Stacking Energy and Ecological Systems

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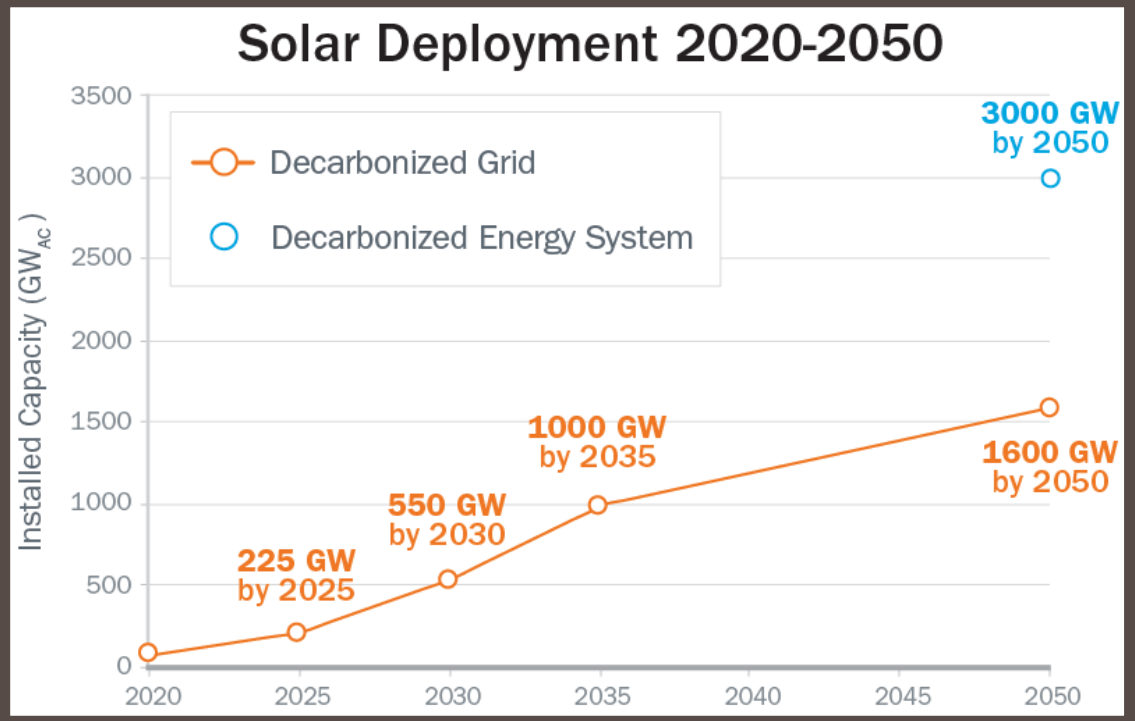
Solar Deployment – Rising Expectations



Solar Futures Study

Preliminary modeling shows that decarbonizing the entire U.S. energy system could result in as much as 3,200 GW_{ac} of solar energy. . .

Solar Futures Study, DOE SETO 2021

Concretely, this would require the deployment of roughly 2,500 gigawatts (GW) of wind and solar generation (30 times present capacity) in a high renewables scenario . . .

Williams et al. 2014

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Bifacial PV

- How does site management and materials impact bifacial PV performance?
- How does site management and materials impact bifacial PV temperature and albedo?
- How *sustainable* are such materials?

Home › News › Better understanding of 'albedo' will unlock funding in bifacial solar

News | Renewables | Solar | Strategic Development | World Regions

Better understanding of 'albedo' will unlock funding in bifacial solar

nicholasnhede - September 29, 2021

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Image by Bruno /Gerr

One Earth

Gold Standard for the Global Goals | 1 ton of CO_2 offset

CellPress

Review

Sand, gravel, and UN Sustainable Development Goals: Conflicts, synergies, and pathways forward

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SUMMARY

Sand, gravel, and crushed stone are the most mined materials on Earth. Aggregates constitute the foundation for modern civilization and are essential for providing shelter, infrastructure, and communication, but are an increasingly scarce resource. Here, we review the interconnections between the impacts of aggregate mining and the services they provide. We show that the conflicting impacts on the environment and humankind disrupt the net positive effects of aggregate mining on sustainable development. Focusing on low- and middle-income countries, we link these interconnections to the United Nations Sustainable Development Goals and identify critical obstacles to a sustainable future for global aggregate resources. Our assessment identifies an urgent need to improve knowledge on: (1) direct and indirect impacts of extraction on human health, (2) system-level impacts on ecosystems and the services they provide, and (3) how to meet the projected trajectories of global aggregate demand.

INTRODUCTION

Sand, gravel, and crushed stone (collectively referred to herein as aggregates) are the most in-demand materials on the planet in terms of volume.[1,2] Together, they are a central foundation of our economies and integral to sectors such as construction,

development within the country of origin. Yet aggregates play an increasingly important role in many economies, providing access to basic housing and public infrastructures and livelihoods for large numbers of informal miners in low- and middle-income countries (LMICs).[3]

Despite the central importance of aggregates, the impact of

metal commodities, and these products are often exported to markets in high-income countries (HICs), management and governance do not take into account the central importance of aggregate resources in the planning of future sustainable

aggregate extraction on the environment and society, covering economic development, global trade, and inequality, as well as landscape changes, ecosystem implications, and environmental health, while providing a broad variety of examples of its implications. Second, we present the first assessment of potential

One Earth 4, August 20, 2021 © 2021 Elsevier Inc. 1095

" . . .conflicts related to ecological destruction, livelihood disruption and labour rights violations."

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Sixth Mass Extinction – Meet 30 x 30 Vision



bridled white-eye, ivory-billed woodpecker, Bachman's warbler

little Mariana fruit bat

On September 29th 2021, the U.S. Fish and Wildlife Service declared 23 species (see slide), including nine birds and one bat species, officially extinct.

Currently, only 12% of US land, 11% of freshwaters, and 26% of oceans have some degree of conservation-based protection.

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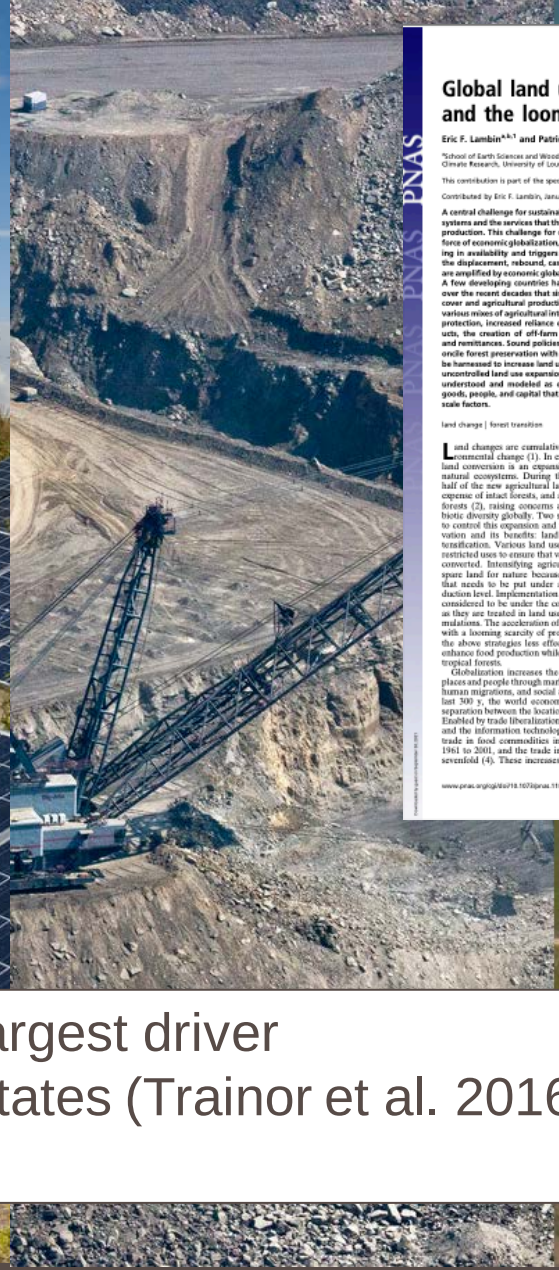

Global land use change, economic globalization, and the looming land scarcity

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Contributed by Eric F. Lambin, January 18, 2011 (sent for review November 21, 2010)

A central challenge for sustainability is how to preserve forest ecosystems and the services that they provide us while enhancing food production. This challenge for developing countries confronts the force of economic globalization, which seeks cropland that is shrinking in availability and triggers deforestation. Four mechanisms—the displacement, rebound, cascade, and remittance effects—that are amplified by economic globalization accelerate land conversion. A few developing countries have managed a land use transition over the recent decades that simultaneously increased their forest cover and agricultural production. These countries have relied on various mixes of agricultural intensification, land use zoning, forest protection, increased reliance on imported food and wood products, the creation of off-farm jobs, foreign capital investments, and remittances. Sound policies and innovations can therefore reconcile forest preservation with food production. Globalization can be harnessed to increase land use efficiency rather than leading to uncontrolled land use expansion. To do so, land systems should be understood and modeled as open systems with large flows of goods, people, and capital that connect local land use with global-scale factors.

land change | forest transition

Land changes are cumulatively a major driver of global environmental change (1). In extent, the most important form of land conversion is an expansion of crop and pastoral land in natural ecosystems. During the 1980–2000 period, more than half of the new agricultural land across the tropics came at the expense of intact forests, and another 28% came from disturbed forests (2), raising concerns about environmental services and biotic diversity globally. Two strategies are commonly proposed to control this expansion and therefore promote nature conservation and its benefits: land use zoning and agricultural intensification. Various land use zoning schemes allocate land to restricted uses to ensure that valuable natural ecosystems are not converted. Intensifying agriculture, in contrast, is thought to spare land for nature because higher yields decrease the area that needs to be put under agriculture to reach a given production level. Implementation of these two strategies is generally considered to be under the control of national policies, at least as they are treated in land use change modeling and policy formulations. The acceleration of economic globalization in tandem with a looming scarcity of productive land globally may render the above strategies less effective in promoting land uses that enhance food production while preserving ecosystems, especially tropical forests.

Globalization increases the worldwide interconnectedness of places and people through markets, information and capital flows, human migrations, and social and political institutions. Over the last 300 y, the world economy has experienced an increasing separation between the location of production and consumption. Enabled by trade liberalization, progress in transport technology, and the information technology revolution (3), the cross-border trade in food commodities increased more than fivefold from 1961 to 2001, and the trade in all raw wood products increased sevenfold (4). These increases were registered by those in total and per capita volumes of freight movement, and in the proportion of freight moving over very large distances (5).

Agricultural intensification or land use zoning in a country may trigger compensating changes in trade flows and, thus, affect indirectly land use in other countries. Between 2000 and 2005, tropical deforestation was positively correlated with urban population growth and exports of agricultural products (6), except in sub-Saharan Africa. Urban and wealthy nation consumers have higher consumption levels than rural inhabitants in tropical regions where agricultural expansion takes place, thus increasing the level of production stresses there. Economic globalization also increases the influence of large agribusiness enterprises and international financial flows on local land use decisions, in some cases weakening national policies intended to promote a public good. However, trade also carries the potential to increase global land use efficiency by allowing for regional specialization in land use and productivity increases as a response to a global shortage of productive land.

This paper analyzes the challenges and opportunities for preserving natural forest ecosystems while enhancing food production in tropical developing countries under conditions of scarcity of unused productive cropland and economic globalization. It does so by drawing on examples from a few developing countries that have succeeded in increasing simultaneously their forest cover and agricultural production. These successes suggest that designing policies to reconcile development with nature conservation requires understanding land change as part of global-scale, open systems.

Conceptual Framework

The area available for nature conservation can be represented as:

$$\text{Land for nature} = \text{Total land area} - (\text{Agricultural area} + \text{Settlements}) \quad [1]$$

This view asserts that to maximize the land allocated for nature conservation, the land area used to produce agricultural output must be minimized (7), taking into account geographic variations in ecological attributes, land quality, and the availability of production factors. At a global scale, the demand for a given agricultural product should be equal to its supply. The required agricultural area is given by the global food equation (8), for a product i:

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The authors declare no conflict of interest.

Freely available online through the PNAS open access option.

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Energy development is now the largest driver of land-use and land-cover change in United States (Trainor et al. 2016, *PLOS One*).

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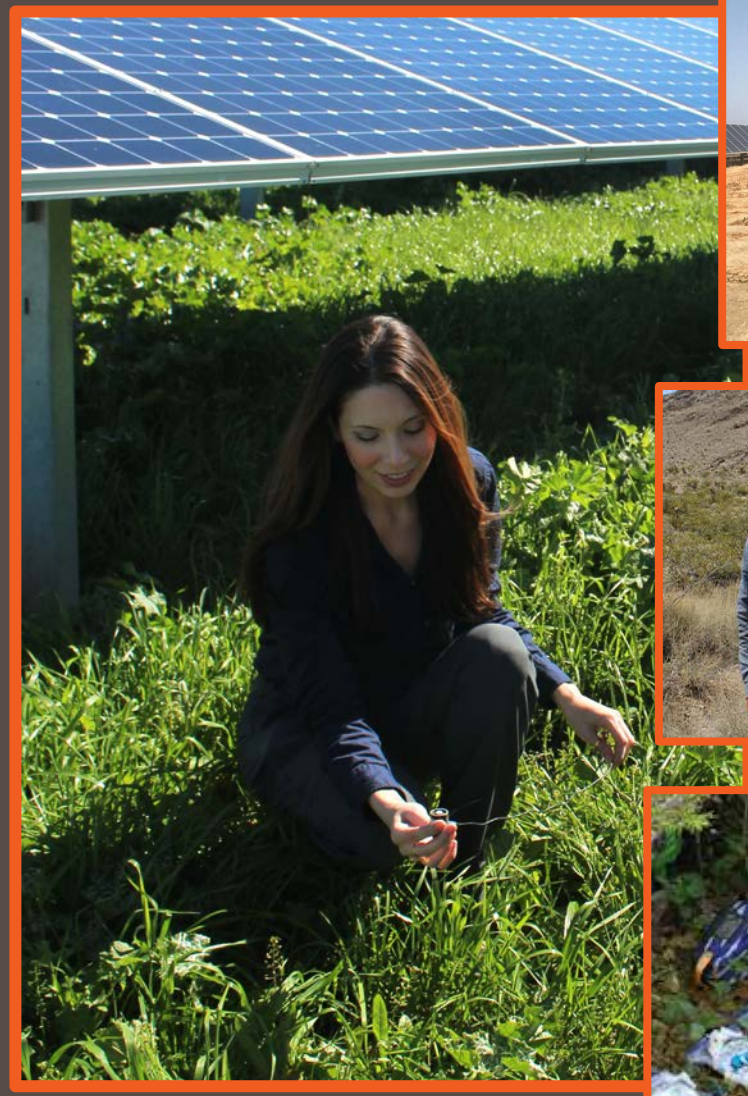

How will we meet our rapid renewable energy goals while maintaining our need for food production and conservation?

WildENERGY UCDAVIS

ARIDLAB
aridlands | ecology | sustainability

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Stacking Energy Systems & Ecosystems Outcomes

Ecological Restoration for Techno-Ecological Synergies of Solar Energy:

Promoting Vegetation, Pollinators, Soil Quality, and Ecosystem Services

Study Site: The Sacramento Municipal Utility District's Rancho Seco II ground-mounted solar PV site.

Ecological restoration at solar energy facilities may serve as a mechanism to increase techno-ecological synergies of solar energy development, yet both the practical implementation and potential benefits of restoration is understudied.

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California Prairie – An endangered ecosystem . . .

Vegetation in the Central Valley of California was historically characterized as a flower-dominated prairie biome.

When naturalists descended into the Central Valley in 1868 and found a sea of flowers, one wrote, "Here it is not as in our great western prairie, flowers sprinkled in grass, but grass in the flowers."

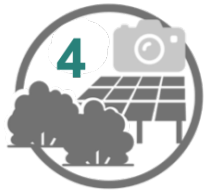
Native California grasslands, with fibrous root systems, are a more resilient C sink than California forests in response to 21st century changes in climate (Dass et al. 2018).

Objectives

Native plant mix selection and re-establishment, across PV array areas (with assessment of PV performance) and as hedgerows

Plant and pollinator habitat assessment, with biodiversity and trait analyses

Soil properties characterization, including of soil carbon sequestration; crevice restoration options for California tiger salamanders



Techno-ecological synergy analysis, including impacts on PV performance and cultural services owing to the beautification of an energy landscape

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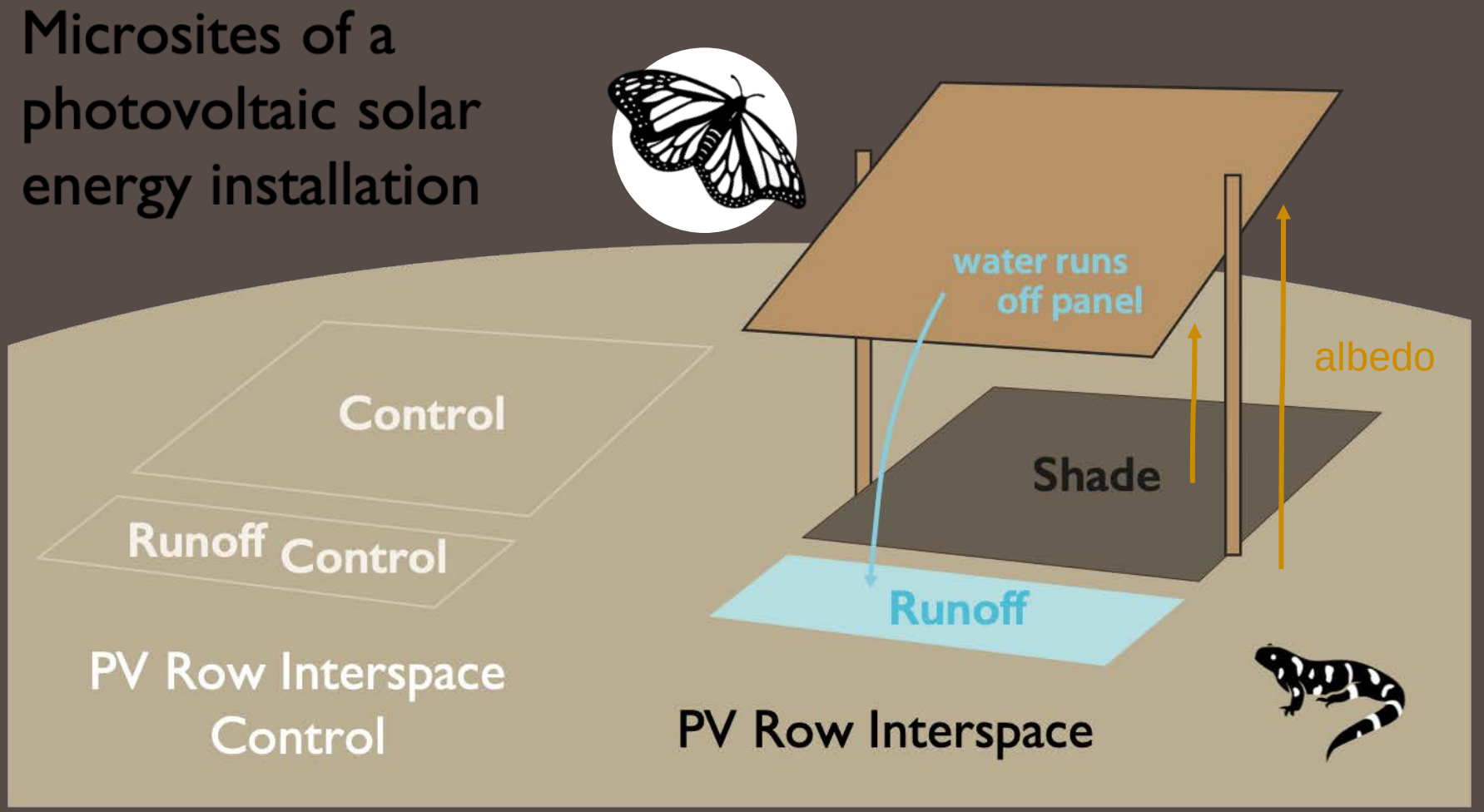
PV-Microsite-Bifacial Performance Feedbacks

Ground-mounted photovoltaic solar energy installations create novel microsites. Restoration across microsites may uniquely impact PV performance, plant establishment, pollinator behavior, and amphibian settlement activities.



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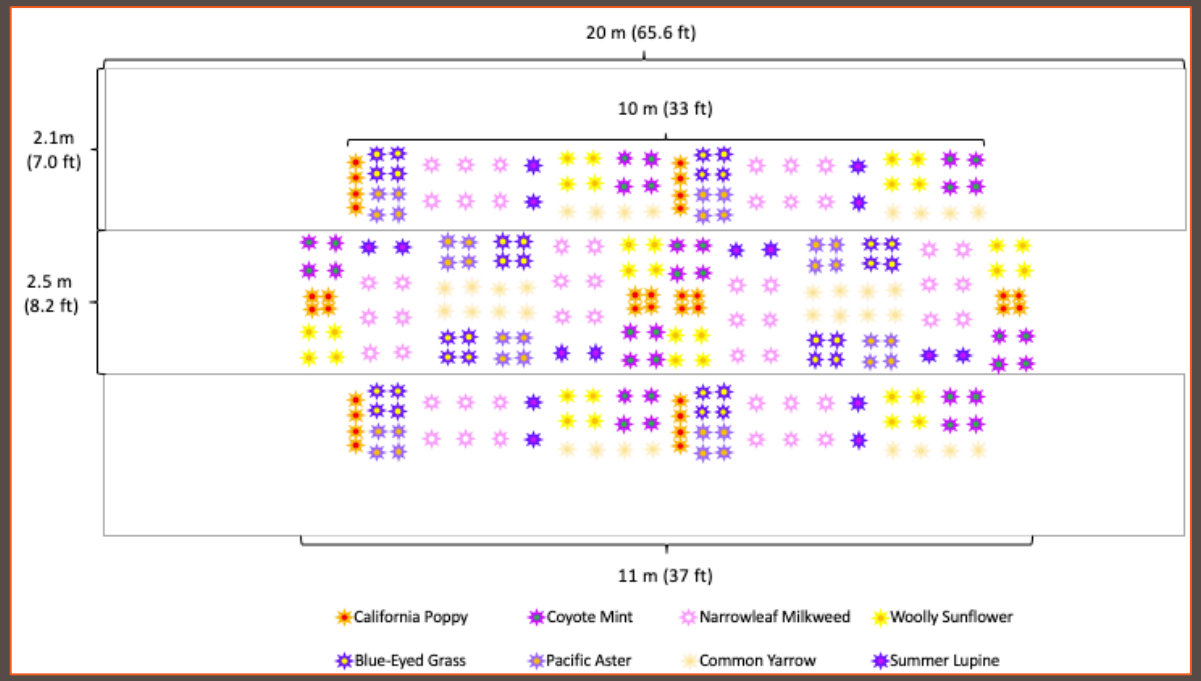
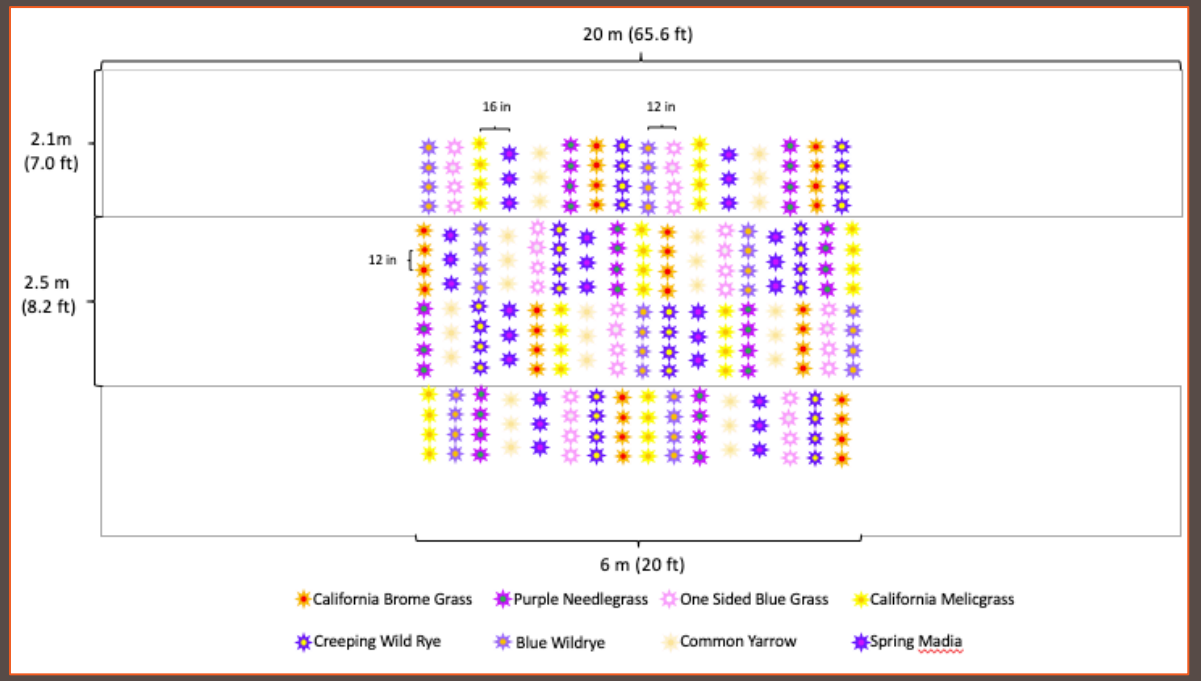
Treatments and Plant Species

Monarch Habitat Treatment



Prairie Habitat Treatment










Soils, Sequestration, and Salamanders

i. Does ecological restoration in a Central Valley PV solar energy facility improve soil carbon sequestration (e.g., owing to fine root production and melanization) and other indicators of soil quality?
ii. What impact does conventional site preparation and ecological restoration have on crevices and burrows of the Central Valley California tiger salamander and can this inform habitat restoration for this threatened species?
iii. What are the perceptions and values of tribal members and tribal-stakeholders towards ecosystem service restoration in a California prairie?

California ground squirrel (*Otospermophilus beecheyi*) or other mammalian-formed burrow at Rancho Seco that California tiger salamanders (*Ambystoma californiense*) may settle in.

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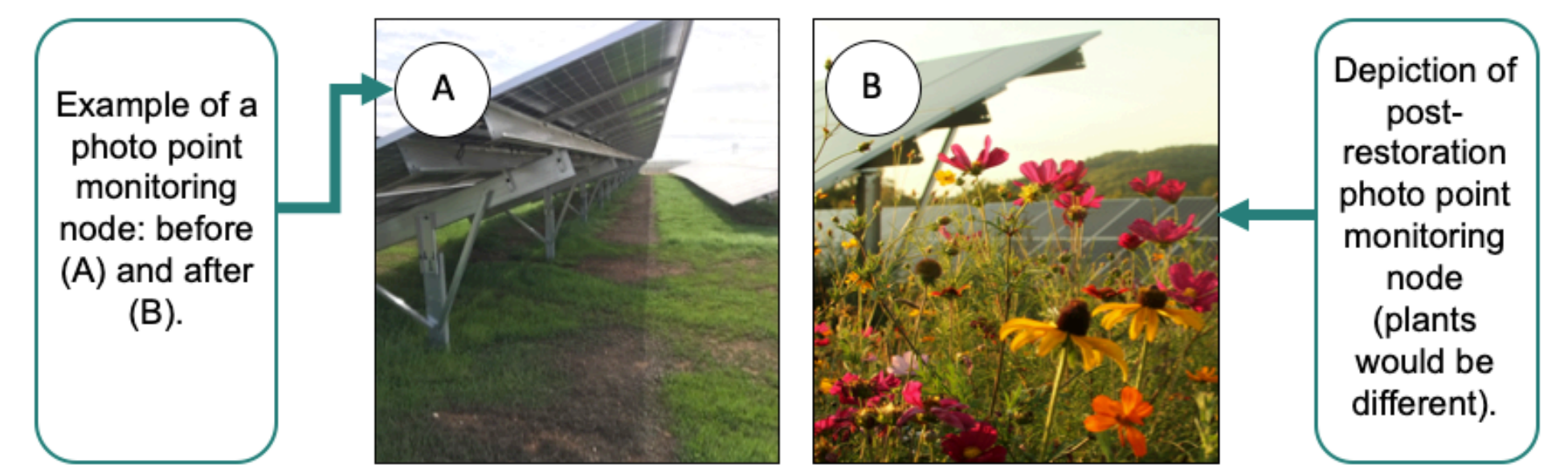
Cultural Services



We will conduct a survey to understand and quantify the role and importance of such restoration efforts on landscape-level aesthetics (i.e., “beautification”), customer satisfaction, corporate responsibility, and the extent to which it serves as a *cultural* ecosystem service.

Cultural ecosystem services are identified as ecosystems providing recreation, aesthetic enjoyment, physical and mental health benefits, and spiritual experiences.

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Stacking Energy Systems & Ecosystems Outcomes

Over the course of four years we anticipate the following outcomes:

1) Practical, science-informed guidance on the stacking of ecosystem restoration and PV solar energy development, emphasizing impacts on PV performance;
2) High impact scientific research outcomes on PV-restoration interactions, including industry- and policy-relevant knowledge (e.g., native vegetation selection, soil carbon sequestration, listed species implications, tribal engagement) for PV development in the Central Valley of California and beyond;
3) Broad-scale quantification of techno-ecological synergies of ecological restoration at solar facilities, and;
4) Educational opportunities, outreach activities, and job training.