Emerging Agrivoltaic Regulatory Systems: A Review of Solar Grazing

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In recent years, tensions have grown in rural communities in response to rapid development of utility-scale solar energy production facilities over the proper use of rural land, particularly between agricultural and solar energy production. Ongoing land use tension between agriculture and solar energy production has motivated some landowners to co-locate solar panels and crops or livestock on the same plot of land in a process called agrivoltaics. The evolution of agrivoltaics from an experimental land use strategy to a viable diversification method for farmers necessitates an analysis of existing zoning laws, tax policies, and contractual agreements that farmers must abide by—and which may inhibit the full development of agrivoltaics into an industry. This article analyzes existing agrivoltaics policy by reviewing the history of how agricultural land use has shifted over time as well as by examining existing zoning and taxation laws for agrivoltaics. Further, this article applies the evidence analyzed to the rapidly growing practice of solar grazing, a subfield of agrivoltaics that involves farmers grazing sheep and other livestock on utility-scale solar energy facilities. The article reviews existing grazing contracts and best practices from adjacent grazing industries to offer regulatory insights for the developing agrivoltaics industry. The article concludes by positing further research questions and proposing legislative reforms that may provide a friendlier legal landscape for agrivoltaics and other dual-use operations at the nexus of agriculture and renewable energy.

Introduction

The desire for vast tracts of open land used to develop new renewable energy systems in the 21st century has led to tension over whether to allocate land for agricultural or energy uses; fortunately, these two land uses need not compete. Growing fruit and grazing sheep beneath vast solar arrays represent some of the most promising combinations of land uses in recent times. Agrivoltaics is a dual-use approach allowing land to generate power from solar photovoltaics (PV), commonly known solar panels, with agricultural production to generate solar power and produce food simultaneously.[1] As research has expanded the possibilities of coupling

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[1] Stephan Schindele et al., *Implementation of Agrophotovoltaics: Techno-economic Analysis of the Price-Performance Ratio and its Policy Implications*, 265 Applied Energy 2 (2020),

agriculture and renewable energy, agrivoltaics now takes many forms, including the creation of pollinator-friendly solar sites, testing crop production beneath solar panels in multiple regions of the United States and Japan, and establishing solar grazing contracts under which livestock are brought to solar farms to graze.[2] In addition to these novel methods, several potential applications exist for agrivoltaics, including livestock production, commodity-scale crop production, and smaller-scale horticultural operations.[3] Agrivoltaics are an emerging concept that is ripe for research, as studies only recently began in the mid-late 2010s and many major studies remain underway.[4]

Zoning, taxation, and contractual arrangements are critical to the regulation and overall viability of agrivoltaic operations.[5] Commensurately, developing agrivoltaic-friendly legal landscapes requires an analysis of how zoning laws, tax policies, and agrivoltaic contracts must evolve to support climate-friendly agriculture and energy production.

Current zoning laws exist primarily to mitigate land-use conflicts by creating physically distinct zones for incompatible land uses.[6] When concerning agriculture and renewable energy, agricultural zoning restrictions such as lot and building size requirements hamper the diversity of activity that can occur on-farm.[7] Moreover, in some states where a particular land use is not specified, the silence can be prohibitive unless a permit or special exception allows the activity.[8] The existence of activities such as agrivoltaics compels policymakers to consider whether renewable energy and agriculture are truly incompatible uses when research shows they can be synergistic.[9] While agrivoltaics offers diversified income to

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https://www.sciencedirect.com/science/article/pii/S030626192030249X
[https://perma.cc/F7KN-2A6D].

[2] *Id.*

[3] Though first proposed in 1982, little movement was made upon it up until the last decade. Mohd Ashraf Zainol Abidin et al., *Solar Photovoltaic Architecture and Agronomic Management in Agrivoltaic System: A Review*, 13 SUSTAINABILITY 1, 6 (2021).

[4] *Id.* at 1.

[5] Alexis S. Pascaris, *Examining Existing Policy to Inform a Comprehensive Legal Framework for Agrivoltaics in the U.S.*, 159 ENERGY POLICY 1-2 (2021).

[6] Kate A. Voit, *Pigs in the Backyard or the Barnyard: Removing Zoning Impediments to Urban Agriculture*, 38 B.C. ENVTL. AFF. L. REV. 537, 546 (2011).

[7] *Id.* at 540; Pascaris, *supra* note 5, at 1-2.

[8] F. P. Becker, Solar-Permissive Model Zoning Ordinances: Rationale, Considerations, and Examples 7 (Dec. 2019) (Capstone project, The Pennsylvania State University) (on file with the Centre Regional Council of Governments and Centre Regional Planning Agency).

[9] Alexis S. Pascaris et al., *Life Cycle Assessment of Pasture-Based Agrivoltaic Systems: Emissions and Energy Use of Integrated Rabbit Production*, 3 CLEANER AND RESPONSIBLE CONSUMPTION 2, 9 (2021) ("The viability and profitability of these systems all appear promising as there are synergistic benefits of increased yield for some shade-tolerant crops, as well as more sustainable

landowners, "more often the loss of farmland and increased land competition set renewable energy policies at odds with farmland policies."[10] As such, numerous legal gray zones for zoning and taxation leave developers, farmers, and local governments without much guidance in establishing collaborative land use systems.

According to the National Agricultural Law Center and the U.S. Census of Agriculture:

> [T]he number of farms with renewable energy producing systems has grown exponentially, particularly solar panels. In 2009, a total of 9,509 farms in the U.S. had renewable energy producing systems. That number rose to 57,299 in 2012 and more than doubled in five years to 133,176 in 2017. Similarly, the number of farms with solar panel systems grew from 7,968 in 2009 to 36,311 in 2012, and to 90,142 in 2017. A total of 1,420 farms reported wind turbines in 2009, of which only 14 are considered "large wind" (greater than 100kW). By 2017, a total of 14,136 farms had wind turbines.[11]

With such enormous growth in the renewable energy and agriculture nexus, guidance and regulations are critical to the understanding and promotion of compatible dual-use land operations, namely through zoning and taxing regulations that clarify the purpose and method of co-installation. Zoning regulations are inherently local, because land use is a reserved police power of the states and left to municipalities to govern.[12] Localities establish land use plans, wherein zoning districts establish building construction rules, such as height and size restrictions for buildings; further, "[w]ithin each zoning district, each parcel of land is assigned at least one as-of-right land use, while permitting accessory uses typically associated with those principal uses. Variances of these standards may be awarded when landowners can prove that the zoning standards impose unnecessary hardships."[13]

(environmentally and economically) form of vegetative maintenance for solar developers hosting livestock-based agrivoltaic systems . . . .pasture-based agrivoltaic system features a dual synergy that generates a significant reduction in greenhouse gas emissions and fossil energy demand.").

[10] Peggy Kirk Hall et al., *Land Use Conflicts Between Wind and Solar Renewable Energy and Agricultural Uses*, THE NATIONAL AGRICULTURAL LAW CENTER, 2 (Jan. 10, 2022), https://researchrepository.wvu.edu/cgi/viewcontent.cgi?article=1104&context=law_faculty [https://perma.cc/Q227-M8KN].

[11] *Id.* at 3.

[12] *Id.* at 2.

[13] NATHALIE J. CHALIFOUR ET AL., LAND USE LAW FOR SUSTAINABLE DEVELOPMENT 587 (IUCN 2007).

Taxation structures also heavily impact decisions to engage in agrivoltaic practices. A shift in tax burdens sometimes follows the installation of solar energy on agricultural land. In many instances, agricultural land benefits from current use policies that disincentivizes activity that would change the land's previously designated use.[14] In some states, current use programs explicitly prohibit installation of solar arrays on agricultural land, while in others, regulations allow for limited conversion and installation of renewable energy without tax penalties.[15] These inconsistent regulations create uncertainty for the financial viability of agrivoltaic operations and possible legal consequences that might follow from the breach of these zoning and taxing legislation.

In conjunction with zoning and taxing issues, the contractual arrangements between livestock owners and solar utility companies to establish solar grazing operations offer valuable regulatory insight. Research into crop production under solar panels is still underway, so this practice has yet to extend to widespread commercial use. [16] Solar grazing—another novel and developing commercial practice—is far more prevalent than solar array crop production and indicates how the developing agrivoltaics industry is presently choosing to allocate risk and responsibility.

In Part II, this article will cover the history of shifting agricultural land use in the United States and the increasing development of operations that co-locate renewable energy sources with agricultural production. Part III of this article will address the current state of agrivoltaics regulations, with a focus on zoning and taxation regimes, as well as the ways different approaches to regulation affect agrivoltaic practices. This part also offers points of improvement for zoning ordinances and taxation provisions to enable the growth of agrivoltaics. Part IV of this article examines solar grazing, an emerging sub-field of agrivoltaics, as well as the lack of regulatory structure which hinders its development. Part V of this article dives into the contractual arrangements between livestock owners and solar site managers to provide an overview of the available template contract allocations of risk and responsibilities between the parties. Part VI will then look to other instances of livestock management, such as targeted grazing

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[14] *Community Planning Toolbox: Current Use Taxation*, VT. NAT. RES. COUNCIL, https://vnrc.org/community-planning-toolbox/tools/current-use-taxation/ (last visited Oct. 5, 2022) [https://perma.cc/KH32-44QW].
[15] *See Farmland Solar Policy State Law Database*, FARM AND ENERGY INITIATIVE, https://farmandenergyinitiative.org/projects/farmland-solar-policy/state-law-database/ (last visited Oct. 5, 2022) [https://perma.cc/U9HQ-PJ5W].
[16] Research Communications, *What is Agrivoltaics?*, THE UNIV. OF AZ. (Feb. 26, 2018), https://research.arizona.edu/stories/what-is-agrivoltaics [https://perma.cc/7ENX-NXHY].

for wildfire management in California, for insight on how to reform contractual arrangements between livestock owners and solar site managers to best benefit both parties. The article concludes with further research suggestions and legislative reform options that would foster a more feasible landscape for agrivoltaics.

I. Background of Shifting Agricultural Land Use in the United States

Since the turn of the century, the amount of farmland in the United States has declined from nearly 940 million acres in 2001 and 2002 to roughly 895 million acres in 2021.[17] Shifts in agricultural land use occur regularly for multiple reasons, including "changing commodity and timber prices, agricultural and natural resource policies, urban pressure, and environmental factors (e.g., droughts) prompt[ing] private landowners to shift land to uses that maximize economic returns."[18] As the challenges of climate change mount and strain the existing methods of agricultural production, altered land use may be one of the only viable options for sustainable production.[19] The Economic Research Service's (ERS) Major Land Uses (MLU) series indicates that between 2002 and 2012, droughts in several major crop-producing regions resulted in above-average failed cropland acreage, reaching 17 million acres in 2002 and 13 million acres in 2011.[20] Idled cropland, a majority of which is enrolled in the Conservation Reserve Program (CRP), also increased during the most recent droughts despite a reduction in overall land enrolled in the CRP.[21] This suggests that some farmers voluntarily removed land from crop production because of "poor growing conditions or constrained irrigation water supplies."[22]

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[17] U.S.D.A. & NASS, *Farm & Lands in Farms: 2021 Summary* (Feb. 2022), https://downloads.usda.library.cornell.edu/usda-esmis/files/5712m6524/6h441w232/vx022h58v/fnlo0222.pdf [https://perma.cc/8C9Z-5RW6]; U.S.D.A. & NASS, *Farm & Lands in Farms: 2004 Summary* (Feb. 2004), https://downloads.usda.library.cornell.edu/usda-esmis/files/5712m6524/hm50tv598/bn9999296/FarmLandIn-03-03-2004.pdf [https://perma.cc/974X-3M7W].
[18] U.S.D.A, *Major Land Uses*, https://ers.usda.gov/topics/farm-economy/land-use-land-value-tenure/major-land-uses/#:~:text=About%2052%20percent%20of%20the,%2C%20and%20farmsteads%2Ffarm%20roads.&text=Land-use%20change%20 occurs%20for%20a%20variety%20of%20reasons (Aug. 20, 2019) [https://perma.cc/QK95-QXMN].
[19] *Id.*
[20] Daniel P. Bigelow & Allison Borcher, U.S.D.A, Major Uses of Land in The United States 20 (2012), https://www.ers.usda.gov/webdocs/publications/84880/eib-178.pdf?v#:~:text=In%202012%2C%20the%20major%20land,)= [https://perma.cc/3T4N-S8E4].
[21] *Id.* at 16.
[22] Daniel Bigelow, *A Primer on Land Use in the United States*, U.S.D.A (Dec. 4, 2017), https://www.ers.usda.gov/amber-waves/2017/december/a-primer-on-land-use-in-the-united-states/ [https://perma.cc/LG3W-HHFK].

Notably, the shifts in agricultural land use and production have "resulted in highly simplified agricultural landscapes" that are "associated with the degradation of key ecosystem services—or the benefits humans receive freely from the environment—that are essential to agricultural production, such as soil fertility, nutrient cycling and genetic biodiversity."[23]

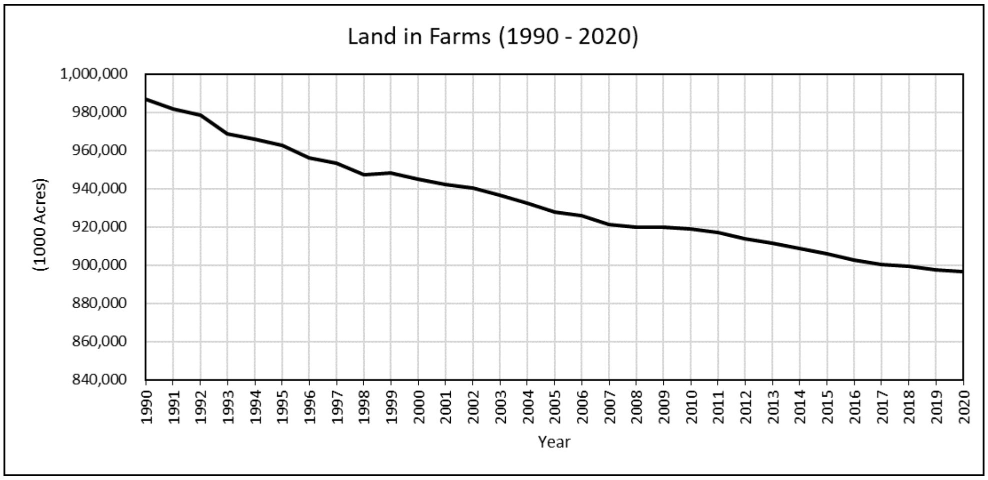

Figure 1: Land in Farms (1990-2020).[24]

In response to degradation of land and the climate, state and local government entities are increasingly adopting regulations to encourage renewable energy installations.[25] Data suggests government promotion of renewable energy is having a potentially adverse effect on agricultural land, as demand for renewable energy increases the value of land for that purpose.[26] For example in Wisconsin, a corn and soybean farmer leased 322 acres to a solar-power cooperative at an annual rate of $700 an acre; in Connecticut, a farmer leased 11 acres of his farm for solar development to help his financially struggling operation; and in North Carolina, a farmer leased 34 acres to a solar developer for payments in the range of $700-$1000/acre.[27]

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[23] Kaitlyn Spangler et al., *Past and Current Dynamics of U.S. Agricultural Land Use and Policy*, 4 Frontiers in Sustainable Food Sys. 1, 1-2 (2020).

[24] Chart generated from data found in U.S.D.A., *Farms and Land in Farms*, https://usda.library.cornell.edu/concern/publications/5712m6524?locale=en (Feb. 18, 2022) (information synthesized from dozens of reports on this page) [https://perma.cc/ZPG8-6VXQ].

[25] Patricia E. Salkin, *The Key to Unlocking the Power of Small Scale Renewable Energy: Local Land Use Regulation*, 27 J. of Land Use & Env't L. 339, 339 (2012).

[26] Kirk Maltais, *Struggling Farmers See Bright Spot in Solar*, Wall St. J. (Sept. 27, 2019, 8:45 AM), https://www.wsj.com/articles/struggling-farmers-see-bright-spot-in-solar-11569242733 [https://perma.cc/XS89-TDV6].

[27] *Id.*; Jan Ellen Spiegel, *New Farmland Harvest – Solar Energy – Creating Political Sparks*, CT Mirror (Feb. 21, 2017), https://ctmirror.org/2017/02/21/new-farmland-harvest-solar-energy-creating-political-sparks

Though regional and environmental considerations are relevant to the viability of renewable energy land use, policies nonetheless will often blanket-prohibit renewable energy installations on agricultural land.[28] In some cases, states with policies promoting renewable energy have also passed restrictive solar siting laws at the state or local level.[29] In the case of solar energy installations, siting regulations are generally used to protect residential areas from commercial generation and traffic.[30] In North Carolina, "land-use regulations can put limits on the allowed uses for some land and thus limit landowners' options, in some cases affecting the viability of solar development" where "agricultural land has been exempted from certain regulations due to 'grandfathering,' and changing the land use to solar may remove these exemptions, which can affect the ability to return the land to agricultural use in the future."[31]

Furthermore, local governments have used land-use regulations to prohibit solar development outright. In 2017, Corrituck County, North Carolina, banned solar energy development through land-use regulations after pushback from residents who were concerned about the damage solar panels could cause in a hurricane or tornado and also believed the county's existing arrays were unsightly.[32] That same year in Connecticut, a state law was passed that required the Connecticut Department of Energy and Environmental Protection (DEEP) to consider a solar project's impacts to forestland and prime farmland as part of the environmental impacts that are considered when determining whether a project's benefits outweigh its costs.[33] Another notable restriction on solar energy development on agricultural lands was passed in 2019 when the Oregon Land Conservation and Development Commission approved a rule that bans solar development

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[https://perma.cc/Z673-V3M8]; Elizabeth Ouzts, *Farmers, Experts: Solar and Agriculture 'Complementary, Not Competing' in North Carolina*, ENERGY NEWS NETWORK (Aug. 24, 2017), https://energynews.us/2017/08/28/farmers-experts-solar-and-agriculture-complementary-not-competing-in-north-carolina/ [https://perma.cc/K8G3-QJYB].

[28] Rajinder Singh Sungu, Comment, *Growing Energy: Amending the Williamson Act to Protect Prime Farmland and Support California's Solar Future*, 21 SAN JOAQUIN AGRIC. L. REV. 321, 322 (2011-2012).

[29] Tommy Cleveland & David Sarkisian, *Balancing Agricultural Productivity with Ground-Based Solar Photovoltaic (PV) Developments*, N.C. UNIV., N.C. CLEAN ENERGY TECH. CTR., (2019), https://nccleantech.ncsu.edu/wp-content/uploads/2019/10/Balancing-Agricultural-Productivity-with-Ground-Based-Solar-Photovoltaic-PV-Development-1.pdf. [https://perma.cc/99EU-GGC6].

[30] National Association of State Energy Officials, *Zoning and Siting*, https://www.naseo.org/issues/solar/zoning (last visited Oct. 11, 2022) [https://perma.cc/476G-Y6JU].

[31] Cleveland & Sarkisian, *supra* note 29.

[32] Jeff Hampton, *Currituck County Bans Solar Farm Development*, THE VIRGINIAN-PILOT (Feb. 21, 2017, 12:00 PM), https://www.pilotonline.com/government/article_a81d9768-0529-59b8-bf10-5d2a050dc8c1.html [https://perma.cc/7S4Y-YVMK].

[33] S.B. 943, Gen. Assemb., Jan. Sess. (Conn. 2017).

on Class 1 and 2 soils but allows developments up to 12 acres on class 3 and 4 soils and developments of up to 20 acres if the development includes agricultural uses.[34]

While some may refer to the instances where state and local governments enacted restrictions on solar energy development as NIMBYism, or Not In My Backyardism, the term may not fit the reasoning for the restrictions. Scholarly literature defines NIMBY as "the sentiment in which one supports something in general or in the abstract, but not if it is to be located close by."[35] When this definition is applied to actual energy infrastructure, the argument for NIMBYism begins to break down. In a study of 16,000 residents living in areas where a new energy infrastructure project was being developed, proximity to the infrastructure project was found to play a minimal role in whether members of the public supported the project.[36] Rather, studies posit that resistance to energy projects is a "rational reaction to how a new infrastructure project affects residents' property values or disrupts their attachment to their local landscape or community."[37]

With this position in mind, one may view public opposition to a new solar project not as an inevitable outcome resulting from the proximity of residents local to the project, but instead as a result of the project being developed in a manner that does not consider the local landscape or community culture. Local resistance and state-erected barriers are ripe issues for the remedies available through inventive zoning and taxing mechanisms that promote better located solar energy systems. Many zoning policies nationwide are silent on the issue of agrivoltaics directly, leaving local governments, solar utilities, and farmers to come to their own arrangements or amend zoning ordinances.[38]

Though alternative energy sources are central to sustainable production systems, as renewable energy installations physically develop to

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[34] Cassandra Profita, *Oregon Restricts Solar Development on Prime Farmland*, OPB (June 3, 2020, 6:45 p.m.), https://www.opb.org/news/article/solar-development-farmland-oregon-ban/ [https://perma.cc/T5AV-7QWV].

[35] Sanya Carley et al., *Energy Infrastructure, NIMBYISM, and Public Opinion: A Systematic Literature Review of Three Decades of Empirical Survey Literature*, 15(9) ENV. RESEARCH LETTERS, 02 , 093007 (2020).

[36] David M. Konisky et al., *Proximity, NIMBYism, and Public Support for Energy Infrastructure*, PUBLIC OPINION QUARTERLY 84(2), 391–418 (2020).

[37] Sanya Carley & David M. Konisky, *Will NIMBYs Sink New Clean Energy Projects? The Evidence Says No—If Developers Listen to Local Concerns* (Aug. 11, 2021, 8:30 a.m.), https://theconversation.com/will-nimbys-sink-new-clean-energy-projects-the-evidence-says-no-if-developers-listen-to-local-concerns-164052 [https://perma.cc/H3XJ-893C].

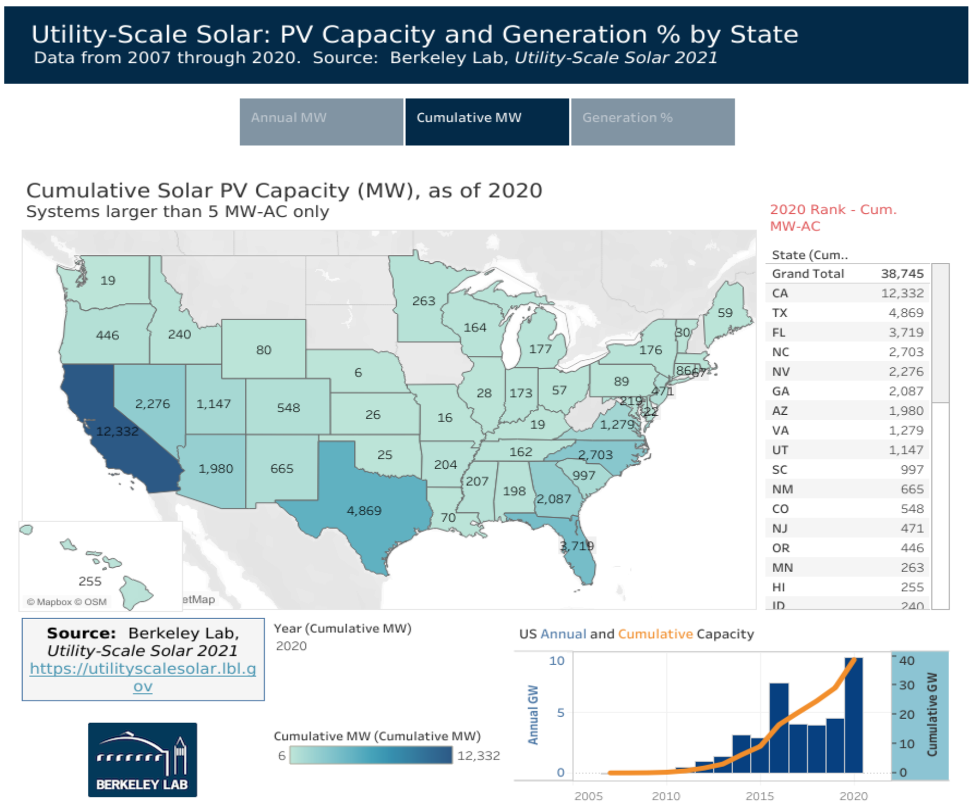
[38] Hall et al., *supra* note 10, at 11-12.

meet growing energy demands, costly land-use implications could possibly follow and warrant designation.[39] For example, wind energy development impacts on land use "include site preparation, on-site construction of turbines, and associated development of access roads and transmission lines that can cause wildlife habitat fragmentation or displacement . . . however, the land footprint of wind energy in terms of extent, intensity, and duration is minimal compared to most other energy sources."[40] Similarly, hydroelectric power impacts land-use when "[t]he dam and resulting reservoir changes in the distribution and function of both aquatic and terrestrial species, and the construction of dams instigated new settlement by the inhabitants of the flooded area."[41] Solar power, on the other hand, offers less intensive land-use options with the ability to place panels on roofs and utilize passive space heating.[42] Regardless of the method, "the growing land use footprint of energy development, termed 'energy sprawl,' will likely cause significant habitat loss and fragmentation with associated impacts to biodiversity and ecosystem services."[43] Considering these land use implications, the advent of single-use land, namely in the renewable energy context, seems to be waning, especially the promising co-installation of renewable energy sources on agricultural lands, where the two work synergistically to use resources efficiently, maintain production, and preserve ecosystems.

Solar farms are a series of ground-mounted solar panels installed across large swaths of land, generating power for both the farmer and the surrounding electric grid. In 2020, solar power comprised roughly 3% of U.S. electricity.[44] The National Renewable Energy Laboratory claims that just .6% of U.S. land mass could power the country if dedicated to utility-scale solar operations.[45] Some research demonstrates that "farm profitability can be increased about two-and-a-half times," depending upon

[39] Virginia H. Dale et al., *The Land Use-Climate Change-Energy Nexus*, 26 J. of Landscape Ecology 755, 760 (2011).
[40] *Id.*
[41] *Id.*
[42] *Id.*
[43] Anne M. Trainor et al., *Energy Sprawl is the Largest Driver of Land Use Change in the United States*, Plos One 1 (2016), https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0162269 [https://perma.cc/JD29-49UJ].
[44] Mickey Francis & Manussawee Sukunta, *Solar Generation was 3% of U.S. Electricity in 2020, but We Project it Will Be 20% by 2050*, Energy Information Administration (Nov. 16, 2021), https://www.eia.gov/todayinenergy/detail.php?id=50357#:~:text=November%2016%2C%202021-,Solar%20generation%20was%203%25%20of%20U.S.%20electricity%20in%202020%2C%20but,will%20be%2020%25%20by%202050&text=According%20to%20our%20Electric%20Power,from%20all%20sources%20in%202020 [Ihttps://perma.cc/JB6A-EA8Q].
[45] P. Denhold &and R. Margolis, U.S. Dept. of Energy, The Regional Per-Capita Solar Electric Footprint for the United States, Nat'l Renewable Energy Lab'y 15 (2007), https://www.nrel.gov/docs/fy08osti/42463.pdf [https://perma.cc/E4C8-D7VX].

crop production, as "solar lease revenues are essentially risk free to the farmer; the price, of course, is that the solar fraction of the land is not accessible to the farmer for grain cultivation for a long period."[46] Though financially viable (if funding can be obtained for start-up costs), ecological impacts also follow with the installation of solar farms, including habitat loss, rainfall and drainage interference, or contact causing injury or death.[47] While utility-scale operations are more common, present research shows that installation of solar on small farms, distributed over several pieces of land, could mitigate ecological impacts and increase financial stability for lower-income farms.[48]



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[46] Arjun Makhijani, *Exploring Farming and Solar Synergies: An Analysis Using Maryland Data*, INST. FOR ENERGY AND ENV'T RESEARCH 33 (Feb. 25, 2021), https://agrisolarclearinghouse.org/wp-content/uploads/info-library/agrisolar-info/solar-grazing/solar-suitable-grazing-animals/EXPLORING%20FARMING%20AND%20SOLAR%20SYNERGIES%20AN%20ANALYSIS%20USING%20MARYLAND%20DATA.pdf [https://perma.cc/LLM9-VTES].

[47] Arshian Sharif et al., *Role of Solar Energy in Reducing Ecological Footprints: An Empirical Analysis*, J. OF CLEANER PROD. (2021).

[48] Makhijani, *supra* note 46, at 8.

Figure 2: Utility-Scale Solar: PV Capacity and Generation % By State (Berkeley Lab 2021).[49]

As land use continues to change, regulations must consider the continued development of agrivoltaics and other instances of the co-location of renewable energy and agricultural production. In doing so, zoning and taxation regimes are crucial to understand, and reform efforts should address the ways in which ordinances and legislation do not align with the promising prospect of agrivoltaics.

II. Zoning and Taxing of Agrivoltaics

A. Zoning for Agrivoltaics

State development of zoning regulations for agrivoltaics has been neither consistent nor comprehensive. Because most zoning decisions occur at a local level, and usually only after prompted by some sort of conflict or difficulty, the zoning landscape for agrivoltaics is emerging unevenly. While all states and localities have the goal of reducing incompatible land uses through their zoning regulations, very few are privy to the synergies of agriculture and renewable energy—zoning ordinances reflect as much. While zoning mechanisms for allowing primary and accessory uses exist, agricultural districts are often distinct from those of solar and energy production.[50] Agricultural zoning restrictions such as lot and building size requirements hamper the diversity of activity that can occur on-farm.[51] Moreover, in states where a particular land use is not specified, the silence can be prohibitive unless a permit or a special exception allows the activity.[52] Activities such as agrivoltaics compel policymakers to consider whether the installation of solar operations on agricultural land are truly incompatible uses when research shows they can be mutually beneficial. Whether for reasons of incompatibility or the lack of policies governing agrivoltaics, the nature of agrivoltaics and how it should be zoned warrants examination.

Agrivoltaic crop production differs substantially from traditional agriculture and is intentionally designed to maximize resource efficiency. When examining efforts to develop resilient farming strategies to face the tests of climate change, agrivoltaics offer significant promise "to provide

[49] Utility-Scale Solar 2021 (illustration), *Utility-Scale Solar*, Berkeley Lab (2021), https://emp.lbl.gov/utility-scale-solar [https://perma.cc/PHY5-EM7Y].
[50] Hall et al., *supra* note 10, at 11, 17-18.
[51] Voit, *supra* note 6, at 547; Pascaris, *supra* note 5, at 1-2, 7.
[52] Becker, *supra* note 8.

sustainability benefits across land, energy, and water systems."[53] Agrivoltaics go beyond maximizing land use by allowing for dual agricultural and solar operations; it adds an alternative and comparatively stable form of income for farmers used to volatile commodity crop prices and provides protection for crops and workers from severe weather, such as heat waves and hail storms.[54] Data shows that carefully spacing the density of solar panels and planting shade tolerant crops can minimize yield loss from the presence of solar panels while providing farmers with a roughly 8% increase in annual income from the generation of energy.[55] Furthermore, if the land used only to grow shade tolerant crops, like lettuce, were modified to incorporate agrivoltaic production, data projects that between 40-70 gigawatts of solar energy to the U.S. national energy mix.[56]

While the science of agrivoltaics is promising, social and political barriers to its growth remain problematic. The network of stakeholders in agrivoltaics operations presents unique political and socio-economic dynamics that have proven complex to navigate. To establish an agrivoltaic system, landowners, farmers, local government entities, and solar utility companies must act cooperatively to establish a regulatory schematic and contractual arrangements, without much established guidance. Barriers to adopting agrivoltaics include:

- Desired certainty of long-term land productivity;[57]
- Market potential;[58]
- Just compensation;[59]
- A need for predesigned system flexibility to accommodate different scales, types of operations, and changing farming practices; and[60]

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[53] Sami Touil et al. *Shading Effort of Photovoltaic Panels on Horticulture Crops Production: A Mini-Review*, 20 Rev. in Env't Sci. and Bio/Tech. 281, 281 (2021).
[54] Fraunhofer Institute for Solar Energy Systems ISE, *Agrivoltaics: Opportunities for Agriculture and the Energy Transition* 3 (Oct. 2020), https://www.ise.fraunhofer.de/content/dam/ise/en/documents/publications/studies/APV-Guideline.pdf [https://perma.cc/7KCP-YCPR].
[55] Harshavardhan Dinesh & Joshua M. Pearce, *The Potential of Agrivoltaic Systems,* 54 Renewable and Sustainable Energy Rev. 299, 306 (2016).
[56] *Id.* at 305.
[57] Alexis S. Pascaris et al., *A First Investigation of Agriculture Sector Perspectives on the Opportunities and Barriers for Agrivoltaics*, 10 Agronomy 9 (Nov. 28, 2020), https://www.researchgate.net/publication/347397656_A_First_Investigation_of_Agriculture_Sector_Perspectives_on_the_Opportunities_and_Barriers_for_Agrivoltaics [https://perma.cc/ZC9S-2V9V].
[58] *Id.*
[59] *Id.*
[60] *Id.*

- Concerns surrounding conversion of agricultural land to other uses and theoretically losing its agricultural potential.[61]

In particular, the issues of how solar operations on agricultural land should be zoned (if permitted) and taxed have raised questions among stakeholders pursuing establishment of an agrivoltaic operation.[62] While deeply intertwined, zoning and taxing represent two separate issues facing the deployment of agrivoltaics. Often, one of the first questions facing farmers who are considering agrivoltaics is whether a solar operation can be installed on land zoned as agricultural.

The agrivoltaic design systems do not fit neatly into existing zoning policies premised upon single-use land, fit for only agricultural use *or* solar development. Although agrivoltaic systems have intrinsic agricultural function, "agrivoltaic systems are [still] subject to the permitting and regulatory process of a conventional solar PV installation, with the added condition of placement on agricultural land."[63] Given that zoning rules incentivize particular land uses and "state-provided incentives for agricultural or solar energy production can, in some cases, be the determining factor in the decision to invest in solar or agriculture development," local governments hold the unique power to influence agrivoltaic development.[64]

Further, while agrivoltaics do align with existing zoning mechanisms for solar development and agricultural land, many simple remedies offer viable solutions for local governments. The implementation of overlay districts are one of the most promising avenues of promoting agrivoltaics through zoning, "because they entail conditional or special permit uses that are permissive of solar in certain zones, which gives local governments opportunity for strategic siting of agrivoltaics in their jurisdiction."[65] Additionally, zoning regulations addressing decommissioning plans and removal procedures, varying temporary and long-term land-use standards, and explicit approval of agrivoltaic

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[61] *See, e.g.*, Dan Charles, *How to Have Your Solar Farm and Keep Your Regular Farm, Too*, NPR (Oct. 9, 2020), https://www.npr.org/2020/10/09/919225272/how-to-have-your-solar-farm-and-keep-your-regular-farm-too [https://perma.cc/XP3M-CTTS].
[62] Pascaris, *supra* note 5, at 4-7.
[63] *See supra* text accompanying note 5.
[64] Cleveland & Sarkisian, *supra* note 29, at 4.
[65] Pascaris, *supra* note 5, at 7.

development and removal of zoning barriers[66] to its implementation would all incentivize agrivoltaic systems.[67]

Illinois presents an example of legislation addressing decommissioning plans, with the state requiring solar and wind energy developers to enter into Agriculture Mitigation Agreements between the state Department of Agriculture and the respective county governments ensuring the energy site will be deconstructed if it is abandoned or when it reaches the end of its useful life.[68] Anecdotal evidence from New Jersey highlights the presence of land-use concerns, as a proposed 80-acre solar farm was vociferously opposed by residents of the Pilesgrove Township in which one resident told town council members: "You were the first town to adopt a right to farm ordinance! Don't forget your vision for this township, and what it should remain to be."[69] The widespread implementation of decommissioning plans that revert land used for solar development back to its natural state may assuage local concerns regarding the conversion of land from agricultural to energy land use that can cause delay or cancellation of a solar project.

B. Taxing Agrivoltaics

Existing taxation policies are typically focused on zoning categorizations, which may unduly prohibit the development of agrivoltaic installations. When pursuing agrivoltaic operations in some states, "agricultural land must be rezoned to allow solar energy development, effectively increasing the tax burden on these lands" representing one instance in which "current energy policies operate against energy sovereignty" and food justice.[70] Beneficial taxation programs, like current use policies, "create an incentive for private landowners to keep their land undeveloped by providing some relief from market pressure to convert

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[66] The North Carolina Clean Energy and Technology Center identified certain land use regulations potentially relevant to (and preventative of) agrivoltaic operations: "local zoning and land use rules (fencing, buffer zones between buildings and roads, border shrubs/trees, etc.)"; "floodplain development rules"; "erosion and sedimentation rules"; "permitting regarding military and air traffic impact"; "water rules (i.e. Neuse nutrient strategy rules, Coastal Area Management Act rules)"; and "USDA wetland impact rules." Tommy Cleveland and David Sarkisian, *Balancing Agricultural Productivity with Ground-Based Solar Photovoltaic (PV) Development*, North Carolina University, Clean Energy Technology Center (2019), https://nccleantech.ncsu.edu/wp-content/uploads/2019/10/Balancing-Agricultural-Productivity-with-Ground-Based-Solar-Photovoltaic-PV-Development-1.pdf [https://perma.cc/ZB5J-F8C4].

[67] *Id.*

[68] 505 ILCS 147/1 (West 2016).

[69] Charles, *supra* note 61.

[70] Chelsea Schelly et al., *Energy Policy for Energy Sovereignty: Can Policy Tools Enhance Energy Sovereignty*, 205 Solar Energy 109, 110 (2020).

agricultural, open space, and forest land to economically 'best uses' through development."[71] Farmland enrolled in current use taxation programs are often prohibited from installing solar arrays, though some states like Pennsylvania have recognized this barrier and taken steps to rectify it.[72] In states where solar arrays are prohibited, local governments may revoke current use enrollment and/or assess land-use change penalties.[73]

State laws regarding taxing agrivoltaic operations, if they even exist, are complex in nature. In Massachusetts, for example, "land in active agricultural or horticultural use is entitled under M.G.L. c. 61A ("Chapter 61A") to reduced property tax rates."[74] Though Massachusetts' regulations consider situations where solar panels are installed on farmland that are exclusively occupied by solar arrays and thus can no longer be farmed, agrivoltaics—where agricultural use is still critical if not the primary use—are governed according to the ordinary agricultural use laws that do not account for solar installations.[75] In that instance, agrivoltaic projects would fall under a separate regulatory section that still alters taxation from the reduced rates available for solely agricultural use land.[76] Taxation regimes like those in Massachusetts create confusion and financial uncertainty when installing agrivoltaic operations, even when done so under state-supported programs like the Solar Massachusetts Renewable Target Program that makes other economic benefits available.[77] Alternatively, Rhode Island's current-use taxation programs *do* allow for the installation of renewable energy on-farm, but only exempt a land-use change tax "if the owner converts not more than 20% of the total acreage of land, and may convert additional acreage without penalty if its sites a dual-use renewable energy system."[78]

Overall, a range of approaches to taxing solar arrays installed on agricultural land creates inconsistent approaches to regulating agrivoltaics, including:

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[71] *Id.*; MASS. GEN. LAWS CH. 61A, §§ 1-24 (2016).
[72] GENEVIEVE BYRNE, FARM AND ENERGY INITIATIVE, FARMLAND SOLAR POLICY DESIGN TOOLKIT: CURRENT USE TAXATION 70 (2020).
[73] *Id.* at 18.
[74] Jonathan Klavens, Courtney Feeley Karp, and Elizabeth Mason, *Solar Project Development: The Special Case of Agrivoltaic Projects*, BOSTON BAR JOURNAL (Nov. 18, 2020), https://bostonbarjournal.com/2020/11/18/solar-project-development-the-special-case-of-agrivoltaic-projects [https://perma.cc/3P6N-RRZA].
[75] *Id.*
[76] *Id.*
[77] *Id.*
[78] R.I. GEN. LAWS § 44-27-1 (2016).

- Solar arrays may never be sited on enrolled agricultural land;
- Solar arrays are not permitted on quality soils;
- Solar arrays may be sited on a case-by-case basis;
- Solar arrays of limited size may be sited on enrolled land;
- Solar arrays serving the farm may be sited on enrolled land; and
- Solar defers or cancels current use enrollment without penalty.[79]

Agrivoltaics literature identifies one solution as ensuring that "all agrivoltaic systems within [local government] jurisdiction[s] continue to be zoned and taxed agriculturally, given they maintain the agricultural function of the land."[80] Additionally, "a short tax holiday could be used as an incentive to deploy agrivoltaics and thus maintain local agricultural employment on the land. This may be particularly appropriate where additional capital costs are needed for agrivoltaics (e.g. extra fencing for pasture fed rabbit-based agrivoltaics)."[81] When drafting zoning policies, agrivoltaic experts recommend that the term "solar farm," be avoided for clarity's sake and that administrative processes account for "solar development located on different site-types (for example, prime farmland, brownfields, and residential rooftops)."[82] While much research is dedicated to the science of agrivoltaics, research specifically on zoning policies for agrivoltaics may help homogenize taxation approaches and create greater certainty for farmers and solar developers. Zoning policies, in addition to other financial incentives, are critical considerations as studies of agrivoltaics continue.

III. Solar Grazing and Emerging Regulatory Systems

Solar grazing is a subfield of agrivoltaics that has grown rapidly during the past several years and focuses on grazing livestock on the same land used for solar energy generation, typically for the purpose of

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[79] BYRNE, *supra* note 72, at 72.

[80] Alexis Pascaris et al., *Integrating Solar Energy with Agriculture: Industry Perspectives on the Market, Community, and Socio-Political Dimensions of Agriculture*, ENERGY RESEARCH & SOCIAL SCIENCES 75, 6 (2021). https://www.sciencedirect.com/science/article/abs/pii/S221462962100116X [https://perma.cc/5Y3L-GYZZ].

[81] *Id.*at 9.

[82] BYRNE, *supra* note 72, at 7.

vegetation management.[83] By implementing solar energy within established local practices, solar grazing has potential to be successful in rural communities.[84] New York provides a strong example of the solar grazing industry's growth, increasing from 79 acres of solar farms that incorporated grazing in 2018 to roughly 1000 acres in 2020, with continued growth projected in future years.[85] Growth in the emerging solar grazing industry is largely driven by the American Solar Grazing Association (ASGA), a not-for-profit trade association of farmers, solar developers, and academic researchers who share best practices and facilitate research to increase the viability of solar grazing as a business.[86]

While it is difficult to determine exactly when the first solar grazing operation began, a news article mentions a solar site in Titusville, New Jersey incorporating sheep into the grazing process in 2010.[87] Solar grazing typically involves a grazier signing an agreement with a solar developer to maintain the vegetation on a solar farm with livestock; therefore fitting into the broader field of targeted grazing, a much older practice defined as "the application of a specific kind of livestock at a determined season, duration, and intensity to accomplish defined vegetation or landscape goals."[88] Landscape goals associated with targeted grazing include controlling invasive plant life, reducing wildfire risk, and using alternatives to herbicide in vegetation management.[89] The Western United States is a popular region for targeted grazing, as livestock have been used as a method to create firebreaks around populated areas of Nevada, California, and Arizona.[90] Understanding the implementation of targeted grazing in various scenarios

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[83] Center for Environmental Farming Systems, *Solar Grazing*, https://cefs.ncsu.edu/food-system-initiatives/nc-choices/solar-grazing/ (last visited Oct. 5, 2022) [https://perma.cc/K98X-WKDY].
[84] Alexis Pascaris, *The Social Dimensions of a Technological Innovation: Agrivoltaics in the U.S.* (2021) (Open Access Master's Thesis, Michigan Technological University).
[85] Severin Beckwith, The Solar Grazing Planner: An Easy-To-Use Extension Tool for Sheep Producers Rotationally Grazing On Solar Sites 11 (2021) (M.P.S. term paper, Cornell University) (on file with Cornell University ECommons), https://ecommons.cornell.edu/handle/1813/111083 [https://perma.cc/6YDL-UKDJ].
[86] American Solar Grazing Association, *Want to Get Involved With Solar Grazing?*, https://solargrazing.org/ (last visited Oct. 5, 2022) [https://perma.cc/ZBZ3-XAYV].
[87] Angelo Fichera, *Sheep Keep Solar Power Clean,* THE INQUIRER, July 4, 2015, at B1-B3.
[88] Karen Launchbaugh & John Walker, *Targeted Grazing: A New Paradigm for Livestock Management, in* TARGETED GRAZING: A NATURAL APPROACH TO VEGETATION MANAGEMENT AND LANDSCAPE ENHANCEMENT 2, 3-8 (2006), https://www.webpages.uidaho.edu/rx-grazing/Handbook/ASITargetGrazingBook2006.pdf [https://perma.cc/69EY-5PKK].
[89] *Id.*
[90] Charles A. Taylor Jr., *Targeted Grazing to Manage Fire Risk*, *in* TARGETED GRAZING: A NATURAL APPROACH TO VEGETATION MANAGEMENT AND LANDSCAPE ENHANCEMENT, *supra* note 88, at 107-12.

around the United States may provide valuable insight for farmers, landowners, and utility owners who wish to utilize solar grazing.

The benefits of solar grazing to graziers center around financial diversification and the availability of additional pastureland. When examining the financial benefits of solar grazing, the costs and revenues differ depending on whether the grazier directly contracts with the solar developer or is hired as a subcontractor by a landscaping company, as graziers can earn a net income of $241/acre when they are directly contracted, and $59/acre when they are subcontracted.[91] A study conducted at a Cornell University Research site paid a grazier $300 per acre ($16,200 total), which also created a part time job to help perform on-site labor.[92] While contract payments for solar sites cannot typically be disclosed to the public, studies suggest that solar grazing has the potential to be a viable business livestock graziers can diversify into.[93]

The structures by which graziers are compensated for bringing their sheep onto the site can vary. In 2013, a solar developer in Hawaii leased land from a farmer to construct a solar farm; additionally, the farmer was then hired to maintain the grounds of the solar farm, a duty which was accomplished via grazing sheep.[94] This unique structure allows for the farmer to earn dual payments from the presence of the solar farm on his land, with earnings derived from the land rent and for the grounds maintenance.[95] Another payment structure entails a solar developer constructing a solar farm on a plot of land not owned by the grazier and then hiring the grazier to bring sheep onto the solar farm. In this scenario, the grazier will collect payments for grazing their livestock on the solar farm, but will not earn land rents as the grazier does not own the land.[96] This payment structure is exemplified in the Cornell University solar

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[91]NIKOLA KOCHENDOERFER ET AL., THE AGRICULTURAL, ECONOMIC AND ENVIRONMENTAL POTENTIAL OF CO-LOCATING UTILITY SCALE SOLAR WITH GRAZING SHEEP, DAVID R. ATKINSON CENTER FOR A SUSTAINABLE FUTURE 4 (2019), https://solargrazing.org/wp-content/uploads/2021/02/Atkinson-Center-Full-Report.pdf [https://perma.cc/8RGT-ED9P].

[92] NIKOLA KOCHENDOERFER, & MICHAEL L. THONNEY, GRAZING SHEEP ON SOLAR SITES IN NEW YORK STATE: OPPORTUNITIES AND CHALLENGES,,CORNELL U. DEPT. OF ANIMAL SCI. 1 (2021), https://solargrazing.org/wp-content/uploads/2021/02/Solar-Site-Sheep-Grazing-in-NY.pdf [https://perma.cc/5SMY-Z7TB].

[93] *Id.* at 2.

[94] Molly A. Seltzer, *There's a New Job in the Solar Industry*, SMITHSONIAN MAGAZINE (Feb. 6, 2018), https://www.smithsonianmag.com/innovation/theres-new-job-in-solar-industry-180968039/ [https://perma.cc/V56E-7WAN].

[95] *Id.*

[96] Charles, *supra* note 61.

grazing study and at numerous solar sites in New Jersey.[97] In yet another instance, Hoosier Energy, an Indiana energy cooperative, developed solar sites and actively sought out sheep farmers who would be willing to manage the vegetation through solar grazing as a pilot project to test the feasibility of the practice.[98] The Indiana scenario differs from both the Hawaii and New Jersey examples, because in this case there was no payment to the farmer for their grazing services; instead, the benefit to the farmer was solely the additional pastureland provided in the form of the solar site.[99] Notably, the energy cooperative still employed a landscaping company to maintain the vegetation that the sheep would not eat.[100]

In addition to financial payments, graziers benefit from the availability of additional pastureland on which to graze their livestock. As discussed, the solar grazing industry in New York had expanded to 1,000 acres in 2020, highlighting the vast amount of additional land made available for livestock grazing that would have otherwise been maintained with traditional groundskeeping methods.[101] As graziers gain access to the additional land for grazing livestock, it may increase incentives for larger flock sizes, especially when graziers contract to graze larger solar farms and need a larger flock in order to adequately manage the vegetation on the land. Potentially, the larger flock size needed to maintain solar sites during the grazing season could also result in an increase in lamb sales for the grazier, bringing in extra revenue beyond the payments per acre for solar grazing.

A. Benefits to Solar Developers

Solar developers who contract for solar grazing on their sites tend to cite a reduction in operations and maintenance costs as the main benefit of the practice, but they may also benefit from an increased relationship with the public resulting from bringing livestock onto the solar farm.[102] A solar

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[97] Kochendoerfer & Thonney, *supra* note 92; Kelly Pickerel, *Don't Eat Your O&M Costs- Leave It to Those with Four Legs*, SOLAR POWER WORLD (Aug. 29, 2016), https://www.solarpowerworldonline.com/2016/08/dont-eat-solar-om-costs-leave-four-legs/ [https://perma.cc/NYR2-VTF4].

[98] American Solar Grazing Association, *ASGA Call 33 Indiana Solar Grazing Trial & Multiple Land Use with Rocky Mountain Institute* (Sept. 8, 2020) https://drive.google.com/file/d/1gLD3X0Zwhbv7DQAV5r1Xm-kprti0GJQT/view [https://perma.cc/DA24-WDPM].

[99] *Id.* at 30:08.

[100] *Id.* at 29:37.

[101] Beckwith, *supra* note 85.

[102] Kelly Pickerel, *Don't Eat Your O&M Costs- Leave it to Those with Four Legs*, SOLAR POWER WORLD (Aug. 29, 2016),

development company in New Jersey implemented solar grazing at its smallest, 16-acre site and claimed to achieve a 50% reduction in vegetation-related operations and maintenance costs; soon after, the company brought solar grazing onto a larger 26-acre solar site and saw vegetation-related operations and maintenance costs drop from $25,000 a growing season to $10,000.[103] One Arizona solar grazier estimates their services cost 30% less than a professional landscaping crew, which further supports claims of cost savings benefits to solar developers using graziers for vegetation management.[104] Notably, solar developers who plan for solar grazing when constructing the solar site must be cognizant of additional costs which may be required to ensure grazing can successfully take place without harming the livestock or causing damage to the solar panels. The National Renewable Energy Laboratory (NREL) created a table detailing the additional cost of various agrivoltaic practices on the construction of a 500-kW solar installation.[105] While these additional costs increase the initial cost of solar site construction, it is possible that the savings created by utilizing solar grazing for vegetation management can recover the initial investment. More research is needed to determine the viability of recovering the costs of initial investment.

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https://www.solarpowerworldonline.com/2016/08/dont-eat-solar-om-costs-leave-four-legs/ [https://perma.cc/9GY9-KKPC].

[103] *Id.*

[104] Taylor Brown, *Mowers in Sheep's Clothing: Flock Clears Vegetation Around Solar Panels in Southeastern Arizona,* CRONKITE NEWS (July 4, 2018), https://cronkitenews.azpbs.org/2018/07/04/sheep-solar/ [https://perma.cc/4KQ2-DSW7].

[105] KELSEY HOROWITZ ET AL., NAT'L RENEWABLE ENERGY LAB'Y, CAPITAL COSTS FOR DUAL-USE PHOTOVOLTAIC INSTALLATIONS: 2020 BENCHMARK FOR GROUND-MOUNTED PV SYSTEMS WITH POLLINATOR-FRIENDLY VEGETATION, GRAZING, AND CROPS 12-13 (2020), https://www.nrel.gov/docs/fy21osti/77811.pdf [https://perma.cc/8PX6-ZW6W].

Cost Category	Baseline Value	PV + Grazing	PV + Pollinator	PV + Crops
Fencing	$16,843	+10%	0%	+20%
Water Well*	$0	+100%	0%	0%
Site Investigation	$3,644	+100%	+100%	+100%
Clearing & Grubbing	$6,349	-20%	+50%	-50%
Soil Stripping & Stockpiling	$2,245	-20%	+50%	-70%
Grading	$5,963	+50%	+50%	-50%
Soil Compaction	$2,415	-30%	+50%	-80%
Column Foundation	$17,084	+50%	+50%	-80%

*PV + Grazing sites require a water well setup, which is not mandatory in other dual-use PV applications. 0%–100% in PV + Grazing is equal to $0–$10,000 while in other use cases 0% refers to no change to existing base case value.

Figure 3: Increases in solar site construction costs related to planning for agrivoltaics.[106]

Beyond reducing operations and management costs, solar grazing has the potential to mitigate local opposition to solar site development which can lead to local governments halting solar developer's projects.[107] Opposition to solar siting is common in rural communities, however, the addition of solar grazing to the plans for solar sites may reduce opposition by ensuring that the solar site land remains in agricultural production in some capacity.[108] Stakeholder engagement in the planning of a renewable energy project can lead to a project that generates local benefits by investing the money in the community.[109]

B. Limitations to solar grazing

As solar grazing has evolved as a practice for vegetation management, so too has an understanding of the challenges to widespread implementation of the method, such as livestock predation, logistics, and local policy. Because solar grazing sites are typically not on the farmer's land, adequate protection of livestock herds such as sheep can be difficult, making solar grazing unattractive to graziers, like shepherds. For example, a shepherd grazing his sheep on a solar farm in Arizona claimed that solar grazing would not be a possibility without dogs to guard the sheep, and that he was so concerned about sheep predation that he brought pregnant sheep back to his farm to lamb and did not bring lambs to graze until they were older.[110] In one of the Indiana energy cooperative's pilot sites for solar

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106 *Id.* at 13.
107 Pascaris, *supra* note 84, at 12-15.
108 *Id.* at 81-82.
109 *Id.* at 82-83.
110 PBS, *How a Four-legged Mowing System Keeps Solar Farms Producing Energy*, PBS News Hour (Aug. 24, 2018),

grazing with sheep, no guard dog was present and sheep were lost due to predation, causing a loss for the shepherd.[111] Predation illustrates a risk that shepherds or other livestock farmers must be willing to take when choosing solar grazing. Thus, it may dissuade more risk-averse farmers from entering their herds into this practice.

One limitation for farmers engaging in solar grazing is the costs of transporting livestock to a grazing site, while another limitation for the solar site owner is the potential need to negotiate with multiple parties.[112] Farmers generally have little to no say in the solar siting process; consequently, when a solar site is constructed, it may not be financially sensical to graze at the site due to the costs associated with transportation to and from the grazing site.[113]

Another challenge prospective solar grazing farmers must consider is the cost of liability insurance. Because solar sites are such valuable assets, solar developers will generally want to carefully review potential contracts that bring a third party onto the site. The contract review process could become expensive if solar developers insist on the farmer owning an insurance policy as a part of the contract.[114] Farmers, however, may not need liability insurance if they are employed by a landscaping company as a subcontractor to manage the vegetation on a solar farm.[115] Furthermore, the ASGA provides a free solar grazing contract template that anyone can use, which may reduce the legal costs associated with drawing up a contract.[116] Relatedly, the potential need for solar site owners to contract with multiple farmers to graze larger sites, if the area lacks sizable herds, can dissuade solar site owners from solar grazing because it involves too much risk.[117]

Finally, local and state policy can present obstacles to implementing solar grazing. As previously mentioned, developing solar energy installations on agricultural land can result in penalties to the landowner in the form of rescinded tax benefits or other fines.[118] Notably, policy

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https://www.pbs.org/newshour/show/how-a-four-legged-mowing-system-keeps-solar-farms-producing-energy [https://perma.cc/KR4D-855Q].

[111] American Solar Grazing Association, *supra* note 98, at 31:15.

[112] Kochendoerfer, & Thonney, *supra* note 92, at 7.

[113] *Id.* at 3.

[114] Kochendoerfer et al., *supra* note 91, at 5.

[115] *Id.* at 4.

[116] American Solar Grazing Association, *ASGA Solar Grazing Contract Template*, https://solargrazing.org/contract/ (last visited Oct. 5, 2022) [https://perma.cc/F3DC-L3EQ].

[117] Kochendoerfer & Thonney, *supra* note 92, at 6.

[118] Jennifer Ifft et al., Cornell Univ. David R. Atkinson Ctr. For A Sustainable Future, Large-Scale Solar Information and Research Needs for NYS 8 (2021),

limitations are not uniformly negative, and in some states policies actively promote dual land use. The most prominent policy is the Massachusetts Solar Renewable Target (SMART) Program.[119] The program sets minimum solar energy generation capacities in the state and provides compensation for both small- and large-scale solar developers with solar sites that allow for dual agricultural and energy land use to earn $0.24/kWh, depending on whether solar tracking is present on the site.[120] Projects under 25 kW are eligible for compensation for ten years, and projects over 25 kW are eligible for compensation for 20 years.[121] Additionally, in New Jersey, agricultural land may retain its farmland assessment while being used for solar energy generation if the solar facility meets a range of criteria regarding generation capacity, and in North Carolina, farmers do not pay a tax penalty if the solar installation allows a dual agricultural use.[122]

IV. An Examination of Template Solar Grazing Contracts

The following section details the two form solar grazing contracts that are currently available for free. The first comes from the American Solar Grazing Association, a non-profit founded to promote sheep grazing on solar installations, seeking to facilitate research and development of best practices in the solar grazing industry.[123] The second is from the North Carolina Center for Environmental Farming Systems in partnership with North Carolina State University, North Carolina Agricultural and Technical State University, and the North Carolina Department of Agriculture and Consumer Services.[124] Both offer similar but varied approaches to allocation risk and responsibilities amongst the parties, detailed below.

The ASGA, in collaboration with the Food and Beverage Law Clinic at Pace University, has created a template form for sheep grazing contractual arrangements between solar utilities and livestock owners.[125] A second contract option addresses limited vegetation management

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https://solargrazing.org/wp-content/uploads/2021/02/Cornell-Large-Scale-Solar-Info-and-Research-Needs.pdf [https://perma.cc/P4KM-E339].

119 Commonwealth of Massachusetts, *Solar Massachusetts Renewable Target (SMART) Program*, Mass.gov., https://www.mass.gov/info-details/solar-massachusetts-renewable-target-smart-program [https://perma.cc/LS3K-8G6Z].

120 *Id.*

121 *Id.*

122 Ifft et al., *supra* note 118.

123 American Solar Grazing Association, *supra* note 116.

124 *Sheep Grazing Agreement*, Ctr. for Env't Farming Sys. (2018), https://cefs.ncsu.edu/food-system-initiatives/nc-choices/solar-grazing/ [https://perma.cc/ZQ55-NQMW] [hereinafter "CEFS Agreement"].

125 American Solar Grazing Association, *supra* note 116.

strategies.[126] Notably, the contract qualifies solar grazing as only "an arrangement in which sheep graze at a solar site for purposes of vegetation management," and contemplates that "the contract will be entered into between a sheep farmer and a solar site manager," excluding other livestock and the needs that may follow.[127] The template form offers a Master Services Agreement ("MSA"), a Form of Statement of Work, and optional riders such as fencing and signage that can be added to the MSA.[128]

Under the ASGA form contract, the livestock owner maintains responsibility for fulfilling vegetation management standards regardless of whether the sheep alone can effectively maintain the land.[129] Additionally, the Site Manager maintains the ability to terminate work without prior cause, though livestock owners can negotiate early termination fees and/or payment for the set contract price in this event. The livestock owner, however, may only terminate without cause where "such termination must occur at or following the end of a grazing season."[130] As for site regulation rights and duties, the livestock owner (1) "shall be responsible for the health and wellbeing of the sheep, including keeping adequate water and mineral supply"; (2) "shall have access to the Solar Site periodically . . . to perform toxicity testing of the soil"; (3) "shall have 24 hour access to the [livestock]"; (4) "shall be permitted to keep herding and guardian animals including but not limited to dogs, at the Solar Site"; and (5) "shall notify the Site Manager within 24 hours" of any damage caused to solar equipment.

Site Managers, on the other hand, (1) "shall provide prompt verbal notice to the [livestock] farmer if . . . aware that any of the sheep are apparently suffering from illness or accident"; (2) "shall provide . . . 24 hours' notice (except in the case of an emergency, when Site Manager shall provide as much notice as is reasonably practical) of need for repairs or of need to access panels within a . . . grazing area"; and (3) "shall not plant the prohibited vegetation types, if any, listed in the Statement of Work."[131] Under this arrangement, no herbicides, pesticides, or fungicides may be used on the solar site.[132] In addition to these responsibilities, Site Managers are responsible for providing permanent, secure perimeter fencing and gating, as well as covering the costs of any necessary repairs and maintenance, and must allow the livestock owner to place necessary interior

[126] *Id.* at 1.
[127] *Id.*
[128] *Id.*
[129] *Id.* at 2.
[130] *Id.* at 3-4.
[131] *Id.* at 5.
[132] *Id.*

fencing.[133] If the Site Manager fails to perform these obligations, the form contract provides that the livestock owner may perform those obligations and seek reimbursement.[134]

The last clauses of the form contract cover requirements for subcontractors, visitors, indemnification, and insurance. Livestock owners are permitted to subcontract the performance of services just as the Site Manager is permitted to subcontract performance of "fencing, signage, and security obligations."[135] The livestock owner indemnifies the site manager for breach of contract and gross negligence, while the site manager indemnifies the livestock owner from breach and gross negligence, making the allocation of risk relatively well distributed.[136] Notably, the livestock farmer releases the Site Manager "from any claims arising from any death to sheep on a Solar Site or any damage to the Sheep Farmer's personal property on a Solar Site caused by natural events, except to the extent such injury, death, or damage results from the gross negligence or willful misconduct of the Site Manager," though the livestock owner is similarly released from claims of damage or injury caused by natural activity of the sheep, barring gross negligence on the livestock owner's part.[137] Finally, the livestock owner is required to carry insurance and cover the costs of commercial general liability, commercial automobile liability, and workers compensation insurance (to the extent required by law).[138]

Another form contract provided by the North Carolina Cooperative Extension and Center for Environmental Farming Systems Initiative offers an alternative perspective of liability assignment and other contractual constraints.[139] First, the form provides insight as to why certain livestock may not be appropriate in certain instances of solar grazing.[140] The template contract contains a "Sheep Only" provision that specifies it is "understood that Contractor will not provide goats or other ruminants that could bite and chew the electric cables or other electric devices present in the Facilities."[141] Second—and departing from the ASGA contracts—the North Carolina indemnification clause holds the livestock owner to a slightly higher standard, requiring them to be indemnified for simple negligence as

[133] *Id.*
[134] *Id.*
[135] *Id.* at 5-6.
[136] *See id.* at 6.
[137] *Id.*
[138] *Id.* at 7.
[139] CEFS Agreement, *supra* note 124.
[140] *Id.*
[141] *Id.*

opposed to gross negligence.[142] Further, North Carolina's termination right is unilaterally for the site manager.[143] If the livestock owner chooses to end the season prior to the specified time in the original contract, the form requires renegotiation.[144] Renegotiation can be a complicated process necessitating additional legal fees and could place a burden on the livestock owner.

V. Policy Examples for Solar Grazing

When considering how to regulate solar grazing operations, targeted grazing operations in other industries offer guidance on how to allocate rights and responsibilities amongst parties. This section briefly explores grazing for wildfire management and examples of codified targeted grazing operations.

A. Targeted grazing for wildfire management in California

The East Bay Regional Park District is a 125,000-acre system located in Alameda and Contra Costa Counties in California.[145] As part of the 2013 District Master Plan's goal to conserve, enhance, and restore the biological resources of the park district, the district used targeted grazing along with other vegetation management methodologies such as prescribed burning, mechanical treatments, and integrated pest management.[146] According to the park district website, over 9,000 heads of livestock graze on roughly 65% of the district land (6,000 cattle, 1,500 sheep, and 1,600 goats).[147] Not all of the livestock is owned by the park district, and grazing licenses are offered for farmers interested in grazing their herds on the park district lands.[148] The park district's wildland vegetation program manager and the rangeland specialist oversee the East Bay Regional Park District's licensing program, with each grazing unit's management aiming to minimize wildfire potential and brush encroachment, maintain or enhance native grassland communities, control and manage invasive weedy vegetation, enhance wildlife habitat, protect and enhance riparian and

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[142] *Id.*
[143] *Id.*
[144] *Id.*
[145] East Bay Regional Park District, *Welcome*, https://www.ebparks.org/ (last visited Oct. 5, 2022) [https://perma.cc/8C8Q-GJTE].
[146] East Bay Regional Park District, *Master Plan 2013* (July 16, 2013), https://www.ebparks.org/sites/default/files/master_plan_2013_final.pdf [https://perma.cc/D4JC-P3UV].
[147] East Bay Regional Park District, *Grazing*, https://www.ebparks.org/natural-resources/grazing (last visited Oct. 5, 2022) [https://perma.cc/7PXN-PBM2].
[148] *Id.*

wetland habitat values, and control and minimize erosion.[149] Farmers that want to graze their livestock on park district lands must pay rent for the license year, which is determined by the average selling price of beef cattle weighing 500-800 pounds and the number of animal unit months (AUMs) the farmer will be grazing on the park lands; altogether, the rental per AUM may range from $16.00 to just under $24.00.[150] In addition to rent, the farmer is responsible for any utilities used on the grazing premises and for all taxes assessed on the grazing operation.[151]

Concurrent with the farmer's financial responsibilities are the legal responsibilities allocated by the licensing agreement.[152] Licensees must own insurance for commercial general liability (CGL), automobile liability, and workers' compensation, all of which must cover a minimum of $1,000,000 per occurrence; furthermore, the licensee's insurance must grant additional insured status to parties associated with the park district and count as those parties primary insurance coverage should a claim be filed against the licensee.[153] Finally, the insurance policy must include a waiver of subrogation, self-insured retentions, acceptability of insurers, verification of coverage, and the right of the district to modify the insurance requirements considering special risks or consequences.[154]

The East Bay Regional Park District has over 50 years of experience using targeted grazing and highlights benefits like fire hazard reduction, benefits to plant life, and benefits to wildlife.[155] The licensing agreement between farmers and the park district is a beneficial example of how to formulate an agreement for targeted grazing, and it may serve as a foundation for future agreements between farmers and landowners who are hoping to use targeted grazing or solar grazing across the United States.

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[149]East Bay Regional Park District, *supra* note 146, at 40-41.
[150] *East Bay Regional Park District Grazing License*, EAST BAY REGIONAL PARK DISTRICT, Exhibit B (2020), https://www.ebparks.org/sites/default/files/blobdload.aspx_6_1.pdf [https://perma.cc/7K3G-XBUR].
[151] *Id.* at 19.
[152] *See id.* The licensing agreement contains a number of provisions assigning rights and responsibilities between involved parties.
[153] *Id.* at 15-16.
[154] *Id.* at 16.
[155] East Bay Regional Park District, *Benefits of Grazing Animals*, https://www.ebparks.org/natural-resources/grazing/benefits (last visited Sept. 21, 2022) [https://perma.cc/KTD2-Q959].

B. Targeted Grazing in City Code in Dubuque

In addition to livestock grazing for maintenance of public lands, the use of grazing to maintain private property is also growing in popularity. Dubuque, Iowa has enacted a controlled livestock grazing program that allows private landowners to contract with farmers to engage in targeted grazing within the city limits.[156] Restrictions on the targeted grazing program include limiting the permissible livestock to female and neutered male sheep and goats, and only allowing herds to graze a property for a period of up to 30 days once per year.[157] Additionally, contractors must obtain a permit with the city of Dubuque to offer targeted grazing.[158] Permits to offer targeted grazing cost $300, and contractors must also obtain a $5,000 surety bond with the city government to operate within city limits.[159] In contrast to the agreements filed to practice targeted grazing in the East Bay Regional Park District, contractor insurance is not a requirement to obtain a permit or file a surety bond to practice targeted grazing in Dubuque, as the program rules specify that insurance requirements must be negotiated by the contractor and landowner.[160]

Livestock grazing programs like the one operating in Dubuque, Iowa are supported by Goats on The Go, a national organization with a network of affiliates who seek to substitute traditional vegetation management practices with livestock grazing.[161] Goats on The Go touts livestock grazing as an effective and environmentally friendly alternative to vegetation management with herbicides or lawn mowers, pointing out that the goats eat "problem vegetation" without threatening desirable plants, that invasive plant seeds are not usually viable after a goat consumes them, and that the only by-product of the practice is fertilizer.[162] The organization promotes targeted grazing in residential and commercial areas on its website by encouraging readers, who may be cautious about whether the practice is allowed by city ordinance, to carefully read and interpret city code and by providing a list of "Dos and Don'ts" to follow when drafting an ordinance

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[156] DUBUQUE, IA., CODE OF ORDINANCES ch. 6, § 7-6A-2 (2018).
[157] *Id.*
[158] *Controlled Livestock Grazing Permit*, THE CITY OF DUBUQUE, https://cityofdubuque.org/2684/Controlled-Livestock-Grazing-Permit (last visited Sept. 21, 2022) [https://perma.cc/SUG4-U2BB].
[159] *Id.*
[160] *Id.*
[161] Clarke News, *Clarke Welcomes Goats to Campus as Part of Ongoing Sustainability Efforts*, CLARKE UNIV. (June 21, 2022), https://www.clarke.edu/news/clarke-welcomes-goats-to-campus-as-part-of-ongoing-sustainability-efforts/ [https://perma.cc/D8MP-CQY4].
[162] Goats on the Go, *Why Goat Grazing for Vegetation Control?*, https://www.goatsonthego.com/why-goats (last visited Sept. 21, 2022) [https://perma.cc/UF5F-Q6V].

that would specifically allow targeted grazing within city limits.[163] This alternative method of regulating solar grazing through ordinances offers an additional layer of information dictating rights and responsibilities that might be considered in the development of contracts between livestock owners and solar site managers.

Conclusion

Solar grazing is a new industry with great potential for graziers and solar developers. Solar grazing presents the opportunity for graziers to diversify their income through the receipt of payments for their flock's grazing services, and to further increase revenues by grazing additional heads of livestock to adequately meet livestock grazing standards.[164] At the same time, solar developers benefit from solar grazing through cost saving measures and increased local acceptance of solar projects.[165] While solar grazing does incur additional costs in the planning stage as solar sites have to be designed to accommodate livestock, cost reductions are achieved through reduced operations and maintenance costs.[166] Since solar grazing includes agricultural operations, it has the potential to garner the support of residents in rural areas who may otherwise oppose solar site development as it removes land from agricultural production and disrupts local cultures.[167] Going forward, research should focus on further identifying the benefits of solar grazing to graziers and solar developers, analyzing the economic and social potential of the practice.

Increased demand for renewable energy in the form of state and federal policies, combined with a restructuring of agricultural land associated with drought, flooding, and changing market conditions have led to a tension concerning the conversion of land historically used for agriculture into land used for renewable energy generation. While not a cure-all, agrivoltaics and its various subfields present a solution to the land use dilemma by allowing for the co-location of agricultural and energy land uses on the same plot of land. While promising, legal barriers to agrivoltaics abound that require action if the practice is to become more widespread, namely zoning, taxation, and liability laws. Local zoning laws have resulted in a patchwork of attitudes regarding the development of solar energy

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163 Goats on the Go, *FAQ About Weed and Brush Control with Goats*, https://www.goatsonthego.com/local-gov-faq (last visited Sept. 21, 2022) [https://perma.cc/6XAV-SMCZ].
164 Kochendoerfer & Thonney, *supra* note 92, at 2.
165 Pascaris, *supra* note 84, at 109.
166 Pickerel, *supra* note 97.
167 Pascaris, *supra* note 84, at 82.

infrastructure on agricultural land, and laws specifically mentioning agrivoltaics are few and far between. The current zoning silence regarding agrivoltaics can be oppressive, preventing development for fear of fines or other legal action. Concerns over zoning coincide with concerns over taxation, as a change in land use designation from agricultural to renewable energy can result in a drastic change in the taxes levied on the landowner. Finally, farmers wishing to engage in agrivoltaics must also consider the liability risk they are taking on by practicing agriculture near an asset as valuable as solar panels.

The lack of legislative action on agrivoltaics presents legislators with a tabula rasa that may be used to accelerate the widespread implementation of the practice. Solutions to the discussed challenges of agrivoltaics include (1) the development of overlay districts that allow for land to be zoned for both agricultural and energy uses, (2) the creation of tax incentives that increase the affordability of agrivoltaics, and (3) the dissemination of legal resources that farmers and solar developers can use to improve agrivoltaic contracts while reducing legal costs. Implementation of these recommended solutions can be supported by further research on the impact of policies such as Massachusetts' SMART Program and on the effect of contracts used in practices like agrivoltaics such as targeted grazing. Altogether, agrivoltaics presents extensive potential to solve a variety of issues, and continued research on the topic will enable the further development of the practice from a niche technology into a healthy industry.

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