AMERICAN SOLAR GRAZING ASSOCIATION

United States Solar Grazing 2024 Census

ASGA
AMERICAN SOLAR GRAZING ASSOCIATION

Funding Source: U.S. Department of Energy National Renewable Energy Laboratory

Photo from Nittany 1 Solar Farm courtesy of Lightsource bp

EXECUTIVE SUMMARY

CONTENTS

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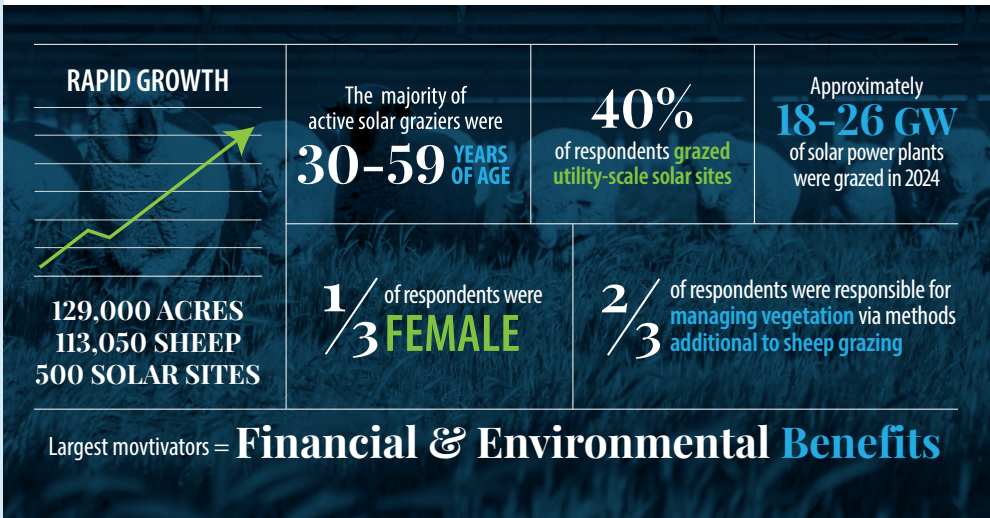
Solar photovoltaic (PV) energy generation is expected to play an increasingly important role in the global energy transition. **Agrivoltaics**, the co-location of solar PV and agriculture, is expected to expand across small and large scale operations, especially in the form of livestock grazing, otherwise known as **solar grazing**. Despite preliminary data collected independently by the **American Solar Grazing Association** (ASGA) and the **National Renewable Energy Laboratory** (NREL) there has not been a broadly organized effort dedicated to capturing the full scope and scale of solar grazing in the U.S. Therefore, thanks to a concerted effort by both ASGA and NREL, the 2024 United States Solar Grazing Census sought to generate the most comprehensive estimates of solar grazing to-date. The information gathered also provides important demographic information of U.S. solar graziers, while inventorying adjacent data on best practices, motivations, and challenges of solar grazing.

The U.S. Solar Grazing Census was completed in two stages via electronic surveys. Round 1 took place between September 29, 2023 and January 31, 2024. Round 2 took place between August 14, 2024 and October 25, 2024, and only those Round 1 respondents who identified as active solar graziers were asked to complete the second survey. The purpose of Round 2 was to strengthen response credibility by clarifying previously reported information and soliciting more detail.

The following report provides a summary of Census highlights, beginning with sections on Background and Methods. Next, Participant Demographics are shared, followed by an illustration of the regional Scale of Solar Grazing with a highlight on Grazier Specific Demographics on page 6. The report body includes a large section on Operations and Solar Grazing in Practice, including subsections on Sheep, Site Management, Panels & Utility, and Contracts. Finally, there is data reported on Solar Grazier Perspectives. The report concludes with a summary of Major Learning Points and Next Steps.

ASGA, NREL, and their partnering authors and contributors are grateful for the time and effort of all 2024 Census respondents. The utility and significance of these data have greatly improved understanding of the scope of solar grazing in the U.S. The intention is to continue this valuable pursuit and produce a U.S. Solar Grazing Census in years to come.



BACKGROUND AND DEFINITIONS

Solar photovoltaic (PV) energy generation is expected to play an increasingly important role in the global energy transition to reduce greenhouse gas emissions, mitigating negative impacts on climate. Solar PV could potentially account for up to half of total global electricity generation by 2050[1]. Increasing solar PV installation (Figure 1)[2] poses potential land use conflicts with agricultural and otherwise "green" or "natural" landscapes. Solar PV has a higher land footprint than other clean energy sources and could require up to 10 million acres under the most extreme projections of solar deployment in the United States[3,4]. Agrivoltaics is an approach that combines agricultural activities with solar energy generation, and can reduce the potential for land-use conflicts, support agricultural operations, improve natural resource value, and provide ecosystem services. Solar grazing is the most widespread form of agrivoltaics, which uses livestock to maintain vegetation and ecosystem services at solar sites.

Previous attempts to track the scope of solar grazing have relied on voluntary input from solar graziers and developers. Additionally, as the industry grew, the American Solar Grazing Association (ASGA) attempted to estimate the number of acres being grazed by sheep based on reports within its membership. In 2021, ASGA released a fact sheet titled ***What is Solar Grazing and How Does It Work?***,[5] which estimated **15,000 acres** of solar land was being grazed by sheep. ASGA also created an interactive tool, the Solar Grazing Map[6], which allows ASGA members to pin where they are grazing and declare operation size and if they are actively seeking solar contracts. The National Renewable Energy Laboratory's (NREL) InsPIRE Project also maintains a comprehensive Agrivoltaics Map[7], which currently identifies that more than **230 sites**, encompassing over **53,000 acres**, are being managed by solar grazing.

Despite the valuable information the ASGA and NREL maps provide, there has not been a broadly organized effort dedicated to capturing the full scope and reach of solar grazing. Therefore, in 2024, ASGA, in partnership with NREL, released the first ever U.S. Solar Grazing Census. This Census seeks to generate the most recent and comprehensive estimates of the scale and reach of solar grazing in the U.S. to-date. Additionally, the information gathered provides important demographic information of solar graziers, while inventorying adjacent data on best practices, motivations, and challenges of solar grazing. ASGA is uniquely positioned to provide this information.

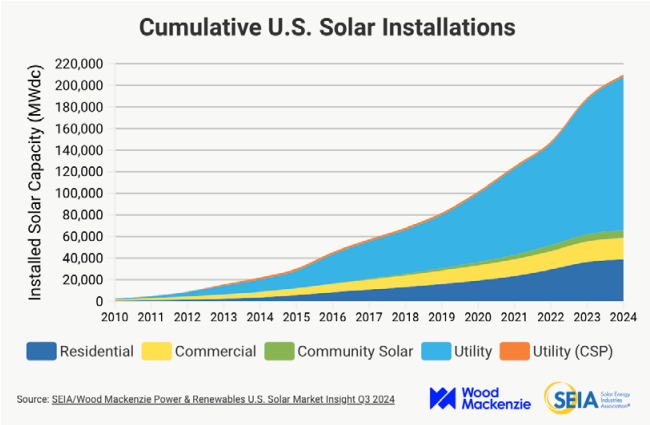


Figure 1. *Cumulative U.S. Solar Installations* https://seia.org/research-resources/solar-industry-research-data/
Source: SEIA/Wood Mackenzie Power & Renewables U.S. Solar Market Insight Q4 2024

*The **American Solar Grazing Association** (ASGA) is a farmer-led membership community with nearly 1,000 members representing a diverse group of farmers and solar developers and the leading voice of the solar grazing industry. We provide educational programming and resources for farmers and set professional standards and best practices for solar grazing, while working to educate the general public and important stakeholders on its economic, social, and environmental benefits.*

1 Nijsse, F. J. M. M., Mercure, J.-F., Ameli, N., Larosa, F., Kothari, S., Rickman, J., Vercoulen, P., & Pollitt, H. (2023). The momentum of the solar energy transition. Nature Communications, 14(1), 6542. https://doi.org/10.1038/s41467-023-41971-7
2 SEIA. (n.d.). "Solar Market Insight Report." Accessed July 18, 2024. https://seia.org/research-resources/us-solar-market-insight/
3 van Zalk, J., & Behrens, P. (2018). The spatial extent of renewable and non-renewable power generation: A review and meta-analysis of power densities and their application in the U.S. Energy Policy, 123, 83-91. doi:https://doi.org/10.1016/j.enpol.2018.08.023
4 Margolis, R. (2021). Solar Futures Study Databook (GO102021). National Renewable Energy Laboratory - Data (NREL-DATA), Golden, CO (United States); National Renewable Energy Lab. (NREL), Golden, CO (United States). https://doi.org/10.7799/1830416
5 American Solar Grazing Association. (2021). "What Is Solar Grazing and How Does It Work?" https://solargrazing.org/wp-content/uploads/2021/11/ASGA-SolarGrazing_brochure2021-CMYKbleeds-1.pdf
6 American Solar Grazing Association. (n.d.). "Solar Grazing Map - American Solar Grazing Association." Accessed December 11, 2024. https://solargrazing.org/map/
7 National Renewable Energy Laboratory. (n.d.). "InSPIRE/Agrivoltaics Map | Open Energy Information." Accessed December 11, 2024. https://openei.org/wiki/InSPIRE/Agrivoltaics_Map

CENSUS METHODS

The U.S. Solar Grazing Census was completed in two stages. Round 1 was administered via Tally Forms between September 29, 2023 and January 31, 2024. The survey consisted of 59-65 questions, depending on if the Census was taken as an individual or on behalf of a business/organization. Response types were a combination of multiple choice, single choice, drop down, yes/no, and short answer. Several questions were designated "optional" to avoid any contractual confidentiality conflicts for graziers. Round 1 was the most comprehensive of the two stages and sought to gain as much information from respondents as possible. Sections included personal information, demographics, business/organization information, personal farm information, experiences with solar grazing, characteristics of grazed solar sites, solar grazing operation details, solar operation and management details, and familiarity with ASGA.

Round 2 of the U.S. Solar Grazing Census took place between August 14, 2024 and October 25, 2024, and was administered via Tally Forms. Respondents were also given the option to share their information as a phone/Zoom interview-style call. For Round 2, only those who were identified as active solar graziers during the first round were invited to participate. The purpose was to strengthen response credibility by clarifying information from the first stage. Additionally, this stage allowed graziers to update their grazing inventories of acreage and number of sheep. There were 17-30 total questions depending on if graziers were updating their numbers, grazing in multiple states, and/or grazing as part of a business/organization. Many of the questions were designated "optional," and response types were a combination of short answer, drop down, yes/no, and single choice. Round 2 included personal information, solar grazing business details, operational logistics, and pricing and income. The questionnaire concluded with an invitation for participants to update the ASGA and NREL maps with their most current information.

A variety of promotional tools were used to acquire Census participation. For Round 1, an email was sent to ASGA's full membership network on multiple occasions with an invitation to participate in the Census. ASGA and NREL also extended an invite to several individual organizations asking them to share the Census with their own networks. The Solar Farm Summit and AgriSolar Clearinghouse both created blogposts helping to recruit participation in the Census. The Census was shared several times via Instagram, LinkedIn, and ASGA's professional network, Mighty Networks. Furthermore, ASGA formally introduced the U.S. Solar Grazing Census during a monthly workshop. Preliminary results from Round 1 were shared at the April 2024 ASGA Webinar and the NREL InSPIRE ASTRO Spring Meeting. Round 2's promotion was direct to individuals and involved sending multiple emails to grazier participants from Round 1. Additionally, individuals, who may have unintentionally reported double counting numbers (e.g. if a solar developer and their grazier both declared the same numbers), were contacted for data clarification and reconciliation.

ROUND 1: Sept 29, 2023 - January 31, 2024

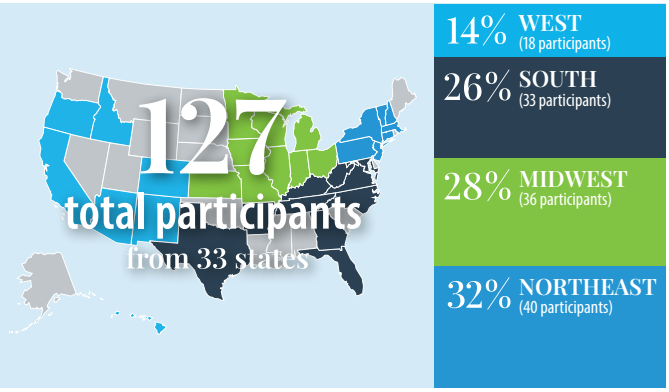
- Personal Information and Demographics
- Business and Organization Information
- Farm Information
- Experience with Solar Grazing
- Characteristics of Solar Sites Grazed
- Solar Grazing Operation Details
- Solar Operation and Management Details
- Familiarity with ASGA

ROUND 2: August 14 - October 25, 2024

- Personal Identifying Details
- Sole Proprietor or Partnership
- Solar Grazing Business
- Operation Logistics
- Pricing and Income
- ASGA/NREL Maps

PARTICIPANT DEMOGRAPHICS

Census recruitment efforts resulted in **127 total responses**. (Solar grazier-specific demographics are reported in the following section on Scale of Solar Grazing.) A regional breakdown shows the greatest number of participants, 40, resided in the Northeast, while the smallest participant number, 18, came from the West region. Comparable numbers of participants came from the Midwest and South regions, 36 and 33 respectively. Average participant age was 45.3, ranging from 22 to 80 years. Most participants completed the Census as individuals, 70%, while 30% responded on behalf of a business organization. Of the total, 61% of participants reported supporting paid employees.



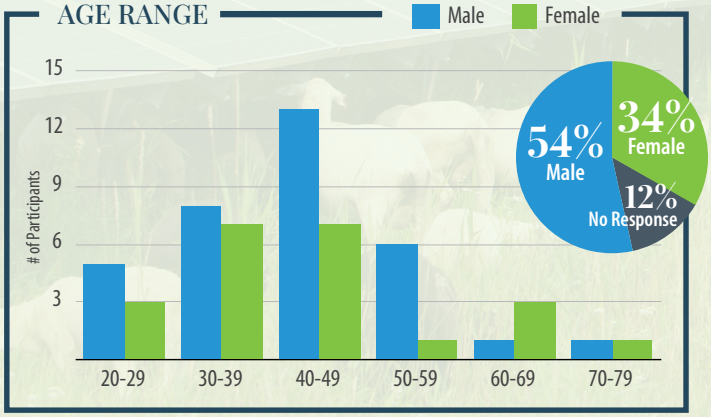
Regardless of their profession or affiliation in the solar grazing industry, participants were asked to respond to questions about grazing and farming experience, as well as land tenureship. This provided additional context into participant familiarity with agriculture or land management generally. Data highlighted that 87% of participants had livestock grazing experience outside of the solar industry and had spent from 1 to 61 years farming or ranching. In fact, each participant was farming between 1 and 7,380 acres of land at the time of the Census, an average of 343 acres per participant. In terms of land tenureship, 44% of participants owned land, 17% leased, and 39% both owned and leased land.

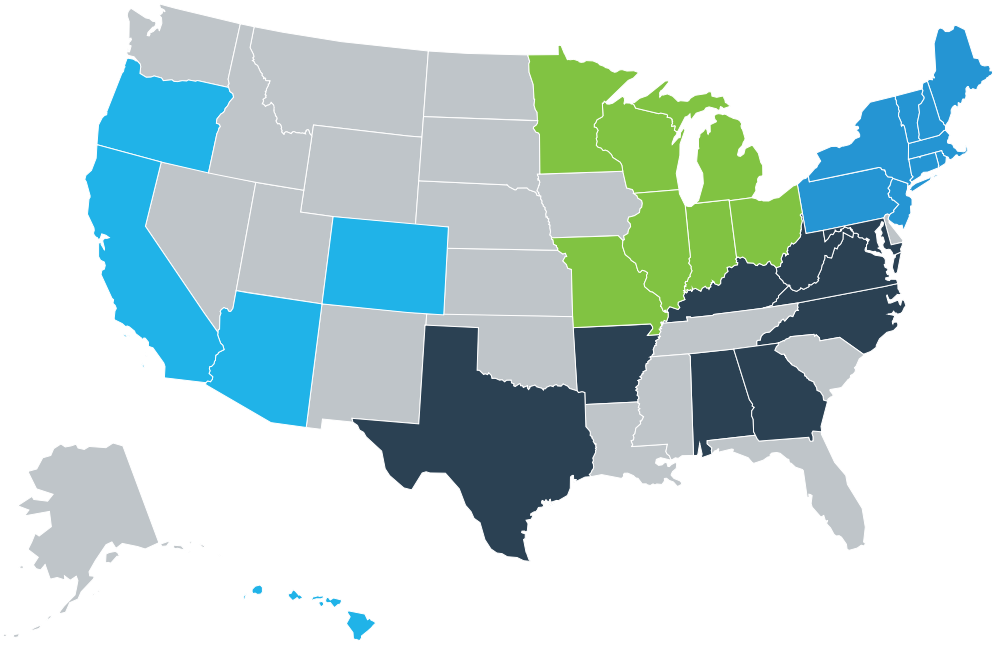
45.3
AVERAGE AGE
of 111 respondents
min: 22 | max: 80

Solar Grazier Demographics

Of the 127 participants, there were **65 actively solar grazing** at the time of the Census. The majority of active solar graziers were male and between 30 and 59 years of age. Over a third of solar graziers reported as female, which is a significant proportion for the agricultural sector. The longest any respondents had been engaged in solar grazing was 11 years.

3.47 AVERAGE YEARS SOLAR GRAZING
of 55 respondents / min: 1 | max: 11





30 States
Reported Solar Grazing

129,261 Acres | 113,050 Sheep
506 Solar Sites

MIDWEST
6,852 Acres
13,254 Sheep
148 Sites

NORTHEAST
4,600.5 Acres
13,274 Sheep
145 Sites

WEST
30,728.25 Acres
24,541 Sheep
104 Sites

SOUTH
87,080 Acres
61,981 Sheep
109 Sites

REGIONAL TRENDS

The 2024 Census revealed that the scale of solar grazing in the U.S. is actually much larger than previously understood. This magnitude can be attributed to a recent exponential expansion of solar grazing in tandem with the rise of the solar industry as a leader in renewable energies. The Census also showed clear regional variations as the geographical landscape of solar grazing takes shape.

ACRES = 129,261 total

MIDWEST	NORTHEAST	SOUTH	WEST
6,852	4,601	87,080	30,728
		Texas: 68,626 total	California: 21,750 total

According to SEIA's method for estimating power capacity per acre, the Census recorded that approximately 18-26 GW of solar sites were being grazed in 2024[8]. The South region exceeded the combined values of the Midwest, Northeast, and West in both sheep numbers and acres engaged in solar grazing. However, the total number of solar sites in each region demonstrated less disparity. This indicates that while the Midwest, Northeast, and West regions had similar numbers of solar sites using solar grazing, it can be assumed these sites were on average smaller in both total acreage and sheep numbers than sites in the South, which likely consisted of larger operations. **California and Texas accounted for a bulk of the numbers for sheep and acres in the West and South.**

SHEEP = 113,050 total

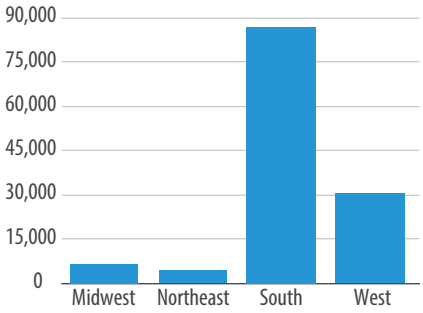
MIDWEST	NORTHEAST	SOUTH	WEST
13,254	13,274	61,981	24,541
		Texas: 36,237 total	California: 15,800 total

The totals presented here are absolute values. Average stocking rates cannot be determined by comparing total sheep numbers and total acres for each region. Stocking rate across solar grazing operations is very nuanced and can vary greatly by environmental and economic context, conditions that were not surveyed in the Census. Additionally, a hybrid grazing-mowing approach to solar site management is not uncommon, and the precise degree to which this was implemented and influenced sheep numbers per acre or per site is not clear in Census data.

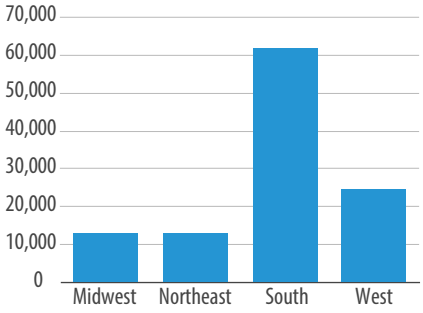
SOLAR SITES = 506 total

MIDWEST	NORTHEAST	SOUTH	WEST
148	145	109	104
		Texas total: 55	California total: 82

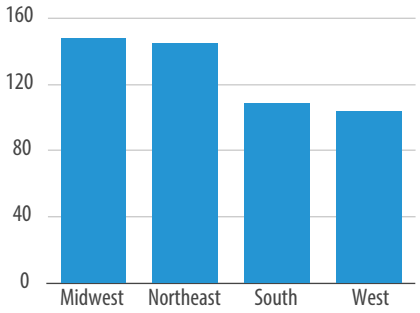
Acres Solar Grazed by Region



Sheep Solar Grazed by Region



Solar Sites Grazed by Region

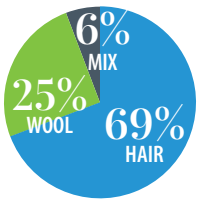


8 SEIA. (n.d.) "Land Use & Solar Development." Accessed April 4, 2025. https://seia.org/initiatives/land-use-solar-development/

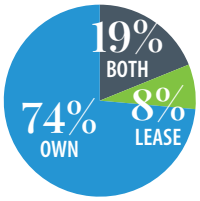
SHEEP

Solar grazing has pushed the sheep industry into new territory. The majority of solar graziers owned the sheep they use for solar grazing, and hair breeds were more common than wool breeds on solar sites. This correlates to the South region being the largest deployer of solar grazing, where hair sheep would be more adapted for a warmer, humid climate.

Type of Sheep



Own or Lease

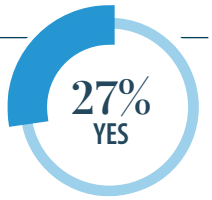


When are Sheep On-site?

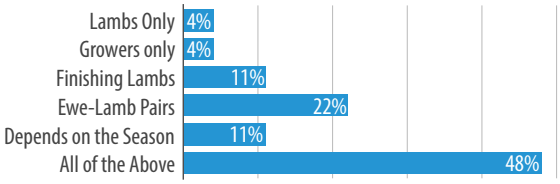
In regions where forage does not grow year-round, sheep were usually moved off-site, unless hay could be fed on site to sustain sheep during winter months.

Buy-In Stockers?

The majority of solar graziers relied on their existing flock to maintain site vegetation management requirements, sometimes as a hybrid approach, using both grazing and mowing techniques. However, some chose to purchase additional stock, also known as "buy-in stockers" to successfully meet the vegetation management demands of a site.



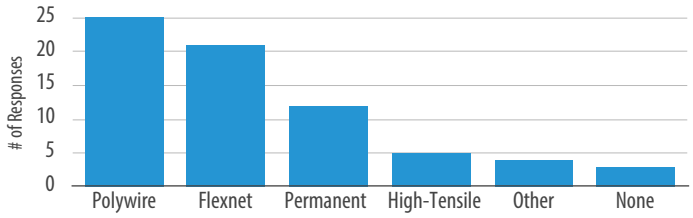
Production Stages of Sheep used on Solar Sites



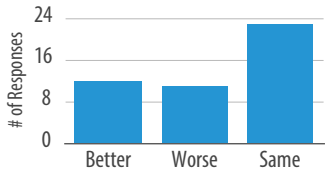
SITE MANAGEMENT

Solar grazing requires special management considerations beyond the needs of typical solar operations that use only mechanical mowing for vegetation management. Livestock friendly fencing, water access, predation control, and grazing strategy were all reported as critical considerations for successful solar grazing management.

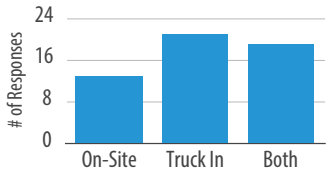
Type of Interior Fencing Used on Solar Sites



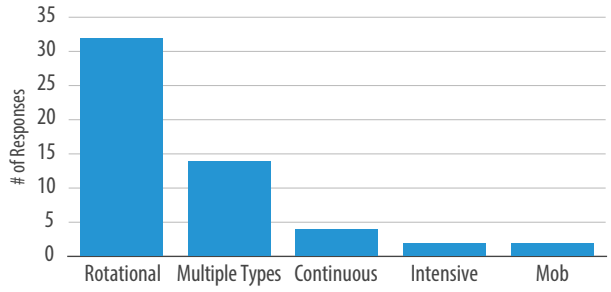
Predator Loss compared to home operation



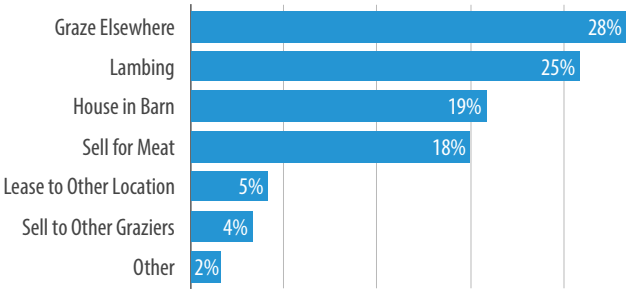
Water Access



Grazing Techniques Used at Solar Sites



Animals in the Off-Season

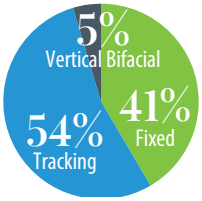


PANELS & UTILITY

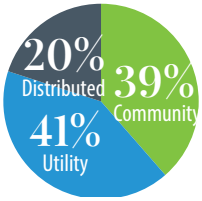
Sheep have proven to be a valuable asset to solar site vegetation management. Because of their size, they are adaptable to various solar design and infrastructure configurations. Sheep grazing was commonly utilized on both large, utility-scale solar sites and smaller community and distributed generation facilities, as well as fixed and tracking style solar arrays. Over 40% of respondents reported grazing utility scale solar sites.

The numbers reported here represent the number of Census responses received, rather than the total amount of acres or power capacity, using each panel and facility type. Future Census work will aim to further analyze how facility type impacts solar grazing.

Panel Types



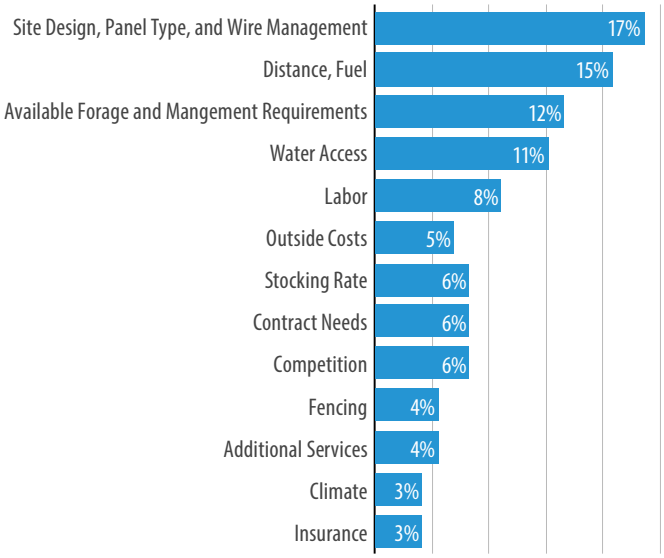
Facility Types



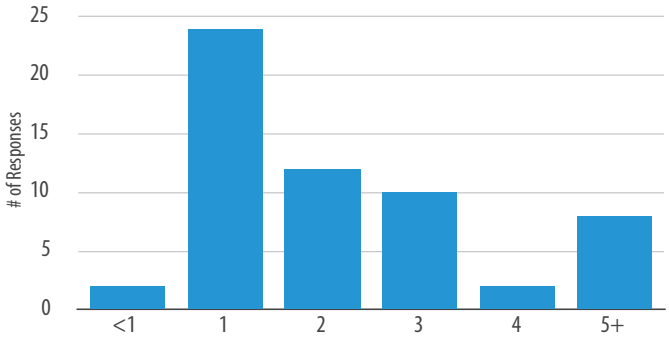
CONTRACTS

An emergent field, the solar grazing industry had no precedent for negotiating contractual or legal agreements. Therefore, logistical and needs-based drivers have influenced the way partnerships between graziers and operators are formalized. To support formalizing partnerships between graziers and solar asset owners, the American Solar Grazing Association developed a solar grazing contract template in 2018 and updated it again in 2022. The most popular contract length was reported as **one year**. The most influential factor in contract price was *"site design, panel type, and wire management"* as these factors can heavily influence labor needs. Approximately two-thirds of respondents reported being held responsible for managing vegetation via methods additional to sheep grazing.

Contract Considerations

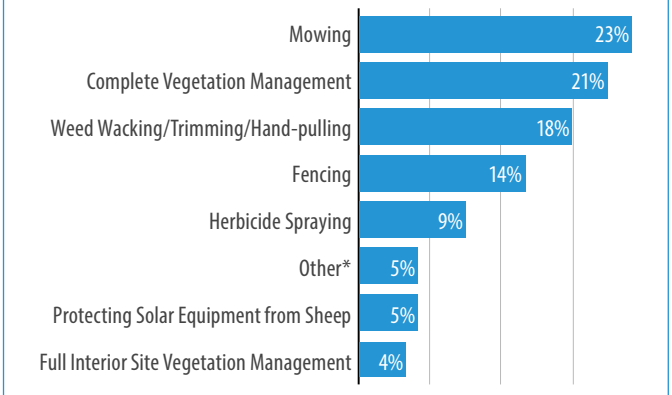


Contract Length in Years



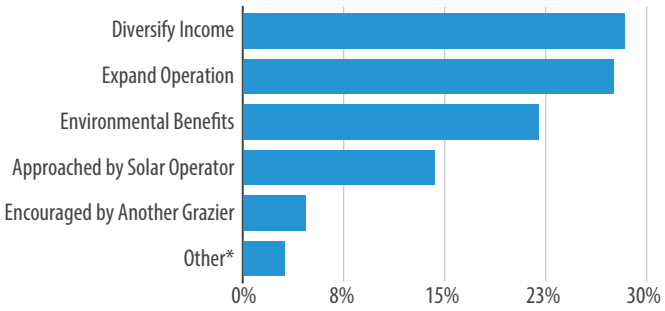
65% Graziers Considered their Solar Operation **FINANCIALLY STABLE**

61.54% Graziers Reported Providing **ADDITIONAL SERVICES**



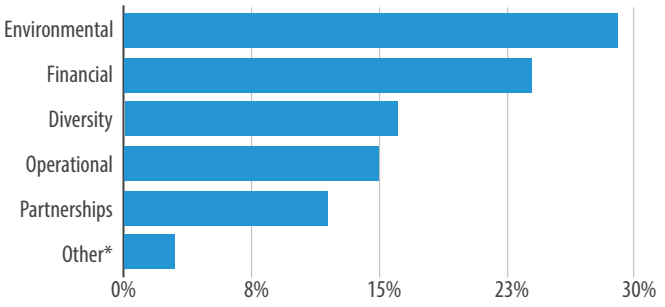
* Snow Plowing, Road Repairs, Discing

WHY Did Respondents Start Solar Grazing?



*Alternative Vegetation Management, Research, Livestock Benefits

BENEFITS of Solar Grazing



*Agricultural Production, Education and Research, Animal Health and Welfare, Land Stewardship, and Survival

Over **50%** of respondents were **financially motivated**, and environmental benefits were the next largest motivating factor to begin solar grazing.

Environmental benefits took the lead in participant responses, reflecting an emphasis on both the production of renewable energy and healthy land management. Financial benefits closely followed in priority with diversity and operational benefits enhancing existing agricultural business. Fewer responses identified partnership establishment as a key benefit to solar grazing. Finally, 3% of respondents defined "other" benefits, such as agricultural production, education and research, animal health and welfare, land stewardship, and survival.

What makes a successful partnership?

Most respondents characterized a successful partnership as one that is **mutually beneficial**.

- Mutually Beneficial - 38%
- Good Communication - 23%
- Livestock is Prioritized - 12%
- Environment is Prioritized - 10%
- Potential to Extend Contracts - 5%
- Grazier Manages all Vegetation - 3%
- Community is Engaged - 3%
- Flexible - 3%
- Accessibility is Prioritized - 2%

"Only way I was able to be profitable as a livestock producer and first-generation farmer with no access to land/inherited property."

"Sheep as an Afterthought"

CHALLENGES

To better understand the challenges of managing livestock on solar power plants, the Census surveyed solar grazier opinions. Proper fencing, water access, and overall site design consistently emerged as the most common issues affecting the difficulty (or ease) of grazing livestock on solar sites. Wire management and forage quality were the next most popular concerns. When asked about common problems on solar sites, solar graziers reported that poor wire management was the most problematic, while poor communication and gate management were also significant.

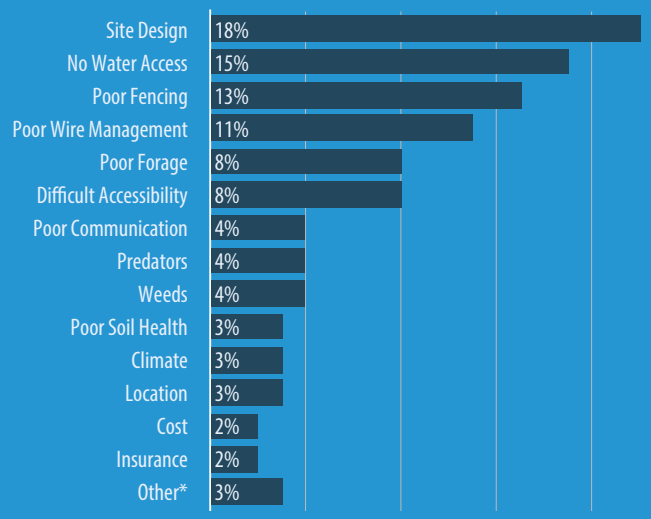
GUIDELINES/BEST PRACTICES

Solar graziers illustrated differing opinions about the implementation of industry standards or best practice guidelines. Some graziers appreciated full independence while others felt they could benefit from industry guidance.

"I learned all my lessons the hard way, BUT if there were resources like ASGA back in 2016 maybe I wouldn't have had to learn the hard way..."

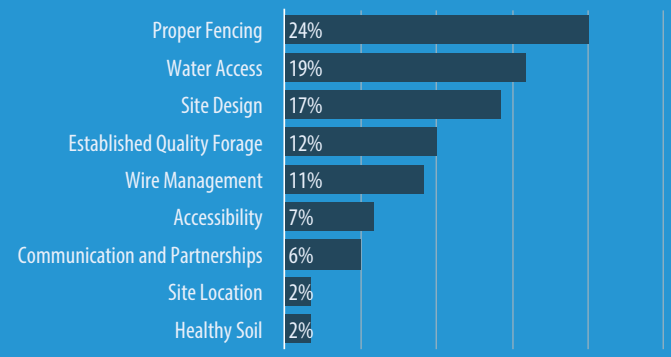
"I prefer the autonomy/flexibility of creating my own terms as each site is unique in its own way."

What makes a solar site DIFFICULT to graze?

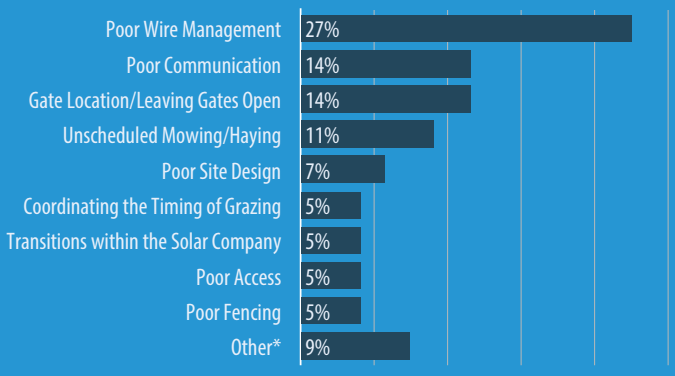


*Management Expectations, Partnerships with USDA, Prior Land Management, Sheep as an Afterthought

What makes a solar site EASY to graze?



What are COMMON O&M PROBLEMS?



*Contract Length, Not Connecting Electric Fence, Pricing, Theft

"Communication is key! When we take the time to touch base with the O&M company, we are able to work more efficiently."

MAJOR LEARNING POINTS

- The scale of solar grazing in the U.S. is much larger than previously understood and undergoing **rapid growth**. As of October 2024, approximately **113,050 sheep** were grazing **129,000 acres** across over **500 solar sites**.
- Sheep grazing was commonly utilized on both large, utility-scale solar sites and smaller community and distributed generation facilities, as well as fixed and tracking style solar arrays.
- Over **40%** of respondents reported grazing **utility-scale solar** sites.
- There were clear **regional variations**, with the South region exceeding the Midwest, Northeast, and West in both sheep numbers and acres engaged in solar grazing. However, the total number of solar sites were similar across all four regions, suggesting that sites were on average smaller in both total acreage and sheep numbers in the Midwest, Northeast, and West.
- Site design, water access, and fencing were the top three factors that solar graziers reported as affecting the difficulty of grazing a solar array. The most influential factor in contract price was "site design, panel type, and wire management" as these factors can heavily influence labor needs.
- The majority of active solar graziers were between 30 and 59 years of age and over a third reported as female.
- Approximately two-thirds of respondents reported being held responsible for managing vegetation via methods additional to sheep grazing, including mechanical mowing.
- Over 50% of respondents were **financially motivated**, and **environmental benefits** were the next largest motivating factor to begin solar grazing.

NEXT STEPS

This report highlights the scope of U.S. solar grazing in 2024. Solar grazing is a rapidly growing industry. Authors and contributors support the efficacy and importance of Census work and intend to continue tracking the evolution of U.S. solar grazing in the coming years.

Results shared in the 2024 U.S. Solar Grazing Census Report provide a high-level summary and reveal gaps in understanding, sparking new questions and ideas for further investigation. For example, in Round 2 graziers were asked to report on their numbers of acres, sites, and sheep on a state basis, though this level of breakdown was not requested for many of the questions asked in Round 1. Future Census efforts will delve deeper into geographic scales, as well as other key topics such as facility, panel, and sheep type, on a site basis.

Verification of respondents and responses, while cross-checking the potential for double-counting, was a challenge of the 2024 Census. Still, the data collection relied on participant provision of accurate responses, therefore, careful review of each survey was given to avoid inaccurate reporting. Future Census efforts will solicit additional information on the participant and site-levels, including locations and owner/operator details, to strengthen the accuracy of reported data.