North Carolina Solar Land Use and Agriculture

2022 Update

NC SUSTAINABLE ENERGY ASSOCIATION

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About North Carolina Sustainable Energy Association

North Carolina Sustainable Energy Association (NCSEA) is the leading 501(c)(3) non-profit organization that drives public policy and market development for clean energy. Our work enables clean energy jobs, economic opportunities, and affordable energy options for North Carolinians. Learn more about NCSEA, our mission, and vision at www.energync.org.

Executive Summary

Dating back to 2009, NCSEA has monitored and collected data on all solar installations across the state of North Carolina. This data has been informative to measuring the significant growth of the industry and the associated economic benefits to the state. In the process of aggregating this data, NCSEA has also utilized the opportunity to track land use associated with the growth of solar in North Carolina, which led to the creation of the North Carolina Solar and Agriculture Report first produced in 2017. According to this study conducted by NCSEA and the NC Department of Agriculture & Consumer Services, the report outlined that only .19% of cropland in North Carolina had been repurposed for utility-scale solar development.

NCSEA used a similar methodology to the previous analysis to conduct an updated land use study using data through 2021.

Solar and agriculture are two significant industries in North Carolina. The state has long been atop the national leaderboard in solar photovoltaics (PV) with more than 7,460 megawatts (MW) of installed capacity. As of March 2022, North Carolina ranks fourth in the country for total installed capacity according to the Solar Energy Industries Association.[1] While solar PV systems can be divided into a few different categories depending on their size and/or use, the analysis in this report focuses on utility-scale systems – specifically those 1 MW or greater in their nameplate capacity. According to NCSEA's data, there are 703 of these systems currently installed in the state totaling a generation capacity of 5,786 MW.

Agriculture is another important industry in the state. As of 2021, there were 45,100 farms in North Carolina producing goods, such as soybeans, corn, sweet potatoes, and livestock according to the US Department of Agriculture.[2] In 2020, North Carolina led the country in sweet potato production, was third in turkey production, and third in hog and pig production, all according to the US Department of Agriculture.[3] When combined, the NC Department of Agriculture & Consumer Services says that agriculture and agribusiness are the largest industry in the state, representing almost $96 billion.[4]

Utility-scale solar PV development has grown significantly in North Carolina since 2009, increasing from three total systems in 2009 to more than 700, with some of that development occurring on agricultural land. To better understand the types of area that these installations occupy, NCSEA conducted a land use analysis with GIS footprints of each solar PV system with a nameplate capacity of 1 MW or more combined with land use data from the National Land Cover Dataset.[5]

"This farm has been in the family longer than we can trace back. We would never consider selling, so our solar lease is really good, and the land is really good. If anything or anybody else had come along, we would have said no. But we know the value of clean energy, and to promote it in this area meant a lot to us."

- Helen Livingston, NC Farm owner

This analysis is an update to a project that NCSEA conducted with the North Carolina Department of Agriculture and Consumer Services in 2017 about the land occupied by utility-scale solar PV systems in North Carolina.[6]

The analysis found that utility-scale PV systems occupy 38,081 total acres of land. The analysis also found that 31,125 acres of that total are considered agricultural land – defined as cultivated cropland, evergreen forest, or pasture/hay. In total, the state of North Carolina is comprised of 31,537,616 acres of land, with 10,999,656 being attributed to agricultural purposes. Given these numbers, solar PV only occupies 0.12% of the total land area of the state and 0.28% of agricultural land.

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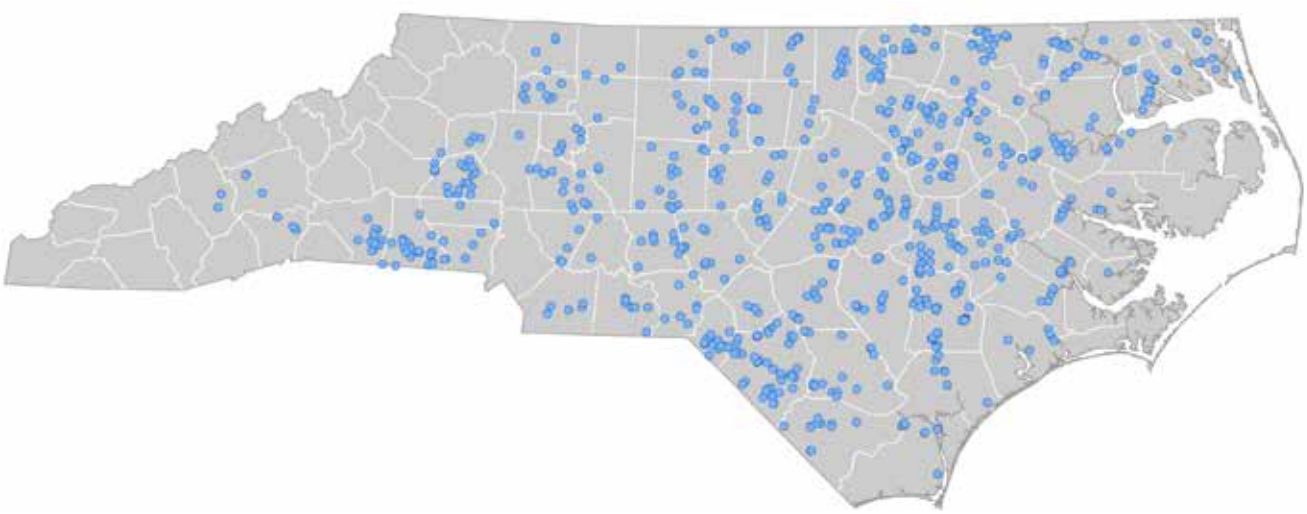

Figure 1. Locations of utility-scale solar PV systems with generating capacity of 1 MW or greater in NC

Compared to other forms of redevelopment, classified as either Developed, Open Space (i.e. single-family housing, golf courses, parks) or Developed, Low Intensity (i.e. single-family housing), which each comprise 7.18% and 3.42% of agricultural land respectively, PV development covers a low amount of agricultural land.

While utility-scale solar PV development has occurred on a small amount of agricultural land in North Carolina, there are other land uses that have repurposed significantly more land, such as residential home development. Regardless, for the small amount of agricultural land that solar PV does occupy, there are methods of system installation that can co-locate agricultural activities with solar PV, such as planting beneath raised solar PV panels and allowing for animals to graze in and around operating systems in a practice called agrivoltaics.[7] Furthermore, solar PV systems can offer a place to add pollinator habitats to support local ecosystems.

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Agriculture in North Carolina

State Economic Benefits from Agriculture

Agriculture has long been the leading industry in the state, providing thousands of jobs and contributing billions of dollars in revenue for North Carolina while leading the country in the production of many commodities. According to the NC State Agricultural Extension, in 2021, 16% ($96 billion) of the state's GSP ($592 billion) came from agricultural activities.[8] Agriculture also employs almost 780,000 people, which is 17.5% of North Carolina's workforce. These workers are spread over 45,100 farms which occupy 8.3 million acres according to the US Department of Agriculture.[9]

Agricultural National Ranks

North Carolina is also an agricultural leader in the country. For some of these products, North Carolina is or is among the nation's leaders. According to the NC Department of Agriculture, close to 60% of all the sweet potatoes grown in the United States are grown in North Carolina.[10]

COMMODITY	NATIONAL RANK
SWEET POTATOES	1ST
TOBACCO	1ST
POULTRY & EGGS	1ST
HOGS & PIGS	3RD
TURKEYS	3RD
CUCUMBERS	3RD
BELL PEPPERS	3RD

Table 1. North Carolina national commodity production ranks (2020) according to the US Department of Agriculture[11]

Solar PV in North Carolina

State Economic Benefits from Solar

Renewable energy is a significant industry in the state, providing nearly 100,000 jobs in North Carolina, according to E2 (Environmental Entrepreneurs) and representing almost $20 billion in investment since 2007 according to a study from RTI International.[12, 13] Solar photovoltaics are the largest subset of the clean energy economy besides energy efficiency, with over 8,000 jobs.

Additionally, utility-scale solar PV systems contribute significant tax revenue to the counties in which they are installed. In a previous project quantifying those taxes, NCSEA found that on average, the property taxes paid after a system was installed increased by over 450%, when including real estate, personal property, and rollback taxes when applicable and available.[14] In total, the solar PV systems included in the study paid over $13.5 million in taxes.

Solar National Rank

North Carolina is also a national leader in the clean energy industry with the 9th most total clean energy industry jobs of any state. North Carolina also has the 4th most solar PV generating capacity in the US according to the Solar Energy Industries Association.[15]

STATE	RANK	SYSTEMS	CAPACITY (MW)
CALIFORNIA	1	1,445,035	34,950
TEXAS	2	148,936	13,845
FLORIDA	3	118,273	8,206
NORTH CAROLINA	4	28,467	7,811
ARIZONA	5	209,513	5,644
NEVADA	6	79,097	4,511
GEORGIA	7	4,768	4,269
NEW JERSEY	8	146,116	3,854
VIRGINIA	9	25,154	3,761
MASSACHUSETTS	10	125,219	3,607

Table 2. Ten states with the most solar PV generating capacity

Economic Benefits of Solar to Agricultural Landowners

Hosting a utility-scale solar PV system on one's land can be an opportunity for a landowner to generate a more stable and potentially higher income than normal farming operations. While lease amounts are not publicly available, a variety of sources report values between $300-$2,000 per acre depending on the exact situation – and typically these rent payments increase over the length of the lease.[16] In fact, according to the US Department of Agriculture, even at the low end of those lease payments, solar PV would pay better per acre than barley, oats, or hay production.[17]

Land Occupied by Utility-Scale Solar PV in North Carolina

2017 Report

In the original iteration of this land use analysis, NCSEA collaborated with the NC Department of Agriculture & Consumer Services to determine the amount of agricultural land that utility-scale solar PV systems occupy in North Carolina. Using a similar methodology to this analysis, NCSEA found that the 341 systems that were installed at that time occupied 11,559 total acres of land - 9,074 of which were agricultural land. Also at that time, there was 4,745,014 acres of agricultural land in North Carolina, which means that utility-scale solar PV systems occupied 0.19% of the state's agricultural land.

2022 Report

Methodology

NCSEA calculated land use figures by drawing GIS footprints utilizing aerial imagery of each solar PV system installed in North Carolina, superimposing these footprints over land use GIS files, and calculating the amount of land each footprint occupied in each land use category. The first solar PV systems included in this analysis were installed in 2009, so NCSEA used land use data from 2008. NCSEA compared land use data from before any of the solar PV systems were installed to quantify the amount of land occupied by solar PV as well as the amount that was previously used for agriculture.

Specifically, NCSEA utilized data from our Renewable Energy Database (REDB), a statewide clearinghouse of installed renewable energy systems, to identify 1 MW and greater in nameplate generating capacity systems. The REDB is the most comprehensive source of renewable energy system information in North Carolina and sources its data from the NC Utilities Commission.

The footprints of these systems were mapped out using the latest NC OneMap orthoimagery. NC OneMap is a source of geospatial data compiled from various government agencies and universities in North Carolina.[18]

This analysis yielded 703 GIS footprints, which were then overlaid on a land cover GIS file from the National Land Cover Dataset (NLCD). The NLCD dataset classifies land in the United States into categories based on its usage and contents including open water, vegetated lands (forests, grasslands, moss, lichens, etc.), and even levels of developed land. This data is provided by the Multi-Resolution Land Characteristics Consortium (MRLC) and includes federal agencies, such as the US Geological Survey, Bureau of Land Management, and US Forest Service.[19]

NCSEA then used ArcGIS's ArcMap program to identify the sections of the NLCD data that the solar PV systems occupy, totaling up the amount of area in each land use category.

Example

The following images demonstrate this process for the Holstein solar PV system, a 20 MW installation located in Maxton, NC, and completed in 2015.[20]

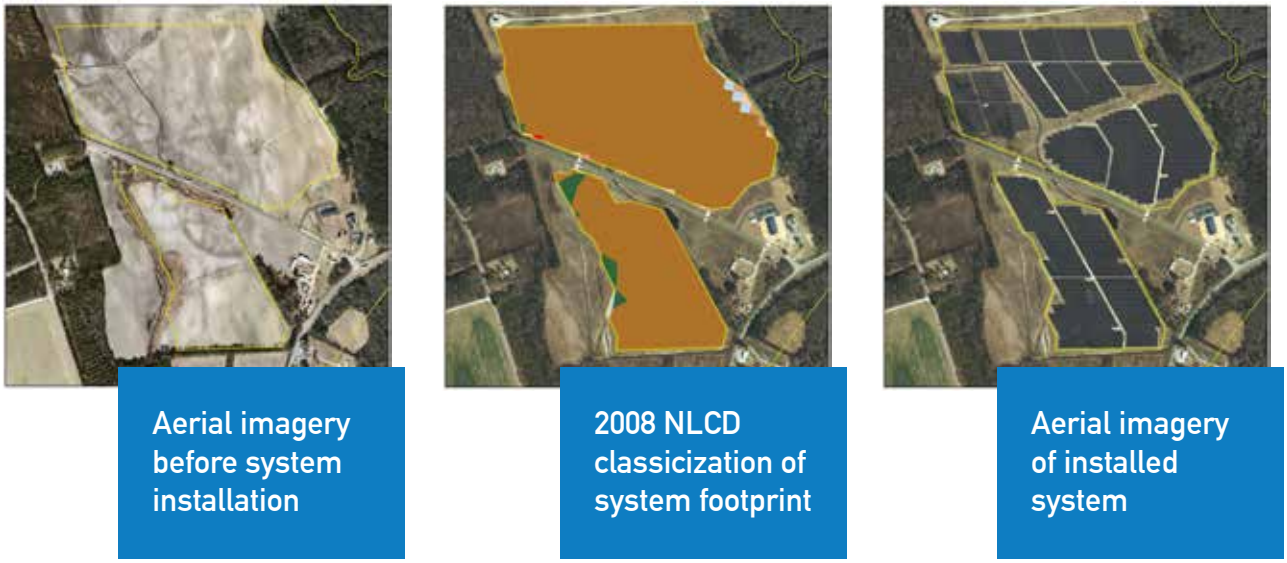


Figure 2. Aerial imagery and GIS files of a utility-scale solar PV system in North Carolina

The Holstein system occupies a footprint of 115 acres that was mostly cultivated cropland before installation.

Land Cover Categories

The National Land Cover Dataset labels 20 types of land use, but four of these are exclusive to Alaska.

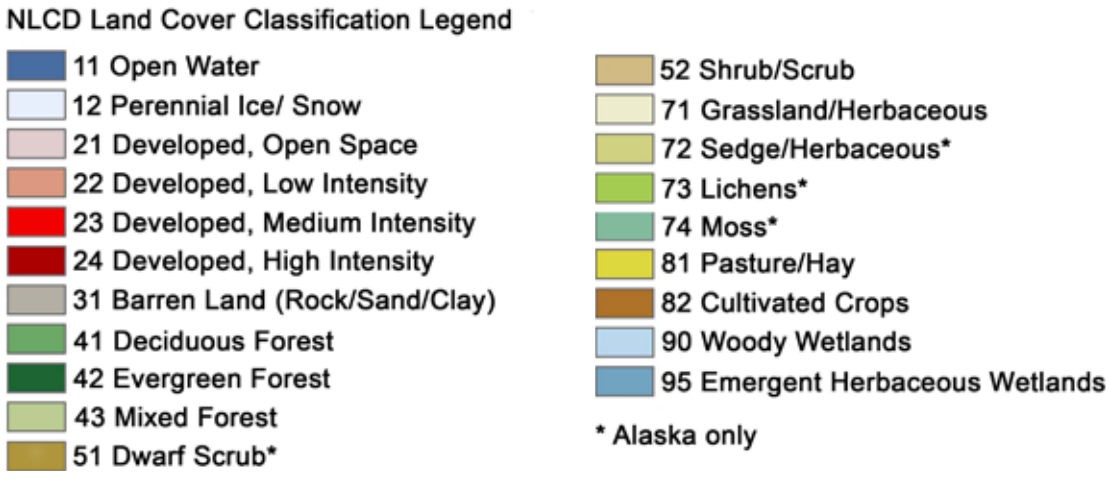


Figure 3. NLCD land cover classification categories

While most of the land cover classifications are self-evident, it is important to define the four "developed" categories. According to the MRLC, these are how the developed categories are characterized:[21]

- **Developed, Open Space** - areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20% of total cover.
    - These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes.
- **Developed, Low Intensity** - areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20% to 49% percent of total cover.
    - These areas most commonly include single-family housing units.
- **Developed, Medium Intensity** - areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50% to 79% of the total cover.
    - These areas most commonly include single-family housing units.
- **Developed, High Intensity** - highly developed areas where people reside or work in high numbers.
    - Examples include apartment complexes, row houses and commercial/industrial. Impervious surfaces account for 80% to 100% of the total cover.

Results

From NCSEA's analysis, the 703 installed solar PV systems 1 MW or greater in nameplate capacity occupy a total of 38,081 acres of land. Of that total, 23,601 acres, or 62%, were categorized as cultivated cropland in 2008. The next highest categories of land use were evergreen forest (4,984 acres, 13%), deciduous forest (2,682 acres, 7%), and pasture/hay (2,540 acres, 7%).

LAND USE CATEGORY	ACRES
DEVELOPED, OPEN SPACE	477
DEVELOPED, LOW INTENSITY	141
EMERGENT HERBACEOUS WETLANDS	59
DEVELOPED, MEDIUM INTENSITY	44
BARREN LAND	16
OPEN WATER	15
DEVELOPED, HIGH INTENSITY	2
TOTAL	38,081

LAND USE CATEGORY	ACRES
CULTIVATED CROPS	23,601
EVERGREEN FOREST	4,984
DECIDUOUS FOREST	2,682
PASTURE/HAY	2,540
GRASSLAND/HERBACEOUS	1,006
MIXED FOREST	959
SHRUB/SCRUB	866
WOODY WETLAND	687

Table 3. Land occupied by solar PV systems 1 MW or greater in nameplate capacity by category from 2008 NLCD data

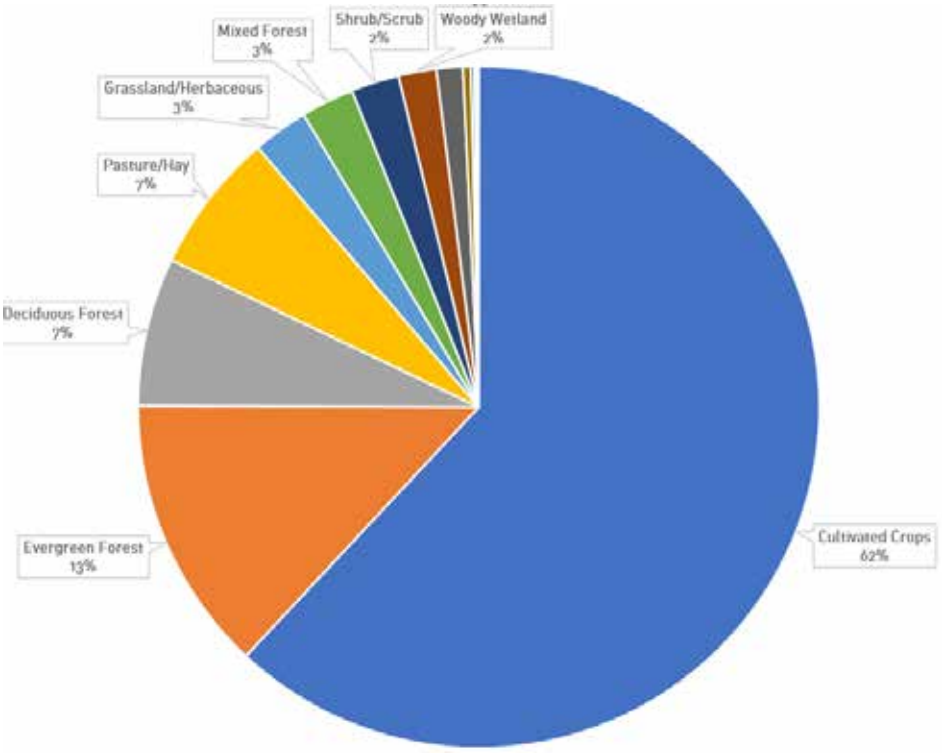


Figure 4. Breakdown of NLCD land use categories of NC solar installation footprints

NCSEA also calculated land use totals for the entire state of North Carolina from that same 2008 NLCD land use file.

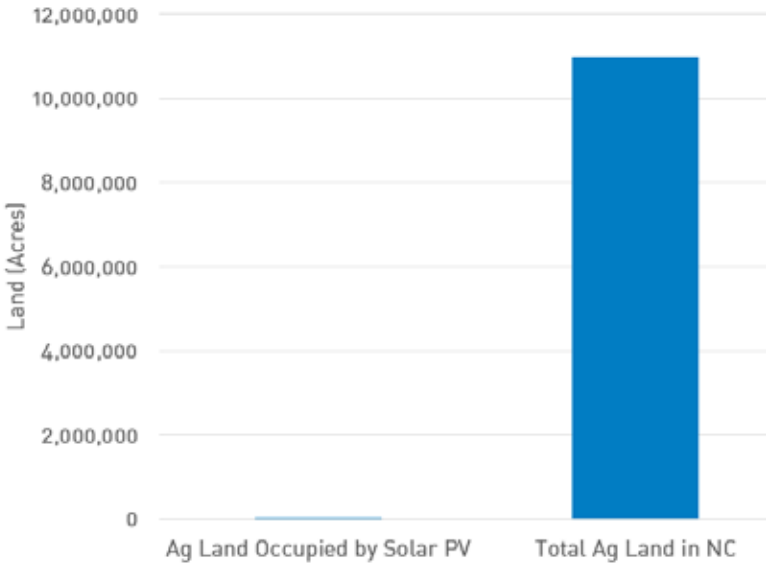
LAND USE CATEGORY	ACRES
DECIDUOUS FOREST	6,103,708
WOODY WETLAND	4,583,597
CULTIVATED CROPS	4,337,847
EVERGREEN FOREST	4,150,557
MIXED FOREST	3,241,144
PASTURE/HAY	2,511,251
DEVELOPED, OPEN SPACE	2,265,552
DEVELOPED, LOW INTENSITY	1,079,383

LAND USE CATEGORY	ACRES
SHRUB/SCRUB	1,024,732
GRASSLAND/HERBACEOUS	772,049
OPEN WATER	492,115
DEVELOPED, MEDIUM INTENSITY	396,321
EMERGENT HERBACEOUS WETLANDS	374,962
DEVELOPED, HIGH INTENSITY	137,789
BARREN LAND	66,608
TOTAL	31,537,616

Table 4. Land use categories from 2008 NLCD data for all of NC

Using similar designations from other agricultural land use studies, NCSEA combined the cultivated crops, pasture/hay, and evergreen forest categories to establish an agricultural land use category.

This means solar PV systems occupy 31,125 acres of a total 10,999,656 acres of agricultural land in North Carolina, or 0.28%. When compared to the land use data from the entire state, these solar PV systems occupy 0.12% of all the land in the state.



This means solar PV systems occupy 31,125 acres of a total 10,999,656 acres of agricultural land in North Carolina, **OR 0.28%**.

When compared to the land use data from the entire state, **THESE SOLAR PV SYSTEMS OCCUPY 0.12%** of all the land in the state.

Figure 5. Agricultural land occupied by solar PV systems and total agricultural land in North Carolina

Discussion

Solar PV systems in some cases do occupy formerly agricultural land; however, it is worth noting that these systems have contributed to much less agricultural land loss than other forms of development. According to a report from the American Farmland Trust highlighting data from 2001-2016, 731,600 acres of North Carolina farmland were developed in total.[22]

Not all the solar PV systems included in this analysis were installed during that period of time. If they were, the amount of agricultural land they occupy would only represent 4.25% of the total agricultural land lost. Other land uses, especially low-density residential development, comprise the lion's share of agriculture redevelopment with 78% of the total area loss.

Other land uses, especially low-density residential development, comprise the lion's share of agriculture redevelopment with 78% of the total area loss.

In the case of low-density residential development, this type of activity has a much more permanent impact on the landscape compared to solar PV systems, which oftentimes have a measurable lifespan.

For instance, this neighborhood in Johnston County has a total footprint of 330 acres, 150 of which are former cropland. This development not only includes homes, but also permanent roadways and utilities servicing each of the households.

Figure 6. Before (2005) and after (2021) aerial photos of a neighborhood in Johnston County

Highway construction is another significant type of land development, as seen with US 70 and I-795 in Goldsboro, NC.

Figure 7. Before (2000) and after (2021) construction of US 70 Bypass and I-795 in Goldsboro

Utility-scale solar PV systems have a typical lifespan of around 25 years. In some cases, these facilities may be modified or repowered at the end of their useful life, but they can also be returned to their previous land use provided that certain precautions are taken during the initial construction phases. The same cannot be said for these other types of land use.

Responsible Solar Land Use

Native Plants and Pollinators

While more solar PV systems and other forms of clean energy installations are needed to transition away from fossil fuels, they should not come at the expense of the natural features found on the land they occupy.

Organizations including The Nature Conservancy offer general principles when citing and constructing these systems to reduce their impact within local ecosystems but emphasize that specific recommendations will vary between specific locations. Recommendations include restoring native vegetation and grasslands, avoiding erosion, and steering clear of locations with high native biodiversity.[23]

Further, large-scale solar PV installations are an opportunity to develop pollinator habitats supportive of organisms such as bees and butterflies that are integral to various ecosystems. The North Carolina Pollinator Conservation Alliance provides a list of specific native species that should be considered, along with a series of recommendations outlining where to locate those plants in proximity to systems, while creating buffer areas around the solar PV systems themselves.[24]

Decommissioning

Utility-scale solar PV systems generally have a lifespan of around 25 years and unless they are repowered, these systems are usually removed from where they are installed. While there are concerns about the quality and usefulness of the land after that removal, utility-scale solar PV systems have minimal permanent environmental impact when the proper care is taken. Although decommissioning responsibilities are generally lease-specific and can sometimes be directed by a county ordinance, typically the project developer oversees removal.

As part of 2019's HB 329, the North Carolina General Assembly directed the NC Department of Environmental Quality (DEQ) to "establish a regulatory program to govern (i) the management of end-of-life photovoltaic modules....and (ii) decommissioning of utility-scale solar projects."[25] According to DEQ, this study found "financial assurance requirements are not necessary to ensure proper decommissioning."[26] Regardless, DEQ now recommends that currently operating systems can decommission according to their current plans but new systems will have to provide financial assurance mechanisms of some kind five years before their end of operation.[27]

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