others.
- Learning more about Indigenous management of southern California ecosystems using fire and including Indigenous people in the management of these ecosystems.
- Assess which communities are disproportionately impacted by smoke and other air quality impacts.

Priority research directions

- Include atmospheric interactions into fire modeling to better predict fire behavior and its ecological effects.
- Investigate differential responses of fuel treatments to mild vs severe fire weather conditions.
- Influence of the timing of controlled burns on biodiversity including species reproduction, movement, and the food web.
- How does forest thinning influence 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.
- What are the criteria for reforestation after high severity fire and to what extent should reforestation be implemented?
- How are vulnerable species responding to controlled fire and catastrophic fire?

F. Invasive species

Invasive species have transformed California's ecosystems, impacted agriculture productivity, and in many cases these recent arrivals have become a permanent part of California's diversity and ecological dynamics. The Mediterranean climate,

widespread disturbances including waves of colonization, changing fire dynamics have fueled these invasions. While many invasive species are widespread, there have been some important successful eradication and control efforts leading to ecosystem restoration and native species recovery. Invasive species management involves prevention, early detection, eradication, and control. Only through monitoring biodiversity is early detection of invasive species possible and equally important is impact monitoring to assess the effectiveness of eradication efforts, which often require ongoing stewardship to achieve long-term control.

Priority information and program implementation

- Mapping and modeling locations of invasive species, including expert knowledge and community science efforts, with a focus on early detection of leading edges of invasion.
- Support extension of weed control information and reduce reliance on chemical control while maintaining herbicide applications when warranted.
- Interactive explorer mapping tool with spatially explicit information on transportation corridors, underpasses, culverts and bridges.

Priority research directions

- Invasive species biology including seed viability and response to control measures.
- Disease interactions between non-native and native bees.

G. Species and ecocultural conservation

Information gaps on species and ecocultural taxa and their habitat needs limit our ability to conserve biodiversity across California. In addition to extending protection of woodlands, shrublands, and grasslands from habitat conversion, we need to pay particular attention to the protection of desert ecosystems as they face pressures from industrial scale solar, recreation, and extraction.

Priority information and program implementation

- Fine scale and updated vegetation maps for all Counties.
- Maps of landforms to readily identify watershed features including urban areas and deserts.
- Management plans for rare species including best management practices, climate change impacts, implementation costs and qualifications, that could be readily folded into regional planning efforts. This will require rare species data, and streamlining accessibility of existing data (e.g., CNDDDB) is needed.
- Map of mitigation lands and more ways to do advanced mitigation and contribute to protected lands networks and connectivity.
- Survey of biodiversity, carbon sequestration, and water regulation on working lands.

Priority research directions

- Working with Indigenous knowledge-bearers, while honoring data sovereignty, to identify culturally important species and assess extent to

which these are disconnected from access and stewardship by Indigenous people and threatened by global change.

- Retrospective studies and monitoring of stewardship activities across conservation areas and their influence on community composition, carbon sequestration, hydrology/soil moisture, and food webs.
- Species occurrence/abundance data with a focus on lesser surveyed areas of the State, including what is on private lands. Moving beyond only threatened and endangered species to include lesser-known cryptic species, migratory species, and taxa of ecocultural importance.
- Streamline use of monitoring technologies such as ground based sensors and e-DNA, as well as community science efforts.
- Data on wildlife corridor efficacy and function.
- Modeling and mapping climate refugia including soil moisture modeling to address future increases in climate-water deficit that will drive changes in plant communities.
- Habitat suitability modeling under different climate scenarios at finer spatial scales that can be used to consider assisted migration and other stewardship options.
- Phenology monitoring with a focus on ecocultural species and those that depend on species associations.
- Historical ecology, including species accounts, focused on former wetlands to provide guidance for restoration.
- Belowground processes, including the influence of water deficit on microbial processes; and root function and climate sensitivity.
- Experimental research to measure climate change effects on soil seed banks, germination, phenology, and seed set to help inform species and habitat movement and management.
- Measure variation in plasticity and other adaptive traits for widespread species at risk from climate change.
- Investigate trends of species/populations and/or occurrence across gradients of protected areas (GAP status 1 - 4) including working lands to inform what stewardship activities can best support conservation goals.
- Bioenergetics modeling to understand habitat needs for desired populations.

H. Planning and policy

We need to better couple land conservation efforts for biodiversity protection with land-use planning and expand statewide policies to limit habitat conversion. The historical, institutional, and political climate under which environmental policies (including the Forest Practice Act, California Environmental Quality Act, Endangered Species Act, and the Clean Water Act) were developed has left California's grasslands, shrublands, desert vegetation and woodlands at risk of continued large-scale habitat conversion. First and foremost, we need to stave off the continued large-scale conversion of these habitats into monoculture production, subdivision, or other development. This means expanding our efforts to stop habitat conversion

beyond forestlands, critical habitat, and biodiversity hotspots. The conversion of these cover types is not directly regulated by the State, in comparison with the State's current role in overseeing tree removal and regeneration on conifer-dominated sites. In the majority of cases, land use and land conservation decisions affecting these cover types are made at the local level. Absent compensation, the level of protection that can be expected from local land use regulations is influenced by the extent to which regulations limit the current or future economic returns to private landowners. This results in an inconsistent, and often non-existent, level of protection across habitat types and the species they harbor, which are far more numerous in the unprotected habitats than in conifer dominated ecosystems. Finally, a major push is needed to expand ways for 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).

Priority information needs and implementation

- Increased use of cross-jurisdictional authorities to increase stewardship actions at a landscape scale.
- Extend the ecological review under the Forest Practices Act from a focus limited to conifer forest conversion to also include review of large-scale conversion of woodlands and shrublands.
- Shared understanding and templates for stewardship costs to improve budgeting and realistic planning.
- Identify longer-term funding streams, including block grants and tax relief, as well as small seed-money distributed through backbone organizations to support stewardship actions and monitoring is critical.
- Reduce the administrative overload for implementing stewardship interventions such as instream restoration and using fire.
- Regional planning to develop new green infrastructure and access as sea level rise occurs along the coast and bays to adapt to sea level rise.
- Explore short term stewardship agreements or certification for working lands to allow working lands to contribute to 30x30 goals.
- Assess effectiveness of mitigation banks and projects and conservation easements and other private lands conservation instruments.
- Property tax breaks for private landowners who participate in research and stewardship activities (see Ecolabs in Texas tax code that allow University researchers on private land for studies).
- Follow up on violations and identify revisions to the Clean Water Act, Endangered Species Act, Fish and Wildlife Regulations, and Marine Protected Areas to advance stewardship options.
- Better tracking of local land use regulation changes leading to loss of workings lands for conservation.