Solar Farms on U.S. Farmland: Comprehensive Analysis 2024-2025

Solar development on U.S. farmland remains minimal on a national scale but is highly concentrated in agricultural areas. As of 2024-2025 data, solar farms occupy approximately **550,000-600,000 acres** with capacity-based estimates ranging to **1.25 million acres of farmland** — representing between **0.06-0.14%** of America's 876 million total farm acres. However, the impact is concentrated, with over 70% of rural solar projects installed on agricultural land, and nearly half targeting the nation's most productive soils.

Current Solar Installation Data (2024-2025)

National Solar Capacity

- **Total U.S. Solar Capacity (2024)**: ~240 GW installed
- **2024 Additions**: 50 GW (record-breaking year)
- **Utility-Scale Solar**: 41.4 GW added in 2024 (33% growth)
- **Community Solar**: 1,800 MW added in 2024

Utility-Scale Solar Breakdown by Segment

- **Utility-Scale**: 65% of total capacity (~156 GW)
- **Residential**: 32.9 GW across 4.6+ million systems
- **Commercial & Industrial**: 14.8 GW across 140,400+ systems
- **Community Solar**: 7.9 GW across 3,404 projects

Source: SEIA Solar Market Insight Report 2024

Total U.S. Farmland Data (2024)

Current Farmland Statistics

- **Total U.S. Farmland**: 876 million acres (2024)
- **Number of Farms**: 1.88 million farms
- **Average Farm Size**: 466 acres
- **Total Cropland**: 328 million acres
- **Prime Farmland**: 313.7 million acres

Source: USDA NASS Farms and Land in Farms 2024

Solar Development on Farmland: The Numbers

Current Solar Footprint on Agriculture

Current Estimate:

- **Solar on Farmland**: Approximately 550,000 – 600,000 acres (peer reviewed measurement through 2021), with capacity-based estimates ranging to 1.25 million acres.
- **Percentage of Total Farmland**: 0.06% - 0.14% depending on measurement method.
- **Measurement Methods**: Direct facility footprint measurements vs. Capacity calculations (GW x acres/MW assumptions).

Sources: "Variation in estimates of the footprint of large, ground-mounted photovoltaic solar energy in the United States." Journal of Environmental Management 394 & American Farm Bureau Federation Solar Analysis

Understanding Data Variations

Estimates of solar land use vary significantly based on measurement methodology:

Measurement Approach Differences:

- **Panel Array Only**: Measures just the solar panels and spaces between rows (smaller estimate)
- **Full Facility Footprint**: Includes everything within the fence line – panels, access roads, equipment, buffer areas (29-34% larger than array-only measurements)
- **Capacity Calculations**: Estimates based on total of GW capacity x assumed acres per MW x percentage on farmland (varies by assumptions used)

Research Findings:

A 2025 peer-reviewed study (Levin et al., Journal of Environmental Management) comparing three major solar databases found:

- Panel array measurements: 623-668 km² (154,000-165,000 acres) through 2018
- Full facility footprint: 939 km² (232,000 acres) through 2018
- The difference matters for understanding actual land impact

Why This Matters:

When reviewing solar development data, clarify whether figures represent:

- Panel-covered area only
- Total fenced facility area
- Capacity-based calculations
- Time period covered

All approaches are valid but serve different purposes. For land use impact analysis, full facility footprint measurements provide the most complete picture.

Source: Levin et al. (2025). "Variation in estimates of the footprint of large, ground-mounted photovoltaic solar energy in the United States." Journal of Environmental Management 394.

Prime Farmland vs. Other Agricultural Land

American Farmland Trust Analysis

- **83%** of future solar development projected on farmland
- **49%** of agricultural solar development on "Nationally Significant" land
- **"Nationally Significant" Definition**: Most productive, versatile, and resilient soils

Prime Farmland Impact

- **Total Prime Farmland**: 313.7 million acres
- **Projected Conversion**: ~1 million acres (0.32% of prime farmland)
- **Current Impact**: Highly concentrated in specific counties

Source: American Farmland Trust Smart Solar Program

Why Prime Farmland is Targeted

Solar developers prefer prime farmland because it offers:

- Flat, cleared terrain

- Existing electrical infrastructure
- Low development costs
- Accessibility for construction

The same characteristics that make land ideal for farming also make it least expensive for solar development.

Detailed Analysis by Project Scale

Utility-Scale Solar (≥1 MW)

- **Total Projects**: 6,000+ projects nationally
- **Average Size**: 15-20 MW per project
- **Land Requirement**: 6-10 acres per MW
- **Geographic Distribution**: All regions, concentrated in rural areas

Community Solar

- **Projects**: 3,404 projects (7.9 GW)
- **Average Size**: ~2.3 MW per project
- **Growth Rate**: Record 1,800 MW added in 2024
- **Key Markets**: New York, Massachusetts, Minnesota, Maine

Source: NREL Community Solar Data

Comparison: Solar vs. Other Land Uses

Context for Solar Land Use

- **Solar on Farmland**: 550,000-1.25 million acres (0.06% - 0.14%) depending on measurement method and time period
- **Corn for Ethanol**: 30 million acres (3.4% of total farmland)
- **Conservation Reserve Program**: 26 million acres enrolled (2.9% of total farmland).
- **Urban Development**: Consumes 1+ million acres of farmland annually
- **Solar Growth**: Even at the highest estimates, solar uses less land than lost to sprawl in a single year

Land Use Efficiency

- **Solar vs. Ethanol**: 1 acre of solar = 31 acres of corn ethanol (energy output)
- **Water Usage**: Solar requires minimal water vs. intensive irrigation for crops
- **Reversibility**: Solar installations are temporary vs. permanent urban development

Source: Arevon Energy Analysis

Agrivoltaics: The Emerging Solution

Agrivoltaics—the co-location of agriculture and solar generation—is emerging as one of the most promising strategies to transform the perceived conflict between renewable energy development and agricultural land preservation into collaboration.

- NREL reports that suitable land area for agrivoltaics in the United States could exceed 1 million square miles—far more than would ever be needed for either agriculture or solar development alone.
- Research shows that partial shading from solar panels can reduce crop irrigation needs by up to 40% while maintaining or even improving yields for certain crops.
- Variable-height mounting systems allow farming equipment to operate underneath panels.
- Recent projects at Colorado State University are testing vertical bifacial solar installations that integrate wireless soil monitoring probes and accommodate large-scale agricultural tillage, planting, and irrigation equipment.
- Shade-tolerant crops like lettuce, kale, and herbs often perform better under partial shade conditions.

Research and Development

Academic institutions across the United States are leading groundbreaking research into agrivoltaic applications, creating a robust foundation of scientific knowledge that supports the technology's expansion:

The University of Arizona received $1.725 million from a $10 million USDA grant for the SCAPES project (Sustainably Colocating Agricultural and Photovoltaic Electricity Systems) to study agrivoltaics across different land types and climate scenarios. U of A also led the first field-data assessment of agrivoltaics in the United States, finding that agrivoltaics increases the efficiency of both solar panels and crop production through cooling effects.

University of Massachusetts Amherst operates a three-year research project supported by the U.S. Department of Energy evaluating the impacts of dual-use solar on crop productivity and the agricultural economy, studying butternut squash, lettuce, hay production, and cranberry cultivation. UMass developed a pollinator-friendly certification program for solar PV facilities in Massachusetts, working with state and federal agencies, pollinator experts, and stakeholders. And researchers developed analytical spreadsheet tools published in the Journal of Extension to help farmers make informed decisions about incorporating agrivoltaics into their operations.

Colorado State University faculty are funded by USDA-NIFA's Sustainable Agricultural Systems program to build replicated Experimental Agrivoltaic Research Arrays over native Colorado grasslands and vegetable plots. CSU also received funding through Colorado's $500,000 agrivoltaics grant program to install research plots featuring raspberries grown under solar panels at the CSU Spur campus. Finally, CSU partnered with Sandbox Solar to complete a vertical bifacial agrivoltaic installation in 2024, studying field corn and horticultural crops growing between solar modules.

Cornell University operates the Solar Grazing Project at the 54-acre Cascadilla Community Solar Farm, studying optimal sheep grazing management with six different stocking densities to determine effects on animal welfare, plant biodiversity, pollinator habitat, and soil carbon sequestration. Researchers are also investigating how sheep grazing density impacts soil organic carbon, pollinator habitat, and vegetation biodiversity in solar arrays through a multi-year USDA-funded study. Cornell established an

Agrivoltaics Research Program in 2023 with $1 million in funding from New York State, focusing on crop production beneath solar panels.

Research is also happening at Oregon State University, North Carolina State University, Texas A&M and Purdue University. This extensive research network is generating peer-reviewed data that validates agrivoltaics as a scientifically sound approach to land use optimization. The growing body of research is helping farmers, developers, and policymakers make informed decisions about implementing dual-use systems across diverse agricultural regions and climate zones.

Tools and Maps for Tracking Solar Projects

1. CleanView Solar Farms Map
2. USGS Solar Photovoltaic Database
3. SEIA Major Solar Projects List
4. InSPIRE Agrivoltaics map

Additional Data Sources and Links:

- USDA Economic Research Service
- Solar Energy Industries Association (SEIA)
- American Farmland Trust
- USDA NASS Farms and Land Data
- CleanView Solar Farm Tracker
- USGS Solar PV Database
- Great Plains Institute Land Footprint Analysis