Principles of Low Impact Solar Siting and Design

The Nature Conservancy in North Carolina

Solar energy facilities show great potential for providing sustainably-sourced electricity and are increasingly playing a larger role in meeting our energy needs. They produce little to no carbon emissions and are an essential component of the effort to mitigate climate change. Currently, North Carolina ranks second in the United States in installed solar (after California).[1] Since 2011, over 600 solar facilities have been built on over 30,000 acres across the state, with another 20,000 acres permitted for construction over the next 4 years. The Nature Conservancy (TNC) supports replacing fossil fuel electric generation with solar and wind energy, and increased implementation of well-sited and designed systems. Aligning this with TNC's core mission of protecting and restoring natural systems and biodiversity requires emphasis on the need to site these facilities in ways that avoid, minimize, and mitigate potential impacts to the environment. Our strong preference is for solar panels to be sited on rooftops and in urban environments; a study from the US Department of Energy estimates that 23% of North Carolina's energy demand could be met with rooftop solar.[2] However, large, ground-mounted utility scale solar photovoltaic (PV) projects enjoy a significant competitive advantage[3] and therefore it is in everyone's interest that these projects be developed responsibly.

Rooftop solar uses existing structures and requires no additional land development.

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There are various energy sourcing and use scenarios that will allow us to reduce the trajectory of earth's warming to less than 2°C through changes to the electric generation sector. These include combinations of reductions in energy use, carbon capture and sequestration technologies, and transition to renewable and other carbon-free electric generation. Solar facilities contribute towards the mitigation of climate change,[4] but if sited improperly, can have negative consequences to biodiversity and natural

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[1] Solar Energy Industries Association (SEIA). Accessed December 2018.
[2] Gagnon, P., R. Margolis, J. Melius, C. Phillips, and R. Elmore. 2016. Rooftop Solar Photovoltaic Technical Potential in the United States: A Detailed Assessment. National Renewable Energy Laboratory.
[3] Massachusetts Institute of Technology. 2015. The Future of Solar Energy. Report.
[4] International Renewable Energy Agency. 2018. Global Energy Transformation: A Roadmap to 2050. Report.
[5] Oakleaf, J. R., Kennedy, C. M., Baruch-Mordo, S., West, P. C., Gerber, J. S., Jarvis, L., & Kiesecker, J. 2015. A world at risk: Aggregating development trends to forecast global habitat conversion. PLoS ONE, 10(10).
[6] NC Clean Energy Technology Center, NC State University. 2017. Balancing Agricultural Productivity with Ground-based Solar Photovoltaic (PV) Development. Report.

communities.[5] The amount of North Carolina's electricity generation that could realistically come from utility-scale solar is projected to be as high as 20%,[6] which would require approximately 140,000 acres of ground-mounted utility scale solar. Based on our analysis (see the NC Solar Siting Webmap), it is possible to site this number of acres of solar facilities in areas that have minimal impact to natural communities and biodiversity. Advancements in renewable energy technology are occurring rapidly, allowing for an increase in electricity produced per acre, thus reducing total acreage needed.

The primary purpose of these Principles is to inform and potentially guide solar energy developers, operators, and other stakeholders to site, construct, and operate solar facilities in ways that minimize impacts to natural ecosystems and biodiversity. We understand that siting of solar is a complicated process with many factors and criteria, and TNC is not attempting to address the comprehensive suite of criteria such as electric grid access, social issues, engineering, site topography, permitting requirements, and costs. In addition, utility scale solar projects require approval by state agencies via the NC State Environmental Review Clearinghouse, which should flag any environmental concerns. Thus, rather than duplicating existing processes, the TNC Principles and NC Solar Siting Webmap are intended as resources for solar developers, and the spatial data can be included as an additional, important consideration in developers' existing siting process. We wish to work with solar developers and operators to help implement these Principles to the extent feasible and can provide them with GIS data for use in the siting process.

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

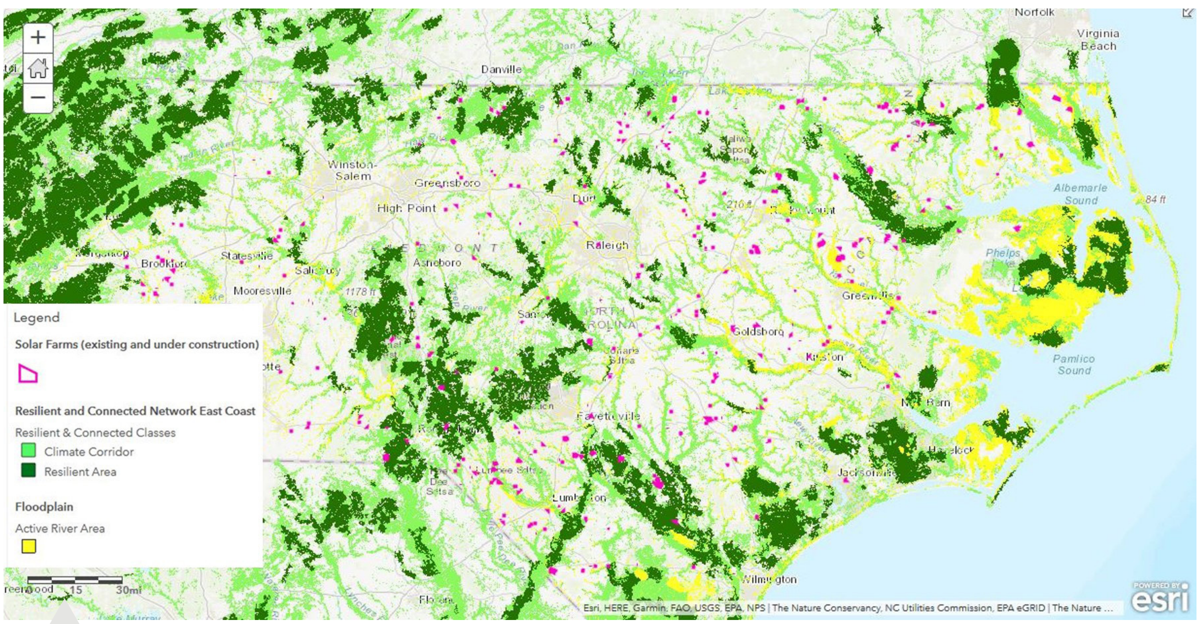
[7] There is no "one size fits all" approach to solar facility design. Each solar facility needs to be evaluated based on natural landform and hydrology, native plant and wildlife species presence, and ecosystem functions. For example, wildlife corridors may be most relevant for an installation in a 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.

1. AVOID AREAS OF HIGH NATIVE BIODIVERSITY AND HIGH QUALITY NATURAL COMMUNITIES

Avoid siting in the Resilient Connected Network (RCN) resilient areas: Siting solar facilities to avoid areas with high biodiversity is the simplest yet most important step in siting solar. TNC urges developers not to locate facilities in "resilient areas" of the RCN.[8] The NC Solar Siting Webmap identifies resilient areas that 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. We do not recommend mitigating biodiversity loss by moving sensitive species from a solar site to natural habitat, due to the low success rates associated with these efforts.[9]

TNC's Resilient and Connected Network (RCN) project is the first study to comprehensively map resilient lands and significant climate corridors across Eastern North America. Released in October 2016, the study took eight years to complete, involved 60 scientists, and developed innovative new techniques for mapping climate-driven movements of species. The analysis incorporates areas that are TNC NC chapter conservation priorities and NC Natural Heritage Areas. The NC Solar Siting Webmap contains two layers of the RCN: resilient areas and climate corridors.

Note on permitting: While critical habitat can be considered in siting a solar facility, it does not affect many acres in NC (see USFWS Critical Habitat map); consultation with the USFWS may be required when development might impact a threatened or endangered species.



Screenshot of the online, interactive NC Solar Siting Webmap. © TNC

[8] See Principle #3. If field visits reveal disturbed or degraded habitat then site may be acceptable for solar site development; however, note that even disturbed sites in the RCN could potentially be restored (e.g., a pine plantation) which is preferable.
[9] Hernandez, et al. 2014. Environmental impacts of utility-scale solar energy. Renewable and Sustainable Energy Reviews, 29, 766-779.

2. ALLOW FOR WILDLIFE CONNECTIVITY, NOW AND IN THE FACE OF CLIMATE CHANGE

Avoid siting in and fragmenting the RCN climate corridors: In the United States, most research on the environmental impacts of solar facilities has focused on large western installations on public lands. In the Southeast, installations are rapidly being developed on smaller (<100 acres) private lands, with the potential to create smaller but more numerous fragmenting features. Habitat connectivity is rarely considered during siting. Little is known about the potential impact of solar facilities on wildlife movement and it varies greatly from site to site and type of wildlife. For example, flying wildlife (e.g. birds and bats) movements are likely minimally impacted by solar development, whereas ground-based wildlife may experience more impact to daily or seasonal movement. Further, as plant species and wildlife shift their ranges because of climate change, barriers to such shifts could occur and any development, including solar, could impede these shifts.[10] We recommend avoiding the construction of solar facilities in RCN "climate corridors" (see NC Solar Siting Web-map).[11] These climate corridors encompass areas that species are likely to use for periodic or seasonal movements and shifts in ranges over time in response to climate change, generally in upward (in elevation) and northward directions across the landscape.

Where appropriate, use wildlife-friendly fencing or unfenced wildlife corridors: Wildlife connectivity and movement may be of greatest concern where there is adjacent habitat disrupted by the presence of the solar facility (e.g., intact forestland on two or more sides). Solar facilities generally use fencing that may act as a barrier to larger, ground-based wildlife movement. The NC Solar Siting Webmap can be used to identify solar facilities that are sited within or adjacent to the resilient areas or climate corridors, and thus good candidates for practices that improve wildlife connectivity.

While best management practices for wildlife-friendly fencing are still under research, we recommend using fencing that allows small-to-medium sized animals (e.g., turtles, racoons, birds) to pass through (e.g., 6 ft. tall 12.5 gauge Fixed Knot Deer Busters 17/75/6 deer mesh galvanized fence with three strands of 12.5 gauge 4 point barbed wire, Fortress Fencing). TNC is evaluating this

Comparison of a standard chain-link fence (left) with a wildlife-permeable fence (right). © Liz Kalies/TNC

[10] Opdam, P. and D. Wascher. 2004. Climate change meets habitat fragmentation: linking landscape and biogeographical scale levels in research and conservation. Biological Conservation, 117, 285-297.
[11] See Principle #3. If field visits reveal disturbed or degraded habitat; and/or little to no connectivity, then site may be acceptable for solar site development.

fencing to determine its effectiveness. Another approach is to provide wildlife passages (8″ diameter HDPE pipe) roughly 500′ apart around the site. When implementing wildlife-permeable fence, equally important is providing on-site vegetation that provides cover for animals when moving through the site (see Principles #5 and #6).

The best method for allowing movement of both large and small animals, and particularly appropriate in large solar installations (i.e., >50 acres), is to retain unfenced wildlife passageways through the solar facility. Solar developers typically avoid development near rivers, streams and their associated riparian areas and wetlands, and these areas can then serve as wildlife passageways.

Developers omitted this streambed from the solar facility footprint; this can now act as a wildlife passageway through the site.

© Google Earth

3. PREFERENTIALLY USE DISTURBED OR DEGRADED LANDS

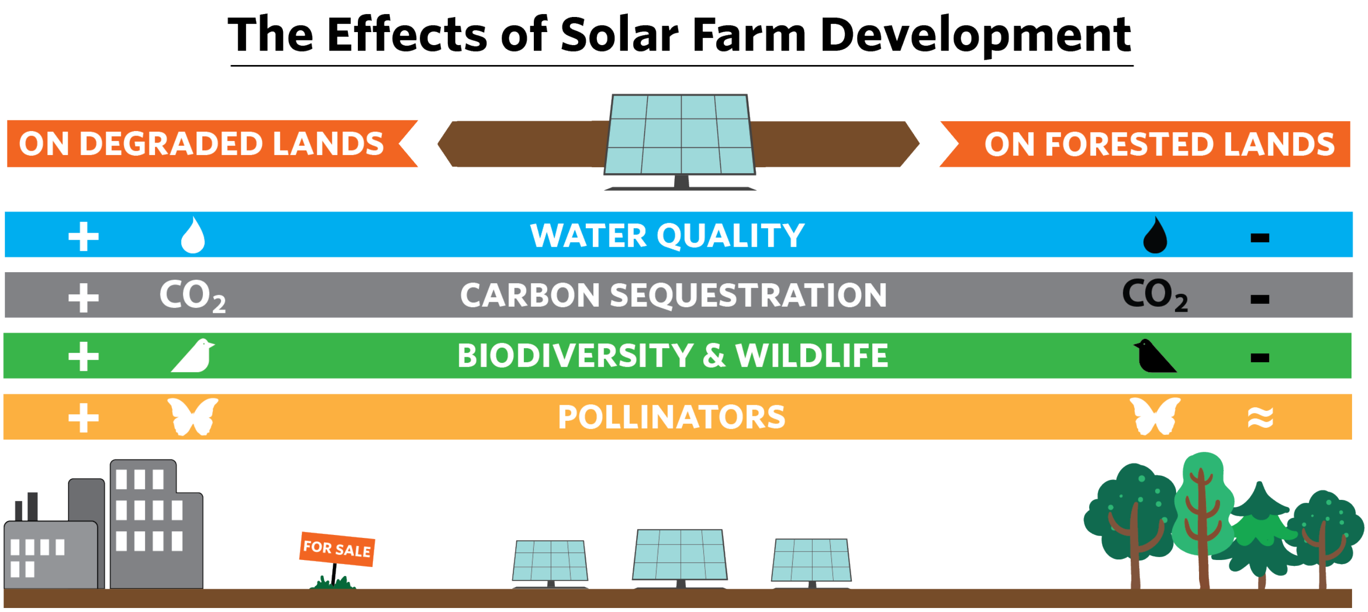
Preferentially site on degraded lands with little vegetation and/or poor soil quality: Choosing the most degraded sites for solar facility development (e.g., Brownfields, sites with prior development, little or no vegetation, poor soil quality, etc.) reduces impacts to wildlife habitat. Clearing native forest-land or grasslands should be avoided. It should also be noted that some sites that were previously developed and then abandoned may contain new vegetation and young forest (i.e., early successional habitat) that can be beneficial to wildlife species. Thus, defining "degraded" requires a site-level evaluation of intact soil, vegetation, and wildlife habitat.

Using degraded sites should reduce the amount of biologically sequestered carbon lost due to solar project construction. Clearing forestland disturbs sequestered carbon, thus reducing the benefits of clean energy production in the short term. While ultimately an acre of PV solar will result in less carbon emissions than the equivalent amount of forestland can sequester, the optimal scenario is when forestland is left intact to continue its role in carbon sequestration, and solar is sited elsewhere. Similarly, if an intact grassland is cleared and graded for solar development, it would result in loss of carbon from the soil organic layer, decreased microbial biomass and activity, and additional loss of soil through erosion and runoff.

Developers should preferentially site solar facilities on cleared land with poor soils that are least suitable for agriculture. Consult with the NC Department of Agriculture & Consumer Services for more guidance on agricultural soil quality or consult the NC Realistic Yield Expectation (RYE) Mapping tool that was developed by NC state agencies.

Principles #1 and #2 and the accompanying spatial data are provided at a coarse scale. Principle

#3 should be applied at the parcel level to further determine whether a site would be acceptable for development, based on other ecosystem services gained or lost. The following graphic illustrates how the "ecosystem services" nature provides to people are compromised least when solar facilities are sited on degraded lands:



© Avery Bond/TNC

Retain or plant native vegetation/trees in buffers or outside of perimeter fence: After the solar facility is sited, biologic carbon sinks can be incorporated into the site via vegetated buffers or trees, which provide additional benefits (wildlife, pollinators, etc.). See Principles #5 and #6 for recommendations on incorporating native vegetation and wildlife features.

4. PROTECT WATER QUALITY AND AVOID EROSION

Do not site in floodplains: Not locating solar facilities in these areas is both protective of floodplain ecological function, and also guards solar facilities from flooding, especially during extreme weather events, ensuring the resilience and reliability of our energy supply into the future. Generally, avoiding steeply sloped sites that require extensive grading will reduce potential for erosion, sedimentation, and runoff, and thus reduce impacts to water quality.

Note on permitting: If the proposed solar facility will cause any disturbance to a stream or wetland, then the developer must apply for a 401 WQC or Isolated and Other Non-404 Jurisdictional Wetland and Waters USACE permit.

Floodplains are displayed in the NC Solar Siting Webmap and are based on TNC's Active River Area (ARA) data which spatially defines the natural ranges of variability in freshwater and riparian ecosystems in terms of system hydrology, sediment transport, processing and transport of organic materials, and key biotic interactions. The ARA is generally calibrated to approximate the Federal Emergency Management Agency (FEMA) 100-year floodplain but may extend beyond this area as it does not consider flood control infrastructure.

Buffer streams and wetlands: Construction of a solar facility, in most cases, requires a NC Department of Environmental Quality (DEQ) Stormwater Pollution Prevention Plan (SWPPP) to control and manage erosion and sediment runoff. This SWPPP plan supports a Construction Stormwater permit. The NC Wildlife Resources Commission further recommends a 100-foot buffer on each side of perennial streams, a 50-foot buffer on intermittent streams and jurisdictional wetlands. In addition, a developer may choose to incorporate water features or wetlands into solar facility design (typically in peripheral areas and not under solar arrays) as supplemental habitat (see Principle #6).

Note on permitting: NCDEQ's erosion and sediment control plan requires measures designed to provide protection from a rainfall event equivalent in magnitude to the 10-year peak runoff, or in areas where High Quality Waters are a concern, the requirement is for a 25-year storm. Runoff velocities must be controlled so that the peak runoff from the 10-year storm will not damage the receiving stream channel at the discharge point. A sufficient buffer zone along any natural watercourse is required to contain all visible sediment to the first 25% of the buffer strip nearest the disturbed area. An undisturbed 25-foot buffer must be maintained along trout waters. Graded slopes must be vegetated or otherwise stabilized within 21 calendar days of completion of the construction. Off-site sedimentation must be prevented, and a ground cover sufficient to prevent erosion must be provided.

5. RESTORE NATIVE VEGETATION AND GRASSLANDS

Integrate the planting of native and/or pollinator vegetation where appropriate: While one goal may be to mitigate impacts of solar facilities on wildlife, another vision is that solar facilities have the potential to produce net wildlife habitat benefits, playing a key role in restoring native grasslands plants and wildlife to the southeastern United States. Native grassland habitats were once plentiful in the Southeast, but with development and other changes in land use and management, there is now less than 1% of historical native grassland habitat remaining in the Southeast. Solar facilities represent an opportunity to restore this vegetation to the landscape. The NC Pollinator Conservation Alliance has developed detailed guidance on how to plant solar facilities with native vegetation, with a focus on how to attract pollinator species (bees, butterflies, birds), and recommendations for management (e.g., avoid summer mowing). When compared to turf grass, the use of native vegetation increases biodiversity at the site, requires less mowing and herbicide use, minimizes erosion issues, more effectively attenuates the flow of stormwater, and increases soil health and carbon sequestration. We also recognize that restoration with native plants may not always be feasible, in which case non-native, non-invasive pollinator-friendly plants (e.g., clover) can be an acceptable alternative. Pollination is a key service that this practice provides, and thus its implementation may be most relevant for solar facilities located within an agricultural matrix, although natural ecosystems will also benefit from this service.

Pollinator-friendly vegetation on a solar facility in Cleveland, North Carolina. © Liz Kalies/TNC

6. PROVIDE WILDLIFE HABITAT

Protect and restore on-site wildlife habitat features (e.g., wetlands, vegetated buffers): If there are special habitat features in or near the proposed solar facility that cannot be avoided via the siting process, the developer can consider incorporating them into site design. Florida Power and Light has designated facilities that provide habitat as "solar sanctuaries" and include vegetated areas and buffers, intact (or restored) wetlands, and patches of forest. This existing habitat is likely in use by native wildlife prior to development.

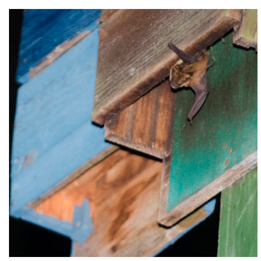
Provide supplemental wildlife habitat as appropriate: Create or restore vegetation on the site (see Principle #5) and focus on native plant species and communities that provide wildlife cover, food (e.g., fruit, mast, pollen), and breeding habitat. As practical, the solar site should be designed with open areas spread throughout and planted and maintained with taller plant species. This practice would benefit pollinators, create diversity across the site, and provide needed shelter islands to aid in the movement of small-to-medium sized animals.

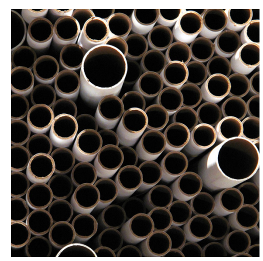
Supplemental habitat features can also be added to a site to encourage native wildlife to use and live near or on the site. Determining the best features to include depends on the species of native wildlife in the region that might benefit from additional nesting or foraging structures (e.g., raptor perches to replace cleared trees). While these practices have not been tested on solar facilities, they are successful in a variety of other suburban and urban settings; they include: downed wood, bird perches, bat boxes, bird nesting boxes, and sand piles (for native bees).


DOWN WOOD


BIRD NESTING BOXES


BIRD PERCHES


BAT BOXES


BEE NESTING BOXES

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North Carolina

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