Morris Ridge Solar Energy Center
Case No. 18-F-0440

Agricultural Integration Plan:
Managed Sheep Grazing & Beekeeping

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2020

MORRIS RIDGE SOLAR PROJECT

AGRICULTURAL INTEGRATION PLAN: MANAGED SHEEP GRAZING & BEEKEEPING

1. Introduction

The Morris Ridge Solar Project is a proposed solar farm on approximately 1,060 acres in the Town of Mount Morris, southern Livingston County, New York. The project site is within an area farmed primarily in a cash cropping rotation. The Morris Ridge Solar project is being designed to integrate agricultural uses, including a managed grazing system that utilizes sheep grazing to control vegetation growth under and around the solar panels. Sheep grazing is a method of vegetation control used on solar facilities around the world and is increasingly being used in the Northeastern United States to provide a solution that can promote and incorporate an agricultural use within a solar photovoltaic facility.

The Morris Ridge Solar project is also being planned to accommodate honeybees and honey production. Through the incorporation of pollinator-friendly vegetation into the project design, solar farms can create suitable habitat for honeybees. Co-locating honeybee apiaries and solar farms has been proven to be a successful method of integrating agricultural use at solar farms throughout North America.

Morris Ridge Solar Energy Center, LLC (MRSEC), an indirect subsidiary of EDF Renewables, LLC has engaged the services of Agrivoltaic Solutions LLC (AVS), a New York company owned and operated by sheep producers. AVS is assisting MRSEC with site design and planning, and with coordination of local farmers who may have an interest in scaling their operations to realize this opportunity.

2. Managed Grazing

2.1 Overview of Managed Grazing

a) Vegetation Control

Solar facilities must have steady and regular vegetation control during the growing season to prevent shading and produce electricity efficiently. A managed grazing system for solar sites offers many benefits over the competing mechanical vegetation management systems. Vegetation that grows underneath panels reaching heights above the leading edge of panels will cause shading and must be mown or grazed several times per year. Sheep grazing at an appropriate stocking density are highly effective in eating vegetation around and under panel areas that can be hard to reach or expensive with conventional mowing equipment. Sheep are small and agile enough to easily graze underneath panels and racking equipment. Their behavior does not predispose them to standing or jumping on site equipment or chewing on electrical wiring, as goats might be inclined to do. Their size and strength mean that any rubbing on equipment is unlikely to cause damage, as cattle would likely do. The perimeter fences installed as part of the solar project will serve to contain the grazing sheep within the designated grazing area.

A correctly planned and implemented grazing plan with appropriate animal stocking density will offer comparable or superior vegetation control performance to a conventionally mowed site.

b) Soil Health Benefits

Sheep grazing has an important role in maintaining soil health over the lifespan of a solar installation. A properly planned and managed rotational grazing system offers benefits through:

- Direct fertilization of the soil biota within the Project area contributes to healthy soil ecology.
- Proper grazing and rest periods. These cyclical periods both encourage and protect plant root development.
- Living plant root structures in the soil year-round enhance soil microbial activity, nutrient flows, and a well-functioning water cycle.
- A permanent sod of pasture grasses prevents erosion: meaning soils are retained and enhanced.
- Soil structures are improved over time.

It is very important to make a distinction between a managed rotational grazing system and a more traditional "set stock" pasture model with no grazing rotations. The Morris Ridge Solar project area intends to be grazed with a planned rotation. The system of rotational grazing greatly improves soil health and forage yield over set stock (continuous grazing) or mechanical mowing, and thus can support greater animal stocking rates. Greater stocking rates and higher levels of animal performance with managed grazing will increase the economic returns to the farmers who will be contracted to graze the site.

c) Agricultural Economics

The grazing program at the Morris Ridge Solar project is designed to mitigate the agricultural and economic impact of the development by maintaining agricultural production at the site. Grazing offers the following benefits for participating local farmers:

- Farmers can use the long-term grazing contract with MRSEC to build and scale commercial sheep enterprises. The access to securely fenced grazing areas during the warm season can provide a resource base for a sheep flock that produces feeder or market lambs. The grazing area within the project provides a feed stock resource that the farmer would, traditionally, need to pay to rent. Farmers can use their animals, time and expertise and gain an additional income stream from a vegetation maintenance contract with the solar array owner.
- The income from the grazing contract provides meaningful revenue and can improve farm viability for both new and established farm operations. Rates for farmers in New York State who directly contracted for vegetation maintenance with solar firms averaged $555/acre in 2018[1]. These numbers are based on generally smaller sites. Larger projects such as Morris Ridge would generally have lower rates for vegetation maintenance due to greater economies of scale. However, these will still be paid contracts.
- The Morris Ridge Solar project will be designed with efficient grazing in mind. There will be permanent low interior fencing installed for easier grazing rotations. MRSEC may also install semi-permanent aboveground water lines fed by on-site wells or delivered water for ease of water delivery to the sheep flocks.

[1] Cornell University, 2018. Atkinson Center Grant Research 2018. https://solargrazing.org/atkinson-center-grant/

2.2 Managed Grazing Model for the Morris Ridge Solar Project

a) Grazing Plan

The Agricultural Integration Plan is built around a managed rotational grazing system outlined by a Prescribed Grazing Plan (PGP, see Attached). The PGP is a blueprint for managed grazing that determines:

- Target animal stocking rates
- Timing of animal moves
- Duration of pasture rest periods post-grazing

The PGP is used in order to facilitate management of the site that achieves targets for vegetation control, animal production and soil health. The grazing plan is designed to perform 95%+ of vegetation maintenance with a small amount of mechanical trimming to be performed by farmer/contract holder on an as-needed basis.

The PGP takes the 1,060 grazeable acres and divides them into separately managed pods based on the layout of the solar panels. Each pod will have a planned number of sheep and will be further subdivided into paddocks. It is intended that each pod will have its own flock of sheep. The sheep will rotate from paddock to paddock every 1-4 days. A farmer will be able to read and understand the materials presented in the PGP and use it as a planning tool for their grazing season.

The PGP was prepared by AVS and is included as an Attachment to this Plan.

b) Contracts

The Morris Ridge Solar project will seek to contract the grazing through local farmers who either currently own sheep or wish to expand sheep enterprises as part of their farm business. To engage with these farmers and determine which candidates are best fit for the contracted grazing, MRSEC and AVS have worked to conduct outreach locally and assess interest from the farm community. Initial interest has been solid, with several area farmers expressing interest in contract grazing either parts of the site or the entire site.

Before the start of construction, MRSEC and AVS will offer more outreach to the agricultural community in the Project area. AVS will conduct a formal process with the goal of obtaining formal proposals from interested farmers.

MRSEC's objective is to obtain long term (5+ year) contracts for managed grazing at the site. Having contracts of this duration offers more security for farmers and will allow them to invest in animals and facilities that they may need. The total number of sheep (mature ewes) projected for the project area as currently proposed is 3,847. These animals may be contracted from one or more farms and provide a significant contribution to the local agricultural economy.

Farm income potential from an operation of this scale is significant, as is the investment to provide the necessary infrastructure. Farmers who already have livestock at this scale in the region will be in the best position to use existing barns, equipment, employees and other infrastructure to support a solar grazing operation. The ewes will need winter housing and feed, and transportation to and from the solar site as well as daily management on-site. Several of the farmers who are directly adjacent to the solar site have

expressed interest in bidding on this work and would be well positioned to move their flock onto the site each spring.

Lamb production in the Northeast is growing. The NY State sheep flock grew 8.8% in 2019, from 80,000 to 87,000 total head[2]. The largest markets for lamb in the U.S. are the urban areas on the East coast, and production has been rising to meet demand. Many of the lambs produced in the East are sold through the New Holland Sales Stables in New Holland, PA. This auction regularly sells 1,000+ lambs per week and is a good source of price discovery for regional sheep producers.

c) Farm Economics

Sample Economic Analysis

The following is a sample revenue analysis of a 2,400-ewe breeding flock. This many sheep grazed with their lambs would be roughly equivalent in terms of animal units as 3,800 mature sheep. This model operates on a few assumptions:

- Once-per-year winter lambing, accommodating for the grazing schedule at the solar site. Lambs may be weaned off ewes before the start of grazing.
- Hair breed sheep, producing no wool and requiring no shearing to save on maintenance and labor costs. Northeast wool markets are not particularly lucrative for a commercial flock at this scale.
- 1.6 lambs per ewe per year – average to good productivity for a Northeast flock.
- 20% ewe cull rate (480 ewes/year) - a typical to high cull rate.
- 3% lamb loss – average to slightly better than average mortality.
- 13% lambs retained for replacements – yielding 480 ewe lambs.
- 1.35 lambs sold per ewe – 1.6 lambs per ewe minus loss and retained replacements.
- Lambs grazed on the solar site with the ewes
- Lambs sold live in late summer/early fall at 85lbs for $1.75/lb - Pricing based off of low average prices at the New Holland Livestock auction, New Holland, PA[3].
- Cull ewes sold at 140 lbs for $0.50/lb - Pricing based off of low average prices at the New Holland Livestock auction, New Holland, PA.

Gross Revenue

Lamb sales	$481,950.00
Cull ewe sales	$33,600
Grazing Contract	$50,000.00 - $100,000.00[4]
Total	$565,550.00 - $615,550.00

[2] USDA, 2019. State Agriculture Overview – New York.
https://www.nass.usda.gov/Quick_Stats/Ag_Overview/stateOverview.php?state=NEW%20YORK
[3] mymarketnews.ams.usda.gov/viewReport/1913
[4] Range presented because contracts have not yet been negotiated. Range is projected based on current rates for utility scale solar grazing.

d) Assumptions

There is a wide range of variables in assessing the cost structure of this enterprise, but there are some assumptions that can be made:

- These sheep would need roughly 1,100-1,300 tons of winter feed, mainly forage purchased or produced locally.
- The sheep would require around 4 full time personnel for care and management.
- Capital investment in animals, facilities and equipment could likely be in the range of $1,000,000 - $1,500,000 if starting "from scratch".
- This represents a single operator holding the contract for the entire site. There are many different business models that may fit into the vegetation maintenance plan. For instance, a lower-risk, less capital-intensive model would be a farm holding the grazing contract and purchasing feeder lambs each spring to grow-out on the site and sell in the fall. Alternatively, if a few of the local lamb producers who already have infrastructure to accommodate overwintering of the sheep participate in grazing the Morris Ridge Solar project or lease barn facilities to grazers, that could further reduce required capital cost investments.

3. Beekeeping

3.1 Overview of Beekeeping

a) Context and Experience

The Morris Ridge Solar project is being planned to accommodate honeybees and honey production. MRSEC has engaged in a plan of action to facilitate this. The following few paragraphs describe EDF Renewable's track record with solar honey production, the planning for bees at Morris Ridge Solar, and the agri-economic context for such an initiative.

EDF Renewables is familiar with the approach of siting hives at their ground mounted solar arrays. The Gees Bees Honey Company (Gees Bees)[5] is located near Ottawa Ontario and is responsible for foraging the EDF Renewables 200-acre Arnprior Solar site. In this arrangement EDF Renewables participates in Gees Bees Host A Hive program. This program allows EDF Renewables to host hives and purchase honey produced at the Arnprior Solar site. The honey is fully processed and purchased in cases of one-pound jars by EDF Renewables. All processing and other honey products are handled by Gees Bees. The 200-acre solar site benefits from the addition of these pollinators. In addition to hosting the pollinators, the site's vegetation has been managed with rotationally grazed sheep for 4 seasons. The rest period (for the vegetation) created by managed rotational grazing creates a supply of blooming flowers throughout the growing season for the bees at the site to rely upon as a food source.

b) Agricultural Economics

Per capita consumption of honey in the United States has steadily increased over the past twenty years. The average American consumes 1.4 pounds of honey per person per year.[6] New York State has 19.5 million

[5] Gees Bees Honey Company, 2020. https://www.geesbees.ca/

[6] Statista.com, 2018. https://www.statista.com/statistics/328897/per-capita-consumption-of-pure-honey-in-the-us/

residents yet produces between 3.3 and 3.6 million pounds of honey per year, making the state a net importer of honey in a nation that is a net importer of honey[7] . Roughly half of the honey consumed in the United States goes into other food, which in the case of solar honey is a potential value-add position that several beekeeping operations elsewhere in the United States have taken advantage of. From Solarama Crush, a solar-honey beer produced in Minnesota[8], to Alchemist Beer's Honey Bunch, this emerging market would be accessible to New York breweries, cideries, and other marketplaces. The UC Davis 2019 report attributes this stream of food products that incorporate honey to be the major growth sector for the honey industry.

Indirect benefits to adjacent agriculture by hives located adjacent to solar sites were studied at by a team at Yale University in 2019[9]. "Pollinator -friendly solar benefits depend greatly on surrounding crop type." The predominant crops in the Morris Ridge Solar project area are corn, soy, and hay crops. The Yale study found a 6.3% crop yield increase for soy in Minnesota located near pollinators as it is a moderately pollinator dependent crop. As corn and hay crops are not pollinator dependent, there would be no impact on these crops. However, the 2019 Town of Mount Morris Agricultural and Farmland Protection Plan indicates that the Town would like to encourage an increase in diversified small farms, including fruit and vegetable crops. Honeybees have been shown to benefit this type of agriculture in other regions and in the Yale study. Therefore, as Livingston County diversifies its agriculture, there would be a mutual benefit for solar honey producers and area farmers.

3.2 Beekeeping Model for the Morris Ridge Solar Project

a) Beekeeping Plan

MRSEC will allow the beekeepers to install bee yards at one or more locations at the Morris Ridge Solar project. These bee yards will be incorporated into the final site design. Bee yards typically are flat, well drained sites that allow beekeepers 24/7 access to their hives. They are also sited with other criteria in mind, as per Penn State Extension's 2007 guide *Beekeeping Basics*' guidelines. Bee yards are typically located several miles from one another, which is an industry standard best practice. A two- or three-mile radius is standard to allow for enough nectar source for each colony. The bee yards at Morris Ridge Solar will be designed to follow this standard to the extent feasible. Bee yards in southern Livingston County are commonly secured with electric fencing, which will likely be the case at Morris Ridge Solar. This is due to the presence of a black bear population in this area. The DEC provides wildlife guidelines that MRSEC will incorporate into the contract with the Morris Ridge Solar project site's beekeepers[10].

The solar site will be seeded with a seed mix designed for the special circumstances of the site: grazing, honey production, low-growing, shade and sun tolerant. The seed mix will be selected based on soil testing results, which is scheduled for fall 2020. The seed mix will be something akin to Ernst Conservation Seed's Fuzz & Buzz Mix. A mix of pasture grasses, legumes (all flowering plants), and forbs (more flowers), it is a diverse and robust blend designed to balance the needs of agrivoltaic production. The seed mix is integral to the vegetation management plan. The vegetation management is planned to support perennial pastures that

[7] Contributions of the U.S. Honey Industry to the U.S. Economy, UC Davis, 2019. https://aic.ucdavis.edu/wp-content/uploads/2019/02/HONEY-COMPLETE-DRAFT_FEBRUARY-11-2019.pdf
[8] https://www.minnesotamonthly.com/food-drink/drinks-cocktails/new-at-56brewing-the-sustainably-brewed-solarama-crush/
[9] Maximizing Land Use Benefits from Utility-Scale Solar, Yale Center for Business and the Environment, 2019. https://cbey.yale.edu/research/maximizing-land-use-benefits-from-utility-scale-solar
[10] Empire State Honey Producers Association, 2020. https://eshpa.org/ny-dec-bear-law

nearly always have flowering plants. This perennial rotation of the sheep keeps vegetation in sequence of rest and grazing. This sequence is cyclical, and the structure allows the legumes and forbs time to flower from May to October. With the planned rotation of the sheep, the availability of nectar from flowering plants across a large area that are stimulated to bloom consistently throughout the season should allow the bees to thrive.

b) Contracts

MRSEC plans to host bee hives at the Morris Ridge Solar project after construction. This summer and fall, AVS will conduct outreach with regional beekeepers at Beekeeping Conferences and other Beekeeper-centric events to gauge interest. Beekeepers will be encouraged to fill out a form letter of interest at the AVS website, Bees + Solar[11]. Initial conversations with several commercial beekeepers indicate that interest will be strong, in part because of the bee yard or yards that will be set aside for the honey producers. Large, commercial scale bee yards with truck access and hundreds of acres of adjacent bee-friendly plantings to accommodate foraging are a rare opportunity for beekeepers.

MRSEC anticipates that one firm will be selected to provide beekeeping services at the Morris Ridge Solar project. This firm will meet guidelines set by MRSEC, State and Local Laws, and general good practice. The beekeepers on site will be advised that they should be in full compliance with the New York State Beekeeping Laws[12]. The beekeepers will be advised to reference the Pollinator Network at Cornell, led by Dyce Labs, in order to maintain best industry practices[13]. The information sponsored by the Dyce Lab is robust and research led. Most beekeepers are members of their regional clubs, which also serve to keep beekeepers up to date on best practices and the latest issues. Commercial beekeepers typically have commercial liability insurance. These and other criteria will be used to select the beekeeping partner for the solar site.

MRSEC plans to negotiate a similar arrangement at Mount Morris as the Arnprior Solar site. The New York beekeeper selected will have a contract with MRSEC, potentially based on the Sample Pollination Services Contract found at the Cornell-Pollinator Network[14]. The beekeepers might provide pollination services for a set fee and might sell a set portion of the honey to MRSEC every year. MRSEC would in this manner directly support a local business with a steady contract and purchase of the product.

c) Farm Economics

The honey produced at Morris Ridge Solar should find a ready market and join an established supply chain. The majority of the honey would be sold according to the contracted beekeeper's business plan. EDF-Renewables anticipates purchasing some portion of the honey produced on site, as stated above, while the remainder enters the commercial marketplace for honey. New York State tends to rank in the top 10 to 20 producers in the United States as per the USDA NASS reports[15].

Sample Economics for Morris Ridge Solar Honey

The following is a list of some economics and their assumptions as it would pertain to hosting a commercial beekeeper at the MRSEC.

[11] Agrivoltaic Solutions LLC, 2020. https://www.agrivoltaicsolutions.com/about-1
[12] Empire State Honey Producers Association, 2020. https://eshpa.org/beekeeping-laws
[13] Cornell University Pollinator Network, 2020. https://pollinator.cals.cornell.edu/resources/
[14] Cornell University Pollinator Network, 2020. https://pollinator.cals.cornell.edu/resources/
[15] USDA, 2018. https://www.nass.usda.gov/Publications/Todays_Reports/reports/hony0318.pdf

Costs:

- There should be no added costs for insurance.
- There should be no added costs for the contract.
- The other costs to check hives, transport hives, etc. would be the same as they would be for any other hive placement.
- The costs to fence the bee yard would fall to the beekeeper. The electric fence and any posts would then be the property of the beekeeper's business. Note that this is standard practice in the industry around bee yards due to different preferences by beekeepers and a variability in bar pressure by region.

Income:

- Assuming 2 bee yards are installed at MRSEC, and average honey production per bee colony, 56 pounds per year, then 5040 pounds of honey would be produced annually[16].
- Honey sold on the wholesale market in 2019 averaged $4.37/pound[17]. At this wholesale rate, the estimated 5040 pounds of honey from the MRSEC bee yards would gross $22,025 on the wholesale market.
- Honey sold at the retail average in 2019 of $7.71/pound. At this retail rate, the estimated 5040 pounds of honey from the MRSEC bee yards would gross $38,858 on the retail market.
- Honey from solar arrays is currently being sold as a premium product in some regions, and the added retail value here could be explored by a producer operating at the MRSEC bee yards.

4. Conclusion

EDF-Renewables has taken care to strategically plan for a high level of agricultural integration at the Morris Ridge Solar Facility. The solar facility is proposed to create a new opportunity for a livestock grazier and a commercial honey producer in the region. Over the rest of 2020, AVS and EDF-Renewables will work to find the right farm partners to facilitate the plans identified above. The construction plans will be fine-tuned with a grazing operation in mind. The future site graziers will have several years to bring their livestock operations up to speed in harmony with the construction schedule. Our team looks forward to project success that incorporates and strengthens the regional agricultural community in the Morris Ridge Solar Project.

Attachment: Preliminary Sheep Pasture Rotation and Grazing Plan

[16]https://www.beeculture.com/u-s-honey-industry-report-2017/

[17] https://www.honey.com/honey-industry/statistics/wholesale-honey-price

Attachment:

Preliminary Sheep Pasture Rotation and Grazing Plan

Morris Ridge Solar Energy Center
Case No. 18-F-0440

Preliminary Sheep Pasture Rotation and Grazing Plan

Prepared for:

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1. Introduction

Ground-mounted solar sites, by nature of their planned design, have ample fenced areas. From the view of an agriculturalist and grazier, the fencing at solar sites is uniquely suited to serve as grazing areas that, once subdivided into grazing paddocks will assume ideal conditions for a pasture rotation with sheep. The perimeter fencing serves as predator deterrent, the solar panels provide shading and shelter for the animals, and the land used for solar arrays provides palatable pasture species for ruminant nutrition. In turn, rotationally grazed sheep provide adequate and comparatively cheap vegetation management, optimal ground coverage, and thus reduced erosion and run-off, as well as agricultural usage of lands that can add to the viability of farming communities.

1.1. Goals for Managed Grazing at Morris Ridge Solar

The Morris Ridge Solar project, located in the Town of Mount Morris, Livingston County NY, will be sited on approximately 1,060 acres. A managed sheep grazing system is being proposed at the project site to:

- Prevent vegetation from shading the solar panels
- Control invasive plant species
- Avoid the growth of woody plants near solar panels,
- Maintain a diverse plant community
- Maximize pollinator habitat & co-location opportunities with apiaries while still controlling vegetation
- Maximize the opportunity for soil carbon sequestration by increasing topsoil and root mass, and
- Control erosion.

To achieve these goals, a rotational grazing system is proposed, and a grazing plan has been designed as a template for the potential grazier(s). Rotational grazing is a technique where animals are moved as one group, from one pastured area ("paddock") to the next (Hodgson, 1979). Only one paddock is grazed at any given time throughout the rotation, while the other paddocks are given a rest period to achieve pasture regrowth. The sheep are managed in a controlled manner and not allowed to freely roam or continuously graze. Compared to set-stock (continuous) grazing, rotational grazing inhibits weed growth, improves the health of pasture, sustains healthy vegetation, and improves sheep health.

2. Rotation Planning

The Morris Ridge Solar project was assessed for a planned grazing rotation based on the preliminary project layout. The project was grouped into 6 separate pods (or "sections"), each surrounded by agricultural or chain link perimeter fences (Figure 1). Each of these fenced pods will be subdivided into permanently fenced arrays, which will be further subdivided into individual temporarily fenced areas called paddocks.

The grazing plan maximizes the benefit of the planned installation of paddocks and lays out a schedule for the movement of the sheep to facilitate the goals of managed grazing, stated above. Specifically, the managed grazing allows both rest time and growth time for the vegetation within each solar pod. Rest time and growth rates of vegetation are the fundamental elements around which rotational grazing are planned.

2.1. Defined Terms

Project: The Morris Ridge Solar Energy Center in its entirety.

Pod (or Section): The perimeter fencing of the project creates the opportunity to divide the project into smaller areas for planning the sheep rotation based on the fencing that is already planned for the project. The project has

6 subdivisions known as *pods*. Each pod will, as explored below, range from 65 to 290 acres. A separate sheep flock will be assigned to each pod by the flock manager. The precise number of sheep in a pod may be adjusted over the season according to the flock manager. The flock is sized to be enough sheep to cover the entire pod in a full rotation. A full rotation is +/- 40 days in reality, but 45 days on the reference tables below.

Permanently Fenced Array: Pods are subdivided into contiguous groups of panels by interior fencing (typically 3-foot high woven wire fence on wood posts) to create individual permanently fenced arrays. The entire group of permanently fenced arrays forms one contiguous block of fenced panel areas.

Paddock or Grazing Paddock: This is the smallest unit under discussion. It is a grazing unit created by the design of this Grazing Plan. Their individual average size for Morris Ridge is projected at 4.5 acres. Paddocks will be created using cross fencing – typically a temporary fence that cuts across the solar array and meets the perimeter fences at each terminus.

2.2. Grazing System

The following describes the progression from largest (project) to smallest subdivision (grazing paddock) discussed in the grazing plan:

Project → Pod → Permanently Fenced Array → Grazing Paddock

This grazing plan allows that there will be 6 managed flocks of sheep across the project. Each one of the 6 *pods* will be grazed by a separate flock and enrolled into a separate grazing rotation. As outlined in Table 1 below, the stocking rate of each pod will be set at 3.6 sheep per acre.

Each flock's projected size is calculated to be enough sheep to cover an entire pod in a full rotation, i.e. for Pod 1, the amount of sheep needed to graze 65.6 acres in a 45-day rotation. The precise number of sheep in a pod may be adjusted over the season according to the flock manager. The number of sheep planned per pod can be found in Table 1.

Table 1. Grazing Plan Morris Ridge Solar Project

	Item	*Section 1*	*Section 2*	*Section 3*	*Section 4*	*Section 5*	*Section 6*	*Total*
Rotation	Section size, ac	65.6	243.6	131.9	263.9	246.4	108.5	1,059.9
	Number of paddocks	24	45	30	47	44	43	233
	Paddock size, average ac							4.5
	Rest period, days	45	45	45	45	45	45	45.0
	Days in paddock	1.9	1.0	1.5	1.0	1.0	1.0	1.2
Sampling and analysis	Vegetation cover: %, ac	75% 49.2	75% 182.7	75% 98.9	75% 197.9	75% 184.8	75% 81.4	75% 794.9
	OM / yard², lbs	2.0	2.0	2.0	2.0	2.0	2.0	2.0
	DM % / yard², lbs	18% 0.4	18% 0.4	18% 0.4	18% 0.4	18% 0.4	18% 0.4	18% 0.4
	DM / ac, lbs	1,742	1,742	1,742	1,742	1,742	1,742	1,742.40
	DM / paddock, lbs	85,726	318,336	172,367	344,865	321,996	141,788	1,385,077
	Refusals: %, lbs	30% 25,718	30% 95,501	30% 51,710	30% 103,459	30% 96,599	30% 42,536	30% 415,523
	Total paddock DM, lbs	60,008	222,836	120,657	241,405	225,397	99,251	969,554
	Average sheep weight, lbs	160	160	160	160	160	160	160
	DM Intake: % BW, lbs	3.5% 5.6	3.5% 5.6	3.5% 5.6	3.5% 5.6	3.5% 5.6	3.5% 5.6	3.5% 5.6
Section total	**Total acreage**	65.6	243.6	131.9	263.9	246.4	108.5	**1,059.9**
	Total sheep	238	884	479	958	894	394	**3,847.4**
	Stocking rate	3.6	3.6	3.6	3.6	3.6	3.6	**3.6**

Each pod of the Morris Ridge Solar project is not directly connected to the adjacent pod but spatially separated based on landowner participation in the project and available land. The advantage for a flock manager to consider each pod individually is threefold:

1. The flock remains within one pod and can potentially be moved with minimal trucking;
2. The size of each flock remains manageable within the fenced pods; and
3. The individual pods can be administered individually, i.e. bid on and subsequently managed by different farmers during the RFP process.

The grazing plan requires additional division of each pod into a permanently fenced array, which is typically done with 3-foot high woven wire fence on wood posts. Figure 1 demonstrates a preliminary breakdown of pods into permanently fenced arrays.

Each permanently fenced array will be further divided into smaller temporary grazing units. These grazing units, known as *paddocks*, are created by using the planned permanent perimeter fencing and portable, battery charged Electronet® fencing. The Electronet® is a portable fence that is a product familiar to farmers in in the grazing community. It is a white, lightweight fence that is energized using a portable battery, battery/solar combination, or 110V power supply. This fencing is simple to power on/off and will only be located inside the permanently fenced areas.

The Electronet® will be installed by the grazing manager according to the grazing plan. It will allow for an optimal use of the permanent fencing to form some paddock walls, although some paddocks may be formed entirely by lengths of portable fencing. It is a versatile product that will allow the grazing manager a high level of control over the vegetation. The portable, battery charged Electronet® fencing would allow for a simple, logical rotation.

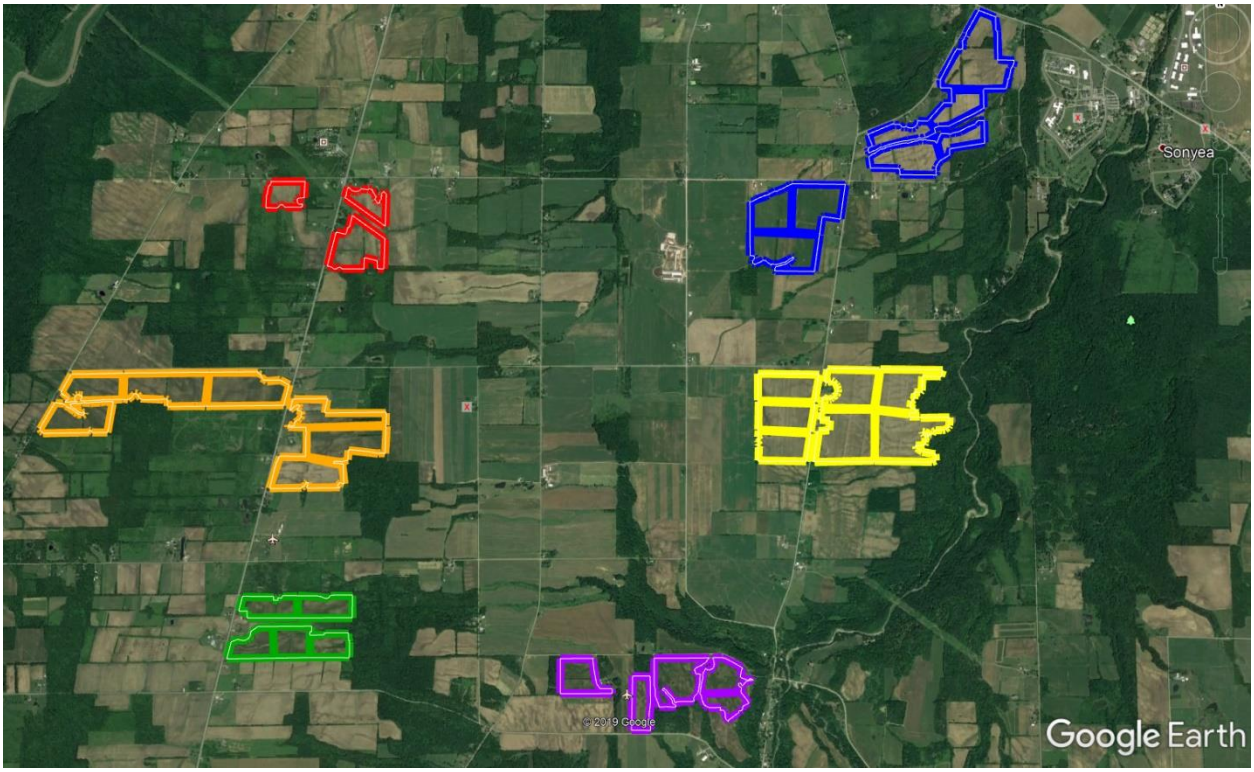

Figure 1. *Morris Ridge Project Site Layout with Distinctly Colored Pods (Trending West to East). Please note that this is based on the preliminary layout and is not the final layout.*

Pod 1: red. A total of 65.6 acres containing 3 permanently fenced arrays and divided further into 24 grazing paddocks

Pod 2: orange. A total of 243.6 acres containing 7 permanently fenced arrays and divided further into 45 grazing paddocks.

Pod 3: green. A total of 131.9 acres containing 6 permanently fenced arrays and divided further into 30 grazing paddocks

Pod 4: blue. A total of 263.9 acres containing 8 permanently fenced arrays and divided into 47 grazing paddocks

Pod 5: yellow. A total of 246.4 acres containing 7 permanently fenced arrays and divided into 44 grazing paddocks

Pod 6: purple. A total of 108.5 acres containing 4 permanently fenced arrays and divided into 43 grazing paddocks

The grazing paddock calculations are based on the total number of sheep per pod and a targeted number of days that sheep will be allowed to graze each paddock (i.e., the grazing period, which will be four days or less). The grazing period is a key factor guiding each grazing paddock's planned acreage. The grazing paddock's size determines the overall number of grazing paddocks within each permanently fenced array the pod. As explained further below, the overall grazing rotation of a pod is determined based on a combination of the size of the individual paddocks, the size of the flock, and the rest period (i.e., the period of time that a paddock will be allowed to rest and regrow between grazing periods).

(Permanently fenced array (ac) / Grazing paddock size (ac) = Number of paddocks (#)

Rest period (days) / Number of paddocks (#) = Grazing days per paddock (days)

2.3. Grazing and Rest Periods

The amount of time the sheep will spend in a paddock (i.e., the grazing period), should be considered through the lens of forage regrowth. To allow for optimal plant regrowth, the time any flock spends in any one grazing paddock should not exceed 4 days. The regrowth of forage species starts after 4 days of being grazed, and any grazing of this early regrowth can adversely affect plant health. Furthermore, a 4-day maximum rotation period reduces fecal matter contamination, minimizes the creation of sacrifice areas (e.g., areas associated with water or mineral supplements that may potentially receive excessive livestock use), and improves pasture hygiene.

The rest time for a given grazed area is largely guided by management for the sheep flock's health. The rest time can be considered the window during which the sheep are not present in a paddock and forage species are provided an opportunity to recover and regrow. The pasture rest period (time between grazing periods) in the US Northeast should not be less than 40 days to minimize internal parasite pressure for sheep. Internal parasites are a health risk to the sheep but not to humans.[1] As the managed grazing is partially aimed at optimizing the health of sheep and their food sources, this health risk to sheep is minimized by following the prescriptive grazing plan below.

Guiding the recommended rest period of each area is part of the life cycle of a sheep parasite known as the barber pole worm. The specific concern of graziers around which grazing plans in the Northeast are designed is the barber pole worm or H. contortus. *H. contortus.* It lives in soils in humid climates such as New York State. Barber pole worm can climb up the stems of vegetation cut short and, while grazing, be ingested by sheep. From there it makes its way to the sheep's 4th stomach where it acts as a parasite. It has a life cycle of 40 days; thus, a clean pasture, or pasture

[1] The internal parasites of sheep are not zoonotic and therefore a threat only to the health of sheep.

that will not contain barber pole worms, can only be achieved with rest periods of 40+ days to avoid reinfection through ingestion of larvae. However, in effective grazing regimens with parasite-resistant sheep flocks, exceptions to the 40-day rule can be made by the flock manager if the vegetation pressure is too high to adhere to a 40-day rest period before re-grazing.

Guiding the recommended grazing period is another aspect of sheep health. The recommended grazing period for any given area of a solar array is not to exceed 4 days. The flock manager will determine the right grazing period for the sheep within the 4-day allowance. This decision is determined typically by the quantity of vegetation in the area, the quality of vegetation available and other pasture or flock management goals. Once the sheep are moved to a new paddock, the grazed area is to be rested (i.e. not grazed) for 40 or more days before the flock returns to it.

2.4. Additional Details

Construction of the solar array will initially reduce the percent vegetation coverage in newly commissioned solar sites. Full vegetation coverage cannot be expected in the first 1-2 years. Our estimate for New York State solar sites is to adjust coverage expectations down by 15 to 35% during those first couple of years. This number will be adjusted upward as reseeding efforts take effect. Because full vegetation coverage is possible in and around the panels, there should be no reduction in the productivity of the solar site as compared to a traditional pasture once the site has recovered from construction. This grazing plan accounts for changes in growth using systematic forage testing in order to calibrate the grazing schedule with the forage or food availability for the flocks.

The project also consists of access roads, inverter pads and other site infrastructure that may consume a few percent of the area within each pod and effectively reduce the overall vegetation cover of the area. This acreage should be estimated and considered separately for each individual paddock by the flock managers.

As previous management regimes for solar sites might consist of hay fields, crop fields, marginal pastures or brush areas, the vegetation coverage is expected to be heterogeneous after installation is complete. Vegetation sampling must be performed following construction in order to determine sheep stocking rate and density, which is a requirement prior to establishing a grazing rotation. Tabular dry matter and nutrient values as they are published for uniform stands of established crops, hay field or other, are not adequate for evaluating solar array site vegetation for grazing. A detailed organic matter (OM) vegetation sampling protocol is published on the American Solar Grazing Association (ASGA) website [www.solargrazing.org]. The grazing rotation will largely depend on the amount of forage dry matter (DM) growing within the individual areas. Flock managers may perform vegetation sampling at regular intervals each season to analyze the nutritional value and quantity of the forage. This will allow for adjustments to the planned grazing rotation.

Forage analysis laboratories such as Dairy One provide detailed analyses that can be used to calculate the available DM per grazing paddock from submitted OM samples. Dry Matter is the percent plant weight not including water content. These DM values are necessary to establish the amount of available feed for sheep, and eventually the sheep stocking rate and density. Typically, pasture DM values in the Northeastern US for well-maintained pastures are between 18-25%, depending on the season. Pasture utilization should be between 70 and 85% to ensure optimal regrowth and animal nutrition. Thus, pasture refusals (uneaten vegetation remaining after grazing) should be part of the calculation and should be between 15% and 35%. Trampled vegetation is also included in refusals and is a normal part of the regenerative process, feeding the soil.

It is recommended to graze uniform animal groups such as: dry (non-lactating) ewes, open (non-pregnant) ewes, ewes in their early stages of pregnancy, yearling ewes or growing lambs of at least 60 lb. Alternatively, 50% of their mature body weight in case of small breeds. In the case of groups of growing lambs, the lambs should be of the same sex or the males neutered.

Depending on the breed and uniformity of the group of sheep, an average weight for the individual animals in the flock can be determined.

Table 2 gives an overview of BW (body weight) and feed intake across popular Northeastern sheep breeds. According to NRC nutritional requirements for small ruminants (NRC, 2007), daily DM consumption per animal can be estimated as a percentage of bodyweight.

Table 2. Body weight and feed intake.

Breed	*Stage of production*	*Body weight, lbs*	*Feed intake, DM %BW*	*Feed intake, lbs DM*
Katahdin hair sheep	Growing lamb, 50% mature BW	65	2.5	1.6
	Yearling	110	3.0	3.3
	Open, dry ewe	130	3.5	4.6
Polypay composite	Growing lamb, 50% mature BW	80	2.5	2.0
	Yearling	130	3.0	3.9
	Open, dry ewe	160	3.5	5.6
Texel	Growing lamb, 50% mature BW	90	2.5	2.3
	Yearling	150	3.0	4.5
	Open, dry ewe	180	3.5	6.3

These calculations can be used to determine the optimal number of sheep per paddock according to body weight and stage of production. By using this with the chosen grazing rotation days (or rest period), the stocking rate (the necessary sheep number for the calculated grazing time within each paddock) can be calculated. Once the stocking rate is determined, a grazing plan can be established (see Table 1).

Forage Species:

Soil testing will be performed at the Morris Ridge Solar project site before the commencement of grazing. The soil testing will inform the species suitable for seeding on the site. A typical pasture blend for solar sites would include 60-70% grasses [2-4 species that are regionally adapted, meet solar site height criteria and are selected for grazing suitability], 30% legumes [2-4 species that meet the above criteria] and up to 10% forbs [broadleaf plants that are tolerant to grazing, regionally adapted, non-toxic to sheep and contribute to the site's biodiversity]. The exact seeding rates and sequence will be determined from the soil testing results and information about current crop production across the project area. Any reseeding, which is a typical part of pasture maintenance, should be accomplished with an eye towards maintaining a rich blend of grazing friendly, solar compatible, pollinator friendly species.

In addition to this, the seeding of various establishment species may be recommended to reduce soil erosion and serve as nurse crops to complement the perennial solar site pasture mix recommended above. The establishment species would be installed prior to the start of Project construction, if appropriate.

Typically, well managed Northeast pastures can achieve yields above 2,500 lbs DM per acre. The yield discussed above is substantially lower; as it is expected that the solar array pastures will take time after establishment to reach their full potential. It is necessary to plan a grazing rotation prior to the grazing season, which would be used to guide a flock manager's rotation plan. The flock manager would then use his/her own experience and observations to decide on a daily basis if the rotation plan is reasonable and responsible, and to make necessary adjustments in rotation days and stocking rates.

Two examples of common adjustments to rotation plans include:

- First, in late spring after rain events and with the warming weather, stocking rates may have to be increased to be able to clear the vegetation growth.
- Secondly, in the summer, sheep may have to be moved from paddock to paddock faster than they were in spring or fall due to the slowed growth of cool-season vegetation.

Predator Protection:

Based on the final facility design, if any culverts are determined to require predator barriers to protect grazing sheep, appropriate features will be added such as culvert grates, an example of which is shown below. Note that these barriers would only be required if a culvert of sufficient size is constructed that may allow predators such as coyotes to enter grazing areas.

3. Animal welfare

Regardless of season, ad libitum clean and fresh water access is crucial for animal welfare (NRC, 2007). Site-specific amenities like well water or connection to municipal water lines are ideal, but transported water is typical of solar grazing operations. Prior to the commencement of grazing, suitable fresh water sources will be identified for the project site. Municipal water is not currently available to the project site; therefore, sources that will be considered include existing wells, new wells, existing ponds, or the use of water tanks on-site that are filled by fresh water transported to the site via truck.

The total number of sheep anticipated for this project (3,000-3,500) will be broken into 6 sub-flocks, one per pod. If feasible, a well or water source will be available for each of the six pods. It is anticipated that the wells or other water source will tie into 1-inch plastic irrigation line that lays on top of the ground and can reach each paddock in the array. Watering troughs will tie into this and the line can be drained in the fall and remain in place for the winter.

For sheep of the recommended production stages (non-lactating and > 60 lbs growing lambs), water requirements are very low in spring and fall, and higher during the summer months. Typically, dry, non-gestating ewes will consume between 5 and 10 % of their body weight in water daily. Each well/water source will likely be serving up to 400 to 600

sheep, and should not need to draw more than 500-600 gallons a day in the hottest part of the summer. In early spring and late fall, the sheep will need close to no water from the wells/water source.

A map of the preliminary water sources that are being considered is included as Figure 2.

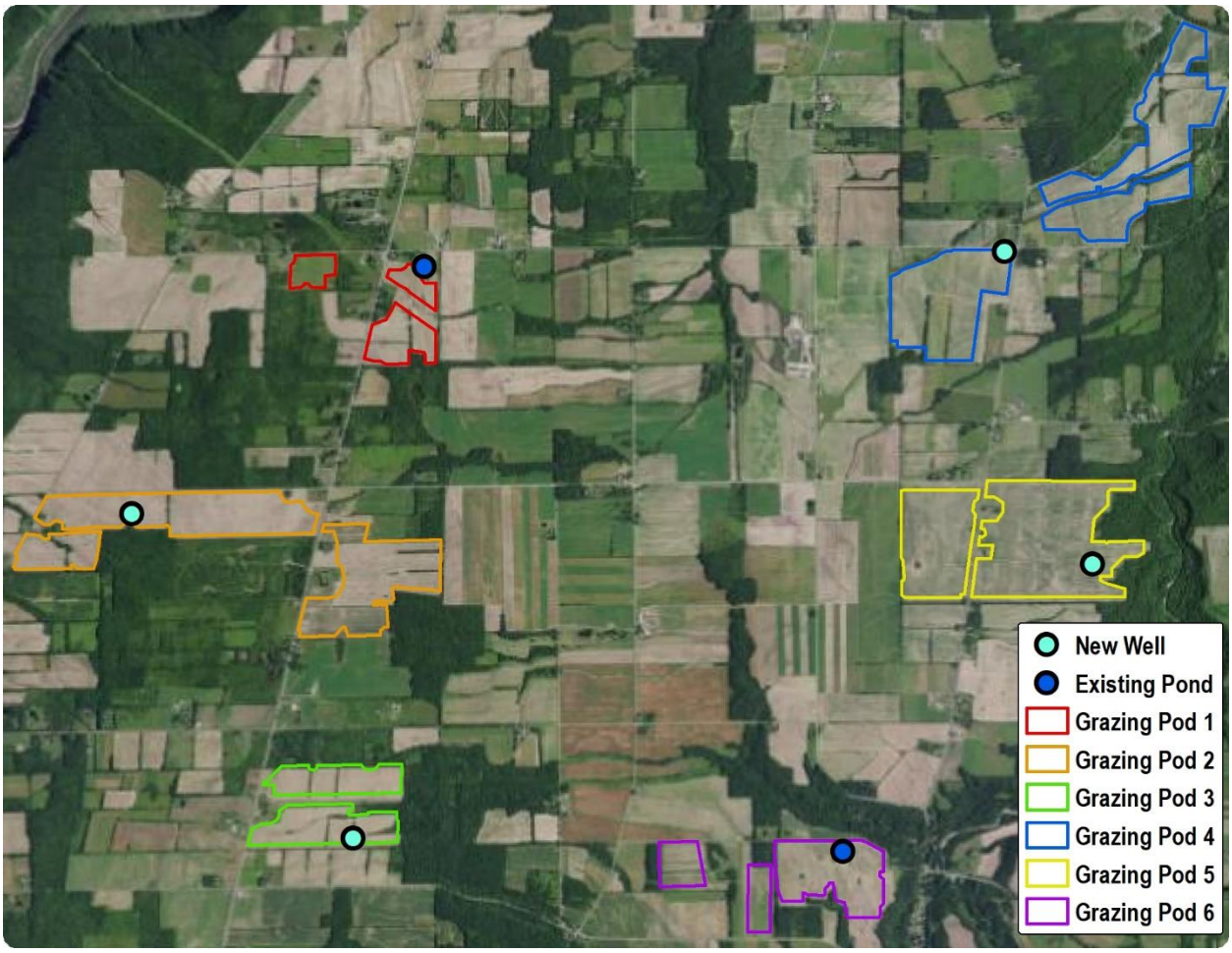

Figure 2. *Morris Ridge Project Site Layout including pods and the location of water sources (new wells and existing ponds) under consideration. Please note that this is preliminary and not the final design.*

Granulated mineral feed (Cargill, 2019) must be available ad libitum and contain adequate concentrations. This is an important animal welfare and nutritional requirement that cannot be overstated. Mineral feed should be offered in troughs that can be moved with the flock according to the rotation and rotation days. Mineral feed is specially blended and commercially available for sheep producers.

Sheep will be visually inspected on every rotation day by the flock manager. Moving the flock(s) to their next paddock is a great time to seek out, monitor, and care for any sheep that require it.

A closer inspection of each member of the flock is recommended at regular intervals (every 6 weeks on site). This inspection is only possible with the use of a handling system. A well thought-out handling system will be an essential tool for the flock manager. Handling systems for sheep can be portable or permanent.

The handling system can be located at a central location for each pod and be permanent, or it can be collapsible and transported on a trailer. Either way, the possibility to gather the flock(s) to perform management tasks at any given time throughout the grazing season must be ensured. The system must allow gathering, leading in a single-file line through a treatment chute, stopping, and sorting of sheep. There are several commercial manufacturers of these systems available in the US, including Sydell, Premier 1, and D-S livestock.

Whatever the flock managers at the project choose, there will be areas available to dedicate to a handling yard in each pod. Handling yard siting within each pod can be decided once the final civil layout is made.

Animal health and well-being:

Each spring, before the flocks begin the grazing season, certain protocols are recommended to ensure they are in optimal health before their work at the solar site begins.

Sheep care and protocols should include, and can be done in a handling system chute:

- Feet must be checked and trimmed
- Ear tags replaced or added, in compliance with USDA regulations
- Wool sheep must be shorn
- Body-condition scored before moving on site. This is a measurement that can easily be performed in a chute on-site and is part of normal management chores. It provides information about the nutritional and health status of any animal on site and can be used to adjust the grazing rotation.
- Sheep should be individually handled and scored using the FAMACHA (FAffa MAlan CHArt) protocol, a visual inspection of the blood vessels under the lower eyelid. FAMACHA scoring is a standard practice in the sheep industry developed in South Africa to promote more effective practices for management of internal parasites that cause anemia and, sometimes, mortality.
- In compliance with FAMACHA protocols, sheep that score high should be treated with a commercially available de-wormer 24 hours prior to entering the pastures every season. Prior to being moved onto the solar site, the sheep should be kept in a dry-lot and be fed hay after deworming. This practice prevents reinfection of the sheep [from internal parasites: again, not a zoonotic concern].

Approximately every six weeks at the solar array the flocks should be run through the handling systems with the following objectives:

- FAMACHA (Wyk and Bath, 2002),
- 5-point checks (Bath and van Wyk, 2009) and parasite monitoring or treatment.

4. Conclusion

A successful grazing rotation on large solar sites with sheep is based on the following:

- Initial, planned grazing rotation
- Experience and ability to observe when the rotation days and stocking density must be adjusted throughout the season
- A well-managed and clean, healthy flock deployed on pasture
- Stringent treatment protocols for flock specific health issues
- Fulfilled nutritional requirements
- Access to mineral feed and clean and fresh water 24/7
- Pasture hygiene (limited fecal contamination, moving of high frequency areas like water and mineral)
- Health checks on every rotation day
- Well-designed handling systems for 6-week animal checks and parasite monitoring and treatment

At the Morris Ridge Solar project, we anticipate the flock managers will follow these protocols and achieve success.

5. Additional Terms

Forage: (1) Edible parts of plants, other than separated grain, that can provide feed for grazing animals, or that can be harvested for feeding. Includes browse, herbage, and mast. (2) The material found, harvested and consumed by livestock themselves that fulfills their nutritional needs. Credit Oregon State Animal Science Dept & Purdue University Extension

Forage Mass: The total dry weight of forage per unit area of land, usually above ground level and at a defined reference level. Credit Oregon State Animal Science Dept

Paddock: A relatively small subdivision generally fenced (permanently or temporarily) and used to control livestock grazing. Credit Purdue University Extension

Pasture: A grazing management unit, enclosed and separated from other areas by fences or other barriers, that's devoted to producing forage for harvest, primarily by grazing. Credit Purdue University Extension

Refusals: Forage remaining on the land after grazing.

Rest: To leave an area of grazing land ungrazed or unharvested for a specific time, such as a year, a growing season, or a specified period required within a particular management practice. Credit Oregon State Animal Science Dept

Stocking rate: Is the relationship between the number of animals and the size of forage resource on which they are placed. It is typically calculated as the amount of available forage divided by pounds eaten per month. Credit, University of Florida Extension.

Stocking Density: The number of animals on a part of pasture for a certain portion of time. Credit, University of Florida Extension.

OM: Vegetative Organic matter: Everything contained in a feed or forage sample including the water.

DM: Dry Matter: Dry Matter represents everything contained in a feed sample except water; this includes protein, fiber, fat, minerals, etc. In practice, it is the total weight of feed minus the weight of water in the feed, expressed as a percentage. It is determined by drying the feed sample in an oven until the sample reaches a stable weight. Credit University of Georgia Extension

Literature

Bath, G. F., and J. A. van Wyk. 2009. The Five Point Check© for targeted selective treatment of internal parasites in small ruminants. Small Ruminant Research 86(1):6-13. doi: https://doi.org/10.1016/j.smallrumres.2009.09.009

Cargill. 2019. Cargill Lamb & Sheep Mineral Premix, http://blogs.cornell.edu/newsheep/management/feeding/agway-sheep-mineral-mix/.

HODGSON, J. 1979. Nomenclature and definitions in grazing studies. Grass and Forage Science 34(1):11-17. doi: 10.1111/j.1365-2494.1979.tb01442.x

NRC. 2007. Nutrient Requirements of Small Ruminants: Sheep, Goats, Cervids, and New World Camelids. The National Academies Press, Washington, DC.

Wyk, J. A. V., and G. F. Bath. 2002. The FAMACHA system for managing haemonchosis in sheep and goats by clinically identifying individual animals for treatment. Vet. Res. 33(5):509-529.