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Office of the Assistant Secretary for Civil Rights
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Dual Use Practices for Solar Energy Systems



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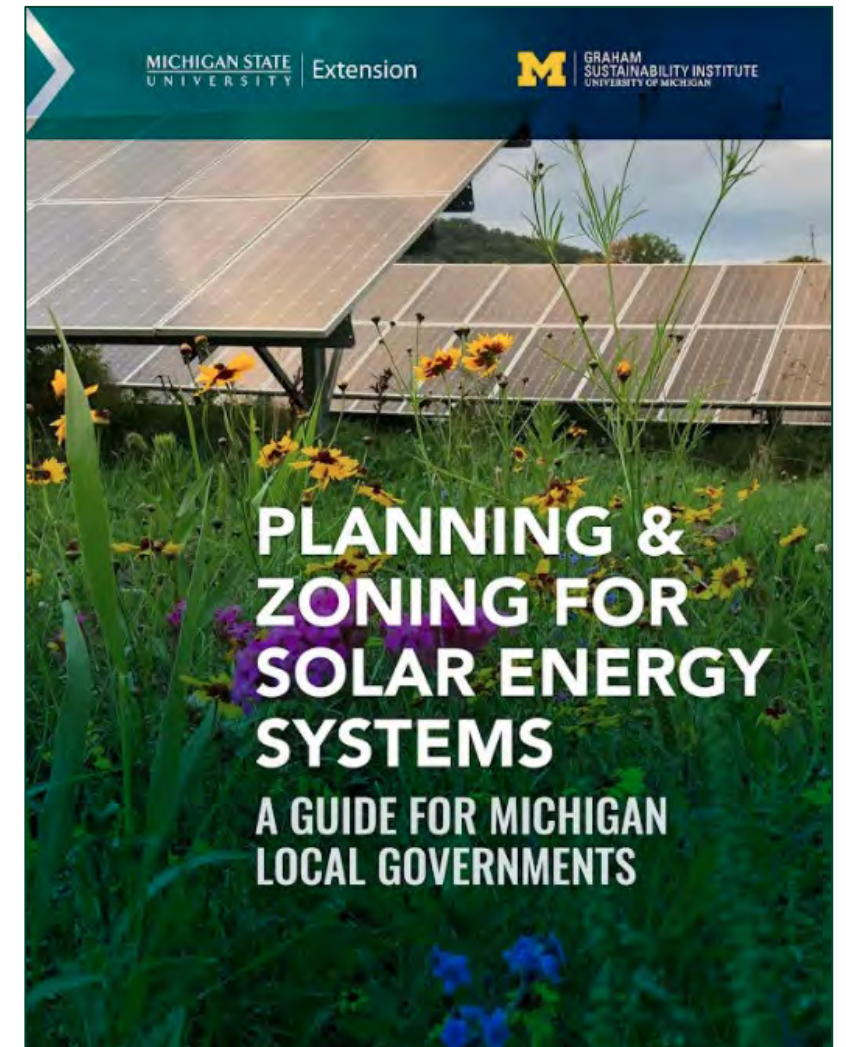
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extension.msu.edu/solarzoning





Dual Use

Land should never be used exclusively for solar power production.



Photo credit: Charles Gould



Photo credit: Charles Gould



Photo credit: Rob Davis



Photo credit: Charles Gould



Grazing and Forage Production

- Solar sites that incorporate rotational livestock grazing and forage production as part of an overall vegetative maintenance plan.



Photo credit: Charles Gould



Photo credit: Charles Gould



Operation and Maintenance Cost Differences by Management Practice

- Authors cite Enbar et al. (2016) that the budget range for vegetation management is \$0.50 to \$1.80/kWdc/yr, depending on site characteristics and size (in acres).
- Mean values per unit of PV capacity
 - Turfgrass (9) - \$1.51/kWdc/yr
 - Sheep grazing (15) - \$1.55/kWdc/yr
 - Gravel (2) - \$1.75/kWdc/yr
 - Native vegetation (28) - \$2.23/kWdc/yr

Source: McCall J, Macdonald J, Burton R, Macknick J. Vegetation Management Cost and Maintenance Implications of Different Ground Covers at Utility-Scale Solar Sites. *Sustainability*. 2023; 15(7):5895.

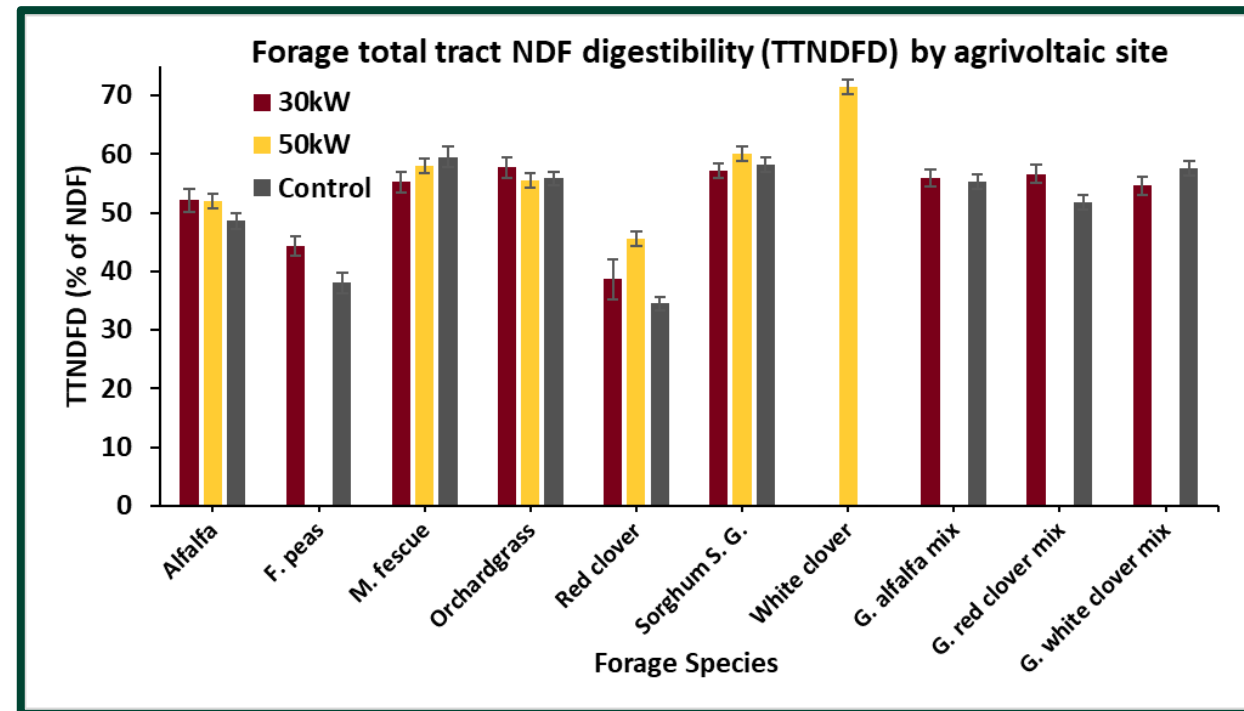
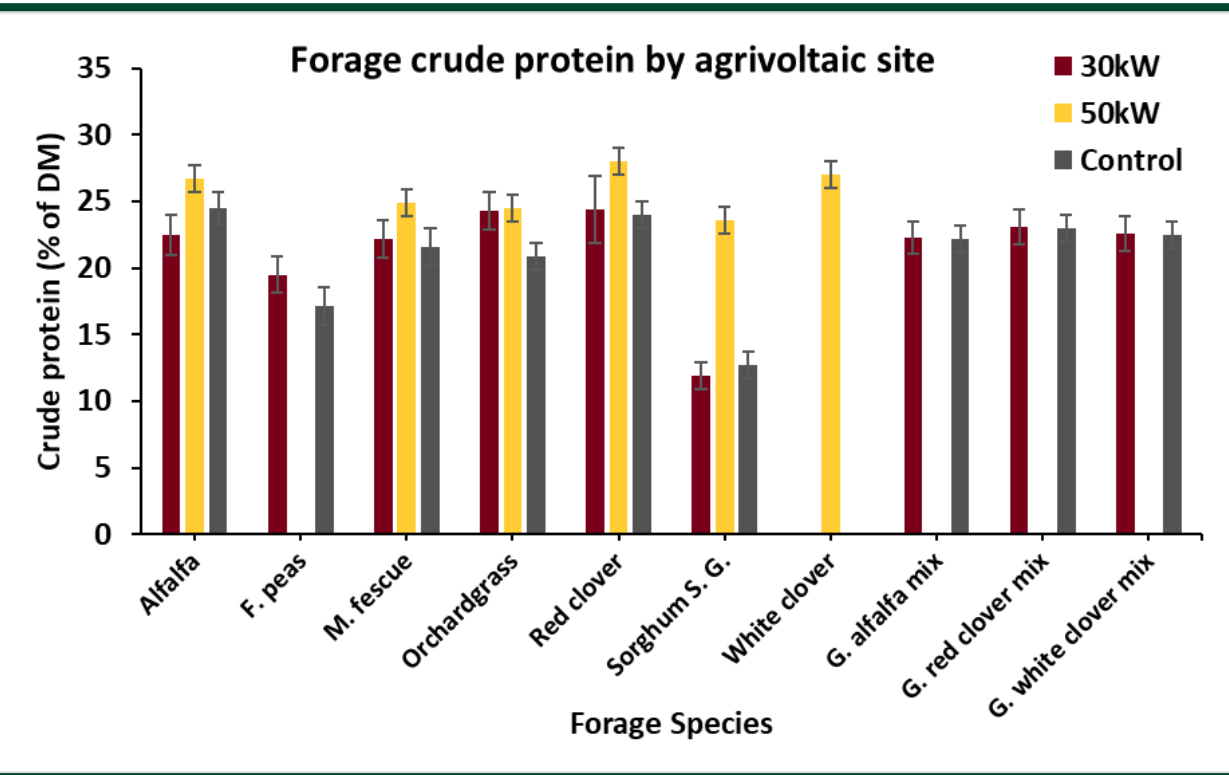
<https://doi.org/10.3390/su15075895>



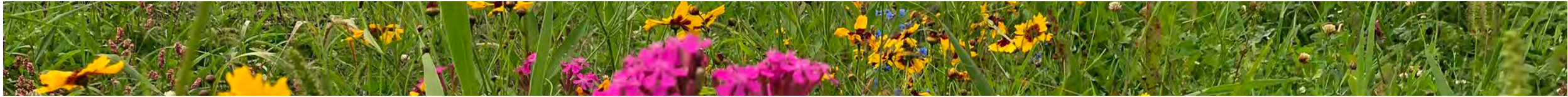
Photo credit: Fresh Energy



Forage Crude Protein and Digestibility Comparison



Source: S.L. Portner, B.J. Heins, E.S. Buchanan, M.H. Reese. 2022. Agrivoltaics site effects on forage biomass and nutritive value, University of Minnesota.



Pollinator Habitat



The site should be designed and planted to achieve a score of at least 76 on the [Michigan Pollinator Habitat Planning Scorecard for Solar Sites](#).



Developed by the MSU Department of Entomology to guide vegetation management decisions at solar installations to be more supportive of native pollinators.



Check the boxes and add up the points to determine if the plan meets or exceeds pollinator habitat establishment standards.



Use during initial planning stages to ensure the desired outcome is achieved.



For more local information on pollinators and habitat visit www.pollinators.msu.edu.

Michigan Pollinator Habitat Planning Scorecard for Solar Sites

This form was developed by the MSU Department of Entomology to guide vegetation management at solar installations to make them more supportive for native pollinators. Check the boxes and add up the points to determine whether the plans meet or exceed the minimum requirements. For more local information on pollinators and habitat: www.pollinators.msu.edu

PROJECT DETAILS
 Solar developer: _____
 Vegetation consultant: _____
 Project location: _____
 Project size (acres): _____

FLORING PLANT SCORES

5. FLOWERING PLANT SPECIES SEEDING IN PERIMETER AREA (species with more than 1% cover)

<input type="checkbox"/> 5-10 species	+1 pts
<input type="checkbox"/> 10-15 species	+3 pts
<input type="checkbox"/> 16-20 species	+8 pts
<input type="checkbox"/> >20 species	+10 pts

Exclude invasive plant species from total

6. PLANT DIVERSITY UNDER SOLAR ARRAY*

<input type="checkbox"/> Grass only	+2 pts
<input type="checkbox"/> Clover/grass mix	+8 pts
<input type="checkbox"/> Low-growing wildflower mix	+10 pts

7. PERCENT OF SITE PLANNED TO BE DOMINATED BY WILDFLOWERS**

<input type="checkbox"/> 0 - 25%	0 pts
<input type="checkbox"/> 26 - 50 %	+3 pts
<input type="checkbox"/> 51-75 %	+8 pts
<input type="checkbox"/> More than 75%	+15 pts

Projects may have different species mixes under the solar array panels and in the perimeter. Flower cover should be averaged across the entire site.

8. SEEDS USED FOR WILDFLOWER AREAS

<input type="checkbox"/> Mixes are seeded using at least 40 seeds/square foot	+5 pts
<input type="checkbox"/> All wildflower seeds are from a source within 150 miles of the site	+5 pts

9. SEASONS WITH AT LEAST THREE BLOOMING FORB SPECIES PRESENT (check all that apply)

<input type="checkbox"/> Spring (April-May)	+5 pts
<input type="checkbox"/> Summer (June-August)	+5 pts
<input type="checkbox"/> Fall (September-October)	+5 pts

SITE SCORES

1. SITE PLANNING AND MANAGEMENT

<input type="checkbox"/> Detailed plant establishment and vegetation management plan developed	+10 pts
<input type="checkbox"/> Site plan developed with a vegetation management company	+5 pts
<input type="checkbox"/> Signage legible at forty or more feet stating pollinator friendly solar habitat	+3 pts

2. HABITAT SITE PREPARATION PRIOR TO IMPLEMENTATION

<input type="checkbox"/> Measures taken to control weeds during season prior to seeding	+10 pts
<input type="checkbox"/> No weed control	-20 pts

3. INSECTICIDE RISK

<input type="checkbox"/> Planned on-site use of insecticide or pre-planting seed/plant treatment (excluding buildings/electrical boxes, etc)	-40 pts
<input type="checkbox"/> Communication with local chemical applicators and site registered on https://msu.driftnet.org/imag	+20 pts

4. AVAILABLE HABITAT COMPONENTS WITHIN 0.25 MILES (check/add all that apply)

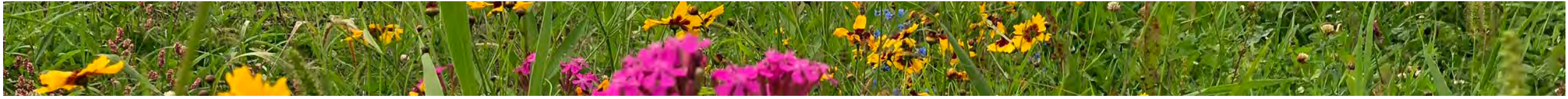
<input type="checkbox"/> Native bunch grass for bee nesting	+1 pt
<input type="checkbox"/> Open sandy soil areas for bee nesting	+1 pt
<input type="checkbox"/> Trees/shrubs for bee nesting	+1 pt
<input type="checkbox"/> Clean, perennial water sources	+1 pt

Total points:

Provides exceptional habitat 90+ points
Meets pollinator standards 76 – 89 points
Does not meet standards below 75 points

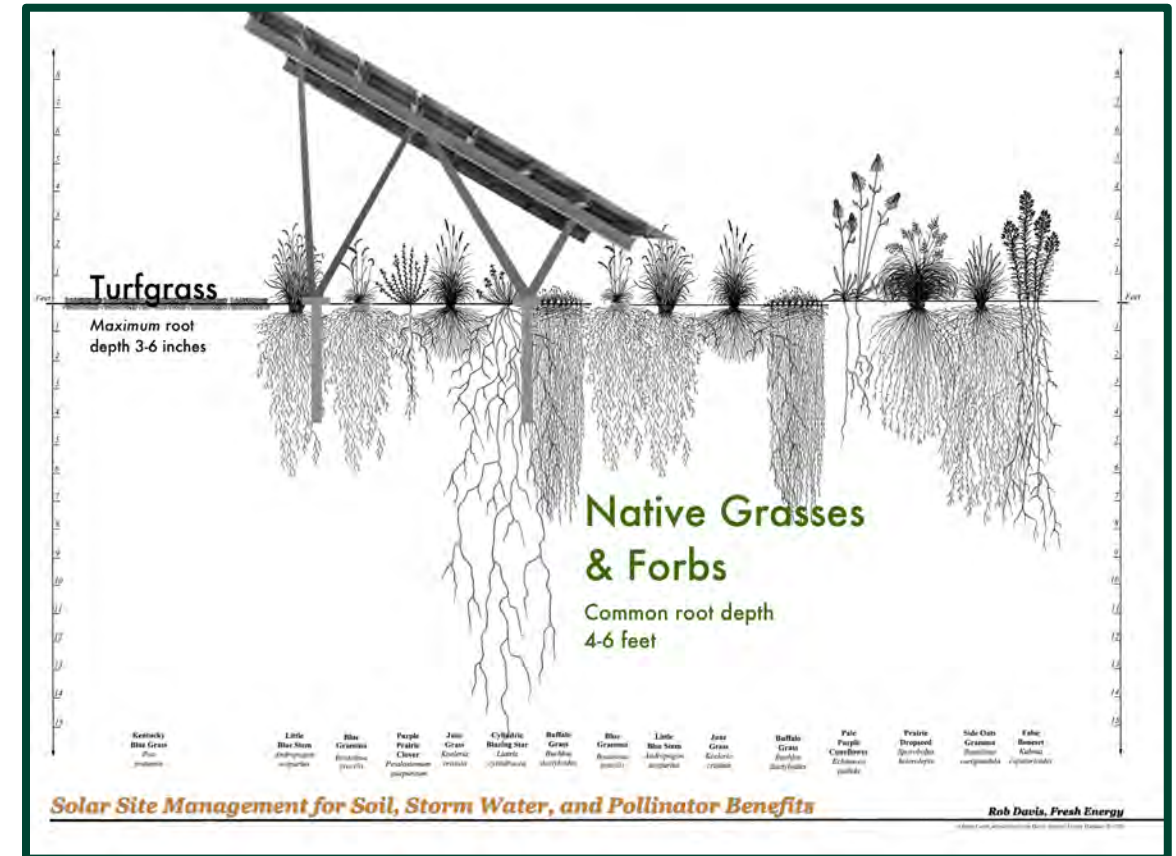
* For seeding in the panel array, these can be a short-stature wildflower mix or clovers and other non-native species beneficial to pollinators. If clovers are used, these should be seeded in locations separate from the native wildflowers in the perimeter locations.
 ** Wildflowers in Question 7 refer to forbs which are flowering plants that are not woody, and are not grasses, sedges, etc. Measurements of percent cover should be based on the percent of the ground surface covered by foliage as viewed from above.
 Refer to www.nativeplants.msu.edu or a local native wildflower supplier for advice on plants that are attractive to pollinators and will work in various Michigan settings.
 For more on pollinator habitat: www.pollinators.msu.edu

MICHIGAN STATE UNIVERSITY Extension



Reasons for Establishing Pollinator Habitat

- Deep roots improve water infiltration, recharge groundwater, sequester carbon, and reduce soil compaction.
- Contributes to local biodiversity and other ecological benefits like soil health.
- Stem the decline of pollinators.
- Provides nesting and feeding habitat, which supports healthy populations of native pollinators.
- Enhancing crop pollination leads to improved crop yield.



Source: Rob Davis, Center for Pollinators in Energy, Fresh Energy



Evaluating the impact of increased pollinator habitat on bee visitation and yield metrics in soybean crops

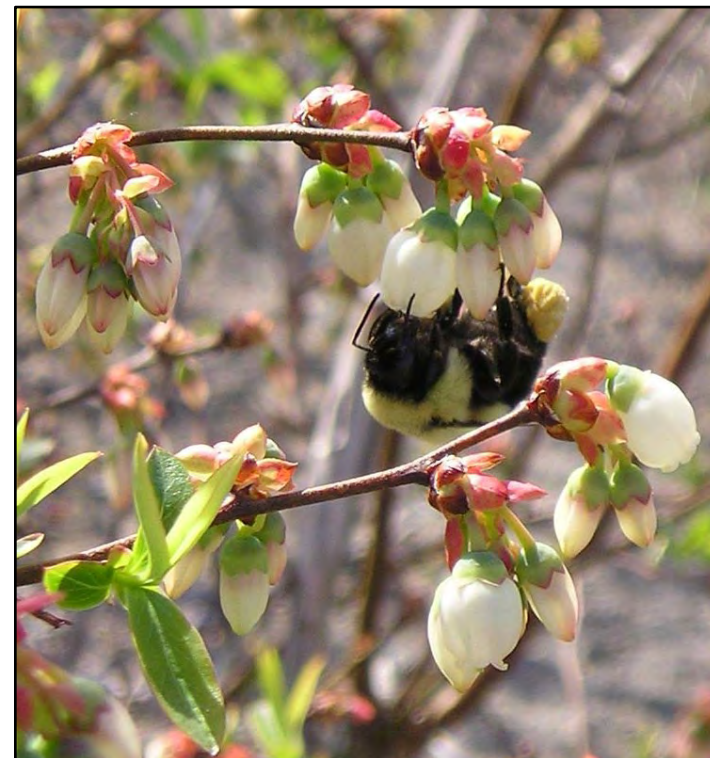
- How does the presence of the habitat, and resulting pollinator community, impact soybean yield?
 - Heavier seeds and more seed per plant.



Source: Hannah K. Levenson, April E. Sharp, David R. Tarpy, Evaluating the impact of increased pollinator habitat on bee visitation and yield metrics in soybean crops, *Agriculture, Ecosystems & Environment*, Volume 331, 2022, 107901, ISSN 0167-8809,

Impact of flower plantings on pollination-dependent crops

- Fifteen perennial wildflower species were established adjacent to highbush blueberry fields to determine if they would increase the abundance of wild pollinators during crop bloom and enhance pollination and yield.
 - Honeybees visiting blueberry flowers had similar abundance in enhanced and control fields in all 4 years of this study.
 - Wild bee and syrphid abundance increased annually in the fields adjacent to wildflower plantings.
 - Higher crop yields and the associated revenue exceeding the cost of wildflower establishment and maintenance.



Source: Blaauw, Brent R. and Rufus Isaacs. 2014. Flower plantings increase wild bee abundance and the pollination services provided to a pollination-dependent crop. *Journal of Applied Ecology* 2014, 51, 890-898.



Conservation Cover

- Solar sites designed in consultation with conservation organizations that focus on restoring native plants, grasses, and prairie with the aim of protecting specific species (e.g., bird habitat) or providing specific ecosystem services (e.g., carbon sequestration, soil health).

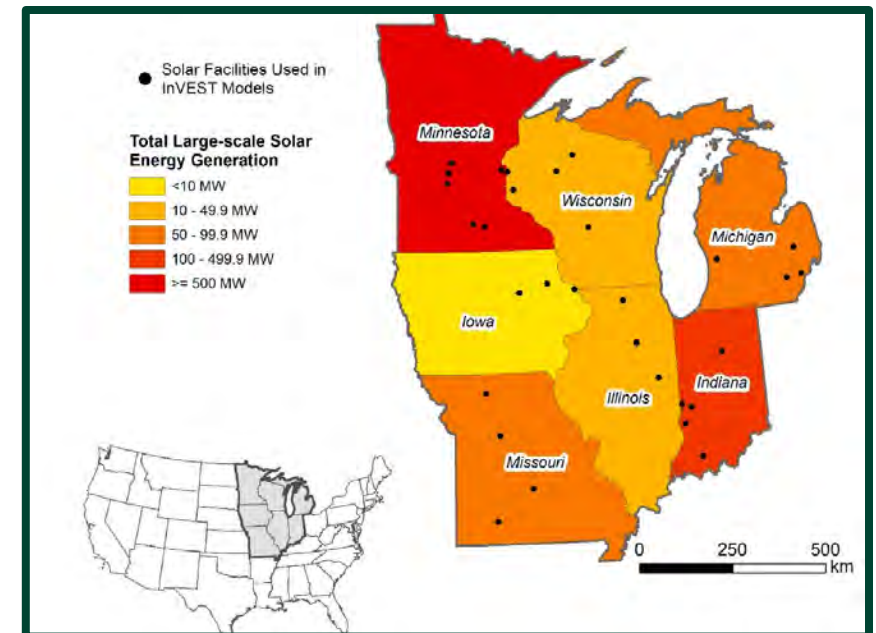


Photo courtesy of Charles Gould



Conservation Cover: Ecosystem services

- Walston et al. examined the potential response of four ecosystem services (carbon storage, pollinator supply, sediment retention, and water retention) to native grassland habitat restoration at 30 solar facilities across the Midwest United States.
- Results
 - Compared to presolar agricultural land uses, solar-native grassland habitat produced:
 - A 3-fold increase in pollinator supply.
 - A 65% increase in carbon storage potential.
 - Increases in sediment and water retention of over 95% and 19%, respectively.

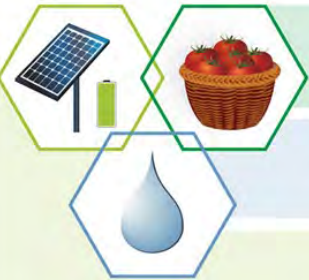


Source: Walston, L.J. et al. (2021). Modeling the ecosystem services of native vegetation management practices at solar energy facilities in the Midwestern United States, *Ecosystem Services*, Volume 47, February 2021.



Agrivoltaics

Agrivoltaics



- Vegetable crops share the land with solar panels.
- Shaded plants need less water and cool the back of the solar panels.
- Cooler solar panels capture more energy from the sun.

#FEWNexus



Photo credit: Charles Gould



Agrivoltaics



Photo credit: Charles Gould

Crops that can be grown under solar arrays

- Greens (lettuce, spinach, kale, Swiss chard, mustard)
- Brassicas (broccoli, cauliflower, cabbage, Brussel sprouts)
- Root crops (carrots, rutabaga, beets, radishes, potatoes, garlic)
- Herbs (parsley, mint, coriander, basil, cilantro)
- Berries (strawberries, blueberries, gooseberries)
- Peas, bush beans, peppers, tomatoes, leeks, onions



Agrivoltaic influence on soil moisture, micrometeorology and water-use efficiency

- The goal of this study was to show that the impacts of microclimatology, soil moisture, water usage, and biomass productivity should be considered in designing solar energy systems to take advantage of potential net gains in agricultural and power production.
- Significant differences in mean air temperature, relative humidity, wind speed, wind direction, and soil moisture were observed.
- A significant increase in late season biomass was observed for areas under the PV panels (90% more biomass).
- Areas under PV panels were significantly more water efficient (328% more efficient).



Source: Hassanpour Adeb E, Selker JS, Higgins CW (2018) Remarkable agrivoltaic influence on soil moisture, micrometeorology and water-use efficiency. PLoS ONE 13(11): e0203256.
<https://doi.org/10.1371/journal.pone.0203256>



Reducing Frost Damage in Nectarines and Apples



Treatment	% flowers no damage	% flowers minor damage	% flowers mortal damage
AV	19%	81%	0
Control	4%	64%	32%

- If the number of flowers after the frost event is higher than the thinning requirements, no consequences in yield due to frost could be observed.
- However, when the number of flowers are below the thinning requirements, the AV system can preserve yield.

Source: Protecting Flowers of Fruit Trees from Frost with Dynamic Agrivoltaic Systems, 2023, Gerardo Lopez P. Juillion , V. Hitte , Y. Elamri , V. Liesnak , Y. Montrognon , L. Denoyel, J. Chopard, S. Persello and D. Fumey



Vertical Bifacial Solar Arrays

Vertical bifacial panel reduces snow and dust accumulation.

Provides two output peaks during the day, with the second peak aligned to peak electricity demand.

Khan, M., Hanna, A., Sun, X., and Alam, M. (2017). Vertical Bifacial Solar Farms: Physics, Design, and Global Optimization. *Applied Energy*. 206. 10.1016/j.apenergy.2017.08.042.



Photo credit: Jean-Philippe Delacre

Some things to consider

- Agriculture has evolved over time.
- Land use resources comparison
 - 2022 Ford F-150 V8 4WD using E85 at 13 mpg => 200 bu corn per acre => 7,280 miles per year
 - 2023 Ford Lightning takes 49 kWh per 100 miles => 553,000 miles per year
- Climate change.





Keys to implementing dual use practices

- To implement dual use practices successfully, rigorous planning with all the parties is needed.
- Conversation and clear communication of expectations and outcomes before construction or engaging in a partnership ensures a greater chance of long-term productive partnerships.



Photo credit: Harvest Solar



Considerations when developing policy that supports dual use practices

- Prioritize solar development on buildings and land not suited for agriculture.
- Farmers are interested in solar projects that enhance farm viability.
- Craft policy that create opportunities for farming.
- Invest in and support 1862, 1890, and 1994 land-grant institutions.



Photo credit: Ben Darling, MSU



Considerations when developing policy that supports dual use practices

- Develop incentives that promote dual use.
- Allowances for changes in technology and flexibility in system design.
- Solar developers want to know what the “rules of engagement” are.
- Ensure underserved communities are fully represented in decision making process and receive associated benefits.



Photo credit: MSU



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