A National Strategy for the Co-location of Solar and Agriculture

Native Pollinator Habitat Establishment on Solar Farms in the United States

A Multifaceted Guide to Best Sustainable Practices

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Executive Summary

As solar development has increased in volume across the United States, concern has grown about the solar industry's impact upon agricultural land, including community solar moratoriums to limiting solar development on certain soil classifications in local ordinances. Furthermore, the restriction of solar development on agricultural land could severely limit the amount of viable acreage available to develop future projects. However, utility-scale solar development is exceedingly not the primary driver in the loss of viable agricultural land.

If the United States were to rely solely on solar energy for its power source, seven to nine million acres of land, or roughly 33,000 km^2, of land would be required. That is roughly 0.4% of the total land area of the United States. This land area is less area than what major roads occupy and is roughly the same area devoted to surface coal mining. Now that solar is expanding at unprecedented rates, there is an impact that needs to be addressed at the local level, as well as in relation to total available farmland in the United States.

As a good neighbor, the solar industry has an opportunity to be part of the solution by conserving pollinators. The thousands of acres of pollinator habitat the solar industry could support through this initiative is unprecedented. Deploying new habitat at a time when the solar industry is rapidly growing will have measurable impact in areas across the United Sates with current and future solar farm clusters.

Pollinators are crucial to the United States' food supply and agricultural productivity, playing a key role in the size, health, and quality of a wide variety of harvests. Unfortunately, many pollinator species are in decline due to disease, ecosystem destruction, environmental factors, and other issues, hurting thousands of farms across the nation. At the same time, solar energy projects are expanding and agricultural-adjacent land is often a desirable location for solar arrays. Planting native vegetation and managing it in a way that is meaningful and beneficial to pollinators can expand pollinator populations and improve the aesthetics of solar arrays. During the operational life of the project, the solar facility could support productive soils on the solar farm itself and the surrounding farmland. In addition, long-term pollinator habitat management lends itself towards public relations consequences, highlighting the importance of the monarch butterfly and other at-risk pollinator species.

The vegetation portfolio of a solar farm is unique to each site. Differences in seed mix coincide with the location of the mix on the solar site. To distinguish between using a more diverse, native seed mix versus a foraging material, such as clover, alfalfa, and non-native species, requires appropriate vegetation management to provide pollinator habitat. The most practical areas for native seeding on a solar farm are the buffer and perimeter areas due to a less stringent restriction on plant height. This type of installation can result in the creation of more diverse pollinator habitat and diminish invasive weed growth. Furthermore, meaningful and incremental improvements, with the pollinator friendly scorecard as the preferred approach, are necessary to demonstrate a foundation for the development of a large-scale pollinator implementation plan. Authorizing the creation of a pollinator standard can allow solar energy generating facilities to bring an additional benefit to their surrounding communities.

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I. Why Pollinator-Friendly Solar Sites?

A. The Need

Across the United States, the price of solar energy has decreased to the point of becoming the most cost-effective source of electric generation in many places. This has led to a major increase in the rate of solar deployment. Solar energy development is likely to escalate the amount of land used to build more clean energy infrastructures as the nation responds to climate change. Within this context, there is an understandable concern about the solar industry's impact upon agricultural activities. Local governments, community members, and land use development groups have growing concerns about solar farms' impact upon agricultural productivity.[C2]

Each hour, more than 40 acres of agricultural land is lost to development in the United States. Erosion is the cause of 1.7 billion tons of topsoil lost annually. Development has occupied over 25 million acres of agricultural land since 1982, an area comparable to Rhode Island and Indiana collectively. Without productive soils on agricultural lands, the 91% of fruits and 77% of vegetables humans rely on as a food source are at risk. Valuable agricultural land not only provides humans with a source of nutrition, but also environmental quality benefits, inclusive of biodiversity and wildlife. Of the protected species in the United States, roughly half rely on 80 percent or more of their habitat as private agricultural lands.[1]

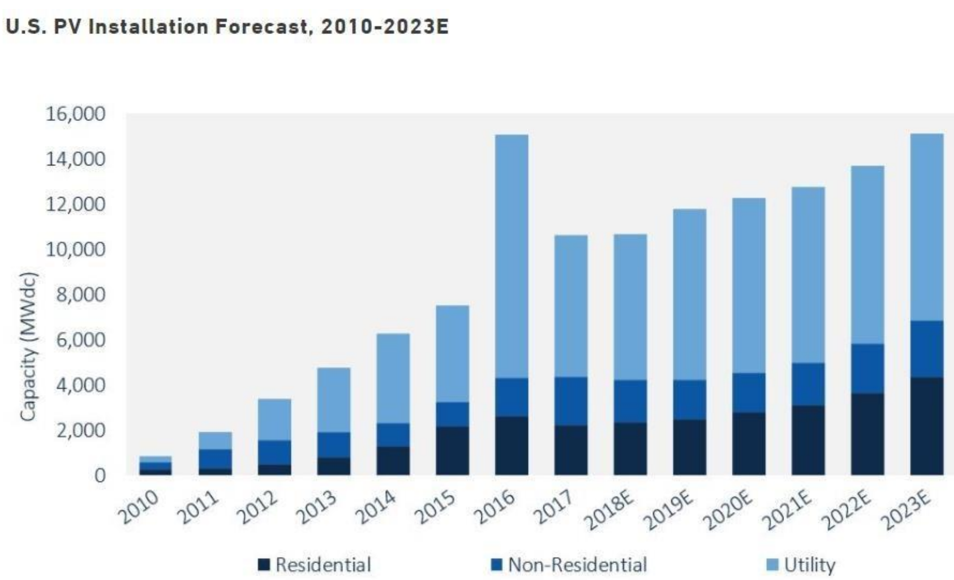

Figure 1. In 2017 alone, roughly 6,000 MWdc of utility-scale solar was deployed across the country.[2] At the end of 2016 in North Carolina, a leading state for utility-scale solar development, solar farms displaced 9,000 acres of farmland compared with the 1 million acres of agricultural land lost in North Carolina due to development in the 10 years prior to 2016.[3]

[1] The American Farmland Trust. "Farmland." 2018, https://www.farmland.org/our-work/areas-of-focus/farmland.

[2] "US Residential and Utility-Scale Solar Markets See Installations Fall for the First Time." Green Tech Media, 2018, March 15, https://www.greentechmedia.com/articles/read/us-residential-and-utility-scale-solar-see-installations-fall-firsttime#gs.bi8N0VM.

[3] NC Sustainable Energy Association. "North Carolina Solar and Agriculture." 2017, April, https://energync.org/wpcontent/uploads/2017/04/NCSEA_NC_Solar_and_Agriculture_4_19.pdf.

If the United States were to rely solely on solar energy for its power source, seven to nine million acres, roughly 33,000 km^2, of land would be required equating to only 0.4% of the total land area of the United States. This land area is less area than what major roads occupy and is roughly the same area devoted to surface coal mining. Ethanol requires twice as much land area for corn production, which is less than 7% of gasoline's energy content. The chart below highlights land uses as they relate to development and energy production, in comparison to agricultural land exploited.[4]

Figure 6.2 Land Requirements for Large-Scale PV Deployment Compared to Existing Land Uses

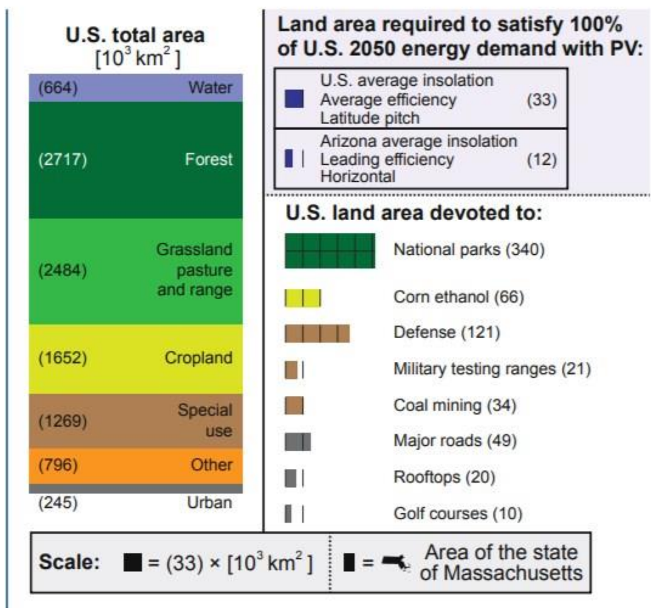

Figure 2. The land requirements for solar generation is based off the predicted electricity requirements for the U.S. 2050. The electricity requirement is averaged to approximately 0.5 TW annually. The land areas for all other uses are represented of current data. Each number in parentheses has a unity of thousands of km^2.[3]

Now that solar is expanding at unprecedented rates, there is an impact that needs to be addressed at the local level, as well as in relation to total available land in the United States. Public education on solar energy and other renewable energy alternatives has been unable to parallel the rate of solar development. Furthermore, local authoritative bodies, community members, and land use development groups have growing concerns about the solar industry's impact upon agricultural activities. This sentiment has taken different forms across markets from community opposition, provisions in local ordinances banning solar development on certain classifications of soils, to state-level Agricultural & Market Commissions exploring the regulation and limitation of solar development. Furthermore, the restriction of solar development on agricultural land could severely limit the amount of viable land available to develop future projects.[C2]

Nearly every solar project requires local government approval. New York is an example market where the local government approval tends to be more difficult in comparison to other states due to local town regulations. All townships have autonomous control of their own land use development regulations, and

[4] "The Future of Solar Energy." The Future of Solar Energy, Energy Initiative, Massachusetts Institute of Technology, 2015, http://energy.mit.edu/wp-content/uploads/2015/05/MITEI-The-Future-of-Solar-Energy.pdf.

some have instituted moratoria for solar development on agricultural land.[C4,C5] In June of 2016, NY adopted the Pollinator Protection Plan, which allocated $500,000 to the investment of pollinator-friendly habitat installation and education.[5] The state is also intending to adopt legislation that creates a standard for the collocation of solar and pollinators. The installation of pollinator-friendly habitat on solar farms is supported by the state and should create agricultural benefits at the township level. Additional restrictions or limitations on solar development risk not allocating fiscal resources for ecological and environmental services, such as pollinator habitat installation and management.[C4,C5]

From a budgeting perspective, the National Renewable Energy Laboratory (NREL) predicts by 2020 that site preparation costs will account for 20% of all installation costs involved in utility-scale solar projects. NREL responded to this significant cost factor by analyzing low-impact solar development, which has now more broadly been labeled as the co-location of solar and agriculture.[6]

As a good neighbor, the solar industry has an opportunity to be part of the solution by conserving pollinators. The thousands of acres of pollinator habitat the solar industry could support through this initiative is unprecedented. Deploying new habitat at a time when the solar industry is rapidly growing will have measurable impact in areas across the United Sates with current and future solar farm clusters.[C2] As an example, the monarch butterfly is currently at risk to be listed as a threatened or endangered species and has extensive conservation networks across the country to further strategize on its habitat protection, inclusive of primary food sources along seasonal migratory routes.[7] If no solution is found to reduce stresses on the Monarch butterfly, as well as other pollinator populations, radical changes, such as particular pesticides' banning and altered farming practices, should be considered.

The United State Fish and Wildlife Service (USFWS) has recently established Candidate Conservation Agreement with Assurances (CCAAs). CCAAs provide a joint voluntary commitment between USFWS and the solar developer to establish and monitor habitat for candidate species. Large utility-scale solar companies can become involved in the CCAA and safeguard their efforts for wildlife conservation through operational and public relations benefits, with the option to renew throughout the life of the solar farm. The solar company would gain credit with USFWS for sustainable practices towards wildlife and habitat conservation. Candidate species are those that are not listed as threatened or endangered yet but are candidates for the Endangered Species Act (ESA). A classic example is the Monarch butterfly.[8]

Danaus plexippus plexippus, the Monarch butterfly, is the iconic and charismatic image of North American butterflies when the season changes from spring to summer. Monarch butterflies are most well-known for their seasonal migration that begins in the northern plains of Canada and the U.S. and finishes in the northern area of Mexico City, as well as the coast of California in forest groves. Unfortunately, over 80% of central Mexico populations and 74% of coastal California populations have deceased since the 1990s. There are four primary threats to the current populations in North America: herbicide resistant crops, pesticide use, climate change, and logging. Monarchs rely on milkweed as a food source. With the advent of herbicide-resistant crops, milkweed has declined due to habitat degradation. All four threats primarily reduce the amount of available habitat for monarchs to survive, providing an opportunity for the solar industry to harness its arable land to preserve milkweed and other

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[5] "New York State Pollinator Protection Plan." Department of Environmental Conservation, 24 June 2016, www.dec.ny.gov/docs/administration_pdf/NYpollinatorplan.pdf.

[6] "Co-Locating Agriculture and Solar." NREL Webinar, Fresh Energy, 2018, https://fresh-energy.org/nrelwebinar/.

[7] "Monarch Conservation." The Xerces Society » Monarch Conservation, https://xerces.org/monarchs/.

[8] "Candidate Conservation Agreements." U. S. Fish and Wildlife Service Ecological Services Program, Oct. 2017, www.fws.gov/endangered/esa-library/pdf/CCAs.pdf.

native vegetation for not only Monarchs, but all pollinators. More extreme weather patterns, primarily with colder temperatures and more intense frost heaves during the winter, have resulted in fatal winters for the species and have changed bloom times for flowering plants. Reliable food sources along the migration routes are further decimated.[4] Action items on how solar developers can assist with monarch conservation along migratory routes will be detailed in the implementation plan section.

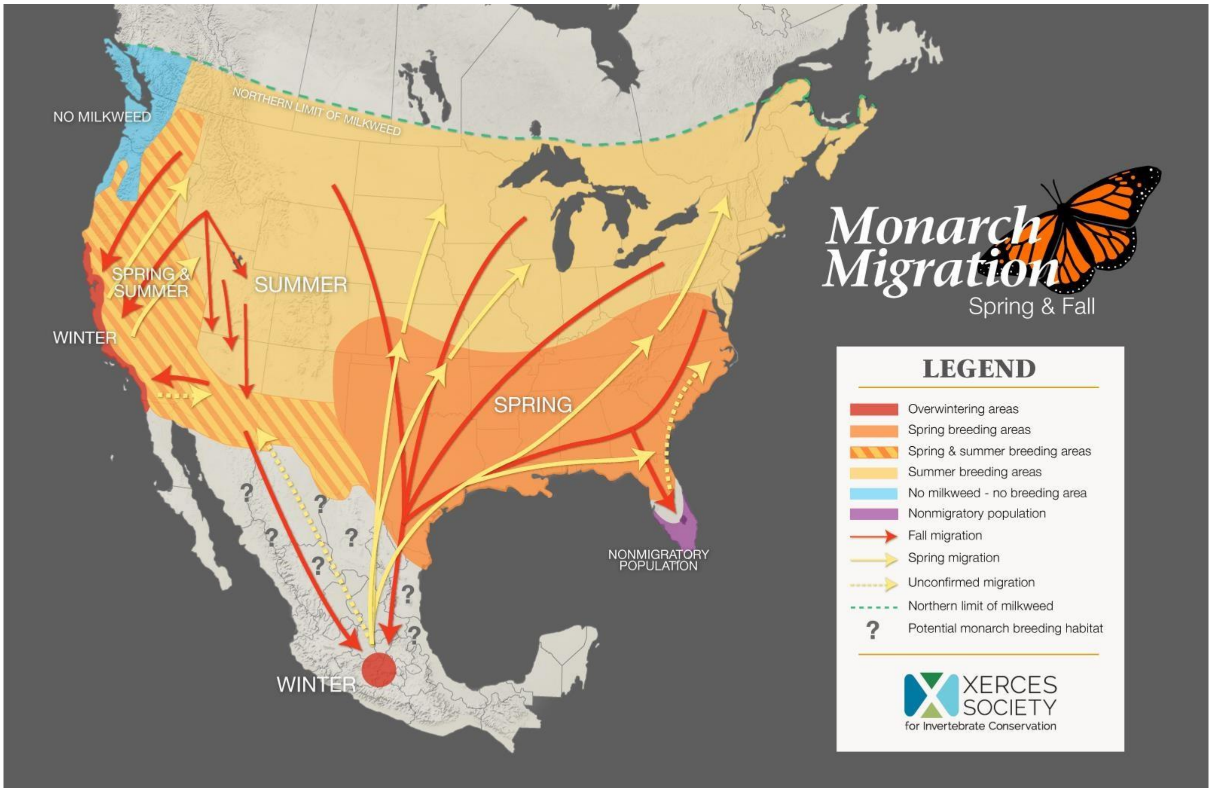

Figure 3. North American Seasonal Migratory Patterns for the Monarch Butterfly to identify primary breeding areas on a cyclical basis.[4]

DEFINITIONS AND CONCEPTS

❖ Pollinator

Pollinators allow plants to reproduce through a fertilization process of transferring pollen between flowers. Bees, birds, and insects are all classified as pollinators. Aside from bees, primary pollinators include butterflies, bats, beetles, wasps, and hummingbirds.[8]

❖ High diversity pollinator mix

The primary function of a high diversity pollinator mix is to provide the appropriate habitat vital to pollinators' survival and successful pollination. Therefore, flower and nesting habitat must be accessible. The flowers provide pollen and nectar for the pollinators. The primary and preferred food source for all pollinators is native plants. Pollinator gardens do not use pesticides as they are harmful to pollinators' health, especially neonicotinoids.[9]

There are four potential areas where high diversity pollinator mix can be planted on a solar farm: along roads and equipment footprint, array area, rows and alleys, and the buffer area.

Pollinator-Friendly Acreage Location	**Classification**
Minimal acreage in buffer area	1
Entire buffer area	2
Entire buffer area + area between rows	3
Entire buffer area + area between rows + underneath panels	4

Table 1a. Classification system for pollinator-friendly areas. Order of preference for acres to be pollinator-friendly. The number 1 represents the lowest amount of acreage designated to support pollinator habitat, while 4 is the highest amount of acreage. Upfront costs will be minimalized with a lower number of agreed pollinator-friendly acreage.[C1]

Average Acreage for 2MW Pollinator Habitat		
20% PF Site Plan	50% PF Site Plan	80% PF Site Plan
4 acres	10 acres	16 acres

Table 1b. Estimation of associated acreage with a 2 MW solar facility. The average 2 MW solar farm is 20 acres. Expected acreage for pollinator-friendly (PF) habitat is calculated based on the percentage of the site to be seeded with pollinator-friendly seed mixes.[C7]

❖ Neonicotinoids

Insecticides are used for pest control and land management for agricultural practices, including urban and rural areas. Neonicotinoids are the most common and widely used insecticide worldwide. When pollinators pick up and deliver nectar and pollen, toxins are also ingested, leading to changed behavior and fatalities through quick absorption of the neonicotinoid. Neonicotinoid compounds are systemic and

[8] "Pollinators 101." Native Pollinators in Agriculture, Native Pollinators in Agriculture Project, 2018, http://agpollinators.org/pollinators-101/.

[9] "Gardens." The Xerces Society, The Xerces Society for Invertebrate Conservation, http://xerces.org/pollinatorconservation/gardens/.

directly affect pollinators' and humans' nervous systems. In addition, neonicotinoids persist within the soil for years despite the method of its application. For example, in woody plants, neonicotinoid residue has been identified six years after initial application. A primary concern for preserving pollinator habitat is neonicotinoids' ability to contaminate vegetation proximal to the sprayed area. Wildflowers and other pollinator-friendly plants for residential and garden use are advised at much higher rates than for agricultural crops, thereby correlating to higher rates of adverse effects towards pollinators.[10]

❖ Colony Collapse Disorder (CCD)

CCD is the general term used by beekeepers worldwide to describe drastic declines in honeybee populations. Bumblebees have also suffered from CCD, as well as other species of bees. Neonicotinoids are still a debated pesticide that has correlations to global bee population declines; however, there is not a direct causal relationship between the two factors. The general process behind CCD is a bee colony will produce fewer queen bees because there is not enough pollen for the foragers to carry. Without a substantial number of queen bees, the entire hive fails.[11]

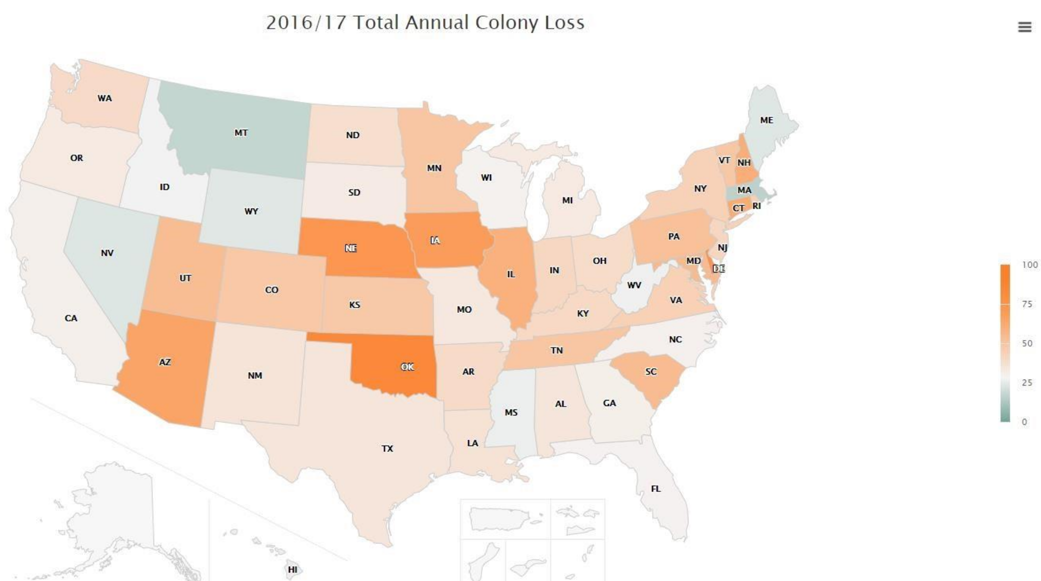

Figure 4. National honey bee colony loss. Darker colored states represent a higher percentage of population loss from 2016 to 2017.[12]

❖ Herbicide-resistant crops

Also known as Roundup™ Ready Crops, herbicide-resistant crops are a product of genetic modification through the large agricultural industry in the U.S. Primarily, corn and soy, these crops are resistant to glyphosate. Glyphosate is an herbicide that is fatal to any vegetation it encounters, aside from the resistant crop, thereby eliminating any noxious weeds, but also any beneficial vegetation, such as that for pollinators.[4]

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[10] "Neonicotinoids and Bees." The Xerces Society, The Xerces Society for Invertebrate Conservation, https://xerces.org/neonicotinoids-and-bees/.

[11] Keim, Brandon. "Controversial Pesticide Linked to Bee Collapse." The Xerces Society , Wired Science, 29 Mar. 2012, http://xerces.org/2012/03/29/controversial-pesticide-linked-to-bee-collapse/.

[12] Kuo, Loretta. "U.S. Beekeepers Lost 40 Percent of Bees in 2014-15." Bee Informed Partnership/University of Maryland, ScienceDaily, 13 May 2015, www.sciencedaily.com/releases/2015/05/150513093605.htm.

❖ Native Bees

The colonists brought honey bees, *Apis mellifera,* with them from Europe in the 1600s, introducing the first honey bees to North America. However, North America has about 4000 species of indigenous bee species that are equally beneficial pollinators, and even better, in many cases, than honey bees.[13] Native bees are deemed "native" if they naturally live and reproduce in a given area or region. Native bees and wild bees are terms used interchangeably, in comparison to managed bees which are actively kept by beekeepers. *Apis mellifera* is the most common managed pollinator in the United States. Beekeeping can yield beeswax, honey, and pollination services.[6]

Unlike honey bees, native bees do not produce honey, and most of them live out their lives in relatively small areas so we can't transport them in boxes by the thousands to crops as they bloom around the country.[14] Some native bees are more efficient pollinators than honey bees. For example, 1 acre of apple pollination needs 250 female orchard mason bees (native) or 15,000-20,000 foraging honey bees (1.5-2 hives). Native bees have been observed in very diverse crop systems and can improve the pollination of honey bees. It is important to note that honey bee cross pollination is not an equivalent to wild bee pollination due to the diverse services and species of native bees.[6]

Most native bees do not sting and each female maintains her own nest, with the common location being in the ground through a series of tunnels and brood cells. Within each cell, pollen and nectar are placed to fertilize the egg. Native bees that do not reside in ground tunnels are in wood tunnels, many of which were pre-constructed by beetle larvae. The bumble bee is the most commonly known social bee in the United States. Bee behavior is a common way to determine the type of bee, in comparison to a wasp or fly. Wasps are predators because they provide their young with prey (spiders or insects), whereas bees feed their young nectar and pollen. Wasps provide their young with prey because it provides the energy needed to fly.[11]

❖ Ecoregion

An ecoregion is a geographical boundary defined by similar ecosystem characteristics and environmental resources. This spatial framework allows for consistent monitoring and evaluation of native seed mixes for an area and the success of the area's correlative pollination services. The four ecosystem components are biotic, abiotic, aquatic, and terrestrial. [11] When developing land management strategies for pollinator habitat conservation, it is critical to identify the ecoregion, considering the following factors for native seed mix species: native distribution, bloom time & color, drought resistance, height, animals benefitted, light and soil exposure, supplier, price, and seeding rate.

❖ Solar Photovoltaic (PV) Technology

Photovoltaic (PV) cells are also known as solar cells. The primary function of PV cells is to directly convert the sun's light, or photons, into electricity (voltage) for energy generation across the United States. This type of energy generation is termed the PV effect and was founded in 1954.[15]

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[13] Vaughan, Mace. "Guidelines for Providing Native Bee Habitat on Farms." Farming for Bees, 2015, www.xerces.org/wpcontent/uploads/2008/11/farming_for_bees_guidelines_xerces_society.pdf

[14] Eskew, Olivia. "Solar Sites Going Pollinator-Friendly." Blog & News, Bee City USA, 14 July 2017, www.beecityusa.org/blog-andnews/solar-sites-going-pollinator-friendly.

[15] "Solar Photovoltaic Technology Basics." Working With Us, National Renewable Energy Laboratory, www.nrel.gov/workingwithus/re-photovoltaics.html.

❖ Utility-Scale Solar Farm

Distributed generation is different from a utility-scale solar farm depending on the end-buyer of the electricity and the size of the project. Distributed generation is sold to wholesale utilities, while utilityscale solar is sold to consumers. Fixed-price electricity is a benefit to utility-scale solar farms because during peak demand hours, fossil fuel-derived electricity is expensive. A newer technology to utilityscale solar designs is built-in storage capacity. The effect is having a constant electricity source, despite the sun's availability. Time of day and weather are the two primary factors affecting the sun's accessibility. In the United States, there is currently 528 MW of concentrated solar power (CSP). The solar industry is currently most prominent in the Southeast region of the US. To conceptualize the amount of energy output in relation to coal-fired power plants, 7.6 million tons of CO_2 will not be emitted in the Southwest through 4 GW of CSP, which is the equivalent of 8 coal-fired power plants. Other emissions that are eliminated through utility-scale power plants include particulate matter, greenhouse gases, mercury, and smog-forming chemicals. From a cost perspective, in the state of California, 4 GW of CSP saves energy consumers at least $60 million annually due to lowering the reliance on natural gas as an electricity source.[16]

❖ Zoning

Zoning approval is if not the most difficult, one of the most challenging steps in the process to developing a solar farm in each jurisdiction. A jurisdiction is typically a town, community, or county that controls and governs land use development practices within that area. Prior to construction of a solar farm, each development proposal must have jurisdictional approval. The establishment of pollinator-friendly habitat and further wildlife conservation is a mitigation measure to gain further approval.[C1] The end goal is to educate a jurisdiction of how pollinator-friendly habitat implementation and land management practices can directly benefit the community through a net income generation. By not establishing turf and applying harmful pesticides, farmers could experience an increase in crop yield through an increased presence of pollinators.[C7]

❖ Conservation Easements

Both voluntary and legal, a landowner and a land trust or other organization establishes an agreement to protect the land from being harmed. The purpose is to ensure the pre-existing natural resources and values of the land are not taken away from the landowner during any development or land alteration. The landowner does not maintain ownership of the restricted uses outlined in the conservation easement.[18] In relation to pollinator habitat, the Farm Bill of 2008 allows the USDA to establish conservation programs on agricultural land. These programs are incentivized and pollinator habitat is a top priority for the 2008 Farm Bill. The USDA places a higher importance on native bees due to the key role they play in agricultural economics and food web security and diversity. The following is a list of some of the conservation practices approved by the USDA to enhance pollinator habitat[17]:

- Alley cropping
- Channel bank vegetation
- Contour buffer strips
- Cover crop

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[16] "Utility-Scale Solar Power." SEIA, Solar Energy Industries Association, 2017, www.seia.org/initiatives/utility-scale-solar-power.
[18] "What Is a Conservation Easement?" Conservation Easement Defined, Merrill W. Linn Land & Waterways Conservancy, 2010, https://linnconservancy.org/protecting-your-land/conservation-easements/conservation-easement-defined/.
[17] "Using Farm Bill Programs for Pollinator Conservation." Technical Note No. 78, Aug. 2008, https://plants.usda.gov/pollinators/Using_Farm_Bill_Programs_for_Pollinator_Conservation.pdf.

- Hedgerow planting
- Prescribed grazing
- Constructed wetland
- Tree/shrub establishment
- Early successional habitat development/management
- Pest management
- Riparian herbaceous cover
- Riparian forest buffer
- Vegetative barriers

❖ Integrated Vegetation Management (IVM)

Rick Johnstone, President of IVM Partners, Inc., is an IVM expert in the United States and began this endeavor in 2003. IVM is a land management practice that stems from environmentally safe and sustainable methods to ensure proper habitat for pollinators and other wildlife. The diversity of native species rises, while the invasion of noxious weeds and other non-native species is controlled using selective herbicide treatments.[18] IVM was first used as an alternative land management practice on utility rights-of-way and was supported by the EPA in 2006. As of 2016, there is a new collaboration between the EPA, Edison Electric Institute, US Department of Interior, US Department of Agriculture, and the Utility Arborist Association to coordinate cross-sector practices that are more sustainable, and ultimately enhance pollinator and wildlife habitat.[21]

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[18] "Case Studies." Integrated Vegetation Management (IVM) Partners, IVM Partners, 2015, www.ivmpartners.org/case-studies/.
[21] "Integrated Vegetation Management (IVM) Practices around Utility Rights-Of-Way." EPA, Environmental Protection Agency, 26 Dec. 2017, www.epa.gov/pesp/integrated-vegetation-management-ivm-practices-around-utility-rights-way.

STRATEGIC INITIATIVE DESIGN

Solar Industry Benefits

Large utility-scale solar developers have an opportunity to partner with national experts and affiliated lead entomologist to implement best practices that are meaningful and beneficial to create a pollinator standard. This standardization process would allow solar energy generating facilities to bring an additional benefit to their surrounding communities. Pollinator-friendly solar farms and the potential colocation of bee hives is a constructive and engaging response to local concerns about the development of solar on agricultural land.

Dr. Marla Spivak, McKnight Distinguished Professor in Entomology at the University of Minnesota, told Solar Power World “it has so many benefits, not just to bees, which are directly tied to our food system through pollination services, but also improve soil quality, retention of nutrients and, ultimately, water quality.”[19] Below is a list of possible benefits from the implementation of pollinator habitat on solar farms.

- During the solar farm’s operation, soils rest and rebuild while the deep-rooted plants add organic matter and fertile top soil.[20]
- With pollinator habitat, storm water runoff can decrease 8-23%, depending on storm severity and amount of rainfall. A diverse mix of plants have stronger hydrologic performance standards than turf-grasses and other monocropping practices. [20]
- Increased community and decision-maker buy-in for zoning approval [C2]
- Reduced dust suppression needs[C2]
- Positive corporate branding [C2]
- Potential reduction in storm water and wetland mitigation investments [C2]
- Reduced incidence of mower-solar collisions[E1]
- Potential future savings resulting from reduced conservation easement claw back and/or permitting benefits being discussed in multiple states [C2]
- Potential to reduce tree buffers in favor of larger pollinator friendly buffers [C2]

If the solar industry becomes an involved player in pollinator friendly site implementation, the industry can advocate for these shifts sooner rather than later to usher in a market-wide change placing business pressure on other industry players to adapt. The net result is acres of pollinator friendly habitat, positive branding across the solar industry and the diffusion of the perennial agricultural vs. solar concerns that is an underlying, or at least purported, cause of many drastic project-level and market-level shifts.

There are risks associated with a shift towards pollinator friendly habitat, but are relative to potential long-term O&M savings. The long-term O&M savings is to be anticipated in most areas; however, sitespecific limitations should be taken into consideration when identifying costs. The long-term cost reduction potential will help the solar industry to meet or exceed ambitious O&M goals in most settings.

Economic Value of Pollinator Habitat

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[19] Misbrener, Kelsey. “Solar Arrays Abuzz Thanks to New Pollinator-Friendly Vegetation Initiative.” Solar Power World, Solar Power World, 1 May 2017, www.solarpowerworldonline.com/2017/05/pollinator-friendly-solar-vegetation/.

[20] Davis, Rob. “Soil, Crop, & Storm Water Benefits of Solar Sites.” Agriculture, Fresh Energy, 22 Mar. 2016, https://freshenergy.org/soil-crop-storm-water-benefits-of-solar-sites/.

Pollinators provide an ecological service required by 90% of the world's wild plant species and 75% of crops. Annually, native bees contribute more than $3 billion to the U.S. agricultural economy. Commercially managed honey bees contribute more than $15 billion each year due to pollination for over 100 crops.[9] Across the nation, $29 billion are generated on an annual basis in agricultural production due to insects' pollination services.[21]

Directly Pollinated Crops	Indirectly Pollinated Crops
Apples Almonds Blueberries Cherries Oranges Squash	Alfalfa Sugar beets Asparagus Broccoli Carrots Onions
$16.35 billion	$12.65 billion
$29 billion	

Table 2. Farm income generation in the U.S. in 2010 due to pollinators.[21]

A 2016 report[22] from the United Nations elaborates why we are so concerned about pollinators these days: "More than 40 percent of invertebrate pollinator species, particularly bees and butterflies, face extinction" which places the United States, as well as other nations, in direct threatening food crises. Solar sites can significantly contribute to the health of both honey bees and native pollinators.[23]

Furthermore, cost-benefit analyses suggest that this can be done with relatively minimal upfront costs and expected long term savings. In most places, pollinator habitat can be deployed in a cost neutral fashion in instances where long term O&M costs can be reduced. In many cases it is possible to deploy and maintain pollinator habitat that leads to financial savings.[C2]

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[21] Ramanujan |, Krishna. "Insect Pollinators Contribute $29 Billion to U.S. Farm Income." Cornell Chronicle, Cornell University, 22 May 2012, https://news.cornell.edu/stories/2012/05/insect-pollinators-contribute-29b-us-farm-income.

[22] "Deliverable 3(a): Thematic Assessment of Pollinators, Pollination and Food Production." Pollination Assessment | IPBES, IPBES Secretariat, www.ipbes.net/deliverables/3a-pollination.

[23] Clark, Carol. "U.N. Report Warns 40% of Pollinators Face Extinction." Agriculture - Emory University, Futurity, 29 Feb. 2016, www.futurity.org/bees-pollinators-extinction-1112572-2/.

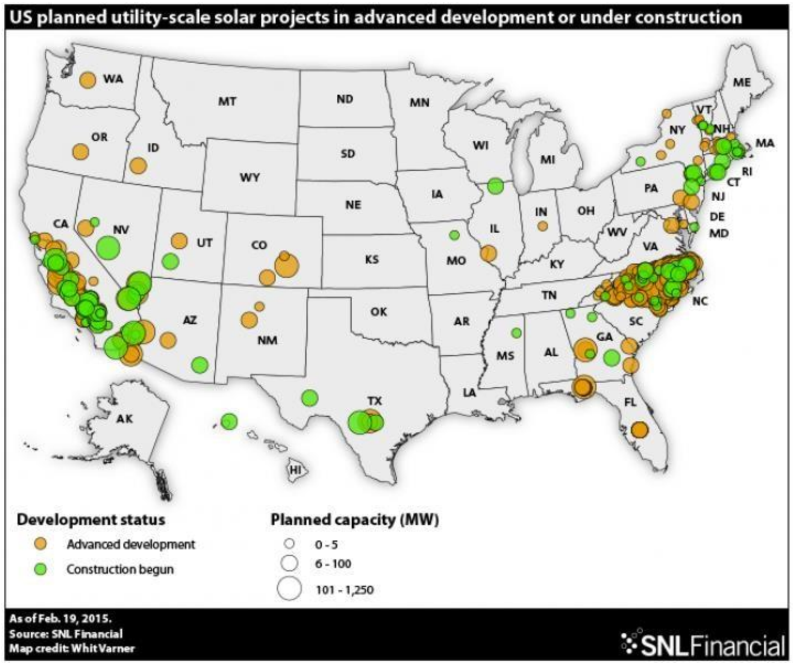

Figure 5. National implemented and planned utility-scale solar development.[24]

As a forecast for 2018, total farmers' profits will be 6.7% lower than 2017. Profit margins have not been this low since 2006. In comparison to 2013, profits are expected to be 52% lower. Lower profits are often correlated with a rise in loan borrowing, further compounding economic hardships on the average American farmer.[25] However, the agriculture sector provides a window of opportunity to encourage a healthier and more sustainable environment. As a rapidly growing sector, the solar industry has provided economic, environmental, and social benefits across the US.

[24] Magill, Bobby. "Sunny Side East: Solar Takes Off in Eastern U.S." Climate Central, Climate Central, 27 Feb. 2015, www.climatecentral.org/news/eastern-us-solar-development-18714

[25] Wilson, Jeff, and Alan Bjerga. "U.S. Farm Income to Hit 12-Year Low." Bloomberg.com, Bloomberg, 7 Feb. 2018, www.bloomberg.com/news/articles/2018-02-07/u-s-farm-income-to-hit-12-year-low-as-agriculture-rout-persists.

HISTORY OF POLLINATOR FRIENDLY HABITAT ASSESSMENT FORM

In May of 2015, a federal national strategy entitled the "National Strategy to Promote the Health of Honey Bees and Other Pollinators" was created by the White House's Pollinator Health Task Force. The importance and risks associated with pollinator decline then became more aligned with citizens' awareness of food security in relation to our agricultural industry.[26]

Fresh Energy, an independent nonprofit organization in Minnesota, spearheaded the initiative behind the co-location of solar and agriculture through the establishment of pollinator habitat in 2015.[30] The motivation to instill a standard across the solar industry began with Dr. Guy Parker, an ecologist who implemented novel vegetation designs on the Westmill solar array in England.[27] The following year, Minnesota became the first state to establish pollinator-friendly vegetation on solar arrays, which was paralleled by a state scorecard. The scorecard serves as a tool to assign a point value, on a scale of 100, with 70 as the minimal score to be classified as acceptable habitat.[28]

Fresh Energy, alongside the US Department of Energy and the National Renewable Energy Lab, as well as the Department of Interior Conservation Training Center, Electric Power Resource Institute, and others, led a national public relations campaign to produce honey on solar arrays with pollinator habitat.[29] The initial idea was triggered by a partnership between Fresh Energy and Bolton Bees to create the Solar Honey Company.[30]

Following Minnesota, researchers at the Gund Institute for Environment at the University of Vermont published a scorecard for Vermont.[31] Multiple states have enacted laws that encourage pollinator-friendly practices for solar arrays through proposed land use policies, such as reducing penalties for land taken out of conservation easements if pollinator-friendly management is adopted. For example, New York adopted a statewide Pollinator Protection Plan to message the importance of pollinator conservation, whether that be along a state highway, backyard, or a large utility-scale solar farm.[2] In addition, Maryland passed a law that is in align with Minnesota and Vermont's scorecards to further develop the legislation necessary for a state scorecard.[32]

In December of 2016, a substantial investment of $4 million was announced by General Mills, Natural Resources Conservation Service (NRCS), and the Xerces Society. The protection and restoration of pollinators and their habitats across North American farmlands became precedential with this national commitment. Through 2021, technical assistance centered on conservation and land management

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[26] "National Strategy To Promote The Health Of Honey Bees And Other Pollinators," 19 May 2015. Pollinator Health Task Force,
https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/Pollinator%20Health%20Strategy%202015.pdf. [30] Davis, Rob. Using Solar PV to Save Pollinators, 21 September 2015. Fresh Energy, https://fresh-energy.org/october-28-usingsolar-pv-to-save-pollinators/.

[27] Montag, Hannah, et al. "The Effects of Solar Farms on Local Biodiversity: A Comparative Study," April 2016. Clarkson & Woods and Wychwood Biodiversity, http://www.solar-trade.org.uk/wp-content/uploads/2016/04/The-effects-of-solar-farmson-local-biodiversity-study.pdf.

[28] Davis, Rob. "188-2: Minnesota Sets Standard for Land Use on Solar Sites," 24 May, 2016. Fresh Energy, https://freshenergy.org/mn-votes-beeslovesolar/.

[29] Davis, Rob. "Co-location of Solar and Agriculture Webinar," 18 January 2017. Fresh Energy, https://fresh-energy.org/colocation-of-solar-and-agriculture/.

[30] Bolton, Chiara, et al. "Solar Honey." Solar Honey Certified, 2017, www.solar-honey.com/.

[31] "Pollinator-Friendly Solar Resources." Pollinator-Friendly Solar Resources | Agriculture | The University of Vermont, UVM Extension, 2018, www.uvm.edu/extension/agriculture/pollinator-friendly-solar.

[32] "Pollinator-friendly solar: everybody loves it." 15 May 2017. Fresh Energy, https://fresh-energy.org/pollinator-friendly-solareverybody-loves-it/

practices will be given to farmers by both General Mills and NRCS, through the USDA, to increase flowering hedgerows and native wildflower habitats of more than 100,000 acres. Chief Jason Weller of the NRCS highlighted the opportunity privately owned farmland (roughly two-thirds of the continental US) has for improving pollinator habitat and health.[33]

Exhibit 1 in the Appendix demonstrates where pollinator habitat has been integrated with solar farms. Primary areas of the co-location of solar and agriculture include Minnesota, Vermont, Maryland, and New York. Looking to the months and years ahead, it appears likely that states will begin to incentivize pollinator friendly habitat in some fashion. It is possible that some incentives and voluntary programs may eventually shift into mandates in some states.

[33] "General Mills, NRCS and the Xerces Society Announce Multi-Year, $4 Million Investment in Pollinator Habitat." The Xerces Society, The Xerces Society for Invertebrate Conservation, 1 Dec. 2016, https://xerces.org/2016/12/01/general-mills-nrcs-andthe-xerces-society-announce-multi-year-4-million-investment-in-pollinator-habitat-2/.

POLLINATORS & THE SOLAR VALUE CHAIN

The underlying question now remains as to why this has not been done at scale yet, as the long-term value from more environmentally-friendly land management practices outweighs that of current traditional land management practices across the solar industry. The long-term impact of utility scale solar upon agriculture is an increasingly important issue for decision-makers to consider at a local and state level. Creative risk mitigation may not have been deployed at scale because these issues pose more risk now than they have in the past.[C2]

The cost of all seed mixes and vegetative practices is relatively low compared to other elements of developing a solar farm and so has not received priority attention relative to more immediate business concern. Seed mixes and land management are typically less than 1% of the total cost of a project.

Since the issue has received little attention, wisdom within the solar industry designates pollinator friendly farms to be more expensive, which is generally true in terms of upfront cost, and pose potentially expensive O&M changes and risks. Those who have not taken a holistic look at the value proposition generally believe that upfront costs will be too high relative to the benefits. Application of more upfront capital to create pollinator friendly habitat might not appear to be a sound business decision relative to other capital needs, especially in capital limited market conditions.[C2]

Recognition of value requires a holistic, long-term, multi-role accounting of costs and benefits. It is typically outside the scope of EPC to consider zoning, O&M, or corporate branding benefits when making site investment decisions. A multi-role value stream requires either a single entity or immense collaboration among various entities to realize value. Few parties are or have historically been situated in a market position to capture value of this type. In cases where multiple companies are involved in the development process, it is unlikely for one party to prioritize the delivery of zoning, corporate branding, or long-term O&M benefits for another party in a transaction.[C2]

CASE STUDIES

Each case study serves as an introduction to a specific market/state where pollinator habitat has been implemented on solar farms or is currently under consideration through local authoritative bodies and/or state policy.

North Carolina

North Carolina has seen the concern for prime farmland consistently, though less intensely than other markets. Recently, public interest in farmland degradation has increased drastically with concerns over the number of solar farms present and fears over the use of herbicides for general maintenance. This sentiment is only expected to continue. The implementation of pollinator gardens presents a unique opportunity to beautify and change perceptions of solar farms, particularly in a market where earlier solar farms lack vegetative buffers.[C2]

The NC Department of Agriculture and Consumer Services, NC State University, NC Cooperative Extension, the NC Farm Bureau, and state non-profit organizations have been developing a "living" NC Pollinator Protection Strategy since 2014. The document serves as a continually evolving set of guidelines for a varied audience, primarily focusing on landscapers, beekeepers, farmers, pesticide applicators, and homeowners. Primary topics to be included in this document are pesticide regulations, pollinator biology and health, BMPS, IPM strategies, and other various resources on pollinator habitat implementation and longevity.[34]

In NC, cattle ($373 million) and dairy production ($205 million) are heavily reliant on alfalfa and clover seeds as a food source.[35] The table below outlines the direct and indirect effect pollinators have on crops in NC, as represented by annual economic production value.

Directly Pollinated High Value Crops	Production Value ($/year)	Cross-Pollinated Crops	Production Value ($/year)
Blueberries	$66 million	Soybeans*	$483 million
Strawberries	$27 million	Cotton*	$467 million
Apples	$27 million	Tomatoes	$53 million
Cucurbits	$10 million	Bell peppers	$30 million

Table 3. Economic value of pollinators in 2011 in NC. Soybeans and cotton had a 10-15% yield increase due to cross-pollination.[38]

There are currently efforts through the North Carolina Pollinator Stewardship Working Group to address pollinator habitat assessment and appropriate monitoring and evaluation across all solar farms.

[34] "Introduction to the North Carolina Pollinator Protection Strategy." Intro to Strategy, NC Agr, www.ncagr.gov/pollinators/documents/Introtostrategy.pdf.

[35] Adamson Follow, Nancy. "Pollinator Conservation on Small Farms by Nancy Adamson at CFSA12 on ..." LinkedIn SlideShare, The Xerces Society for Invertebrate Conservation, 27 Oct. 2012, www.slideshare.net/NancyXerces/pollinator-conservation-onsmall-farms-by-nancy-adamson-at-cfsa-27-oct-2012.

New York[C4,C5]

NY is a home-rule state, which implies that all townships have autonomous control of their own land use development regulations. There is a large percentage of towns that are including agricultural land restrictions in their land use ordinances, sometimes outright banning solar development on ag land. In June of 2016, NY adopted the Pollinator Protection Plan, which allocated $500,000 to the investment of pollinator-friendly habitat installation and education for the 2017-2018 NY Budget.[2] The installation of these habitats on solar facilities is supported by the state and should counteract the prohibitive restrictions on ag land adopted by townships.

New York State has more than 450 pollinator species. The number of pollinators in NY took a turn for the worse for 2016 when population estimates were last conducted. Commercial migratory bees had reduced in number by 70% and managed pollinator colonies were roughly half their original population size. Wild pollinators are also continuing to decline.[2] The Department of Environmental Conservation has listed "Species of Greatest Conservation Need" inclusive of 34 bee, butterfly, and moth species.[36]

Agricultural production covers 7.2 million acres in NY.[37][38] Rob Davis, Director of the Center for Pollinators in Energy said, "Many of New York State's premier crops, such as apples, alfalfa, soybeans, pumpkins, and berries, rely heavily on pollination yet in 2016 New York State lost fifty percent of its managed pollinator colonies and populations of native pollinators and other beneficial insects continued to decline. Solar arrays…provide a once-in-a-generation opportunity to enable significant private-sector investment in acres and acres of clean and healthy pollen and nectar for the insects that are urgently needed in agriculture."[39]

The opportunity for the co-location of solar and agriculture presents itself wherever there is a growing solar industry presence. The choice becomes whether to implement native pollinator habitat on these solar farms, or peruse traditional turf or gravel. Deep-rooted flowers, grasses, and sedges provide an excellent option to promote the agricultural industry. Through strategic pollinator habitat implementation, the solar industry can support the growth of wild pollinators and reduce costs that farmers spent on commercial pollinators in NY.

[36] Species of Greatest Conservation Need (SGCN). NY Department of Environmental Conservation, www.dec.ny.gov/animals/9406.html.

[37] "Farms and Land in Farms 2017 Summary." Farms and Land in Farms, USDA, National Agricultural Statistics Service, Feb.

[38] , https://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1259.

[39] Davis, Rob. "New York State Pollinator Benefits." Director of the Center for Pollinators in Energy, 2017.

Total Production & NY Market Share (2014)			
Crop Type	Value of Production (US) ($/yr)	Value of Production (NY) ($/yr)	NY Market Share of Total Domestic Yield
Apples	2,870,745,000	240,355,000	8.373%
Alfalfa	10,569,103,000	160,602,000	1.519%
Soybeans	39,474,861,000	144,207,000	0.365%
Beans	980,622,000	52,137,000	5.317%
Squash	187,820,000	31,371,000	16.703%
Pumpkins	143,158,000	20,493,000	14.315%
Peaches	629,524,000	12,640,000	2.008%
Cucumbers	168,038,000	10,091,000	6.005%
Strawberries	2,821,854,000	7,520,000	0.266%
Pears	467,194,000	3,472,000	0.743%
Cherries	873,361,000	3,042,000	0.348%
Blueberries	825,759,000	2,800,000	0.339%
Total	60,012,039,000	1,157,960,000	1.930%

Table 4.[40] Based on mean bee foraging distance, average farm size in NY, and state spending on commercial pollinators, there is an estimated increase in farm income due to pollinator habitat installation on a single solar project in NY is between $364.26 – $3,088.56 within an impact range of 18.5 farms.[C7]

Maryland[C3]

Across the state of Maryland, there is a mix of counties that are pro-utility scale solar and those that are against the industry, ultimately placing moratoriums on any future project development. As a generalization, the state is pro-solar. However, there sentiments vary drastically when the scale of the solar project is increased to utility projects. From an agricultural perspective, 32.8% of the state's land is farmland.

Baker Point, a 9 MW solar site in Frederick County, MD announced pollinator habitat installation at a ribbon-cutting ceremony in November of 2017. There are 9 native plant species in the buffer area of the site which provide foraging habitat across all blooming seasons. In addition, 15 honeybee hives are colocated at the site, outside of the fence line, in which each hive will produce roughly 30 pounds of honey per season.

> *Kirsten Traynor, beekeeper at the Baker Point solar project and editor of American Bee Journal, said, "Beekeepers across the state are grateful for the state legislature's actions to increase pollinator habitat. Pollinators like honey bees provide every third bite we eat, but are often starved in our fragmented landscape. Last year alone, our state lost 55 percent of their honey bee colonies. It is our hope that the pollinator solar bill and projects such as Cypress Creek*

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[40] "Wild Bees of New York." Pollinator Network @ Cornell, Cornell College of Agriculture and Life Sciences, 2018, https://pollinator.cals.cornell.edu/wild-bees-new-york.

> *Renewables' Baker Point project will provide important habitat that supports pollinator health, while also increasing awareness of our intertwined relationship to these fragile creatures."*[41]

Frederick County passed a moratorium on utility-scale solar recently with a closely divided 4-3 vote. The common county perception was utility-scale solar projects would eliminate agricultural land, thereby destroying the farming industry. However, from the solar industry perspective, this simply isn't possible due to the stringent requirements each solar project must meet prior to construction and development. Unless the bill is reversed, there will be no further utility-scale solar development in Frederick County. To further the development of solar energy across the state, counties without moratoriums should be informed about pollinator habitat implementation and its expected benefits.

Crop	2011 Economic Value ($)
Soybeans	$204,094,000
Watermelon	$8,736,000
Apples	$7,650,000
Peaches	$4,735,000
Cantaloupes	$1,320,000
Cucumbers	$1,050,000
Total	**$227,585,000**

Table 5. Farm income generation in MD in 2011 due to pollinators.[42]

From a historical and legislative perspective, Maryland has a different regulatory framework when compared to other states in the Northeast. In 1999, a statewide legislation was passed that required all farmers to provide nutrient management plans inclusive of pesticide use and phosphorus and nitrogen soil levels. Thus, there is an acceptance for a more rigorous regulatory framework throughout the state's agricultural industry.

Currently, the state's goal is to have beneficial habitat statewide for pollinator conservation, as understood by the state's Department of Agriculture. The primary stakeholders in the planning and implementation of the MD Pollinator Protection Plan (PPP) were the Department of Agriculture, the Department of Natural Resources, and the Soil Conservation District. In addition, Rob Davis from Fresh Energy and the Center for Pollinators in Energy, with large seeding companies and utilities were part of the discussion. Currently, a pollinator habitat working group exists as an advising committee to further form certification requirements for the MD scorecard, as is enacted in MN and VT.

The Bee Lab, directed by Dr. Dennis vanEngelsdorp, has a crucial role in research and development on the effects of neonicotinoids and other pesticides on pollinators. From the results of the Bee Lab, MD is stressing the most significant correlations with pollinator decline are varroa mites and fractured habitat, not pesticide use. Consequentially, there has been contradictory ideas about the impacts of pesticide

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41 " Bebon, Joseph. Project Developers Tout Bee-Friendly Solar Sites. Solar Industry, 16 Nov. 2017, https://solarindustrymag.com/project-developers-tout-bee-friendly-solar-sites.

42 USDA NASS, 2012; Morse and Calderon, 2000. http://www.vanengelsdorpbeelab.com/uploads/3/1/0/9/31090787/value_of_honey_bees_in_md.pdf.

elimination versus habitat preservation. Hence, there is a strong need for a verification process. The pollinator working group is filling that void.

An example participant in pollinator habitat installation in MD is Perdue Farms which has 20 acres of habitat at their headquarters.[43]

South Carolina[C8]

As a matter of public policy, the state of South Carolina wants to encourage agricultural land to remain agricultural land. Farmland generates less money than solar farms or other forms of commercial development. A property that is used for agricultural purposes is taxed at a much lower rate. Factors such as soil conditions, crop yield availability, and topography are how a parcel of land is assessed and classified. This classification is completed to incentivize agricultural use as public policy tool through rollback taxes. Therefore, any non-ag uses of the land are not incentivized by the state. Rollback taxes must be paid for up to 5 years to the county and are directly tied to any property use changes, including if the land is dormant.

For large industry players, with at least $2.5 million invested in SC, fee-in-lieu of property taxes can result in the developer saving 40% in property taxes. This agreement is also between the developer and the county.[44]

As an example, planting sweet potatoes on solar farms in SC could provide tax implications in the state. However, changing the property use to be exclusively agricultural land to a classification of primarily agricultural land with a small percentage of a crop, such as sweet potatoes, will most likely not be accepted, and furthermore incentivized, by the county. The bottom line is the parcel of land to be developed must withhold credibility in the specific land classification.

Illinois[C9,C10]

The Illinois solar market was spurred by The Future Energy Jobs Act (SB 2814) which included an ambitious adjustment to the RPS, requiring IOU's and ARES to source 25% of eligible retail electricity sales from renewable energy by 2025. The new RPS calls for significant procurement of renewable energy over the next 2-3 years.[45] The IPA (Illinois Power Agency) is the organization responsible for procuring renewables on behalf of IL utilities and have issued RFP's for utility solar projects.[49]

Solar development across the state is many times like the general response to solar development across the US. The public reaction of "I am not against solar development, but I am against it going in X area" represents communities' common apprehensions as they are unsure of the implications it may have for their community, and ultimately is a large change from traditional energy practices and sources. A common fear is solar development will degrade property values. For IL more specifically, prime farmland is a common point of discussion as IL is a leader in agriculture economies in the US. If a solar farm is taking historical agricultural land, community opposition stems around decreased soil health for future farming use.

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[43] Matthew Teffeau, Director of Government Relations, MD Department of Agriculture. "Maryland Pollinator Protection." 2017.

[44] Fee in Lieu, South Carolina Department of Revenue, 2018, https://dor.sc.gov/tax/fee-in-lieu.

[45] "Future Energy Jobs Act." Future Energy Jobs Act, www.futureenergyjobsact.com/.

[49] "Welcome to the Illinois Power Agency." Illinois Power Agency - IPA, IPA, 2018, https://www2.illinois.gov/sites/ipa/Pages/default.aspx.

From a geographical perspective, the state is minimally vegetated and flat. Solar panels are therefore more visible to the public and are believed to be an "eye sore" by some. The concept of food deserts and food scarcity is often exacerbated in IL when local towns fear a large decrease in available land for producing sufficient crops for consumption. Furthermore, drain tiles allow proper drainage offsite. If these tiles are damaged, citizens are concerned with excess drainage into their property.

A concern for solar development in Illinois, and more widely, the Midwest, is the agricultural practice of corn detasseling in which mechanical pollination is used (human labor), rather than natural pollination via pollinators. Caution should be taken into consideration when establishing relationships with communities involved in corn detasseling, as agricultural development may be geared away from increasing natural pollinator habitat.

Primary stakeholders in the debate over the co-location of solar and agriculture are the Farm Bureau and IL state assessors. Farm Bureau has mixed feelings on solar development and it is therefore important to explain the benefits of solar development and any potential agriculture benefits that could result from pollinator habitat development. Primary supporters of solar development are Local Economic Development Commissions and local school boards, as tax revenues are an incentive for renewable energy development. An example is the Kankakee County Community College's Renewables Program. The state's Environmental Law and Policy Center is also active in solar development legislation creation.

Michigan[C11]

Development of solar in Michigan is facing a hurdle due to land use requirements of an agricultural tax abatement called PA 116. This program only allows farmers to stay in the program if their land remains in agricultural use, such as growing a crop or raising livestock.[46] However, taking any portion of farmland out of the program requires a zoning change to industrial or commercial which most landowners have concerns about. Also, local zoning jurisdictions are reluctant to rezone due to the legality of "spot zoning" in Michigan (having a different zoning use in the middle of an existing one). Currently, there is no process for a Conditional or Special Use Permit process for utility-scale solar in Michigan on farmland.

As we look for a solution, there might be an opportunity to keep the land in the agricultural zoning if we can show continued farm use by planting a cover crop or establishing a pollinator habitat. However, the efficacy of these ideas is unknown in Michigan thus rendering the need for further conservations with the Department of Agriculture to see if such an idea would be supported.

A primary stakeholder in the discussion around pollinators is Rufus Isaacs with Michigan State University who is the lead on the Integrated Crop Pollination (ICP) Project. This project quantifies the direct benefits of pollinators which is an excellent start to the current void of peer-reviewed scientific literature on direct metrics and tools for pollinator benefits.[47] There is a potential to use the results of this study to further other research interests through pilot programs across solar farms to further quantify and detail pollinators' influences on the solar farm and surrounding agricultural land. More specifically, having an estimated expected gain in income/revenue to farms in the affected area of the pollinator habitat is not unreachable.

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[46] "Farmland Preservation General Information", Department of Agriculture & Rural Development, State of Michigan, 2018, http://www.michigan.gov/mdard/0,4610,7-125-1599_2558---,00.html.

[47] "The Integrated Crop Pollination Project." Michigan State University, 2018, http://icpbees.org/.

The Southeastern Michigan Beekeepers Association (SEMBA) is in collaboration with the MSU extension and could be a great source for updated research on recent impacts to MI's bee populations, co-location of hives on solar farms, and any potential risks they would like to vet based on their beekeeping experiences. Lobbying efforts for pollinator preservation, in alignment with opposition towards PA 116, could have a focal point with not only SEMBA, but the larger statewide beekeeping network.

Michigan does not currently have a scorecard for pollinator habitat on solar farms, like that of MN and VT. However, there is discussion of creating a state scorecard which would serve as a consistent way to measure pollinator habitat impacts and continual monitoring for the state.[E1]

Oregon[C12]

Oregon has a standardized land use planning system that rates soil quality on a 1-8 scale. Siting solar is regulated on these solar ratings and is a conditioned use on exclusive farm use (EFU) land. All agricultural land is classified as EFU or Special Agriculture to determine solar siting rules, or a version thereof. Solar projects are not only classified by their size, but also on the specific soil type. Non-arable land without irrigation is poor soil. For arable land that isn't high-value, 20 acres is the limit and 320 acres is the limit for nonarable soils. If a soil is high-value, the solar developer is limited to 12 acres in size. Through this statewide land use planning system, many limitations are placed on solar development.
The western portion of the state is characterized topographically as the Willamette Valley of Oregon. The area is prized for vineyards and farming and the perception of solar as detrimental to farmland is building from land watch groups. Vineyard management groups are often pairing with those interested in protecting watersheds and biodiversity. Therefore, the opportunities behind grassroots movements is crucial in this area of Oregon, as local efforts are not just talking to the public, but also building momentum through community action.

In addition, there is an abundance of beekeeping groups across the state that could serve as excellent stakeholders in facilitating on-the-ground conversations with town authorities and agricultural representatives.

A significant portion of Portland General Electric (PGE) territory is in jeopardy of an eventual moratorium on all utility scale solar and/or the adoption of altered siting rules due to the perception that farm land is threatened by utility scale solar projects on high value soils. Moratoriums are expected during the spring of 2018 in association with the negative perceptions of solar development on highvalue soils. Alternatively, there are very few solar projects currently under development on high-value soils.

One solution to consider in future solar development is the concept of a "commercial agricultural enterprise." Prospects for the co-location of bee hives, in addition to pollinator habitat on the solar farm, could generate an amount of revenue that is comparable or better than traditional agricultural practices. Therefore, an opportunity may exist for solar development on high-quality soils if the land is managed appropriately with pollinator habitat and beekeeping. A more specific initiative is to integrate row planting of native pollinator species.

IMPLEMENTATION METHODOLOGY

The following section provides resources and guidelines for initial steps in pollinator habitat design and execution. A primary factor to consider is geographical location of a site to ensure the correct native seed selection. After seed mix is finalized, the co-location of hives and other species, such as the monarch butterfly, the solar developer would like to support should be incorporated into the final site plan. Primary roles included in site plans are zoning, Engineering, Procurement, & Construction (EPC), and Operations & Maintenance (O&M).

Seed Choice and Establishment

Implementing pollinator programs necessitates identifying native seed mixes to support pollinator habitats that are ecologically appropriate and well adapted to the region and site. Prairie Restorations estimates that for every square foot of land, 3.5 native plants should become established.[48]

Rather than broadly spraying herbicides and mowing to ensure weed control, proper monitoring and evaluation are recommended to reduce maintenance operations. For example, pollinator habitat on solar sites may be maintained by mowing in the winter to encourage natives to outcompete non-native species, planting low-growing forage for pollinators under and between solar arrays, and actively managing and spot treating noxious and invasive plant species.

Figure 6. To identify appropriate seed mixes, seed species nativity, and relative weather and climate, the Xerces Society has identified 10 regions in the US and Canada.[49]

Seed mixes designed specifically to benefit Monarch butterflies are dominated primarily by milkweed. Prior to planting milkweed, there are 4 primary factors to incorporate into any designated land area.[50]

- ❖ The habitat area should not have any pesticides applied nor unplanned mowing.
- ❖ Monarch caterpillars use native milkweeds as a food source.

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[48] Hollinger, Colleen, et al. “Native Seed Inventory Estimation.” Prairie Restorations, Inc, 2017.

[49] “Pollinator Conservation Resource Center.” The Xerces Society, The Xerces Society for Invertebrate Conservation, https://xerces.org/pollinator-resource-center/.

[50] Venture, The Monarch Joint. “Create Habitat for Monarchs.” MJV News RSS, The Monarch Joint Venture, 2018, www.plantmilkweed.org/.

- Adult butterflies use native flowers, as are prescribed in general pollinator-friendly seed mixes, as a food source. To maximize the efficiency and foraging success associated with the native flowers, all 3 blooming periods should be included. Energy for migration and breeding are necessary from early, middle, and late blooming species.
- Herbicides should be used minimally on and around designated pollinator habitat. Insecticides are to never be applied. Herbicides are only used for noxious weeds and invasive species mitigation and control.

To assist with the growth in citizen science on monarch migrations, risks associated with population declines, and appropriate foraging habitat, the following organizations are a resource[52]:

- Journey North
- MonarchWatch.org
- Xerces Society for Invertebrate Conservation
- Project Monarch Health
- Monarch Larva Monitoring Project
- Milkweeds of the National Park Service

When choosing the type of milkweed to plant, it is important to distinguish the species based on the ecoregion, and its associated soil and geography. The table below details the milkweed species associated with each region in the US.[51]

[51] "Monarch Joint Venture," University of Minnesota, https://monarchjointventure.org/images/uploads/documents/MilkweedFactSheetFINAL.pdf.

Region	Species	Soil/Geography Type
Northeast	common swamp butterfly whorled poke	well drained soils damp, marshy areas well drained soils prairies and open areas woodland areas (not NE, KS, MO, ND, SD)
South Central	green antelopehorn = green milkweed antelopehorn zizotes	dry areas and prairies desert and sandy areas sandy/rocky prairies and fields
Southeast	butterfly whorled white aquatic sandill/pinewoods	well drained soils prairies and open areas thickets and woodlands hydrated soils dry sandy areas and soils; some FL regions
Western (not AZ)	Mexican whorled showy	dry climates and plains (not CO, UT, NM, AZ) savannahs and prairies
Arizona	butterfly antelopehorn rush Arizona	well drained soils desert and sandy areas desert areas riparian areas and canyons
California	Mexican whorled showy desert California heartleaf woolly woolly pod	dry climates and plains savannahs and prairies desert regions grassy areas rocky slopes dry deserts and plants clay soils and dry areas

Table 6. Milkweed species associated with region nativity and geographic conditions.[53]

State	Company	Website	Milkweed Species
NC	Sow True Seed	http://www.sowtrueseed.com	butterfly, common
NY	Blossom Meadow Farm	www.blossommeadow.com	common
	Eastern Monarch Butterfly Farm		swamp
MD	Chesapeake Valley Seed Inc	www.chesapeakevalleyseed.com	butterfly, swamp, common

Table 7. Example milkweed seed providers in the Mid-Atlantic and Northeast.

Land Management Monitoring and Evaluation

Prairie Restorations is a land management company in Minnesota with the most experience, in terms of years in business and solar acres under management, in the US for pollinator-friendly habitat implementation and control. When installing pollinator-friendly habitat, the following points have been adopted from Prairie Restorations and should be taken into full consideration.[E2]

- The first 3-4 years are the most intensive and crucial in terms of needed maintenance.
- Mowing is typically the predominant maintenance strategy during the first and second growing season. Typically, 2-3 mowings are needed depending on weather patterns, etc.
- During the 3rd growing season and beyond, maintenance becomes more targeted control. IPM is common technique deployed during this time frame and on an as needed basis after the 3rd growing season. IPM involves spot treatment of certain herbicides by a crew on foot or with ATVs.
- Straw mulching for erosion control is often costly. For sites that do not have a steep grade/slope, straw mulching is not necessary. The purpose of planting the cover crop is to allow the native seeds to germinate quickly, while also providing erosion control.
- After site construction, heavy machinery can compact the soil. Disking, or other soil loosening methods, may be used to properly prepare the soil for seeding.

In general, a minimum of a 5-year contract between the land management company and the solar company is necessary for all monitoring efforts of pollinator habitat, due to the nature of native seed germination and growth. After the fifth year, annual visits by the management company are advised to identify any additional mowing needs.[E2]

Growing Season	Land Management
1	2-3 mowings
2	2-3 IPM trips
3	2-3 IPM trips
4	2 IPM trips
5	1 IPM trip

Table 8. An outline of timed management practices per the recommendations of Prairie Restorations. A growing season represents the year. Years 2 and 3 typically require the highest amount of maintenance, and are therefore, the costliest. Time and resources should be invested more extensively during this time to reduce noxious weed growth and ensure proper seed establishment. [E2]

Solar Site Constraints

It is important to note that if a solar facility is not to be fully planted with pollinator-friendly seed mixes, a turf or other traditional alternative should not be planted. For example, if only the buffer area is being seeded or only a portion of the array is being seeded, a less expensive native mix should still be seeded on the other portions of the site. Alternatives to using a multi-species and diverse pollinator seed mix are clover and other crops that provide pollinator services, while also preventing soil erosion and storm water runoff.[E2] By covering the entire side in beneficial and meaningful species, the benefits of the habitat area can extend across the entire site and nearby agricultural land. The most preferable option is to use native species across the entire site. Long-term costs can be significantly reduced.

If these recommendations are not accounted for, there would be a mix of land management practices and seed mixes across one site. Having both traditional mowing with more intense herbicide spraying on part of the site while practicing pollinator habitat practices on another part of the site, would require an increase in labor, resources, and number of site visits, thereby increasing the time and resources spent on site monitoring and evaluation over the course of the solar farm's lifetime. Ultimately, a solar developer should always consult with the land management company to ensure appropriate monitoring and evaluation plans, as well as approved land management practices such as spot spraying, IPM, and no mowing after the critical phase of seed establishment.

From a site perspective, there are constraints due to the infrastructure of the solar farm itself. Factors to consider include: shading risk (land topography and panel height), disturbed vs. undisturbed land, wetlands buffers, native distribution of seed mix, bloom time & color, drought resistance, animals benefitted, soil moisture content and drought tolerance, supplier, cost of seed mix and seeding, and the seeding rate. For further information on native seeds in the United States, each solar developer should have a national (or regional) seed database which compiles the site factors to serve as a reference tool.

Pollinator Friendly Habitat Assumptions[C2]

- ❖ Seed Mixes
  - All plants have a maximum height underneath and between the panels.
- ❖ Site Assumptions
  - Options available to install pollinator friend habitat on all or a portion of sites
  - Buffers and areas directly not under panels are most appropriate and cost-effective areas of site for pollinator friendly habitat
  - Pollinator friendly habitat under panels is also possible, but harder to achieve. Low growing shrubs, clovers, and grasses are possible to use under panels.
- ❖ Long Term Pollinator Friendly O&M Savings Is Very Likely Achievable if:
  - Local fire regulations allow for accumulation of biomass
  - Vegetation maintenance plan is modified for pollinator habitat
  - Site appropriate seed mixes are used at right time of year
- ❖ Higher Net Present Value for Pollinator Friendly Area of Sites Relative to Turf Area is Very Likely
  - NPV of traditional land management practices (turf) is greater than or equal to additional upfront cost of pollinator friendly farms
- ❖ Higher Upfront Seeding Costs for Pollinator Mixes
  - Seed cost is primary driver of increased cost relative to turf costs
  - Seeding areas not under panels is less labor intensive, so assume less additional costs for buffers, etc.
  - Some upfront costs will be discounted by the Investment Tax Credit (ITC), 30%
- ❖ Pollinator Assumptions
  - Pollinator turf initially requires 2-4 cuts/year in year 1
  - Pollinator habitat "Integrated Pest Maintenance" / spot treatment of invasive species 2-3 times per year in years 2 and 3
  - Once pollinator habitat is established, will need 0-2 mowing per year, depending upon local fire regulations regarding biomass

Co-location of Hives[E2, E3]

The following template should be considered when installing bee hives on a solar facility. The recommendations are sourced from The Solar Honey Company[33] and Prairie Restorations[52] in Minnesota.

- Complete a site analysis inclusive of pollinator habitat viability. Factors to consider include soil type, sunlight/shade presence, water source, size of property, presence of other hives on surrounding land, and presence of farmland and existing vegetation suitable for pollinator foraging.
- Determine viability of current landowner to manage hives. Solar developers are recommended to detail the knowledge the beekeeper has about hive management, appropriate insurance, and the history of beekeeping in the surrounding area.
- Establish a contract with a professional beekeeping company/firm to increase commitment and longevity of hive management when possible.
- The beekeeper should have liability insurance.
- Inquire with the agriculture academic institution or the state agriculture department to provide contacts and recommendations for apiary establishment. If in an area where a professional beekeeping firm is not active, contact universities/academic institutions and extension agents to gain further support and resources on who to contact and how to properly establish an apiary on site.
- Install the hives outside of the fence line when possible to reduce safety concerns for the landowner, surrounding community members, and the beekeeper(s). Issues that can be prevented by placing the hives inside the fence include vandalism and having to gain authorized access for the beekeeper onto the solar site.
    - The primary factor for the solar developer to consider is the presence of drive-up access to the bee yard for the beekeeper.
    - The primary concern for the beekeeper is eastern sun exposure. If in the northern part of the US, the beekeeper would like a northwest wind block, if the hives are staying at the location throughout the winter.
- If desired, structure the presence of hives as a community engagement strategy to facilitate active participation of local citizens in the co-location of solar and agriculture. Marketing and public relation strategies should be further detailed to include ribbon cutting ceremonies, honey extraction events, and other honey-oriented affairs.

"The Solar Honey Company promotes the productive use of land under and around ground mounted solar panels. Typically, turf grass or gravel is placed under the panels. SHC believes there is a better way: planting the land with pollinator-friendly species and locating beehives among them. Beekeeping is farming."[33]

[52] Hollinger, Colleen, et al. "Co-Location of Hives on Solar Farms." Prairie Restorations, Inc, 2017.

- Solar Honey® is the iconic example of honey extracted from hives located on a pollinator-friendly solar farms. The honey can be used as a marketing tool to gather further public support, spread awareness of the importance of pollinator habitat, and dull tensions between the farming and solar communities.
- Potential profits can be made from selling honey produced on solar facilities in customized honey jars with the solar company's logo. For further information, The Solar Honey Company is an excellent resource.[33]

Development Checklist for Pollinator Friendly Habitat Implementation

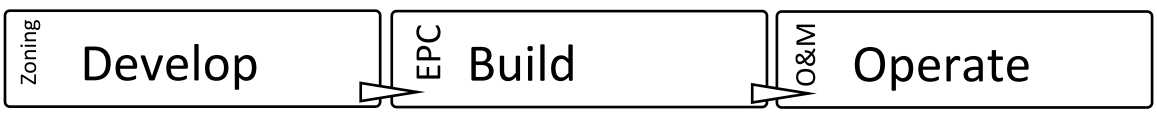

Figure 7.[C1] The solar development process of develop, build, and operate is represented by internal roles, such as zoning, EPC, and O&M. To streamline pollinator habitat installation and management within the existing development framework, diligence is required within each role. The following tabular list of questions serve as a checklist by internal role to determine the feasibility of pollinator friendly habitat implementation for any single solar farm.

ZONING[C4, E1]
❖ How large is the zoning area in which the pollinator site will be implemented? ❖ Is the site located in an active agricultural where pollinator habitat will increase yields? ❖ Are their publicly visible spaces where people can see the solar farm? ❖ Can the tree buffer be reduced in favor of pollinator habitat to save up front costs? ❖ What is the timeline for pollinator habitat installation? ❖ What are the benefits of community buy-in for pollinator-friendly solar farms? ❖ What type of seed mixes are included in the pollinator proposal? Particular flowers, native species, etc. ❖ What type of maintenance is required for pollinator-friendly habitats? Are herbicides used? If so, what type? Will mowing be required? If so, how often? ❖ Are their local fire regulations that require periodic mowing of pollinator friendly areas to reduce fire safety risk? ❖ Where exactly will the pollinator vegetation be located? Are they under panels, along the roads, or all over site? ❖ When during the construction process does the installation of the pollinator plants and the hives occur? ❖ Are there any specific permits that are tied to approval the pollinator habitat? If so, what are those requirements? ❖ Is there a pollinator friendly messaging plan at the local level? ❖ What is the level of community support of the co-location of solar and agricultural lands currently in this town/jurisdictional area? ❖ How many beehives in State X? (see USDA state on # of bee hives) ❖ What is the kill rate for bee hives in that state? Apply the *Bee Informed Partnership* honeybee kill rate to the USDA number of bee hives in state. This will approximate the number of bee hives killed annually. • Multiply # of bee hives by 20,000 bees per hive • Multiply # of dead honeybees by 13 mm per bee. • Have these statistics been presented to a nearby college or high school biology or environmental science or beekeeping class? • Would those students like to voice their opinion and concern for bees at a planning or city council meeting? ❖ Does the state have a pollinator protection plan? ❖ Have the stakeholders involved in the creation of the Pol Protection Plan been informed of the solar company's plan to create solar array? ❖ What nonprofit/government-affiliated groups in the state work on pollinator health issues? Have they been informed? ❖ Acres in county X in X state that are farmed ❖ What are the primary crops within X state and X county? (Use USDA Agriculture Statistics) How do those crops benefit from pollinators and other insects? ❖ How many acres in X county are cover-cropped? Are soil conservation measures thoroughly implemented in X county? ❖ How will the high-performance vegetation on the solar array benefit the soil?

ENGINEERING PROCUREMENT & CONSTRUCTION (EPC)[C3]
❖ Is the correct seed mix chosen for: • Climate • Height of racking system • Soil conditions (too much rock?) ❖ What is the upfront cost difference for pollinator habitat vs a typical grass seed mix? ❖ Does the chosen subcontractor have experience with preparing the site for a pollinator habitat, spreading seed in the approved manner, and ensuring that the seed takes? If not, are they willing to adapt vegetation maintenance plans? ❖ Are there any specific permits that are tied to approval the pollinator habitat? If so, what are those requirements? ❖ How will the various sections of the solar farm each be pollinator-friendly? ❖ Will signs be implemented to demarcate pollinator-friendly habitat? ❖ What will the seed mix maximum height be for the surrounding vegetative buffer? ❖ For herbicides, can traditional herbicides still be used? How often can the herbicides be sprayed? ❖ Are there particular areas of the site where pollinator friendly mixes will not work? ❖ Will the pollinator friendly seed mix germinate at the time of year installed? If not, what is the plan for installing pollinator habitat? ❖ What does it cost to reseed the pollinator habitat section of the solar farm if seeding fails the first year? ❖ How does the seed price change with an increase in seed supply? ❖ How much bulk seed supply is available from X supplier in X year?

OPERATIONS & MAINTENANCE + CIVIL ENGINEERING[C6]
❖ Does the installed height of array match design? ❖ What site conditions exist that may complicate erosion and control measures? ❖ What site conditions exist that may lead to increased shading? North facing slopes, site elevation, row spacing, etc. ❖ Can the 3-5 years required establishment of the habitat be included in the EPC seeding contract? ❖ If the above is not available, what has been budgeted to get the site to a low maintenance existence what year will this occur. Has this pricing been confirmed locally? ❖ Are you aware of any fire safety restrictions that will require additional mowing of pollinator friendly habitat to reduce fire safety risk present by accumulated biomass? ❖ Which year will the solar company break even on costs for pollinator habitat installation? ❖ Where are the most savings accrued? Mowing? ❖ What percentage of sites will require revegetation?

THE FUTURE OF POLLINATOR HABITAT AND THE SOLAR INDUSTRY

There are 2 primary shortcomings that exist within the solar industry to identify the direct benefits of pollinator habitat on solar farms. The solar industry is not the primary driver of the larger issue of solar and agriculture co-location. However, due to the novelty of the pollinator habitat initiative, these topics need further research and quantification to gain a more holistic view of what, if any, threats exist to pollinator habitat implementation at a national scale.

Needs for Innovation

- Decommissioning

Due to the average solar farm's lifetime of 30-40 years and the industry being relatively new, in comparison to other energy sectors such as coal and oil, there is not a significant amount of information about how decommissioning a solar site affects the land and ultimately, the pollinator habitat installed. Further quantitative research is needed that compares the land prior to solar farm construction and after the solar farm is removed. As a minimum, soil compaction, storm water runoff, and soil erosion levels should be maintained over the course of the solar farm, with an improved ecosystem and soil value during the mature pollinator habitat period.[C2]

- The Monarch

Candidate Conservation Agreements with Assurances (CCAAs) provide a joint voluntary commitment between the US Fish and Wildlife Services and the solar developer. Large developers would have a seat at the table as a leader in the solar industry to determine what land management practices are necessary to facilitate proper habitat conservation in relation to the candidate species. Those involved in the advisory council would be included in the CCAA gaining both operational and PR benefits. Accreditation would be received from the USFWS for sustainable practices to protect the health of the monarch butterfly over an agreed upon timeframe. The agreement is voluntary and the level of financial commitment is flexible, allowing developers to treat the initial phases of the CCAA process as a trial-and-error period. Leeway allows the developer to determine what style and amount of leadership is desired to pursue in habitat and wildlife conservation.[53]

CCAAs are currently developing in the utility and right-of-way sectors through the University of Illinois at Chicago.[59] "The Rights-of-Way As Habitat" working group is the leader in the effort to establish and maintain pollinator-friendly vegetation on utility lands and other right-of-ways, based on the "National Strategy to Promote the Health of Honey Bees and Other Pollinators" established in May 2015 by the White House's Pollinator Health Task Force.[28]

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[53] Iris Caldwell, Program Manager of Sustainable Landscapes, Energy Resources Center, The University of Illinois at Chicago. Lori Nordstrom, Assistant Regional Director for Ecological Services, USFWS. "Candidate Conservation Agreements with Assurances." 2018

RECOMMENDATIONS

The case studies and current motivation within the solar industry to co-locate solar and agricultural land, specifically in the form of pollinator habitat has led to the development of the following recommendations. The intended audience is solar developers in the United States. There is not a restriction on solar sites' sizes or locations. Each recommendation should be adapted to provide a more robust set of site-specific guidelines for pollinator-friendly habitat installation and management.

Recommendation 1. Viability of Habitat Assessment Form (HAF)

The habitat assessment form for establishing pollinator habitat on solar farms was initiated in Minnesota as a collaboration between the state's Department of Agriculture, Fresh Energy, an independent nonprofit organization facilitating dialogue and action in communities for a cleaner energy future, and solar companies. The idea is plain and simple – to get as much pollinator-friendly habitat in the ground as possible. Scalability is there due to the expansion of the solar industry, in terms of the acreage that it covers. From a political perspective, the co-location of solar and agriculture varies widely across markets and MN has a niche fit for strong collaboration between both the solar and agriculture industries for a win-win scenario. Having a standard allows solar companies, and other large industry players, to establish a framework and metric of comparison to determine if a habitat has been properly installed. It is a great starting point for the initial pilot phase of addressing the need for more pollinator habitat in the U.S.[54] However, room for improvement does exist. Here are principle questions to consider for the future viability of the pollinator habitat.

- ❖ How is the land evaluated prior to establishing pollinator habitat?
  - Factors to consider include prior pesticide use, surrounding land type, use, and history, soil type, presence of watersheds
  - How do you determine if the existing land (prior to building a solar farm) has been exposed/still has significant pesticides?
- ❖ How will the land be monitored and evaluated in terms of the uptake of pollinator friendly seeds, germination, and longevity?
  - Metrics to identify accuracy of land monitoring over a detailed time frame are needed ❖ How will the site be assessed when a solar farm is decommissioned?
- ❖ Who is the primary point of contact for allocating a site's points?
  - Resubmission of scorecard - check points should be established for the lifetime of a solar farm (1 year, 3 year, 5 years, 10 years, and then after every 10th year remaining) to ensure the uptake of native seeds
- ❖ Outline guidelines on how to improve habitat based on each resubmission's score. Points should be allocated on when seeding occurs

Recommendation 2. Pollinator 101 Solar Industry Trainings

Trainings for the solar industry should be provided on a routine basis to cover the following topics: pollinator conservation, herbicide use, and importance of their habitat. The goal of these trainings is to identify and understand the value proposition pollinator habitat has for solar farms. To achieve this goal, the primary task is to identify methods for how to change traditional business practices to save money and pollinators. The target audience for these trainings are those holding O&M, zoning, and EPC roles. As a follow-up to these trainings, concise talking points should be outlined and distributed to relevant roles that consistently interact with local community members, highlighting the importance of local board and zoning-affiliated meetings.

If the company does not feel they have the internal expertise to deliver pollinator trainings, a third party should be approved as a training lead. Examples include staff from a local cooperative extension, beekeepers' associations, or Xerces Society.

Recommendation 3. National Seed Supply Inventory

Due to the increasing growth of the solar industry across the United States, scaling is a central risk that must be considered and assessed. To accurately predict the amount of seeds needed based on the state or region, the solar company should provide the following information for the seed vendor(s):

- Timing – Give at least 4-6 months' notice from seeding to desired seed vendor. If possible, provided estimated acreage to be seeded.
- Volume – To be determined based on location of the solar facility. If there are multiple local seed vendors with a smaller inventory, first assess the size of the inventory and establish committed working relationships with those vendors to instill local collaboration and economic development. One of the largest seed suppliers in the US is Ernst Seeds in New Jersey, as well as Prairie Moon Nursery in Minnesota.
- Species availability

Prairie Restorations is an excellent example of a land management company that grows thousands of pounds of native grasses and flower seeds. With any business transaction, proper communication and advanced notice is key to ensure sufficient seed inventory from the desired local vendors. As part of their business model, they guarantee successful establishment of the first 3 growing seasons, inclusive in the land management contract.

Recommendation 4. Research Questions for Academic Partnerships

- Short-Term Goals
  - Increase credibility of habitat assessment forms
  - Establish monitoring and evaluation metrics of a solar facility based on the overall pollinator value
- Long-Term Goals
  - Design test sites to research and develop data for the following questions:
    - How have the diversity of bee species and frequency of sightings changed since the implementation of a pollinator habitat at X solar facility?
    - How does the variance in percentage of pollinator-friendly land (20%, 50%, 80%) lead to differences in crop yield and bee species sightings across solar project sites?
    - To what extend have commercial pollination costs been offset per farm due to an increased presence of native pollinators?
    - How has crop yield changed for farms within the impact range of the pollinator habitat, controlled for weather-related yield differences? [C7]
  - Engagement with local community
    - X% increase in crop yield to nearby farmer/local community
    - Number and size of farms in active markets/states that grow pollinator dependent crops

Recommendation 5. Public Pollinator Educational Materials

Common community fears in relation to pollinator habitat all too often coincide with getting stung by a bee, too high of costs for pollinator habitat installation and mitigation, and an increase in operational and occupational risks for the solar facility. In addition, local authorities occasionally stipulate prescriptive pollinator habitat design that does not align with solar development or pollinator habitat guidelines, threatening project development. To avoid common community fears, the following factors should be included in educational materials for outreach purposes to any community a solar facility is being considered.

- The purpose of installing pollinator habitat is to preserve native bee populations.
- Risk is always present in an outdoor work setting, such as that of a solar facility. The nature of outdoor work in comparison to controlled indoor environments should be highlighted.
- Honeybees are only a small portion of the pollinators that will benefit. Therefore, the chance of getting stung by a bee is X. Include the following criteria when making this statement.
    - Region
    - Time of year
    - Climate change risk
- Explain spot spraying and how certain insecticides can target wasps/other non-pollinators to reduce the presence of unwanted pests.
- Pose the option of additional safety gear for employees on the ground to mitigate sting risk. Include the associated costs of equipment and any precautions for individuals with a known bee allergy.
- Outline current or planned collaboration with the local beekeeper organization to determine additional costs and interpret community sentiments from a vetted source.
- Understand sub-contractors and other 3rd parties' liability insurance.
- Design pollinator educational material to cover biology basics and risk mitigation tactics
    - Different types of bees
    - Bee life cycle (active vs. dormant stages)
    - Create planting and spraying schedules in coordination with life cycles (seasonality)
- Compare bee sting incidents and deaths to that for pesticide poisoning. This serves as a counter-argument to not implementing pollinator habitat.

Recommendation 6. Bird and Bat Habitat Conservation

- Benefits
    - Bats eat large quantities of mosquitoes which could reduce community and vegetation managers' fears and risk of Zika
    - Increased community and decision-maker buy-in for zoning approval
    - Positive corporate branding
    - Competitive advantage
    - Bring benefits to nearby agricultural activities
    - Attract insect-eating birds
    - Reduction (and potential elimination) of nonnative turf grass

- Increase in biodiversity
- Over 300 native bird species in US are threatened by climate change[1]
- Native plants produce seed or grain = primary food source for native birds

❖ Example Benefits Specific to NC
- Limited native seed supply in NC
- Planting native seeds that also benefit native bird species in NC provides multiple opportunities for future native plant preservation and development
    - Native seed supply scaling up
    - Partnerships with local nurseries and cooperatives
    - Increase community buy-in
    - Support and expand local pollinator populations

NC Native Bird Species Benefitted
- Spring and fall migrating birds: solar farms = foraging and rest habitat
- Wintering sparrows and finches
- Nesting birds need next box installation (fence perimeter)
- If bird habitat exists in proximity to a solar farm, breeding bird species can also forage there.
- NC native birds as an example

Birds with Likely Benefit		**Nesting Birds**
American Goldfinch	Field Sparrow	Eastern bluebird
Blue Grosbeak	Grasshopper Sparrow	Tree Swallow*
Eastern Meadowlark	Savannah Sparrow	Purple Martin**
Ruby-throated Hummingbird	Vesper Sparrow*	Barn Owl*
Indigo Bunting	White-throated Sparrow	American Kestrel*
Chipping Sparrow	Red-winged Blackbird	
Song Sparrow		

Table 9. For most sites, the Eastern Bluebird and Tree Swallow would benefit. Purple Martin and Barn Owl/American Kestrel require additional suitable habitat nearby for them to take up residence. Therefore, an analysis of the land surrounding the site is necessary.[55] Nesting plans are available online through NestWatch.[56]

*Climate-threatened species; **Needs nearby water source

According to Audubon Society, placing bird boxes on a site without installed pollinator habitat would be beneficial to a few species of NC birds.[55] Bird boxes are roughly $25 per box. The number of boxes to be installed is dependent upon site size, seed mix to be planted, and surrounding foraging habitat.[57]

Recommendation 7. STEM Outreach + Agricultural Sustainability

"Emerging Explorer Dino Martins says that from long-tongued bees to hawk moths, pollinators are the hidden workers that keep the planet running…. 'Pollinators are one of the strongest connections between conservation and something everyone needs—food.'…Martins acts as a pollinator himself, carrying crucial information to Kenya's isolated farmers, schoolchildren, and a larger world of travelers and scientists."[58]

The installation of pollinator-friendly habitat underneath and between solar panels that already exist/will exist at academic centers such as universities, technical schools, and primary and secondary institutions provides multiple opportunities for research collaboration and study sites for quantifying the benefits of pollinators. Potential research topics are:

- Seed inventory and seed supply by state
- Quantitative pollinator benefits
- Risk assessment of pollinator habitat, inclusive of all types of pollinators

For younger students, the importance of nutrition, garden development and local resources through community engagement efforts could serve as a parallel to existing biology and environmental science curriculums. As a form of monitoring and evaluation, students' knowledge can be assessed through pre- and post-tests. Example topics to address include pollinator biology, nutrition, local food sustainability, solar energy and other renewable energy topics.

Partnerships with high-level science-based organizations such as Xerces Society and National Geographic Society could provide an excellent opportunity for on-the-ground technical and academic information and structure. Pollinator biology, conservation and wildlife biology, nutrition and school gardening, and local food systems sustainability are all key components of existing science curricula. If stakeholders are engaged appropriately, further partnerships could develop with local beekeeper's associations to establish hive co-location. Ultimately, unexpected partnerships between academia, non-profit organizations, and the solar industry result in a shift towards corporate social responsibility initiatives, with advantageous storytelling potential.

Recommendation 8. Soil Compaction Alleviation through Cover Crop Services

During site construction and decommissioning, the soil is compacted due to the impacts of heavy machinery. When designing and approving land management plans for pollinator habitat, actions and costs should be outlined to reflect soil compaction mitigation. If the soil remains compacted, carbon sequestration is disrupted and native seeds are less likely to properly establish. Without thorough initial site assessment, long-term costs will increase due to improper site preparation.

Service	Pollinator-Friendly Cover Crops
Nitrogen source	Alfalfa, vetch, cowpea, lupin, partridge pea, sunn hemp, white clover, red clover
Nitrogen scavenger	Canola, phacelia, sunflower
Erosion control	Canola, crimson clover, cowpea, white clover
Forage value	Crimson clover, white clover, canola, forage radish
Weed management	Canola, sunflower, buckwheat, cowpea, sunn hemp
Nematode management	Brassicas, mustards, canola
Soil compaction reduction	Radish, canola, lupines, mustards, brassicas

Table 10. Ecological services provided by pollinator-friendly cover crops.[59]

Recommendation 9. Brownfield Development

Phytoremediation is more cost-effective and less energy intensive than current brownfield remediation methods. Plants with deep root systems with the ability to breakdown contaminants are a viable option to cleaning the land to establish a viable habitat for future pollinators on brownfield sites. After the plants have reached maturity and the contaminants have been harvested in the soil, the plants are then disposed of as chemical waste. Over a longer timeframe, the concentration of contaminants within the groundwater lessens.[60]

The current plants being used for phytoremediation are listed below.[61] The plants in bold are those that are also recommended to support pollinator habitat on solar sites.

- Hybrid poplars, willow, and cottonwood trees
- Wetland and aquatic plants – water hyacinth, bulrush, reed, parrot feather
- Legumes – **clover, alfalfa, cowpeas**
- Grasses – rye, Bermuda grass, sorghum, fescue
- Hyperaccumulators for metals – alyssum (nickel), alpine pennycress (zinc)

APPENDIX

EXHIBIT 1 – KNOWN ACTIVE POLLINATOR FRIENDLY SITES BY DEVELOPER

Developer	Location	Size
Cypress Creek Renewables	Baker Point, MD	60 acres
	Empire, MN	120 acres
	Poughkeepsie, NY	20 acres
	Jefferson, NY	11 acres
	New York Portfolio	
Encore Renewables – Bee the Change	Middlebury, VT	500 kW, 4 acres
	Middlebury, VT	500 kW, 400 acres
Connexus Energy	Ramsey, MN	
Grassroots Solar	Dorset, VT	
	Pawlet, VT	
Green Lantern Group - Bee the Change	New Haven	500 kW, 4 acres
GroSolar – GMP, ArrowWood, SE Group	Williston, VT	4.7 MW-AC, 25-30 acres
	Richmond, VT	2.0 MW-AC, 10-12 acres
	Hartford, VT	4.99 MW-AC, 25-30 acres
	Panton, VT	4.9 MW-AC, 25-30 acres
	Williamstown, VT	4.99 MW-AC, 25-30 acres
All-Earth Renewables – Bee the Change	Burlington, VT – Rock Point School	142 kW, 1 acre
Ben & Jerry’s	Waterbury, VT	500 kW, 4 acres
Mont Vert – Bee the Change	Proctor, VT	66 kW, 0.5 acres
Soveren Solar – VSECU Project	Guilford, VT	500 kW, 4 acres
Vermont Community Solar – Brattleboro Management Company	Guilford, VT	500 kW, 3.1 acres
North Star Solar	Marshall, MN	100 MW, 1000 acres
Aurora Solar (Enel Green Power)	MN (20 locations)	100 MW, 1000 acres
Minnesota Power	Camp Riley, MN	10 MW, 62 acres
Marshall Solar (NextEra Energy)	Marshall, MN	60 MW, 400 acres
NRG	MN portfolio	
IPS	MN portfolio	
US Solar	MN portfolio	
Dairyland Power	WN	Numerous sites
Alliant Energy	Dubuque, IA	
Nebraska Public Power District	NE	53 acres

EXHIBIT 2 - CONTACT DIRECTORY

Name	**Title**	**Reference Annotation**
Bryanna Glod	Senior Director, Development	C1
Ethan Case	Policy Manager	C2
David Wagner	Senior Project Manager, EPC	C3
Marisa Scavo	Senior Zoning Manager, Development	C4
Cate Parker	Regional Zoning Manager, Development	C5
Justin Amason	Operation Manager, O&M	C6
Sazzy Gourley	Intern, Development	C7
Harry Johnson	Senior Economic & Community Development Advisor	C8
Shane Shields	Senior Zoning Manager, Development	C9
Amanda Fornelli	Project Manager, Development	C10
Kevin Borgia	Midwest Policy Director	C11
Amy Berg Pickett	Regional Zoning & Outreach Manager, Development	C12
Andrew Sundling	Project Manager, Acquisitions	C13
Rob Davis	Director, Center for Pollinators in Energy	E1
Colleen Hollinger, Mike Evenocheck	Prairie Restorations Inc	E2
Chiara and Travis Bolton	Bolton Bees, Solar Honey Company	E3

*All reference annotations with a “C” are employees of Cypress Creek Renewables. All reference annotations with an “E” are external to Cypress Creek Renewables.

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