NATUREWATT LLC.

A GUIDE TO ENVIRONMENTALLY AND SOCIALLY RESPONSIBLE UTILITY-SCALE SOLAR DEVELOPMENT IN THE SOUTHEASTERN UNITED STATES

by

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Utility-scale solar photovoltaic electricity generation is growing rapidly across America, and as a result, concerning impacts on the natural environment are starting to add up. Recognizing that North Carolina has the second largest capacity of utility-scale solar generation in the country, the Nature Conservancy of North Carolina has been compelled to intervene (SEIA, 2019). Concerned about the negative impacts to the natural environment that solar development can cause, The Nature Conservancy of North Carolina has identified best practices for sustainable solar development and begun to explore ways to incentivize industry adoption (TNC, 2019). To this end, they called upon us, a Duke University Nicholas School of the Environment Masters Project team, to develop the first iteration of a voluntary-based certification system for eco-friendly solar farms.

To create a certification program with the natural environment in mind, the first step was to identify core objectives for the guidebook, the reference document of the certification. This first objective was to compile negative impacts of solar development and provide mitigation and avoidance practices. The second was to estimate the qualitative costs and benefits of each practice so that stakeholders know what costs and benefits consider before they decide to pursue the certification. The last objective for the guidebook was to compile measurement tools for each practice so that the certification requirements are standardized and measurable. Together these objectives culminated in a guidebook that accomplishes the Nature Conservancy's mission to protect and restore natural systems and biodiversity.

The first step in the guidebook compilation process was to review the *Principles of Low Impact Solar Siting and Design* written by Elizabeth Kalies of the Nature Conservancy of North Carolina. This document is the foundation of the certification, as it lays out six principles that reflect the core practices of sustainable solar development. These principles include avoiding areas of native biodiversity, allowing for wildlife connectivity, using disturbed land, protecting water quality, restoring native plant species, and protecting and providing wildlife habitat (TNC, 2019). We aimed to further this research by reviewing additional literature regarding the impacts of solar development and other relevant topics, such as existing solar certification and other environmental certifications. In addition, informal interviews were used to gain stakeholder insight on existing mindful practices and new ideas surrounding community engagement. Once the research was complete, the writing of the guidebook began.

The certification, entitled NatureWatt, is awarded through compliance with the NatureWatt Guidebook. This guidebook is comprised of four sections: Siting, Design, Social Impact, and Compliance. Each section contains principles supplemented by criteria that aim to provide a complete inventory of sustainable tactics for each step of solar project development. Each criterion contains measurement tools that must be used to measure compliance as well as qualitative, expected costs and benefits that stakeholders may incur. The NatureWatt Guidebook goes beyond the tangible aspects of solar development and includes tactics that address social impact. From promoting diversity, to community education, the guidebook offers innovative ways to address inequities in the communities where solar projects are built. The guidebook went through an extensive revision process, which included reviews by solar industry stakeholders.

The NatureWatt certification draws attention to the importance of mindfulness of the surrounding environment during the siting and design of utility-scale solar generation. It is a comprehensive guidebook that allows for innovation and profitability, while allowing for the natural environment to thrive as it cohabitates with the new development. Further research opportunities will require subject matter experts who can place value on certain ecosystem services and experts who can create an implementation plan for industry adoption.

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Disclaimer: Because most of our interviewees wish to remain anonymous we are not releasing names or affiliation of those participating in several of the interviews conducted as part of this Masters Project. Instead, interviews are cited in-text as (interviewee job title, date of interview). The full interview bibliography can be found on page 42.

Introduction

Utility-Scale Solar Development in North Carolina:

Installed solar power in North Carolina has increased tremendously from less than 1MW in 2007 to 5,662 MW in 2019 (SEIA, 2019). As of 2020, the state ranks second in the nation for cumulative solar installations (SEIA, 2019) (Figure 1.).

Figure 1. Top 10 solar states based on the cumulative installed capacity through 2019, (SEIA, 2019)

The rapid growth is in large part due to solar-friendly policies, economic factors, and the expansion of solar energy companies in North Carolina (Meeks, 2018). This growth in solar has brought numerous economic benefits to the state, including over $1.4 billion in revenue and over

6,719 full time equivalent jobs (Aldina et al., 2017). Solar energy also plays a vital role in helping North Carolina reach its Renewable Energy and Energy Efficiency Portfolio Standard (REPS) of 12.5% renewable energy sales by 2021 (Aldina et al., 2017). Other benefits that solar has brought to the state include: greenhouse gas reductions, improved air and water quality, and increased energy security. Of the various types of solar technology (e.g., roof-top PV, thermal solar, etc..), utility scale PV solar farms are the most cost-effective for generating electricity production as judged by the Cost of Electricity (LCOE) (National Renewable Energy Laboratory, 2019).

Impacts of Utility-Scale PV Solar Farm Development:

Solar farms are ground mounted solar PV installations exceeding 1 MW and require at least 5 acres of land (Southern Environmental Law Center, 2017). While solar farms allow reducing the combustion of fossil fuels, they still have negative environmental impacts (Figure 2.).

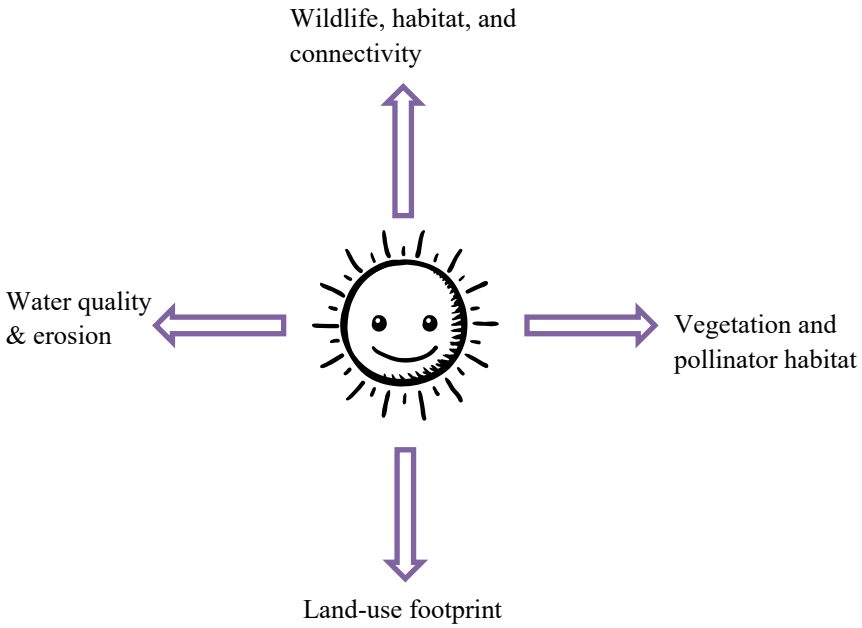


Figure 2. Examples of environmental factors impacted by utility-scale solar development (TNC, 2019)

Not different from other interventions of the landscape, solar farms can have negative environmental impacts. This is because land being considered for solar development is often home to protected species and provides other valuable ecosystem services. Furthermore, solar developers are increasingly looking to develop on agricultural land, adding to the already serious concerns of food growers (Aldina et al., 2017). In addition, the North Carolina public has expressed worries regarding potential negative effects of solar farms on the state's economy and environment (Aldina et al., 2017).

Some detrimental land impacts of solar farm development may include the clearing of native vegetation and subsequent planting of fescue grass (TNC, 2019). Mowing and spraying herbicides to maintain the fescue grass is often necessary, which can lead to soil erosion. In addition, the construction process can lead to decreased soil productivity, as well as surface water run-off. Solar farm development can also lead to habitat fragmentation due to impermeable fencing. Additionally, habitat loss can occur due to the conversion of native land. The construction and maintenance of power transmission and distribution lines required to connect solar farms to the grid can also harm wildlife due to the use of herbicides to control the growth of plants and trees near the wires and to the construction of access roads for maintenance crews. Lastly, the extraction, transportation, processing and end-of-life disposal of materials required for solar PV has a considerable carbon footprint, although still significantly lower than coal or gas with carbon capture and storage (Pehl et al., 2017). Although the environmental implications of solar farm development may not be worse than those of coal, there is an opportunity to develop utility scale PV in a more environmentally and socially responsible manner, given the prospects for massive development of this resource in the next two decades (Groesbeck & Pearce, 2018).

Moving Towards Sustainable Solar Farm Development:

In response to the demand for sustainable solar farms, many organizations are collaborating with developers to minimize ecosystem impacts. One such organization is our client, the Nature Conservancy (TNC). TNC is assisting in doubling renewable energy generation in the U.S. (compared to 2016 levels) and is aiming for at least 75 percent of solar installations to be sited in low-impact areas (TNC, 2019). TNCs mission and expertise in environmental conservation, allows it to work closely with solar developers on the identification and implementation of environmentally-conscious practices. In this vein, TNC released a set of guidelines for low impact solar siting and design (TNC, 2019). TNC's guidelines include a set of siting and design practices that mitigate the potentially harmful environmental impacts of solar farms. These practices include but are not limited to: siting on degraded land, providing permeable fencing or wildlife passages, planting or retaining native vegetation, and providing tree buffers around the solar farm (Figure 3.).

Summary of Principles and Practices: See TNC's NC Solar Siting Webmap for spatial data

PRINCIPLE	SITING	DESIGN[7]
1. Avoid areas of high native biodiversity and high quality natural communities	Avoid siting in resilient areas	
2. Allow for wildlife connectivity, now and in the face of climate change	Avoid siting in and fragmenting climate corridors	Where appropriate, use wildlife-friendly fencing or unfenced wildlife passage-ways
3. Preferentially use disturbed or degraded lands	Preferentially site on degraded lands with little vegetation and/or poor soil quality	Retain or plant vegetation/trees in buffers or outside of perimeter fence
4. Protect water quality and avoid erosion	Do not site in floodplains	Buffer streams and wetlands
5. Restore native vegetation and grasslands		Integrate the planting of native and/or pollinator vegetation where appropriate
6. Provide wildlife habitat		Protect and restore on-site wildlife habitat features (e.g., wetlands, vege-tated buffers); provide supplemental habitat as appropriate

[7] There is no "one size fits all" approach to solar facility design. Each solar facility needs to be evaluated based on natural landform and hydrology, native plant and wildlife species presence, and ecosystem functions. For example, wildlife corridors may be most relevant for an installation in a forested matrix, whereas pollinator habitat may be more appropriate in an agricultural setting. The NC Solar Siting Webmap can help identify solar facilities that are candidates for best design practices based on their position on the landscape.

Figure 3. Summary of TNC's Principles and Practices (TNC, 2019). Image source: page 2 of TNC's Principles of Solar Siting and Design.

In addition of the work from multiple organizations, a push from more environmentally conscious development of solar farms may be pushed by the public which increasingly favors these practices. For example, students in a Social Science Surveys for Environmental Management course at Duke University found from a survey of 65 subjects, that members of the Triangle are more willing to accept solar farm development if innovative design practices are implemented (ENVIRON 557, Spring 2019). To stay in line with the environmental benefits of solar energy, solar facilities need to address the social and environmental implications of development. As solar energy capacity continues to grow rapidly across the Southeast, best practices for environmentally and socially responsible development need to be adopted at a higher rate.

Given the increasing demand from various stakeholders for sustainable solar farm development, the NC TNC has the objective of using its guidelines for low-impact siting and design as the basis for a point-based certification program for southeastern U.S. utility-scale solar farms. The objective of this Masters Project is to design such certification program and to outline the next steps for its implementation. The different principles guiding practices for certification are described in detail in the NatureWatt Guidebook presented in Appendix 1. The certification program will be administered through a Limited Liability Company (LLC), NatureWatt, formed under the North Carolina Nature Conservancy. The NatureWatt program is designed based on a review of existing certification frameworks such as B Corps, LEED, SolSmart, and Forest Stewardship Certification (FSC) (FSC, n.d., USGBC, n.d., B Lab, n.d., SolSmart, n.d.) and interviews with certification experts, ecologists, and solar energy experts. The certification program contains four sections, including: Siting, Design, Social Impact, and Compliance (Appendix 1). Within each section, there is a description of the principles that the solar facility must follow and a number of best practices that should be adopted in relation with such principle.

The guidebook also provides references to tools that facilitate implementing those practices ore measuring their impact (Appendix 1).

The Role of Environmental Certifications:

As various stakeholders, such as businesses, become increasingly aware of the importance of sustainable development, they often implement an environmental management system. Environmental standards and certifications are frequently part of environmental management systems (Hui et al., 2015). Standards and certifications have long played a significant role in helping businesses move towards positive environmental and social impact. Certifications allow businesses to differentiate more environmentally and socially responsible products from their traditional counterparts. They aid in inducing consumer trust in an organization's output, as well as outlining clear criteria and goals for a given product or service.

A ubiquitous environmental certification is the Leadership in Energy and Environmental Design (LEED) certification, a green building rating system created and administered by the U.S. Green Building Council (Rosa, 2016). To obtain LEED certification, projects are ranked against one of six different rating systems. Building projects then earn points for meeting prerequisites and credits across nine areas of building excellence (USGBC, n.d.). The LEED certification contains four different levels of achievement, ranging from Certified to Platinum, depending on the magnitude of points scored on the chosen rating system. The LEED certification has revolutionized the U.S. building industry. Other benefits of the LEED certification include: increased property value, lower daily O&M costs, reduced environmental impact, and increased occupant health (Rosa, 2016).

Another well-known certification program is the Forest Stewardship Council (FSC) certification (FSC, n.d.). FSC, a non-profit organization, ensures that forestry is carried out in a

socially and environmentally responsible manner. Wood and paper products with an FSC certification can be traced back to a sustainably managed forest that provides environmental, social, and economic benefits (FSC, n.d.). FSC offers two types of certification: Forest Management and Chain of Custody. In order to obtain either certification, FSC-Accredited Certification Bodies verify that forests are in compliance with the certification requirements. Unlike LEED, the FSC certification is not point-based. Rather, forest managers must comply with a set of 10 principles and 70 criteria to obtain certification (FSC, n.d.). There are various ways forest managers can comply with each criteria since the nature of forest management is highly dependent upon several factors, such as location.

A certification that is taking the corporate business world by storm, is the B Corps Certification, administered by B Lab, a non-profit organization (B Lap, n.d.). Rather than creating value solely for stakeholders, Certified B corporations create value through incorporating the interest of all stakeholders (B Lab, n.d.). This means Certified B corporations create value for their employees, communities, consumers, and the planet. The B Certification has helped separate companies that are greenwashing from those that are genuinely doing business for good. Businesses earn the certification by scoring an 80 or above on the B Impact Assessment and changing their legal business status (B Lab, n.d.). The Impact Assessment measures business impacts across governance, workers, community, environment, and customers.

Market-based certifications as successful and prominent as the LEED, FSC, and B Corps can serve as a valuable framework for developing certifications across other industries, such as the solar industry.

Literature Review:

Existing Solar Certifications:

A few efforts to enforce sustainable solar development stem from state or county regulations. For instance, several states have implemented pollinator-friendly solar initiatives. Minnesota passed bill HF 3353 to create standards and guidelines for creating pollinator-friendly solar facilities (CESA, 2020). Similarly, Maryland, South Carolina, Illinois, Michigan, Vermont, and New York also have legislation surrounding native vegetation and provision of pollinator habitat (CESA, 2020).

In addition, multiple states are incentivizing socially responsible solar development, especially farming-friendly initiatives. For example, in North Carolina, if agricultural land is converted for non-agricultural uses, such as solar development, then the property owner will face a deferred tax penalty (CESA, 2020). However, the penalty can be avoided if agricultural production can be co-located with the solar facility.

In the private sector, electric utility companies are actively responding to environmental concerns by innovating in the design of solar farms. For example, Georgia Power is working with wildlife agencies to mitigate the impact of their solar facilities on the endangered gopher tortoise (Southern Environmental Law Center, 2017). Another utility, Xcel Energy, Minnesota's largest utility, mandates that solar developers layout their plans for preserving or introducing native vegetation in the proposed sites (Dunbar, 2019).

In addition to various stakeholder initiatives for sustainable solar development, a few solar certification programs have recently come to fruition. One such program is SolSmart, funded by the U.S. Department of Energy Solar Technologies Office (SolSmart, n.d.). SolSmart certifies communities that are committed to removing obstacles to solar development and promoting the

growth of the solar sector. Points are awarded across eight categories: 1) permitting; 2) planning, zoning, and development regulations; 3) inspection; 4) construction codes; 5) solar rights; 6) community engagement; 7) market development; and 8) finance (SolSmart, n.d.). Some of these categories consider the environmental and social impacts of solar development. For example, communities earn points for incentivizing co-location of solar within existing infrastructure, such as parking lots (SolSmart, n.d.). In addition, SolSmart applicants are rewarded for increasing access to solar energy across low-to-moderate income groups (SolSmart, n.d.).

Silicon Ranch, Shell's U.S. solar platform, is currently developing a 3rd party certification program, Regenerative Energy™ (Silicon Ranch Corporation, 2019). The program will certify projects that combine regenerative agricultural practices with solar power production. However, the program is still in its nascent stages. In addition, it may be a while until the certification gains significant adoption rates. According to several solar energy experts (NC Solar Developer, 2020), co-location of agriculture and solar energy must overcome many challenges before reaching scale and becoming cost-effective.

A non-profit in San Francisco, CA, Center for Resource Solutions, is administering the Green-e Energy certification program. The program certifies and verifies renewable energy credits, including those generated by solar energy projects (Green-E, 2020). In order to be certified, electricity generated from a renewable energy project must meet a set of rigorous standards to minimize environmental impacts (Green-E, 2020).

Despite the important actions from several stakeholders to promote sustainable practices for utility-scale solar farm development, and the existence of solar-related certification programs , to the best of our knowledge, The Nature Conservancy is the only organization currently pursuing the creation of a comprehensive market-based voluntary certification program. Such program is

focused both on the social and environmental impacts of utility-scale solar development (Kalies, 2019) and encompasses all stages throughout the solar development process, from planning to siting and design.

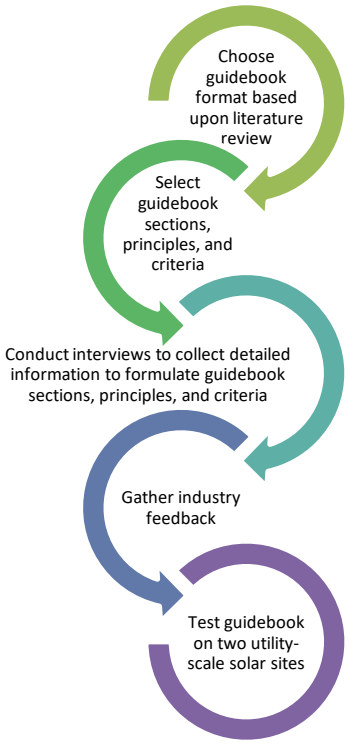
Methods

Overview:

To begin developing the NatureWatt certification program, we conducted a literature review. We reviewed existing research on the environmental and social impacts of utility-scale solar development and potential mitigation pathways. Furthermore, we reviewed existing certification programs to inform the guidebook format. We decided to model the NatureWatt certification format after the FSC certification program, which contains ten main principles and 70 criteria that must be complied with (FSC, n.d.). Each of the ten principles is broken down into criteria which provide details about how to comply with respective principles (FSC, n.d.).

Once the format of the guidebook was chosen, we created a list of sections, principles and criteria, based upon TNC's existing low-impact siting and design guidelines, supplemented by other relevant research on low-impact solar development. We then conducted informal, semi-structured interviews with stakeholders across the utility-scale solar industry, conservation landscape, and certification sphere to fill out details across all of the principles and criteria. In total, thirteen 30-minute interviews were conducted. The information gained throughout the interviews was complemented by existing literature on environmentally and socially responsible solar development. Once principles and criteria were filled in, we presented the draft guidebook to a NC solar developer for review (NC Solar Developer, 2020). Lastly, we applied the siting and design sections of the guidebook to two utility-scale solar sites in NC for proof of concept.

Figure 4. Overview of steps taken to create NatureWatt guidebook



Guidebook Format:

The first step in developing the guidebook was to choose a preliminary format of the document. We reviewed existing certifications, such as LEED, FSC and B Corps, to identify alternative formats, and studied in detail the FSC with the help of an FSC professional from the Duke Forest who explained how this certification works in practice – from what elements are certified (the timber tract) to who certifies the forest (3rd party auditors) (Duke University Forest Director, 2019). The FSC layout, listing principles and criteria fit squarely our vision for the NatureWatt certification and hence we adopted this format. However, different from the FSC which certifies a facility only if it meets all the criteria laid out in the guidebook, NatureWatt will certify facilities that obtain a minimum of points. This is because due to the geographic diversity of the regions where solar farms are installed, meeting all the criteria may be too burdersome and near infeasible, as confirmed by an ecosystem service specialist from the Nicholas Institute for Environmental Policy Solutions at Duke University (Policy Associate, Ecosystem Services, 2019).

Guidebook Content Creation:

The NatureWatt guidebook aims to certify utility-scale solar farm development across four sections: Siting, Design, Social Impact, & Compliance. These sections were included because together, they encompass the social, political, and environmental dimensions of sustainability in solar development. Sustainable solar farm development goes beyond minimizing environmental impact and should also consider the social and political context. The Siting and Design sections are included to encompass TNC's existing guidelines for low-impact utility-scale solar development. The Social Impact section is included to highlight the importance of a diverse and equitable solar industry (SEIA, 2019). In addition, The Nature Conservancy desires the certification program to expand beyond the protection of the natural environment and into the protection and enhancement of the surrounding communities of development, and it is important that the guidebook thoroughly covers this entire scope. Lastly, the Compliance section aims to ensure that all utility-scale solar farms applying for the NatureWatt certification abide by relevant policies and regulations.

To fill out these sections with principles and criteria, we collected qualitative data across the four sections. We collected information through informal interviews with a variety of solar development, conservation, and environmental certification stakeholders and online research to further expand upon the ideas discovered through the interviews.

The interviewees provided us with their insight across the four guidebook sections. Their answers represent a collection of existing best practices and new hopes for practices going forward. For the Siting and Design sections, interviews focused on understanding typical development practices and identifying opportunities for NatureWatt intervention. In addition, we sought to learn about existing and future practices that take the natural and social environment into special

consideration during siting and design. For instance, one member of a solar development team recalled innovative ways for preserving the natural environment through native foliage and maintaining wetlands on site (NC Solar Maintenance Specialist, 2019). Regarding operations and maintenance, interviews and research focused on the cost of maintaining solar farms once constructed. We sought information on the cost of maintaining the site with mowing compared to alternatives, such as planting native vegetation growth and livestock grazing. Conversations with developers also helped us uncover reasons for stakeholder buy-in and helped analyze how this certification could be introduced into the market. Interviewees gave us details about what factors would drive adoption of the certification, as well as what challenges would be faced and potential ways to overcome them.

The Social Impact section highlights a collection of creative ways solar development could positively impact the surrounding community. Interviewees described emerging innovative practices they think will spur community involvement and increase positive perception of solar development. Stakeholders spoke to socioeconomic impacts they have witnessed first-hand through solar development, such as seeking contract work locally. Because taking care of the local workers is important to TNC, a human resources professional guided us in our efforts to consider other aspects of PV development such as diversity in the workforce and livable wage (NC Labor Standards Expert, 2019).

Guidebook Proof of Concept:

The writing of the guidebook began with the conclusion of the first round of informal interviews. Throughout the writing process, we met biweekly to receive feedback on the guidebook from our client contact and our advisors. At first, the guidebook consisted of only sections, criteria,

and principles. Measurement tools for each criterion were then added to the guidebook to establish how the facility must show evidence of compliance. In addition, qualitative cost and benefit tables were included to inform the users of costs they may incur and benefits they may experience by developing the facility in compliance with NatureWatt. The tables are qualitative because actual costs of these practices proved to be wildly variable. Upon completion of the guidebook, a local solar developer provided industry feedback helping solidify the final edits (Principal of a NC Solar Site Company, 2020).

For proof of concept, the final review of the guidebook consisted of a virtual walkthrough of two solar sites in North Carolina to see how the sites would fare through the siting and design portions of the certification (Appendix 2.). This walkthrough also consisted of a visit to one of the sites in-person to observe specific characteristics of the site up close, such as the on-site wetland, sediment and erosion control, and groundcover.

Introducing NatureWatt:

We designed the first iteration of *NatureWatt: A Guide to Environmentally & Socially Responsible Solar*. It is a comprehensive guidebook that compiles best practices for eco- and socially friendly solar development. It provides measurement tools to report compliance, as well as qualitative costs and benefits that the stakeholders may incur to comply. The guidebook features four sections: Siting, Design, Social Impact, and Compliance.

The Siting and Design sections seek to mitigate the tangible footprint on the natural environment. The Social Impact section seeks to spur workforce diversity and inclusion in the solar industry and reward stakeholders for forging innovation. The Compliance section is included to ensure that the stakeholders are in legal compliance during development. Each section is broken

down into principles, then criteria, tackling the specific considerations of water quality and erosion, natural biodiversity, community relations, among others. The guidebook serves as a first iteration, with hopes that further research will be conducted and valuation experts will be consulted in order to assign point values to each criterion.

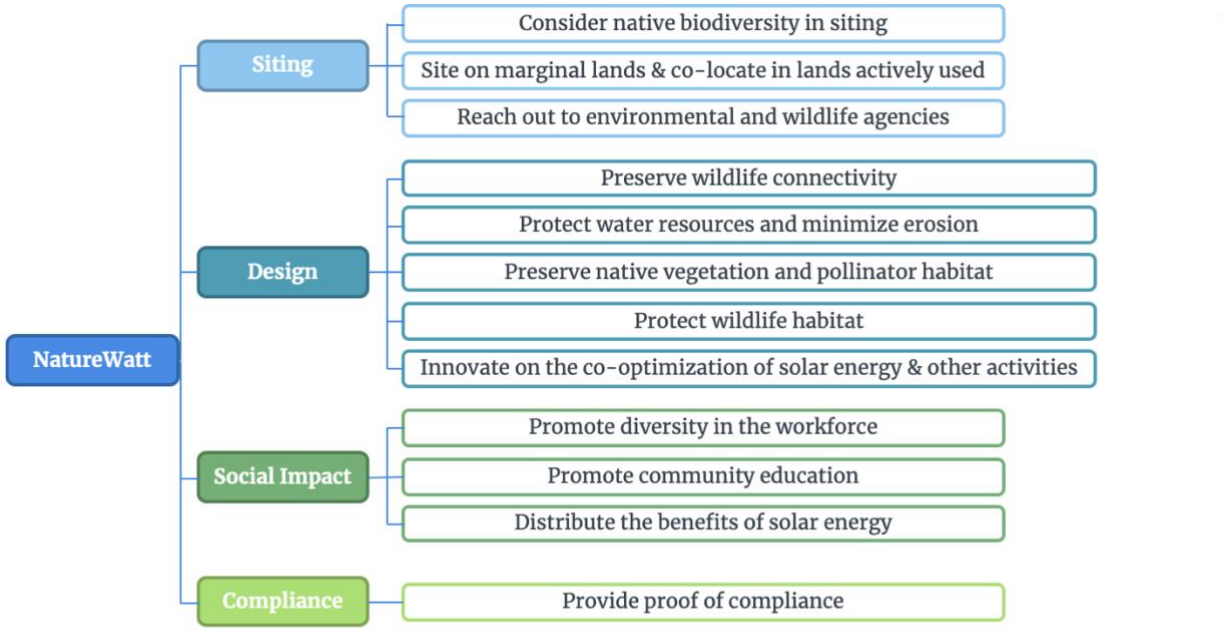


Figure 5. Overview of NatureWatt sections and principles

Overview of NatureWatt Principles:

Siting:

The first section of the guidebook includes principles which are relevant to reducing the environmental impacts of the siting process. The following section gives an overview of each of the siting principles and why they are important to consider.

Siting Principle 1: Consider Native Biodiversity in Siting:

The first siting principle in the NatureWatt guidebook is to consider native biodiversity and to avoid disturbance to biologically-fragile and critical ecosystems. Critical and sensitive

ecosystems often contain a high level of biodiversity which provides communities with various ecosystem services, such as water purification and carbon sequestration (TNC, 2019). In addition, these ecosystems often provide climate change adaptation and resilience. For example, wetlands can serve as buffers during flooding events by absorbing flood waters (TNC, 2019). In summary, Siting Principle 1 aims to encourage the environmentally responsible siting of solar facilities. It achieves this by recommending avoiding specific lands types, such as contiguous forest land.

The first type of land that Siting Principle 1 aims to protect is Resilient Areas. Resilient Areas are defined by the Nature Conservancy as land that is able to support its species and ecosystems in the face of stressful events, such as climate change (TNC, 2016) (Figure 5.). Second, the principle also aims to protect Climate Corridors. Climate Corridors are areas of land that are vital for species movement, especially in the face of climate change (TNC, 2019) (Figure 6.).

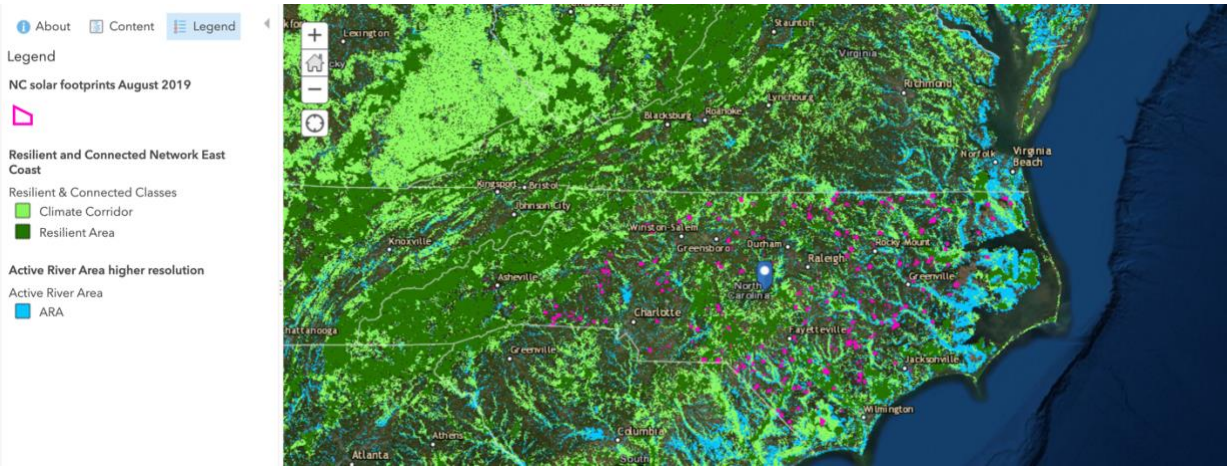


Figure 6. North Carolina Nature Conservancy map of resilient areas and climate corridors in North Carolina (TNC, 2019)

Third, protection of forested land is also facilitated through this principle. Forested areas provide countless benefits from carbon sequestration to habitat provision. Lastly, this principle

also protects floodplains, which also provide a variety of ecosystem services, such as: groundwater recharge, flood and erosion control, and water quality protection (FEMA, 2020).

Other types of land that should also avoid development are those which require grading for the placement of the solar facility. Land grading has been found to significantly disturb soil health and productivity (Hernandez et al., 2014). Grading can also lead to other negative impacts, such as accelerated erosion, land slippage, and habitat destruction (NY DEC, n.d.).

Lastly, land that is far from load demand should be avoided. Assuring that solar facilities are placed closest to where electricity consumption occurs reduces the need to build additional transmission infrastructure.

Siting Principle 2: Site on Marginal Lands & Co-Locate in lands actively used:

The objective of Siting Principle 2 is to maximize land-use efficiency by taking advantage of marginal lands, as well as existing infrastructure. Marginal lands include contaminated and degraded lands (Macknick et al., 2013). By developing on marginal lands, impact to pristine lands is minimized. In addition, there are several well-researched advantages associated with developing on marginal lands. For example, marginal lands are often located in lower-income communities; therefore, a solar facility could increase local economic well-being through job creation (Macknick et al., 2013). In addition, since the environmental impacts of developing on marginal lands is lower than on pristine lands, community stakeholders may be more likely to support the solar project. However, developing on marginal lands may require a lengthy and costly contamination clean-up process.

Figure 7. Elizabeth Mine Solar Farm in Orange County, Vermont. 345 watts cover what used to be a strip mine for copper ore (Harvey, 2017). Image source: Green Energy Times

Land-use efficiency can also be increased by placing solar facilities within existing infrastructure. For example, a facility could be placed in land with ongoing farming operations which is a practice known as agricultural co-location or agrivoltaics (Macknick et al., 2017) (Figure 8.). By co-locating solar farms with agricultural facilities, both crop generation and renewable energy production goals can be met. In fact, several studies have shown that facility co-location increases crop yield and soil health (Macknick et al., 2017). Co-location can also provide benefits to solar production since some vegetation provides a cooling effect, which increases PV efficiency (Macknick et al., 2013). Agricultural co-location could help to minimize competition for productive agricultural land between solar developers and farmers.

Figure 8. A solar installtion co-located with agricultrual plants at the University of Arizona. Image source: Greg A. Barron-Gafford

Siting Principle 3: Reach out to Environmental and Wildlife Agencies:

The 3rd principle aims to reduce siting impacts on the environment by engaging relevant stakeholders throughout the solar facility siting and planning process. By engaging natural resources experts, such as the US Fish and Wildlife Services, project developers can gain insight into alternatives to minimize environmental impacts at a particular site. Engaging with natural resource experts early-on in development could also smooth out environmental review processes. Preliminary consultations with stakeholders would increase the developer's environmental awareness about the community in which they wish to develop. As a result, community members may become more supportive of the facility if the developer has facilitated communication with relevant constituents. Lastly, by engaging environmental experts, the developer will gain insight into which siting and design practices to implement to protect species and their surrounding environment.

Design:

The following section of the guidebook pertains to designing the solar PV facility in a way that minimizes environmental impacts once a site has been selected. The following principles incorporate best practices for environmentally conscious design of the solar facility footprint.

Design Principle 1: Preserve Wildlife Connectivity:

The first design principle is included to mitigate potential habitat fragmentation caused by the footprint of the solar facility. By complying with the wildlife connectivity principle, the solar facility will ensure that habitat connectivity is retained. Habitat connectivity is crucial for species movements, whether it be daily or seasonal movement, or range shifts resulting from the changing climate. In addition, wildlife movement is essential for gene flow, which maintains species

biodiversity (Lui et al., 2018). Fragmented habitat may inhibit species from locating food, shelter, or mates (TNC, 2019).

Facilities can provide wildlife connectivity using a variety of methods. One way to allow for wildlife movement is to install wildlife-friendly fencing (Figure 10.). For example, Pine Gate Renewables installed permeable fencing at one of its North Carolina facilities in 2018. The larger holes at the bottom of the fencing allows small-to-medium sized species, such as rabbits, squirrels, and racoons, to pass through (Misbrener, 2019). Another way to allow movement of small-to-medium sized species is to install high-density polyethylene (HDPE) piping. However, the preferred and most effective way to enable wildlife movement is through retaining unfenced passageways throughout the solar facility (Figure 9.). For example, if a solar facility is sited close to a wetland, the wetland can serve as a wildlife passageway if it's omitted from the solar facility footprint (TNC, 2019).

Figure 9. An omitted streambed from a solar facility footprint acts as a wildlife passageway. Image source: Google Earth

Figure 10. A permeable wildlife fence on the left compared to a standard chain-link fence on the right. Image source: Liz Kalies (left) & Alicia Oberholzer (right)

Design Principle 2: Protect Water Resources and Minimize Erosion:

The Protection of Water Quality and Minimization of Erosion principle is included to avoid potential erosion and stormwater runoff caused by the solar facility (Figure 11.). If not controlled for, stormwater runoff from the solar facility could enter local bodies of water and increase water pollution. A cost-effective practice that can help prevent stormwater runoff from entering local bodies of water is providing a vegetative buffer around a solar facility. The vegetation can improve local water-quality by limiting the movement of runoff.

Furthermore, the principle aims to protect resources that provide water management services, such as wetlands. Wetlands provide water filtration, habitat for many species, and flood control (SELC, 2017). If a wetland is on the same site as the solar facility or near the same site, special protective measures should be taken to protect the valuable water feature. Best practices include leaving vegetation around the wetland intact, keeping debris from entering the wetland, and avoiding construction close by the wetland (TNC, 2019).

Figure 11. Erosion occurring at a NC solar facility, in part due to grading. Image source: Alicia Oberholzer

Design Principle 3: Preserve Native Vegetation and Pollinator Habitat:

Design Principle 3 is included to help protect native vegetation that provides habitat for pollinators, which bring the global economy $217 billion dollars annually (Pollinator Partnership, 2020). In addition, pollinators are responsible for providing the world population with one out of every three bites of food (Pollinator Partnership, 2020). Given their vital role, the solar industry has the potential to protect pollinator populations by providing high-quality habitat. By increasing the abundance of native vegetation, solar facilities can have a positive impact on pollinator populations. Increased pollinator populations can increase nearby agricultural and garden yield (NC Pollinator Alliance, 2018).

Planting native vegetation is not only beneficial to local pollinators, it can also improve soil health, water quality, and provide habitat for other species (Misbrener, 2017). While the upfront cost of planting native vegetation is higher than standard turf, it reduces long-term operation and maintenance costs of the site. This is because the planting of native vegetation reduces the need for onsite mowing, which makes up a significant portion of maintenance costs (NC Solar Facility Horticulturist, 2019). According to a horticulturist we consulted, mowing costs are approximately $55 per acre / per time. Because facilities in North Carolina typically get mowed six times per year (NC Solar Facility Horticulturist, 2019), a 40-acre farm would spend $13,200 per year on mowing. Planting native vegetation can halve mowing needs, therefore saving $6,600 annually for a 40-acre farm.

The NC Pollinator Alliance, in collaboration with the NC TNC, has already released a pollinator scorecard for solar facilities (NC Pollinator Alliance, 2019). The scorecard ranks facilities across various indicators to determine whether or not it provides adequate pollinator habitat. The NatureWatt certification utilizes the pollinator scorecard as a way to determine compliance with Design Principle 3.

Figure 12. A NC solar facility before and after the planting of native vegetation. Image source: Liz Kalies.

Design Principle 4: Protect Wildlife Habitat:

This principle aims to protect local wildlife through habitat protection, restoration, and supplemental habitat provision. Utility-scale solar development can lead to the loss of wildlife on and near the site (Defenders of Wildlife, n.d.). Rather than displace wildlife, solar projects should allow wildlife to thrive near and on the site. There are a multitude of ways for solar facilities to become stewards of wildlife, and this principle encompasses the best practices for doing so.

Prior to development, preventative measures can be taken to protect existing habitat features. For example, construction plans should ensure that elements of the facility don't interfere with existing habitat features, such as burrows. If existing habitat features are impacted throughout development, then efforts should be made to restore them. For example, retention ponds can be used to restore wetlands. Lastly, additional habitat features can be supplied to further support wildlife conservation (Figure 13.). Native tree and shrub species can be used to create a hedgerow which mimics an early successional forest, which in turn supports a multitude of species (NC Pollinator Alliance, 2018). Additionally, vegetated buffers provide important habitat functions

such as: nesting, food supplies, and shelter (NC Pollinator Alliance, 2018) (Figure 14.).

Figure 13. Examples of supplemental habitat features for solar sites. Image source: TNC Principle of Solar Siting and Design

Figure 14. Vegetated buffer and stream found in a NC solar facility provide wildlife habitat. Image Source: Alicia Oberholzer.

Design Principle 5: Innovate on the co-optimization of solar energy and other activities:

The last design principle aims to encourage solar facilities to adopt innovative practices to decrease their environmental footprint and provide valuable services to surrounding communities. It outlines various pathways for solar facilities to provide more than just energy onsite. Many stakeholders in the solar industry are taking advantage of the dual-use potential of solar facilities.

Eagle Point solar farm in Meford Oregon partnered with a local beekeeper to create the country's largest solar apiary (Peters, 2018) (Figure 15.). Other solar companies, such as Carolina

Solar Services, partner solar facilities with livestock keepers to provide a biological vegetation management solution (Carolina Solar Services, n.d.) (Figure 14.). Other dual land uses include the growing of crops underneath solar panels, also called agrivoltaics. Many research studies have found that certain crops actually grow better underneath solar panels. For example, researchers at the University of Arizona found that tomato production doubled in the shade the PV panels provide (Pigott, 2019). They also found that their agrivoltaics scheme significantly increased PV efficiency by cooling the panels (Pigott, 2019). The innovation section provides incentives for utility-scale solar developers to drive innovation across the sector.

Figure 13. Eagle Point Solar Farm in Medford, Oregon contains 49 beehives onsite. Image source: Pinegate Renewables.

Figure 14. Livestock grazing on a utility-scale solar farm in NC. Image source: Carolina Solar Services.

Social Impact:

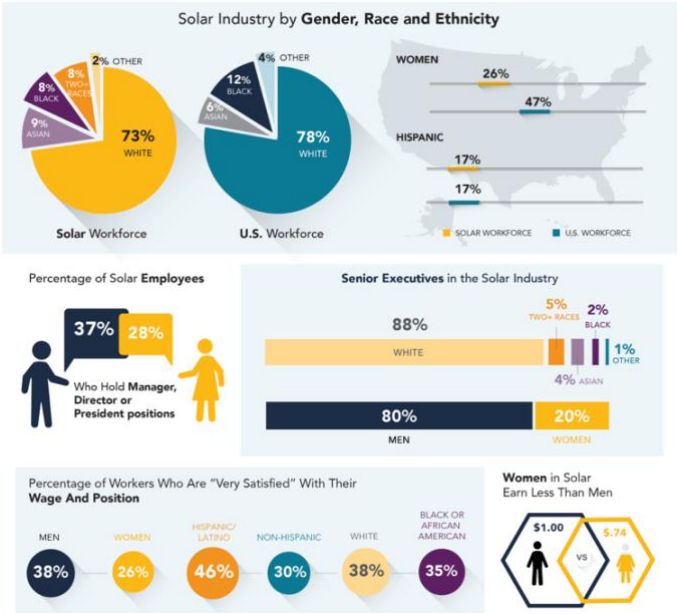
Sustainable utility-scale solar development doesn't only pertain to environmental impacts, but also to social impacts. The Social Impact section is included to ensure that solar development maximizes the well-being of the surrounding community and its constituents. It is only made up of one three principles that seek the adoption of best practices for maximizing the social and economic well-being of communities impacted by the development of the facility. The three

principles are: Promote Diversity in the Workforce, Promote Community Education, and Distribute the Benefits of Solar Energy.

Social Impact Principle 1: Promote Diversity in the Workforce:

The utility-scale solar industry has the potential to play a vital role in increasing diversity of the solar workforce. A 2019 study conducted by the Solar Foundation found that 88 percent of senior executives across solar firms surveyed are white and 80 percent are male (SEIA, 2019) (Figure 17.). As a result, the social impact criteria for the Promote Diversity in the Workforce principle in the NatureWatt guidebook outline best practices to enhance diversity and inclusion across the solar industry. By promoting diversity and inclusion, the utility-scale solar industry can become more accessible to disadvantaged populations.

Figure 17. Solar industry by gender, race, and ethnicity through 2019. Image source: SEIA & The Solar Foundation.



Social Impact Principle 2: Promote Community Education:

The community education section principle aims to facilitate community engagement through the provision of educational resources. By providing educational experiences and opportunities to engage with the solar facility, developers can promote awareness about renewable energy. For example, the facility could provide a test plot for local community college students to learn about solar electricity generation.

Social Impact Principle 3: Distribute the Benefits of Solar Energy:

The last component principle of the Social Impact section emphasizes increasing access to solar electricity for rural, low-income communities. Many Americans lack access to solar energy because they cannot afford the upfront cost of rooftop solar or their building lacks sufficient roofspace. As a result, utility-scale community solar projects can provide clean energy access to those who don't have access to rooftop solar. Another way to increase solar energy access is through working with rural electric cooperatives to provide electricity to isolated communities. For example, Mohave Electric Cooperative provides the Havasupai Tribe in the Grand Canyon with electricity from a solar facility (Karaim, 2019) (Figure 18.).

Figure 15. Solar arrays power the Havasupai Tribal School and government buildings in Supai village, Arizona. Image source: USEPA.

Compliance

Compliance Principle 1: Provide Proof of Compliance:

There are a variety of federal, state, and local regulations with which solar facilities must comply. This principle states that in order to maintain the NatureWatt certification, the facility must provide proof of compliance with these regulations on an annual basis. If a solar facility isn't continuously complying with regulations, then it negates other sustainable development efforts. For example, if a solar facility provides a proper stormwater pollution plan to comply with the Clean Water Act, and then is later discovered to be producing discharge, then the NatureWatt certification would be nullified.

Certification Landscape:

Certification and Auditing Process:

Throughout the creation of the guidebook, we also sought to create ways in which NatureWatt would be implemented. Due to the fragmented nature of the solar development process and the typical involvement of multiple entities, we envision NatureWatt to be a multi-tiered certification. Each tier of certification will be awarded throughout the three main steps of the development process: Siting, Design and Operations & Maintenance. Hence, the tiers will be NatureWatt Siting, NatureWatt Design, and NatureWatt O&M (Figure 19.).

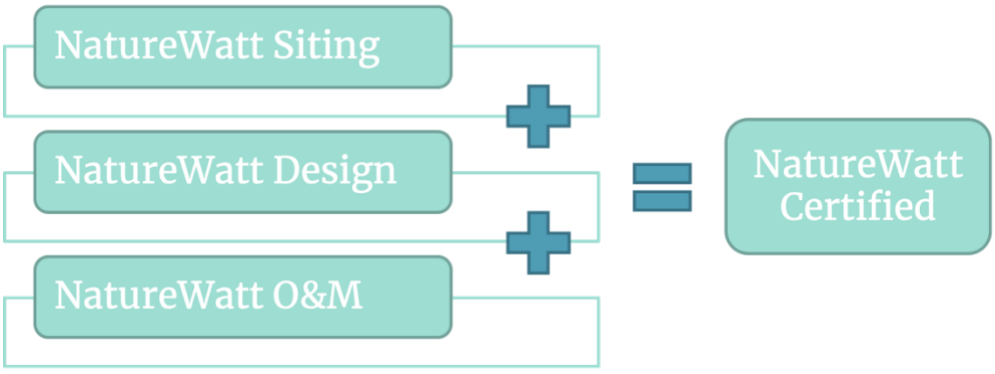


Figure 16. Overview of NatureWatt certification tiers

Once a facility has obtained all three tiers, they are wholly NatureWatt certified. However, it is not required that a facility earns all three tiers, a facility may choose to stop at a specific tier if they so desire. The Social Impact and Compliance components of the guidebook can be split across each certification based upon a principle's relevance.

The tiers were designed with the high-level of stakeholder collaboration in mind. Many times, a company will first design the facility, and a second company will then construct the facility. For example, Invenergy develops, owns, and operate its facilities but is not responsible for the engineering, procurement, and construction processes (Invenergy, n.d.). A third company is often times in charge of operation and maintenance. An example is Carolina Solar Services, which solely offers operation & maintenance services for utility-scale PV owners (Carolina Solar Services, n.d.). It is quite typical that a separate company will then own the facility. For example, most utility-scale solar farms in North Carolina are owned by a public utility (Principal of a N.C. Solar Site Development Company, 2020), rather than the solar development company. However, there are several solar development companies that perform each step of the development process in-house, as well as own some of their renewable energy assets, such as Sun Tribe Solar (Sun Tribe Solar, n.d.). Given that many facilities differ in stakeholder involvement, one certification tier would create a convoluted timeline and increase the amount of collaboration required. For a tiered certification approach, the multiple entities can more easily work together throughout each step of the development process to ensure the facility is awarded each tier of the NatureWatt certification in a stepwise fashion.

The certification will be allocated to the facility itself. As a result, the facility will be NatureWatt certified, rather than the organizations involved in developing the facility. This is due to the highly fragmented development process. This way, all organizations participating in the

development process can be recognized for being involved in producing a NatureWatt certified facility. Third party auditors, ideally using drones to more efficiently use the time of on-site visits, would certify each tier of the certification process. Developers could use a web-based app to track their progress so that they could predict the score their facility will receive. Interviewed developers emphasized the importance of all stakeholders having recognition by the Nature Conservancy for their NatureWatt efforts, which would help to ensure the success of attaining the certification tiers (Principal of a NC Solar Development Company, 2020) . Having established whom was to be recognized, it was important for us to build a case for why they would want to be certified.

Stakeholder Buy-In:

Informal interviews with developers allowed assessment of stakeholder buy-in and potential drivers for NatureWatt uptake in the market. A utility-scale solar developer advised that the certification would not attract buy-in if it increased both the timeline and the expense of the project (Senior Manager, Business Development, 2019). Numerous interviewees focused less on the expense of the environmental considerations due to the trivial amount of money that design costs in comparison with interconnection costs. In addition, the introduction of the certification tiers aims to smooth out the certification timeline by enabling a stepwise certification process, rather than trying to administer the certification all at once with multiple stakeholders involved.

Many interviewees showed initial support for the idea of the certification and argued that NatureWatt could gain traction by increasing the success rate of solar projects. This could be accomplished by increasing positive public perception of solar farm development. For example, a utility that is facing pressure to close its fossil fuel-fired generating units may pledge to only procure NatureWatt certified solar sites as a way to show its commitment to responsible

development. The introduction of NatureWatt would be unlikely to expedite development permitting processes; however, it could draw early attention to certain environmental considerations that overlap with existing required compliances. NatureWatt, for instance, can help a developer keep track of its environmental permitting requirements.

We also explored ways in which federal and local policies and regulations could encourage adoption of NatureWatt. The certification could see quick adoption if policy and regulation were altered to mandate certification for all solar development across the country. However, changing federal, state and local policy would prove challenging, and it might be more reasonable to request the added cost of environmental consideration proposed by NatureWatt to be eligible for the federal investment tax credit for solar farms. NatureWatt could also be more easily taken into the market if it were incorporated into an existing driver for renewable energy, such as the Renewable Energy Certificates (RECs) created by the U.S. renewable energy market. Currently, RECs are issued when one MWh of electricity from a renewable energy resource is generated and delivered to the grid (EPA, n.d.). RECs include a list of attributes describing characteristics of the generating resource; we believe NatureWatt could be included in this data set and add increased numeric value to the RECs themselves. In addition, there could be potential for NatureWatt to be incorporated into states' Renewable Portfolio Standards. For example, a given state could mandate that x% of utility-scale solar facilities are NatureWatt certified.

NatueWatt could also play a role in mitigating the costs of carbon taxes (voluntary or of potential mandatory payment in the future) for companies that invest in NatureWatt certified facilities. Many of the practices throughout the guidebook increase carbon sequestration and these efforts could be reflected as tax reductions if a national carbon tax was to one day be implemented. In addition, if a company wishes to offset their carbon, then investing in a NatureWatt facility

could offer more carbon sequestration than a non-certified facility of the same size. These suggestions for regulation changes might seem lofty but having the biggest players in the market demanding NatureWatt certification could spark policy change.

Ultimately, the main economic driver of NatureWatt is the buyer of the solar farm. A company, whether a utility or a company working to offset its carbon, has the power to demand the way in which its generation facilities are built. They could choose to include wetlands and other environmental considerations because they are paying for it, whether through lost profit because of less solar generation or through initial upfront implementation costs.

Conclusions & Further Research:

Solar development in the United States is growing at a fast pace. In North Carolina, the installed capacity of solar PV has grown 5,000-fold in the last decade. With the installation of this green energy resource comes a large development footprint on the natural environment. The Nature Conservancy of North Carolina identified the need for a guidebook of best practices for eco-friendly solar development and sought our help to gather these practices, gain stakeholder insight, and create a comprehensive guide to eco-friendly solar development.

Our final product is a guidebook for environmentally and socially responsible solar development in the southeastern United States. We divided the certification into four sections comprised of principles that focused on the tangible characteristics of site and design and intangible impacts of equity and inclusion. The guidebook summarizes findings of the academic literature we reviewed as well as the information and opinions provided by a variety of stakeholders that we interviewed. Regretfully, we did not speak with any utility representatives,

which could have altered our understanding of stakeholder buy-in. For future iterations, it would be beneficial to talk with utility representatives to get their viewpoint on such a program.

It is important to keep in mind that we developed this guidebook specifically for the southeastern United States. Many principles in the guidebook that are dependent on location-based factors would need to be amended before the certification could be applied to regions outside of the southeastern United States. For example, the native vegetation principle would need to be altered because native vegetation in the southeastern U.S. differs from that in other regions. Despite this, many of the measurement tools we identified are nation-wide resources, so similar guidebooks could be created with ease for other regions of the country. This provides a research opportunity for subsequent research teams. Iterations of the guidebook can be created for each geographical region of the U.S. to create a nation-wide certification program.

In order to facilitate adoption of NatureWatt it would be desirable to adapt and customize the measurement tools listed in NatureWatt guidebook (Appendix 1.) to respond to the specific needs of developers in North Carolina. The resulting NatureWatt toolkit -developed by a research team with geospatial expertise- could for example include an interactive map showing to users if a specific solar site and design is in compliance with NatureWatt criteria.

Further, the guidebook needs to be altered to fit into the multi-tiered certification that we envision for NatureWatt as described above. Currently, the guidebook is divided into four sections, and we suggest splitting these sections into three separate certification tiers: siting, design, O&M with Compliance and Social Impact principles included where relevant. In addition, the costs and benefits tables should be taken beyond qualitative analysis. We suggest performing an in-depth cost and benefit analysis that not only allows for actual cost of compliance but also measures the

benefits to facility owners, communities and ecosystems. As mentioned earlier, we omitted a point-based system due to lack of subject matter expertise. We recommend holding focus groups with ecologists and valuation experts in order to effectively assign points to each criterion.

Literature Cited

Al-Kaisi, M. (2000). Conservation buffers and water quality. In *Integrated Crop Management* (Vol. 13). Iowa State University Extension and Outreach.

Carolina Solar Services. (n.d.). Livestock Services. Retrieved from http://carolinasolar.services/services/#livestock

Canran Liu, G. N., Matt White, Andrew F. Bennett. (2018). Identifying wildlife corridors for the restoration of regional habitat connectivity: A multispecies approach and comparison of resistance surfaces. *PLoS One*. doi:10.1371/journal.pone.0206071

Center for Resource Solutions. (2017). *Green-e Framework for Renewable Energy Certification*. Retrieved from https://www.green-e.org/docs/energy/framework/Green-e%20Framework%20for%20Renewable%20Energy%20Certification.pdf

Dunbar, E. (2019). Pollinator-friendly solar energy becomes the norm in Minnesota. *MPR News*. Retrieved from https://www.mprnews.org/story/2019/06/20/pollinatorfriendly-solar-energy-becomes-the-norm-in-minnesota

Eddie Chi-man Hui, K.-h. Y., Cheuk-kin Tse. (2016). The impact of environmental management awards and certifications in property management on property price. *Facilities, 38*. Retrieved from https://www.emerald.com/insight/content/doi/10.1108/F-04-2013-0029/full/html

Environmental Protection Agency. (n.d.). Renewable Energy Certificates (RECs). Retrieved from https://www.epa.gov/greenpower/renewable-energy-certificates-recs

Erin Lieberman, J. L., David Tucker. (n.d.). *Making Renewable Energy Wildlife Friendly*. Retrieved from https://defenders.org/sites/default/files/publications/making_renewable_energy_wildlife_friendly.pdf

Farms, S. R. (n.d.). Services. Retrieved from https://www.sunraisedfarms.com/what-we-do

Federal Emergency Management Agency. (2018). Benefits of Natural Floodplains. Retrieved from https://www.fema.gov/benefits-natural-floodplains

Forest Stewardship Council. (n.d.). Certifcation. Retrieved from https://us.fsc.org/en-us/certification

Invenergy. (n.d.). What we do. Retrieved from https://invenergyllc.com/what-we-do/overview

James Gunnar Groesbeck, J. M. P. (2018). Coal with Carbon Capture and Sequestration is not as Land Use Efficient as Solar Photovoltaic Technology for Climate Neutral Electricity Production. *Science Report, 8*. doi:https://doi.org/10.1038/s41598-018-31505-3

Jordan Macknick, B. B., Graham Hill. (2013). *Overview of Opportunities for Co-Location of Solar Energy Technologies and Vegetation*. Retrieved from https://www.nrel.gov/docs/fy14osti/60240.pdf

Jordan Macknick, C. L., Gail Mosey, and Jenny Melius. (2013). *Solar Development on Contaminated and Disturbed Lands*. Retrieved from https://www.nrel.gov/docs/fy14osti/58485.pdf

Jordan Macknick, L. C., and Rob Davis. (2017). Co-Location of Solar and Agriculture: Benefits and Tradeoffs of Low-Impact Solar Development.

Karaim, R. (2019). Co-ops and Native Nations, 'A Join Effort'. Retrieved from https://www.cooperative.com/remagazine/articles/Pages/electric-co-ops-native-american-nations.aspx

National Renewable Energy Laboratory. (2019). Annual Technology Baseline: Electricity. Retrieved from https://atb.nrel.gov/electricity/2019/

Maryam Arbabzadeh, R. S., Jeremiah X. Johsnon, Gregory A. Keoleian. (2019). The role of energy storage in deep decarbonization of electricity production. *Nature Communications, 10*. doi:https://doi.org/10.1038/s41467-019-11161-5

Meeks, M. (2018). 'It Sort of Exploded': the Rapid Rise of Solar Energy in North Carolina. *The Daily Tar Heel*. Retrieved from https://www.dailytarheel.com/article/2018/09/solar-energy-0831

Michaja Pehl, A. A., Florian Humpenöder, Alexander Popp, Edgar G. Hertwich, Gunnar Luderer. (2017). Understanding future emissions from low-carbon power systems by integration of life-cycle assessment and integrated energy modelling. *Nature Energy, 2*, 939-945. doi:https://doi.org/10.1038/s41560-017-0032-9

Misbrener, K. (2017). Solar Arrays Abuzz Thanks to New Pollinator-Friendly Vegetation Initiative. *Solar Power World*. Retrieved from https://www.solarpowerworldonline.com/2017/05/pollinator-friendly-solar-vegetation/

Misbrener, K. (2019). Pine Gate Renewables and The Nature Conservancy Test Wildlife-Permeable Fencing for Solar Plants. *Solar Power World*. Retrieved from

https://www.solarpowerworldonline.com/2019/02/pine-gate-renewables-the-nature-conservancy-wildlife-permeable-fencing/

Morgan Lyons, A. P. (2019). Solar Industry Releases New Diversity and Inclusion Reports With a #DiversityChallenge for Energy Organizations. Retrieved from https://www.seia.org/news/solar-industry-releases-new-diversity-and-inclusion-reports-diversitychallenge-energy

South Carolina Habitat Act, (2018).

Permits, New York State Department of the Environment. (n.d.). *Question 1 - Impact on Land - Full EAF*. Retrieved from https://www.dec.ny.gov/permits/91709.html

Peters, A. (2018). This new solar farm combines clean energy and beehives. *Fast Company*. Retrieved from https://www.fastcompany.com/40588875/this-new-solar-farm-combines-clean-energy-and-beehives

R.R. Hernandez, S. B. E., M.L. Murphy-Mariscal, F.T. Maestre, M. Travassoli, E.B. Allen, C.W. Barrows, J. Belnap, R. Ochoa-Huesco, S. Ravi, M.F. Allen. (2013). Environmental impacts of utility-scale solar energy. *Renewable and Sustainable Energy Reviews, 29*, 766-779. doi:https://doi.org/10.1016/j.rser.2013.08.041

Robin Aldina, D. P., Brian Seo, Lauren Masatsugu, Samantha Childress, Matilda Odera. (2017). *North Carolina Solar and Agriculture*. Retrieved from climateforward.org/program/program-and-project-forms/

Rosa, M. (2016). Looking Back: LEED History. Retrieved from https://www.sigearth.com/leed-history/

Silicon Ranch. (2019). Silicon Ranch Launches Regenerative Energy™. Retrieved from https://www.siliconranch.com/silicon-ranch-launches-regenerative-energy/

Solar Energy Industries Association. (2019). North Carolina Solar. Retrieved from https://www.seia.org/state-solar-policy/north-carolina-solar

SolSmart. (n.d.). What is SolSmart. Retrieved from https://solsmart.org/how-we-help/what-is-solsmart/

Southern Environmental Law Center. (2017a). *The Environmental Review of Solar Farms in the Southeast U.S*. Retrieved from https://www.southernenvironment.org/uploads/audio/Solar_EnvReviewProcess_SitingSolar_Final.pdf

Southern Environmental Law Center. (2017b). New report shines light on sustainable solar farm development in the Southeast. Retrieved from

https://www.southernenvironment.org/news-and-press/news-feed/new-report-shines-light-on-sustainable-solar-farm-development-in-the-southe

Sun Tribe. (n.d.). About. Retrieved from https://suntribesolar.com/about/

Terry, G. (2020). *State Pollinator-Friendly Solar Initiatives*. Retrieved from Clean Energy States Alliance: https://www.cesa.org/

The Nature Conservancy. (n.d.). Terrestrial Resilience Core Concepts. Retrieved from http://maps.tnc.org/resilientland/coreConcepts.html
assets/State-Pollinator-Friendly-Solar-Initiatives.pdf

U.S. Green Building Council. (2019). Recertification Guidance for LEED Buildings. Retrieved from https://www.usgbc.org/resources/recertification-guidance-leed-buildings

U.S Green Building Council. (n.d.). About LEED. Retrieved from https://www.usgbc.org/press/about-leed

Interview Citations

For confidentiality reasons, we cannot release the majority of the names or the organizations affiliated with our interviewees. As a result citations are formatted as follows (date of conversation, title of interviewee, organization type). Citations are ordered by date.

September 2019. Liz Kalies. Director of Science. The Nature Conservancy (NC).

9 October. 2019. Policy Associate, Ecosystem Services. Nicholas Institute for Environmental Policy Solutions.

10 October. 2019. Forest Director. Duke University.

13 October. 2019. Senior Manager, Business Development. U.S. Independent Renewable Development Company.

14 October. 2019. Principal. NC Solar Site Development Company.

21 October. 2019. Solar Facility Horticulturist. U.S. Solar Development Company.

22 October. 2019. Solar Maintenance Specialist. U.S. Solar Development Company.

23 October. 2019. Former Auditor. SCS Global Services.

24 October. 2019. Site Operations Manager. U.S. Solar Development Company.

24 October. 2019. Solar Design Expert. U.S. Solar Development Company.

27 October 2019. Solar Project Engineer. U.S. Solar Development Company.

28 October 2019. LEED Accredited Professional. Duke University

11 February 2020. Labor Standard Expert. Labor Union.

Appendices

Appendix 1. NatureWatt Guidebook

NatureWatt: A Guide to Environmentally & Socially Responsible Solar Development

SECTION 1: SITING

SITING PRINCIPLE 1: CONSIDER NATIVE BIODIVERSITY IN SITING

This facility shall seek to avoid siting on areas which contain "high levels of native biodiversity and high-quality natural communities" as described by TNC's Principles of Solar Siting & Design (TNC, 2019).

Intent: By avoiding areas with "high levels of native biodiversity and high-quality natural communities" (TNC, 2019), the solar facility will aim to minimize impacts to sensitive environmental resources and other critical areas. These resources are ones which provide ecosystem services and support climate change adaptation and resilience. Impairing these natural assets will be avoided through compliance with this principle.

Resources:

- "Best Practices in Responsible Land Use for Improving Biodiversity at a Utility-Scale Solar Facility"
- "Renewables Siting Guide"
- "TNC Principles"
- "Solar energy development impacts on land cover change and protected areas"

C1.1.1: The facility shall not be located in a Resilient Area.

Intent: Resilient Areas are defined by TNC as those which "contain high levels of landscape diversity and local connectedness that increase resilience to climate change. These areas are likely to have the highest levels of species biodiversity now and in the future and should remain undeveloped." It is also not recommended to relocate impacted species from a solar site to other habitat due to low success rate in mitigating biodiversity loss (TNC, 2019). As such, these areas should avoid development.

Guidance: The site should not overlap with a Resilient Area identified by the "NC Solar Siting Webmap".

Measurement tools:

- For North Carolina and Southeast only: NC Solar Siting Webmap
- Potential measurement tool for outside of Southeast: Resilient Land Mapping Tool

Costs and benefits to consider:

Potential Costs	Potential Benefits
Lost electricity generation potential from avoiding Resilient Areas	Economic value provided by the ecosystem services produced in Resilient Areas
Lost revenue associated with the electricity generation potential of Resilient Areas	
Depriving a given area of clean energy access	

C1.1.2: The facility shall not be located in a climate corridor.

Intent: Climate corridors are defined by TNC as areas that are likely to be used by wildlife for periodic or seasonal movement (TNC, 2019). In addition, they encompass areas that wildlife may move toward in response to climate change. Developing in climate corridors can inhibit important wildlife movement now and as climate change progresses. This criteria aims to minimize the impact of solar development on important wildlife movement.

Guidance: The site should not overlap with a Climate Corridor identified by the "NC Solar Siting Webmap".

Measurement tools:

- For North Carolina and Southeast only: "NC Solar Siting Webmap"
- Potential measurement tool for outside of Southeast: "Resilient Land Mapping Tool"

Costs and benefits to consider:

Potential Costs	Potential Benefits
Lost electricity generation potential from avoiding Climate Corridors	Economic value of the ecosystem services provided by wildlife using climate corridors
Lost revenue associated with the electricity generation potential of Climate Corridors	
Depriving a given area of clean energy access	

C1.1.3: The facility shall avoid siting on land where clear-cutting of trees has been conducted within recent years.

Intent: This criterion aims to preserve forested areas which serve as critical wildlife habitat and migration corridors or are significant carbon sinks and provide climate change resiliency.

Guidance: Avoid siting on land where clear-cutting of trees has been conducted within the last 3 years. Point deduction ranges as follows:

- 15 - 25 percent of tree cover removed = X points lost
- 26 - 50 percent of tree cover removed
- 51 - 75 percent of tree cover removed
- 76 - 100 percent of tree cover removed

Measurement Tools: "Global Forest Change Tree Cover Loss", it also includes natural causes of tree cover loss so this is a limitation to consider. It also does not specify the magnitude of tree cover loss. A more accurate remote sensing tool needs to be developed. In addition, land owners know when the last timbering has occurred on their land.

Costs and benefits to consider:

Potential Costs	Potential Benefits
Lost electricity generation potential from avoiding land that has experienced clear-cutting in recent years	Economic value of the ecosystem services provided by species supported by contiguous forest land
Lost revenue associated with the electricity generation potential of land that has experienced clear-cutting in recent years	
Depriving a given area of clean energy access	

C1.1.4: The facility will be penalized for the clear-cutting of trees to build the solar facility.

Intent: This criterion aims to preserve forested areas which serve as critical wildlife habitat and migration corridors or are significant carbon sinks and provide climate change resiliency.

Guidance: This criterion is an alternative to the above. The facility shall hire a forester to estimate the square footage of forest within the parcel per acre. Once the square footage of basal area is calculated, the square footage of trees removed will be divided by total square footage of basal area to result in a percentage of basal area removed. Point deduction ranges as follows:

- 15 - 25 percent of basal area removed = X points lost
- 26 - 50 percent of basal area removed
- 51 - 75 percent of basal area removed
- 76 - 100 percent of basal are removed

A portion of points can be earned back if the facility demonstrates that the removed trees will be put to reuse (e.g. sold to be constructed into furniture) thereby avoiding the release of the stored carbon.

Measurement Tools:

- A hired forester shall measure a plot per acre with a ten-factor prism to calculate the average basal area per acre. By multiplying the sqft of basal area per acre by the acreage of the site, the total amount of sq ft of basal area is calculated. This is also known as performing a timber cruise.
- Cheaper but less accurate alternative: Use I-Tree tools to calculate basal area within user-selected areas.

Limitations: The measurement of basal area does not account for age of the tree, the amount of carbon sequestration, nor size/height of the tree.

Costs and benefits to consider:

Potential Costs	Potential Benefits
Lost electricity generation potential from avoiding contiguous forest land	Economic value of the ecosystem services provided by species supported by contiguous forest land
Lost revenue associated with the electricity generation potential of contiguous forest land	
Price of hiring a professional forester	
Depriving a given area of clean energy access	

C1.1.5: The facility shall be placed where load demand is highest.

Intent: This criterion aims to mitigate the aimless placing of solar sites where additional infrastructure would be required to be built. It aims to serve areas that have increasing loads and places energy services where they are most demanded.

Measurement Tools: Population density (population per square mile) of the community to be receiving the electricity is maximized near the facility: "World Population Review".

Costs and benefits to consider:

Potential Costs	Potential Benefits
Potentially difficult to find undeveloped land	Increased acceptance of solar as it is directly

near the increased load	serving a community with high energy demand
Depriving a given area of clean energy access	

C1.1.6: The facility shall not be located in a 100-year floodplain.

Intent: This criterion aims to avoid the potential negative consequences associated with development in floodplains such as high insurance fees, damage to equipment, erosion, and ruining the ecological role of a floodplain. A floodplain that is classified as a 100-year floodplain has a 1 percent probability of flooding in a given year.

Guidance: The developer shall use the following resources to pursue land that falls outside of floodplains. The Federal Emergency Management Agency has created a National Flood Hazard Layer that can be employed in Google Earth Pro for easy identification of floodplains on a national level. (If you do site in a 100-year flood plain then you will lose x points).

Measurement Tools:

- "National Flood Layer Web Map Service": This provides the display of flood zones and labels as well as floodways and other protected areas. This application can be used for free in Google Earth. This provides national data. The user must use the most updated version, FEMA NFHL v3.2 kmz file.
- "North Carolina Solar Siting for Climate Resilience": This provides a map of active river areas in North Carolina. It defines the natural range of variability that are present in waterways.

Costs and Benefits to Consider:

Potential Costs	Potential Benefits
Typically floodplains are flat; therefore, one is losing potentially easy-to-develop land	By avoiding floodplains, you protect equipment from the potential damage that could be caused by floating debris during floods
Depriving a given area of clean energy access	Ensures resilience and reliability during extreme weather events by avoiding siting in a floodplain
Lost electricity generation potential from avoiding floodplains	Protects the ecological function of a floodplain
Lost revenue associated with the electricity generation potential of floodplains	Avoiding the costs of elevated equipment

C1.1.7: If the facility is located in a 500-year floodplain, guidelines must be followed as to not jeopardize environmental health and the reliability of the energy source.

Intent: This criterion acknowledges that floodplains due to their extensive size and flat nature can be ideal for solar array installation. This criterion aims to mitigate the risk associated with installing solar in a 500-year floodplain.

Guidance: Siting in a 500-year floodplain is an automatic x point reduction. The following practices can be executed in order to gain points back:

- Elevate the following at least 1 foot above the 500-year water surface elevation (+x pts)
    - Electrical service equipment
    - Inverter skid platforms
    - All other permanent structures (PV panels, etc.)
    - Temporary structures such as construction trailers
- Embedment of columns supporting the PV poles must be strong enough to withstand a 500-year flood event (+x pts)
- If risk of severe erosion due to a flood is present, structural improvements of the site must be constructed (+x pts)
- Fencing that allows the flow-through of the flood is installed (+x pts)

Measurement tools:

- National Flood Layer Web Map Service: This provides the display of flood zones and labels as well as floodways and other protected areas. This application can be used for free in Google Earth. This provides national data. The user must use the most updated version, FEMA NFHL v3.2 kmz file.
- North Carolina Solar Siting for Climate Resilience: This provides a map of active river areas in North Carolina. It defines the natural range of variability that are present in waterways.

C1.1.8: The facility shall be located in a place with a maximum slope of no greater than 10 percent, thus avoiding significant grading of the land.

Intent: Siting on steeply sloped land requires extensive grading for typical development practices. If grading is not avoided, it can increase erosion, sedimentation, and runoff which can jeopardize water quality.

Guidance: Land is inherently not completely level, and it will be difficult to avoid grading at all. The purpose of this criterion is to avoid *extensive* grading. The developer with use the measurement tools below to evaluate the slope of potential site parcels. The developer should seek out land with a slope no greater than 10 percent.

Applicability and Exceptions:

- If the developer chooses to site on sloped land and does not grade the land, then this criterion may be omitted.
- If the sloped land is south-facing, grading can be avoided as a south-facing slope would maximize solar production.

Measurement Tools:

- USGS Topographic Maps: Can be easily viewed on Google Earth Pro to have a rough estimate of slope.
- Google Earth Pro Natural Elevation Tool: Draw multiple lines across the parcel to understand the variance of elevation and identify slope of the land

Costs and Benefits to Consider:

Potential Costs	Potential Benefits
Losing money by not grading land, resulting in fewer panels placed	Saving money through the avoidance of grading land
Depriving a given area of clean energy access	
Lost electricity generation potential from avoiding sloped land	
Lost revenue associated with the electricity generation potential of sloped land	

SITING PRINCIPLE 2: SITE IN MARGINAL LANDS & CO-LOCATE IN AREAS OF EXISTING LAND-USE ACTIVITIES
C1.2.1 This facility shall maximize the use of disturbed or contaminated lands OR be sited in conjunction with existing land uses and infrastructure.

Intent: This principle aims to use the potential of contaminated and disturbed lands to host utility-scale solar power. Developing on contaminated and disturbed lands can create jobs and revitalize local economies (NREL, 2013). In addition, selecting contaminated and disturbed lands over greenfield sites can have advantages when it comes to permitting and environmental mitigation.

The principle also aims to maximize siting of solar facilities on land that is already being used for other activities, such as on-going farming operations. Through increased land-use efficiency, development impacts will be reduced.

Guidance: one or more of the following can be implemented to comply with this principle:

- Siting on environmentally contaminated land, including: superfund sites, Resource Conservation and Recovery Act sites, brownfields, abandoned mine lands, and closed landfills (NREL, 2013).
    - Measurement tools:

    - Superfund sites
    - RCRA corrective sites
    - Brownfields
    - Abandoned metal mines
    - Abandoned coal mines
    - National Mine Map Repository
    - EPA RE-Powering Mapper: "EPA's RE-Powering Mapper is an online interactive web application, that allows users to visualize key information on renewable energy potential at specific contaminated lands, landfills and mine sites."
- Costs and benefits to consider

Potential Costs	Potential Benefits
Site remediation if necessary	Job creation
Cost of increased safety measures that need to be taken on certain contaminated sites	Environmental benefits from facilitating the clean-up of a site
Cost of potential liability issues associated with developing on certain contaminated lands	Decreased Levelized Cost of Electricity (EPA, 2018)
Transaction costs associated with developing on contaminated lands	"Additional land lease revenue to the town or city site owner" (EPA, 2018)
Cost of stakeholder engagement	"Increased tax payments for the land and/or renewable energy systems to the local municipality and/or state" (EPA, 2018) = increased property value
Cost of additional machinery required for contaminated land development	Use of local businesses to help construct the project
Cost of removing existing infrastructure that can't be reused	Often have existing infrastructure onsite that can potentially be re-utilized
Cost of more complex permitting, tests, and inspection processes	Often located nearby existing utility infrastructure and roads → lessens the need to develop new transmission infrastructure
Extended project development timeline	If co-location of PV and agriculture, then the site can be returned to cultivation after the decommissioning of the solar facility

- Siting on disturbed lands.

- Guidance: According to the USGS, disturbed lands as those lands that are in an altered and non-vegetative state due to disturbances (NREL, 2019). Disturbances can be caused by human activity (e.g. clearing trees) or by natural means (e.g. wind, fire, etc.).
- Examples of disturbed lands (NREL, 2019):
    - Barren lands
    - Invasive species-impacted lands
    - Recently burned lands
    - Gravel pits
- Measurement tools:
    - Potential tool for tracking invasive species-impacted land
    - This USGS land cover map includes recently disturbed lands:
    - Map that contains barren lands
    - Map that classifies soil types and whether or not they are suitable for agriculture
    - A spatial tool should be developed that maps out disturbed lands suitable for solar development
- Costs and benefits to consider:

Potential Costs	Potential Benefits
Cost of controlling invasive species if developed on invasive species-impacted lands	Decreased development pressure on agricultural lands and open space
Cost of extra machinery needed for developing on certain land cover types	Increased property value
	Potential for decreased site preparation costs, land acquisition costs, permitting costs, and weed control costs

- Siting in conjunction with existing land uses, such as: ongoing farming operations, parking lots, existing energy projects, and warehouses.
    - Measurement tools:
        - PVMapper, Google Maps, or other spatial siting tools used by most solar developers
- Costs and benefits to consider:

Potential Costs	Potential Benefits
Cost of more strategic planning process required	Decreased O&M costs if sited in conjunction with agricultural operations
Cost of liability insurance	Increased agricultural productivity and financial benefits to landowners

In the case of co-location with agricultural operation, increased cost of connection and placing infrastructure where it optimally needs to be	Reduction in site preparation costs, expedited permitting process, reduction in installation costs, reduction in environmental mitigation investments
Increased cost of safety / legal processes if co-locating with agricultural operation	Increased solar energy production from cooler air environment created under panels in the case of agricultural co-location (NREL, 2017)
Grazing by cows can damage a solar farm	vegetation underneath and around solar panels → reduced the levels of dust and soiling on panels" (NREL, 2017)
Solar generates more value than agricultural crops in most cases so more valuable to just develop that cropland	Increased property value
More expensive decommissioning plan	
Potential need to elevate panels, especially for agrivoltaics	

*note: very mixed research findings on benefits and costs of co-location with agricultural land
Resources:

- "NREL Solar Development on Contaminated and Disturbed Lands"
- "EPA Handbook on siting renewable energy projects while addressing environmental issues"
- "The Environmental Review Of Solar Farms In The Southeast U.S."
- "Building Solar Projects on Brownfields Is Hard Work. But There's Massive Upside to Getting It Right"
- "Siting Renewable Energy on Contaminated Land and Mining Sites"
- "Co-Location of Solar and Agriculture: Benefits and Tradeoffs of Low-Impact Solar Development"
- "Overview of Opportunities for Co-Location of Solar Energy Technologies and Vegetation"

SITING PRINCIPLE 3: ENGAGE ENVIRONMENTAL AND WILDLIFE AGENCIES
C1.3.1 The facility shall partner or consult with environmental and /or wildlife agencies to inform protection of wildlife species and the surrounding natural communities.

Intent: Through creating partnerships and consulting with environmental and wildlife agencies early-on in the development process, developers will receive expert insight into how they can minimize environmental impact. In addition, this can smooth out environmental review procedures.

Measurement tools: were consultation or partnerships created with any of the following agencies throughout the development process?

- U.S. FWS
- U.S. EPA
- U.S. DOE
- National Marine Fisheries Service,
- BLM
- State soil conservation commissions
- local permit issuing authorities
- State DEQ

Costs and benefits to consider:

Potential Costs	Potential Benefits
Cost of consultation	Smoother environmental permitting process due to knowledge gained during consultations
Search cost (e.g. time spent researching & looking for consultation stakeholders)	
Time spent consulting	

SECTION 2: DESIGN

DESIGN PRINCIPLE 1: PRESERVE WILDLIFE CONNECTIVITY
This facility shall allow for wildlife connectivity to protect wildlife movement patterns

Intent: This principle aims to avoid habitat fragmentation, which impairs wildlife movement. Habitat fragmentation greatly hinders wildlifes' ability to locate food, shelter and mates (TNC, 2019). As a result, it can lead to biodiversity loss (TNC, 2019). Through avoiding habitat fragmentation and providing wildlife connectivity, the developer will minimize impact to wildlife movement.

C2.1.1: The facility shall be equipped with wildlife-friendly fencing or wildlife passages.

Intent: This criterion aims to enable wildlife to move to adjacent habitat when disrupted by the solar facility, and improve wildlife connectivity.

Guidance: Utilize fencing that allows small-to-medium sized animals to pass through. Alternatively wildlife passageways can be provided using HDPE pipe.

Measurement tool: Provide proof of purchase of wildlife fencing or photographic evidence (drone footage) that wildlife fencing has been installed.

Costs and benefits to consider:

Potential costs:	Potential benefits:
Cost of fencing higher than traditional fencing	Ecosystem services provided by wildlife when left undisturbed
Cost of potential damage to farm due to wildlife activity	
Cost of lower level of security when compared to traditional fencing	

C2.1.2: The facility shall include unfenced wildlife passageways throughout the solar facility.

Intent: This criterion is the optimal method for allowing movement of species of different sizes.

Guidance: Wildlife passageways should be included throughout the solar facility blueprint. A few key points should be considered when retaining unfenced wildlife passageways:

- Design of passageways should be species specific
- Design of passageways should consider the type of movement of the species in consideration (daily home range, dispersal movements, seasonal migration, shifts due to climate change, etc.)
- The shorter & wider the passageway, the better
- Landscape positioning should be considered (e.g. are you connecting the same types of habitat or a diversity of habitats?)
- Habitat quality within the corridor should be considered (e.g. vegetation, habitat features, etc.)

Measurement tool: The blueprint of the solar facility must contain a wildlife passageway design

Costs and benefits to consider:

Potential costs:	Potential benefits:
Lost electricity production from leaving part of site undeveloped and associated profit loss	Ecosystem services provided by wildlife when left undisturbed

Resources:

- "Identifying wildlife corridors for the restoration of regional habitat connectivity"

DESIGN PRINCIPLE 2: PRESERVE WATER QUALITY & AVOID EROSION

This facility shall seek to protect water quality and minimize erosion.

Intent: This principle aims to protect and minimize the impact on the function of wetlands and other resources that provide natural water management services. In addition, it aims to minimize erosion impacts from stormwater run-off and the construction phase.

Resources:

- "Stormwater design manual"
- "5 Factors That Complicate Erosion Control on Solar Farms"
- "DOE Environmental Assessments"

C2.2.1: The facility shall provide a 100-foot buffer on perennial streams, and a 50-foot buffer on intermittent streams and jurisdictional wetlands, as recommended by the North Carolina Wildlife Resource Commission (TNC, 2019).

Intent: A buffer helps mitigate the amount of pollution that can reach a body of water, thus mitigating the negative impact on water quality.

Guidance: The facility must abide by the guidelines for sediment and erosion control developed by the NC Department of Environmental Quality. The facility may use the state specific guidelines only if they meet or exceed the NC DEQ guidelines.

Applicability: If no perennial streams, intermittent streams or wetlands exist on the property, this criterion can be omitted. However, it is encouraged to consider water features wetlands, or vegetative buffers as supplemental habitat.

Measurement Tools:

- "NC DEQ Erosion and Sediment Control Planning and Design Manual"

Cost and Benefits to Consider:

Potential Costs	Potential Benefits
Buffers limit the size of the solar array resulting in a decrease in earning potential	Buffers create habitat for small wildlife, and maintain water quality by filtering out chemicals

C2.2.2: The facility shall take special care to protect wetlands both on-site and off-site.

Intent: Wetlands serve vital ecological functions; therefore, measures beyond allowing for a buffer should be taken to preserve these functions.

Guidance: The facility shall take part in one or more of the following.

- Minimize soil disturbance and erosion near wetland areas by avoiding the removal of vegetation within 10ft of wetlands (+x pts)
- Prevent debris from logging to enter the wetland by storing the debris at least 200 ft from wetland site (+x pts)
- Maintain the natural wetland by avoiding degradation caused by construction that is closer than 200ft (+x pts)

Measurement Tools:

- Photographic evidence, such as drone footage, is required to receive points for this criterion

Potential Costs	Potential Benefits
Limiting the size of the solar array resulting in less profit	Providing ecosystem service for those interested in observing wildlife
Extended construction time due to specialized care and procedures	Protecting on-site water quality positively impacts off-site water resources for surrounding communities and the watershed as a whole

DESIGN PRINCIPLE 3: PROTECT NATIVE VEGETATION AND POLLINATOR HABITAT (this entire principle is based on the TNC pollinator scorecard and the NC Pollinator Conservation Alliance guide)

C2.3.1: This facility shall seek to restore native vegetation and grasslands to support pollinators.

Intent: This principle aims to leverage the potential of solar facilities to produce net wildlife habitat benefits through the restoration of native vegetation. The planting of native vegetation instead of turf grass will increase biodiversity, provide pollinator habitat, reduce the need for mowing and herbicide use, mitigate erosion and stormwater runoff, increase soil health, and sequester carbon (TNC, 2019).

Guidance: In order to comply with this principle, the facility must meet pollinator standards as deemed by the North Carolina Solar Site Pollinator Habitat Planning and Assessment. This means that a minimum score of x must be obtained on the following scorecard:

Resources:
- "NC Solar Technical Guidance"
- TNC Pollinator Habitat Scorecard

North Carolina Solar Site Pollinator Habitat Planning and Assessment created by NC TNC & NC Pollinator Conservation Alliance:

1. **Planned Native Flowering Plant Diversity in Buffer Areas (species with more than 1% cover)**
- 5-10 flowering species +x pts
- 10-15 flowering species +x pts
- 16-20 flowering species +x pts
- >20 flowering species +x pts

2. **Planned Native Grass Diversity in Buffer Areas**
- 2 species +x pts
- 3 or more species +x pts

3. **Planned Native (or Naturalized) Plant Diversity in Rows and Under Solar Array***
- 1-3 species +x pts
- 4-6 species +x pts
- More than 7 species +x pts

4. **Planned Percent of Site Dominated by Native Plant Species****
- 0-10% +x pts
- 11- 40 % + x pts
- 41-70 % + x pts
- More than 70% + x pts

5. **Seasons with at Least Three Blooming Species Present (check all that apply)**
- Spring (March-May) +x pts
- Summer (June-August) +x pts
- Fall (September-November) +x pts

6. **Site Preparation Prior to Implementation**
- Measures taken to control weeds prior to seeding +x pts
- None -x pts

7. **Observed Habitat Components Within 0.25 Miles (check all that apply)**
- Native bunch grass for bee nesting +x pts
- Native trees/shrubs for bee nesting +x pts
- Clean, perennial water sources +x pts
- Created nesting habitat features +x pts

(please see NC Technical Guidance for Native Plantings on Solar Sites)

8. **Site Planning and Management (check all that apply)**
- Detailed establishment and management plan +x pts
- Mowing occurs only after August 15,

and before spring each year +x pts
- Signage legible at forty or more feet stating pollinator-friendly solar habitat +x pts

9. Insecticide Risk
- Planned on-site use of insecticide or pre-planting seed/plant treatment (excluding buildings/electrical boxes, etc) -x pts
- Communication/registration with local chemical applicators or on www.fieldwatch.com to prevent drift +x pts

TOTAL POINTS: _____

Provides Exceptional Habitat: x and higher
Meets Pollinator Standards: x – x

* For the array seeding, these can be a short-stature wildflower mix or clovers and other non-native, naturalized species beneficial to pollinators. If clovers are used, these should be seeded in locations separate from the native wildflowers in the perimeter/buffer locations.

**Measurements of percent cover should be based on the percent of the ground surface covered by foliage as viewed from above. To measure cover diversity, it is recommended to use plots, and/or transects for accurate measurements.

Measurement Tool: Achieving a score of x or higher on the Pollinator Scorecard

Costs and benefits to consider:

Potential Costs	Potential Benefits
Cost of native vegetation seed mixes is more expensive than turf	Increased agricultural yield due to increased pollinator activity where nearby farming operations are present
Longer germination period so cannot use for DEQ soil stabilization control	In the long-run, reduced O&M costs due to less mowing needed (reduced small off-road engine use)
Lack of distributors for native vegetation that grows to less than 18-24 inches	Reduced herbicide use in the long-run
Increased maintenance cost until germination	Rainwater infiltration and pollutant removal, helpful for downstream water quality

Height constraints	Creation of pollinator habitat
	Insulation / reduce risk of frost heave and also reduced need for dust suppression

DESIGN PRINCIPLE 4: PROTECT WILDLIFE HABITAT
C2.4.1: The facility shall seek to protect, restore, and provide supplemented wildlife habitat that is directly impacted by solar development.

Intent: This principle aims to protect and restore on-site wildlife habitat features that will "encourage native species to use and live near or on the site" (TNC, 2019).

Resources:
- "Impact of solar energy on wildlife"
- "Utility-scale solar & wildlife stewardship"
- "Making renewable energy wildlife friendly"

1. **Measure to Protect Wildlife Habitat**
- Preserve on-site wetland features +x pts
- Protect existing burrows on-site +x pts
2. **Restore Natural Habitat that Was Damaged During Construction**
- Plant native vegetation as a buffer near the property edge +x pts
- Create an on-site wetland from a retention pond +x pts
3. **Provide Supplemental Habitat Features to Replace Features**
- Provide bird perches for predatory birds +x pts
- Provide down wood on site for small mammal foraging +x pts
- Include nesting bird boxes +x pts
- Include bat boxes +x pts
- Include bee nesting boxes +x pts
4. **Planned Native Hedgerow/Screening Area**
- At least 50% of hedgerow/screen will be planted with flowering plant species +x pts
- At least 50% of hedgerow/screen will be planted with native plant species +x pts
- Hedgerow/screen will be a minimum of 30 ft wide +x pts

Costs and benefits to consider:

Potential Costs	Potential Benefits
Fewer solar panels due to buffers and potential habitat preservation results in less revenue	Increased aesthetics of site leads to less community gripes
Expenses associated with supplemental wildlife accessories	Ecosystem service provided of bird watching to local community
	Positive reputation created through caring about

	wildlife well-being

DESIGN PRINCIPLE 5: CO-OPTIMIZATION OF SOLAR FACILITIES

Intent: The goal of this principle is to promote the innovative dual use of land while minimizing competition for land. In addition, it is an opportunity to demonstrate how solar facilities can provide more than just energy. There are multiple ways to achieve this, including but not limited to:

- Support local bee populations and beekeeper livelihood through the creation of a solar apiary.
    - Intent: Provide affordable space for a beekeeper to care for the hives that in turn pollinate native vegetation within the site and surrounding agricultural farms(link).
    - Measurement tool: provide documentation that illustrates how a solar apiary will be implemented into the project.
- Allow for Co-Location of Energy Technology and Agriculture "solar sharing" "agrivoltaics"
    - Intent: Support local economy by allowing local farmers or other interested parties to pay a small fee to grow certain crops in unused spaces that do not interfere with energy generation.
    - Crop Ideas:
        - Mushroom farming below panels: Elevated panels create shade below the panels which create a suitable environment for fungi growing
        - Panels protect the plants from frost. This can increase the growing season for various veggies, including avocados, cilantro, peppers, tomatoes and mangos (Jossi, 2018)
        - Salsa garden of cilantro, tomatoes, and pepper → used only half the water of those growing out in the open and grew well in the environment beneath the panels (Jossi, 2018)
        - Leafy greens like lettuces, chards, and kale → researchers found that basil plants produce larger leaves, kale leaves are longer and wider, and chard leaves are larger (Ecological Society of America, 2019)
        - Herbs and spices that grow well in the shade of panels
    - Measurement tool: Provide documentation that illustrates how agrivoltaics will be incorporated into the solar project or provide photographic evidence of agrivoltaics in solar facility footprint (drone footage).
- Support the local livestock population by allowing sheep or other small livestock to graze instead of mowing
    - Intent: Pasture grazing allows for improved animal health and well-being, as grazed forage possesses higher nutritional quality than hay products. Grazing also improves the recycling of soil nutrients and helps to maintain healthy soil. In

addition, paying a low cost to the keeper of the livestock to bring their animals to the site helps support the farmer financially.
    - Measurement tool: Provide written contract with a livestock keeper(s) or photographic evidence of livestock grazing (drone footage).
- Allow interested parties to pay a small fee to plant fruit trees along the perimeter of the installation in order to create a community-owned garden.
    - Intent: The facility will be seen as a source of energy generation, but also as a source of nourishment.
    - Measurement tool: Provide documentation that illustrates how a community garden will be incorporated into the solar project or photographic evidence of the community garden (drone footage).
- Utilize the solar lease as a way to preserve productive land so that it can be returned to other productive uses, such as crop cultivation, once the system is decommissioned and removed.
    - Intent: Since solar facilities are temporary, apply best operation and maintenance practices, along with a robust decommissioning plan will aim to ensure that land can be returned to other productive uses after decommissioning.
    - Measurement tool: Provide decommissioning plan describing how the land will be left in better condition than its original state.
- Create an outdoor amenity, such as a shaded gathering place or outdoor workspace, through the construction of a solar canopy.
    - Intent: promote the multi-use of utility-scale solar installations and educate users about solar energy.
    - Measurement tool: Provide documentation that illustrates how a solar canopy will be incorporated into the solar project or photographic evidence of the solar canopy (drone footage).
- Propose your own co-optimization innovation project by submitting your idea to NatureWatt

SECTION 3: SOCIAL IMPACT

SOCIAL IMPACT PRINCIPLE 1: PROMOTE DIVERSITY IN THE WORKFORCE

This solar facility shall maximize the long-term social and economic well-being of the local communities impacted by the development of the facility.

Intent: This principle addresses the need for solar developers to take into consideration the importance of diversity and inclusion in the solar industry. Its intent is to increase the representation of socioeconomically disadvantage populations across the solar industry.

Resources:
- "SolSmart Guide:
- "Solarize Guidebook"
- "Community Solar SEIA"
- "Guide to community solar"
- "Solar power and agriculture"

- "Co-location of agriculture and solar"

C3.1.1: The organizations involved in the design, development & maintenance of the facility shall work to create an all inclusive workforce that goes beyond legal compliance and good faith efforts of diversity and inclusion, and involves local community members in which the project is being developed.

Intent: This criterion emphasizes the importance of having a workforce that reflects the diversity of America and aims to engage the local community in which the solar development will impact.

Guidelines: The developer must show evidence of x or more of the following equity criteria in order to meet NatureWatt standards of certification.

- Hiring of economically disadvantaged workers
    - Intent: The organization(s) will provide employment opportunities to those who need it most and provide economic development within low-income communities.
    - Measurement Tools: 10% of positions created by the solar project will be given to low-income workers who are earning less than 80% of the Area Median Income determined by this Area Median Income Lookup Tool.
- Under-resourced Workforce Development
    - Intent: The organization(s) will help build wealth in under-resourced communities by focusing training and workforce development within those communities.
    - Measurement Tools: The organization(s) shall show documentation indicating that they have engaged in workforce training within the community, this can include:
        - Documentation demonstrating that workforce development services have been obtained from a local non-profit or organization
        - Monetary donation to a local workforce training program
        - Provision of apprenticeship/training programs registered with the Department of Labor
- Hiring of ex-offenders and providing them with continuing education services or mentoring services
    - Intent: Across different groups of socioeconomically disadvantaged members, ex-offenders are significantly less likely to be hired (Hunt et al., 2018). Hiring ex-offenders can increase their economic outcome and thus help prevent further offenses.
    - Measurement Tools: Documentation providing the presence of a program for recruiting and contracting ex-offenders OR statistic of how many ex-offenders have already been hired or contracted
- Prioritize the Hiring of Union Workers
    - Intent: Unions often ensure that their members are given liveable wages and an adequate benefits package (Philly Labor, 2013). Workers who are paid adequately are more likely to work harder. In addition, union workers are often held to a higher standard of work quality.
    - Measurement tools: Submission of contract documentation with union
- Increased Diversity and Inclusion within Workforce

    - Intent: Diversity and inclusion are essential to making the solar industry as accessible as possible, and fostering a creative and innovative workforce.
    - Measurement Tools: Either report your current employee statistics that reflect diversity and inclusion within your company or develop a strategy to increase diversity and inclusion over the next 5 years. Below are ways to satisfy this criterion:
        - Present statistics for the % of management that is from previously excluded populations &
        - Present statistics for the % of employees that are women &
        - Present statistics for the % of employees that reside in low-income communities &
        - Present statistics for the % of employees that are people with disabilities
        - Present that the percent of ethnic minorities within your company is equivalent the percent of ethnic minorities in the site owner's area
        - Present evidence that there is a company policy in place for the active recruitment of women and ethnic minorities
- Increased Local Hiring
    - Intent: The organization(s) shall make sure a certain share of local jobs that are created through construction go to local residents.
    - Measurement Tools: The organization(s) shall employ no less than 5 temporary employees for solar farm construction. If the organization(s) is contracting out construction, the contractor must show evidence of local employment.

C3.1.2: The organization(s) shall provide a livable wage and benefits for its workers and contractors.

Intent: Taking care of your employees and their families financially spurs loyalty and hard work.

Guidance: The minimum wage can sometimes fall short of meeting the requirements for a basic quality of life. A livable wage will take into consideration the cost of food, essential needs, housing, and the size of the family. Use the following tool to set a livable wage.

In addition, providing health benefits helps improve health outcomes for employees and their families. A lack of health insurance imposes a large fiscal burden on families and negatively impacts employee well-being.

Measurement Tools:
- "Living Wage Calculator MIT": This calculates the hourly rate that an individual must earn to support his or herself and their family. The organization must provide the living wage calculated for the location of the facility or higher.
- Documentation demonstrating that the organization(s) provides health insurance for its full-time employees and domestic partners of full-time employees and their dependents.

C3.1.3: The organizations involved in the design, development, and maintenance of the facility shall maximize safety standards for its workers and contractors.

Intent: To help protect the mental and physical well-being of the workforce involved in the construction, development, and maintenance of the solar facility.

Measurement tools: The organization(s) shall show documentation indicating that they have safety standards in place during each phase of design, development, and maintenance. This must include providing OSHA 10-hour training and workers compensation.

SOCIAL IMPACT PRINCIPLE 2: PROMOTE COMMUNITY EDUCATION

Intent: This principle highlights the potential of the utility-scale solar industry to be involved in raising awareness and knowledge about the benefits of renewable energy.

C3.2.1: The organizations involved in the design, development, and maintenance of the facility shall provide innovative way(s) to engage with the community and enhance community relations.

Intent: This criterion seeks to enhance and enrich the well-being of the community.

Guidance: Examples of an "innovative engagement" may include, but are not limited to the following:

1. **Promote Interest and Education of Solar Resources:** Provide capacity building opportunities to local communities through hands-on, educational experiences.

- Provide a 1-acre test plot to a local university or community college for research purposes.
    - Intent: Foster a relationship with local university or community college and inspire technical careers in renewable energy.
    - Measurement Tools: Present documentation of the correspondence and agreement of the established educational relationship with local university.
- Promote solar curriculum through the school system visits to the site for bi-annual tours.
    - Intent: Instill excitement and interest about renewable energy in the younger generations which helps to create eco-minded adults.
    - Measurement Tools: Present documentation of the correspondence and agreement of the established educational relationship with local school system.
- Organize public solar workshops (focus groups, presentations, etc.)
    - Intent: Public workshops will help provide information about solar to concerned and curious members of the public.
    - Measurement Tools: Present documentation of the correspondence and agreement upon the organization of public workshops with local community groups.
- Distribute solar job training and career opportunities in communities of development.
    - Intent: Leverage the growing renewable energy sector to develop the local solar workforce.
    - Measurement Tools: Present documentation proving solar job training, which could include class rosters, email correspondence, or photographs of the training.

SOCIAL IMPACT PRINCIPLE 3: DISTRIBUTE THE BENEFITS OF SOLAR ENERGY

Intent: This principle aims to distribute access to the benefits of solar energy across socioeconomically disadvantaged communities. In addition, it ensures that features of cultural, historical, and social importance aren't disturbed by solar energy development.

C3.3.1: The organizations involved in the design, development, and maintenance of the facility shall ensure that impacts to valued community features are minimized, and will increase local access to the solar energy produced by the facility.

- Protect scenic views.
    - Intent: Minimize the impact to scenic areas that are valued by the community.
    - Measurement Tools: Run viewshed analysis using ArcGIS Pro, or use a similar online tool such as the "Visibility Viewshed Generator" ensuring the solar farm is out of view from a specified location.
- Protect historical and cultural resources.
    - Intent: Minimize visual impacts to important historical and cultural resources and preserve character-defining features.
    - Measurement Tools: Run viewshed analysis using ArcGIS Pro, or use a similar online tool such as the "Visibility Viewshed Generator" ensuring the solar farm is out of view from a specified location.
- The solar facility to be developed will generate power for local non-profit(s) and/or community-service oriented facilities.
    - Intent: Support the efforts of local non-profits and other service oriented facilities by providing them with access to renewable energy solutions.
    - Measurement Tools: Provide documentation of the correspondence and agreement of supplying power between the developer and the local non-profit or service orientated facility.
- The facility to be developed will be a utility-scale community solar farm.
    - Intent: Provide stakeholders who aren't able to develop onsite solar with equal access to solar energy generation & its associated benefits.
- The facility to be developed will be providing electricity to rural low-income communities, such as Native American tribes, through an electric cooperative.
    - Intent: Provide communities who face energy poverty with clean, reliable access to electricity.
- The facility will be incorporated into a microgrid project
    - Intent: This can help under-resourced communities withstand power disruptions
- The facility will be a simple installation combined with battery storage
    - Intent: This can help under-resourced communities withstand power disruptions

Costs and benefits to consider:

Potential Costs	Potential Benefits
Time spent searching for local contractors and local employees	Positive reputation of working with the community
Resources and time spent educating the public	Positive PR for your company within community and promotes renewable energy as

	an industry as responsible development
Paying more than minimum wage to laborers	A higher wage leads to a more motivated workforce
Risk associated with hiring less educated workers	Economic revitalization & community development
Time and resources spent on developing and implementing equity programs	

SECTION 4: COMPLIANCE

PROVIDE PROOF OF COMPLIANCE
COMPLIANCE PRINCIPLE 1: THE FACILITY MUST BE IN COMPLIANCE WITH ALL FEDERAL, STATE, AND LOCAL LAWS GOVERNING THE SITING AND DEVELOPMENT PROCESS.

Measurement tool: The site owner must submit a compliance report on an annual basis to demonstrate that the facility is continuously obeying all federal, state, and local laws related to renewable energy assets.

Guidebook Literature Cited

Environmental Protection Agency. (2018). Learn More About RE-Powering. Retrieved from https://www.epa.gov/re-powering/learn-more-about-re-powering

Ecological Society of America. (2019). Solar panels cast shade on agriculture in a good way. *ScienceDaily*. Retrieved from https://www.sciencedaily.com/releases/2019/07/190729123751.htm

Dougherty, J. (2013). Why Hire Union Workers. Retrieved from http://phillylabor.com/why-hire-union-workers/

Jordan Macknick, C. L., Gail Mosey, and Jenny Melius. (2013). *Solar Development on Contaminated and Disturbed Lands*. Retrieved from https://www.nrel.gov/docs/fy14osti/58485.pdf

Jossi, F. (2018). Solar Farms Produce Power—and Food. *Scientific American*. Retrieved from https://www.scientificamerican.com/article/solar-farms-produce-power-and-food/

Macknick, J. (2019). *Co-Location of Agriculture and Solar: Opportunities to Improve Energy, Food, and Water Resources*. Retrieved from https://www.nrel.gov/docs/fy19osti/73696.pdf

Priscillia Hunt, R. S., Lisa Jonsson, Flavia Tsang. (2018). *Incentivizing Employers to Hire Ex-Offenders What Policies Are Most Effective?* Retrieved from https://www.rand.org/pubs/research_briefs/RB10003.html

The Nature Conservancy. (2019`). *Principles of Low Impact Solar Siting and Design*. Retrieved from https://www.conservationgateway.org/ConservationByGeography/NorthAmerica/UnitedStates/edc/Documents/ED_TNCNCPrinciplesofSolarSitingandDesignJan2019.pdf

Appendix 2. NatureWatt Case Studies

This section presents the results of two case studies to demonstrate in practice how to assess compliance with the siting and design principles of NatureWatt. The case studies look in detail at two solar facilities located in North Carolina. We were able to visit the first site in person to apply the guidebook. However, the guidebook was applied virtually to the second site.

Site 1
Size: 5 MW, 40 acres
Location: North Carolina

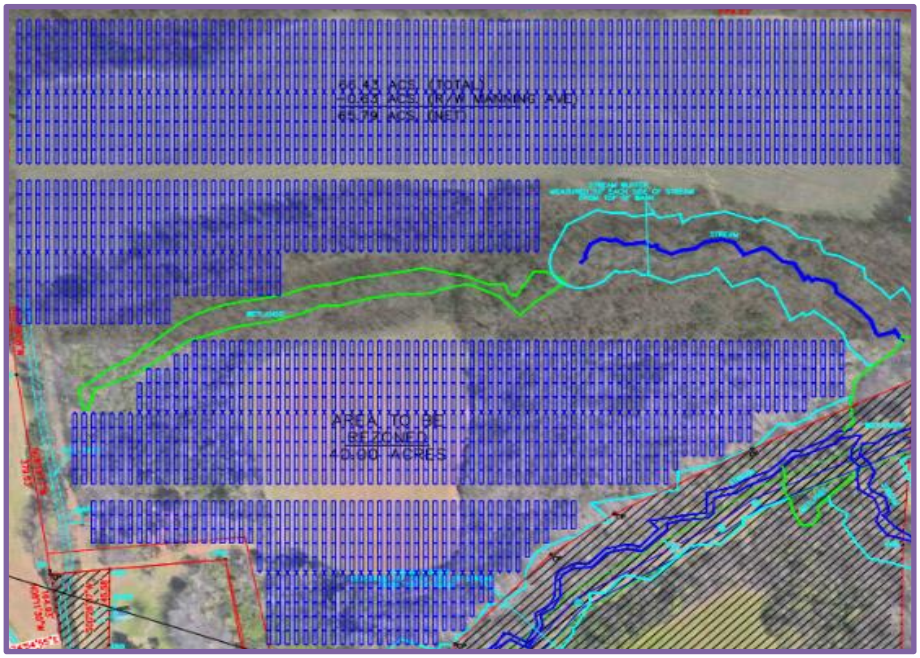


Figure 17. Site 1 footprint. Image source: Liz Kalies

Siting:

Principle 1: Consider native biodiversty in siting

C1.1.1: The facility shall not be located in a Resilient Area

Site 1 is in compliance as it does not overlap with any Resilient Areas in the NC Solar Siting webmap.

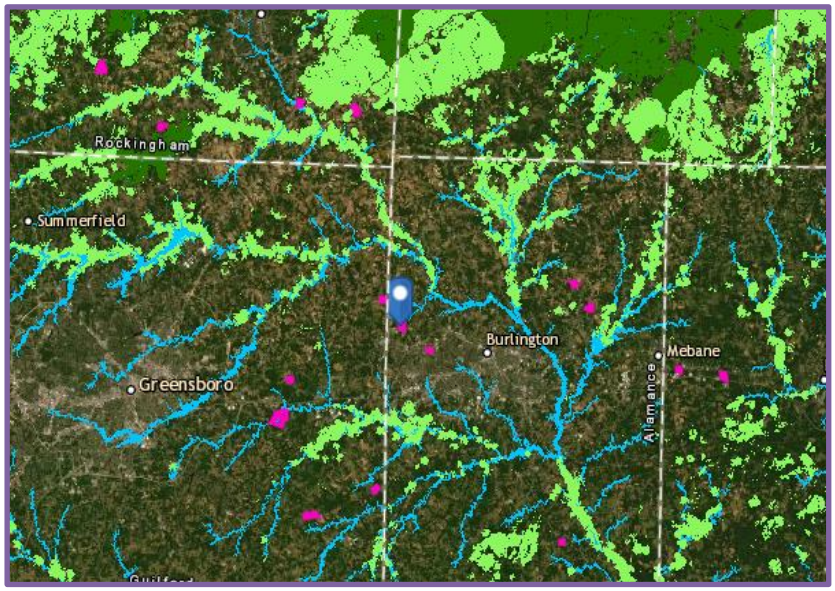


Figure 18. NC Solar siting webmap shows no overlap between the site and resilient areas (dark green). Image Source: TNC NC Solar Siting Webmap.

C1.1.2: The facility shall not be located in a climate corridor.

Site 1 is in compliance as it does not overlap with climate corridor in the NC Solar Siting webmap.

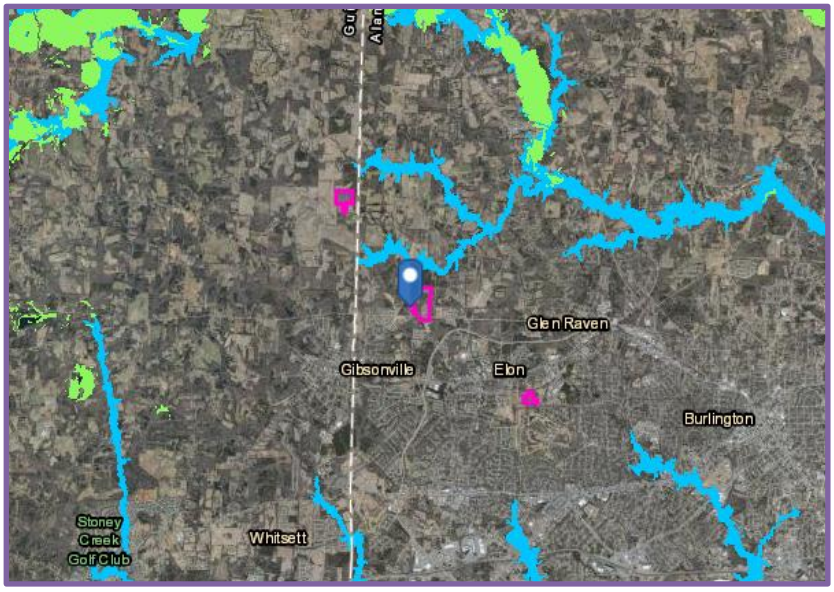


Figure 19. NC Solar siting Webmap shows no overlap between the site and resilient areas (light green). Image Source: TNC NC Solar Siting Webmap.

C1.1.3: The facility shall avoid siting on land where clear-cutting of trees has been conducted within recent years.

Site 1 is not in compliance as the Global Forest Change map indicates that tree loss occurred on the site in 2017. The magnitude of the tree clearing is unclear.

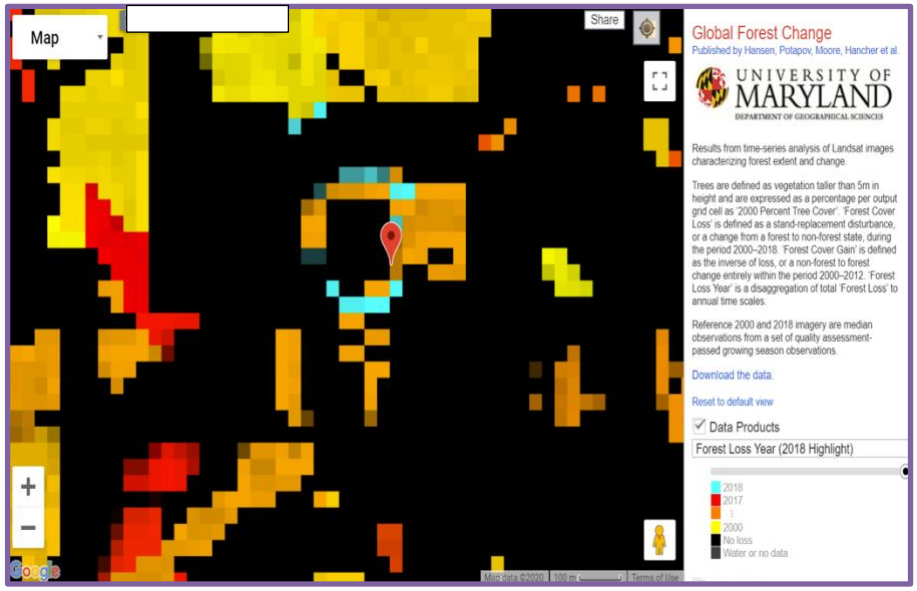


Figure 20. University of Maryland Global Forest Change Map shows tree loss in 2017. Image Source: University of Maryland

C1.1.4: The facility will be penalized for the clear-cutting of trees to build the solar facility.

Site 1 would lose points because tree clearing was conducted onsite, however the basal area that was removed could not be determined in retrospect.

C1.1.5: The facility shall be placed where load demand is highest.

Site 1 is in compliance as it provides electricity to Duke Energy customers where population density is adequately high.

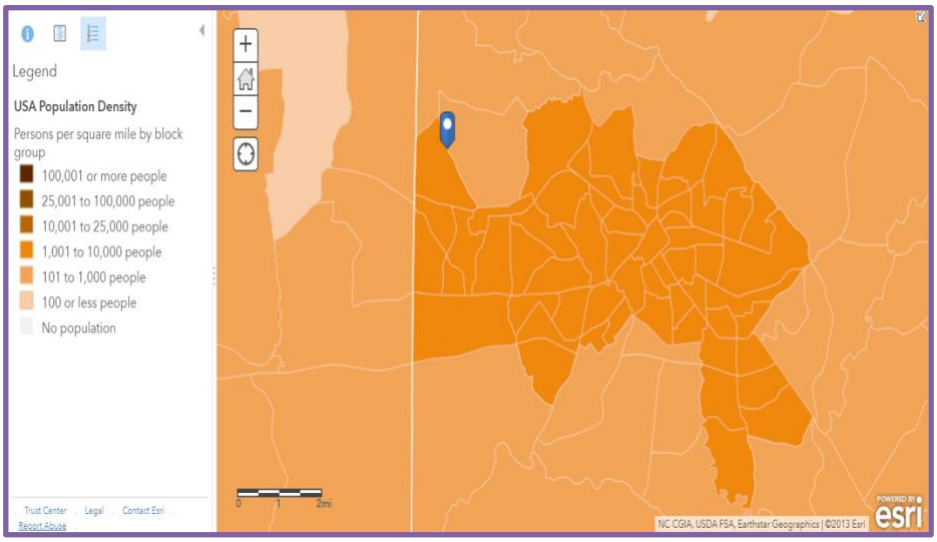


Figure 21. USA population density near the solar site is 1,001 to 10,000 people per square mile. Image Source: ESRI ArcGIS Online.

C1.1.6: The facility shall not be located in a 100-year floodplain.

Site 1 is in compliance as it does not overlap with a 0.2-1% flood zone in the FEMA Flood Map Service map.

Figure 22. The site does not overlap with a 100 nor 500-year floodplain. Image Source: US Floodplains, ESRI ArcGIS Online.

C1.1.7: If the facility is located in a 500-year floodplain, guidelines must be followed as to not jeopardize environmental health and the reliability of the energy source.

Site 1 is in compliance as it does not overlap with a 0.2-1% flood zone in the FEMA Flood Map Service map.

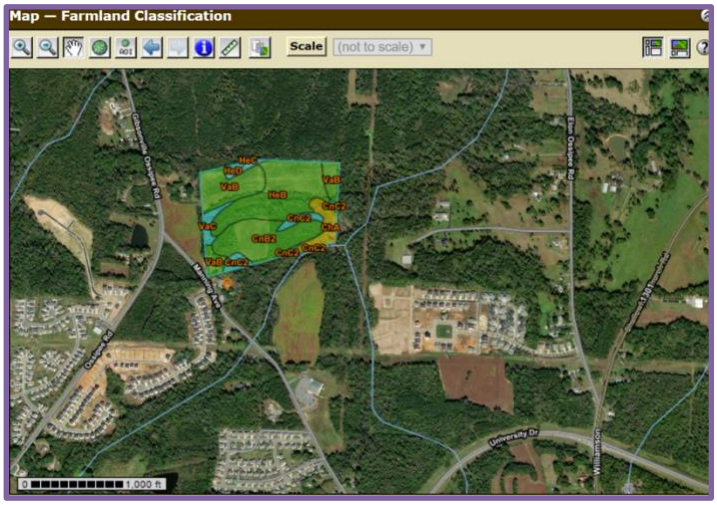
C1.1.8: The facility shall be located in a place with a maximum slope of no greater than 10 percent, thus avoiding grading of the land.

Site 1 is not in compliance as grading was conducted to prepare the site (Solar Maintenance Specialist, 2020).

Principle 2: Site on marginal lands & co-locate in lands actively used

C1.2.1 This facility shall maximize the use of disturbed or contaminated lands OR be sited in conjunction with existing land uses and infrastructure.

Site 1 is not in compliance because it was sited on prime agricultural land according to U.S. Department of Agriculture Map. Also it is not sited on contaminated or disturbed land. It also is not sited in conjunction with existing uses or infrastructure.



Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
ChA	Chewacla loam, 0 to 2 percent slopes, frequently flooded	Prime farmland if drained and either protected from flooding or not frequently flooded during the growing season	2.6	7.3%
CnB2	Cullen clay loam, 2 to 6 percent slopes, moderately eroded	All areas are prime farmland	8.9	24.5%
CnC2	Cullen clay loam, 6 to 10 percent slopes, moderately eroded	Farmland of statewide importance	2.3	6.3%
HeB	Helena sandy loam, 2 to 6 percent slopes	All areas are prime farmland	12.2	33.6%
HeC	Helena sandy loam, 6 to 10 percent slopes	Farmland of statewide importance	0.4	1.1%
HeD	Helena sandy loam, 10 to 15 percent slopes	Farmland of statewide importance	0.5	1.4%
VaB	Vance sandy loam, 2 to 6 percent slopes	All areas are prime farmland	8.2	22.8%
VaC	Vance sandy loam, 6 to 10 percent slopes	Farmland of statewide importance	1.1	3.1%
Totals for Area of Interest			**36.2**	**100.0%**

Figure 23. U.S. Department of Agriculture Map shows that soil found on the site consists of farmland of statewide importance. Image Source: U.S. Department of Agriculture.

Principle 3: Reach out to environmental and wildlife agencies

C1.3.1 The facility shall partner or consult with environmental and /or wildlife agencies to help ensure protection of wildlife species and the surrounding environment.

Compliance with this criteria could not be determined by the site visit.

Design:

Principle 1: Preserve wildlife connectivity

C2.1.1: The facility shall be equipped with wildlife-friendly fencing or wildlife passages.

Site 1 is not in compliance as it contains regular, barbed-wire fencing (Figure 26.). It does not contain wildlife passages either.

Figure 24. Barbed wire fencing at site 1 does not allow for wildlife movement. Image Source: Alicia Oberholzer

C2.1.2: The facility shall retain unfenced wildlife passageways throughout the solar facility.

Site 1 is not in compliance as it does not contain unfenced wildlife passageways throughout the solar facility.

Principle 2: Protect water resources and minimize erosion

C2.2.1: The facility shall provide a 100-foot buffer on perennial streams, and a 50-foot buffer on intermittent streams and jurisdictional wetlands.

Site 1 is in compliance as it contains adequate vegetated buffers to protect an onsite wetland and perennial stream (Figure 27.).

Figure 25. Vegetated buffer at site 1 protecting onsite perennial stream and riparian wetland. Image Source: Alicia Oberholzer

C2.2.2: The facility shall take special care to protect wetlands both on-site and off-site.

Site 1 is in compliances as the facility has a high-quality sediment, erosion, and run-off prevention system in place to protect the wetland and perennial stream onsite (Figure 28.).

Figure 26. Run-off filtration system on site 1 to filter run-off water before it enters the onsite wetland and perennial stream. Image Source: Alicia Oberholzer

Principle 3: Preserve native vegetation and pollinator habitat

C2.3.1: This facility shall seek to restore native vegetation and grasslands to support pollinators.

Site 1 is in compliance as it has planted a clover pollinator mix to support local pollinators (Figure 29.).

Figure 27. Image 4. Clover mix on site 1 providing pollinator habitat. Image Source: Alicia Oberholzer

Principle 4: Protect wildlife habitat

C2.4.1: The facility shall seek to protect, restore, and provide supplemented wildlife habitat that is directly impacted by solar development.

Site 1 is in compliance as there is an onsite riparian wetland which provides habitat for wildlife (Image 5).

Figure 28. Riparian wetland on site 1 providing wildlife habitat. Image Source: Alicia Oberholzer

Principle 5: Innovate on the Co-Optimization of Solar Energy and Other Activities

Site 1 is not in compliance as it has not implemented any innovative design practices listed in the guidebook.

Site 2
Size: 1.88 MW
Location: North Carolina

Figure 29. Site 2 solar site (no footprint available). Image Source: Google Maps.

Siting:

Principle 1: Consider native biodiversity in siting

C1.1.1: The facility shall not be located in a Resilient Area

Site 2 is in compliance as it does not overlap with any Resilient Areas in the NC Solar Siting webmap.

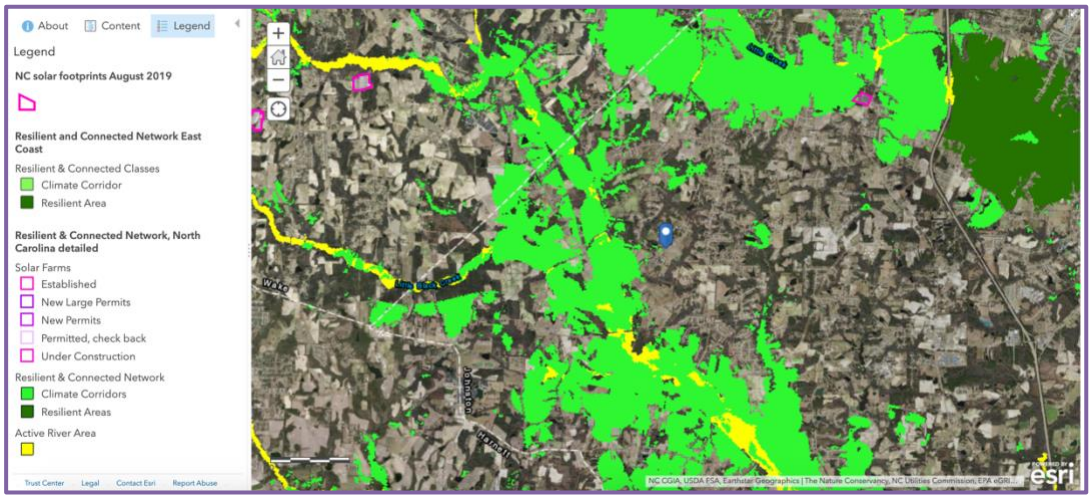


Figure 30. NC Solar Siting Webmap shows no overlap between the site and resilient areas (dark green). Image Source: TNC NC Solar Siting Webmap.

C1.1.2: The facility shall not be located in a climate corridor.

Site 2 is in compliance as it does not overlap with climate corridor in the NC Solar Siting webmap.

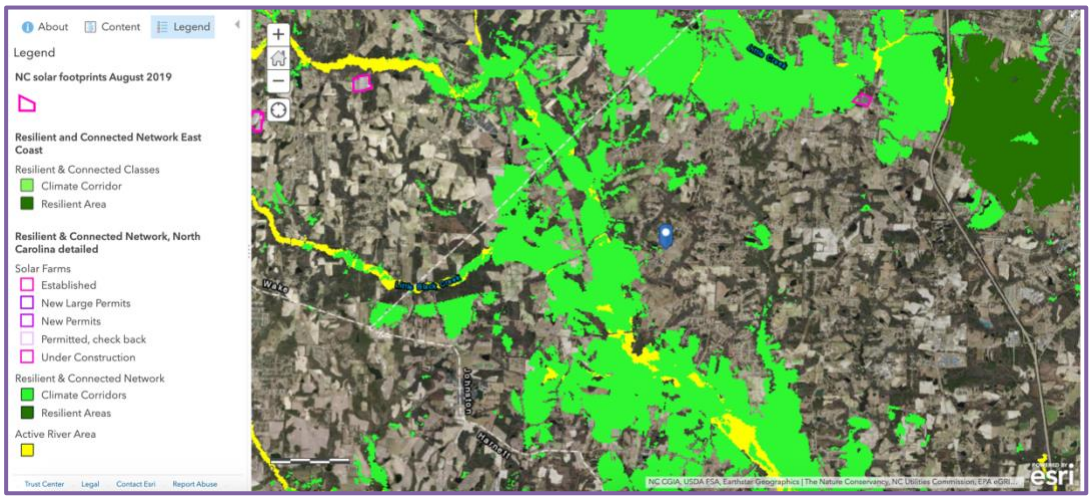


Figure 33. NC Solar Siting Webmap shows no overlap between the site and climate corridors (light green). Image Source: TNC NC Solar Siting Webmap.

C1.1.3:The facility shall avoid siting on land where clear-cutting of trees has been conducted within recent years.

Site 2 is in compliance as the Global Forest Change map indicates that no tree loss has occurred on the site within 3 years.

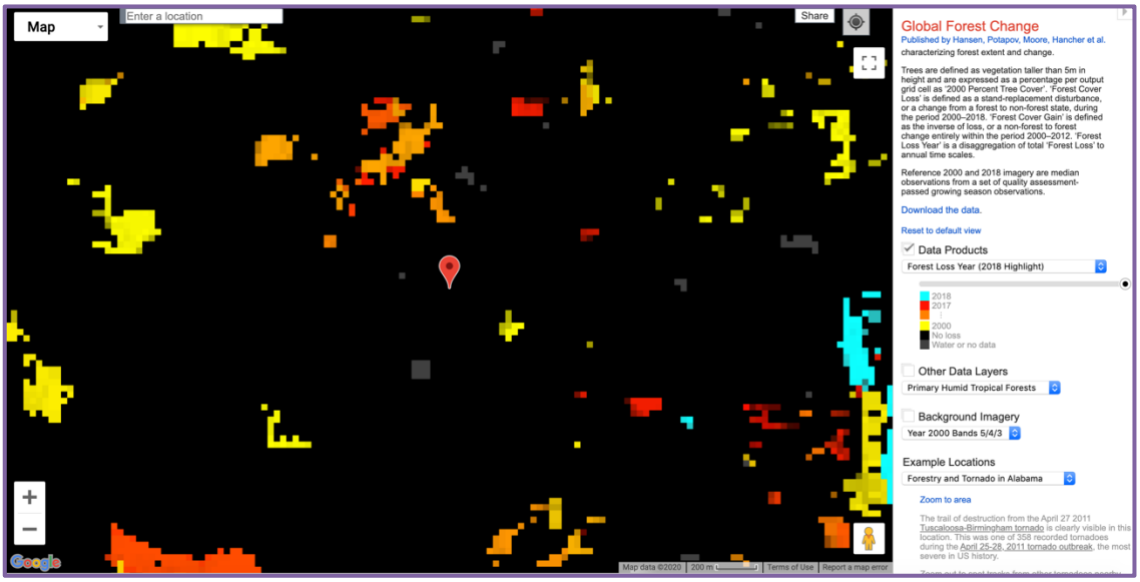


Figure 31. Thi University of Maryland Global Forest Change Map shows no recent tree loss. Image Source: University of Maryland

C1.1.4: The facility will be penalized for the clear-cutting of trees to build the solar facility.

It could not be determined whether clear-cutting occurred to prepare the site for the solar facility.

C1.1.5: The facility shall be placed where load demand is highest.

Site 2 is in compliance as it provides electricity to Duke Energy customers where population density is adequately high.

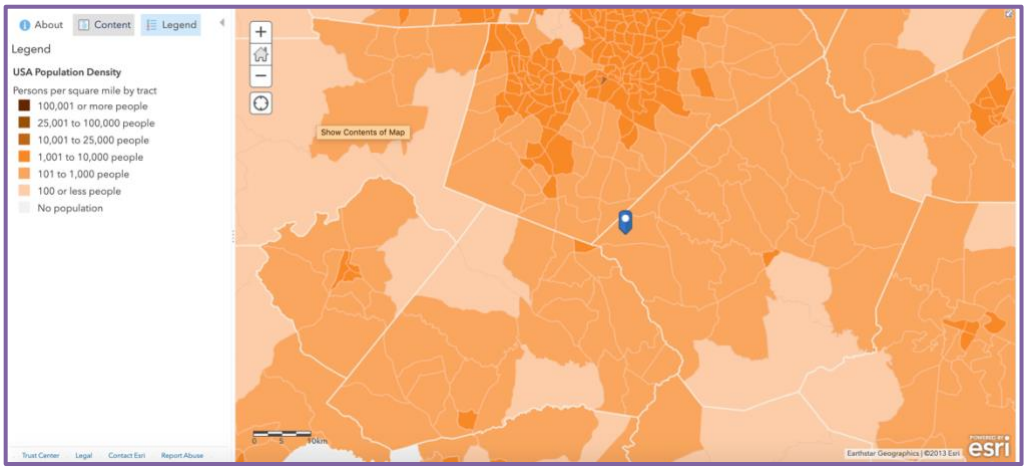


Figure 32. USA population density near the solar site ranges from 101 to 10,500 people per square mile. Image Source: ESRI ArcGIS Online.

C1.1.6: The facility shall not be located in a 100-year floodplain.

Site 2 is in compliance as it does not overlap with a 0.2-1% flood zone in the FEMA Flood Map Service map.

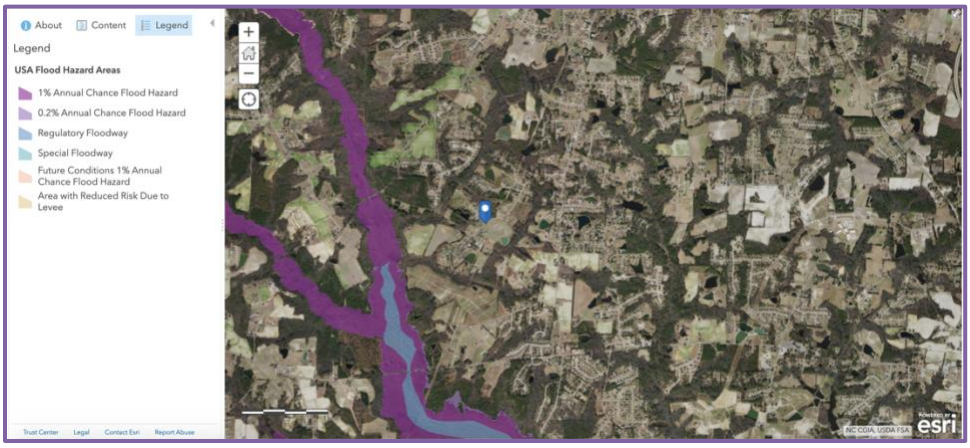


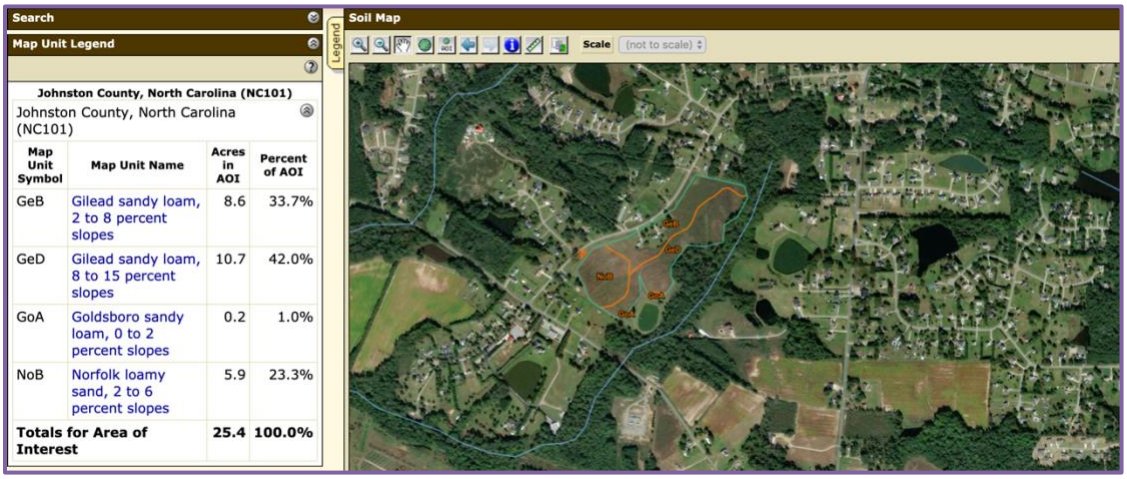
Figure 33. The site does not overlap with a 100 nor 500-year floodplain. Image Source: USA Flood Hazard Areas, ESRI ArcGIS Online.

C1.1.7: If the facility is located in a 500-year floodplain, guidelines must be followed as to not jeopardize environmental health and the reliability of the energy source.

Site 2 is in compliance as it does not overlap with a 0.2-1% flood zone in the FEMA Flood Map Service map.

C1.1.8: The facility shall be located in a place with a maximum slope of no greater than 10 percent, thus avoiding grading of the land.

Site 2 is likely not in compliance as some of the land has a slope greater than 10%.



Johnston County, North Carolina (NC101)

Johnston County, North Carolina (NC101)

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
GeB	Gilead sandy loam, 2 to 8 percent slopes	8.6	33.7%
GeD	Gilead sandy loam, 8 to 15 percent slopes	10.7	42.0%
GoA	Goldsboro sandy loam, 0 to 2 percent slopes	0.2	1.0%
NoB	Norfolk loamy sand, 2 to 6 percent slopes	5.9	23.3%
Totals for Area of Interest		**25.4**	**100.0%**

Figure 34. UC Davis soil map shows that some of the site contains a slope of 8% to 15%. Image Source: U.S. Department of Agriculture.

C1.2.1 This facility shall maximize the use of disturbed or contaminated lands OR be sited in conjunction with existing land uses and infrastructure.

Site 2 is not in compliance as it was sited on prime agricultural land according to U.S. Department of Agriculture Map. It also is not sited on contaminated or disturbed land. It also is not sited in conjunction with existing uses or infrastructure.

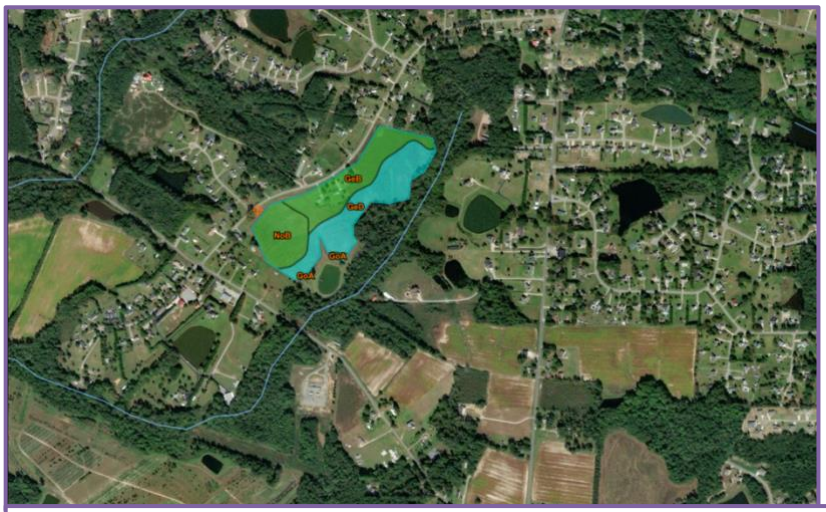


Figure 35. U.S. Department of Agriculture Map shows that site consists of farmland of statewide importance. Image Source: U.S. Department of Agriculture.

Summary by Map Unit — Johnston County, North Carolina (NC101)

Summary by Map Unit — Johnston County, North Carolina (NC101)

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
GeB	Gilead sandy loam, 2 to 8 percent slopes	All areas are prime farmland	8.6	33.7%
GeD	Gilead sandy loam, 8 to 15 percent slopes	Farmland of statewide importance	10.7	42.0%
GoA	Goldsboro sandy loam, 0 to 2 percent slopes	All areas are prime farmland	0.2	1.0%
NoB	Norfolk loamy sand, 2 to 6 percent slopes	All areas are prime farmland	5.9	23.3%
Totals for Area of Interest			**25.4**	**100.0%**

C1.3.1 The facility shall partner or consult with environmental and /or wildlife agencies to help ensure protection of wildlife species and the surrounding environment.

Compliance with this criterion could not be determined.

Design

Principle 1: Preserve wildlife connectivity

C2.1.1: The facility shall be equipped with wildlife-friendly fencing or wildlife passages.

Site 2 is in compliance as it contains permeable wildlife fencing (Figure 38.).

Figure 36. Permeable fencing on site 2 enabling wildlife movement. Image Source: Liz Kalies

C2.1.2: The facility shall retain unfenced wildlife passageways throughout the solar facility.

Site 2 is not in compliance as it does not contain unfenced wildlife passageways throughout the solar facility.

Principle 2: Protect water resources and minimize erosion

C2.2.1: The facility shall provide a 100-foot buffer on perennial streams, and a 50-foot buffer on intermittent streams and jurisdictional wetlands.

N/A as site 2 is not near any of the above water features.

C2.2.2: The facility shall take special care to protect wetlands both on-site and off-site.

Site 2 is in compliances as the facility is making an effort to convert an onsite retention pond into a wetland (Liz Kalies, 2019).

Principle 3: Preserve native vegetation and pollinator habitat

C2.3.1: This facility shall seek to restore native vegetation and grasslands to support pollinators.

Site 2 is in compliance as it contains a diverse pollinator vegetation mix, including native vegetation (Figure 39.).

Figure 37. Native vegetation mix providing pollinator habitat on site 2. Image Source: Liz Kalies

Principle 4: Protect wildlife habitat

C2.4.1: The facility shall seek to protect, restore, and provide supplemented wildlife habitat that is directly impacted by solar development.

Site 2 is in compliance asnative vegetation is allowed to grow and there is a plan to eliminate winter mowing (Liz Kalies, 2019). In addition, there are plans to convert a retention pond into an onsite wetland (Liz Kalies, 2019).

Principle 5: Innovate on the Co-Optimization of Solar Energy and Other Activities

Site 2 is not in compliance as it has not implemented any innovative design practices listed in the guidebook.