Co-Location of Solar and Agriculture: Benefits and Tradeoffs of Low-Impact Solar Development

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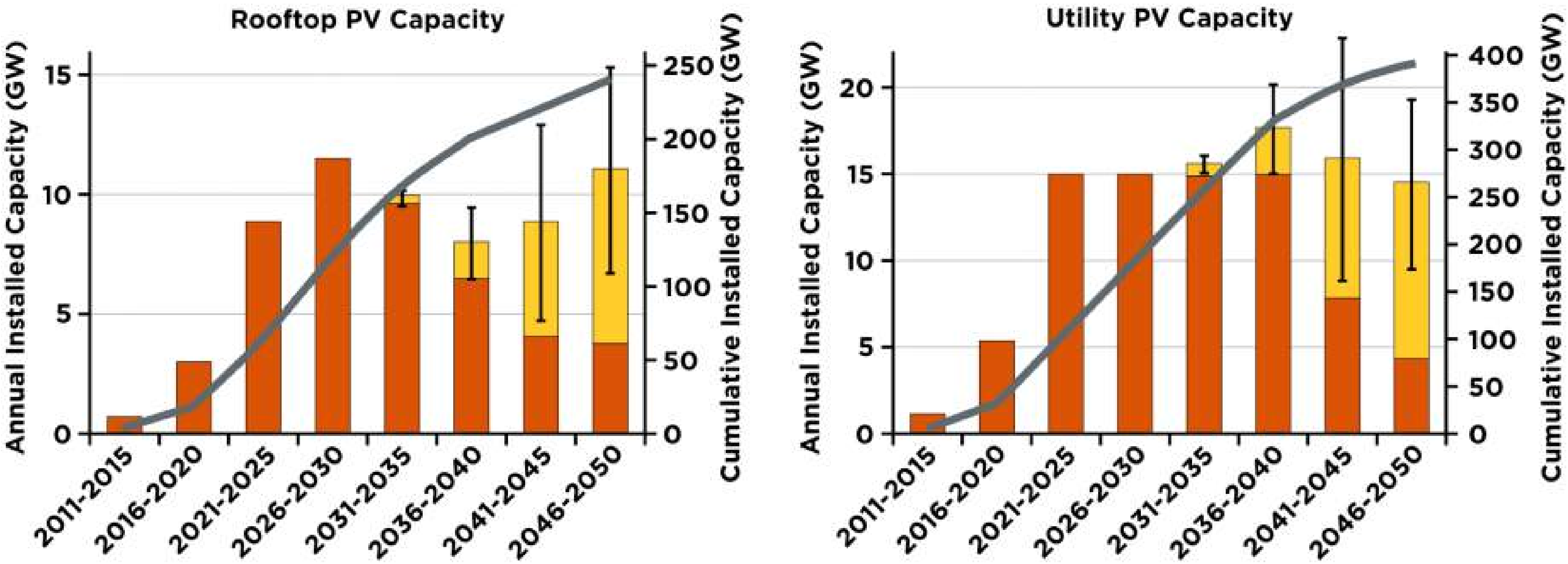
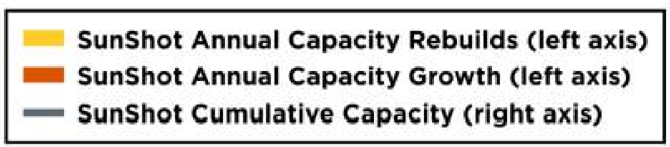
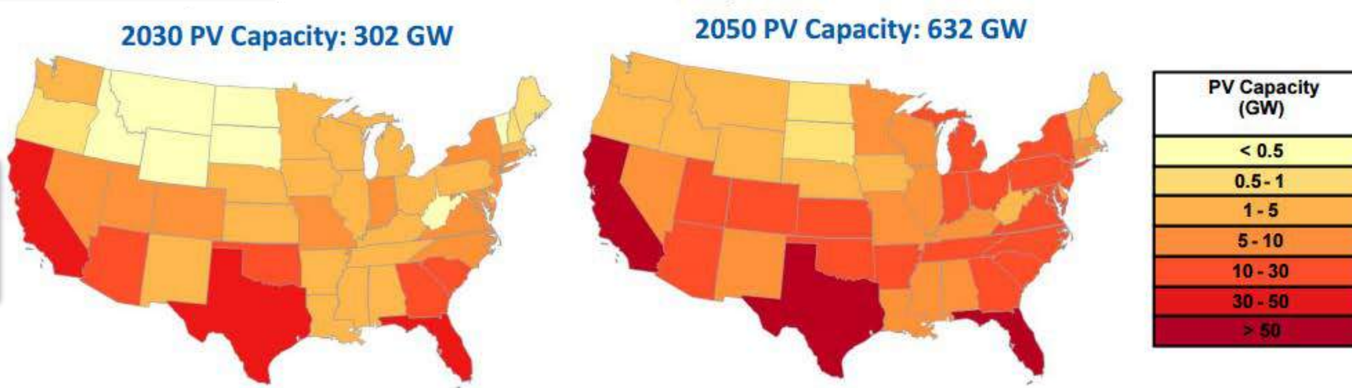
January 12th, 2017

Motivation: Department of Energy SunShot Solar Goals





Cumulative Installed PV and CSP Capacity in the SunShot Scenario in 2030 and 2050



2030: 3 million acres
2050: 6 million acres

Motivation: Conventional Utility-Scale Solar Land Preparation Approach

Conventional site preparation activities can also be expensive

Site preparation is expected to account for 20% of utility-scale PV installed costs in 2020 (DOE 2012)

Reducing site preparation costs via low-impact site development can lead to cascading reductions in other environmental-related costs and risks

Conventional Site Preparation Practice	Current Cost Contribution	Potential Cost Reductions through Low-Impact Design
Geotechnical Investigation	0.5% - 1.5%	0% - (25%)
Clearing and Grubbing	1.0% - 2.0%	25% - 90%
Soil stripping and stockpiling	1.0% - 2.0%	20% - 90%
Grading	3.0% - 6.0%	50% - 90%
Soil Compaction	1.0% - 3.0%	50% - 75%
Foundation for vertical support	4.0% - 8.0%	2% - 5%

Other Cost and Performance Categories	Potential Cost Reductions through Low-Impact Design
Land Acquisition	5-10% reduction in land requirements
Permitting	1-5% reduction in permitting costs
O&M for weed control	2-7% reduction in O&M
Degradation	1-3% improvement in annual panel degradation
Efficiency	1-3% improvement in efficiency due to temperature impacts

Alternate Vision: Low-Impact Solar Development

Mule deer (Odocoileus hemionus) fawn and doe – wildlife utilizing shade beneath panels.

What is Low-Impact Site Preparation?

It can mean a lot of things in different areas, bus some general concepts are:

Conventional Site Preparation	Low-Impact Site Preparation
Clearing and grubbing of soil and roots	Existing vegetation is left intact or is replaced with low-growing native vegetation species or crops
Topsoil stripping and stockpiling	Existing topsoil is left in place to allow for the successful growth of native vegetation and to promote soil health post-decommissioning of the solar project
Land grading and leveling utilizing heavy machinery	Natural contours of land are worked into the design and configuration of the solar project, with minimal if any land grading required
Soil compaction utilizing heavy machinery	Soil and vegetation are left intact to facilitate the growth of native vegetation, improved stormwater management through less runoff and erosion, and soil health
Land footprint for the foundations of vertical support structures, often including concrete	Lower land footprint for foundations of vertical support structures, often driven piles
Vegetation that supports habitat is discouraged and removed	Vegetation that supports habitat (e.g., pollinator species, other native fauna) is encouraged
O&M activities include herbicide spraying, mowing of weeds and other vegetation	Minimal O&M activities due to low-growing native vegetation species, could involve livestock grazing

Categories of low-impact solar development

- Solar Centric
  - Minimal changes to solar configuration
  - Low-lying vegetation for ground cover and habitat

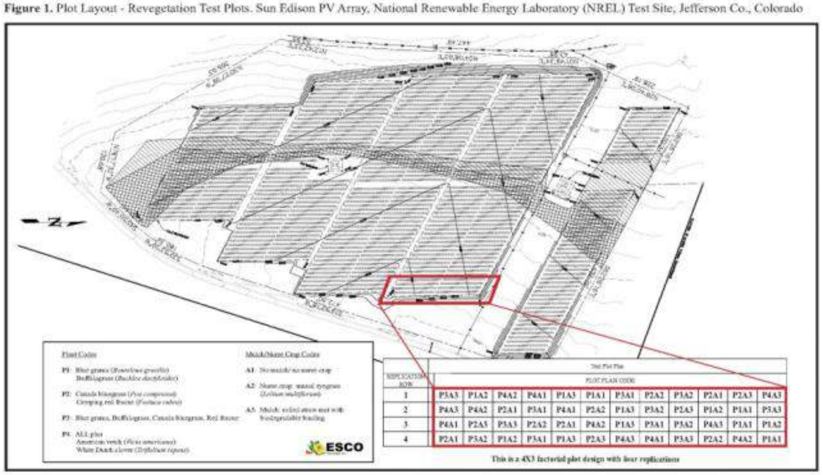
- Vegetation Centric
  - Minimal changes to vegetation design
  - Large spacing in solar technologies

- Co-Location and Co-Optimization
  - Solar and vegetation configurations are designed jointly for maximum dual output

Source: Macknick, Jordan, Brenda Beatty, and Graham Hill. 2013. *Overview of Opportunities for Co-Location of Solar Energy Technologies and Vegetation*. NREL/TO-6A20-60240, National Renewable Energy Laboratory, Golden.

NREL Wind Site: Solar-Centric Approach

Figure 1. Plot Layout - Revegetation Test Plots. Sun Edison PV Array, National Renewable Energy Laboratory (NREL) Test Site, Jefferson Co., Colorado



How well does low-height native vegetation grow underneath and between solar panels?

Source: Beatty, B., Buckner, D., McCall, J., and J. Macknick. *Forthcoming 2017. Vegetation Performance under a Solar PV Installation.* National Renewable Energy Laboratory, Golden

CA Valley Solar Ranch: Solar-Centric Approach

How can solar installations affect endangered species' habitats and other vegetation?

Can solar projects improve habitat?

Sunflower Farm: Vegetation-Centric Approach

How can solar be integrated into agricultural activities without reducing output?

Sunflowers for oil production grown under panels in Wisconsin

Milwaukee Journal Sentinel, 2011

Center-Pivot Irrigation: Vegetation-Centric Approach

How can solar be integrated into agricultural activities without reducing output?

Yellow areas show unused and non-irrigated lands where solar could be developed

Source: Roberts, B. (2011). *Potential for Photovoltaic Solar Installation in Non-Irrigated Corners of Center Pivot Irrigation Fields in the State of Colorado*. NREL/TP-6A20-51330. Golden, CO: National Renewable Energy Laboratory.

Solar and Agriculture Co-location

- Massachusetts Co-location Test Facility
- Innovative installation and structural design
- Multiple crop types (broccoli, kale, beans, chard, peppers)
- Varied spacing in between panels
- U-MASS-Amherst (Stephen Herbert)
  - Agriculture
  - Engineering
  - Economics

Photos courtesy of Stephen Herbert

University of Massachusetts Test Plot—2016 Activities

Study Design

Crop Planting

Harvesting

Data Collection and Analysis

Photos courtesy of Stephen Herbert

Solar and Agriculture Co-location

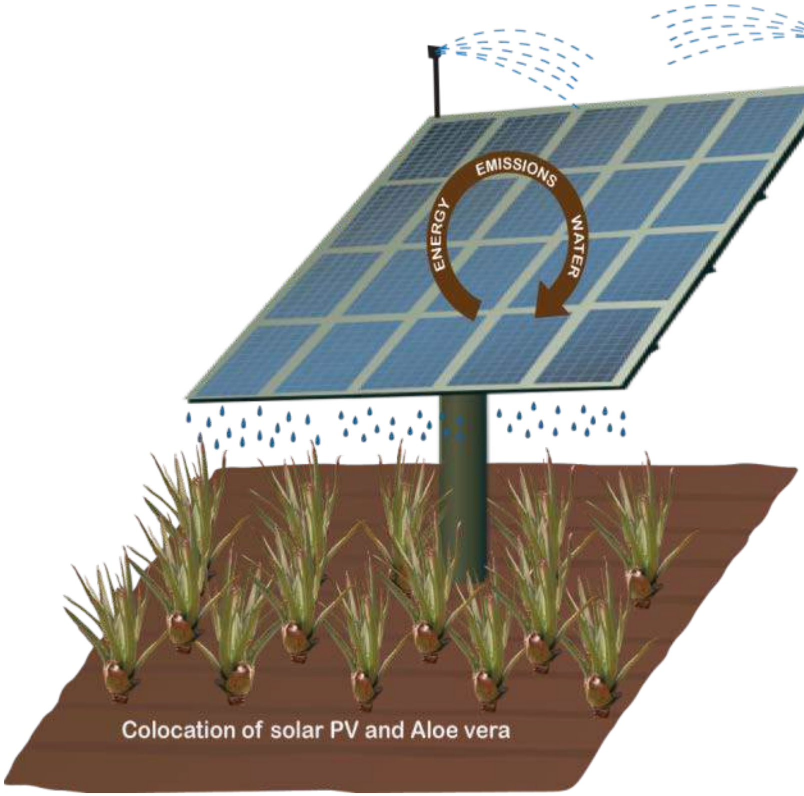
http://www.theecologist.org/siteimage/scale/0/0/387348.jpg

Ranching and grazing

Photo courtesy of Stephen Herbert

Solar and Agriculture Co-location

India: Aloe Vera



Source: Ravi, S., J. Macknick, D. Lobell, C. Field, K. Ganesan, R. Jain, M. Elchinger, and B. Stoltenberg (2016), Colocation opportunities for large solar infrastructures and agriculture in drylands, *Applied Energy,* 165: 383-392.

Photos courtesy of Sujith Ravi

Solar and Agriculture Co-location

Desert Southwest and Mexico: Agave

Source: Ravi, S., D. Lobell and C. Field (2014), Tradeoffs and synergies between biofuel production and large-scale solar infrastructure in deserts, *Environmental Science & Technology*, 48(5), 3021-3030

Solar and Agriculture Co-location

"We are a family-owned, first-generation business producing location-specific honey. We see a market demand for agricultural products produced in conjunction with solar energy.

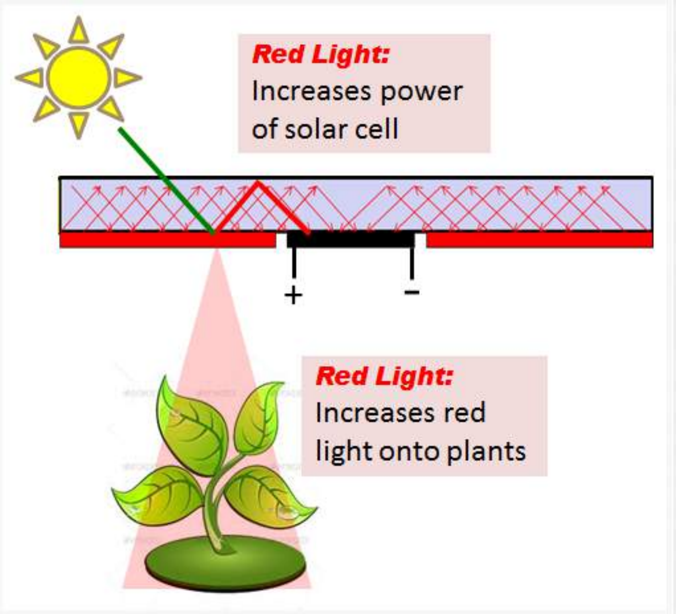
"Solar arrays that include abundant pollinator habitat present an opportunity for us to grow our business."

-Chiara and Travis Bolton, BoltonBees.com

Solar and Agriculture Co-location

Foraging habitat for insects that are beneficial to agriculture. Vegetation that includes forbs (flowers) increases abundance and diversity of bees and other insects that pollinate crops.

Solar and Agriculture Co-location



Greenhouses

SOLICULTURE

Potential Benefits of Co-Location of Solar and Agriculture/Vegetation

Benefits to Land/Owners

- Self-generation of electricity and reduced energy bills
- Additional income stream and increased revenue security
- Compatible with grazing activities, provides shade and cover for livestock
- New market opportunities for shade tolerant crops
- Control of wind and soil erosion
- Protection of natural habitat
- Safeguarding soil health
- Improved habitat for pollinator species

Benefits to Solar Developers

- Reductions in site preparation and installation costs
- Reductions in O&M costs
- Reduced need for dust suppression
- Reduction in litigation vulnerability
- Decreased permitting time
- Increased solar energy production from cooler air zone created under modules
- Reduction in environmental mitigation investments

The driving motivation of this research is to provide quantitative data to evaluate these claims

Overview of InSPIRE-An NREL Project through U.S. Department of Energy

Meeting SunShot Cost and Deployment Targets through
Innovative Site Preparation and Impact Reductions on the Environment (InSPIRE)

Low-Impact Site Development

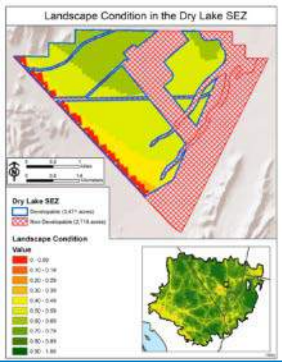
Reduces and identifies upfront capital costs, O&M costs, and risks

Reduces environmental impacts and costs that lead to further costs

Comprehensive Mitigation Plan

Identifies and works to reduce compensatory mitigation costs

Smarter regional planning for highest conservation impact at lowest cost



Innovative Siting Locations

Reduces and identifies costs on contaminated lands and co-located agricultural projects

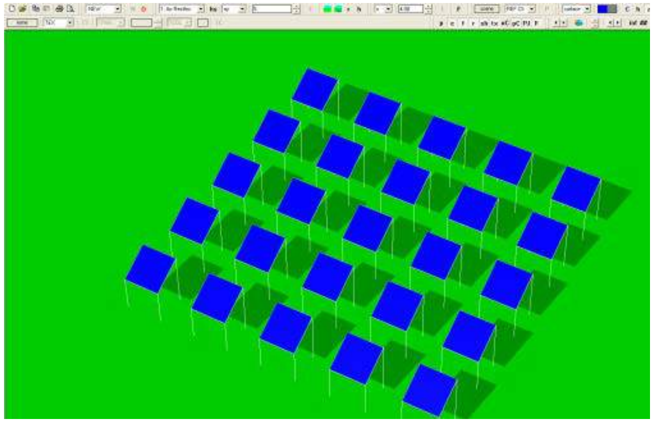
Expands economically viable lands to meet SunShot deployment goals

Extensive Stakeholder Engagement

Data collection
Data and results validation
Dissemination
Frequent feedback and interaction

Smart, low-impact siting designs and planning can reduce installation and operation costs, financial risks, and environmental impacts of commercial and utility-scale solar projects.

Research needs and benefits



- Robust quantitative data to back up anecdotal evidence
- Field studies
- Desktop studies
- Regional variations
- Solar configuration options
- Vegetation varieties
- Cost (O&M and initial) tradeoffs
- Long-term planning and development

Partners and Stakeholders

Experienced project team leverages expertise from across US and world

IEA PVPS

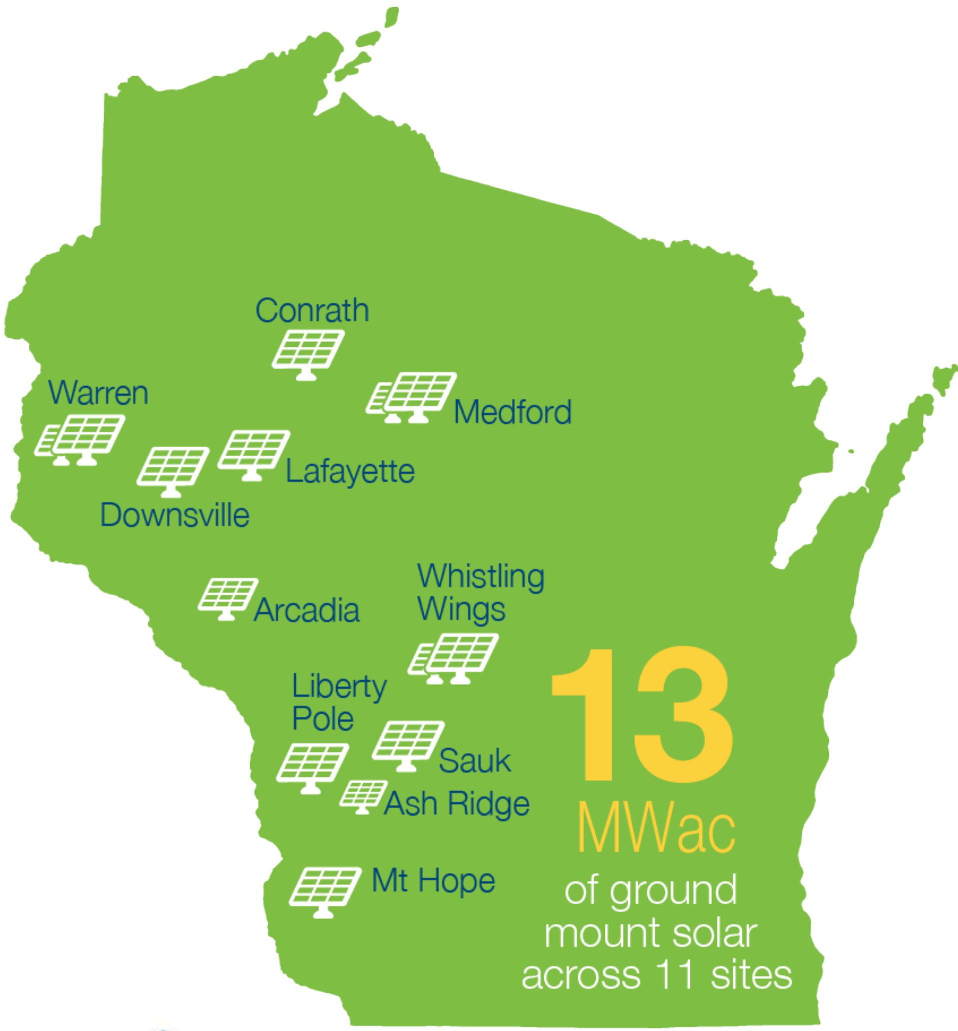
- Enhanced stakeholder engagement ensures timely and relevant products to the market
- Results integrated into NREL's soft cost and solar technology modeling tools
- Complementary, non-duplicative products informed by industry needs
- Frequent interaction and validation from industry

Closing Thoughts

- There are many opportunities for synergies between agricultural and solar energy communities
- Solar projects can be designed and constructed in ways that minimize environmental impacts and reduce costs
- Greater interaction with stakeholder groups can improve viability of solar and agriculture in the future
- Integrated planning activities can lead to widespread benefits
- Additional test plots and new data collection opportunities will improve the robustness of scientific research
- Additional stakeholder outreach is needed

Laura Caspari
SoCore Energy

Dairyland Portfolio Seed Mixes — Acreage Summary



Project	Total Acreage	Dry-sandy Seed Mix	Dry-mesic Seed Mix	Mesic To Wet Seed Mix
Warren	16.4		14	2.4
Downsville	9.5		4.5	5
Arcadia	7.51		7.51	
Lafayette	8.87		8.87	
Whistling Wings	10.81	10.81		
Ash Ridge	5.4		5.4	
Mt Hope	10.6		10.6	
Liberty Pole	9.3		6	3.3
Sauk	8.56		8.25	0.31
Medford	15.93			15.93
Conrath	7.87			7.87
Total	**110.75**	**10.81**	**65.13**	**34.81**

Pollinator Habitat Created

In addition to the 110.75 acres currently under construction, the additional three sites in the Dairyland portfolio will contribute another 41.5 acres, for a total of 152.25 acres of native pollinator habitat

Land equivalent to more than 92,000 homes having a 6'x12' pollinator garden.

PROPRIETARY

Sandy Grass and Wildflower Mixes

Sandy Grass
Side Oats Grama
Blue Grama
Kalm's Brome
Poverty Oat Grass
June Grass
Little Bluestem
Prairie Dropseed

Wildflower Mixes

Yarrow	New Jersey Tea	Golden Alexander	Gray Goldenrod
Prairie Onion	Partridge Pea	Wild Bergamot	Upland Goldenrod
Leadplant	Sand Coreopsis	Spotted Beebalm	Stiff Goldenrod
Tall Thimbleweed	White Prairie Clover	Sand Evening Primrose	Calico Aster
Columbine	Purple Prairie Clover	Foxglove Beardtongue	Frost Aster
Prairie Sage	Silky Prairie Clover	Showy Penstemon	Arrow-leaved Aster
Common Milkweed	Large-leaved Aster	Prairie Cinquefoil	Prairie Spiderwort
Butterfly Weed	White Snakeroot	Prairie Rose	Hoary Vervain
Whorled Milkweed	False Boneset	Black-eyed Susan	Heart-leaved Alexander
Canada Milk Vetch	Bush Clover	Blue-eyed Grass	

Dry to Mesic Grass and Wildflower Mixes

Dry to Mesic Grass
Side Oats Grama
Blue Grama
Kalm's Brome
Plains Oval Sedge
Sprengel's Sedge
Poverty Oat Grass
Bottlebrush Grass
Silky Wild Rye
June Grass
Little Bluestem
Prairie Dropseed

Wildflower Mixes			
Yarrow	Canada Milk Vetch	Stiff Goldenrod	Drummond's Aster
Leadplant	Partridge Pea	Wild Bergamot	Calico Aster
Tall Thimbleweed	White Prairie Clover	Prairie Cinquefoil	Frost Aster
Columbine	Purple Prairie Clover	Prairie Rose	Arrow-leaved Aster
Prairie Sage	Large-leaved Aster	Black-eyed Susan	Prairie Spiderwort
Common Milkweed	White Snakeroot	Gray Goldenrod	Hoary Vervain
Butterfly Weed	False Boneset	Upland Goldenrod	Heart-leaved Alexander
Whorled Milkweed	Bush Clover		

Mesic to Wet Grass and Wildflower Mixes

Mesic to Wet Grass

Side Oats Grama	Fox Sedge
Small Yellow Fox Sedge	Poverty Oatgrass
Plains Oval Sedge	Bottlebrush Grass
Bottlebrush Sedge	Silky Wild Rye
Fringed Sedge	Rattlesnake Manna Grass
Bristly Cattail Sedge	Fowl Manna Grass
Porcupine Sedge	Dudley's Rush
Sprengel's Sedge	Soft Rush
Pointed Broom Sedge	Fox Sedge
Stalk-grain Sedge	

Wildflower Mixes

Yarrow	Wild Bergamot
Nodding Onion	Marsh Betony
Columbine	Mountain Mint
Canada Milk Vetch	Black-eyed Susan
Nodding Bur Marigold	Mad Dog Skull Cap
Purple Prairie Clover	Ohio Goldenrod
Large-leaved Aster	Stiff Goldenrod
Grass-leaved Goldenrod	Drummond's Aster
White Snakeroot	Calico Aster
Bush Clover	Frost Aster
Monkey Flower	

Benefits of using a diverse native pollinator seed mix

- Resiliency to variable climate
- Tolerant of changing sun exposure
- Increases storm water infiltration
- Insulation / reduce risk of frost heave
- Improves quality of storm water runoff
- Minimal maintenance
- Reduce use of pesticides
- Deters growth of non-native species
- Creation of pollinator habitat

PROPRIETARY

Rob Davis
Fresh Energy


A standard practice


x25 years

Solar Site Vegetation & Performance

- Performance profile for solar site vegetation:
  - Resilient to droughts
  - Resilient to intense downpours
  - Insulation / reduce risk of frost heave
  - Minimal maintenance
  - Low-growing
  - Full-sun & shade tolerant
  - Beneficial to the pollinators needed for agriculture

Benefits of Performance Vegetation on Solar Sites

- Mowing is nearly eliminated after the site's first four years
- Sites that benefit pollinators are particularly attractive to corporate sustainability executives (buyers)
- Stormwater performance of deep-rooted native plants
- Opportunity for significant increase in public support during siting phase and ongoing—beekeepers, fruit/vegetable farmers, and other conservationists
- Insulation / reduce risk of frost heave

Announcing New Steps to Promote Pollinator Health

MAY 19, 2015

Summary: Pollinators are critical to the Nation's economy, food security, and environmental health.

Poor Pollination

- 70% of crops
- 100’s of billions / year

Source: Gund Center for Ecological Economics

Pollinator Habitat Benefits Agriculture

- Nature Conservancy completed an economic analysis of wild pollinator contribution to 10 major crops.
- In nearly all cases and especially for tomatoes, blueberries, melons, cucumbers, squash, apples, peaches, and bell peppers, <u>gross revenues increase directly because of the installation of pollinator habitat</u>—and that's even after subtracting out implementation costs.

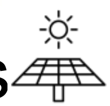
http://bit.ly/BeesCrops

Table shows the value of production attributable to wild pollinators in New Jersey (based on average prices and yields, 2007-2011).

Crop	% of yield from wild pollinators	Value of production ($) from wild pollinators	Value of production boost
Squash	81%	$9,640,000	$1,171,300
Tomatoes	18%	$5,530,000	$149,300
Blueberries	10%	$8,213,000	$123,200
Bell Peppers	10%	$3,301,000	$49,500
Watermelons	10%	$343,000	$5,100
Peaches	9%	$3,142,000	$42,400
Apples	9%	$2,008,000	$27,100
Cucumbers	9%	$1,281,000	$17,300
Cantaloupes	8%	$689,000	$800
Soybeans	5%	$1,583,000	$11,900

Economic analysis of wild pollinator contribution to 10 major crops, Nature Conservancy. http://bit.ly/BeesCrops

Pollinator-Friendly Solar Seeded in 2016

2,330 acres 

0.01 percent of farmland

equal to…

>1,400,000
6’x12’
pollinator
gardens

Ag Leaders Established a Vegetation Standard for Pollinator-friendly Solar

State Rep. Rod Hamilton (R)
Chair, Agriculture Finance Committee
Member, Agriculture Policy Committee

State Senator Dan Sparks (DFL)
Chair, Agriculture Policy Committee
Member, Commerce & Consumer Protection Policy and Finance Committee

Statute 216B.1642
Subd. 2. Recognition of beneficial habitat**.** An owner of a solar site implementing solar site management practices under this section may claim that the site provides benefits to gamebirds, songbirds, and pollinators only if the site adheres to guidance set forth by the pollinator plan…

https://www.revisor.mn.gov/statutes/?id=216B.1642


Dr. Karen Oberhauser
University of Minnesota
Dr. Marla Spivak
University of Minnesota

Solar Site Pollinator Habitat Assessment Form

For solar companies to claim pollinator/wildlife habitat benefits on solar sites

1. PERCENT OF SITE DOMINATED BY WILDFLOWERS

- ☐ 1-15 percent — 10 points
- ☐ 16-30 percent — 15 points
- ☐ 31-45 percent — 20 points
- ☐ 46-60 percent — 25 points
- ☐ 61+ percent — 30 points

Total points ☐

Note: Project may have "array" mixes and diverse border mixes; forb dominance should be averaged across the entire site. Forb dominance should exclude native ragweeds.

2. % OF SITE DOMINATED BY NATIVE SPECIES COVER

- ☐ 1-25% — 5 points
- ☐ 26-50% — 10 points
- ☐ 51-75%. — 15 points
- ☐ 76-100% — 20 points

Total points ☐

3. COVER DIVERSITY (# of plant species with >2% cover)

- ☐ 1-9 species — 5 points
- ☐ 10-19 species — 10 points
- ☐ 20-39 species — 15 points
- ☐ > 40 species — 20 points

Total points ☐

Exclude invasives from species totals.

4. SEASONS WITH AT LEAST 3 BLOOMING SPECIES PRESENT (check/add all that apply)

- ☐ Spring — 10 points
- ☐ Summer — 5 points
- ☐ Fall — 5 points

Total points ☐

See BWSR Pollinator Toolbox for Information about bloom season

5. AVAILABLE HABITAT COMPONENTS WITHIN .25 MILES (check/add all that apply)

- ☐ Native bunch grasses for nesting — 5 points
- ☐ Trees and shrubs for nesting — 5 points
- ☐ Clean, perennial water sources — 5 points

Total points ☐

6. AVAILABLE HABITAT COMPONENTS ON-SITE (check/add all that apply)

- ☐ At least 2% milkweed cover — 5 points
- ☐ At least 3% native shrub cover — 5 points
- ☐ Detailed mgmt. plan developed (see example plan) — 10 points
- ☐ 3 or more signs legible at twenty or more feet stating pollinator friendly habitat — 5 points

Total points ☐

7. INSECTICIDE RISK (% of project adjacent to insecticide use such as non-organic cropland, or on-site use)

- ☐ 1-25% — -10 points
- ☐ 26-50% — -15 points
- ☐ 51-75% — -20 points
- ☐ 76-100% — -25 points
- ☐ On-site use — -30 points

Total points ☐

This doesn't include herbicide being used for weed control

Grand Total ☐

Provides Exceptional Habitat	**85 TO 100**
Meets Pollinator Standards	**70-84**

Developer: ____________________

Project Location: ____________________

Project Size: ____________________

Target Seeding Date: ____________________

Send completed forms to: Dan.Shaw@state.mn.us

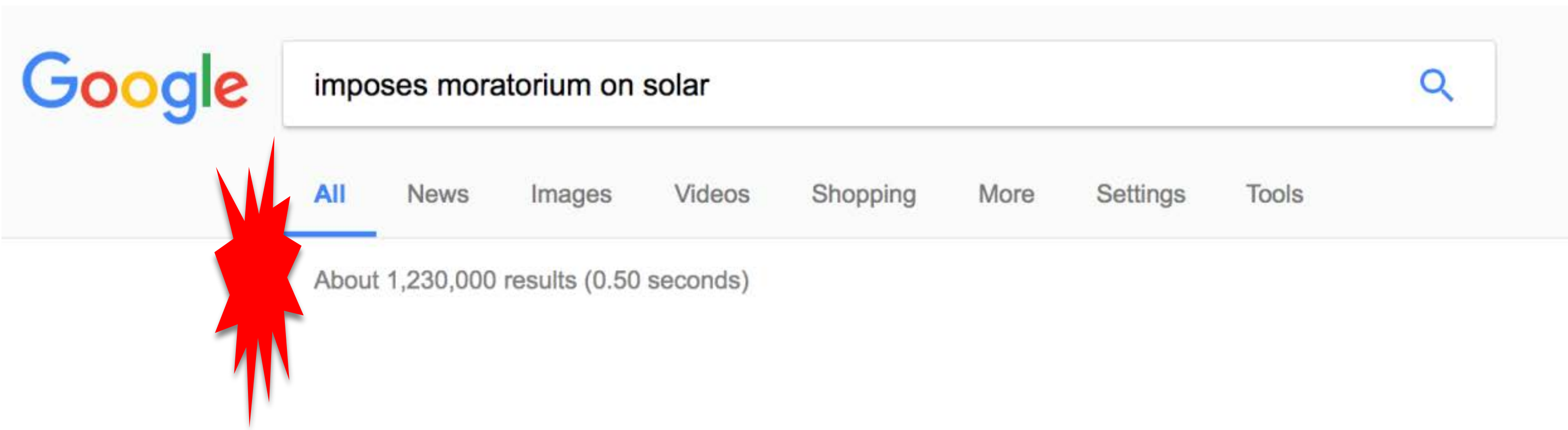
Note: Measurements of percent "cover" should be based on "absolute cover" defined as the percent of the ground surface that is covered by a vertical projection of foliage as viewed from above. To measure cover diversity it is recommended to use plots, and/or transects in addition to meander searches for accurate measurements. Wildflowers in

Fresh Energy

Audubon
MINNESOTA

MinnesotaCorn
GROWERS ASSOCIATION

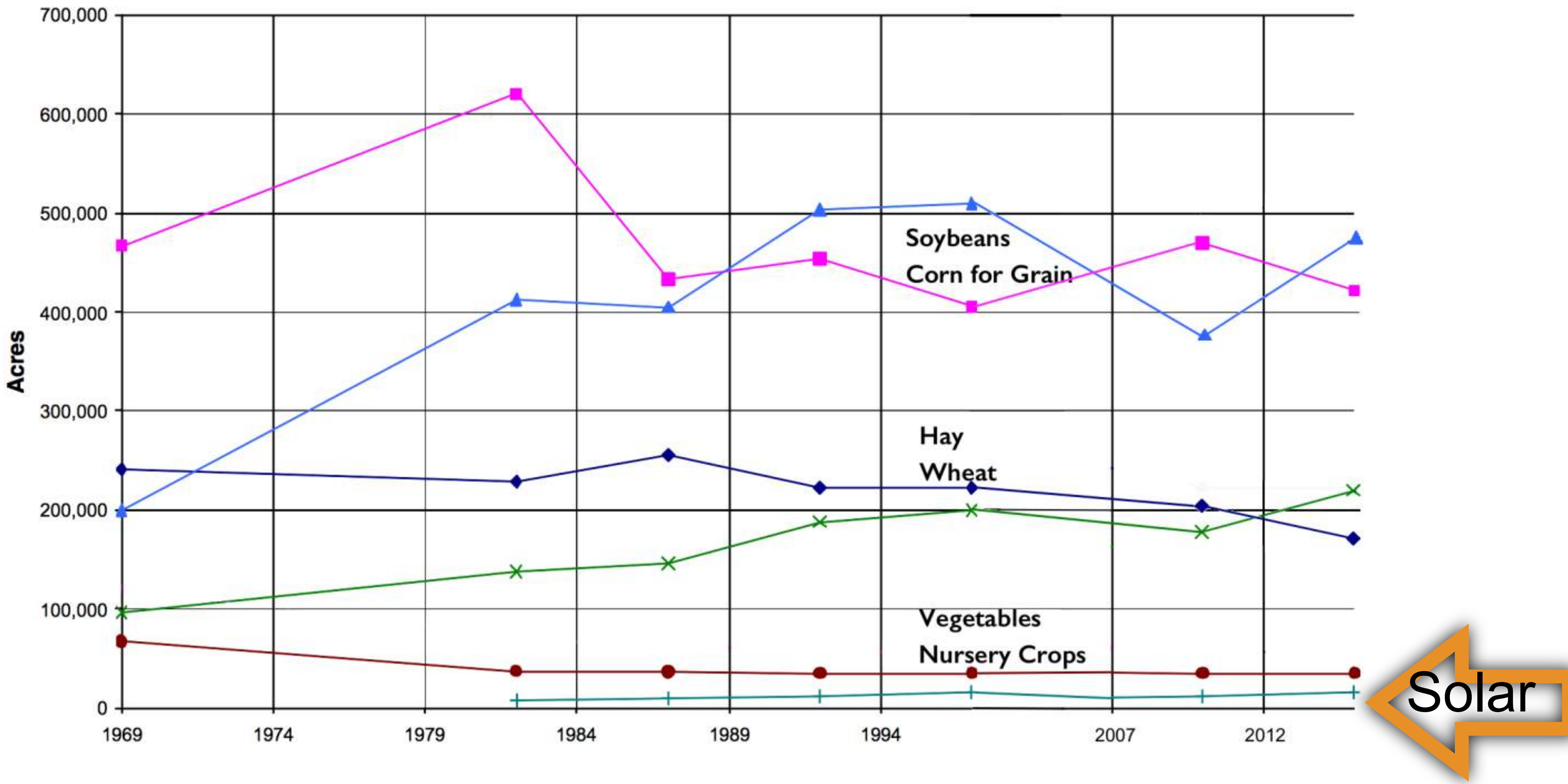
Minnesota
Farmers
Union


Google
imposes moratorium on solar
All
News
Images
Videos
Shopping
More
Settings
Tools
About 1,230,000 results (0.50 seconds)

Solar array, Ohio

Photo: Janelle Patterson, *Marietta Times*

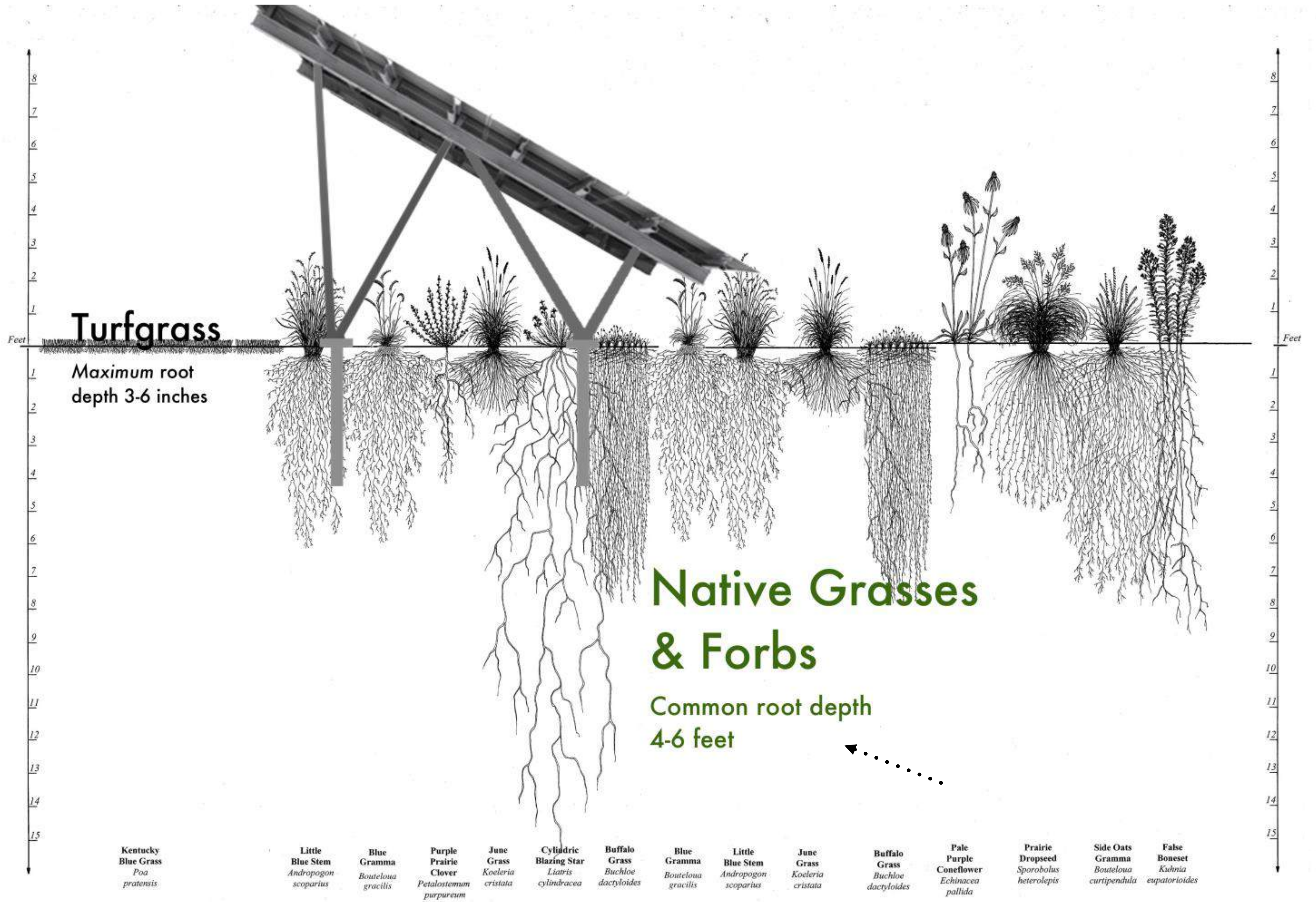
Farmland in Maryland



Jobs for the Rural Economy

Before

After



Turfgrass
Maximum root depth 3-6 inches
Native Grasses & Forbs
Common root depth 4-6 feet
Feet
Kentucky Blue Grass Poa pratensis
Little Blue Stem Andropogon scoparius
Blue Gramma Bouteloua gracilis
Purple Prairie Clover Petalostemum purpureum
June Grass Koeleria cristata
Cylindric Blazing Star Liatris cylindracea
Buffalo Grass Buchloe dactyloides
Blue Gramma Bouteloua gracilis
Little Blue Stem Andropogon scoparius
June Grass Koeleria cristata
Buffalo Grass Buchloe dactyloides
Pale Purple Coneflower Echinacea pallida
Prairie Dropseed Sporobolus heterolepis
Side Oats Gramma Bouteloua curtipendula
False Boneset Kuhnia eupatorioides

Project Highlights

Green Power

Aurora Solar
100 MW distributed solar array
16 sites
1,000 acres

Pollinator-friendly seed mix used on all sites

Sample General Composition of Seed Mix for use within Solar Panel Array

No Mow Turf with Forbs; Seeding Rate: 42 seeds per Sq. ft./ac	**Height**	**Bloom Time**	**oz./acre**	**Seeds/oz.**	**Seeds/sq. ft.**
Cover Crop					
Avena sativa (Oats)[1]	3'	NA	20lbs/ac	1,100	8.9
Grasses					
Bouteloua curtipendula (Side oats grama) PLS	1-2'	Jun-Nov	8.0	6000.00	1.10
Bouteloua gracilis (Blue grama) PLS	1'	Jul-Oct	4.0	40,000.00	3.67
Buchloe dactyloides (Buffalo grass--BOWIE cultivar) PLS	5"	Apr-Dec	128.0	3,600.00	10.58
Carex bicknelli (Copper shouldered oval sedge) PLS	1-3'	Mar-May	2.0	17000.00	0.78
Koeleria macrantha (Junegrass) PLS	10-20"	Apr-Jun	4.0	200,000.00	18.37
Sporobolus heterolepis (Prairie Dropseed) PLS	2-3'	Jun-Aug	4.0	16,000	1.47
Forbs					
Allium canadense (Wild garlic)	1-2'	May-Jul	8.0	560.00	0.10
Allium stellatum (Prairie onion)	8-18"	Jul-Aug	1.00	11,000.00	0.25
Anemone canadensis (Canada Anemone)	1-2'	May-Jun	1.00	8,000.00	0.18
Anemone patens (Pasqueflower)	3-18"	Apr-May	1.00	18,000.00	0.41
Asclepias tuberosa (Butterfly-weed)	1-2'	Jun-Aug	2.00	4,300.00	0.20
Echinacaea angustifolia (Narow leaved Purple Coneflower)	1-2'	Jun-Jul	2.00	7000	0.32
Sisyrinchium campestre (Prairie blue-eyed grass)	4-16"	May-Jun	1.00	45,000.00	1.03
Solidago nemoralis (Gray goldenrod)	1-2'	Aug-Oct	0.50	300,000.00	3.44

COMMUNITY ENERGY SOLAR

North Star Solar
100 MW solar array
1,000 acres
Largest single-site array in the Midwest

Pollinator-friendly seed mix from Minnesota Native Landscapes used throughout

	Scientific Name	Common Name	% of Mix	PLS lbs/ac	Total PLS lbs	Seeds/ Sq Ft
Grasses:	Bouteloua curtipendula	Side-Oats Grama	35.00	2.80	2.80	10.23
	Bouteloua gracilis	Blue Grama	12.00	0.96	0.96	14.10
	Carex bicknellii	Bicknell's Sedge	1.50	0.12	0.12	0.75
	Carex radiata	Eastern Star Sedge	1.50	0.12	0.12	1.81
	Carex vulpinoidea	Fox Sedge	1.25	0.10	0.10	2.98
	Koeleria macrantha	Junegrass	1.25	0.10	0.10	7.35
	Schizachyrium scoparium	Little Bluestem	14.50	1.16	1.16	6.39
	Sporobolus cryptandrus	Sand Dropseed	4.00	0.32	0.32	23.51
	Sporobolus heterolepis	Prairie Dropseed	5.00	0.40	0.40	2.35
Forbs:	Achillea millefolium	Yarrow	0.40	0.03	0.03	2.06
	Agastache foeniculum	Fragrant Giant Hyssop	0.25	0.02	0.02	0.66
	Allium stellatum	Prairie Onion	0.50	0.04	0.04	0.16
	Anemone canadensis	Canada Anemone	0.25	0.02	0.02	0.06
	Aquilegia canadensis	Columbine	0.25	0.02	0.02	0.28
	Asclepias syriaca	Common Milkweed	0.75	0.06	0.06	0.09
	Asclepias tuberosa	Butterfly Milkweed	0.75	0.06	0.06	0.09
	Asclepias verticillata	Whorled Milkweed	0.25	0.02	0.02	0.08
	Aster oolentangiensis	Sky-Blue Aster	1.25	0.10	0.10	2.94
	Aster laevis	Smooth Blue Aster	0.75	0.06	0.06	1.21
	Aster lateriflorus	Calico Aster	0.80	0.06	0.06	5.88
	Astragalus canadensis	Canada Milk Vetch	0.75	0.06	0.06	0.37
	Coreopsis palmata	Prairie Coreopsis	0.50	0.04	0.04	0.15
	Dalea candida	White Prairie Clover	3.00	0.24	0.24	1.67
	Dalea purpureum	Purple Prairie Clover	3.00	0.24	0.24	1.32
	Desmodium canadense	Canada Tick Trefoil	1.00	0.08	0.08	0.16
	Helianthus pauciflorus	Stiff Sunflower	0.40	0.03	0.03	0.05
	Monarda fistulosa	Wild Bergamot	0.75	0.06	0.06	1.54
	Liatris aspera	Rough Blazing Star	0.75	0.06	0.06	0.35
	Lupinus perennis	Wild Lupine	0.25	0.02	0.02	0.01
	Penstemon gracilis	Slender Beardtongue	0.40	0.03	0.03	7.05
	Potentilla arguta	Prairie Cinquefoil	0.25	0.02	0.02	1.69
	Pycnanthemum virginianum	Mountain Mint	0.50	0.04	0.04	3.23
	Ratibida columnifera	Long-Headed Coneflower	1.00	0.08	0.08	1.23
	Rudbeckia hirta	Black Eyed Susan	1.25	0.10	0.10	3.38
	Solidago nemoralis	Old Field Goldenrod	0.50	0.04	0.04	4.41
	Solidago rigida	Stiff Goldenrod	1.50	0.12	0.12	1.81
	Verbena stricta	Hoary Vervain	1.25	0.10	0.10	1.03
	Zizia aurea	Golden Alexanders	0.75	0.06	0.06	0.24
Cover Crop:	Triticum aestivum	Winter Wheat		10.00	10.00	

Species subject to change based on price and availability at the time of planting

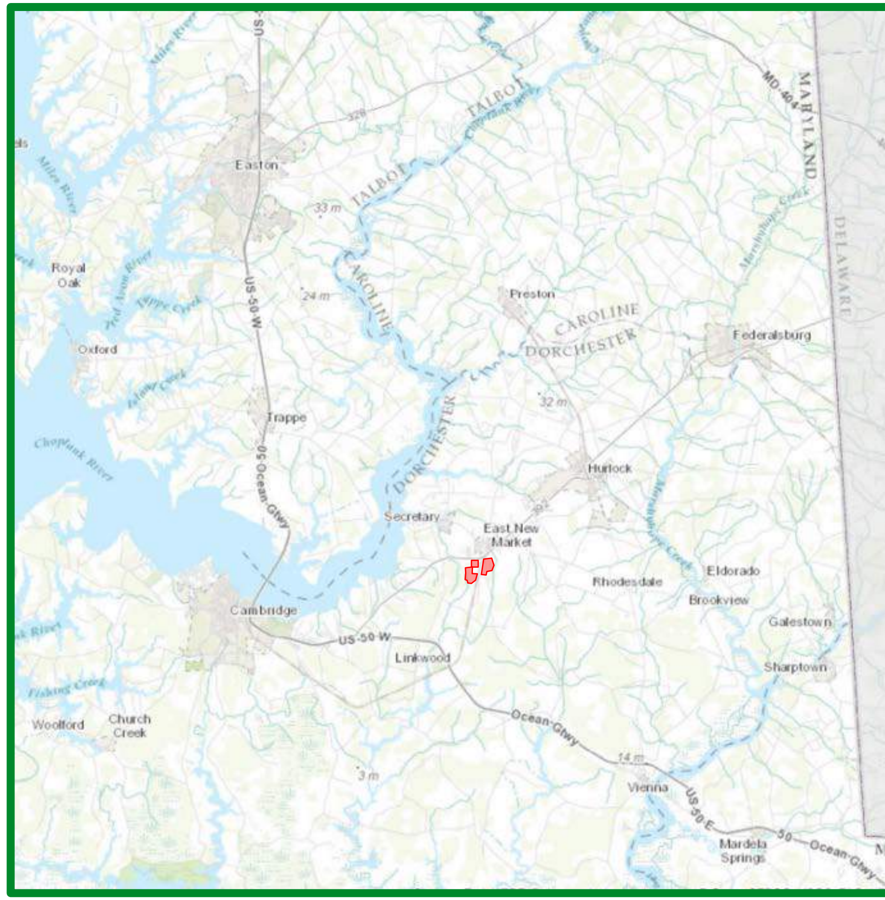
OneEnergy
RENEWABLES

In development planning:
Sunnee Bee Solar
20 MW solar array
167 acres

Pollinator-friendly seed mix from Ernst Conservation Seeds

B-Corporation

BEST for THE WORLD 2016



Eastern Shore, Maryland

Minnesota Power & Camp Ripley

Solar Farm Short Native Mix	Species	PLS/acre	Height(in)
Short height general dry prairie native mix.	Sideoats Grama	3.00	18-30
	Little Bluestem	3.00	18-30
	Buffalograss	3.00	18-30
	Kalm's Brome	0.50	24-36
	Blue Grama	1.00	12-15
	Junegrass	0.25	6-12
	Prairie Dropseed	0.25	18-30
	Grass Total	**11.00**	
	Black Eyed Susan	0.20	18-24
	Purple Prairie Clover	0.20	18-24
	Partridge Pea	0.20	18-24
	Purple Coneflower	0.20	18-24
	Yarrow	0.01	12-18
	White Prairie Clover	0.10	18-24
	Large Flowered Beard Tongue	0.04	12-24
	Butterfly Milkweed	0.05	18-24
	Total PLS/Acre	**1.00**	
	Oats	25.00	
	Total PLS/Acre	**37.00**	

Connexus Energy
Performance Characteristics:
1. Visual appeal
2. Maintenance free for existing grounds crew
3. No loss of solar performance
4. Ecological services highlighted in company marketing materials

Vegetation seeded and maintained by Prairie Restorations, Inc
Seeded in Oct. 2014. Pictured in July, 2016.

Newsletter

Connexions

A member update.

CONNEXUS® ENERGY

September 2016

Pollinator haven at Connexus solar garden

For honey bees and butterflies, it doesn't get much better than the pollinator-friendly habitat found in Connexus Energy's community solar garden. Recently, Fresh Energy, with the help of Prairie Restoration, assessed our site, and we received a perfect 100 score on the Solar Site Pollinator Habitat Assessment. That means our solar garden not only provides solar energy for our members, but it also provides exceptional habitat to help struggling pollinators.

What is pollinator-friendly habitat?

Pollinators, such as honey bees, butterflies, hummingbirds, and bats, assist plants in reproduction by transferring pollen. This allows the plant to produce berries, nuts, and other foods important to the survival of many species of wildlife and the world's food supply. Recently, there have been many reports of a steady decline in the population of pollinators, due in large part to the loss of habitat they need to survive.

Thank you

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