Texas Watershed Coordinator Roundtable - Agenda

November 7, 2024 | 9:00 am – 3:30 pm

Texas Farm Bureau Convention Center

7410 Fish Pond Rd, Waco, TX 76710

8:30 a.m. Event Sign In

9:00 a.m. Welcome, Introductions and Roundtable Overview
- Lucas Gregory, *Associate Director, TWRI*
- Jay Bragg, *Commodity & Regulatory Activities Associate Director, Texas Farm Bureau*

9:15 a.m. Utility-scale Solar in Texas
- Lucas Gregory, *Associate Director, TWRI*

9:30 a.m. Current State of Policy and Research
- Jessica Karlsruher, *Chief Executive Officer, TREAD Coalition*
- Rouhangiz (Nasim) Yavari, *Postdoctoral Researcher, Agricultural and Biological Engineering, Penn State University*
- Nuria Gomez-Casanovas, *Assistant Professor, TAMU Dept Rangeland, Wildlife & Fisheries Mgmt, Vernon Research Center*

10:30 a.m. Networking Break

10:45 a.m. Perspectives on the Development Process
- Garrett Bader, *Texas Smart Solar Specialist, American Farmland Trust*
- Raina Hornaday, *Co-Founder & Owner, Caprock Renewables*
- Ben Needham, *Professional Services Consultant, KerTec, LLC*
- Meredith and Eric DeBorde, *Owners, Lazy D Farm*
- Q&A

12:00 a.m. Networking Lunch Break

1:00 p.m. Best Practices and Resources
- Katie Myers, *Rural Programs Coordinator, Tarrant Regional Water District*
- Garrett Bader, *Texas Smart Solar Specialist, American Farmland Trust*
- Charles Kneuper, *State Resource Conservationist, USDA-NRCS Texas*

2:15 p.m. Networking Break

2:30 p.m. Water Quality Monitoring
- Lucas Gregory, *Associate Director, TWRI*
- Ryan McManamay, *Associate Professor, Environmental Science, Baylor University*

3:00 p.m. Brief Agency Updates
- EPA, TCEQ, TSSWCB

3:20 p.m. Wrap-Up & Program Evaluation
- Next Roundtable – Spring 2025

The Texas Watershed Planning Program is managed by the Texas Water Resources Institute and is funded through a Clean Water Act Section 319(h) nonpoint source grant provided by the Texas State Soil and Water Conservation Board and U.S. Environmental Protection Agency.

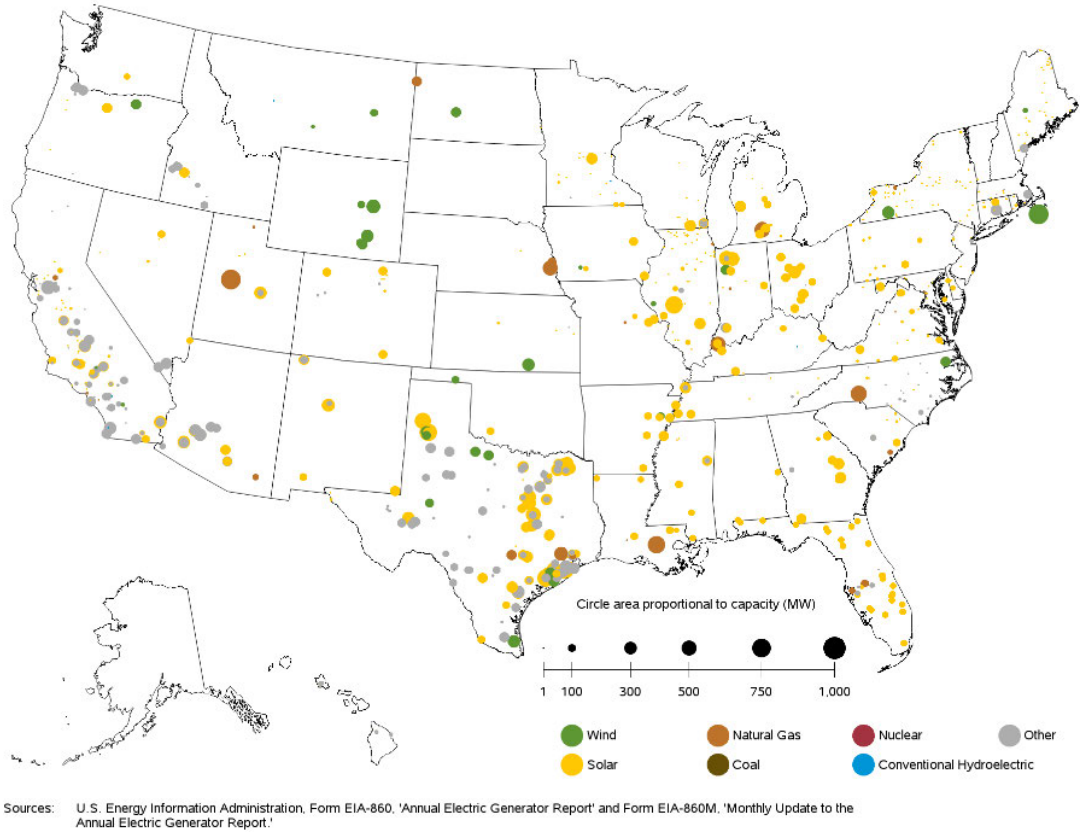
UTILITY SCALE SOLAR IN TEXAS

- Texas is a top solar producer in the nation
- Development rate higher than other states

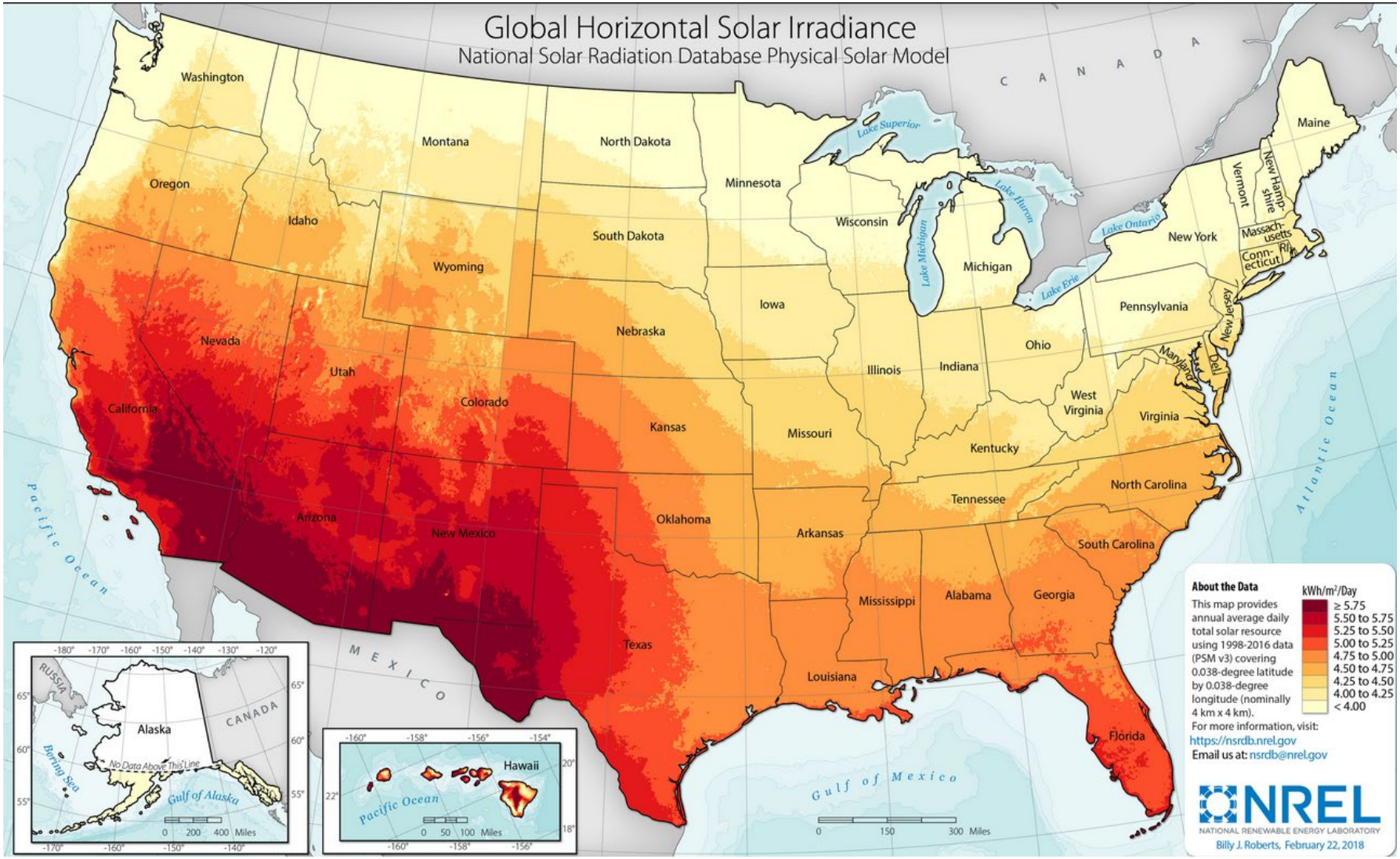
al view of the ENGIE Sun Valley Solar project in Hill County, Texas, on March 1, 2023. Credit: Mark Felix/AFP via Getty Im

PLANNED ENERGY PROJECTS

SEP 24 – AUG 25



Sources: U.S. Energy Information Administration, Form EIA-860, 'Annual Electric Generator Report' and Form EIA-860M, 'Monthly Update to the Annual Electric Generator Report.'

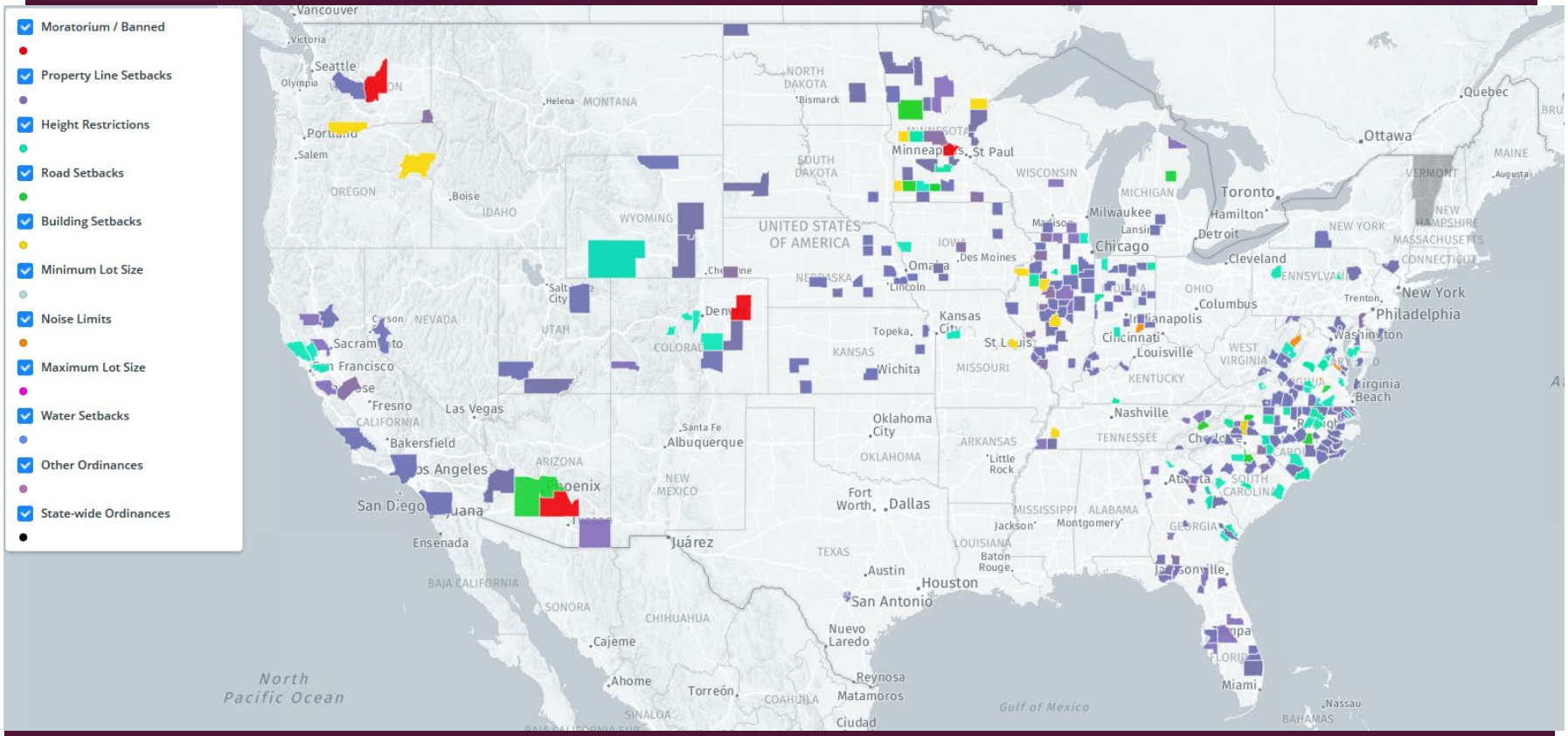

Global Horizontal Solar Irradiance
National Solar Radiation Database Physical Solar Model
Washington
Oregon
California
Nevada
Idaho
Montana
Wyoming
Utah
Arizona
Colorado
New Mexico
North Dakota
South Dakota
Nebraska
Kansas
Oklahoma
Texas
Minnesota
Iowa
Missouri
Arkansas
Louisiana
Wisconsin
Illinois
Michigan
Indiana
Ohio
Kentucky
Tennessee
Mississippi
Alabama
Georgia
Florida
South Carolina
North Carolina
Virginia
West Virginia
Pennsylvania
New York
Maine
Vermont
New Hampshire
Massachusetts
Connecticut
RI
New Jersey
Maryland
Del
Lake Superior
Lake Michigan
Lake Huron
Lake Erie
Lake Ontario
CANADA
MEXICO
Pacific Ocean
Atlantic Ocean
Gulf of Mexico
Alaska
RUSSIA
CANADA
Bering Sea
Gulf of Alaska
No Data Above This Line
Hawaii
Pacific Ocean
0 200 400 Miles
0 50 100 Miles
0 150 300 Miles
About the Data
This map provides annual average daily total solar resource using 1998-2016 data (PSM v3) covering 0.038-degree latitude by 0.038-degree longitude (nominally 4 km x 4 km).
For more information, visit:
https://nsrdb.nrel.gov
Email us at: nsrdb@nrel.gov
kWh/m²/Day
≥ 5.75
5.50 to 5.75
5.25 to 5.50
5.00 to 5.25
4.75 to 5.00
4.50 to 4.75
4.25 to 4.50
4.00 to 4.25
< 4.00
NREL
NATIONAL RENEWABLE ENERGY LABORATORY
Billy J. Roberts, February 22, 2018

CONCERNS WITH SOLAR

- Erosion
- Water quality
- Land consumption
  - Up to 10 ac/MW
- Local issues
  - Traffic
  - Rural road destruction
  - Not abiding by agreements
  - Noise
  - Lack of Rules/Regs

Images captured by Fox affiliate FOX26 Houston KRIV show extensive damage to Fighting Jays Solar in Fort Bend County, Texas. (FOX26 Houston KRIV)

Photo Credit: nacleanenergy.com



SOLAR ORDINANCE DISTRIBUTION

CA. 2022

MAP CREDIT: ANTHONY LOPEZ WWW.NREL.GOV

Industrial Solar: Politics & Policy

Jessica Karlsruher, CEO
TREAD Coalition

Texas Real Estate Advocacy & Defense (TREAD) Coalition

TREAD Coalition is a nonpartisan, member-based organization that advocates for and defends the rights of landowners and rural communities at the federal, state and local levels.

Advocacy

- Energy Infrastructure
- Water Rights In Texas
- Eminent Domain
- Fair Property Taxes
- Fundraising State Parks
- Broadband In Texas

Rural Future Conditions Impact

- Texas has a growing population of, on average, 800 people a day
- 1000+ acres lost to land fragmentation per day
- Displacing farming and ranching for energy infrastructure

Wind & Solar Projects in Texas

Renewable Energy	Existing	Future
Wind Projects	334	107
Solar Projects	129	525

These numbers are based on current PUC and ERCOT numbers for 2023 and do not include any decommissioned projects.

Enel Green Power's massive 181-MW Lily solar + storage project in Texas now operational

By SB Staff January 4, 2022

Enel Green Power North America has begun operating two new clean power plants, including its first renewables-plus-storage hybrid project. The new additions come as the company embarks on an accelerated growth plan involving the addition of 6.5 GW of new renewable capacity and 1.4 GW of energy storage over the next three years. Enel also began operations of the 140 MW Rockhaven wind farm in Oklahoma.

The 181 MW Lily solar + storage project, located east of Dallas, Texas, is the company's first hybrid project in North America that integrates a renewable energy plant with utility-scale battery storage.

Hybrid Solar

Storage Facility

8 https://pv-magazine-usa.com/2023/02/06/2023-will-see-the-most-utility-scale-solar-added-in-a-single-year/

Permitting Process for Routing of Transmission Lines and Pipelines

PUBLIC UTILITY COMMISSION

CERTIFICATION PROCESS FOR TRANSMISSION LINES

VS

RAILROAD COMMISSION

CERTIFICATION PROCESS FOR PIPELINE ROUTING

DEFINE THE PROJECT

Identify beginning and end points of the project.

ENVIRONMENTAL ASSESSMENT AND ROUTING ANALYSIS

1. Identify study area based on project definition.
2. Gather data about study area.
3. Meet with local representatives to discuss routing constraints and opportunities in the study area.
4. Send consultation letters to local, state, and federal agencies and officials soliciting information about the study area.
5. Map environmental and land use constraints in study area.
6. Determine preliminary route segments and substation sites based on maps, aerial photos, constraints data and field visits.
7. Publish notice of open house in local newspapers and send invitation for open house to any owners of land within 300 feet of any preliminary route segments.
8. Hold open houses to gather public input.
9. Analyze preliminary route segments and substation sites to develop the primary alternative routes.
10. Prepare Environmental Assessment Report.

PUC APPLICATION PROCESS

1. Submit an application to the Public Utility Commission of Texas (PUC) to amend Certificate of Convenience and Necessity (CCN).
2. Upon filing of the application, send notices to landowners whose properties may be crossed or are within 300 feet of any alternative routes.
3. Send notices to municipalities and electric utilities that are within five miles of the project and to county governments where the project is located.
4. Following the filing of the application, interested parties will have an opportunity to participate in an intervention process.

INTERVENTION?

Within 45 days after application is submitted.

YES

ADMINISTRATIVE HEARING

Technical review of project routing.

Testimony filed by all parties.

Administrative hearing.

Administrative law judge prepares proposed final order.

NO

PUC STAFF REVIEW

PUC staff conducts review and makes recommendation to approve project as submitted or approve with modifications.

PUC MAKES DECISION WITHIN 12 MONTHS

Approval of an application gives the authorization to build the new transmission project along the route selected by the PUC.

DEFINE THE PROJECT

Pipeline developer internally defines route and need to exercise eminent domain.

ENVIRONMENTAL ASSESSMENT AND ROUTING ANALYSIS

1. Pipeline developer conducts all studies internally; not subject to Railroad Commission review.
2. Public meeting on pipeline held at discretion of developer; when public meetings are held, citizens usually are not allowed to pose questions "town-hall style," but rather must individually approach developers at information tables to ask questions.

RRC APPLICATION PROCESS

Developer provides:

1. Two-page self-reported Pipeline Classification Certificate as gas utility or common carrier with stated power of eminent domain.
2. Three-page checklist for Application for Permit to Operate a Pipeline in Texas.
3. A map of pipeline route.

INTERVENTION

Neither landowners or public entities can cause administrative hearing.

No notice given to landowners or affected public entities that pipeline permit has been applied for or granted by the Railroad Commission.

RRC GRANTS T4 APPLICATION

Permit to operate already approved.

Permitting Process for Renewable Energy

Nueces County, TX

McLennan County, TX

There is NO permitting process or regulatory oversight for renewable energy in Texas

Wind

- A company applies for a Federal Aviation Association (FAA) permit. Additionally, wind projects don't have to consider any wildlife laws.
- It's up to the discretion of the company and landowner to negotiate the lease and/or power purchase agreement (PPAs) which is an arrangement where a third party developer installs, owns, and operates an energy system on a customer's property.

Solar

- A company applies for a Stormwater Prevention Plan permit from Texas Commission for Environmental Quality (TCEQ) and a Pollution Prevention Plan permit from the U.S. Army Corps of Engineers.
- Depending on the project, these permits are only applicable during construction.
- There is no additional permitting for the siting and construction of these projects.

9 http://www.inquiriesjournal.com/articles/1738/wind-energy-legislation-strategies-for-the-lone-star-state#:~:text=62%20Texas%20does%20not%20have,to%20consider%20any%20wildlife%20laws

ERCOT Lack of Oversight

West Texas Ranchers File Lawsuit Against ERCOT for Violation of Lone Star Infrastructure Protection Act

Lawsuit alleges ERCOT violated its fiduciary duty to Ward-Walker Seven Oaks Ranch and Cole Ranch

DEL RIO, Texas, May 5, 2023 /PRNewswire/ -- Texas attorney Dallas J. Barrington has filed a lawsuit on behalf of Ward-Walker Seven Oaks Ranch and Cole Ranch against the Electric Reliability Council of Texas (ERCOT), GH America Investments Group (GHA), GH America Energy, and Greenalia Wind Power Blue Hills, for violating the Lone Star Infrastructure Protection Act (SB 2116), which became law in 2021.

ERCOT previously granted GH America, a subsidiary of China-based Xinjiang Guanghui Industry Investment Co., the ability to develop a 46-wind turbine project until the Texas legislature passed SB 2116 in April 2021. The act prohibits entities from China, Russia, Iran, and North Korea access to Texas' critical infrastructure. However, ERCOT allowed the project to proceed. GHA, controlled by Xinjiang oligarch Sun Guangxin, acquired over 130,000 acres in the county with plans for wind and solar developments.

"As ERCOT refuses to follow the law and protect local power systems for our ranchers in Val Verde County, against Chinese developers, we have no choice but to turn to the District Court of Val Verde County, and respectfully request that ERCOT and other Defendants be made to abide by the laws of Texas," said Dallas J. Barrington, Attorney for Cole Ranch Holdings, LLC, & Ward-Walker Seven Oaks, Ranch, LLC.

S.B. No. 2116

AN ACT

relating to prohibiting contracts or other agreements with certain foreign-owned companies in connection with critical infrastructure in this state.

BE IT ENACTED BY THE LEGISLATURE OF THE STATE OF TEXAS:

SECTION 1. This Act may be cited as the Lone Star Infrastructure Protection Act.

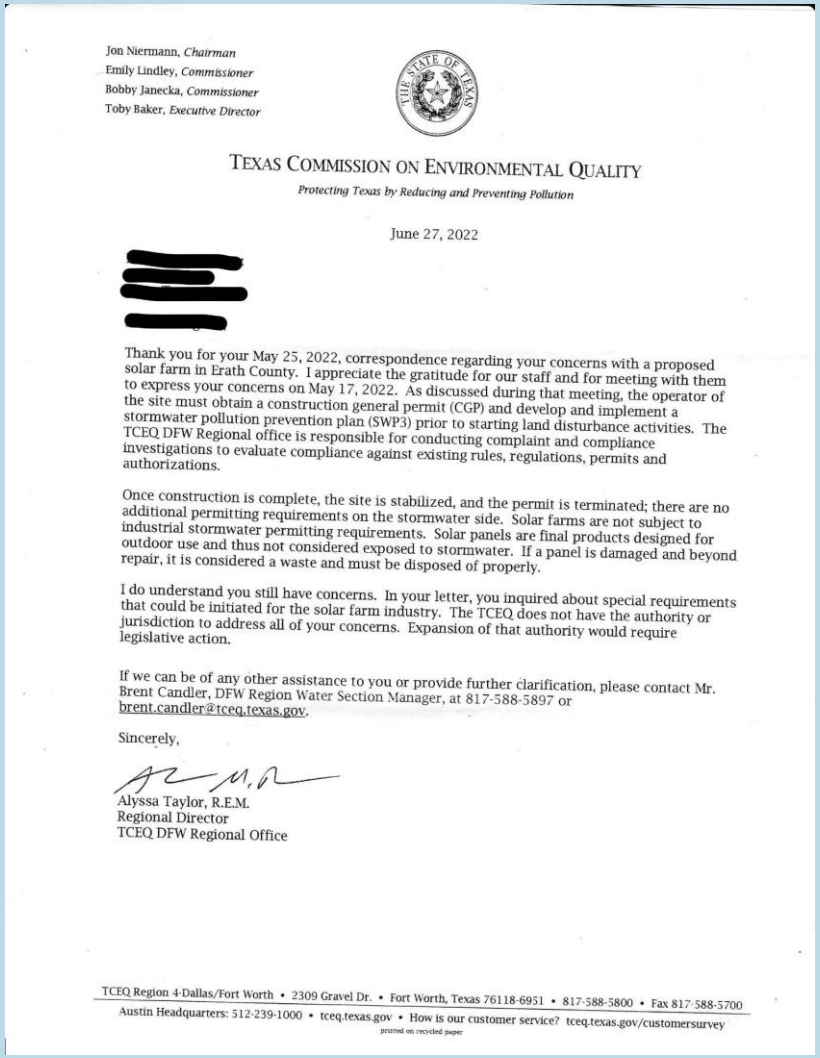
SECTION 2. Subtitle C, Title 5, Business & Commerce Code, is amended by adding Chapter 113 to read as follows:

CHAPTER 113. PROHIBITION ON AGREEMENTS WITH CERTAIN FOREIGN-OWNED COMPANIES IN CONNECTION WITH CRITICAL INFRASTRUCTURE

Sec. 113.001. DEFINITIONS. In this chapter:

(1) "Company" means a sole proprietorship, organization, association, corporation, partnership, joint venture, limited partnership, limited liability partnership, or limited liability company, including a wholly owned subsidiary,

TCEQ Lack of Oversight



Jon Niermann, *Chairman*
Emily Lindley, *Commissioner*
Bobby Janecka, *Commissioner*
Toby Baker, *Executive Director*

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Protecting Texas by Reducing and Preventing Pollution

June 27, 2022

[redacted]

Thank you for your May 25, 2022, correspondence regarding your concerns with a proposed solar farm in Erath County. I appreciate the gratitude for our staff and for meeting with them to express your concerns on May 17, 2022. As discussed during that meeting, the operator of the site must obtain a construction general permit (CGP) and develop and implement a stormwater pollution prevention plan (SWP3) prior to starting land disturbance activities. The TCEQ DFW Regional office is responsible for conducting complaint and compliance investigations to evaluate compliance against existing rules, regulations, permits and authorizations.

Once construction is complete, the site is stabilized, and the permit is terminated; there are no additional permitting requirements on the stormwater side. Solar farms are not subject to industrial stormwater permitting requirements. Solar panels are final products designed for outdoor use and thus not considered exposed to stormwater. If a panel is damaged and beyond repair, it is considered a waste and must be disposed of properly.

I do understand you still have concerns. In your letter, you inquired about special requirements that could be initiated for the solar farm industry. The TCEQ does not have the authority or jurisdiction to address all of your concerns. Expansion of that authority would require legislative action.

If we can be of any other assistance to you or provide further clarification, please contact Mr. Brent Candler, DFW Region Water Section Manager, at 817-588-5897 or brent.candler@tceq.texas.gov.

Sincerely,

Alyssa Taylor, R.E.M.
Regional Director
TCEQ DFW Regional Office

TCEQ Region 4-Dallas/Fort Worth • 2309 Gravel Dr. • Fort Worth, Texas 76118-6951 • 817-588-5800 • Fax 817-588-5700
Austin Headquarters: 512-239-1000 • tceq.texas.gov • How is our customer service? tceq.texas.gov/customersurvey
printed on recycled paper

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TCEQ Investigation Report – Solar Project

STW CGP_TXR1504ER_CP_20210616_Investigation
Texas Commission on Environmental Quality
Investigation Report

Copy

The TCEQ is committed to accessibility. If you need assistance in accessing this document, please contact oce@tceq.texas.gov

Customer: Primoris Renewable Energy, Inc.
Customer Number: CN605622794

Regulated Entity Name: BIG STAR SOLAR PROJECT
Regulated Entity Number: RN111207767

Investigation # 1746082

Incident Numbers 359702

Investigator: MINDY MCDONOUGH

Site Classification CONSTRUCTION GENERAL PERMIT FOR STORMWATER

Conducted: 06/16/2021 – 06/16/2021

SIC Code: 1629

Program(s): STORMWATER

Investigation Type: Compliance Investigation

Location:

Additional ID(s): TXR1504ER

Address: 183 CISTERN RD, ROSANKY, TX , 78953

Local Unit: REGION 11 - AUSTIN

Activity Type(s): SWCCICGP - SW CCI Construction General Permit
SWCMPL - SW Complaint

Principal(s):

Role	Name
RESPONDENT	PRIMORIS RENEWABLE ENERGY INC

BIG STAR SOLAR PROJECT - ROSANKY
6/16/2021 Inv. # - 1746082
Page 4 of 7

Copy

events. Mr. Williams provided a response on July 21, 2021 (Attachment No. 7 – Jeddo Road Clean-up Response). Primoris provided a response timeline including rainfall setbacks, photos, foreman timesheets, and a plan to construct a rock check dam and to seed the ground.

Conclusions and Recommendations
The complaint was substantiated. A sediment discharge occurred due to poorly designed, installed, and maintained erosion and sediment controls. Additional non-compliance issues were noted.

Primoris has been responsive in correcting stormwater control deficiencies and making improvements by adding additional controls each time the complainant reported a sediment discharge. A NOV letter was sent to Mr. Williams noting and resolving five of six violations detailed in the EIF.

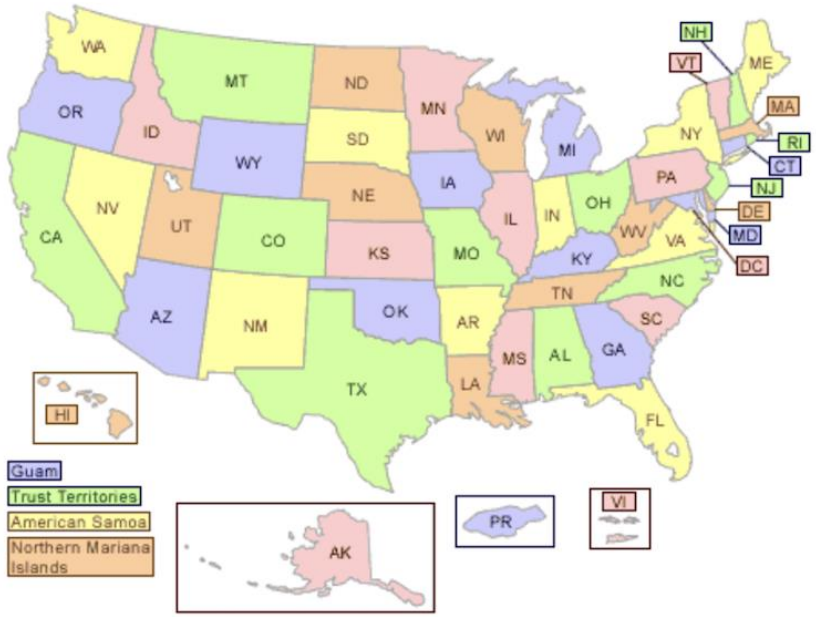
A final letter of findings was sent to the complainant.
NOV Date 08/18/2021 **Method** WRITTEN

OUTSTANDING ALLEGED VIOLATION(S)
ASSOCIATED TO A NOTICE OF VIOLATION

EPA Oversight Over Recycling of Renewables

Links to Hazardous Waste Programs and U.S. State Environmental Agencies

State regulatory requirements for generators may be more stringent than the federal program. To help current and potential hazardous waste generators follow the regulations in their state, both a map and an alphabetically linked list of states and U.S. territories' websites are given below. Wherever possible links to the pages related to solid and hazardous waste are provided. All of these links are outside of EPA's website and EPA is not responsible for the content of these websites.



14 https://www.epa.gov/hwgenerators/links-hazardous-waste-programs-and-us-state-environmental-agencies

Texas Legislature

88th Legislative Session Bills Addressing Renewable Energy

House

HB 171
HB 1013
HB 1254
HB 1443
HB 2549
HB 695
HB 2549
HB3707

Senate

SB 7
SB 154
SB 624
SB 1290*
SB 1699

SB 624 by Kolkhorst / HB 3707 by Patterson

Renewable Energy Generation Facility Permit Requirements & Restriction

- Standard public notice and permitting provisions similar to that of transmission lines
- Permit requirements include:
  - Public internet website
  - Setbacks of 1,000 feet of a property line
  - Signage at the entrance of facilities
- An environmental impact statement in coordination with TPWD and Texas A&M Agrilife
- Reporting requirements for size and location of projects
- Decommissioning plan in compliance with Chapter 301 and 302 Utilities Code

Business & Commerce Committee

- Examine and report on the direct and indirect impacts that variable resources, such as wind and solar, have on grid resiliency, consumer prices, and market uncertainty.

- Evaluate the state's ability to keep pace with increasing electricity demand related to population growth and energy intensive technologies such as electric vehicles, data centers, Bitcoin & AI.

- Review and report on the impact of **SB2627** which established the Texas Energy Fund (TEF).

- Explore emerging technologies with the potential to add new dispatchable power to our electric grid.

Committee on Finance

- **Texas Energy Fund**: **SB2627** and Senate Joint Resolution 93, 88th Legislature, Regular Session;
- **Texas Water Fund**: **SB28** and Senate Joint Resolution 75, 88th Legislature, Regular Session;
- **Centennial Parks Conservation Fund**: **SB1648** and Senate Joint Resolution 74, 88th Legislature, Regular Session

Committee on State Affairs

- **SB 1699**, relating to electricity service in the ERCOT power region, including the participation of aggregated distributed energy resources in the ERCOT market; and

- **SB 2627**, relating to funding mechanisms to support the construction, maintenance, modernization, and operation of electric generating facilities

Committee on Culture, Recreation & Tourism

- **SB1648**, relating to the centennial parks conservation fund.

- Conservation of Texas Farm and Ranch Lands:
  - Evaluate the purpose and effectiveness of the Texas Farm and Ranch Lands Conservation Program.
  - Identify the trends and impacts of land fragmentation given the state's rapid population growth.
  - Examine the ecological and economic benefits of existing land conservation programs and the role of strategic conservation initiatives preserve critical natural resources.

Committee on Natural Resources

- Conduct active oversight to ensure the intended legislative outcome of all legislation, including the following:

- **SB28**, relating to financial assistance provided and programs administered by the Texas Water Development Board.

    - Water Reuse Expansion
    - Reliability of Clean Water Access
    - Groundwater Infrastructure

Your Property Rights Matter

Fixing a rigged market is not an attack on the free market.

Your Property Rights Matter

Join the Coalition

Friend

- Receive updates about legislative items that matter most to Texas Landowners
- Receive Calls-to-action Access to online land resources
- Exclusive TREAD Talks

Corporate Land Partner

- Preferred vendor in our online resources
- Informational materials in our online resources
- Logo on Land Partner Page
- Invitations to exclusive events

Neighbor

- Receive updates about legislative items that matter most to Texas Landowners
- Receive Calls-to-action Access to online land resource
- Exclusive TREAD Talks
- Receive a TREAD bumper sticker

Land Steward

- Receive updates about legislative items that matter most to Texas Landowners
- Receive Calls-to-action
- Access to online land resources
- Exclusive TREAD Talks
- Receive a TREAD bumper sticker
- Invitations to special events

Stay Up To Date!

LIFETIME MEMBER!

Legacy Landowner

- Receive updates about legislative items that matter most to Texas Landowners
- Receive calls-to-action
- Access to online land resources
- Exclusive TREAD Talks
- Receive a TREAD bumper sticker
- Invitations to exclusive events
- Eligibility to serve on a TREAD Committee

Thank You

Jessica Karlsruher, Chief Executive Officer
TREAD Coalition
jessica@treadcoalition.org

Understanding and managing impacts of solar farms on landscape hydrology: insights from field monitoring and modeling

Lauren McPhillips, Rouhangiz Yavari, Cibin, Arash Massoudieh, and Jonathan Duncan

Civil & Environmental Engineering

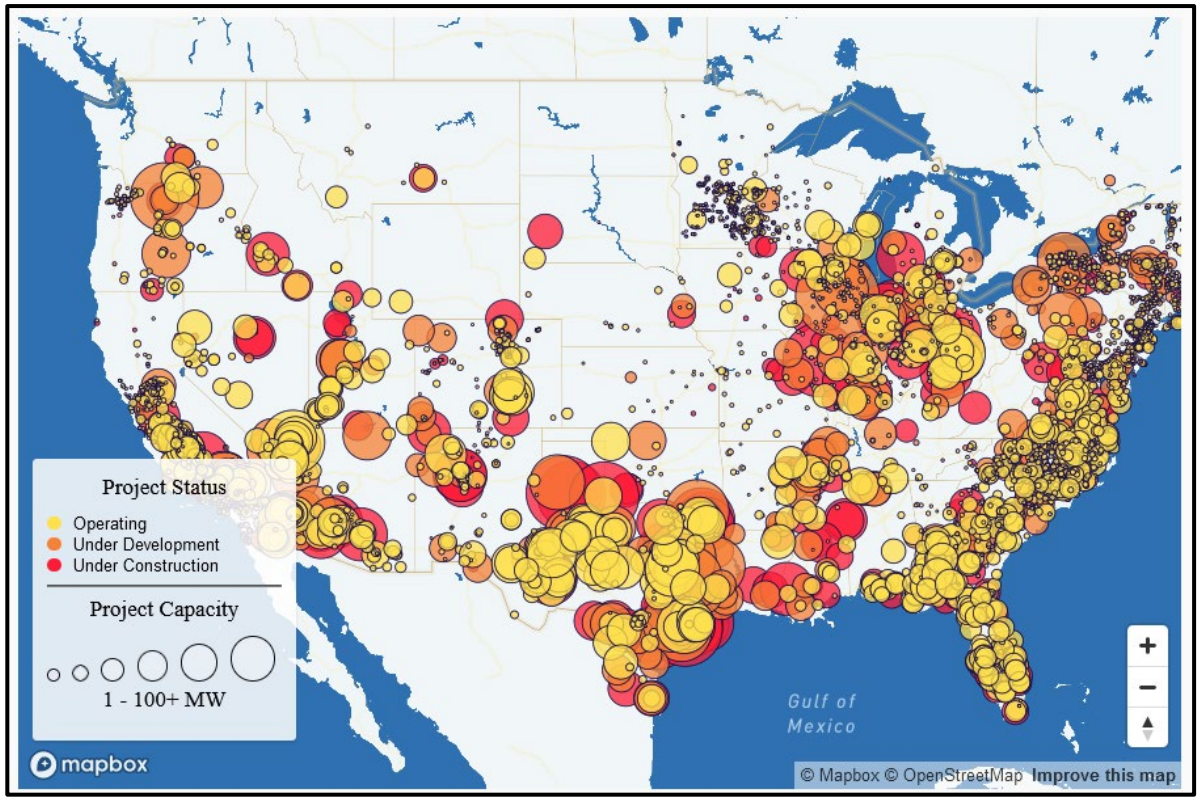
Agricultural & Biological Engineering

PennState

Motivation for this work

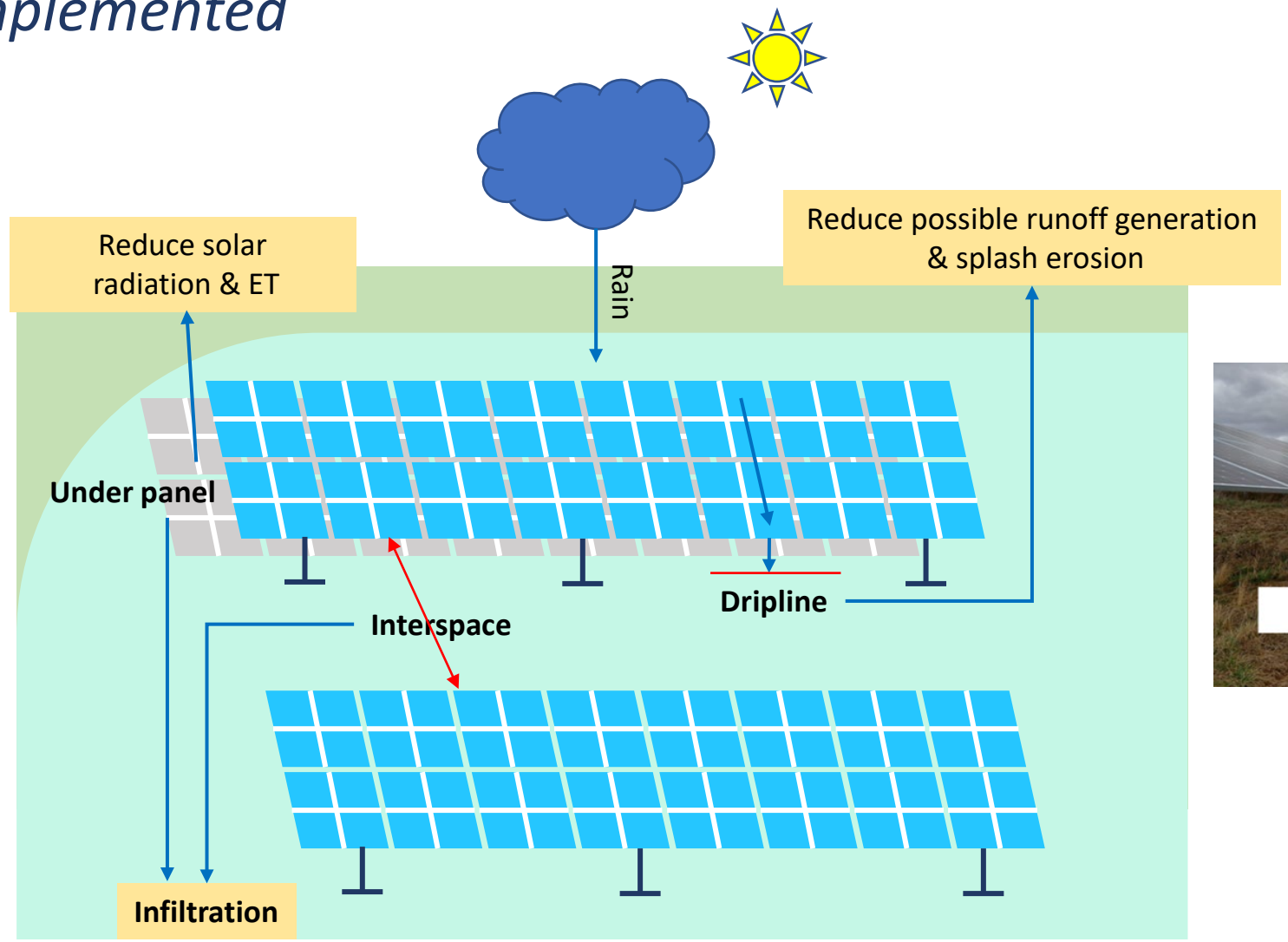
There is rapid development of solar farms happening, which is critical for reducing our carbon footprint!

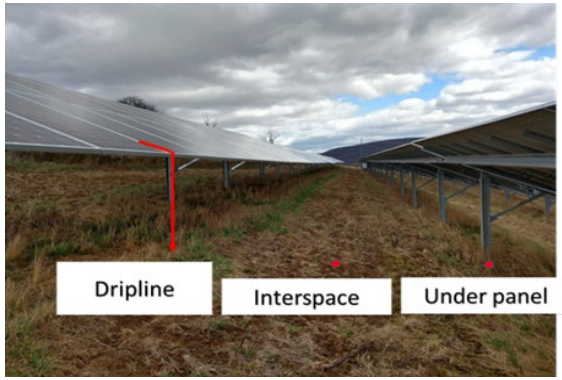
….but we want to understand implications of this land use transition, and support best implementation practices



Map source: Solar Energy Industries Association

There is the potential to alter vegetation, soils, and hydrology, depending on how a solar farm is implemented





Our 2022 review demonstrates how little scientific research had been done to understand these changes & the huge variability (or lack) in stormwater management guidance

ENVIRONMENTAL RESEARCH
INFRASTRUCTURE AND SUSTAINABILITY

TOPICAL REVIEW

Minimizing environmental impacts of solar farms: a review of current science on landscape hydrology and guidance on stormwater management

Rouhangiz Yavari[1], Demetrius Zaliwciw[2], Raj Cibin[3] and Lauren McPhillips[4]

*Guiding **Questions** in Our Research*

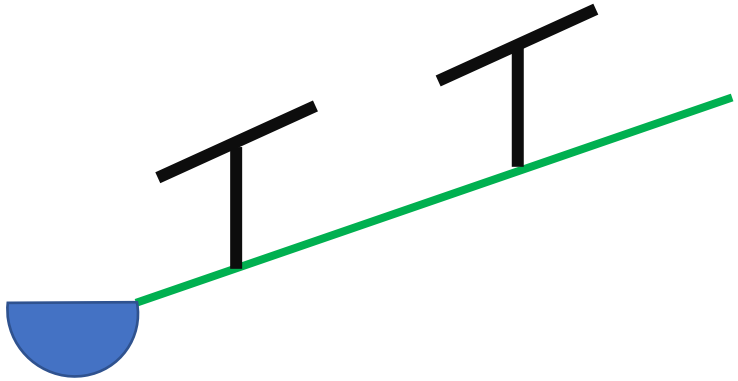
- How do ground-mounted solar panels alter hydrologic processes and soil properties?
- What are best management practices to minimize impacts and maximize co-benefits …particularly on more challenging ‘marginal’ lands?

Our Approach

- Field evaluation at solar farms in central PA with complex terrain

- Hydrologic modeling to better understand our sites + and the best management practices for stormwater management

Study Area (site 1)

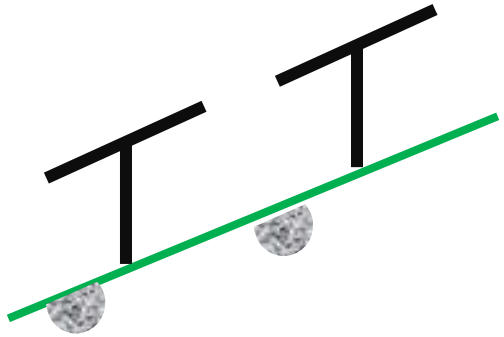


Panels oriented with land slope, and infiltration basin at base

Site 1 : Characteristics

- 20-25 % slope
- Silty clay loam soils
- Meadow vegetation
- Infiltration basins at base of slope, for runoff calculations MN solar stormwater calculator

Study Area (site 2)



Panels oriented with slope, with infiltration trenches

Site 2 : Characteristics:

- Variable slope ~5-15%
- silty clay loam soil w/ rocky outcrops
- Meadow vegetation
- Contoured infiltration trenches

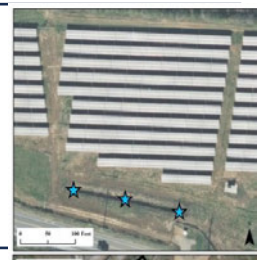
Key Types of Data Collection

Vegetation surveys

Soil properties

Solar radiation (for ET calculation)

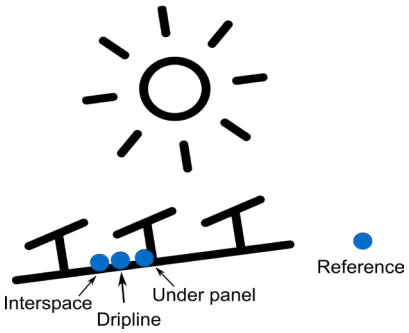
Water level in infiltration basin



Manual (VWC)

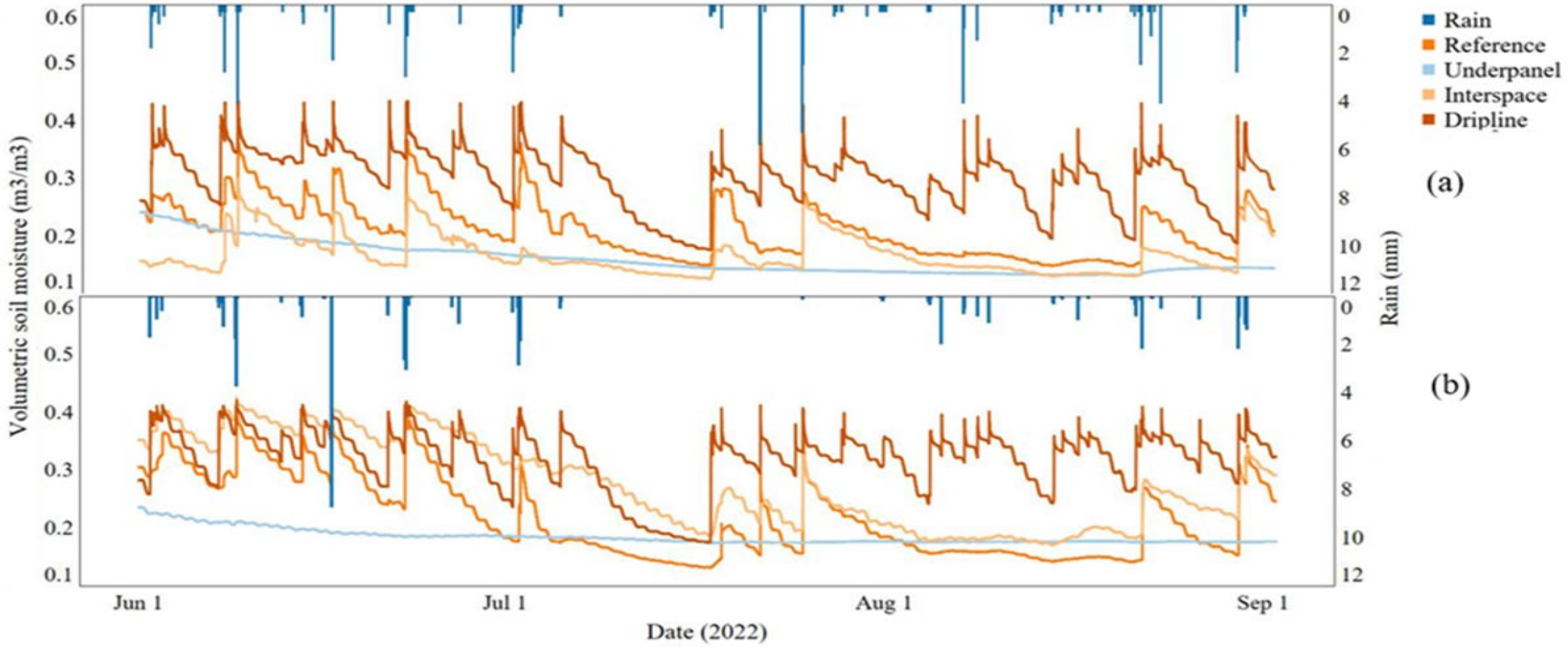
Soil moisture sensor clusters+

manual measurements



Results: continuous soil moisture measurements

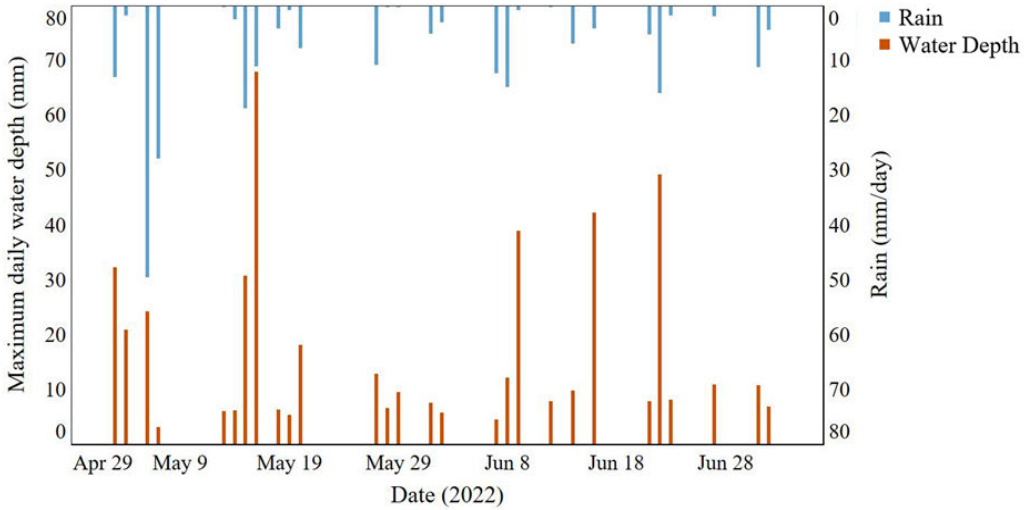
- There is evidence of short periods of saturation at dripline during these events
- The interspace has a few short spikes to saturation, but generally for less duration than dripline, so <u>there is clearly infiltration occurring in interspace</u>



Results: Runoff monitoring

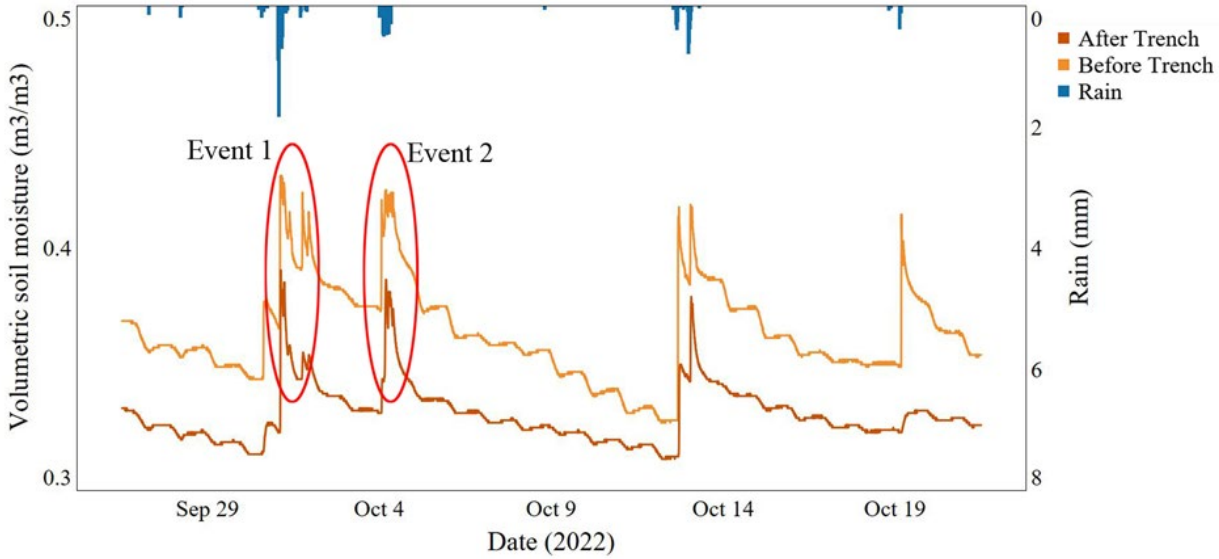
Site 1:

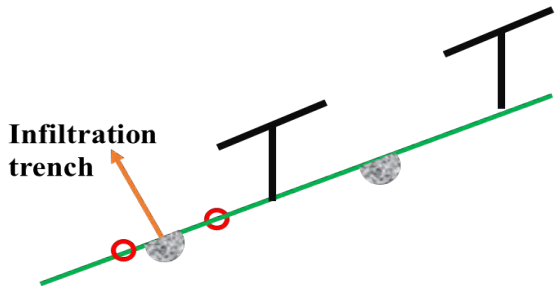
There are periods of runoff generation, but water depth doesn't come close to exceeding infiltration basin capacity



Site 2:

There is lower soil moisture/ less saturation after infiltration trenches





Our published paper of field investigation in 2 solar farms

Journal of Hydrology 638 (2024) 131474

Contents lists available at ScienceDirect

Journal of Hydrology

journal homepage: www.elsevier.com/locate/jhydrol

Research papers

Quantifying soil moisture and evapotranspiration heterogeneity within a solar farm: Implications for stormwater management

Rouhangiz Yavari Bajehbaj [a,*], Raj Cibin [b], Jonathan M. Duncan [c], Lauren E. McPhillips [d]

[a] Department of Civil and Environmental Engineering, The Pennsylvania State University, University Park, PA, USA
[b] Department of Agricultural and Biological Engineering, Department of Civil and Environmental Engineering, The Pennsylvania State University, University Park, PA, USA
[c] Department of Ecosystem Science and Management, The Pennsylvania State University, University Park, PA, USA
[d] Department of Civil and Environmental Engineering, Department of Agricultural and Biological Engineering, The Pennsylvania State University, University Park, PA, USA

Modeling (Site 1)

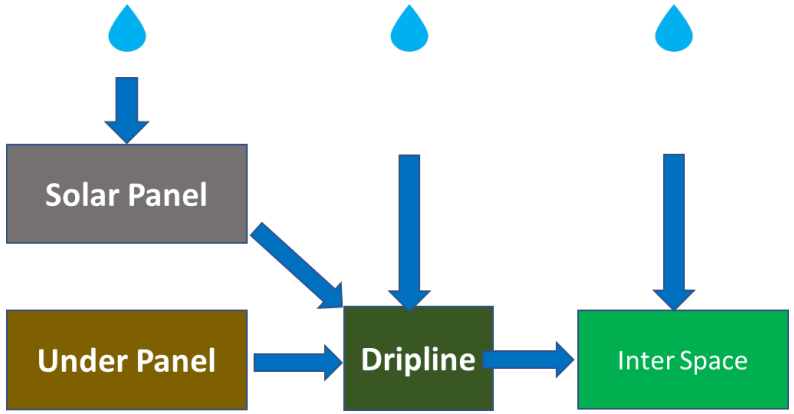
OpenHydroQual:

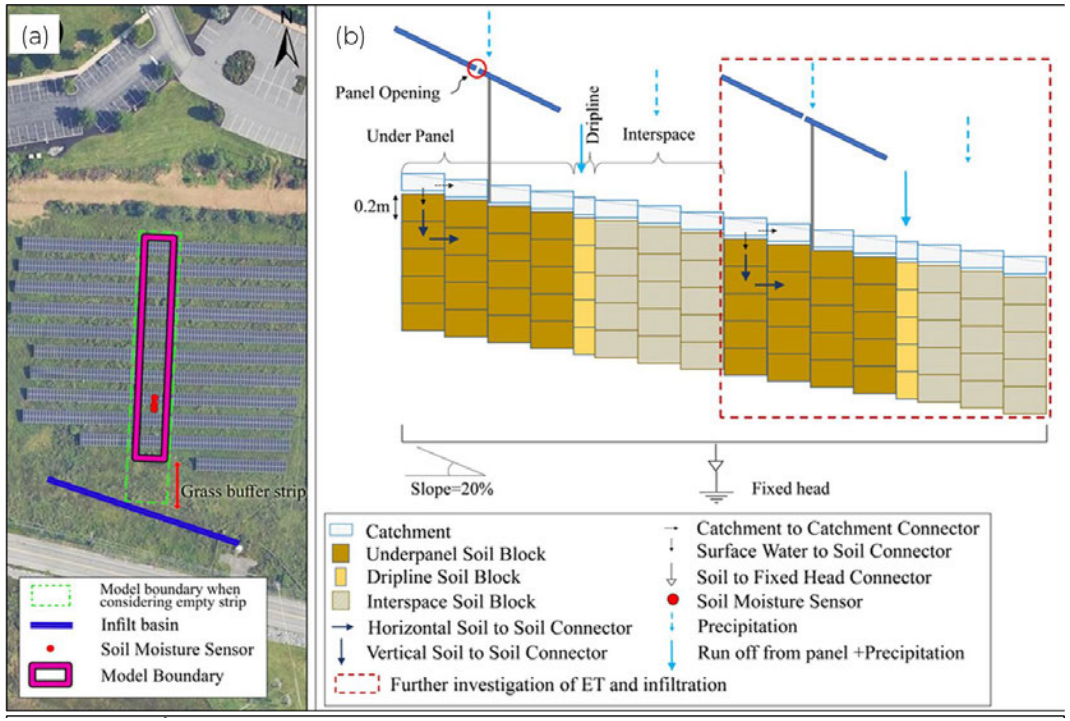
open-source physical hydrological model similar to Hydrus

Soil moisture data for calibration

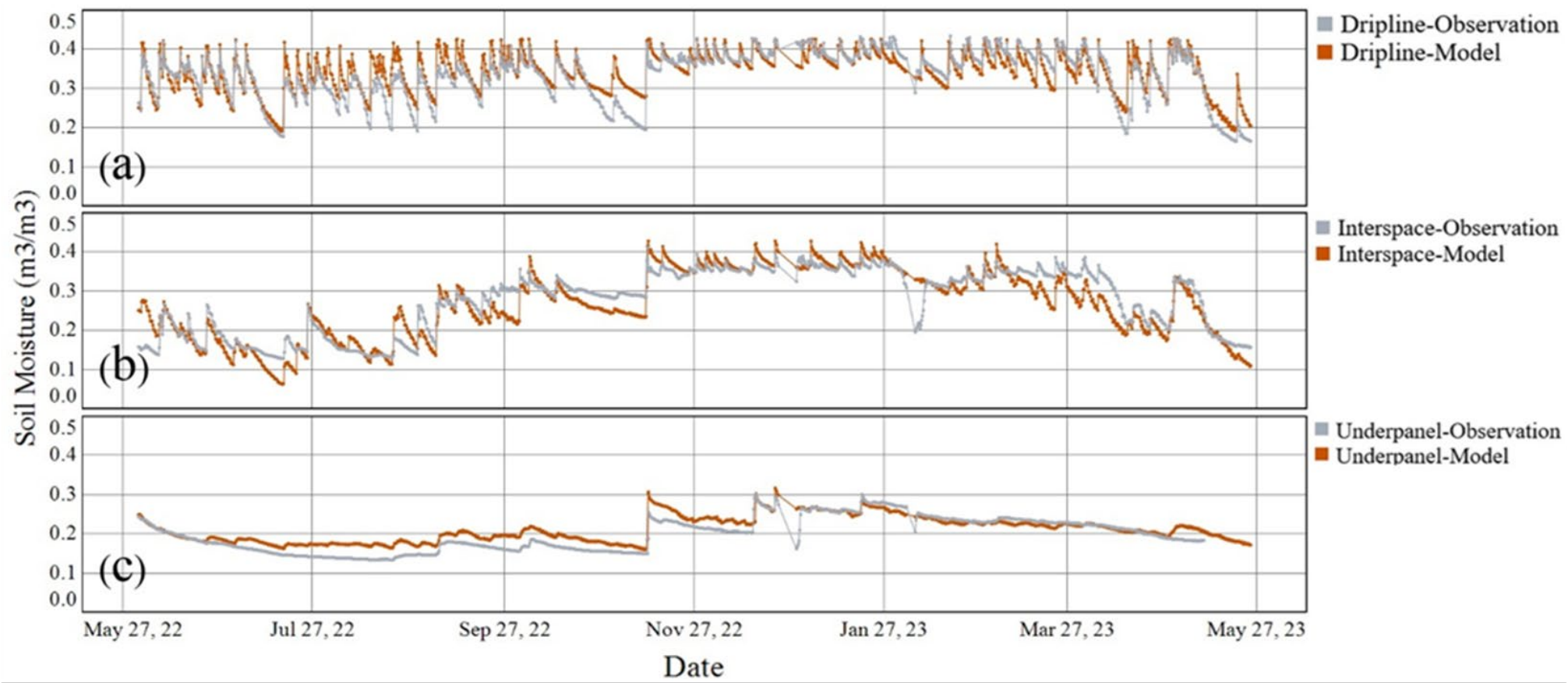
Model scenarios

- Current condition in solar farm
- Pre-development
- Increased interspace width
- Decreasing the impact of vegetation
- Impact of change in storm intensity
- Adding grass buffer between panels and road

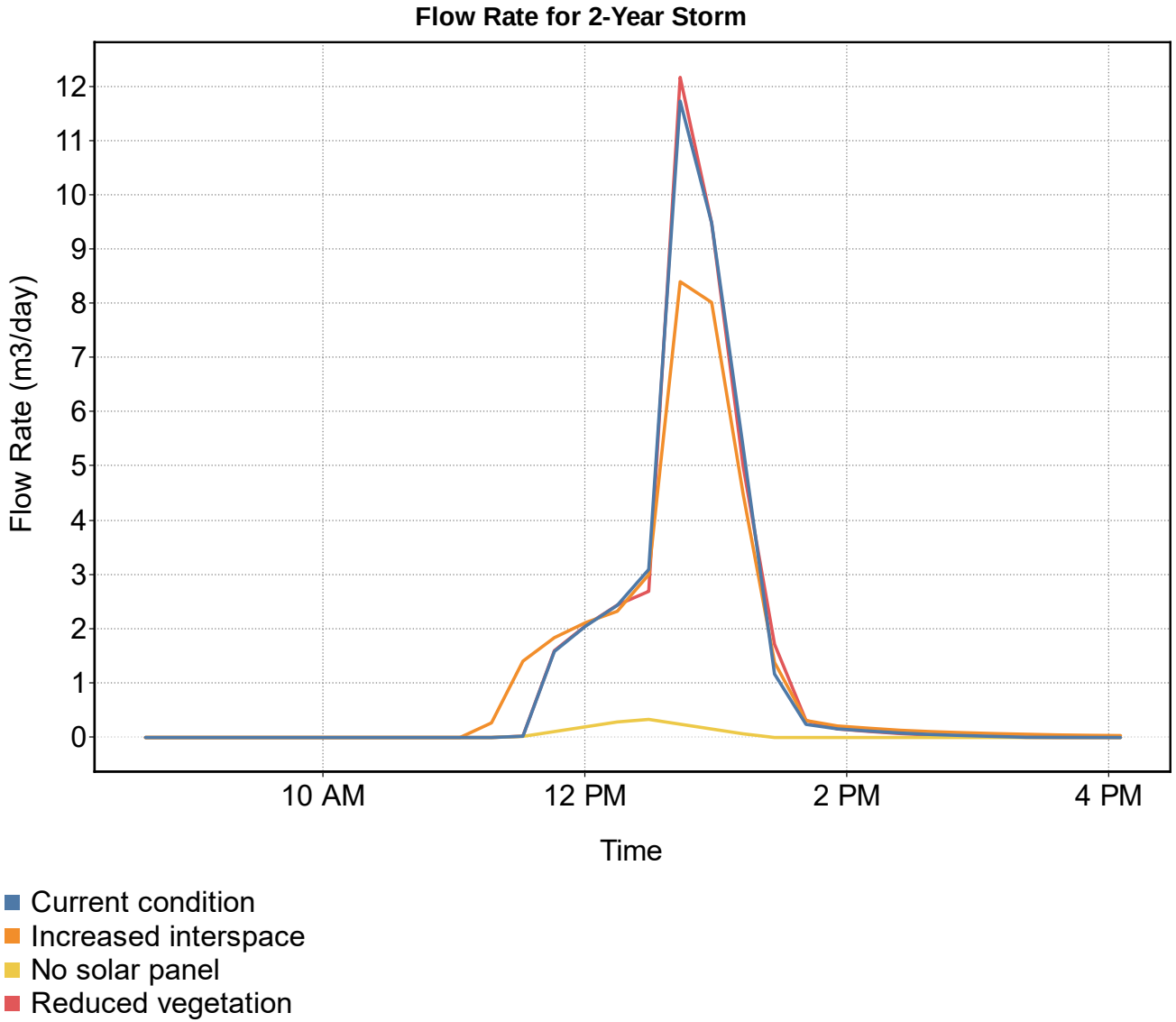




The model calibration and validation using the soil moisture observations demonstrated a strong fit, indicating reliable predictive performance.



Storm runoff hydrographs show peak flow rates and runoff volume increase with solar farm implementation on our site



Scenario	Max Flow (m3/day)	Runoff depth (cm)
Pre-paneled	0.33	0.02
Current condition	11.73	0.53

Max Flow and runoff volume

Pre-paneled < all other scenarios

Increasing interspace reduces max flow

Decreasing vegetation increase the max flow

Conclusions

- Water is redistributed with increased moisture and runoff generation at driplines, but there is evidence of enhanced infiltration in the interspace zone
  - These patterns have been observed in field data and successfully replicated in a model
- Vegetation height and ET is consistently lower under panels but there still was good vegetation coverage under panels
- Stormwater management at our two monitored sites was effective in infiltrating and detaining runoff for the observed storm events
- Our model indicates that implementation of solar panels increases runoff depth and peak flow rate compared to pre-development

Recommendations

Research needs

- There is additional need for additional field data collection related to runoff generation and function of stormwater management features on solar farms

Management opportunities

- An open interspace between panel rows & vegetation coverage under panels is critical for supporting infiltration and reducing erosion- healthy vegetation and well-draining soils can help manage runoff on solar farms.
- For certain sites- such as very large sites or sites with poorly draining soils or high slopes, properly sized engineered stormwater management practices are necessary to manage runoff.

Rouhangiz (Nasim) Yavari
rmy5091@psu.edu

Questions?

Funders

PennState
College of Agricultural Sciences

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WATER RESOURCES
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pennsylvania
DEPARTMENT OF AGRICULTURE

USGS
science for a changing world

100-yr and 2-yr results

Table 4: Maximum flow (m3/day) for different land management scenarios for two 24 hour design storm events

Land configuration	Maximum flow (m3/day)		Runoff depth (cm)	
	2-year event	100-year event	2-year event	100-year event
Interspace 4m	8.4	66.84	0.49	7.04
Current condition + Manning decreased by %50 (Manning 0.03)	12.7	69.33	0.5	7.25
Current condition	11.73	67.5	0.53	7.2
Base scenario (Pre-panel)	0.33	59.7	0.02	5.7

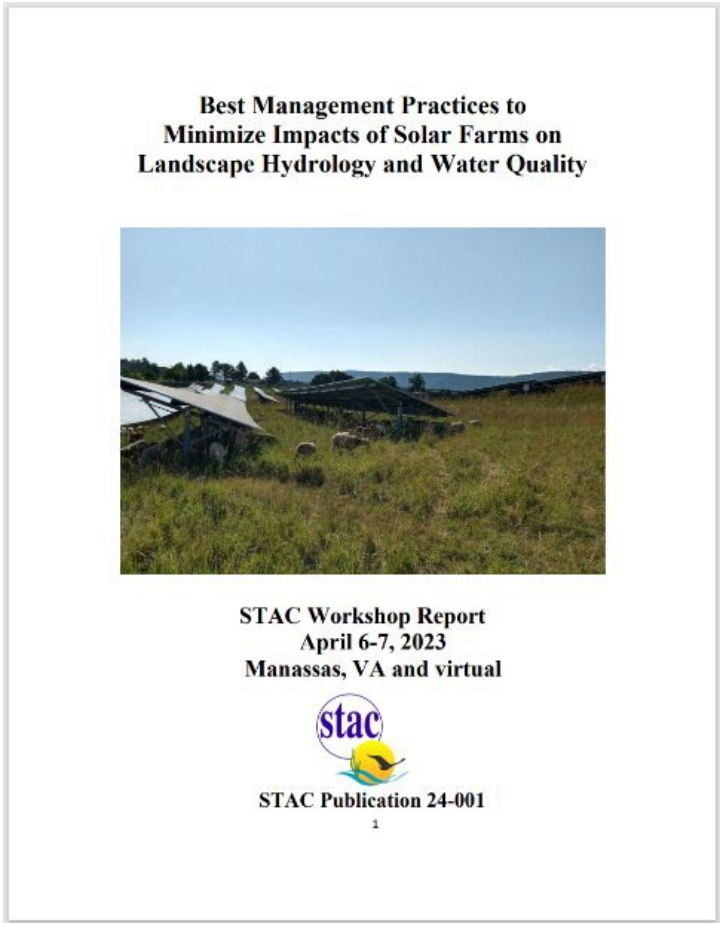
Runoff for different scenarios (yearly investigation)

Table 3. Summary of runoff depth for the solar farm models run for the period of June 1, 2022 to June 1, 2023

Scenario	**Total Runoff Depth (cm/year) (just 10 row_no grass buffer strip of land)**	**Runoff Coefficient**
Base scenario (pre-panel)	1.74	0.02
Current condition (interspace 3m; Manning 0.06)	3.02	0.035
Interspace 4m	3.2	0.038
Current condition + Manning decreased by %50 (Manning 0.03)	3.17	0.038

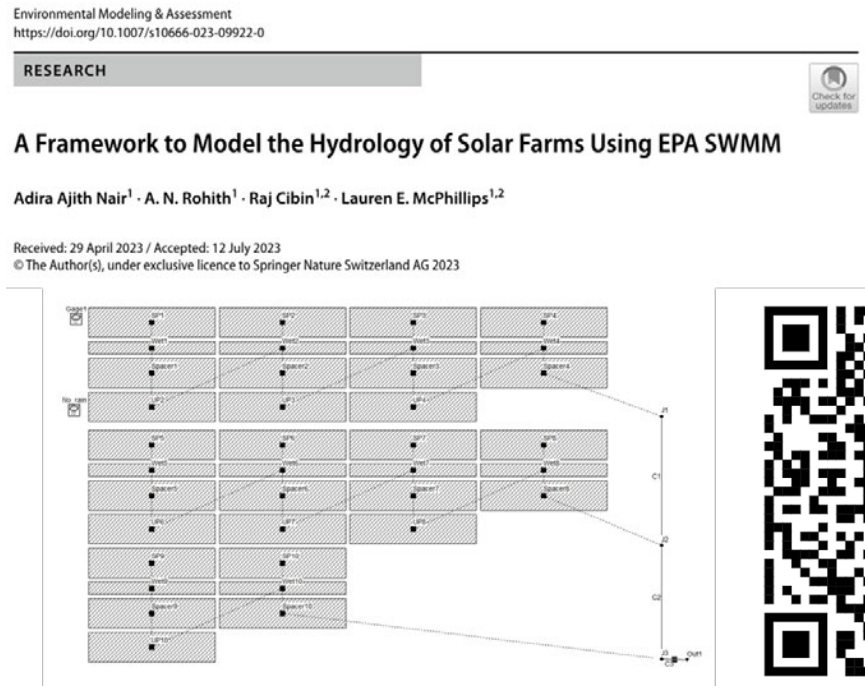
Other references

Chesapeake Research Consortium Science & Technical Advisory Committee Workshop Report



Modeling solar farms in SWMM….

Our team has also developed a model for solar farms in EPA SWMM (but this model was uncalibrated)


Environmental Modeling & Assessment
https://doi.org/10.1007/s10666-023-09922-0

RESEARCH

Check for updates

A Framework to Model the Hydrology of Solar Farms Using EPA SWMM

Adira Ajith Nair[1] · A. N. Rohith[1] · Raj Cibin[1,2] · Lauren E. McPhillips[1,2]

Received: 29 April 2023 / Accepted: 12 July 2023

Other references for modeling

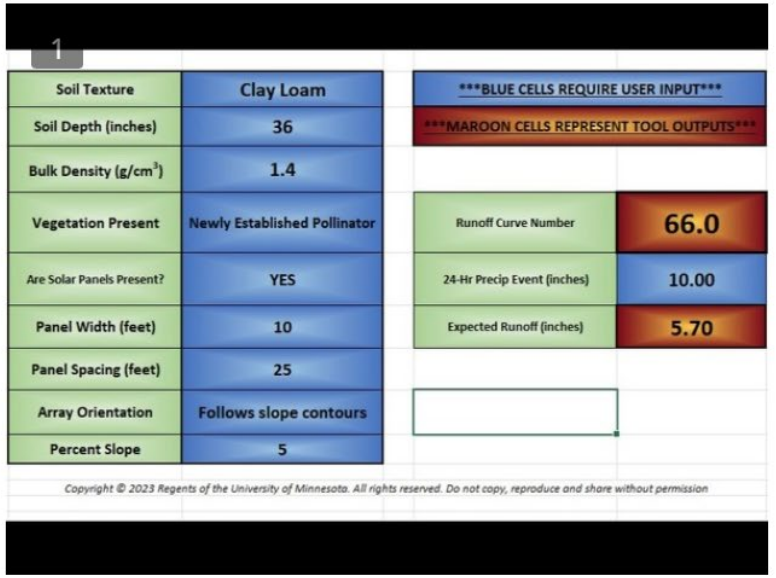
A solar farm stormwater calculator from UMN colleagues

PV-SMaRT Solar Farm Runoff Calculator Version 3.1

An innovative spreadsheet-based runoff calculator to estimate stormwater runoff from ground-mounted solar photovoltaic sites for pre-construction as well as post-construction site-specific conditions.

Technology No. 2023-053

DOWNLOAD PDF



https://www.nrel.gov/solar/market-research-analysis/pv-smart.html

Agrivoltaics: maximizing ecosystem benefits with solar

Nuria Gomez-Casanovas

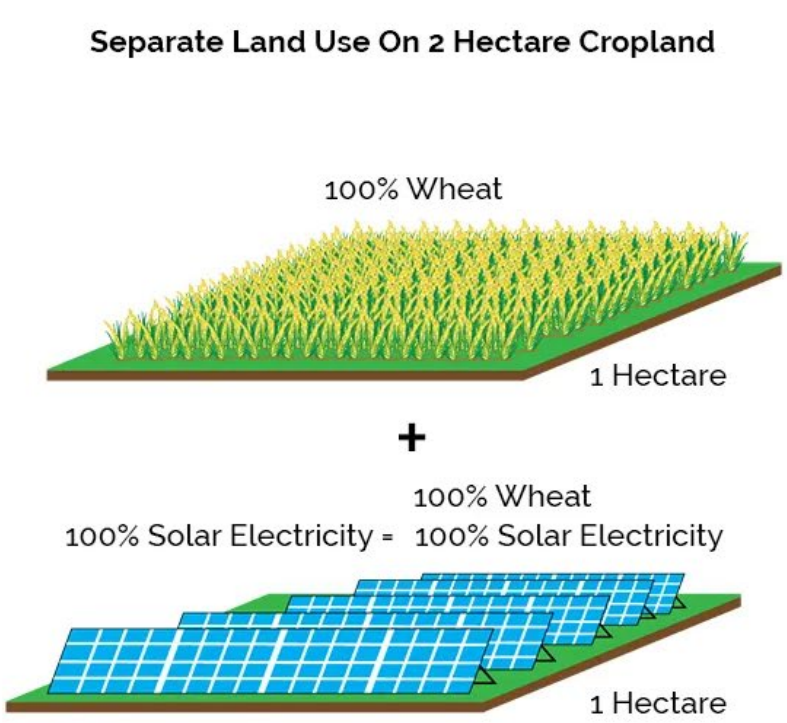
Assistant Professor in Regenerative System Ecology

Texas A&M AgriLife Research Center @ Vernon

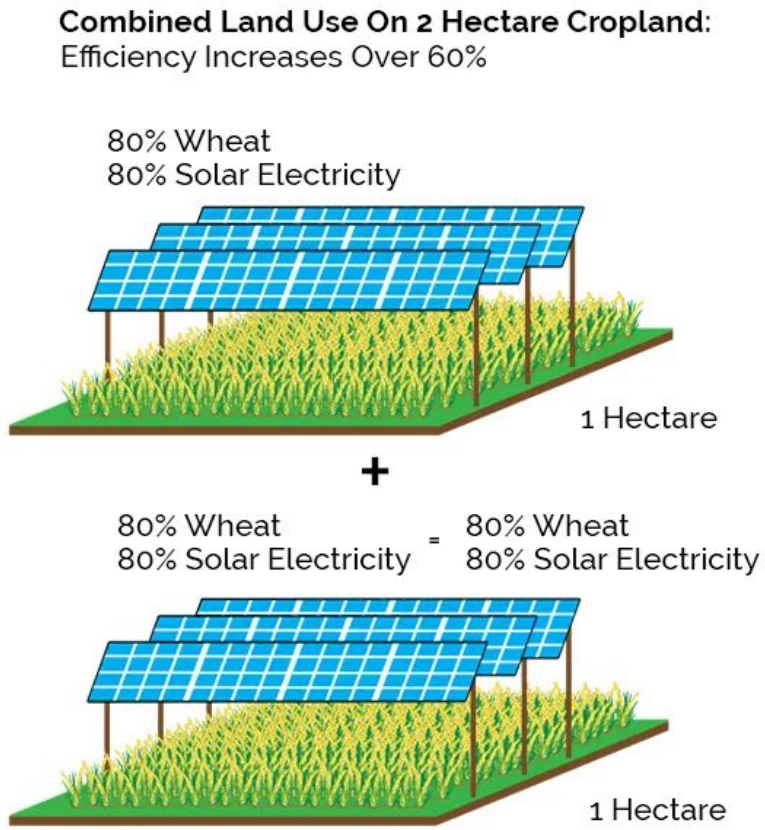
Rangeland, Wildlife & Fisheries Management Department
Texas A&M University

Utility scale photovoltaics (PV) systems are land intensive

Business-as-usual : PV/food production

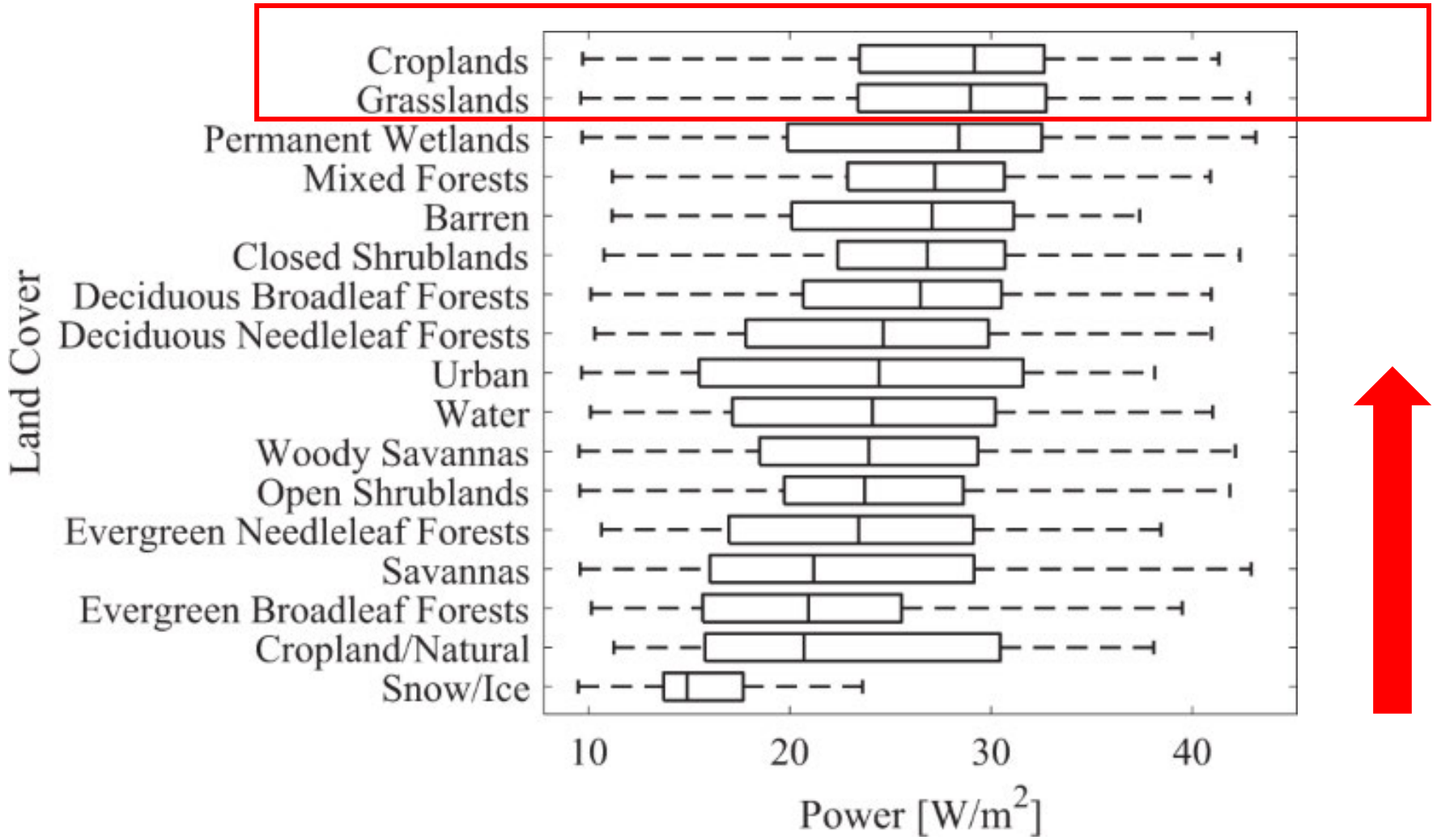


Agrivoltaics (AV)



Source: https://weekly.regeneration.works/p/-solar-farming-our-way-out-of-a-climate

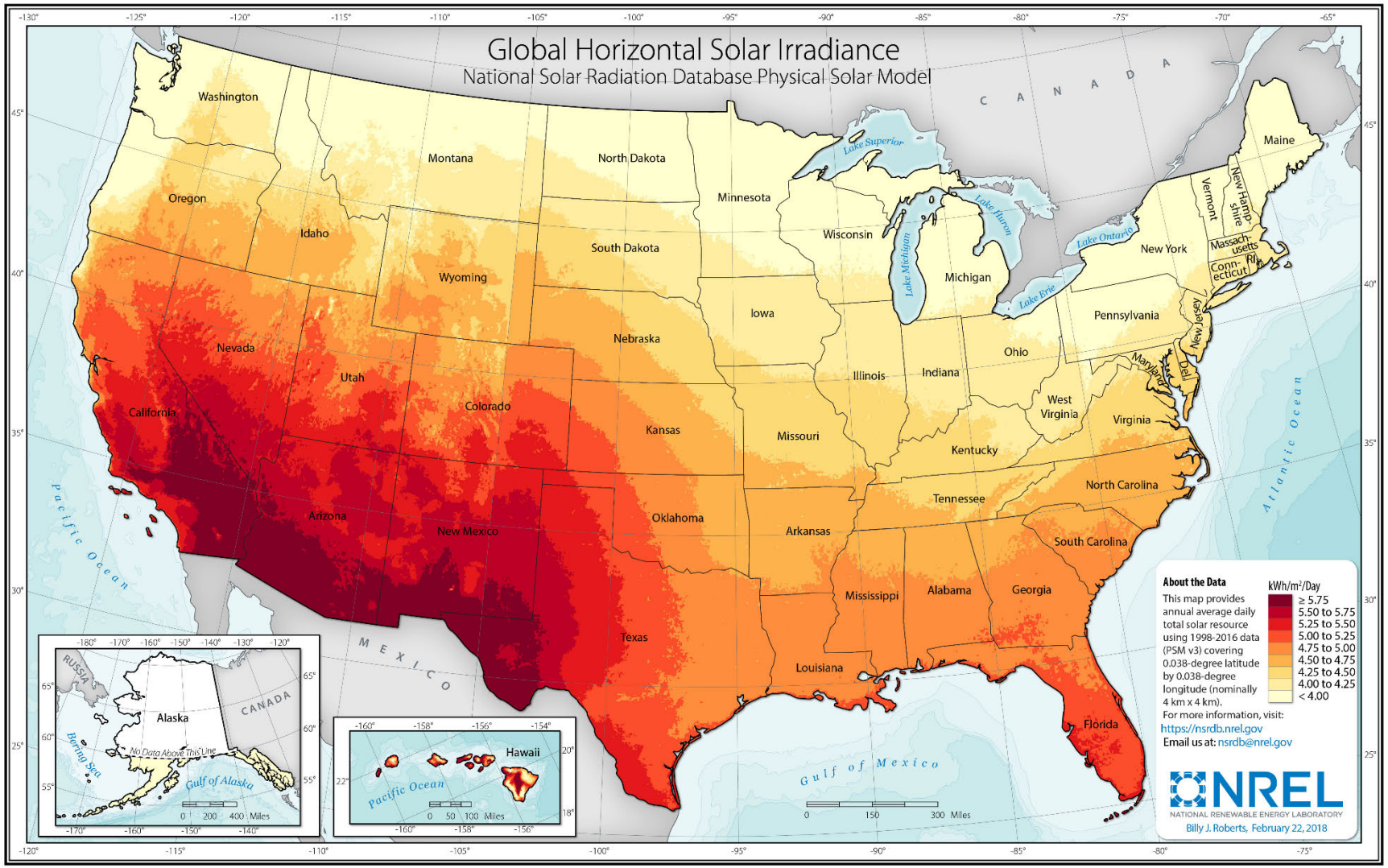
Cropland and grassland are within the land covers with largest solar energy generation potential



Highest energy production

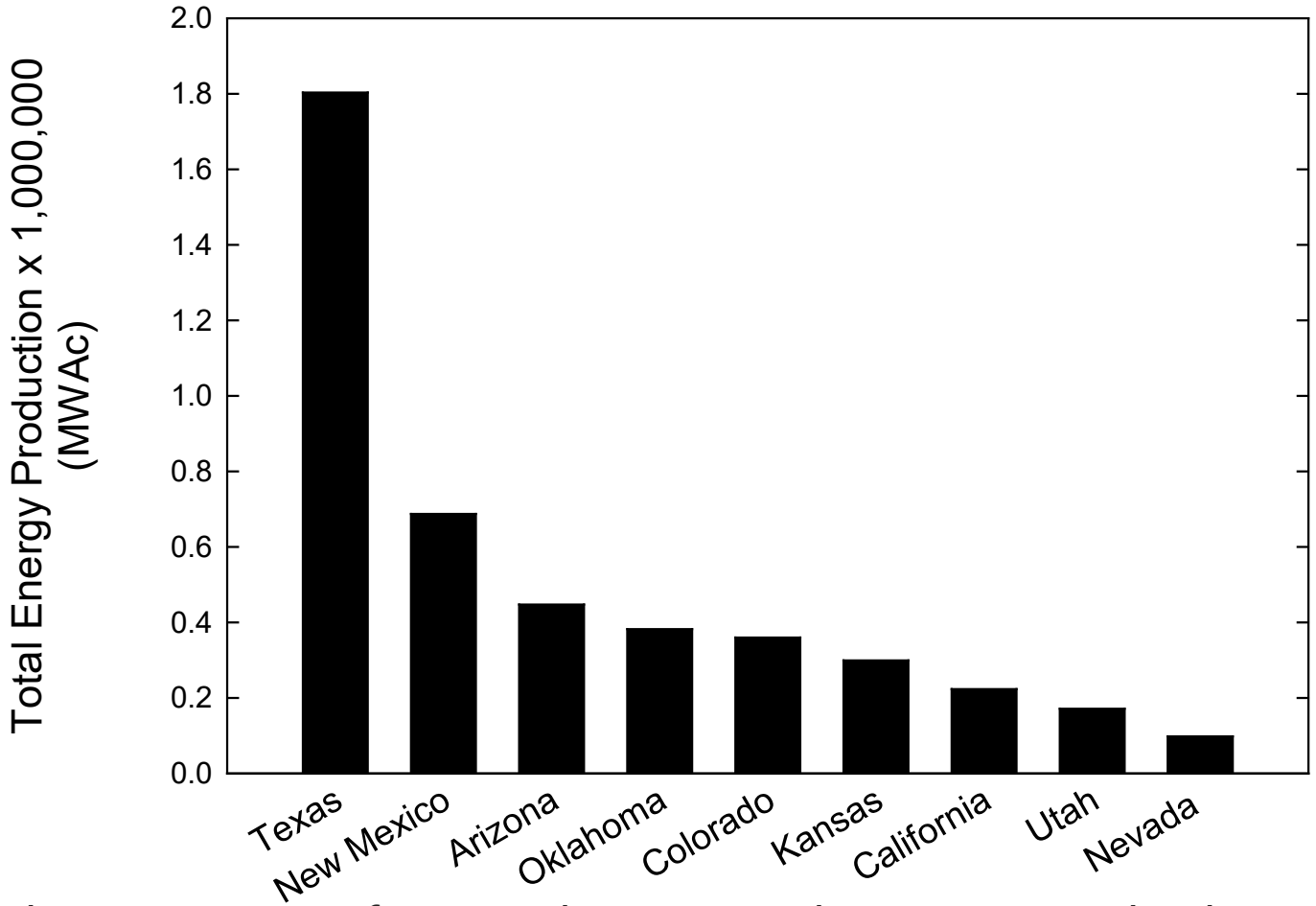
Adeh et al (2019), https://doi.org/10.1038/s41598-019-47803-3, Sci Rep

Texas is poised to become a nationwide leader in solar energy



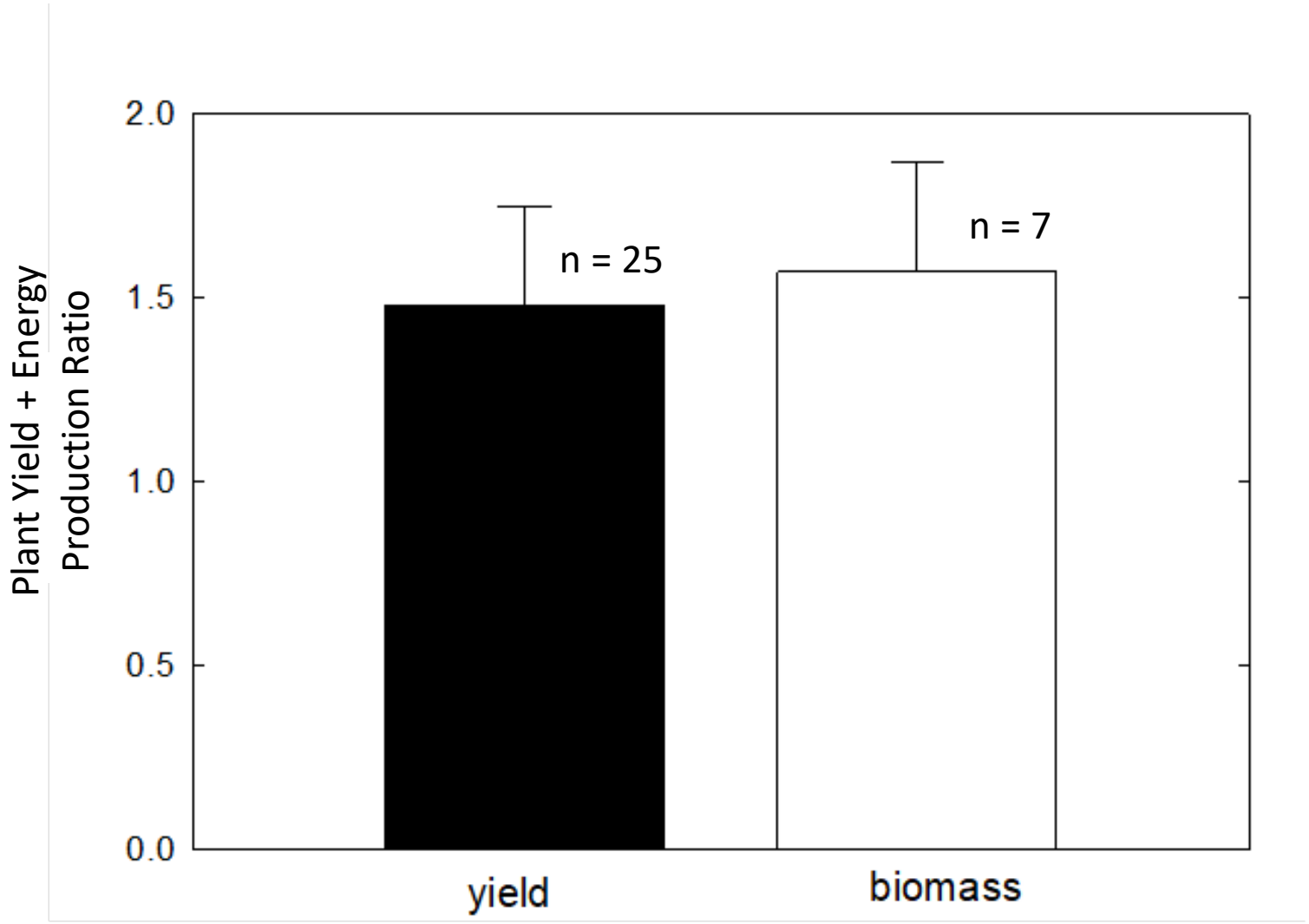
Annual average daily total solar resource (1998-2016). Source: https://www.nrel.gov/gis/solar-resource-maps.html

Texas is poised to become a nationwide leader in solar energy



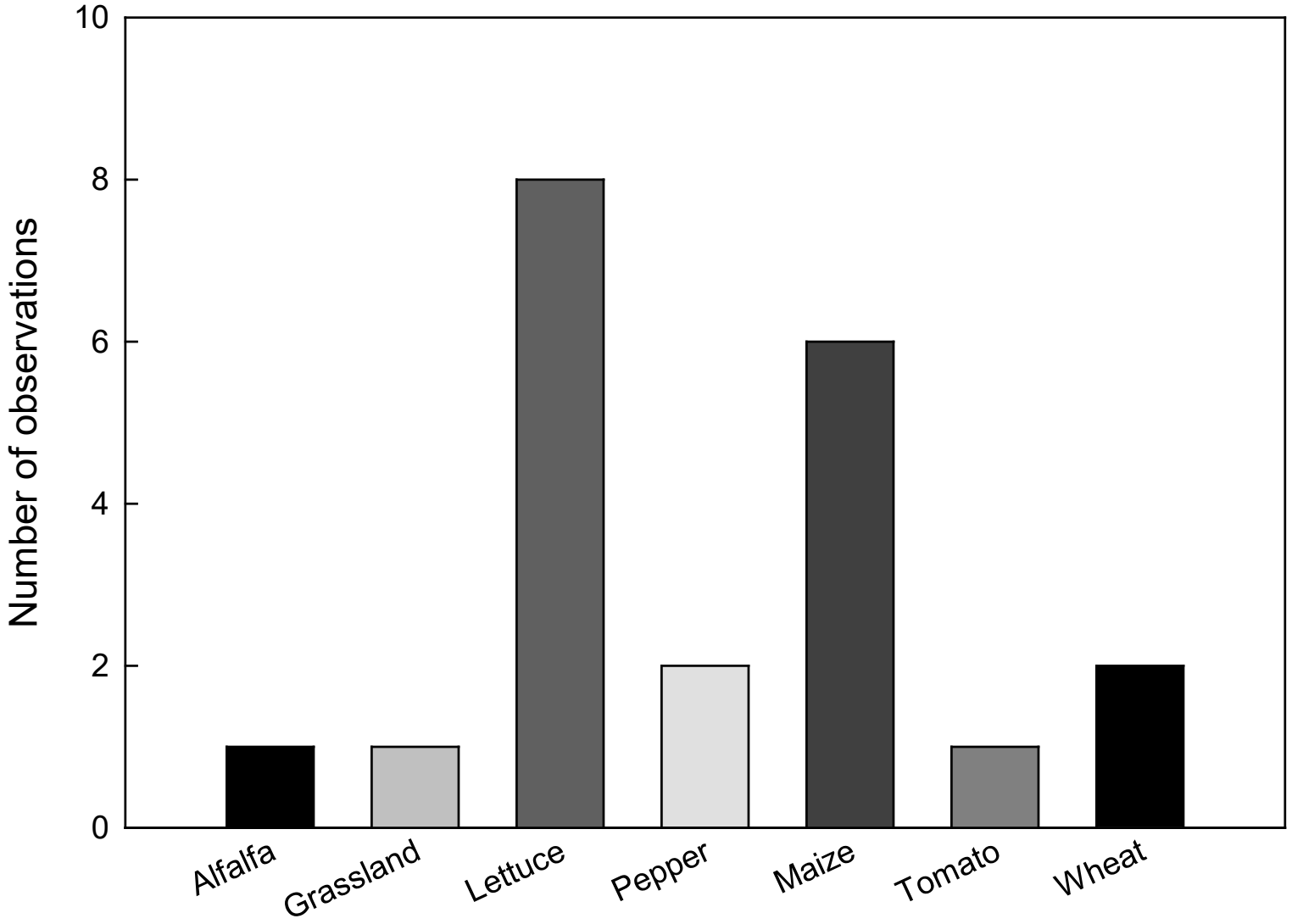
Back-of-the-envelope estimates of potential energy production in rangeland per state. Sources: “Agrivoltaics Map.” InSPIRE, National Renewable Energy Laboratory; https://www.nass.usda.gov/AgCensus/

AV enhances both plant and energy productivity compared to PV or ag alone…



If the Ratio is >1 : the plant yield and energy productivity from the AV system is larger than productivity of either ag alone or PV alone

Gomez-Casanovas et al (2023), https://doi.org/10.1016/j.xcrp.2023.101518, Cell Reports Physical Science

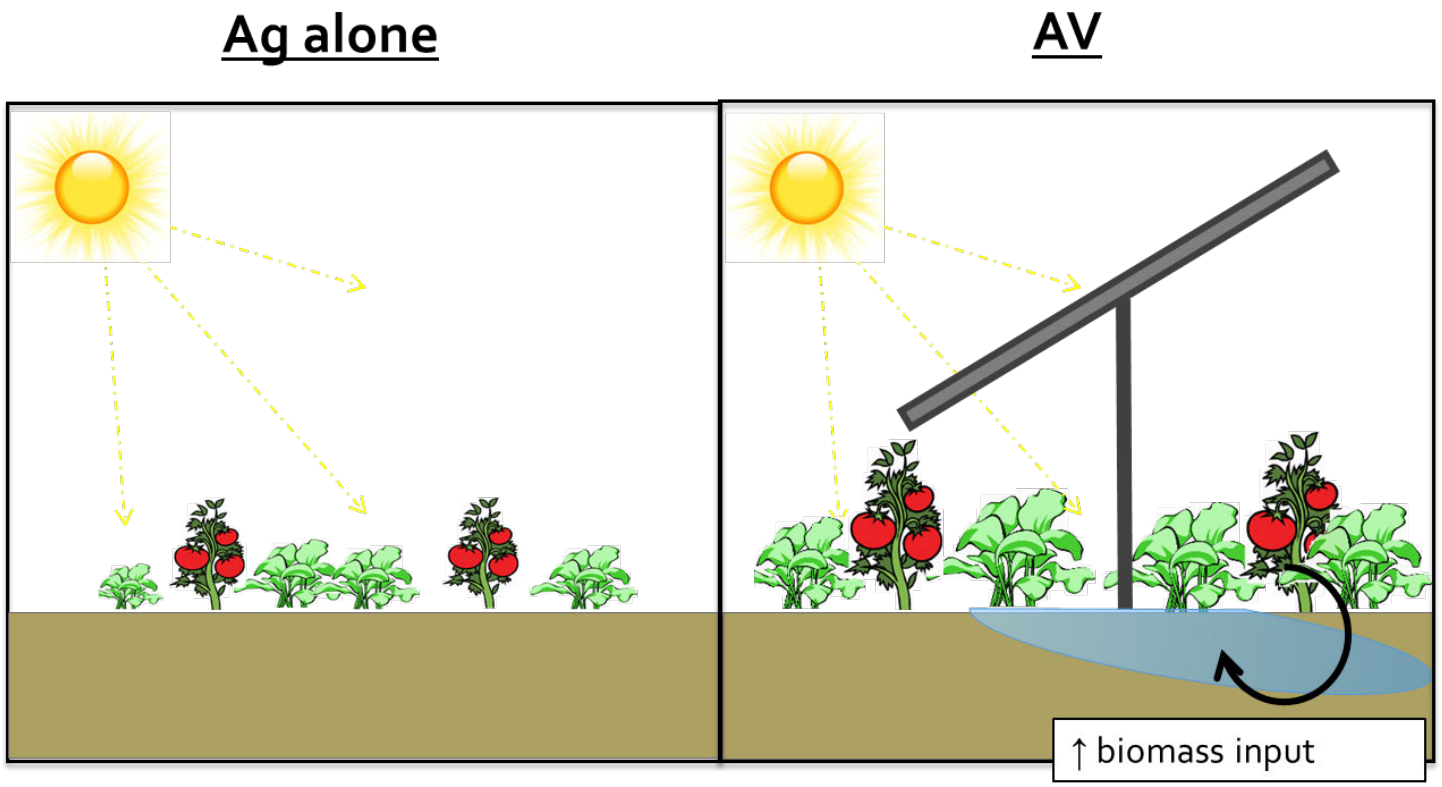


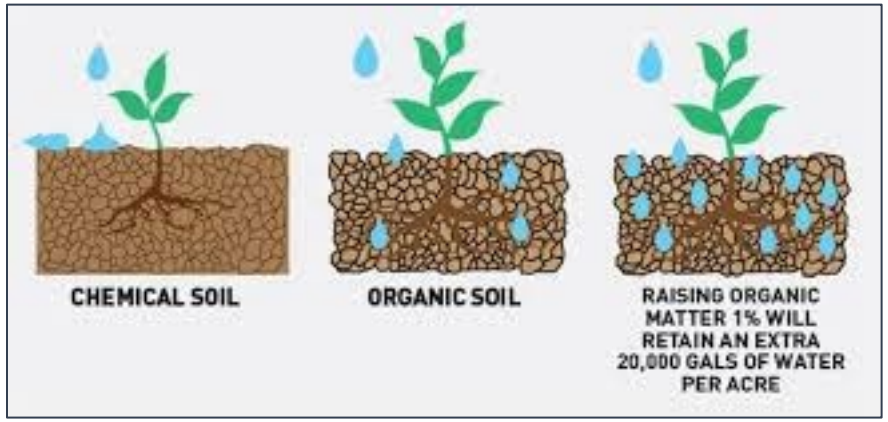
…But knowledge on AV impacts across a wide range of crops and forage species is limited…

…And very limited knowledge on major commodities in TX…

Gomez-Casanovas et al (2023), https://doi.org/10.1016/j.xcrp.2023.101518, Cell Reports Physical Science

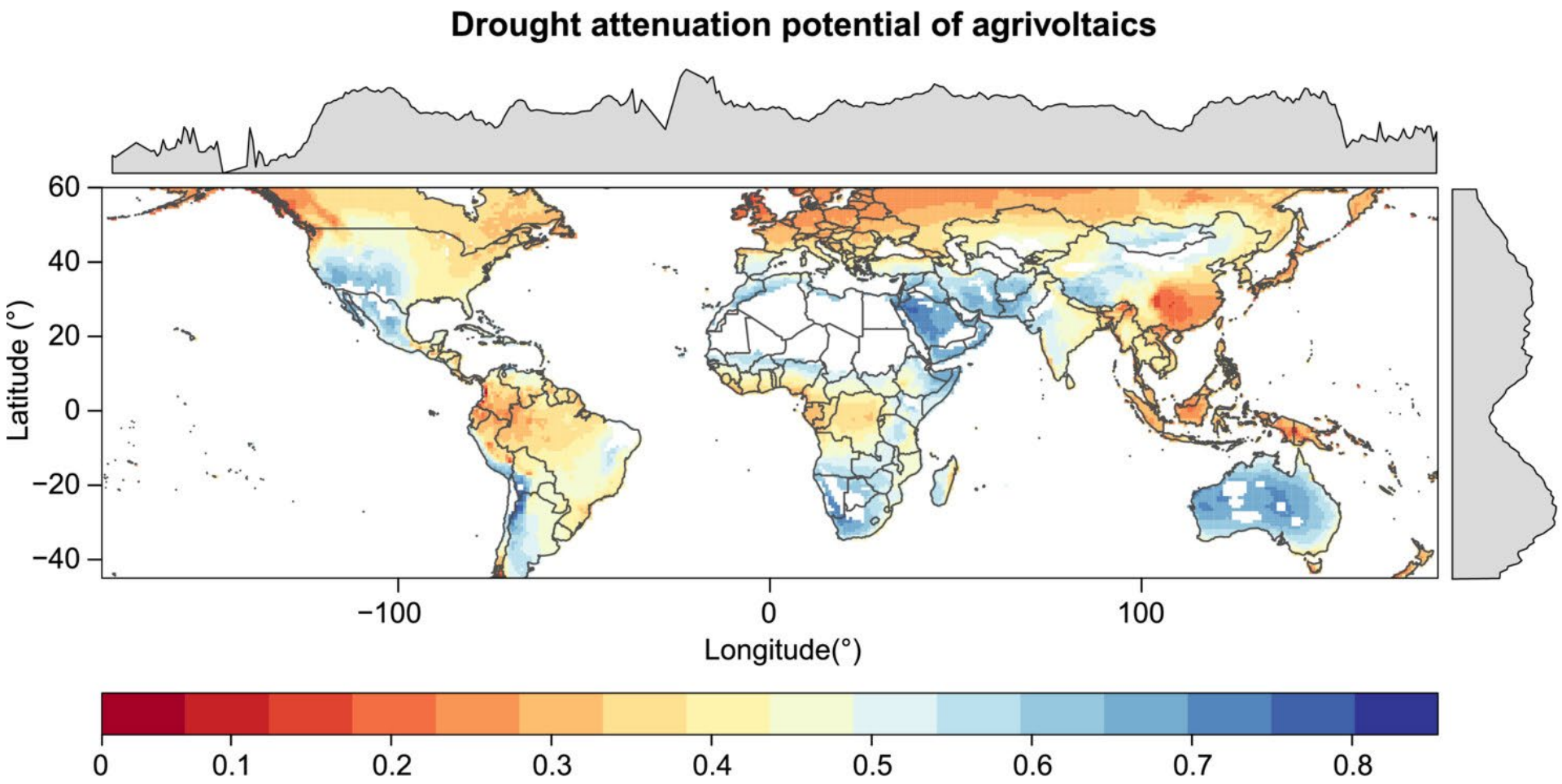
AV provides shading and enhances the capacity of soils to act as a 'sponge' for retaining water





Gomez-Casanovas et al (2023), https://doi.org/10.1016/j.xcrp.2023.101518, Cell Reports Physical Science

AV could enhance resilience of our food systems to climate change

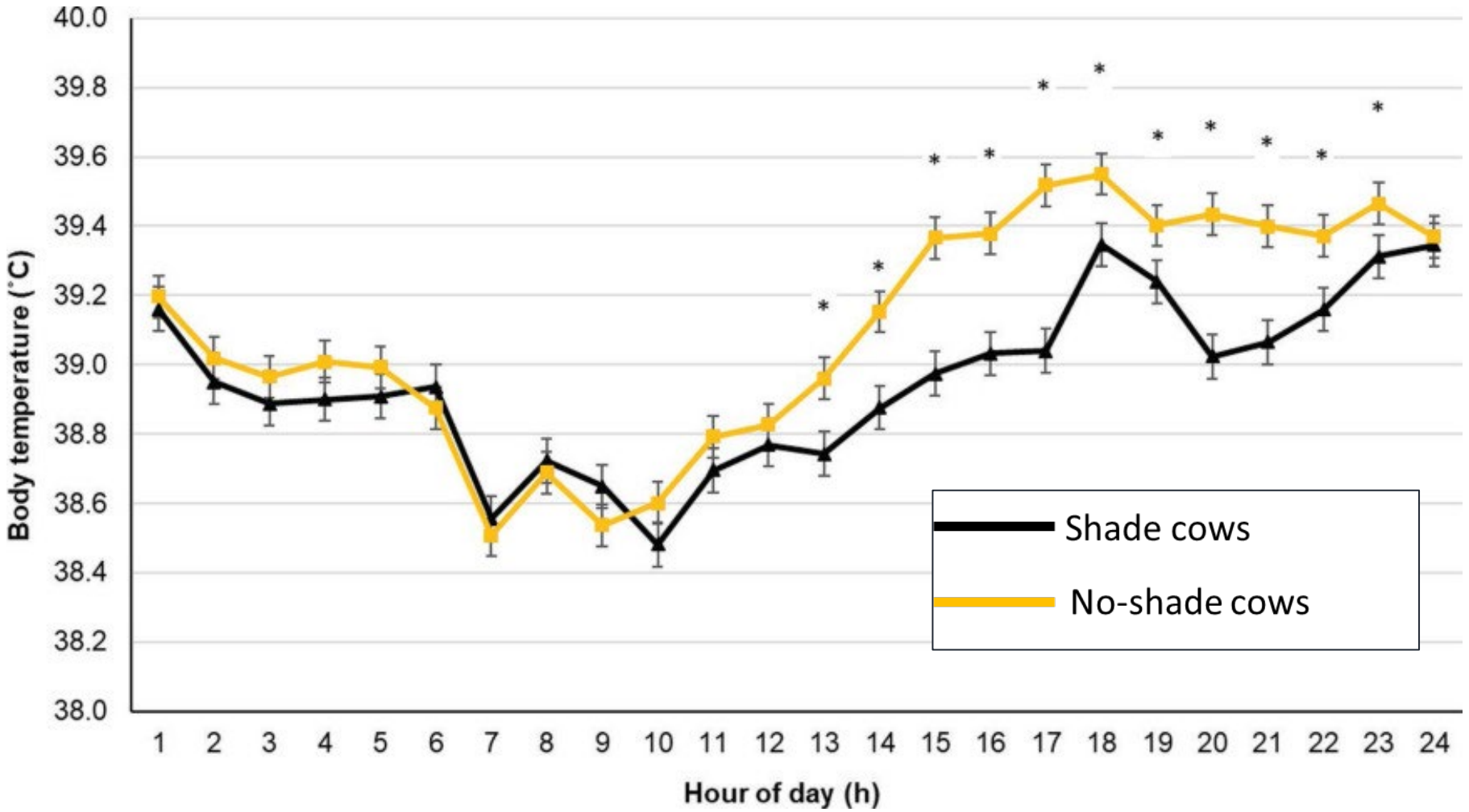


No potential

Maximum potential

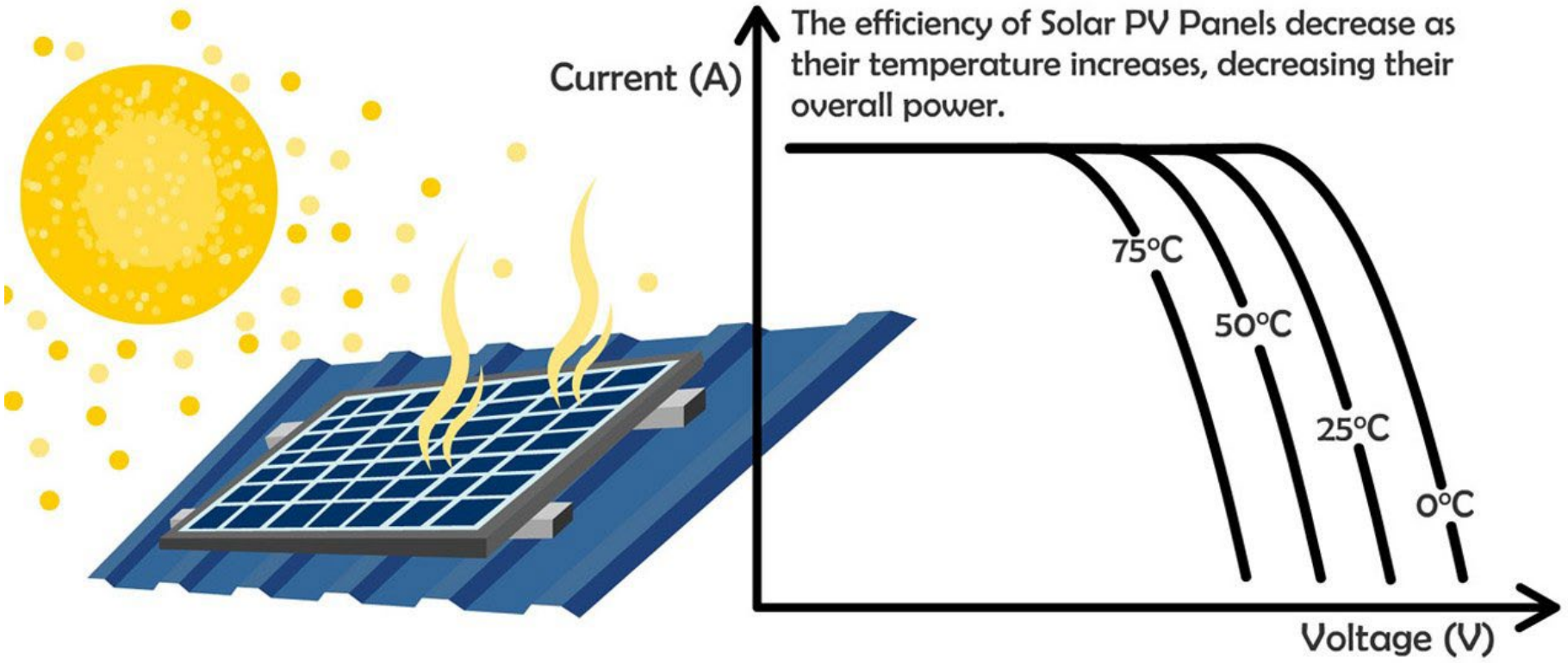
Schweiger and Pataczek (2023), https://doi.org/10.1002/ppp3.10371,, Plants, People, Planet.

AV can enhance the resilience of the livestock production systems by alleviating animal heat stress



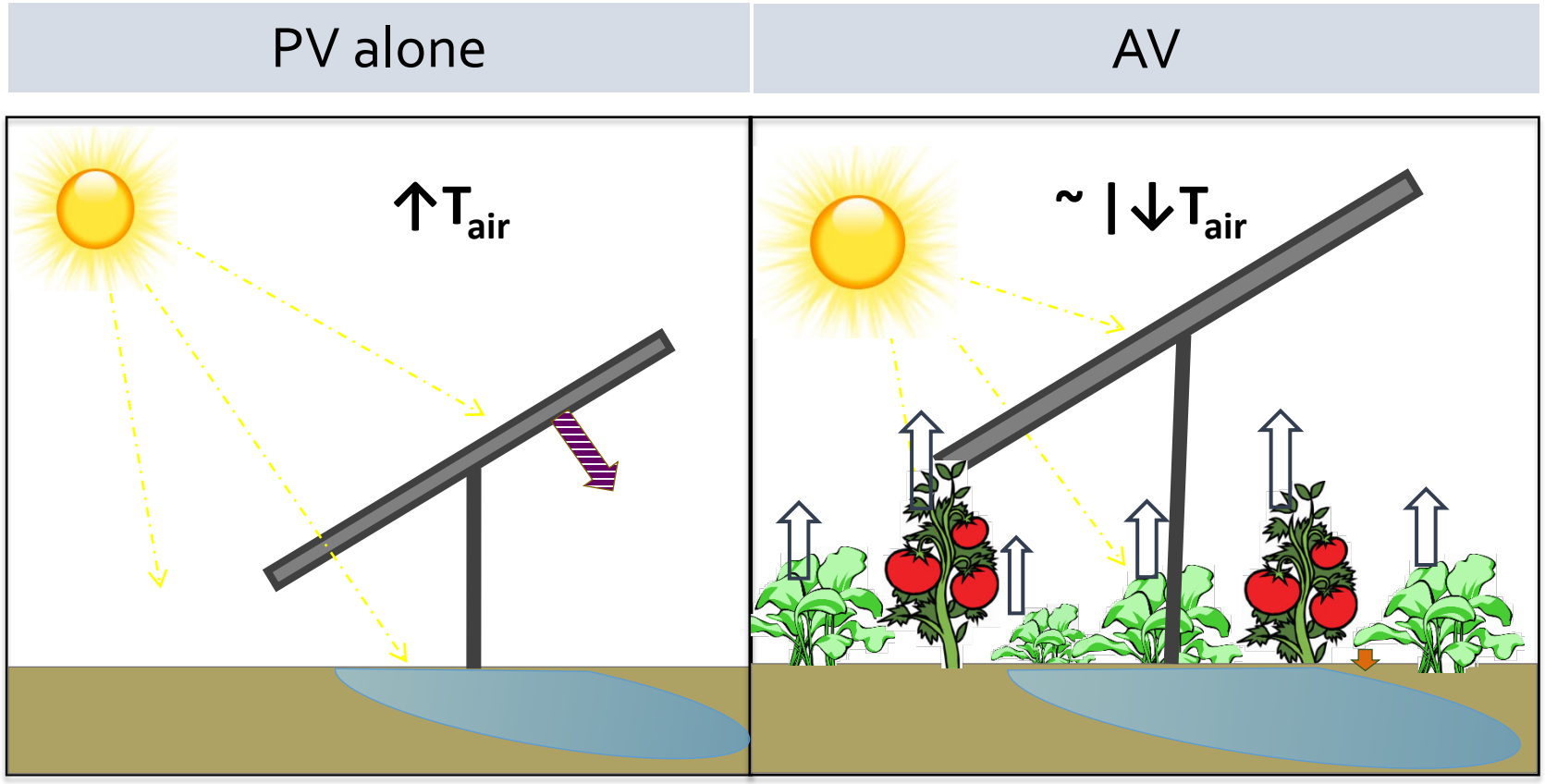
Sharpe et al. (2020), https://doi.org/10.3168/jds.2020-18821, Journal of Dairy Science.

Utility-scale PV systems are vulnerable to climate change…but



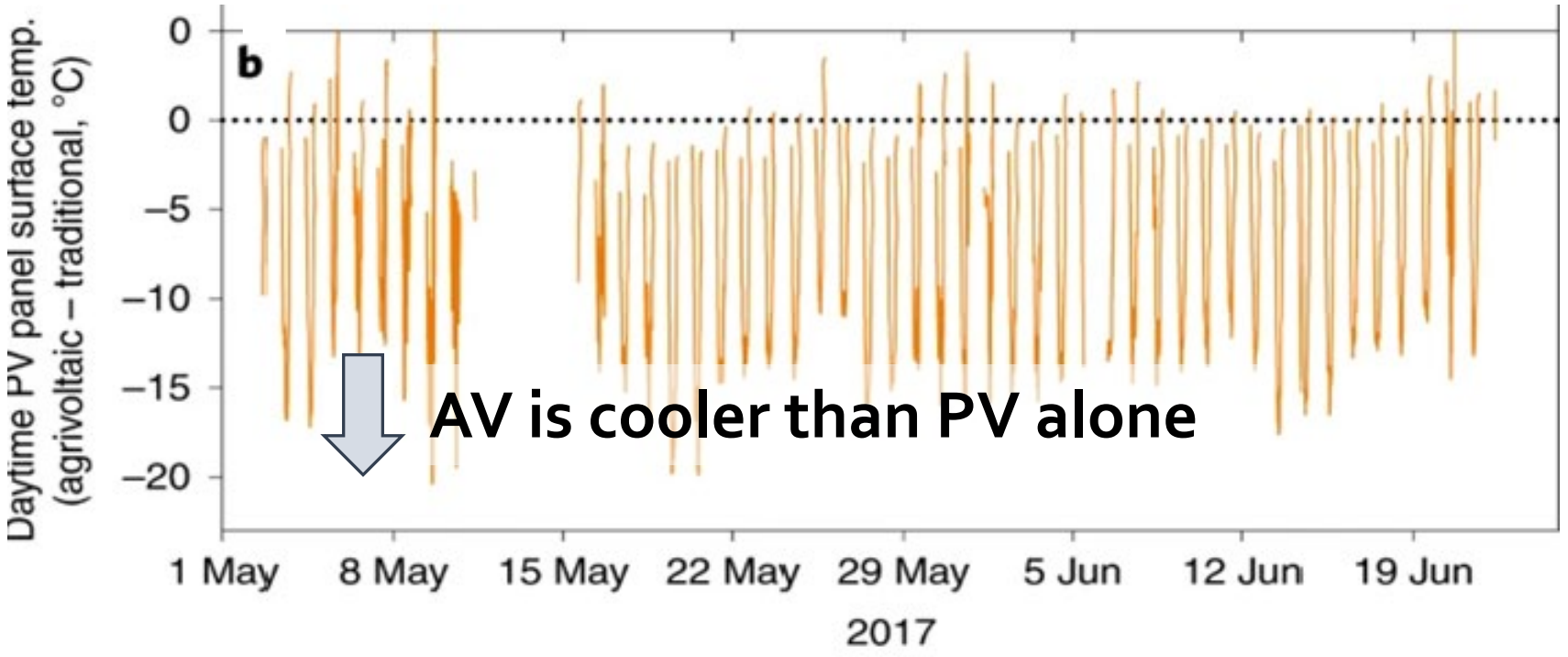
Source: https://couleenergy.com/datasheet-values-rating-of-a-solar-panel/

Plants under panels can have a 'cooling effect'



⇧ Evapotranspiration ('plant cooling effect')

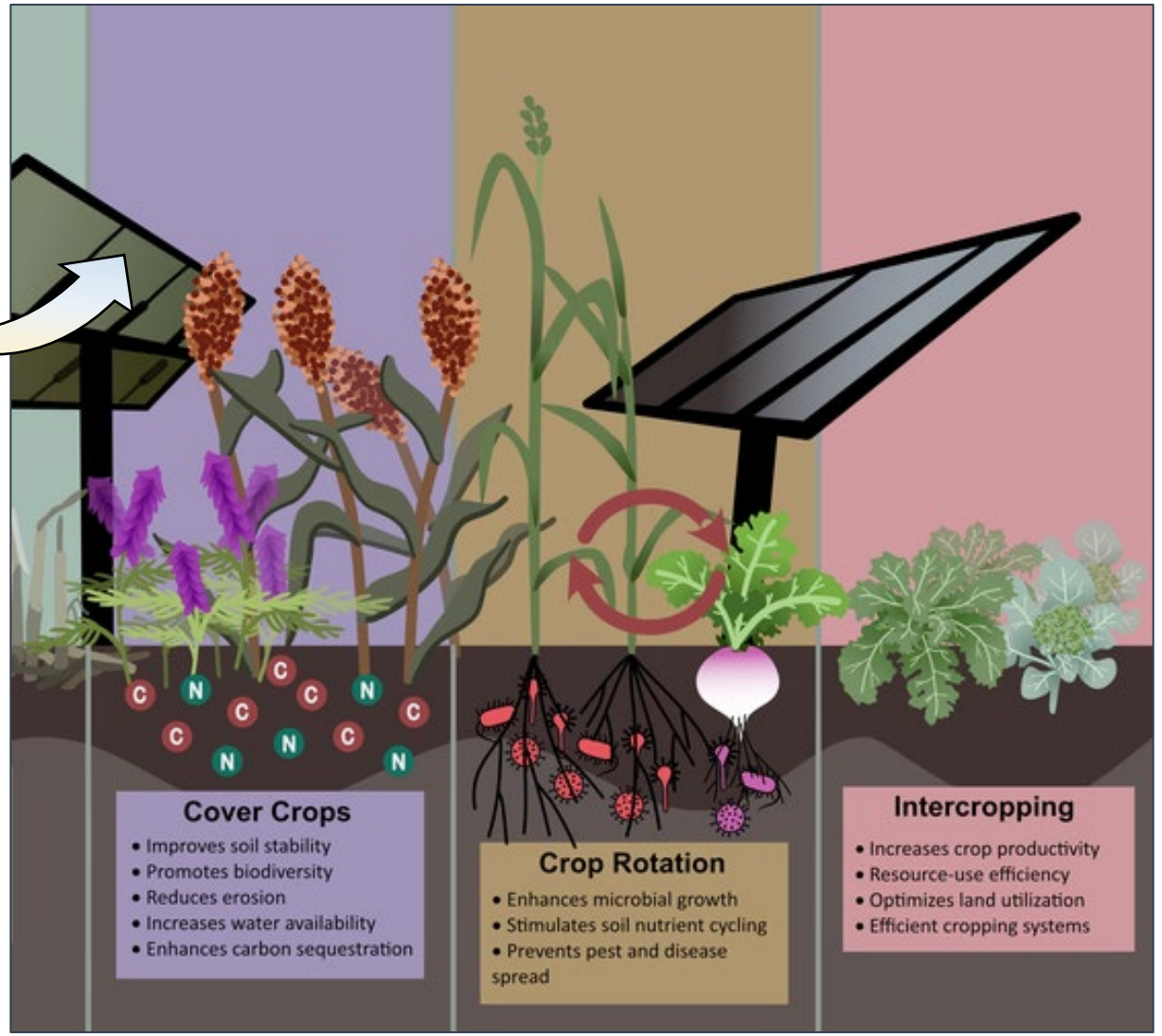
Gomez-Casanovas et al (2023), https://doi.org/10.1016/j.xcrp.2023.101518, Cell Reports Physical Science



A V can enhance the resilience of our energy systems to climate change…but more information is needed

Barron-Gafford et al (2019), doi.org/10.1038/s41893-019-0364-5, Nat Sustain

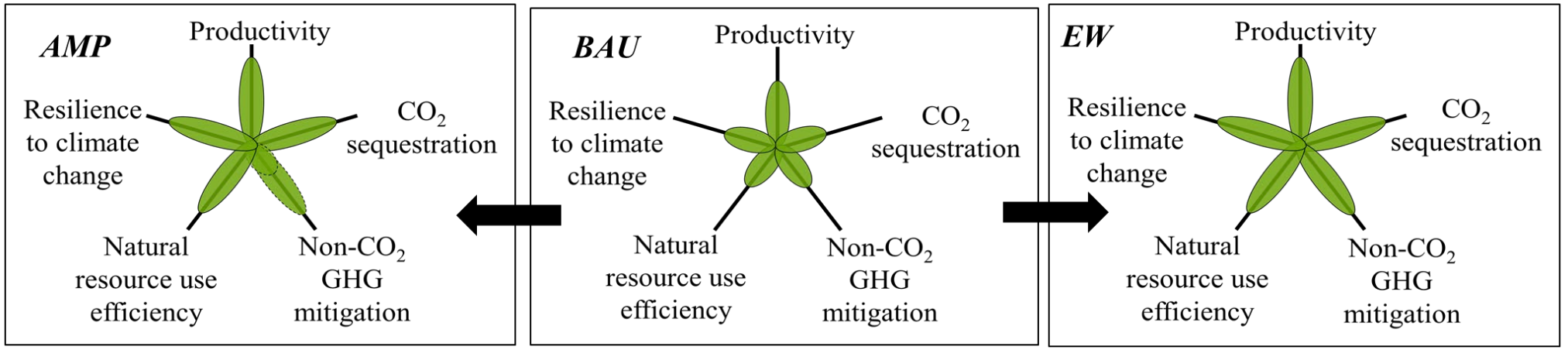
AV + regenerative practices is a win-win in cropland



Time A, Gomez-Casanovas N…(2024) Plants, People, Planet, https://doi.org/10.1002/ppp3.10481

AV + regenerative practices is a win-win in rangeland

Potential effect of emerging strategies on several environmental benefits of grasslands compared to business-as usual management (BAU) illustrated as 'flower' diagrams. We conclude that all these strategies could promote at least some of the following benefits of grasslands: CO_2 sequestration, non-CO_2 GHG mitigation, productivity, resilience to climate change, and an efficient use of natural resources (land, water and nutrients).



Gomez-Casanovas N...(2021). Science of the Total Environment, https://doi.org/10.1016/j.scitotenv.2021.149466..

Positive perception

Incorporates crop or animal farming (88% support)

Benefits farmer & local economy

Benefits environment

On agricultural land

Negative perception

Land valued by the community (natural systems)

Visible from one's property (32% opposition)

Overall perception

82% of respondents support AV deployment

AV can be a solution for solar and farming to co-exist while providing benefits to both stakeholders

Pascaris et al (2022). Green technology, Resilience and Sustainability, https://link.springer.com/article/10.1007/s44173-022-00007-x

Conclusions

- Compared to either an Ag system alone or a PV system alone, AV could :
  - Enhance energy and plant production, but knowledge in diverse systems across a wide range of environments is needed.
  - Enhance the resilience of our food and energy systems.
  - Enhance the overall goods and benefits obtained from cropland and rangeland, especially when AV is combined with regenerative practices
  - Improve public support for solar.

Outline

- AFT's role
  - Opportunities and Challenges
- Resources
- Solar Leasing Considerations

American Farmland Trust

AFT Strategies in Texas

Increase the resilience of Texas' agricultural lands, farmers and ranchers, and surrounding communities, through:

- Increasing adoption of conservation practices
- Promoting regenerative grazing
- Farm Transfer and Succession Planning
- **Advancing Smart Solar**

Smart Solar as a Solution?

Benefits, Challenges, and Opportunities

Landowner Lease Payments

Tax Revenue and Community Benefits

Prime Farmland Conversion

Developers Outcompete Farmer-Renters

Utility-Scale Array Impacts to Farm Economy

Agrivoltaic Arrays that Pair Solar and Agricultural Production

American Farmland Trust

Resources

- AFT's PNW Solar Leasing Guide (2022)
- National Agricultural Law Center
  - Understanding Solar Energy Agreements (Shannon Ferrell 2019)
  - Farmland Owner's Guide to Solar Leasing (Hall et al. 2019)
  - Land Use Conflicts Between Wind and Solar Renewable Energy and Agricultural Uses (Hall et al. 2022)
- Conservation Considerations for Solar Farms (2024)
  - NRCS Fact Sheet

Phases of a solar lease

Source: AFT, FC 2022

	PHASE	EVENTS
	Siting phase	Identifying properties Contacting landowners Letter of Intent
	Development or option phase	Option agreement + Solar lease Due diligence Regulatory permitting Power purchase agreement (PPA)
	Construction phase	Solar lease begins
	Operational phase	Maintenance
	Decommissioning phase	Solar lease ends (25+yrs later)

- Letter of Intent (LOI)
- Option (to Lease) Agreement
- Solar Lease

What happens here is negotiated before

Initial Considerations

- Length of commitment
- Legal interests
- Family matters
- Impacts to the land, farm
- Taxes
- Government Programs
- Liability and insurance
- Neighbor and community relations
- Who is the developer

Source: AFT, FC 2022

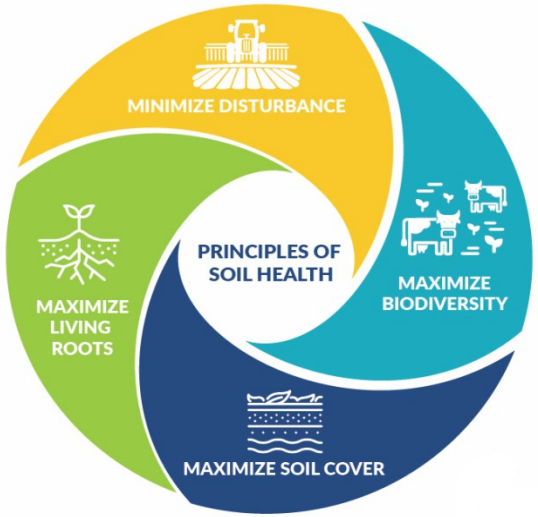
TOTAL LEASE LENGTH

When we add up all these phases, we realize how long the land could be subject to the lease:

PHASE	TIME
Option phase	2–5 years
Construction phase	2–3 years
Operations phase	25–30 years
+ Renewals	5–10 years
Decommissioning phase	1–2 years
TOTAL LENGTH	**35–50 YEARS**

Conservation Consideration for Solar Farms

- Protect Soil Health
  - NRCS's soil health principles
- Factsheet
  - Soil Conservation
  - Vegetation Management
  - Wildlife Considerations



Source: USDA NRCS

USDA Natural Resources Conservation Service
U.S. DEPARTMENT OF AGRICULTURE

Conservation Considerations for Solar Farms
NRCS Fact Sheet

Introduction

Ground-based, utility-scale solar panel installations used for electricity generation of 1 MW or greater are commonly referred to as 'solar farms' (US Energy Information Administration, 2020). The purpose of the solar farm is to generate and sell electricity, therefore it is key that the collection, generation, and distribution of energy is not hampered by factors that reduce capacity. Management of natural resources on a facility's footprint is beneficial to enable it to maintain capacity. Natural resource concerns, such as soil erosion, dust, runoff, and damage from wildlife or livestock, frequently occur during construction and operation of solar farms.

The Natural Resources Conservation Service (NRCS) and its partners provide financial and technical assistance for producers and landowners to restore, enhance, and preserve the Nation's productive landscapes and natural resources. Producers, landowners and developers should consider the following natural resource conservation concerns regarding solar farms.

Soil Conservation

Healthy soils are critical for proper function of the water cycle and for providing habitat for a diversity of organisms. Soil conservation concerns include soil erosion by water and wind, compaction, water ponding, pollutants, and loss of organic matter. Four principles that guide land management to support healthy soil are: (1) maximize soil cover, (2) minimize soil disturbance, (3) maximize living roots, and (4) maximize biodiversity. These principles can apply to solar farms during planning, construction, operation, and even decommissioning activities.

Soil erosion, by water or wind, is a key resource concern that is often a consequence of construction and infrastructure projects. Erosion generally occurs where soils have been heavily disturbed or left uncovered as bare ground. With solar farms, wind erosion can cause problems when wind-blown soil ends up on the surface of panels, reducing their electricity output and possibly leading to permanent damage. Water erosion from runoff and concentrated flows can damage infrastructure, equipment, and facilities, leading to increased maintenance and repair costs. It can also lead to detrimental offsite environmental effects including gullies and the transport of sediment.

Steps to take during the construction and operation to conserve soil include:

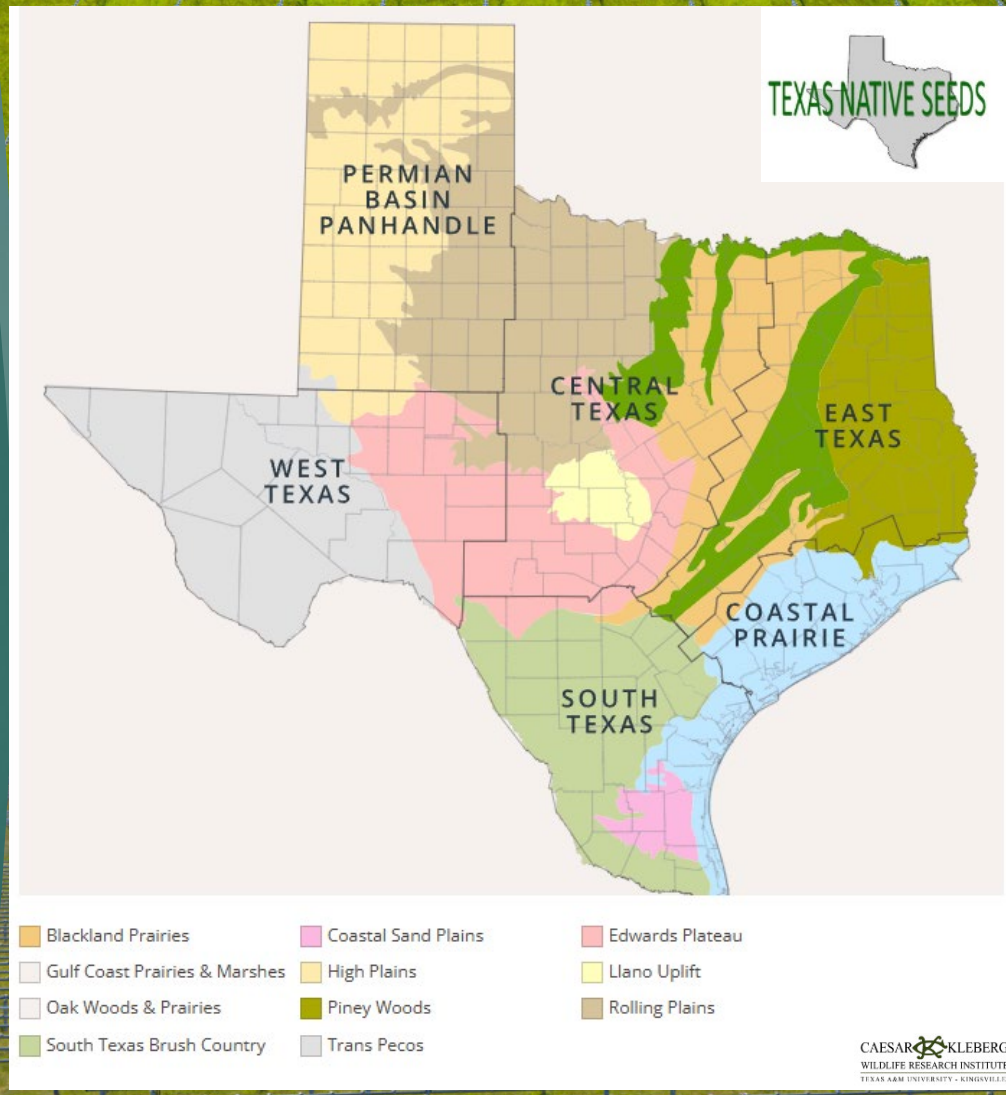
- Limiting disturbance and compaction from heavy machinery to only the most necessary areas such as access roads and other areas with frequent or intense use.
- Preserving on-site topsoil; covering and preventing soil movement by applying mulches and erosion control mats or socks.
- Designing sites for optimal runoff flow with diversions, terraces, basins, and other earthworks.
- Maintaining a healthy perennial vegetative cover on the soil under and between solar panel rows to encourage infiltration and prevent erosion. Ideally, the vegetated distance between the rows of panels should be no less than the maximum horizontal width of the panel rows.
- Planting windbreaks perpendicular to the prevailing wind direction to reduce wind erosion.
- Utilizing dust control measures on unpaved roads and surfaces.

More Information

This fact sheet provides conservation considerations regarding solar farms for a general audience. For producers and landowners, there may be program-specific rules or requirements that could affect potential participation in USDA programs which are not included in this document. NRCS encourages producers and landowners to utilize the complete NRCS conservation planning process to address natural resource concerns through the implementation of conservation practices.

Other Considerations

- Plan for heavily used spaces
- Water rights
- **Pre-construction seeding**
  - Texas Native Seeds
  - Extension, etc.
- Continuing to farm
  - Around the site?
  - Provide vegetation management services during the operations phase?



Planning for Agrivoltaics

- Vegetation management services (Operations):
  - Who will be providing?
  - Landowner = Right of first refusal
- Current options
  - Sheep/hay
- Infrastructure:
  - Water access
  - Fencing/Gates
  - Loading/unloading areas

Source: Texas Solar Sheep

ASGA

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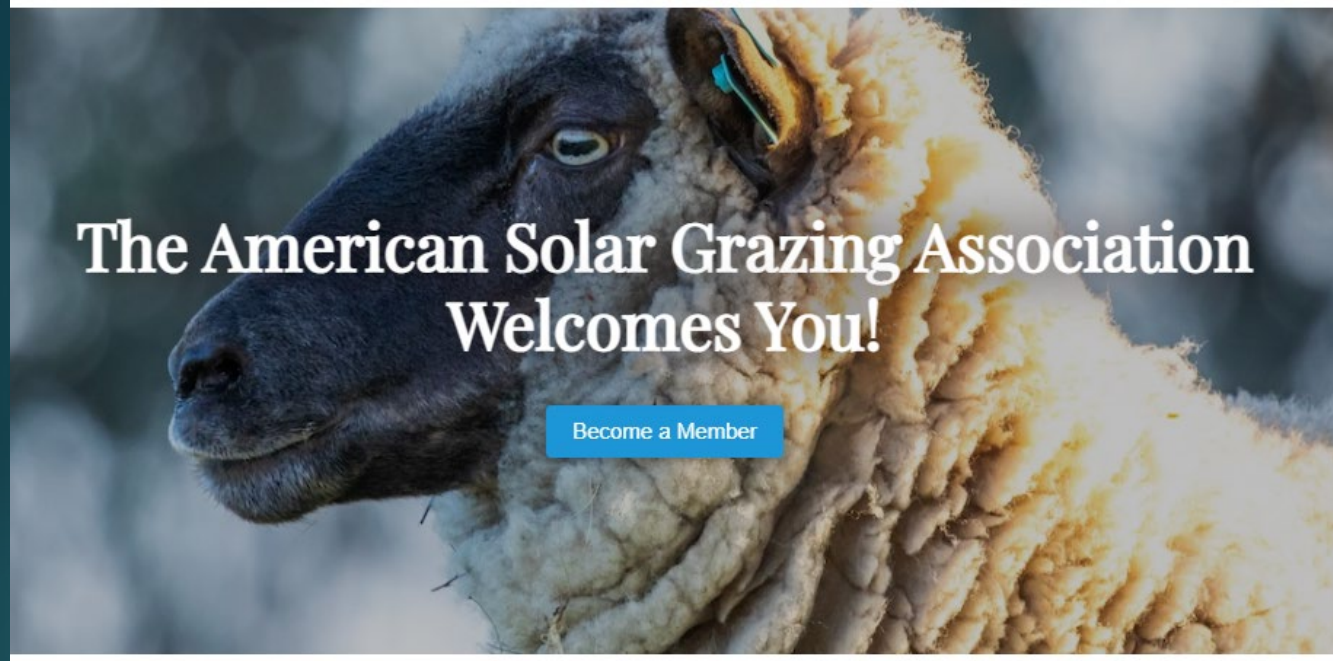


Solar Grazing Resources

ASGA Certification™ for Solar Grazing Training

Search the ASGA Solar Grazing Map

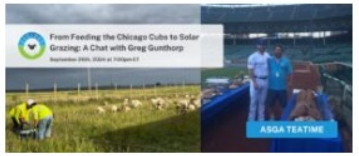
Join Our Solar Grazing Webinars

Archived Calls

ASGA Call 81: Will Harris on Regenerative Solar Grazing and a Bold Return to Giving a Damn

By ASGA | October 3, 2024

We were very fortunate to have Will Harris from White Oak Pastures join us for a special interview. It's an understatement to say that Will strongly believes in his bold...



Midwest Solar Grazing: Opportunities, Challenges, and Lamb Marketing with Greg Gunthorp (ASGA Workshop Replay)

By ASGA | September 26, 2024

Watch the recording for our discussion with hogfarmer Greg Gunthorp, who recently began a utility-scale solar grazing operation in Indiana. Greg has a long history in the farm to market...

Insurance for Solar Grazing (ASGA Workshop Replay)

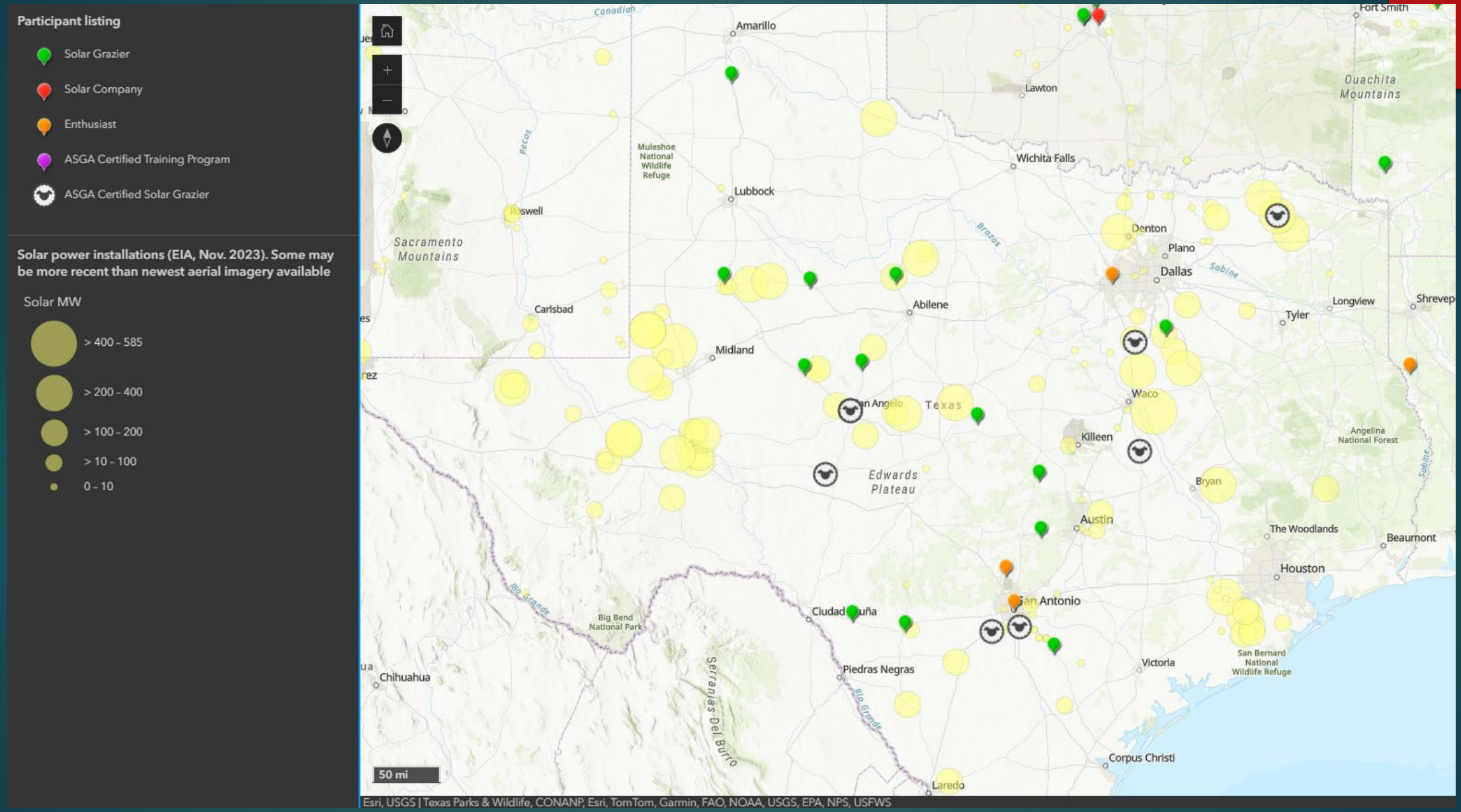
By ASGA | September 16, 2024

Chad Raines (solar grazier from Texas), Ken Dewitt (Insurance Agent at Pruitt Agency), and Adam Sotirakopoulos (Operations and Maintenance at Enel, a solar developer) joined us to discuss the basics...

Saving Time with Herding Dogs on Community and Utility Scale Solar (ASGA Teatime Replay)

By ASGA | August 29, 2024

Sheep herding dogs are essential working companions for many solar graziers, saving graziers time and money when moving sheep. For this Teatime, we had a fantastic discussion on acquiring and managing...

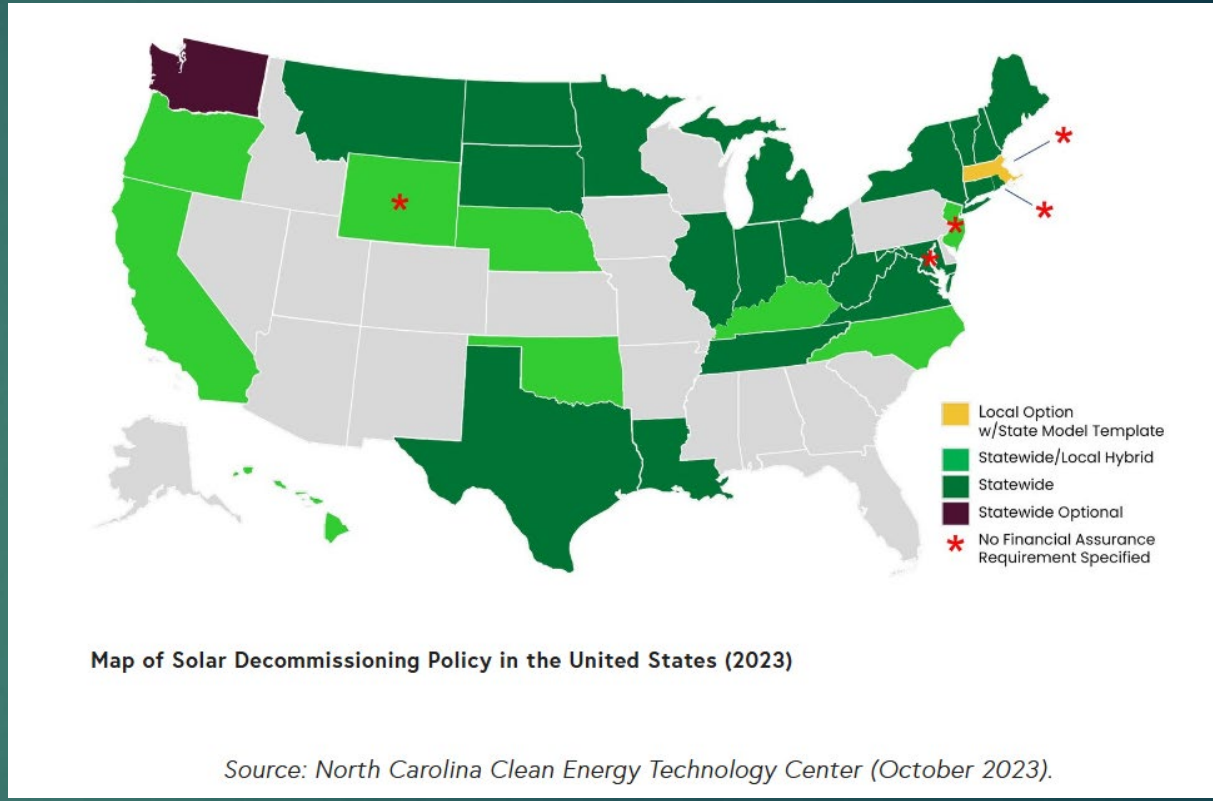

Participant listing
Solar Grazier
Solar Company
Enthusiast
ASGA Certified Training Program
ASGA Certified Solar Grazier
Solar power installations (EIA, Nov. 2023). Some may be more recent than newest aerial imagery available
Solar MW
> 400 - 585
> 200 - 400
> 100 - 200
> 10 - 100
0 - 10
Amarillo
Lawton
Wichita Falls
Lubbock
Roswell
Sacramento Mountains
Muleshoe National Wildlife Refuge
Pecos
Brazos
Denton
Plano
Dallas
Sabine
Longview
Tyler
Abilene
Carlsbad
Midland
Waco
Texas
Killeen
Edwards Plateau
Angelina National Forest
Bryan
Austin
The Woodlands
Beaumont
Houston
San Antonio
Big Bend National Park
Rio Grande
Ciudad Acuña
Piedras Negras
Victoria
San Bernard National Wildlife Refuge
Chihuahua
Serranias Del Burro
Corpus Christi
Laredo
Ouachita Mountains
Fort Smith
50 mi
Esri, USGS | Texas Parks & Wildlife, CONANP, Esri, TomTom, Garmin, FAO, NOAA, USGS, EPA, NPS, USFWS

Decommissioning

- SB 760: took effect on September 1, 2021
  - decommissioning of solar power facilities
- Restoration obligations:
  - Solar energy devices, transformers, substations, and overhead lines
  - Foundations and buried cables to a depth of 3 feet

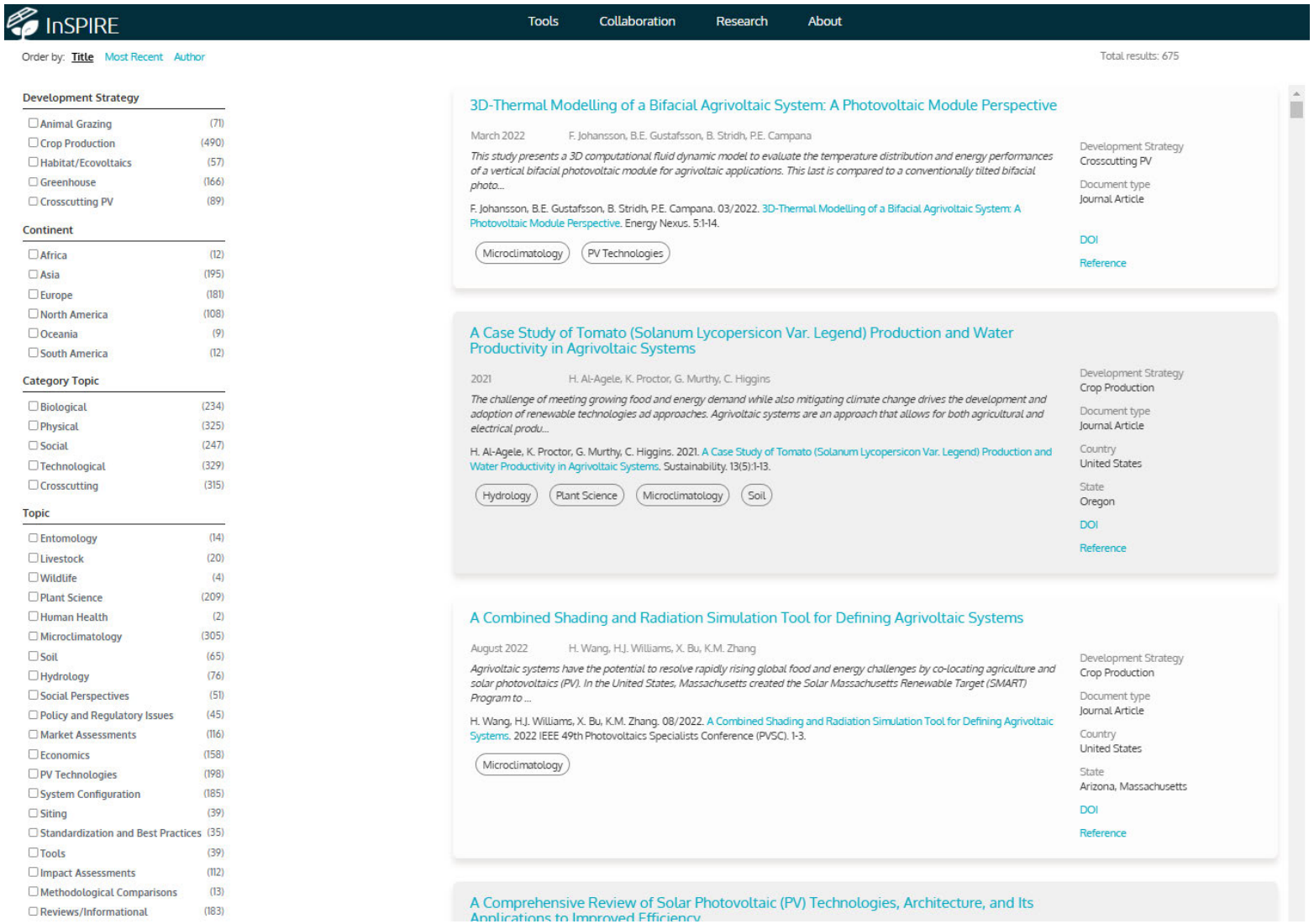
Must be in lease, but only triggered if landowner requests

  - *Roads*
  - *Rocks removal and surface restoration*
  - *Reseed with native grasses*
- Financial security



Map of Solar Decommissioning Policy in the United States (2023)

Source: North Carolina Clean Energy Technology Center (October 2023).



InSPIRE: National Renewable Energy Lab

DATA BASE

Solar Beneficial Management Practice Database

▼ Background

With solar development increasing rapidly across the US, the impacts to wildlife and their habitat are often not considered. State fish and wildlife agencies, who exercise primary statutory responsibility for the management of fish and wildlife as a public trust resource within their borders and provide critical scientific expertise and technical guidance, have begun creating their own beneficial management practices (BMPs) to address and minimize wildlife impacts from solar development within their state. The Association of Fish and Wildlife Agencies created a BMP Database as a resource to collate existing state fish and wildlife agency best management practice documents in one standardized, searchable database. This database centralizes all existing BMPs and will allow for a "one-stop-shop" resource for state agencies to update and/or develop their own state-specific best management practices as well as for solar project proponents, and the public.

▶ Methods

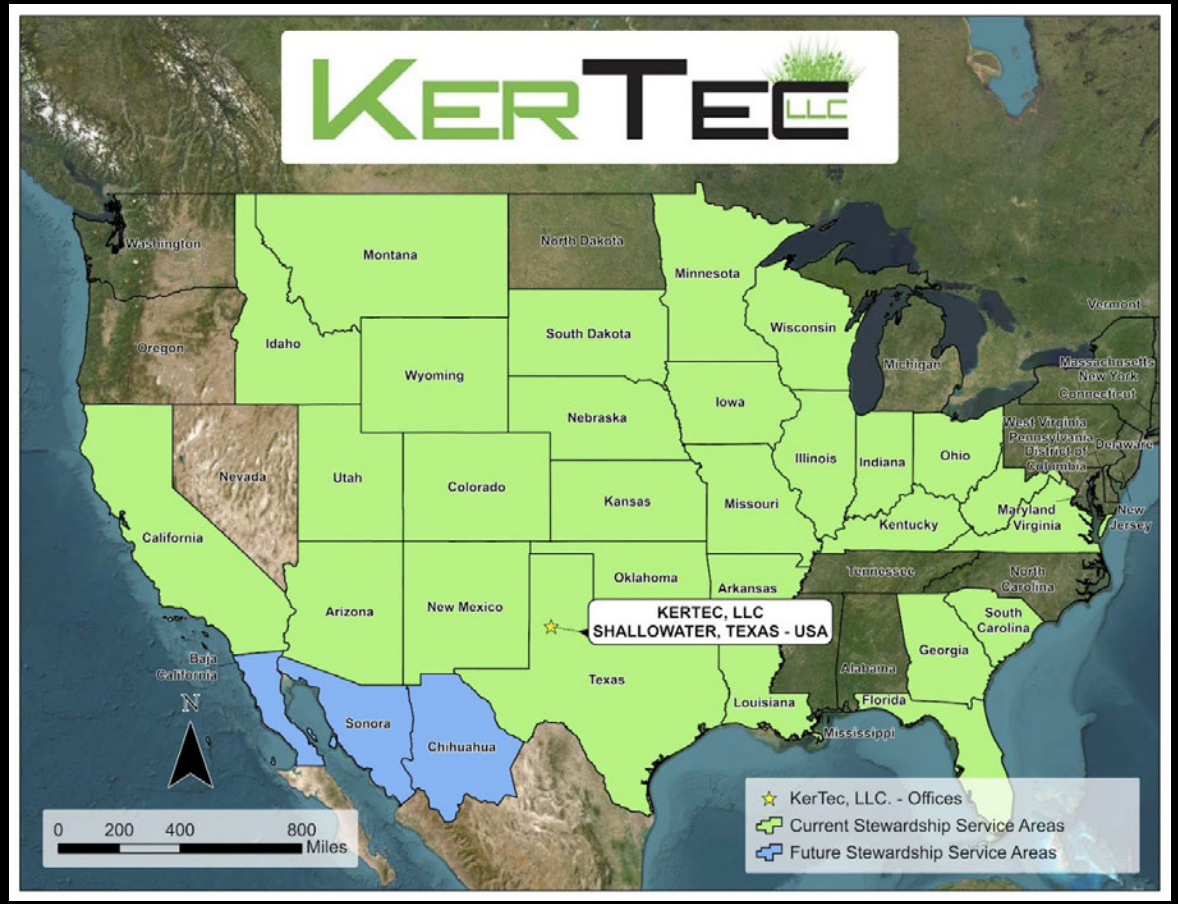
Resources

- Association of Fish and Wildlife Agencies: https://www.fishwildlife.org/solar-beneficial-management-practice-database
- Best Practices: Photovoltaic Stormwater Management Research and Testing (PV-SMaRT): https://betterenergy.org/wp-content/uploads/2023/01/PV-SMaRT-Best-Practice.pdf
- USDA NRCS: Conservation Considerations for Solar Farms: https://www.nrcs.usda.gov/sites/default/files/2024-03/Conservation_Considerations_Solar_Farms.pdf
- InSPIRE: https://openei.org/wiki/InSPIRE
- The Natinoal Agricultural Law Center Resources: https://nationalaglawcenter.org/center-publications/renewableenergy/
- American Solar Grazing Association: https://solargrazing.org/
- AFT PNW Solar Leasing Guide: https://farmlandinfo.org/wp-content/uploads/sites/2/2022/11/AFT-PNW-solar-leasing-guide.pdf

Perspectives on the Development Process

KERTEC LLC

KerTec: Over 60,000 acres successfully reclaimed since 2014



Building the Right Team

KerTec Professional Staff with experience in:

- — Surface Use Agreements
- — Land Stewardship Practices
- — SWPPP Review and Execution
- — Soils and Vegetation Consulting
  - - Reclamation of erodible lands during construction
  - - Soil Fertility and Nutrient Management
  - - Seed species for Reclamation
  - - Rangeland Management (at scale)

Ability to work alongside:

- — Landowners
- — Attorneys
- — Project Stakeholders
  - - Owners, Developers, EPCs

KerTec's Seed Industry Experience

— Combined 70+ years experience recommending, designing, and procuring custom seed blends

— Regularly work with some of the Nation's largest seed suppliers

— Ability to leverage our network to source some of the best seed available

— Customizable seed blends for any size project while focusing on Client-and-site-specific goals

— Utilizing a science-based approach in the world of reclamation

Science-based Reclamation

EDUCATION OF EXECUTIVE & KEY STAFF

Master of Science in Plant and Soil Science
Bachelor of Science in Plant and Soil Science
Bachelor of Science in Conservation Law
Bachelor of Science in Range Science
Bachelor of Science in Environmental Science
Bachelor of Science in Horticulture: Turfgrass Management
Bachelor of Science in Recreation, Park & Tourism Sciences
Registered Landman: American Association of Professional Landmen
Qualified Preparer of Stormwater Pollution Prevention Plan (QPSW3P)
Qualified Compliance Inspector of Stormwater (QCIS)
Level II Conservation Planner Certification
Certified Nutrient Management Specialist

Paradigm Shift: Milestone Planning

— Renewable industry is recognizing the importance of Vegetation Management and Land Stewardship

— Some of KerTec's largest Clients are incorporating KerTec's Milestone plans across their portfolio in effort to:
  - Achieve permit compliance
  - Establish portfolio uniformity
  - Seamless integration over multiple projects
  - Supplemental plans designed to adapt

— Setting goals and collaborating with industry leaders ultimately builds sustainable projects

— Conducting site-due-diligence during "Planning Phase" pays dividends over the life of project
  - Reduced O&M costs can be in the $MMs
  - Early detection for risk mitigation

Land Stewardship

— Sustainable vegetation on projects of scale

— Focus on soil health and tilth from the planning phase through the time of decommissioning

— Protecting and preserving topsoil, ***onsite***

— Setting goals and collaborating with industry leaders to steward lands through time of decommissioning

— Industry leaders and service providers executing agrivoltaics on projects of scale
- Grazing
- Crop farming
- Apiaries, etc.

Milestone Planning for Success

Pre-Construction Site Preparation

SWPPP Implementation, Maintenance, and Repairs

SWPPP Monitoring, Inspections, and Reporting

Soil & Seedbed Compaction testing, analysis, and application

Erosion Control Best Management Practices (BMPs)

- — Temporary and/or Permanent Soil Stabilization
- — Seeding (Drill and Broadcasting)
- — Erosion Control Blanket installation
- — Silt Fence and/or Fiber-Wattle installation
- — Hydroseeding and/or Hydromulching
- — Hay Blowing and Crimping
- — Fleximat or TRM Design and Installation
- — Vegetative Buffer Design and Installation

Periodic Vegetation monitoring during construction

Vegetation Management

- — Mechanical, Grazing, & Chemical

Pre-Construction Site Preparation

Pre-Construction Site Preparation

Planning for success from the ground, up

— Strategic planting of cover crop species

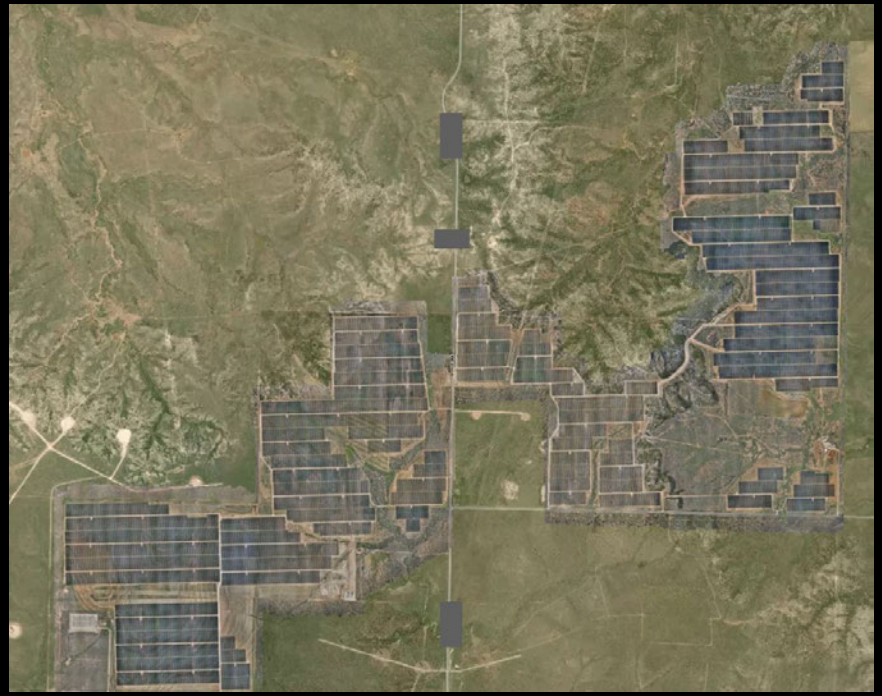
- Competition to weeds and undesirable vegetation

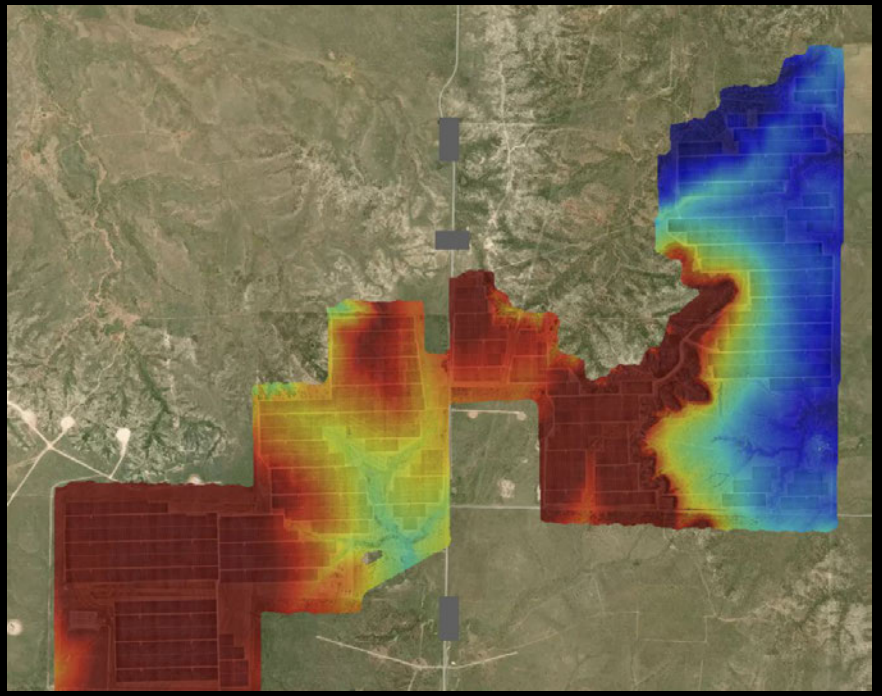
  * At the project pictured, non-desirable vegetation (weeds) were reduced by 10x due to the cover crop's success

- Maintaining or improving soil health in preparation for permanent seeding

- Topsoil stability going into construction

Understanding Site Topography & Conditions





Understanding Background Soils & Vegetation

Native Soil Characteristics & Health

— Background Soil Sampling to understand existing:

- Macronutrients
- Micronutrients
- Organic Matter
- pH

— Understand depth of topsoil

— Sampling prior to construction

— Sampling after disturbance

— Amending soils per sampling results

Natural Vegetation and Coverage

— Understand what vegetation is onsite

— Understand the natural coverage of the site

Temporary Stabilization during Construction

SWPPP Compliance:

— Idle lands (14 days or greater) are required to be stabilized

— Temporary vegetation typically includes annual/seasonal species

— Includes mechanical stabilization:
- Hydromulch (Koton Hydromulch, pictured)
- Erosion Control Blankets
- Straw mulch and crimping
- High performance turf matting, etc.

Vegetation Monitoring during Construction

Monitoring of Vegetation:

— Understanding site-specific goals for the project

— Identify areas of concern
  - Prescribe mitigation strategies for identified areas of concern

— Verify vegetative goals within the Arrays

— Verify vegetative goals outside the Arrays

— Forecasted vegetative maintenance inputs

— Site-wide analysis/interpretation of collected data

Permanent Stabilization during Construction

SWPPP Compliance:

— Upon completion of construction, soil must be permanently stabilized

— Stabilization by obtaining at least 70% perennial vegetation on site

— Includes mechanical stabilization:
- Hydromulch (Koton Hydromulch, pictured)
- Erosion Control Blankets
- Straw mulch and crimping
- High performance turf matting, etc.

Vegetation Management through Decommissioning

Contact US

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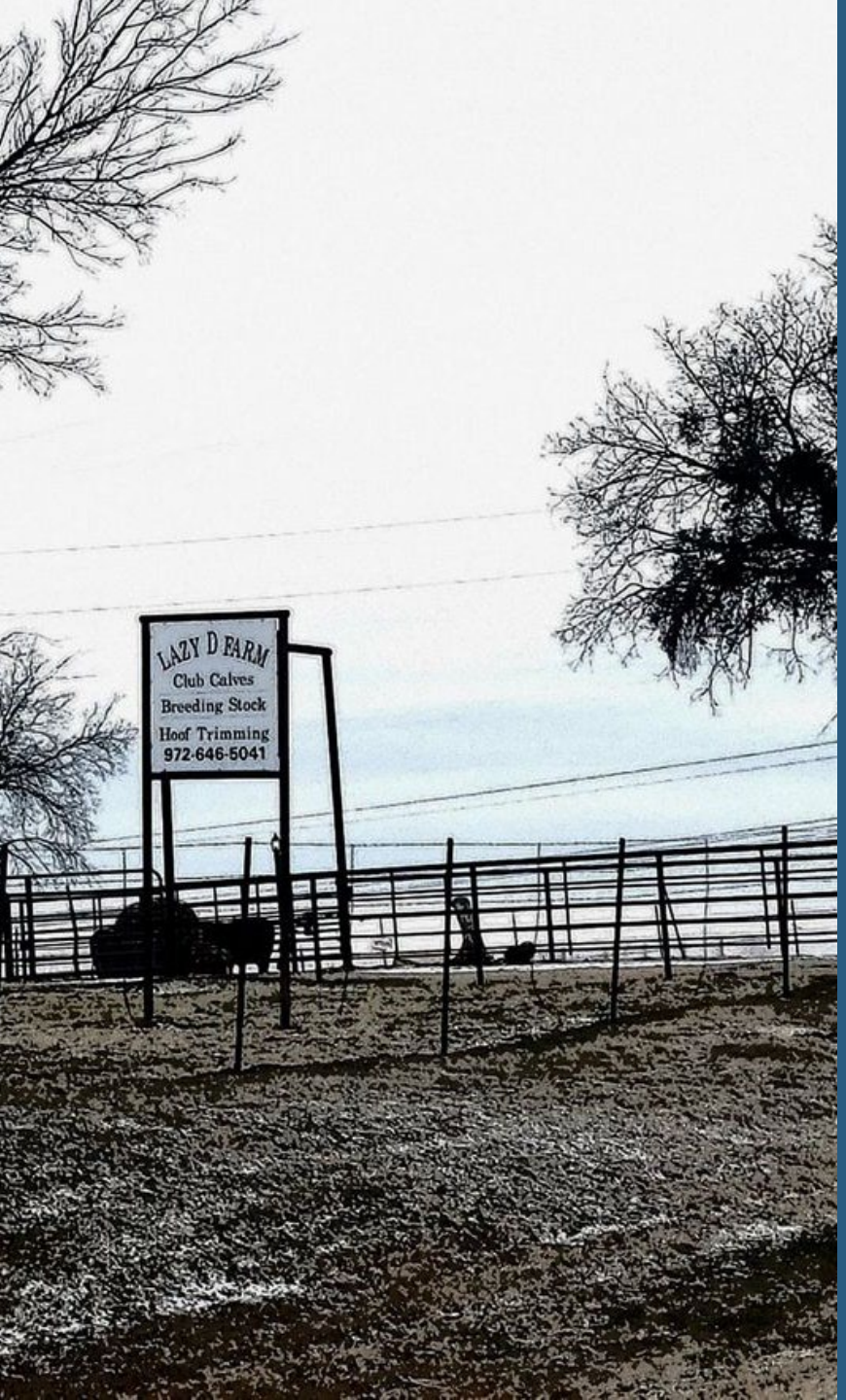


LAZY D FARM

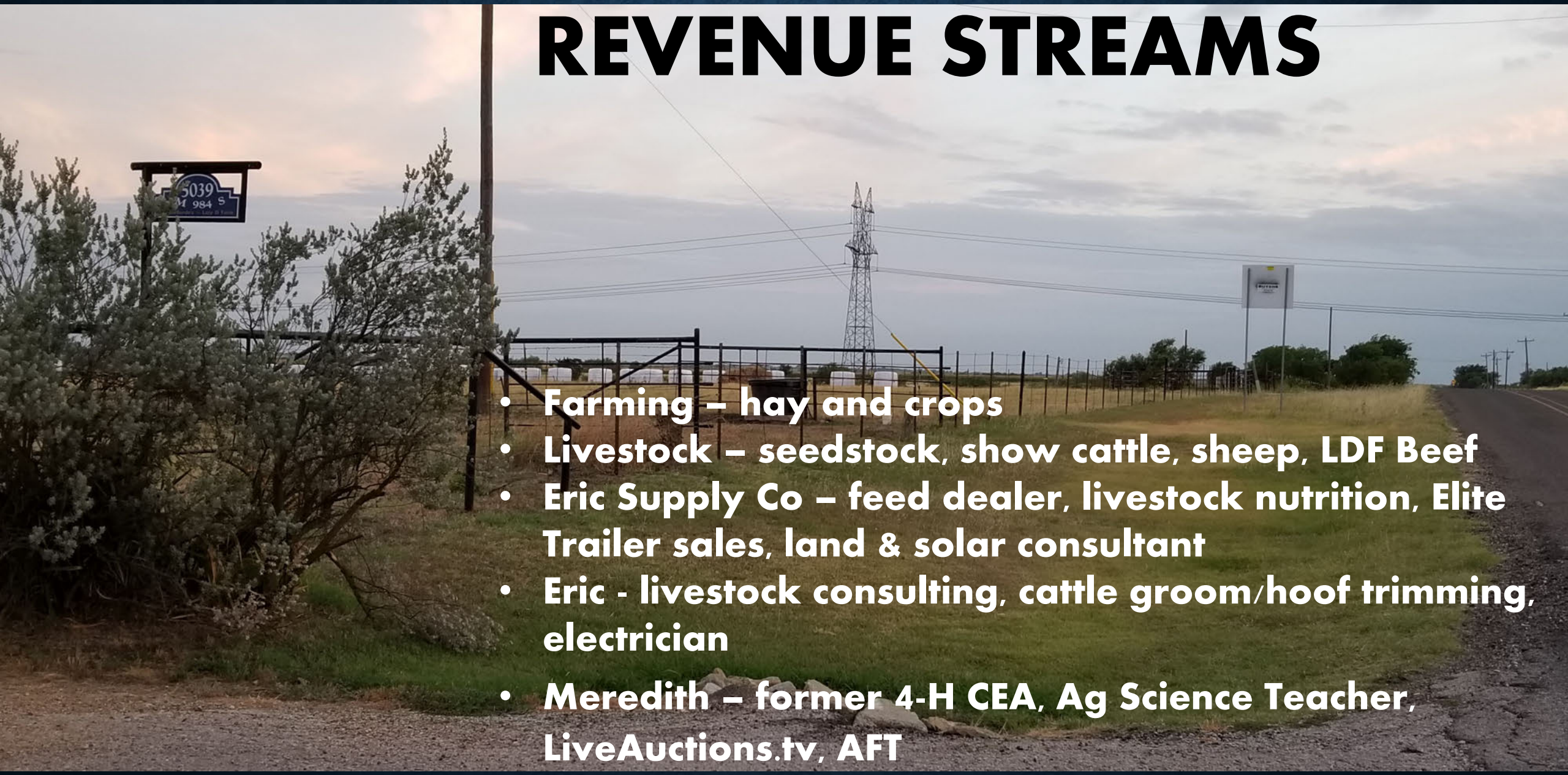
Bardwell, Texas

GENERATIONAL ELLIS COUNTY FARMER/RANCHER

Brayden & Brigham DeBorde

4TH GENERATION

REVENUE STREAMS



- Farming – hay and crops
- Livestock – seedstock, show cattle, sheep, LDF Beef
- Eric Supply Co – feed dealer, livestock nutrition, Elite Trailer sales, land & solar consultant
- Eric - livestock consulting, cattle groom/hoof trimming, electrician
- Meredith – former 4-H CEA, Ag Science Teacher, LiveAuctions.tv, AFT
- Solar Farm & Agrivoltaics – added in 2020

STEWARD THE LAND

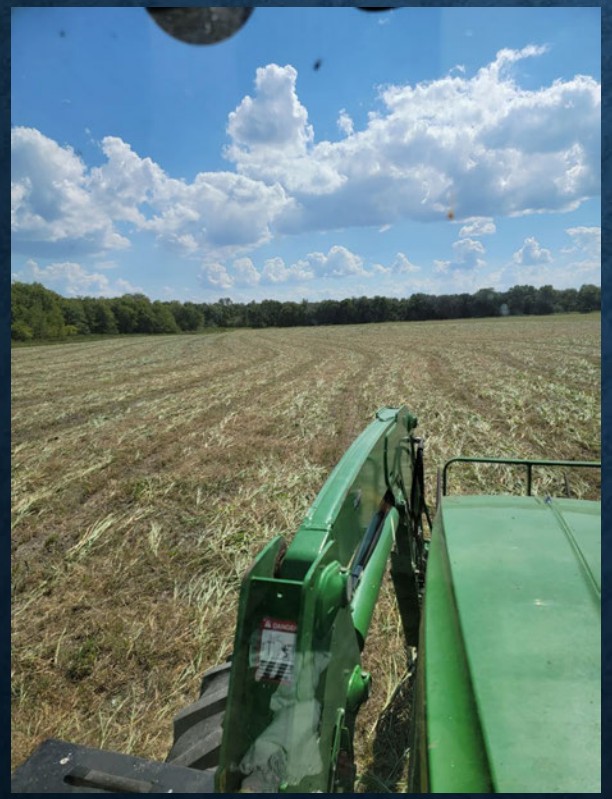
Soil health

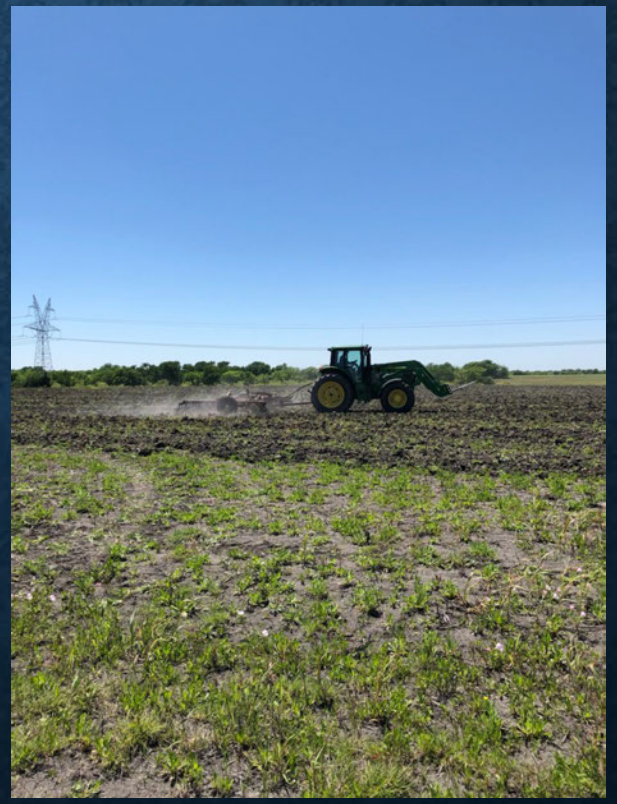
Preserve water

Build/maintain ecosystems

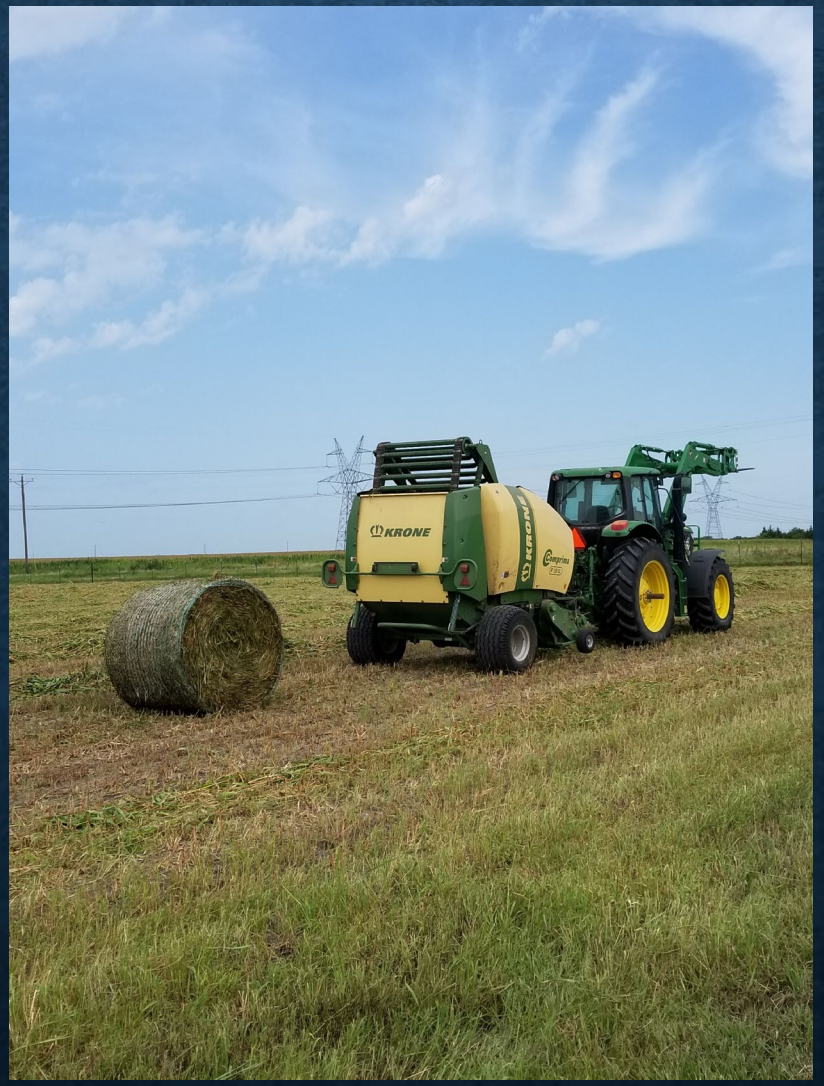
Manage livestock

Photos taken prior to solar farm





WE WILL LEAVE THE LAND BETTER THAN WE FOUND IT FOR THE NEXT GENERATION



2016

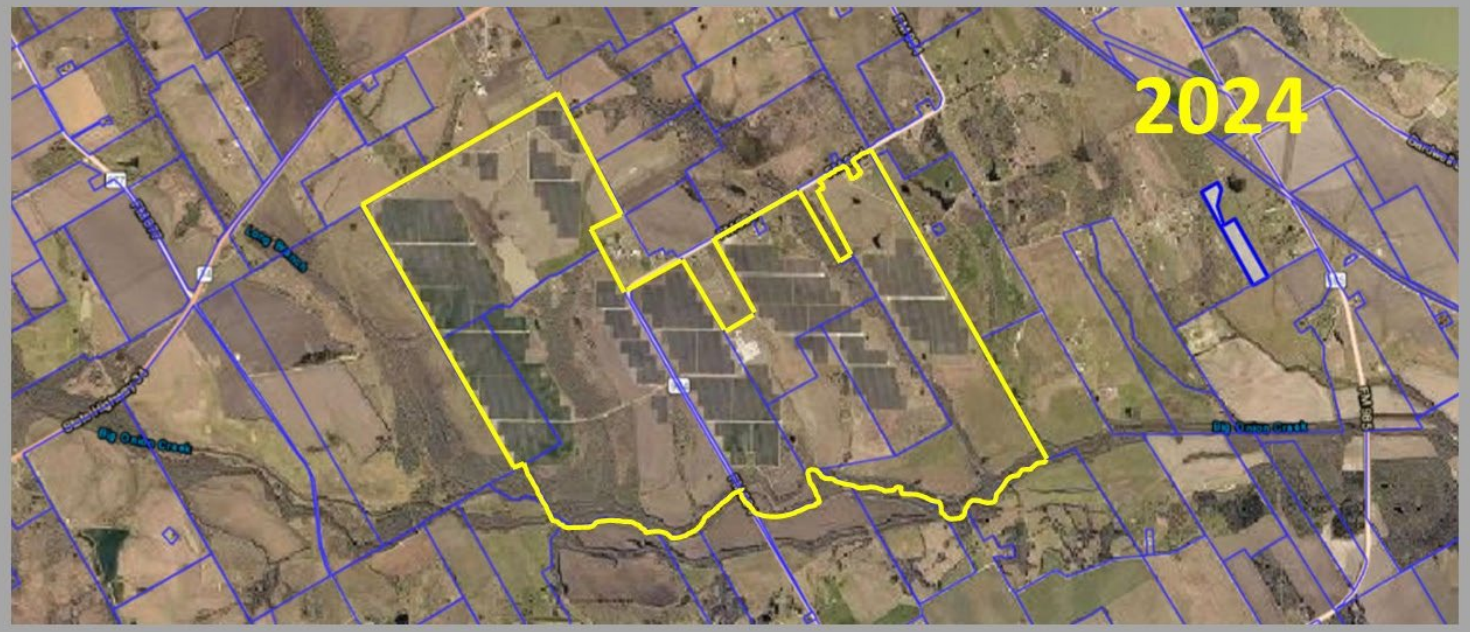
2016

SHORTHORN #1 FOR YIELD GRADE OF ALL MATERNAL & BRITISH BREEDS

Breed	Fat Cover	USDA Quality Grade	Calculated Yield Grade	% Retail Product	Yield Grade Breed Placing
Shorthorn	**0.485**	**Low Choice**	**2.6**	**64.37**	**1**
Hereford	0.580	Low Choice	2.8	63.43	2
Red Angus	0.598	Low Choice	2.9	63.13	3
Angus	0.639	Avg Choice	3.0	62.89	4

Source: Meat Animal Research Center (MARC)

America's First
SHORTHORN
BEEF
LOCALLY RAISED

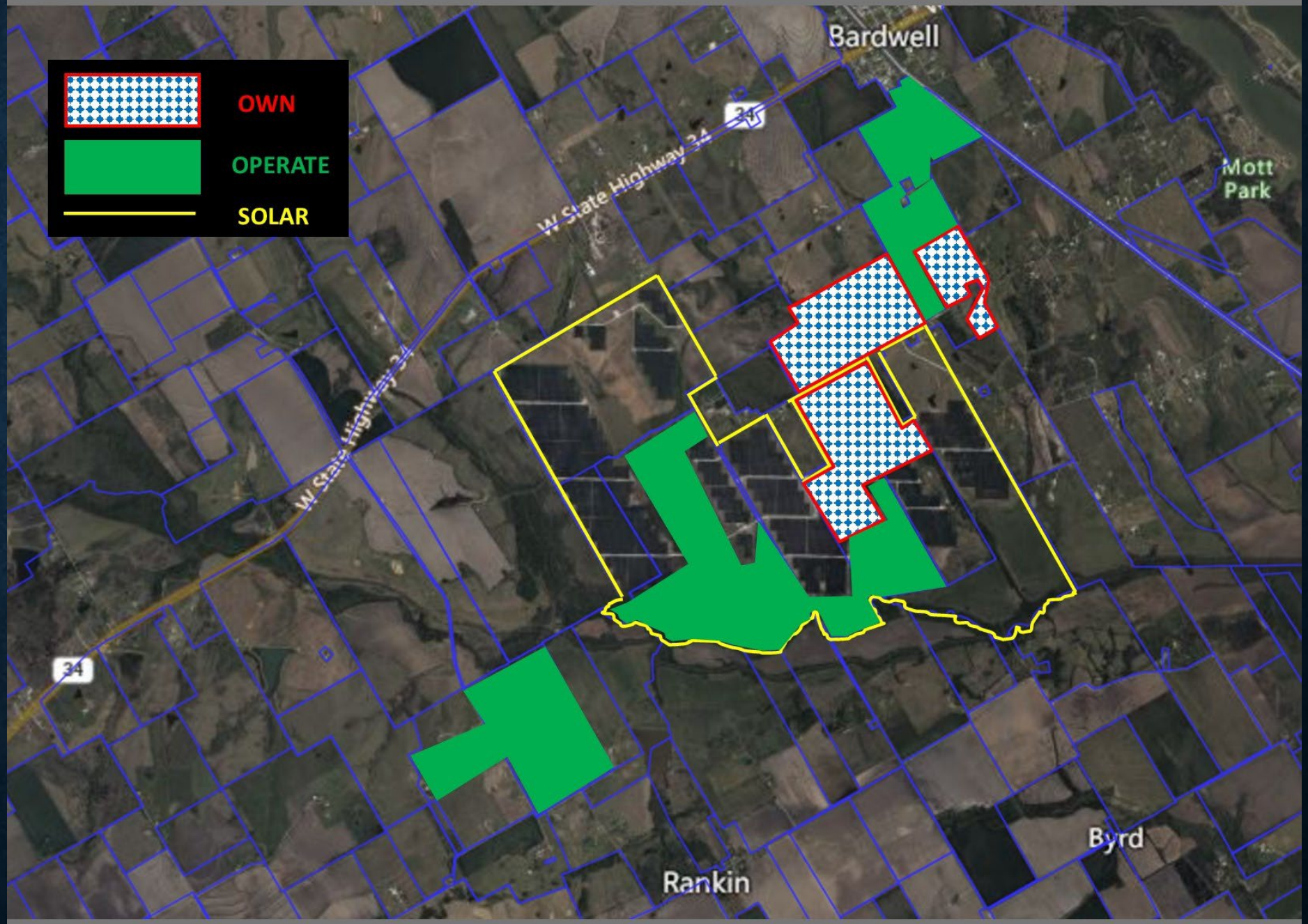


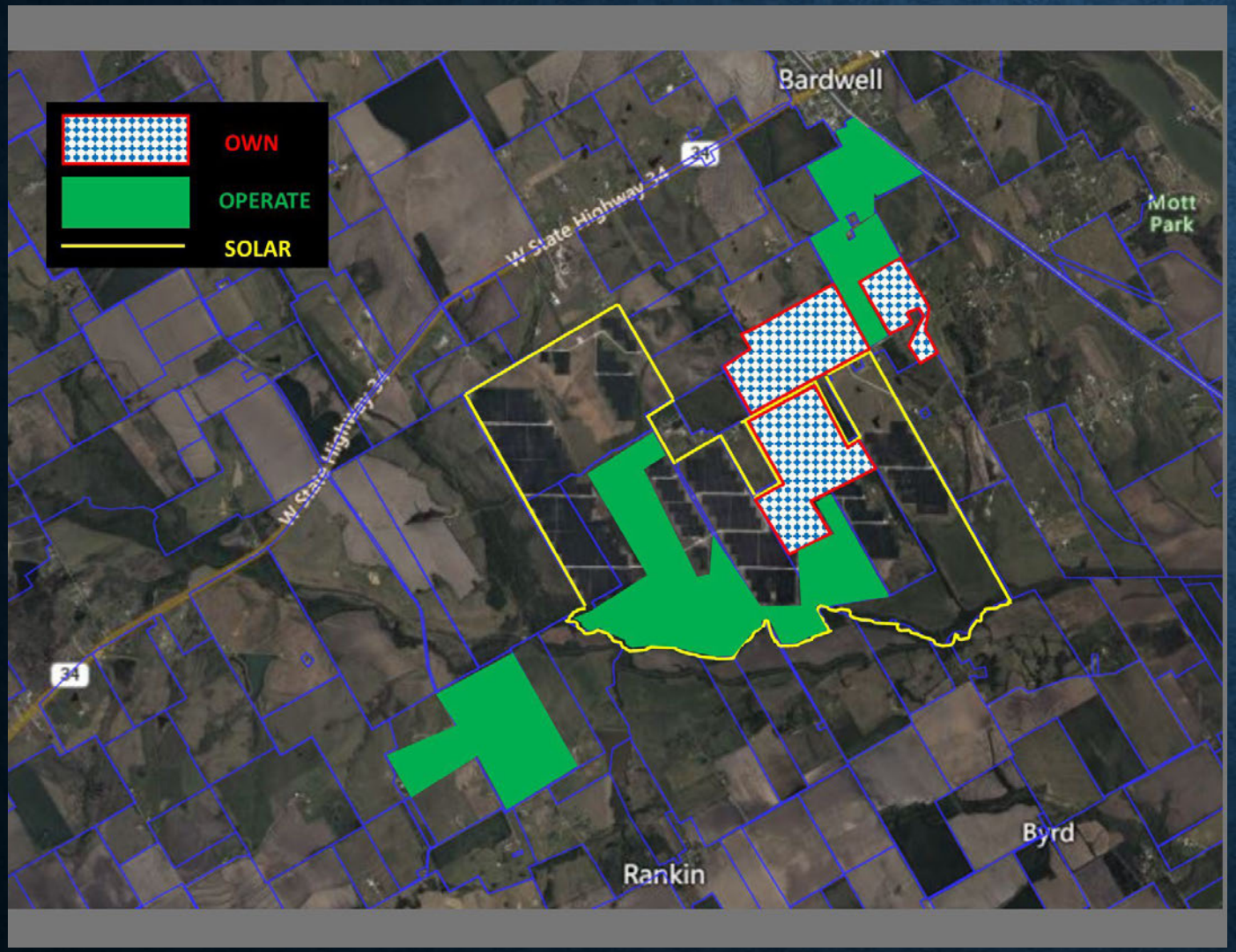
WHY SOLAR?

Protect Agriculture Land

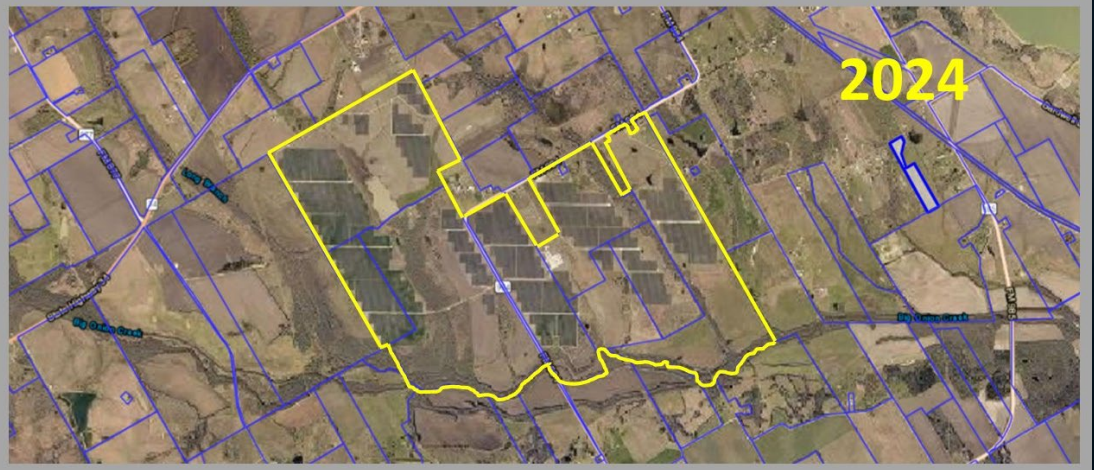
Protect Ecosystem/Habitat

Protect the Blackland Soil


OWN
OPERATE
SOLAR
Bardwell
Mott Park
W State Highway 34
34
Rankin
Byrd


OWN
OPERATE
SOLAR
Bardwell
Mott Park
W State Highway 34
34
Rankin
Byrd


2014
5000 ft
Resolution


2024

Elm Branch Solar

163MWDC

/135MWAC home-grown renewable energy

156,000 metric tons

carbon emissions abated each year for healthier air

33,700

fuel-burning cars taken off road (equivalent)

24,790

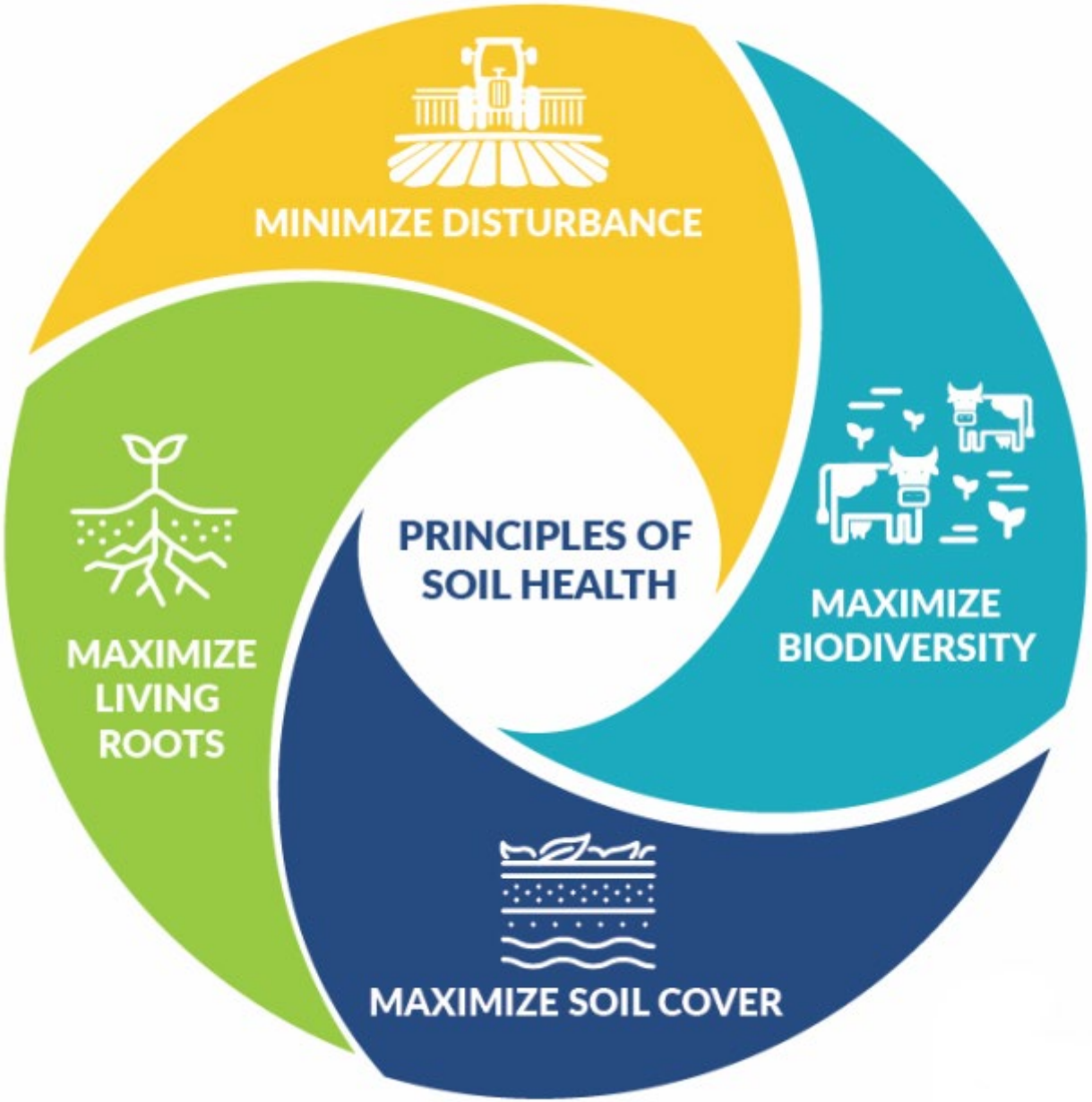
equivalent US homes powered per year

300

jobs created during construction, supporting local labor

We farm and our greatest resource is our soil and water.

SOIL HEALTH MATTERS



Agrivoltaic Management

CANNOT predict the weather

CAN manage your assets

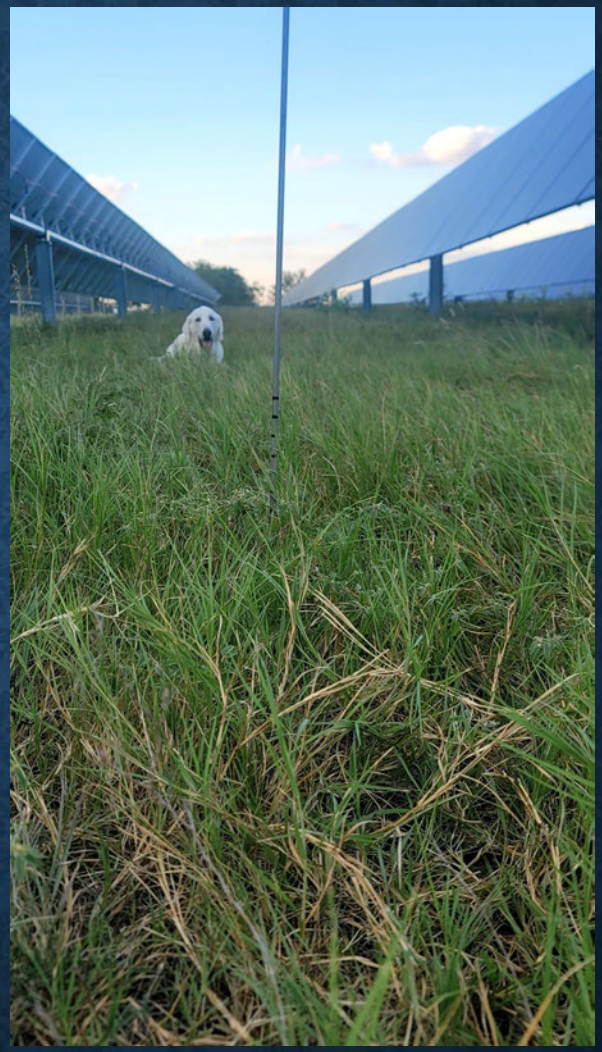
Keep records of

- *Sheep Health*
- *Soil Health*
- Pasture Score
- Vegetation
- Microbial/worm
- Soil test (Haney)

Agrivoltaics

Habitat/Ecosystem

Ground Coverage



Soil Temperature

Native Plant Health

CONDITIONING FACILITY FOR SHEEP, DOGS, CATTLE

BARRIERS TO SOLAR:

- Landowner rights & knowledge
- Construction company
- Local USDA/SWCD practices avoided

Habitat Restoration Project

WNBRI

Western Navarro Bobwhite Recovery Initiative

Spring 2024

Awarded incentive for conservation efforts from Navarro SWCD partnership with MillerCoors & TRWD

A Passion for Kids and Cattle

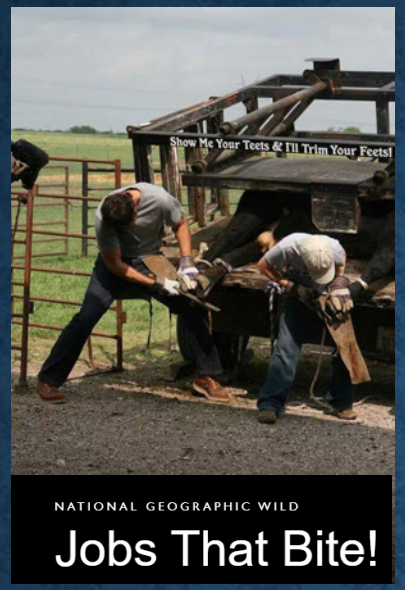
Meredith, Eric, Brigham and Brayden DeBorde

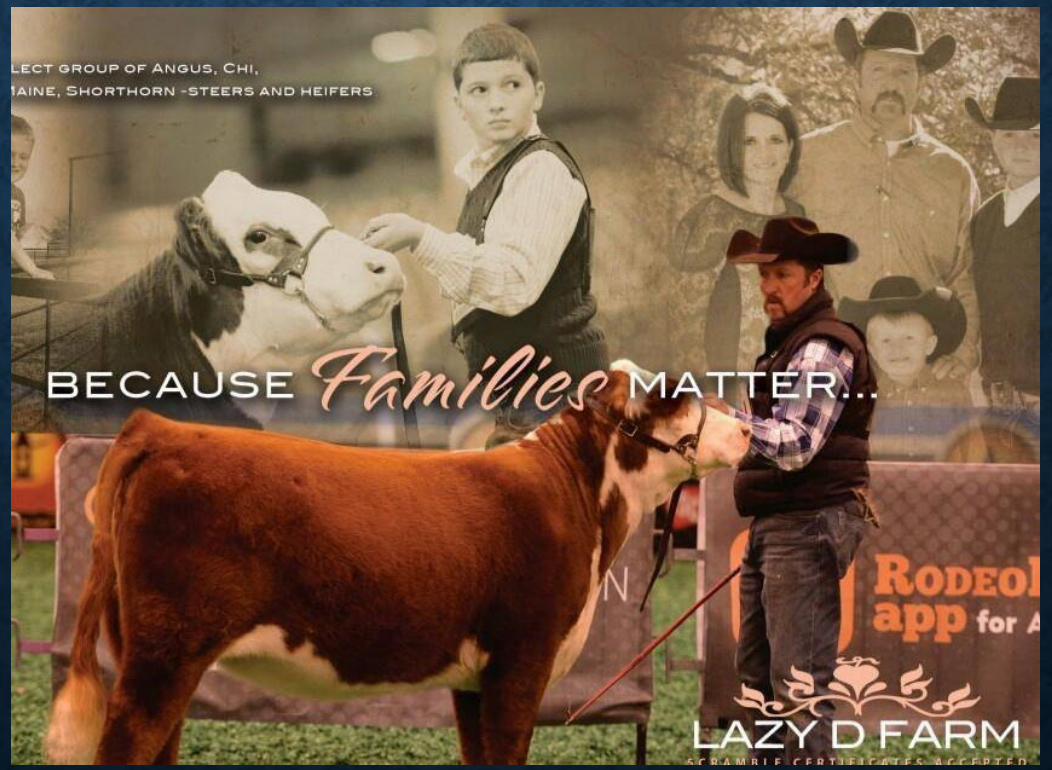
Don't limit yourself.

That's the first advice Meredith DeBorde offered her agricultural science students at Ennis High School during her first week on the job this past August. It's a principle that has served her and her husband, Eric, well. After all, teaching was not her first career option. Similarly, Eric made sure he had another skill to fall back on, even though he wanted to be in the show cattle business. That's why in addition to holding an agricultural degree, he's also a licensed electrician.

The couple, who met at Tarleton State University, has two sons, Brayden, 12, and Brigham, 5.

They raise club calves and own a feed supplement company, Top Line Nutrition, which has dealers across the state and mail-order customers nationwide.





REWARDS

Solar BMPs for Water Quality

Texas Watershed Coordinator Roundtable

Katie Myers

Full Circle Moment

- 2023 Texas Riparian Association Urban Riparian Symposium discussion/survey highlights: commonly asked questions

What is the effect on hydrograph/runoff?

What BMPs are working on site?

What are barriers to BMP implementation?

Solar panel designs to reduce hydrological change?

Who can best regulate/how to involve different levels of gov't?

Solar BMPs: A Watershed Perspective

- Need for BMPs that account for regional variation in soils, vegetation communities, and climate

Primary Goals of BMPs

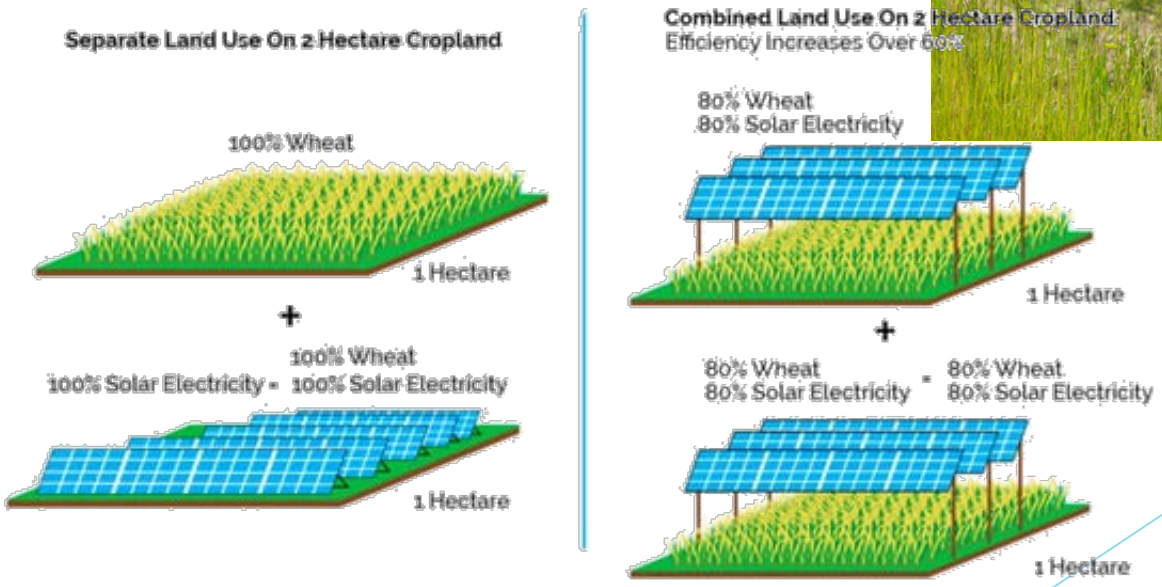
- Maintain ground cover
- Soil health management
- Minimize hydrological impact

Maintain Ground Cover

- Double seeding/pre-seeding
- Keep cover during construction
- Use natives where possible but be mindful of establishment times
- Prioritize native buffers around panel array areas

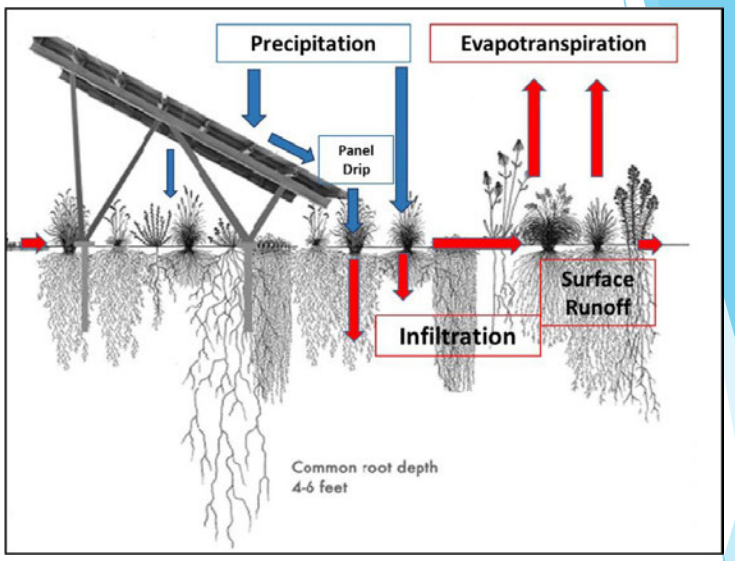
Soil Health Management

- Know your local soils
- Maintain long-term ag viability
- Maintain ag use where appropriate

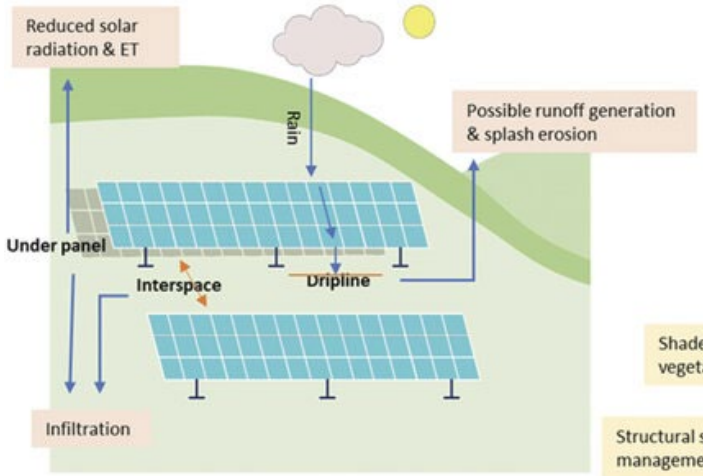


Minimize Hydrological Impact

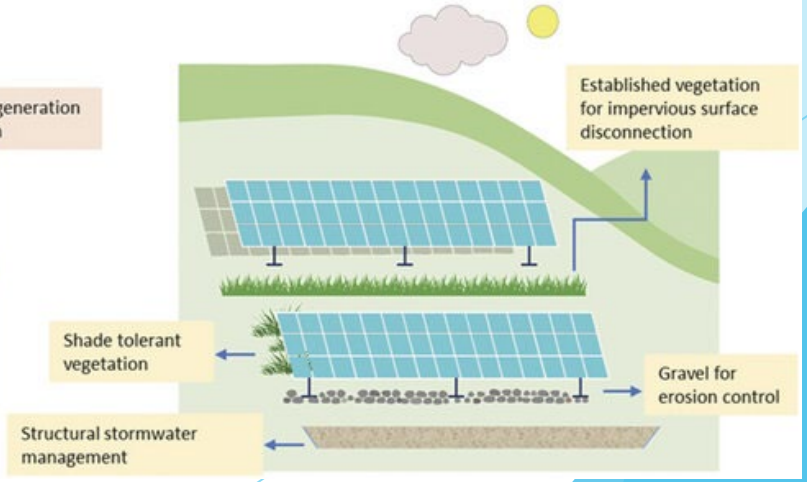
- Minimize grading during construction
- Generous riparian buffers/setbacks
- Appropriate stormwater infrastructure where needed
- Panel characteristics – tilt and spacing



Hydrology of a solar farm



Key management practices



Barriers to BMP Implementation

Making the case for cost-effectiveness

- 3 pathways:
  - "good actor" image
  - Policy incentives (punishment/reward)
  - Solid cost savings analysis

Need for empirical research on hydroecological effects

- Research is not keeping pace with development
- Responses of soil, vegetation, and hydrology to various methods can differ greatly between regions

Barriers to BMP Implementation

Failure to include local natural resources experts in planning and development stages

- Rigidity in project development and execution processes
- Need for greater education and empowerment of landowners and natural resource professionals considering solar leases

Cultivating a mindset of holisitic environmental and community benefit

- Maximizing solar profit often means minimizing other productive uses
- Fold in other environmental services values

Contact

- Katie.Myers@TRWD.com
- Watersheds@TRWD.com

Texas Watershed Coordinator Roundtable

Perspectives on the Development Process

Garrett Bader
American Farmland Trust
Texas Smart Solar Specialist
gbader@farmland.org

American Farmland Trust

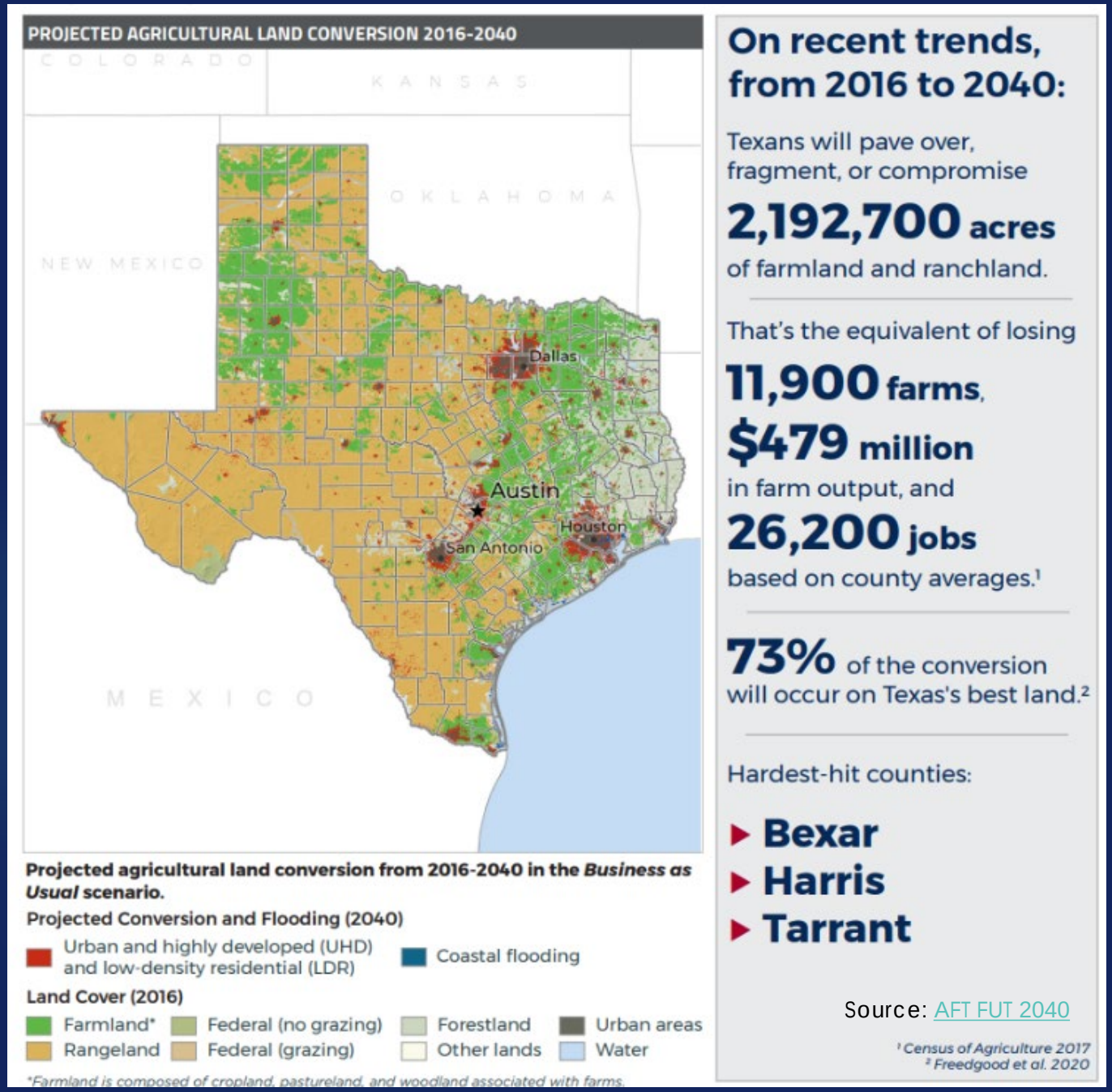
American Farmland Trust

Saving the Land that Sustains Us

Protecting Farmland

Keeping Farmers on the Land

Promoting Sound Farming Practices



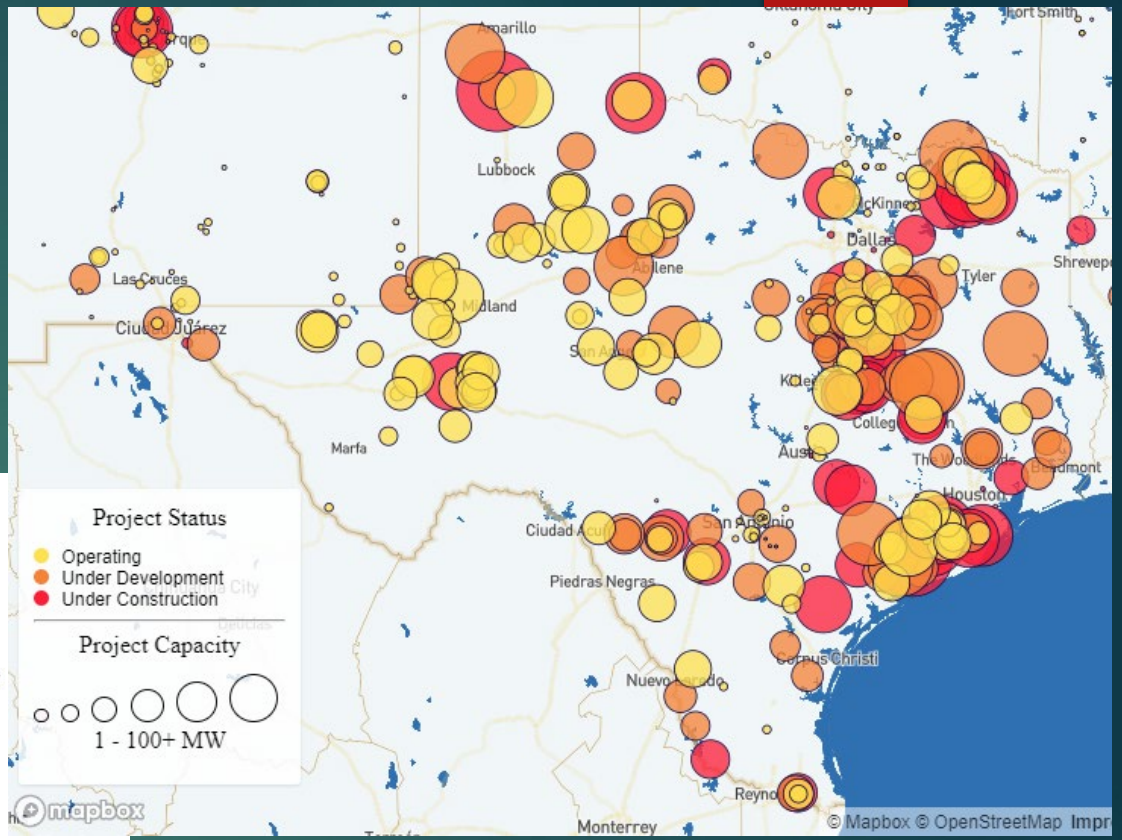
- **Farm's Under Threat 2040:**
  - **2001-2016 data**
- **2022 Census of Agriculture**
  - **2017-2022**
    - **1.6 million acres**
    - **17,700 farms**
    - **Average age of Texas farmer 60 years old**

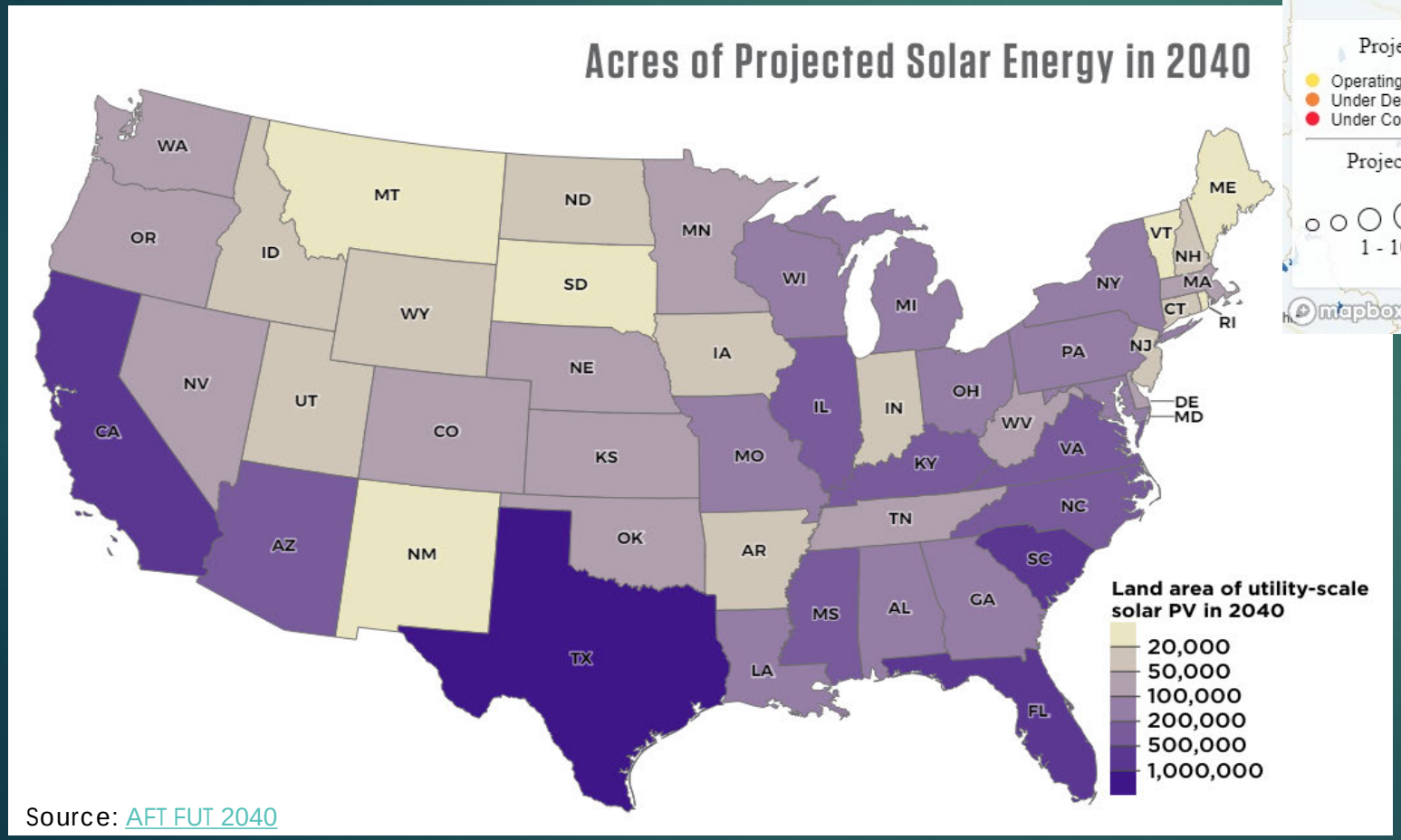
texasfarmbureau.org
https://texasfarmbureau.org › Texas Agriculture Daily

Ag census shows Texas lost over 17700 farms

Feb 22, 2024 — **Texas lost about 887 acres per day**, according to ag census data. And the number of farms decreased from 248,416 to 230,662. It's a trend ...

- Texas leads country in most utility-scale solar

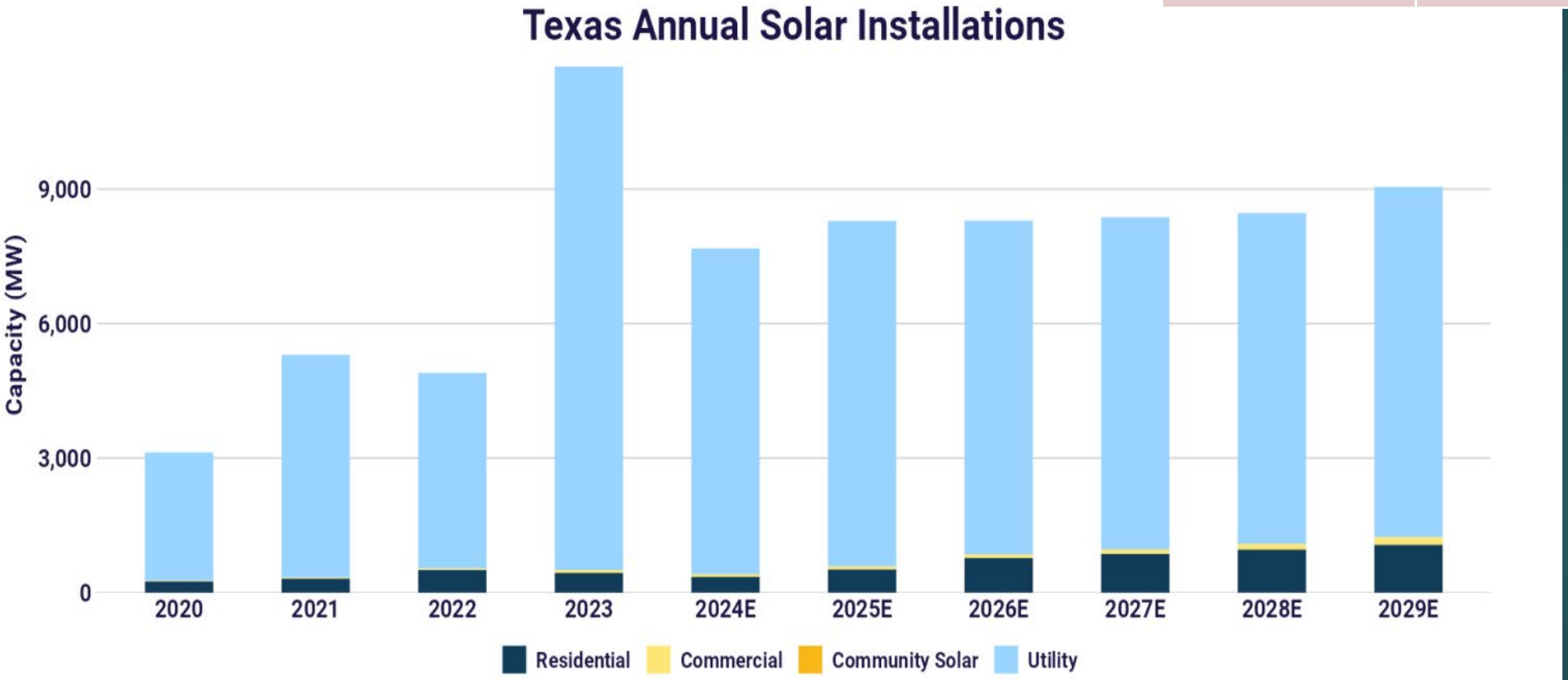




Source: AFT FUT 2040

System sizes:	# of TX homes	Acres
7.4KW	1 (median)	Rooftop
1 MW	120	4-10
100 MW	12,000	400-1,000

Source: SEIA: What's in a Megawatt



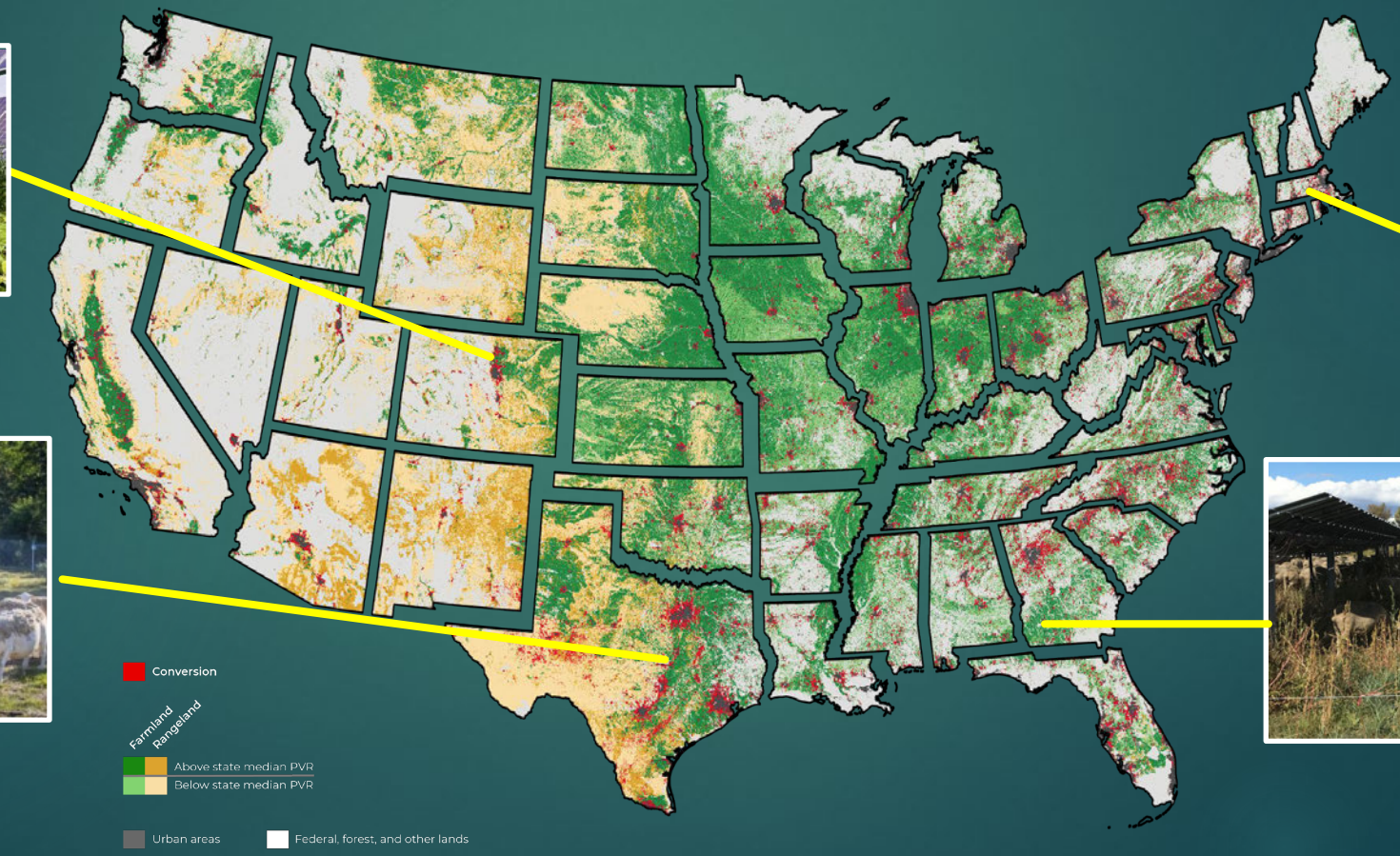
Learn more at seia.org/states

Solar Energy Industries Association®

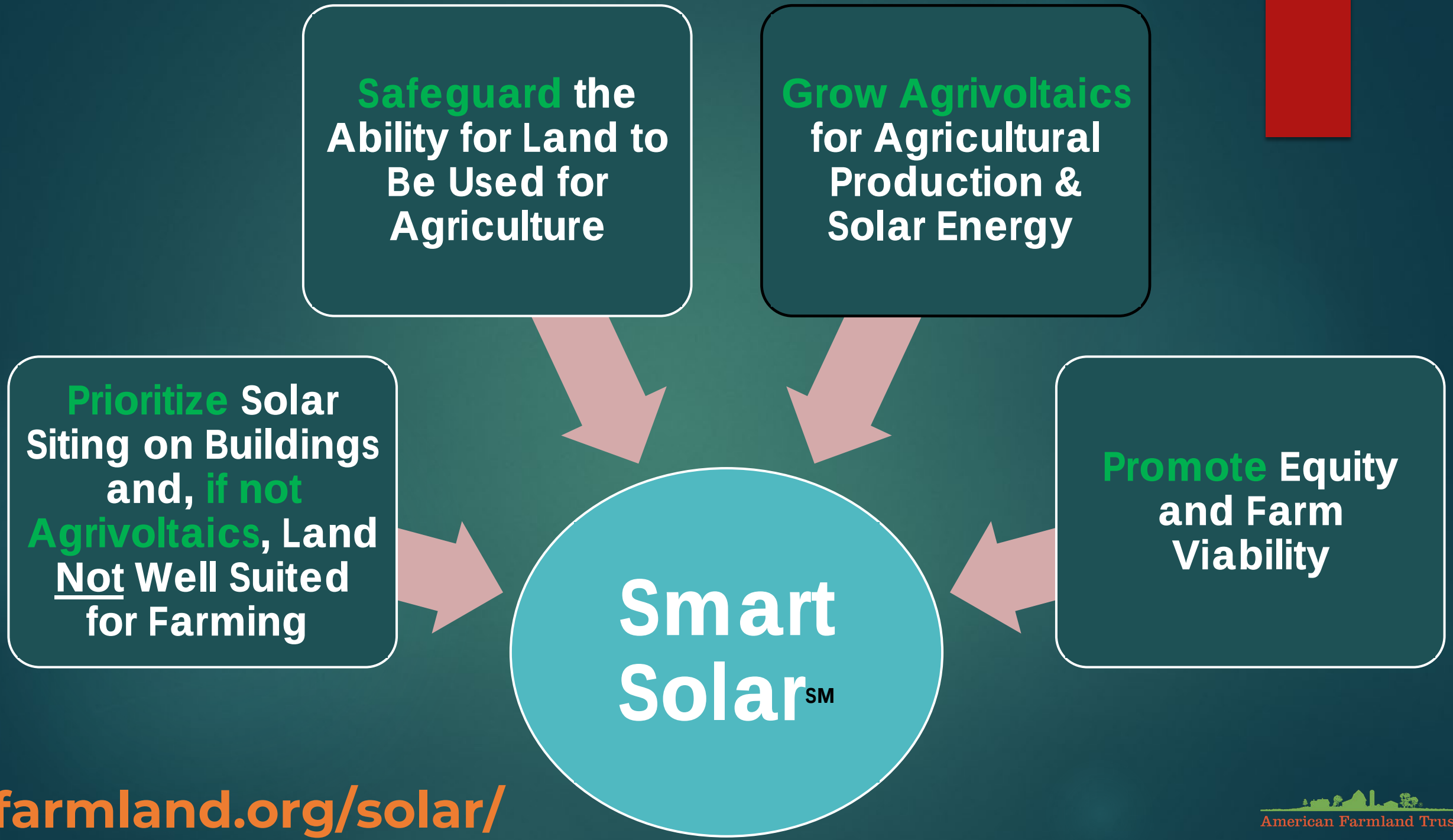
September 2024

Smart Solar advances equally important goals:

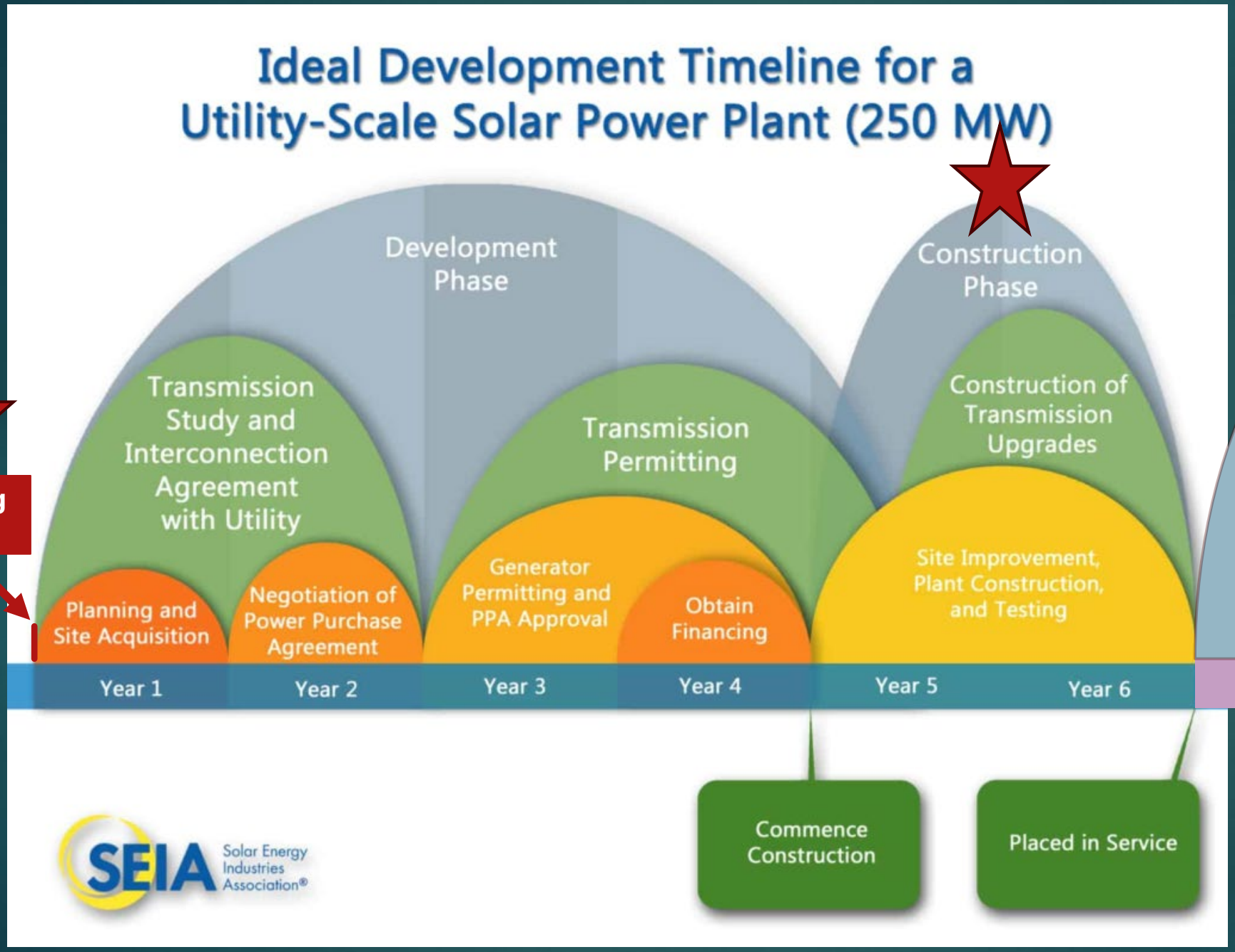
1. Strengthening farm viability
2. Safeguarding land well-suited for farming and ranching
3. Accelerating solar energy development



American Farmland Trust


Safeguard the Ability for Land to Be Used for Agriculture
Grow Agrivoltaics for Agricultural Production & Solar Energy
Prioritize Solar Siting on Buildings and, if not Agrivoltaics, Land Not Well Suited for Farming
Promote Equity and Farm Viability
Smart Solar℠
farmland.org/solar/
American Farmland Trust

Ideal Development Timeline for a Utility-Scale Solar Power Plant (250 MW)



SEIA Solar Energy Industries Association®

American Farmland Trust

Perspectives on the Development Process

Meredith and Eric DeBorde

Owners, Lazy D Farm

Ben Needham

Professional Services Consultant

KerTec, LLC.

Raina Hornaday

Co-Founder & Owner

Caprock Renewables

INVESTIGATING IMPACTS OF COMMERCIAL SOLAR ON RUNOFF WATER QUALITY & QUANTITY

LUCAS GREGORY &
ED RHODES

Texas Water Resources Institute
make every drop count

Texas' first solar farm is in southeastern San Antonio, dubbed Blue Wing. It has an array of 215,000 photov
panels that capture sun rays and turn them into power.

PROJECT BACKGROUND

- Increasing questions from stakeholders regarding commercial scale solar environmental impacts
  - What runs off or leaches out of panels?
  - What ends up in a creek after it rains?
  - How much erosion are solar farms causing?
- No published literature on the subject to answer questions with
- Only computer model generated info exists

In September 2018, sediment from the construction of a nearby solar farm, AL Solar, flowed into Chattahoochee River in Alabama. It was one of four solar farms that were recently involved in construction permit violations and stormwater mismanagement issues. Henry M. Jacobs, Chattahoochee Riverkeeper

Texas Water Resources Institute
make every drop count

PROJECT APPROACH

Project Goals

- Document differences in surface runoff and ambient volume and quality between developed solar and undeveloped areas
- Evaluate accumulation of metals in stream sediment over time
- Evaluate perceptions of solar farm environmental impacts

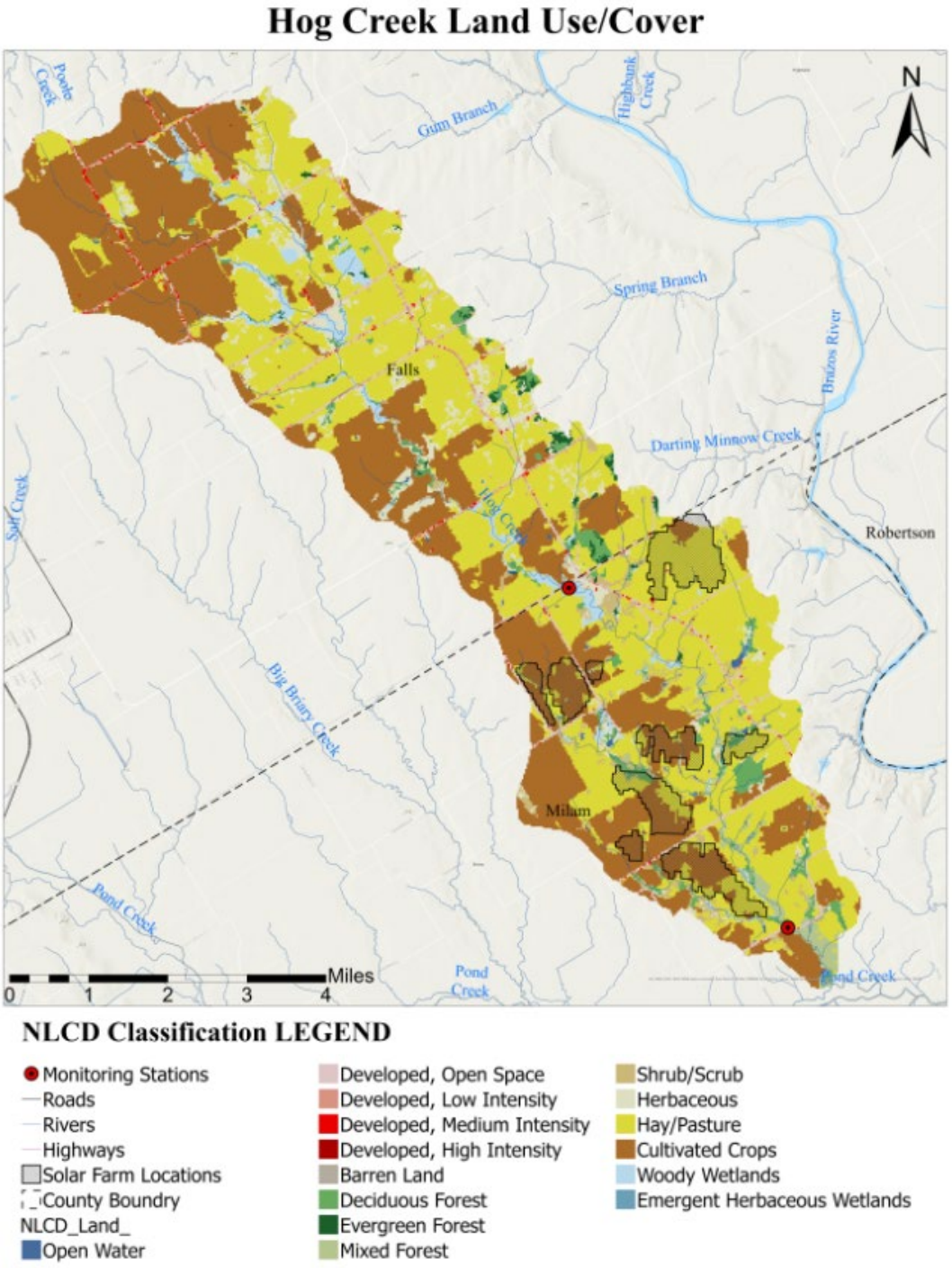
Hypotheses

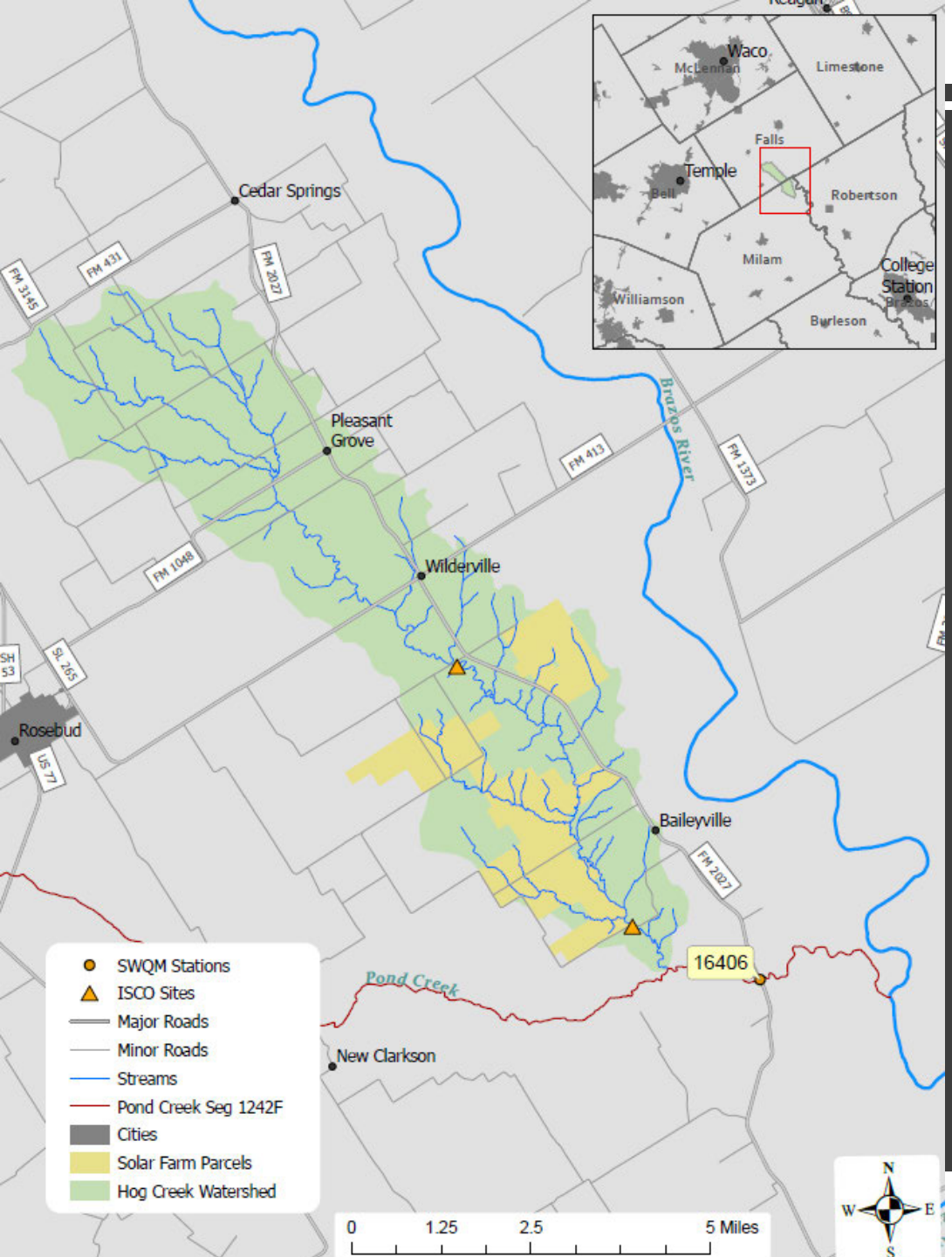
- Ambient water quality constituent loads will not differ significantly upstream and downstream
- Stormflow water quality constituent loads will differ significantly upstream and downstream

Texas Water Resources Institute
make every drop count

Watershed Area

- Hog Creek
- Trib of Pond Creek
- Brazos River
- Milam and Falls Counties
- 100% rural, working lands
  - Pasture
  - Row crops
  - Small grains
  - Very small communities





Monitoring Approach

- Bracket solar development
- Upstream/Downstream Sampling Design
- Routine baseflow and storm sampling
- Concentrations and Flow
- Estimate load differences upstream vs. downstream

PARAMETERS MEASURED

- Flow
- TSS
- Turbidity
- pH
- Temp
- DO
- Conductivity
- Fluorescent DOM
- Cadmium
- Chromium
- Copper
- Tellurium
- Lead
- Nickel
- Zinc

OUTPUTS, OUTCOMES, AND PLANS

- Data assessment highlighting findings
- Survey results highlighting public perceptions
  - Technical report
  - Peer-reviewed publications
- Goal - continue monitoring long-term
  - Do panel impacts change throughout their lifespan?
  - What happens after mass storm damage?
  - How much erosion occurs in channel over time?

QUESTIONS

Lucas Gregory

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Ed Rhodes

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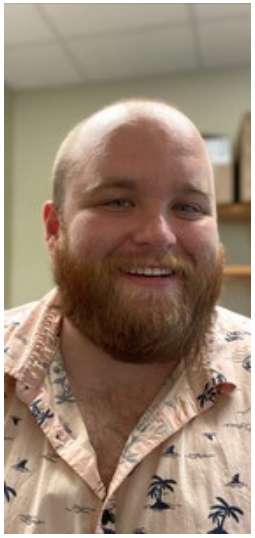
Funding Provided by TSSWCB's On The Ground Conservation Program: OTG 24-01

SSOLAR
Solar-farm Stream Observation and Long-term Adaptive Research

Ryan McManamay
Associate Professor
Department of Environmental Science

Baylor University

SSOLAR Team



Jordan Jatko
PhD Student

Emeka Orji
PhD Student

Micah Bowman
PhD Student

Dr. Kayla Garrett
Teaching
Postdoctoral
Scholar

Baylor University

SSOLAR Farms

- **Roseland Solar + Storage (Enel Green Power)**
  - 640 MWdc with 59 MWdc storage
  - 4263 acres
- **Copperhead Solar**
  - 150 MW and 100 MWh storage
- **True North Solar (Avangrid)**
  - 240 MW
- **Robinson Solar (Cypress Creek Renewables)**
  - 5 MW
  - 50 acres
- **Markum Solar (Scout Clean Energy, Brookfield Renewable)**
  - 161 - 209 MW
  - 800 acres

Monitoring Framework

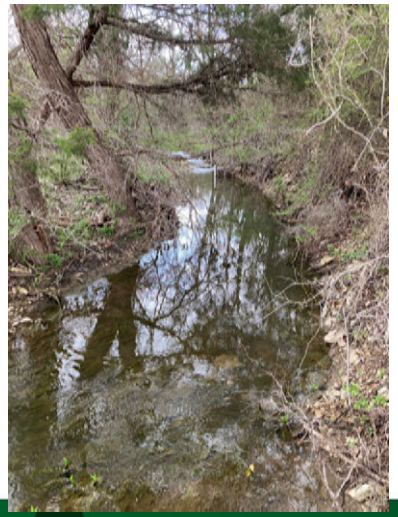
- Paired watershed design
  - Reference
  - Impacted
- Event-based sampling
  - Grab samples for Turbidity
  - Water quality sonde deployments
- Continuous sampling
  - Pressure transducers (water-level)
  - Game cameras (water-level)
  - Weather stations

Markum Solar
Impacted Site

Reference Site
Rock Spring

Base flow

Storm-flow



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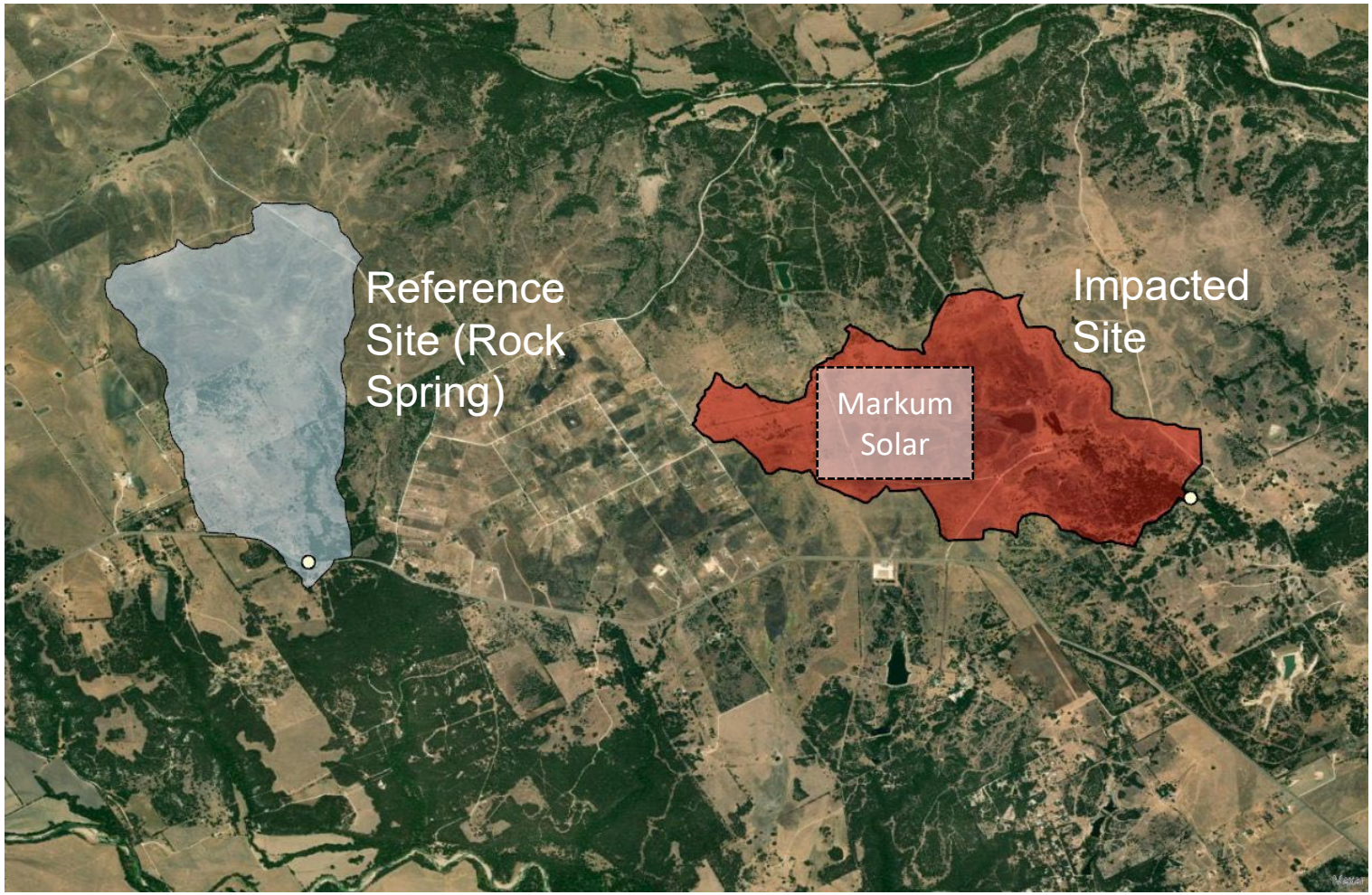
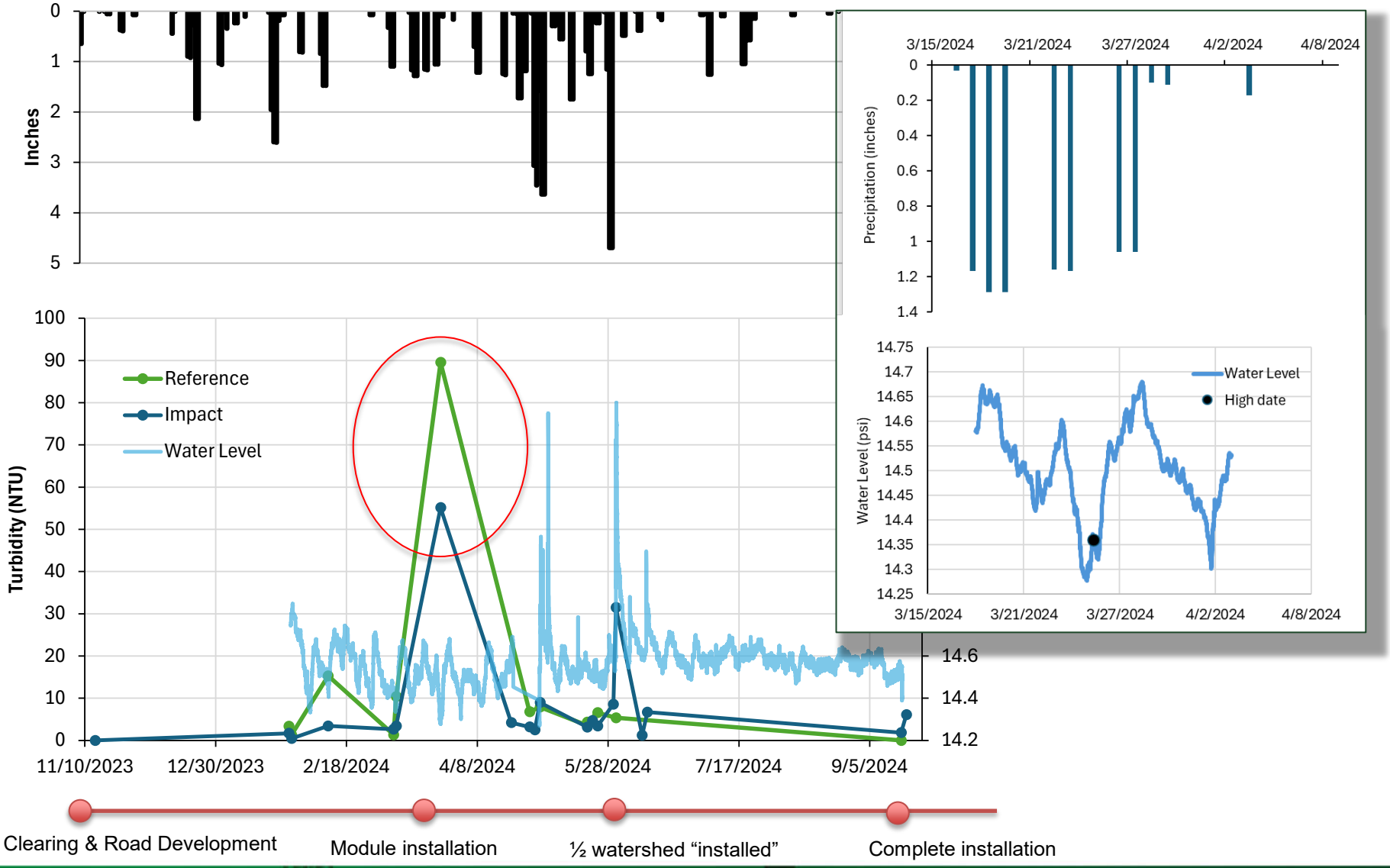
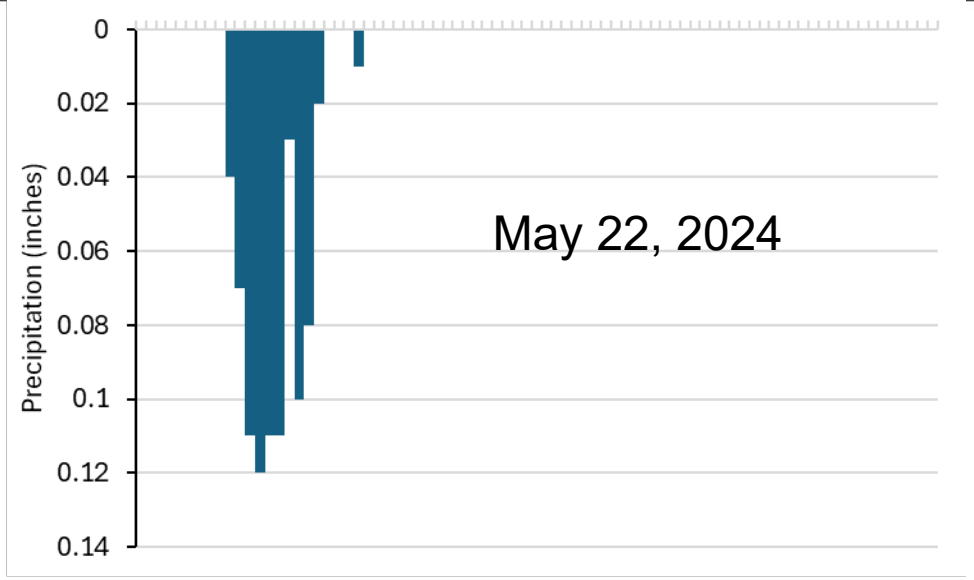
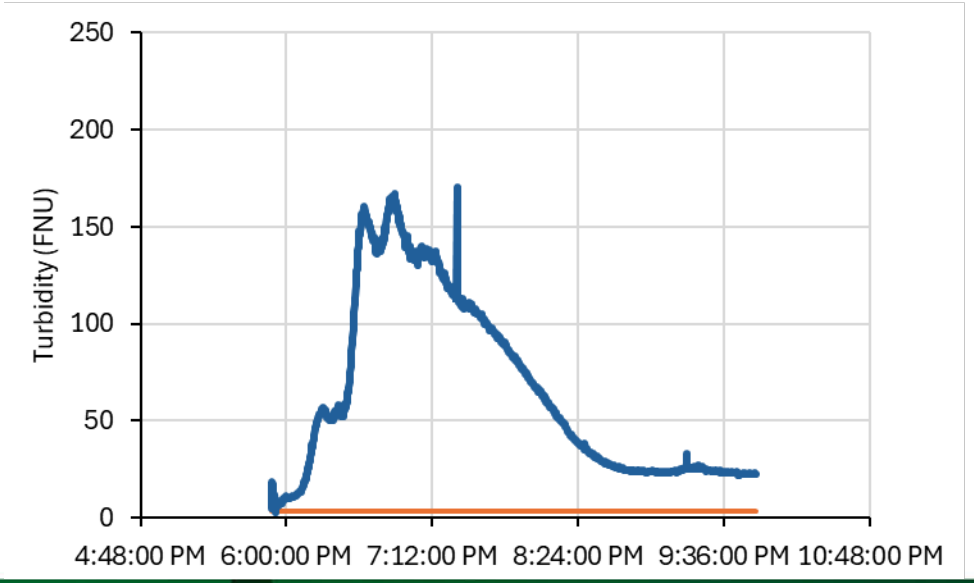

Reference Site (Rock Spring)
Impacted Site
Markum Solar


2023-07-23 00:00 - 2023-07-23 23:59, Sentinel-2 L2A, False color
July 2023
500 m
Credit: European Union, contains modified Copernicus Sentinel data 2024, processed with EO Browser
Copernicus sentinelhub


Inches
0
1
2
3
4
5
Turbidity (NTU)
100
90
80
70
60
50
40
30
20
10
0
Reference
Impact
Water Level
14.6
14.4
14.2
11/10/2023
12/30/2023
2/18/2024
4/8/2024
5/28/2024
7/17/2024
9/5/2024
3/15/2024
3/21/2024
3/27/2024
4/2/2024
4/8/2024
Precipitation (inches)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
Water Level (psi)
14.75
14.7
14.65
14.6
14.55
14.5
14.45
14.4
14.35
14.3
14.25
Water Level
High date
Land Clearing & Road Development
Module installation
½ watershed "installed"
Complete installation





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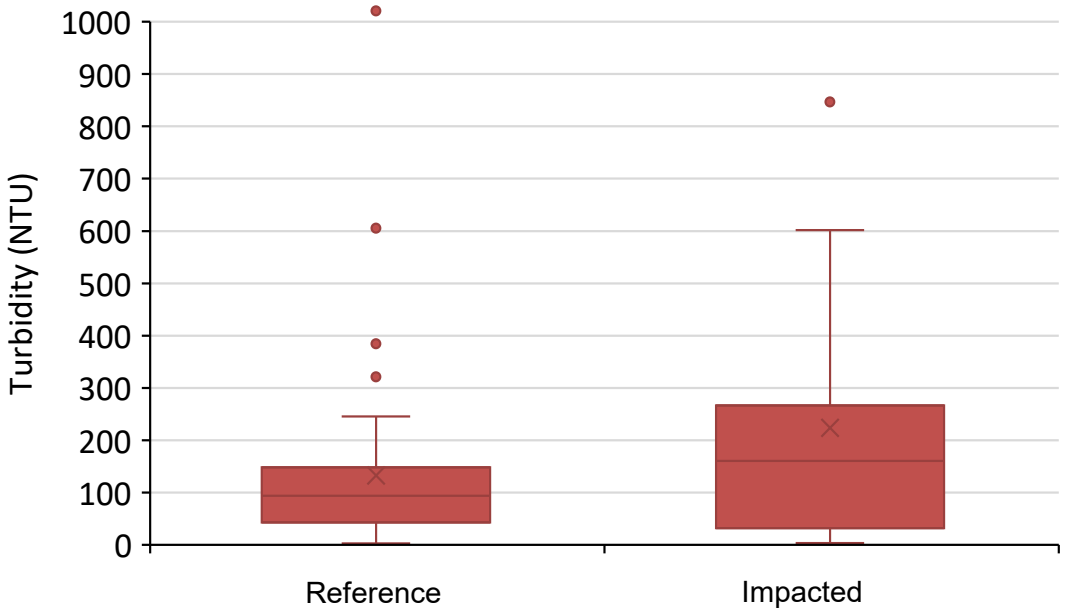
Otto Texas:

- Roseland, Copperhead, True North
- Streams (Brushy Creek, Big Creek, Hogpen Creek)

- 14 sites
- 13 events
- 115 observations

- ~ 40% increase in mean turbidity
- 50% increase in median turbidity



Otto Texas:

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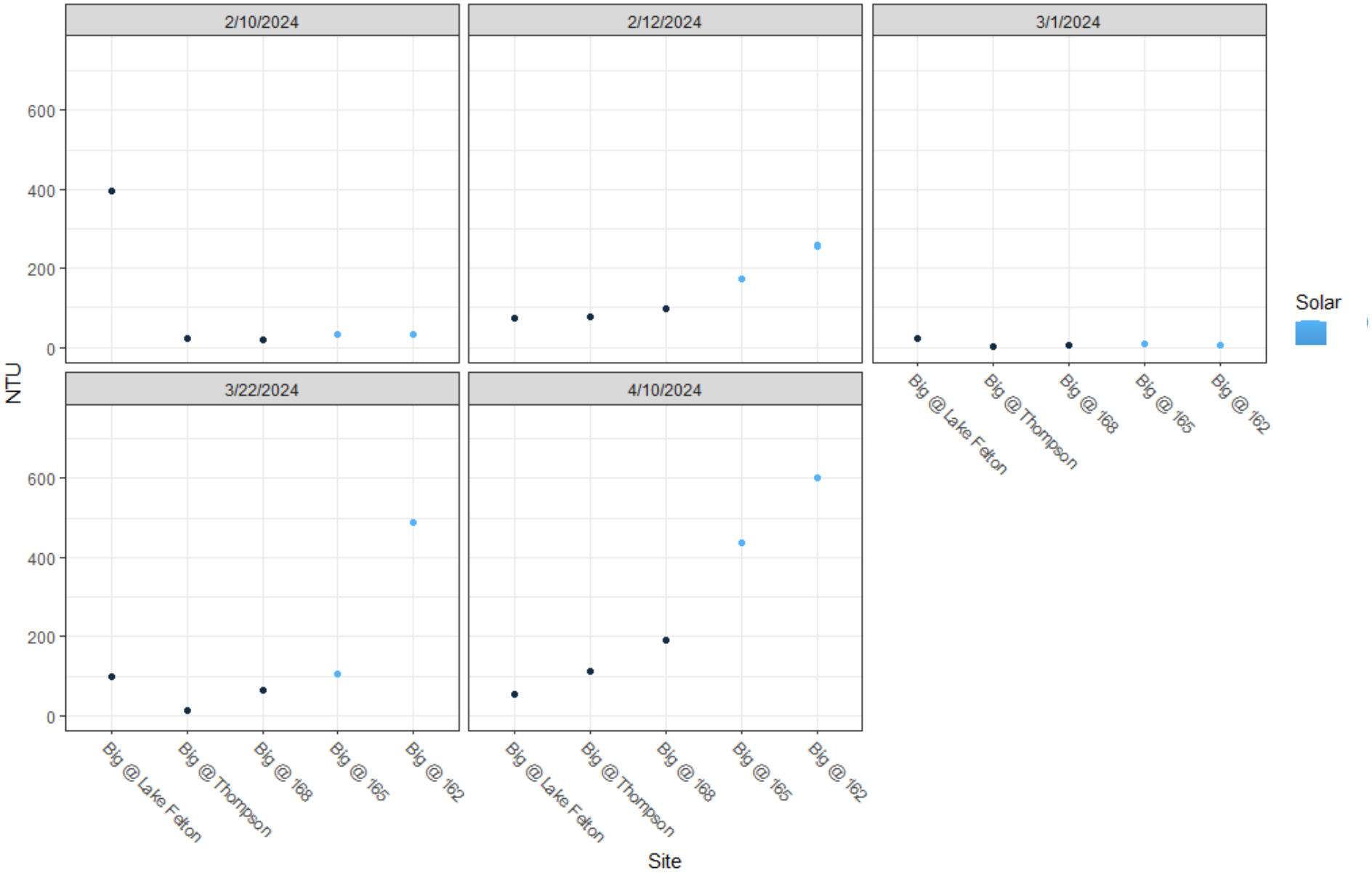

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55 °F 2024/02/11 00:03:23
Baylor University

April 9, 2024

Baylor University

April 9, 2024

Baylor University

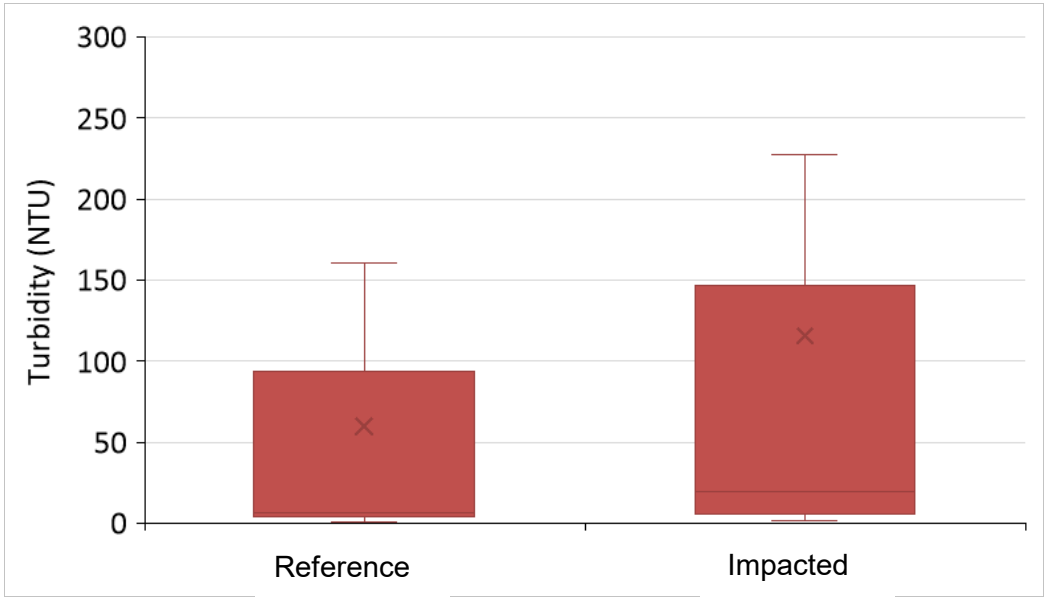
Baylor University

Robinson Texas:

- Robinson Solar
- Flat Creek

- 2 sites
- 9 events
- 18 observations

- ~ 100% increase in mean turbidity
- > 200% increase in median turbidity



Future Work

- Increase observations, continuing sampling across more events
- Expand observation network to more field sites
- Conduct field forensics to understand pathways of runoff and turbidity
- Build a hydrologic observation dataset to support hydrologic modeling
- Utilize remote sensing efforts to understand field management strategies and vegetation cover
- Seek stable funding support
- Coordinate work with partners
  - TWRI and TRWD

Acknowledgements

- Department of Environmental Science, Baylor University
- McManamay Lab
- Undergraduate Students
  - Benjamin Trotter
  - Epiphany Velasco
- Tarrant Regional Water District
- Texas Water Resources Institute

Baylor University

Thank you!!

Baylor University

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txH2O

txH2O magazine features stories on current water resources research and outreach programs in Texas and priority water issues facing Texas.

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Water Resources Training Courses Update

This newsletter provides periodic updates of upcoming trainings on riparian and stream restoration, watershed protection planning, and other water resource workshops.

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https://urbanriparian.twri.tamu.edu

UPCOMING TEXAS WATERSHED PLANNING PROGRAM TRAININGS

HTTPS://TEXASWPP.TWRI.TAMU.EDU

Stakeholder Facilitation

- December 11-12, 2024
- Online Only
- Charlie McPherson, Tetra Tech
- $50 registration fee
- Topics:
  - Understanding your audience
  - Engaging stakeholders
  - Facilitating meetings
  - Sustaining stakeholder groups

Texas Watershed Planning Short Course

- January 27-30, 2025
- Bandera, Texas – Mayan Ranch
- In-Person Only
- $200 registration fee
- Room and board @ $144/night
- Topics:
  - EPA 9 Elements of Successful WBPs
  - 6 Steps in WBP Process

ROUNDTABLE WRAP UP

- Feedback form → Scan the QR Code →
  - Topics of interest for next time
  - Programs that you would like to learn more about
- Next Roundtable: May 2025 – College Station
  - Registration info will be in a future Trainings Newsletter

Questions or Comments:

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