Mobilizing Finance for Land Conservation at the Energy-Land-Agriculture Nexus

Can Ecosystem Services Valuation Bring Additional Value Streams to Minnesota's Pollinator-Friendly Solar Industry?

Photo courtesy of Rob Davis, Fresh Energy

Whitney Mann, Katie Siegner, Maria Urrutia and **Scott Wentzell**

Yale Center for Business and the Environment

Yale SCHOOL OF FORESTRY & ENVIRONMENTAL STUDIES

ACKNOWLEDGMENTS

This work was supported by Yale Center for Business and the Environment.

The authors are Whitney Mann (Yale MEM 2019), Katie Siegner (Yale MEM 2019), Maria Urrutia (Yale MEM 2019), and Scott Wentzell (Yale MEM 2019).

Many people supported the ideas and effort that went into this paper. We would like to thank Stuart DeCew, executive director of the Yale Center for Business and the Environment (CBEY), for serving as the advisor to our independent study for the spring semester of 2019. Rob Davis, director of the Center for Pollinators in Energy at Fresh Energy, also provided invaluable advice and consultation as one of the primary thought leaders in the pollinator-friendly solar landscape. In collaboration with Rob, we organized a reception and panel discussion on solar land use best practices at Yale, and we would also like to thank the panelists involved in that agrivoltaics event for their thoughts and input on this work: Jordan Macknick, lead energy-water-land analyst at NREL; Gavin Meinschein, lead civil engineer at Engie; and Elysa Hammond, vice president of environmental stewardship at Clif Bar. We also benefited from conversations with several practitioners in the space, including Kevin Hackett, client strategy director at Native Energy; Marcus Krembs, director of sustainability at Enel; Olivia Eskew, sustainability and communications associate with Cypress Creek Renewables and Cate Parker, associate director of community partnerships with Cypress Creek Renewables; Mike Evenocheck, director of sales & marketing at Prairie Restoration; and Melissa Lewis, assistant section manager for the Minnesota Board of Water & Soil Resources.

The report was edited by Chris Lewis, news editor at Yale Center for Business and the Environment. The graphic design was created by Henk van Assen, Senior Critic at Yale University School of Art, together with Meghan Lynch and Izzy Natale, designers at HvADESIGN.

The authors thank these individuals for their valuable insights, support and assistance.

COPYRIGHT

December 2019

Introduction: Valuing the Co-Location of Solar Development

Siting solar projects is often complicated by land use tensions and trade-offs. At seven acres of land per megawatt of generating capacity, solar has a sizable land footprint — one that is only expected to grow as solar and renewables meet a larger share of U.S. energy needs. Given the climate imperative to transition to a zero-carbon energy mix, accommodating the land use requirements of large-scale solar projects is a critical component of renewable energy policy development. From a land use impact perspective, solar installations are relatively benign compared to other forms of development, and importantly, they can be designed to provide net benefits to surrounding ecosystems and communities. A growing body of research is exploring co-location opportunities on solar sites — from planting pollinator habitat to growing crops among the panels.

Pollinator-friendly solar development has taken root as one such co-location opportunity for solar projects. By planting deep-rooted perennial vegetation in and around solar panels, pollinator-friendly solar projects can provide a host of ecosystem services, including habitat for wild insect pollinators, groundwater recharge, reduced erosion, soil carbon sequestration and improved crop yields from the increase in pollination services. These benefits offer real value for a range of stakeholders, and yet are currently unmonetized by the traditional market forces that drive solar project development. Without guidance on how to fully account for the value of ecosystem service generation, uptake of pollinator-friendly solar projects lags behind what stakeholders might want or expect.

This financing gap is symptomatic of a broader theme across environmental markets: ecosystem services, or "environmental externalities," are challenging to internalize and are rarely monetized. Developing market mechanisms that value ecosystem services and unlock conservation finance could also bring unique sources of capital to pollinator-friendly solar development, helping to spur industry growth. In addition, the ecosystem service monetization strategies discussed in subsequent sections may have broader application for other types of conservation projects.


Photo courtesy of Rob Davis, Fresh Energy

This paper begins by reviewing the background and current status of pollinator-friendly solar development with a focus on progress in Minnesota. We then discuss the potential for ecosystem services valuation to incentivize pollinator-friendly solar projects by monetizing the environmental benefits that projects generate. Next, we review the potential of an ecosystem services market in Minnesota to meet the dual goals of improving the efficiency of statewide conservation spending and promoting

pollinator-friendly solar development. Finally, we present financial structures to advance land use best practices on solar sites. Our hypothesis is that efficiently integrating the value of ecosystem services with conventional solar project finance is the missing link for expanding pollinator-friendly solar development for the benefit of all stakeholders.

Pollinator-Friendly Solar Development

Pollinator-friendly solar refers to a vegetation management plan that solar developers can implement on project sites. Typically, the land cover under solar projects is gravel or turfgrass, neither of which provide much in the way of environmental benefits to the surrounding area. Pollinator-friendly solar projects plant a diverse seed mix of perennial grasses and wildflowers throughout the site, which provide a host of ecosystem services — most notably, as the name indicates, native plants create valuable and needed habitat for wild pollinators including bees and butterflies. The deep-rooted perennial vegetation also benefits the soil, water and surrounding environment in a variety of ways. The practice offers a potential win-win-win for multiple stakeholders; our paper investigates the extent of pollinator-friendly solar development in Minnesota and beyond, and how this kind of low-impact development can be more appropriately valued and encouraged by political and market forces.

Pollinator-Friendly Development in Minnesota

As large-scale solar spreads into the Midwest, the prospect of solar projects taking prime farmland out of production has provoked a new land-use tension. In recent years, this has manifested in Minnesota, a leading agricultural producer with a large and growing number of ground-mount solar installations. Recognizing the importance of sustaining both agriculture and clean energy in Minnesota, agricultural and energy stakeholders are collaborating to inform the way solar development takes shape in the state.

Fifty-four percent of Minnesota's total land area is farmland, and the state has a strong vested interest in maintaining agricultural production, its second-largest economic sector.[1] However, Minnesota farmers are currently faced with low commodity prices and increasing production costs, leaving many with negative net incomes even after government subsidies.[2] Additionally, between 1997 and 2012, Minnesota lost more than 1.5 million acres of farmland, according to the American Farmland Trust.[3] While some agricultural interests perceive solar development as yet another threat to farmland, an increasing number of farmers are turning to the sun as their next — and potentially far more lucrative

1 "Minnesota Agriculture: The Foundation of Minnesota's Economy," Minnesota Department of Agriculture, 2018, https://www.leg.state.mn.us/docs/2008/other/080928.pdf.

2 Kelly Asche, "The State of Rural Minnesota, 2019," Center for Rural Policy and Development, 2019, https://www.ruralmn.org/wp-content/uploads/2019/02/State-of-Rural-2019-Report.pdf.

3 Christopher Walljasper. "Disappearing Farmland: Small Towns Trade Farmland for Residential Development," Midwest Center for Investigative Reporting, 2018, https://investigatemidwest.org/2018/09/18/disappearing-farmland/.

— cash crop.[4] Solar developers in the Midwest often look to farmers as the primary land lessors for large-scale installations. The money from solar leases can provide an important additional income stream for farmers, serving as a de facto form of crop insurance in the event of a bad harvest or providing incomes to support less productive lands or lands idling to restore overworked soils. The benefits to farmers who lease land to solar developers rise exponentially when the solar installation is designed to restore and improve the health of the underlying soils, as is possible with solar land use best practices.

At the same time that agriculture is struggling, solar development in the state is booming. Minnesota has a 10% solar carve-out in its renewable portfolio standards (RPS) and a strong community solar program, which made it the third largest non-residential solar market in 2017.[5] By the end of 2018, solar capacity crossed the 1 gigawatt (GW) threshold and is poised for continued growth in the years ahead. For Minnesota to meet its 10% solar RPS, the state will need to install roughly 5 GW of new solar, which will require an estimated 35,000 acres of land — a small but non-negligible footprint relative to farmland. Adopting best practices for solar projects' vegetation management plans will be important for sustaining the growth of the two industries.

As solar development continues in Minnesota, diverse stakeholders should be engaged to advance sustainable land use practices. Farmers, local government officials, rural residents, energy interests and conservation organizations have various priorities when it comes to solar projects and land use impacts; many of those interests could be met by more thoughtful consideration of the multiple benefits and co-location possibilities that solar projects present.

In 2016, Minnesota passed the first voluntary pollinator-friendly solar standard in the United States and the state now has numerous such projects in operation and under development. The state's standard was bolstered by utility company Xcel Energy's announcement in 2018 that it would be requiring developers to submit vegetation management plans for all future solar requests-for-proposals (RFPs).[6] As pollinator-friendly solar projects spread, researchers and other stakeholders are beginning to more carefully quantify the types of environmental benefits that the perennial plant mixes can provide. In addition to pollinator habitat, deep-rooted grasses and wildflowers can improve water quality and quantity; build soil health and reduce soil erosion; and boost surrounding crop yields thanks to the pollination services provided by the more abundant insect pollinators.

4 Genevieve Bookwalter, "The Next Money Crop for Farmers: Solar Panels," The Washington Post, February 22, 2019, https://www.washingtonpost.com/business/economy/the-next-money-crop-for-farmers-solar-panels/2019/02/22/2cf99e8c-3601-11e9-854a-7a14d7fec96a_story.html?noredirect=on&utm_term=.51fd079a7b5a.

5 Cody Nelson, "Minnesota's Solar Capacity Jumped Almost 50 Percent Last Year." MPR, February 26, 2019, https://www.mprnews.org/story/2019/02/26/minnesotas-solar-capacity-jumped-almost-50-percent-last-year.

6 Catherine Morehouse, "In Bid to Help Bees, Xcel to Require Vegetation Disclosure in Solar RFPs," Utility Dive, October 12, 2018, https://www.utilitydive.com/news/in-bid-to-help-bees-xcel-to-require-vegetation-disclosure-in-solar-rfps/539521/.

Policy Support for Pollinator-Friendly Solar

The co-benefits of pollinator-friendly solar development have economic implications as well. Developers — and, by extension, project owners and investors — have the potential to realize private returns from the reduced operations and maintenance costs associated with the lower-maintenance perennial vegetation. Additionally, the cooler microclimate created by the plantings is associated with increased panel efficiency and thus higher project revenues. Farmers with land near project sites could also see a financial upside, if they plant pollinator-dependent crops on abutting land. At no additional cost, farmers can reap the benefits of improved crop yields generated by the increase in wild insect pollinators. Finally, the aesthetic appeal of pollinator-friendly projects can help streamline local permitting and build community approval for the project, reducing solar development soft costs.

Given the environmental and economic benefits on the table, pollinator-friendly solar development is a practice that should be encouraged throughout the solar industry. However, despite the potential for private benefits, few developers are taking initiative to build perennial vegetation management plans into projects in the absence of a policy push. This suggests the presence of behavioral failures, as well as the uncertainty and greater upfront costs associated with a relatively novel practice in a traditionally risk-averse industry.

Targeted policy interventions could pave the way for more pollinator-friendly solar practices. As a first step to filling the education gap, policies that support research and development, stakeholder engagement, and demonstration projects could help build awareness of pollinator-friendly solar in both energy and agricultural/land use communities. Thinking beyond the voluntary standards that several states have passed, states or utilities could mandate pollinator-friendly solar practices. Xcel's move to require vegetation management plans in all future solar RFPs is a move in that direction. Additionally, state agencies or regulatory authorities could provide incentives such as fast-tracked permitting for solar developers that commit to pollinator-friendly projects. However, in considering the most efficient and effective policy interventions, it is important to understand the location-specific benefits that the projects could provide, both economically and environmentally. Pollinator-friendly solar projects that are incentivized according to the value of the ecosystem services they provide offer a promising model for efficient policy design.

A specialized solar renewable energy credit could accommodate such a targeted incentive. Research and modeling efforts have potential to quantify the monetary value of ecosystem services that a pollinator-friendly solar project provides per unit of energy output. Our team's 2018 cost-benefit assessment of pollinator-friendly solar revealed an estimated value of $0.20-2.80 per megawatt-hour (MWh), mostly driven by the pollination services that these projects provide.[7] That dollar-per-MWh adder

7 The lower values in the range reflect when a pollinator-friendly solar array is sited near corn, which is not pollinator-dependent, versus soy or other crops, which would see yield increases thanks to pollination.

could be included on top of the renewable energy credit values that a project is eligible for, as states like Massachusetts have done with its Solar Massachusetts Renewable Target program to encourage low-impact solar development.[8] In addition to entering into solar renewable energy credit compliance markets, these "sweetened" solar credits might also find willing buyers in voluntary markets, where companies with strong sustainability principles may pay a premium for the additional environmental benefits that pollinator-friendly solar provides.

Another critical policy question is the appropriate duration of the incentive, and whether it should be a one-time up-front payment or a performance-based, longer-term cash flow. Arguments exist for either side. Given the greater investment of time and money required to develop a solar project as pollinator-friendly, an up-front payment might best reduce that hurdle; additionally, developers will realize operations and maintenance cost savings throughout the life of the project, reducing their need for ongoing value streams. However, in order for the ecosystem services of such a project to be realized, the developer must be committed to the upkeep and monitoring of the perennial vegetation, which supports the case for ongoing incentives. As it stands, the science and research needed to accurately value the environmental benefits of pollinator-friendly solar projects are nascent; however, the ongoing National Renewable Energy Laboratory (NREL) InSPIRE study (Innovative Site Preparation and Impact Reduction on the Environment) is working to better quantify the environmental, social and economic costs and benefits associated with these projects.

We now review what pollinator-friendly solar projects look like in practice, before turning to an exploration of ecosystem services valuation and "payment for ecosystem services" models, as they might apply to the solar space.

Case Studies: Pollinator-Friendly Solar Projects in Practice

The two case studies below showcase how specific pollinator-friendly projects have unfolded on the ground, to illustrate the multiple stakeholders involved and how they engage in the development process. As noted above, pollinator-friendly solar has the potential to drive benefits for a range of stakeholders and sectors, including environmental, agricultural and community interests. In addition to these projects, other pollinator-friendly solar arrays have incorporated novel stakeholders and value streams such as beekeepers siting their apiaries on-site, allowing either the developer or beekeeper to market the honey as a value-added product. Craft brewers in Minnesota and Vermont have also incorporated honey produced on pollinator-friendly solar sites into their beer. Beyond the stakeholders that are currently engaged, we see potential for pollinator-friendly solar to bring new collaborations across land, energy and agricultural sectors.

8 Massachusetts Department of Energy Resources, "Solar Massachusetts Renewable Target (SMART) Program Summary," presented at Creating a Clean, Affordable, and Resilient Energy Future for the Commonwealth, April 26 2018, https://www.mass.gov/files/documents/2018/04/26/SMART%20Program%20Overview%20042618.pdf.

Aurora Solar Project

SIZE: 150 MW
DEVELOPER: ENEL GREEN POWER NORTH AMERICA
LOCATION: MINNESOTA

As Enel Green Power was in the process of developing its 150-MW Aurora Solar Project, situated across 16 sites in Minnesota, the developer learned of the state's intention to pass a voluntary pollinator-friendly solar standard. Enel had been considering their vegetation management plan at the time, and their environmental permitting lead took steps to engage with the Minnesota Department of Natural Resources as well as the Department of Agriculture on the standard's development. In addition to these state stakeholders, Minnesota research and academic institutions weighed in on both the standard and Enel's vegetation management plan.

Researchers at an Aurora solar site.
Photo: National Renewable Energy Laboratory

Once Enel committed to a pollinator-friendly vegetation plan, restoration company Minnesota Native Landscapes helped shape the specifics of the seed mix and management plan. (Native landscaping companies are critical stakeholders and local partners in these projects, as they are typically responsible for site preparation and management during the initial years of the project, when the vegetation is becoming established.)

Throughout the project development process, Enel also conducted outreach with local officials, who raised questions and concerns about the project's footprint and land use impact. Despite the fact that a project of that size is ultimately permitted at the state level, Enel entered into several side agreements with local governments to ensure their concerns were addressed. The Aurora Solar Project has been operational since 2017, and the sites have been seeded with pollinator-friendly vegetation for over a year now. More recently, Enel entered into a research agreement with NREL and Argonne National Labs to study the impacts of the vegetation selection and management practices on surrounding farms and ecosystems.

"Low-impact solar development, including native and pollinator-friendly vegetation practices, provides numerous, stacked benefits in the form of ecosystem services, operational efficiency and positive stakeholder relations." —Marcus Krembs, Director of Sustainability, Enel Green Power North America

Clif Bar Solar Project

SIZE: 2 MW
DEVELOPER: BORREGO SOLAR
LOCATION: IDAHO

Clif Bar's solar project alongside educational signage. Photo courtesy of Clif Bar & Co.

Clif Bar's support for an on-site pollinator-friendly solar project is an example of how private businesses can contribute to the expansion of pollinator-friendly development practices into new markets. The 2 MW solar project the company is building adjacent to their bakery is the largest behind-the-meter, customer-owned solar project in the local utility service area, and will provide 30% of the electricity demand for the facility.

According to Elysa Hammond, Clif Bar's vice president of environmental stewardship, the company's motivation to build this pollinator-friendly solar array is to continue reducing their environmental footprint as well as "to create a bakery that thinks like a tree — running on solar energy, recycling waste and sustaining its community." This solar project is thus one component in a suite of environmental initiatives at the facility, including using only organic ingredients and helping employees to purchase and drive fuel-efficient hybrid and electric vehicles.

The pollinator-friendly solar array is also being designed as an education center: the installation will include a trail through the array, allowing students and other community members to visit and learn about the project.

Clif Bar is also planning to partner with research centers like NREL and leading nonprofits like Fresh Energy for guidance as they work with a landscaping company on the native plant seed mix for the array. Once the array is seeded, the perennial vegetation will replace the bare ground visible in the photo above. Additionally, Clif Bar plans to offer pollinator-friendly habitat seeds to visitors in order to further attract monarch butterflies — the state insect of Idaho — to the area. Ultimately, Clif Bar hopes that the construction of this project will push Idaho Power, the state utility, as well as other private companies and community members to support pollinator-friendly solar and spur its widespread adoption throughout the state.

The focus for the remainder of this paper is on bringing conservation finance and payment for ecosystem service strategies into the solar development arena, to accelerate and scale pollinator-friendly practices on solar sites.

Valuing Ecosystem Services

Planting deep-rooted perennial vegetation for pollinator habitat can enable and reinforce a variety of ecosystem services. Ecosystem services can be understood as the benefits that nature provides to society. For example, deep-rooted vegetation is known to improve soil health, which supports crop production and can help increase food security. Healthier soils also reduce topsoil erosion, improve water quality and increase groundwater recharge, restoring water stocks for drinking and irrigation. All of these ecosystem services deliver monetary value — for example, increases in farmer income, decreases in municipal water treatment bills — and yet they are not valued by traditional economic markets. Without appropriate market signals, policies, incentives and investments often lag behind what would be required to protect natural capital resources and conserve an efficient level of ecosystem services.[9]

Land use decisions, such as between agriculture, conservation or other uses, are thus blurred by inadequate evaluation of non-market ecosystem services. As Johnson et al. point out, "intensive provision of one service, such as crops, almost always is associated with lower provisions of other services. Thorough evaluation of tradeoffs among market and non-market agricultural ecosystem services, both now and in the uncertain future, can inform policies and decisions that support multifunctional agricultural systems that provide a suite of ecosystem services."

Accordingly, improved valuation and accounting of ecosystem services is a necessary foundation for economically and ecologically efficient land use planning and decision-making.

Yet, there are a number of challenges in assigning a fair price to ecosystem services. First, ecosystem services are highly dependent on spatial variability in climate and landscapes. Differences in soil type, topography and watershed characteristics impact the amount and type of ecosystem services an area is capable of providing. For example, converting a plot of land from gravel to native vegetation near a river's headwaters will lead to multiple benefits, such as nutrient reduction and moderated streamflow, to be realized by stakeholders along the river's length. Converting the same plot of land at the mouth of the river, however, would have a smaller absolute impact for fewer stakeholders.

9 Kris A. Johnson, Stephen Polasky, Erik Nelson, and Derric Pennington, "Uncertainty in Ecosystem Services Valuation and Implications for Assessing Land Use Tradeoffs: An Agricultural Case Study in the Minnesota River Basin," Ecological Economics 79 (July 2012): 71-79, https://www.sciencedirect.com/science/article/pii/S0921800912001887.


Photo courtesy of Rob Davis, Fresh Energy

Another factor challenging the valuation of competing land uses is that ecosystem service benefits often accrue both within and outside of the plot of land being used. Consider again the example of land conservation efforts near a river's headwaters. Interventions such as planting riparian buffers or reducing nutrient use upstream will deliver ecosystem service benefits to landowners downstream. These downstream beneficiaries might reside in a different municipality or even a different state than that of the original intervention site. This separation poses a free rider challenge for projects that provide widespread ecosystem improvements: current policies or markets — to the extent they exist — are rarely structured to connect upstream interventions to their downstream beneficiaries.

Finally, ecosystem services are not necessarily realized in a consistent, streamlined fashion. After converting a plot of land from intensive agriculture to native vegetation (in conjunction with a pollinator-friendly solar project, for example) ecosystem service benefits will accrue at an increasing rate as the plants establish and grow in the depleted soils. Those benefits would then be expected to level off and stabilize over time. Further, benefits like carbon sequestration may only be actively provided for a handful of years, while benefits like nutrient filtering and groundwater recharge would persist for as long as the vegetation is maintained. Distinguishing the time-varying impacts of ecosystem service valuation adds another layer of complexity in identifying the best means to pay for these services.

Despite these complexities, the tools and requisite scientific understanding exist to quantify ecosystem services at a hyper-local and project-specific level. Tools such as the Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) model developed by Stanford University's Natural Capital Project and the U.S. Geological Survey use complex geospatial analysis to evaluate an array of ecosystem services with a high degree of granularity.[10] InVEST allows for comparison of ecosystem services across a range of land use and management practices — as well as improved understanding of costs and benefits over time that result from various land management practices.

The InVEST model is an effective desktop tool for quantifying land, water and carbon benefits that may result from land management practices. On-the-ground research at NREL and other academic institutions is currently underway, though, to help to fill the gap on quantifying the specific ecosystem services provided by pollinator-friendly solar projects. The Innovative Site Preparation and Impact Reduction on the Environment (InSPIRE) study is one prominent example. InSPIRE is a collaboration

10 Richard Sharp et al., "InVEST User Guide," The Natural Capital Project, Stanford University, University of Minnesota, The Nature Conservancy, and World Wildlife Fund, 2018, http://releases.naturalcapitalproject.org/invest-userguide/latest/.

between NREL, Argonne National Laboratory, academic institutions, industry leaders, and numerous other organizations that "seeks to improve the environmental compatibility and mutual benefits of solar development with agriculture and native landscapes."[11] Through a series of controlled test plots at existing solar facilities, the InSPIRE study seeks to inform best practices for co-locating solar development with other productive land uses, including pollinator-friendly plantings. A key output of the InSPIRE study will be a more nuanced understanding of the scale — and value — that the ecosystem services associated with pollinator-friendly solar provide.


Photo courtesy of Rob Davis, Fresh Energy

Research and quantification of ecosystem services is a critical first step to improved land use management policy and practice; however, scientific studies remain poorly integrated with economic markets. Across the board, studies are up-front in highlighting the uncertainties of ecosystem service valuation, which "stems from the standard problem in environmental economics of assessing non-market values."[12] A growing economic subfield focused on valuing natural capital is helping to bridge this divide, but for now, most land managers, planners and investors are left with little insight into stakeholders' willingness to pay for the ecosystem services provided by any given project.

The dollar value of various services will inevitably vary according to local environmental conditions and community demand for improved ecosystem outcomes. For these reasons and more, there is no single scientific approach that would allow for a definitive valuation of ecosystem services. In short, it is impractical to expect that arbitrarily monetized ecosystem services would result in private transactions between providers and beneficiaries. Without an established market for monetizing and selling ecosystem services, it can be challenging to appropriately incentivize optimal landscape interventions. This is a potential barrier for the large-scale dissemination of pollinator-friendly solar projects.

The following section will begin by discussing the current status of conservation funding in Minnesota, which is largely independent of and uninfluenced by ongoing ecosystem service valuation studies. This presents a thorny question for the valuation of environmental benefits stemming from projects such as pollinator-friendly solar: "[If] we often lack good signals for the relative value of non-market ecosystem services and habitat conservation, should controversial or imprecise estimates of marginal

11 "DOE InSPIRE Project Overview," National Renewable Energy Laboratory, 2018, https://openei.org/wiki/InSPIRE/Project.

12 Stephen Polasky, Erik Nelson, Derric Pennington, and Kris A. Johnson, "The Impact of Land-Use Change on Ecosystem Services, Biodiversity and Returns to Landowners: A Case Study in the State of Minnesota," Environmental Resource Economics 48 (2011): 219-42, http://cedarcreek.umn.edu/biblio/fulltext/Environmental_and_Resource_Economics_2011_Polasky.pdf.


Photo courtesy of Rob Davis, Fresh Energy

value be used? Or should ecosystem services and habitat conservation measures that lack robust estimates of marginal value be excluded from the accounting of net benefits?"[13] Following an overview of conservation finance in Minnesota, we introduce how a new ecosystem service market model could help improve funding efficiency.

A Market for Ecosystem Services in Minnesota

Conservation Finance

Financial resources for land conservation to protect Minnesota's soil, water and other natural resources are available at the national, state and local levels. This section will introduce sources of conservation finance in Minnesota whose funding allocation goals align with the ecosystem service value that pollinator-friendly solar projects could provide. The intent is to highlight opportunities for strategic collaboration between Minnesota's existing conservation efforts and pollinator-friendly solar initiatives.

Minnesota is divided into 90 Soil & Water Conservation Districts[14] and 46 Watershed Districts[15] that establish natural resource goals and help funnel funds from federal and state governments to local landowners. At the federal level, funds for projects that improve water quality are available through programs like the Federal Clean Water Act Section 319 Program, which supports efforts to protect water quality and establish Total Maximum Daily Loads. Other federal programs include the Agriculture Best Management Practices Loan Program, which facilitates low-interest loans to landowners to prevent runoff, and the Natural Resources Conservation Service's Environmental Quality Incentives Program, which supports farmers in addressing natural resource concerns such as water and air quality, groundwater, soil erosion, and wildlife habitat.

13 Kent Kovacs et al., "Evaluating the Return in Ecosystem Services from Investment in Public Land Acquisitions." PLoS ONE 8, no. 6 (June 2013): https://doi.org/10.1371/journal.pone.0062202.

14 Soil & Water Conservation Districts are units of local government that connect landowners with financial resources and technical assistance to support management of natural resource programs.

15 Watershed districts govern freshwater resources according to naturally-defined watershed boundaries.

At the state level, Minnesota taxpayers finance two primary mechanisms for natural resource conservation. The Environment & Natural Resources Trust Fund has provided $500 million to roughly 1,000 projects statewide since its first implementation in 1991. The fund's Legislative-Citizen Commission on Minnesota Resources (LCCMR) issues an annual RFP "open to everyone with innovative ideas for environment and natural resources projects that could provide multiple ecological and other public benefits." The commission then ranks projects according to a strategic plan and submits recommendations to the Minnesota House and Senate for approval. LCCMR priority project areas include land use practices, habitat degradation and energy production. The fund fulfills around 40% of the approximately 180 funding requests received annually, providing an average of $40 million per year to resource conservation projects across Minnesota.[16]

Additionally, in 2008, Minnesota voters passed the Clean Water, Land, and Legacy Amendment to raise revenue for conservation through a tax increase. One third of this revenue is allocated to the state's Clean Water Fund to "protect, enhance, and restore water quality in lakes, rivers, and streams and to protect groundwater from degradation"; another third is allocated to the Outdoor Heritage Fund to be spent "only to restore, protect, and enhance wetlands, prairies, forest and habitat for fish, game, and wildlife."[17] Clean Water Fund and Outdoor Heritage Fund resources are allocated by the Board of Water and Soil Resources and the Lessard-Sams Outdoor Heritage Council, respectively, through RFP processes.[18]

While Minnesota has significant programming and resources available for conservation, the opportunities are uncoordinated and can be difficult to navigate. Additionally, the resources are insufficient to cover statewide demand. The Minnesota Pollution Control Agency reports that for nonpoint source pollution watershed projects implemented in Minnesota since 2010, roughly one third of funding has been federal, 15% has been from state funds, 5% from local resources, and nearly half (47%) has been financed by landowners.[19]

In addition to governmental and quasi-public funding sources, numerous private and public-interest groups are engaged in funding environmental conservation and remediation efforts in the state. Foundations, corporations and private philanthropists invest in both conservation and ecosystem services initiatives. Conservation-focused nonprofits raise money to reinvest those dollars in projects on water conservation, water quality benefits, erosion prevention and countless other ecosystem services. Land trusts acquire and set aside tracts of land for conservation and preservation. Despite a wide array of

16 "Proposal & Funding Process," Legislative-Citizen Commission on Minnesota Resources, 2019, https://www.lccmr.leg.mn/funding_process/process_main.html.

17 "Outdoor Heritage Fund," Minnesota's Legacy, accessed November 13, 2019, https://www.legacy.mn.gov/outdoor-heritage-fund.

18 "Outdoor Heritage Fund."

19 "Spending for Watershed Implementation Projects," Minnesota Pollution Control Agency, 2018, https://www.pca.state.mn.us/water/spending-watershed-implementation-projects.

potential funders with vested interest in paying for ecosystem services, connecting these funders with projects that can deliver improved ecosystem services remains a challenge.

One promising example of a multi-stakeholder effort to create a payment for ecosystem services system in the Midwest is the Ecosystem Services Market Consortium, which brings together researchers, farmers, corporations and nonprofits to develop, study and fund projects that promote soil health. The Consortium launched in February of 2019 and plans to implement pilot projects across the United States through 2021.[20]


Photo courtesy of Rob Davis, Fresh Energy

CONSERVATION FUNDERS IN MINNESOTA

Overall, Minnesota makes considerable funds available to protect its natural resources, but a lack of coordination between funding sources discourages private investors from participating in conservation financing and masks market indicators of true ecosystem service value. A dedicated, open marketplace for buying and selling ecosystem services could facilitate more streamlined transactions between parties. It could also incentive private investment for projects like pollinator-friendly solar that generate ecosystem services, and catalyze progress toward statewide conservation goals through more efficient financing.

Prioritizing transparency and liquidity through a market-based system has the potential to improve environmental outcomes, increase private funding in conservation financing and accelerate projects. This system could take the form of a clearinghouse or auction model that serves as a platform for connecting actors who can deliver ecosystem services with those who are interested in paying for those services.

Making the Case for an Ecosystem Services Market

A market-based system can address a number of shortcomings in the valuation and provision of ecosystem services — as well as optimize the benefits of pollinator-friendly solar development. In later sections, we will explore some of the formats and structural designs such a market could assume. This

20 "Timeline," Ecosystem Services Market Consortium, accessed October 6, 2019, https://ecosystemservicesmarket.org/.

section will highlight the benefits of a market system, particularly for the case of pollinator-friendly solar development in Minnesota.[21]

Streamlined financial resources: Resources for conservation in Minnesota are spread across public and private sources and can be difficult to identify and navigate. Designing a platform to aggregate resources will make them more accessible to individuals and entities interested in implementing conservation projects in the state. Further, resources are currently allocated on an all-or-nothing project basis, and landowners are usually left as the primary financiers of conservation projects on agricultural lands. Combining resources from multiple sources could contribute to financing more projects on the margin.

Enabling multi-stakeholder participation to increase demand: Each conservation fund in Minnesota is guided by a unique strategy and set of priorities. Similarly, private organizations may be interested in supporting a subset of specific ecosystem services according to their stewardship goals. A well-structured market for ecosystem services can accommodate diverse stakeholders with multiple motivations for paying to protect the ecosystem services in question. Aggregating funds from various financiers can support a greater diversity of conservation projects.


Photo courtesy of Rob Davis, Fresh Energy

Aggregation of ecosystem services to increase supply: On the supply side, aggregating conservation projects and breaking out the ecosystem services enabled by each will provide a platform to better connect ecosystem service efforts with funding. For example, any single pollinator-friendly solar project, depending on size, may not realize valuable enough ecosystem services to merit the transaction costs of identifying stakeholders willing to pay for those services. But pooling projects increases market liquidity and permits participation of small and large financial players. Aggregation also decreases investor risk. In other words, through a market platform, a corporation interested in streamflow restoration might finance a portfolio of streamflow protection projects across the state, improving their chances of realizing their stewardship goals compared to acting as the sole investor in one or two projects.

Optimized conservation funding: A more liquid market for ecosystem services through streamlined funding and multi-stakeholder participation will help ensure conservation funds in Minnesota are allocated to the least costly, most impactful land use interventions. A well-functioning market could better showcase the world of possible conservation measures to achieve statewide goals around natural resources and highlight the path to deliver those with most benefit at least cost to Minnesota taxpayers.

21 Pollinator-friendly solar may be a strong candidate to pilot a proposed market for ecosystem services, but the fundamentals of the program are transferable to land conservation programs and practices more broadly.

Breaking through geographic barriers: A market platform would facilitate payments across districts, watersheds, and other socio-geographical boundaries. For instance, Louisiana conservation funders — interested in reducing the nutrient loading in Mississippi headwaters that contributes to hypoxia downstream — could finance the creation of buffer strips on Minnesota farms. National organizations looking to contribute to carbon reduction through soil sequestration might seek to fund farmers' efforts to build soil carbon in certain favorable geographies.


Photo courtesy of Rob Davis, Fresh Energy

Scaling pollinator-friendly project impacts: Multi-stakeholder input through a market exchange will illuminate the specific ecosystem service outcomes stakeholders want to see most, and the regions where they want to see them provided. Preferences communicated through spatially specific bids can incentivize pollinator-friendly solar developers to site projects where they will realize the most benefit. For instance, through a market platform, developers might learn that establishing pollinator-friendly vegetation on a particular site might create a habitat corridor, and as such, conservation groups might be interested in paying more to support a pollinator-friendly project on that land. Furthermore, developers face a decision between a range of native seed mixes whose ability to restore ecosystem functioning generally increases with cost. Without funding from groups interested in ecosystem services, developers will likely choose the least costly seed mix to comply with pollinator-friendly standards. However, connecting developers with willing financiers can help maximize the impact of pollinator-friendly solar projects since the market would provide a platform that communicates willingness to pay for the added benefit of higher cost seed mixes and inform a more comprehensive cost-benefit analysis around solar projects' vegetation management decisions.

Removing the burden of land conservation from farmers: Traditionally, auctions for ecosystem service grants have relied on farmers to submit bids and commit to implementing land conservation efforts. Providing solar developers an incentive to implement beneficial land use practices can spread this responsibility and grow the community of sustainable land managers.

Contributions to ecosystem service valuation research: While the conservation community struggles to identify a robust method to evaluate ecosystem services for policy design, a market that breaks down conservation projects by regional ecosystem services can provide information on ecosystem service valuation through *revealed preference* findings.

There is clear potential to create additional value and liquidity through ecosystem service markets. The following section explores the potential motivations of various Minnesota stakeholders for participating

in such a market, and, to the extent possible, quantifies each stakeholder's aggregate potential funding capacity.

Market Participants

Potential participants in an ecosystem services market in Minnesota are similar to the existing participants in conservation efforts, and include government agencies, nonprofits, foundations, land trusts, companies and farmers. However, based on their mission and capacity, stakeholders' participation will vary depending on the environmental services and benefits such a market would provide.

The table below presents a stakeholder map that outlines the various ecosystem services that different stakeholders value and might potentially finance through a market mechanism. This qualitative description is guided by the amount of funding available from each stakeholder in Minnesota, based on initial research. Detailed information about potential participants, their projects, and available funds can be found in Table 1 in the Appendix section.

The previous sections have reviewed the science and economics of a market for ecosystem services in Minnesota, along with potential participants in it. In the remaining sections, we propose a suite of potential mechanisms for this market that could be implemented to appropriately value and incentivize the environmental benefits that pollinator-friendly solar projects — as well as other land stewardship projects — provide.

ECOSYSTEM BENEFITS AND STAKEHOLDER MAP

Stakeholder	Groundwater Recharge	Avoided Carbon Emissions & Carbon Sequestration	Pollinator Habitat	Avoided Soil Erosion
Govt agencies				
NGOs				
Private companies				
Foundations				
Land trusts				
Farmers/ landowners				

LEGEND

$10 million or more	
Less than $10 million	
No Data	

Auction and Market Structures

An auction or marketplace to price ecosystem services and incentivize their conservation could assume a number of formats contingent on stakeholder participation and preferences. In this section, we will explore fundamental market components, introduce potential structures, consider preliminary design factors and discuss trade-offs. We do not promote one model over another, and we recognize that this is not an exhaustive list of possible structures and important considerations in market design.

Supply and Demand Bids

In any of the ecosystem service market formats we consider, bids are specific to geography, ecosystem service and the timeline over which ecosystem services are realized. Locational and time-based specifications of bids are revealed through ecological modeling programs, like Stanford's InVEST, based on site and project characteristics. There are two types of bids: 1) "supply bids" from entities developing or financing land use changes that might generate ecosystem service value, and 2) "demand bids" from entities looking to support specific ecosystem services. Supply bids may come from pollinator-friendly solar developers, investors or holding companies. Demand bids could stem from any of the conservation stakeholders outlined in preceding sections.

In general, supply bids specify the minimum price the bidder is willing to accept for an ecosystem service generated in a specific region over a given time period by a project they own or are considering developing. For example, a pollinator-friendly solar developer could offer a supply bid for groundwater recharge in the Rock River watershed of the Missouri River Basin. This bid might supply 1 acre-foot of groundwater recharge per year for years 3-5 of project operation, and 2 acre-feet of groundwater recharge per year for years 6-20 of project operation, at a certain price per acre-foot of groundwater.

Demand bids specify the maximum price the bidder is willing to pay for an ecosystem service generated in a specific region over a given time period. For example, a conservation group could offer a demand bid for 5 tons of soil carbon sequestration annually for 10 years from anywhere in the state of Minnesota, at a certain price per ton of carbon sequestered. Market bids clear when a supply bid price is less than or equal to a demand bid price for the same ecosystem service in the same region.

Photo courtesy of Rob Davis, Fresh Energy

Market and Auction Formats

One potential market format is a trading platform where supply and demand bids are entered and clear on a continuous basis. Such an open exchange would offer ongoing transparency to support planning processes for developers. Alternately, auction events could be held sporadically at predefined intervals. Some popular auction formats include sealed bid auctions, wherein bidding entities do not have any information about their competition, and clock auctions, where prices increase or decrease over a series of rounds and bidders can adjust bid volumes and prices strategically according to information about their competition.

For auction models, primary decisions informing design should address the related issues of who bids first and what is auctioned. In other words, the products being auctioned could be ecosystem services or funding for ecosystem services. For example, consider an auction where the product is funding for ecosystem services. In such an auction, demand for ecosystem services would first be aggregated in the form of how much stakeholders are willing to pay for ecosystem services, and then suppliers would submit bids to access the funds; the supply bidders willing to accept the lowest payments to develop or finance projects that realize ecosystem services where they are being demanded will "win."

This type of added financial incentive would help developers overcome the initial cost hurdle associated with the more time-consuming and expensive establishment of pollinator-friendly vegetation mixes, compared to turf grass or gravel. Developers who have a head-start on pollinator-friendly solar development practices, or who experience lower project costs, might have the advantage of bidding low and thus attracting the necessary environmental equity to finance pollinator-friendly solar projects at upfront-cost-parity with conventional solar. Advancing pollinator-friendly solar projects through this sort of incentive model could help drive down costs of realizing Minnesota's conservation and clean energy goals.

Timing and Monitoring of Auction Products

We expect that bidders in an auction or market will have different preferences related to timing of payments for ecosystem services realized over a project's lifetime as well as for monitoring to ensure performance. Some stakeholders might prefer a pay-for-performance structure that facilitates paying for ecosystem services annually as they are realized by projects. Other stakeholders might be comfortable relying on upfront modeling predictions and prefer to finance ongoing ecosystem services up-front; for instance, companies hoping to demonstrate environmental impact in an annual report may prefer this option, so they can share the story of how they financed a new pollinator-friendly solar project.

As we have noted, attributing ecosystem service generation over time to any given land use is highly complex. It is also exacerbated by the challenge of disentangling the impacts of climate change and

other land use changes. Accordingly, project monitoring could add considerable resource requirements, if it is highly valued by participating stakeholders. At the same time, one benefit of a market for ecosystem services is the flexibility to accommodate non-conforming bids from a variety of diverse stakeholders. Aggregating the diversity of financing preferences can help catalyze more development by building flexibility into potential payment streams across demand bids with a range of constraints.

Trade-Offs Between Market Formats

Auction and marketplace formats face trade-offs across a number of considerations. One key trade-off is administrative costs and the time and resources required to implement different formats. There are a number of entities who could serve as market administrators, including third-party consultants, publicly funded research institutions or government agencies. Administrators should be well-connected to potential market participants, objective, credible and capable. Specifically, they should possess the capacity to recruit market participants, model ecosystem service production, clear transactions, administer contracts and disburse revenues. These requirements could be delegated between parties with the goal of minimizing program costs as well as transaction costs for participants. Markets for conservation finance and ecosystem services have historically suffered from low participation,[22] and as such, auction design should prioritize robust outreach to potential participants and low transaction costs. Finally, auction design will need to consider local laws and legislative processes to ensure transactions complement — and are permissible within — existing regulations.

In the remaining two sections we explore the link between potential ecosystem service markets and novel financial structures that would support participation of pollinator-friendly projects in such markets. We begin with an overview of traditional solar development and project financing and discuss how that structure may not adequately incentivize pollinator-friendly solar development. We close with an overview of alternative mechanisms that would better align incentives and promote the growth of pollinator-friendly solar development through the valuation of the ecosystem services that such projects deliver.

Solar Finance Structures

The solar industry has matured significantly over the last decade: solar development now occurs at scale in nearly every state in the country. According to NREL, the U.S. solar market reached $21 billion in 2018 and accounted for 23% of all new electricity generating capacity coming online.[23] As development

22 Leah Palm-Forster et al., "Using Conservation Auctions Informed by Environmental Performance Models to Reduce Agricultural Nutrient Flows into Lake Erie." Journal of Great Lakes Research 42, no. 6 (2016): 1357-71, https://www.sciencedirect.com/science/article/pii/S0380133016301447?via%3Dihub.

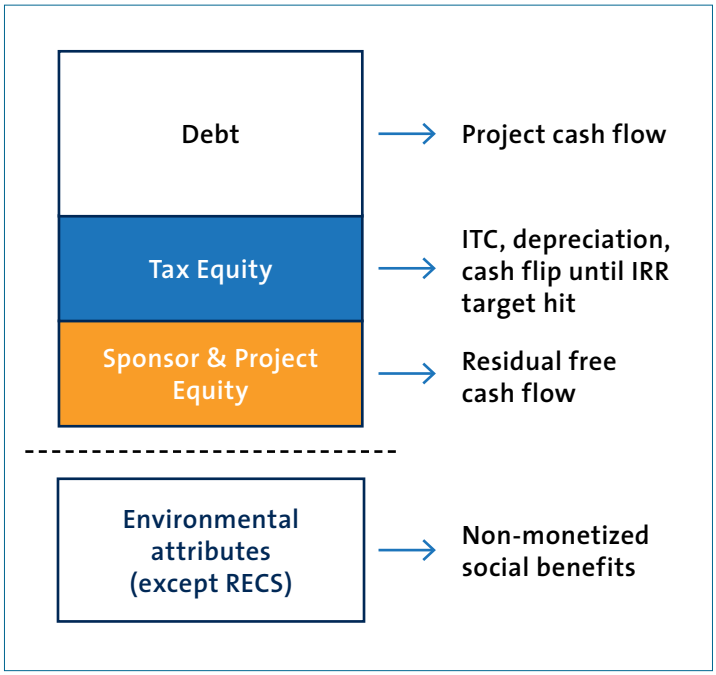
23 David Feldman, Anna Ebers and Robert Margolis, "Q3/Q4 Solar Industry Update," National Renewable Energy Laboratory, 2019, https://www.nrel.gov/docs/fy19osti/73234.pdf.


Photo courtesy of Rob Davis, Fresh Energy

has accelerated, so has the establishment of a robust and well-capitalized solar finance community, which includes both debt and equity providers. Many solar projects have been developed through project financing arrangements, a structure that allows for non-recourse lending serviced by project-level cash flows. This approach has lowered financing costs and attracted institutional equity providers. The figure below details this structure.

Traditional Solar Projects

Under the traditional solar development approach, a project developer raises capital in the market or from a private equity provider to fund the first stages of the project. That sponsor equity supports the team that identifies the project location, obtains the necessary site control and permitting, and secures interconnection with the electricity grid. This may be the riskiest stage in a solar project's evolution and thus equity investors seek a substantial return on their investment. While risky, development or sponsor equity represents a modest fraction of the total cost of a fully constructed solar project. Successful developers spend as little as possible until they believe the project is likely to move forward through construction.



A key milestone during the development stage is securing an offtake agreement with a utility or energy consumer that will purchase the electricity generated by the solar plant. The offtake agreement, or

power purchase agreement (PPA), is the sole source of revenue for most projects and typically sets a dollar value per unit of electricity generated ($/MWh). Additionally, the PPA often assigns the renewable energy credits (RECs) generated by the project to the offtaker, inherently or implicitly assigning a value to those credits. However, aside from the renewable energy attributes created by the project, the remaining environmental benefits remain unassigned and are unmonetized environmental externalities. While it is clear that pollinator-friendly projects produce valuable ecosystem services, these positive externalities are not accurately valued through the traditional solar project compensation mechanism — a PPA. This misalignment has implications for the remaining stages of development and the sources of capital that support each stage of project development, construction and operation.


Photo courtesy of Rob Davis, Fresh Energy

Once a project is ready to begin construction, developers raise additional capital and create a structure for long-term ownership of the asset. We walk through a simplified model of that structure here. An equity investor typically finances part of the project's construction and serves as the long-term asset owner with claims to all of the project's residual free cash flows (after servicing expenses, debt and taxes). These equity investors recover their upfront investment and obtain a return on their investment over time through dividends paid by the project. The dividends do not reflect the unmonetized value of the project's ecosystem services. As a result, most equity investors would not be compelled to provide a larger up-front investment (to cover the higher construction costs of pollinator-friendly solar projects) if their expected yield is not commensurately large enough to compensate for that investment. As discussed below, our modeling shows that pollinator-friendly projects have lower expected annual expenses, but that these costs savings alone may not justify the project's higher capital costs.[24]

In addition to equity investors, most solar projects take on debt to cover a portion of the upfront capital costs. Debt is raised based off the project's projected cash flows and is sized such that the debt can be serviced exclusively from the expected earnings before interest, taxes, depreciation and amortization or "EBITDA"[25] of the project. Since these cash flows also do not account for the unmonetized ecosystem services of a project, debt providers would not provide capital based on these services.

The final investor class providing capital to solar project developers is tax equity investors. The inclusion of a tax equity partner complicates the capital structure of a project, but is often necessary to take

24 Research indicates that pollinator-friendly vegetation growing beneath solar panels may help to create a cooler micro-climate, which improves the efficiency and energy output of the solar farm. If that efficiency improvement is less than 0.4%, a pollinator-friendly project's economic returns will be lower than the comparable traditionally constructed project. For simplicity, here we present analysis assuming no panel efficiency gains from pollinator-friendly vegetation.

25 EBITDA is effectively the cash a project generates after paying its expenses like maintenance.

advantage of the federal tax incentives offered to solar projects in the United States. The federal Investment Tax Credit (ITC) was established through the 2005 Energy Policy Act and creates a 30% tax credit based on the up-front capital costs of a solar project.[26] The credit serves as a dollar-for-dollar reduction on taxes owed to the federal government for eligible investors. For instance, if a project costs $100 million dollars to develop and construct, the ITC would allow a project's tax equity investor to reduce their taxes owed in that year by $30 million. Since tax equity investors receive the majority of their returns from tax benefits, accelerated depreciation and net operating losses, they have little interest or ability to value the ecosystem services delivered by pollinator-friendly solar development.

Challenges in Applying Traditional Finance to Pollinator-Friendly Solar Development

Along each step of the development process and across each class of capital provider, there is a fundamental disincentive to support pollinator-friendly solar development without either additional revenue, lower costs or policy intervention. While the project finance model has helped to finance gigawatts of solar projects in the United States over the past few decades, this traditional model may not be adequate to accommodate and incentivize sustainable land use best practices in solar development. In particular, the types of investors that have traditionally participated in project finance deals may not be the best positioned to value and monetize the unique environmental benefits and ecosystem services generated by pollinator-friendly solar projects.

The environmental benefits of pollinator-friendly solar accrue slowly over time and may depend on a variety of localized factors such as soil quality, weather, surrounding land uses and community interest. While quantifying the volume of ecosystem services provided may be possible, quantifying the dollar value of those services is a harder task. Given these uncertainties, it is unlikely that a traditional investor would allocate much value to social externalities without a clear path to value and monetize those benefits.

Previous research we conducted showed that pollinator-friendly solar projects have lower operations and maintenance costs compared to traditional solar projects. These cost savings offset a portion — but not necessarily all — of the additional capital costs associated with developing these projects. Our model showed an expected internal rate of return (IRR) for an equity investor in a traditional solar project in Minnesota of approximately 6.25%. A comparable pollinator-friendly solar project receiving no additional incentives would generate an IRR of approximately 6.0%. This is also assuming no panel efficiency gain stemming from the cooler microclimate produced by the perennial vegetation, an assumption that is being tested and quantified by ongoing research. The 25-basis-point spread between the two development practices is nontrivial and indicates it may be difficult to encourage broad adoption of pollinator-friendly practices without financial incentives, policy encouragement or other external drivers.

26 "Investment Tax Credit for Solar Power," *EnergySage*, 2019, https://www.energysage.com/solar/cost-benefit/solar-investment-tax-credit/.

While there is certainly a role for policy support to drive pollinator-friendly solar development, market forces could also encourage these development practices if the ecosystem services provided by such projects are appropriately valued. In order for this to happen, it will be critical to link the benefits generated by pollinator-friendly solar to willing financiers — such as through the market or auction models we suggest above. In the following section, we explore novel ownership models and investment strategies that can bridge the gap between traditional solar project finance and the conservation finance potential that accompanies pollinator-friendly solar projects, thus aligning financial and environmental interests.

New Ownership Structures

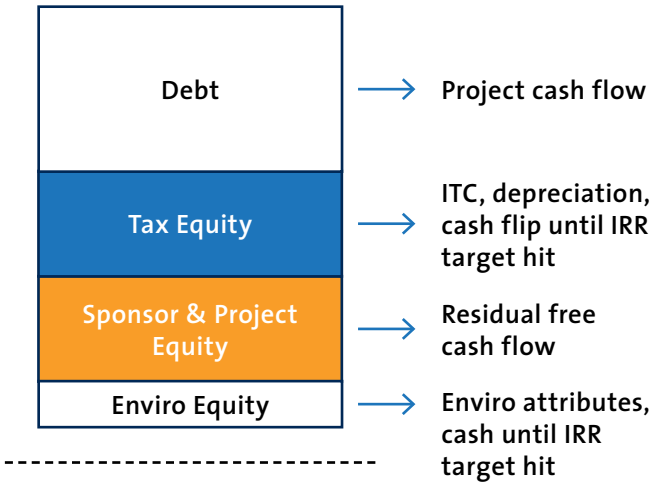
The creation of a trading house or auction system for ecosystem services does not remove all barriers to monetizing the environmental benefits generated by pollinator-friendly solar development. In particular, it is unlikely that traditional investors will be interested in accepting the risk of properly valuing and selling a novel environmental product with minimal transaction history and unknown liquidity. The types of capital providers that invest in renewable energy projects have a limited appetite for risk; thus, they would be unlikely to support pollinator-friendly development on the unproven assumption that ecosystem service payments would provide adequate additional revenue to increase the project's yield enough to justify the additional up-front capital costs. This misalignment indicates that there may be a need to bring in new types of investors to take on the risk of monetizing these benefits. Below we explore several such novel sources of project finance capital to support pollinator-friendly solar development.

ENVIRONMENTAL EQUITY INVESTORS

Social impact investors provide capital for companies and projects that generate social and environmental benefits, but that appear to be too risky or too illiquid for more mainstream equity providers.[27] The monetization of ecosystem services may be an appropriate investment vehicle for these types of investors. The environmental equity investor would make a relatively modest initial capital investment in a project to support the establishment of pollinator-friendly plantings during development. In turn, this investor would receive the environmental attributes generated from the project (excluding renewable energy credits) over time. These benefits could be sold to other parties for compliance or conservation purposes through the proposed market mechanisms introduced above. While the environmental equity provider's return would depend on the value the market placed on the project's ecosystem services, minimal required rates of return could also be included. For instance, the environmental equity investor could be entitled to a small fraction of the project's overall cash flow to ensure the investor recovers their investment over a set period of time.

27 Vivek Pandit and Toshan Tamhane, "A Closer Look at Impact Investing," *Mckinsey Quarterly*, 2018, https://www.mckinsey.com/industries/private-equity-and-principal-investors/our-insights/a-closer-look-at-impact-investing.

ENVIRONEMENTAL EQUITY



Environmental equity investor can lower WACC by taking "returns" via environmental attributes

PROS:

- Relatively small capital investment to unlock large benefits
- Potential financial upside for all equity investors
- Does not require additional policy changes

CONS:

- Requires established marketplace to monetize
- Further complicates project financing
- Depends on new, hypothetical equity provider (introduces uncertainty)

In order to align incentives for all investors in the project, the goal would be to raise enough environmental equity to reduce the traditional project equity provider's contribution to a level that will allow that investor to earn a return commensurate with typical solar developments. We have calculated that, on average in the state of Minnesota, the environmental equity capital contribution would need to cover 2.2% of the upfront capital costs of the project, or about $0.0235 per watt of installed capacity (this assumes the environmental equity investor receives no cash from the project).[28] This modest contribution would serve to de-risk the project and deliver a return to the traditional equity investor equal to the expected return of prevailing solar project finance.

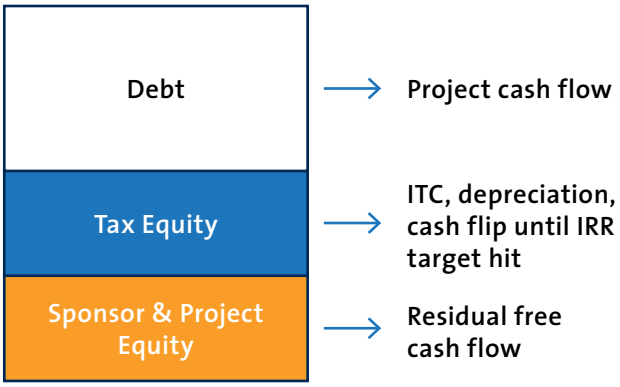
OFFTAKER CONTRACTS FOR ENVIRONMENTAL BENEFITS

Another approach, and perhaps the simplest, is for the monetization of ecosystem services through the offtake agreement. Current PPAs involve a purchase of both energy and renewable energy attributes. It is conceivable that in the future, additional environmental attributes stemming from pollinator-friendly projects may be quantified and allocated to the offtaker through the PPA. Effectively, the offtaker would agree to pay a small premium above the prevailing market rate for a solar contract that includes the rights to both the renewable energy attributes (RECs), but also all other environmental attributes

28 For all modeling in this section we assume that pollinator friendly solar projects have no increase in electricity output. However, there is compelling research indicating that native grasses may serve to cool the ambient air beneath the solar panels, boosting the efficiency of those panels.

of the project (for instance, soil carbon sequestration). Indications of offtaker willingness to pay include Xcel's recent move to consider vegetation management plans in future solar RFPs, and the move by the Electric Power Research Institute — a membership group representing 90% of the U.S. utility market — to establish its Power in Pollinators initiative. The higher PPA value would increase the project's revenue and allow the project's equity owners to achieve the yield required for them to support the pollinator-friendly project.

CONTRACT FOR ENVIRONMENTAL BENEFITS BY OFF-TAKER



Off-taker agrees to receive environmental attributes in addition to energy and RECS for the duration of the PPA. Results in higher project cash flow and sponsor equity IRR.

PROS:

- No changes to project finance structure
- Line of sight between projects and offtakers, allowing for verification
- Promotes environmental stewardship of offtakers

CONS:

- Requires customers to pay a nontrivial premium for the product
- Is an illiquid product that may not fully value the project's ecosystem benefits (non-optimized)
- May require policy to certify environmental attributes

Based on modeling work, we estimate that the average PPA price would need to increase by $1.30 per megawatt hour (MWh) in order for a project's revenue to deliver an IRR (unlevered, pre-tax) commensurate with a traditional solar project in the state of Minnesota.[29]

CONSERVATION EQUITY INVESTORS

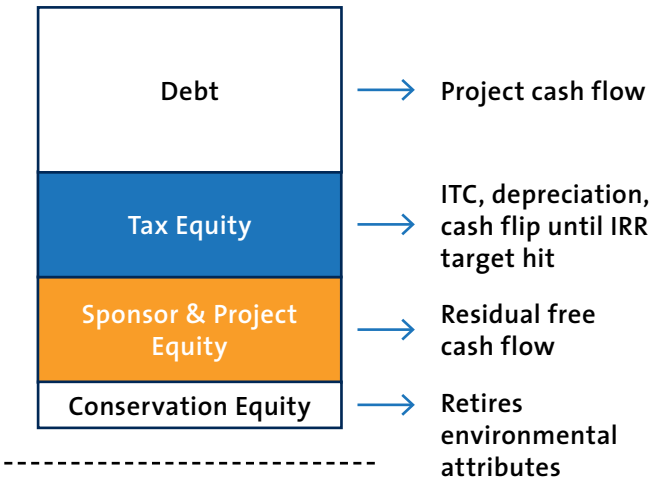
The previous two examples have sought to assign a monetary value to the ecosystem service benefits generated by a pollinator-friendly solar project. While these approaches may yield higher total utility to all participants, they are transactionally complicated and may still fail to assign value to some of the intrinsic benefits these projects offer (for instance, aesthetic value). Given these intrinsic properties, it may be possible to attract a completely novel source of equity to support project development.

29 This is based on a hypothetical 10 MW project. Attribute value adders to PPA prices would vary by project size and project particulars.

Conservation organizations actively fund projects to set aside habitat, remediate land and preserve species; these goals could potentially also be met by co-locating solar projects with well-managed pollinator habitat. Given that alignment, it is possible that philanthropic conservation dollars may be channeled into solar development to "buy down" the project development costs such that developers and all the parties financially involved in a project are incentivized to implement quality pollinator-friendly practices. The dollar value contribution would be equal to that of the environmental equity investor, but there would be no expectation of monetizing the ecosystem services from the project. Instead, the land between the panels would be preserved and maintained to achieve various conservation objectives, such as increasing pollinator populations, restoring wild prairie landscapes or supporting endemic species.

This model may be more attractive to conservation organizations if the up-front investment came with stipulations of ongoing monitoring and an agreement to transition the land to a conservation easement after the useful life of the project.

CONSERVATION FUNDING



Conservation equity investor can lower WACC by monetizing conservation attributes up front, and taking no project returns

PROS:

- Does not require complicated ownership structure
- Brings in novel source of capital and may reduce project opposition
- Would likely maximize conservation practices given investor interest

CONS:

- Unproven model
- Requires channeling funding away from other conservation efforts
- May require granting future land rights to conservation organization, constraining future land value

DEBT SUPPORT: INTEREST RATE BUY-DOWN

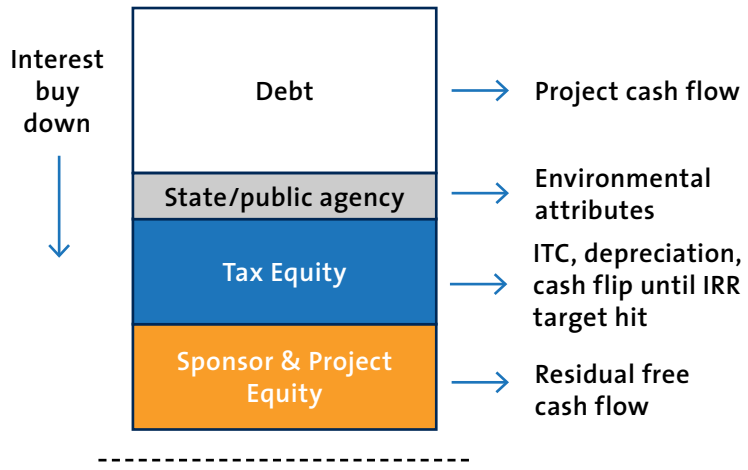
In addition to options for introducing new equity investors or project revenues, strategies that lower interest rates and increase debt leverage could also help boost returns for equity investors. As interest

rates decrease, projects are able to take out larger loans, thus allowing the equity investors to put less of their own money into a project, and to reap a higher return from the project's cash flows.

Given this dynamic, a key focus of future policy could be supporting pollinator-friendly projects with low-interest debt. Historically, incentives like this have taken the form of interest rate buy-downs. This means that the government pays either an initial sum to a bank or otherwise supports a portion of a project's periodic interest payments. As a result, the project faces a lower effective interest rate and can either take on more debt or have lower loan repayments. This either lowers the equity contribution up front or increases distributions to the equity investor.

A state may be motivated to implement such a policy as an incentive to developers to construct best-in-class projects that deliver strong local and environmental benefits. Additionally, the state may opt to retain ownership of the ecosystem services from incentivized projects and retire those attributes for compliance or public conservation goals. For instance, benefits such as water filtration or riparian buffer zones may support efforts to comply with federal laws such as the Clean Water Act.

PUBLIC INCENTIVE – INTEREST RATE BUY-DOWN



State agency buys down debt interest rate to incentivize PF solar development and de-risk for lenders. Lowers WACC and environmental attributes assigned directly to state agency

PROS:

- Likely the most capital-efficient intervention (smallest up-front cost)
- Does not alter project financing structure

CONS:

- Requires policy intervention and public subsidy
- Challenging line of sight into transaction costs for policy-makers
- Blended after-tax IRR does not fully account for time-value differences in return to project equity versus tax equity

Our modeling shows that an interest rate buy-down of approximately 28 basis points (0.28%) would boost the equity owner's after-tax return to be on par with a similar traditionally constructed solar project. The details of each project's financing are unique, but we estimate that an up-front interest rate

buy-down would require between 0.8% and 1% of a project's capital expenditure to be invested to buy down the lender's interest rate and deliver an after-tax equity IRR commensurate with a comparable traditional solar project.[30]

Conclusion

Pollinator-friendly solar represents a promising and impactful co-location opportunity that allows solar projects to coexist with — and add value to — their surrounding environment. While these projects create many different benefits and ecosystem services, they remain undervalued by existing policy and financial structures. As a relatively novel development practice in the solar industry, the project-specific costs and benefits have yet to be thoroughly studied and played out. As more projects are developed according to pollinator-friendly principles, we expect understanding and appreciation of the resulting ecosystem services to grow.

However, given the persistent challenges and uncertainties associated with ecosystem services modeling and valuation, policy and market-based interventions are warranted to spur best-practice development as solar becomes more prominent. Pollinator-friendly solar projects have the potential to attract new types of investors and to integrate with and reinforce new and existing conservation finance markets. While a robust array of funding sources and programs exist to fund conservation projects that create ecosystem services, there remain opportunities to improve stakeholder coordination, lower barriers to entry for new participants, and promote more efficient monetization of environmental benefits.


Photo courtesy of Rob Davis, Fresh Energy

A more liquid and streamlined marketplace that unites conservation funders with a diverse array of potential projects could overcome many of the historic difficulties associated with valuing and financing land and water conservation efforts. Such a system would provide clarity and transparency by aggregating supply and demand and revealing various stakeholders' willingness to pay for ecosystem services. Pollinator-friendly solar projects are particularly well positioned to benefit from this kind of a market or auction for ecosystem services, as they already rely on unique, sophisticated financial structures that could be adapted to incorporate new revenue streams. Bringing

30 This calculation requires numerous assumptions. We modeled an initial annual interest rate of 6%, debt service coverage ratio of 1.4x and maximum debt-to-equity ratio of 60:40. The calculation is based on the net present value of future interest payments, and the dollar value is the difference between the net present value of interest payments at a 6% interest rate — discounted at 6% — and interest payments at a 5.72% interest rate — also discounted at 6%.


Photo courtesy of Rob Davis, Fresh Energy

novel sources of capital into these projects would help align investor, developer and asset owner incentives in favor of pollinator-friendly solar development, which may require a greater outlay of time and financial resources at the outset. By valuing the ecosystem services generated throughout the project lifetime, pollinator-friendly solar projects would realize higher returns, spurring developers to prioritize these projects over traditional forms of solar development.

Importantly, the market mechanism we propose is not without its shortcomings and would need to be carefully crafted to avoid over-incentivizing certain practices or over-allocating profits to certain actors. One pitfall we recognize is the potential for the accelerated deployment of pollinator-friendly solar projects to result in faster conversion of farmland to other uses — this energy-versus-agriculture tension would have to be carefully monitored to ensure sustainable outcomes in states where auctions or similar market mechanisms are deployed. Additionally, the creation of an operating market is likely to consume a non-trivial amount of time and resources, which may require public or philanthropic subsidy. Lastly, it is important to note that a good number of pollinator-friendly solar projects are currently under development in the absence of this proposed new market, indicating that there are other drivers to implement these practices.

Nevertheless, we see great promise in the possibility of new markets to unlock better valuation and incentives for pollinator-friendly solar development. Building bridges to connect the renewable energy industry with agricultural interests and conservation finance has real potential to result in beneficial outcomes for all stakeholders. With appropriate management, the seeds of this ecosystem services market model could bear fruit in Minnesota and beyond.

Appendix

TABLE 1. POTENTIAL AND CAPACITY OF MINNESOTA STAKEHOLDERS TO ENGAGE IN THE MARKET

Stakeholder	Organization	Project	Funding Type	Available Funds	Application Period	Description
Government agency	Minnesota Department of Agriculture	AGRI Sustainable Agriculture Demonstration Grant Program	Grant	$250,000	August (2019)	Fund projects that increase sustainable agriculture practices as well as farms' profitability and resource efficiency
Government agency	Minnesota Board of Water & Soil Resources	Clean Water Fund	Grant	$7-$12 Million	Fiscal Year	Contribute to the protection and enhancement of lakes, rivers, streams and groundwater
Government agency	Minnesota Board of Water & Soil Resources	Erosion Control and Water Management Program	Cost share			Support practices for erosion and sedimentation control, as well as water quality problems
Government agency	Natural Resources Conservation Service	Conservation Stewardship Program	Grant	$18 per acre each year	May 10 (2019)	Support landowners' conservation efforts
Nonprofit	The Nature Conservancy	Minnesota Headwaters Fund	Grant	$10 million		Conservation of Mississippi River watersheds in Minnesota
Land trust	Minnesota Land Trust	Sauk River Watershed Habitat Protection & Restoration Program	Grant		May 1 & November 29, 2019	Protect the Sauk River watershed habitat
Land trust	Minnesota Land Trust	Bufflands Protection Program	Grant		March 1, 2019	Protect habitat in southeastern Minnesota
Land trust	Minnesota Land Trust	Conservation Loan Program	Loan	$50 Million	Fiscal Year	Offer financial and technical assistance to organizations that protect and recover natural habitats and increase access to green spaces
Land trust	Northern Waters Land Trust	Landowner Resources for Land Conservation	Grant			Conserve and protect wildlife habitat on the shorelines of recreational lakes in north central Minnesota
Private companies	Natural Capital Investment Fund	Natural Capital Investment Fund loans	Loan	$5,000 to $750,000	Fiscal Year	Help organizations and farmers grow operations, increase profitability, and have positive environmental and community impact
Foundation	Northwest Minnesota Foundation	Omdahl Environment and Conservation Fund	Grant		Fiscal Year	Support programs, projects, and activities that contribute to environmental and conservation causes
Foundation	Blandin Foundation	Blandin Foundation Grants	Grant	$1000 - 50,000	January 1 – December 31	Support projects that strengthen rural Minnesota
Government agency	USDA	Value-Added Producer Grant	Grant	$30 million; capped at $75,000 for planning grants & $250,000 for working capital grants.		This is a United States Department of Agriculture rural development program that helps farmers expand market opportunities and increase their income
Government agency	USDA	Environmental Quality Incentives Program	Grant	$1.75 billion (2018)		Assist farmers in implementing conservation practices