Grazing Sheep on Solar Sites in New York State: Opportunities and Challenges

Scope and scaling-up of the NYS sheep industry to graze ground-mounted photovoltaic arrays for vegetation management.

Nikola Kochendoerfer and Michael L. Thonney

Department of Animal Science, Cornell University, Ithaca, NY 14850, USA

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Contents

Introduction

In New York State 2,113 farms raise sheep on 46,669 acres with an inventory of 80,195 sheep and lambs, and 68,699 lambs sold per year [1].

The type of terrain and the class of photovoltaics used in solar site construction determine the number of acres needed per MW, however there is no universally accepted standard. For ground-mounted, constructed and fenced photovoltaic installations, we estimate 6 acres per MW [2] and categories of 1) Distributed Solar Energy (DSE) facilities between 1 and 20 MW, occupying a land area between 6 and 120 acres, and 2) Utility Scale Solar Energy (USSE) facilities of 20 MW or more on 120 acres or more. In December 2020, a total of 659 DSE were installed or in the pipeline in NY with an output of 2,874 MW [3, 4] on ~17,245 acres. Additionally, 132 USSE facilities (> 20 MW) [4], potentially occupying a land area of 68,878 acres and producing 11,480 MW could go online by 2023.

To avoid panel shading and damage from vine and tree growth causing reduced electricity production, the vegetation within these solar sites must be managed. This can be achieved by mechanical landscaping methods or grazing with sheep flocks. Vegetation management with sheep is an emerging industry in NY since 2017. Based upon estimates by the American Solar Grazing Association (ASGA) [5], 900 acres (sites ranging between 8 and 150 acres) are currently under vegetation management with grazing sheep in NY. The industry grew from 79 acres grazed in NY in 2018 [6] to 1,700 acres anticipated to be grazed in 2021. Vegetation management contracts between sheep farmers and solar power plant operators result in diversified, taxable service income for sheep farms of between $300 and $500 per acre of solar site per year, up to $450,000 in 2020. As of February 2021, ASGA's national membership, launched in the fall of 2020, was 246 members. The membership is comprised of solar professionals and sheep industry professionals.

Grazing sheep fulfill a clear purpose within these solar sites, while simultaneously increasing the income and financial viability of the farmer owning the grazing sheep. In addition, solar farm grazing reduces entry barriers for young and beginning farmers interested in sheep enterprises. Equipment investment costs for sheep grazing on solar sites ($30 per sheep and $77 per acre, [6]), are lower than for other pasture management systems, especially with perimeter fencing already in place. No specific infrastructure aside from predator proof permanent fencing is required from solar developers. However, water access in the form of wells is an inexpensive measure over the lifetime of the solar array that developers may take to ease labor requirements for sheep flock managers and create well-intentioned and effective working relationships. Contracts, communication, and information detailing insurance requirements are available from the ASGA as authored by the Pace Law School's Food & Beverage Law Clinic [7]. A total of 34 Cooperative Extension Specialists and Educators are currently available state-wide to provide knowledge and support to sheep farmers grazing solar sites, informed by research on grazing sheep on solar sites by the Cornell University Sheep Program [8].

Grazing Experiment at Cornell University

The Cornell University Sheep Program collaborates with researchers from the Cornell School of Integrative Plant Science, Soil and Crop Sciences Section[1] and Entomology[2] in conducting an on-going experiment on the 54-acre South arrays of the Solar Farms NY Cascadilla Community Solar Farm to quantify grazing stocking densities and yearly stocking rates to optimize forage production, pollinator (bees) and predator insects (ladybugs) habitat, and soil carbon sequestration. Preliminary data show that the management of flocks of up to 150 ewes (yearly stocking rate of 3 sheep per acre) is feasible and provides a realistic prospect for job creation and ample opportunities for new and beginning sheep farmers, as well as ecosystem services:

- Sheep farm income for the flock owner (Cornell University Department of Animal Science) providing vegetation management was increased by $300 per acre or $16,200 for this research site and created a half-time position with 10 h of grazing season labor on-site per week.

[1] Johannes Lehmann, Biogeochemistry; Antonio DiTommaso and Scott Morris, Weed Science.
[2] Scott McArt and Paige Muñiz, Bee Pollinators; John Losey and Todd Ugine, Ladybugs.

- Animal health and welfare was excellent, with intestinal parasite FAMACHA scores of 1.5 [9] and body condition scores of 3.5 [10] and shade and shelter continuously available under panels.
- Conception rates, including spring breeding seasons, were high at 82.5%, and a total of 134 lambs was sold ($24,451) from ewes bred and grazed on site, providing access to locally produced meat, with another 106 ewe lambs retained to expand the flock.
- Diverse pastures were maintained across grazing density treatments throughout the grazing season. A total of 160 species (125 dicots, 33 monocots, and 2 non-angiosperm) were identified. Of these, 120 were perennial, 10 biannual, and 30 annual species, and 49% of the identified plants were native.
- Pastures provided habitat for a variety of bee pollinator species as well as a density of 0.17 ladybug (*Coccinellidae*) species (both in the adult and larval stages) per m^2 [11] across grazing density treatments and throughout the season.
- Results of this experiment, relating sheep stocking densities and yearly stocking rates to soil carbon accrual, will eventually provide clear pathways to grazing recommendations leading to optimal soil carbon sequestration by way of fecal and urinary N, increasing root matter to draw carbon into the soil for storage. This will place ruminant production animal agriculture as a key strategy of mitigating climate change by sequestering carbon over time [12].

Effective grazing and vegetation management practices and ensuing economic and environmental benefits will have long-term impact because of the duration (25+ years) of solar site lease contracts.

Distributed Solar Energy (DSE) facilities (1 to 20 MW on 6 to 120 acres)

Context

Approximately 17,245 acres of DSE projects are currently installed or in the pipeline in NY [3, 4]. Northeast U.S. grazing recommendations range between 1 sheep per acre for marginal land, and up to 5 sheep per acre for improved pasture and average a yearly stocking rate of 3 sheep per acre, providing potentially 51,735 sheep grazed in NY in this solar site category.

Benefits

- Best management practices (site-specific stocking rates and a grazing rotation that can optimally service site vegetation, habitat, and soil) may lead to environmental benefits providing Regulating, Supporting, and Provisioning Ecosystem Services like pollination, soil health and food, respectively [13], for 25+ year lease agreements.
- Soil organic carbon sequestration potential and soil health (soil organic matter, active carbon, protein, respiration, aggregate stability, and available water capacity) in NY soils of all texture groups is high in pasture systems [14]. Grazing solar sites may thus offer considerable potential for carbon sequestration and – due to the long-term lease agreements – to continued carbon storage and thereby long-term atmospheric carbon dioxide removal (CDR).
- Solar grazing enterprises will increase and diversify the income of sheep farmers and thus benefit rural community livelihood and financial viability.
- Management of solar site vegetation with sheep compared with mechanical mowing could contribute to decreased foodshed size, increasing access to locally produced meat, with increased community support and acceptance of both animal agriculture and renewable energy from solar sites.
- Solar site grazing will lower barriers for new farmers to start sheep farm enterprises and help existing farmers to expand their operations due to grazing income from vegetation management and decreased need for rented land.
- Unofficial reports from solar site developers and operators and landscaping business owners suggest that grazing is cheaper than traditional vegetation management and could save up to $300 per acre annually for solar site operators.

- Significant lamb sales income from grazing solar sites could lead the New York State Department of Agriculture and Markets (NYSDAM) to reconsider allowing landowners and municipalities to maintain these acres in agricultural production and exempt from non-agricultural property taxes.

Opportunity

Of the 2,113 total sheep farmers in NY, 646 farms reported flock sizes of 25 to 299 sheep [1]. If 10 MW were serviced per sheep farmer (60 acres, and 180 sheep), an estimated 287 sheep farming enterprises could be engaged to provide the required 51,735 grazing sheep. This would increase the sheep farm sector by 14% with up to 2,400 equivalent farms and could increase the NY sheep flock by 65% to 131,930 sheep and lambs. Access to winter feed, a challenge for flock growth, would be derived from haying vacant, on-farm summer pastures. Between 2012 and 2017, New York dairy farms declined by 779 farms [1], offering vacant barn facilities that could be retrofitted cost effectively to provide inexpensive winter housing for sheep flocks.

Sheep grazing on solar sites could generate taxable service income of between $5,173,500 and $8,622,500 for the service of vegetation management. At a slaughter price of $180 per lamb [15] and Northeast estimates of 1.3 lambs sold per ewe per year, 67,256 additional lambs could increase lamb sales by $12,105,990 per year. Infrastructure servicing the New York sheep industry is in place and can be scaled up. The Cornell Sheep Program has a wide reach with Northeast sheep producers and supports the farming community with timely research and guidance. The current 34 Cornell Extension Livestock Specialists and Educators are available to provide this emerging industry with critical knowledge and advice on sheep husbandry, best management practices, and grazing strategies based upon research from Cornell's solar grazing trials. The American Solar Grazing Association (ASGA), formed in 2017, is also available to provide guidance, match solar site developers with sheep farmers, and assist in contracting and site design.

Grazing marginal and extensive land under solar panels with sheep could benefit surrounding communities by generating up to 17,245 acres of land with a highly diverse forage species composition including a significant proportion of native plant species, thus providing valuable habitat for wildlife like ground-breeding birds and reptiles [16] and native bee pollinators, key Biological and Cultural Ecosystem Services.

Challenges

- Of 2,113 total farms, 1,440 (68%) manage fewer than 25 sheep. Farmer expertise and knowledge of large flock management and best practices will have increase to ensure high animal welfare and quality lamb carcasses.
- Of the available 34 Cornell Cooperative Extension Livestock Educators, only a few are trained in sheep production. Increasing the sheep flock by 65% will require up-scaling of programming for sheep Extension.
- Extension expertise will be necessary to provide guidance in retrofitting old barns or building new sheep barn facilities to provide adequate winter housing for the growing sheep flock.
- About 13 auction barns are available across upstate NY, but few are organized to market slaughter lambs. Guidance would need to be provided to the auction barns to better advertise auction days and match producers and buyers.
- Matching interested farmers to grazeable sites is challenging, especially because farmers have no influence in solar siting. The sheep flocks must be checked 3 times per week and more often during summer when water requirements are higher, which could require long drives to the closest grazeable solar sites for sheep farmers. This may be resolved by newly emerging businesses like subscribed grazing businesses that could create trucking jobs by rotationally grazing among sites, or by employing local people to check on the sheep.
- Improved marketing strategies (for locally produced, welfare approved, grass-fed, solar raised, meat) will be needed for the increased lamb supply and increase market potential. However, the Northeast has the single largest concentration of lamb consumers in the US and sheep numbers in NY State grew by 9% from 2019 to 2020, while nationally sheep numbers declined [17] suggesting 1) industry growth separate from solar grazing, and 2) a supply response to the increase demand for local meat [18].

Barriers

- The slaughterhouse capacity for livestock (both custom and USDA) in New York is very limited, substantially reducing options for local marketing of lamb and increasing barriers for farmers to sell their lambs [18, 19] at a scale that does not yet warrant trucking to large regional auctions like the one in New Holland, PA.

Utility Scale Solar Energy (USSE) facilities (> 20 MW, > 120 acres)

Context

To meet the challenge of supplying 70% of renewable energy by 2030, 21.6 GW of USSE must be installed in NY State [20] with an estimated 129,600 acres of land for panels. Draft findings reported to NYSERDA [21] estimate 10.6 GW of solar installations by 2030, an estimate that is currently exceeded with 68,878 acres (11,480 MW) of USSE in the pipeline [4]: If these installations go online, an equivalent of 1.0% of the total NY agricultural land (6,900,000 acres) or 6.8% of the agricultural land planted to corn silage and corn grain (1,020,000 acres), or 14.5% of land planted to soybeans, other grains, and vegetables (474,000 acres), or 2.0% of land harvested for hay and haylage including alfalfa (3,430,000 acres) [1] would be in use for USSE. Several publications have acknowledged the potential of agricultural land being targeted for USSE facilities due to inherent characteristics like being cleared from brush, road access, and the bulk electricity grid going through counties with a high proportion of these lands [20, 22, 23]. Vegetation control can be done easily with sheep on solar farms sited on hillier marginal land less amenable to crop production. Yearly stocking rates of 3 sheep per acre would lead to potentially an additional 206,634 sheep.

Benefits, opportunities, challenges, and barriers for grazing sheep on USSE facilities are very similar to those of Distributed Solar Energy but are modified due to the larger scale of these projects.

Benefits

- If sheep grazing on solar sites will replace sheep that would have been produced elsewhere with similar GHG emissions, then sheep production will not be an added source of GHG emissions. In this case, using sheep rather than machinery to manage vegetation on solar sites will reduce GHG emissions by the amount that would be emitted from mechanical mowing. However, sheep grazing requires some fossil fuels for trucking sheep to and from sites, as well as for checking the sheep on site, which may reduce this GHG benefit.
- Community acceptance of USSE facilities will likely be increased if the benefits of grazing can be listed as mitigation opportunities such as 1) lower vegetation management greenhouse gas emissions, 2) biodiversity, habitat creation, 3) soil conservation, health, and carbon sequestration, and 4) decreased foodshed size.
- Continued societal support may emerge from the combination of greenhouse gas emission reductions through renewable energy generation as well as actual removal of atmospheric caron dioxide (CDR) through soil organic carbon accrual, as combinations of both approaches are rare.
- Solar sites built on land owned by a farming business may offer considerable increases in farm viability via long term and secure land lease income.
- New businesses will emerge to service these unique opportunities with targeted grazing operations modeled after those in the western U.S. [24], supported by additional services from veterinarians, shearers, hoof trimmers, truckers, barn-builders, slaughter-house operators, butchers, farm service providers, and suppliers.
- Sheep farmers could start forming cooperatives, graze larger sites together, and arrange markets for lambs throughout the state, perhaps employing a marketing manager, with overall strengthening of the NY State sheep industry.

Opportunity

Of the 2,113 total sheep farmers in NYS, 35 farms reported flock sizes between 300 and 999 sheep, and only 4 farms reported flock sizes larger than 1,000 sheep [1]. If 25 MW were serviced per sheep farmer or employed flock manager (150 acres, and 450 sheep), an estimated 459 sheep farmers could be engaged with an equal number

of jobs created. This would increase the sheep farm sector by 22% to 2,572 equivalent farms and could increase the NY sheep flock by 258% to 286,829 sheep and lambs.

Initially, ewes or feeder lambs would have to be transported from other states to stock these sites. With shifts in the western lamb industry [25], the supply is realistically available. However, the yearly grazing income in NY of $20,663,400 to $34,439,000 will also be used in part to build sheep housing and sustainable handling infrastructure and create sheep farming businesses that will outlast the site-lease period and remain a vital part of NY agriculture. With a base of 54,000 breeding ewes in NY, after 4 years, with a 40% ewe lamb retention and calculated with Northeast estimates of 1.3 sheep sold per ewe per year, 268,624 additional lambs sold at $180 per lamb will add $48,352,356 in sales per year [15]. Currently, 123 million metric tons of lamb are imported to the US per year, an increase of 176% between 2012 and 2019 [26]. With an average Northeast carcass weight of 40 lb [27], < 0.01% of the imported lambs would be offset by the additional lambs produced in NY, a number that is too small to expect large impacts on lamb and carcass price.

Based on traditional landscaping methods with equipment running times of 1.6 h per acre with standard, gas powered equipment (70 HP, 52.2 KW skid steer mower) and 2 mowings per year, a reduction in fossil fuel CO_2 equivalent gross of 1,428 t could be realized on 68,878 acres per year [28] when grazing these sites with sheep as opposed to traditional landscaping methods. However, travel emissions to transport and monitor sheep in grazing systems must be considered.

There are ~1.7 millions of underutilized forage acres in NY [29]. Grazing solar sites that are built on these perennial croplands (pastures or hayfields) may reduce pressure to convert natural and forest lands to agricultural land or solar sites, lowering greenhouse gas emissions resulting from direct land use changes [30].

With demand for locally produced meat increasing in 2020 during the COVID-19 pandemic [18] independently from sheep grazed on solar sites, growing the slaughterhouse capacity for USDA-inspected and custom slaughter facilities for both retail and whole-sale is a major opportunity for the NY food system. Additional supply of lamb and mutton from solar grazing could speed this process and provide multiple benefits such as job creation, decreased foodshed size, decreased imports, and reduced greenhouse gas emissions from food transport.

Challenges

- If sheep grazing solar sites increases the global flock, rather than replacing sheep elsewhere, there will be an increase in GHG emissions that should be compared with that from mechanical mowing. Also, if the solar sites were previously in agricultural production, there could be leakage (increased production in other States or regions) because that production will need to be produced elsewhere to meet market demand, and there may be considerable GHG emissions from this leakage.
- In NY, 62% of cultivated agricultural land is not fully owned by the farm operator [1]. If landowners terminate lease contracts with farm businesses to enter long-term lease agreements to solar developers, considerable displacement of farming operations may occur in areas with concentrated solar site construction, and subsequent leakage into adjacent areas.
- Increasing the flock size (including buying in feeder lambs or ewes from other states) may be challenging to veterinary services and the New York State Sheep/Goat Health Assurance Program (NYSSGHAP).
- With flock sizes of > 450, retrofitting vacant dairy barns may not create labor efficient systems conducive to animal health and welfare and, thus, create the need for investment in new winter housing facilities.
- With 900 lb DM requirement per 140 lb ewe in 180 winter days (3.5% of body weight (BW) offered per day), an additional 45,563 acres (0.22 acres/ewe) of hay at 4,000 lb dry matter (DM) yield per acre will be needed to provide winter feed, suggesting an increase of 1.4% of the current hayfield acres available in NYS [1] if no pastureland currently used for sheep grazing (46,669 acres, [1]) is used for hay production due to sheep grazing on solar sites.
- Sheep are kept on bedded packs that remain inside the barn during the winter creating compost before spreading on fields as manure. Manure management guidelines for the sheep industry will have to be formulated and published to ensure best management practices and limit the amount of emitted climate pollutants and nitrogen run-off.

- At a flock size scale of > 450, the lack of local auction houses and slaughter facilities is challenging, yet not a barrier because slaughter lambs can be shipped in trucks holding ~350 lambs to larger regional auction houses like the New Holland Sales Stables in PA (one of the largest in the U.S.) for a price of ~$4.00 per loaded mile. However, given the 138,034 lambs sold in 2020 at the New Holland Sales Stables in PA [31], a potential 270% increase (372,878 lambs) may affect lamb price considerably and harm sheep producers not participating in vegetation management contracts.
- The fixed location of solar sites may result in sheep flock owners or managers having to relocate to areas with USSE facilities so that flock owners may be many miles away and must employ nearby managers.

Barriers

- There will be an increased need for farm sector expertise in sheep management knowledge and grazing techniques. Most sheep in the state are kept in flock sizes under 300 sheep (98.5%). Required skills like nutritional and flock health management, breeding and winter lambing management, and high quality feed procurement increase significantly with flocks > 300 sheep.
- USSE facilities may be too large to be grazed by one sheep farm operation. Potentially having to hold contracts with multiple sheep flock owners may not be attractive to solar site operators.
- It can be expected that USSE facilities will be planned and built near bulk transmission lines to limit electricity transmission cost for solar developers. Except for Seneca and Montgomery Counties, the counties with the highest concentration of sheep and lamb sales in 2017 are in the vicinity of bulk transmission lines (Figure 1). However, with sheep farmers and flock owners having little influence on solar siting, the location and matching of USSE facilities and larger scale sheep farmers may be a barrier, especially in the short term.

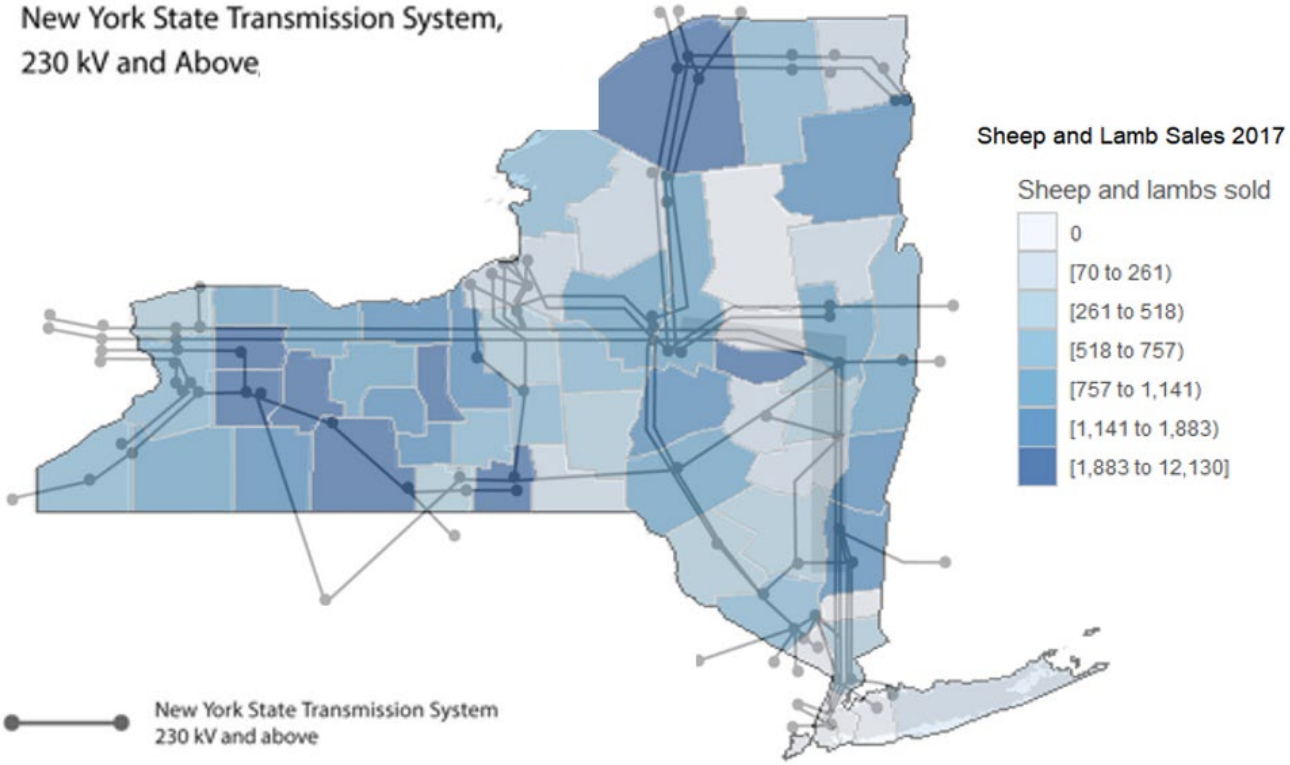

Figure 1. Transmission lines [4] and sheep and lamb sales in 2017 in NY State [1].

Conclusions

The development of DSE (1 to 20 MW) and USSE facilities (>20 MW) will occur simultaneously, not offering the opportunity for a gradual scaling up of flocks for vegetation management.

Entrepreneurs have opportunities to circumvent solar grazing barriers. If the slaughterhouse capacity in NY does not increase to meet increasing demand of locally produced meat, there are opportunities to sell large quantities of live lambs to regional markets in PA and MI. If solar sites are located at distances from sheep farming enterprises, livestock trucking businesses can be engaged to transport sheep among solar sites, helping to limit the travel requirements for sheep farmers, and local flock managers can be hired. Both Cornell Cooperative Extension and veterinary services could be barriers in the short term, but they may expand with and provide the necessary expertise to sustain a scaling up of the sheep industry. New business ventures and cooperatives may be created among sheep farming entrepreneurs to service large USSE facilities.

Changing land-use from agriculture to solar sites could cause increases in GHG emissions and carbon leakage (cascading spill-over effects leading to emission reductions in some counties and states offset by an increase in others). Therefore, developers and communities should be encouraged to site solar installations on pasture, underutilized, and marginal land.

Solar grazing provides an opportunity for growth of the NY sheep industry. Expansion of related services and businesses are needed to support the numerous benefits of this emerging industry.

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