Sustainable Solar Siting in Connecticut: Ecological, Energy, and Economic Trade-offs

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Introduction

Renewable portfolio standards (RPS) aimed at reducing greenhouse gas emissions have sparked the development of renewable energy across the United States. For example, Connecticut has set a mandatory RPS target of 44% by 2030, with 40% from class one renewables[1]. However, as of 2017, only 12.9% of Connecticut's electricity came from class one renewables[2]. RPS targets begin to increase by 2% per year[1] beginning in 2021, requiring aggressive procurement of renewable energy to meet targets. The deployment of ground-mounted, utility-scale solar energy has been a popular option for meeting mandated targets. As solar development increases, it is important to consider trade-offs between land uses, ecosystem services, and the effect of public perception toward renewable energy projects[3,4]. For instance, replacing forest with solar will reduce carbon emissions from the state's electricity generation but also removes the forests' carbon storage and sequestration services. We will use spatial analyses and land use, ecosystem services, and energy models to answer the following questions:

1. Considering electricity infrastructure, ecosystem services, energy production, and economics, where are optimal locations for ground-mounted, utility-scale solar siting in Connecticut?
2. How do municipalities around Connecticut perceive ground-mounted, utility-scale solar development, and how do community characteristics and previous experience with solar development influence those perceptions?
3. How do solar siting scenarios change under future land use forecasts?

Study Area & Data

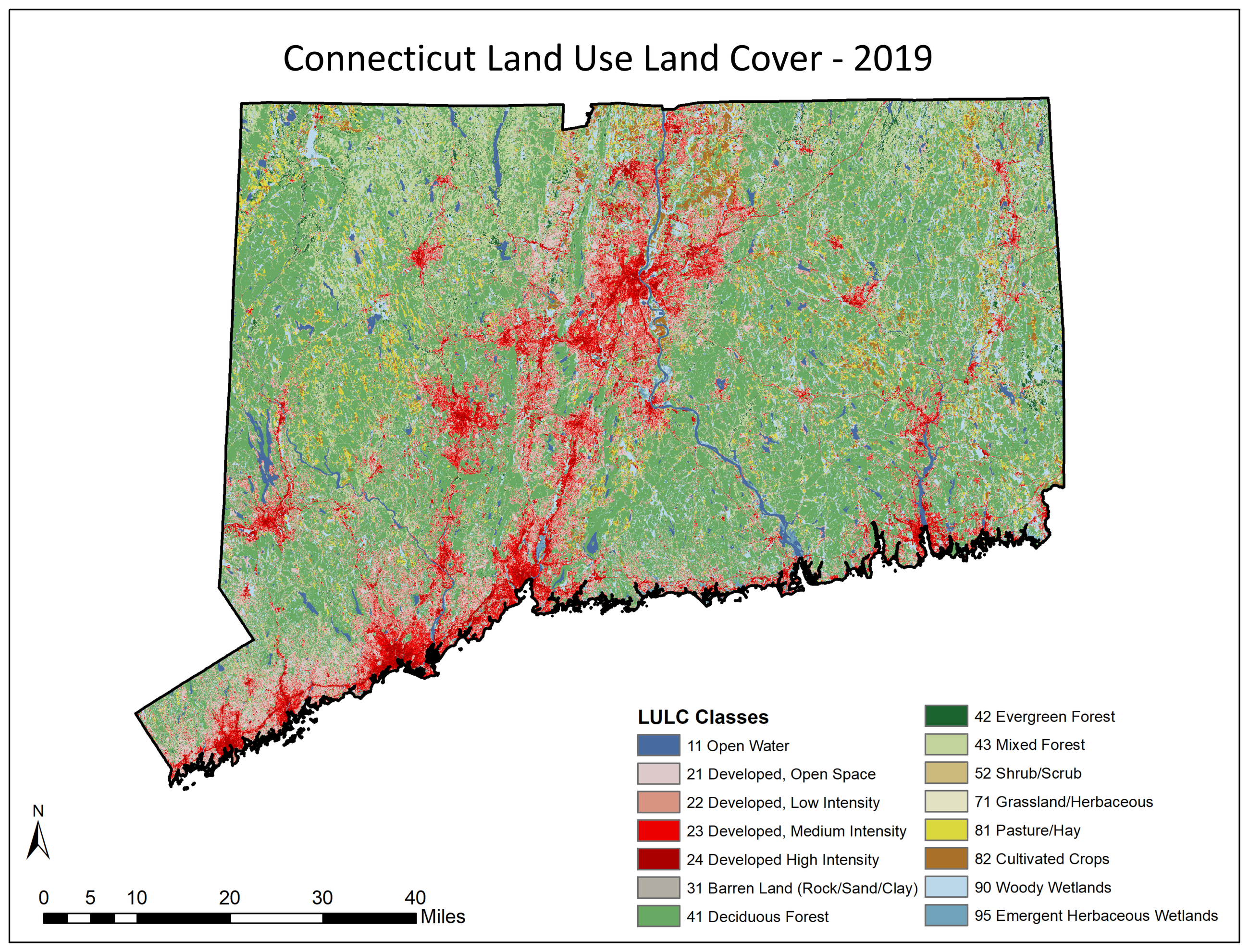

Figure 1. USGS Land use land cover map of Connecticut, a product of the National Land Cover Database[5]. We will apply our methods in Connecticut.

Table 1. Data inputs by category, which will be included in our models.

Land Suitability	Ecosystem Services	Electricity Infrastructure	Energy Production / Cost	Community Input
Land Use/Land Cover	Land Use/Land Cover	Location of high & low voltage lines	Electricity produced	Survey responses
Core forest	Carbon Storage & Sequestration	Capacity of high & low voltage lines	Installation cost	
Soil designation	CO_2 emissions offset by renewable energy sources	Location of substations	Operating costs	
Aspect & slope	Nutrient loading	Capacity of substations		
Threatened, endangered, & species of concern habitat	Annual Precipitation			
	Watersheds			
	Pollinators			

Methods

The questions and methods outlined in this project were informed by a series of stakeholder meetings. This project makes use of a multi-step process whereby we integrate results from multiple models. We outline a four-step process resulting in a real-time and forecasted techno-ecological-financial output. Figure 2 below captures the four steps required to evaluate the tradeoffs between ground-mounted, utility-scale solar energy production and ecosystem services in Connecticut. The final output is a series of maps used by stakeholders to evaluate sustainable locations for solar development in Connecticut. The steps are as follows:

1. Forecast LULC using the TerrSet Land Change Modeler (LCM).
2. Develop conditional scenarios for suitable solar sites.
3. Estimate solar energy production and cost.
4. Estimate various ecosystem services using InVEST.

We have also developed a survey aimed at assessing the perceptions of solar energy within Connecticut communities that will be used alongside the model to help contextualize the social dimensions of solar energy.

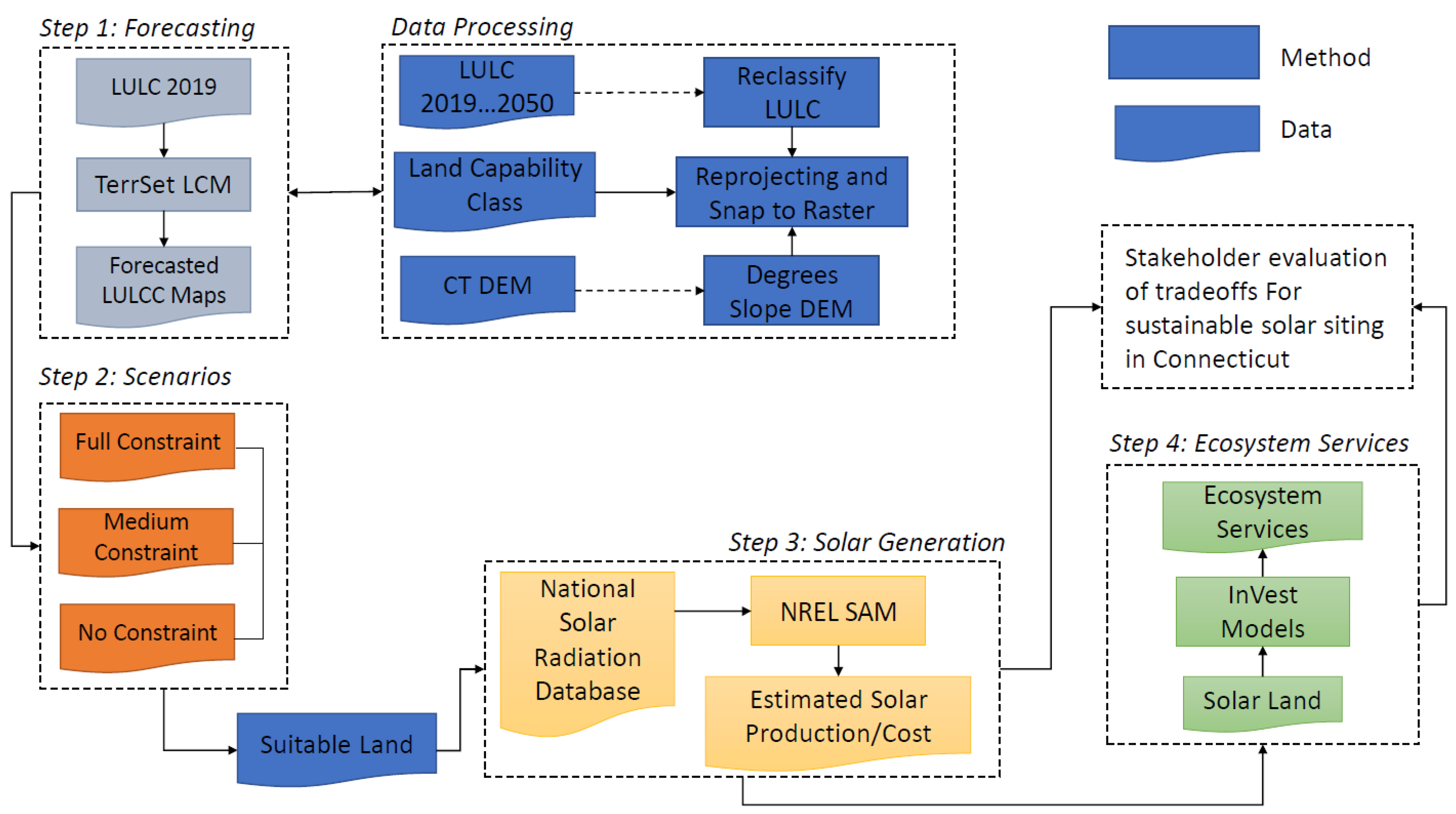

Figure 2. Techno-ecological-financial model for sustainable solar energy development in Connecticut.

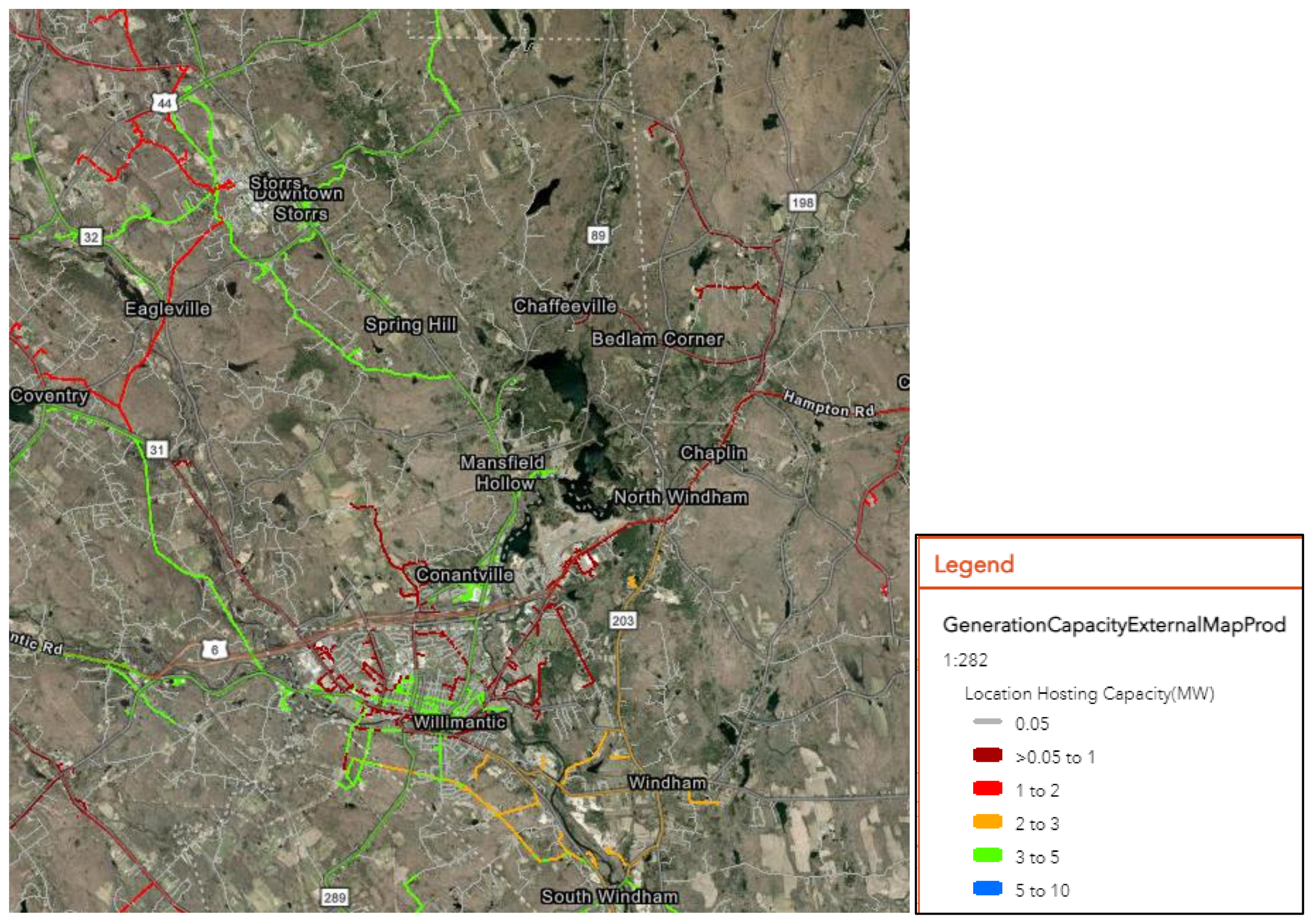

Figure 3. Example hosting capacity map, indicating distribution line capacity (in MW). Solar energy interconnection is highly dependent on the availability of these lines to take on additional electricity. (Source: https://www.arcgis.com/apps/webappviewer/index.html?id=4a8523bc4d454ddaa5c1e3f9428d8d8f)

Expected Outcomes

Current & Forecasted
Solar siting prioritization models

- Easily accessible, online sustainable solar siting mapping tool.
- Multiple scenarios based on different prioritization schemes.
- Iterative model development based on extensive stakeholder engagement.
- Incorporate land suitability, ecosystem services, grid infrastructure and capacity, energy output.
- Results from survey of municipal leaders in Connecticut.
- Medium resolution forecasted land use in Connecticut.

Applications

- **Public agencies**
  - Inform future state policy, including the Sustainable, Transparent, and Efficient Practices for Solar Development (STEPs) at the Connecticut Department of Energy and Environmental Protection.
  - Useful as a resources for policymakers when developing incentive structures for solar development.
- **Communities**
  - Inform decision making about optimal locations for solar development.
  - Help communities conceptualize their land use priorities.
  - Provide the opportunity for communities to consider solar energy specific zoning.
- **Solar developers**
  - Provides a holistic method when considering current and future locations for solar development.
  - Useful in facilitating a community understanding both in support for and opposition to solar projects, which could lead to better solutions for increasing public support.
- **Utilities**
  - Inform Connecticut electric utility of optimal locations for solar energy that account for conservation of land use and ecosystem services.

References & Acknowledgements

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