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**Expanding Climate Action Through
Nature-Based Solutions**

Advisory Panel Summary Document

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Expanding Climate Action Through Nature-Based Solutions
Climate Advisory Panel

Climate change is an unprecedented crisis that affects every aspect of life in California. Intensifying wildfires, heat waves, floods, sea level rise, and drought are already causing substantial damage to California's natural and cultural resources, communities, public health, and economy. Climate smart land management provides a functional way to build resilience and achieve carbon neutrality by mid-century. This will require intentional and science-driven action and will rely on engagement and input from California's diverse communities and climate change experts.

The California Natural Resources Agency created the Climate Action Advisory Panel to consolidate current knowledge, highlight information gaps, and recommend actions. The panel includes specialists from academic and research institutions across California, representing expertise in climate-ecosystem interactions, forestry and fire protection, forest ecology, oceanography, landscape architecture, and climate adaptation and resilience.

The panel emphasizes the critical need for policymakers to engage local communities and a wide range of stakeholders in the process of making equitable and sustainable decisions regarding natural and working lands. The panel considered California's land and coastal habitats to identify opportunities to build resilience to climate change, increase carbon sequestration, and contribute to people's livelihoods. They examined the role of conservation in supporting carbon neutrality, building climate resilience, and protecting biodiversity and sensitive habitats. These elements informed their recommended strategies to build climate resilience into existing protected lands and coastal waters and identify which factors must be considered for future climate resilient acquisitions or management decisions. In addition, the panelists They also developed strategies and best practices for accelerating climate smart land management, identified barriers to scaled implementation, and outlined current programs and additional opportunities for evaluating progress in California.

California's environment, economy, and public health are intrinsically linked. In both terrestrial and coastal ecosystems, climate change has already impacted biodiversity, including changes to species distribution, community structure, and ecosystem function. Communities throughout the State have already been affected and, without cuts to carbon emissions from human sources, continued changes will increase risks to people and nature. The ecosystems that support California depend on thriving and diverse biological communities. They provide clean water, natural removal of the carbon dioxide that causes climate change, and pollination of fruit and crops. Habitats, such as forests and wetlands, which are critical for long-term storage of carbon, are increasingly at risk from urbanization, climatic shifts, and extreme events such as wildfires and ocean heat waves. Climate change will continue to affect plant and animal species and ecosystems and result in system-wide changes to natural and agricultural

productivity, carbon sequestration, and biodiversity. Effective stewardship of natural and working lands will be essential to avoid, slow, or mitigate the worst impacts on California's communities and ecosystems.

Policy and Management Recommendations

1. Apply an adaptive approach to conservation across all landscapes that is continually reassessed as ecosystems are affected by climate change — Conservation of California's varied landscapes and habitats is essential for reaching the goal of carbon neutrality and increasing the resilience of the State's communities and ecosystems. To support these efforts, the Panel made the following recommendations for both conservation of current habitats and opportunities for increasing resilience and carbon neutrality in protected and managed landscapes:

- Protect against habitat loss and fragmentation, particularly near urban boundaries and in coastal habitats, to help maintain carbon sequestration, protect biodiversity, limit exposure to climate risks, and increase climate resilience.
- Protect habitats with high carbon storage that are likely to persist and grow to support long-term carbon neutrality while maintaining high biodiversity in these areas[1].
- Conserve established refugia and restore potential refugia in both land and coastal habitats to enhance biodiversity and habitat resilience.
- Invest in land acquisition, improvements, and high-quality management of parks and open spaces in and around cities to benefit underserved communities who are often the most negatively affected by health impacts related to air pollution and extreme heat caused by urban heat islands.
- Partner with California Native American tribes to share knowledge and learn effective practices for conserving ecosystems and cultural resources.

These efforts will be significantly affected by available funding and the rate of climate change. In addition, community engagement will be one of the most important factors in the successful implementation of each recommendation. Local communities need to be involved in all aspects from planning to implementation, including workforce development, to ensure equity and sustainability. Policy decisions, planning, and implementation must also be developed in coordination through meaningful government to government consultation and partnership with California Native American tribes.

2. Protect and restore habitats with high carbon density or sequestration potential, and those that support communities and contribute to carbon neutrality more broadly — As California moves forward in developing strategies to mitigate climate change by promoting carbon sequestration, it is important to rigorously assess which habitats and ecosystems present significant opportunities for meeting these goals. Lands and coastal waters should be evaluated for current and historical carbon storage, the potential for future carbon sequestration with restoration or management, and the stability of the stored carbon and risk of carbon loss due to climate change or land use change.

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1 Soto-Navarro, C., et al. "Mapping co-benefits for carbon storage and biodiversity to inform conservation policy and action." *Philosophical Transactions of the Royal Society B* 375.1794 (2020): 20190128. [*Link*]

Coast redwood forests, coastal vegetated habitats, and agricultural and grazing lands all have significant potential for carbon sequestration. Old-growth forests contain substantial carbon stores, though some are at increasing risk of carbon loss due to wildfire. Coastal vegetated habitats such as wetlands, salt marshes, and seagrass meadows, hold additional potential value for blue carbon storage if successful restoration can reverse the loss of almost 90 percent of the historical habitat. It is important to note that continued climate change could cause species range shifts that alter the extent and distribution of natural carbon stocks and expose ecosystems to novel pests and diseases.

Co-benefits and broader contributions to achieving carbon neutrality beyond carbon sequestration must also be considered in prioritizing habitats for protection or restoration. Forests, which contain the most ecosystem carbon storage in California[2], also provide much of the state's water supply and protect essential biodiversity. It is difficult to quantify the carbon sequestration value of urban and community green spaces. However, increasing the extent and access to these landscapes can positively impact community health, moderate urban heat islands, and potentially decrease energy use, thus moving these regions closer to carbon neutrality. Through climate smart land management, working lands sequester carbon and can offer additional co-benefits such as improved water quality and quantity, renewable resources derived from biomass, and wildlife habitat. Wetlands, such as those in the San Francisco Bay Delta, provide significant carbon storage, while also contributing to erosion control, supporting biodiversity, improving water quality, and providing protection from sea level rise, flooding, and storm surge. Protection and restoration of these multi-benefit landscapes are essential for equitably achieving the State's climate goals and improving the resilience of all of California's communities.

3. Implement strategies to accelerate climate smart land management, particularly for ecosystems with high carbon sequestration potential and multiple co-benefits — To support these efforts, the Panel made the following recommendations to accelerate climate smart land management across California's landscapes:

- Immediately implement a shift from reactive fire suppression in forests to proactive vegetation management, prescribed and cultural burns, and managed natural wildfire to reduce the risk of catastrophic wildfire under climate change while taking steps to minimize the effects on air-quality.
- Increase active reforestation efforts in areas that are recovering from severe wildfires and suffer from reduced natural regeneration as a result.
- Encourage sustainable forest practices in working forests, including decreas-es in single-age tree stand management, to increase resilience and long-term carbon storage.
- Restore wetlands, salt marshes, and seagrass ecosystems to maintain and protect these habitats from future sea level rise.
- Develop effective and dynamic regional land use planning that considers biodiversity, carbon storage, species range shifts due to climate change, and climate resilience at landscape scales.

2 *Gonzalez, P. et al. 2015. Aboveground live carbon stock changes of California wildland ecosystems, 2001-2010. Forest Ecology and Management 348: 68-77 [Link].*

- Increase development of both urban tree canopy and green spaces to moderate urban heat islands, decrease energy use, and contribute to carbon sequestration.
- Develop more comprehensive vulnerability assessments for agricultural lands that integrate biophysical and environmental stressors, heat, and socio-economic factors.
- Actively engage local communities in conservation planning and implementation.
- Coordinate and actively partner with California Native American tribes through meaningful government to government consultation and co-management agreements in conservation planning and implementation.

Implementing these recommendations will require overcoming a combination of natural and societal barriers. Water availability is essential to both agricultural and urban adaptation, and future water availability will constrain carbon accumulation potential in many California ecosystems. Ecosystems will also continue to be directly affected by climate change, including by increasing temperatures and extreme climatic events, challenging management and conservation efforts. Regulations to protect the environment and ensure public participation often present challenges and delays to implementation. However, public participation, including engagement with local communities, is essential to ensuring all voices are heard and can contribute and benefit from these measures. Active partnership and meaningful government to government consultation with California Native American tribes is imperative to co-managing conservation efforts that respect and benefit California Native American lands, cultural and natural resources, and concerns. In addressing climate change, California has an important opportunity to increase access, workforce development, employment, and resource availability in underserved communities and California Native American tribes. Ultimately, project success and sustainability will depend on the establishment of enduring and inclusive partnerships that are equally focused on both climate smart land management and critical intersections with environmental justice.

4. Improve data on landscape-scale refugia — Although data and methods are available for identifying refugia in both land and coastal habitats, to effectively build climate resilience and protect biodiversity, it is important to consider migration, dispersal, and connectivity among systems. California's Essential Habitat Connectivity Project[3] can serve as a foundation for continued integration of these data types. In marine systems, progress has been made with seascape-level protections, however, more work is needed to implement data-driven measures that account for the dynamic nature of the ocean environment. Conservation decisions must also account for risks from current and future disturbances related to climate change in identifying refugia in both land and coastal habitats.

Beyond recognizing current refugia, the Panel prioritized the need to identify regions with high potential to become refugia. This includes effectively managing working lands to maintain biodiversity, as well as considering a greater conservation focus on

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3   *California's Essential Habitat Connectivity Project [Link]*

land where water availability and economics could limit agricultural uses in the future and where urbanization and development pressure threatens natural and working lands. Urban and agricultural riparian zones also represent potential refugia if efforts are made to restore and protect these habitats.

5. Track ecosystem carbon and biodiversity to monitor and better adapt to impacts from climate change — The California Air Resources Board currently maintains the State greenhouse gas inventory, including carbon in ecosystems[4]. Existing efforts to estimate and track ecosystem carbon in California use a range of methods, time scales, and spatial scales across varied ecosystems. In tracking carbon storage, combining above-ground ecosystem carbon measurements and remote sensing is essential. The Canada National Forest Carbon Monitoring, Accounting, and Reporting System[5] should be considered for application in California. Assessing carbon in coastal habitats, soil, and detritus currently requires direct measurements, but increased investment in monitoring and collection would provide essential information for evaluating California's carbon stocks.

As ecosystems and communities are increasingly affected by climate change, it will also be important to monitor and track changes in ecosystem biodiversity. Tools such as the Singapore Index on Cities' Biodiversity[6] can provide communities with the ability to assess biodiversity conservation efforts against their individual baselines, as was done as part of the city of Los Angeles' 2020 Biodiversity Report[7]. California's Marine Protected Area Monitoring Program[8] and the Multi-Agency Rocky Intertidal Network[9][9] led by UC Santa Cruz, represent multi-agency collaborations for tracking and monitoring coastal biodiversity. Environmental monitoring and tracking can also be an opportunity for increased public engagement through community science and making the data easily accessible online.

Lack of project communication and data accessibility are currently some of the most significant issues with environmental tracking and monitoring. Programs currently exist for tracking and monitoring separate facets of climate change and ecosystem carbon and biodiversity, but going forward, it is essential that greater communication and collaboration is established between these efforts. This includes cooperation between all stakeholders involved in environmental tracking and monitoring within governments, academic institutions, and private organizations. Related, sustained investment in open data and open science practices are critical for nimble decision making and to facilitate community engagement.

Addressing climate change will require engagement and input from all of California's diverse communities. Although these recommendations can help slow climate change and reduce some of the worst impacts, concerted and cooperative efforts will be needed to protect California's biodiversity, ecosystems, and people.

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4 *California Air Resources Board, Current California GHG Emission Inventory Data [Link]*
5 *Canada National Forest Carbon Monitoring, Accounting, and Reporting System [Link]*
6 *Singapore Index on Cities' Biodiversity [Link]*
7 *Los Angeles' 2020 Biodiversity Report [Link]*
8 *California's Marine Protected Area Monitoring Program [Link]*
9 *Multi-Agency Rocky Intertidal Network [Link]*

Advisory Panel Questions

1. What land and coastal habitats, including urban and community green spaces, should California classify as having significant opportunity to contribute to our goals of achieving carbon neutrality and building climate resilience? Do some landscapes inherently have greater potential than others? Of these landscapes, which have the longest-term sequestration benefits?

2. Do we have the scientific understanding to identify areas of refugia in California that should be built into our approach to 30x30 and the NWL Climate Smart Strategy?

3. How can conservation best support California's goals of achieving carbon neutrality and building climate resilience? What factors are critical for increasing climate resilience in existing protected landscapes and coastal waters, and how should these be incorporated into new climate resilient acquisitions or conservation management decisions in California?

4. What strategies or best practices would you identify as critical to accelerating climate smart land management across all of California's landscapes? Are there barriers to scaling these actions, and if so, what can the State of California do to address them?

5. How do you recommend we measure and track progress of our collective climate smart land management efforts? What are the leading science-based frameworks for evaluating and monitoring our progress, and what are their pros and cons for use in California?

Advisory Panel Biographies

Moderator Lara Kueppers, Ph.D.
Associate Professor, Energy & Resources Group, University of California, Berkeley and Faculty Scientist, Climate and Ecosystem Sciences Division, Berkeley Lab

Lara Kueppers is an Associate Professor in the Energy and Resources Group at UC Berkeley and a Faculty Scientist at Berkeley Lab. She is an interdisciplinary environmental scientist, with expertise in ecological responses and feedbacks to climate change. She uses field experiments and observations, as well as numerical models, to understand climate-ecosystem interactions, with a current focus in Western US and tropical forests. Her work has examined shifts in subalpine forest carbon cycling and species distributions with climate warming, effects of irrigation on regional climate in California and nationally, and most recently, the role of disturbance and regeneration processes in projections of ecosystem change. Previously, Dr. Kueppers was a Research Scientist in the Climate and Ecosystem Sciences Division at Berkeley Lab, where she helped launch a decadal, multi-institutional tropical forest research project, and Assistant Professor at UC Merced, where she helped stand up degree programs and departments in the inaugural years of the campus. She holds a PhD from UC Berkeley, and MS and BS degrees from Stanford University.

Esther Marguiles, ASLA
Associate Professor of Practice, University of Southern California School of Architecture Master of Landscape Architect + Urbanism

Esther Margulies is an associate professor of practice and assistant director of the USC Master of Landscape Architecture + Urbanism program. She recently collaborated with USC Professors John Wilson and William Berelson on the Urban Trees Initiative project to assist the City of Los Angeles with an equity based urban forest strategy. Ms. Margulies is a licensed landscape architect and founder of the Office of the Designed Landscape. Her firm is primarily focused on public open space and institutional projects where there is great potential for academic research and policies related to climate adaptation to intersect. She is also a co-founder of the Los Angeles River Public Art Project, a 501.c.3 organization advocating for a robust and equitable public art and culture infrastructure on the longest metropolitan river in the Western United States. Ms. Margulies serves on the advisory board of the Los Angeles Neighborhood Land Trust and as a planning commissioner for the City of Los Angeles in the coastal zone of the City of Los Angeles. She received her bachelor's degree from Cornell University and a master of landscape architecture degree from the Harvard Graduate School of Design. She lives in Venice, California.

Patrick Gonzalez, Ph.D.
Principal Climate Change Scientist, U.S. National Park Service, and Associate Adjunct Professor, University of California, Berkeley

Patrick Gonzalez, Ph.D., is a forest ecologist, Principal Climate Change Scientist of the U.S. National Park Service, Associate Adjunct Professor at the University of California, Berkeley, and a faculty affiliate of the Institute for Parks, People, and Biodiversity and the Energy and Resources Group of the University of California, Berkeley. He advances science-based action on human-caused climate change through research on climate change, ecosystems, wildfire, and carbon solutions and assistance to local people and policymakers on biodiversity conservation and natural resource management. Dr. Gonzalez has conducted field research in Africa, Latin America, and the U.S., published in Science, Proceedings of the National Academy of Sciences, and other journals, and contributed science to policy in positions in Washington, DC. He has stood publicly for scientific integrity and broadened public understanding of climate change in 121 published articles on his research in the New York Times and other media. Dr. Gonzalez has served as a lead author for four reports of the Intergovernmental Panel on Climate Change, the science panel awarded a share of the 2007 Nobel Peace Prize.

Dr. Tessa M. Hill, Ph.D.
Professor, Department of Earth & Planetary Sciences and Bodega Marine Laboratory, University of California, Davis

Tessa Hill is a Professor in the Department of Earth & Planetary Sciences, and Coastal and Marine Sciences Institute ,at the University of California, Davis. Research interests include climate change, both past and present, and understanding the response of marine species to environmental perturbation. She is part of the Bodega Ocean Acidification Research (BOAR) group at Bodega Marine Laboratory, which aims to understand the impact of ocean acidification on marine species and West Coast communities. Tessa leads an industry-academic partnership to understand the consequences of ocean acidification on shellfish farmers on the Northern California coast, and a partnership with the UC Davis CalTeach program to develop ocean curriculum for middle school students. Tessa's work has been featured in a variety of media outlets (e.g., NPR, The New York Times, Al Jazeera America, Science Friday).

J. Keith Gilless, Ph.D.

Professor Emeritus of Forest Economics, University of California, Berkeley, Chair, California Board of Forestry and Fire Protection

Keith Gilless is the former Dean of UC Berkeley's Rausser College of Natural Resources. His research has focused on wildland fire protection planning, forest management decision making, regional economic analysis, and modeling markets for forest products. He received a BS degree forestry from Michigan State University and a joint PhD forestry and agricultural economics from the University of Wisconsin, Madison. Gilless was first appointed to California's Board of Forestry and Fire Protection in 2011, which he has chaired since 2013. At Berkeley, Gilless held professorial appointments in the Department of Environmental Science, Policy, and Management and the Department of Agricultural and Resource Economics. He has previously held visiting professor and researcher appointments at Beijing Forestry University and the International Institute for Applied Systems Analysis in Laxenburg, Austria. Gilless is a recipient of the Berkeley Academic Senate's Distinguished Teaching Award as well as its Distinguished Service Award, and the co-author of two textbooks on forest resource management and economics. He retired from active faculty status in 2020, but still serves the campus as the Secretary of the Berkeley Division of the Academic Senate, and as a member of the Board of Directors of the Faculty Club, the Council of Friends of the Bancroft Library and Faculty Advisor for the Ecosystems Management and Forestry undergraduate major.

Tapan Pathak, Ph.D.

Cooperative Extension Specialist in Climate Adaptation in Agriculture, Division of Agriculture and Natural Resources, University of California, Merced

Dr. Tapan Pathak is a Cooperative Extension in Climate Adaptation in Agriculture at UC Merced. His statewide research and Extension efforts are focused on understanding climate change impacts and translating weather and climate information into useful agricultural decision support system tailored to agricultural clientele needs. Prior to joining the UC in 2015, he was a faculty member at University of Nebraska, Lincoln. His Ph.D., MS, and BS degrees are in agricultural engineering.