Establishing Pollinator Habitat at Solar Farms in North Carolina: a Feasibility Study

By

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Abstract

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North Carolina's production of solar energy has undergone rapid growth since the implementation of the state's Renewable Portfolio Standard (RPS) in 2007. As of January 2015, there are 150 solar power generators, or solar farms, in operation in North Carolina (NC). There are plans to increase the capacity in operation from 573 megawatts (MW) to 3034 MW. The average size of solar farms in North Carolina is around 5 MW; a solar farm of this power generating capacity utilizes 42 acres as estimated by the National Renewable Energy Laboratory's (NREL) 2012 methods. As more large-scale solar farms are constructed, demands on land use will also continue to rise. Solar farms generally mow as needed throughout the growing season to keep vegetation from shading the solar panels and reducing their efficiency. By mowing, fossil fuels must be burned and large areas of potentially suitable habitat for wildlife are lost. This study addresses how land is being converted to accommodate for solar farms, and the potential for pollinator habitat to be established at solar farms in NC. Feasibility for the establishment of pollinator habitat was assessed based on previous land use, vegetation selection, and cost comparison with current management techniques. Fifty sites were sampled at random from a list of 477 existing and planned solar facilities registered with the North Carolina Renewable Energy Tracking System (NC-RETS) to assess their change in land use. Geographic and zoning information were provided from dockets filed on the North Carolina Utilities Commission (NCUC) website and county geographic information system (GIS) parcel data. The results of the sample indicate that the majority of the solar facilities were being constructed on land that was utilized for agricultural purposes. Other former land uses included forestry, landfill, airport, rural residential, industrial and commercial properties. Based on previous land use, alternative vegetation selection, and cost comparison with current vegetation management techniques, the potential to create pollinator habitat at solar farms in North Carolina is likely to be feasible.

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Biography

Airell Swanson graduated from the University of North Carolina at Wilmington with a Bachelor Degree of Science in Marine Biology in 2009. Post-graduation, Airell worked in the Gulf of Mexico following the MC-252 Deepwater Horizon oil spill, where he worked as a Marine Technician assisting in plankton and deep sea coral surveys. After working for Continental Shelf Associates in the Gulf of Mexico, Airell enrolled in NC State's Master of Environmental Assessment Program in 2013 to build upon his professional experience in assessing environmental issues. Airell has worked, and continues to work as a carpenter restoring historic homes in downtown Wilmington, North Carolina. Upon graduation, Airell will be taking an extended vacation to Costa Rica to hone his Spanish speaking skills, surfing, diving and fishing. While in Costa Rica, Airell will be seeking employment as an Environmental Scientist and would like to utilize his understanding of chemical interactions with biota and the natural environment. Airell is also interested in developing viable solutions to reducing anthropogenic impacts on the environment, as the human population continues to grow.

Table of Contents

Tables

Figures

Introduction

In efforts to reduce greenhouse gas emissions and dependency on limited fossil fuel reserves, utilization of renewable energy has been increasing worldwide (IPCC 2011, Shafiee and Topal 2009). The amount of electricity generated by solarvoltaic (SV) panels has been growing exponentially, and in recent years, has experienced growth rates of 30% per year (IPCC 2011). The potential for solar power to provide electricity exceeds other renewables like hydroelectric, and wind, as the sun provides more than 2500 TW of technically accessible energy over the earth's surface (Nelson 2003). Decreases in the price of solar panel production (Bazilian et al. 2013), improved solar technologies (Tyagi et al. 2013), and government incentives (Sarzynski et al. 2012) have fostered solar energy development. In addition to mitigating impacts to climate change and improving energy independence, solar energy provides benefits to job creation, improved quality of life in developing countries, and stabilization of degraded land.

North Carolina became the first state in the southeastern United States to adopt and implement a Renewable Portfolio Standard (RPS) in 2007. The goals of the RPS were to: "Diversify the resources used to reliably meet the energy needs of consumers in the State, provide greater energy security through the use of indigenous energy resources available within the State, encourage private investment in renewable energy and energy efficiency, and provide improved air quality and other benefits to energy consumers and citizens of the State" (Session Law 2007-397, Senate Bill 3) (Gaul and Carley 2012). Large tracts of agricultural land are being converted for utility scale solar installations in North Carolina as many farmers are attracted to the stability of income from solar farming. NC ranked second in the country in 2013 for added solar voltaic (SV) capacity, with 245 MW of utility-scale solar installations in operation (Lovelady, 2014). As of January 2015, the state currently has 150 solar farms in operation, with a capacity of 573 MW, and another 377 solar facilities with a capacity of 3,034 MW in various stages of planning and development (Brun 2015).

The National Renewable Energy Laboratories (NREL) conducted a study to estimate the land use of solar farms in the United States. Acreage was estimated for 72 percent of solar farms planned and operational in 2012. For small scale SV installations (1MW-20MW), direct land use was estimated at 5.9 MW/ acre and indirect land use was estimated at 8.3 MW/acre. For large scale SV installations (>20 MW), direct and indirect land use was estimated at 7.2 and 7.9 MW/acre respectively (NREL 2013). Direct land use was defined as the area directly covered by the panels; indirect land use was defined as the area included within the fenced in perimeter of the solar facility. As more solar farms are built in North Carolina, the amount of land occupied by solar farms will increase as a result. The North Carolina Renewable Tracking System (NC-RETS) was a program started by the North Carolina Utilities Commission (NCUC) to issue and track renewable energy certificates (REC). When a solar facility is planned to be built and become connected to the grid, it must register with the NC-RETS. Each facility registered with the NC-RETS has a docket associated with it that can be accessed by the public on the NCUC website, which contains registration statements and other documentation involved in the application and permitting process for solar development. There were a total of 477 facilities registered with the NC-RETS as of February 28, 2015 with an average size of 7.8 MW; the most common capacity (mode) was 5 MW.

Solar farms in the UK have demonstrated the ability to incorporate biodiversity management plans (BMP) into planning the operation and maintenance of solar farms (BRE 2014) by planting wildflower seed mixes that provide foraging habitat for pollinators between rows of solar panels. This management technique provides ecological enhancements for pollinators by creating areas of natural habitat, as opposed to mowing, which creates an area of low biodiversity. In addition, mowing requires the burning of fossil fuels and, thus, reduces the greenhouse gas benefit of the renewable energy generation. There has been an interest in exploring alternatives to mowing at solar farms and a need to consider the potential for solar farms to provide ecological benefits (Hernandez et al. 2014). This study aims to describe the potential for a more environmentally sound alternative.

Establishing wild flower meadows at solar farms could provide benefits to pollinators and solar farms alike. Bees and other pollinators, which humans depend on for much of our agricultural food production, are in need of habitat, as the loss of their habitat has largely attributed to their decline (Aizen 2009). By selecting for vegetation that would provide pollen and nectar to pollinators, while not exceeding a height that would shade solar panels, a potential alternative land management technique could be developed. The Xerces society, seed companies, and pollinator conservation groups, have developed seed mixes that can be tailored to meet the needs of solar farms and pollinators. Investigating landscape solutions to promote conservation of honeybees and other pollinators at North Carolina solar farms will provide a basis for assessing: the ability to create pollinator habitat at solar farms, logistics of implementing alternate groundcover, and environmental impacts associated with the proposed management strategy. This study will establish a foundation and develop criteria for consideration of the aforementioned alternative to mowing and other vegetation control techniques to be implemented at existing and planned solar farms in North Carolina.

Methods of Vegetation Control and Environmental Impacts of Solar Farms

A vital component to the long term success of solar facilities is ongoing maintenance of the facility's grounds which can be overlooked in the planning process of solar development. Solar farms manage vegetation in a variety of ways to prevent shading of solar panels. The following paragraphs outline the most common vegetation management strategies and their associated advantages and disadvantages.

Mowing is the most commonly observed method of vegetation control (Hernandez 2013). As long as the rows of solar panels are oriented such that a mower can fit between them, the majority of the facility can be bush-hogged with the use of a small farm tractor. The areas under solar panels that cannot be reached by a mower can later be cut with a trimmer. One disadvantage to this process, in addition to the ongoing costs, is that rocks and other debris can damage solar panels as they are ejected in the mowing process. A primary objective in utilizing solar energy is to reduce greenhouse gas emissions; mowing involves the burning of fossil fuels, which adds to greenhouse gas emissions and can be viewed as another disadvantage.

Sheep grazing at solar farms is a practice that has been used at some solar farms in North Carolina and is one that provides benefits to the environment and agriculture. Sunraised Farms™, a company operating in North Carolina, collaborates with local farmers and solar farm land managers to provide graze lands for the sheep and sustainable grounds maintenance for solar farms. The sheep rotate from solar farm to solar farm, on a schedule that permits grasses to regrow, and then be grazed again before they shade the solar panels. The sheep are harvested and butchered as adults and sold to food markets, one of which is Whole Foods™. This type of grounds maintenance capitalizes on the potential for solar farms to utilize their agricultural zoning for food and energy production.

Short growing grasses, and low growing ornamental plants are sometimes used as ground cover. Ornamental plant species are generally more expensive than other forms of vegetation, requiring watering and weeding, and would be best suited for use on small scale facilities. Low-grow grasses are an attractive option for solar farms in that they grow to a determinant height and can enhance the efficiency of solar panels in lower latitudes where temperatures are high and vegetation allows for absorption of heat that would otherwise be reradiated by bare earth (Hernandez 2013).

Other less desirable methods of vegetation control include spraying of herbicides, utilization of vegetation barriers, gravel, or mulch. Gravel and mulch can be very expensive when used on a large scale, and often times require intermittent spraying of weeds, as vegetation manages to grow through these types of barriers over time. Spraying of herbicides introduces chemicals into the environment, which is generally regarded as a negative impact due to the indiscriminate effects of eliminating plant life. One of the major drawbacks to completely stripping land of vegetation is that the land will not have the capacity to serve as a sink for carbon dioxide. Additionally, land cleared of vegetation is more susceptible to soil erosion than land that has been revegetated.

Solar farms are generally built on areas of land that are cleared of vegetation and graded as part of the construction process, although in some cases forested lands are cleared (Turney 2011). Dockets filed on the NCUC website are publicly available and contain documents produced in the application and construction process for solar farms including: applications for registration, state clearinghouse comments, and certificates for proposed construction. Prior to construction, sites must acquire permits for soil and erosion control from the North Carolina Department of Natural Resources (NCDENR) pursuant to The Sedimentation and Pollution Act of 1973. In some cases, other certifications such as Section 401 Water Quality permits are required depending on proximity to wetlands or other protected habitats. Review of site plans and comments are made by the North Carolina Wildlife Resources Commission (NCWRC) to ensure construction of the planned facility is in compliance with the State Environmental Policy Act (SEPA) (G.S. 113A-1 through 113A-10; 1 NCAC 25), and the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.). The State Clearinghouse handles interagency review of site plans and communication with companies involved with constructing solar facilities. The NCWRC makes recommendations based on site proximities to Natural Heritage Sites, areas that may contain endangered species, and other recommendations such as for the protection of wetlands through specified riparian buffers.

The NCWRC recommends re-vegetation of disturbed soils with a seed mix referred to as the "basic mix" with the addition of native species to enhance habitat for wildlife including wild turkeys, bobwhite quail, songbirds and other species. While the recommended seed mix provides habitat for bird species, it is not adequate for providing year round habitat for pollinators due to the relatively small blooming period of flowering plants contained in the mix. State Clearinghouse documents did not indicate whether or not it is mandatory that solar sites are re-vegetated per NCWRC recommendations. The NCWRC suggests that once the vegetation is established it requires little maintenance in terms of mowing, however a few of the species in table 1 grow to a height that would shade solar panels which would create the need to mow regularly throughout the growing season. Table 1 summarizes the basic mix and native species as suggested by the NCWRC with the expected height at maturity and seed cost. A further discussion of planting methodology, maintenance and costs are covered in more detail in the discussion section of establishing pollinator habitat portion of this paper.

Table 1. Suggested Vegetation by the NCWRC

Common Name	**Scientific Name**	**Height**	**Price/Lb.**	**Lbs./Acre**	**Approximate Price/Acre**
Oats, Wheat, Rye grain	N/A	8"-3'	$5-10 (Bag)	1-2 (Bags/acre)	$11.25
Red Clover	*Trifolium pretense*	1-3'	~$3	10	$30
Creeping Red Fescue	*Fescuta rubra*	1-3'	~$2-3	20	$50
Lanceleaf Coreopsis*	*Coreapsis lanceolata*	2-3'	~$14	1-2	$21
Deertongue*	*Dicanthelium clandestinum*	3-4'	~$12	1-2	$18
Black Eyed Susan*	*Rudbeckia hirta*	1-3'	~$16	1-2	$24
Showy Partridge Pea*	*Chamaecrista fasiculata*	2-3'	~$14	1-2	$21
Showy Tickseed*	*Bidens aristosa*	3-4'	~$16	1-2	$24
Switchgrass*	*Panicum virgatum*	4-6'	~$8	1-2	$12
Blue Bigstem*	*Andropogoa gerardii*	4-6'	~$10	1-2	$15

Basic vegetation mix with native species as advised for site re-vegetation by the NCWRC. As seen in Docket SP-3104, “State Clearinghouse’s Comments” for Mariposa Solar Facility in Gaston County, NC.
*Native Species

While the net environmental effects of solar farms are beneficial to humans and the environment, the fact that solar farms potentially utilize large areas of land cannot be ignored. Moving forward, as more solar farms are built, thousands of acres regionally and millions globally are likely to be impacted (Turney 2011). As land becomes scarcer, it will be increasingly necessary to consider the most efficient use of the land. By assessing the types of land solar farms are utilizing and the feasibility of creating pollinator habitat, alternatives to mowing, as well as the potential to mitigate land use impacts of solar farms can be investigated.

Assessment of Solar Farm Land Use in North Carolina

Methods

A database containing all registered renewable energy producing facilities in North Carolina as of February 28, 2015 was obtained from the NC RETS; the database contained operating and planned sites. The database was downloaded as a Microsoft Excel file. The file was first sorted by type of power generator, to omit other forms of renewable energy like biomass and hydroelectric. The file was then sorted by facility size. Projects with capacities of less than 2MW were omitted to exclude roof top and residential solar facilities. There were 471 remaining facilities after sorting the original file. In order to obtain a random sample of the remaining facilities, an Ablebits Microsoft Excel add-on was downloaded which enabled random shuffling of rows within a spreadsheet; each row represented a facility. After shuffling the facilities, the first 50 that could be located through docket information were analyzed.

Docket numbers for each facility were included in the spreadsheet. On the NCUC website, dockets are available to search and view by the public. As mentioned, within the dockets are registration sheets, reports of proposed construction, state clearinghouse comments, and other documents pertaining to the development and permitting of solar facilities. In the registration sheets, the user can find information that identifies the parcel of land occupied by the proposed solar facility. The location was as defined by the company constructing the facility. Locations were specified by geographic coordinates, addresses, and in some cases, by descriptions of proximity to intersecting roads. Site maps were also useful in identifying parcels where facilities were to be built.

Once the location and county of the facility was identified, the parcel was then located on the county GIS map in which the solar facility was to be built. By viewing the tax card for the parcel identified, the parcel ID or NC Parcel Identification Number (NC PIN) could be recorded as well as the zoning information. In addition to zoning information, land use descriptions on parcel tax cards further described whether the land was partially wooded, agricultural, vacant, residential, forested, commercial or industrial. Five sites were not evaluated due to certificate cancellation or the dockets containing insufficient information to locate the parcel, i.e. poor map imagery or poor description of site location. In order to maintain a total of fifty site evaluations, additional sites from the database were analyzed; a notation as to why the record was not used is included in the appendix. To evaluate the mode of solar farm capacities, Microsoft Excel's MODE.MULT function was applied to the database of 471 facilities registered with the NC-RETS (>2MW).

Results

Twenty-nine of fifty sites surveyed (58%) for previous land use category were entirely, or in part, utilized for agricultural crop production with a capacity of 171.2 MW and an estimated acreage of 1,421. Ten sites (20%) were zoned rural residential with a capacity of 49.9 MW and an estimated acreage of 414.. Five were industrial (10%) with a capacity of 35.5 MW and an estimated acreage of 295. Three sites were woodland (6%) with a capacity of 13.8 MW and an estimated acreage of 115. There was one commercial and one former landfill site, each with a capacity of 5 MW and an estimated acreage of 42 accounting for 2% of the entire sample. One site was at an airport with a capacity of 20 MW and an estimated acreage of 166. The most common site capacity was 5 MW. Table 1 summarizes the number sites surveyed by previous land use, and estimated acreage as determined by the NREL estimation methodology.

Table 2. Summary of Previous Land Use and Estimated Acreage

Previous Zoning/ Land Use	Count	Total MW	NREL Estimated Acreage*
Agriculture	29	171	1,421
Rural Residential (Vacant)	10	50	415
Industrial	5	36	295
Woodland	3	14	115
Commercial	1	5.0	42
Landfill	1	5.0	42
Airport	1	20	166

Summary of Previous Land Use and Estimated Indirect Land Use of Solar Farms
*Defined by NREL as 8.3 acres/MW for indirect land use

Discussion

Suitable habitat for pollinators and other wildlife could be created at most of the sites that were surveyed, although depending on zoning ordinances creation of habitat in industrial zones, commercial zones, or at airports may prove difficult. The most appropriate sites would likely be those that were utilized for agricultural production because of the increased fertility of soils and likelihood that they would be able to sustain vegetation to provide habitat. Figure 1 illustrates the change in land use for a 5 MW solar facility constructed on land that was previously used for agricultural production; the site is located in Bladen county, North Carolina (34°32’05.27” N, 78°48’55.81” W) and was assessed through docket SP-2296 sub 0, which can be found listed as the last record in the appendix.

Figure 1.

Bladenboro Solar Farm (5 MW) - A typical example of land use change for solar in NC from agricultural use to solar. Left side image taken 12-13-2012; right side image was taken 11-20-2013. Image Source: Google Earth

Establishing Pollinator Habitat

Crop Selection

Creating wildflower meadows at solar farms to provide habitat for pollinators requires implementing vegetation that meets certain criteria for both pollinators and solar farms. Vegetation height should be limited so that it does not shade solar panels, allowing for the panels to produce energy most efficiently. To provide pollinators with nectar and pollen, a selection of a variety of flowering plant species that produce these two resources throughout a long time window would be ideal. By developing a seed mix that selects for vegetation based on these criteria, a potential assemblage of flowering plants can be created that would be suitable for use at solar farms and create habitat for pollinators.

Table 3. American Meadows™, Solar Farm Color Turf Mix

Common Name	**Botanical Name**	**Flower Color**	**Height**	**Bloom Period**	**Type**
Hard Fescue*	*Festuca ovina*	NA	4-6"	NA	Perennial
Chewing Fescue*	*Fescuta commutate*	NA	8-12"	NA	Perennial
Creeping Red Fescue*	*Festuca rubra*	NA	8-12"	NA	Perennial
Perennial Ryegrass*	*Lolium perenne*	NA	12-24"	NA	Perennial
Kentucky Bluegrass*	*Poa pratensis*	NA	18-24"	NA	Perennial
Chinese Forget Me Not	*Cynoglossum amabile*	Blue	18-24"	spring-summer	Annual
Siberian Wallflower	*Cheiranthus allionii*	Orange	10-18"	Spring	Biennial
California Poppy	*Eschscholzia californica*	Orange	12-18"	spring-summer	Annual
Purple Coneflower	*Echinacea purpurea*	Pink, Purple	18-30"	Summer	Perennial
Single China Aster Mix	*Callistephus chinensis*	Pink, Purple, White	12-36"	summer-fall	Annual
Red Poppy	*Papaver rhoeas*	Red	12-30"	Summer	Annual
Lance Leaved Coreopsis	*Coreopsis lanceolata*	Yellow	18-36"	summer-fall	Perennial

Blue Flax	*Linum perenne*	Blue	18-30"	spring-summer	Perennial
Baby Blue Eyes	*Nemophilia menziesii*	Blue	4-12"	spring-summer	Annual
Globe Gilia	*Gilia capitate*	Blue	12-24"	Spring	Annual
Indian Blanket	*Gaillardia pulchella*	Red, Yellow	12-24"	Summer	Annual
Tidy Tips	*Layia platyglossa*	Yellow, White	6-12"	Summer	Annual
Plains Coreopsis	*Coreopsis tinctoria*	Red, Yellow	30-36"	summer-fall	Annual
Sweet Alyssum	*Lobularia maritima*	White	8-16"	spring-fall	Annual
Lavender Hyssop	*Agastache foeniculum*	Purple	<36"	summer-fall	Perennial
Fleabane Daisy	*Erigeron strigosus*	White	20-30"	spring-summer	Annual
New England Aster	*Aster novae-angliae*	Purple	<48"	late summer-fall	Perennial
Bergamot	*Monarda bradburiana*	Purple	12-24"	summer-fall	Perennial

*Grasses for sediment stabilization

Various seed companies and pollinator conservation groups, like the Xerces Society, have suggested seed mixes that provide pollen and nectar sources throughout most months of the year that can be tailored to meet the needs of pollinators and solar farms. By selecting species based on height, and flowering time with information provided in wildflower field guides from the United States Department of Agriculture, a wildflower seed mix of native and naturalized flowering plant species can be derived. Table 3 includes various species of annual and perennial wildflowers with attributes based on maximum height, flower color, and bloom period. This particular mix is provided by American Meadows™, a seed company that has created this mix specifically for solar farm re-vegetation and sediment stabilization. All of the species in Table 3 grow in North Carolina's predominant hardiness zones, which are zones 7b and 8a. It should be noted that this assemblage of vegetation is one of many that could potentially meet the criteria for establishing wildflower meadows at solar farms.

Site Preparation

Site preparation is a key step in establishing wildflower meadows. Land must be cleared of all vegetation as it would compete for resources and hinder growth of the desired vegetation. The best time to prepare a site for sowing wildflower seeds would be immediately after construction of the solar array is completed. When solar farms are built, land is graded and most, if not all, vegetation is removed. Soil can become compacted during the construction process, which would hinder the establishment of seeds, as their roots have difficulty penetrating the soil. In order to reverse soil compaction, tilling of the soil to a depth of 6" is recommended to allow for root penetration. This process would be followed by raking of the coarsely tilled soil to create a flat surface in preparation for seeding.

There are a few options for preparing a site that has been reestablished with grasses or weeds after the construction process. Tilling once a month throughout an entire growing season, covering the area with material that prevents penetration of sunlight and water, or a combination of tilling and spraying non-residual herbicide can prepare a site for planting. However, these methods can be expensive, time consuming, have negative environmental consequences and may require more time and energy than would be feasible for a large scale solar farm. The least expensive option for establishing pollinator habitat at solar farms would be to sow the fields soon after construction such that weeds would not have a chance to revegetate the site. This way, undesired vegetation would not need to be removed before sowing wildflower seeds which would involve added costs.

Planting and Maintenance

The NCWRC and American Meadows™ each have guidelines for planting and maintenance for areas that have been cleared and are ready to re-vegetate. American Meadows™ recommends that wildflower seeds be planted in the spring, summer, or fall. However, the heat of North Carolina's summers may prove too extreme for seed germination, without regular watering. The NCWRC states in their guidelines on seed mixes for re-vegetating disturbed sites that wildflower rich mixes be sown in the early fall, although early springtime planting would also permit cool, moist conditions. Seeds should be broadcast with a mechanical spreader, and pressed into the prepared soil by using a seed roller. Spreading straw helps stabilize soil while keeping the seeds moist for germination and prevents wildlife such as dove and quail from foraging excessively on the seeds.

Wildflower meadows are generally regarded as low-maintenance, which is to say there is some maintenance that extends beyond the work that goes into planting the first year. American Meadows™ recommends reseeding areas that have poor coverage the following spring. American Meadows™ also recommends mowing once each fall, when flowers have ripened and dropped their seeds. The entire area should be mowed to a height of 4-6 inches to prime the site for the next growing season.

Cost Analysis

This cost analysis is based on a 5 MW solar farm which is the most common size solar farm in North Carolina and as estimated by the NREL and would utilize about 42 acres. A properly sowed wildflower meadow would require little maintenance once established, whereas an unmanaged site would require regular mowing throughout the growing season. The upfront costs of establishing pollinator habitat based on seed and labor/equipment would be costly, but in the long run, a wildflower meadow would require less labor/equipment use than mowing, and could potentially serve as a cost effective alternative. The cost of seed as well as estimated yearly costs for yearly mowing, establishment of a wildflower meadow and an established meadow can be quantified. Table 4 summarizes these costs.

Table 4. Cost Analysis

	Mowing and Utilizing the NCFWS Mix	**Wildflower Meadow Year 1-2**	**Established Wildflower Meadow**
Labor Hours	64	32	16
Labor Rate ($/Hr)	30	30	30
Machine Hours	64	32	8
Machine Rate ($/Hr)	50	50	50
USFWS Seed Costs ($)	939	0	0
American Meadows™ Seed Cost ($)	0	8,215	1,643
Total	$6,059	$10,775	$2,523
Total Per Acre Per Year	$144	$257	$60
Lifetime Total (25 years)	$151,475	NA	$63,075

Summary of yearly costs associated with mowing and utilizing the NCFWS seed mix, establishment of a wildflower meadow in the first two years, and an established wildflower meadow.

The amount of seed needed varies based on how rich of a wildflower meadow is desired. American Meadows™ recommends for a meadow-like stand, spreading 11 pounds of their seed mix per acre; the cost for 10 pounds is $180. Therefore a 42 acre site would require 457 pounds of seed, which equates to $8,226. The cost of utilizing the NC WRC suggested mix has an average cost of $23 per acre which equates to $966 for a 42 acre area. Depending on the ratio of the different plant species in the NC WRC mix, the cost could fluctuate greatly as the range in cost per acre for this mix ranges from $11.25-$50 per acre.

The cost of yearly mowing has been estimated based on mowing eight times per year, and taking a full 8 hour work day to complete. The cost of establishing a wildflower meadow is based on tilling compacted soil and spreading seed, which has been estimated to take a total of four eight hour days. Labor and machine costs have been estimated at thirty and fifty dollars an hour respectively. For a well-established wildflower meadow it has been estimated that 20 percent of the meadow will need reseeding, which is represented by a seed cost of 20 percent of the first years cost; seed companies recommend that the established meadow is mowed once per year in the fall to a height of six inches. It has been estimated that between mowing and reseeding the wildflower meadow once per would take two eight hour workdays. While establishing a wildflower meadow is estimated to cost $10,775, which is roughly $4,500 more than annual mowing costs ($6,059), the cost of a well-established meadow (estimated at $2,523/year) could be far less expensive than mowing over the lifetime of a solar facility. Based on this analysis, over the course of 25 years, a wildflower meadow could save $77,625 in costs associated with mowing. $77,625 in savings has been estimated based on the cost of 20 percent reseeding annually and the first year's investment in seed subtracted from the cost of yearly mowing estimates multiplied by 25. It should be noted that labor and machine costs are based on estimates and could fluctuate according to the company providing the services or individual site.

Discussion

The objectives of this report were to sample a portion of solar facilities (planned and operational) to analyze how solar farms were utilizing land in North Carolina, based on their previous land use, quantify the approximate land use, and establish the feasibility for establishing pollinator habitat based on vegetation selection and projected costs. The results of the study indicate that solar farms are being built at a rapid pace in the state and are utilizing relatively large quantities of agricultural land that could potentially provide ecological benefits to pollinators.

Solar farms are well situated for pollinator, bird and small mammal preserves in that they are large areas of generally undisturbed land and are closed to the public and protected by fences and barbed wire. The crisis involving population declines of the honey bee, and other pollinators has become apparent in recent history. Habitat loss, which is believed to be a major contributor to population decline (Aizen 2009), could be mitigated through creating habitats at solar farms. Wildflower meadows beautify solar facilities and could potentially gain support from the public in serving to enhance the local ecosystem.

Countries such as the UK have well established solar facilities and guidelines for protecting biodiversity at these sites. In some cases, alliances have been formed between bee-conservation organizations and solar farms to establish habitat at these facilities. In the United States, there are advocacy organizations such as the Natural Resources Defense Council (NRDC) and Defenders of Wildlife, and non-governmental organizations like the Xerces society which strive to protect and improve pollinator habitat. As more agricultural land becomes occupied for solar farms in North Carolina the potential for establishing pollinator habitat will increase. Given the high upfront cost of establishing wildflower meadows, it would be interesting to see what kind of involvement or funding might be available through creating an alliance between solar developers and conservation trusts.

More research needs to be conducted to further evaluate which sites are best suited for habitat creation in terms of soil richness and proximity to other land uses. One potential problem may lie in the spraying of pesticides on adjacent parcels and the effect the pesticide drift may have on the species meant to be protected. Alternatively, crops that require pollination, such as cucumbers, watermelon, and blueberries could potentially receive great benefit when grown in proximity to pollinator habitat.

The wildflower mix as advertised by American Meadows™ is merely one of many options that could be suited for establishment of pollinator habitat. The mix could be tailored to include more or less of a certain species or even omit some of the taller varieties like the Plains Coreopsis (*Coreopsis tinctoria*) or New England Aster (*Aster novae-angliae*) which can grow to 36” and 48” respectively. A trained ecologist, plant biologist, or perhaps a team of conservation biologists could design and implement a site plan and BMP that would benefit wildlife and solar farms alike. The results of this study indicate that solar farms could potentially be suitable sites for pollinator habitat establishment as a long-term cost effective alternative to other vegetation management techniques.

References

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Appendix

Spreadsheet of Solar Farms Sampled from NCUC

Docket #	Sub	Company	Facility	Capacity (MW)	County	Parcel # or PIN	Landuse (Zoning)
SP-3604	0	TWE Laurinburg Solar Project, LLC	Laurinburg Solar	5.0	Scotland	010245 01045	Industrial
SP-4476	0	Boaz Farm Solar, LLC	Boaz Farm	5.0	Lee	965295899500	Rural Residential Vacant
SP-1912	0	Wilson Farm 1, LLC	Wilson Farm 1	5.0	Wilson	3734587838	Rural Residential Vacant
SP-362	3	QVC, Inc.	QVC Rocky Mount	2.5	Edgecombe	379913017400	Industrial
SP-4069	0	Green Solar Farm, LLC	Green Solar Farm	5.0	Martin	702819	Agricultural
SP-3798	0	Franklinton Solar, LLC	Franklinton Solar	5.0	Franklin	1894082556	Agricultural
SP-2443	0	Carthage Farm, LLC	Carthage Farm	7.0	Moore	863000612838	Agricultural
SP-2777	0	Angel Solar, LLC	Angel Solar	5.0	Catawba	364906494007	Rural Residential Vacant
SP-3671	0	Keen Farm, LLC	Keen Farm	5.0	Johnston	167100805761	Agricultural
SP-3214	0	Westside Solar Farm, LLC	Westside Solar Farm	3.8	Randolph	7740299264	Woodland
SP-3795	0	Guernsey Holdings, LLC	Guernsey Holdings	5.0	Anson	656100789963	Agricultural
SP-2971	0	Williamston West Farm, LLC	Williamston West Farm	5.0	Martin	702127	Agricultural
SP-2567	0	Shadow Solar, LLC	Shadow Solar	3.0	Rutherford	10740	Agricultural
SP-3379	0	Kinston Davis Farm, LLC	Kinston Davis Farm	5.0	Lenior	17999	Agricultural
SP-4405	0	Siler Solar, LLC	Siler Solar	5.0	Chatham	16070	Commercial
SP-4901	0	Fresh Air Energy XXXVIII, LLC	Boykin PV1	17.0	Cumberland	479452358	Agricultural
SP-4469	0	Thomas Solar 2, LLC	Thomas Solar 2	5.0	Insufficient information in docket		
SP-1636	0	Hutchinson Farm, LLC	Hutchinson Farm	5.0	Cleveland	26380	Rural Residential Vacant

SP-3031	0	Stagecoach Solar, LLC	Stagecoach Solar Farm	5.0	Vance	0375 01015	Rural Residential Vacant
SP-2374	0	Wadesboro Farm, LLC	Wadesboro Farm	5.0	Anson	647513144110	Agricultural
SP-2198	0	Roper Farm, LLC	Roper Farm	5.0	Cleveland	2573018945	Industrial
SP-1642	3	Apple, Inc.	PV2-Catawba County	20.0	Catawba	363709055767	Industrial
SP-2486	0	FLS Solar 200, LLC	FLS Solar 200	4.3	Robeson	31062296800	Agricultural
SP-3828	0	Sedberry Farm, LLC	Sedberry Farm	5.0	Moore	950400430850	Rural Residential Vacant
SP-2611	1	ESA Four Oaks NC I, LLC	Four Oaks Solar Farm	5.0	Johnston	167100426821	Agricultural
SP-3659	0	Faison Farm, LLC	Faison Farm	5.0	Duplin	256000014636	Agricultural
SP-4440	0	Spring Hope Solar 2, LLC	Spring Hope Solar 2	5.0	Insufficient information in docket		
SP-2898	0	Yanceyville Farm 3, LLC	Highway 62	5.0	Caswell	82029	Agricultural
SP-3675	0	Highwater Solar I, LLC	Highwater Solar	5.0	Wayne	3601140715 & 3601041212	Agricultural
SP-2922	0	Elroy Farm, LLC	Elroy Farm	5.0	Wayne	3528627420	Agricultural
SP-3145	0	Yadkin 601 Farm, LLC	Yadkin 601 Farm	5.0	Yadkin	489900940922	Agricultural
SP-3173	0	Auten Road Farm, LLC	Auten Road Farm	5.0	Gaston	3567223416	Former Landfill
SP-3104	0	Mariposa Solar Center, LLC	Mariposa Solar Center	5.0	Gaston	3579778630	Agricultural
SP-2273	1	Wayne Solar I, LLC	Wayne Solar	5.0	Insufficient information in docket		
SP-2904	0	FLS Solar 260, LLC	Walters Solar Farm	5.0	Robeson	928752017200	Rural Residential Vacant
SP-4767	0	Cotten Farm, LLC	Cotten Farm	5.0	Lee	964406820100	Rural Residential Vacant
SP-4446	0	Warrenton Solar 1, LLC	Warrenton Solar 1	5.0	Warren	2947200561	Agricultural/ Woodland

SP-2542	0	Brenden Solar, LLC	Brenden Solar	5.0	Certificate canceled		
SP-3438	0	Nitro Solar, LLC	Nitro Solar	5.0	Johnston	2000174788	Agricultural
SP-3377	0	Foxfire Farm, LLC	Foxfire Farm	5.0	Johnston	260300635402	Agricultural
SP-2710	0	Goldengate Farm, LLC	Goldengate Farm	5.0	Wayne	3529137763 & 3529235463	Woodland
SP-393	1	United Therapeutics Corporation	XPF Solar Field PV-1	3.0	Durham	73804861320	Industrial
SP-1304	1	Shannon Farm, LLC	Shannon Farm	5.0	Robeson	936919003600	Agricultural
SP-2042	1	Calypso Solar, LLC	Calypso Solar	5.0	Duplin	256000558367	Agricultural
SP-2665	13	Fresh Air Energy - II, LLC	Shawboro Road	20.0	Currituck	8958664814 &8958789045	Agricultural
SP-2471	0	Market Farm, LLC	Market Farm	5.0	Rockingham	890604921706	Rural Residential Vacant
SP-2509	0	Elmwood Solar, LLC	Elmwood Solar	3.0	Certificate canceled		
SP-3036	0	Vicksburg Solar, LLC	Vicksburg Solar Farm	5.0	Vance	53302001	Woodland
SP-2887	0	HXOap Solar One, LLC	HXOap Solar One	20.0	Halifax	397820819324	Airport
SP-3852	0	Floyd Solar, LLC	Floyd Solar	5.0	Robeson	925785898400	Agricultural
SP-4616	0	Chickenfoot Solar, LLC	Chickenfoot Solar Farm	5.0	Robeson	939150533400	Agricultural
SP-4842	0	GTP 2 LLC	GTP 2	5.0	Lenoir	452800651459	Agricultural
SP-4315	0	Cline Solar, LLC	Cline Solar	5.0	Insufficient information in docket		
SP-3930	0	Stikeleather Farm, LLC	Stikeleather Farm	5.0	Alexander	3778692786	Rural Residential Vacant
SP-4473	0	Exum Farm Solar, LLC	Exum Farm	5.0	Lenoir	456903028933	Agricultural
SP-2296	0	Bladenboro Farm,LLC	Bladenboro Farm	5.0	Bladen	25811664323	Agricultural