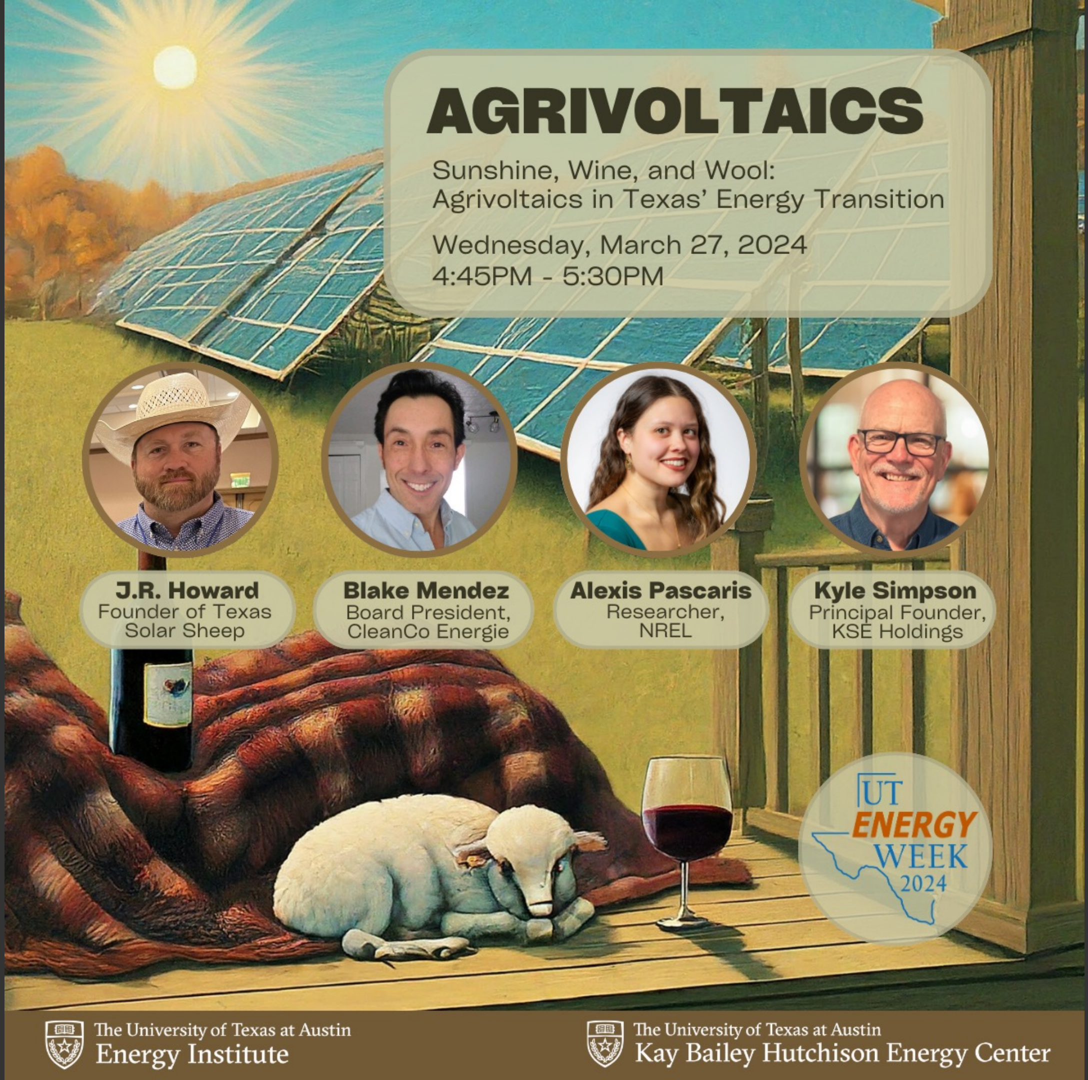
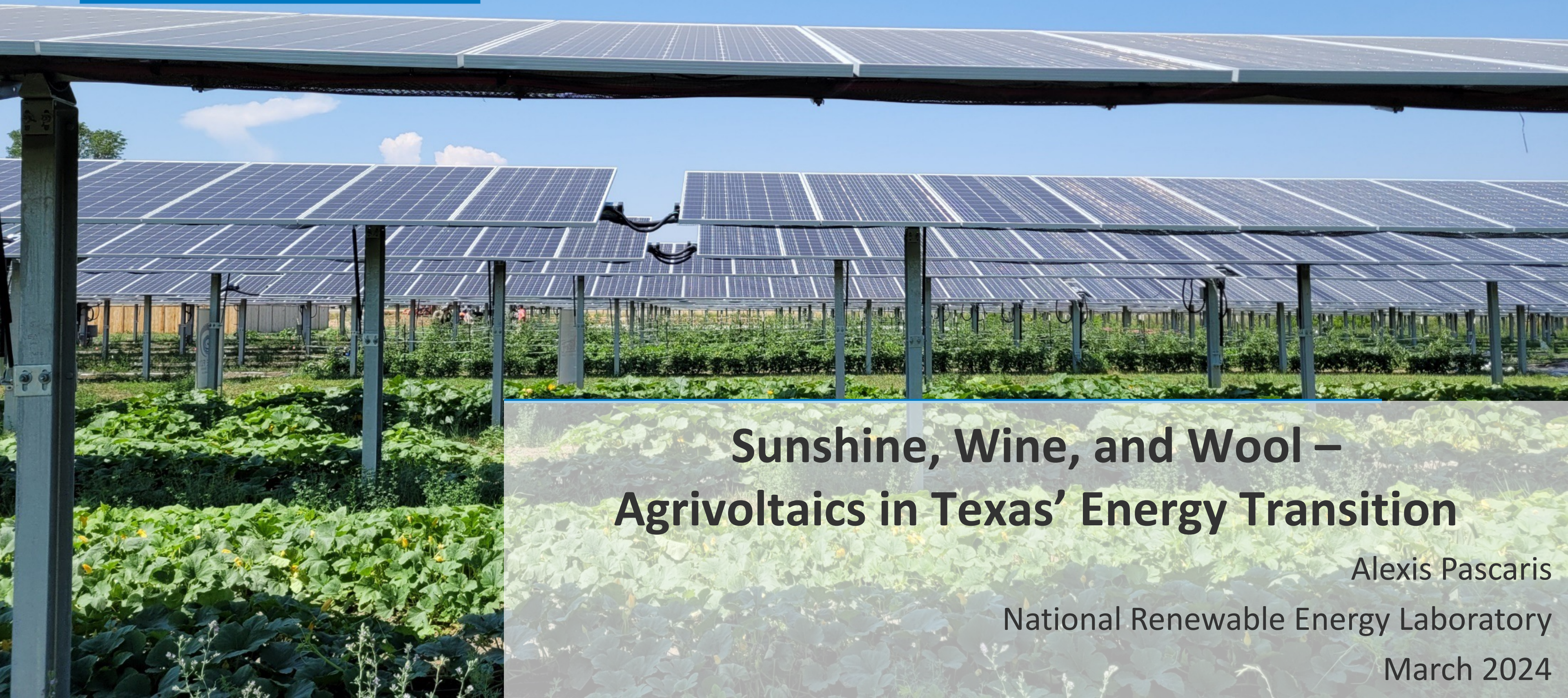

AGRIVOLTAICS
Sunshine, Wine, and Wool:
Agrivoltaics in Texas' Energy Transition
Wednesday, March 27, 2024
4:45PM - 5:30PM
J.R. Howard
Founder of Texas Solar Sheep
Blake Mendez
Board President, CleanCo Energie
Alexis Pascaris
Researcher, NREL
Kyle Simpson
Principal Founder, KSE Holdings
UT ENERGY WEEK 2024
The University of Texas at Austin
Energy Institute
The University of Texas at Austin
Kay Bailey Hutchison Energy Center



Sunshine, Wine, and Wool – Agrivoltaics in Texas’ Energy Transition

Alexis Pascaris

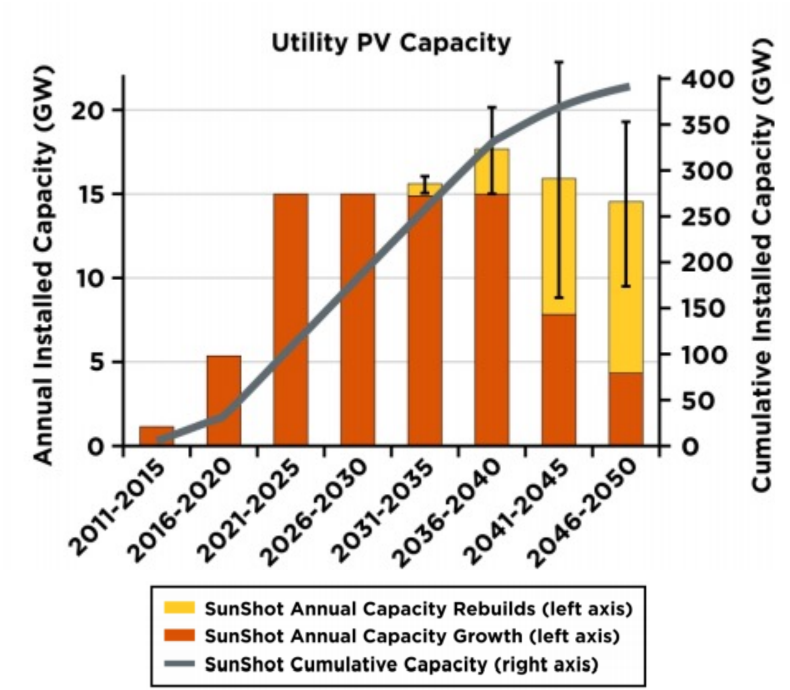
National Renewable Energy Laboratory

March 2024

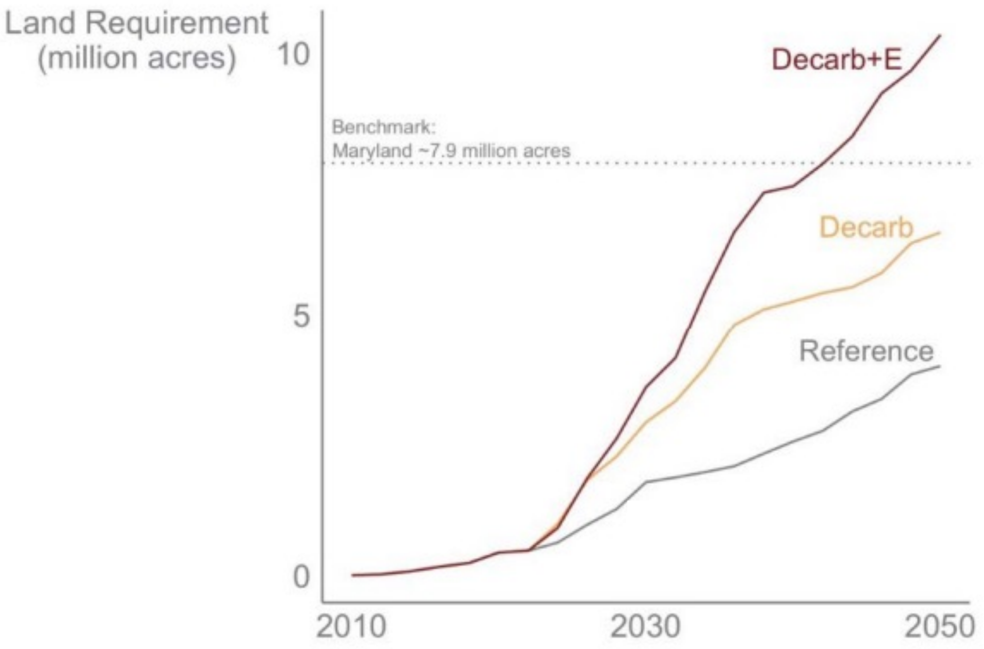
Outline

1. Confluence of Solar and Agricultural Trends
2. Agrivoltaics 101
3. Food-Energy-Water Nexus Lessons Learned
4. Agrivoltaics in the Permian Basin
5. Q&A

Context: Solar Power Deployment is Growing Rapidly



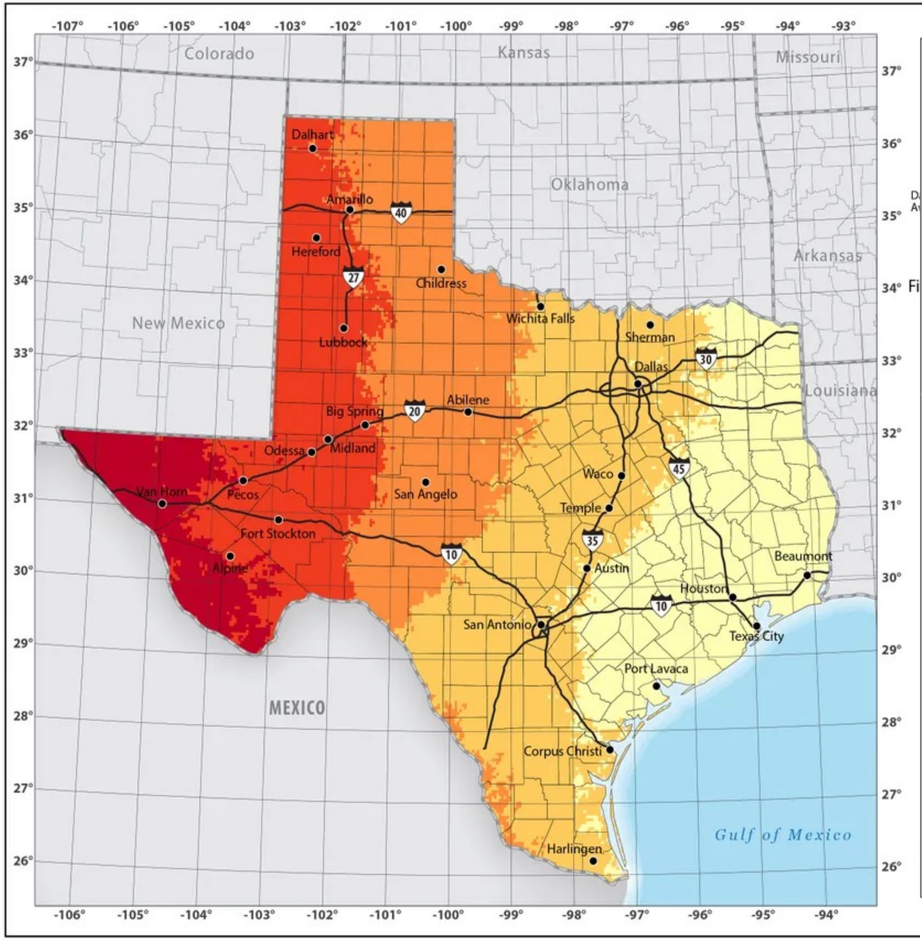
2030: 2 - 4 million acres
2050: 4 - 10 million acres



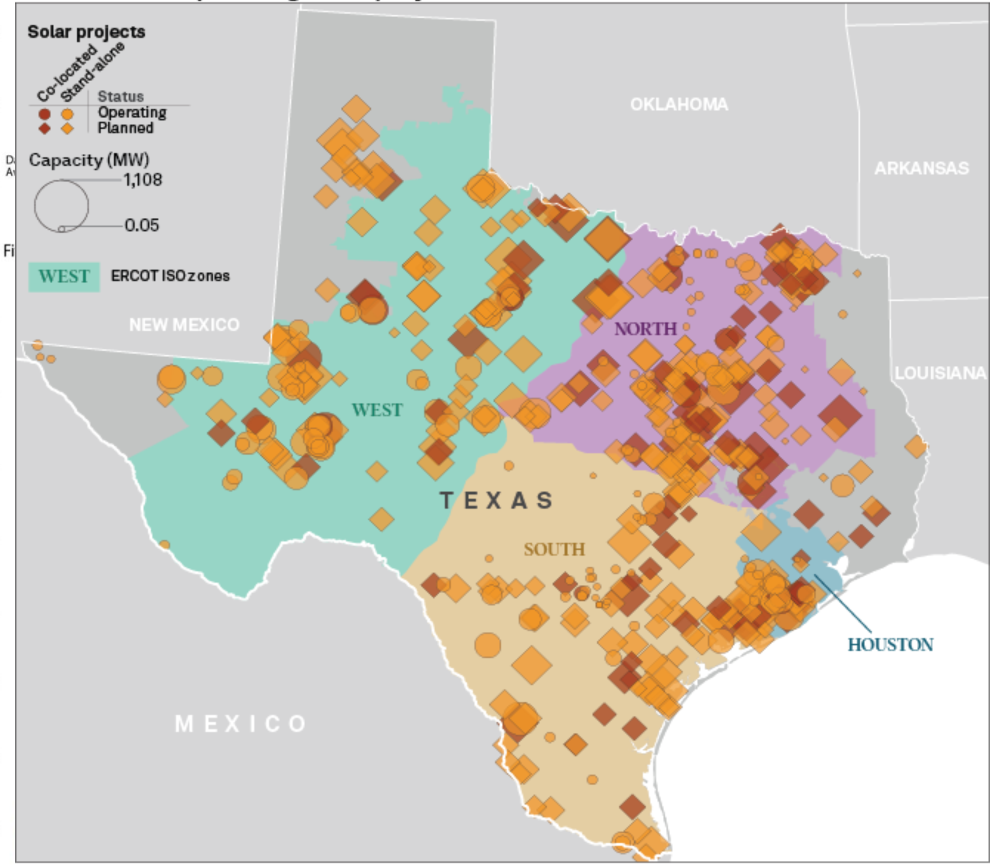
Land Requirements for U.S. Solar Deployment in the Solar Futures Study Scenarios

Source: Heath, Garvin, Dwarakanath Ravikumar, Silvana Ovaitt, Leroy Walston, Taylor Curtis, Dev Millstein, Heather Mirletz, Heidi Hartmann, and James McCall. Environmental and Circular Economy Implications of Solar Energy in a Decarbonized US Grid. No. NREL/TP-6A20-80818. National Renewable Energy Lab.(NREL), Golden, CO (United States), 2022

Solar Energy Resource Potential in Texas



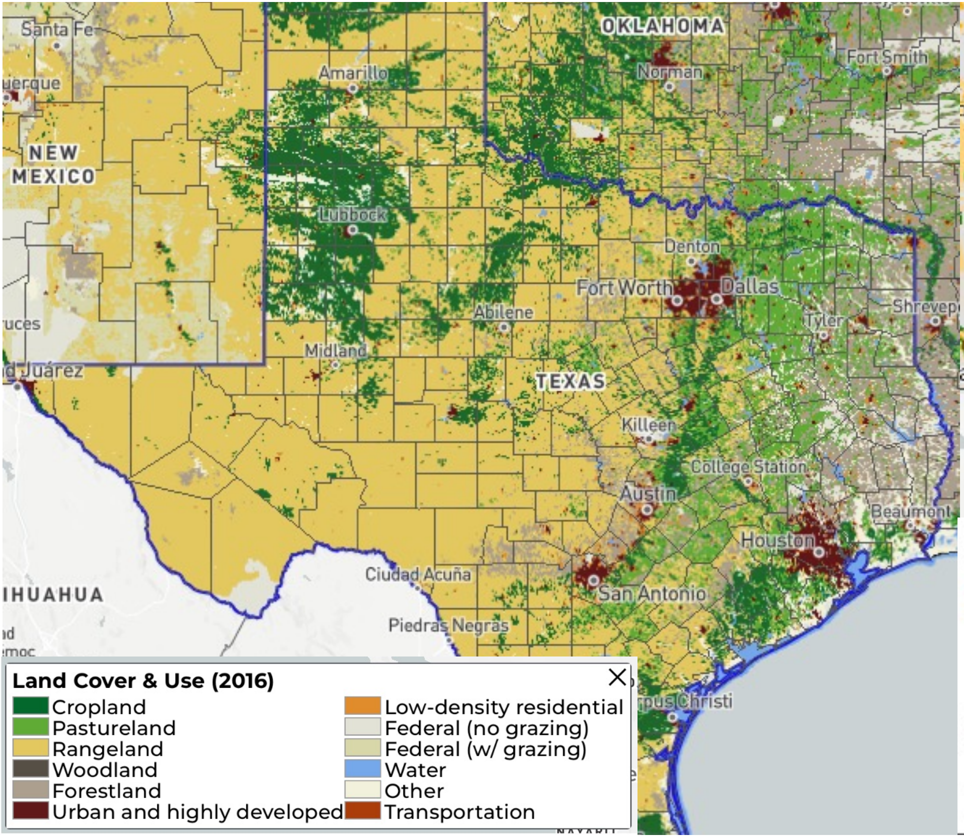
Planned and operating solar projects in Texas



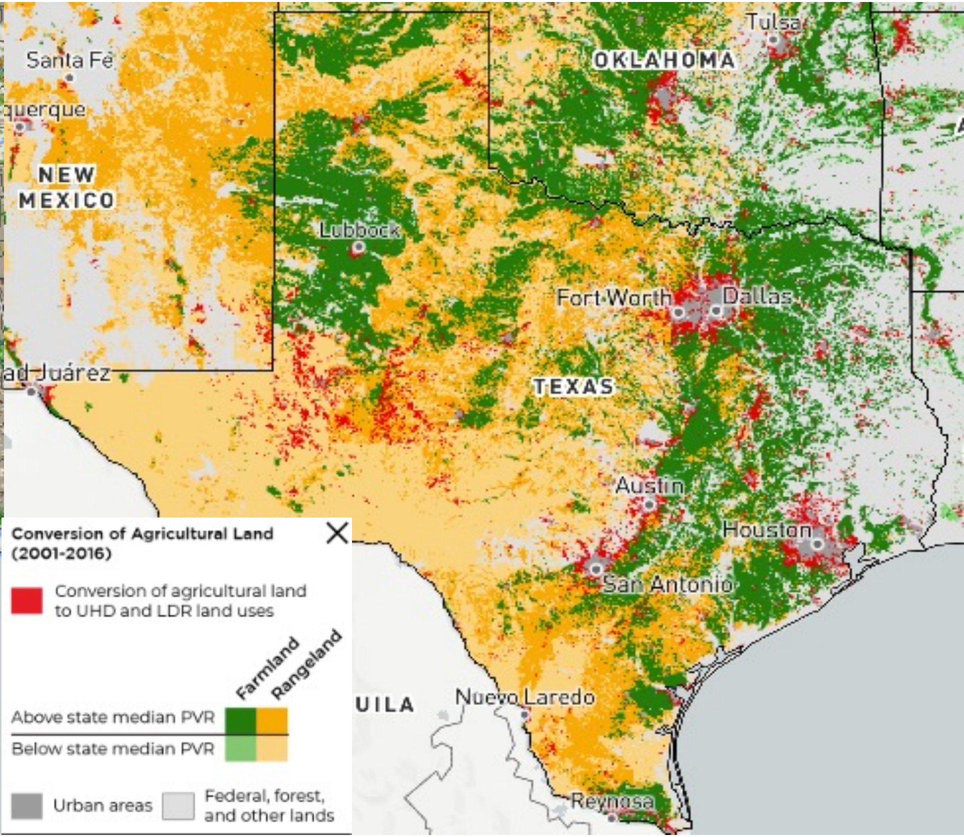
As of Dec 15, 2023.
Map credit: Jonathan Paul Lalgee.
Source: S&P Global Market Intelligence.

Challenge: Potential Land Use Conflicts

Land Use and Cover



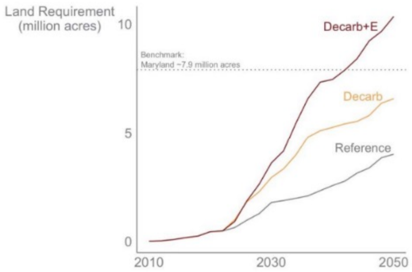
Conversion of Ag Land (2001-2016)



Images: American Farmland Trust, Farms Under Threat Report

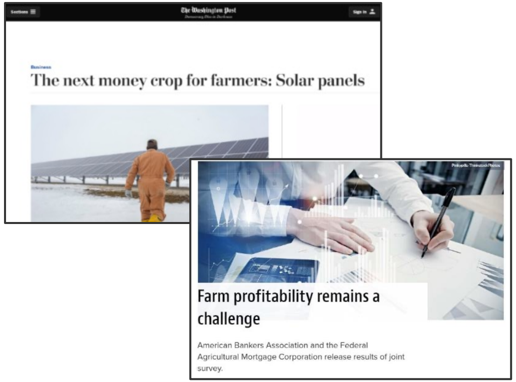
Agrivoltaics Motivation: Confluence of Solar and Agricultural Trends

Rapid Expansion of Utility-Scale Solar



Solar Land Requirements:
2030: 2 - 4 million acres
2050: 4 - 10 million acres

Potential Economic Benefits


The Washington Post

The next money crop for farmers: Solar panels

Farm profitability remains a challenge

American Bankers Association and the Federal Agricultural Mortgage Corporation release results of joint survey.

Public Opposition to Solar on Agricultural Lands


METRO | SPORTS | BUSINESS | OPINION | RHODE ISLAND | POLITICS | EDUCATION | LIFESTYLE | MARIJUANA | ARTS | MAGAZINE | CARS

Solar projects increasingly meeting local resistance

By Katheleen Conti

The New York Times

He Set Up a Big Solar Farm. His Neighbors Hated It.

A push toward renewable energy is facing resistance in rural areas where conspicuous panels are affecting vistas and squeezing small farmers.

Agrivoltaics offers an opportunity to:

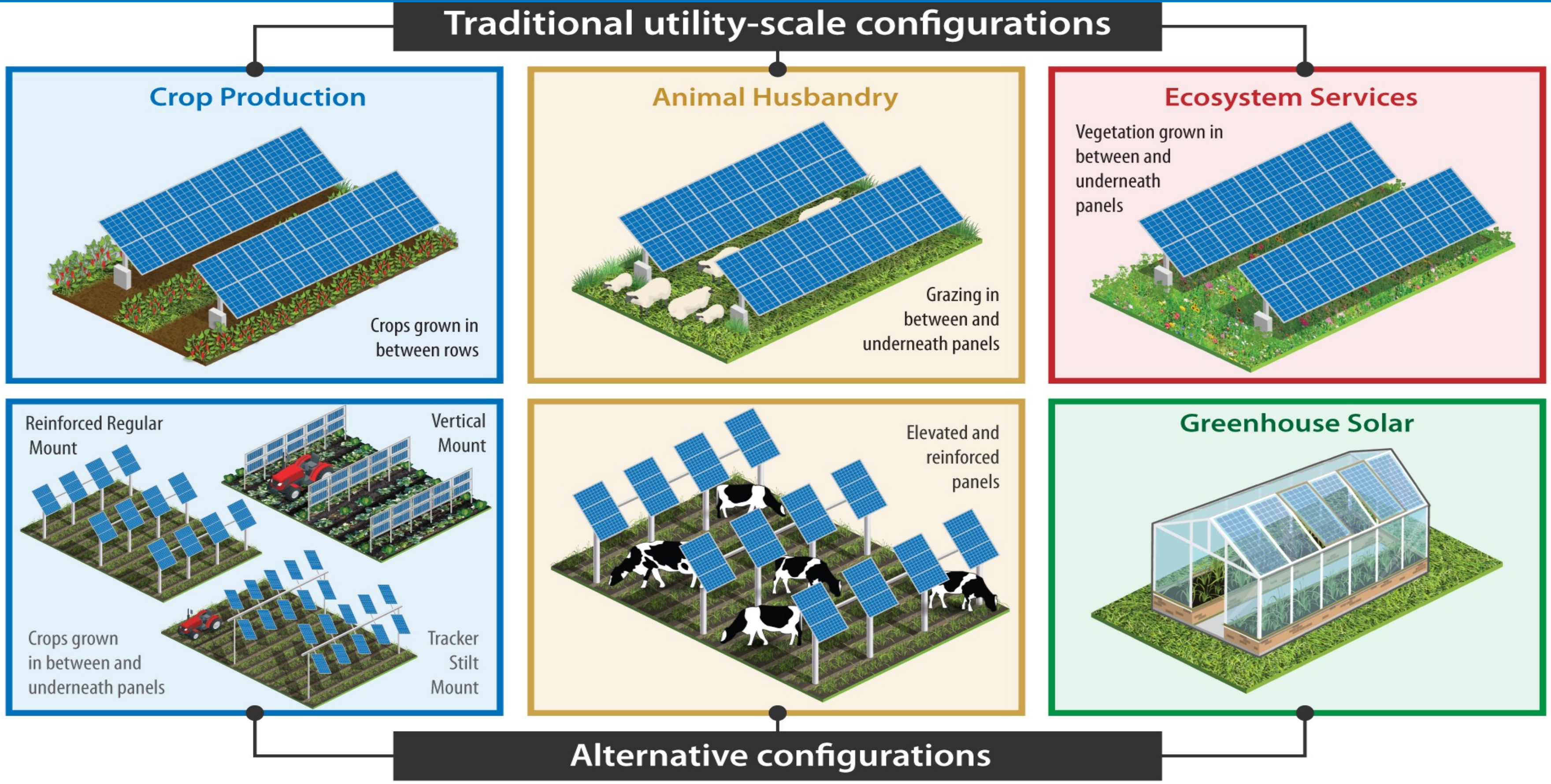
- Improve economic resilience of our food system and farmers
- Keep agricultural lands in production and in beneficial use
- Improve social acceptance of solar in agricultural communities

Source: Heath, Garvin, Dwarakanath Ravikumar, Silvana Ovaitt, Leroy Walston, Taylor Curtis, Dev Millstein, Heather Mirletz, Heidi Hartmann, and James McCall. Environmental and Circular Economy Implications of Solar Energy in a Decarbonized US Grid. No. NREL/TP-6A20-80818. National Renewable Energy Lab.(NREL), Golden, CO (United States), 2022

Vision: Mutual Benefits of Solar and Agriculture

Images: Werner Slocum, Dennis Schroeder, NREL; AgriSolar Clearinghouse

Diverse Agrivoltaics Applications



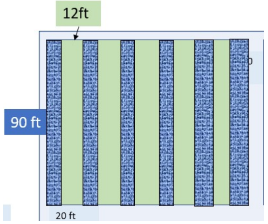
Macknick, Jordan, Hartmann, Heidi, Barron-Gafford, Greg, Beatty, Brenda, Burton, Robin, Seok-Choi, Chong, Davis, Matthew, Davis, Rob, Figueroa, Jorge, Garrett, Amy, Hain, Lexie, Herbert, Stephen, Janski, Jake, Kinzer, Austin, Knapp, Alan, Lehan, Michael, Losey, John, Marley, Jake, MacDonald, James, McCall, James, Nebert, Lucas, Ravi, Sujith, Schmidt, Jason, Staie, Brittany, & Walston, Leroy. The 5 Cs of Agrivoltaic Success Factors in the United States: Lessons from the InSPIRE Research Study. NREL/TP-6A20-83566. https://doi.org/10.2172/1882930

Configuration Tradeoffs

Energy-Focused | Farmer-Focused

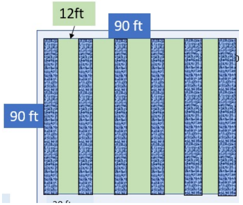
Utility Scale Height and Spacing ("Traditional")

- Highest energy production and lowest cost
- Least ergonomic for farmers and lower compatibility with a range of agricultural equipment



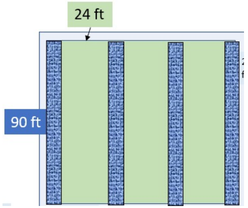
Elevated Panels, Traditional Row Spacing

- More ergonomic for hand labor
- Higher construction cost for same energy production as Traditional



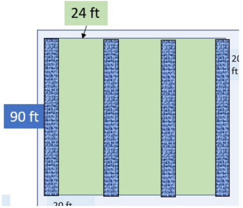
Utility Scale Height, Wide Row Spacing

- Allows for wider ag equipment and farming of more land
- Difficult for farmers to navigate around the field



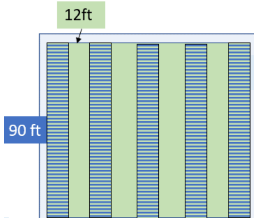
Elevated Panels, Wide Row Spacing

- Ergonomic for farmers, allows for wide ag equipment, and easier to navigate the field



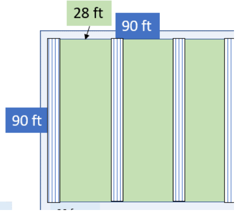
Elevated Panels, Interspaced Panels, Traditional Row Spacing

- Allows more sunlight to enter around/under panels
- Can plant directly under panels
- Does not allow for wide equipment (only farmer friendly for certain operations)



Vertical Bifacial Panels, Wide Row Spacing

- Most ag equipment friendly/widest space between rows
- Largest tradeoff for energy production



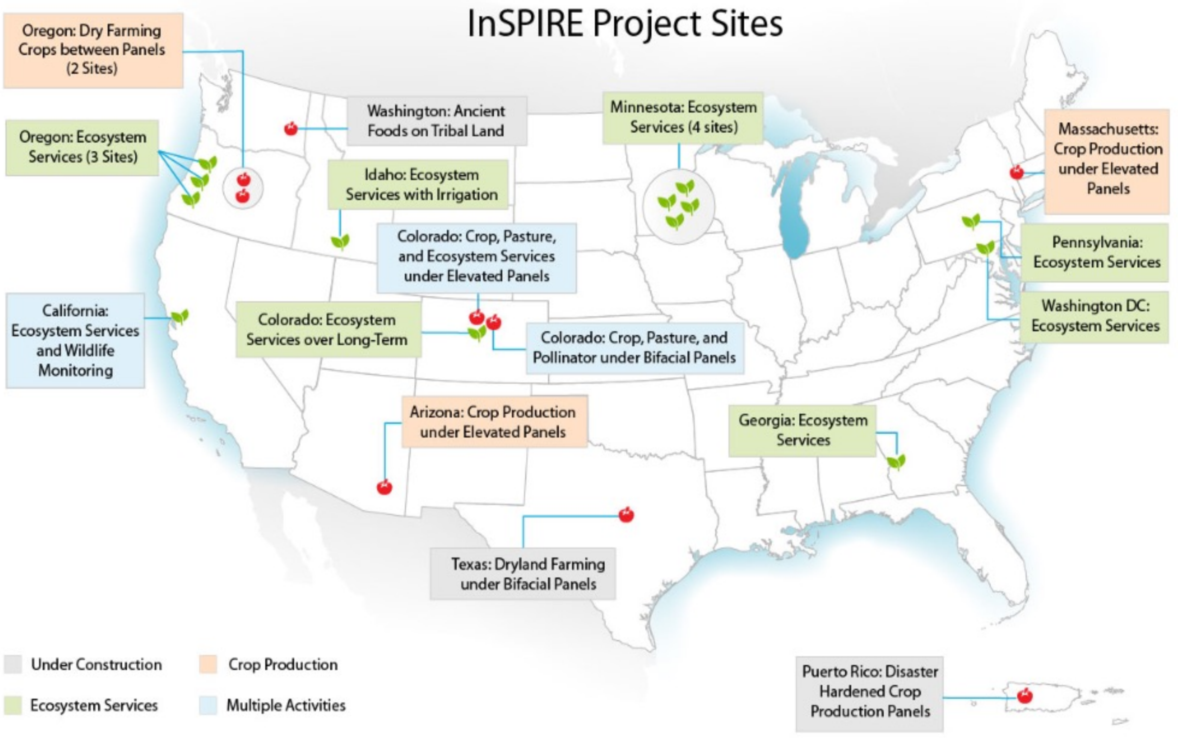
Increasing Energy Production

The InSPIRE Project

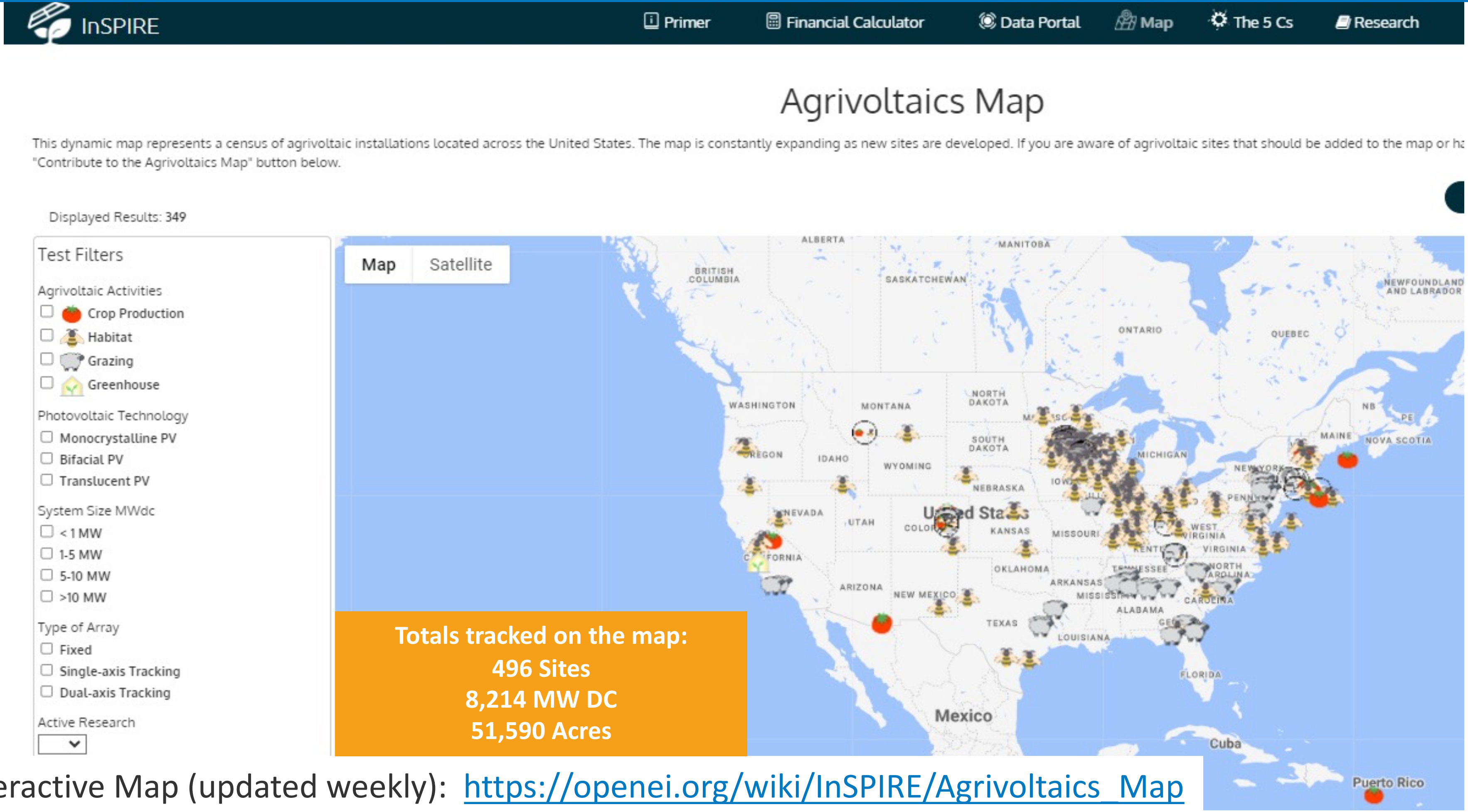
Innovative Solar Practices Integrated with Rural Economies and Ecosystems

- InSPIRE has 24 active field research projects across the United States
- **Analytical research:**
  - Cost-benefit tradeoffs of different agrivoltaics configurations
  - Assessing research gaps and priorities
  - Tracking agrivoltaics projects across the United States
- **Field-based research:**
  - Novel agrivoltaic and traditional utility-scale PV designs integrated with multiple activities
  - Assessing agricultural yields and irrigation requirements in arid environments
  - Grazing standards and best practices
  - Pollinator habitat and ecosystem services

https://openei.org/wiki/InSPIRE



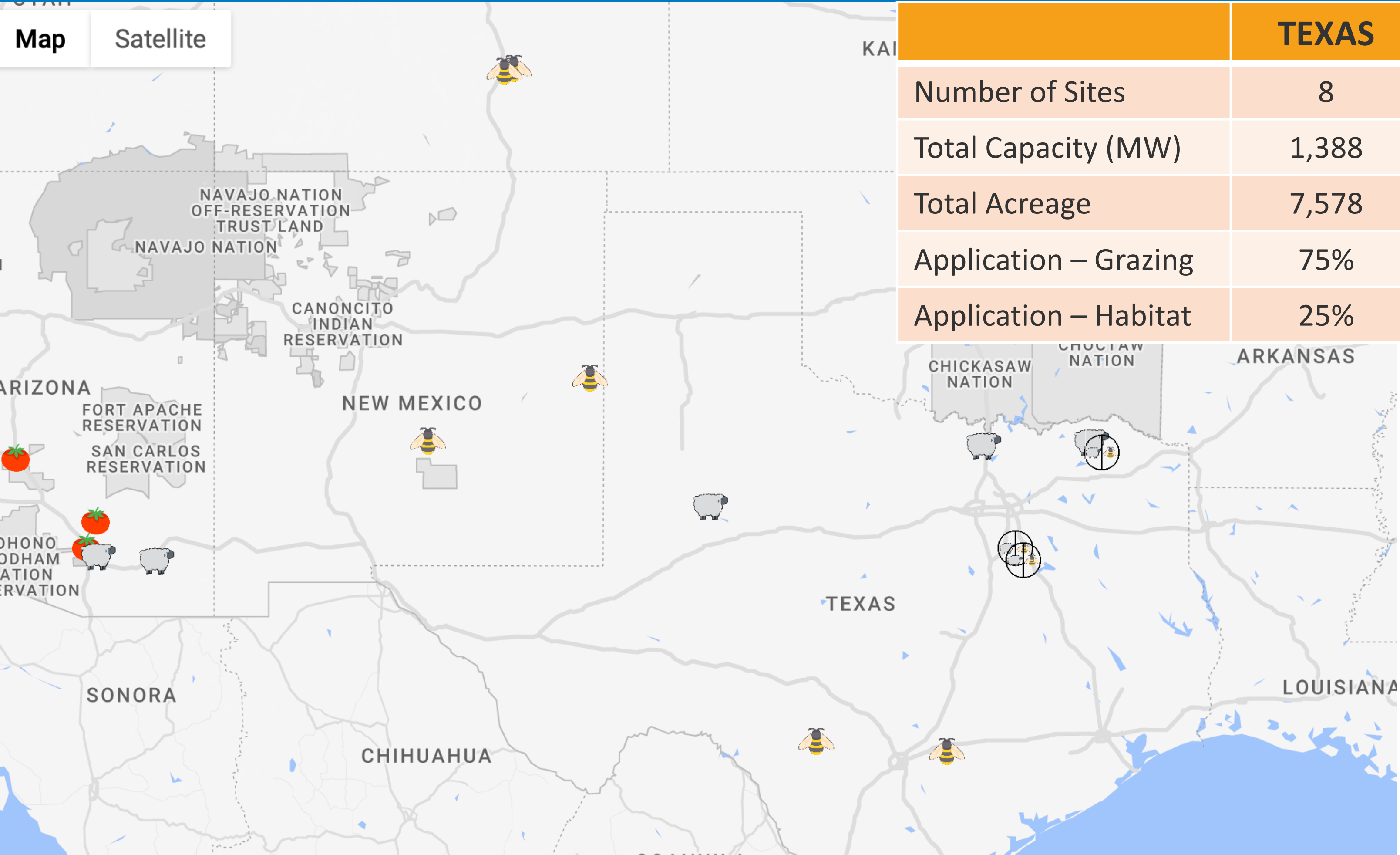
Tracking Agrivoltaics Projects – Map Resource



Totals tracked on the map:
496 Sites
8,214 MW DC
51,590 Acres

Interactive Map (updated weekly): https://openei.org/wiki/InSPIRE/Agrivoltaics_Map

Texas and New Mexico – Current Status of Agrivoltaics



	TEXAS	NEW MEXICO
Number of Sites	8	2
Total Capacity (MW)	1,388	6
Total Acreage	7,578	33
Application – Grazing	75%	0%
Application – Habitat	25%	100%

Crop Production Under and Around Solar Panels – Lessons Learned

- Crops can be grown directly underneath elevated panels or in between rows
- Hand-harvested or small machine-harvested crops
- Crop performance varies based on location and solar design configurations

Cost and Design Factors:

- Increased panel heights (optional)
- Increased panel spacing (optional)
- Change in O&M needs (more frequent presence on-site)
- Access to water
- Agricultural revenue



Solar-integrated Grazing – Lessons Learned

- Sustainable grazing practices can improve soils
- Potential cost reductions from standard mowing practices
- Ongoing work evaluating pastureland performance
- Can be compatible with pollinator habitat

Cost and Design Factors:

- Temporary fencing on-site
- Fencing considerations around site
- Water access
- Panel heights (for cattle)

https://solargrazing.org/

ASGA



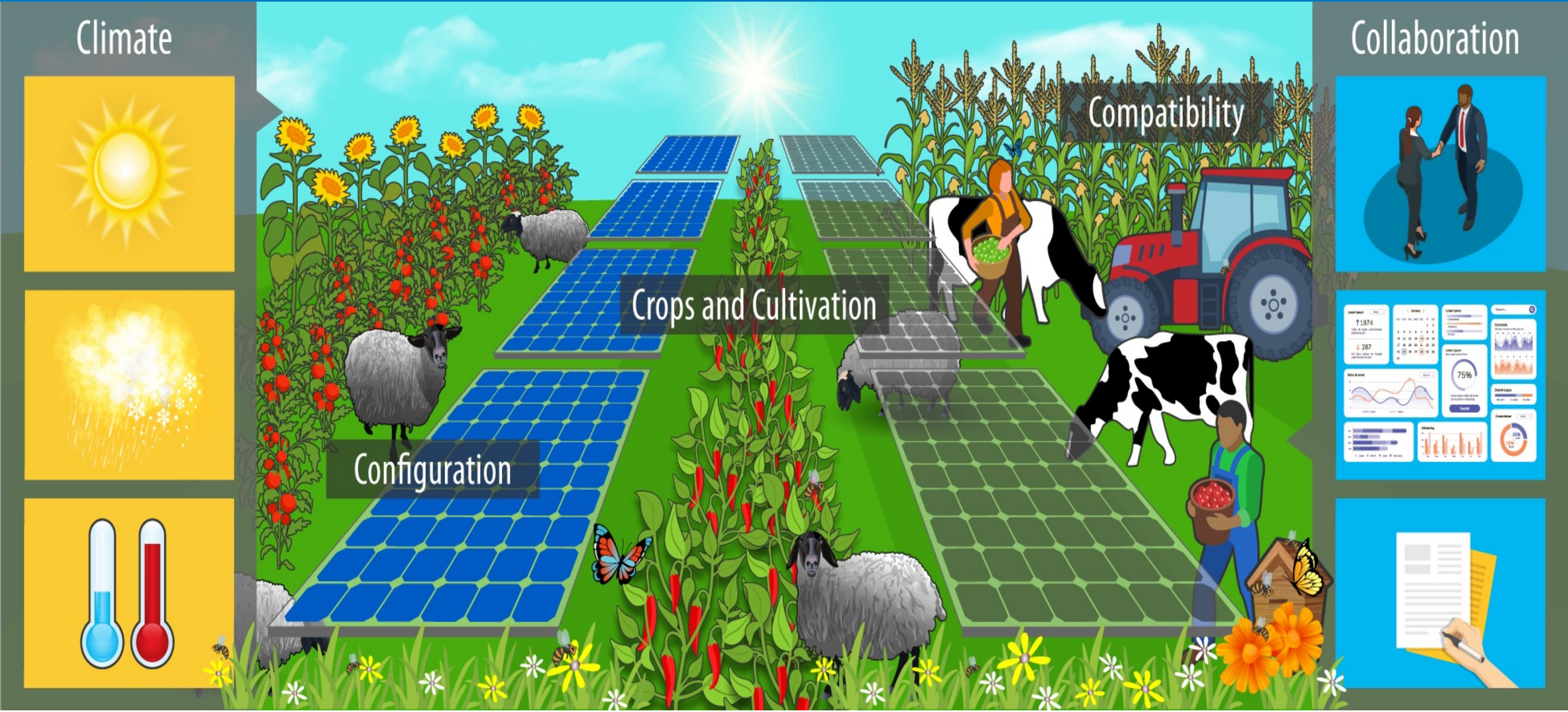
Pollinator-friendly Vegetation "Ecovoltaics" – Lessons Learned

- Native and pollinator-friendly vegetation can host beneficial insects
- Increased beneficial insect populations can benefit nearby farms
- Ongoing research evaluating species that thrive in partial shade of solar panels

Cost and Design Factors:

- Panel heights (to increase or not to increase?)
- Seed mix selection and purchase
- Reduction (usually) in O&M needs over time
- Potential stormwater management benefits

The 5 C's of Agrivoltaic Success



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What is needed for agrivoltaics to grow?

More research on:

- Agronomic impacts across geographies
- Environmental (soil and hydrologic) impacts
- Cost comparisons across stages of development

Innovation in:

- Soil management/construction best management practices
- System hardware (e.g., racking)
- Farm equipment
- Cross-sector partnerships

-Workforce development
-Training & curriculum

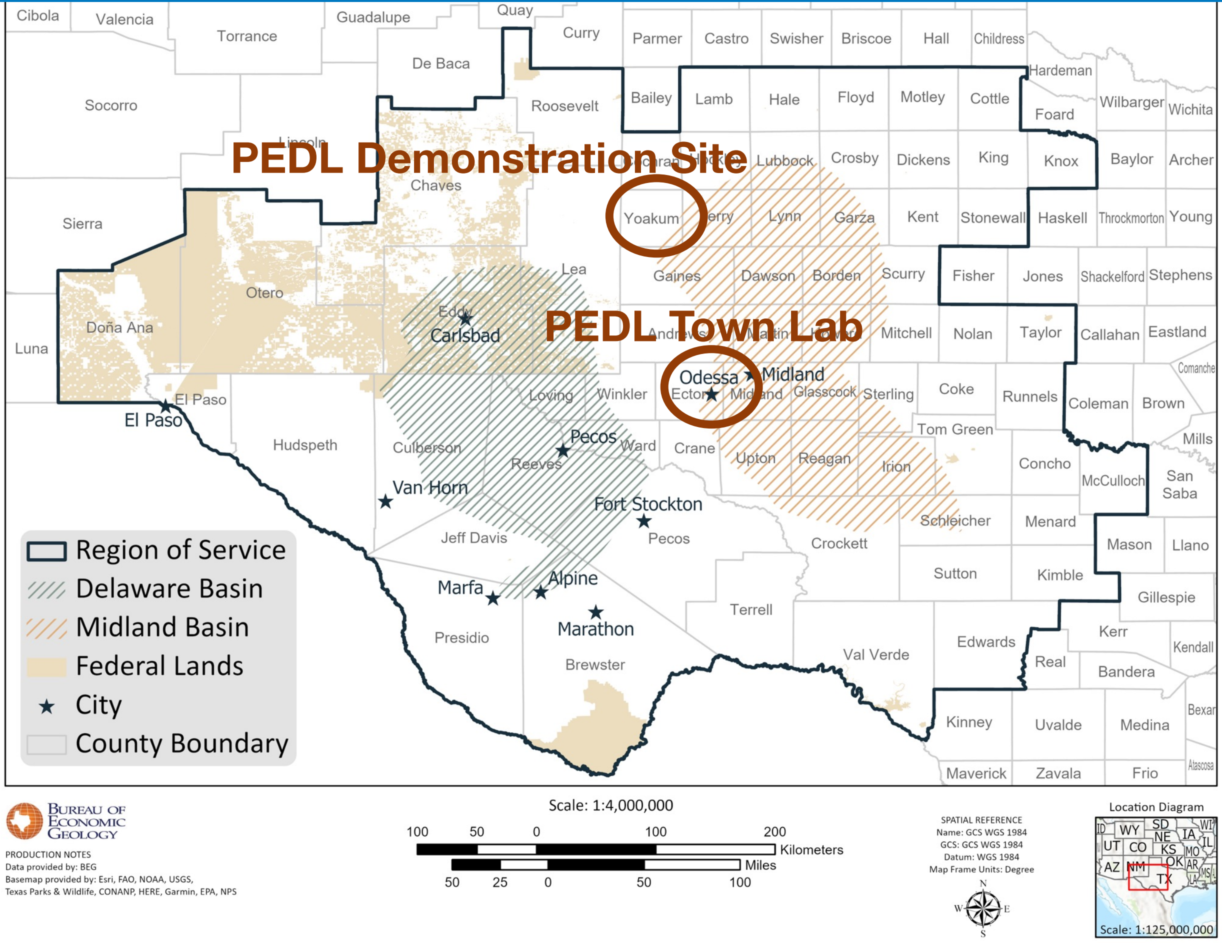
Permian Energy Development Lab (PEDL) – Agrivoltaics Demonstration Site

Initial Concept: 10-acre agrivoltaic demonstration site

Currently in scoping process for project – **looking for partners and agrivoltaics expert working group members**

Potential agrivoltaics solutions:

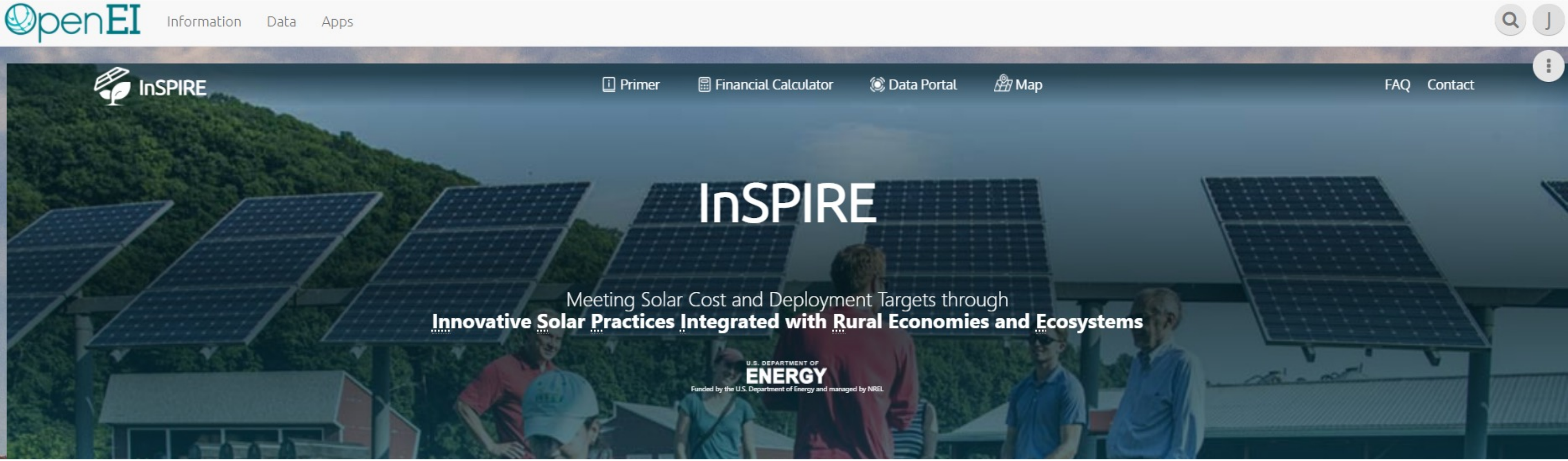
- Cattle and sheep grazing on range land
- Crop production with available irrigation (e.g., cotton, specialty crops)
- Native/pollinator vegetation trials
- Demonstration of different PV system designs and scales



PERMIAN Energy Development Lab

https://pedl.tech

Thank you!



InSPIRE website: https://openei.org/wiki/InSPIRE

Alexis.Pascaris@nrel.gov

NREL
Transforming ENERGY

Crop Agrivoltaics
Program Strategy and Oversight

We help farmers harvest the sun twice.

Blake Mendez
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Project Owner Representative

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