



Smart Solar Siting on Farmland: Achieving Climate Goals While Strengthening the Future for Farming in New York



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About American Farmland Trust

American Farmland Trust (AFT) is the largest national organization dedicated to saving the land that sustains us by protecting farmland, promoting sound farming practices and keeping farmers on the land. AFT unites farmers and environmentalists in developing practical solutions that protect farmland and the environment. We work from “kitchen tables to Congress”—tailoring solutions that are effective for farmers and communities and can be magnified to have greater impact. Since our founding, AFT has helped to protect nearly seven million acres of farmland and led the way for the adoption of conservation practices on millions more. AFT has a national office in Washington, D.C., and a network of field offices across America where farmland is under threat. We established our New York office in 1990, as the state is home to some of the most threatened farmland in the nation.

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Cover Photo Credit: AgriSolar Clearinghouse

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Executive Summary

New York's Climate Leadership and Community Protection Act of 2019 (CLCPA) sets ambitious goals into law to dramatically reduce carbon emissions. This includes achieving generating 70% renewable energy for the electric grid by 2030 and 100% clean energy by 2040. Meeting these targets will involve a major shift in New York's energy profile; in 2020, New York produced 27% of its total energy from existing renewable sources, mostly generated by hydroelectric power, with wind accounting for almost 4% of all utility-scale net generation in New York, and solar accounting for only 2.5%. Two-thirds of the solar generation came from small-scale systems with capacities of less than 1 megawatt (MW).ⁱ

The amount of new generation from solar will need to grow dramatically over the next two decades, with large-scale solar installations permitted through New York state's Office of Renewable Energy Siting expected to play a key role in meeting these energy targets. Widespread deployment of utility-scale solar, including both distributed generation and large-scale projects, presents opportunities and challenges for farmers and rural communities across New York. With the right planning, project design, and farmer and community engagement, utility-scale solar can be developed in ways that reduce or avoid significant impacts to active farmland and agricultural communities.

New York state must develop and implement smart solar siting strategies to meet state climate goals while supporting its agricultural economy and future food security. To better define smart solar siting strategies in New York, American Farmland Trust (AFT) engaged with farmers, local government officials, solar developers, land trusts, and environmental organizations across the state to develop a smart solar siting framework and recommendations designed to avoid, minimize, and mitigate the impacts of solar development on New York's most productive farmland and on farm viability. AFT's proposed framework and recommendations reflect key findings and themes from surveys of nearly 750 farmers, local government officials, and land trusts, as well as from roundtable discussions with regional stakeholders and solar developers.

AFT found that the economic benefits of solar leases are not well distributed within or across agricultural communities and vary according to farmer land tenure arrangement and concentration of solar development within a community. At the individual farm level, solar leases can provide a vital secondary source of income to farmers that own their land to help their farm operations remain viable and keep farmland within families to transfer to the next generation. AFT's survey results also indicated concern that solar projects could take tens of thousands of acres out of production and negatively impact local farming communities. For example, it appears that solar development is already making farmland more scarce and costly for some farmer-renters, particularly in places with many proposed large-scale projects. In some cases, solar development is causing farmers to lose access to rented land, a particularly troubling challenge for New York's dairy farmers.

At the farm community level, solar siting on farmland can have harmful cumulative impacts by creating costly challenges for farmer-renters, removing active farmland from production in the short-term, and potentially reducing the availability, quality, and productive capacity of farmland in the long-term. The loss of active and high-quality farmland can also negatively impact farm viability by making it less profitable for agricultural service providers and other support systems to stay in business, therefore raising the cost of doing business for remaining farms, many of whom are already struggling.

Some farmers are also expressing interest in dual-use solar where agricultural activities and solar energy production are maintained simultaneously on the same piece of land. Agrivoltaic projects, a kind of dual use solar, are specifically designed to support a viable farm operation and may include features that

require additional investment, such as elevated panels and wider spacing to allow for crop or forage production or for livestock grazing within the facility area. Robust dual use solar applications may offer a potential path forward to expand solar production without negatively impacting farm and agricultural viability by allowing agricultural production to continue. However, further applied research will be needed to determine feasibility and best management practices.

AFT incorporated survey responses and stakeholder roundtable feedback into the development of a recommended 3-step solar siting framework designed to encourage solar developers to avoid, minimize, and mitigate impacts to farmland. The first step of the framework categorizes solar projects based on the impact of the project facility area to New York mineral soil groups (MSG) 1-4, which largely align with prime farmland. The resulting categorization (Orange, Yellow, or Green) determines the per acre farmland conversion mitigation fee to be applied to the project. The per acre fee is based on a multiplier of the average cost to protect farmland in the county or region where the project is located. The second step of the framework allows developers to achieve discounts on their mitigation payment through practices that minimize or mitigate the impacts of solar siting on farmland, such as genuine incorporation of agrivoltaics. The third step provides recommendations on agency implementation and verification of the criteria developers must meet to receive the mitigation fee discount.

Recognizing that the fees are collected to mitigate impact to high quality farmland, based on stakeholder conversations, AFT strongly recommends that mitigation fees be primarily used to permanently protect farmland. Where appropriate, a portion of the revenues could be invested in programs that support local farmland protection planning, agricultural viability projects, land access programs, or implementation of soil health best management practices. Survey respondents and roundtable participants expressed a strong preference for funds to be spent within host communities. AFT also recommends development of local cumulative farmland conversion thresholds from all development to ensure a sufficient base of farmland to sustain farm viability. In 2020, a solar law passed in New Jersey restricting grid-supply solar siting to no more than five percent of prime farmland acres in an agricultural development area. Similar policies in New York could prevent any one community, particularly in areas seeing high levels of development, from bearing disproportionate negative impacts.

AFT makes additional recommendations to advance smart solar siting in New York, including prioritizing siting on alternative or non-agricultural sites, working with farmers and communities to support agricultural viability, and implementing best management practices to protect soil health when siting solar on farmland. AFT also recommends investing in farmland protection and land transition programs and creating a system to track impacts of solar on farmer-renters to inform strategies that can reduce and address farmer displacement. Finally, AFT identifies various opportunities for future research. This includes more feasibility studies for utility scale agrivoltaic systems, and analyses of solar project construction, operations, and decommissioning impacts on agricultural soils.

Solar siting is advancing rapidly in New York to meet the state's climate goals of 70% renewable energy by 2030 and 100% clean energy by 2040, and much of that development is targeted towards farmland. However, with the right policies, incentives and research, solar development can avoid or minimize the most serious negative impacts on the availability and viability of New York's best farmland and the strength of its agricultural economy and food security. Implementing the smart solar siting strategies recommended in this report can help farmers and agricultural communities capitalize on the benefits of solar development, explore new markets, participate in cutting-edge research partnerships, and continue growing the food we need now and in the future, all while combatting climate change.

No Farms, No Food: Protecting Farmland for the Future

New York's farmland forms the basis of \$44 billion in annual economic activity and supports 163,000 jobs.ⁱⁱ New York is also unique in that farmers grow and produce the "full plate," from fruits and vegetables to grains and legumes, to dairy and animal protein.ⁱⁱⁱ The need for strong local food systems has been made more acute during the COVID-19 pandemic with breaks in global food supply chains resulting in empty grocery shelves, increased prices, and delivery delays. In contrast, shorter supply chains whose foundation is local farmland are more resilient to such shocks and disruptions. In the face of rapidly warming global temperatures and increasingly frequent extreme weather events, we must also reckon with a changing understanding of where and how we can grow food. New York will likely play a greater role in national food security in the future due to its fertile land, abundant water, proximity to population centers, and ability to grow the whole plate – and therefore must carefully consider what is at stake with every acre we lose.

Farmland is an irreplaceable resource that is all too often taken for granted, as are the farmers who own and manage it. AFT's 2020 "Farms Under Threat: The State of the States" report revealed that New York is among the states with the highest farmland conversion threat in the nation –over a quarter of a million acres of farmland were developed, or fragmented by low-density residential development, between 2001 and 2016 alone (Figure 1).^{iv} Over half of this loss occurred on the most productive, versatile, and resilient farmland, or the best soils for growing food and crops over time with minimal environmental impact. Farmland loss has been concentrated around urban areas in

Farmland Loss in New York State

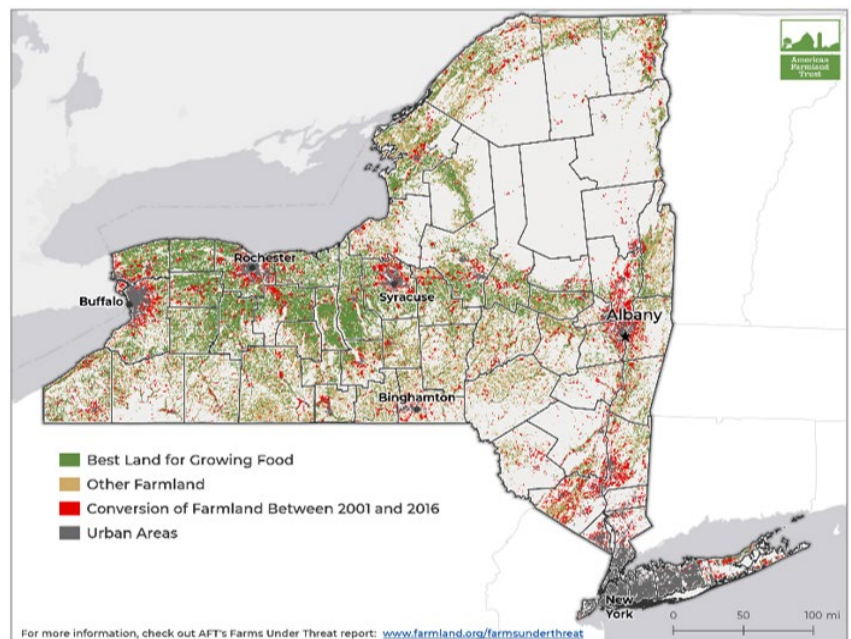


Figure 1 – Source: Farms Under Threat (AFT)

Ratio of Farmers 65 and Older to Farmers Under 35

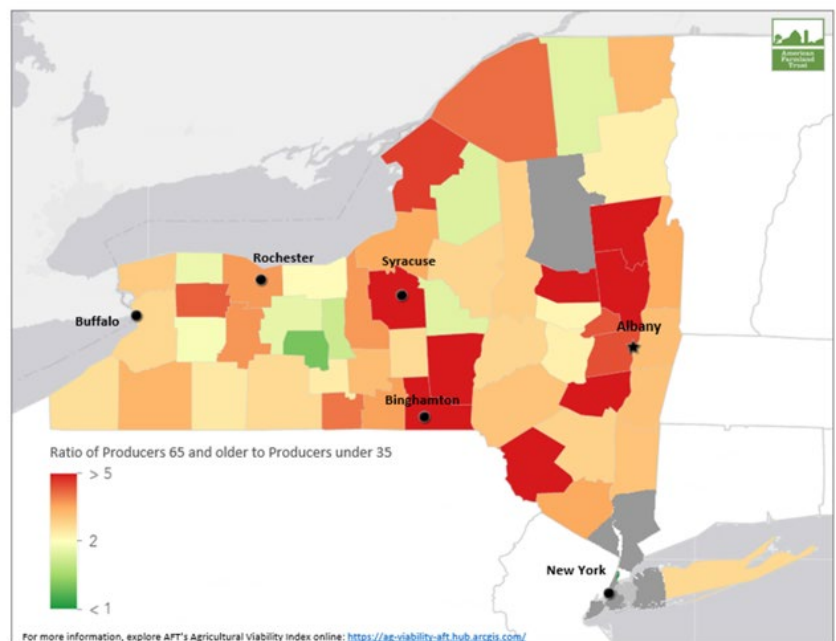


Figure 2 – Source: USDA 2017 Census Data

New York and created disproportionate pressure for some counties, particularly those around urban centers that serve as “foodsheds”.^v Of the ten counties with the highest percentage of farmland loss during this time period, seven grow fruits and vegetables as a primary crop, and most are near or contain major urban centers that need this healthy food.^{vi}

In addition to sustaining our food supply and supporting one of New York’s largest industries, farmland also provides a range of invaluable ecosystem services. Key among them is carbon sequestration, which, according to the New York Agriculture and Forestry Advisory Panel’s 2021 recommendations to the Climate Action Council, will be a part of the strategy to meet economy-wide net-decarbonization in New York by 2050. Loss of high-quality farmland to development not only diminishes food production and carbon sequestration capacity, it also frequently pushes farming to more marginal lands that require greater inputs leading to greater environmental impact to achieve comparable production.^{vii}

New York’s farmland is under further threat due to an impending intergenerational transition. Farmers comprise only 2% of the population, and their average age is over 57 years old, with roughly a third over the age of 65. Ninety-eight percent of farmers in New York are white, and the average ratio of farmers over 65 to farmers under 35 statewide is 4:1, with individual county ratios as high as 11:1 in Broome, 7:1 in Saratoga, and 6:1 in Greene (Figure 2). AFT research found that senior operators own or rent over 2 million acres of land, and 92% of them don’t have a successor prepared to take over.^{viii} Meanwhile, young, new, and beginning farmers, and farmers of color face significant barriers finding affordable land from which to launch successful farm businesses. The 2017 USDA census revealed that only 44% of farmers show net gains of income from farming, while only 15% had a net gain of \$50,000 or more.^{ix}

New York agriculture faces a shifting landscape that threatens its future viability unless the state continues investing in and accelerating efforts to protect farmland, help a diverse new generation of farmers access land, and address climate change. These actions will ensure New York has the quality farmland and skilled farmers needed to grow food now and in the future.

Summary of Challenges Facing New York Agriculture

- High threat to farmland with loss of over a quarter million acres between 2001 and 2016
- High farmland conversion potential during the unfolding intergenerational transition of farmland. One third of farmers over 65 years old, 92% without a next generation farmer prepared to take over
- High barriers to entry for young and historically marginalized farmers, especially Black, Indigenous, and Farmers of Color
- Impacts from extreme weather and climate change
- Economic challenges, particularly for the New York dairy industry

Solar Siting on Farmland: Opportunities and Conflicts

In 2019, the New York Climate Leadership and Community Protection Act was signed into law with ambitious mandates to generate 70% renewable electricity by 2030, and 100% zero-emission electricity by 2040. As a result, solar development in New York is rapidly accelerating and presents both opportunities and challenges to achieving a resilient agricultural economy and food system. According to the New York State Energy Research and Development Authority (NYSERDA), New York generates approximately 27% of its power from renewable sources, most of which comes from hydroelectric facilities (88%), with the remainder from wind, solar and biomass. The substantial new generation capacity to reach the 2030 and 2040 clean energy goals is expected to come from offshore and land-based wind and solar. Importantly, large-scale land-based solar is expected to play an essential role in meeting New York's 2030, 2040, and 2050 goals (Figure 3).

Climate Leadership and Community Protection Act (CLCPA)

Signed into law in 2019, the CLCPA set several renewable energy and emissions reductions targets including:

- 70% renewable energy for the grid by 2030 and 100% by 2040
- 85% reduction in GHG emissions from 1990 levels and economy-wide net decarbonization by 2050
- 6 gigawatts (GW) of distributed solar by 2025. Target increased to 10 GW in 2021

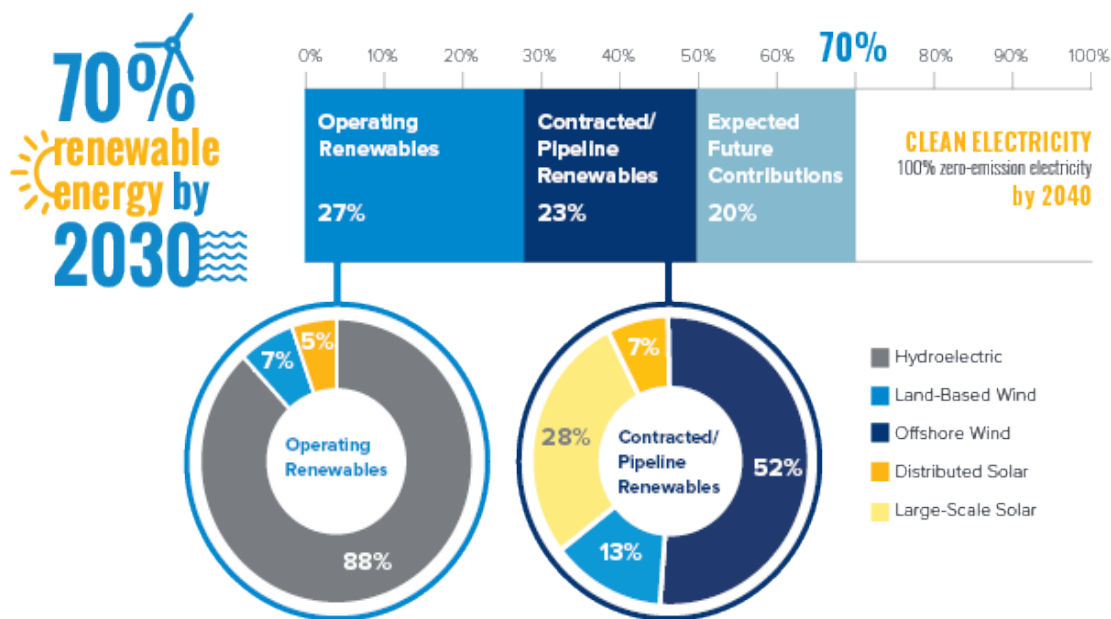


Figure 3 - Clean Energy Standard Progress to Date (Source: [NYSERDA](#))

Like farming, solar power generation requires relatively flat, cleared, sunny land, as well as proximity to grid infrastructure to transport energy from where it is generated to where it's needed. In response to the acceleration of solar development in New York state, local communities, farmers, and other stakeholders are raising important questions about how to accommodate this new land use in ways that maximize positive benefits and minimize negative impacts on farmland, the farm economy, food security, and rural livelihoods. As a result, this has caused tension in communities throughout New York state, in some cases resulting in moratoria on new solar projects. These tensions are closely tied to

scale, private property rights, and who wields the power to shape the future of so many rural communities.

Local governments that have passed solar land use laws hold permitting authority through a local review process for distributed generation solar facilities (generally 5 megawatts [MW] or less), but large-scale solar facilities (20-25MW+) are reviewed by the Office of Renewable Energy Siting (ORES) within the New York Department of State.¹ With large-scale solar set to rapidly outpace smaller projects, the locus of decision-making power over the future of rural agricultural landscapes has shifted. Although ORES regulations state a goal to avoid, minimize, and mitigate large-scale projects' impacts on farmland and require developers to submit maps and other information to determine the extent to which projects achieve those goals, reviewers at the state level may be less fully aligned with, or aware of, local agriculture and farmland protection priorities.

Data and trends so far show that good quality farmland has been a first-choice site for solar development.^x Cornell University researchers Katkar et al. analyzed existing solar development in New York built as of 2018, all distributed or small-scale projects, and found that 44% of projects were sited on crop, pasture, or hay land, and 58% of solar projects were built on good quality soil, defined by the study authors as prime farmland or farmland of statewide importance (Figure 4). **The researchers also found that, even when excluding these two categories of farmland based on soil quality, cropland and hay and pastureland still made up the majority (82-85%) of the land suitable to host solar to get us to 2030 goals.**

Soil Quality Under Solar Projects (2018)

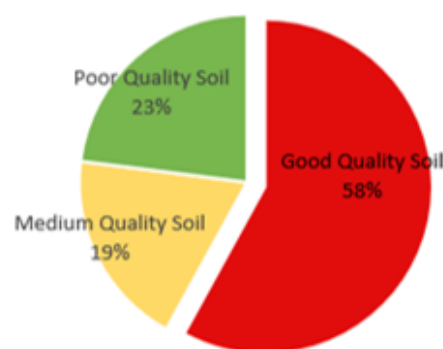


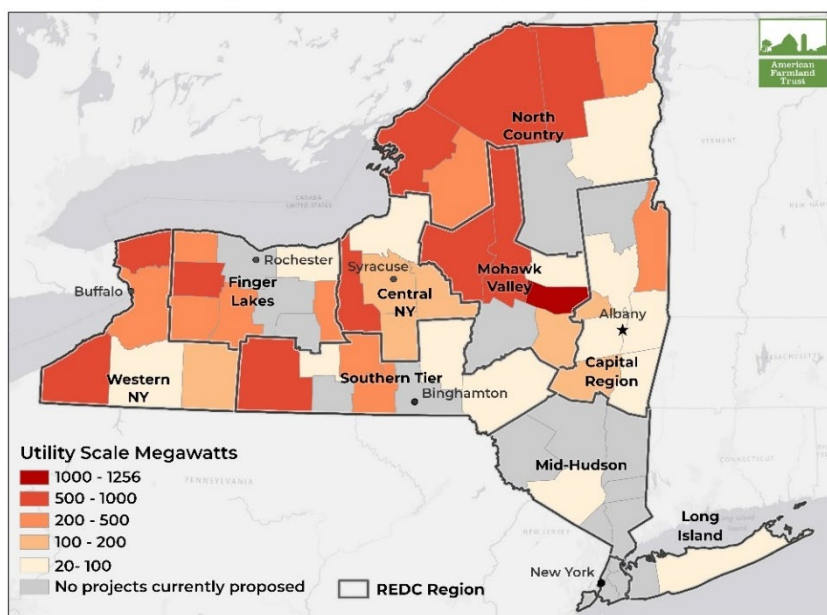
Figure 4 – Source: Katkar et al.

Projections of how many gigawatts of solar, and therefore how many acres of land, are required to meet the state's climate goals vary widely, and the actual number remains unknown without a clear understanding of how much on- or off-shore wind will be developed. Katkar et al. conservatively estimated a need for 21.6 GW of installed utility scale solar by 2030 to fill the 70x30 goal.^{xi} However, higher future clean energy goals, increased electrification, and improved storage and efficiency will also influence, and likely increase, the amount of renewable energy New York needs to generate. A study prepared for the New York Independent System Operator (NYISO) included estimates as high as 38 GW of utility scale solar needing to be installed by 2040.^{xii} Using a metric of 5-7 acres per MW, this need translates to anywhere between 108,000 and 266,000 acres of ground mounted solar, much of which will be large scale projects as the solar market and permitting processes shift.² **If all this development occurs on farmland, New York could convert as many farmland acres to solar development in the next 15 years as was lost to all residential, commercial and other land uses between 2001-2016.**

¹ The Office of Renewable Energy Siting was established in 2020 through the Accelerated Renewable Energy Growth and Community Benefit Act. Large-scale solar projects are reviewed through the 94-C process.

² The projected land area needed to meet CLCPA targets and to support expected solar development is a function of project design, system capacity and solar panel efficiencies, and projections vary between 5 and 10 acres per megawatt.

Proposed Large Scale Solar Development, August 2021



Data Source: New York Independent System Operator, Inc. (NYISO) Interconnection Queue

Data Access Date: August 10, 2021

Figure 5 – Large Scale Solar Proposals, Aug 2021

Table 1 – Proposed Large scale solar percentages by REDC Region

REDC Region	% of Total Proposed Large-Scale Solar
North Country	22%
Mohawk Valley	22%
Finger Lakes	17%
Western NY	14%
Southern Tier	9%
Central NY	8%
Capital Region	6%
Mid Hudson	1%
Long Island	<1%

Figure 5 shows where in New York large scale solar projects are seeking interconnection into the grid, representing approximately 14.3 GW of large-scale solar proposals as of August 2021.³ When grouped by Regional Economic Development Council (REDC) region, the North Country and the Mohawk Valley each contained over one fifth of proposed projects (Table 3), likely due to the relatively low cost of land when compared to other regions.

Local communities, farmers and other stakeholders are raising important questions about how to incorporate solar into rural landscapes in ways that maximizes positive benefits and minimizes negative impacts on farmland, the farm economy, food security, and rural livelihoods. Expanding renewable energy production is key to addressing climate change but keeping land in farming will remain necessary to grow the food, fiber, and fuel we need to survive. This is particularly true in a state with plentiful land and water resources. Further, farming that embraces regenerative or climate-smart practices can also draw down atmospheric carbon and store or sequester it in the soil, which is key to New York’s strategy for economy-wide net-decarbonization in New York by 2050. Recent research shows that widespread national adoption of just two regenerative practices—cover crops and no till—would sequester the carbon equivalent of removing up to 260 million automobiles from American roadways each year.^{xiii} While farmland may offer the easiest siting choice, it is not always the best choice to maximize benefits.

³ Some projects are still in the initial stages of their permitting process, but all projects have a degree of site control, i.e., lease agreements with landowners.

Achieving Balance Through Smart Solar Siting

At the local level, the net impact of solar development on farmland depends on how many solar projects a community may host, what percentage of land they impact, the quality of that land, and how long solar panels stay on the land. Agricultural economies are interdependent, with support services (e.g., veterinarians or seed dealers) that need enough farm customers to keep them in business. While solar projects can support individual farm businesses, large-scale solar development will likely be a contributing, if not deciding, factor to the future viability of these local economies because projects span hundreds and sometimes thousands of acres in a single community. On the other hand, well-sited, smaller, community scale projects of 5 MW or less, seem less likely to significantly reduce land availability in a farm community unless many projects are concentrated in one area, or they are spaced in a way that fragments the landscape. However, small scale projects alone will likely not get New York to its climate goals.

We need a smart solar siting strategy in New York to balance competing solar and farmland land use needs, both of which provide critical public goods and have a key role to play in the state's efforts to combat climate change.⁴ Guided by an advisory committee representative of agricultural, government, developer, and conservation stakeholders across New York, American Farmland Trust (AFT) led a process to better identify the impact of solar siting on farmers and farmland in the state. AFT engaged farmers, local government officials, solar developers, land trusts, environmental organizations, soils experts, and many others through surveys and roundtables to better understand current attitudes towards solar development on farmland, and to develop a framework and recommendations for achieving smart solar siting in New York.

What is Smart Solar Siting?

The goal of smart solar siting is to maximize renewable energy generation while supporting farm viability and protecting our most productive farmland by:

- Promoting siting solar panels on lands that will support farm viability and avoid high quality farmland
- Embracing agrivoltaics (with rigorous, well-defined standards), where solar energy production and farming occur simultaneously on the same piece of land
- Ensuring oversight for projects that will impact farmland, farms, and the farm economy to implement best practices in construction, operation, decommissioning, and regenerative soil management

⁴ Though it is important and preferable for farmers to generate renewable energy for on farm use, the following report is about siting solar facilities to generate electricity for off farm use. Note that it is AFT's position that solar installations that generate electricity for on farm use should be located on rooftops, existing structures, and marginal land.

Project Methods

AFT conducted [three surveys](#) in July 2021 of farmers, local government officials at the town and county level, and land trusts and environmental organizations. Samples selected were not random, and therefore the data throughout this report should not be generalized as selection bias may be present.

Responses from both farmers and local government officials were geographically representative of the state (excluding the counties that make up New York City). A total of 407 farmers, 368 local government officials, and 28 land trusts and environmental organizations responded to the survey. Though most respondents completed the survey in full, not all questions were required and therefore the number of responses to each question varies and is labeled throughout the report. Survey responses were used to shape the initial draft framework and recommendations, which were then presented to the project advisory committee and at multiple stakeholder roundtable discussions with solar developers, farmers, local government officials, representatives from state agencies, land trusts, environmental organizations, and with Cornell University. The additional feedback from roundtable attendees and the advisory committee was incorporated into the final framework and recommendations. For more information about the makeup and representativeness of the survey respondents, survey findings, and stakeholder roundtables, please see the [Appendix](#).

The following report is meant to provide state and local governments, solar developers, and farmers with the information and tools they need to develop a path forward balancing multiple critically important land uses, all of which will be vital in the fight against climate change.



Photo Credit: Shawn Linehan

Survey Finds Mixed Impacts to Farmland and Farm Viability

In New York, 74% of farmers and local government officials surveyed reported that solar was proposed or sited on farmland in their communities. When asked what impacts to farm viability they expected to see, 77% of all survey respondents reported negative or mixed positive and negative impacts, but farmers as a subset responded more negatively than local government officials or land trusts and environmental organizations (Figure 6).⁵

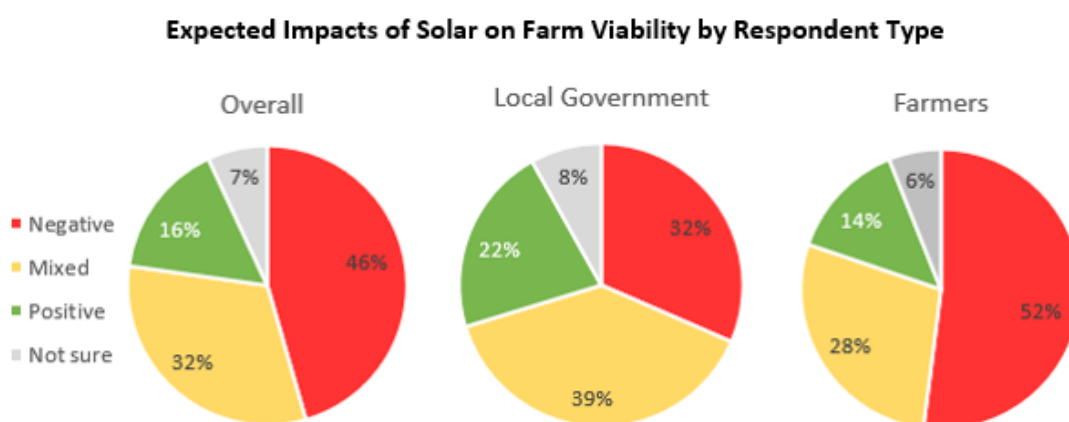


Figure 6 N=427 (Overall), N=111 (Local Government), N=298 (Farmers)

When split by region, farmers in the Mohawk Valley and in Western New York, which both have high volumes of large-scale solar projects proposed, described the expected impacts of solar siting on farm viability more negatively than farmers in other regions (Figure 7). No farmers surveyed in Central New York expected positive economic impacts from solar development.

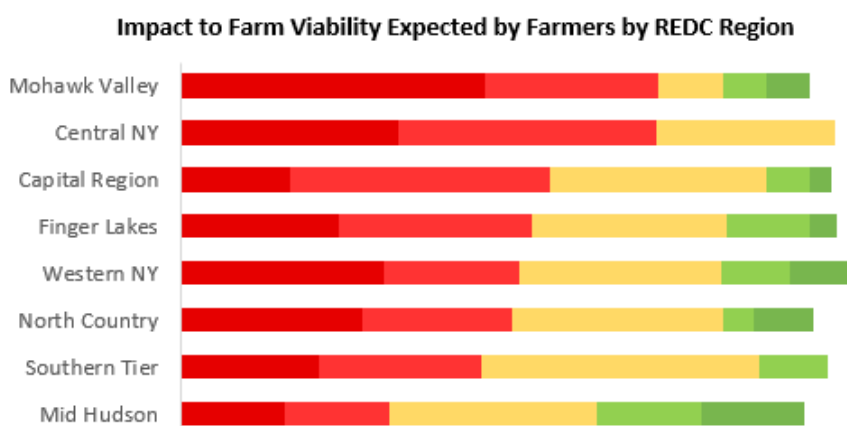


Figure 7 (N=436)

⁵ Answer options were 'very positive', 'mostly positive', 'mixed or neutral', 'mostly negative', or 'very negative', and included space for open-ended responses. The chart depicting overall responses includes responses from farmers, land trusts and environmental organizations, and local government officials. Land Trusts and environmental organization responses were not separated out further due to the small response number (N=28).

Solar Development Can Positively Impact Farm Viability for Farmers Who Own Their Land

Forty-two farmers (10% of farmer respondents) reported that they were already hosting or exploring hosting a solar project on their land.⁶ When asked why they were hosting solar, the vast majority said it was to earn extra income (Figure 8). Of the farmers not currently hosting solar, just over half (53%) were interested in hosting solar projects in the future, and similarly cited additional income as a key reason (Figure 9). The next most frequent motivation chosen for hosting solar was transitioning the farm to the next generation, at 37% and 39% of farmers respectively. This is notable given New York's aging farmer population. Additionally, 37% of farmers interested in hosting solar said they were motivated by an interest in dual use or continuing to farm under and around solar panels.

**Motivations for Farmers
Currently Hosting Solar Projects**

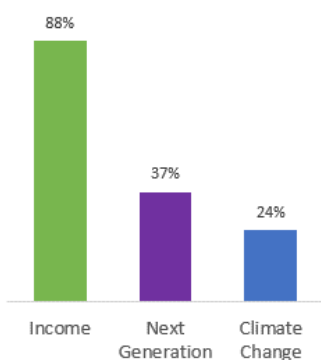


Figure 8 (N=42)

**Motivations for Farmers
Interested in Hosting Solar in the Future**

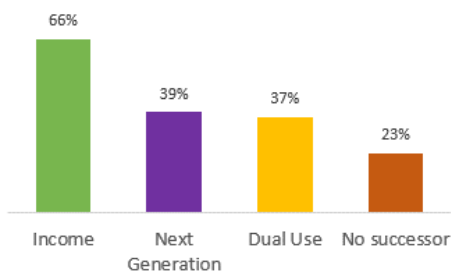


Figure 9 (N=34)

On average, farmers interested in hosting solar said they would be willing to lease about 16% of their land (N=71), indicating many farmers would prefer to lease a small portion of their farm but not all of it. If developers approach farmers with this in mind, they can better support the host farm's viability while searching for land to lease for solar projects. Figure 10 shows the expected impacts of solar projects both for farmers currently hosting, and farmers interested in hosting solar on their farm.

For those currently hosting projects, 60% reported that the solar project will either allow them to continue farming or will have no impact on the farm operation, whereas only 35% of farmers interested in hosting projects in the future chose these answers. For those interested in hosting projects, many more were unsure the impact it would have—likely because the question was not posed about actual projects. Among both groups, a minimal percentage expected to stop farming altogether due to solar.

What Farmers Had to Say

"Solar development will provide supplemental income to those farmers that are interested to reinvest into their business. Personal property rights are important... ideally solar arrays go on less productive land, however the farmer should have that choice."

—Farmer in the Finger Lakes

"[One] positive effect is to have a more diverse price structure in [the] agricultural community. Farming is a price taker at the bottom of the food chain. Profitable soils stay farmed."

—Farmer in the Finger Lakes

"When landlords choose to rent their farmland to solar companies instead of a farmer, that farmer will lose rental ground. This will be bad for farmers. But when a solar farm rents land from a farmer, that farmer will have income from that land that will (presumably) be higher than the contribution from growing crops, so it will make that farm more viable."

"[Solar siting] will bring a different stream of revenue to a farmer for a portion of their land. This will allow them to keep farming in other sectors... It will also allow for other forms of farming in and around the panels - sheep, bees, pumpkins, potentially beef, etc."

—Farmer in Western NY

⁶ 15 of these projects were small-scale, 15 were large-scale involving multiple landowners, the rest were unsure.

Though this data isn't generalizable, this is a promising finding, revealing that very few farmers appear to be interested in solar as a way to exit farming altogether.

Reported and Expected Impacts Solar Projects Will Have on Farm Operations

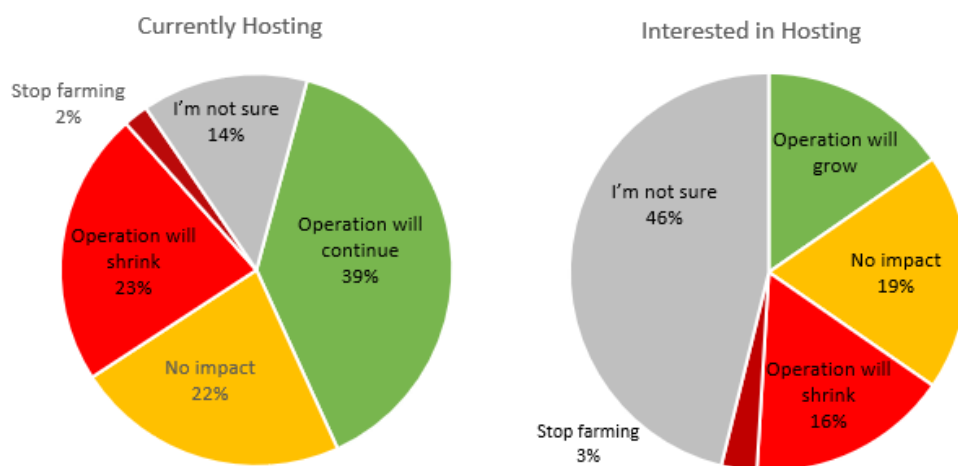


Figure 10 (N=42, N=104)

What Farmers Have to Say

"We are in Mount Morris and people from Arkport travel [27 miles] to Mount Morris to rent land. That is how tight land is becoming."

—Farmer in the Finger Lakes

"The land being developed isn't owned by farmers so it is being taken away from farmers because we can't compete with the prices they offer."

—Farmer in the Finger Lakes

"The highest farm leases are \$150/acres...the solar company is paying \$1,800/acre to rent the land. ... How can local farms compete with that? They can't."

—Farmer in the Southern Tier

"[Developers are] paying 10 times more per acre rental per year. Crop farmers can't match the \$1,000-\$1,400 these solar companies offer."

—Farmer in the Finger Lakes

Solar Development Can Negatively Impact Viability for Farmer-Renters

Another key determinant of the impact solar development will have on farming is who owns the land that will be hosting arrays. Access to land is critical for any farm operation, and for new, beginning, and farmers of color who often cannot afford to buy land outright, the availability of suitable farmland to rent makes the impact solar will have on the amount and affordability of rented lands an important equity issue for the state. Loss of rented land can be devastating to a farm business, and so efforts to ensure farmer-renters are not unduly impacted as the state builds out solar development are vital. In New York state, 65% of farmers rent land from a mix of active and non-operating farmland owners, and the percent of farmland that is rented varies by county (Table 2).^{xiv}

Table 2 – Counties with 10 highest percentages of rented farmland

County	% of Total Farmland that is Rented
Chemung	73%
Cortland	61%
Columbia	44%
Orange	40%
Monroe	39%
Sullivan	37%
Erie	36%
Genesee	35%
Ontario	34%
Cayuga	33%

Farmer-renters are at a disadvantage because they typically have little say in the fate of the land they rely on for their business to survive and are outcompeted by solar developers, who pay multiple times (sometimes as high as 10x) over the cost farmers can afford to pay per acre. While this income may be a boon for landowners, it often means that farmers who are renting land under consideration for a solar lease are displaced and must find alternate lands farther afield. This can increase business operating costs and make thin profit margins even thinner, or force them to adjust their farm business to remain profitable while farming fewer acres.⁷ **Sixty-one percent of farmer-survey respondents reported renting farmland, of which over half reported one or more negative impacts to farmland rentals due to solar development: nearly three quarters reported increased land scarcity, 68% reported land was costlier to rent, and 36% said they lost land they used to rent (Figure 11).**⁸

Over 50% of farmer-renters in 5 out of 8 REDC regions reported negative impacts on their ability to rent farmland in their communities (Figure 12). In both the Mohawk Valley and North Country, the two regions with the current highest share of proposed large-scale solar projects, 15% of farmers reported losing access to land they used to rent. Over 25% of farmers in the Mohawk Valley and Central New York reported that land to rent was becoming scarcer, while 16-22% of farmers overall, excluding those in the Southern Tier and Mid-Hudson, reported that land is becoming more expensive to rent due to solar.

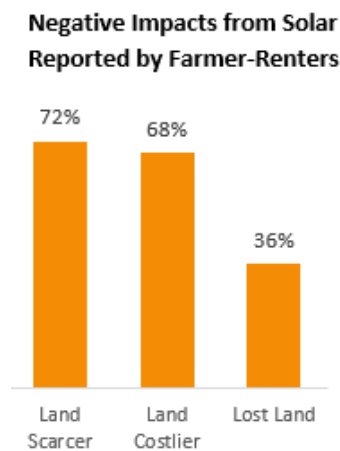


Figure 11 (N=113)

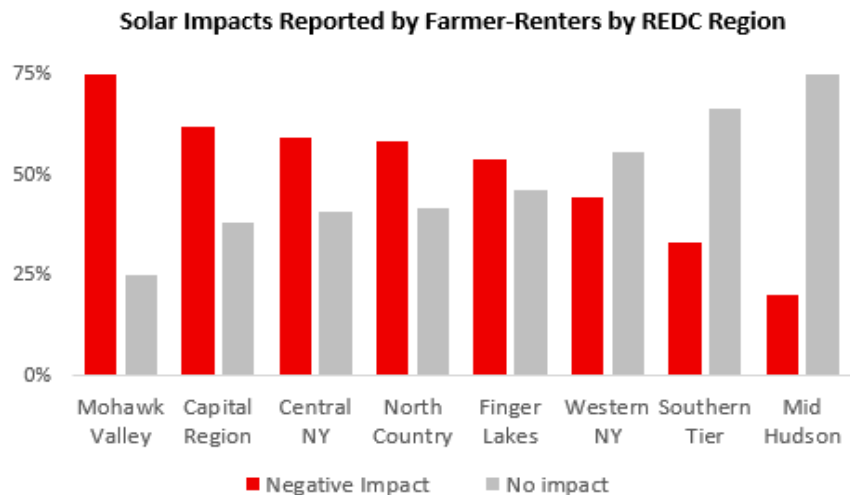


Figure 12 (N=120)

⁷ This paper and the resulting recommendations assume solar developers are leasing land for solar rather than purchasing it outright. However, solar developers sometimes do purchase land, and data should be collected to determine how common this practice is. If developers are purchasing land outright, a different set of assumptions and recommendations to preserve farm viability may apply, however recommendations for agrivoltaics and best practices for construction, and decommissioning still apply.

⁸ The impact of solar development on farmland was determined through self-reported information from impacted farmer-renters. It is not yet supported by statistical analysis confirming solar development as the driving factor.

Solar Development Has Mixed Impacts on the Viability of Dairy Farms in New York

Dairy is a significant part of the agricultural industry in New York state, representing half of all farm sales.^{xv} Dairy farmers are price-takers and have struggled for many years to make ends meet as input costs rise and surpass the price they receive for their milk. Both the positive and negative impacts of solar development appear to manifest acutely for dairy farmers. Solar leases can be a key source of supplemental income to provide relief and invest in profitability, but dairy farmers also need large quantities of land to support grazing and forage crop production for their herds and to implement nutrient management plans. Changes in the availability and price of rental farmland in a farm community at large can quickly diminish dairy farmers' thin profit margins. AFT's survey found that more dairy farmers reported being contacted by a solar developer to host an array for off-farm use compared to other farmers,⁹ and reported negative impacts to their ability to rent more frequently.

What Dairy Farmers Have to Say

"Being a dairy farm there is a limit to how big a circle we can profitably haul feed and manure in. Every acre that is lost makes us haul farther increasing our cost." *—Farmer in the Finger Lakes*

"Farmland is not very available. We have farmers who rent land next to us who are traveling half an hour from their dairy farm to rent the land." *—Farmer in the Finger Lakes*

"[The] town of Lansing is being targeted for a tremendous amount of solar primarily on viable, highly productive farmland due to existing infrastructure that is no longer utilized by a coal generation plant. Our farm alone stands to lose 3-400 acres which makes nutrient management interesting." *—Farmer in the Southern Tier*

"Proposed solar developments in my area are looking to lease land from landowners who currently lease their land to the neighboring farmers and have for years. This land is used to raise crops for livestock feed (mostly dairy). The solar developers are willing to pay a substantial amount more to lease this land, thus taking it out of production agriculture, and leaving the livestock farmers short on acres for feed production." *—Farmer in the Finger Lakes*

"All four solar projects within five miles of our home took viable farmland. The farmers were leasing the property from the owner and are now struggling to find enough land to grow corn to support their cows." *—Farmer in the Mid-Hudson*

⁹ While survey respondents were not asked specifically about the impacts from solar to dairy farms, farmers who responded to the survey were asked to report their main farm products and so AFT was able to compare responses from this sector of the farm industry with answers from other farmers.

Farmland Loss Can Trigger a Domino-Effect of Cumulative Negative Impacts at the Community Level

Whether solar projects positively or negatively impact farm viability at the community level depends on the size and number of solar projects, how and where they are constructed, the total amount of farmland within a community, and combined impacts to individual farmer-landowners and farmer-renters. While farmer-landowners may use the income from solar leases to keep land in farming and reinvest the money into the profitability of their farm operation, if solar development removes too much farmland from production in the community, it could also reduce farm viability for the whole community, impacting not only surrounding farm businesses but all the other businesses that support them. This could trigger a domino effect of increased development, solar and otherwise.^{xvi} **Current proposed solar development is unevenly distributed across the state and more highly concentrated in some counties and regions than others, creating the possibility of collapse of some agricultural communities, particularly where projects span thousands of acres, while others emerge unaffected or strengthened.**

Solar Development Has Mixed Impacts on Intergenerational Transfer of Farmland

It remains unclear under which circumstances solar projects either help farmers keep land in farming and transition it to the next generation or contribute to the permanent loss of farmland. Some survey respondents identified the potential of solar projects, particularly agrivoltaic projects, to help support farms and make it possible to transition them to the next generation. Others viewed solar as a last resort if farmers were unable to identify a successor. For farmer respondents currently hosting or interested in hosting solar projects, 37-39% indicated they were doing so to pass the farm to the next generation, but 23% of farmers interested in hosting solar indicated they would do so if they *didn't* have a successor (Figures 8 and 9).

The net impact of solar on the intergenerational transition of farmland is further complicated by the long lifetimes of these projects, and unknown impacts on future soil quality or ability to farm the land. While solar development may prove to be a temporary land use when compared to residential development, it can still take farmland out of production for decades. Farmers already hosting solar arrays shared that their lease length varied with an average of 29 years and a maximum of 50 when including all options to renew. Some respondents questioned the likelihood that this land would return to farming after the lifespan of the project either because the soils would be irreparably changed or there would be no one left with the knowledge to farm it after all that time had passed.

What Farmers Have to Say

“Our county has a high concentration of farming, and we could be losing almost 4,000 acres [35%] to solar in the near future of active farmland.”

—Farmer in the Mohawk Valley

“Solar farms create very few local jobs during construction and almost none during operation. Losing a farm loses jobs both through the farm and through supply chain and post process at the farm. Ownership also shifts from local to remote so profits from the farm are no longer spent locally.”

—Farmer in Western NY

“Taking farmland out of production creates a trickle-down effect. All the other businesses losing business. For example, it takes a minimum of \$200 an acre for crop support per acre. This includes seed and fertilizer sales, fuel, equipment repairs and payments on new equipment, tires, sprays, twine and bale wrap, dairy supplies, fencing the list goes on and on.” —Farmer in the Mohawk Valley

What Farmers Have to Say

“Those over age 50 who have no retirement after a lifetime farming are seriously considering leasing while younger producers are very hesitant to sign.” —*Farmer in the Southern Tier*

“[F]armers who are nearing retirement age with no one to continue farming are looking for retirement investment with solar ... are pleased that these projects are available to them. Those with farms that have generations to pass on are unhappy [with that] because they always have the need for more land.” —*Farmer in the Southern Tier*

“The leases typically are for more than a generation of a farming family (24-48 years). Even if the land stays in the family during the lease, the expertise needed to farm it successfully will be not passed to succeeding generations during the length of the lease, and more small farms will be lost to larger, more centralized farms.” —*Farmer in the Southern Tier*

Impacts of Solar Decommissioning on Farmland are Unknown

Many survey respondents raised concerns about the long-term impacts of solar siting on soil quality, food production capacity, and the ability of farmers to adapt to changing climate and economic realities. These important questions about what happens to farmland after the life of the solar project remain unanswered because no projects have been in operation long enough to find out. Survey respondents and roundtable participants both frequently raised the questions about whether farmland put under solar panels would be as valuable or productive after panels are decommissioned. They also questioned whether current best practices would be sufficient to retain or restore the unique physical, chemical, and biological properties of quality farmland. When asked what their plans were for decommissioning, 25 of the farmers already hosting solar projects (63%) require developers to remove all installations; 4 (10%) don't, and 11 (28%) were unsure (N=42).

Farmers Prefer Avoiding Siting Solar on Prime Soils

Soil quality varies widely across regions, counties, and even individual farms with some land being incredibly well suited to farming, and other land less-so. To date, 58% of solar development in New York has taken place on soils well-suited for farming.^{xvii} Among AFT's survey respondents, 69% of farmers currently hosting solar projects reported solar was sited on actively farmed productive land and an additional 9% said it was on productive land that was not actively farmed. 42% reported solar was sited on their marginal land.

In AFT's Farms Under Threat Report, farmland that is “well-suited to agricultural production” is:

1. Classified as "Nationally Significant" according to AFT's rating of productivity, versatility, and resiliency (PVR);
2. Designated as prime farmland, unique farmland, or as farmland of state or local importance according to NRCS definitions;
3. Used to produce unique or high-value crops, especially fruits, nuts, and vegetables, even if it does not qualify under #1 or #2 above; or
4. Classified through a regional, state, or local process as additional land that meets this definition

AFT gathered stakeholder feedback on what soil types should always, sometimes, or never be developed for solar based on soil quality alone. The majority of farmers surveyed preferred that solar never be sited on Mineral Soil Groups 1-4, which strongly overlap with prime farmland, while land trusts and local government officials took a more nuanced approach.¹⁰ Half of farmers favored never siting solar on actively farmed land regardless of soil type (Figure 12). In open responses, 117 survey respondents overwhelmingly expressed a preference for solar siting to happen first on brownfields, previously disturbed areas, rooftops, and marginal lands and to avoid prime farmland. Thirty-six percent of farmers interested in hosting solar said they would only put solar on their worst farmland and 22% favored siting on their more marginal farmland to support the continuation of their farm operation.

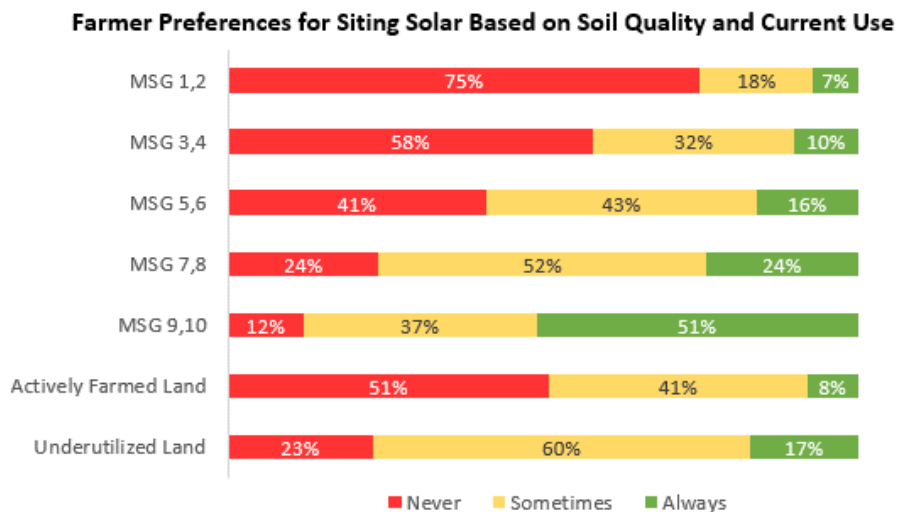


Figure 12 (N=369)

Agrivoltaics: Farming and Generating Solar Energy on the Same Land

Agrivoltaics, or agricultural dual-use solar, refers to a solar installation that integrates solar arrays and farming activity on the same land. Agrivoltaic solar installations maintain, rather than displace, farming activity by making agricultural production an integral part of the project design and operation. Projects design and plans for construction and decommissioning are created with a farmer or other expert in a manner that retains or enhances the land's agricultural productivity and viability during and after the life of the project. Agrivoltaic projects should maintain farming activities similar to what was previously possible given the quality of the land and the infrastructure (e.g., support businesses, processing capacity, markets) that already exist in the community. When these conditions are met, agrivoltaic projects can be a win-win, with farmers maintaining

What Farmers Have to Say

"The sun shines just as brightly on crummy land for farming as it does on our best." –*Farmer in the North Country*

"They should put solar on land that can't be farmed or land that is in a floodplain. Seems crazy to put solar on prime farmland just because it's convenient. There's plenty of land that is...unusable for agriculture." –*Farmer in the Mohawk Valley*

"We are selling one of our farms to a Solar Company which will be supplying energy to our community and New York State. This farm was exceptionally ...heavy clay and very difficult to farm on." –*Farmer in the Capital Region*

¹⁰ AFT used Mineral Soil Groups, as opposed to USDA SSURGO soil types or farmland class, to align with existing NYSEDA mitigation requirements. According to AFT's GIS analysis, 96% of MSG 1-4 also meet the USDA definition of prime farmland; 95% of farmland classified as Mineral Soil Groups 4-7 meet the USDA definition of soils of statewide importance; 95% of farmland classified as Mineral Soil Groups 6-9 meet the USDA definition of 'not prime farmland'; and 98% of 'prime if drained' farmland is split between MSG 4-6.

What Farmers Have to Say

“We are in contract for a 46-acre utility solar project on our farm. We are also planning to graze sheep to raise for market on those same 46 acres. Win-win!” –Farmer in Western New York

Dual Use: The Difference Between Agrivoltaics and Co-Location

Agrivoltaic projects are designed with a farmer to support the farm and prioritize forage and/or crop production. Co-location projects may include pollinator-friendly plants or sheep for vegetation management, but these activities are secondary to power production and incidental to project design and operations.

agricultural production and gaining additional supplemental income from lease payments while also ensuring disinvestment in farming does not occur in the community as a result of the solar project.^{xviii} AFT considers agrivoltaics to be the preferred approach when siting solar on land that is well-suited for agricultural production.

Surveyed farmers expressed a willingness to experiment with agrivoltaics and co-location. Of the 338 farmers who answered a question about dual-use, 45% were interested in grazing livestock and 36% were interested in grazing sheep, and 41% of farmers were interested in growing crops under and around solar panels. Interestingly, as this is often cited as a barrier to agrivoltaic experimentation, one third of farmers were willing to try navigating farm equipment and tractors in between panels.¹¹ Thirty seven percent of farmers also identified interest in dual- use as one of the conditions under which they would consider hosting solar on their farm (Figure 9).

The potential of agrivoltaics to minimize conflict between food and energy production is promising but conditional on continued research, field testing and, ultimately, proof of concept. A Cornell study completed in 2021, for example,

determined that grazing sheep on utility scale solar sites can be a cost-effective method to control on-site vegetation and provides financial benefits to sheep farmers interested in accessing such facilities.^{xix} As this was limited to grazing, further studies now need to be undertaken for different crop and livestock operations in different climates.¹² As more agrivoltaic installations are developed, more research will be needed to evaluate performance, identify the types of crops that can grow profitably in different climates, and assess the impact that these projects have on soil health and growing conditions.¹³

¹¹ Nearly half (46%) of farmers were also willing to permanently protect their land after the life of the solar project.

¹² See <https://solargrazing.org/cornell-university/> and <https://www.umass.edu/news/article/umass-amherst-study-will-assess-impact>

¹³ At present, AFT is directly involved in publicly funded research using experimental solar array design and site trials to monitor and evaluate soil characteristics, growing conditions and agricultural productivity.

Summary of Survey Findings

- Expected impacts from solar to farm viability were mixed with farmers generally expecting more negative impacts. Income from solar leases can benefit individual farmer owner-operators, and it is a strong motivating factor, but projects could create negative cumulative impacts at the farm-community level.
- Farmers generally were interested in leasing 16% of their land for solar, on average.
- Solar projects can displace farmer-renters from the lands they depend on to operate their businesses. Over half of farmer-renters reported experiencing negative impacts from solar projects including land scarcity (72%), higher rental prices (68%), and losing access to land they used to rent (36%). Negative impacts to farmer-renters were reported more frequently in regions with high levels of proposed solar development.
- Dairy farmers reported being negatively impacted by solar more frequently than other farmers.
- The majority of farmers prefer not to site solar on prime farmland or actively farmed land.
- Between 33-41% of farmer-respondents were open to exploring dual-use, or agrivoltaic, projects.
- Survey respondents were concerned that farmland may never be returned to its original state if and when solar panels are removed.



Photo Credit: Vineyard Sky Farms

Recommendations to Achieve Smart Solar Siting on Farmland: Smart Solar Siting Mitigation Framework

It's clear that farmland is a first-choice site for solar developers, and some synergies exist for solar to support farm viability. New York has over 9 million acres of farmland, and while not all of it is suitable for solar, there is still sufficient land to make strategic choices about where and how solar is sited so that it supports farmers and farm viability and protects farmland. **In light of these findings and with broad stakeholder support, AFT recommends that New York State and local governments implement the following mitigation framework to stem farmland loss and support farm viability in communities hosting solar projects.** This framework, formed through multiple rounds of expert and stakeholder input, strives to support accelerated expansion of renewable energy while also protecting New York's best soils for growing food and preserving farm viability in rural communities. AFT hopes that this proposed framework will facilitate continued interagency and stakeholder dialogue and ultimately, adoption of more robust mitigation policies.

This framework does not seek to stop solar projects but instead embraces the idea that solar development should maximize positive benefits, and avoid, minimize, and mitigate the negative impacts of siting solar on farmland. Its primary goal is to minimize non-dual use siting on high quality agricultural land and, if unavoidable, to raise funds to protect other farmland in the host community and invest in actions that support farm viability. **Although this framework focuses on soil quality as the key decision-making metric, other metrics can and should be explored by state and local governments when implementing this framework, such as the degree to which the farm where projects are proposed contributes to the local economy, how microclimates interact with soil quality, or how the farm's proximity to an urban center may contribute to food security now and in the future.**

Recommended Implementation of this Mitigation Framework

New York State: Incorporate into the mitigation program currently part of the Large-Scale Renewable solicitations, as well as any future NY-Sun programs.

Local Governments: Incorporate into payment in lieu of tax (PILOT) agreements or other host community benefit arrangements.

This smart solar siting framework is comprised of three parts:

Part 1: Classifying proposed solar projects based on impacted MSG 1-4 soils to determine mitigation costs.

Part 2: Calculating discounts that can be applied to the total mitigation cost based on the degree to which the project supports farm viability or incorporates agrivoltaics.

Part 3: Confirming implementation and verifying the performance of mitigation activities throughout the life of the project.

This framework reflects general consensus within the farm community that was surveyed by AFT and other stakeholders around the importance of protecting prime farmland and farm viability while supporting farmer choice and ensuring mitigation fees collected directly support host communities. It also reflects the potential, pending further proof of concept, of agrivoltaics to maximize benefits to both farmers and society.

Part One: Classify Solar Projects by Quality of Soils Affected to Determine Mitigation Costs

In this framework, projects are first categorized as Orange, Yellow, or Green based on the percentage of the project facility area proposed on high-quality farmland. The state-level framework below uses

Mineral Soil Groups (MSG) 1-4 soils, chosen based on stakeholder preference and the strong overlap of MSG 1-4 soils with the USDA Prime Farmland designation. However, when applied within a local community, other qualifications, such as Soils of Statewide Importance or other factors, may be equally valuable and individual communities may wish to adapt the framework to prioritize local farmland protection priorities.¹⁴

Category	Initial Project Classification	Fee
Orange	Project facility area includes 25% or more actively farmed MSG 1-4 ; and > 30 acres MSG 1-4	Per-acre fee of 150% of cost of protecting farmland within impacted REDC region applied to project MSG 1-4 acres
Yellow	Project facility area includes 10-25% actively farmed MSG 1-4 ; and > 30 acres MSG 1-4	Per-acre fee of 100% of cost of protecting farmland within impacted REDC region applied to project MSG 1-4 acres
Green	Project facility area includes less than 10% actively farmed MSG 1-4	No mitigation fee

**Actively farmed land is defined as land that has been farmed at least one of the last five years*

The initial project classification, and resulting mitigation fee, is determined by the percentage of MSG 1-4 soils included as part of the proposed project facility area.¹⁵ Mitigation fees are only calculated and collected on actively farmed MSG 1-4 acres when the impacted area exceeds 30 acres.¹⁶ At the state level, AFT proposes that this framework would not apply to projects that include 30 acres or less of MSG 1-4 in order to avoid negatively penalizing small-scale and distributed generation projects, which experience tighter margins, may have a harder time avoiding prime soils, and may be less impactful to agriculture due to their smaller size. However, it may make sense to adjust or eliminate this minimum acreage threshold when implementing this framework at the local level, where local governments are responsible for permitting small-scale solar projects. Conversely, if trends continue towards large projects of thousands of acres each or more, the percentage triggers may need to be revisited to sufficiently mitigate the impacts from increasingly larger projects converting more acres.

While it is important to note that calculating fees based on development value may continue to disproportionately drive solar projects into areas with lower development and land values, this is an

¹⁴ NYSDAM, NRCS, Cornell University, and other involved parties should ensure state MSG maps are actively updated and remain current. In cases where soil quality does not align with mapped classifications, state agencies and local governments should also accept alternative forms of acceptable proof from solar developers, such as soil tests.

¹⁵ The classification percentages were developed based on data supplied by AFT's GIS team, who determined developable acres for large scale solar based on distance to infrastructure and slope, and then quantified the acreage that was classified in each MSG category per county. Percentages adopted by state and local governments should be designed to be rigorous, yet, workable in guiding developer siting decisions away from high quality farmland or other locally defined priority resources.

¹⁶ Efforts should be undertaken to ensure that the 30-acre threshold does not inspire creative compliance, such as breaking up a single larger project developed by the same company with the same landowner into multiple 29-acre projects.

existing trend that will continue without a framework like this in place. Implementing this mitigation framework offers benefits to host communities that do not currently exist but would be high enough to defray impacts and support continued farm viability. AFT also acknowledges that land has value beyond its development potential and tying the fee to the value of the purchase of development rights may not work best for every community. Local agricultural and farmland protection boards and other thought leaders should review and adapt this framework as they see fit to ensure it accomplishes its goals to avoid, minimize, and mitigate impacts to farmland and farm viability while achieving climate action.

Mitigation fees are determined by this initial classification, and fees should be calculated to reflect the average full per-acre cost of protecting farmland in that REDC region, or, in the case of local government implementation, by using local appraisals.¹⁷ The purpose of high mitigation fees associated with the orange category is to strongly disincentivize siting solar projects on large percentages of prime farmland. If this is not possible, this higher fee would provide extra funds for investing in supporting agricultural viability, as communities that suffer large farmland losses face greater challenges to the viability of their farm economy. The mitigation fee for the yellow category is equal to the cost of protecting farmland so that an equal number of acres can be protected to those lost. Green category projects do not pay a mitigation fee, as an incentive to avoid prime farmland. Unlike the current mitigation regime in place, under this framework solar developers are incentivized to avoid impacts to prime farmland to benefit from large cost savings. Please reference the [Appendix](#) for an example of how this framework may work as a decision support tool for a 300-acre project impacting varying amounts of prime farmland.

Part Two: Calculate Mitigation Fee Reductions That Support Continued Farm Viability

The second part of the smart solar siting framework is a series of potential discounts to the total mitigation payment that solar developers can achieve if they minimize the conversion of farmland out of production and maximize support to farm viability. The discounts are intended to reflect the relative social value of these activities as expressed by stakeholders, the difficulty and cost of implementing these different practices, and the extent to which these practices minimize the impacts of solar siting on farmland. Fee discounts included below are informed recommendations; actual discounts should be developed with further stakeholder input. Solar developers who implement multiple actions to support a viable farm operation and develop an agrivoltaic project could reach a cumulative discount of over a third of the initial mitigation fee amount.¹⁸ **However, in recognition of the detrimental impacts of displacing farmers from land they rent without their involvement in that decision, solar projects that displace farmer-renters and negatively impact their businesses should not qualify for the full discount.** For all categories, mitigation fees would be collected once at the start of commercial operation of the solar project.

¹⁷ State farmland protection award amounts should be adjusted to reflect inflation and the full cost of the farmland protection project, including soft costs and stewardship costs, before the average is taken. For more detail on the proposed calculation method, please see the [Appendix](#).

¹⁸ If state or local government officials increase percentage discounts offered, they may wish to consider instituting a cap on total discounts a project is eligible for.

Adjuster	Fee Discount	Verification Required to Achieve Discount
Supports Farm Viability and Intergenerational Transfer	e.g., 10%	Submission of Letter of Attestation and Farm Business and/or Transition plan proving solar is key to success
Incorporates Agrivoltaics	100% discount on acres used for agrivoltaics	Project designed with farmer, continued farm activity annually verified
Incorporates Co-Utilization	e.g., 10-15%	Project consults farmer to design plan, continued farm activity annually verified
Managed for Soil Health	e.g., 5-10%	Project consults with Soil and Water Conservation District or other expert (NRCS) to design plan, continued management annually verified
Improves Pollinator Habitat	e.g., 5%	Project meets state standards for pollinator performance and includes apiary

Part Three: Confirm and Verify Activities Throughout the Life of the Solar Project

Verifying the consistent and long-term implementation of proposed dual-use and co-utilization practices is critical to reducing farmland loss and supporting farm viability, and therefore strict verification and implementation should be key to retaining these discounts. AFT therefore recommends the following:

Farm Viability and Intergenerational Transfer

The discount amount ultimately given to the project should be commensurate with the level of rigor required to verify that the project is going to support continued farm viability that would not have been possible in the absence of the project. **AFT recommends that state agencies require that landowners working with the solar developer submit a letter of attestation detailing the current quality and use of the land proposed for solar and provide a business and/or transition plan to the New York State Department of Agriculture and Markets detailing how the solar project supports continuation of the operation.** NYSDAM could choose to interview farmers to confirm the veracity of the plan and gather additional information about the impact of solar development on their farm operation.

Agrivoltaics, Co-utilization, Soil Health, and Pollinator Discounts

To receive an agrivoltaic or co-utilization discount, the project should be created and designed in partnership with the farmer or grazer. **AFT strongly recommends that state agencies consider a verification period (e.g., 5 years) to ensure that practices are established properly. It is then advisable for solar project owners and the farmer to revisit existing plans for agrivoltaics and co-utilization to reflect lessons learned and adjust plans.** Any changes made to management plans should be communicated to the New York Department of Agriculture and Markets for review and re-approval. *Some form of these activities should continue throughout the full life of the project to retain initial project discounts.* After this establishment period, yearly verification of continued activities should be performed through annual reports to NYSEDA with periodic site visits and farmer interviews. If the activity discontinues, the solar project owner will owe the discount they received on the fee plus interest, unless they are able to prove it was through no fault of their own¹⁹.

¹⁹ Periodic site visits should check for signs of disinvestment in the farming activity.

To receive a soil health or pollinator discount, projects should be created with the appropriate expert or following certification standards, if available, and pollinator projects should include an on-site apiary. In the case of soil health, the developer should engage the local soil and water conservation district, NRCS office, or another qualified expert to put together a conservation plan reflecting the four NRCS soil health principles.²⁰ These projects should be subject to annual verification for the first 5 years to ensure practices are being implemented or established properly, during which time soil health indicators must remain at or above the baseline. Baseline soil samples should be taken before project construction, and yield, soil health, and other data should be shared every 3-4 years with NYSEERDA and NYSDAM who should then make this data available to stakeholders to continue to build the academic and practical understanding of these projects.

Recommended Use of Mitigation Funds: Supporting Farmland Protection and Farm Viability

To mitigate farmland loss, the primary use for mitigation funds should be to support permanent farmland protection in host communities. This recommendation was strongly supported in survey responses and in stakeholder roundtables. To accomplish this at the state level, mitigation funds could be added to each REDC region's allocation during an annual state farmland protection (FPIG) RFA or RFP, and maximum effort should be made to target these funds to host communities. Stakeholders requested that the state make information available on funds collected and where and how they are used to provide oversight in ensuring they advance farmland protection and farm viability goals in host communities.

A small portion of mitigation funds could also be used to support locally identified priorities to protect farmland and support farm viability, such as for farmland protection planning, agricultural economic development, adoption of soil health practices, and market development for dual-use products. This is particularly important in host communities where land trusts and agricultural and farmland protection boards are not as active. Roundtable participants identified PILOT agreements, Industrial Development Agencies, and community development funds as possible vehicles to disseminate this funding.

Potential Uses for Mitigation Fees to Support Farm Viability in Host Communities

Land access and business technical assistance programs for new and beginning farmers: Loans, business planning support, or legal support

Capital projects to support farm viability: On- and off-farm processing, packing, storage, aggregation, and distribution

Adoption of soil health best practices: Technical assistance, purchase of equipment, seed purchase, or planning

Summary of Framework

Part 1: Classify solar projects by quality of impacted soils to determine mitigation costs, which are tied to average cost of farmland protection in the impacted REDC region.

Part 2: Calculate mitigation fee reductions based on actions taken by developers to avoid, minimize, and mitigate impacts to farm viability.

Part 3: Confirm and verify activities throughout the life of the solar project.

Collected mitigation fees should go primarily towards farmland protection in host communities but can also be used to support farm and agricultural viability initiatives. If the mitigation framework is implemented, AFT also recommends periodically reviewing the impacts of this framework to ensure it is achieving its intended effect.

²⁰ Learn more about the 4 soil health principles [here](#).

Limiting the Cumulative Effect of Farmland Loss on Local Farm Economies

Thriving local farm economies are built on interdependent relationships between economically viable farms and the businesses that support and serve them. This requires having enough of each to support their mutual success. As some farms cease operating or land is taken out of production due to solar or other development, a domino effect for the remaining farms can ensue where agricultural support businesses close or relocate because they no longer have enough farms to work with. In turn, this increases the cost of doing business for the remaining farms and spurs more closures. In fact, a recent 2020 study by American Farmland Trust concluded that farmland remaining in areas of New York experiencing low density residential development is ten times more likely to be taken out of production than farms without such development.^{xx}

Consequently, there is a threshold beyond which farming communities cannot absorb further farmland loss, whether to solar or other forms of development, and remain viable for agriculture. This threshold can be determined by many factors: the current economic strength of farm businesses, the types of farms in the community and their land needs, current land availability, past and current development encroachment, zoning laws, farmer age and succession planning, and more.

Precipitated by this new pressure, AFT recommends that local communities and the state of New York explore capping all development, solar or otherwise, on prime farmland in order to limit the cumulative impact of development within local farm communities. New York state should invest in research and support local processes to help communities determine the right thresholds at which to set their cap. In the context of solar siting, surpassing this defined threshold should preclude project permitting or trigger increasingly higher mitigation fees. Local communities should undertake the process of defining a local development cap to incorporate into comprehensive plans, land use laws and permitting processes, zoning, and other policies for all development, including solar. These important factors can sit within or outside of agricultural districts, meaning the threshold should be based on total agricultural lands, not just those belonging to agricultural districts. New York State should grant the authority to set and enforce caps to local governments by ensuring ORES will not override these local caps.

Mitigating Impacts on Farmer-Renters

Beyond impacting the potential for developers to achieve discounts in the mitigation framework, more research is needed to understand how to best help impacted farmer-renters. However, roundtable participants suggested additional ideas that could be implemented by developers and governments. This includes requiring developers to pay for loss of crop production until farmer-renters re-establish themselves or helping farmer-renters access and pay for experts who can help them find other land to farm. **Finally, farmers who currently rent land may wish to seriously explore the benefits of contractual agreements over handshake deals to protect themselves from loss of land due to solar development.**

New Jersey Sets 5% Development Cap

In July 2021, New Jersey enacted a solar bill ([S2605/A4554](#)) that includes a 2.5% threshold limitation on conversion of prime farmland in agricultural development areas (ADA) to utility-scale solar. The legislation permits a waiver from the state Department of Agriculture and Board of Public Utilities (BPU) for additional solar development up to a hard cap of no more than 5% of prime farmland within an ADA. This cap approach protects farm economies without curtailing individual landowner rights.

Other Strategies for Governments and Developers to Achieve Smart Solar Siting on Farmland

In addition to implementing the framework and other suggestions above, AFT makes the following recommendations to federal, state, and local governments, and to solar developers to achieve smart solar siting in New York.

Actions Governments Can Take to Reduce Solar Pressure on Farmland

Incentivize, streamline, and accelerate approvals for siting on rooftops, disturbed areas, and marginal lands. Stakeholders expressed a clear preference for siting on rooftops, parking lots, landfills, brownfields, and marginal lands *before* siting on productive farmland. While farmland is and will remain a top siting choice for solar developers to achieve climate goals, other opportunities to site projects on these preferred areas should be accelerated. NYSEERDA's Build Ready program is an example of an action New York state is taking that could be ramped up to advance development in these areas, particularly if they are more expensive to develop. A farmer-led aspect to that program, where farmers rather than developers identify the land on which they are interested in hosting solar, could also be explored. Local governments should identify ways to streamline approvals for all these types of projects.

Prioritize new transmission development to areas that have high concentrations of marginal farmland. New utility-scale solar development is highly restricted to areas with the infrastructure, land, and capacity to host them. This is particularly true of new large-scale projects. Federal, state, and local governments should work together to plan and streamline new transmission buildout to areas with lower concentrations of good quality farmland to avoid these conflicts in the future and to help farmers make better use of marginal land.

Continue to advance energy efficiency in buildings. Improving energy efficiency, and other measures to reduce energy grid demand and with it—demand for land to host projects, should be advanced as quickly as possible.

Increasing Federal, State, and Local Investments to Advance Farmland Protection and Smart Solar Siting

Invest in research to determine best practices for construction and decommissioning. Since solar is likely to be sited on farmland, and developers argue that these structures are temporary, the gold standard of best practices that will enable land to be reclaimed and used for agriculture after the life of the project should be established and followed for construction, operation, and decommissioning. State and federal agencies should invest in research to build out more knowledge of the best practices for solar array construction and decommissioning to support soil health and ensure the ability of the land to be farmed after the life of the project.

Invest in Applied Agrivoltaic Research. As this report shows, farmers are interested in agrivoltaics, and this innovative practice could reduce farmland-related tensions and land use conflicts. To get to this stage, federal and state governments must invest in more long-term research in different climates, regions, and with different cropping systems to provide proof of concept and advance understanding of risks, economics, and potential social impacts of agrivoltaic systems.

Pending proof of concept, design and incorporate market mechanisms that incentivize agrivoltaic projects to support developer innovation. If research provides proof of concept for both the farmer and the developer, agrivoltaics carries with it great potential to reduce land-use conflicts between solar and farming while supporting farm viability, and therefore should be financially incentivized. These incentives will be necessary as these projects are more expensive than traditionally designed arrays and would only be offered to projects that meet well-defined standards. Such incentives will need to be designed to keep ratepayer rates as low as possible, and with enough regulatory flexibility that projects are still built. Pending continued agricultural activity throughout the life of the project, agrivoltaic projects that meet well-defined standards could also be exempt from current-use conversion penalties and could retain agricultural use valuation discounts.

Increase funding and support for farmland protection and farmland protection planning. Concurrent with solar buildout, federal, state, and local governments should increase funding for farmland protection programs like the USDA Agricultural Conservation Easement-Agricultural Land Easement program and the New York state Farmland Protection Implementation Grant (FPIG) program in their annual budgets.

Help aging landowners transition, and new and beginning farmers access land. The aging of farmers in New York and throughout the country, and the challenges that new, beginning, and BIPOC farmers face in accessing land are well documented. The state and federal government should continue to focus attention and resources towards programs that support farmland access and transition to a new generation, such as farmland protection and PDR programs, Farmland for a New Generation New York, and new and beginning farmer loan and business technical assistance programs.

Pass Community Preservation Act legislation in New York. The New York state legislature should pass Community Preservation Act legislation authorizing all municipalities to raise local funding for farmland protection. This action will support local decision making to fund local conservation efforts, such as has been successfully done in municipalities such as Suffolk County, and the towns of Warwick and New Paltz.

New York State Agency Actions to Achieve Smart Solar Siting

Ensure best practices are strictly followed when siting solar on farmland. While research is conducted to define the gold standard of best practices, ORES, NYSERDA, NYSDAM, and New York state must require developers to follow the NYSDAM Construction and Mitigation Guidelines, which outline how solar projects should be constructed and decommissioned to protect farmland. Verification and monitoring requirements currently put in place, such as hiring an environmental monitor, must be strictly followed to ensure guidelines are fully implemented.

Collect data on farmer-renter displacement and reduce mitigation fee discounts and other public incentives for solar projects that displace farmer-renters. NYSDAM should implement a hotline or other mechanism to enable farmer-renters to register a complaint if they lose land due to a proposed solar project. Such a process could collect information on the impact on their farm, their location, farm size, farm type, and other important factors. This information can be used in determining whether mitigation

fee discounts for projects will be awarded, to inform state and local permitting processes, and to further illuminate the impacts to farmer-renters from solar as state buildout advances.²¹

Improve New York’s Farmland Protection program administration in light of solar development.

NYSDAM should release FPIG funding annually and work to complete projects within two years or less so that the state farmland protection program remains an attractive and feasible option for farmers, particularly when compared to solar leases. The current model easement should also be reviewed to determine whether and how to incorporate agrivoltaics as an allowable use on conserved land. Finally, appraisers evaluating farms for potential FPIG funding should incorporate solar lease valuation potential into their PDR appraisal methodology. Without this analysis, PDR appraisals focused on agricultural value will be artificially low in places that are experiencing significant pressure from solar development.

Partner with academic institutions and developers to collect and aggregate data from all projects currently coupling any agricultural activities with solar energy generation. The state or an academic institution should be made responsible for collecting and aggregating data from dual use projects in operation along with other pertinent peer-reviewed research monitoring the performance of dual-use solar projects. Standards should be developed for what information should be collected and how, and these protocols should be followed by all developers engaging in agricultural activities on their project.²² New York state agencies could even partner with institutions of higher education to establish a state solar research hub to serve as a clearinghouse for information, coordinate and support regional research initiatives, and facilitate inter- and intra-state collaboration between stakeholders.²³

Support local stakeholder-driven processes to plan for agriculture and renewable energy. NYSDAM and NYSERDA should provide funding, resources, and training to support robust, stakeholder-driven local and regional farmland protection planning efforts, and the development and incorporation of renewable energy permitting into new and existing plans and land use laws. These stakeholder efforts could include land trusts, local government officials, and local farmland protection leaders.

How Solar Developers Can Help Achieve Smart Solar Siting

Work with farmers, land trusts, and community members to support farm and agricultural viability. As desired by farmers surveyed, solar developers should work with farmers to identify a portion of the farm with marginal and less productive farmland to host solar projects and innovate and incorporate agricultural dual use into projects. Developers should take into strong consideration whether siting choices will negatively impact any farmer-renters in the host community, and work to avoid this impact. Developers should also familiarize themselves with established local farmland protection plans and engage with local conservation experts, including local land trusts and members of agricultural and farmland protection boards, before approaching community members to host solar projects.

²¹ The FDA [Adverse Event Reporting System](#) Public Dashboard could serve as a potential model for this system.

²² This could include annual farm production yield data, soil testing, benefits and downsides for the solar project to the farm, and other metrics that will help advance understanding of the benefits or costs of designing solar projects paired with agricultural activities.

²³ The [Agrisolar Clearinghouse](#) is an example of coordinated information sharing.

Advance energy storage. AFT strongly supports efforts and initiatives to increase the deployment of energy storage paired with solar projects as pathways to reduce the overall land footprint needed to meet state solar energy targets.

Conduct baseline soil health testing before project construction and share data with NYSERDA and NYSDAM. This will ensure that there is a record of the baseline the farmland hosting the array must be restored to during decommissioning. The state of farmland soils should also be tested and tracked during, and after the life of the project, and information should be shared with researchers and government agencies to add to the body of research and understanding of how solar projects impact soils, and to ensure decommissioned projects leave the land in a farmable state.

Ensure decommissioning bonds fully cover the costs of removing solar installations from farmland and returning the land to its previous state. Developers should be required to fully cover the costs of remediating soils to re-establish the baseline levels of organic matter, compaction, and other soil health determinants.

Recommendations for Further Research and Partnerships

The projected scope and scale of solar siting on farmland raises many questions about how to maximize positive long-term impacts while minimizing negative impacts on our farmers, soils, and farm economy. There is an abundant need for research and many opportunities for partnerships between farmers, institutions of higher education, state agencies, solar developers, and non-profit organizations to collaborate on further defining and achieving smart solar siting. In addition to the research outlined above to define thresholds for tolerable conversion, assess the outcomes of the mitigation framework, and mitigate impacts to farmer-renters, AFT recommends the following additional areas of research and partnership to achieve long-term smart solar siting on farmland.

Grow the Body of Knowledge on Agrivoltaics. As highlighted throughout this report and in the recommendations, agrivoltaics may hold great potential for New York to reduce land use conflict between solar and farming. While co-location with grazing sheep is becoming a more widely used practice to manage vegetation beneath solar panels, solar projects that pair energy generation with crop production or large livestock are still rare. Well-designed field trials are needed to determine which crops and livestock are suitable for agrivoltaic production in different climates, the impacts to crop and electrical yields and farm profitability, and ways to improve the cost-effectiveness of modified solar project designs and construction. There is great opportunity for cutting-edge research which requires great long-term collaboration, and increased public and private investment.²⁴

Evaluate Market Viability of Products Produced on Solar Projects. The successful widespread adoption of co-location and agrivoltaics on solar projects hinges on the existence of markets for products like sheep (meat and fiber), honey, and crops produced on solar projects. A better understanding of existing supply chains is needed to identify gaps and investment opportunities to make it easier to bring solar food products to market, particularly related to slaughter capacity. There may also be opportunities for research on consumer preferences and willingness to pay for these products.

²⁴ USDA NIFA recently funded a [study](#) at the University of Illinois.

Monitor Impacts of Long-Term Solar Siting and Decommissioning on Soil Quality. Now is the opportune moment to launch longitudinal studies tracking the impact of solar projects and different land management practices on soil quality after the useful life of the solar project. There have been few solar projects, especially large-scale, in operation for longer than a decade – let alone the full 25-year or longer duration. Stakeholders raised many questions about the impact of solar development on soil quality, whether farmland can be returned to its original state after decommissioning, and the disposal of solar panels after the life of a project. These questions must be answered now to establish best practices that need to be put in place and followed in the future to preserve the ability of the land hosting solar projects to be farmed should panels be removed, as promised, by developers.

Study the Viability of a “Smart Growth” Model for Solar Development. Throughout this report, important questions were raised about what impact different scales and scenarios of solar development would have on farm viability. While the assumption may be that small-scale solar has a lesser impact on community farm viability, AFT’s *Farms Under Threat: The State of the States* report revealed that low-density residential development made farmland conversion 10 times more likely for the farms that remain in these fragmented communities. Studies to better understand the impacts of a low-density solar development model on the farms that remain should be undertaken to help answer the question of whether a smart growth approach for solar is needed to support continued farm viability into the future.

Conclusion: Working Together as We Look Ahead

Decarbonizing our electrical grid by increasing renewable energy generation is critical. However, the choices we make today about where and how solar projects, particularly large -scale facilities, are sited on active farmland will make a difference to rural economies and influence our ability to farm and grow food in New York to feed ourselves and reap environmental benefits now and into the future. While solar development can support farms and agricultural economies, these benefits are not guaranteed. It is possible and necessary to site solar in a way that helps New York meet its climate goals and supports farm viability with minimal displacement of farmers from our best farmland. But this will take strong policies, innovative thinking, and active dialogue and action from solar developers, farmers, researchers, land trusts, and government officials.

If we undertake this critical work together, we will help avert climate disaster, strengthen rural economies, and continue to feed ourselves – all by successfully achieving smart solar siting on farmland.

Citations

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- ⁱ US EIA. “New York State Energy Profile.” Accessed January 5, 2022. <https://www.eia.gov/state/print.php?sid=NY>.
- ⁱⁱ Schmit, Todd. “The Economic Contributions of Agriculture to the New York State Economy: 2019.” Extension Bulletin. Cornell, August 2021. https://dyson.cornell.edu/wp-content/uploads/sites/5/2021/08/EB2021-04_TShmit.pdf.
- ⁱⁱⁱ Haight, David, Laura Ten Eyck, and Sanaz Arjomand. “Cultivate New York: An Agenda to Protect Farmland for Growing Food and the Economy.” Saratoga Springs: American Farmland Trust, January 11, 2016. <https://farmlandinfo.org/publications/cultivate-new-york/>.
- ^{iv} Freedgood, Julia, Mitch Hunter, Jennifer Dempsey, and Ann Sorenson. “Farms Under Threat: The State of the States.” Northampton: American Farmland Trust, May 13, 2020. <https://farmlandinfo.org/publications/farms-under-threat-the-state-of-the-states/>. (Hereafter referred to as Farms Under Threat: The State of the States)
- ^v Farms Under Threat: The State of the States
- ^{vi} USDA NASS. “2017 Census of Agriculture - Volume 1, Chapter 1: State Level Data.” Accessed May 7, 2021. https://www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Volume_1,_Chapter_1_State_Level/New_York/.
- ^{vii} Farms Under Threat: The State of the States
- ^{viii} American Farmland Trust. “Keeping Farmers on the Land: New Research Underscores Need to Address Farm Transition in New York.” Gaining Insights, Gaining Access. Saratoga Springs, April 1, 2016. https://s30428.pcdn.co/wp-content/uploads/sites/2/2019/09/AFT_NY_FS_GainingInsights_GainingAccess.pdf.
- ^{ix} USDA 2017 Census of Agriculture.
- ^x Katkar, Venkatesh, Jeffrey Sward, Alex Worsely, and Max Zhang. “Strategic Land Use Analysis for Solar Energy Development in New York.” *Renewable Energy*, no. 173 (April 2021): 861–75. <https://doi.org/10.1016/j.renene.2021.03.128>. (Hereafter referred to as Katkar *et al.*)
- ^{xi} Katkar *et al.*
- ^{xii} Lueken, Roger, Samuel A. Newell, Jurgen Weiss, Jill Moraski, and Stephanie Ross. “New York’s Evolution to a Zero Emission Power System: Modeling Operations and Investment through 2040.” May 18, 2020. <https://www.nyiso.com/documents/20142/12610513/Brattle%20New%20York%20Electric%20Grid%20Evolution%20Study.pdf/6a93a215-9db3-d5a0-6543-27b664229d3e>.
- ^{xiii} Bruner, Emily, and Jen Moore. “Combating Climate Change on US Cropland.” Washington, DC: American Farmland Trust, February 5, 2021. https://s30428.pcdn.co/wp-content/uploads/sites/2/2021/02/AFT_Combating_Climate_Change_USCropland_report.pdf.
- ^{xiv} USDA 2017 Census of Agriculture.
- ^{xv} USDA 2017 Census of Agriculture.

^{xvi} Katkar *et al.*

^{xvii} Katkar *et al.*

^{xviii} Macknick, Jordan, Brenda Beatty, and Graham Hill. "Overview of Opportunities for Co-Location of Solar Energy Technologies and Vegetation," December 1, 2013. <https://doi.org/10.2172/1115798>.

^{xix} Kochendoerfer, Nikola, Lexie Hain, and Michael L Thonney. "The Agricultural, Economic and Environmental Potential of Co-Locating Utility Scale Solar with Grazing Sheep," 2021, 7. Cornell University Atkinson Center for a Sustainable Future. <https://solargrazing.org/wp-content/uploads/2021/02/Atkinson-Center-Full-Report.pdf>

^{xx} Farms Under Threat: The State of the States