# Fact Sheet:
# The Science of Solar-Pollinator Habitat: How Current and Future Research Can Help Us Understand the Role of Pollinator-Friendly Solar in Biodiversity Conservation

*By Leroy J. Walston, Heidi Hartmann, and Laura Fox, Argonne National Laboratory*

*Example image of solar-pollinator habitat at a solar site in Minnesota.*
**Photo: Argonne National Laboratory**

Many climate scientists, energy planners, and governments agree that continued deployment of solar energy is needed to achieve our country's [grid decarbonization] and [net zero] goals. With these goals in sight, and the decreasing costs of solar energy technologies, it may come as no surprise that solar has recently emerged as the nation's fastest growing source of electricity.[1] And this rapid rate of solar development is expected to continue. For example, approximately 1,000 gigawatts of solar energy – most of which is generated by ground-based photovoltaic (PV) solar plants – would be required by 2035 in order to put the United States on track for net zero $CO2$ emissions targets by mid-century.[2] That is more than 10 times our nation's current rate of solar development.[3]

Without a doubt, considerable amounts of land will be needed to meet future solar energy projections. The current rate of solar energy development has already increased the pressure on land resources for energy generation and other land uses (e.g., agriculture, habitat for biodiversity, etc.). Therefore, sustained development of solar energy will depend on proper siting to avoid ecological conflicts and land-sharing solutions that synergize this form of renewable energy development with other land uses.

The co-location of solar energy and native habitat restoration (i.e., "solar-pollinator habitat") has quickly gained attention as one dual-use method to safeguard biodiversity and increase the site's ecosystem service potential. Solar-pollinator habitat typically focuses on the planting and establishment of early successional native grasses and forbs among the PV panels and other portions of the solar facility. When effectively established, solar-pollinator habitat can function as a site of native habitat restoration, which could support insect pollinators and other wildlife and

1 Energy Information Administration, https://www.eia.gov/electricity/monthly/.
2 DOE Solar Futures Study, https://www.energy.gov/eere/solar/solar-futures-study.
3 Solar Energy Industries Association, https://www.seia.org/research-resources/major-solar-projects-list.

improve other ecosystem services of the site (e.g., carbon sequestration, soil quality, and water conservation). See **Figure 1**.[4]

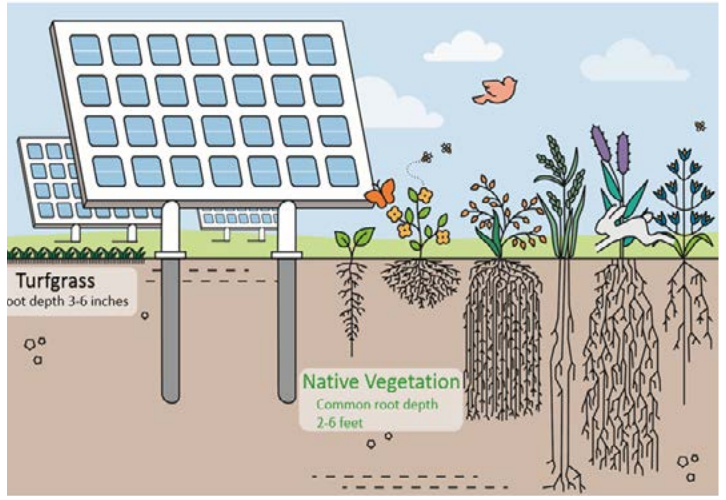


**Figure 1.** Illustration of the theoretical ecosystem services of solar-pollinator habitat. Compared to conventional groundcover such as turfgrass, solar-pollinator habitat can provide higher-quality habitat for biodiversity. In addition, the greater above- and below-ground biomass of solar-pollinator habitat can improve other ecosystem services, such as water and soil conservation and carbon sequestration.

The idea of solar-pollinator habitat sounds like a logical win-win for solar energy and biodiversity. However, there is little empirical evidence on the effectiveness of this strategy. Several factors can influence the feasibility and ecological effectiveness of solar-pollinator habitat, such as geography, seed availability and cost, previous land use, soil type, and solar size and design (e.g., PV panel height and spacing). With the current pace of solar energy development, research to understand the role of these factors on the ecological performance of solar-pollinator habitat needs to be conducted quickly, across different sizes and configurations of solar deployment, and across different geographic regions to connect these factors with ecological outcomes that will inform the development of the science-based solar-pollinator management practices.

## What does the current research tell us about the effectiveness of solar-pollinator habitat?

There is a small but growing body of peer-reviewed literature on the potential ecological benefits of solar-pollinator habitat. Most of this research focuses on two main aspects: 1) vegetation establishment and management; and 2) biodiversity responses (**Figure 2**). From the limited amount of published work, we understand that at least in some situations solar PV panels can support native vegetation growth that can provide habitat for insect pollinators.[5] And there are many more unpublished case studies and current research projects that will further help answer questions about solar-pollinator habitat.

**Vegetation Establishment & Management**

- What seed mixes (or plant species) are recommended based on geography, soil type, and solar design (e.g., panel height)?
- What vegetation management (e.g., moving regimines) are recommended to optimize vegetation establishment?

**Biodiversity / Wildlife Responses**

- Does biodiversity increase over time with establishment of solar-pollinator habitat?
- How do post-construction measures of biodiversity compare to pre-construction measures?
- What ecosystem services are provided by biodiversity supported by solar-polllinator habitat (e.g., pollination services)

**Figure 2**. Types of questions driving current ecological research on solar-pollinator habitat.

One of the longest-running and widely known projects focused on evaluating the opportunities and best practices for solar-pollinator habitat is the Innovative Solar Practices Integrated with Rural Economies and Ecosystems (InSPIRE) project. Initiated in 2016 with funding from the U.S. Department of Energy's Solar Energy Technologies Office, the InSPIRE project seeks to improve the environmental compatibility and mutual benefits of solar development with agriculture and native landscapes. A major part of this project is conducting innovative field-based research on solar-pollinator habitat to inform best practices and help understand how this practice could benefit surrounding agricultural communities. The InSPIRE project maintains a database and map on the various agrivoltaics and solar-pollinator habitat projects across the country. In this database[6], there are currently over 270 reported solar-pollinator project sites with a combined total electricity production capacity of 1,200 MWdc and occupying over 6,600 acres of land (**Figure 3**).

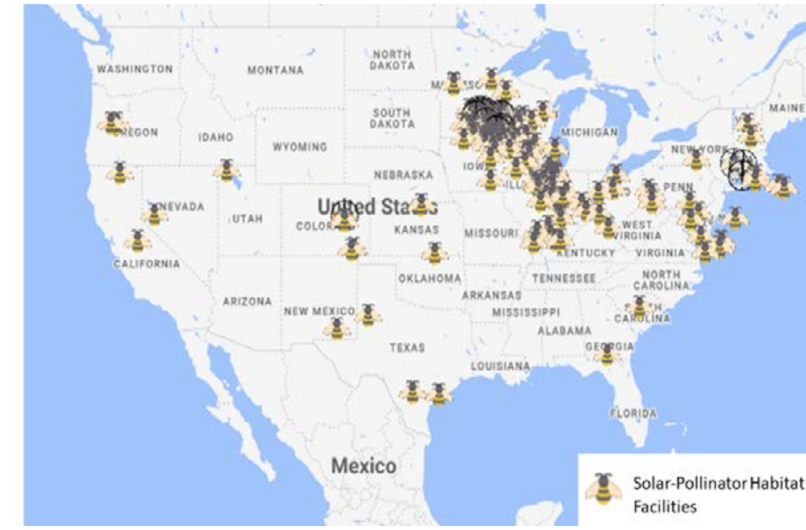


**Figure 3.** The InSPIRE Agrivoltaics Map, showing the locations of solar-pollinator projects in the United States. View the interactive map HERE.

Another DOE-funded project examining the ecological performance of solar-pollinator habitat is the Pollinator Habitat Aligned with Solar Energy (PHASE) project. Initiated in 2021, the goal of this project is to evaluate the economic and ecological implications of solar-pollinator habitat plantings at large-scale solar facilities (>10 MW) in the Midwestern U.S. Of primary focus in the PHASE project are the influence of scale and configuration of pollinator plantings on vegetation establishment and the responses of certain taxonomic groups of wildlife such as native bees, birds, and bats. In addition, a seed-selection tool is being developed through this project to allow users to identify an appropriate mix of plant species that would be suitable for large-scale solar facilities based on the site's geographic location, soil type, solar site configuration, and other characteristics.

## How can research keep pace with the rapid rate of solar deployment?

Continued field research on the ecological aspects of solar-pollinator habitat is critical to developing best management practices. The challenge, however, is time. Field research will require several years or more to fully understand how vegetation establishes, evaluate vegetation management practices such as mowing or livestock grazing, and understand how certain wildlife taxa respond to this new type of habitat. It is, therefore, imperative that as much research be concurrently conducted as possible over the coming years using consistent methodologies. This will facilitate the rapid science-based decision-making needed to commensurately support the nation's fast-evolving renewable energy transition. In addition, this research needs to be conducted across a range of geographies and solar configurations to understand the extent to which solar-pollinator habitat can be ecologically effective – either as a mitigation method to offset impacts of solar development or to provide a net benefit for biodiversity.

Fortunately, there are several methods that can facilitate the collection of field data in a systematic yet timely and cost-effective manner to support the needed expansion of research on solar-pollinator habitat. These methods are summarized below as the following:

- Streamlined Systematic Field Survey Methods
- Environmental Sensors
- Environmental DNA (eDNA) Approaches
- Unmanned Aerial Vehicle (drone) Applications

4 Walston et al. (2021), https://doi.org/10.1016/j.ecoser.2020.101227.

5 Graham et al. (2021), https://doi.org/10.1038/s41598-021-86756-4.

6 InSPIRE "Agrivoltaics Map", https://openei.org/wiki/InSPIRE/Agrivoltaics_Map.

Photo: Argonne National Laboratory

**Streamlined Systematic Field Survey Methods** for insects, such as the [Xerces Society's Streamlined Bee Monitoring Protocol](), provide an easy-to-adopt and repeatable framework for monitoring insect responses to solar-pollinator habitat. These survey protocols could assist in the timely collection of data on the abundance and diversity of different insect taxonomic groups in a consistent fashion across different scales of solar energy developments and geographic regions.

Photo: Argonne National Laboratory

**Environmental Sensors** such as acoustic recorders (microphones) and motion-triggered wildlife cameras provide a way to continuously and passively monitor biodiversity at solar sites. These sensors can be used to survey for vocal wildlife (insects, birds, bats) and detect how wildlife move and interact with the solar site. When combined with artificial intelligence (AI) analytical methods, such as species-specific bioacoustic recognition algorithms, these technologies offer an advantageous timely and low-cost approach to understand the biodiversity responses to solar-pollinator habitat.

Thanks to advancements in high-throughput DNA sequencing, **environmental DNA (eDNA)** has recently emerged as a viable approach for the rapid, accurate, and cost-effective assaying of biodiversity , and this innovative technology holds a lot of promise for the rapid and broad-scale characterization of biodiversity[7] at solar sites. With little manual labor in the field, these technologies can be used to quickly detect the presence of target species using polymerase chain reaction analyses or evaluate community diversity using genetic metabarcoding techniques.[8]

Photo: Argonne National Laboratory

**Unmanned Aerial Vehicle (Drone)** technologies have really taken off in the past decade (pun intended), allowing researchers to use these devices to quickly and frequently collect high-resolution aerial imagery over a large amount of ground. High-resolution drone imagery has begun to be used for habitat characterizations, such counting flowers or milkweed stems.[9] As such, drone applications paired with AI advancements in computer vision to automatically identify and count target vegetation will improve the ability to quickly evaluate the establishment of solar-pollinator habitat across large regions.

Photo: Argonne National Laboratory

---

7 van Klink et al. (2022). https://doi.org/10.1016/j.tree.2022.06.001.
8 Harper et al. (2022). https://doi.org/10.1002/edn3.370
9 Monarch Joint Venture, https://monarchjointventure.org/mjvprograms/science/remote-sensing



**This material is based upon work supported by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) under the Solar Energy Technologies Office Award Number DE-EE0009372.**