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Solar Power or Forests? A Cost-Benefit Analysis of Forest Land Conversion in the Northeastern United States ☆

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ABSTRACT

This study conducts a cost–benefit analysis of replacing forest land with a large-scale solar (LSS) photovoltaic (PV) facility, using data from a proposed 9.35 MW_{DC} project in the Northeastern United States. The analysis quantifies and monetizes key impacts over a 20-year timeframe, including reductions in carbon dioxide emissions from solar electricity generation, lost carbon storage and sequestration from deforestation, lost ecosystem services, and potential reductions in nearby property values. The results under various scenarios show positive net present values ranging from 2.7 to 12.7 million US dollars at 3% discount rate, indicating that the benefits of the solar PV project outweigh the costs of forest land conversion. Results also show that benefits and costs are distributed disproportionately with costs being borne primarily by those living in proximity to the LSS facility. This research contributes to ongoing debates about land use trade-offs in renewable energy expansion and provides a systematic framework for evaluating the economic efficiency of LSS projects that replace forests. The findings may guide policymakers and communities in assessing the overall desirability of hosting such developments, especially in areas with significant forest cover.

1. Introduction

Growing concerns surrounding climate change have prompted a rapid transition from carbon-intensive fuels to renewable energy sources (Rogelj et al., 2018). Among renewable energy options, solar technology emerges as a promising choice, offering zero operational carbon emissions and one of the highest energy outputs per unit of land area among renewable sources (Capellán-Pérez et al., 2017). As a result, the installed capacity of solar photovoltaics (PV) has experienced rapid growth in the United States (US) and globally, driven by a combination of factors including declining costs, enhanced policy support, and increasing demand for low-carbon energy sources (Crago, 2021; Cherp et al., 2021). In the US, additions to utility-scale solar PV capacity have experienced a significant increase, rising from 8 GW in 2012 to 138 GW in 2023 (International Renewable Energy Agency (IRENA), 2023).

Solar energy production spans a wide range of scales, from residential rooftop installations to expansive utility-scale facilities. The latter, in particular, necessitate considerable land allocation to accommodate the vast arrays of photovoltaic panels required for large-scale solar (LSS) power generation (Hernandez et al., 2015). In many regions, the development of LSS PV projects is highly debated, with some groups in favor of increased renewable energy generation while others express questions and concerns about a variety of factors, including land use. The debate over land use for solar electricity production is especially contentious when it concerns solar siting on forested lands (Cape Cod Collaborative, 2019). The deployment of solar PV facilities on forested land is most prevalent in the northeastern and southeastern regions of the US (Larson, 2021). This trend raises significant concerns about the consequences of deforestation, including the detrimental effects on carbon sequestration and storage, the disruption of vital ecosystem services (Keene, 2021; Merzbach, 2022) and the negative impact on natural aesthetics and property values in surrounding communities (Brinkley and Leach, 2019; Gaur and Lang, 2023).

Given the complexity and far-reaching implications of these issues, a comprehensive cost–benefit analysis (CBA) is essential to accurately assess the trade-offs associated with the conversion of forested land to solar PV farms. CBA is a systematic approach for evaluating the economic efficiency of policies or projects by identifying, quantifying, and comparing all relevant costs and benefits in monetary terms (Boardman

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et al., 2018). The scope of CBA can range from national-level analysis as in the Regulatory Impact Analysis performed by the US Environmental Protection Agency (EPA) for all major regulations (EPA, 2024), to local analysis of impacts such as those for watershed conservation in several sites in Hawai'i (Burnett et al., 2017), the adoption of sustainable urban drainage systems in a neighborhood in Germany (Johnson and Geisendorf, 2019), and household adoption of improved biomass cookstoves in Mexico (García-Frapolli et al., 2010). The net benefit, calculated as total benefits minus total costs, indicates whether a project has the potential to improve social welfare. By monetizing all impacts, CBA enables direct comparison of otherwise disparate factors, facilitating more informed decision-making.

Local governments deciding whether to allow LSS PV development in their communities face complex trade-offs. While the benefits of carbon savings are global in nature, the costs of lost ecosystem services and disrupted natural views are borne locally, making direct comparisons challenging. This challenge is particularly relevant in states like Massachusetts and Rhode Island, where conflicts have emerged specifically around solar siting on forested lands, centering on habitat loss, ecosystem fragmentation, and the trade-off between renewable energy production and forest conservation (Keene, 2021; Gaur and Lang, 2023).

While previous studies have highlighted the importance of including social and environmental impacts in solar project assessments (Mallik and Singh, 2020), and life cycle assessments have evaluated environmental impacts (Milousi et al., 2019), there remains a gap in the literature regarding comprehensive CBA of LSS development on forested land. To address this gap, we apply the CBA framework to quantify and monetize these diverse impacts in comparable units. We use data from a proposed 9.35 MW_{DC} project in a town in the Northeastern US and consider impacts such as CO_2 emissions reduction from replacing grid electricity with solar electricity, lost CO_2 storage and sequestration from deforestation, lost ecosystem services due to deforestation, and reduction in property values due to proximity to a solar farm. Our "All Impacts" estimates show that the LSS project built on previously forested land will provide net benefits of 311,216 in 2020 US dollars over a 20-year time period at a 3% discount rate. We conduct sensitivity analyses on a range of assumptions, including the discount rate and the assumed CO_2 emissions from deforestation, to test the robustness of our findings.

The paper proceeds as follows. In Section 2, we present a review of the relevant literature. In Section 3, we describe the background and setting of our study. In Section 4, we discuss the implementation of CBA including data sources. Section 5 presents results and Section 6 presents conclusions.

2. Literature review

The rapid growth of solar PV deployment in the US and globally has spurred the development of literature studying the myriad impacts of solar energy expansion, including impacts on greenhouse gas emissions, the natural environment and ecological systems, and local property values.

Technological assessments and engineering studies have established that solar power has zero operational emissions of CO2 and other local air pollutants (EIA, 2025). Nevertheless, when examining the entire life cycle, solar energy does generate some emissions, particularly from the production of materials needed to manufacture solar panels and related infrastructure. Based on a thorough review of existing studies that used Life Cycle Analysis (LCA) to estimate the carbon footprint of different energy generation sources, the National Renewable Energy Lab (NREL) reported that the CO2 footprint of solar PV has a median value of 46 g of CO2 per kWh, which is less than 10% that of electricity from natural gas (NREL, 2021). The estimated life cycle emissions has a wide range and are highly sensitive to assumptions about location and plant life. A study in Alberta Canada by Mehedi et al. (2022) found that life cycle GHG emissions for a utility scale solar PV system had a mean value of 123.8 g of CO2 per kWh. Despite the estimate being higher compared to the median reported by NREL, Mehedi et al. (2022) concludes that solar has positive energy returns with a payback averaging 3.8 years.

Hernandez et al. (2014) reviewed a wide range of LSS impacts documented in the literature, including those on biodiversity, land use, water and soil resources, as well as human health. In terms of land use impacts, this study reported that solar development permits have been granted on federal land in California that can put some plant and animal habitats at risk. Subsequent research by Hernandez et al. (2015) found that solar installations in California are located primarily in natural environments such as shrublands and scrublands and that the majority of installations are within 5–7 km of protected areas. The study further classifies 0.5% of installations are being "incompatible" or undesirable owing to its close proximity to protected areas.

For communities hosting LSS, local impacts are of primary concern. Hedonic pricing studies have provided empirical evidence on the capitalization of solar facility externalities into property values. Dröes and Koster (2021) found a decrease of approximately 2.6% in valuation of properties within 1 km of solar installations in the Netherlands, with disamenity effects per unit energy comparable to wind infrastructure. In England and Wales, Maddison et al. (2023) found that properties less than 5 km in distance from a utility-scale solar farm experienced a 5.4% decrease in property values. Maddison et al. (2023) extended their analysis by identifying directional heterogeneity in disamenity effects and found that properties south of installations experienced larger impacts, potentially due to glare externalities. In the UK, Jarvis (2024) reported no significant reduction in property values for properties proximate to large (>1 MW) solar projects. In the US Southeast, Abashidze and Taylor (2023) examined the effects of LSS development on neighboring agricultural land values in North Carolina. Unlike studies on residential properties, their analysis of 1,676 agricultural land transactions near 299 solar farms revealed no direct positive or negative spillover effects of solar farms on nearby agricultural land values. In the US Northeast, Gaur and Lang (2023) employed quasi-experimental methods with repeat sales identification, finding negative capitalization effects particularly pronounced for developments on undeveloped "greenfield" sites. Their results showed that homes within 0.6 miles of solar arrays experienced a 1.5%–3.6% reduction in value (equivalent to $4,721–$11,330 in 2019 dollars), with greenfield developments specifically causing property price reductions of 2.0%–4.4% and rural installations leading to reductions of 2.5%–5.8%. These findings suggest substantial local welfare impacts not fully internalized in project development decisions.

Recent literature has highlighted significant distributional considerations in renewable energy deployment. Jarvis (2024) identified systematic inefficiencies in planning authority decisions, where local concerns receive disproportionate weight relative to broader societal benefits, resulting in suboptimal renewable energy investment. These findings highlight the importance of incorporating distributional analysis into project evaluation frameworks.

The integration of social and environmental impacts into economic assessment frameworks represents a more comprehensive approach to the evaluation of renewable energy projects. Mallik and Singh (2020) demonstrated that conventional financial metrics undervalue renewable projects by approximately 62% when compared to comprehensive cost-benefit methodologies incorporating broader societal impacts. This gap between financial and economic returns highlights the importance of comprehensive analytical frameworks for public policy decisions—particularly for land use trade-offs with complex intertemporal and spatial dimensions.

Although existing literature has examined various aspects of solar development impacts, a significant gap remains in the assessment of forest-to-solar conversions. Existing research has not adequately addressed the specific carbon dynamics, ecosystem service trade-offs, and distributional implications of displacing forest ecosystems with LSS facilities. This information is particularly pertinent to regions like the

Northeastern US, where forest cover is substantial and solar development often requires vegetation clearing.

This paper contributes to the literature by providing the first CBA for installing LSS on forested land. Our findings inform current debates on the desirability of hosting LSS developments for communities, especially when these sites replace forests. The analysis presented in this paper may provide guidance for local communities, especially those in the Northeast, seeking to quantify the costs and benefits of solar development as input for decision making. Although this analysis uses data from a particular site, many forested lands in the Northeast can be characterized similarly to our study site (Keene, 2021). Furthermore, our methodology can be easily adapted to other settings by modifying relevant assumptions. This paper further contributes to the existing gray literature, which consists of reports and other publications not produced by commercial publishers or peer-reviewed journals, on the impact of LSS siting. By providing quantified and monetized values of different impacts, the costs and benefits identified in the gray literature can be directly compared to each other.

3. Background

The solar industry in the US has experienced significant growth in recent years. According to the Solar Energy Industries Association (SEIA) (2024), the industry had an average annual growth rate of 22% over the past decade. In 2023, a record-breaking 32.4 gigawatt direct current (GWdc) of solar capacity was installed, representing an increase of 51% compared with the previous year. As of 2024, the US has installed over 179 GW of solar capacity, which is sufficient to power nearly 33 million homes (SEIA, 2024). This substantial growth can be attributed to several factors, including robust federal policies such as the solar Investment Tax Credit, rapidly declining costs, and increasing demand for clean electricity in both the private and public sectors (Mehedi et al., 2022; L'Her et al., 2024).

In March 2024, Massachusetts was ranked 10th in the country for total installed solar capacity, with 5,070.28 MW installed, including 237.51 MW in 2023. The solar industry has invested over 11 billion US dollars in Massachusetts, with 585 million US dollars invested in 2023 (SEIA, 2024). The state's solar growth has been driven by supportive policies like the Solar Massachusetts Renewable Target (SMART) program, which aims to add 3,200 MW of solar capacity (Massachusetts Government, 2022). The debate over solar siting on forest land is especially relevant in Massachusetts, where ground-based solar accounted for approximately 6,000 acres of land conversion between 2012 and 2017, representing roughly one-quarter of all development in the state (MassAudubon, 2020). Moreover, researchers at Clark University found that 49% of forest loss in Massachusetts in 2019 was attributable to the construction of solar arrays (Tao et al., 2023). This rapid expansion of solar capacity raises important questions and concerns.

Extensive land conversion associated with LSS development has raised concerns about the counterintuitive contribution of LSS power plants to increased greenhouse gas emissions. The installation of LSS arrays often necessitates the removal of vegetation, particularly in forested areas, which may release stored carbon and eliminates the potential for future carbon sequestration (Abbasi et al., 2011; Lovich and Ennen, 2011; Hernandez et al., 2014). In addition to the impact on carbon sequestration, the loss of forested land can disrupt vital habitat and the affiliated ecosystem services that include air and water filtration, protection against erosion and flooding, and recreational access (Cape Cod Collaborative, 2019; MassAudubon, 2023). In response to these concerns, Massachusetts has developed specific policies regarding solar development on forested land. The state's SMART program includes provisions and incentive adjustments for projects sited on forested land, recognizing both the need for renewable energy expansion and the importance of forest preservation. These policies continue to evolve as new evidence emerges regarding the environmental and economic impacts of different siting choices.

4. Methodology

This section outlines our approach to conducting a CBA for the proposed LSS project. We begin by describing the CBA framework, followed by detailed explanations of how we quantified benefits and costs. The section concludes with our method for calculating net present value (NPV) and an overview of our scenario analysis.

4.1. CBA framework

This study utilizes the CBA framework to assess the economic and environmental implications of converting forested land to an LSS facility. Our analysis compares the proposed development scenario, in which forested land is cleared for the installation of an LSS project, with a baseline scenario in which the existing forest ecosystem remains undisturbed. We evaluate impacts from the perspective of community members whose community will host the solar project. Some community members, often those living in proximity to the project's location may experience more impacts than those who live farther away. We assume that community members are also global citizens impacted by the effects of climate change from increased carbon dioxide emissions. Since we take the perspective of community members, we do not include as impacts the payment received by the private landowners from the sale of land for the LSS project. We also do not consider the profit obtained by the LSS project developer from operating the solar facility.

We quantify and monetize key impacts over a 20-year timeframe, which corresponds to the typical lifespan of solar panels. The benefits considered in this analysis include the reduction in carbon dioxide emissions resulting from the displacement of fossil fuel energy by the proposed LSS project. The costs addressed encompass carbon emissions and lost carbon sequestration resulting from deforestation, loss of ecosystem services due to site clearing, and potential reductions in property values for nearby houses if the project is perceived as visually unappealing. All monetary values are expressed in 2020 US dollars.

The project site is located in Amherst a rural town in the Northeastern US (see Appendix Figs. A.1 and A.2). The site is forested land comprised mainly of mixed oak, white pine, and hardwood species, consistent with forest cover type classifications that include 'mixed oak', 'white pine hardwood', and 'white pine oak'. Additionally, the site is bordered by residential lots, creating an interface between the natural forested landscape and neighboring developed properties.

The analysis incorporates multiple key parameters across project specifications, economic considerations, and environmental factors. Table B.2 in Appendix B provides a summary of these parameters and their values. These parameters form the foundation for our quantification of benefits and costs, which we discuss in detail in the following sections.

4.2. Quantification of benefits

The primary benefit of the LSS installation stems from avoided carbon emissions. The project has a capacity of 9.35 MW_{DC}, with an estimated initial annual electricity production of 11,709,449 kWh (calculated using the National Renewable Energy Laboratory's PVWatts tool using Amherst, MA as the location).

To quantify this benefit, we consider two approaches for estimating avoided emissions: the average grid emissions rate and the marginal emissions rate. The average grid emissions rate for Massachusetts in 2022, as reported by the US Energy Information Administration (EIA), was 952 lbs/MWh or 0.000432 metric tons CO_2/kWh (EIA, 2023). This rate reflects the average emissions across all electricity sources in the state. However, recognizing that solar electricity may displace generation from the marginal source, typically natural gas in Massachusetts, we calculate a marginal emissions rate of 0.000448 metric tons/kWh using EIA data for natural gas electricity generation in 2022.

This marginal rate is slightly higher than the average rate, potentially indicating a greater carbon benefit from solar electricity generation.

To monetize these avoided emissions, we employ the social cost of carbon (SCC), an important metric for evaluating the economic impact of carbon-intensive projects. Given the variability in SCC estimates across time and studies, we utilize two values in our analysis:

1. A conservative estimate of 56 US dollars per metric ton of CO_2 for emissions in 2025, based on the Interagency Working Group (IWG) findings using a 3% discount rate (IWG, 2021).
2. An updated estimate of 210 US dollars per metric ton of CO_2 for 2025, derived from recent US EPA research (EPA, 2023). This higher value, using a 2% discount rate, reflects methodological updates recommended by a report from the National Academies of Sciences, Engineering, and Medicine (2017).

For our analysis, we calculate annual carbon emissions avoided over the project's 20-year lifespan, incorporating both the avoided emissions value (AEV) per kWh and the gradual decrease in solar panel efficiency. We define the AEV per kWh as:

$$\text{AEV per kWh} = \text{Emissions Rate} \times \text{SCC} \quad (1)$$

The value of carbon emissions avoided (B_t) for each year is then calculated as:

$$B_t = E_0 \times (1-d)^{(t-1)} \times \text{AEV per kWh}, \quad t = 1 \text{ to } 20 \quad (2)$$

where E_0 represents the initial annual electricity generation, d is the annual efficiency degradation rate (set at 0.5% (Deline et al., 2024)), and t is the year.

In our analysis, we pair the average grid emissions rate with the conservative SCC estimate for our primary scenario, while using the marginal rate with the higher SCC estimate for sensitivity testing. This approach captures the range of potential carbon benefits under different assumptions.

4.3. Quantification of costs

Deforestation of the 41.4-acre project site results in the loss of valuable ecosystem services, such as air pollution removal and avoided runoff, and also releases stored carbon and prevents future sequestration. To estimate loss of ecosystem services and carbon storage of the project site, we used i-Tree Canopy, a peer-reviewed software suite developed by the USDA Forest Service in cooperation with Davey Tree Expert Company and other partners (i-Tree, 2006). i-Tree Canopy uses randomly generated point sampling and user-defined cover classes to provide statistically valid estimates of tree and other cover types within a predefined area. The tool then uses these cover estimates to calculate ecosystem services and values. For carbon storage and sequestration, i-Tree Canopy employs peer-reviewed allometric equations and biomass equations that relate tree size to carbon storage. These equations are derived from extensive field measurements across various species and regions. The tool's air pollution removal estimates are based on well-established pollution removal rates for urban tree canopy, while avoided runoff calculations use the leaf surface area and local annual rainfall data. i-Tree Canopy's use of local environmental data, such as pollution concentrations and weather patterns, ensures that its estimates are tailored to the specific project location. This methodology has been widely used in urban forestry research and management, providing a reliable and cost-effective means of assessing the environmental benefits of tree cover (Nowak et al., 2008; Cowett and Bassuk, 2020).

The i-Tree Canopy report provided estimates for the amount of carbon stored ($C_{storage}$) in the project area, the annual carbon sequestration (C_{seq}), the annual value of air pollution removal, and the annual value of avoided runoff for the 41.4-acre area. The report estimates 4,720.76 metric tons of CO_2 is stored (114.028 metric tons per acre) and 156.04 metric tons of CO_2 is sequestered annually (3.769 metric tons per acre per year) in the project site. The cost of carbon emissions from initial deforestation (C_{CED_t}) is calculated as $C_{CED_t} = C_{storage} \times SCC, \quad t = 0$. The cost from the loss of annual carbon sequestration (C_{LCS_t}) is given by $C_{LCS_t} = C_{seq} \times SCC, \quad t = 1, \ldots, 20$.

Ecosystem services include the removal of air pollutants which is valued at 203 US dollars per year and the prevention of runoff which is valued at 247 US dollars per year. The air pollutants removed include Carbon Monoxide (CO), Nitrogen Dioxide (NO2), Ozone (O3), Sulfur Dioxide (SO2), Particulate Matter less than 2.5 μm (PM2.5), and Particulate Matter between 2.5 and 10 μm (PM10). The cost of loss in annual ecosystem services (C_{LES_t}) is $C_{LES_t} = \$203 + \$247 = \$450, \quad t = 1, \ldots, 20$.

Beyond the environmental costs associated with lost carbon sequestration and ecosystem services, the installation of LSS facilities can also have economic impacts on nearby properties. Several studies have documented a decrease in property values for homes near utility-scale solar facilities (e.g., Dröes and Koster, 2021; Jarvis, 2024; Maddison et al., 2023). To estimate the potential cost of the reduction in property values for homes near the proposed solar project, we use the findings of Gaur and Lang (2023) because their study includes the state of Massachusetts (along with the adjacent state, Rhode Island). As discussed in the literature review section, their results show that houses within 0.6 miles of solar installations depreciate 1.5%–3.6% following construction of a solar array. To provide a conservative estimate, we use 2% decrease in property values within 0.6 miles of a solar installation. It is important to note that this impact is separate from the loss of ecosystem services. Gaur and Lang (2023) find that the average negative effect on property values is primarily driven by solar developments on farm and forest lands ("greenfields") and in rural areas. They suggest this could be due to the combination of solar-specific disamenities and loss of open space amenities, as well as the incongruence of industrial solar arrays with highly valued rural character.

The total cost of the reduced property values (C_{RPV_t}) is calculated as: $C_{RPV_t} = n \times p \times v, \quad t = 0$, where n is the number of properties affected, p is the median property value, and v (equal to 2%) is the percentage decrease in the property values attributable to the solar project. This cost is incurred only at the start of the project (t = 0). We determined that $n = 110$ based on the number of residences that are located within a radius of 0.6 miles from the project site.[1] Fig. A.3 in Appendix A shows buildings within 0.6 miles of the project site. For p, we use the average median home price in Amherst, MA for the years 2020–2023, which is 442,193 US dollars.[2] The use of multiple years of data smooths out short-term fluctuations in the housing market and provides a more stable estimate for our analysis. The annual values of home prices were adjusted to 2020 US dollars to maintain consistency with other monetary values in the analysis.

The total cost of the project C_t is given by:

$$C_t = C_{CED_t} + C_{LCS_t} + C_{LES_t} + C_{RPV_t} \quad (3)$$

4.4. Net present value and scenario analysis

To evaluate the net benefit of the project, we calculate its NPV using both 3% and 5% discount rates. This approach accounts for varying time preferences in the valuation of future costs and benefits. The NPV is computed as:

$$NPV = \sum_{t=0}^{T} \frac{B_t - C_t}{(1+r)^t} \quad (4)$$

[1] This estimation was conducted using OpenStreetMap data and spatial analysis in R programming (Team, 2023; Pebesma et al., 2018). Specifically, we created a 0.6 mile buffer around the project site's coordinates (latitude: 42.40182, longitude: −72.48696) and enumerated the building footprints within this buffer using OpenStreetMap data (Padgham et al., 2017).

[2] Data obtained from Redfin (www.redfin.com).

Table 1
Overview of impacts included in different CBA scenarios.

Impact	All Impacts	Carbon Only	Carbon and Ecosystems Services
Benefits			
Reduced Carbon Emissions (From Electricity)	✓	✓	✓
Costs			
Reduced Property Values	✓		
Deforestation (Loss of Ecosystem Services)	✓		✓
Deforestation (Stored Carbon Release, Lost Sequestration)	✓	✓	✓

where B_t represents the benefits in year t and C_t represents the sum of all the costs in year t, r is the discount rate, and T is the project's timeframe (20 years). A positive NPV indicates that the discounted benefits exceed the discounted costs, suggesting the project's economic desirability.

To ensure the robustness of our findings, we present results under two alternative scenarios in addition to the baseline "All Impacts" scenario. The "Carbon Only" scenario isolates the carbon-related impacts, considering only the benefits of reduced carbon emissions and the costs associated with carbon emissions from site deforestation and lost sequestration. The "Carbon and Ecosystem Services" scenario excludes the cost of reduced property values, allowing us to evaluate the project's NPV in the absence of potential negative perceptions about proximity to the LSS installation. Table 1 summarizes the impacts included in each of the scenarios.

In the sensitivity analysis, we further explore different assumptions about the amount of carbon released during deforestation. We model scenarios where 100%, 80%, and 50% of the estimated carbon storage in trees is released as initial emissions.

5. Results and discussion

This section presents the findings of our CBA for the proposed 9.35 MW_{DC} ground-mounted LSS project in Amherst, Massachusetts. We examine the NPVs under various scenarios and discount rates, considering different impact factors such as carbon emissions, ecosystem services, and property values.

5.1. Baseline case analysis

Our analysis yielded positive NPVs across all scenarios and discount rates examined, indicating that the benefits of the solar PV project outweigh the costs of forest land conversion. Table 2 presents the results assuming that all of the carbon in the cleared forest is released, for the three scenarios considered: "All Impacts", "Carbon Only", and "Carbon and Ecosystem Services". The "All Impacts" scenario, which comprehensively includes property value impacts, yielded NPVs ranging from 2,042,777 US dollars at a 5% discount rate to 3,983,345 US dollars undiscounted, with an NPV of 2,665,936 US dollars at a 3% discount rate. This variability underscores the critical role of discount rate selection in assessing long-term environmental projects. A detailed breakdown of costs and benefits for the "All Impacts" scenario with 100% initial carbon release and 3% discount rate is provided in Table B.1 in Appendix B.

There are additional impacts excluded from this analysis. Benefits may arise from economic activity during the construction phase, including expanded local employment and greater patronage of businesses by out-of-town employees working on the LSS project. Excluded costs include ecological impacts from wildlife disturbance or habitat fragmentation, negative impacts to groundwater, and short-term burden on local infrastructure, particularly roads, during the construction phase. These excluded impacts are generally second-order impacts and are unlikely to affect our conclusions. Nevertheless, it is important to acknowledge their potential significance. In some settings, these impacts could be substantial and should be included in the CBA of siting an LSS facility on forested lands.

To further understand the impact of different factors, we compared the "All Impacts" scenario with two alternative scenarios that exclude property value impacts. The "Carbon Only" and "Carbon and Ecosystem Services" scenarios consistently showed positive and higher NPVs. At a 3% discount rate, these scenarios yielded NPVs of 3,645,455 US dollars and 3,638,760 US dollars respectively, compared to 2,665,936 US dollars for the "All Impacts" scenario.[3]

The minimal difference between the "Carbon Only" and "Carbon and Ecosystem Services" scenarios (less than 0.2%) indicates that the monetized impact of lost ecosystem services is relatively small compared to the carbon benefits. However, the substantial drop in NPV (about 26.8%) when property value impacts are included in the "All Impacts" scenario emphasizes the significant local economic cost of the project. This contrast underscores the importance of addressing community concerns in LSS project planning and implementation, as local impacts can dramatically alter the overall economic assessment of such projects.

To better understand these NPV differences, we examine the components of total benefits and costs. Fig. 1 illustrates this breakdown. The benefits consist entirely of carbon savings from displaced fossil fuel electricity generation. On the cost side, reduced property values comprise the largest component at 70.8% of total costs under the "All Impacts" scenario. This highlights that a significant portion of the project's costs would be borne by households near the LSS site.[4] Carbon release and lost sequestration account for 28.7% of costs, while lost ecosystem services represent only 0.5%, explaining the minimal difference between the "Carbon Only" and "Carbon and Ecosystem Services" scenarios.

While this breakdown provides a snapshot of the overall costs and benefits, it is helpful to consider how these components are distributed over time. Fig. 2 shows the cumulative benefits and costs over the 20-year life of the project. The benefits show a steady increase over time, reaching approximately 4 US million dollars by year 20. This reflects the ongoing carbon savings as solar generation displaces fossil fuel-based electricity. In contrast, costs have a large initial value, primarily due to assumed upfront property value impacts, followed by a much slower increase from ongoing ecosystem service losses, carbon release and foregone carbon sequestration. The cumulative costs reach about 1.37 US million dollars by year 20, with cumulative benefits exceeding costs by year 5.

The temporal distribution of impacts provides crucial insight into the project's economic viability and helps explain the NPV variations across different scenarios and discount rates. The cumulative growth trend of benefits and costs contributes to the positive NPVs seen across all scenarios, particularly at lower discount rates. The inverse relationship between discount rates and NPVs is evident: lower rates assign

[3] Detailed results for all scenarios and discount rates are available in the supplementary file.

[4] In this analysis, we assumed that loss in property values occur at the start of LSS siting. In reality, the cost will only be experienced by affected households when their properties are sold. Losses experienced further in the future would be discounted and would therefore be smaller. However, this can be offset by rising property values. Due to the uncertainty of the value of this impact, we present scenarios that exclude loss in property values.

Table 2
CBA results using baseline SCC (56 US dollars per metric ton CO_2) with 100% initial carbon release.

	All Impacts			Carbon Only			Carbon and Ecosystem Services		
	U	3%	5%	U	3%	5%	U	3%	5%
Benefits	$5404,293	$4039,818	$3394,468	$5404,293	$4039,818	$3394,468	$5404,293	$4039,818	$3,394,468
Costs	($1420,948)	($1373,882)	($1351,691)	($439,124)	($394,363)	($373,258)	($448,124)	($401,057)	($378,866)
NPV	$3983,345	$2665,936	$2042,777	$4965,170	$3645,455	$3021,210	$4956,170	$3638,760	$3015,602

Notes: Values in parentheses are negative. Annual values of benefits, costs, and NPVs for the All Impacts scenario at a 3% discount rate are shown in Table B.1 in the Appendix. Detailed annual values for all other scenarios are provided in Tables 1–8 of the Supplementary Material.

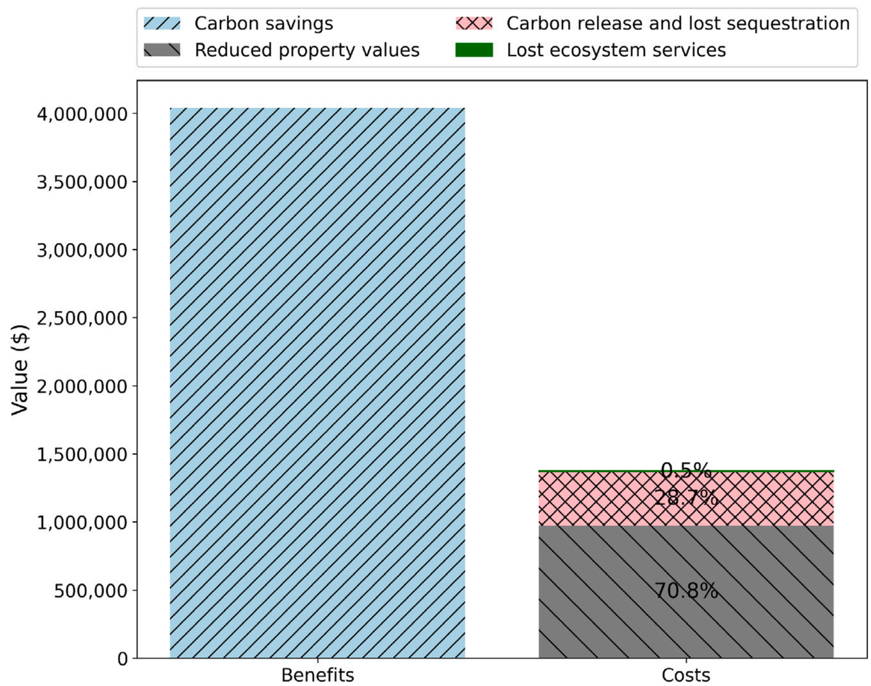

Fig. 1. Components of total benefits and costs.

greater weight to future benefits, a characteristic particularly relevant to long-term environmental projects like LSS installations. This temporal aspect, especially the rapid break-even point, further emphasizes the importance of considering both immediate local impacts and long-term global benefits in the economic assessment of such projects, while also highlighting the strong economic case for LSS installations even in the short term.

The net carbon benefit of the project is worth highlighting given the attention in public discourse about the trade-offs in carbon savings from solar electricity replacing grid electricity and lost carbon storage and sequestration from cleared trees. Fig. 3(a) provides a visual representation of the cumulative CO2 emissions and savings over the project's lifetime, clearly illustrating the crossover point where cumulative savings surpass cumulative emissions. Fig. 3(b) shows that by the first year, carbon benefits exceed costs in monetary terms.

In this analysis, we used current electricity grid emissions to quantify the benefit of replacing grid electricity with solar electricity. Two important limitations warrant discussion. First, we do not account for co-pollutant impacts of solar power installation and operation (Dauwalter and Harris, 2023), which could add to local environmental costs. Second, as the grid achieves higher decarbonization rates and battery storage technology advances, the average emissions associated with grid electricity will decrease, potentially reducing the carbon savings from solar installations. While our analysis shows that carbon benefits exceed costs in the early stages of the project, suggesting that future grid decarbonization is unlikely to reverse the net benefits, the magnitude of these benefits is likely to change over time. Future studies could provide more precise quantification of the carbon impact of solar projects by incorporating projected changes to the electrical grid's fuel mix, the integration of energy storage technologies, and comprehensive co-pollutant impacts.

5.2. Sensitivity analysis

5.2.1. Carbon release scenarios

To test the robustness of our findings, we conduct sensitivity analysis considering 80% and 50% initial carbon release scenarios in addition to the 100% carbon release scenario assumed in our main analysis. The assumption of 100% release of carbon is appropriate in settings where the wood cut from forest land is used in pulp or paper production. In this case, almost all the carbon stored in the forest biomass is released. If wood cut from forest land is used such that some of the stored carbon is retained (for example, for wood boards or furniture), initial carbon emissions could be less, as represented by the 80% and 50% initial carbon emission scenarios in this analysis.

Fig. 4 illustrates that higher carbon retention from forest biomass yields increased NPVs across all discount rates. Under the "All Impacts" scenario at a 3% discount rate, retaining 20% and 50% of stored carbon increases the NPV by 52,872 US dollars and 132,181 US dollars, respectively, relative to the baseline NPV of 2,665,936 US dollars. As detailed in Tables 3 and 4, these improvements stem from reduced costs while benefits remain constant at 4,039,818 US dollars.

These results demonstrate the significant influence of forest biomass end-use on project economics. While our conservative baseline assumes

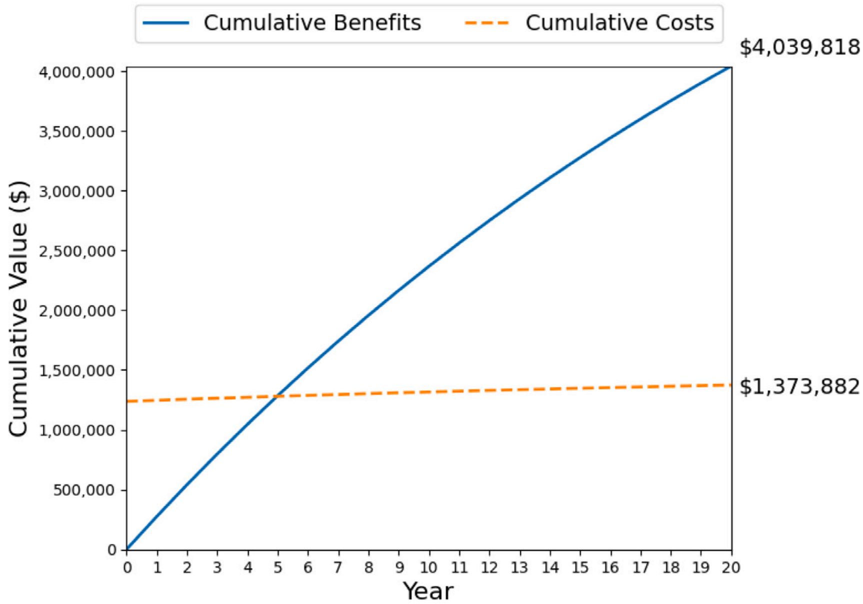

Fig. 2. Cumulative benefits and costs over time (All Impacts, 100% Initial Carbon Release, Discounted at 3%).

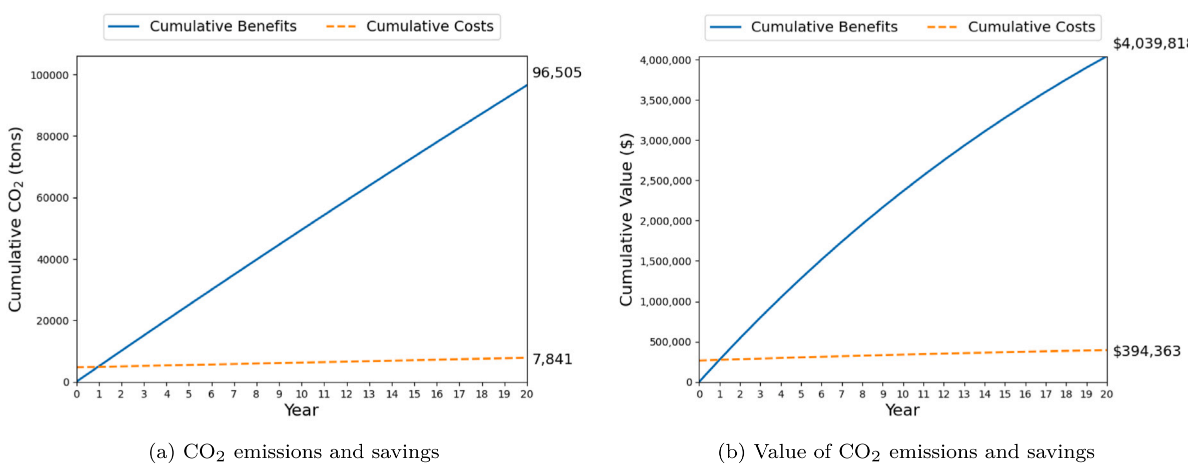

Fig. 3. Cumulative benefits and costs over time (Carbon Only, 100% Initial Carbon Emission, Discounted at 3%)

Table 3
CBA results, 80% initial carbon release.

	All Impacts			Carbon Only			Carbon and Ecosystem Services		
	U	3%	5%	U	3%	5%	U	3%	5%
Benefits	$5404,293	$4039,818	$3394,468	$5404,293	$4039,818	$3394,468	$5404,293	$4039,818	$3394,468
Costs	($1368,076)	($1321,010)	($1298,818)	($386,251)	($341,490)	($320,385)	($395,251)	($348,185)	($325,993)
NPV	$4036,217	$2718,808	$2095,650	$5018,042	$3698,328	$3074,082	$5009,042	$3691,633	$3068,474

Notes: Values in parenthesis are negative. Annual values for each scenario are available in Tables 9–17 of the Supplementary Material.

Table 4
CBA results, 50% initial carbon release.

	All Impacts			Carbon Only			Carbon and Ecosystem Services		
	U	3%	5%	U	3%	5%	U	3%	5%
Benefits	$5404,293	$4039,818	$3394,468	$5404,293	$4039,818	$3394,468	$5404,293	$4039,818	$3394,468
Costs	($1288,767)	($1241,701)	($1219,509)	($306,942)	($262,181)	($241,077)	($315,942)	($268,876)	($246,685)
NPV	$4115,526	$2798,117	$2174,959	$5097,351	$3777,637	$3153,391	$5088,351	$3770,942	$3147,783

Notes: Values in parenthesis are negative. Annual values for each scenario are available in Tables 18–26 of the Supplementary Material.

complete carbon release, directing harvested wood toward carbon-preserving applications could substantially reduce the actual carbon impact. This finding underscores the importance of incorporating biomass utilization strategies into LSS project assessments on forested lands.

5.2.2. SCC

To evaluate the robustness of our findings with respect to the SCC, we conducted an analysis using the higher SCC estimate of 210 US

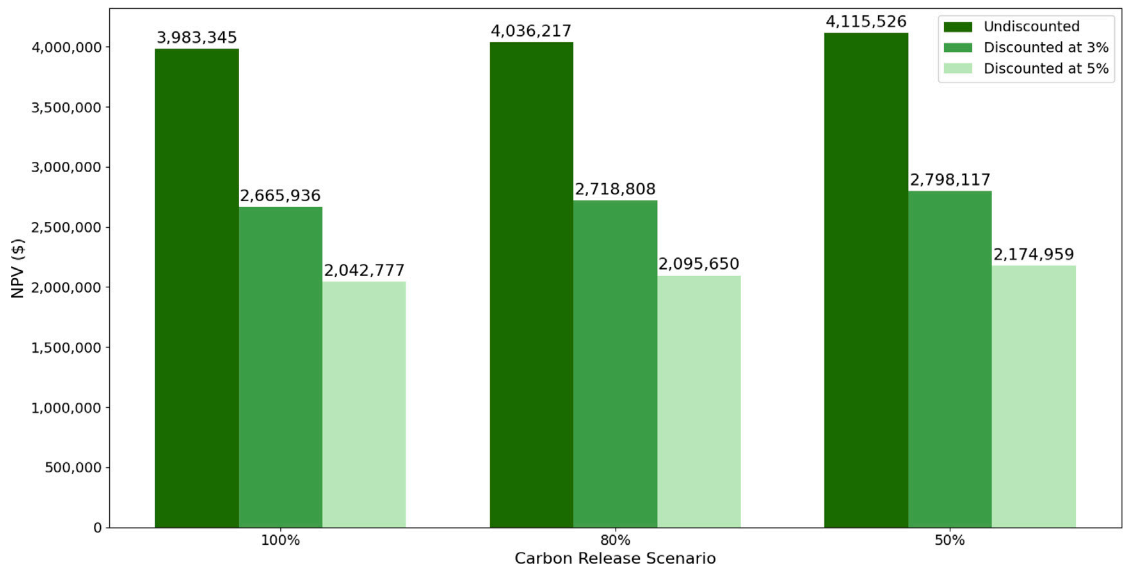

Fig. 4. NPV by Discount Rate and Carbon Release (All Impacts).

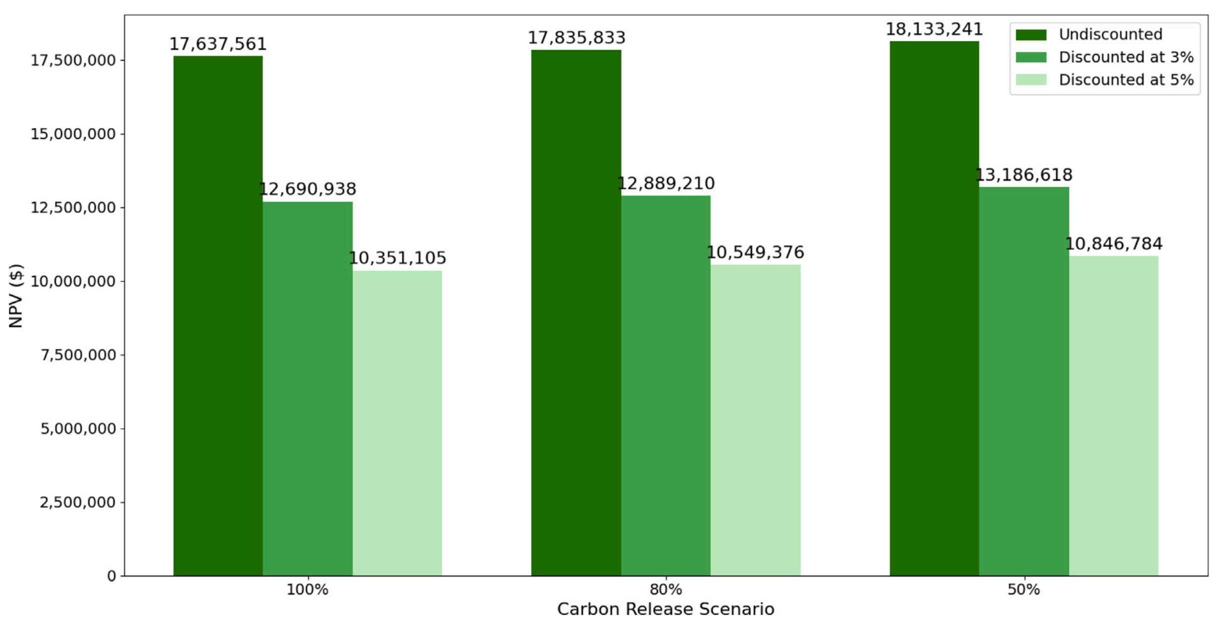

Fig. 5. NPV by Carbon Release Scenario and Discount Rate Under Higher SCC (210 US dollars per metric ton CO_2).

Table 5
CBA results using higher SCC (210 US dollars per metric ton CO_2), 100% initial carbon release.

	All Impacts			Carbon Only			Carbon and Ecosystem Services		
	U	3%	5%	U	3%	5%	U	3%	5%
Benefits	$20,266,099	$15,149,317	$12,729,254	$20,266,099	$15,149,317	$12,729,254	$20,266,099	$15,149,317	$12,729,254
Costs	($2628,538)	($2458,379)	($2378,150)	($1646,713)	($1478,860)	($1399,717)	($1655,713)	($1485,555)	($1405,325)
NPV	$17,637,561	$12,690,938	$10,351,105	$18,619,386	$13,670,457	$11,329,537	$18,610,386	$13,663,762	$11,323,929

Notes: Values in parenthesis are negative. Annual values for each scenario are available in Tables 27–35 of the Supplementary Material.

dollars per metric ton of CO_2, while maintaining the average emissions rate of 0.000432 metric tons/kWh.

As shown in Table 5, under the "All Impacts" scenario with 100% initial carbon release and 3% discount rate, the NPV increased from

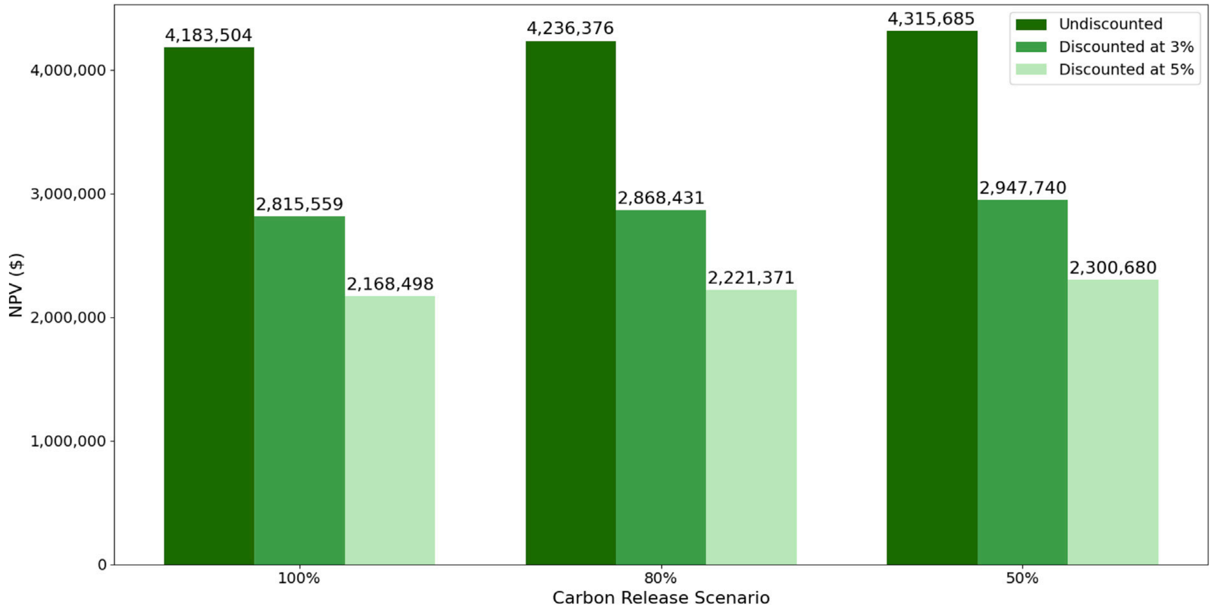

Fig. 6. NPV by Carbon Release Scenario and Discount Rate Using Marginal Emissions Rate.

Table 6
CBA results using marginal emissions rate, 100% initial carbon release.

	All Impacts			Carbon Only			Carbon and Ecosystem Services		
	U	3%	5%	U	3%	5%	U	3%	5%
Benefits	$5604,452	$4189,441	$3520,189	$5604,452	$4189,441	$3520,189	$5604,452	$4189,441	$3520,189
Costs	($1420,948)	($1373,882)	($1351,691)	($439,124)	($394,363)	($373,258)	($448,124)	($401,057)	($378,866)
NPV	$4183,504	$2815,559	$2168,498	$5165,329	$3795,078	$3146,931	$5156,329	$3788,383	$3141,323

Notes: Values in parenthesis are negative. Annual values for each scenario are available in Tables 36–44 of the Supplementary Material.

the baseline case of 2,665,936 US dollars (using 56 US dollars SCC) to 12,690,938 US dollars—a 376% increase. This substantial change demonstrates the high sensitivity of the project valuation to SCC assumptions. The analysis reveals strong economic viability across all carbon release scenarios and discount rates, as shown in Fig. 5. NPVs range from 10,351,105 US dollars (100% release, 5% discount rate) to 18,133,241 US dollars (50% release, undiscounted), demonstrating robust economic performance under higher SCC estimates. A notable finding is the asymmetric impact of increased SCC on the project's costs and benefits. While higher SCC magnifies both avoided emissions benefits and forest carbon loss costs, the impact is greater for avoided emissions benefits.

These findings suggest that higher SCC estimates — which some researchers argue better reflect the true SCC — strengthen the economic case for siting LSS facilities on forested land. However, although higher SCC values amplify global benefits, they do not affect local costs, particularly property value impacts. This disparity highlights the challenge of balancing global environmental benefits with localized economic costs in LSS siting decisions.

While our sensitivity analysis confirms the project's economic viability under higher SCC estimates, this enhanced economic justification should be evaluated in conjunction with local concerns and ecological impacts that may not be monetarily quantified. This comprehensive analysis of the trade-offs in LSS siting decisions underscores the importance of considering both quantifiable and non-quantifiable factors in policy formulation.

5.2.3. Marginal emissions rate

We conducted an additional analysis using the marginal emissions rate of 0.000448 metric tons CO_2/kWh instead of the average grid emissions rate of 0.000432 metric tons CO_2/kWh, maintaining the baseline SCC of 56 US dollars per metric ton. This approach indicates that solar generation typically displaces natural gas-fired power plants, which serve as the marginal generation source in Massachusetts.

The marginal emissions rate analysis yields higher NPVs across all scenarios, as shown in Table 6. Under the "All Impacts" scenario with 100% initial carbon release and 3% discount rate, the NPV increases from 2,665,936 US dollars to 2,815,559 US dollars—a 5.6% increase. This modest increase demonstrates the small difference between marginal and average emissions rates in Massachusetts' electricity grid.

Fig. 6 shows NPV variations across carbon release scenarios and discount rates under the marginal emissions assumption. Values range from 2,168,498 US dollars (100% release, 5% discount rate) to 4,315,685 US dollars (50% release, undiscounted). While NPV patterns mirror the baseline case analysis, values are consistently higher due to increased benefits from avoided emissions. Whereas the choice between marginal and average emissions rates affects project benefits, its impact is relatively modest compared to other parameters, particularly the SCC. This results from Massachusetts' electricity grid composition, where marginal and average emissions rates differ only slightly. However, this methodological choice could have greater implications in regions with larger differences between marginal and average grid emissions rates. These results also highlight the influence of regional electricity market characteristics on the magnitude of benefits from solar PV deployment.

6. Conclusion and policy implications

This study provides the first comprehensive cost–benefit analysis of converting forested land to an LSS PV facility. Using data from a proposed 9.35 MW_{DC} project in the Northeastern US, we find that benefits exceed costs across all scenarios. The baseline analysis yields a net present value of 2,665,936 US dollars (3% discount rate), driven

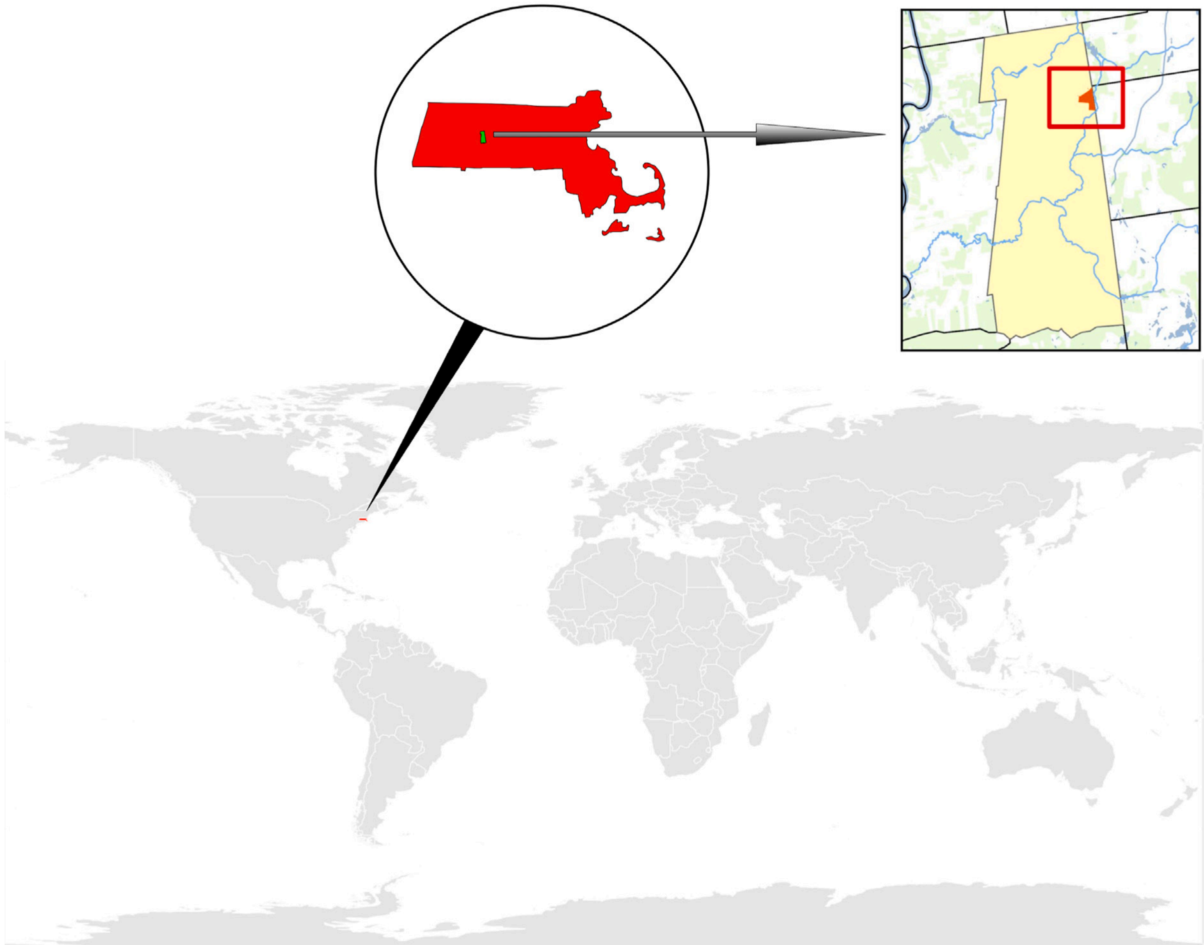

Fig. A.1. Global and regional location of the project site. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

primarily by avoided carbon emissions from displaced fossil fuel-based electricity generation.

Our analysis reveals a critical distributional challenge: while benefits accrue globally through emissions reduction, costs are concentrated locally, with property value impacts affecting households within 0.6 miles of the facility comprising 70.8% of total costs. In terms of carbon impacts, the temporal analysis shows that despite substantial initial costs, the project achieves its carbon break-even point within the first year of operation, suggesting that concerns about carbon payback periods appear to be overstated. Sensitivity analyses using higher SCC values, varying assumptions about initial carbon release, and marginal emissions rates all confirm the robustness of our findings. Despite being site-specific, this analysis provides a systematic framework for evaluating solar siting decisions, which can be adapted to different settings to provide input to local communities and policymakers about the impact of solar siting in their community.

The findings of the paper have several policy implications. First, the overwhelmingly positive NPV suggests that solar projects on forest land should not be opposed based on the lack of overall net benefits. Second, the result on positive carbon savings also implies that objections to solar projects should not be based solely on concerns about carbon emissions. Finally, it is important to note that the results of cost benefit analysis should be taken as one of several inputs to decision making about solar siting. Our finding on the unequal distribution of benefits and costs suggests that the availability of mechanisms to address local impacts (for example, through community benefit agreements) would be an important consideration in the decision to proceed with solar development. Furthermore, local decision makers should consider whether there are other impacts not included in this CBA (for example, broader ecological impacts such as habitat fragmentation or groundwater impacts) that would be especially relevant to their community.

Our analysis also suggests future research directions that may improve decision making related to solar siting. First, economic analyses could investigate the effectiveness of various compensation mechanisms for affected property owners and explore market-based approaches to internalize local costs. Second, environmental assessments could quantify broader ecological impacts, including habitat fragmentation, wildlife corridors, and biodiversity metrics. Third, grid integration studies could analyze how increasing grid decarbonization rates affect the long-term benefits of forest-sited solar projects. Finally, policy research could evaluate the effectiveness of different regulatory frameworks in balancing local and global interests in renewable energy siting decisions. As communities evaluate renewable energy siting decisions, our findings provide evidence for the economic viability of solar development on forested land while emphasizing the importance of addressing distributional impacts and community concerns in project implementation.

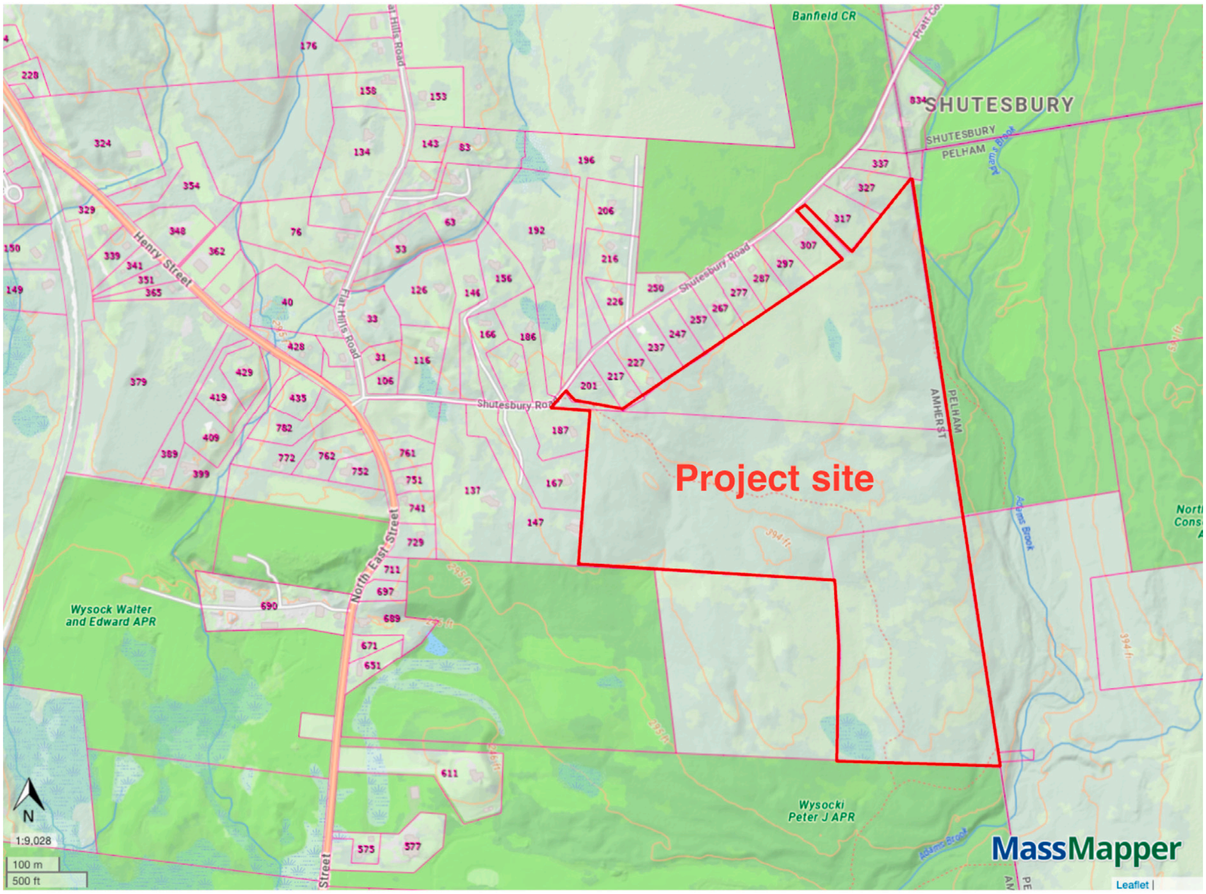

Fig. A.2. Detailed map of the area surrounding the project site. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

CRediT authorship contribution statement

Christine L. Crago: Writing – original draft, Project administration, Conceptualization, Supervision, Formal analysis, Writing – review & editing, Resources, Methodology. **Maryam Feyzollahi:** Writing – original draft, Writing – review & editing, Methodology, Data curation, Visualization, Formal analysis. **Richard W. Harper:** Resources, Writing – review & editing, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Site maps

Fig. A.1 illustrates the geographic location of the study area within a global and regional context. The circular inset highlights Massachusetts (in red) and the town of Amherst (in green). The rectangular inset provides a detailed view of Amherst, with a red box marking the exact location of the solar PV project site.[5]

Fig. A.2 shows the proposed solar PV installation site (marked by red boundary lines and labeled "Project site"). The map displays property boundaries, parcel numbers, and the spatial arrangement of the project area in relation to adjacent properties. The northeastern boundary marks the municipal border with Shutesbury, while the surrounding green areas indicate protected forested lands. Water features, including wetland systems, appear as blue linear elements mainly in the eastern and southeastern edges of the project site. Pink lines show property divisions between adjacent land parcels.

Fig. A.3 illustrates the spatial distribution of buildings (blue points) within a 0.6-mile radius (red circular boundary) surrounding the project site (green point). Geographic coordinates define the area precisely, with longitude ranging from 72.500° W to 72.470° W and latitude from 42.390° N to 42.410° N. The distribution pattern shows higher building density in the northwestern and northern areas, with fewer structures in the southeastern section.

Appendix B. Tables

See Tables B.1 and B.2.

Appendix C. Supplementary data

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.landusepol.2025.107679.

Data availability

Data will be made available on request.

[5] This map is based on information from the Shutesbury Road Solar Project report provided by the Town of Amherst (www.amherstma.gov).

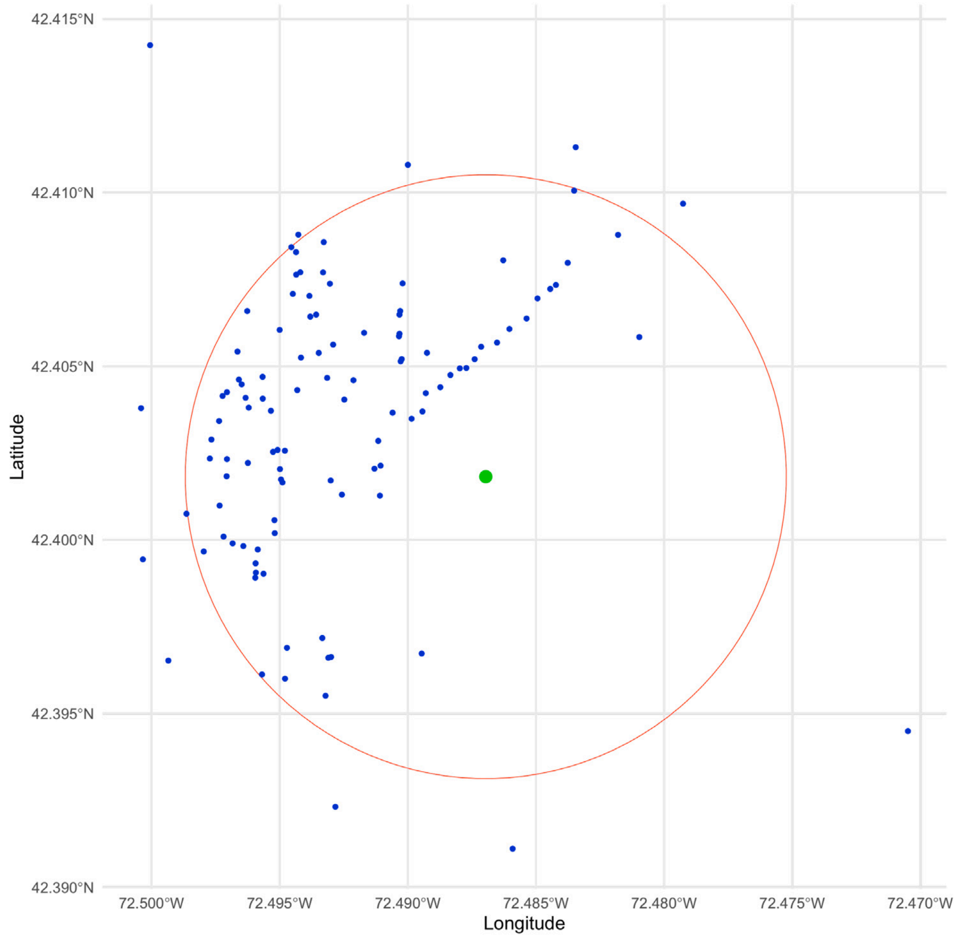

Fig. A.3. Buildings within 0.6 miles of the project site. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Table B.1
All Impacts, discounted at 3% (100% Initial carbon release).

Year	Benefits	Costs			Total
	Reduced Carbon Emissions	Reduced Property Values	Deforestation (Lost Ecosystem Services)	Deforestation (Carbon Emissions, Lost Sequestration)	
0	0.00	(972824.60)	0.00	(264362.52)	(1237187.12)
1	275024.26	0.00	(436.89)	(8483.54)	266103.83
2	265678.78	0.00	(424.17)	(8236.45)	257018.16
3	256650.86	0.00	(411.81)	(7996.55)	248242.49
4	247929.71	0.00	(399.82)	(7763.64)	239766.25
5	239504.92	0.00	(388.17)	(7537.52)	231579.22
6	231366.40	0.00	(376.87)	(7317.98)	223671.55
7	223504.43	0.00	(365.89)	(7104.83)	216033.71
8	215909.62	0.00	(355.23)	(6897.90)	208656.49
9	208572.89	0.00	(344.89)	(6696.99)	201531.01
10	201485.46	0.00	(334.84)	(6501.93)	194648.69
11	194638.87	0.00	(325.09)	(6312.55)	188001.22
12	188024.93	0.00	(315.62)	(6128.69)	181580.61
13	181635.73	0.00	(306.43)	(5950.19)	175379.11
14	175463.64	0.00	(297.50)	(5776.88)	169389.26
15	169501.28	0.00	(288.84)	(5608.62)	163603.82
16	163741.53	0.00	(280.43)	(5445.26)	158015.84
17	158177.50	0.00	(272.26)	(5286.66)	152618.58
18	152802.54	0.00	(264.33)	(5132.68)	147405.52
19	147610.22	0.00	(256.63)	(4983.19)	142370.40
20	142594.34	0.00	(249.15)	(4838.05)	137507.14
Total	4039817.90	(972824.60)	(6694.86)	(394362.63)	2665935.81

Values in parentheses are negative.

Table B.2
Definition of key parameters.

Parameter	Value	Description/Source
Project Specifications		
Project Capacity	9.35 MW_{DC}	Ground-mounted solar PV facility
Initial Electricity Generation	11,709,449 kWh/year	Calculated using NREL's PVWatts tool
Panel Degradation	0.5% annually	Based on industry standards
Project Timeframe	20 years	Typical solar panel lifespan
Project Area	41.4 acres	Total forest area converted
Economic Parameters		
Discount Rates	3% and 5%	Standard rates for environmental projects
Property Value Impact	2% decrease	For properties within 0.6 miles
Environmental Parameters		
Social Cost of Carbon	Base: $56 Alternative: $210	IWG (2021) estimate for 2025 EPA (2023) estimate for 2025
Emissions Rates	Average: 0.000432 Marginal: 0.000448	Massachusetts grid average Natural gas generation rate
Carbon Release Scenarios	100%, 80%, 50%	Percentage of stored forest carbon released initially

References

Abashidze, N., Taylor, L.O., 2023. Utility-scale solar farms and agricultural land values. Land Econ. 99 (3), 327–342.

Abbasi, T., Premalatha, M., Abbasi, S., 2011. The return to renewables: Will it help in global warming control? Renew. Sustain. Energy Rev. 15 (1), 891–894.

Boardman, A.E., Greenberg, D.H., Vining, A.R., Weimer, D.L., Analysis, C.-B., 2018. Concepts and practice. In: Routledge Handbook of Deradicalisation and Disengagement.

Brinkley, C., Leach, A., 2019. Energy next door: A meta-analysis of energy infrastructure impact on housing value. Energy Res. Soc. Sci. 50, 51–65.

Burnett, K., Wada, C., Balderston, A., 2017. Benefit-cost analysis of watershed conservation on hawai'i island. Ecol. Econom. 131, 262–274.

Cape Cod Collaborative, 2019. Forests vs solar farms: A position statement. URL https://capecodclimate.org/wp-content/uploads/2021/06/Forest-solar-position-final-11-14-19.pdf.

Capellán-Pérez, I., De Castro, C., Arto, I., 2017. Assessing vulnerabilities and limits in the transition to renewable energies: Land requirements under 100% solar energy scenarios. Renew. Sustain. Energy Rev. 77, 760–782.

Cherp, A., Vinichenko, V., Tosun, J., Gordon, J.A., Jewell, J., 2021. National growth dynamics of wind and solar power compared to the growth required for global climate targets. Nat. Energy 6 (7), 742–754.

Cowett, F., Bassuk, N.L., 2020. Street tree diversity in massachusetts, USA. Arboric. Urban For. 46 (1), 27–43.

Crago, C.L., 2021. Economics of solar power. In: Oxford Research Encyclopedia of Environmental Science. Oxford University Press.

Dauwalter, T.E., Harris, R.I., 2023. Distributional benefits of rooftop solar capacity. J. Assoc. Environ. Resour. Econ. 10 (2), 487–523.

Deline, C., Jordan, D., Sekulic, B., Parker, J., McDanold, B., Anderberg, A., 2024. PV Lifetime Project – 2024 NREL Annual Report NREL/TP-5K00-90651. National Renewable Energy Laboratory, Golden, CO.

Dröes, M.I., Koster, H.R., 2021. Wind turbines, solar farms, and house prices. Energy Policy 155, 112327.

EIA, 2023. Massachusetts electricity profile. URL https://www.eia.gov/electricity/state/massachusetts/.

EIA, 2025. Solar explained: Solar energy and the environment. URL https://www.eia.gov/energyexplained/solar/solar-energy-and-the-environment.php.

EPA, 2023. Supplementary Material for the Regulatory Impact Analysis for the Final Rulemaking, Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review. Technical Report, Environmental Protection Agency, URL https://www.epa.gov/environmental-economics/scghg, Docket ID No. EPA-HQ-OAR-2021-0317.

EPA, 2024. Guidelines for Preparing Economic Analyses, Technical Report EPA-240-R-24-001, third ed. U.S. Environmental Protection Agency, Washington, DC.

García-Frapolli, E., Schilmann, A., Berrueta, V.M., Riojas-Rodríguez, H., Edwards, R.D., Johnson, M., Guevara-Sanginés, A., Armendariz, C., Masera, O., 2010. Beyond fuelwood savings: Valuing the economic benefits of introducing improved biomass cookstoves in the Purépecha region of Mexico. Ecol. Econom. 69 (12), 2598–2605.

Gaur, V., Lang, C., 2023. House of the rising sun: The effect of utility-scale solar arrays on housing prices. Energy Econ. 122, 106699.

Hernandez, R.R., Easter, S., Murphy-Mariscal, M.L., Maestre, F.T., Tavassoli, M., Allen, E.B., Barrows, C.W., Belnap, J., Ochoa-Hueso, R., Ravi, S., et al., 2014. Environmental impacts of utility-scale solar energy. Renew. Sustain. Energy Rev. 29, 766–779.

Hernandez, R.R., Hoffacker, M.K., Murphy-Mariscal, M.L., Wu, G.C., Allen, M.F., 2015. Solar energy development impacts on land cover change and protected areas. Proc. Natl. Acad. Sci. 112 (44), 13579–13584.

i-Tree, 2006. i-Tree Tools. USDA Forest Service and Davey Tree Expert Company, URL https://canopy.itreetools.org/, (Accessed 25 November 2024).

International Renewable Energy Agency (IRENA), 2023. Solar Energy. International Renewable Energy Agency, URL https://www.irena.org/Energy-Transition/Technology/Solar-energy.

IWG, 2021. Interagency Working Group on Social Cost of Greenhouse Gases, United States Government. Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide. U.S. Environmental Protection Agency, Washington, DC, Docket ID No. EPA-HQ-OPPT-2021-0057-0097.

Jarvis, S., 2024. The economic costs of nimbyism: evidence from renewable energy projects. J. Assoc. Environ. Resour. Econ.

Johnson, D., Geisendorf, S., 2019. Are neighborhood-level SUDS worth it? An assessment of the economic value of sustainable urban drainage system scenarios using cost-benefit analyses. Ecol. Econom. 158, 194–205.

Keene, M., 2021. Forty-five acre solar farm pitched for Northeast Amherst. URL https://www.amherstindy.org/2021/11/05/forty-five-acre-solar-farm-pitched-for-northeast-amherst.

Larson, E., 2021. Net-zero america: Potential pathways, infrastructure, and impacts. Princeton University.

L'Her, G., Osborne, A., Flanagan, R., Deinert, M., 2024. Localized economic and environmental benefits of residential solar in the United States. Renew. Energy 120433.

Lovich, J.E., Ennen, J.R., 2011. Wildlife conservation and solar energy development in the desert Southwest, United States. BioScience 61 (12), 982–992.

Maddison, D., Ogier, R., Beltrán, A., 2023. The disamenity impact of solar farms: A hedonic analysis. Land Econ. 99 (1), 1–16.

Mallik, P.K., Singh, L., 2020. A cost benefit analysis of solar energy as a source of sustainable energy. Pranjana J. Manag. Aware. 23 (1), 01–11.

Massachusetts Government, 2022. Solar massachusetts renewable target (SMART) program. URL https://www.mass.gov/info-details/solar-massachusetts-renewable-target-smart-program.

MassAudubon, 2020. Losing Ground: Nature's Value in a Changing Climate. Technical Report, Massachusetts Audubon Society, URL https://www.massaudubon.org/our-work/publications-resources/losing-ground.

MassAudubon, 2023. New Report Shows We Can Build Solar Energy While Conserving Nature. Technical Report, Massachusetts Audubon Society, URL https://www.massaudubon.org/news/latest/new-report-shows-we-can-build-solar-energy-while-conserving-nature.

Mehedi, T.H., Gemechu, E., Kumar, A., 2022. Life cycle greenhouse gas emissions and energy footprints of utility-scale solar energy systems. Appl. Energy 314, 118918.

Merzbach, S., 2022. Panel sends moratorium on big amherst solar projects to council. Amherst. Bull. URL https://www.amherstbulletin.com/Panel-recommends-large-scale-solar-moratorium-in-Amherst-44872455.

Milousi, M., Souliotis, M., Arampatzis, G., Papaefthimiou, S., 2019. Evaluating the environmental performance of solar energy systems through a combined life cycle assessment and cost analysis. Sustainability 11 (9), 2539.

National Academies of Sciences, Engineering, and Medicine, 2017. Valuing Climate Damages: Updating Estimation of the Social Cost of Carbon Dioxide. The National Academies Press, Washington, DC, URL https://doi.org/10.17226/24651.

Nowak, D.J., Crane, D.E., Stevens, J.C., Hoehn, R.E., Walton, J.T., Bond, J., 2008. A ground-based method of assessing urban forest structure and ecosystem services. Arboric. Urban For. (AUF) 34 (6), 347–358.

NREL, 2021. Life Cycle Greenhouse Gas Emissions from Electricity Generation: Update. Technical Report NREL/FS-6A50-80580, U.S. Department of Energy, National Renewable Energy Laboratory, URL https://docs.nrel.gov/docs/fy21osti/80580.pdf.

Padgham, M., Lovelace, R., Salmon, M., Rudis, B., 2017. Osmdata. J. Open Source Softw. 2 (14).

Pebesma, E.J., et al., 2018. Simple features for r: Standardized support for spatial vector data. R J. 10 (1), 439.

Rogelj, J., Popp, A., Calvin, K.V., Luderer, G., Emmerling, J., Gernaat, D., Fujimori, S., Strefler, J., Hasegawa, T., Marangoni, G., et al., 2018. Scenarios towards limiting global mean temperature increase below 1.5 c. Nat. Clim. Chang. 8 (4), 325–332.

SEIA, 2024. Solar Industry Research Data. Solar Energy Industries Association, URL https://www.seia.org/solar-industry-research-data.

Solar Energy Industries Association (SEIA), 2024. U.S. Solar Market Insight. Solar Energy Industries Association, URL https://www.seia.org/us-solar-market-insight.

Tao, S., Rogan, J., Ye, S., Geron, N., 2023. Mapping photovoltaic power stations and assessing their environmental impacts from multi-sensor datasets in massachusetts, United States. Remote. Sens. Appl. Soc. Environ. 30, 100937.

Team, R.C., 2023. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria, URL https://www.R-project.org/.