NEEDS ASSESSMENT AND FINANCIAL FEASIBILITY OF SOLAR SHEEP GRAZING COOPERATIVES IN THE NORTHEAST UNITED STATES

A Thesis

Presented to the Faculty of the Graduate School

of Cornell University

In Partial Fulfillment of the Requirements for the Degree of

Master of Science

by

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May 2023

ABSTRACT

Increasing public policy support for solar energy production in the United States provides opportunities for farms to expand into vegetative management services for array operators and remediates some concerns associated with the loss of farmland. A farmer-owned solar grazing cooperative is examined to understand the potential for transaction cost savings of collective action. A needs assessment survey to current and prospective sheep farmers demonstrates sufficient interest to explore a cooperative business model for coordination across farms and solar sites. A detailed analysis of the costs associated with contract negotiation, mobilization, and shepherding services identifies minimum lease payment rates required from solar array operators for financial feasibility. Profit margins and returns on investment suggest competitive returns to alternative investment opportunities and where cooperative returns are at or nearly twice as large as those from individual action, but with results highly sensitive to lease payment rates secured.

BIOGRAPHICAL SKETCH

Yunjie Li is currently in her second year of study in Applied Management and Economics at Cornell University. In May 2023, she will graduate with a Master of Science degree, with a focus in the food and agriculture economics concentration. She received a Bachelor of Arts degree from Occidental College, with a double major in Mathematics and Economics. Summer has demonstrated great passion in economic research. During her two-year program, she also possessed an interest in finance and took a number of classes in Johnson Business School at Cornell. In the summer of 2022, she worked with an economic consulting firm, responsible for qualitative research and quantitative data analysis on international litigation cases. The experiences in and outside of school provided her with valuable theoretical knowledge, analytical skills, and research ability. Other than academic and work life, she enjoys painting, hiking and snowboarding in her spare time.

ACKNOWLEDGMENTS

I would like to express my deepest appreciation to my committee chair Prof. Todd Schmit, who never failed to guide and inspire me throughout my entire research length. He has demonstrated as an exceptional researcher and economist, with passion, intelligence, and academic rigor, always encouraging and supporting me to progress and become a better researcher. My work would not have been possible without the nurturing of Prof. Schmit. I would also like to extend my gratitude to Extension Associate Roberta (Bobbie) Severson, who offered tremendous help to me during my research. It was a great delight working with her in the survey analysis process; I very much appreciate her valuable advice and encouragements. I would also like to extend my sincere thanks to my minor committee, Prof. Calum Turvey, for providing valuable feedback and suggestions in my thesis defense. Special thanks to my parents, who have always blindly believed and rooted for me, making it possible in the first place for me to pursue my dream in economics. Funding for this research was made possible by the U.S. Department of Agriculture's (USDA) Agricultural Marketing Service through grant 21FSMIPNY1002-00. Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the USDA.

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1. Introduction

The Northeast region of the United States has experienced a significant policy shift towards solar energy in recent years as states in the region aim to reduce their carbon emissions and transition to a cleaner energy system. With the increasing demand in solar energy, farmland becomes one of the most suitable targets for solar developers as they are generally open with ample sunlight, flat, and closer to electricity infrastructure, all of which are essential and cost-effective for solar companies (Pederson 2021). However, solar companies' interests in farmland as their source for solar energy production raise concerns about the permanent conversion of farmland from agriculture use. According to Mow (2018), solar energy capacity in the year 2030 could reach 329 gigawatts (GW), which would require approximately 1.8 million acres of land in the United States. While this takes up only 0.1% of total farmland, "there is growing concern over the land use impacts of solar energy development on fertile agricultural land, which can consequently displace farming and food production" (Mow 2018). Acknowledging the potential harm in agriculture production and farm viability, many states have proposed policies to address this issue (Mow 2018).

The system of agrivoltaics is a growing industry that can be introduced to, in part, balance the demand for agriculture production and renewable energy goals. Agrivoltaics, also known as co-location, refers to agricultural production, such as crops or livestock, raised under or near solar panels. As a major category of agrivoltaics, pairing livestock grazing and solar energy production is regarded as an efficient way to benefit both farmers and solar developers at the individual and industry levels. The emphasis on solar energy resources and best management practices for agrivoltaics presents a unique opportunity to revitalize the sheep sector in many regions in the United States.

Grazing sheep under solar arrays to control vegetative growth increases farm income derived by providing vegetative management services and drives a need for more sheep. Such an increase in supply calls for additional players in the marketplace and a coordinated and collaborative response to take advantage of the opportunity in a way that maximizes financial returns to sheep farms.

Research previously conducted at Cornell University explore the potential for sheep farmers in New York State (NYS) to offer grazing services (Kochendoerfer and Thonney 2021). According to data from the New York State Energy Research & Development Authority (NYSERDA), an estimated 10.6 GW of solar installations are anticipated to be in planning or production phases by 2030, which could result in the conversion of over 68,000 acres of land to utility-scale solar. If fully utilized for grazing and assuming a stocking rate of 3 sheep per acre, an additional 204,000 sheep would be required to maintain the land (Kochendoerfer and Thonney 2021). To put that in perspective, NYS is currently home to about 79,000 sheep, implying a sheep farming industry growth of 258% to meet new grazing demand (USDA 2022).

Discussions with the American Sheep Grazing Association (ASGA) reveal that many individual farmers lack the necessary resources and negotiating skills to secure grazing contracts with solar array operators, and these operators prefer to deal with a single agent for contractual agreements and grazing logistics rather than multiple farmers. Negotiating individual agreements at scale is highly inefficient, creating significant barriers to entry and reducing financial feasibility.

Cooperatives remain relevant and significant in numerous industry sectors, but especially in agriculture. The organizations are characterized by member owners who support the firm and possess formal rights to its assets, including control rights and access to residual earnings (Chaddad & Iliopoulos 2012). Such businesses are designed to promote the collective well-being of their

members, providing both monetary and non-monetary benefits. For example, through an online choice experiment with dairy farmers in the United States, Munch et al. (2021) estimate that beyond financial returns cooperatives bring to their members, members additionally value their control rights equivalent to 2.3% of their average milk price. Ultimately, the decision to join a cooperative depends on whether an individual believes that membership will result in better outcomes (broadly defined) compared to alternative strategies.

At this point, there is currently no contemporary research that examines the implications of co-locating sheep farming with solar energy developments through a farmer-owned cooperative grazing model. This research aims to provide a needs assessment for solar grazing informed by existing sheep and non-sheep farmers and critical insights into the financial requirements for a successful cooperative business; i.e., demonstrating the cooperative's ability to provide benefits to sheep farmers that go beyond what they could achieve as individuals.

We continue with a description of the farm survey data and the results from it. This is followed by a description of the financial feasibility model and empirical results. We close with conclusions, implications, and directions for future research.

2. Survey Data

To have a better understanding of the demand for and potential development of solar grazing cooperatives, a needs assessment survey was administered to gather input from current and prospective sheep farmers.[1] The survey was designed as a convenience sample as a predetermined population of respondents was unavailable. The survey was advertised through multiple communication channels and was pre-tested by the research advisory team including sheep farmers and livestock extension educators for clarity, as well as by the research team for style and flow.

[1] The full survey is available in Appendix 2

Opened online via Qualtrics on September 25, 2022 and closed on January 15, 2023, the survey was promoted three times during the open window of time. The survey was available both online and through hard copy (paper) versions. In some cases, educators worked with a single farmer or groups of farmers to assist in completing the survey online or had producers complete the survey in hard copy to which it was then transferred into the Qualtrics version. It was promoted to extension educators representing 11 universities located in New England, New York, Ohio, and Mid-Atlantic states for further dissemination. It was also promoted through all Cornell Cooperative Extension (CCE) offices in NYS, through 13 sheep industry associations in the Northeast, and distributed nationally by the American Sheep Grazing Association (ASGA) and American Sheep Industry Association (ASIA). The Qualtrics link and other online resources (i.e., a hard copy version of the survey and promotional advertisements) were also disseminated through press releases sent to agriculture trade publications and individual farmers through a database constructed of 1,700 email addresses of sheep farmers located within 11 Northeast states.

To prevent noise from survey scammers, four screening questions about sheep farming were required to be answered correctly before moving to the formal portion of the survey. Respondents with familiarity in sheep farming would easily know the answers. A financial incentive was also provided: persons completing the survey and sharing their name and email address were enrolled in a random drawing for one of three $100 Amazon gift cards.

At the beginning of the survey, respondents selected one of eight descriptions of themselves that that most closely characterized them:

1. I am a full-time sheep farmer grazing my sheep under solar arrays,
2. I am a part-time sheep farmer grazing my sheep under solar arrays,
3. I am a sheep farmer grazing my sheep and sheep I lease from others under solar arrays,
4. I lease some or all of my sheep to another person who grazes them under solar arrays,
5. I am a sheep farmer not currently grazing under solar arrays but am interested in exploring,
6. I am a sheep farmer and am not interested in grazing my sheep under solar arrays,

7. I am a non-sheep farmer interested in grazing sheep under solar arrays, and
8. I am a new or beginning farmer interested in sheep farming and grazing under solar arrays.

Depending on the nature of the survey question, either a subset of or all respondent types were presented questions. For example, inquiries about current solar grazing practices, distances to solar sites, and time demands were limited to respondent types 1, 2 and 3. As the survey continues, respondents were directed to different questions, as appropriate.

A total of 1,481 survey responses were received. Of these, 154 were pretesting responses, 474 failed the screening questions; 128 passed the screening questions but answered no others, and 122 passed the screening questions and gave their respondent type but answered no others. Hence, 603 observations (41%) are usable for analysis. The survey data contain 176 variables particularly relevant to solar sheep grazing (e.g., contract negotiation, mobilization, and shepherding services).[2] The breakdown of all respondents by type is shown in Figure 1.[3]

The largest type of respondents is sheep farmers not currently grazing under solar arrays but are willing to explore, taking up to 47% of the total sample. The next largest type are full-time sheep farmers already grazing under solar arrays. The large majority of responses show interests in exploring solar grazing business (90%), a result not surprising from this type of survey (i.e., sample selection bias). However, the interest in grazing across a range of respondent types (i.e., current solar graziers, sheep farms not solar grazing, and non-sheep farmers interested in exploring solar grazing) is useful to gauge industry interest and informs cooperative development processes.

[2] Additional questions/variables on potential cooperative services including collective marketing, slaughter, processing, and branding activities are also included and will be examined in future research.

[3] Some questions ask for specific numerical answers; e.g., farm size by head of sheep, travel distances and hourly demands for different solar grazing activities. Values entered may appear unreasonable given other answers and produce questionable outliers in the data. We define outliers as data points that are plus/minus two standard deviations above/below the mean; i.e., beyond the 2.5 and 97.5 percentiles of all observations. Outliers are deleted prior to the analysis using the *winsor2* command in Stata.

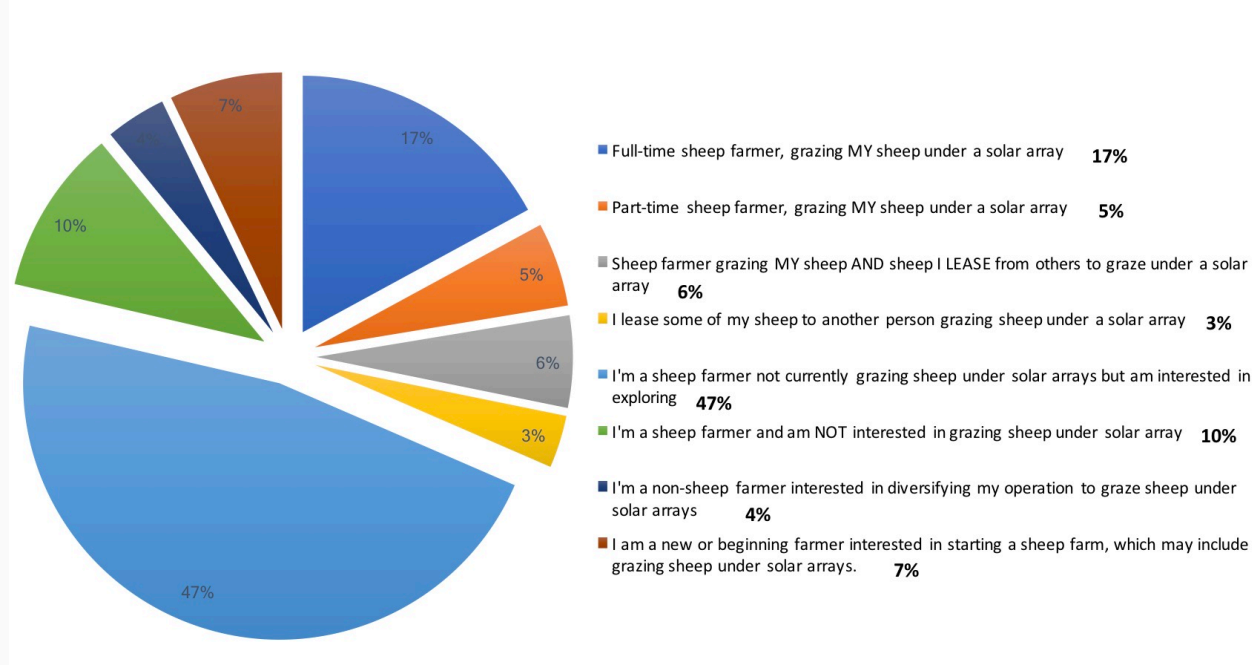

Figure 1 – Respondent Farming Status Distribution (N = 603)

The focus of our analysis is on the Northeast U.S.; however, the survey was available broadly and included valid responses from 44 different states. Respondents are categorized by region: the Northeast (N = 392) and Non-Northeast (N=211). The Northeast region is comprised of 11 states: New York, Maine, Massachusetts, Vermont, Connecticut, New Hampshire, Pennsylvania, Maryland, New Jersey, Delaware, and Ohio, and the District of Columbia. Summary statistics computed from current grazier respondents on the number and size of solar arrays grazed and the distance and time demands for different grazing activities (e.g., mobilization and shepherding) are also used to inform baseline parameters of the financial feasibility model.

2.1 Survey Analysis

The needs assessment analysis presents useful insights about farmers' opinions towards different aspects of solar grazing. Given differences in sheep farming practices and utility-scale solar energy installations across the country, we limit our focus to the Northeast region subsample. Further we

aggregate the eight respondent types into four groups (A, B, C, and D) by the nature of their solar grazing activity and interests:

A. Sheep farmers whose sheep graze under solar arrays currently (respondent types 1, 2, 3, and 4),
B. Sheep farmers not grazing sheep currently, but are interested in pursuing it (respondent type 5);
C. Existing, new, or beginning farmers without sheep considering solar sheep grazing (respondent types 7 and 8); and
D. Sheep farmers not interested in solar sheep grazing (respondent type 6).

Several questions explore industry need for a farmer cooperative to provide alternative shared services and asks the respondents to assess their likelihood of joining a cooperative to utilize these services.[4] For example, the questions for contract negotiation services are:

- In your opinion, what is the industry need for a cooperative or other business owned by multiple farmers to *negotiate contracts* between and site operator and whomever is providing vegetative management services? (not needed, somewhat needed, needed, very needed, or extremely needed), and
- How likely would you utilize a cooperative or other business owned by multiple farmers to *negotiate contracts* between site operators and persons providing vegetative services if provided for a reasonable fee? (not likely, somewhat likely, likely, very likely, and extremely likely).

Scores were assigned from 0 (not needed/likely) to 4 (extremely needed/likely), incremented by one for each ascending order of need/likelihood. Average scores and the percent of respondents rating services needed/likely or above are computed by group and service component (Table 1). Average industry scores were highest for farmers experienced with solar grazing, demonstrating collaborating on services is incrementally valuable to them; i.e., they identify the potential for transaction costs savings through combined efforts. Such results may be particularly useful in communications with existing sheep farmers but inexperienced in solar grazing as their scores were generally the lowest among those considering solar grazing.

[4] Open ended answers for these questions under "It depends, briefly describe" are excluded from the quantitative analysis here but are captured in other written summaries associated with this research.

Table 1 – Industry need for and likelihood of individuals using cooperative grazing services, Northeast Region, by group.

		Contract Negotiation				Mobilization				Shepherding			
		Industry[b]		Individual[c]		Industry		Individual		Industry		Individual	
Group[a]	N	Avg.	Need+	Avg.	Likely+	Avg.	Need+	Avg.	Likely+	Avg.	Need+	Avg.	Likely+
A	75	**2.09**	69%	**2.24**	**70%**	**1.86**	**59%**	**2.02**	**65%**	**2.00**	**72%**	**2.03**	**66%**
B	229	**1.98**	65%	1.70	43%	1.61	48%	1.27	36%	1.64	52%	**1.44**	41%
C	37	1.89	**73%**	**2.05**	**62%**	**1.81**	**62%**	**2.00**	**64%**	1.39	46%	1.17	35%
D	51	1.86	**71%**	0.97	26%	1.66	57%	1.28	31%	**2.03**	**71%**	1.19	**44%**

Source: Author survey

[a] Respondents by group include: A = Sheep farmers whose sheep graze under solar arrays currently; B = Sheep farmers not grazing sheep currently but interested in pursuing; C = Existing, new, or beginning farmers without sheep considering solar sheep grazing; and D = Sheep farmers not interested solar sheep grazing.

[b] The industry scores represent the average industry need (Avg.) for a cooperative to provide the service of respondents in that type, where not needed = 0, somewhat needed = 1, needed = 2, very needed = 3, and extremely needed = 4. Need+ represents the percent of respondents that answered needed or higher.

[c] The individual scores represent the average likelihood that respondents would use those services of the cooperative, where not likely = 0, somewhat likely = 1, likely = 2, very likely = 3, and extremely likely = 4. Likely+ represents the percent of respondents that answered likely or higher.

For those participating or are interested in exploring solar grazing (A, B, C), mobilization and shepherding service scores are lower than for contract negotiation (Table 1). This is consistent with concerns expressed elsewhere regarding animal health concerns for comingling of sheep. Furthermore, for some there is resistance to having others monitor their sheep – an aspect they are well familiar. In any event, scores above one, and frequently near or above two, demonstrate sufficient interest in exploring cooperative business models for provision and execution of collaborative grazing services. The relatively high industry need scores for contract negotiation and shepherding by group D is recognition that these services would be valuable for the industry even though they have no interest in participating in solar grazing themselves.

2.2 Barriers and Challenges

Barriers in solar grazing and challenges in owning sheep were asked of all survey respondents. Using a similar scoring system as above, average scores across potential barriers, differentiated by group, are shown in Table 2.[5] Experienced solar graziers are primarily concerned with travel distances (and time demands) for monitoring sheep and time and equipment constraints for supplemental mowing. Existing sheep farmers not solar grazing see access to water for their sheep, travel distances, and the cost of liability insurance as their primary constraints. New and beginning farmers also recognize capital constraints in terms of needed trucks and trailers.

Availability of and access to water is part of the contract negotiation process, particularly as it relates to who is responsible for providing water to the sheep and how often. In many cases, drilling a well to access water on site for the sheep is necessary and comes with a significant cost (at least for the initial grazing season on site). The relatively low value of this barrier for current solar graziers likely implies that this is provided by array operators.

[5] Potential barriers (challenges) were enumerated as "not a barrier (challenge)" = 0, "small barrier (challenge)" = 1, "medium barrier (challenge)" = 2, and "larger barrier (challenge)" = 3.

Table 2 – Barriers to solar sheep grazing, average scores by group, Northeast region.[a]

Barrier	All N = 392	A N = 75	B N = 229	C N = 37	D N = 51
Easy access to water	**1.79**	1.16	**2.01**	**1.78**	1.73
Travel distance to monitor sheep	**1.79**	**1.50**	**1.94**	1.50	**1.79**
Cost of insurance	**1.77**	1.38	**1.89**	**1.83**	**1.79**
Insurance requirements	1.68	1.24	1.84	1.43	**1.79**
Negotiating the contract	1.62	1.08	1.79	1.62	1.70
Time on site to mow or trim	1.62	**1.44**	1.74	1.33	1.54
Access to person willing to lease my sheep	1.58	0.97	1.75	1.65	1.67
Time on site to monitor sheep	1.52	1.24	1.60	1.32	1.73
Lack of knowledge about solar grazing	1.52	1.23	1.58	1.62	1.58
Equipment needed to mechanically mow or trim	1.50	**1.40**	1.55	1.49	1.44
Access to handling equipment at the solar site	1.48	1.10	1.51	1.64	**1.82**
Identifying the array operator	1.43	0.77	1.69	1.16	1.43
Access to trucks/trailers to move sheep	1.14	0.96	1.13	**1.73**	0.98

Source: Author survey, highest scores in bold font.

[a] Respondents by group include: A = sheep farmers whose sheep graze under solar arrays; B = sheep farmers not grazing sheep currently but interested in pursuing; C = existing, new, or beginning farmers without sheep considering solar sheep grazing; and D = sheep farmers not interested solar sheep grazing. Average scores are computed where not a barrier = 0, a small barrier = 1, a medium barrier = 2, and a large barrier = 3.

Liability insurance requirements are likely beyond insurance limits currently used by many farm operators, accordingly the additional cost can be a significant issue for farmers, and was also scored relatively high by group A. Monitoring sheep typically happens two times per week; with a grazing season around 27 weeks, this represents a significant cost in farmer time, fuel, and other expenses. The primary barriers align well with potential services offered by a cooperative: contract negotiation, group liability insurance, mobilization, and shepherding services.

When asked about challenges of owning sheep, group responses are more similar (Table 3); i.e., adequate financial returns, access to capital, and sufficient infrastructure are common challenges across farm production industries. Capital constraints associated with sheep farming are particularly important to recognize when considering cooperatives as a capital investment requirement of members is often an important part of the overall capitalization plan of the business. Mobilization and shepherding services require significant capital investments related to trucks, trailers, and fencing, along with the reinvestment of the depreciation of those assets over time.

Table 3 – Challenges to owning sheep, average scores by group, Northeast region.[a]

Challenge	All N = 392	A N = 75	B N = 229	C N = 37	D N = 51
Adequate profit margins	**1.88**	**1.37**	**2.07**	**1.89**	**1.72**
Money & capital to invest in sheep business	**1.77**	**1.47**	**1.84**	**2.19**	**1.55**
Access to facilities & buildings	**1.27**	1.20	**1.34**	**1.51**	0.86
Access to land	1.24	**1.30**	1.30	1.17	**0.94**
Access to machinery & equipment	1.16	1.15	1.18	1.46	0.88
Access to veterinary care	0.78	1.04	0.66	0.83	0.88
Overall knowledge of sheep management	0.62	0.99	0.44	1.03	0.56

Source: Author survey, highest scores in bold font.

[a] Respondents by group include: A = sheep farmers whose sheep graze under solar arrays; B = sheep farmers not grazing sheep currently but interested in pursuing; C = existing, new, or beginning farmers without sheep considering solar sheep grazing; and D = sheep farmers not interested solar sheep grazing. Average scores are computed where not a challenge = 0, a small challenge = 1, a medium challenge = 2, and a large challenge = 3.

As part of any cooperative development process, gauging interest in members taking on leadership and governance roles in the business is essential. Specifically, respondents were asked the following:

- If a cooperative or other business owned by multiple farmers was formed to provide assistance to farmers grazing sheep under solar arrays and strengthen the viability of the sheep farming sector, what is your interest in the following to support this effort?[6]

A set of interests, some limited to nonmember (customer) activities or being paid employees of the cooperative, are shown in Table 4 and average numerical scores presented by group. Some interests can be interpreted similarly; e.g., become a "member owner of the cooperative" and "become a part owner of the business", but also reflect the diversity of contemporary cooperative business models. For example, members are often (and correctly) described as member owners as they have ownership rights and responsibilities of the business; however, nonmember investment (say through a preferred stock offering that pays a dividend) is also possible (subject to the bylaws of the organization) that is also (and correctly) a form of ownership in the business.

[6] As part of the full survey, respondents were also asked about interest in cooperatives serving input supply and marketing functions for members. This question on interest in cooperative governance came at the end of the survey.

Table 4 – Interests in actions of the cooperative, average scores by group, Northeast region.[a]

Interest	All N = 392	A N = 75	B N = 229	C N = 37	D N = 51
Become a member-owner of a cooperative	**1.59**	**1.82**	**1.58**	**2.00**	**0.91**
Provide guidance & leadership to develop & launch the business	**1.38**	1.67	**1.37**	**1.60**	0.76
Be a "customer only" with access to services when needed	**1.36**	**1.90**	**1.20**	1.56	**1.00**
Become part owner of the business	1.23	1.70	1.12	**1.58**	0.66
Serve in a leadership capacity (director, officer, committee)	1.19	1.71	1.09	1.25	0.69
Be a paid contract service provider	1.14	**1.85**	0.96	1.32	0.66
Become part of the paid management team	1.09	1.61	0.92	1.20	**0.91**
Become an investor in the business	1.00	1.60	0.83	1.24	0.59
Become a paid employee	0.93	1.51	0.75	1.12	0.63

Source: Author survey, highest scores in bold font.

[a] Respondents by group include: A = sheep farmers whose sheep graze under solar arrays; B = sheep farmers not grazing sheep currently but interested in pursuing; C = existing, new, or beginning farmers without sheep considering solar sheep grazing; and D = sheep farmers not interested solar sheep grazing. Average scores are computed where not interested = 0, somewhat interested = 1, interested = 2, and very interested = 3.

It is perhaps not surprising that current solar graziers (group A) rate being a paid "contract service provider" for the cooperative relatively high given their current industry experience; however, they also rank second across all groups in terms of interests in becoming "member owners". Perhaps also consistent with their experience, they may recognize what they prefer to "do" and "not do" with respect to solar grazing and, therefore, rank highly being a (nonmember) "customer" of the cooperative's services based on what they most need. Perhaps most important is Group A farmers also have the highest interests in investing in the business, providing guidance and leadership on the development of the business, and serving in a leadership capacity after the business is formed (in member and/or paid management roles). Relevant experience is incredibly valuable to the development process of a new cooperative business and in using that experience to inform others who are considering being part of it.

While lower in relative magnitude, current non-solar grazing sheep farmers rank being a member owner of the cooperative and providing guidance and leadership through the development

process most important to them. Non-sheep farmers ranked being a member owner of the cooperative most important them as, perhaps, a reflection of less experience in sheep farming and the individual benefits they would receive by joining ownership with sheep farmers that have that wisdom to share. The lower interests scores for becoming an investor in the business may well reflect the capital constraint issues described above or perhaps to less interest in ownership through investment as opposed to ownership through use (patronage).

Generating adequate member equity support during the development of a cooperative often delays cooperative start-ups or even stops the process in its entirety. Accordingly, financial feasibility analyses, encompassing both operational and investment costs and returns to member investment is crucial in informing the development process early on.

3. Financial Feasibility

Financial evaluation is a critical component of the process of cooperative development as it informs potential investors and users of the business the expected profitability of the venture, the sensitivity of the results on key parameters, and compares differences in financial performance of the business through collaborative and individual action. In assessing the feasibility of a new solar grazing cooperative, we develop 10-year pro forma financial projections assuming a base set of input parameters based on credible sources.

The outputs of the financial modeling include standard financial statements: an income statement, balance sheet, cash flow statement. Sensitivity analysis on particular parameters is also conducted. The financial model summarizes financial performance by year based a comprehensive set of revenue, expense, and equity calculations. Each financial statement provides different, yet complementary, insights into the financial performance of a business.

The income statement (IS) presents revenues and operating expenses of the cooperative by year. In our setting, operational revenues are derived solely from lease payments solar array operators make to the cooperative for vegetative management services.[7] There are several operating and capital expenses related to the costs of services, management expenses, capital investment, and depreciation. Revenues and costs are a function of the growth of the business over time. Revenue less costs represent earnings before interests and taxes (EBIT) and subtracting EBIT by interest expenses related to loans generates profit before patronage.

Different from traditional corporations, profits generated in cooperatives do not all go to dividends and/or unallocated equity (i.e., retained earnings). The distributions of profits by cooperatives, as approved by the board of directors each year, can be paid out as dividends (generally uncommon), retained as unallocated equity, and/or distributed to members in cash and/or equity as patronage refunds based on member use (patronage) of the business.[8] In this case, patronage is determined by the number of sheep provided for grazing services.

Since cooperatives follow the IRS Subchapter T single taxation principles, not all earnings are included in the calculation of income taxes for the cooperative. In general, taxable income for the cooperative is computed as profit before patronage less cash patronage refunds, qualified stock patronage refunds, and nonqualified stock redemptions. In this way, net income is defined as profit before patronage less income taxes in each year. A profit margin (PM) and return on investment (ROI) are computed each year. PM represents net income divided by total revenue (i.e., lease payments) and ROI is net income divided by total investment (assets).

[7] The survey also includes components for cooperative input supply and collective marketing services. The financial feasibility of these business components, subject to farmer interest, is left for future research; however, starting with cooperative services limited to solar grazing is appropriate as a first step.

[8] Stock patronage refunds can be distributed in either qualified or nonqualified forms. The allocation affects to whom (the cooperative or the member) and when income taxes are paid. For ease of exposition, we assume all stock patronage refunds are qualified distributions, requiring a minimum cash distribution of 20% and for which members pay the income taxes in the year of distribution on both the cash and equity portions.

The balance sheet (BS) reports the cooperative's financial position in assets, liabilities, and member equities each year. In our case, assets include cash on hand, other short-term assets, land, buildings, and equipment. Total assets represent the sum of assets less accumulated depreciation. Liabilities include a working capital loan, a long-term loan (portion of initial capital investment), and, deferred revenues from grant funding (portion of the initial capital investment). Member equities include upfront membership stock/investment (with voting rights), qualified stock from retained patronage refunds, and unallocated equity (retained earnings). As usual, the amount of the cooperative's total assets is equal to its total liabilities and member equity.

The cash flow statement (CFS) is especially significant in assessing financial feasibility. The CFS reports net cash inflows/outflows each year, the net change in cash, and cash at the end of the year. Cash flows are reported separately for operating activities, investing activities, and financing activities. Operational cash flows include net income from operation, other income (e.g., grants), and changes in depreciation. Investment cash flows in our case are limited to the cash outflows from capital investment for equipment.[9] Financing cash flows relate to liabilities and member equity; namely, the change in long-term debt, cash patronage refunds, qualified stock patronage refunds redeemed, new member stock investments, and direct investments via grant funding in the base year. The net change in cash is computed as a sum of all changes in cash in the three sections. Cash at the end of the year is simply the net change in cash in that year plus the cash at the beginning of the year (or the end of the prior year).

As the financial distribution of profits is unique in a cooperative setting, end-of-year cash flows represent a particularly salient factor in evaluating the financial status of the business. Cash flows should be sufficient to distribute patronage refunds to members and redeem member equities

[9] We assume fully depreciated assets generate no residual cash flow from their disposition (sale).

as scheduled.[10] Accordingly, we define 'financial feasibility' such that end-of-year cash flows are positive by year two of the cooperative.[11] In so doing, the cooperative is in a healthy cycle to sustain the business and generate benefits to members in the long run.

Input Parameters

To generate reliable and informative results from the financial forecasting model, defining (and defending) numerous operational parameters is necessary. Below we present input parameters for the baseline model by revenue and by cost component related to contract negotiation, mobilization, and shepherding services provided by the cooperative (Table 5).[12]

The model includes a base year (year 0) where member recruitment is completed, the business is established, financial resources are obtained, a core management team and board of directors are functioning, and capital investments are completed prior to the first year of grazing services (year 1); i.e., there is no operating income in the base year. We assume that all costs incurred in the base year (operational and capital) are satisfied by upfront member investments (40%), loans (40%), and grant funding (20%).[13] We assume an 8% interest rate for the initial long-term loan associated with the capital investment and a 10 year loan term. The interest rate on the $250,000 annual working capital loan is 7%.

[10] We assume that retained patronage refunds are redeemed on a five-year revolving fund; i.e., first in, first out.
[11] For flexibility, we allow cash flows to be negative in year one up to the maximum of the working capital loan.
[12] The financial model is constructed such that an input parameter file is defined separately for easy customization of financial results with alternative parameter settings.
[13] In our application, the grant is a one-time payment in the base year (year 0). Following financial accounting principles, it is classified as "other income" in the financial statements and amortized over the length of time for which it is used for; i.e., it follows the same (8-year) depreciation schedule of the capital equipment. Therefore, it shows up in the income statement amortized over the first eight years of operation. It also shows up in the balance sheet as "deferred revenue", which offsets the income amount in the income statement. Since the grant is received as cash in the base year, there is a cash inflow in financing activities by the full amount. The amortized amount of "other income" is subtracted from the net income in cash flow statement in the section of operating activities.

Table 5 – Baseline input parameters for financial feasibility projections.

Parameters	Value
General	
Solar grazing land anticipated in 2021 (acres)	1,700
Penetration rate (percent)	8.4
Stocking rate (sheep/acre)	3
Length of grazing season (weeks)	27
Fuel price ($/gallon)	5.00
Average driving speed, mobilization/shepherding (miles/hour)	45
Annual inflationary cost rate (%)	2
Annual inflationary lease rate (%)	3
Supplemental mechanical mowing cost ($/hour)	60
Average time spent mechanical mowing (hours/acre)	0.5
Useful life of trucks & trailers (years)	8
Farm-to-truck ratio, farm-trailer ratio, truck-to-driver ratio	20/40/5
Annual truck maintenance cost ($/truck)	1,000
Annual trailer maintenance cost ($/trailer)	500
Core Management Team	
Chief Executive Officer ($/year)	65,000
Logistics Supervisor/Member Relations ($/year)	50,000
Contract Specialist/Array Marketing ($/year)	50,000
Sales/Marketing ($/year)	50,000
Accountant, Contract ($/year)	53,000
Member Directors (number)	5
Director compensation ($/year)	5,000
Benefit rate (%)	30
Investment & Equity	
Investment allocation, Grant/Loan/Member common stock (%)	20/40/40
Capital investment loan interest rate (%)	8
Loan amortizations term (years)	10
Base Year Investment, including Startup costs ($)	1,220,357
Working capital loan ($)	250,000
Working capital loan rate (%)	7
Allocated equity patronage refund revolving period (years)	5
Total members	358
Common stock member investment ($/member)	1,364
Contract Negotiation	
Farmer legal fees ($/contract)	380
Co-op efficiency, legal fees (%)	67
Farmer liability insurance cost ($/acre)	50
Co-op efficiency, cost per acre (%)	60
Mobilization	
Wage for truck drivers mobilization ($/hour)	65
Value of farmer's time ($/hour)	50
Small/Medium/Large farms without trailers (%)	60/40/0
Truck (large) cost for mobilization ($)	100,000
Truck fuel mileage (mpg)	10
Trucks for mobilization (% of truck fleet)	33
Medium trailer cost, 20-25 head capacity ($)	10,000
Large trailer cost, 70-75 head capacity ($)	20,000
Large trailers for mobilization (% of trailer fleet)	57
Annual farm payment for own mobilization, Medium ($/farm)	300
Annual farm payment for own mobilization, Large ($/farm)	450
Average mobilization mileage one way (miles)	90
Co-op efficiency mobilization (%)	75
Average within season mobilization (trips/year/flock)	1.125
Loading/Unloading time on site, farm/array (hours)	1

Table 5 – Baseline input parameters for financial feasibility projections. (cont.)

Shepherding, Fence installation	
Wage rate, shepherding services, fence installation ($/hour)	40
Truck (medium) cost for shepherding/fence install ($)	60,000
Trucks for shepherding/fence install (% of fleet)	67
Fuel mileage of truck, medium (mpg)	20
Average fencing perimeter, 2.67 acre paddock (ft)	1,294
Cost for single spike netting, 164' x 35" ($)	135
Average distance travelled to solar farm (miles)	90
Average shepherding visits (number/week)	2
Co-op efficiency rate, shepherding (%)	62.5
New fencing installation time (hours/acre)	1.0
Existing fencing repair and adjustment time (hours/acre)	0.5
Co-op efficiency rate, fencing (%)	80

3.1 Market Projection

Market projection of the demand for grazing services and the investment and labor inputs associated with it are determined for baseline revenue projections and solar grazing market penetration. Installed solar capacity in NYS as of quarter 4, 2021 was 3,381 MW; at an average rate of 6 acres/MW, this implies a solar array coverage area of 20,284 acres.[14] With a solar growth projection over the next five years of 4,877 MW, this implies a compound annual growth rate of 20%.[15] NYS renewable energy goals were used to determine growth rates for the rest of the 10-year projection.[16] Specifically, annual solar acreage growth rates (%) by year are set at: 20, 21, 22, 18, 14, 10, 6, 4, 1, and 1.

Kochendoerfer and Thonney (2021) estimate that approximately 900 acres of solar arrays were actively grazed by sheep in NYS in early 2021, but that it was expected to grow to 1,700 acres by the end of the year. Using this year-end figure, 8.4% of current solar acres are grazed by sheep (i.e., 1700/20284). We apply this percentage (or penetration rate) to the estimated solar acres, by year, in our projections.

[14] https://www.seia.org/state-solar-policy/new-york-solar
[15] $(((3381 + 4877)/3381)^{1/5}) - 1 = 0.20$.
[16] https://www.seia.org/state-solar-policy/new-york-solar

The New York Independent System Operator (NYISO) provides information on the projected distribution of solar arrays by size. Based on MWs of output and converting to acreage equivalents, 72% of solar arrays are classified as small (average 100 acres), 23% medium (average 200 acres), and 5% large (average 1,300 acres) (NYISO 2021). Total acreage demand and the distribution of arrays by size is used to project the demand for sheep and in understanding the kinds of arrays the cooperative will be servicing, respectively.

The number of sheep needed for grazing is based on an average stocking rate of 3 sheep per acre (ASGA 2021) times the projected array acres grazed; i.e., solar acre projections times the market penetration rate. The total number of sheep needed is distributed across sheep farms based on the current distribution of farms by size; i.e., 68% small (average 10 sheep), medium 30% (average 160 sheep), and large 2% (average 800 sheep) (USDA 2022). Doing so allows us to project the makeup of members, by farm size, in the cooperative. The total number of sheep farms needed to meet the market capture is equivalent to the number of co-op members in the base year (358 in our baseline scenario). Growth of the co-op over time through new members and farm growth are proportional to the growth in solar acreage.

3.2 Revenue

Cooperative revenue is based on lease payments from solar array owners for vegetative management services. Lease payments are agreed upon through contract negotiation with array owners and can vary based on other conferred responsibilities associated with the vegetative services provided; e.g., responsibility for access to water, fencing, site development, and maintenance standards. Recent solar lease payments in the Northeast U.S. range from $250 to $750 per acre (ASGA 2022). The baseline model solves for the minimum lease payment subject to the financial feasibility condition outlined above (based on cash flow) and the profit distribution to

cash patronage refunds, qualified stock patronage refunds, and retained earnings. As shown later, and assuming 20/70/10 profit distribution, respectively, the minimum lease payment required is $590, well within the historical range.

3.3 Costs

We consider a cooperative offering contract negotiation, mobilization, and shepherding services on behalf of its members. We assume a 27 week grazing season following Kochendoerfer and Thonney (2021). Wage rates for cooperative employees and contractors follow prevailing wage rates in the region (Table 5). To account for increases in business skills and inflationary pressures, we assume lease payments increase 3% per year, while operational costs (i.e., labor and supplies) and capital investments (i.e., fencing, trucks, and trailers) increase 2% per annum. All capital expenditures (trucks, trailers, and fencing) have an 8-year useful life and are depreciated using the straight line method.

3.3.1 Contract Negotiation

Relevant costs for contract negotiation include the constitution of the core management team, liability insurance requirements, and legal services (Table 5). The core management team is composed of a Chief Executive Officer (CEO), a Contracts Specialist/Array Marketing Manager, and a Logistics Supervisor/Member Relations Manager. The core management team are salaried employees of the cooperative with benefits (30%). We assume accountant services are contracted out (no benefits). A five member board of directors receives modest annual compensation ($5,000 per director).

Liability insurance costs are measured on a per acre base and set at an individual farm rate of $50 (ASGA 2022). Since the cooperative negotiates insurance rates based on a policy that provides coverage for all members, we introduce a cooperative efficiency parameter (60%) that

represents a percentage applied to the individual rate; i.e., a $30/acre insurance cost for the cooperative. Similarly, we provide a cooperative efficiency parameter of 67% for legal services related to contract negotiation since significant efficiencies in time are expected as the cooperative operates over multiple, similar, contracts. Advisory team input on individual farm legal costs implied a $380 per contract fee (Table 5).

3.3.2 Mobilization

Costs related to mobilization services relate to purchases of transportation vehicles (trucks and trailers), labor costs for drivers, and fuel expenditures. In discussions with the advisory team, we expect some member resistance to cooperative mobilization services, and that those members have the means and preference to do those services on their own (i.e., 40% of small farms, 60% of medium farms). As this reduces capital and labor requirements of the cooperative, the cooperative provides flat rate compensation to those members based on the average rate of outsourced hauling services (Table 5). This also simplifies the distribution of profits to all members at the end of each year.

Trucks, trailers, and fencing are all purchased new. Two-thirds of the trucks have a smaller tow capacity (suitable for small trailers and shepherding services) and one-third have a larger tow capacity. We assume proper biological controls are in place to allow for more than one farm's sheep on large trailers. As such, more trailers purchased are large (57%) than medium (43%) in size. Annual maintenance costs for trucks and trailers are included (Table 5). Sizing the truck and trailer feet is based on the number and relative sizes of farms.[17] We also allow for within season mobilization and assume that 25% of the farms' sheep move twice during the growing season (i.e., a within-season mobilization factor of 1.125).

[17] Specifically, the farm to truck ratio is 20, implying that each truck can adequately serve 20 farms, on average. The farm to trailer ratio is 40 and the driver to truck ratio is 5.

Fuel costs are based on fuel prices ($5/gal), average speed (45 mph), and an average distance traveled between cooperative, farm, and solar array locations (90 miles) (Table 1). The distance is based on the average distance between major solar sites in NYS (NYSERDA 2022). Sensitivity analyses on travel distances are conducted.

The Logistics Supervisor is responsible for efficiently determining mobilization routes based on farm and solar array locations. Assuming distances between the co-op, farms, and array are equal, consider a situation where four sheep farms are needed to adequately graze a solar array (Figure 2). If each farm is responsible for their own mobilization, this amounts to 16 trip segments per year (8 at the beginning of the season and 8 at the end). Conversely, if the co-op picks up the sheep at each farm and delivers them to the solar array, 12 trip segments are required; i.e., an efficiency parameter of 75% (i.e., 12/16). Labor costs are a function of both travel time and loading/unloading times (i.e., 1 hour per site).

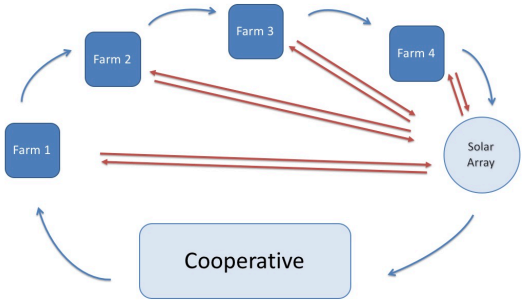

Figure 2 – Efficiency Parameter of Mobilization

3.3.3 Shepherding

Costs related to shepherding services also relate to transportation (trucks), as well as fencing material costs, labor for inspection and fencing installation, and related fuel expenditures. Shepherding involves evaluation of the sheep on site during the season and monitoring fencing and vegetative conditions.

Costs of fencing are a function of cost per feet and paddock size (Table 5). We assume paddock sizes are evenly distributed among 1, 2, and 5 acre paddocks, for an average paddock size of 2.67 acres and 1,294 linear feet. Initial fence installation time is one hour per acre, and preexisting fencing requires repair and adjustments of one half of that amount. Efficiencies gained by experience imply a fencing efficiency rate of 80% for the cooperative. Supplemental trimming is outsourced out at $60 per hour for a 2-acre trim.

Given repeated site visits (twice per week) over the grazing season, fuel and labor expenditures are significant. The fuel efficiency of the trucks is higher for shepherding since no trailer is needed. The logic of the efficiency parameter for shepherding is similar to that from mobilization (Figure 3). Consider that the cooperative can inspect four sites within five one-way trips per day, whereas individual farms collectively make eight; i.e., a shepherding efficiency parameter of 62.5% (5/8).

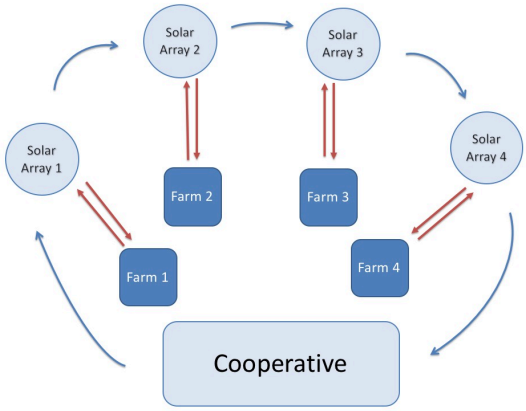

Figure 3 – Efficiency Parameter of Shepherding

4. Financial Results

The 10-year IS projections based on the baseline parameter assumptions are presented below (Table 6). To visualize the gain in transaction costs savings generated by the cooperative, we also present results for a non-cooperative scenario; i.e., all cooperative efficiency parameters are set to

100%, suggesting absence of time or financial efficiency when farmers arrange to manage all services individually (Table 7). Given the financial feasibility condition and baseline parameters, the minimum lease payment for the cooperative is $590 per acre in year 1.

The profit margin in the first year is 12% and increases steadily. Part of this increase is a reflection of annual lease payments per acre that are above cost rates (i.e., 3% versus 2%). It is also attributable to a constant size core management team. Given strong growth projections in the model this is likely too restrictive on costs.[18] Since mobilization and shepherding costs are proportional to growth, labor costs are appropriately accounted; however, increases in the size of the management staff for operational logistics, array marketing, and member relations is likely to increase. Comparably, ROI is 5% in year 1 and increases to 21% by year 10.

As expected, PM and ROI are lower each year under the individual action scenario. ROI remains reasonable by the end of the projection period but assumes lease payment rates follow the cooperative scenario. Costs for the management team remain since the work functions associated with them are necessary. These would either be hired costs to the individual or opportunity costs of the individuals' time, both appropriate for inclusion. We also leave the income tax rules the same as in the cooperative scenario. While operating individually does not provide subchapter T allowances, in the cooperative scenario taxes are applied only at the cooperative level, with member-level taxes via cash and qualified stock patronage refunds excluded.

[18] Over the 10 year period, solar sites, acres grazed, number of sheep grazing, and number of members (assuming all growth is through new membership not current member farm growth) increase from 14 to 41, 1,700 to 4,815, 5,100 to 14,444, and 358 to 1,012. Changes in the size of the management team with growth are left to future research.

Table 6 - Income Statement for Cooperative operation, year 0 through year 10 (lease payment year 1 = $590/acre).

Variable	0	1	2	3	4	5	6	7	8	9	10
Revenue	-	1,235,123	1,533,687	1,920,220	2,325,058	2,719,454	3,068,710	3,336,389	3,558,688	3,685,835	3,817,525
Service cost	-	(222,443)	(272,854)	(319,944)	(381,728)	(441,616)	(475,360)	(500,108)	(514,997)	(525,301)	(534,255)
Gross profit	-	1,012,679	1,260,834	1,600,277	1,943,330	2,277,839	2,593,350	2,836,282	3,043,691	3,160,534	3,283,270
Management expense	(303,024)	(669,187)	(761,157)	(854,634)	(981,991)	(1,111,360)	(1,204,002)	(1,287,657)	(1,347,479)	(1,398,505)	(1,438,801)
Depreciation	(114,667)	(162,340)	(209,315)	(261,864)	(316,724)	(377,324)	(439,540)	(487,142)	(421,443)	(397,000)	(383,368)
Other income (Grant)		30,509	30,509	30,509	30,509	30,509	30,509	30,509	30,509	-	-
EBIT	(417,691)	211,661	320,870	514,287	675,124	819,664	980,318	1,091,991	1,305,278	1,365,029	1,461,101
Interest expense		(56,551)	(53,856)	(50,944)	(47,800)	(44,404)	(40,737)	(36,776)	(32,498)	(27,878)	(22,889)
Profit before Patr.	(417,691)	155,109	267,014	463,343	627,324	775,260	939,581	1,055,215	1,272,780	1,337,150	1,438,212
Cash Patr. Refund	**-**	**31,022**	**53,403**	**92,669**	**125,465**	**155,052**	**187,916**	**211,043**	**254,556**	**267,430**	**287,642**
Qualified Patr. Refund	-	108,577	186,910	324,340	439,127	542,682	657,707	738,650	890,946	936,005	1,006,748
Qualified Redeems	-	-	-	-	-	-	108,577	186,910	324,340	439,127	542,682
Income before taxes	(417,691)	155,109	267,014	463,343	627,324	775,260	939,581	1,055,215	1,272,780	1,337,150	1,438,212
Taxable income	(417,691)	15,511	26,701	46,334	62,732	77,526	93,958	105,521	127,278	133,715	143,821
Tax expense	-	4,033	6,942	12,047	16,310	20,157	24,429	27,436	33,092	34,766	37,394
Net income	**(417,691)**	**151,077**	**260,072**	**451,296**	**611,014**	**755,103**	**915,152**	**1,027,779**	**1,239,688**	**1,302,385**	**1,400,818**
Profit Margin		**12%**	**17%**	**24%**	**26%**	**28%**	**30%**	**31%**	**35%**	**35%**	**37%**
ROI		**5%**	**8%**	**11%**	**13%**	**14%**	**15%**	**16%**	**19%**	**19%**	**21%**

Note: Retained Earnings = Taxable income – tax expense, Profit margin = Net income/Lease payment, and Return on Investment = Net Income/Total Assets

Table 7 - Income Statement for Individual operation, year 0 through year 10 (lease payment year 1 = $590/acre).

Variable	0	1	2	3	4	5	6	7	8	9	10
Revenue	-	1,235,123	1,533,687	1,920,220	2,325,058	2,719,454	3,068,710	3,336,389	3,558,688	3,685,835	3,817,525
Service cost	-	(287,659)	(352,351)	(413,608)	(493,377)	(570,319)	(614,128)	(646,415)	(665,938)	(678,484)	(689,679)
Gross profit	-	947,464	1,181,336	1,506,613	1,831,681	2,149,135	2,454,582	2,689,974	2,892,750	3,007,351	3,127,845
Management expense	(303,664)	(803,228)	(926,405)	(1,052,204)	(1,222,473)	(1,394,837)	(1,517,303)	(1,626,719)	(1,704,159)	(1,768,779)	(1,819,751)
Depreciation	(114,667)	(162,340)	(209,315)	(261,864)	(316,724)	(377,324)	(439,540)	(487,142)	(421,443)	(397,000)	(383,368)
Other income (Grant)		30,525	30,525	30,525	30,525	30,525	30,525	30,525	30,525	-	-
EBIT	(418,331)	12,421	76,141	223,070	323,009	407,499	528,264	606,638	797,673	841,572	924,726
Interest expense		(56,572)	(53,875)	(50,962)	(47,816)	(44,418)	(40,749)	(36,786)	(32,506)	(27,884)	(22,892)
Profit before Patr.	(418,331)	(44,151)	22,267	172,108	275,193	363,081	487,515	569,851	765,166	813,688	901,835
Cash Patr. Refund	**-**	**-**	**4,453**	**34,422**	**55,039**	**72,616**	**97,503**	**113,970**	**153,033**	**162,738**	**180,367**
Qualified Patr. Refund	-	-	15,587	120,476	192,635	254,157	341,261	398,896	535,616	569,582	631,284
Qualified Redeems	-	-	-	-	-	-	-	15,587	120,476	192,635	254,157
Income before taxes	(418,331)	(44,151)	22,267	172,108	275,193	363,081	487,515	569,851	765,166	813,688	901,835
Taxable income	(418,331)	(44,151)	2,227	17,211	27,519	36,308	48,752	56,985	76,517	81,369	90,183
Tax expense	-	-	579	4,475	7,155	9,440	12,675	14,816	19,894	21,156	23,448
Net income	**(418,331)**	**(44,151)**	**21,688**	**167,633**	**268,038**	**353,641**	**474,840**	**555,035**	**745,272**	**792,532**	**878,387**
Profit Margin		**-4%**	**1%**	**9%**	**12%**	**13%**	**15%**	**17%**	**21%**	**22%**	**23%**
ROI		**0%**	**1%**	**4%**	**5%**	**6%**	**8%**	**9%**	**11%**	**12%**	**13%**

Note: Retained Earnings = Taxable income – tax expense, Profit margin = Net income/Lease payment, and Return on Investment = Net Income/Total Assets

Given our financial feasibility condition of positive cash flows by the end of year 2, we present ten-year projected cash flows for cooperative (Table 8) and individual (Table 9) scenarios. At a $590/acre lease payment, cash flows at the end of year 2 for the cooperative are just over zero and overcoming the negative cash flow from year 1 (-$75,382).

The net change in cash flows increase through year 9 but drop off slightly in year 10. This is due to a flattening of industry growth combined with higher equity redemptions (from retained qualified stock in year 5). Assuming the same lease payment per acre as realized by the cooperative, the individual scenario (Table 9) does not project a positive net change in cash until the end of year 3 and a positive cash balance until the end of year 6.[19]

4.1 Sensitivity Analysis

Maximizing cash patronage is of particular concern to members with significant equity invested the business. Since the lease payment rate for grazing services drives member returns, we estimate the minimum lease payment necessary under alternative cash distribution levels, keeping all other parameters constant. In other words, as more of the profits are distributed as cash as opposed to qualified stock (to which the members do not receive until five years later), how is the minimum lease payment affected? Keeping all other parameters constant and fixing the portion to retained earnings at 10%, the results are shown in Table 10.

For each 10% addition to cash patronage refunds, minimum lease payments increase at an increasing rate. This makes sense as the financial feasibility condition presumes no increases in long term debt for new investments as they relate to growth and reinvestment of depreciated capital assets. In other words, as more of current year profits are distributed in cash, with a constant growth assumption by year, higher lease revenues are required to fully capitalize the business.

[19] For ease of exposition, we leave a detailed review of the 10-year balance sheet projections for the cooperative to the interested reader (Appendix 1).

Table 8 – Cash Flow Statement for Cooperative operation, year 0 through year 10 (lease payment year 1 = $590/acre).

Variable	0	1	2	3	4	5	6	7	8	9	10
Cash flow from operating activities											
Net income	(417,691)	151,077	260,072	451,296	611,014	755,103	915,152	1,027,779	1,239,688	1,302,385	1,400,818
Depreciation	114,667	162,340	209,315	261,864	316,724	377,324	439,540	487,142	421,443	397,000	383,368
Other income (grant)	-	(30,509)	(30,509)	(30,509)	(30,509)	(30,509)	(30,509)	(30,509)	(30,509)	-	-
Total	**(303,024)**	**282,908**	**438,878**	**682,651**	**897,229**	**1,101,918**	**1,324,182**	**1,484,413**	**1,630,622**	**1,699,385**	**1,784,186**
Cash flow from investing activities											
Capital expenditures	(917,332)	(389,019)	(390,979)	(446,122)	(475,062)	(535,251)	(560,524)	(437,442)	(439,792)	(235,041)	(323,191)
Total	**(917,332)**	**(389,019)**	**(390,979)**	**(446,122)**	**(475,062)**	**(535,251)**	**(560,524)**	**(437,442)**	**(439,792)**	**(235,041)**	**(323,191)**
Cash flow from financing activities											
LT debt increase (decrease)	488,143	(33,696)	(36,392)	(39,303)	(42,448)	(45,843)	(49,511)	(53,472)	(57,749)	(62,369)	(67,359)
Cash part. ref. increase (decrease)	-	(31,022)	(53,403)	(92,669)	(125,465)	(155,052)	(187,916)	(211,043)	(254,556)	(267,430)	(287,642)
Qualified redeems	-	-	-	-	-	-	(108,577)	(186,910)	(324,340)	(439,127)	(542,682)
Member stock investment	488,143	95,447	118,627	151,351	149,988	136,353	109,082	68,176	46,360	8,181	8,181
Other investment (grant)	244,071										
Total	**1,220,357**	**30,729**	**28,832**	**19,380**	**(17,924)**	**(64,543)**	**(236,921)**	**(383,248)**	**(590,285)**	**(760,745)**	**(889,502)**
Net change in cash	**-**	**(75,382)**	**76,731**	**255,909**	**404,243**	**502,124**	**526,737**	**663,722**	**600,544**	**703,599**	**571,493**
Cash at beginning of year	**-**	**-**	**(75,382)**	**1,349**	**257,258**	**661,500**	**1,163,624**	**1,690,361**	**2,354,084**	**2,954,627**	**3,658,226**
Cash at end of year	**-**	**(75,382)**	**1,349**	**257,258**	**661,500**	**1,163,624**	**1,690,361**	**2,354,084**	**2,954,627**	**3,658,226**	**4,229,720**

Net Change in cash = Cash Flow from Operating Activities + Cash Flow from Investing Activities + Cash Flow from Financing Activities. Financial Feasibility Condition: Cash at End of Year 2 > 0/

Table 9 – Cash Flow Statement for Individual, year 0 through year 10 (lease payment year 1 = $590/acre).

Variable	0	1	2	3	4	5	6	7	8	9	10
Cash flow from operating activities											
Net income	(418,331)	(44,151)	21,688	167,633	268,038	353,641	474,840	555,035	745,272	792,532	878,387
Depreciation	114,667	162,340	209,315	261,864	316,724	377,324	439,540	487,142	421,443	397,000	383,368
Other income (grant)	-	(30,525)	(30,525)	(30,525)	(30,525)	(30,525)	(30,525)	(30,525)	(30,525)	-	-
Total	**(303,664)**	**87,664**	**200,478**	**398,972**	**554,237**	**700,439**	**883,855**	**1,011,653**	**1,136,190**	**1,189,532**	**1,261,755**
Cash flow from investing activities											
Capital expenditures	(917,332)	(389,019)	(390,979)	(446,122)	(475,062)	(535,251)	(560,524)	(437,442)	(439,792)	(235,041)	(323,191)
Total	**(917,332)**	**(389,019)**	**(390,979)**	**(446,122)**	**(475,062)**	**(535,251)**	**(560,524)**	**(437,442)**	**(439,792)**	**(235,041)**	**(323,191)**
Cash flow from financing activities											
LT debt increase (decrease)	488,399	(33,714)	(36,411)	(39,324)	(42,470)	(45,867)	(49,537)	(53,500)	(57,780)	(62,402)	(67,394)
Cash part. ref. increase (decrease)	-	-	(4,453)	(34,422)	(55,039)	(72,616)	(97,503)	(113,970)	(153,033)	(162,738)	(180,367)
Qualified redeems	-	-	-	-	-	-	-	(15,587)	(120,476)	(192,635)	(254,157)
Member stock investment	488,399	95,497	118,689	151,431	150,067	136,424	109,139	68,212	46,384	8,185	8,185
Other investment (grant)	244,199										
Total	**1,220,997**	**61,783**	**77,825**	**77,685**	**52,558**	**17,941**	**(37,900)**	**(114,845)**	**(284,904)**	**(409,589)**	**(493,732)**
Net change in cash	**-**	**(239,571)**	**(112,677)**	**30,536**	**131,734**	**183,129**	**285,430**	**459,366**	**411,493**	**544,902**	**444,832**
Cash at beginning of year	-	-	(239,571)	(352,248)	(321,713)	(189,979)	(6,850)	278,580	737,946	1,149,439	1,694,342
Cash at end of year	**-**	**(239,571)**	**(352,248)**	**(321,713)**	**(189,979)**	**(6,850)**	**278,580**	**737,946**	**1,149,439**	**1,694,342**	**2,139,173**

Net Change in cash = Cash Flow from Operating Activities + Cash Flow from Investing Activities + Cash Flow from Financing Activities.

Table 10. Minimum lease payments per acre for alternative patronage distributions.

Retained earnings	10%	10%	10%	10%	10%	10%
Qualified patronage refund	70%	60%	50%	40%	30%	20%
Cash patronage refund	20%	30%	40%	50%	60%	70%
Lease Payment per acre	$590	$605	$625	$650	$690	$755
Dollar change		$15	$20	$25	$40	$65
Percentage change		2.5%	3.3%	4.0%	6.2%	9.4%

As travel distance from sheep farms to solar arrays is one of the major concerns conveyed from the survey, we conduct sensitivity analysis on minimum lease payments over travel distances from 50 to 150 average miles per segment (recall, the baseline is 90 miles). Keeping all other parameters constant as in the baseline scenario, including a profit distribution of 10/20/70 to retained earnings, cash patronage refunds, and stock patronage refunds, respectively), the results are shown in Table 11.

For every additional 20 miles in average travel distance, the minimum lease payment per acre increases by $31. The fixed change in lease payments is expected, since increases in costs (associated with labor and fuel costs) are linear. In other words, if average travel distance is changed in a constant increment (20 miles), the minimum lease payment is changed by a proportional fixed amount. In any event, considering travel distances when negotiating lease rates with array operators is important to cooperative financial feasibility.

Table 11. Minimum lease payments per acre for alternative distant assumptions.[a]

Average travel distance (miles)	50	70	90	110	130	150
Lease Payment per acre	$528	$559	$590	$621	$652	$683
Dollar change		$31	$31	$31	$31	$31
Percentage change		5.9%	5.5%	5.3%	5.0%	4.8%

[a] Profit distribution fixed 10% retained earnings, 20% cash patronage, and 70% qualified stock patronage.

5. Conclusions

Local, state, and federal policy support for expanding renewable energy production in the United States is increasing, with aggressive renewable energy goals. The opportunity for farms to expand vegetative management services with solar array operators is large given that less than 10% of solar acres are currently grazed by sheep. The opportunity can present financial benefits to current sheep farmers and supports overall industry growth. The practice also remediates some of the concerns associated with the loss of farmland to accommodate solar energy production.

Given the relatively large size of solar arrays in or planned for production in comparison to the size of sheep farms in the Northeast U.S., grazing demands for most arrays will require sheep from multiple farms. A farmer-owned solar grazing cooperative is examined to understand the potential for transaction cost savings of collective action that addresses the needs of current and future sheep farmers. A needs assessment survey to current and prospective sheep farmers demonstrates sufficient interest by current solar graziers, sheep farmers not yet experienced in solar grazing, and new farmers interested in entering sheep farming that involves solar grazing to explore a cooperative business model for coordination and management of grazing services across farms and solar sites. Furthermore, differences in expected barriers to grazing sheep under solar arrays across types of farms is informative in developing effective cooperative development information sessions and to identify the potential benefits of collective action.

The survey also demonstrated interest in alternative forms of cooperative enterprise, continued involvement in leadership and facilitation of the cooperative development process, and involvement in governance and leadership of the business looking forward. Less interest in investing in such a venture is consistent with the capital constraints currently faced by farmers;

however, shared investment through a cooperative can provide relatively larger benefits than by individual action, which are highly inefficient when evaluated at industry scale.

The barriers and needs expressed in the survey are accounted for in a financial feasibility model for a proposed farmer-owned solar grazing cooperative. A detailed analysis of the costs associated with contract negotiation, mobilization, and shepherding services identifies minimum lease payment rates required by solar array operators for financial business success. Transaction cost savings of group action (i.e., cooperative efficiencies) are parameterized within the model to compare the differences in financial benefits between cooperative and individual action. Profit margins and returns on investment suggest competitive returns to alternative investment opportunities and where cooperative returns are at or nearly twice as large as those from individual action. However, returns on investment are highly sensitive to the lease payment rates secured.

Once established, the minimum lease payment provides sufficient net returns over the 10-year forecast period to accommodate new capital investment associated with business growth and reinvestment in depreciated capital assets without the need for financial capital secured by debt. Upfront member investment secures buy in for cooperative operations, and retained patronage refunds secure a sound capitalization plan long term. Increases in cash patronage refunds are allowed, but only feasible through increases in lease payment rates. In addition, increases in travel distances between farms and solar sites require larger lease payments.

The financial model is designed to allow for easy customization across alternative input parameters such as capital investment endowments, labor rates, fuel costs, and the size of the core management team. Accordingly, the financial model can serve as an updateable tool throughout the process of cooperative development with interested farmers, and provide useful information to lenders and government agencies for potential financial support.

The results presented here are based on fixed parameter assumptions. Incorporating stochastic processes on primary model parameters through monte carlo simulation or other means will provide a more complete feasibility assessment that takes into account risk. For example, lease payments by array operators are, ultimately, a function of electricity prices through the demand for solar energy. Similarly, mobilization and shepherding services come with large demands for fuel for which prices are quite volatile. Incorporating risk on these parameters provide a more accurate depiction of long-term financial success and identifies opportunities for risk management such as through hedging and fixed contract arrangements.

The full needs assessment also considers expansion of cooperative services into downstream processing and marketing activities. Additional elements examined in the survey include such things as coordinated slaughter/processing arrangements with existing processors, investing in a cooperatively owned processing facility, and product marketing services of cooperative branded products. Such downstream integrations provide opportunities and risks. Evaluating consensus of farmer needs in downstream activities such as these is a logical next step. A careful examination of these issues is a top priority for our continuing research.

Reference

ASGA. “Utility Dive Does a Deep Dive on Solar Grazing - American Solar Grazing Association.” *The American Solar Grazing Association*, 5 Aug. 2020, solargrazing.org/utility-dive-does-a-deep-dive-on-solar-grazing/. Accessed 24 Apr. 2023.

Bridge, Ashley. “There Are Many Ways to Solar Graze - Cornell Small Farms.” *Cornell Small Farms Program*, 20 Oct. 2020, smallfarms.cornell.edu/2020/10/there-are-many-ways-to-solar-graze/. Accessed 24 Apr. 2023.

Chaddad, Fabio, and Constantine Iliopoulos. “Control Rights, Governance, and the Costs of Ownership in Agricultural Cooperatives.” *Agribusiness*, vol. 29, no. 1, 20 Dec. 2012, pp. 3–22, https://doi.org/10.1002/agr.21328. Accessed 27 Aug. 2019.

Friedlander, Blaine. “Engage Public, Explore Methods to Secure NYS Green Energy.” *Cornell Chronicle*, 4 May 2021, news.cornell.edu/stories/2021/05/engage-public-explore-methods-secure-nys-green-energy. Accessed 24 Apr. 2023.

Kochendoerfer, Nikola, and Michael Thonney. *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*. 2021.

Macknick, Jordan, and James McCall. “Agrivoltaics.” *Www.nrel.gov*, www.nrel.gov/solar/market-research-analysis/agrivoltaics.html.

Mow, Benjamin. “Solar Sheep and Voltaic Veggies: Uniting Solar Power and Agriculture.” *Www.nrel.gov*, 6 June 2018, www.nrel.gov/state-local-tribal/blog/posts/solar-sheep-and-voltaic-veggies-uniting-solar-power-and-agriculture.html. Accessed 24 Apr. 2023.

New York Solar Map. 2023.

Pedersen, Bill, and Brooks Lamb. *PRODUCING SOLAR ENERGY WHILE PROTECTING FARMLAND AGRIVOLTAICS Bill Pedersen Brooks Lamb EXECUTIVE SUMMARY 2*. 2021.

“USDA/NASS 2020 State Agriculture Overview for New York.” *Usda.gov*, 2020, www.nass.usda.gov/Quick_Stats/Ag_Overview/stateOverview.php?state=NEW%20YORK.

Appendix 1 – Balance Sheet for Cooperative operation, year 0 through year 10 (lease payment year 1 = $590/acre).

Variable	0	1	2	3	4	5	6	7	8	9	10
Assets											
Short term Assets	250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000
Cash Operation	-	(75,382)	1,349	257,258	661,500	1,163,624	1,690,361	2,354,084	2,954,627	3,658,226	4,229,720
Equipment	917,332	1,306,351	1,697,330	2,143,452	2,618,514	3,153,766	3,714,290	4,151,731	4,591,524	4,826,564	5,149,755
Less Depreciation	(114,667)	(277,007)	(486,322)	(748,186)	(1,064,910)	(1,442,234)	(1,881,774)	(2,368,916)	(2,790,359)	(3,187,359)	(3,570,727)
Total Assets	**1,052,666**	**1,203,962**	**1,462,357**	**1,902,524**	**2,465,104**	**3,125,156**	**3,772,877**	**4,386,899**	**5,005,792**	**5,547,432**	**6,058,748**
Liabilities											
Working Capital	250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000
LT Loan	488,143	454,446	418,054	378,751	336,304	290,460	240,949	187,478	129,728	67,359	-
Defrd. Revenue	244,071	213,562	183,054	152,545	122,036	91,527	61,018	30,509	-	-	-
Total Liabilities	**982,214**	**918,009**	**851,108**	**781,296**	**708,339**	**631,987**	**551,967**	**467,987**	**379,728**	**317,359**	**250,000**
Member Equity											
Member stock	488,143	583,590	702,216	853,568	1,003,556	1,139,909	1,248,991	1,317,167	1,363,527	1,371,708	1,379,889
Qualified stock	-	108,577	295,487	619,827	1,058,953	1,601,635	2,150,765	2,702,506	3,269,112	3,765,990	4,230,056
Unallocated equity	(417,691)	(406,213)	(386,454)	(352,166)	(305,744)	(248,375)	(178,846)	(100,760)	(6,575)	92,375	198,802
Total Equity	**70,452**	**285,953**	**611,249**	**1,121,228**	**1,756,765**	**2,493,169**	**3,220,910**	**3,918,913**	**4,626,064**	**5,230,073**	**5,808,748**
Total Liab. & Equity	**1,052,666**	**1,203,962**	**1,462,357**	**1,902,524**	**2,465,104**	**3,125,156**	**3,772,877**	**4,386,899**	**5,005,792**	**5,547,432**	**6,058,748**

The negative unallocated equity beginning in the base year is purely a consequence of financial accounting principles for grant revenues received and its amortization over time.

Appendix 2 – Full Solar Grazing Sheep Survey

2022 Solar Grazing Sheep Survey – Print Version

Sheep and Solar Grazing Cooperative Development - Needs Assessment

Background. Increasing interest in renewable energy sources, particularly solar energy, presents a unique opportunity to strengthen the sheep sector for both farmers grazing and not grazing sheep beneath solar arrays. Sheep can be used to control vegetation and reduce shading of solar arrays through grazing, which subsequently can increase farm income as a service provider. Grazing under solar arrays often requires identification of the solar site operator, negotiation of a contract for services, coordination of one or more flocks, transportation of sheep to and from the site, and monitoring the sheep while onsite. This may or may not be a lot of work for an individual sheep farmer. As more sites come online the demand for sheep is anticipated to increase. Alternative markets and processing capacity will be needed as well. A cooperative or other business owned by multiple farmers could serve as a useful intermediary between solar array operators and sheep farmers. Additional services could be useful to sheep farmers not grazing solar arrays as well.

The **Cornell University Cooperative Enterprise Program** in collaboration with the **American Solar Grazing Association (ASGA)** and through support of the **USDA Agricultural Marketing Service, Federal State Marketing Improvement Program** is examining the need for one or more such enterprises. The first step is a survey of farmers to identify and quantify the need for a cooperative or other business owned by multiple farmers to provide logistical, transport, marketing, and/or processing services for both farmers grazing and not grazing sheep beneath solar arrays.

Risks and benefits. There are no anticipated risks or benefits for persons participating in this survey. Information gained from the survey will contribute to the understanding the need for a cooperative or other business owned by multiple farmers to provide needed services to sheep producers. Participants will not receive any compensation for participating in the survey. However, persons completing the survey and sharing their name and email address at the end of the survey will be eligible for one of three, $100 Amazon gift cards.

Confidentiality and data security. All completed surveys will be kept in secured storage. Results will be reported only as group data. At no time will any personally identifiable information be publicly reported.

Participation is voluntary. Your participation in this survey is important and voluntary. You may refuse to participate before the survey begins, stop at any time, or choose not to answer any question that makes you feel uncomfortable. The survey should take between 15 and 20 minutes to complete.

If you have any questions, please contact Bobbie Severson, Extension Associate and Cooperative Enterprise Program Executive Director at email: rmh27@cornell.edu or Todd M. Schmit, Professor, Charles H. Dyson School of Applied Economics and Management, Cornell University at email: tms1@cornell.edu.

Thank for contributing your knowledge, experience, and perspectives to this important issue!

A web-based version of the survey is also available at:
One survey per farmer.

This section is to learn about you, the challenges to own sheep overall, and challenges when grazing sheep under solar arrays.

Q1 In which State do you currently reside? _____

Q2 What County is your farm/you located in? _____

Q3 Which one of the following most closely describes you?

- ○ Full-time sheep farmer, grazing MY sheep under solar arrays
- ○ Part-time sheep farmer, grazing MY sheep under solar arrays
- ○ Sheep farmer grazing MY sheep AND sheep I LEASE from others under solar arrays
- ○ I lease some/all of my sheep to another person grazing sheep under solar arrays
- ○ I'm a sheep farmer not currently grazing sheep under solar arrays but am interested in exploring
- ○ I'm a sheep farmer and am NOT interested in grazing sheep under solar arrays
- ○ I'm a non-sheep farmer interested in diversifying my operation to graze sheep under solar arrays
- ○ I am a new/ beginning farmer interested in starting a sheep farm, which may include grazing sheep under solar arrays.

If you answered Q3 with any of the following, go to Q4. If not, go to Q7.

Full-time sheep farmer, grazing MY sheep under solar arrays
Part-time sheep farmer, grazing MY sheep under solar arrays
Sheep farmer grazing MY sheep AND sheep I LEASE from others to graze under solar arrays

Q4 Approximately how many acres did the sheep you own and/or lease graze under solar arrays in 2022? _____

Q5 How many sheep (owned and/or leased) did you graze under solar arrays in 2022?

_____

Q6 How many solar array sites did you graze in 2022?

_____

Q7 How long have you owned and managed sheep?

- ○ Less than 5 years
- ○ Between 6 and 10 years
- ○ Between 11 and 20 years
- ○ More than 20 years
- ○ Do not currently own or manage sheep

Q8 What is the average size of your flock?

- ○ Less than 30
- ○ 31 to 50
- ○ 51 to 100
- ○ 101 to 200
- ○ 201 to 400
- ○ More than 400
- ○ Currently do not own sheep

Q9 Over the course of 2022, on average, how many (head count) of each of the following do you have?

Adult ewes and ewe lambs for breeding purposes _____
Adult ewes, non-breeding, cull _____
Adult rams _____
Wethers _____
Lambs _____

- ○ Currently do not own sheep

If you answered Q3 with any of the following, go to Q10. If not, go to Q12.

Full-time sheep farmer, grazing MY sheep under solar arrays
Part-time sheep farmer, grazing MY sheep under solar arrays
Sheep farmer grazing MY sheep AND sheep I LEASE from others to graze under solar arrays
I lease some/all of my sheep to another person grazing sheep under solar arrays
I'm a sheep farmer not currently grazing sheep under solar arrays but am interested in exploring
I'm a sheep farmer and am NOT interested in grazing sheep under solar array

Q10 Which best describes your interest in expanding your flock?

- ○ Satisfied with current flock size and scale of business, no interest in expanding
- ○ Would expand to meet market demand for lamb meat
- ○ Desire to expand flock to provide grazing services
- ○ Willing to expand flock with expectation to lease sheep to another farmer grazing sheep under solar arrays
- ○ Willing to expand flock with goal to sell sheep to other farmers grazing sheep under solar arrays
- ○ Other, briefly describe: _____

Q11 If the market signals a need for more sheep (e.g., higher prices, increased demand), which best describes how much you would expand your flock over the next 3 years?

- ○ 0%, will not expand
- ○ 25%
- ○ 50%
- ○ 75%
- ○ 100%, Double flock size
- ○ 200%, Triple flock size

Q12 What most prevents you from starting or expanding your flock? (Choose up to 3)

- ☐ Time to downsize
- ☐ Money or financial constraints
- ☐ Access to land
- ☐ Access to dependable labor
- ☐ Access to equipment
- ☐ Access to buildings
- ☐ Access to sale markets
- ☐ Distance to sale markets
- ☐ Access to slaughter or processing facilities
- ☐ Distance to slaughter or processing facilities
- ☐ Other, briefly describe: _____

If you answered Q3 with any of the following, go to Q13. If not, go to Q16.

Full-time sheep farmer, grazing MY sheep under solar arrays
Part-time sheep farmer, grazing MY sheep under solar arrays
Sheep farmer grazing MY sheep AND sheep I LEASE from others to graze under solar arrays
I lease some/all of my sheep to another person grazing sheep under solar arrays

Q13 What type of sheep do you graze under solar arrays? Select all that apply.

- ☐ Dry ewes
- ☐ Cull sheep
- ☐ Wethers
- ☐ Lactating ewes with lambs
- ☐ Weaned lambs
- ☐ Rams

Q14 Who most regularly monitors and manages your sheep grazing under solar arrays?

- ○ Myself or family member
- ○ Employee
- ○ Person who leases my sheep

Q15 Would you allow your sheep grazing under solar arrays to be comingled with sheep from other farms?

- ○ Yes
- ○ No
- ○ Maybe, briefly explain: _____

Q16 In your opinion, what are the barriers when grazing sheep under solar arrays?

Potential barrier	Not a barrier	Small barrier	Medium barrier	Large barrier
Identifying the array operator	○	○	○	○
Negotiating the contract	○	○	○	○
Insurance requirements	○	○	○	○
Cost of insurance	○	○	○	○
Access to trucks/trailers to move sheep	○	○	○	○
Access to handling equipment at solar site	○	○	○	○
Easy access to water	○	○	○	○
Travel distance to monitor sheep	○	○	○	○
Time on site to monitor sheep	○	○	○	○
Biosecurity protocols	○	○	○	○
Equipment needed to mechanically mow or trim	○	○	○	○
Time on site to mow or trim	○	○	○	○
Access to person willing to lease my sheep	○	○	○	○
Lack of knowledge about grazing sheep under solar arrays	○	○	○	○
Other, briefly explain:	○	○	○	○

Q17 In your opinion, what challenges do you face to own sheep?

Potential Challenge	Not a challenge	Small challenge	Medium challenge	Large challenge
Overall knowledge of sheep management (nutrition, health, reproduction, etc.)	○	○	○	○
Access to veterinary care	○	○	○	○
Access to land	○	○	○	○
Access to machinery & equipment	○	○	○	○
Access to facilities & buildings	○	○	○	○
Money & capital to invest in sheep business	○	○	○	○
Availability of markets	○	○	○	○
Slaughter/processing capacity	○	○	○	○
Adequate profit margins	○	○	○	○
Other, briefly explain	○	○	○	○

Contract negotiation and site inspection are important first steps prior to grazing sheep beneath solar arrays. The questions in this section explore these issues.

If you answered Q3 with any of the following, go to Q18. If not, go to the lead in for Q19.

Full-time sheep farmer, grazing MY sheep under solar arrays
Part-time sheep farmer, grazing MY sheep under solar arrays
Sheep farmer grazing MY sheep AND sheep I LEASE from others to graze under solar arrays

Q18 A visit to the solar array is an important first step before contracting to graze sheep. Recognizing that larger sites take more time to inspect, once at a site, approximately how much time does it take to initially investigate a site to be grazed. (Round up to higher number)

- ○ Up to 1 hour
- ○ 1 hour to 3 hours
- ○ 3 hours to less than 5 hours
- ○ 5 to 6 hours
- ○ More than 6 hours

If you answered Q3 with any of the following, go to Q19. If not, go to the lead in for Q22.

Full-time sheep farmer, grazing MY sheep under solar arrays
Part-time sheep farmer, grazing MY sheep under solar arrays
Sheep farmer grazing MY sheep AND sheep I LEASE from others to graze under solar arrays
I lease some/all of my sheep to another person grazing sheep under solar arrays

Q19 How do you contract with the solar array operator?

Option	Yes	No
Contract directly with array operator	○	○
Contract through intermediary or third party (another farmer, landscaper, other service provider)	○	○

Q20 Which type of contracting do you prefer?

- ○ Contract directly with array operator
- ○ Subcontract through an intermediary or third party (another farmer, landscaper, other service provider)
- ○ Makes no difference to me

Q21 What are the largest challenges you face in contract negotiations (up to 3)? Briefly describe.

- **When contracting directly with the array operator:**

- **When subcontracting with a third party:**

Grazing sheep under solar arrays requires a contract between the site operator and whomever is providing the vegetative management. Large solar sites often require flocks from multiple farms. Array operators may prefer to contract with one entity rather than multiple, individual farmers.

Q22 In your opinion, what is the industry need for a cooperative or other business owned by multiple farmers to negotiate contracts between the site operator and whomever is providing vegetative management?

- Not needed
- Somewhat needed
- Needed
- Very needed
- Extremely needed

Q23 How likely would you utilize a cooperative or other business owned by multiple farmers to negotiate contracts between site operators and persons providing vegetative services if provided for a reasonable fee?

- Not likely
- Somewhat likely
- Neither likely nor unlikely
- Very likely
- Extremely likely
- It depends. Briefly explain: _____

Most contract negotiations call for a farmer to have insurance, which can cost as much as $7,000 per sheep farm when independently providing vegetative management services. A cooperative or business owned by multiple farmers could potentially access insurance at more favorable rates.

Q24 In your opinion, what is the industry need for a cooperative or business owned by multiple farmers to provide access to insurance that would meet contract requirements if provided at favorable rates?

- Not needed
- Somewhat needed
- Needed
- Very needed
- Extremely needed

Q25 Assuming competitive rates, how likely would you utilize insurance provided by a cooperative or other business owned by multiple farmers when grazing sheep under solar arrays?

- Not likely
- Somewhat likely
- Likely
- Very likely
- Extremely likely
- It depends. Briefly explain: _____

Grazing sheep beneath solar arrays requires sheep to be transported to and from the solar site, which could be nearby or miles away. Depending on the site, soil conditions, plant growth, weather conditions, and the management strategy to control vegetation, sheep may be transported one or multiple times during the grazing season. Handling equipment (e.g., water, fences, gates) is also needed to load, unload, and manage the sheep.

If you answered Q3 with any of the following, go to Q26. If not, go to Q28.

Full-time sheep farmer, grazing MY sheep under solar arrays
Part-time sheep farmer, grazing MY sheep under solar arrays
Sheep farmer grazing MY sheep AND sheep I LEASE from others to graze under solar arrays
I lease some/all of my sheep to another person grazing sheep under solar arrays
I'm a sheep farmer not currently grazing sheep under solar arrays but am interested in exploring

Q26 Do you have equipment (water, fences, gates, etc.) to handle and manage sheep at solar grazing sites?

- ○ Yes, I have my own handling equipment
- ○ Yes, I share equipment with another farmer
- ○ No, I do not have access to handling equipment

Q27 Do you have handling equipment that can be left on site if sheep are grazing under solar arrays?

- ○ Yes
- ○ No

If you answered Q3 with any of the following, go to Q28. If not, go to the lead in for Q29.

Full-time sheep farmer, grazing MY sheep under solar arrays
Part-time sheep farmer, grazing MY sheep under solar arrays
Sheep farmer grazing MY sheep AND sheep I LEASE from others to graze under solar arrays
I lease some/all of my sheep to another person grazing sheep under solar arrays
I'm a sheep farmer not currently grazing sheep under solar arrays but am interested in exploring
I'm a sheep farmer and am NOT interested in grazing sheep under solar array
I'm a non-sheep farmer interested in diversifying my operation to graze sheep under solar arrays

Q28 Do you have capability to transport sheep to and from grazing sites? Check all that apply.

- ☐ Yes, I have a truck
- ☐ Yes, I have a trailer
- ☐ Yes, I borrow a truck when needed
- ☐ Yes, I borrow a trailer when needed
- ☐ Person leasing my sheep provides transport
- ☐ No, I hire someone to transport my sheep
- ☐ No, I do not have the capacity to transport my sheep

If you answered Q3 with any of the following, go to Q29. If not, go to Q31.

Full-time sheep farmer, grazing MY sheep under solar arrays
Part-time sheep farmer, grazing MY sheep under solar arrays
Sheep farmer grazing MY sheep AND sheep I LEASE from others to graze under solar arrays
I lease some/all of my sheep to another person grazing sheep under solar arrays

Q29 How many miles do you drive each time to transport sheep to and from grazing sites?

Minimum number of miles (round trip) _____
Maximum number of miles (round trip) _____
Average number of miles (round trip) _____
Person leasing sheep provides transport (enter 0) _____

Q30 How many hours round-trip are spent each time transporting sheep to and from grazing sites?

Minimum number of hours (round trip) _____
Maximum number of hours (round trip) _____
Average number of hours (round trip) _____
Person leasing my sheep provides all transport (enter 0) _____

Q31 A cooperative or business owned by multiple farmers could provide transportation services to move sheep. Assuming proper biosecurity controls are in place, what is the <u>industry need</u> for such a business.

- ○ Not needed
- ○ Somewhat needed
- ○ Needed
- ○ Very needed
- ○ Extremely needed

Q32 A cooperative or other business owned by farmers could provide services to transport sheep. How likely are <u>you to utilize</u> transportation services provided by such an enterprise, assuming membership included access to these services at reasonable rates?

- ○ Not likely
- ○ Somewhat likely
- ○ Likely
- ○ Very likely
- ○ Extremely likely
- ○ It depends (briefly describe): _____

Q33 A cooperative or business owned by multiple farmers could provide access to handling equipment for use at solar sites. What is the industry need for such a business to provide handling equipment?

- ○ Not needed
- ○ Somewhat needed
- ○ Needed
- ○ Very needed
- ○ Extremely needed

Q34 How likely are you to utilize handling equipment at the solar site provided by such a cooperative or other business owned by multiple farmers, assuming that membership included access to the equipment for a reasonable fee?

- ○ Not likely
- ○ Somewhat likely
- ○ Likely
- ○ Very likely
- ○ Extremely likely
- ○ It depends (briefly explain): _____

The next few questions focus on monitoring sheep and managing vegetation at solar array sites.

If you answered Q3 with any of the following, go to Q35. If not, go to the lead in for Q39.

Full-time sheep farmer, grazing MY sheep under solar arrays
Part-time sheep farmer, grazing MY sheep under solar arrays
Sheep farmer grazing MY sheep AND sheep I LEASE from others to graze under solar arrays
I lease some/all of my sheep to another person grazing sheep under solar arrays

Q35 How often do you visit sheep at a solar array site?

- ○ Once a week
- ○ Twice a week
- ○ Zero, person leasing my sheep visits the solar array site
- ○ Other (briefly describe): _____

Q36 How many hours do you typically spend traveling to and from solar sites to manage or inspect the sheep during the grazing season?

Minimum hours per week: _____
Average number of hours per week: _____
Maximum hours per week: _____
Person leasing my sheep travels to and from a site (enter 0): _____
It depends (briefly describe): _____

Q37 About how many miles do you drive each week to manage or inspect sheep at solar sites?

Minimum number of miles driven: _____
Average number of miles driven: _____
Maximum number of miles driven: _____
Person leasing my sheep drives to manage and inspect sheep (enter 0): _____
It depends (briefly explain): _____

Q38 Once you arrive at a solar site, how many hours do you spend monitoring and managing the sheep and inspecting the site?

Minimum number of hours: _____
Average number of hours: _____
Maximum number of hours: _____
Person leasing my sheep monitors/manages sheep and inspects site (enter 0): ___
It depends (briefly describe): _____

If you answered Q3 with any of the following, go to Q39. If not, go to Q41.

Full-time sheep farmer, grazing MY sheep under solar arrays
Part-time sheep farmer, grazing MY sheep under solar arrays
Sheep farmer grazing MY sheep AND sheep I LEASE from others to graze under solar arrays

Q39 Recognizing that supplemental mechanical trimming is dependent on weather conditions and pressure of undesirable plants, how many times over the grazing season would you expect to trim weeds, etc. at a solar array site?

- ☐ 0 times
- ☐ 1 to 2 times
- ☐ 3 to 4 times
- ☐ 5 to 6 times
- ☐ More than 6 times
- ☐ Other (briefly describe): _____

Q40 How many hours do you spend mechanically mowing or trimming vegetation at a solar site during the grazing season?

Minimum number of hours: _____
Average number of hours: _____
Maximum number of hours: _____
It depends (briefly describe): _____

Q41 Grazing sheep under solar arrays requires someone to monitor the sheep, check water supply and fencing, and occasionally provide health care. What is the industry need for a cooperative or other business owned by multiple farmers to provide these shepherding services?

- ○ Not needed
- ○ Somewhat needed
- ○ Needed
- ○ Very needed
- ○ Extremely needed

Q42 Assuming one or more persons with the knowledge to monitor the sheep, check the water supply and fencing, and occasionally provide health care are hired by a cooperative or other business owned by multiple farmers, what is the likelihood that you would utilize these services provided by such a business if at reasonable rates?

- ○ Not likely
- ○ Somewhat likely
- ○ Likely
- ○ Very likely
- ○ Extremely likely
- ○ Other (briefly describe): _____

Q43 Contractual arrangements typically call for either all vegetation or "covered vegetation" (vegetation consumed by sheep) to be managed by the sheep farmer. What is the industry need for a cooperative or other business owned by multiple farmers to provide supplemental mechanical trimming, if needed, to maintain the terms of the agreement?

- ○ Not needed
- ○ Somewhat needed
- ○ Needed
- ○ Very needed
- ○ Extremely needed

Q44 What is the likelihood that you would utilize supplemental mechanical trimming services if provided by a cooperative or other business owned by multiple farmers if at a reasonable fee?

- ○ Not likely
- ○ Somewhat likely
- ○ Likely
- ○ Very likely
- ○ Extremely likely
- ○ It depends (briefly describe): _____

Marketing and selling sheep and lambs can be challenging. We seek to understand how you market and sell your sheep, along with anticipated challenges in the future.

If you answered Q3 with any of the following, go to Q45. If not, go to Q52.

Full-time sheep farmer, grazing MY sheep under solar arrays
Part-time sheep farmer, grazing MY sheep under solar arrays
Sheep farmer grazing MY sheep AND sheep I LEASE from others to graze under solar arrays
I lease some/all of my sheep to another person grazing sheep under solar arrays
I'm a sheep farmer not currently grazing sheep under solar arrays but am interested in exploring
I'm a sheep farmer and am NOT interested in grazing sheep under solar array

Q45 Where do you sell your lambs and sheep? Check all that apply.

- ☐ Market directly to consumers
- ☐ Market to food wholesalers, distributors, restaurants, and/or retailers
- ☐ Wet markets
- ☐ Auctions/sale barns
- ☐ Other, briefly describe: _____

Q46 Over the past 3 years, on average, how many SHEEP (including lambs) did you market each year for meat?

- ○ Less than 30
- ○ 31 to 50
- ○ 51 to 100
- ○ 101 to 200
- ○ 201 to 400
- ○ More than 400

Q47 Over the past 3 years, on average, how many LAMBS did you market each year for meat?

- ○ Less than 30
- ○ 31 to 50
- ○ 51 to 100
- ○ 101 to 200
- ○ 201 to 400
- ○ More than 400

Q48 Of the total sheep sold over the past three years, what <u>percentage</u> were sold in each of the following categories?

- Percent lambs for meat: _____
- Percent cull ewes, cull rams: _____
- Percent breeding stock: _____
- Percent feeder lambs: _____
- Percent fiber (hair or wool): _____
- Percent sold for grazing services, weed control: _____

Q49 When thinking about all the sheep (including lambs) you sell, what <u>percentage</u> of the total are sold in the following months? If no animals are sold in a month, enter 0.

- Percent January: _____
- Percent February: _____
- Percent March: _____
- Percent April: _____
- Percent May: _____
- Percent June: _____
- Percent July: _____
- Percent August: _____
- Percent September: _____
- Percent October: _____
- Percent November: _____
- Percent December: _____

Q50 Do you partner with other farmers to transport your sheep to or from market?

- ☐ Yes
- ☐ No
- ☐ It depends (briefly describe): _____

Q51 On average, approximately how far do your sheep travel to market when sold?

- ○ 0 to 30 miles
- ○ 31 to 75 miles
- ○ 76 to 150 miles
- ○ 151 to 250 miles
- ○ 251 to 400 miles
- ○ More than 400 miles

Q52 Marketing sheep can be challenging. In your view, what are the top 3 challenges to marketing and selling lambs and sheep? (Briefly explain).

1.

2.

3.

Q53 In your opinion, what are the top 3 opportunities to market sheep in the future? (Briefly explain)

1.

2.

3.

Q54 Marketing lamb is mixed as farmers sell direct-to-consumers, through auction barns or to wholesalers, distributors, restaurants, and retailers. A cooperative or other business owned by multiple farmers could serve as an additional market channel or provide marketing services. What is the <u>industry need</u> for such a cooperative or other business owned by multiple farmers to assist with marketing lambs?

- ○ Not needed
- ○ Somewhat needed
- ○ Needed
- ○ Very needed
- ○ Extremely needed

Q55 Assuming reasonable fees to access an additional market channel and/or marketing services provided by a cooperative or other business owned by multiple farmers, how likely are <u>you to utilize</u> the marketing services provided by such an enterprise?

- ○ Not likely
- ○ Somewhat likely
- ○ Likely
- ○ Very likely
- ○ Extremely likely
- ○ It depends (briefly explain): _____

Q56 Branding and labeling can differentiate products in the marketplace by highlighting a specific location or production practice, for example. Sheep farms grazing sheep under solar arrays could be a means to differentiate lamb and sheep products. In your view, what is the <u>industry need</u> for such branding?

- ○ Not needed
- ○ Somewhat needed
- ○ Needed
- ○ Very needed
- ○ Extremely needed

Q57 Such branding and product differentiation requires some form of guarantee from the farmer regarding location and/or practices. How likely are <u>you to utilize</u> a brand/label that differentiates products in the marketplace that is developed/controlled by a cooperative or other business owned by multiple farmers?

- ○ Extremely unlikely
- ○ Somewhat unlikely
- ○ Neither likely nor unlikely
- ○ Somewhat likely
- ○ Extremely likely
- ○ It depends (briefly describe): _____

Some sheep farmers have suggested a need for additional capacity to slaughter, butcher, and cut and wrap meat. The next few questions focus on the need for such facilities and services.

Q58 From your current and anticipated future experience, is there an <u>industry need</u> for additional slaughter, butcher, and cut and wrap capacity?

- ○ Not needed
- ○ Somewhat needed
- ○ Needed
- ○ Very needed
- ○ Extremely needed

Q59 A cooperative or other business owned by multiple persons could provide additional slaughter, butcher, and cut and wrap services. What is the likelihood that <u>you would utilize</u> such services if reasonably priced?

- ○ Not likely
- ○ Somewhat likely
- ○ Likely
- ○ Very likely
- ○ Extremely likely
- ○ It depends (briefly describe): _____

Q60 A cooperative or business owned by multiple farmers could negotiate time slots to access slaughter or butchering facilities. In your view, is there an <u>industry need</u> for a business to provide such services?

- ○ Not needed
- ○ Somewhat needed
- ○ Needed
- ○ Very needed
- ○ Extremely needed

Q61 How likely are <u>you to utilize</u> a cooperative or other business owned by multiple farmers to negotiate slaughter/butcher slots on your behalf if offered at reasonable rates?

- ○ Would not utilize
- ○ Might utilize
- ○ Utilize
- ○ Likely utilize
- ○ Definitely utilize
- ○ It depends (briefly describe): _____

Sometimes farmers join together to purchase inputs needed for their individual farms to receive more competitive pricing.

Q62 In your opinion, is there an <u>industry need</u> for a cooperative or other business owned by multiple farmers to pool orders to purchase inputs on behalf of sheep farmers?

- ○ Not needed
- ○ Somewhat needed
- ○ Needed
- ○ Very needed
- ○ Extremely needed

Q63 What is the likelihood that <u>you would utilize</u> a cooperative or business owned by multiple farmers to pool orders to purchase inputs on behalf of sheep farmers if offered at reasonable rates?

- ○ Not likely
- ○ Somewhat likely
- ○ Likely
- ○ Very likely
- ○ Extremely likely
- ○ It depends (briefly explain): _____

Historically people have come together to meet a need or secure goods and services not available when working independently.

Q64 If a cooperative or other business owned by multiple farmers was formed to provide assistance to farmers grazing sheep under solar arrays and strengthen the viability of the sheep farming sector, what is <u>your interest</u> in the following to support this effort?

Action	Not interested	Somewhat interested	Interested	Very interested
Provide guidance and leadership to develop and launch the business	○	○	○	○
Become part owner of the business	○	○	○	○
Become an investor in the business	○	○	○	○
Become a member-owner of a cooperative	○	○	○	○
Serve in a leadership capacity (board member, officer)	○	○	○	○
Become part of the paid management team	○	○	○	○
Become a paid employee	○	○	○	○
Be a paid contract service provider	○	○	○	○
Be a "customer only" (non-owner) of the business	○	○	○	○

Q65 If a cooperative or other business owned by multiple farmers was formed to assist farmers with grazing sheep under solar arrays and strengthen the sheep sector overall, how interested would you be in <u>providing the following services for compensation</u>?

Service	Not interested	Interested	Very interested	Extremely interested
Assist with solar grazing contract negotiations	○	○	○	○
Inspect solar site prior to contract negotiation	○	○	○	○
Transport sheep to/from solar sites	○	○	○	○
Load and unload sheep at solar sites	○	○	○	○
Monitor sheep and grazing conditions at solar sites	○	○	○	○
Provide medical care to sheep at solar sites	○	○	○	○
Provide mechanical trimming/mowing at solar sites	○	○	○	○
Transport sheep to market, slaughter facilities	○	○	○	○
Assist with branding & promotional efforts; e.g., meet with buyers, promote organization	○	○	○	○
Other (briefly describe):	○	○	○	○

Q66 Is there anything else that you would like to share to our investigation of the need for a cooperative or other business owned by multiple farmers to support persons grazing sheep under solar arrays?

Q67 If you want to receive more information about the results of the survey and/or participate in forthcoming farmer focus groups, please share your name and email address. Your contact information WILL NOT be shared.

Name:

Email address:

Verify email address:

Q68. Persons completing the survey are eligible to receive one of three $100 Amazon gift cards. Persons receiving gift cards will be notified in late December 2022. To be entered into the drawing, please provide your name, phone number and email address in order that we might contact you if your name is drawn. Your contact information WILL NOT be shared.

Name:

Email address:

Verify email address:

Phone number:

Thank you for your time completing this survey. Your responses will importantly inform future research and industry outreach activities!