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Dual-use Solar in the Pacific Northwest

A Way Forward

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Foreword

Since the preparation of this report in 2019, much has happened globally and in the United States. From a global pandemic to severe drought and wildfire seasons in the West, the past two years have been dynamic. Regardless, dual-use solar maintains its potential to help decarbonize the electricity sector while achieving other important agricultural and conservation goals.

On the renewable energy policy front, President Biden's Executive Order 14008 on "Tackling the Climate Crisis at Home and Abroad" offered a federal push for climate change mitigation action. In the Pacific Northwest, Washington state is engaged in rulemaking to fully enact its 2019 Clean Energy Transformation Act, which requires 100% clean electricity by 2045, and Oregon passed legislation during its 2021 session that sets a 100% clean target by 2040. Oregon's 2021 legislation follows Governor Brown's 2020 Executive Order 20-04 directing state agencies to reduce and regulate greenhouse gas emissions. The federal support and focus on climate change, coupled with state-level legislation, could provide a much-needed push for the renewable energy industry in the form of incentives, funding, or renewable energy friendly tax code, although specifics are, as yet, unclear.

Regardless, the siting of renewable energy installations in support of these climate change goals is balanced with the conservation and protection of existing resources and activities — from agriculture to maintaining biodiversity. Considering applications that allow for two uses to exist in the same space — such as with dual-use solar — offers a potential way to accomplish both increasing clean energy generation and protecting existing uses and biodiversity.

Executive Summary

This report explores the concept of dual-use solar throughout the United States and its application in Oregon and Washington. Recently in the Pacific Northwest, there has been conflict over the siting of solar energy arrays on land designated for agriculture. With both climate and farmland protection goals to grapple with, the laws that guide the siting of solar projects on farmland in both states are complex, making the potential role for dual-use solar unclear.

Sometimes called co-location, dual-use solar combines utility-scale solar arrays with conservation and agricultural activities to create multifunctional systems with a variety of benefits. Dual-use solar can address concerns about solar on agricultural land, as well as support efforts around conservation and the preservation of crucial pollinators. This report describes the current state of research and development of the four main kinds of dual-use solar:

1. Pollinator-friendly dual-use
2. Conservation dual-use
3. Grazing dual-use
4. Agrivoltaics (solar and crops)

Pollinator-friendly and conservation dual-use provide a suite of ecosystem services, and can often endear a project to the local community. Each type of dual-use solar provides benefits to agriculture that is adjacent to the array or, in the case of grazing or agrivoltaics, that continues on the solar site itself.

Dual-use solar projects are being built across the country, and policies are sprouting up to support this multifunctional solar development. In the Pacific Northwest, the four major forms of dual-use solar are already being tested and put into place. Dual-use solar can benefit Oregon and Washington by supporting farmers and rural governments, providing climate resilience to rural communities, and providing clean and carbon-free energy to the grid. Policies that recognize the value of dual-use solar and support appropriately sited projects can promote dual-use solar in the Northwest and help achieve the region’s climate and agricultural goals.

Key Takeaways

- Dual-use solar is the combination of solar with other land uses, such as native plant restoration or agriculture on the same parcel of land, offering a solution that addresses climate change while also benefiting conservation and agriculture.
- Currently, half of one percent of Oregon and Washington's electricity load is served by solar. If that percentage were to increase to 10% with renewable energy installations siting on farmland, less than 0.2% of the states' 30-million-plus acres of farmland would be impacted.
- Pollinator-friendly dual-use, conservation dual-use, and grazing dual-use solar are all commercially operational in the Northwest. Agrivoltaics is in the early phase of commercialization.
- Dual-use solar development on good agricultural soils can be appropriate as long as the non-solar use matches the quality of the land on which it is sited.
- States are increasingly using policy tools to support dual-use solar, including site-specific pollinator scorecards, monetary incentives for agrivoltaic systems, and tax incentives.
- Land-use policy in both Oregon and Washington does not currently support a framework for multifunctional projects such as dual-use solar.
- State and local policies can recognize dual-use solar as a method for developing solar that is compatible with agriculture. Definitions of solar generation, farmland, and farm uses could be reviewed to ensure they do not preclude dual-use solar.
- Farmers will be encouraged to create a multifunctional farming system with dual-use solar if they can maintain the policy benefits associated with the agricultural use of their land.
- The development of state-specific model ordinances and solar developer best practices for dual-use solar projects could help siting and permitting projects.
- Lands managed by the Department of Natural Resources in Washington and Department of State Lands in Oregon could be good locations for dual-use solar development.
- Tools that connect solar developers with farmers and incentives could help facilitate dual-use solar.
- The Pacific Northwest is ready for the next step in renewable energy development, and dual-use solar offers the region an opportunity to boldly pursue its climate and agricultural goals.

Acknowledgements

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focuses on how to deploy smart, equitable solar in both Washington and Oregon to achieve broader system benefits and societal goals. The project aims to triple the solar capacities of both states, reduce installed costs for rooftop solar by almost half, and double the solar-related employment in the Pacific Northwest by leveraging the technical, social, and economic benefits of solar. The three main areas of focus are solar energy equity, community solar, and the overall social and economic value of solar.

This report is up-to-date as of Aug. 1, 2019, and does not capture changes in the Dual-use Solar or state policy landscapes since that date, as both are rapidly changing.

Climate, Agriculture, Energy, and Land Goals in the Pacific Northwest

As the pressures of a changing climate continue, the Pacific Northwest has been on the forefront of fighting for a stable climate for future generations. The region is also known for its productive soils that Oregonians and Washingtonians have farmed for generations to feed our region and the world. As development and climate change pressures on farmland grow, many people have become concerned about the future of agriculture and, in response, have ramped up efforts to protect land for agricultural use. This report explores the values of climate action and the preservation of agricultural lands and demonstrates how efforts to advance both interests can be realized through dual-use solar development.

Agriculture & Climate

Agriculture is deeply ingrained in the region's history, and remains vital for the economies of both Oregon and Washington. The agricultural industry and the people that rely on it know the Pacific Northwest to be gifted not only with productive soils in our river valleys, but also with open space for cultivating grain, grazing, and fishing off of our coast and in our rivers. In 2017, Washington's agriculture production was valued at $10.6 billion with the state supplying 70% of U.S. apple production.[1] Oregon agricultural products are world famous, from providing all of America's blackberries and hazelnuts[2] to providing the grass seed used in the 2010 men's World Cup[3] and supplying the wool used in the 2014 U.S. Winter Olympic uniforms.[4] People in the Northwest take threats to agriculture very seriously as producers in the region rely upon the land and water to support their families and communities, to produce food crops distributed locally and globally, and to grow a variety of non-food crops.

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[1] "Washington Agriculture." Washington Agriculture | Washington State Department of Agriculture. Accessed June 25, 2019. https://agr.wa.gov/washington-agriculture

[2] Oregon. Oregon Department of Agriculture. *Oregon Agriculture Facts & Figures 2018.* Accessed June 20, 2019. https://www.oregon.gov/ODA/shared/Documents/Publications/Administration/ORAgFactsFigures.pdf

[3] Mayer, James. "Corvallis Firm Supplies Grass for World Cup." Oregonlive.com. May 28, 2010. Accessed July 10, 2019. https://www.oregonlive.com/business/2010/05/corvallis_firm_supplies_grass.html

[4] Caruthers, Teree. "Where There's Wool, There's a Way." Celebrate Oregon Agriculture. November 07, 2017. Accessed July 10, 2019. https://www.celebrateoregonagriculture.com/theres-wool-theres-way/

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Northwesterners also recognize a deep connection to the natural environment and a shared history of environmental protection and stewardship. This sentiment has put climate change as a top concern for many in the region as it presents a threat to the natural environment and the modern world as a whole. Oregonians and Washingtonians recognize that climate change has the potential to hurt Northwestern communities and their interests. In Oregon, annual temperatures are expected to rise on average between two and eleven degrees Fahrenheit by 2080, depending on emission scenarios. To avoid major changes and challenges in the future, researchers are calling for a focus on reducing emissions to minimize warming.[5] According to the National Climate Assessment, "the Northwest is projected to continue to warm during all seasons under all future scenarios, although the rate of warming depends on current and future emissions. The warming trend is projected to be accentuated in certain mountain areas in late winter and spring, further exacerbating snowpack loss and increasing the risk for insect infestations and wildfires."[6] Precipitation will become more variable and high heat and drought events will become more common. We are already seeing some of these effects today. In Oregon specifically: "snowpack is declining, summer streamflow is lowering, wildfire activity is increasing, sea level is rising, and coastal waters are acidifying. Such consequences and others are expected to continue into the decades to come."[7]

These threats matter to us all, but especially farmers. More variable weather patterns, higher risk of drought and wildfires, and loss of snowpack present an existential threat to many farmers in the region. For example, soil erosion is a large issue for farmers, and it will be severely worsened by climate change. One model notes that "In a wetter region of the Plateau

[5] Dalton, M.M., K.D. Dello, L. Hawkins, P.W. Mote, and D.E. Rupp (2017) *The Third Oregon Climate Assessment Report*, Oregon Climate Change Research Institute, College of Earth, Ocean and Atmospheric Sciences, Oregon State University, Corvallis, OR. pp. 4 https://pnwcirc.org/sites/pnwcirc.org/files/ocar3_finalweb.pdf

[6] May, C. et al. 2018: Northwest. In *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment*, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 1036. doi: 10.7930/NCA4.2018.CH24

[7] Dalton, M.M., K.D. Dello, L. Hawkins, P.W. Mote, and D.E. Rupp (2017) *The Third Oregon Climate Assessment Report*, Oregon Climate Change Research Institute, College of Earth, Ocean and Atmospheric Sciences, Oregon State University, Corvallis, OR. pp. 1 https://pnwcirc.org/sites/pnwcirc.org/files/ocar3_finalweb.pdf

(the Palouse in Washington), 4°F of warming resulted in a nearly three-fold increase in soil loss largely during winter due to reduced snow on the ground and increases in rain and snowmelt."[8] Even the wine industry is being affected; grape varietals that can be effectively grown in a given region will change with increased temperatures and amounts of precipitation.[9]

These changes are all occurring within a global context in which the foremost scientists on the topic are telling us we must act within the next decade to mitigate the worst dangers of climate change. The UN Intergovernmental Panel on Climate Change's most recent report states: "In model pathways with no or limited overshoot of 1.5°C, global net anthropogenic CO_2 emissions decline by about 45% from 2010 levels by 2030, reaching net zero around 2050 … Pathways limiting global warming ... would require rapid and far-reaching transitions in energy, land, urban and infrastructure … and industrial systems (high confidence)."[10] If there is no decisive action on this issue in the next decade, we will exceed the 1.5°C target and continue on a path of warming that will threaten our way of life globally.

Energy & Land-use Policy

In response to the threat of climate change, governments in the Northwest have proposed and implemented policies to fight climate change by reducing carbon emissions. Many of these policies focus on clean and affordable renewable energy. For example, in Oregon there is a Renewable Portfolio Standard that mandates the state obtain 50% of its electricity from renewable energy sources by 2040.[11] Washington recently passed legislation that mandates 100% clean energy in the state by 2045, with carbon-intensive coal energy removed by 2025.[12] These policies show a commitment in the Northwest to take on the threat of climate change. Oregon Governor Kate Brown created a climate agenda that includes renewable energy targets and discusses the economic benefits that result from clean energy investments. The Governor

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[8] Farrell P, Abatzoglou J, Brooks E. 2015. The impact of climate change on soil erosion. Regional Approaches to Climate Change for Pacific Northwest Agriculture: Climate Science Northwest Farmers Can Use: REACCH Annual Report Year 4

[9] Jones, Greg. "Oregon Scientist Tracks Climate Change Effects On Wine." Interview by Geoffrey Riley and John Baxster. Jefferson Public Radio. July 23, 2018. https://www.ijpr.org/post/oregon-scientist-tracks-climate-change-effects-wine#stream/0

[10] IPCC, 2018: Summary for Policymakers. In: *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty* [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. *World Meteorological Organization, Geneva, Switzerland, 32 pp.* *https://www.ipcc.ch/sr15/chapter/spm/*

[11] "Energy in Oregon." State of Oregon: Energy in Oregon - Renewable Portfolio Standard. Accessed June 25, 2019. https://www.oregon.gov/energy/energy-oregon/pages/renewable-portfolio-standard.aspx

[12] Merchant, Emma Foehringer. "Washington State Passes Law Requiring 100% Clean Energy by 2045." Greentech Media. April 23, 2019. Accessed June 25, 2019. https://www.greentechmedia.com/articles/read/washington-state-passes-100-clean-energy-by-2045-law#gs.k1p2lj

recognizes that Oregon is positioned to benefit from some of the $335 billion in global annual investment in clean energy if these technologies are encouraged.[13]

Solar energy is a rising player in the renewable energy space, and has followed wind into the Northwest as a major contributor of renewable energy in the region. Solar energy generally refers to electricity generated by arrays of solar photovoltaic panels — a clean method of generating electricity that does not contribute carbon dioxide emissions to climate change. Solar energy only needs sunlight, while fossil fuel technologies rely on fuel extraction, which also hurts the environment and can pollute water sources.[14] Although solar generation is variable, it is also predictable, and it can be paired with wind, storage, and other clean energy technologies across different regions and timeframes to help match energy generation to demand. In addition, solar can provide services to help the grid, especially when paired with storage, including providing confidence to utilities that power will be available during peak energy usage times when the grid is most stressed. Recently, utilities across the country have chosen solar-plus-storage projects over fossil fuels in order to make their systems reliable during these peaks. Solar energy paired with storage helps add capacity and allows utilities to avoid committing to more expensive fossil power plants.[15] [16]

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Other often overlooked advantages of solar are its low costs and economic benefits. The cost of building a utility-scale

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[13] Oregon. Office of the Governor. Carbon Policy Office. *Oregon Climate Agenda: A Strong, Innovative, Inclusive Economy While Achieving State Climate Emissions Goals.*By Kate Brown and Kristen Sheeran. November 28, 2018. Accessed June 25, 2019. https://www.oregon.gov/gov/Documents/Governor%20Kate%20Brown%20Climate%20Agenda.pdf

[14] "Solar Power Plants: Large-Scale PV." Union of Concerned Scientists. December 23, 2015. Accessed June 25, 2019. https://www.ucsusa.org/clean-energy/renewable-energy/solar-power-plants-large-scale-pv

[15] Mai, HJ. "'Opportunities Everywhere': NREL Study Shows Mass Potential for Storage to Provide Peaking Capacity." Utility Dive. July 10, 2019. Accessed July 15, 2019. https://www.utilitydive.com/news/opportunities-everywhere-nrel-study-shows-mass-potential-for-storage-to/558344/

[16] John, Jeff St. "L.A. Looks to Break Price Records With Massive Solar-Battery Project." Los Angeles Department of Water and Power Plans to Sign a 200-megawatt Solar, 150-megawatt Battery Energy Storage Project That Could Break Price Records for PV, Help California Meet Clean Energy Goals. July 01, 2019. Accessed July 15, 2019. https://www.greentechmedia.com/articles/read/ladwp-plans-to-break-new-low-price-records-with-massive-solar-battery-proje#gs.onunby

solar power array has dropped 90% in the last decade.[17] Today, even unsubsidized utility-scale solar energy is among the most affordable sources of power and is cost-competitive, if not lower-cost, than fossil fuels.[18] Solar energy across the U.S. and in the Northwest creates thousands of jobs. In the U.S., approximately 240,000 Americans work in solar; in the Northwest specifically, over 7,600 people are employed by the industry.[19] Specific to utility-scale solar (generally above 1 MW), jobs are created both to construct the solar facility and for its continued operations and maintenance.

Other than direct job creation, solar energy provides other economic benefits, especially in rural communities. Positive impacts of solar include benefits to the local economy during construction from the lodging and feeding of construction employees. In addition, these installations represent a large investment of capital into communities that may not otherwise get a lot of new investment and constitute especially large additions to the property tax base. Large renewable energy projects often infuse money into local governments through property taxes and can bolster educational funding and important infrastructure. One local example comes from Morrow County in Oregon, where a wind project will provide $1 million to Science, Technology, Engineering, Art, and Mathematics (STEAM) education programs in the county each year.[20]

In terms of agriculture, solar facilities offer economic benefits and security for farmers who lease their land for solar. Farmers are often interested in the income associated with leasing a portion of their land as that revenue can be a lifeline for farm diversification or for a long-awaited retirement opportunity.[21] These projects can also offer new revenue from underutilized farmland or difficult-to-farm areas. This was the case for Oregon farmer Dan Mullen, who had 12 acres of panels placed on a triangular field that proved difficult to farm due to its lack of formal irrigation and proximity to the highway. Dan, a fifth-generation farmer, also pointed out another benefit of the solar on his land: "It was a diversification of my farm, is how I looked at it ... It's just another thing I'm farming. So, I've got vegetable crops, I've got permanent crops, and

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[17] Murray, Brian. "The Paradox of Declining Renewable Costs and Rising Electricity Prices." Forbes. June 17, 2019. Accessed July 3, 2019. https://www.forbes.com/sites/brianmurray1/2019/06/17/the-paradox-of-declining-renewable-costs-and-rising-electricity-prices/#6762107061d5

[18] *Lazard's Levelized Cost of Energy Analysis—Version 12.0.*Energy Analysis. 2018. Accessed July 15, 2019. https://www.lazard.com/media/450784/lazards-levelized-cost-of-energy-version-120-vfinal.pdf

[19] "National Solar Jobs Census." The Solar Foundation. 2018. Accessed July 15, 2019. https://www.thesolarfoundation.org/national/

[20] Carla McClain (Crook County Planner), in discussion with the author, 2019.

[21] Lexie Hain (Agrivoltaic Solutions, Solar Grazer), in discussion with the author, 2019.

field crops. Now I've got a solar crop."[22] Solar energy facilities provide a new revenue stream to cover variations in production or the effects of natural disasters (floods, fires, diseases, pests, uncooperative weather). This additional revenue is crucial to the economic stability and sustainability of a farm like Dan's, who hopes to keep his business viable for his children. This kind of "off-farm" income, income not directly from the farm, is significant: "In recent years, slightly more than half of farm households have had negative farm income and therefore rely on off-farm income to support their well-being."[23] Off-farm income is so important in the Northwest that in Oregon and Washington more than half of producers spend 50 or more days working off-farm.[24] With solar, producers can get the revenue they need to support their farming operation and rely less on off-farm income. Farmers can work toward economic security that preserves the farm for the next generation[25] as the additional solar income reduces the pressure on farmers to consider residential or commercial development offers. The resulting opportunity to build a financial cushion also becomes important as farmers face more unpredictable and severe weather events due to climate change.

The benefits of solar are not limited to farmers who host solar facilities. Increasingly, utilities are recognizing the low cost of solar, and are passing along savings from solar energy production to utility customers. Not only are utilities identifying solar in their Integrated Resource Plans (IRPs) as least-cost, least-risk resources that don't emit greenhouse gases, but they are also buying solar as the result of technology-neutral competitive procurements. In its 2019 IRP, PacifiCorp, a large utility spanning six states, identified 500 MW of solar in Southern Oregon and 395 MW of solar near Yakima by 2025 as promising resource options.[26] Meanwhile the result of Portland General Electric's 2018 competitive resource procurement was a combined wind-solar-and-battery-storage project.[27] To meet utilities' goals of providing reliable electricity

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[22] Banse, Tom. "Commercial Solar Arrays On Farmland Cropping Up Bountifully - And Stirring Opposition." Oregon Public Broadcasting. May 16, 2018. Accessed July 18, 2019. https://www.opb.org/news/article/npr-commercial-solar-arrays-on-farmland-cropping-up-bountifullyand-stirring-opposition/

[23] "Highlights From the March 2019 Farm Income Forecast." USDA ERS - Highlights From the Farm Income Forecast. March 07, 2019. Accessed July 25, 2019. https://www.ers.usda.gov/topics/farm-economy/farm-sector-income-finances/highlights-from-the-farm-income-forecast/

[24] United States of America. United States Department of Agriculture. National Agricultural Statistics Service. *2017 Census of Agriculture - State Data.*April 11, 2019. Accessed July 25, 2019. https://www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Volume_1,_Chapter_2_US_State_Level/st99_2_0045_0045.pdf

[25] Liz Curran (Director of Policy, BlueWave Solar) and Lucy Bullock-Sieger (Director of Civil Engagement, BlueWave Solar), in discussion with the author, 2019.

[26] *2019 Integrated Resource Plan (IRP),* Table 8.18. PacifiCorp, October 18, 2019. https://edocs.puc.state.or.us/efdocs/HAA/lc70haa135823.pdf

[27] Portland General Electric. "Portland General Electric and NextEra Energy Resources to Develop Nation's First Major Energy Facility Co-locating Wind, Solar and Battery Storage." News release, February 12, 2019. PGE. Accessed July 23, 2019. https://www.portlandgeneral.com/our-company/news-room/news-releases/2019/02-13-2019-portland-general-electric-and-nextera-energy-resources-to-develop-en

to customers at the least cost and least risk, wind and solar are increasing in the Northwest. The current challenge is to encourage this clean energy future while making sure projects are developed using best practices with our collective interests in mind.

In the Northwest, we have policies that encourage the use of clean energy technologies like solar to advance our goals on climate change, and we also have policies to protect farmland and agriculture. Farmland loss is a national issue that is not unique to the Northwest, as American Farmland Trust makes clear in their Farms Under Threat report from 2018. The report details that between 1992 and 2012, 11 million acres of the best cropland for intensive agriculture was lost to development (3.2% loss), much of which was from urban and low-density residential development.[28] Closer to home, it has been reported that Oregon lost about 9% of its farmland since 1997.[29] That loss is coupled with the fact that "two-thirds (10.45 million acres) of Oregon's agricultural lands will change hands in the next 20 years, according to research from Oregon State University." Some fear that this exchange of lands to the next generation will see farmland go out of production due to generational, economic, or taxation reasons.[30] Other than the direct loss of land designated for agriculture, another fear is the loss of supporting infrastructure for agriculture to development pressures. The Oregon Department of Land Conservation and Development notes, "As farm operations scale down or leave, farm infrastructure, such as feed stores, processing facilities and irrigation districts may start to disappear…" [31] There is real fear over the loss of agriculture designated land, and it should not be taken lightly. In both Oregon and Washington, state and local governments have long had measures in place to ensure farmland is protected when necessary, and these statutes often inform decisions around solar siting on farmland.

[28] Sorensen, A. Ann, Julia Freedgood, Jennifer Dempsey, and David M. Theobald. *Farms Under Threat: The State of America's Farmland.*Report. May 09, 2018. Accessed June 26, 2019. https://www.farmlandinfo.org/sites/default/files/AFT_Farms_Under_Threat_May2018 maps B.pdf. Updated version: https://s30428.pcdn.co/wp-content/uploads/sites/2/2020/05/AFT_FUT_SAF_2020final.pdf

[29] USDA Agricultural Census 2017, *Oregon Historical Highlights*. https://www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Volume_1,_Chapter_1_State_Level/Oregon/st41_1_0001_0001.pdf

[30] "Land Use and Right to Farm." Oregon.gov. Accessed July 10, 2019. https://www.oregon.gov/ODA/programs/NaturalResources/Pages/LandUse.aspx

[31] "Farmland Protection." Farm and Forest. Accessed August 02, 2019. https://www.oregon.gov/lcd/FF/Pages/Farmland-Protection.aspx

In Oregon, the state implemented land-use goals in the 1970s in response to rapid growth and urbanization. Oregon has 19 land-use planning goals that are translated into statewide rules made by the Land Conservation and Development Commission.[32] Goal 2 instructs each county to make its own comprehensive land-use plan which must be consistent with the statewide planning goals.[33] Goal 3 is specific to the protection of farmland and requires counties to identify farmland and zone it for exclusive farm use. Generally, this goal protects farmland and restricts development unrelated to farming. However, there are a lot of uses allowed on farmland under certain acreage limits that are subject to county review including mining, oil and gas extraction, and energy generation from wind and solar.[34] If a developer wants to build a solar site larger than Goal 3 rules allow, they must get a formal exception to Goal 3. But the exception process is general and not tailored to solar; moreover, this avenue has been restricted by recent rule changes and is currently under review by the Oregon Supreme Court. The overlapping rules and goals, and the fact that these goals and the exception process are not made for solar (never mind dual-use solar), combine to make the solar siting review process difficult for local governments. Confusion over how to apply goals and exceptions has led to massive variability between counties in terms of the siting of solar projects on farmland.[35]

Pine Gate Renewables

In most of Washington, land-use decisions are guided by the Growth Management Act (GMA), a series of laws that encourages counties to make comprehensive plans aimed at managing their population growth. In contrast to Oregon, the GMA is not a statewide standard, but instead is

[32] "History of Land Use Planning." Department of Land Conservation & Development. Accessed July 10, 2019. https://www.oregon.gov/lcd/OP/Pages/History.aspx

[33] "Goal 2: Land Use Planning." Department of Land Conservation & Development. Oregon Planning. Accessed July 10, 2019. https://www.oregon.gov/lcd/OP/Pages/Goal-2.aspx

[34] "Goal 3: Land Use Planning." Department of Land Conservation & Development. Oregon Planning. Accessed July 10, 2019. https://www.oregon.gov/lcd/OP/Pages/Goal-3.aspx

[35] In both Oregon and Washington some counties have a moratorium on solar on farmland and some counties allow these projects, sometimes even approving them to exceed acreage limits. This information comes from discussions with the author and Carla McLane (Morrow County Planning Director), Joe Fennimore (Marion County Planning Director), and Dave McClure (Klickitat County DNR Director), 2019.

targeted toward counties with larger populations. To date, 18 of 49 counties are required to make these plans (labelled "full planning counties"), and 11 more counties have opted in. These counties' plans must follow 13 general land-use goals, including goals around concentrating urban growth, encouraging economic development, honoring property rights, protecting open space, and protecting the environment.[36] The GMA includes farmland under "natural resource industries" in its goals, and stipulates that rules should be implemented to preserve "rural character", and requires counties to identify agricultural resource lands in their area.[37] Full planning counties need to preserve these lands and get some guidance from state law on what those resource protection plans should look like. Opt-in counties also have the directive to preserve these lands, but the rules are less prescriptive about how. Non-GMA counties have to designate these lands but otherwise are not guided on the issue of agricultural resource protection.[38] This patchwork of GMA counties and non-GMA counties, in addition to the relatively vague guidance of the GMA goals around land designated for agriculture, leaves Washington's land-use regime and its application to solar on farmland scattered and uncertain. Developers of solar energy need to negotiate the process of permitting sites in counties that might have widely different regulations than their neighbors. In addition, counties might have trouble interpreting vague standards around agricultural resource land protection and applying them to a particular solar project or a dual-use solar project.

In addition to the laws that govern solar siting on farmland in the Northwest being unclear and complicated, recent actions in local governments and state legislatures, agencies, and courts have further unsettled the legal landscape. These changes have been spurred in part by the fact that, while solar energy has been much more prevalent in Oregon than in Washington, both states have started to see larger solar projects seeking permits in recent years.[39]

One of these larger projects is the 25 MW Columbia solar project partially sited on agricultural land in Kittitas County, Wash. Kittitas is a GMA opt-in county that has its own comprehensive plan around the general goals of the GMA. In 2017, the county established a solar moratorium while it considered developing solar-specific regulations after a different solar project sought a permit in the county. During the moratorium, the Columbia project could not apply through the

[36] "Growth Management Act." MRSC. Accessed June 19, 2019. http://mrsc.org/Home/Explore-Topics/Planning/General-Planning-and-Growth-Management/Comprehensive-Planning-Growth-Management.aspx

[37] Comprehensive plans—Mandatory elements. Wash. Rev. Code § 36.70a.070 https://app.leg.wa.gov/rcw/default.aspx?cite=36.70a.070

[38] Ben Serr (Washington Department of Commerce, GMA and Planning), in discussion with author, 2019.

[39] "Renewable Energy Projects: Renewable Northwest." Renewable Northwest. Accessed July 16, 2019. http://renewablenw.org/project_map?field_project_state_value[]=WA&tid[]=9

county and instead applied for land-use approval from the Governor by going through the Washington Energy Facilities Site Evaluation Council (EFSEC). When considering whether to recommend the project's land-use approval to the Governor, EFSEC took into account whether the project followed the state's Environmental Policy Act as well as Kittitas county's comprehensive plan, specifically focusing on concerns over "rural character" and the potential for long-term preclusion of agriculture from these sites.[40] [41] While the EFSEC review was pending, the county ended its moratorium in fall 2018 and adopted new rules that prevent solar from being sited on land zoned for irrigated farmland.[42] Shortly afterward, EFSEC recommended the project for land-use approval and the Governor approved it.[43] It is unclear whether the project could have been approved under the new county ordinance. This process exemplifies the current issues with Washington land-use law with changing permitting regimes, multiple possible permitting bodies, and unpredictable outcomes.

Somewhat similarly, Oregon has seen its own rash of moratoriums on solar. Yamhill[44] and Marion Counties have put moratoriums on most solar development in Oregon after concerns were raised about solar being on agricultural land in the Willamette Valley. In 2018, Yamhill banned solar development on high value soils, which cover most of the county's land area. Marion stopped accepting solar applications in the same year after it couldn't find a compromise between those for and against solar development, and took the solar permitting section out of the code.[45] Marion County approved 31 sites totaling 367 acres before the ban. If all of those sites were to be built on high-value farmland, the projects collectively would use 0.1% of high-value farmland in the county.[46]

In the courts, the siting process in Oregon is also in the midst of potential change. Currently, the Oregon Supreme Court is considering whether to allow a Goal 3 exception for a solar facility that would exceed the current acreage limit imposed by Land Conservation and Development Commission rules. Jackson County granted the facility a Goal 3 exception, but that exception was revoked by the Land Use Board of Appeals, whose decision was upheld on different

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[40] State of Washington Department of Commerce, Columbia Solar Project Land Use Analysis Report, 2018.

[41] Stewart Henderson (Energy Facilities Site Evaluation Council, Senior Policy Advisor), in discussion with the author, 2019.

[42] Sonia Bumpus (Energy Facilities Site Evaluation Council, Manager), in discussion with the author, 2019.

[43] Bernton, Hal. "Gov. Inslee Approves Solar Project on Kittitas County Farmland." The Seattle Times. October 17, 2018. Accessed July 11, 2019. https://www.seattletimes.com/seattle-news/gov-inslee-approves-solar-project-on-kittitas-county-farmland/

[44] Matt Vogt (Yamhill County Planner), in discussion with the author, 2019.

[45] Joe Fennimore (Marion County Planning Director), in discussion with the author, 2019.

[46] Poehler, Bill. "Oregon Could Effectively Ban Solar Farms, but First a Bunch of New Ones Will Be Built." Statesman Journal. January 19, 2019. Accessed July 11, 2019. https://www.statesmanjournal.com/story/news/local/stayton/2019/01/18/oregon-looks-strict-rules-solar-arrays-high-value-farmland/2457949002/

grounds by the Oregon Court of Appeals. Now it is up to the Oregon Supreme Court to rule on whether or not the exception was legal and if the project should be approved.[47] This case further complicates the current legal landscape for solar projects on land designated for agriculture.

These issues of solar on land zoned for farming and solar bans in certain counties came up again when in early 2019 the Oregon Department of Land Conservation and Development (DLCD) held a rulemaking which banned solar from class I and II soils and prime and unique farmland. This land is considered the better land for growing "food, feed, forage, fiber, and oilseed crops",[48] and is considered to be high-value farmland by the state of Oregon.[49] The rulemaking did include some discussion of dual-use solar, and the new rules allow an eight acre increase (from 12 acres to 20 acres) in project size for dual-use solar projects on class III and IV soils. However, the rules still ban dual-use solar projects on a good amount of land, and do not provide a flexible or expansive definition of dual-use solar. This new rule puts around 6% of the state off-limits to solar, especially near population centers in the Willamette Valley.[50] In addition, these rules rely on soil maps that are not granular and plot specific, and rather rely on larger areas to determine what soils are on a certain site.[51]

Lastly, in the 2019 legislative session, the Oregon Legislative Assembly passed Oregon House Bill 2329,[52] which raises the acreage threshold for a solar facility to be reviewed by the state's Energy Facilities Siting Council. By making fewer projects subject to the Energy Facilities Siting Council, this bill aims to give counties more control over solar siting decisions and to make the review process faster and lower-cost while still retaining the standards that ensure projects protect wildlife, cultural resources, and other siting considerations. The bill does not preempt the DLCD rulemaking — counties still must follow the rules governing solar on farmland — but it does add to the litany of changes we have seen around land use and solar in the past few years.[53]

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47 Perkowski, Mateusz, and Capital Press. "Solar Project Hinges on 'industrial' Status." Capital Press. March 12, 2019. Accessed July 11, 2019. https://www.capitalpress.com/state/oregon/solar-project-hinges-on-industrial-status/article_8d87cc18-4459-11e9-89ac-9fb88e32f74c.html

48 USA. United States Department of Agriculture. NRCS Oregon. *Prime Farmland List for Oregon*. OR, 2015. 1-24.

49 Or. Rev. Stat § 215.710 https://www.oregonlegislature.gov/bills_laws/ors/ors215.html

50 Profita, Cassandra. "Oregon Restricts Solar Development On Prime Farmland." Oregon Public Broadcasting. May 28, 2019. Accessed June 5, 2019. https://www.opb.org/news/article/solar-development-farmland-oregon-ban/

51 "Agricultural Soils Assessment." Department of Land Conservation & Development: Farm and Forest. Accessed August 10, 2019. https://www.oregon.gov/lcd/FF/Pages/Soils-Assessment.aspx.

52 "HB2329 2019 Regular Session." Oregon Legislative Information System. Accessed August 12, 2019. https://olis.leg.state.or.us/liz/2019R1/Measures/Overview/HB2329.

53 Oregon. Joint Committee On Ways and Means. *HB 2329 B Staff Measure Summary.*By Krista Dauenhauer. June 14, 2019. Accessed July 11, 2019. https://olis.leg.state.or.us/liz/2019R1/Downloads/MeasureAnalysisDocument/52273

Both Oregon and Washington have overarching land-use goals that are interpreted and codified by counties throughout their respective states. These goals address general land-development issues and account for the importance of land conservation, but they fail to reflect the necessity of achieving climate goals. Under the goals and their implementing rules, it is unclear how to value a clean-energy resource like solar — or other uses that help mitigate climate change and its effects — in land-use decisions. The individual interpretation and codification of these goals leads to decision-making that may be adapted to local conditions but is also fragmented and highly varied. On top of that, the legal architecture for permitting solar is multi-jurisdictional and often is informed or modified by court cases and statutory changes. This architecture has shifted a lot recently with rulemakings (DLCD), EFSEC decisions (Kittitas), statutory changes (HB2329), and court cases (Oregon Supreme Court) all changing solar permitting in recent months. There is a lack of certainty in the region around land-use law as applied to solar energy and no clear standard in either state that considers the benefits of dual-use solar. With both our climate goals and our land-use goals in hand, we can ask how appropriately sited solar on agricultural land is benefitting the climate, local communities, and farmers.

Siting Considerations for Utility Scale Solar

Confusion over the solar siting process often leads to the question of why solar is developed on farmland when other options, such as industrial lands and residential areas, exist. A general explanation of solar siting constraints is needed to better understand the limitations developers face. This section discusses ground-mounted, utility-scale solar projects as they are much more economic and cost competitive with traditional generation resources than residential rooftop solar, and, therefore, more likely to be least-cost resources selected to serve utility customers.[54]

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[54] *Lazard's Levelized Cost of Energy Analysis—Version 12.0.*Energy Analysis. 2018. Accessed July 15, 2019. https://www.lazard.com/media/450784/lazards-levelized-cost-of-energy-version-120-vfinal.pdf


Engie Distributed Solar

In order for a solar project to provide the least cost energy to the consumer, a developer must consider certain criteria. First, larger projects must be sited in regions where markets exist for the power. This means either there needs to be a purchaser (utility) in the region that a project can sell the power to directly via transmission or distribution lines, or an opportunity to pass through the energy and environmental benefits directly to a customer (as in community solar and direct access programs). Next, a project must be sited on lands that are zoned to allow solar through a permitting process and include a willing landowner who will lease their land to the project. Generally industrial, commercial and residentially zoned lands are magnitudes more expensive to site projects on. The base cost of the land is higher due to the existing zoning and opportunity cost of the land. Solar is most feasible when it is sited close to existing infrastructure. Siting solar close to existing substations and transmission lines reduces the cost of energy and limits land disturbances.[55] Other land criteria such as slope, drainage, soil depth, shading, access, and existing easements or encumbrances need to be considered as well. Finally, per Oregon and Washington state laws as well as general expectations of lenders, projects need to demonstrate that they will not have adverse impacts on sensitive cultural and natural resources such as wildlife and water. Each county in Oregon and Washington may also adopt specific ordinances which further reduce opportunities for siting solar. After all of these criteria are considered, the amount of land actually feasible for solar development is quite limited. Despite solar being an important tool in addressing climate change while providing economic opportunities to farmers, dictating that solar not be sited on agricultural lands increases the potential that it's taken off the table.

Discussion of solar siting often results in a debate over the value of different types of agricultural and wildlife lands. In both Oregon and Washington, opponents of solar on crop land west of the Cascades argue that solar should be sited in the arid eastern counties of the

[55] Taylor, Mike, Joyce McLaren, Karlynn Cory, Ted Davidovich, John Sterling, and Miriam Makhyoun. *Value of Solar: Program Design and Implementation Considerations.* Report. pp. V March 2015. Accessed July 15, 2019. https://www.nrel.gov/docs/fy15osti/62361.pdf

state; however, these counties manage important grazing lands and wildlife habitat. Opponents east of the mountains argue solar should be sited on crop land where prior disturbances limit potential impacts to natural and cultural resources and the projects are closer to the consumer. What is ultimately missing from this debate is an acknowledgement that solar can be sited in a way that is both compatible with west-side farmland and east-side grazing and wildlife habitat.

The considerations discussed before help inform why, from a developer's perspective, certain land designated for agriculture is ideal for solar development. For developers, land designated for agriculture can pose the least risk to them in terms of project siting.[56] The land is often flat, has deep soils in which to drive posts for racking, is free of rocks or geotechnical issues, is free of tree cover, and is in large contiguous sections. These conditions mean the site preparation for solar is little to none. Considered another way, using farmland to collect solar energy makes sense as solar production has been occurring on these lands for years, with plants capturing the energy of the sun through photosynthesis.

There is often confusion over the scale of potential solar development on farmland. There can be a "wave of solar" mindset in which it is perceived that solar will cover most of a community or area if it is not controlled. This is understandable, especially with how quickly solar has grown in this country and the fact that solar sites are a new phenomenon in many communities who often are already facing other development pressures. That being said, this perception is often not based on fact in terms of the land requirements of solar and how many projects are actually being built.

Instead, the concern of "solar everywhere" is often based on the typical process a developer goes through to evaluate and even permit a number of sites in order to narrow their portfolio down to the most feasible ones. Developers need to test the viability of the interconnect, conduct the cultural and natural resources studies, obtain permits, do soil and engineering studies, and market and sell the power — all before they fully commit to purchasing any equipment. To avoid the risk of doing all that work on one site that doesn't end up working out, developers plan several sites and only build on the sites that can pass all of those hurdles. A typical development portfolio in any one region might have a handful of projects in development, only one or two of which actually become operational. Land-use regulators and community members tend to see the number of applications as a threat that too many projects

[56] "Upfront Site Screening and Selection." InSPIRE. Accessed June 18, 2019. https://openei.org/wiki/InSPIRE/siting/siting/upfront_site_screening_and_selection

are being built, when in fact these projects are merely being considered and only a few will actually be built.

While it is true that solar is a land-intensive energy resource, energy demand places additional limits on potential solar build-out. Argonne National Laboratory investigated the land requirements for solar in 2016 and estimated that the land needed for all of the solar build-out through 2030, which was projected at 330 Gigawatts (14% of electricity demand), would cover 0.1% of the contiguous U.S.[57] Specific to the Northwest, large potential build-outs of solar in the next few years would only use a small fraction of a percent of farmland in the region, even if they were entirely placed on farmland (which is unlikely).[58]

Allowing solar on rural lands does not need to also open them up to residential and commercial development. Land-use law is premised on treating different uses distinctly and allowing each where it is appropriate. Solar is a unique type of development that is relatively innocuous, can be returned to its previous use after 20-25 years, and offers the potential for co-location with additional uses while also generating revenue.

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[57] Hartmann, Heidi M., Grippo, Mark A., Heath, Garvin A., Macknick, Jordan, Smith, Karen P., Sullivan, Robert G., Walston, Leroy J., and Wescott, Konstance L. Thu . "Understanding Emerging Impacts and Requirements Related to Utility-Scale Solar Development". United States. Pg. xii doi:10.2172/1329640. https://www.osti.gov/servlets/purl/1329640

[58] For example, starting with the 895 MW of southern Oregon and Yakima solar appearing in PAC's IRP, applying a conservative estimate of 8 acres per MW, and using figures of 15.9 million acres of farmland in Oregon and 14.6 million acres of farmland in Washington, that significant solar buildout would only occupy less than 0.03% of Oregon farmland and 0.02% of Washington farmland. For acreage figures, see [Ong, Sean, Clinton Campbell, Paul Denholm, Robert Margolis, and Garvin Heath. *Land-Use Requirements for Solar Power Plants in the United States.*Report. June 2013. https://www.nrel.gov/docs/fy13osti/56290.pdf] (8 acres per MW); [United States of America. United States Department of Agriculture. National Agricultural Statistics Service. *2017 Census of Agriculture - State Data, Oregon.* April 11, 2019. https://www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Volume_1,_Chapter_1_State_Level/Oregon/st41_1_0001_0001.pdf] (15.9 million acres); and [United States of America. United States Department of Agriculture. National Agricultural Statistics Service. *2017 Census of Agriculture - State Data, Washington.* April 11, 2019. https://www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Volume_1,_Chapter_1_State_Level/Washington/st53_1_0001_0001.pdf](14.6 million acres).

Engie Distributed Solar

As the discussion around solar and farmland continues, the limitations on solar siting need to be considered along with the risk of impact to farmlands. This includes consideration of community concerns during the planning processes to ensure a project will serve the best interests of the community. Dual-use solar offers an opportunity for solar advocates to work collaboratively with the farming community and advocates to identify ways to reach our climate goals, as well as agricultural conservation goals.

Dual-use Solar Today

Solar has a multitude of benefits, both in terms of reduced carbon emissions and in terms of rural economics. While these benefits are encouraging, there are still concerns about utility-scale solar projects and their impact on land designated for agriculture. Solar projects across the U.S. have traditionally used turf grass or gravel as their groundcover.[59] These practices, however, fail to advance our goals of supporting agriculture and land conservation even as they generate clean energy and help us abate climate change. Dual-use solar strategies offer several innovative combinations of energy and land-use goals, each with its own unique set of benefits. While this report separates these benefits out into the categories of pollinator, conservation, grazing, and crop dual-use, most projects have benefits that cross these designations.

Much of the push for dual-use solar around the U.S. comes from the need for better development practices that seek to minimize the impact a project has on its site. The National Renewable Energy Laboratory (NREL) has created the InSPIRE initiative around this idea, supporting low-impact solar best practices that include a focus on maintaining vegetation and combining solar with agricultural production. Some of the first steps toward best practices in solar development include reducing grading and disturbance of the land during construction and maintaining vegetation on the land. One change the industry has already adopted en masse is using pile driven posts rather than concrete bases to hold up the racking system that the panels are mounted on. The InSPIRE initiative also includes a focus on reducing topsoil stripping and soil compaction due to heavy machinery, all in an effort to preserve soil health.[60] These best practices for low-impact solar are inherent in dual-use solar development in general and are the basis upon which a multifunctional solar system depends.

Definition of Dual-use Solar Development

As used in this report, dual-use solar is a solar facility that preserves or improves the land it is placed on and provides a suite of benefits in addition to clean energy production. This may include the planting of native vegetation and pollinator species, the creation of an apiary on-site for honey production, the preservation/planting of forage vegetation for grazing of livestock within the facility, or the production of agriculture (crops) underneath and around the array. In defining dual-use solar, it is helpful to think of all the different applications on a spectrum from soil conservation/improvement to row crop agricultural use. Each of these forms of dual-use

[59] "InSPIRE Basics." InSPIRE. Accessed August 02, 2019. https://openei.org/wiki/InSPIRE/Basics

[60] Ibid

solar is multifunctional and increases the land-use efficiency of the facility while providing a multitude of benefits to the developer, the landowner, the local economy, and the environment.

In the United States, pollinator-friendly and conservation forms of dual-use solar are the most explored and currently the most commercially available forms of dual-use. These forms are followed by grazing dual-use which can be found around the country but is much less standardized and researched. Finally, agricultural crop production underneath panels, also known as "agrivoltaics," is on the cutting edge of research and commercialization right now. Researchers are still in the testing phase for this type of dual-use and the first to-scale commercial projects are being introduced.

It is important that when dual-use is defined, it is not simply labelled as solar-plus-agriculture or solar-plus-pollinator-friendly plants. These sites are dynamic and multifunctional in that each part of the system contributes to the other. It is also important to remember that dual-use encompasses a variety of solutions. For example, pollinator-friendly solar should not always be grouped together with agrivoltaics as they offer different benefits and are at different stages in their development.

Pollinator-friendly Dual-use

The rational next step from reducing impacts and *maintaining* vegetation is a focus on *promoting* vegetation that provides a benefit. Pollinator-friendly dual-use solar entails maintaining or seeding wildflowers, pollinator-friendly plants, and native species within a solar array to create large amounts of pollinator habitat.[61] The push for more pollinator habitat is a response to the dire state of many pollinators, such as honey bees and monarch butterflies in the U.S. According to the director of the National Institute of Food and Agriculture, "During the past 30-plus years, our nation's pollinator populations have suffered serious losses due to invasive pests and diseases, such as mites and viral and fungal pathogens, exposure to pesticides and other chemicals, loss of habitat, loss of species and genetic diversity, and changing climate."[62] Solar sites have the potential to offer good habitat with pollinator forage that is mostly free from chemicals as well as providing clean energy to slow the effects of climate change on these crucial pollinators.

[61] Siegner, Katie et. al. "Maximizing Land Use Benefits from Utility-Scale Solar Development", Yale School of Forestry & Environmental Studies. 2018.

[62] Ramaswamy, Sonny. "Reversing Pollinator Decline Is Key to Feeding the Future." U.S. Department of Agriculture. June 24, 2016. Accessed June 20, 2019. https://www.usda.gov/media/blog/2016/06/24/reversing-pollinator-decline-key-feeding-future

If we look more locally at the Northwest, we have lost honeybees at an alarming rate. Oregon lost 24.75% of its bee colonies in the winter of 2017-2018, and Washington lost 21.85% of its bee colonies in that same time period.[63] Those declines represent material losses for apiaries in the region as well as reductions in pollination services for farms. Pollinator loss is a major concern in Oregon where the state became the first in the nation to have a funded mandate that creates a health plan for pollinators.[64] It is widely known that pollinators such as bees, moths, butterflies, and birds help most flowering plants and agriculture. According to the USDA, 90 species of crops in the U.S. require pollination and most of the pollination services needed by American farmers are performed by bees: "Wild and managed bees together add $15 billion in crop value each year."[65] The agricultural and economic importance of pollinators is recognized in the Northwest as well. For the state of Washington, apples, cherries, and pears — three of the top ten agricultural products in the state (by value) — are more than 40% dependent on pollinators.[66] [67] Pollinators have a massive impact on the Northwest, and not only is there inherent value in helping them survive, but their survival also spells the survival of much of our agricultural industry.


Engie Distributed Solar

NREL researchers conducted a study examining the potential benefits of dual-use solar projects to pollinators. The study looked at current and planned (within five years of operation) solar facilities as of 2016, estimated their size due to their expected production, and estimated how much pollinator-dependent agricultural land is within a 1.5 km radius of each solar site (a proxy for the

63 "National Management Survey Map." Bee Informed Partnership. Accessed June 18, 2019. https://bip2.beeinformed.org/loss-map/

64 Scott, Aaron. "The Search Is On For Every Bee Species In Oregon." Oregon Public Broadcasting. October 11, 2018. Accessed July 25, 2019. https://www.opb.org/news/article/oregon-bee-atlas-project/

65 Ramaswamy, Sonny. "Reversing Pollinator Decline Is Key to Feeding the Future." U.S. Department of Agriculture. June 24, 2016. Accessed June 20, 2019. https://www.usda.gov/media/blog/2016/06/24/reversing-pollinator-decline-key-feeding-future

66 "Washington Agriculture." Washington Agriculture | Washington State Department of Agriculture. Accessed June 25, 2019. https://agr.wa.gov/washington-agriculture

67 Leroy Walston et al. "Examining the Potential for Agricultural Benefits from Pollinator Habitat at Solar Facilities in the United States" *Environmental Science & Technology,* 2018, 52, (13), 7566-7576. https://doi.org/10.1021/acs.est.8b00020

foraging distance of pollinators). For Oregon, based on NREL estimates, there are 16,338 acres of pollinator-dependent agriculture within the pollinator forage range of solar projects (current and planned in 2016) whose total footprint is 660.8 acres. That means that 24.7 acres of Oregon's pollinator-dependent agriculture could benefit per one acre of solar planted with pollinator-friendly species.[68] These pollinator-friendly solar projects have the potential to support pollinator populations, support agricultural yields, and achieve state pollinator goals by providing large tracts of habitat to support pollinator populations which otherwise would not be there.

Pollinator-friendly dual-use solar projects offer many benefits to landowners and developers, but additional costs and challenges hinder the development of these systems. One of the main perceived challenges in making pollinator-friendly solar is the increase in cost associated with seeding a site with these types of plants. These costs can vary from site to site, but generally this type of seeding is more expensive up-front than turf or gravel but can deliver reduced management costs throughout the life of the solar project.[69] Developers often work with vegetation-management, landscaping, or conservation companies to find a seed mix that is appropriate for their site. By planting select species, and reducing grading or disturbance of the site during construction, projects can save the costs associated with construction equipment and the need for mowing compared to sites with turf grass.[70]

Engie Distributed Solar, a developer mainly in the Midwest, explains in a white paper that these sites need more maintenance in the first three to four growing seasons but then require much less maintenance over the rest of the project life.[71] In their experience, these sites are cost-neutral or cost-saving, and they anticipate these practices will have portfolio-wide savings of around 20% in maintenance costs.[72] Another solar developer, OneEnergy Renewables, expressed that up-front costs can vary quite a bit with some projects being much more expensive than turf grass and others at cost-parity or below. Despite this variability in up-front expenses, OneEnergy agrees pollinator-friendly dual-use solar projects reduce maintenance costs after three years with the need for mowing dropping to once a year instead of three times a summer, resulting in savings over the life of the project.[73]

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[68] Ibid

[69] "InSPIRE Basics." InSPIRE. Accessed August 02, 2019. https://openei.org/wiki/InSPIRE/Basics

[70] Macknick, Jordan and Laura Caspari and Rob Davis, "Co-Location of Solar and Agriculture: Benefits and Tradeoffs of Low-Impact Solar Development" YouTube, 1:24:24, January 12, 2017 https://www.youtube.com/watch?v=VVapBZUCiw8

[71] Meinschein, Gavin. 2019. "Whitepaper: Solar + Pollinators." Engie Distributed Solar, March.

[72] Ibid

[73] Eric Udelhofen (OneEnergy Renewables), in discussion with the author, 2019.

Pollinator-friendly sites also have advantages over traditional sites with bare ground or gravel as there is less need for dust suppression (dust can interfere with panel efficiency) and less need for application of herbicide on weeds.[74] In addition, the presence of vegetation on the site leads to a cooler microclimate as plants can cool the area when they perform evapotranspiration. A cooler microclimate can lead to better energy production because solar panels start to linearly lose efficiency when they get above 75 degrees Fahrenheit.[75] Researcher Chad Higgins and his colleagues at Oregon State University looked at the relationship between microclimates and panel efficiency in a recently released paper about a solar site in Corvallis, Ore. They note that as the air temperature gets cooler, the efficiency of the panels increases.[76] Other benefits include reducing stormwater runoff and better groundwater infiltration with the use of native, deep-rooted plants. A report by the U.S. Geological Survey showed, "Median infiltration rates more than doubled through the use of native prairie vegetation versus the use of traditional turf. This is a result of the deep root systems of these diverse native plantings and their ability to absorb additional runoff. The roots systems of the prairie vegetation were found at a depth of 4.7 feet, compared to 0.46 feet with traditional turf."[77] With deep roots, these plants also can store and clean stormwater.[78] These deep-rooted plants show a major ecological improvement over turf or gravel (little infiltration), and can potentially reduce the cost of stormwater permitting or other mitigation for landowners or solar developers.[79] There is also a benefit to the farms surrounding sites with better infiltration due to the potential for less flooding of farmland in the area,[80] especially as rains get heavier with climate change.[81]

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[74] "Ground Cover." InSPIRE. Accessed August 02, 2019. https://openei.org/wiki/InSPIRE/low_impact/habitat/ground_cover

[75] Greg Barron-Gafford (University of Arizona researcher), in discussion with the author, 2019.

[76] Chad Higgins (Oregon State University researcher), in discussion with the author, 2019.

[77] Meinschein, Gavin. 2019. "Whitepaper: Solar + Pollinators." Engie Distributed Solar, March.

[78] Gavin Meinschein (Engie Distributed Solar Lead Civil Engineer), in discussion with the author, 2019.

[79] "Ground Cover." InSPIRE. Accessed August 02, 2019. https://openei.org/wiki/InSPIRE/low_impact/habitat/ground_cover

[80] Eric Udelhofen (OneEnergy Renewables), in discussion with the author, 2019.

[81] Farrell P, Abatzoglou J, Brooks E. 2015. The impact of climate change on soil erosion. Regional Approaches to Climate Change for Pacific Northwest Agriculture: Climate Science Northwest Farmers Can Use: REACCH Annual Report Year 4

Minnesota and Pollinator-friendly Dual-use: *One of the hot spots for pollinator-friendly dual-use solar has been Minnesota with its first project coming in 2014. That project was built by Connexus Energy, Minnesota's largest electric cooperative, which recently opened a much larger pollinator site on a solar-plus-storage project in Ramsey, MN. The site, 18 acres with 3.3 MW of solar and 10.6 MWh of storage,*[82] *has pollinator-friendly plants in the array and is surrounded by milkweed for butterflies.*[83] *The project is sited directly adjacent to a pumpkin and melon farm, two crops that are highly dependent on pollinators*[84] *and will benefit from their new pollinator neighbors. The combination of the pollinator-friendly solar and the farm also offers a good setting for honey production. Bare Honey from Minneapolis has now added hives to the site to do just that. This project is a win for the cooperative as they will be able to rely on their own power and use batteries to avoid paying high prices for electricity during peak hours, saving their members money. It is also a win for the local farm and honey businesses that will benefit from this new habitat. Finally, it is a win for the butterflies, bees, and birds that will now have a new place to call home.*[85]

Taking a closer look at the Northwest, pollinator-friendly sites can do a lot compared to traditional solar sites in terms of invasive species control, though there are also complexities to consider with these projects. According to Understory Consulting, an Oregon consultancy on native plants and solar site seeding, native plants can better resist invasive species and comply with noxious weed prevention standards. Understory notes that developers can save money if they are working on a site that already has native vegetation, and they make an effort in the construction process to preserve that vegetation, as preservation will be a lot easier than seeding the whole site.[86] They also note that one local issue to the region is having enough native wildflower seed available in a region to plant at large facilities. For example, in Oregon it is relatively hard to get a large amount of native wildflower seed outside of the Willamette Valley. The availability of seed and planning for the production of seed for a site means developers

82 Weaver, John. "Minnesota Gets Its First Large-scale Energy Storage System (and You Get Free Solar Honey!)." Pv Magazine USA. August 07, 2018. Accessed July 18, 2019. https://pv-magazine-usa.com/2018/08/06/minnesota-gets-its-first-large-scale-energy-storage-system-and-you-get-free-solar-honey/

83 Brian Burandt (Connexus Energy, VP of Power Supply and Business Development), in discussion with the author, 2019.

84 Leroy Walston et al. "Examining the Potential for Agricultural Benefits from Pollinator Habitat at Solar Facilities in the United States" *Environmental Science & Technology,* 2018, 52, (13), 7566-7576. https://doi.org/10.1021/acs.est.8b00020

85 Dunbar, Elizabeth. "Pollinator-friendly Solar Energy Becomes the Norm in Minnesota." MPR News. June 20, 2019. Accessed August 02, 2019. https://www.mprnews.org/story/2019/06/20/pollinatorfriendly-solar-energy-becomes-the-norm-in-minnesota

86 Sean Prive (Understory Consulting, Native Vegetation Expert), in discussion with the author, 2019.

have to start looking into this earlier in the development stage in order to ensure they will have the seed when they need it.[87]

Finally, one additional benefit of these projects to both the developer and the community is the aesthetic improvement to a solar facility. As compared to traditional solar sites, pollinator-friendly sites often feature wildflowers and attract birds and butterflies. This can endear the project to the local community. Community acceptance due to project aesthetics has been crucial for new solar builds in places like Massachusetts, where the initial build-out of solar often did not include consideration of how the projects looked to the community. As solar arrays become more common, communities are demanding better results ecologically and aesthetically from solar facilities.[88] Research has shown that permitting processes, environmental review, and community acceptance all occur better and faster with pollinator-friendly projects.[89]

Pine Gate Renewables, Oregon: Pollinator-friendly Arrays
Oregon is home to a unique set of pollinator-friendly solar arrays developed by Pine Gate Renewables in southern Oregon and the Willamette Valley. The main site is the 10 MW Eagle Point project, a 41-acre array in Jackson County that produces enough clean energy to power 1,575 homes.[90] *It is planted with native prairie, which provides pollinator habitat within the panel rows. In addition to housing native plants, Eagle Point is home to 57 hives that host honeybees.*[91] *In 2018, the project entered into a collaboration with Caldera Brewing to make the "Let's Bee Friends IPA" with honey made on the solar site. John Jacob, owner of Old Sol apiaries and the hives on site, is encouraged by the project and states: "Pollinator-friendly solar farms are a great place to keep managed honey bees, provide habitat for our native bees and wildlife, and support renewable energy and a sustainable food supply."*[92] *John's on-site hives produce honey and queens to be sold as agricultural products. This site is actually*

87 Ibid

88 Liz Curran (Director of Policy, BlueWave Solar) and Lucy Bullock-Sieger (Director of Civil Engagement, BlueWave Solar), in discussion with the author, 2019.

89 Goodrich, Alan, Ted James, and Michael Woodhouse. *Residential, Commercial, and Utility-Scale Photovoltaic (PV) System Prices in the United States: Current Drivers and Cost-Reduction Opportunities.*Report. February 2012. Accessed June 26, 2019. https://www.nrel.gov/docs/fy12osti/53347.pdf

90 "SolarCulture RAC Presentation." Lecture, Rulemaking Advisory Committee, Salem. Accessed June 27, 2019. https://www.oregon.gov/lcd/LAR/Documents/DualUse_RAC_Presentation_20181114.pdf

91 Evan Bixby (Pine Gate Renewables), in discussion with the author, 2019.

92 Gailit, Broc. "Caldera Brewing Introduces Oregon's First Solar Farm Beer "Let's Bee Friends IPA"." Newschoolbeer.com. October 5, 2018. Accessed July 16, 2019. https://www.newschoolbeer.com/2018/10/caldera-brewing-introduces-lets-bee-friends-ipa-unite-supporters-agriculture-clean-energy-pollinator-health.html

considered an agricultural project as honeybees are considered livestock in the state of Oregon.[93] Eagle Point is also the site of an NREL test plot in which researchers are looking at pollinator-friendly plants and how they grow in and around solar panels.[94] At the site, Oregon State University researchers are also studying how pollinator-friendly plants grow under panels. The OSU study is investigating the potential of solar-shaded plants to have a delayed bloom and provided much-needed pollen resources in the later summer months.[95] Pine Gate's other three Oregon sites total 12.4 MW and all feature active research by either NREL or Oregon State University as well.[96] In addition to being a research hub, Eagle Point supports the local economy by creating work for a local landscaping company, buying native seeds, helping Old Sol produce honey and queens, and helping Caldera Brewing with their solar beer. Eagle Point offers a great example of dual-use in the Northwest that supports native plants and continues agricultural production.

John Jacob and his bees, Photo Credit: John Jacob

Pollinator-friendly dual-use solar yields a multitude of benefits that help pollinators in need, help agriculture, and help make solar projects lower-cost. These sites are increasingly common in the U.S. and are accessible financially and technologically for many solar developers.

93 John Jacob (Old Sol Apiaries), in discussion with the author, 2019.

94 Misbrener, Kelsey. "Case Study: Eagle Point Solar Farm Sets Precedent for Solar Apiaries in the United States." Solar Power World. August 31, 2018. Accessed August 15, 2019. https://www.solarpowerworldonline.com/2018/08/case-study-eagle-point-solar-farm-apiary/.

95 Maggie Graham (Oregon State University, researcher), in discussion with author, 2019.

96 "SolarCulture RAC Presentation." Lecture, Rulemaking Advisory Committee, Salem. Accessed June 27, 2019. https://www.oregon.gov/lcd/LAR/Documents/DualUse_RAC_Presentation_20181114.pdf

Conservation Dual-use


Engie Distributed Solar

Solar sites that focus on restoring native plants, grasses, and prairie are considered to be conservation dual-use solar projects. While solar arrays are not traditionally thought of as natural conservation spaces, they offer innocuous environments with relatively little human interference. Solar sites offer protection for native species restoration, while other, unprotected sites might see those species trampled, tamped down, or lost as casualties in efforts to control weeds and invasive species. Beyond supporting pollinators such as bees and butterflies, these arrays can help with bird conservation. According to the National Audubon Society, 314 North American bird species are in danger due to climate change as rising temperatures could force them to lose half of their current ranges by 2080.[97] As climate change and development pressures decrease bird habitat, Audubon states that planting bird-friendly species in "solar sanctuaries" is just what we need. One example of this comes from Kearney, Nebraska, where a 53-acre solar site hosted native species in a migration route that provides habitat for birds and pollinators. This project was a collaboration between the City of Kearney, Nebraska Public Power District, and solar developer Engie, who all rallied around the multifunctional benefits of the site to provide clean energy and bird habitat.[98]

Dual-use solar with native species has the potential to provide and restore crucial vegetation with a myriad of benefits. Many of the benefits described before for pollinator-friendly dual-use also apply to conservation dual-use, including better water infiltration, the cleaning of stormwater runoff, and protection from invasive species. One crucial benefit from these sites comes in the form of soil conservation. Deep-rooted native plants are much better at preventing soil erosion than turf or bare ground. More than just preventing on-site erosion, these plants can catch soil running off of nearby land and store it on-site.[99] This reduction in soil erosion also has

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[97] "Nebraska's Largest Solar Array Is Surrounded by Bird-Friendly Plants." ENGIE Distributed Solar. October 23, 2018. Accessed July 12, 2019. https://www.engiedistributedsolar.com/nebraskas-largest-solar-array-is-surrounded-by-bird-friendly-plants/

[98] Ibid

[99] Gavin Meinschein (Engie Distributed Solar Lead Civil Engineer), in discussion with the author, 2019.

climate impacts as it preserves carbon stocks in the soil that would be lost to erosion.[100] Solar sites with native plants can allow soils to recharge with nutrients and improve the soil on-site for future agricultural uses.[101] In fact, solar sites can be ideal for soil restoration, as the average useful life of a solar installation is around 25 years. After the useful life of the project is over, the panels and racking can be taken out of the ground and the land can be transitioned to other uses such as farmland that can benefit from restored soils.[102] Alternatively, at the end of a project's useful life it can be repowered (the panels are switched for new ones), avoiding the need to build another project.

Lastly, conservation dual-use solar often follows best practices for reducing impacts to wildlife and providing mitigation for any habitat disturbance. Many solar developers must consult with the county and Department of Fish and Wildlife about mitigating the habitat disturbance of their project.[103] Conservation-focused solar projects implement features such as no fencing or permeable fencing that can work into a mitigation plan. Often, projects must have fencing for reasons of liability and protection of equipment, but innovative solar installers have worked with groups like The Nature Conservancy to install wildlife-permeable fencing with large holes to allow better passage than a conventional chain-link fence.[104] Conservation dual-use also has potential as on-site mitigation for wildlife impacts, as it provides natural habitat, especially for pollinators and local bird species. This possibility will vary site by site, but it is another benefit of focusing on conservation within solar arrays.

Conservation dual-use solar, often as a subset of pollinator-friendly dual-use, presents a way to reduce the impact of solar while adding land for native species. Seeding arrays with native species are attainable today for solar developers, and offer a host of benefits ranging from native species support to improved panel efficiency. While this form of dual-use and co-location may not work everywhere, it has the potential to offer solutions that allow for both solar development and land and wildlife conservation.

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[100] May, C. et al. 2018: Northwest. In *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment*, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 391–437. doi: 10.7930/NCA4.2018.CH10

[101] "Ground Cover." InSPIRE. Accessed August 02, 2019. https://openei.org/wiki/InSPIRE/low_impact/habitat/ground_cover

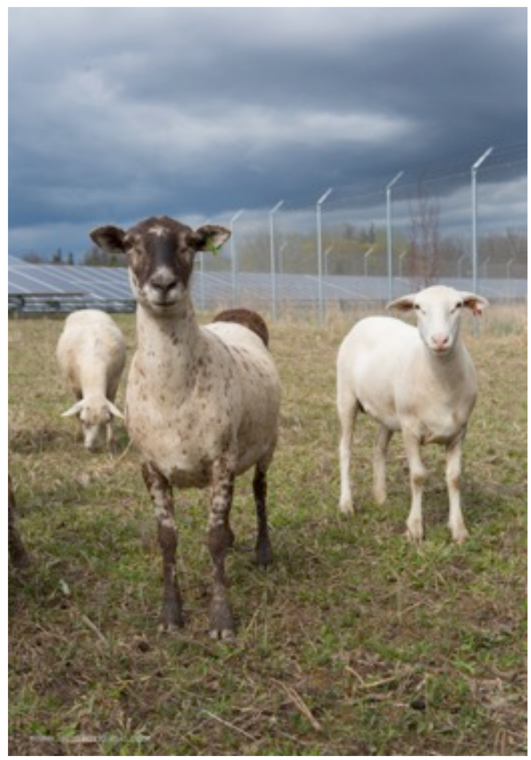
[102] Loren Wiltse (Adams County Planner), in discussion with the author, 2019.

[103] Ann Siqveland (OneEnergy, Director of Project Development), in discussion with the author, 2019.

[104] Ramlagan, Nadia. "Permeable Fencing Helps Make NC Solar Farms Wildlife-Friendly." Permeable Fencing Helps Make NC Solar Farms Wildlife Friendly / Public News Service. May 15, 2019. Accessed July 16, 2019. https://www.publicnewsservice.org/2019-05-15/endangered-species-and-wildlife/permeable-fencing-helps-make-nc-solar-farms-wildlife-friendly/a66472-1

Grazing Dual-use

One of the most intuitive co-location strategies is grazing livestock on solar array sites. Solar arrays can provide a lot of space for forage between and under panels, and having animals eat vegetation also meets the need to keep grass low in order not to shade the panels. Grazing is usually done with sheep or chickens as both of these have little potential to harm the panels or affect energy production.[105] Other grazing animals such as goats or cows are generally not suitable for solar sites (with exceptions), with cows being too large and goats having a predisposition toward chewing on wires or jumping on panels.[106] Solar grazing, especially with sheep, has been done throughout the U.S. on several projects, proving to be a beneficial form of co-location or dual-use. Developers and farmers report that sheep grazing around solar arrays is a win-win. For developers, sheep are a low-cost vegetation management tool that provide the service of keeping vegetation low while maintaining and fertilizing beneficial grasses on site. For the farmer, the solar array presents a large area of forage often surrounded by a fence that can give their herd protection, and the panels can offer needed shade for the sheep. These sites also can offer more forage later in the season as well as increased business opportunities in terms of landscaping contracts, the possible addition of an apiary for honey production,[107] and of course lease payments if the farmer owns the land with the solar array.



Courtesy of www.laurakozlowski.com

One farmer who recognized this opportunity is Lexie Hain, a sheep grazer from the Finger Lakes region in New York who started her own business named Agrivoltaic Solutions LLC. Lexie also works as the Executive Director of the American Solar Grazing Association (ASGA), which promotes solar grazing. Lexie's business provides grazing services to solar sites in the Finger Lakes area totaling 125 acres, with the largest site being 35 acres. When speaking about how sheep are well suited to this type of work, she states: "They will eat almost anything that grows, maintaining an ideal

[105] Meza, Edgar. "Solar Farms Increasingly Popular with UK Farmers." Pv Magazine International. September 11, 2014. Accessed July 16, 2019. https://www.pv-magazine.com/2014/09/11/solar-farms-increasingly-popular-with-uk-farmers_100016390/#axzz3PVE4Dk1W

[106] Brooks Mixon (Sun-Raised Farms), in discussion with the author, 2019.

[107] Lexie Hain (Agrivoltaic Solutions, Solar Grazer), in discussion with the author, 2019.

vegetation height to prevent shading on solar panels. Existing perimeter fences at the solar farms protect them from predators, and the panels themselves provide shelter from rain, wind, and direct sun on hot days. It's a fantastic opportunity for sheep farmers to generate extra income in a mutually beneficial environment."[108] In recent years, companies like Lexie's have been providing vegetation management services for solar array owners.[109]

One of the first companies to do this was Sun-Raised Farms in North Carolina. They began operation in 2012 in Bunn, North Carolina, where a local sheep farmer wanted access to the grass at a solar site. Sun-Raised was able to recognize that goats and sheep have been used to clear vegetation for transmission projects in the past, so this arrangement was just the next iteration of livestock combined with electricity. Today, with 500 acres of solar arrays being grazed under their management, Sun-Raised works as a connector between grazers and developers. It gives nearby grazers access to land and pays them for the total site maintenance, both work done by the sheep and trimming done by the farmer, creating a potential stream of extra income. In turn, Sun-Raised gets paid by the solar array owner for their ground maintenance work.[110] Developers are interested in this model as it has the potential to lower costs and they can either continue grazing, or, if grazing was not there before, add agricultural production to a site.

Solar and Sheep in Bedford, Virginia

Solar with sheep grazing can be found all around the U.S. and especially on the East Coast. In Bedford, VA, there is a 20-acre solar array developed in 2018 maintained by and sheep owned by Liz Akenhead. Liz works with the likes of Daisy May, Minnie, Ruby, Rose, Jingle, and many more (all sheep) to keep the solar panels out of the shade. She also works with her three daughters to maintain the sheep and remove the weeds they won't eat. When asked by a reporter for her thoughts on the combination of solar and her sheep she says: "It's a productive use of the land. Instead of just harvesting solar energy, you can turn it into sheep grazing and promote agricultural use of the land."[111] The family only has to mow sparingly and Liz notices that the grasses grow better underneath the panels, providing better pasture than on her land.

[108] "Nexamp Launches Solar Grazing Program." Feedstuffs. June 25, 2019. Accessed August 05, 2019. https://www.feedstuffs.com/news/nexamp-launches-solar-grazing-program

[109] Lexie Hain (Agrivoltaic Solutions, Solar Grazer), in discussion with the author, 2019.

[110] Brooks Mixon (Sun-Raised Farms), in discussion with the author, 2019.

[111] Smith, Rachael. "Here's a Bright Idea: Sheep Work to Keep Vegetation under Control at Solar Farm in Bedford." NewsAdvance.com. April 27, 2019. Accessed July 3, 2019. https://www.newsadvance.com/news/local/here-s-a-bright-idea-sheep-work-to-keep-vegetation/article_ac6b2e0e-6939-11e9-8635-9b3c3f46097e.html

They use rotational grazing and are glad that the panels make the sheep comfortable with their ability to shelter the animals from wind and rain. They visit the site most days to see how the sheep are doing and monitor the condition of the land.[112] *It is a low-maintenance operation, with the sheep doing most of the work and Liz and her kids watching over.*

Several lessons learned, nuances, and best practices have emerged for this type of dual-use solar between ASGA, Sun-Raised, and others familiar with this topic. First, there are fewer operations and management risks, as well as reduced costs associated with grazing as compared to traditional mechanical cutting. For example, there is less risk of a mower clipping a panel or kicking up a rock and damaging the panels. The Tampa Bay Electric Company recently reported that the cost to have sheep on their solar sites was a quarter of the cost of traditional mowing.[113] Second, the sheep will do most of the work but will not eliminate mowing or hand-weeding outright. According to Lexie, her sheep do about 95% of the work needed; according to Sun-Raised, the sheep do about 75% of the total labor. Often, farmers will prefer to take over the entire grounds' maintenance contract as an additional source of revenue, having their sheep do most of the work and then either mowing or weeding on top of that.[114] Third, water and portable electric fences are often the only pieces of infrastructure needed for the sheep. These sites should have some water access (municipal or well) or be able to haul water to the site. In addition, it is best to rotationally graze the animals around the site and use an electric fence to keep them in a certain area. In terms of additional infrastructure, depending on the climate, the site might need to have extra land or small shelters for rest times.[115]

The details of contracting terms and who gets paid out of the dual-use system often vary by situation. Sometimes, especially in the early days of grazing dual-use, farmers will simply get access to the land for free in an informal arrangement, which is a benefit to farmers in areas with high land costs. Often, though, farmers are formally contracted and paid for the ground maintenance services they provide. This contracting system guarantees the grazer can plan on

112 Ibid

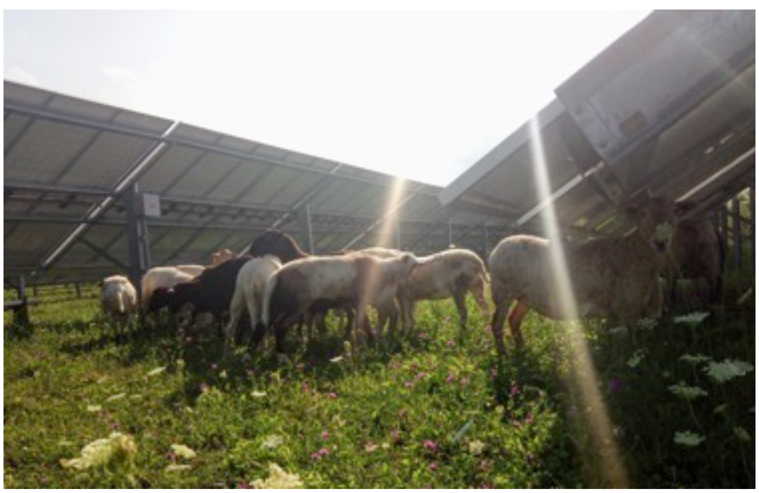
113 Carollo, Malena. "They're Fluffy. They're Hungry. They Work for Tampa Electric." Tampa Bay Times. February 14, 2019. Accessed July 9, 2019. https://www.tampabay.com/business/theyre-fluffy-theyre-hungry-they-work-for-tampa-electric-20190213/

114 Lee Menius (NC Choices), in discussion with the author, 2019.

115 Lexie Hain (Agrivoltaic Solutions, Solar Grazer), in discussion with the author, 2019.

having access to the land through the season, which is crucial to getting grazers on-board with these types of arrangements.[116]

One of the biggest lessons learned is that grazing dual-use solar should be planned in advance if it is to be successful. Developers and farmers should consider how sheep will get to the site, how they will have access to water, what to do if/when they run out of forage, and how to address lambing. These considerations are often set out in a prescribed grazing plan or in the contract between the farmer and the solar developer. Unfortunately, many solar developers do not plan ahead for grazing, and this lack of planning can hamper the effectiveness of these projects for dual-use. For example, when a project is built, the solar developer might not plan for water to be on the site or not build the fence deep enough to keep out predators that can dig under traditional fencing.[117] Developers should also consider grazing when they are making their contracts with the land owner in order to tailor the language to the grazing use. Finally, contracts will need to consider liability issues and safety requirements that meet local and federal standards and are within reach of the average grazer.[118]


Lexie Hain, Agrivoltaic Solutions LLC

As grazing dual-use solar projects increase, there are both opportunities and challenges when scaling this practice. The main opportunity when scaling this type of dual-use solar is that the site design can stay the same as if there were no sheep on the site. We know this as many solar grazing projects to date have materialized with grazing as an afterthought.[119] This means there are no major shifts in the cost to design or make the project, which appeals to developers and reduces energy costs for electricity end-users as well. The first major challenge to scaling this practice is connecting farmers to solar developers. Lexie Hain hopes to match farmers with nearby solar arrays using a mapping tool that is being developed by her association. This tool

116 Ibid

117 Brooks Mixon (Sun-Raised Farms), in discussion with the author, 2019.

118 Lexie Hain (Agrivoltaic Solutions, Solar Grazer), in discussion with the author, 2019.

119 Lexie Hain (Agrivoltaic Solutions, Solar Grazer), in discussion with the author, 2019.

will allow solar developers and farmers to get in contact earlier in the process and hopefully mitigate some of the issues mentioned above. Additionally, as with pollinator-friendly or conservation dual-use, this type of solar will take some extra effort from developers to correctly set up and add in flexibility to support sheep farmers. Hopefully, solar developers will see that grazing dual-use solar adds value in terms of both agricultural production and reduced management costs. Finally, there is the challenge that this practice will not work everywhere. It will only work in areas that can support vegetation and have enough of a sheep industry to graze the acreage.

Despite these challenges, grazing and solar are almost a perfect match with the solar providing benefits to the sheep (shading, more forage) and the sheep providing benefits to the solar (vegetation management). If done using best practices, this system is relatively easy to implement, and helps preserve production on lands designated for agriculture. Moreover, grazing dual-use has already come to a commercial site in the region, and Oregon State University researchers are beginning to test and quantify the benefits of grazing dual-use as well. In addition to their pollinator-friendly dual-use solar projects, Pine Gate Renewables owns a project called "Sheep Solar" near Salem, Ore. The project has a nameplate capacity of 2.2 MW, and started operating in 2017 with sheep actively grazing the site.[120] OSU is doing research on grazing sheep under panels in Corvallis, Ore. Associate Professor Chad Higgins' group recently finished collecting plant and lamb health data from a study in spring 2019. They tested grazing both under panels and in a control area. They are now looking to test whether grazing under panels can support more sheep and sheep growth due to an increase in forage under panels that they found and reported in a 2018 paper. That paper showed forage under panels grew more slowly but also for a longer season, resulting in double the amount of late season forage, and was over 300% more water efficient than the control.[121] These findings mean that the site could feed livestock much later in the season which offers a benefit for grazers. They are also testing the stress levels of the lambs to see if the shaded environment or difference in available forage (both in quantity and nutrition) lowers their stress levels and improves health outcomes (dubbed "lamb happiness"). Initial results show that grazing under solar panels might be able to support more sheep than the control. They are testing again in the spring of 2020 to add certainty to their results.[122]

[120] "Renewable Energy Projects." Renewable Energy Projects. Accessed July 10, 2019. http://renewablenw.org/project_map?field_project_state_value[]=WA&tid[]=9

[121] Hassanpour Adeh, Elnaz et al. "Remarkable agrivoltaic influence on soil moisture, micrometeorology and water-use efficiency." PloS one vol. 13,11 e0203256. 1 Nov. 2018, doi:10.1371/journal.pone.0203256

[122] Chad Higgins (Oregon State University researcher), in discussion with the author, 2019.

Beyond the research being done in the Northwest, there is interest in grazing dual-use systems from farmers such as BJ Mathews from Yamhill County, Ore. BJ sees value in potentially having solar pasture for her ewes and lambs. First, predators are a major problem in her region, and if the solar site has a good fence, that could help protect her flock. Second, BJ sees that her pasture is often unproductive by early June and is encouraged by the prospect of having shaded grasses under the panels with a longer growing season if her flock were to graze under panels. The longer growing season for forage means she doesn't have to spend so much on food for her sheep to feed on. BJ also shares the concerns mentioned before, including that the solar site can't be too far away as she needs to check on the flock consistently, and that there needs to be a better way to connect farmers with solar sites. She adds that there is still research to be done on how many sheep should be on an acre of a dual-use and whether apiaries can be combined with sheep grazing.[123]

Grazing dual-use solar already has proved itself to be a viable and efficient way of co-locating agriculture and solar in the U.S. With proper support, it will continue to grow as an innovative form of vegetation management and land use. The benefits of this dual-use practice continue to be investigated and proven out in our region, and soon we may know if lambs are really happier with clean energy over their heads.

Agrivoltaics

The final category of dual-use solar is crop production underneath solar panels. Often dubbed "agrivoltaics," these panel and crop systems are more vegetation-centric compared to other forms of dual-use, as solar array designs might need to be altered to accommodate crops. From the sites that have been doing this type of dual-use so far, accommodating crops often means raising the panels higher off the ground, usually 8-10 feet, to allow for more sun and make room for agricultural equipment or labor.[124] To date, most of the cases of agrivoltaics are research plots, with the first few larger-scale commercial operations in the U.S. currently in the planning stages.

The idea of agrivoltaics first appeared in the literature in Europe back in the 1980s.[125] Since then, a few major studies have looked at the potential for crop production under panels and what effect shading has on crops. Several studies by Christian Dupraz and Helene Marrou have

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[123] BJ Mathews (Sheep Farmer), in discussion with the author, 2019.

[124] Drew Pierson (Director of Project Development, BlueWave Solar), in discussion with the author, 2019.

[125] Goetzberger, A and Zastrow, A "On the Coexistence of Solar-Energy Conversion and Plant Cultivation" Fraunhofer-Institut for Solare Energiesysteme Oltmannsstrasse 22, D-7800 Freiburg, West Germany, 1981.

investigated different agrivoltaic schemes. These researchers incorporated Land Equivalency Ratios (LERs) into their work to characterize how efficient this model was. LERs with a value greater than one show that the land is being used more efficiently than if it had only one of the elements (solar or agriculture) on it, and they applied this concept to the combination of farmland and electricity production. "A 1.7 LER value would mean that a 100 ha farm would produce as much electricity and food crops as a 170 ha farm with separate productions." [126]

These researchers set up one of the first agrivoltaic systems in 2010 in Montpellier, France, with elevated panels (four meters off the ground) in full-density and half-density arrays set up to understand the effects of the panels over a crop system. When testing lettuces, they found that "... lettuces can maintain relatively high yields under PV, in the (half density) shade treatment and, for some varieties, in the (full density) treatment in spring growing conditions."[127] Dupraz and Marrou also saw water savings in lettuces under panels, with lettuces also adapting to lower light conditions by growing more mass than expected based on the sunlight delivered, specifically growing fewer but larger leaves.[128] [129] They point out that if sunlight is managed (possibly by tracking panels) and extra light is allowed for especially the juvenile part of the plant's life, it can grow close to full production.[130]

Following up on their work, other researchers did a study at the same site as Dupraz and Marrou — but now with tracking panels added. The researchers tested the full-density plot and half-density plot along with two separate tracking plots, one that maximized power production and one that maximized sunlight for the lettuce crops. The best producing system was the power-production-focused tracking system, which was able to achieve 67-77% of normal agricultural production while also achieving 60-90% more electricity production than a full-density static solar array (due to the trackers' ability to capture more energy). The standard tracking system's LER value was always above 1.5 for all three seasons tested.[131]

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126 Dupraz, C., et al. "Combining Solar Photovoltaic Panels and Food Crops for Optimising Land Use: Towards New Agrivoltaic Schemes." *Renewable Energy*, vol. 36, no. 10, 2011, pp. 2725–2732., doi:10.1016/j.renene.2011.03.005.

127 Marrou, H., et al. "Productivity and Radiation Use Efficiency of Lettuces Grown in the Partial Shade of Photovoltaic Panels." European Journal of Agronomy, vol. 44, 2013, p. 60., doi:10.1016/j.eja.2012.08.003.

128 Marrou, Helene, Lydie Dufour, and Jacques Wery. "How Does a Shelter of Solar Panels Influence Water Flows in Soil-Crop System?" *European Journal of Agronomy* 50 2013: 38–51. https://doi.org/10.1016/j.eja.2013.05.004

129 Marrou, Helene et al. "Productivity and Radiation Use Efficiency of Lettuces Grown in the Partial Shade of Photovoltaic Panels." *European Journal of Agronomy* 2013; 44: 54–66.

130 Marrou, Helene et al. "Microclimate Under Agrivoltaic Systems: Is Crop Growth Rate Affected in the Partial Shade of Solar Panels?" *Agricultural and Forest Meteorology*, Volume 177, 2013, Pages 117-132, https://doi.org/10.1016/j.agrformet.2013.04.012.

131 Valle, B., et al. "Increasing the Total Productivity of a Land by Combining Mobile Photovoltaic Panels and Food Crops." *Applied Energy*, vol. 206, Nov. 2017, pp. 1495–1507. doi:10.1016/j.apenergy.2017.09.113

In addition to these studies, researchers in Italy conducted a simulation of maize growing under a real solar tracking system. The researchers simulated 39 years of crop production, and found that growing maize under panels led to less variability and better performance in water-stressed years. While the panel shaded areas performed better in many respects, maize growth under panels performed worse in regular water years. The researchers got LERs ranging between two to three attributed to how well the maize grew and how much energy they made as compared to a normal maize field and a fixed solar system.[132]

These studies' results are quite informative but mixed. Raised panel systems can produce relatively well, especially factoring in both crops and electricity production and considering the productivity of the system as a whole, but raised systems do not always perform well in terms of crop production (especially in less heat/water-stressed years). These studies also offer up a new frame to look at panels over crop systems as a light management system in which tracking panel systems can regulate the amount of sunlight and heat reaching the crops. Strategies based on these studies can be applied to future systems such as light management, crop selection (lettuces are adaptive), and utilization in more arid climates that need the water efficiency provided by these systems.

These European studies constituted the first investigations of agrivoltaic development and have been followed by studies done here in the U.S. The University of Massachusetts Amherst did a study of vegetable growth under a somewhat unique panel array of fixed, raised, and spaced-out panels. The study was conducted over two years and tested the growth of broccoli, swiss chard, kale, pepper, cabbage, and common beans. In the summers of 2016 and 2017, vegetables in full sunlight generally grew better than those in shade, but 2016's hot summer led to the cabbage failing due to heat stress and the shaded beans doing better than the full sun beans.[133] These results add to the idea that agrivoltaics are beneficial in hotter conditions and often will not produce the same yield as full-sun conditions. There are questions as to how representative this study is due to the unique array setup, which is worth keeping in mind.[134]

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[132] Amaducci, Stefano, Xinyou Yin, Michele Colauzzi, "Agrivoltaic systems to optimise land use for electric energy production." *Applied Energy*, Volume 220, 2018, Pages 545-561, https://doi.org/10.1016/j.apenergy.2018.03.081.

[133] Herbert, Stephen. "Vegetables under Solar PV 2016-17." Lecture. June 29, 2018. Accessed July 3, 2019. https://ag.umass.edu/sites/ag.umass.edu/files/pdf,doc,ppt/crop_yield_comparisons_2016_-_2017_umass_farm_nrel_co-location_project.pdf

[134] Liz Curran (Director of Policy, BlueWave Solar) and Lucy Bullock-Sieger (Director of Civil Engagement, BlueWave Solar), in discussion with the author, 2019.

Greg Barron-Gafford started his involvement with solar as a University of Arizona plant ecologist studying the effects of plants on the microclimates around solar arrays five years ago. Since then, he has been focused on agrivoltaic research, with a focus on system challenges and benefits in an arid region such as Tucson, Ariz. Greg explains that many crops get too hot during the day, and the panels protect the plants during these dangerous sun exposure times. Somewhat opposite of this, at night, the area under the panels actually stays warmer and the panels can prevent dangerous frost events, providing yet another benefit to the crops. In terms of water, panel shade reduces direct sunlight on the crops, suppressing evaporation rates and leading to water savings. Through his research, Greg has found that farmers can achieve similar levels of food production beneath solar panels as full-sun environments using significantly less water.

Greg Barron-Gafford

As the effects of climate change become more and more pronounced in the U.S., Greg notes that longer periods of drought followed by heavy rains are predicted for the future. As it turns out, growing crops under the solar panels moderate that variability. Shading, frost prevention, and water savings under the panels moderate seasonal variation and can extend the growing season. Anecdotally, Greg has worked with school programs to plant under their arrays, and has seen impressive results from this moderation of the climate in which the crops grow. Experimental trials have shown that they can produce three crops of carrots as opposed to one by extending the growing season start and end. They also can grow lettuce and basil during the winter when there is usually frost.

On some other sites, Greg's team rotates crops under the panels to see what works well. In Arizona it is often too hot to grow tomatoes in the summer, but below panels they were able to get both a summer and a fall crop. Up to this point, Greg and his team have grown tomatoes, jalapeños, kale, broccoli, chard, carrots, sweet potatoes, melons, basil, cilantro, lemongrass, and chiltepin (wild pepper) all under panels. In these experiments, their team saw jalapeños had a small reduction in yield, and broccoli had a major reduction in yield — but the broccoli result is likely due to the fact that it needs to freeze at certain times to grow correctly and the panels kept the area too warm at night. Most of the crops have either been close to matching or matched the yield of crops in full-sun conditions, and in some cases have produced more. In addition to matching yields, major water savings were achieved on the dual-use plots, confirming and furthering the results of the European studies.

In a new study titled: Agrivoltaics Provide Mutual Benefits Across the Food-Energy-Water Nexus in Drylands, Greg's team tested cherry tomatoes, jalapeño, and native peppers under a raised system (3.3 meters high) much like some of the other systems tested. In their general conclusions, the researchers stated: "We find that shading by the PV panels provides multiple additive and synergistic benefits, including reduced plant drought stress, greater food production, and reduced PV panel heat stress." [135] More specifically, when growing a native pepper under the panels, the pepper's fruit production tripled. In addition, the jalapeños grew just as well as full-sun conditions but were 157% more water efficient.[136] For cherry tomatoes, the plants used less water (they were 65% more water efficient), and: "Ultimately, total fruit production was twice as great under the PV panels of the agrivoltaic system than the traditional growing environment." Water savings were remarkable in this experiment, and the researchers were able to show that soil water lasted two days under panels compared to two hours in the full sun, meaning they can water the system every two days as compared to twice a day.

In addition to the water savings, the researchers also saw a direct benefit of the plants on the panels: Lower daytime temperatures led to better panel efficiency. While different types of panels perform differently, the researchers note that for every 1°C increase in temperature above 25°C, panel efficiency decreases by 0.6%. With the crops underneath the panels, though, "...temperature reductions documented here in the growing months of May-July from the co-location system lead to a 3% increase in generation over those months, and a 1% increase in generation annually."[137] These increases in efficiency can make a big difference in the economics of a solar project. This paper notes that the delineation between crop production and electricity

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135 Barron-Gafford, Greg et al. "Agrivoltaics Provide Mutual Benefits Across the Food-Energy-Water Nexus in Drylands." Manuscript, 2019.

136 Ibid

137 Ibid

production is not helpful when considering new innovations like agrivoltaics: "...this either-or discourse drives many policies and development decisions around conservation practices, land and water allotments for agriculture, and permitting for large-scale renewable energy installations. However, we may require a more holistic and integrated approach centered at the nexus of food, energy, and water system studies."[138] Greg adds that solar and agriculture should not be seen as a zero-sum-game in terms of land use as there is a nexus between the two that needs to be acknowledged.

More locally, Oregon and Washington are at the forefront of these topics in the form of Oregon State University's Nexus of Energy, Water and Agriculture Laboratory (NEWAg) program. As part of this program, researcher Chad Higgins and others are looking into both solar grazing and agrivoltaics, as discussed above. Additionally, researchers are looking into tomato plant growth underneath solar panels and specifically getting reference data for an agrivoltaic crop for modeling future systems and their growing potential.[139] Somewhat separately, researcher Amy Garrett has a project looking into dry farming (non-irrigated) vegetable crops in western Oregon, with one of her test sites using a solar array. At this site, Amy is growing different crops in four separate alleyways in between panels. Two of these alleyways have dry potatoes and one is growing dry beans. The final alleyway is planted with winter squash, tomatoes, and watermelons. Each crop is planted in both a part-shade plot and a full-sun plot to test the difference in yields. This work is part of a three-year contract with NREL and Pine Gate Renewables to explore whether panels could help dry farming, especially given the water savings seen in other studies.[140] With the Northwest taking a lead on agrivoltaic research, the lessons learned in these projects will be directly applicable to this dual-use application in the region.

[138] Ibid

[139] Chad Higgins (Oregon State University researcher), in discussion with the author, 2019.

[140] Amy Garrett (Oregon State University extension researcher), in discussion with the author, 2019.

Agrivoltaics in Action: Part 1

One of the first commercial-scale forms of agrivoltaics is being implemented in 2020. BlueWave Solar is working with farmer Paul Knowlton on bringing this innovative system to life on his farm. Paul's family has been farming their land in Grafton, Mass. for over 150 years and Paul hopes to keep the farm going for future generations. As a vegetable and livestock farmer, he could benefit from consistent revenue that adds support to his variable revenue from agricultural activities. In addition, parts of his land go unused, as it is too expensive and risky to raise livestock or grow vegetables on all of his land. To give Paul the benefit of consistent income and use of his land, he worked with BlueWave Solar to develop a 2.6 MW project followed by a 3.7 MW project a few years later.[141] With the lease payments he has received and will receive in the future, Paul is working on building a greenhouse, upgrading equipment, and making a processing plant for his products. These projects have also allowed his daughter to quit her off-farm job to work on the farm as it is now economically viable.[142]

As the first two projects were successful in supporting his farm, Paul has now moved ahead on another project, this time incorporating dual-use agrivoltaic strategies. It is a 13-acre, 3 MW project set to begin production in the spring of 2020. The site has 2.8 MW reserved for rotational grazing of yearling cattle and 330 kW reserved for growing vegetables underneath. While cattle are not often suitable for grazing these sites, the racking system is strong enough to prevent damage from the yearlings. The system has panels raised 8-10 feet off the ground and somewhat spread out, dimensions that allow the cattle to pass under and reduce shading of the crops.[143] This project is being followed up by another 3 MW agrivoltaic system in southern Massachusetts to be built by BlueWave. This second array is planned to be a storage-backed community solar project that grows butternut squash underneath. The project will provide an important basis for farm succession planning and farmland conservation as it will allow the current farmer to retire in a few years and will provide incentives for new farmers to work on the property rather than liquidating the land for a housing subdivision.[144] These systems are two of the first to take advantage of an incentive for solar combined with agriculture in the state as part of the SMART program (as will be discussed later) and will receive six additional cents per kWh for their solar production as long as they keep up

[141] "BlueWave Solar + Knowlton Farms: Case Study 2018" BlueWave Solar, 2018.

[142] Liz Curran (Director of Policy, BlueWave Solar) and Lucy Bullock-Sieger (Director of Civil Engagement, BlueWave Solar), in discussion with the author, 2019.

[143] Drew Pierson (Director of Project Development, BlueWave Solar), in discussion with the author, 2019.

[144] Ibid

production of both energy and agriculture. Paul and the farmer in southern Massachusetts will both directly receive a large portion of that incentive with the rest split between improvements on their farms and BlueWave.[145] *Paul's site will provide data on yield and other metrics for researchers at UMass Amherst, and BlueWave is collecting data on the array to inform other projects. BlueWave states that "these projects are a first-of-their-kind example for other farms in the region; representing a new revenue stream while conserving agricultural land, maximizing agricultural output and reducing carbon emissions."*[146] *Paul's farm and others are commercializing this technology and showing that these systems can work right here in the United States.*

Example of cattle under solar, BlueWave Solar

Agrivoltaics in Action: Part 2

Developers in the Northwest are seriously considering agrivoltaic systems and the many benefits they offer. Cypress Creek Renewables is planning a 10 MW project in Klamath County, Ore., that proposes to farm native seeds below raised panels along with hosting an apiary on-site. The site, therefore, would produce clean energy, crops, apiary products, support pollinators, and provide other ecological benefits. Called the Merrill Project, this would be the largest commercial agrivoltaic system in the U.S., and make the Northwest a leader in this type of dual-use solar development. The benefits of such a project would include the creation of local renewable energy and the continuation of farming the land. The new system would move away from a crop that is water intensive toward native plants that conserve water. This new native plant production would result in improved soil stability and water infiltration. In this model, the revenues from the solar farm will help subsidize the high upfront cost to start the farming/pollinator/apiary site as high-

145 Ibid

146 "BlueWave Solar + Knowlton Farms: Case Study 2018" BlueWave Solar, 2018.

value native seeds require a significant upfront investment. The benefits to the local economy include part- and full-time farming jobs in addition to the jobs associated with the solar project. The benefits also include establishment of a local apiary and honey/queen business as well as support for native planting organizations. This project could also help provide seeds for other solar arrays requiring native seed which are in short supply in southern Oregon. As of the writing of this report, the project is currently in local permitting proceedings seeking approval. The Merrill Project demonstrates interest from solar developers in the region to innovate and implement multifunctional farming attributes in their project designs. [147]

Agrivoltaics is coming into the commercial phase in the U.S., with Oregon being at the forefront of both research and potential commercialization. There is still a good deal of work to be done to scale this type of system commercially and set up business models that work for both farmers and developers. Agrivoltaics have a good base of research, and the Northwest will benefit from continued investigation by the region's existing research centers, which have a legacy of leadership in pioneering agricultural practices needed to meet the Northwest's future needs. Incentives would also help this concept grow to scale and replicate the benefits expected from the Knowlton and Merrill projects.

[147] Amy Berg Pickett (Senior Community Engagement & Permitting Manager, Cypress Creek Renewables), in discussion with the author, 2019.

Dual-use Policy Trends

Around the U.S., state and local governments have begun to experiment with policy designed to support dual-use solar practices. These policies can help inform what Oregon and Washington might do to support multifunctional solar.

Northwest

Before looking outward, the Northwest already has a policy that supports dual-use solar development. As mentioned in the section on Energy and Land-use Policy, the Oregon Land Conservation and Development Commission recently adopted a rule that bans solar from class I and II soils and prime and unique farmland, but provides for an eight-acre increase in project size for dual-use solar projects on other high-value soils.[148] The rules define dual-use solar as "developing the same area of land for both a photovoltaic solar power generation facility and for farm use."[149] While this definition does include agrivoltaics and grazing, the rule does not directly address pollinator-friendly or conservation dual-use when it comes to the acreage step-up. In addition, the step-up in acreage is temporary (only valid through 2021),[150] which presents a limited policy model when looking to incentivize dual-use solar in the longer term.

Pollinator Scorecard

Looking elsewhere around the country, the most common policy approach found in relation to dual-use development is the pollinator scorecard. While not all scorecards are the same, they are generally voluntary evaluation tools that a developer will fill out if they want their project to be labelled pollinator-friendly. Currently, there are scorecards in Minnesota, Michigan, New York, South Carolina, Maryland, Vermont, and Illinois.[151] For example in Minnesota, sites can only claim to be pollinator-friendly if they abide by the pollinator plan set out by a government body and publicly publish their vegetation management plan.[152] Their scorecard, which they label as a "Pollinator Habitat Assessment", includes questions about how much of the area will be covered by wildflowers and native species, how much diversity there is in the plants,

148 Profita, Cassandra. "Oregon Restricts Solar Development On Prime Farmland." Oregon Public Broadcasting. May 28, 2019. Accessed June 5, 2019. https://www.opb.org/news/article/solar-development-farmland-oregon-ban/

149 OARD 660-033-0130 "Minimum Standards Applicable to the Schedule of Permitted and Conditional Uses" https://secure.sos.state.or.us/oard/viewSingleRule.action?ruleVrsnRsn=258377

150 Ibid

151 Morehouse, Catherine. "Pollinator Habitats: The Bees' Knees of Rural Solar Development." Utility Dive. August 27, 2018. Accessed June 13, 2019. https://www.utilitydive.com/news/pollinator-habitats-the-bees-knees-of-rural-solar-development/530716/

152 2016 Minn. Laws 216B.1642 https://www.revisor.mn.gov/bills/text.php?number=HF3353&version=1&session=ls89&session_year=2016&session_number=0

whether the plants bloom in different seasons, and what insecticides might have been used on the site. The site gets points for more wildflower/native cover, as well as plant diversity, and it loses points for items such as insecticide use. If the site scores over 70 out of 100, it can be designated as pollinator-friendly.[153] A site that receives a pollinator-friendly designation may have an easier time gaining community acceptance and a smoother permitting process, as the designation shows a dedication toward developing solar with best practices. Rob Davis, who runs the Center for Pollinators in Energy at Fresh Energy, thinks of these policies as incremental changes that can make a meaningful benefit.[154] These scorecards help set standards for what pollinator-friendly solar should include and are flexible as they work on a points system. Although these scorecards provide a nudge, they are generally not tied to a tangible incentive or permitting processes and, therefore, should be considered merely a tool to support dual-use solar.

Engie Distributed Solar

Michigan offers an example of one tangible incentive — more land access — that promotes and values multifunctional solar. A recent executive order from the governor allows 3.3 million acres of protected land under the Farmland and Open Space Program to be leased by pollinator-friendly solar projects. These lands can already be leased for other energy activities like oil, gas, and wind generation, but now solar projects that achieve at least a 76 on the state's pollinator scorecard also qualify. This policy aims to add a lot more pollinator habitat on these lands to support the pollinator-dependent agriculture in the state, as well as help preserve the health of the land for future agricultural use.[155]

SMART Adder

Another program that actively incentivizes some of these dual-use strategies comes from the Bay State in the form of the Solar Massachusetts Renewable Target Program (SMART). This program offers a base cents-per-kilowatt-hour tariff to solar generation sold in the state with several adders that can offer a higher rate per kilowatt-hour on top of the base value —

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153 *Pollinator Plan.* Report. January 5, 2019. Accessed July 23, 2019. https://bwsr.state.mn.us/sites/default/files/2019-01/2019 Revised Pollinator Plan 12-26-18.pdf

154 Rob Davis (Director of the Center for Pollinators in Energy, Fresh Energy), in discussion with the author, 2019.

155 Morehouse, Catherine. "Michigan Opens 3.3M Farmland Acres to Bee-friendly Solar Projects." Utility Dive. June 04, 2019. Accessed June 5, 2019. https://www.utilitydive.com/news/michigan-opens-33m-farmland-acres-to-bee-friendly-solar-projects/556090/.

provided a project meets certain conditions.[156] These adders incentivize certain types of solar development, and one of the highest adders creates an incentive for "Agricultural Solar Generation Units." This adder tacks on an additional 6 cents per kilowatt-hour to the base rate if a project is built on land designated for agriculture and active agricultural use continues through the life of the project. To qualify, a project must raise its panels high off of the ground and not shade the ground over 50%, as well as report annually on agricultural production.[157]

As there has been a lot of scrutiny of solar projects on farm and forest land in the state, the adder was worked on and accepted as a compromise to support solar combined with farming. The details of the adder were hard fought, with developers wanting the size of the projects to be capped at 5 MW but with opponents looking at a 1 MW limit. In the end, developers were happy with the 6-cent adder, and land-use advocates were able to keep the system size cap down to 2 MW. In practice, the 2 MW limit is cost prohibitive to many developers, and only a few dual-use solar projects have been approved under this system.[158] In addition, the policy requirements put a static number on panel height and shading effects.[159] These stringent specifications can conflict with the dynamic needs of the crops grown under the systems. Beyond those concerns, farmland advocates were disappointed to see the standards fail to differentiate between different types of agricultural use such as grazing and crop production, even though pasture lands and crop lands are distinct. They also note that the requirements for these projects, such as shading or panel height, are too constraining and can lead to solar projects being built on land designated for farmland without dual-use and with a lower incentive.[160]

The SMART program adder is meant to encourage agrivoltaics through an active incentive. The policy has fallen short of its goals at a couple key junctures, with prescriptive and inflexible rules over project size and array design leading to only a few projects going forward under this adder. One takeaway from the policy is the reporting requirement, which provides a trigger for removing the incentive if a project does not meet its approved agricultural practices on the site.

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[156] "Solar Massachusetts Renewable Target (SMART) Program." Mass.gov. Accessed July 8, 2019. https://www.mass.gov/info-details/solar-massachusetts-renewable-target-smart-program

[157] Massachusetts. Department of Energy Resources. Executive Office of Energy and Environmental Affairs. *Guideline Regarding the Definition of Agricultural Solar Tariff Generation Units.* April 26, 2018. Accessed July 9, 2019. https://www.mass.gov/files/documents/2018/04/26/Agricultural Solar Tariff Generation Unit Guideline 042518.pdf

[158] Liz Curran (Director of Policy, BlueWave Solar) and Lucy Bullock-Sieger (Director of Civil Engagement, BlueWave Solar), in discussion with the author, 2019.

[159] Nathan L'Etoile (New England Regional Director, American Farmland Trust), in discussion with the author, 2019.

[160] Ibid

Tax Incentives

One more policy that actively incentivizes dual-use development comes from Rhode Island. In May 2019, the state implemented legislation passed in 2017 that changed its taxation policy for Farm, Forest, and Open Space Land by exempting some solar and all dual-use from a land-use change tax.[161] This change took away a tax penalty for land-use change if the landowner converts less than 20% of farmland designated under the Farm, Forest, and Open Space program to renewable energy with dual-use completely exempted from that 20% calculation. In the newly implemented regulation, dual-use is defined as when agriculture is allowed to continue under solar, with agriculture including crop cultivation, livestock, and beekeeping. Beyond the exemption from the land-use change tax, the land can be designated as farmland for taxation purposes under "Renewable Farmland" as long as the dual-use site reports annually about electricity and crop production.[162] [163] This new policy demonstrates how states are experimenting with various policy levers to demonstrate their interest in supporting dual-use solar projects.

NC Choices

The last piece of policy to mention is a creative use of a USDA grant program from North Carolina. NC Choices is an initiative of an extension program from North Carolina's land-grant universities that focuses on supporting local food networks for pasture-raised meats.[164] NC Choices is currently the recipient of a USDA Beginning Farmer and Rancher grant to increase meat raising, especially through novel land acquisition strategies, as land access is a major issue for meat producers. One of those land acquisition strategies is dual-use grazing on solar. The program provides three-year grants that help beginning sheep farmers connect with solar projects to graze their animals. The program is quite small, but NC Choices partnered with a couple of major solar companies to connect farmers to nearby sites that fit their flock size.[165] This program offers a solution to the concerns mentioned in the grazing dual-use section where an agriculture extension program works as a connector between developers and farmers to promote land access and a dual-use solar vegetation management strategy.

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[161] 250-40 R.I.Code R. 20-1.5 https://rules.sos.ri.gov/regulations/part/250-40-20-1

[162] 44-27 R.I. Code R. 10.1 http://webserver.rilin.state.ri.us/Statutes/TITLE44/44-27/44-27-10.1.HTM

[163] 250-40 R.I.Code R. 20-1.6 https://rules.sos.ri.gov/regulations/part/250-40-20-1

[164] "NC Choices." Center for Environmental Farming Systems. July 10, 2019. Accessed July 12, 2019. https://cefs.ncsu.edu/food-system-initiatives/nc-choices/.

[165] Lee Menius (NC Choices), in discussion with the author, 2019.

While mostly focused on the East Coast and Midwest, dual-use policy is popping up in many places around the country. Pollinator scorecards are the most widespread policy, but lack a true incentive and regulatory structure for dual-use development. Examples from Massachusetts to Rhode Island show what financial levers can be pulled and offer some lessons learned in terms of policy innovations and policy challenges. Finally, organizations like NC Choices have been innovative with policy and securing grants to build connections between solar and agricultural interests. The next challenge is to learn from these first experiments and see what can be brought back to the Northwest in terms of new ideas and lessons learned.

Dual-use in the Northwest

Dual-use solar can come in many forms, each with discrete benefits and challenges; overall, it represents an innovative way of making solar-energy production a multifunctional system. This next section focuses on the potential benefits and challenges of dual-use solar applications in Oregon and Washington.

Dual-use systems could be quite helpful in the future as climate change becomes more of a factor in this region. Changes to the climate will hurt the agricultural community as climate extremes impact crop yields and quality, which in turn affect financial viability. Solar systems in general, but specifically dual-use systems, can help build farm and farmer resilience in the region. The first way solar can help is through the additional income stream from solar, which will support farmers dealing with increased climate variability and natural disasters. One major threat to farmers is soil erosion, which is likely to increase greatly due to climate change. Dual-use solar can help build resilience to soil erosion through the use of pollinator-friendly and native species. These deep-rooted plants increase water infiltration, potentially reducing irrigation needs in dry periods and reducing the impact of dangerous stormwater run-off during heavy precipitation events.

Continuing in this vein, the National Climate Assessment states that during the recent 2015 drought: "The reduced availability of water for irrigation coupled with heat stress impacted production and livestock health." The report notes that the Northwest region is already vulnerable to climate variability like droughts, and these will only continue to grow more common.[166] These likely events are coupled with the fact that: "Projected warmer and drier summer seasons will likely reduce forage quality and quantity."[167] Dual-use grazing systems offer resiliency against these issues as heat stress on animals like sheep can be reduced simply through the shading of the panels. This same shading can offer habitat for forage to continue growing into the hotter months, as well as water conservation. As forage is reduced by a hotter and drier climate, dual-use solar projects can offer a resilient system for forage growth to support livestock around the region.

Finally, in terms of crop production, Oregon's 2017 Climate Report states that: "Improved irrigation and efficient water management strategies will be necessary to resiliently handle heat

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[166] May, C. et al. 2018: Northwest. In *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment*, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 1036. doi: 10.7930/NCA4.2018.CH24

[167] Ibid

and drought stress and longer growing seasons.” Planting crops under solar in agrivoltaic systems can be one of those water management strategies that reduces heat stress (with the help of increased shading), and allows for better water efficiency of crops. Agrivoltaic systems are a complex and somewhat more expensive method of dual-use, but will increase in value as water conservation and drought-tolerance become more of a necessity.

Beyond the immediate impact of dual-use systems in response to the climate threat, the adverse impacts mentioned in the Climate Report could be lessened if the Northwest and the rest of the country are able to transition to clean energy and avoid the highest emission scenarios. Installing dual-use solar brings clean energy onto our grid and displaces coal and gas in the region. Both Oregon and Washington have set targets for zero-carbon electricity generation, and some of it will likely need to be placed on land designated for farming because of siting constraints. Farms and farmers can benefit economically from diversified land use that works for climate resilience, and there are natural synergies between solar and farms that dual-use solar can facilitate with minimal loss of acreage available for agricultural production.

Looking beyond the climate context, dual-use systems have a place in the Northwest, and can have numerous benefits when applied to appropriate landscapes. Dual-use solar is already commercially developed in the region. Pollinator-friendly solar is currently under operation, and apiaries on solar with honey production are operating and expanding to more sites in the region.[168] In Oregon there is a sheep-grazing operation on a solar project and interest from sheep farmers in doing more.[169] The Merrill solar project, while not yet in operation, demonstrates an intent by developers to apply agrivoltaics. With support from policy makers, these types of projects could be applied to a variety of agricultural lands and soil types. There is great potential to allow farmers to innovate and implement precision farming that utilizes shading from panels as a resource (both for crops and grazing) and increases the overall productivity of the land.

Agrivoltaic dual-use projects involve crop farming and, as such, will need to be placed in areas with good soils that support the production of crops. In arid landscapes, dual-use solar projects may be more challenging due to low rainfall and restrictions on irrigation. In these regions, it would be hard to plant native seeds or support large amounts of forage without irrigation. However, grazing or native pollinator habitat dual-use applications might be possible in these

[168] John Jacob (Old Sol Apiaries), in discussion with the author, 2019.

[169] Amy Berg Pickett (Senior Community Engagement & Permitting Manager, Cypress Creek Renewables), in discussion with the author, 2019.

arid regions with the improved water efficiency and shading provided by the panels. With proper planning, dual-use solar projects could support habitats for pollinators and migratory birds, as well as help along on-going efforts around invasive species control and restoration of native plants. That possible outcome, however, is still speculative, and it must be recognized that dual-use solar will not fit everywhere.

Additionally, it is worth considering developing dual-use solar projects on public lands going forward. In both Oregon and Washington, there are large amounts of state-owned lands that are often leased for commercial activity. Washington State's Department of Natural Resources lands consist of 3-million acres of federally granted trust lands that raise revenue to support public institutions.[170] These lands are often leased for agricultural activities, logging, and — most commonly — grazing, but have also been leased for energy production.To date, two Washington projects have sought out solar land leases, totaling around 1,000 acres. These developments are seen as a win for the state as solar is a higher and better use of the land than grazing alone, especially with grazing only bringing in $2 per acre per year and solar bringing in $300-1,000 per acre and proceeds going to the common school fund.[171] In Oregon, solar development has not occurred on Oregon state lands, but there has been interest. As in Washington, money that is collected from state lands goes directly to the Oregon common school fund.[172] If state lands were able to incorporate dual-use solar, they could also implement conservation measures or grazing. Both states are looking for ways to increase the income these lands bring in, and they can possibly do so responsibly by leasing to dual-use solar projects.

170 "Forest and Trust Lands: WA - DNR." WA Department of Natural Resources. Accessed July 18, 2019. https://www.dnr.wa.gov/managed-lands/forest-and-trust-lands

171 Duane Emmons (Product Sales & Leasing Division Manager, Washington State Department of Natural Resources), in discussion with the author, 2019.

172 Shawn Zumwalt (Property Manager, Oregon State Lands), in discussion with the author, 2019.

Pine Gate Renewables

When done right, dual-use solar provides benefits to agriculture in the region by supporting farmers and farming communities, continuing agricultural production on-site, providing habitat to much needed pollinators, and improving groundwater recharge and reducing runoff. We need these benefits in our region where we see growing threats to the economics of farming, threats to pollinators, and threats to water availability. Dual-use solar projects are currently operating and in the planning stages, however more policy clarity could ensure future solar projects are developed in a manner that complements and supports our region's farming and conservation goals, as well as our clean energy goals.

Potential Strategies for Encouraging Dual-use Solar in Oregon and Washington

Dual-use solar is an innovative and collaborative strategy that supports conservation and agriculture. Each type of dual-use solar described in this report is feasible and achievable in the Northwest, with pollinator-friendly dual-use, conservation dual-use, and grazing dual-use being the most accessible, and agrivoltaics being at the beginning of commercialization. While dual-use solar will not necessarily make sense everywhere, it does help to address concerns over impacts to agriculture and conservation efforts. Going forward, if stakeholders want to encourage the development of policies that acknowledge the benefits of dual-use solar and encourage its application in both Oregon and Washington, several strategies could be considered.

First, both states could acknowledge dual-use solar as a method for developing solar that is compatible with agriculture. This option starts with a flexible and dynamic definition of dual-use that recognizes that different types of dual-use strategies work for different geographic conditions, soil characteristics, and local contexts. This option would require reviewing the definitions of solar generation, farmland, and farm uses to ensure that our laws do not inadvertently preclude dual-use solar practices. There could also be a review of local and state level policies to identify those that could be updated to accommodate appropriate dual-use solar development. In Oregon, this may include reviewing the state land-use goals for how they value dual-use solar in land-use decisions across the state. In addition, modifying the definition of mitigation for solar developments and considering dual-use applications of native habitat and pollinator species for on-site mitigation could be considered.

Second, Oregon and Washington could allow dual-use development on all agricultural soil types as long as regulations and incentives match the non-solar (agricultural) use to the quality of the land and local agricultural economy. Any agricultural use that is paired with solar will need appropriate soil to succeed. Regulations should allow the consideration of dual-use solar on high quality soils if a project can ensure the continued utilization of quality soils for agricultural production. Additionally, farmers and landowners could be empowered to decide if and which soils on their own property are best for appropriate dual-use solar.

Third, establishing solar development best practices for dual-use solar projects (from pollinator-friendly to agrivoltaics) could facilitate siting and permitting projects. Additionally, permitting costs for projects that adhere to these best practices could be lower as an incentive. Best practices for dual-use solar projects may help counties in the region permit projects and understand when a project is making real efforts to be multifunctional. Indeed, a project's adherence to best practices could even be formally established in local ordinances or comprehensive plans or adopted by a permitting body as a condition of project approval on a case-by-case basis. These best practices could be written as flexible standards, since conditions vary from site-to-site and new innovations continue to occur. Best practices could include limiting grading and soil compaction, planting native or pollinator species, continuing or adding livestock production (sheep or bees), continuing or adding crop production below the panels, and planning for decommissioning. The best practices could also include noxious/invasive weed control, dust control, and fire abatement, which several types of dual-use development can address.


Engie Distributed Solar

Local planning and permitting authorities as well as solar developers can ensure that solar projects are compatible with local economies and environments to the greatest extent possible. This process of ensuring compatibility starts with authorities and the solar developer consulting local farmers and community members on how to adapt the solar project to the community. When considering a dual-use solar project, these parties — from the developer and authorities to local farmers and community members — can ensure adequate resources or investments are being made in the region for and as a result of dual-use solar application. Such resources may include access to native seeds, as supplies are often limited and early communication with seed farmers may be necessary to have enough seed in time for seeding the solar site. Such resources also include whatever is necessary to sustain the livestock or crops to be grown in conjunction with the panels, as dual-use solar projects should be set up to ensure that both uses can succeed. When considering dual-use solar projects, permitting authorities could address potential negative impacts to nearby agricultural practices and consider impacts to wildlife as well.

In a region with complex and multi-jurisdictional land-use regimes, decision makers could strive for continuity when designing policy to support dual-use solar development. This could be achieved by establishing state-specific model ordinances that can be adopted at a local level for permitting and zoning. Each state's model ordinance could begin with a clear and flexible definition of dual-use. It could also include permitting standards that are dynamic and allow for responsible development of solar projects where they fit the context of the land. Finally, it could include success measurement standards with financial assurances. For model ordinances that support dual-use solar, mechanisms for compliance could be included that enable authorities to track project milestones and compliance measures, such as yearly reporting or inspections for the project to maintain its dual-use solar status.

Department of Natural Resources' land in Washington and State Lands in Oregon are potential locations for dual-use solar development that conserves soil and natural habitat or co-locates with grazing and agriculture. These lands can get a higher and better use by combining solar with agricultural practices, and dual-use solar projects can support other goals such as continuing farming or land conservation. All of the revenue from these projects goes toward schools in both states and supports education in the region.

Both states could consider giving developers and farmers financial or other tangible incentives to develop solar projects with best practices that provide all of the benefits described above. The SMART program and the Rhode Island tax incentive recognize that dual-use projects, especially agrivoltaics, should be encouraged and might need some support in getting off the ground. State and local governments in the Northwest could consider financial incentives such as property tax benefits, or permitting incentives such as relief from regulations that prohibit solar on certain agricultural soils for dual-use solar projects. In addition, allowing farmers who create a multifunctional farming system with dual-use solar to continue to receive the benefit of agricultural use of their land would be another type of incentive.

Finally, Oregon and Washington could empower farmers to be innovators and reap the benefits of combining solar production with agricultural practices. A tool to connect farmers with solar developers at an early stage in project development could help make dual-use solar easier for both. Empowering innovation could also include providing more funding for research on dual-use solar systems in different settings and sharing of best practices with farmers looking to get involved.

Conclusion

Dual-use solar comes in many shapes and sizes, and offers a way for clean-energy development to work in tandem with land conservation and active agriculture. Dual-use solar includes pollinator-friendly dual-use, conservation dual-use, grazing dual-use, and agrivoltaics. Updated land-use laws and regulations could recognize the value of dual-use solar, and allow projects onto lands designated for agriculture as they provide economic, environmental, and land-conservation benefits to farmers and the region as a whole.

Allowing more dual-use solar would not result in the build out of solar across all lands designated for agriculture. Even under the most aggressive build out, solar would take up a very small fraction of agricultural land in the Northwest and countrywide.[173] [174] Farmland is subject to a number of development threats that, unlike solar, do not allow continued agricultural practices and are more permanent. Outright bans or moratoriums on utility scale solar development are not well tailored to incentivizing thoughtful siting of solar projects, do not allow for innovation leading to an establishment of best practices, and leave farmers seeking to supplement their farming income with few options besides off-farm income or selling to residential or commercial development.

While some aspects of dual-use solar are still in early development, the research presented in this report demonstrates that dual-use solar provides benefits to farmers, the food system, community members, community governments, and the climate. Dual-use solar can also provide benefits to solar developers. Developers should consider how they might incorporate dual-use principles into every project in the Northwest in the future. The Northwest is ready for the next step in renewable-energy development, and dual-use solar offers the region the opportunity to boldly pursue its climate and agricultural goals.

[173] "Solar Energy in the United States." Energy.gov. Accessed August 02, 2019. https://www.energy.gov/eere/solarpoweringamerica/solar-energy-united-states

[174] *2012 USDA Census of Agriculture.* Report Highlights. National Agricultural Statistics Service. September 2014. Accessed August 2, 2019. https://www.nass.usda.gov/Publications/Highlights/2014/Highlights_Farms_and_Farmland.pdf