AMARGOSA
CONSERVANCY

California Institute
for Biodiversity

FRIENDS OF THE INYO
SINCE 1986

DEFENDERS OF WILDLIFE

COFEM
CONSEJO DE
FEDERACIONES
MEXICANAS®

CENTER for
BIOLOGICAL
DIVERSITY
Because life is good.

CONSERVATION
LANDS
FOUNDATION

Transition Habitat
CONSERVANCY

350
BayArea

CALIFORNIA
NATIVE PLANT
SOCIETY

The SummerTree Institute
Making Environmental Education Irresistible

FACTS
Families Advocating for Chemical & Toxics Safety
A project of Center for Environmental Health

MOJAVE
DESERT
LAND
TRUST

SIERRA CLUB CALIFORNIA

MBCA
morongo basin conservation association

Oswit Land Trust

CactusToCloud Institute

the climate center

September 14, 2023

Email to: naturebasedsolutions@resources.ca.gov

RE: Desert Sector Targets for AB 1757

Dear CNRA, CARB, and CDFA:

Thank you for the opportunity to provide input to the California Natural Resources Agency [CNRA], California Air Resources Board [CARB], and California Department of Food and Agriculture [CDFA] on the importance of desert carbon sequestration as part of AB 1757's commitment to reaching our state's broad climate change goals. We are writing to you as a science-focused subgroup of the 30 X 30 Inland Deserts Working Group, affiliated with the statewide 30 by 30 Power in Nature coalition, to urge CNRA's, CARB's, and CDFA's affiliated staff to read the attached comprehensive report, *Nature Based Solutions: Desert Sector*. Our detailed biographies are in the report.

The California desert region has been largely overlooked as a significant carbon sink for several reasons. First, the scarce aboveground vegetation is visually misleading if one assumes a singular correlation between aboveground biomass and carbon sequestration capacity. This misperception is tied to a second reason for overlooking the desert sector: the desert ecosystem primarily sequesters carbon underground. Finally, as an underfunded research ecosystem, the desert sector remains woefully behind its companion ecosystems such as forests, grasslands, chaparral, and wetlands in terms of quantifying, measuring, and modeling carbon sequestration capacity. But

there is more than sufficient research to make this salient point: the desert lands of California are a significant carbon sink and must be included in regional and global carbon accounting.
Our analysis offers three key takeaway messages:

- The desert's carbon storage process differs significantly from more widely understood sectors such as forests, grasslands, chaparral, and wetlands.
- Due to the distinct carbon storage process found in the desert ecosystem, there is one recommended strategy to maximize the desert sector's contribution to carbon emission reduction: it needs to be left undisturbed.
- Large-scale disturbance of deserts, particularly within critical ecosystems such as creosote bajadas and microphyll woodlands, will not only result in the reduction of California's biodiversity, but also in the removal of a long-term carbon sequestration source, releasing calcite carbon that has been stored for millennia.

Specifically, our recommended target for the desert sector is conservation of 100% of undisturbed non-military public lands annually based on current levels, starting in 2024, and that regions displaying higher densities of microphyll woodlands and creosote bajadas be especially prioritized due to their higher capacity for carbon sequestration.

The discrepancy between our group's recommendation and CARB 's (which is to cut land conversion of deserts and sparsely vegetated landscapes by at least 50 percent annually from current levels, starting in 2025) is based on fundamental characteristics of the unique and fragile desert ecosystem. Whereas a forest ecosystem can be disturbed (harvested) with a relatively brief recovery time, and even managed to restore carbon sequestration over the long term, the desert region has no options for recovery of lost carbon within the time-scale of this planning effort. And once the carbon is stored underground in caliche soil layers, it remains there for upwards of thousands of years if left undisturbed. So it is critical to understand that CARB's recommendation would result in *permanent loss of carbon storage for all desert land that has been disturbed*. Here is further reasoning behind our recommendation:

(1) How the desert captures and stores carbon is unique in process and timescale.
While desert plants do capture and store carbon aboveground in foliage and woody tissue, they store much of their captured carbon deep underground in a massive network of connected roots and fungal root-partners, unlike forests which store most of their carbon aboveground or near the soil surface. Some of this carbon is stored in the tiny but numerous filaments of root-partnering fungi, and because there can be so many miles of fungal hyphae in each cubic foot of desert soil, it is attributed with storing one-third of the world's soil organic carbon. Also, much of the carbon that desert plants capture aboveground from the air eventually turns into inorganic carbon underground in mineralized deposits called calcite or caliche. These calcite/caliche deposits can store captured carbon in this inorganic form for millennia.

(2) Quantification of net ecosystem exchange (NEE).

Our recommendation is based on scientific analysis of photosynthesis data from the desert ecosystem [Appendix A]. In plants and soils, atmospheric CO_2 is absorbed during photosynthesis and released during respiration which can be quantified as "net ecosystem exchange", or NEE. In individual years, it can be highly positive or negative depending on the environmental conditions and the variability is extremely high in deserts.

NEE values are critical in assessing carbon sequestration capacity. In many cases, these are short term datasets. We are desperately in need of long-term background data for good decisions.

Based on surface area in vegetation maps, the extrapolated NEE value amounts to 1.5 to 1.88 million tons of carbon annually pulled out of the atmosphere by desert vegetation.

Based on scientific analysis of photosynthesis data from the desert ecosystem, highest priority should be given to conservation of microphyll woodlands and creosote bajadas. The transfer of atmospheric carbon to desert biomass in microphyll woodlands and creosote shrubland is relatively insensitive to local precipitation. These vegetation types have access to alternate sources of water, including moisture from large rain events even miles away that saturate the soil, and access to groundwater by deep roots. These factors allow plants in microphyll woodlands and creosote bajadas to photosynthesize and sequester carbon through the seasons even without local precipitation. For this reason, it is inaccurate to assume that the arid desert climate equates with poor NEE values that form the basis for carbon sequestration.

(3) The undisturbed desert is a long-term carbon sink.

Carbon storage capacity is a function of both quantity and timescale. The desert ecosystem, long regarded as an insignificant carbon sink, outperforms other ecosystems in carbon storage by holding on to that carbon for longer periods of time if left undisturbed. For instance, while a temperate forest may have an average organic turnover time of 25 years, the desert's turnover time is 38 years. That difference is of a higher magnitude for soil/sediment of each ecosystem: the temperate forest average turnover time is 55 years, but the desert's is much more extended at 200 years. **See Appendix B** for a comparison of average organic carbon turnover in years across a spectrum of ecosystems. Unlike the large storage of organic C in most ecosystems, much of the desert total carbon is stored as calcites, generated from soil respiration. If buried and undisturbed, this carbon can remain sequestered for millennia (Schlesinger 1985). *There could be more than 262 million tons of C stored in California deserts as calcites.*

(4) Modeling.

Our group acknowledges the critical role that modeling will play in projecting, measuring and quantifying carbon sequestration within the desert sector. We recommend an additional carbon sequestration modeling framework to reconcile the desert carbon budgets using an ecohydrology approach. Deep water use (rather than precipitation) of microphyll woodlands and creosote bajadas is a more accurate representation of moisture dynamics for these vegetation types. By incorporating deeper water use and using the normalized difference vegetative index {NDVI} as a driver of CO_2 fixation (Rohde et al. 2021), we produce more accurate modeling projections by linking the NEE to deep carbon sequestration [please see attached *Nature Based Solutions: Desert Sector* report for additional supporting data and studies].

(5) Tools, frameworks, collaborations and investments to deliver recommended targets. There are planning tools currently available that allow decision makers the opportunity to simultaneously develop solar installations on desert lands, while protecting conservation values including carbon sequestration all at once. This is the kind of pioneering work that establishes California as an environmental leader. It is laudable that through your work the California Natural Resources Agency (CNRA) and the CARB will have a better understanding about how Natural and Working Lands can contribute to CARB's total carbon stock percent change of -4% by 2045, but we strongly recommend that *the state energy agencies, California Public Utilities Commission and California Energy Commission, also be closely engaged to ensure on-the-ground consistency* with this unprecedented effort.

One planning tool is the Carnegie Energy and Environmental Compatibility [CEEC] model, a multiple criteria model that quantifies each solar installation based on environmental and technical compatibility. *Techno-ecological synergies [TES] is* a second tool for decision-makers seeking to integrate the advancement of utility-scale solar with conservation of our desert lands. This is a framework proposed by a group of researchers led by Dr. Rebecca R. Hernandez of UC Davis which engineers the mutually beneficial relationships between technological and ecological systems to bolster the sustainability of solar energy across a suite of environments including land, water, and built-up systems. Details for both of these planning tools are available in our report.

*There are alternative options to disturbance of intact desert lands***.** We recognize that there is an urgent need to transition to clean energy. Although perhaps well-intended, development of large-scale utility projects across previously undisturbed desert lands is counterproductive. Disruption of desert soils and vegetation releases significant carbon back into the atmosphere, defeating the purpose of natural and working lands utilized as a natural carbon sink. Further, such development on intact lands is not necessary because there are numerous feasible options for developing utility scale solar in California that can deliver the state-estimated need for 70,000 MW of new utility scale solar (CEC 2021) which, if entirely ground-mounted with current technology, would require approximately 350,000 acres of land. Some of these options include:

  - Water-deprived ag lands in the Central Valley estimated to be a minimum of 500,000 acres (Hanak et al, 2019) or as much as 900,000 acres (Escriva-Bou et al, 2023)
  - 250,000+ acres of selenium- contaminated land in the Westlands Water District
  - 200,000+ acres of parking lots in California (USGS 2019)
  - 11,500 megawatts on commercial/industrial rooftops near substations (RETI 2009), with far greater rooftop potential today
  - 4,000 miles of canals and 16,000 miles of highway right of ways
  - Agrivoltaics (ie, slightly elevated or spaced photovoltaic panels) on a portion of the 25+ million acres of farm and ranch lands throughout the state

Investments needed to deliver on targets. Our group has assessed a long-standing need to invest in scientific, peer-reviewed research relevant to identifying, mapping, quantifying, and modeling carbon sequestration in arid desert lands. The desert ecosystem is far behind other ecosystems in obtaining measurable data critical for 30X30 work. There is adequate data to confirm the existence of carbon sequestered underground in the desert, but substantial gaps exist for more granular analysis.

Additionally, we strongly recommend investment in expansion of already existing tools, and consultation with experts in integrating conservation strategies in the desert with technology. For example, the work of Dr. Rebecca Hernandez from UC Davis and her team would provide a mechanism for achieving the dual goals of desert conservation while utilizing technology schemes to maximize carbon sequestration in the desert and protecting biodiversity.

Additional benefits of desert land conservation. Conserving intact desert lands offers additional benefits that are essential to 30 X 30 goals. Conservation of undisturbed desert lands provides protection for one of the most biodiverse ecosystems on the planet. So-called desert “wastelands” are not only richer from a biodiversity standpoint, but they also appear to be incubators of speciation, with many species occurring nowhere else on earth. A recently published study, Pillay et al. (2022, *Frontiers in Ecology and the Environment*, vol. 20, issue 1) looked at patterns of vertebrate animal species richness across our planet. As expected, they found that the tropics ranked number one. However, deserts were the next most species-rich biome when it came to mammals, birds, and reptiles, higher than temperate forests, shrublands, and grasslands. Critical health benefits are conferred by conservation of undisturbed desert lands which include preventing mobilization of dangerous desert dust particulates that contribute to a suite of respiratory illnesses (particularly among disadvantaged communities), and sustaining economic stability provided by tourism and recreation to the desert region’s intact landscapes.

Conclusion.

Our recommendation that the best strategy for employing natural and working lands in the desert region is ***conservation of 100% of undisturbed non-military public lands annually based on***

current levels, starting in 2024 is based on a foundation of scientific literature. The carbon sequestration process in California's deserts occurs primarily underground, and avoidance of disturbance to desert soils is the means to maximize carbon sequestration within the desert sector.

Thank you for the opportunity to contribute comments. We stand by for further discussion and to provide additional guidance.

Sincerely,

Dr. Michael Allen, Ph.D.
Distinguished Professor Emeritus, Department of Microbiology and Plant Pathology
University of California, Riverside

Dr. Cameron Barrows, Ph.D**.**
Conservation Ecologist Emeritus, Center for Conservation Biology
University of California Riverside

Colin Barrows
Co-founder, CactusToCloud Institute

Susy Boyd, MNR
Master of Natural Resources, Oregon State University
Public Policy Coordinator, Mojave Desert Land Trust

Pat Flanagan, B.A.
Biology, California State University, Long Beach
Board member, Morongo Basin Conservation Association

Robin Kobaly, M.S.
Biology and Plant Ecology, University of California, Riverside
Executive Director, The Summertree Institute.

Arch McCulloch, M.S.
Computer Science, Azusa Pacific University.
B.S. Geology / Computer Science, California State University, Dominguez Hills.
Board member, Morongo Basin Conservation Association
Board member, Mojave Desert Chapter of California Native Plant Society.

Joan Taylor
Chairperson, California/Nevada Desert Committee of Sierra Club

Daniel Gluesenkamp, PhD
Executive Director
California Institute for Biodiversity

Wendy Schneider
Executive Director
Friends of the Inyo

Mason Voehl
Executive Director
Amargosa Conservancy

Robin Kobaly
Executive Director
The SummerTree Institute

Kelly Herbinson
Cody Hanford
Joint Executive Directors
Mojave Desert Land Trust

Sam Easley
Executive Director
Transition Habitat Conservancy

Mahtisa Djahangiri
Campaign Strategist
Sierra Club California

Lisa T. Belenky
Senior Counsel
Center for Biological Diversity

Jora Fogg
Associate Program Director
Conservation Lands Foundation

Claire Broome
Clean Energy Team Lead
350 Bay Area

Jenny Wilder
Apple Valley, CA

Sendy Hernández Orellana Barrows
Conservation Program Manager
Council of Mexican Federations (COFEM)
Co-Lead, 30x30 Inland Deserts Working Group

Colin Barrows
Co-Founder
CactusToCloud Institute

Bettina Rosmarino
Land Acquisition Project Manager
Oswit Land Trust

Baani Behniwal
Natural Sequestration Initiative Manager
The Climate Center

Steve Bardwell
President
Morongo Basin Conservation Association

Pamela Flick
California Program Director
Defenders of Wildlife

Nick Jensen, PhD
Conservation Program Director
California Native Plant Society

Lendri Purcell
President
Families Advocating for Chemical and Toxics Safety

Appendix A

Comparison of desert regions with other ecosystems of published net ecosystem exchange [NEE].

Mesquite stands [Desert]	200 kg.ha^{-1}y^{-1} [[Huxman et al. 2004]
Creosote bajada [Desert]	1,000 kg ha^{-1}y^{-1} [Jasoni et al. 2005]
Baja California [wet year]	520 kg ha^{-1}y^{-1} [Hastings et al. 2005]
Sky Island coniferous forest above SoCal de	300 kg ha^{-1}y^{-1} [Allen et al. 2014)
Chaparral [100 y/o, wet year]	520 kg ha^{-1}y^{-1}
Sky Island coniferous forest above SoCal deserts	300 kg ha^{-1}y^{-1} [Allen et al. 2014]
Chaparral [100 y/o, drought year	180 kg ha^{-1}y^{-1}
La Selva tropical rainforest	3,000 kg ha^{-1}y^{-1}
Boreal forest	780 kg ha^{-1}y^{-1}

Appendix B

Deserts undertake the conversion of CO2 (from soil respiration) into calcites. Deserts effectively store both calcites and organic carbon. The table below illustrates average turnover time (years) of organic carbon in both ecosystem types and soil/sediments.
Desert organic carbon once fixed stays in the system longer than in other ecosystems, releasing back to the atmosphere slowly. This storage benefit is most notably pronounced in desert soil and sediment. Calcites, layered into caliche, form from autotrophic respiration from deep roots and symbiotic microbes, and from heterotrophic respiration from the transferred organic matter. Disturbance to desert lands undermines the carbon storage process. Importantly, buried calcites are dissolved upon exposure to air and water. Upon exposure, the CO_2 in calcium carbonates can be released from disturbed soils up to $2.4g\ C \cdot m^{-2} \cdot day^{-1}$, or $24\ kgC \cdot ha^{-1} \cdot day^{-1}$ following a precipitation event (Swanson 2017).

Ecosystem Type	**Ecosystem Organic C Turnover Time**	**Soil/Sediment Organic C Turnover Time**
Desert	38 years	200 years
Temperate forest	25 years	55
Cropland	22 years	40
Perennial grassland	36 years	100

Reichie 2020

References

Allen, M.F., Kitajima, K., and Hernandez, R.R. (2014). "Mycorrhizae and Global Change," in *Trees in a Changing Environment: Ecophysiology, Adaptation, and Future Survival*, eds. M. Tausz & N. Grulke.), 37-59.

Alvar Escriva-Bou, Ellen Hanak, Spencer Cole, Josué Medellín-Azuara. 2023. The Future of Agriculture in the San Joaquin Valley: Public Policy Institute of California

California Energy Commission. 2021. SB 100 Joint Agency Report March 2021: CEC-200-2021-001.

E3 and Black & Veatch. 2009. Summary of PV Potential Assessment in RETI and the 33% Implementation Analysis, CPUC Re-DEC Working Group Meeting, December 9, 2009, p. 24.

Geological Survey data release. 2019. https://doi.org/10.5066/P9UTMB64

Hanak E, Lund J, Arnold B, et al. 2017. Water stress and a Changing San Joaquin Valley. San Francisco, California: Public Policy Institute of California.

Hastings, S.J., Oechel, W.C., and Muhlia-Melo, A. (2005). Diurnal, seasonal and annual variation in the net ecosystem CO2 exchange of a desert shrub community (Sarcocaulescent) in Baja California, Mexico. *Global Change Biology* 11(6)**,** 927-939. doi: 10.1111/j.1365-2486.2005.00951.x.

Hernandez, R. R., Armstrong, A., Burney, J., Ryan, G., Moore-O'Leary, K. A., Diedhiou, I., Grodsky, S. M., Saul-Gershenz, L. S., Davis, R., Macknick, J., Mulvaney, D., Heath, G., Easter, S. B., Hoffacker,M. K., Allen, M. F., & Kammen, D. M. (2019). Techno–ecological synergies of solar energy for global sustainability. *Nature Sustainability*, *2*(7), 560–568. https://doi.org/10.1038/s41893-019-0309-z

Hernandez, R., Hoffacker, M., Murphy-Mariscal, M. et al., Solar energy development impacts on land cover change and protected areas. (2016). *Proceedings of the National Academy of Sciences of the United States of America*, *113*(12), E1768. https://doi.org/10.1073/pnas.1602975113

Huxman, T.E., Snyder, K.A., Tissue, D., Leffler, A.J., Ogle, K., Pockman, W.T., et al. (2004). Precipitation pulses and carbon fluxes in semiarid and arid ecosystems. *Oecologia* 141(2)**,** 254-268. doi: 10.1007/s00442-004-1682-4.

Jasoni, R.L., Smith, S.D., and Arnone, J.A.I. (2005). Net ecosystem CO2 exchange in Mojave Desert shrublands during the eigth year of exposure to elevated CO2. *Global Change Biology* 11**,** 749-756. doi: 10.1111/j.1365-2486.2005.00948.x.

Reichle, D.E. (2020). "Chapter 8 - Energy flow in ecosystems," in *The Global Carbon Cycle and Climate Change*, ed. D.E. Reichle. Elsevier), 119-156.

Rohde, M.M., Stella, J.C., Roberts, D.A., and Singer, M.B. (2021). Groundwater dependence of riparian woodlands and the disrupting effect of anthropogenically altered streamflow. *Proceedings of the National Academy of Sciences of the United States of America* 118(25). doi: 10.1073/pnas.2026453118|1of7.

Schlesinger, W.H. (1985). The formation of caliche in soils of the Mojave-desert, California. *Geochimica Et Cosmochimica Acta* 49(1)**,** 57-66. doi: 10.1016/0016-7037(85)90191-7.

Swanson, A.C. (2017). *Disturbance, restoration, and soil carbon dynamics in desert and tropical ecosystems.* Ph.D., University of California-Riverside.