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AGRIVOLTAICS IN CALIFORNIA

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December 12, 2023

American Farmland Trust

Founded in 1980

Committed to Saving the Land That Sustains Us

- **Protecting Farmland**
- **Promoting Sound Farming Practices**
- **Keeping Farmers on the Land**

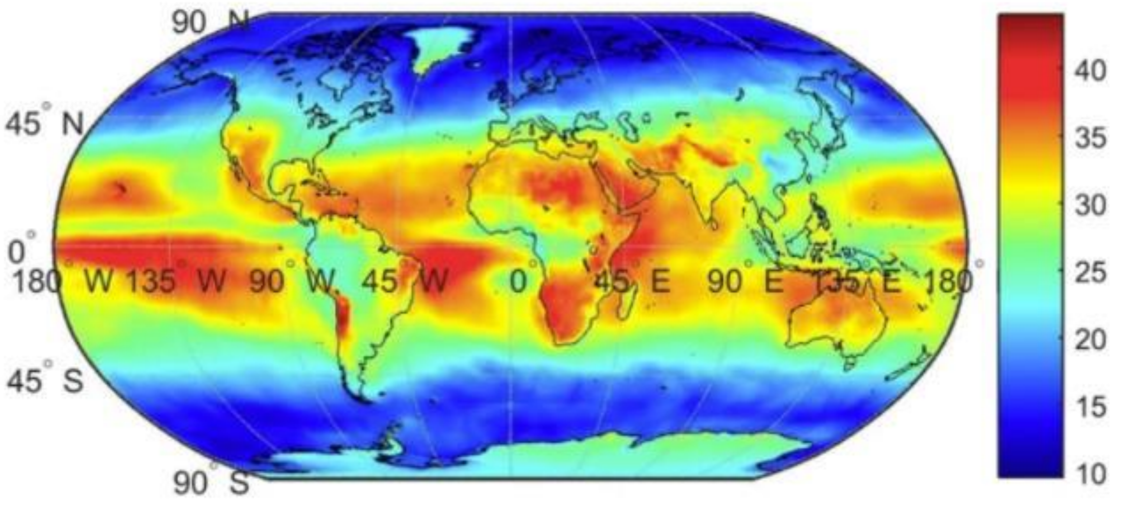
No Farms No Food®
American Farmland Trust

Overview

- Background
- **Why Agrivoltaics?**
- What is Agrivoltaics?
- Benefits & Challenges
- Research
- Q&A

Photo by Werner Slocum / NREL

Land Requirements for Solar



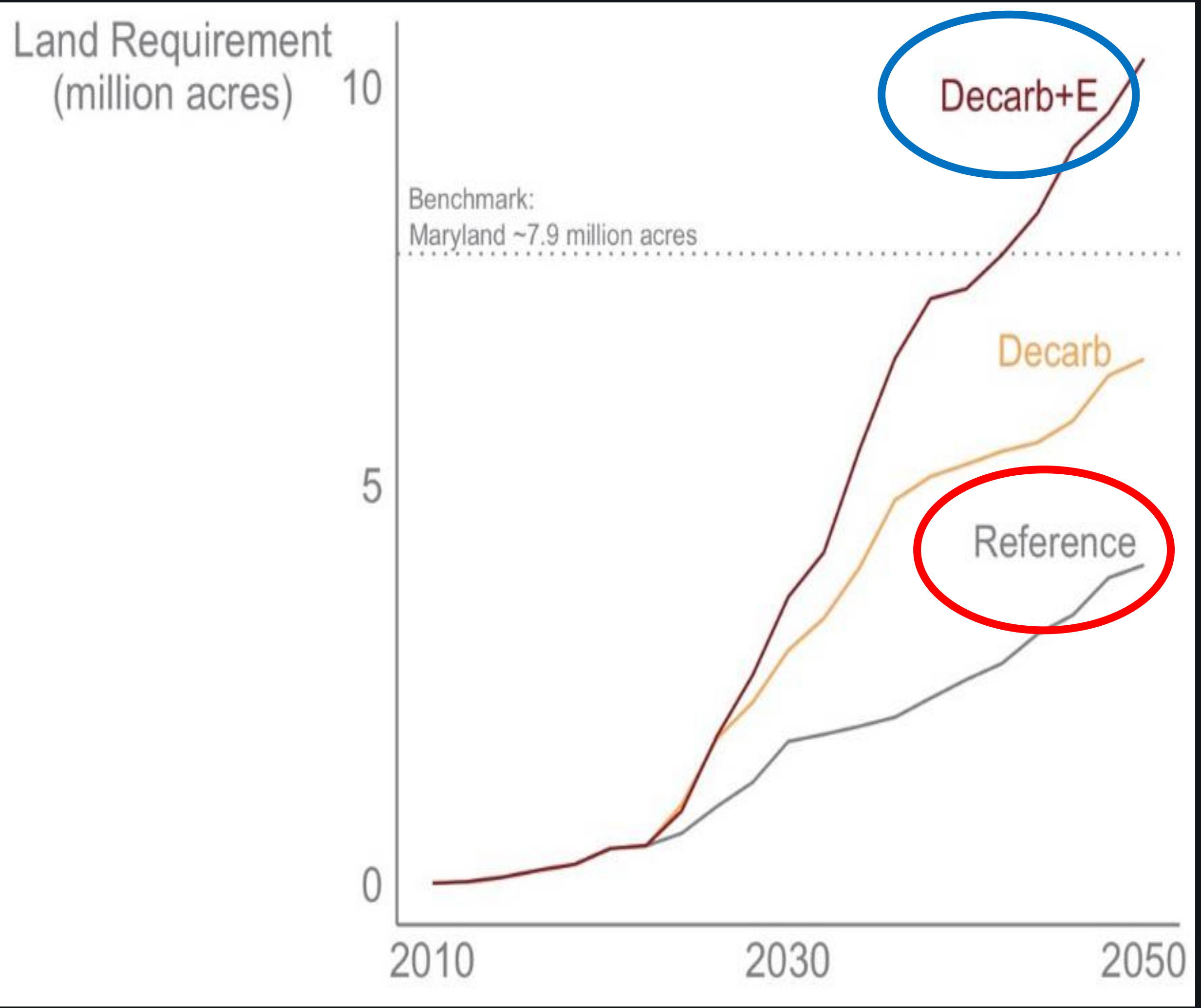
Solar PV Power Potential is Greatest Over Croplands

Elnaz H. Adeh, Stephen P. Good, M. Calaf & Chad W. Higgins

Scientific Reports **9**, Article number: 11442 (2019) | Cite this article

8-10 million acres for solar by 2050

90% in rural communities



Source: DOE SFS

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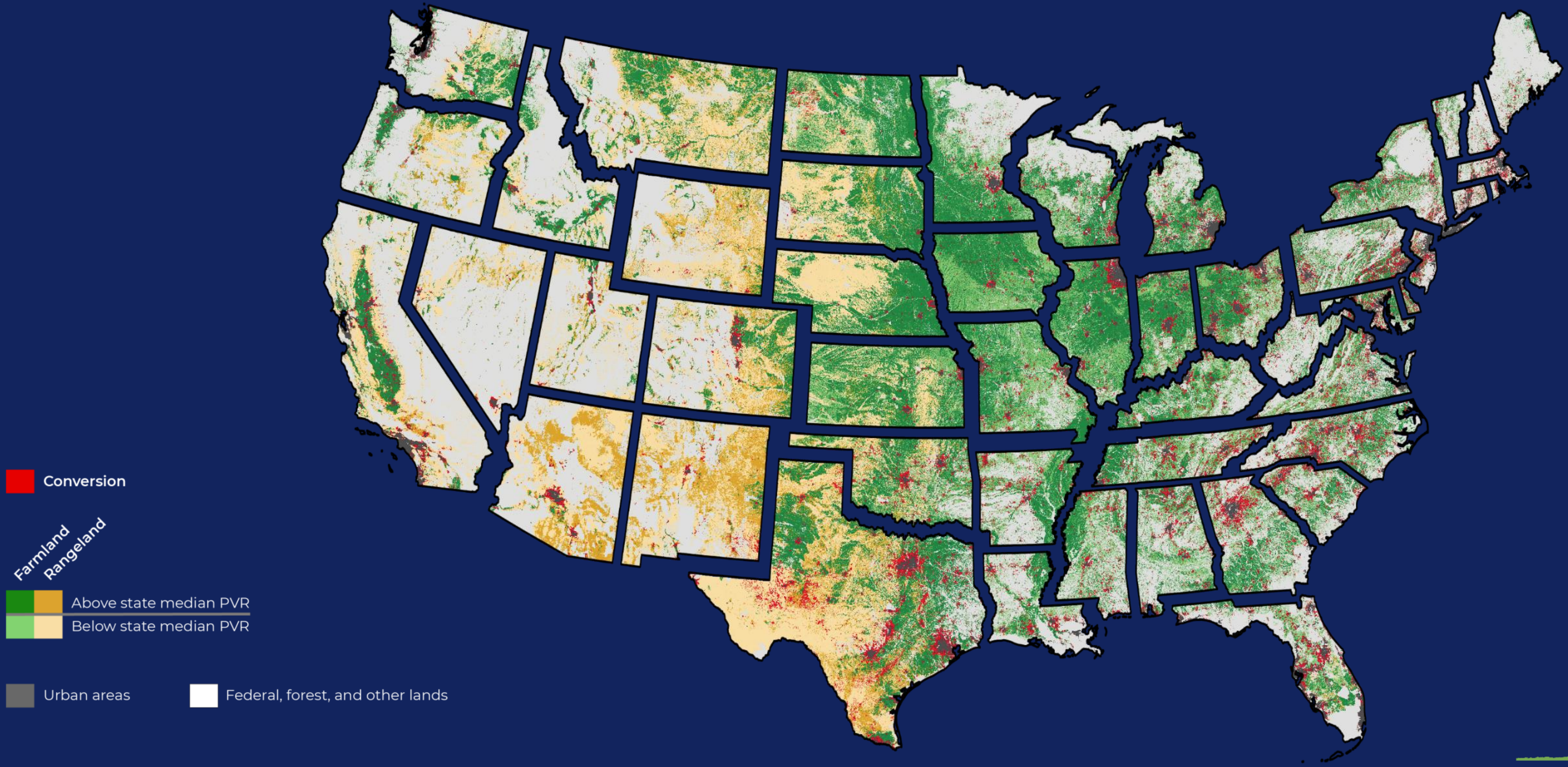
FARMS UNDER THREAT

Smart Solar refers to three equally important goals:

(1) accelerating solar energy development, (2) strengthening farm viability, and (3) safeguarding land well-suited for farming and ranching.



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Dr. Jessica Chiartas
UC Davis
RegenScore

Safeguard the ability for land to be used for **agriculture**

Grow agrivoltaics for agricultural production & solar energy

Prioritize solar siting on **buildings** and land **not** well suited for farming

Promote **equity** and **farm viability**

Smart Solar

farmland.org/solar/

What is Agrivoltaics?

<u>Agri</u>culture + Photo<u>voltaics</u> = Agrivoltaics

Per SB 688 Padilla agrivoltaics are defined as: "solar energy systems integrated into agricultural production within the same land area, also referred to as agrisolar or dual-use solar."


Photo by Werner Slocum / NREL

What is ~~Agrivoltaics?~~ Agriculture?

As defined by the California Agriculture Relations Board agriculture is:

"farming in all its branches...[including] the cultivation and tillage of the soil, dairying, the production, cultivation, growing and harvesting of any agricultural or horticultural commodities, the raising of livestock, bees, fur-bearing animals, or poultry, and any practices performed by a farmer or on a farm as an incident to or in conjunction with such farming operations, including preparation for market and delivery to storage or to market or to carriers for transportation to market."

Photo by Werner Slocum / NREL

Types of Agrivoltaics

- Grazing
- Crop Production
- Greenhouses

Photos: AFT, Silicon Ranch, Soliculture, NREL

What about pollinator habitat?

Pollinator habitat & apiaries alone are **<u>not</u>** agrivoltaics.

Alternative terms:

- Ecovoltaics
- Dual-use solar


Photo by Dennis Schroeder, NREL 52948

Comment | Published: 10 August 2023

Ecovoltaic principles for a more sustainable, ecologically informed solar energy future

Matthew A. Sturchio & Alan K. Knapp

Nature Ecology & Evolution **7**, 1746–1749 (2023) | Cite this article


Photo by Dennis Schroeder, NREL 19912


Photo by CSU

Example Agrivoltaic Configurations

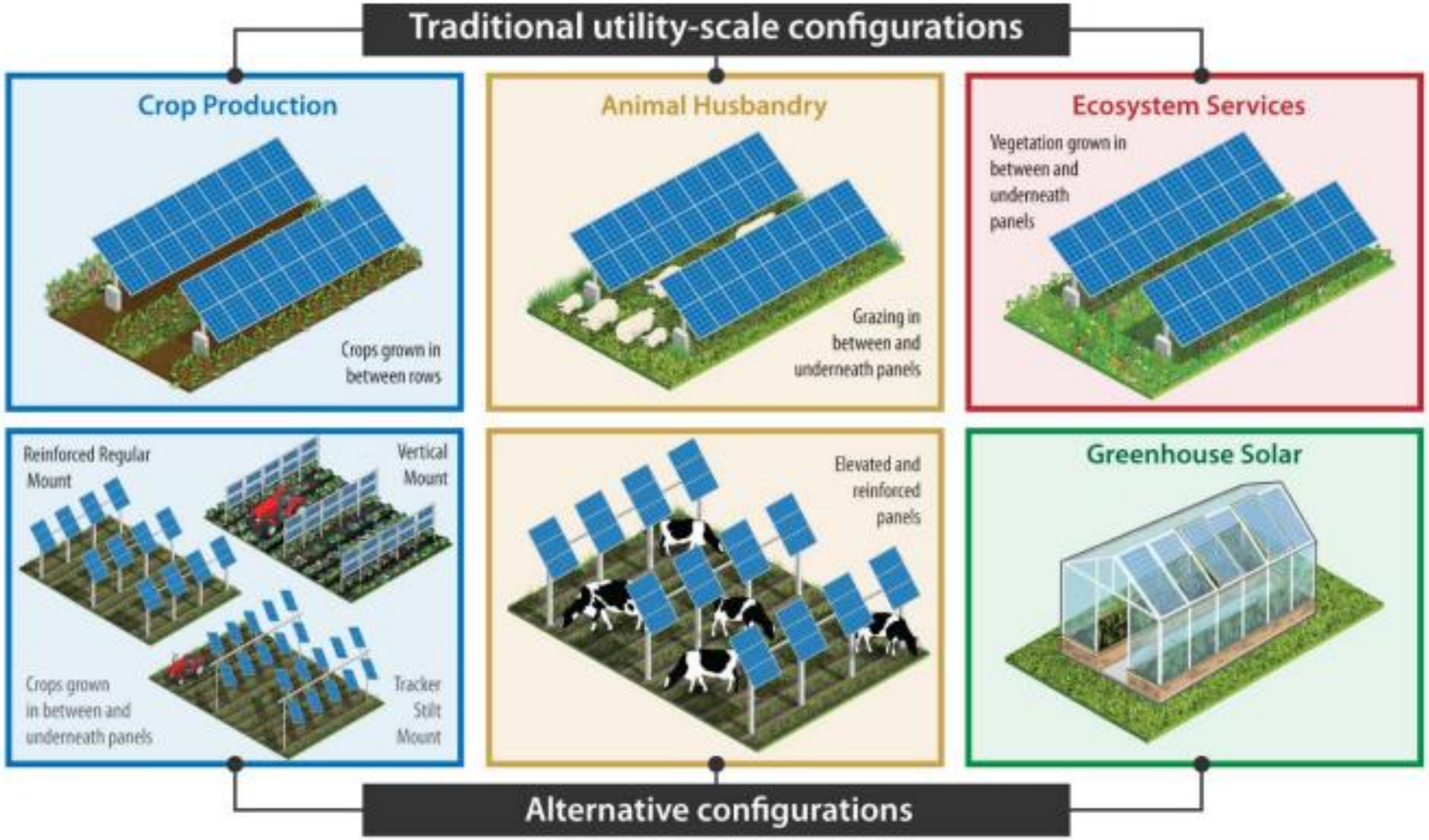


Figure 1. Types of agrivoltaics systems that have been deployed commercially.

Macknick, Jordan, Heidi Hartmann, Greg Barron-Gafford, Brenda Beatty, Robin Burton, Chong Seok Choi, Matthew Davis, Rob Davis, Jorge Figueroa, Amy Garrett, Lexie Hain, Stephen Herbert, Jake Janski, Austin Kinzer, Alan Knapp, Michael Lehan, John Losey, Jake Marley, James MacDonald, James McCall, Lucas Nebert, Sujith Ravi, Jason Schmidt, Brittany Staie, and Leroy Walston. 2022. The 5 Cs of Agrivoltaic Success Factors in the United States: Lessons From the InSPIRE Research Study. Golden, CO: National Renewable Energy Laboratory. NREL/TP-6A20-83566. https://www.nrel.gov/docs/fy22osti/83566.pdf.

Benefits of Agrivoltaics

Food

- Protect crops, livestock from heat stress and drought
- Comparable or improved yields for many crops

Water

- Reduce water use for irrigation by up to 50%
- Increase water use efficiency of crops

Energy

- Improve solar cell efficiency via reduced operating temperatures
- Reduce vegetation management costs

Producers

- Reduce energy and water consumption
- Reduce risk of heat-related illness
- Diversify income

Challenges of Agrivoltaics

Food

- Uncertain impacts on crop yield, nutrition, and flavor
- Potential increase in pest pressure
  - Especially fungus

Water

- Increased spatial variability in moisture distribution

Energy

- Increased capital costs
  - \$0.07 to \$0.80 per W_{DC}
- Increased complexity

Producers

- Negative impacts from construction
- Limited flexibility in farming practices

Agrivoltaics Research: Crops

University of Arizona (Tuscon, AZ)
Barron-Gafford et al. (2019) *Nature Sustainability*

- Chiltepin peppers: ~200% yield increase
- Tomatoes: ~100% yield increase
- Jalapeños: slight decrease

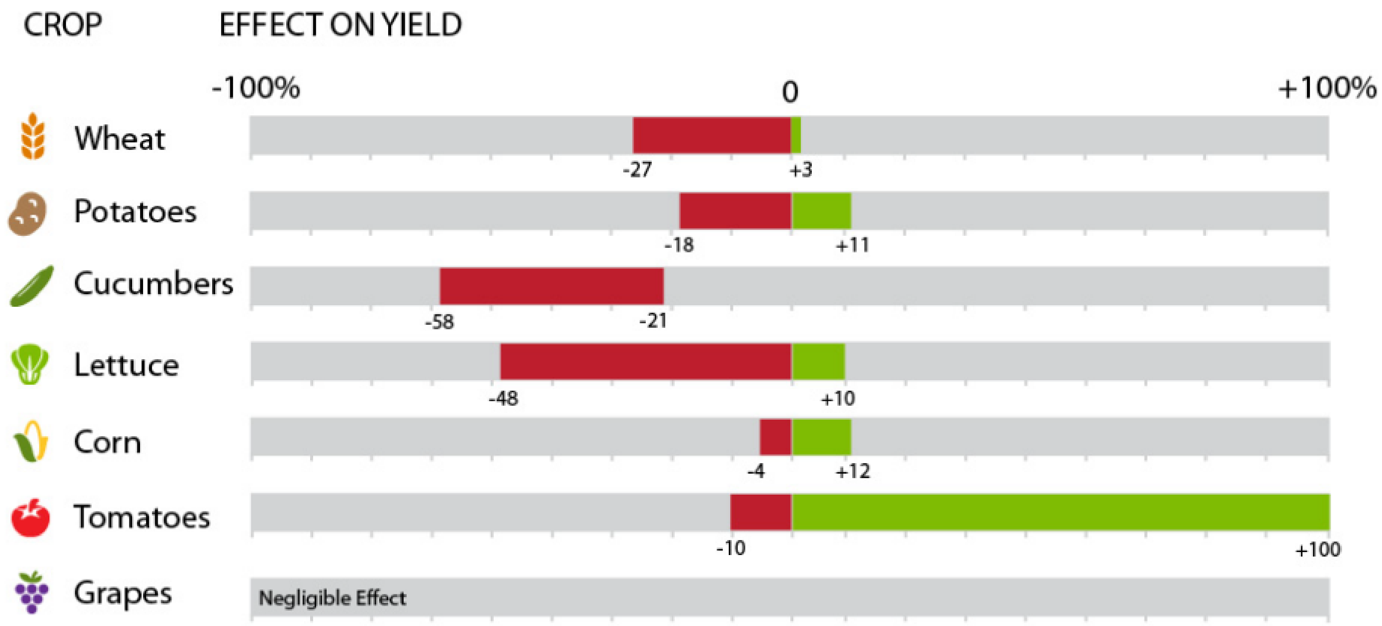
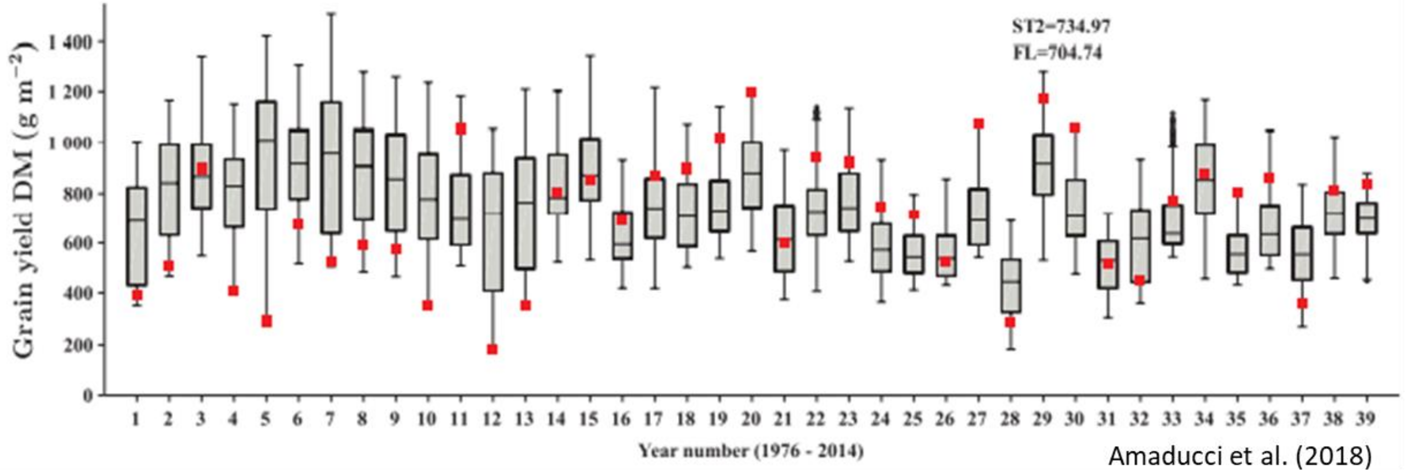


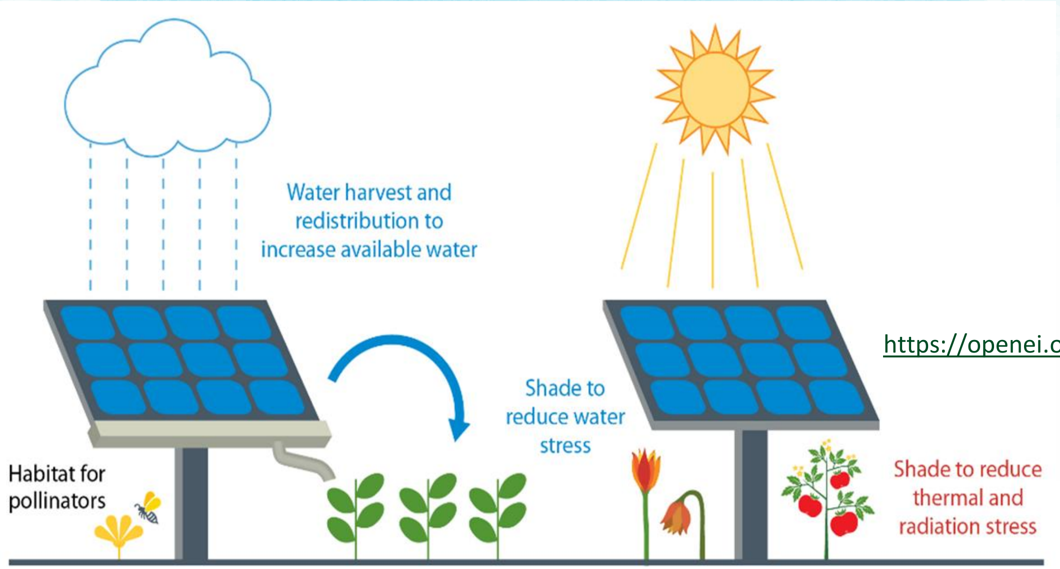
Figure 11. Summary of agrivoltaic crop performance across multiple sites and locations.

Data from (Amaducci et al., 2018; Barron-Gafford et al., 2019; Campana et al., 2018; Campana et al., 2020; Cho et al., 2020; Cossu et al., 2014; Dupraz et al., 2011; Leon and Ishihara, 2018; Marrou et al., 2013a; Marrou et al., 2013b; Prannay et al., 2017; Sukiyama and Nagashima, 2017; Trommsdorff et al., 2021; Valle et al., 2017)

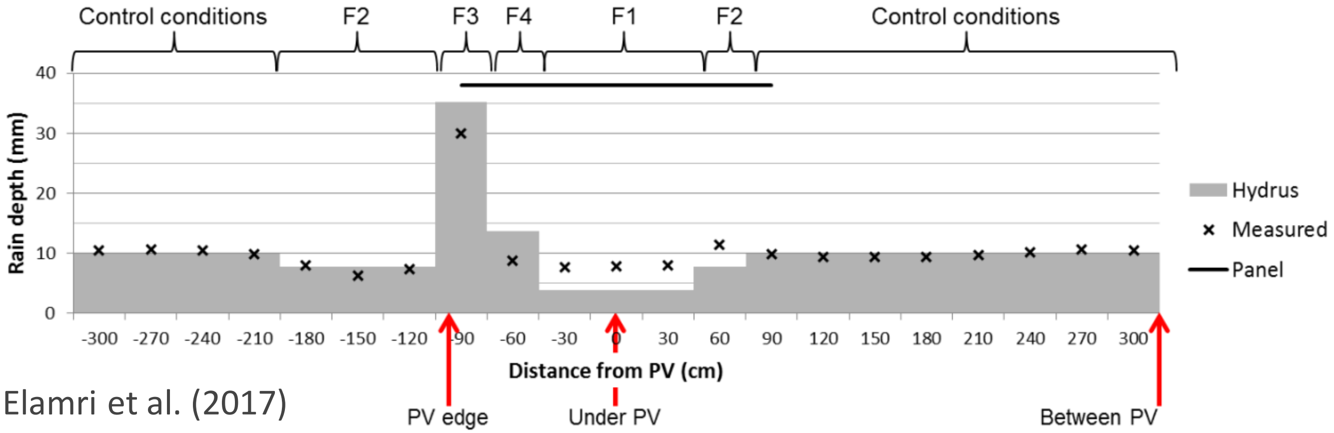


Amaducci et al. (2018)

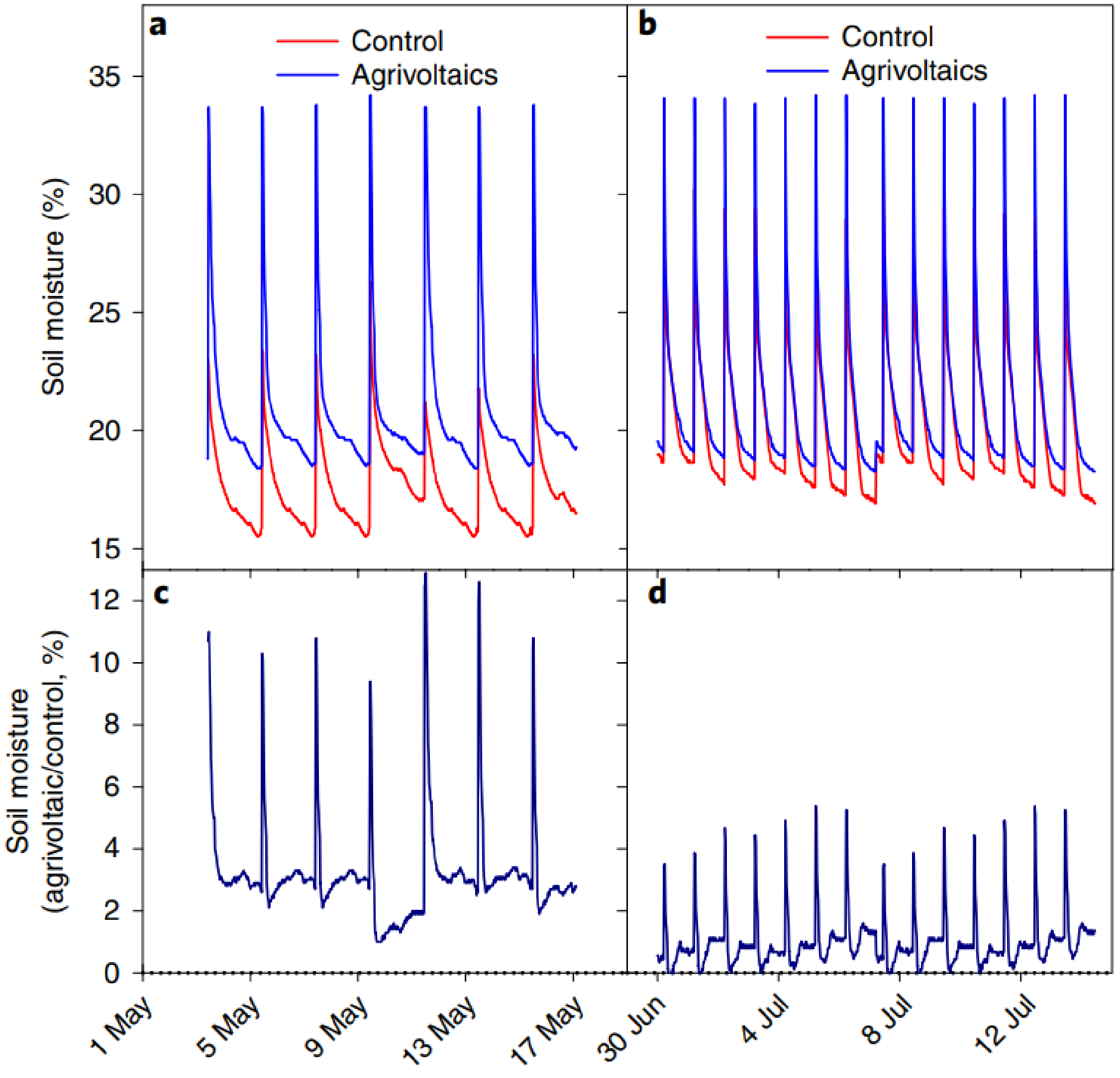
Agrivoltaics Research: Water



https://openei.org/wiki/InSPIRE



Elamri et al. (2017)



University of Arizona (Tuscon, AZ)

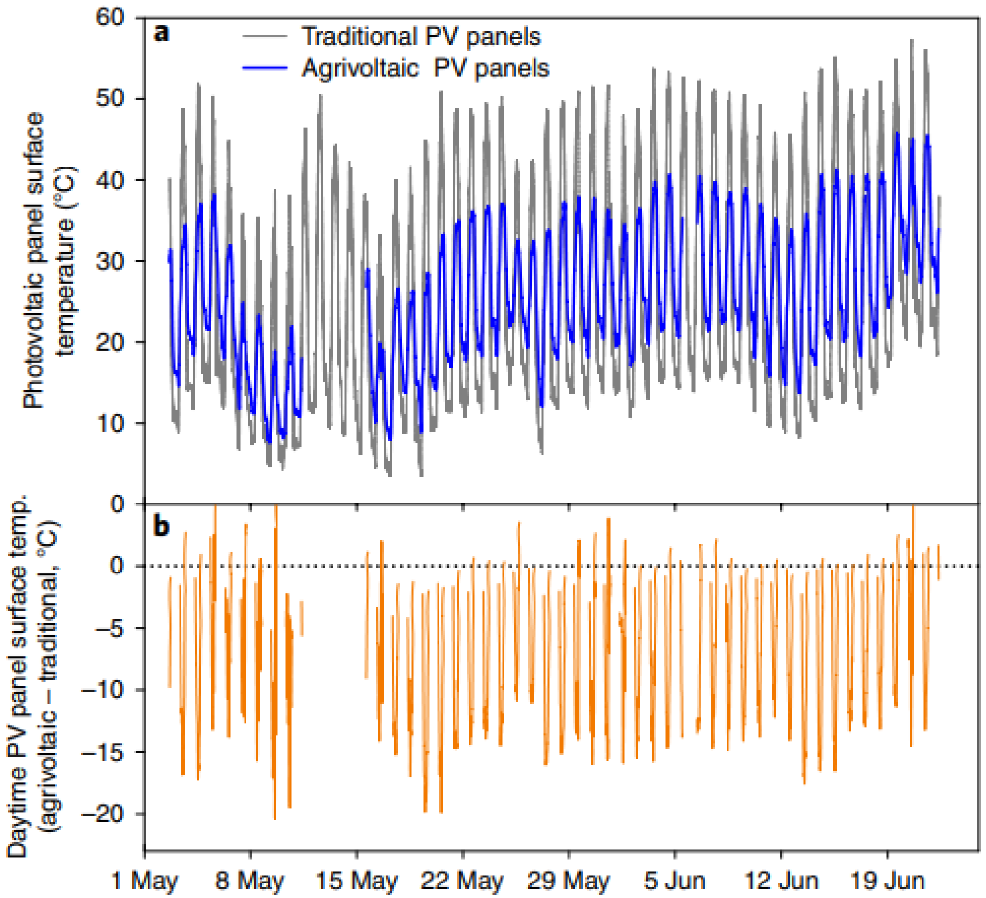
Barron-Gafford et al. (2019) *Nature Sustainability*

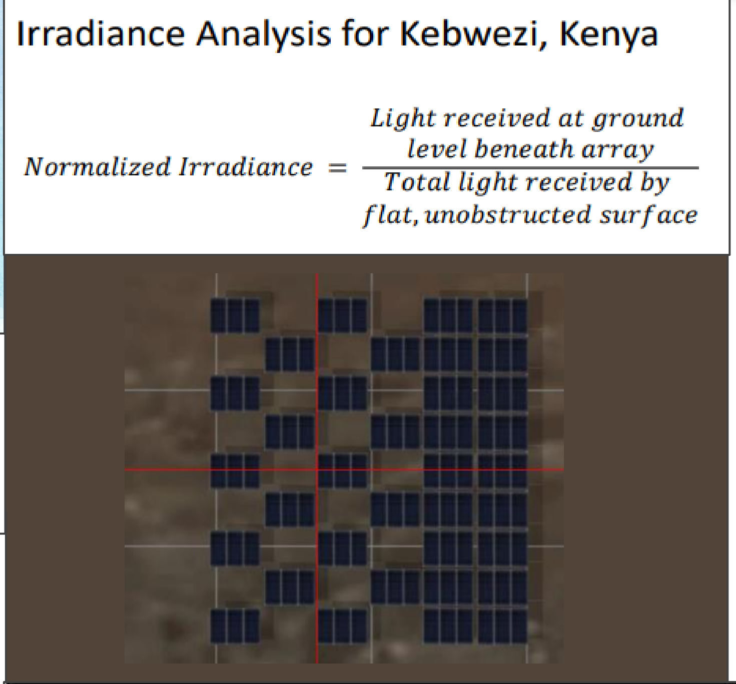
- Peppers need 50% less water
- Tomatoes need 30% less water

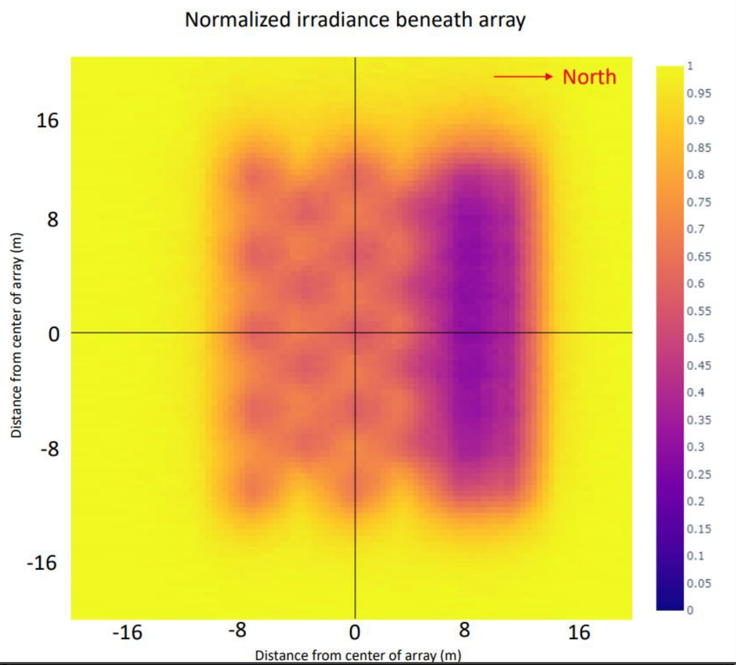
Agrivoltaics Research: Energy

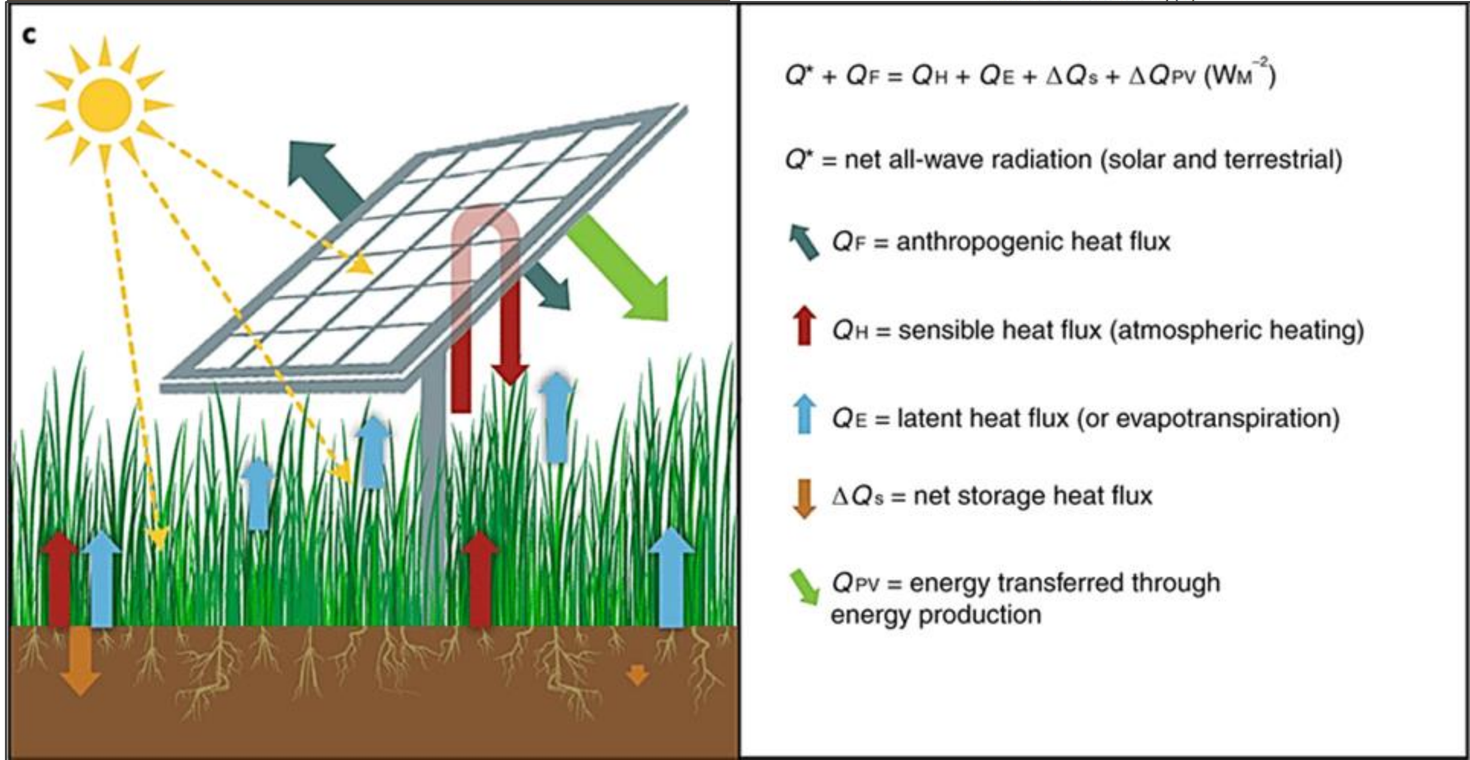
University of Arizona (Tuscon, AZ)
Barron-Gafford et al. (2019) *Nature Sustainability*

- Average summer PV surface temperature reduction: ~9°C
- Annual generation increase: ~2%

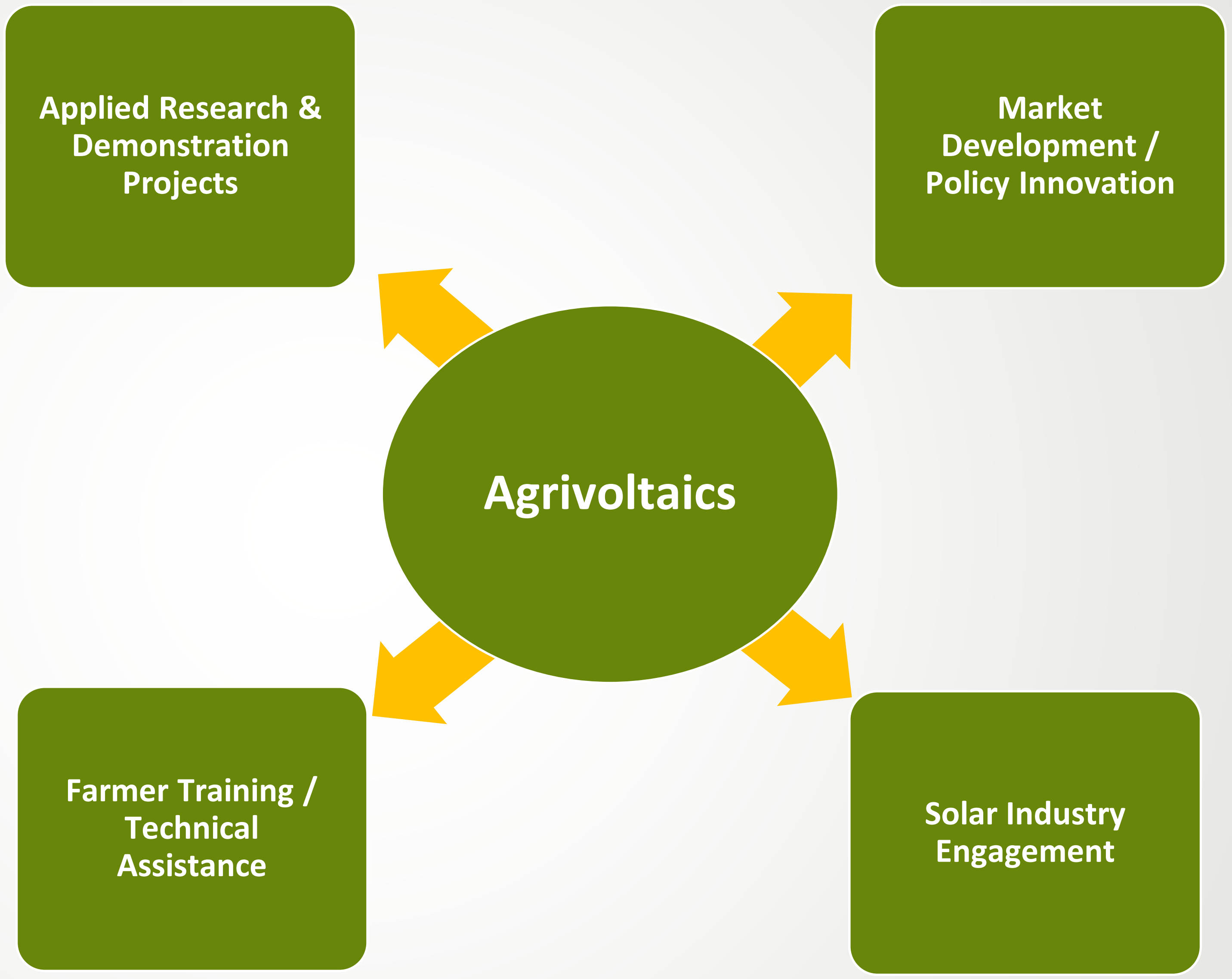








Advancing Agrivoltaics



American Farmland Trust
SAVING THE LAND THAT SUSTAINS US

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Leonard Diggs
Director of Farmer and Rancher Opportunities
Pie Ranch

Ag Equipment

Electrify your Ride

Soletrac 25G

e25G Gear | Solectrac | Compact Electric Tractor

California Core | Solectrac

Monarch MK-V

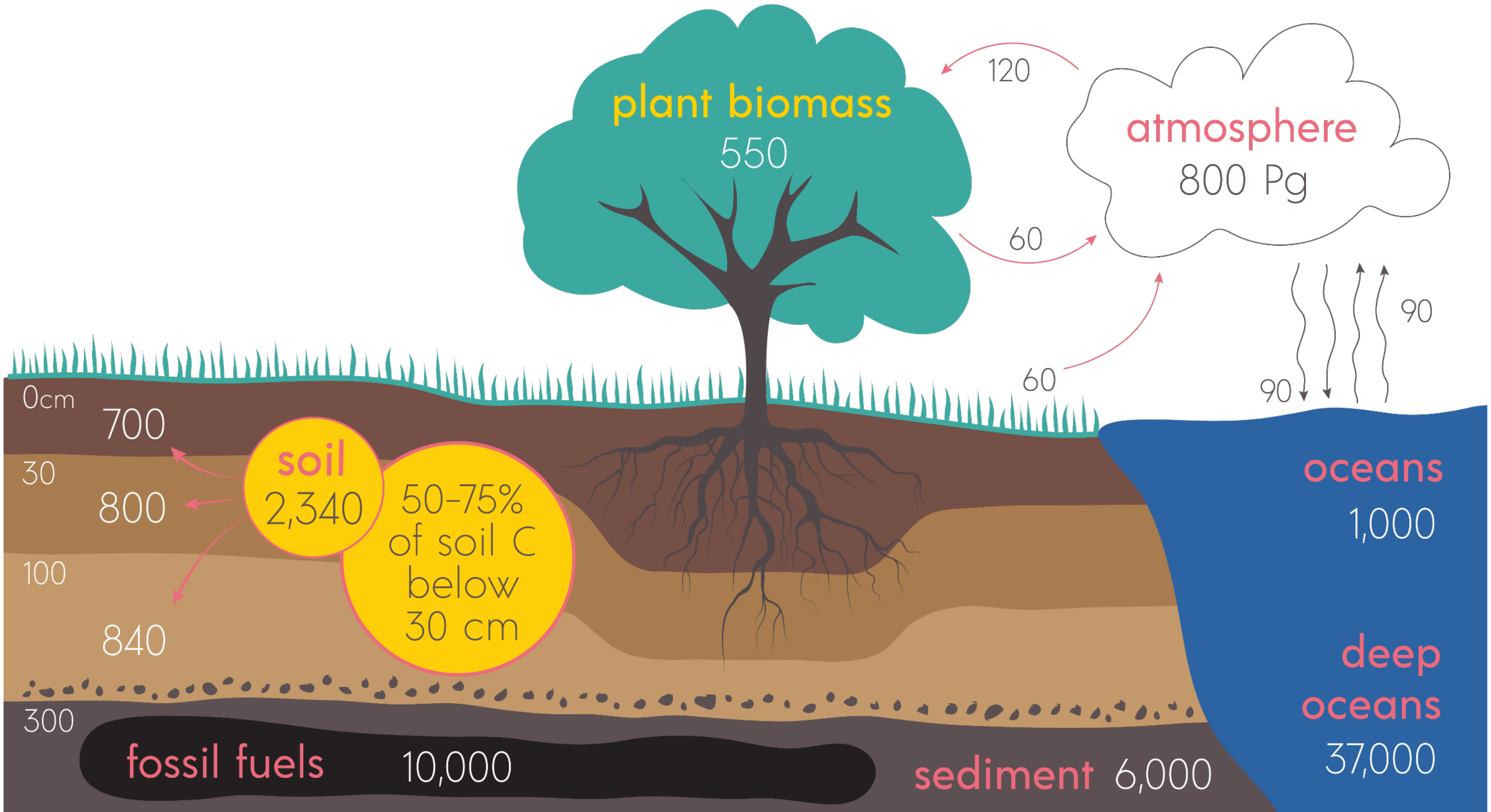
- MK-V an Autonomous Electric Tractor | Monarch Tractor

Technology needed after Storm Damage

Technology needed before Storm Damage

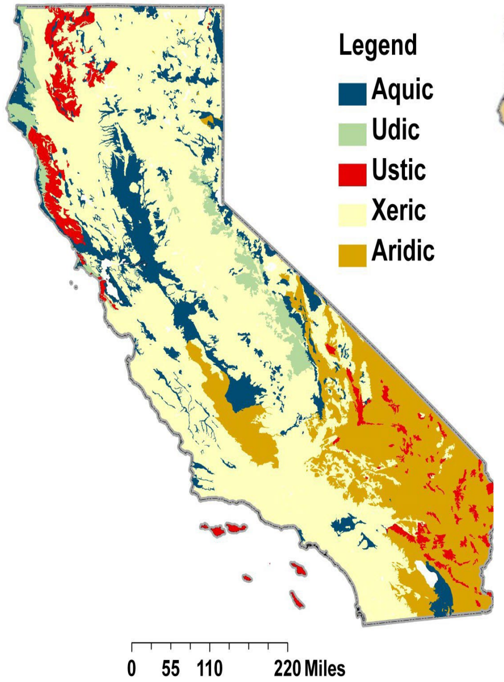
Dr. Jessica Chiartas
UC Davis
RegenScore

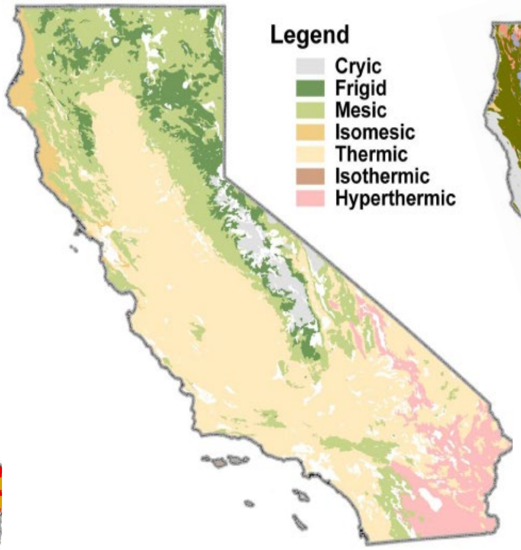
Global Carbon Stocks

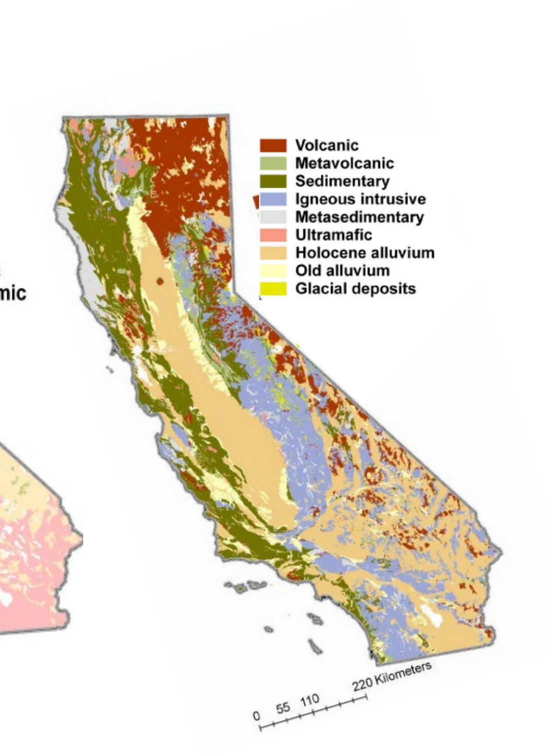


Diversity of California Soils

Temperature, Moisture, Geology, Production System







Credit: California Soil Resource Lab & California LCC

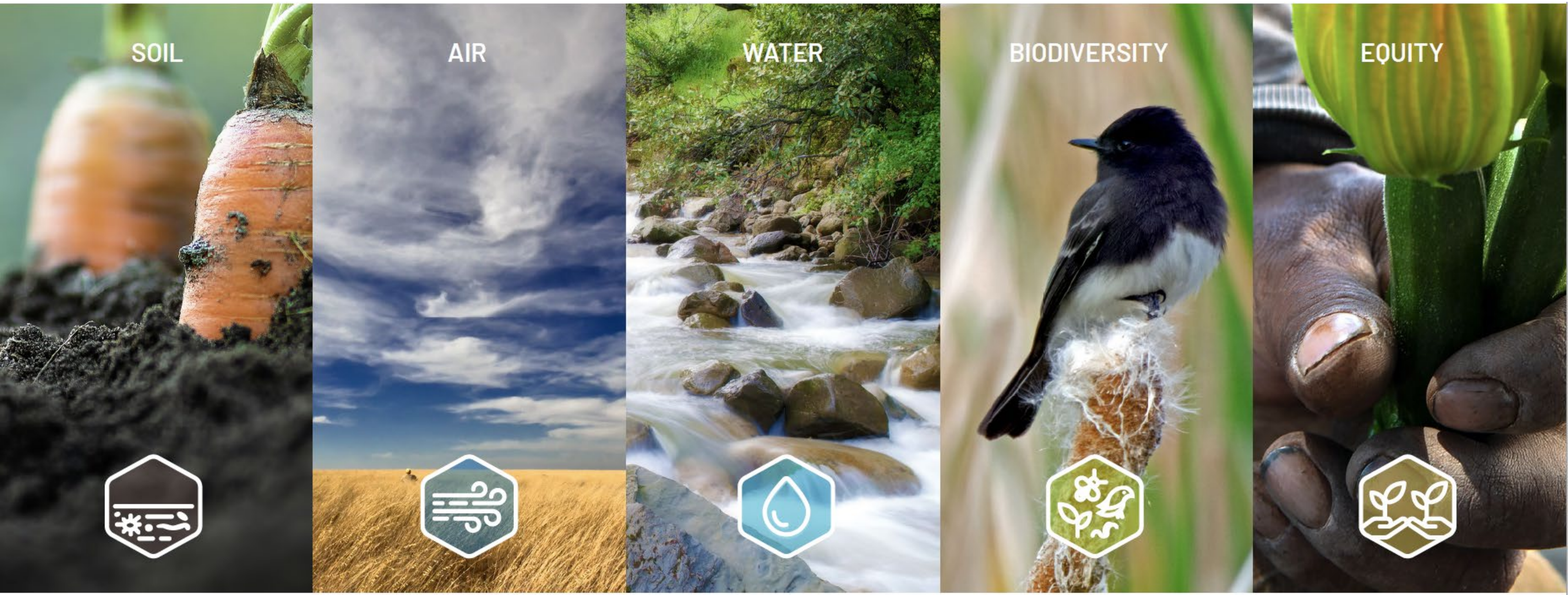
Types of Technologies

- Practice Implementation
  - On-Farm Equipment
  - Farm Management Software
- Monitoring
  - Practices and Outcomes
  - Hardware and Software
- Modeling/Machine Learning
  - Practice Optimization
  - Outcomes Estimation
- Reporting and Verification
  - Data Entry/Storage
  - Data Privacy and Interoperability

Practice-Based Monitoring

- Remote Sensing
  - Reduced Disturbance
  - Cover Cropping
  - Hedgerows and other ‘Farmscaping’
- On-the Ground Monitors/Sensors
  - Irrigation Optimization
  - Fertilizer Optimization
  - Reduced Pesticide Use
  - Reduced Particulate Matter (PM10)

Outcomes-Based Monitoring



Climate Co-benefits

- Reduced GHG emissions (Global Warming Potential)
- Increased Water Infiltration (Reduced Erosion/Flooding)
- Increased Water Holding Capacity (Improved Drought Resilience)
- Creation of Microclimates
  - Wind Protection/Reduction
  - Buffering of Soil and Surface Temperatures
- Provision of Shade (Promotes Farmworker Safety)
- Promotion of Biodiversity (Increased Resistance to Pests/Disease)