A Spatial Database of Existing and Potential North Carolina Renewable Energy (NCRE) Facilities and Resources

By

Helene Elise Cser

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Approved by advisory committee:

Committee Chair: Dr. Gary Blank
Committee Members: Dr. Robert Abt, Dr. Heather Cheshire, and Dr. Dennis Hazel

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Abstract

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        A detailed Geographic Information System (GIS) based database has been created to
show the locations of existing and potential renewable resources and their proximities to energy
facilities capable of harnessing the energy to meet the requirements stated in the NC Renewable
Energy and Energy Efficiency Portfolio Standard (REPS) and North Carolina's Strategic Plan for
Biofuels Leadership 2017. The purposes of this database are to (1) provide preliminary data to
interested parties and (2) encourage sustainable renewable energy development for North
Carolina. The renewable energy resources and facilities that are included in the database include:
animal waste, secondary fuels (biodiesel, biogas, and ethanol), processing residues, electrical
generators (co-firing coal plants, biomass facilities, wood fired boilers, operational and potential
landfill gas projects, solar, wind, and small hydroelectric sources). The database also contains
supporting data such as infrastructure, boundaries, and population centers.
        One problem with the wealth of resources is that they are widely dispersed across the
North Carolina landscape. The expected significance of this spatial database is that it will
provide a tool for encouraging economic growth within the renewable energy industry sector. It
will also provide a baseline state inventory and help ensure the sustainable development of
renewable energy. Those who will find this spatial database mapping useful include parties
interested and involved in sustainable renewable energy development, such as the scientific
community, energy developers, environmental groups, and local planners.
        The documentation and methods of data accumulation used to create this spatial database
consisting of existing and potential renewable resources datasets gathered and created are
provided. An overview of GIS (Geographic Information System) terminology, the geodatabase
structure, and an explanation of the format used to describe the spatial database is provided for
users new to GIS. A database assessment of the strengths, limitations, opportunities, and
potential problems are provided as well. The spatial database currently exists on a server that is
housed within the Forestry Department at the College of Natural Resources.
        It is recommended that all renewable energy data for North Carolina continue to be
consolidated into one spatial database and updated frequently in order to provide beneficial
information for all renewable energy sectors. The spatial database should be housed within an
organization that will maintain and update the data, provide an interactive web application, and
consulting services to interested parties. The organization that will house the spatial database
should form partnerships with various state agencies, non-profit and private organizations, and
universities. Finally, it is recommended that additional data and models be incorporated into the
database to allow for more in depth spatial analysis.

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A Spatial Database of Existing and Potential North Carolina Renewable Energy (NCRE) Facilities and Resources

SECTION 1

INTRODUCTION

In an effort to promote more renewable energy generation, the North Carolina General Assembly adopted Session Law 2007-397 (Senate Bill 3[1]), and adopted the Renewable Energy and Energy Efficiency Portfolio Standard (REPS). The REPS requires that 12.5% of North Carolina electric retail sales from investor owned utilities by 2021 and beyond be acquired from renewable energy sources or energy efficiency measures. Rural electric cooperatives and municipal suppliers are subject to a 10% REPS requirement. Utility companies have varied options:

- generating electric power at a new renewable energy facility,
- using existing facilities to generate electric from a renewable energy resource,
- implementing energy efficiency measures,
- purchasing electric power from a new renewable energy facility,
- purchasing renewable energy certificates from in-State or out-of-State new renewable energy facilities, and
- earning credits if renewable energy generated or saved for a particular calendar year exceeds legislation requirements.

Another act of legislation encouraging the use of biomass resources is North Carolina's Strategic Plan for Biofuels Leadership 2017[2] which states that 10% of liquid fuels sold in NC (approximately 600 million gallons) will come from biofuel resources grown and produced in the state.

A detailed Geographic Information System (GIS) based database has been created to show the locations of existing and potential renewable resources and their proximities to energy facilities capable of harnessing the energy to meet the requirements stated in the REPS and North Carolina's Strategic Plan for Biofuels Leadership 2017. The purposes of this database are to (1) provide preliminary data to interested parties and (2) encourage sustainable renewable energy development for North Carolina. Ultimately, mapping all existing and potential renewable resources in the state will prove useful for determining whether the state will be able to meet the requirements specified in the legislation. However, such a determination will require continued effort to expand the database and maintain the database currency as conditions change in the varied sectors that make up the database.

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[1] NC General Assembly: http://www.ncga.state.nc.us/gascripts/billlookup/billlookup.pl?Session=2007&BillID=S3
[2] NC Biofuels Center: http://www.biofuelscenter.org/

SECTION 2

BACKGROUND

North Carolina has a wealth of resources that can supply the demand for renewable energy development. The renewable energy resources and facilities that are included in the database include: animal waste, secondary fuels (biodiesel, biogas, and ethanol), processing residues, electrical generators (co-firing coal plants, biomass facilities, wood fired boilers, operational and potential landfill gas projects, solar, wind, and small hydroelectric sources). The database also contains supporting data such as infrastructure, boundaries, and population centers. One problem with the wealth of resources is that they are widely dispersed across the North Carolina landscape.

The NC REPS defines renewable energy facilities other than a hydroelectric power facility with a generation capacity of more than 10 megawatts, that either (1) generates electric power by the use of renewable energy resource, (2) generates useful, measurable combined heat and power derived from a renewable energy resource or (3) is a solar thermal energy facility[3]. According to the REPS renewable energy resources include: solar electric, solar thermal, wind, hydropower, geothermal, or ocean current or wave energy resource, a biomass resource (*please see Section 3.1 for full definition*), waste heat derived from a renewable energy resource and used to produce electricity or useful, measurable thermal energy at a retail electric customer's facility; or hydrogen derived from a renewable energy resource[4]. The definitions for renewable energy resources and facilities at this time are vague and open for interpretation by the Utilities Commission. This is a concern because it will impact the types of renewable energy development that will occur within the state.

This spatial database is a valuable tool for preliminary investigation when analyzing the current and potential renewable energy facilities and resources that exist within North Carolina. It was developed to encourage economic growth within the renewable energy industry sector and also as a service to provide data to interested parties within a timely manner. The primary goal was to consolidate data from various federal, state, and private organizations into one database through which spatial analysis can be performed. Spatial data layers were available via the internet in various data types such as tabular and spatial data, or were created in tabular form and spatially referenced. The spatial data layers within the database are available for the public to view on a web application[5] with an easy to use interface. The web application was chosen to allow interested parties who may not have experience with GIS applications, or compatible GIS software, the ability to obtain data and pose spatially based questions.

The expected significance of this spatial database is that it will provide a tool for encouraging economic growth within the renewable energy industry sector. It will also provide a baseline state inventory and help ensure the sustainable development of renewable energy. Those who will find this spatial database mapping useful include parties interested and involved in sustainable renewable energy development, such as the scientific community, energy developers, environmental groups, and local planners.

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[3] N.C. Gen. Stat.§ 62-133.7(a) (7).
[4] N.C. Gen. Stat.§ 62-133.7(a) (8).
[5] Please contact the NCSU Extension Forestry for information concerning the web application at (919) 515-5638.

SECTION 3

RENEWABLE ENERGY RESOURCES AND FACILIITES WITHIN NORTH CAROLINA: BIOMASS, SMALL HYDROELECTRIC, SOLAR, AND WIND

3.1   Biomass Resources

Senate Bill 3 specifies that biomass resources include agricultural waste, animal waste, wood waste, spent pulping liquors, combustible residues, combustible liquids, combustible gases, energy crops, or landfill methane[6]. North Carolina has significant biomass resources but determining the amount available has proven difficult to assess because the resources are widely scattered and the majority of the resource supplies other markets rather than generating electricity to be sold to the grid. A challenge that renewable biomass markets face is obtaining "an adequate supply of biomass fuel at a reasonable cost" (Anderson and Melnyk 26). The facilities to produce electricity from biomass such as sawmills and co-firing coal plants exist but an efficient transportation network does not exist and facilities close to the resource are lacking. It is suggested that in order to lower the fuel production cost biomass facilities are best "in small, distributed applications" (Anderson and Melnyk 26). A spatial database provides a planning tool that allows for new biomass facilities to be sited appropriately close to available resources. The following biomass resources will be briefly discussed with an analysis of datasets within the spatial database:

- Animal Wastes (swine, poultry, cattle)
- Processing Residues
- Secondary Fuels (biodiesel, biogas, ethanol)
- Landfill Methane
- Technology Options for Biomass Resources (co-firing coal plants, biomass facilities, poultry litter facilities, and wood fired boilers)

3.1.1   Animal Wastes

Swine, poultry, and cattle operations produce animal wastes that can be used to produce renewable energy. North Carolina produces a substantial amount of hog waste and harnessing this waste to produce biogas will provide energy and also alleviate environmental problems associated with this waste such as degraded water quality. These wastes can also be burned directly in certain boilers or gasifiers. The spatial database contains the spatial location of swine, dairy, and poultry farms *(Appendix, figures 1-3)*. It also contains proposed sites of electrical facilities that will produce electricity from poultry waste[7] *(Appendix, figure 4)*.

3.1.2   Processing Residues

The locations of wood fired boilers are part of the spatial database and will prove useful when identifying potential sources of processing residues *(Appendix, figure 5)*. Processing

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[6] N.C. Gen. Stat§ 62-133.7(8).
[7] The NC REPS clarifies that the generation of electricity from poultry waste will be combined with wood shavings, straw, rice hulls, or other bedding material, N.C. Gen. Stat.§ 62-133.7(f).

residues can be acquired after harvesting tree and agricultural crops, sawdust from sawmills, and byproducts such as bagasse[8]. The types of facilities that are included in the wood fired boiler data layer are: sawmills, pole manufacturing plants, veneer mills, plywood mills, pulp mills, furniture industries, and lumber and supply companies. The locations of sawmills without wood fired boilers and an assessment on how the residues at the current sawmills are used either for fuel or other purposes would prove useful for further analysis. Other processing residues that are not included in the database include pellets and briquettes which are an end product of utilizing processing residues to produce fuel for industry or household use.

3.1.3 Secondary Fuels (biodiesel, biogas, and ethanol)

The North Carolina Biofuels center is performing or funding research on lignocelluloses sources to produce biodiesel, biogasoline, and bioalcohols fuel from the following sources: woody biomass, miscanthus, switchgrass, crop residues, and algae. Starch and sugar sources to produce bioethanol include: tropical sugarbeets, industrial sweet potatoes, sweet sorghum, grain sorghum, barley, and duckweed. Oilseeds and lipids sources to produce biodiesel include: canola, sunflower, soybeans, camelina, safflower, cottonseed and algae. The spatial datasets that are within this database identify biodiesel distributors, corn refineries, and biogas resources.

Biodiesel

The production of biodiesel is necessary in order to provide a renewable fuel for the current transportation mix. Biodiesel is produced from vegetable oil or animal fats in a refining process referred to as transesterification which removes glycerin from the feedstock, which can be used to produce soap and other applications (Kessler 279). The spatial database contains a list of distributors in North Carolina but does not have data on the source of the fuel being distributed *(Appendix, figure 6)*. In order to reach North Carolina's Strategic Plan for Biofuels Leadership by 2017, the source of homegrown feedstocks should be recorded.

Biogas

Biogas is produced from a mixture of dung, organic matter, and water that ferment in a digester to produce methane and carbon dioxide. Biogas has an advantage in that it can utilize natural gas pipelines and energy systems designed for natural gas (Rosillo-Calle et al. 122). Biogas is another important resource that North Carolina can benefit from because the state ranks second behind Iowa for swine production in the United States. Other resources for biogas include landfill gas and municipal waste.

The spatial database currently contains the locations of all permitted swine and dairy farms in North Carolina, and landfill gas projects *(Appendix, figures 1-2 and 7)*. For the animal operations, the data include the population of animals for each permitted facility. Due to the isolation of most biogas resources it is most likely that renewable energy produced from these sources will be used to power facilities close to the production sites or electric power can be produced and delivered to the grid via a power-purchase agreement. The spatial database will allow for an analysis of the best locations to harvest biogas resources with respect to their location to electricity generators, natural gas pipelines, and transportation networks. For

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[8] Bagasse is crushed refuse from making sugar or ethanol fuel production.

example the greatest concentration of swine farms occurs in the rural areas of the southeastern part of state. Necessary infrastructure is lacking to distribute this biogas to population centers, but the possibility exists to provide renewable energy locally or to create a new distribution facility that can benefit from the utilization of this resource.

Ethanol

Ethanol can be produced locally from a variety of agricultural crops. In the United States most "ethanol is produced from two main plant sources: sugar plants (sugar cane, sugar beets) and starchy plants (wheat, corn)" (Alazard-Toux et al. 331-332). The North Carolina Biofuels center is currently researching different feedstocks in the forestry and agricultural sectors that are the most economically feasible to be grown within the state.

Sugar and starchy plants undergo a fermentation stage (sugars are converted into ethanol) and distillation process (alcohol is separated from water) to produce ethanol (Alazard-Toux et al. 331). Different feedstocks produce different byproducts. The most beneficial byproduct from sugar cane is bagasse that is used an energy source during the distillation process. The byproduct from sugar beets is essentially pulp and the byproduct from wheat and corn is stillage, also known as DDGS – Distiller's Dry Grain with Solubles (Alazard-Toux et al. 331). Pulp and DDGS are used in the animal feed market.

Producing ethanol in North Carolina is more likely to come from feedstocks such as switchgrass and from woody and non-woody biomass sources. The "production of ethanol from lignocelluloses biomass are the object of a great deal of research and development work" and many pilot facilities have been developed but production processes have not reached the commercial stage (Alazard-Toux et al. 379).   The NC Biofuels Center and NC State University are currently researching the economic vitality of woody biomass, switchgrass, and other feedstocks for North Carolina. A spatial dataset of ethanol facilities has been created for the database but currently only one facility exists that will use corn from the Midwest as its feedstock *(Appendix, figure 6)*. This is likely to change if cellulosic ethanol production becomes economically feasible in North Carolina.

3.1.4   Landfill Methane

Landfills contain a variety of organic materials that are decomposed by bacteria under anaerobic conditions which produces methane. Landfills that have a design capacity greater than or equal to 2.75 million tons and 2.5 million cubic meters and have a non-methane organic compound (NMOC) emission rate of 55 tons per year or more are subject to emission standards under North Carolina Air Quality Laws[9]. Landfills that meet this criteria are required to install a gas collection system and control the collected emissions through the use of one or more of the following control devices: an open flare system, control system that reduces NMOC by 98 weight percent, or an enclosed combustor that reduces the outlet of NMOC concentration to 20 parts per million as hexane by volume, or a dry basis of three percent oxygen, or less.[10]

Generating electricity from landfills is possible if a gas recovery program is in place. This is through the development of well fields and collection systems at the landfill. Collected methane can be used for on-site power generation or pipelined to another generating facility.

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[9]NCDENR, Division of Air Quality: http://daq.state.nc.us/rules/rules/Sec1700.shtml, (15A NCAC 02D.1703, (a).
[10] NCDENR, Division of Air Quality: http://daq.state.nc.us/rules/rules/Sec1700.shtml, (15A NCAC 02D.1703, (b).

This spatial database contains operating and potential landfill gas (LFG) projects developed by the Environmental Protection Agency (EPA) Landfill Methane Outreach Program in 2004[11] *(Appendix, figure 7)*. The statewide program NC GreenPower has three of the projects sites from the EPA Landfill Methane Outreach Program listed as program generators *(Appendix, figure 9)*.

3.1.5   Combustion Technology Options for Biomass Resources

Electricity can be generated from biomass feedstocks using the following combustion technology sources: utility scale boilers (co-firing coal plants and wood fired boilers), steam turbines, engine generator sets, and gasifiers. Practical wood fuel sources for the generation of heat or electricity "are wood residues from manufactures and mill residues, such as sawdust and shavings; discarded wood products, such as crates and pallets; woody yard trimmings diverted from landfills; and clean, nonhazardous wood debris resulting from construction and demolition work" (US/DOE 3). There are many conversion technologies to convert biomass into the following: heat, electricity, syngas, pyrolysis oil and by-products, biodiesel, ethanol, and biogas. The conversion technologies for biomass are best summarized in table 1.8 by Rosillo-Calle (18).

The cofiring of biomass in coal plants within North Carolina offers a great opportunity for utilizing biomass and providing renewable energy to the grid because it "can be blended with coal in differing proportions, ranging from 2 to 25 per cent or more" (Calle 19). The U.S. Department of Energy classified North Carolina as having "good" cofiring potential. Their analysis considered such factors as "average delivered state coal prices, estimated low-cost biomass residue supply density (heat content in Btu of estimated available low-cost biomass residues per year per square mile of state land area), and average state landfill tipping fees" (US/DOE 5). The spatial database contains coal plants within North Carolina that have the ability to co-fire biomass, or already use biomass as part of their generation mix *(Appendix, figure 8)*.

Wood fired boilers were included in the database because these facilities already combust biomass resources on site *(Appendix, figure 5)*. The data included in the spatial dataset will be useful for an analysis on the current combustion of biomass for a particular location. The active wood fired facilities include: sawmills, pole manufacturing plants, veneer mills, plywood mills, pulp mills, furniture industries, and lumber and supply companies.

3.2   Small Hydroelectric

The topography and stream network of North Carolina offer the opportunity to develop small hydropower projects throughout the state. Small hydropower projects currently exist and provide renewable energy to the grid through programs such as NC GreenPower[12]. There is a lot of disagreement about whether large hydropower facilities should be considered a renewable energy source and the distinction usually depends on how state legislation defines this source of energy. North Carolina has stated in the Renewable Energy and Energy Efficiency Portfolio Standard (REPS) that a hydropower electrical facility must be 10 MW or less to be considered a renewable energy resource[13].

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[11] EPA, Landfill Outreach Methane Program: http://www.epa.gov/lmop/.

[12] NC GreenPower is a statewide program that purchases renewable energy from program generators and supplies North Carolina's electrical grid with renewable energy.

[13] N.C. Gen. Stat.§ 62-133.7(a)(5).

Although current small hydropower projects exist in the North Carolina, the potential to harness hydropower in nontraditional areas exists such as "drinking water networks, raw or treated wastewater networks, rain water networks, and irrigation networks" (Chenal et al. 234). Adding turbines to wastewater networks provides energy to the grid. Turbines can either be placed before water flows to a wastewater treatment plant or after the wastewater treatment plant. "In both cases, the environmental impact from the turbine is positive, especially in the case of a turbine set after the wastewater treatment plant, since improving the oxygenation of the water on leaving the power plant is possible" (Chenal et al. 243).

Although data to perform an analysis on the feasibility of placing turbines into wastewater networks does not currently exist in the preliminary database, it should be considered in the future as another resource for supplying renewable energy to the grid. The database does however contain small hydropower electrical facilities that are part of the NC GreenPower program *(Appendix, figure 9)*.

3.3   Solar

Solar energy is basically energy derived from the sun in the form of solar radiation. Determining whether solar energy is active or passive depends on the technological application on how solar radiation is captured, converted, and distributed. Active solar energy applications use mechanical systems such as photovoltaic panels and solar thermal collectors to harness the energy. Passive systems harness solar radiation without the use of mechanical applications, for example orienting a building toward the sun, or using solar cookers. Solar energy has recently undergone many technological innovations and the industry is still adapting to compete against other sources of energy. At this time only active photovoltaic generator systems that supply excess energy to the grid via the NC GreenPower program are included in the database *(Appendix, figure 9)*.

3.4   Wind Energy

The best sites to harness wind energy in North Carolina are on top of ridges in the Appalachian Mountains and offshore wind resources. It is more likely that permitting for wind energy sites will be offshore due to the passing of a bill in August 2009 by the North Carolina senate that bans utility-scale wind turbines on mountain ridges. The bill has yet to pass the House. The controversy remains as a result of language within North Carolina's Mountain Ridge Protection Act of 1983 that allows for exceptions for tall buildings or structures that include "[s]tructures of a relatively slender nature and minor vertical projections of a parent building, including chimneys, flagpoles, flues, spires, steeples, belfries, cupolas, antennas, poles, wires, or windmills" (§113A-206, 3b[14].). The wind potential feature class within this spatial database identifies ideal areas for wind development in North Carolina along the coast and ridge tops that do not violate the Mountain Ridge Protection Act *(Appendix, figure 10)*. At this time only active wind generator systems that supply excess energy to the grid via the NC GreenPower program are included in the database *(Appendix, figure 9)*.

The best location to harness wind energy is at a location that "is large and sparsely populated, has strong, relatively persistent winds, and is located close to transmission lines" (Anderson and Melnyk 27). The wind potential dataset provides information where harnessing

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[14] http://www.ncga.state.nc.us/enactedlegislation/statutes/pdf/bysection/chapter_113a/gs_113a-206.pdf

wind power is the greatest but does not take into account other factors such as proximity to transmission lines or population centers. Supporting infrastructure for North Carolina is however, contained within the database to help analyze preliminary siting of wind energy projects.

SECTION 4

SPATIAL DATABASE DESIGN

This section documents the methods of data accumulation used to create this spatial database of existing and potential renewable resources and facilities and provides metadata for the datasets gathered and created. It also provides an overview of GIS (Geographic Information System) terminology, the geodatabase structure, and an explanation of the format used to describe the spatial database. The spatial database currently exists on a server that is housed within the Forestry Department at the College of Natural Resources.

4.1   Background for Users New to GIS

Information on renewable energy facilities or resources was compiled or created using ESRI ArcInfo Desktop Geographic Information System (GIS) software. Data formats used in ArcGIS software can be grouped into either the vector or raster data models. Both of these models represent spatial data that has been georeferenced to a particular location on earth's surface. All of the data contained within this spatial database are vector objects, i.e. data are represented spatially either as a point, line, or polygon. Point features represent objects that have no dimension; line features represent objects in one dimension; and polygon features represent areas. The raster data model will be discussed briefly below because this data model and other formats can be incorporated into a geodatabase model.

A raster data model is basically a grid that contains data as a "series of rows and columns" (Price 22). The rows and columns create small squares or pixels that contain a numeric code to describe the data. The pixel ground dimensions (x, y) define the resolution of the raster data.   Raster data are either discrete or continuous. Discrete data contain a relatively small number of distinct values; continuous raster data contain many different values that change rapidly within the data set. Common examples used to describe discrete data are road data, and elevation maps are an example of continuous data.

In a vector data model each feature contains information called attributes associated with the feature. Attributes are stored in a table that contains records for each feature. This allows for the spatial analysis of attribute information. A vector data model also stores features into single datasets called layers. Thus, if a group of similar point, line, or polygon data are stored together it is considered a feature class. The objects within this feature class share an attribute table and must contain the same feature type (point, line, or polygon). It is also important to note that vector data models can be classified as either topological or spaghetti models. "A spaghetti model simply stores features of the file as independent objects, unrelated to each other" (Price 24). In the topological model, topological relationships such as adjacency or connectivity can be defined for spatially related features.

The following different file formats were used to create this spatial database: shapefiles, geodatabases, and tables. A shapefile is a vector data file that contains only one feature class. The extension that is seen in ArcMap or ArcCatalog is .shp but multiple files exist separately and can be viewed outside of the software. A shapefile can contain the following files: "the .shp file stores the coordinate data; the .dbf file stores the attribute data; the .shx file stores the spatial index which speeds drawing and analysis; the .prj file stores projection information; the .avl is a stored legend; and the .xml file contains metadata" (Price 27-28). A shapefile must have the .shp, .dbf, and .shx files to open properly.

The spatial data sets or shapefiles were incorporated into a geodatabase and stored as a single file with a .gdb extension. A geodatabase uses "an underlying database system to operate" and can "store topological relationships between features and feature classes" (Price 25). The structure of a geodatabase contains feature classes that can exist independently or within a feature dataset that contains like data sets with the same coordinate system. Feature datasets are powerful because they "can store complex associations between feature classes, such as networks or topology" (Price 28). Essentially a geodatabase is a container that contains feature classes, layers, tables, relationships, and other objects.

The tables that exist in ArcINFO Desktop software are attribute tables, feature datasets and stand alone tables. A stand alone table contains records but does not contain a spatial reference and may be stored either as a dBase (.dbf) file or as comma-delimited text files (.csv). Tables containing x, y coordinate data can be spatially referenced as feature classes. An attribute table contains spatially referenced data with records for each feature in the dataset.

4.2   Description of Data

The following format will be used to describe the data contained within the NCRE (North Carolina Renewable Energy) geodatabase:

- Feature Dataset: A grouping of similar feature classes with the same coordinate system.
- Feature Class: Spatial data layer of similar objects.
- Projection: Converts a geographic coordinate system of spherical units to a planar coordinate system using mathematical equations.
- Metadata: simply data about the data, information is stored to document the data source, history, management, and uses. Metadata is stored within the actual feature class.
- Synopsis: Overview of what the data contains and how it can be spatially analyzed.
- Process Description: Describes the source of the data or how it was created or altered.
- Recommendations for the Feature Dataset: Feature classes that will add value to the current dataset or information that was currently not available that should be considered for future analysis.
- Known Error: Describes what type of error the dataset contains such as referential, topological, relative, or absolute error. Referential is "an error in reference to something, such as a wrong address, label, number, or name" (Tomlinson 39). A topological error is an error involving the topology of the spatial data set such as a dangle when two lines fail to connect or when polygons overlap one another. Relative error is "an error in the positioning of two objects relative to each other" (Tomlinson 39). Absolute error is an error in how the data was georeferenced.

Supplementary Datasets will have the following format:

- Feature Dataset
- Feature Class
- Projection
- Metadata
- Source of the Data
- Process Description: if dataset is altered.

4.3   Geodatabase Structure

The structure for the North Carolina Renewable Energy (NCRE) geodatabase is provided below as an outline. The feature classes within the feature datasets will be described in detail with an analysis on the strengths, weaknesses, opportunities, and threats for the data.

Geodatabase: NC_Renewable_Energy.gdb
      Feature Dataset: Biomass_Animal_Waste
           Feature Classes: Swine Farms, Dairy_Farms, Poultry_Farms
      Feature Dataset: Biomass_Biofuel
           Feature Classes: Biofuel_Distributors, Ethanol_Facilities,
           Construction_Waste_Demolition
      Feature Dataset: Electricity Generators
           Feature Classes: (Biomass, Biomass_Other, Biomass_Coal, and Coal_Plants),
           Poultry_Litter_Facility, Wood_Fired_Boilers, (Operational_LFG, and
           Potential_LFG)
      Feature Dataset: Wind_Potential
           Feature Class: NC_Wind_Potential
      Feature Dataset: Renewable Energy Programs
           Feature Classes: LFG_NCGreenPower, Wind_NCGreenPower,
           Solar_NCGreenPower, SmallHydro_NCGreenPower
      Feature Dataset: Population_Centers
           Feature Classes: NC_Cities, NC_County_Seat, NC_Major_City
      Feature Dataset: Boundaries
           Feature Classes: County_Boundaries, East, Charlotte, West, Northeast,
           Piedmont_Triad, Research_Triangle, Southeast
      Feature Dataset: Infrastructure
           Feature Classes: NC_DOT_Roads, Pipelines_Other_Transmission, Railroads,
           NC_Ports

4.3.1   Data Description

Feature Dataset: Biomass_Animal_Waste
Feature Classes: Swine Farms, Dairy_Farm, Poultry_Farms
Projection: NAD_1983_StatePlane_North_Carolina_FIPS_3200, in meters
Metadata: Yes

Synopsis: Those interested in methane capture projects and poultry waste sources will find the feature classes within this feature dataset useful. The feature class of animal operations from NCDENR has been modified to separate swine and dairy farms located in North Carolina. A feature class was created to identify swine operations containing an animal population greater than 2,000 because this size is more economically feasible for biogas projects. The poultry farms shapefile was created by RTI International with the collaboration of the University of Pennsylvania through the Models of Infectious Disease Agent Study[15]. A nationwide spatial layer for poultry operations with approximate farm locations and bird population estimates was generated from 2002 U.S. Census of Agriculture's County totals and other research.

Process Description:

Swine Farms and Dairy Farms

Source of data: NC DENR Div. of Water Quality, Non-Discharge Compliance/Enforcement Section, 20031204, onemap_prod.SDEADMIN.aop: NC Center for Geographic Information and Analysis, Raleigh, North Carolina. The original shapefile was modified to remove referential errors. Cattle and swine attributes were separated into individual shapefiles, and a query for swine populations above 2,000 was performed to create a new shapefile. The shapefile was then imported into the geodatabase.

Poultry Farms

Data was modified from the original source: U.S. Poultry Farms, https://www.epimodels.org/midas/pubsyntdata1.do;jsessionid=0a60c06530d8138ac9b331464b42 a4afbf52b4e807d8.e34OaNaMax8QaO0ObNmTbN8Ob350n6jAmljGr5XDqQLvpAe.

The poultry farms shapefile along with North Carolina County Boundaries was opened in ArcMap and the Clip-Analysis tool was used to obtain poultry farms within North Carolina. The layer was then exported to create a new shapefile. Original Metadata was imported and modified to include the changes to the data and projection. The shapefile was then imported into the geodatabase.

Known Errors:

Swine Farms and Dairy Farms

Referential errors were removed because animal operation points were located outside of the state boundary. Other referential errors may be the result of PO Boxes being used on the permit application instead of the farms physical address. The resulting point locations were not verified or checked for accuracy.

Poultry Farms

Referential errors will exist for this feature class because the locations of poultry farms were obtained using a probability surface model that excludes areas where farms will not occur such as residential areas, airports, commercial districts, etc. For additional information on how the data were derived please visit the website above and view the metadata for the original U.S. Poultry Farms shapefile.

- Strengths: Finding suitable locations for poultry litter facilities based on the population distribution of birds and transportation networks is one spatial analyst task that can be performed with the poultry farms feature class. The spatial locations of biomass resources to produce biogas from methane or electricity from poultry litter are also provided.

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[15] https://www.epimodels.org/midas/pubsyntdata1.do

- Weaknesses: A preliminary analysis of the feasibility of harnessing swine waste into a biofuel suggests that current infrastructure is lacking to distribute this fuel from the rural southeastern part of the state to population centers. With new technology and infrastructure this resource has the potential to provide biogas and provide environmental benefits. The data will need to be updated on a yearly basis to determine the available biomass supply based on animal population.
- Opportunities: Developing a model to determine an estimate of biogas for the swine and dairy farms based on animal population and annual volume of waste will provide potential investors and utility companies vital information on the availability of this resource. The model for biogas estimates should also incorporate infrastructure such as transmission lines to determine the viability of supplying electricity to the grid via a power-purchase agreement. Develop a model that can calculate the expected amount of electricity that a poultry litter facility can generate within a specified area.
- Threats: The referential errors for the swine and dairy farms occur because when obtaining a permit the exact address of the farming operation is not always given. Also, the poultry farm locations are not exact.

Feature Dataset: Biomass_Biofuel
Feature Class: Biofuel Distributors
Projection: NAD_1983_StatePlane_North_Carolina_FIPS_3200, in meters
Metadata: Yes
Synopsis: This feature dataset includes a listing of biofuel distributors located in North Carolina. The most common biofuels are biodiesel and ethanol.
Process Description: A list of Biofuel Distributors was obtained from the NC Solar Center Clean Transportation Fact Sheet. An excel datasheet was created and then the addresses were geocoded to obtain decimal degree coordinates for the study area. The excel file was then saved as a .csv file and placed into ArcCatalog. A feature class was created from the x, y data and added to ArcMap using the "add x, y data" tool. The layer was then exported and projected to match the database. The shapefile was then imported into the geodatabase.
Known Errors: Referential errors may exist if the addresses contained in the fact sheet are incorrect.

- Strengths: This feature class shows the spatial distribution of existing biofuel distributors within North Carolina.
- Weaknesses: Data does not exist for the amount of fuel distributed from the sites or the fuel type.
- Opportunities: Gather relevant information such as fuel type, fuel source, and yearly distributed amount to better assess the supply and demand for biofuels.
- Threats: It may prove difficult to obtain relevant information because some distributors may not wish to disclose such information. The data will also have to be updated annually to provide accurate figures of the amount of fuel distributed yearly and the fuel type.

Feature Dataset: Biomass_Biofuel
Feature Class: Ethanol Facilities
Projection: NAD_1983_StatePlane_North_Carolina_FIPS_3200, in meters
Metadata: Yes

Synopsis: This feature dataset was created to identify ethanol facilities in North Carolina and record the feedstock used to create ethanol fuel and the capacity of the refinery.
Process Description: At the time this feature class was created, only one ethanol facility was under construction. The decimal coordinates were obtained by looking up the parcel address from Hoke County's GIS website. The fuel type and plant capacity was obtained from online research. An excel file was created and then saved as a .csv file and placed into ArcCatalog. A feature class was then created from the x, y data and added to ArcMap using the "add x, y data" tool. The layer was then exported and projected to match the database. The shapefile was then imported into the geodatabase.
Known Errors: Errors at this time do not exist.

- Strengths: This feature class currently shows the spatial distribution of one ethanol facility but allows for new facilities to be entered into the database using basic editing tools in ArcMap. Applying a buffer to facilities within this feature class will be useful when performing crop yield analysis for potential biomass feedstocks.
- Weaknesses: The dataset does contain proposed facilities.
- Opportunities: Update the table to contain the feedstock sources and allow for proposed facilities to be included in the database.
- Threats: The need to continually update the dataset if proposed facilities are included. Also, production capacity will vary from year to year based on economic demand of ethanol fuel.

Feature Dataset: Biomass_Biofuel
Feature Class: Construction and Waste Demolition
Projection: NAD_1983_StatePlane_North_Carolina_FIPS_3200, in meters
Metadata: Yes
Synopsis: This feature dataset contains construction and waste demolition recycling facilities that produce boiler fuel from wood waste. The markets for these facilities include feedstock for engineered woods, landscape mulch, soil conditioner, animal bedding, compost additive, sewage sludge bulking medium, and boiler fuel. The top four recycled categories include wood, drywall/gypsum, paper, and metals. A benefit that these facilities provide is that it offers project developers a way to avoid landfill costs and keeps recyclable material out of landfills. Producing boiler fuel from urban wood waste displaces coal for electricity or steam generation.
Process Description: Gathering relevant data for this feature class is still in progress but one known facility was geocoded to obtain decimal degree coordinates. The excel file was then saved as a .csv file and placed into ArcCatalog. A feature class was created from the x, y data and added to ArcMap using the "add x, y data" tool. The layer was then exported and projected to match the database. The shapefile was then imported into the geodatabase.
Known Errors: Errors at this time do not exist.

- Strengths: The location of facilities that produce boiler fuel will prove useful to the biofuel industry seeking sources of boiler fuel within North Carolina.
- Weaknesses: Data set is not complete and is still in progress.
- Opportunities: Data for all North Carolina Construction and Waste Demolition Facilities that produce boiler fuel needs to be incorporated into the attribute table.
- Threats: No known threats at this time exist for this feature class.

Feature Dataset: Electricity Generators_Biomass
Feature Classes: Biomass_100PER, Biomass_Other, Coal_Biomass, Coal_Plants, and Potential_Cofire_Plants
Projection: NAD_1983_StatePlane_North_Carolina_FIPS_3200, in meters
Metadata: Yes
Synopsis: The data for electricity generators was obtained from the EPA, Clean Energy Resources, eGRID "Emissions & Generation Resource Integrated Database": http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html. The data contains detailed emissions profiles, generation resource mix (megawatt-hours and percent), identification, ownership, corporate affiliation, and coordinate information in latitude and longitude. The feature classes listed above are based on the resource fuel mixes used for electricity generation.
Process Description: Electricity generators with existing and potential biomass generation resource mixes were selected and placed in an excel file. Although the information is primarily used for air emissions, the spreadsheet contains valuable information for estimating the biomass potential that North Carolina could generate from these existing facilities. The excel file was saved as a .csv file and added as a layer into ArcMap using the "x, y coordinated (management)" tool. Layers were created by separating like attributes based on fuel source mixes. The layers were then exported to create separate shapefiles. The shapefiles were then imported into the geodatabase.
Known Errors: The only error that may exist is referential because the attribute information for the facilities is from 2005.

- Strengths: The feature classes are useful for determining facilities that are capable of cofiring biomass or those that currently produce electricity from biomass exclusively. The feature classes also provide an overview of where the most electrical generation exists and the jurisdiction of energy providers. The data contained within the attribute tables of these facilities are useful for determining the MW of electricity that can be generated from biomass based on the current resource mix or based on the boiler technology for the cofiring coal plants. The locations of these facilities are also helpful for the preliminary analysis of the best location to site a new biomass facility.
- Weaknesses: The dataset does not provide information on biomass feedstock sources currently being used to generate electricity.
- Opportunities: An estimate of biomass resources in proximity to the facility would be useful for further analysis such as creating buffers around facilities to determine transportation costs. Further analysis will facilitate the need to obtain accurate biomass resource estimates, and cost-analysis of electrical generation in proximity to the existing facilities.
- Threats: The data provided by the EPA have not been updated since 2005 and do not reflect accurate resource mixes used by the electrical facilities within the database. The data will need to be updated as soon as information becomes available and should only be used for preliminary analysis.

Feature Dataset: Electricity Generators
Feature Class: Poultry Litter Facility
Projection: NAD_1983_StatePlane_North_Carolina_FIPS_3200, in meters
Metadata: Yes

Synopsis: This feature dataset contains proposed facilities that will generate electricity from poultry litter, but the table is flexible to allow for permanent facilities to be added. The approximate location of the proposed facilities was obtained from internet research and other public sources.

Process Description: After researching the proposed sites an excel file was created and latitude and longitude coordinates were obtained from the proposed city location. The locations of the proposed sites are not exact due to lack of information regarding the parcels that the company planned to purchase. The excel data was then imported into ArcMap using the x, y coordinates to create a map layer. This map layer was then exported to create a shapefile. The shapefile was then imported into the geodatabase.

Known Error: Referential error will be high during the preliminary stages of site location. The shapefile will need to be updated once companies obtain permits from NCDENR to begin construction. Once permits are obtained the referential error will be low because the addresses of the facilities will be provided.

- Strengths: The spatial location of the proposed facilities along with the poultry farms shapefile allows for competition within the industry for feasible site locations. It also allows the general public to view where such facilities will likely occur.
- Weaknesses: The data within this feature class are strictly preliminary and do not provide an accurate spatial location of proposed facilities.
- Opportunities: Develop a model to estimate the amount of poultry litter in proximity to proposed facilities to allow for further analysis such as determining transportation costs.
- Threats: Proposed sites will be subject to change so the data will need to be updated as soon as information is made available to the public.

Feature Dataset: Electricity Generators
Feature Class: Wood Fired Boilers
Projection: NAD_1983_StatePlane_North_Carolina_FIPS_3200, in meters
Metadata: Yes
Synopsis: This feature dataset contains a feature class that includes all wood fired boilers within North Carolina. A description of the type of boiler and combustion technology is provided within the attribute table. The facilities listed must have a permit to operate and the data for individual companies was obtained from NCDENR.

Process Description: A list of 2009 Wood Fired Boilers for North Carolina was obtained from NCDENR as an excel file. The excel file was then geocoded to obtain decimal degree coordinates using the facility addresses. After geocoding the data it was saved as a .csv file and placed into ArcCatalog. A feature class from x, y data was created from the .csv file in ArcCatalog. The geographic projection was defined and then the shapefile was projected to match the coordinates of the database. The shapefile was then imported into the geodatabase.

Known Errors: Referential error may occur if facilities permits are no longer active.

- Strengths: Determining the location of sawmills with boilers, wood fired boilers, pulp mills, and other mills with boilers will be useful for those in the woody biomass industry and electrical companies who wish to assess the current demand and use of this natural resource. This feature class offers a better understanding of the infrastructure and network for the woody biomass industry.
- Weakness: The need to update the data will require reviewing and editing the data.

- Opportunities: It will prove useful to assess whether excess energy produced by such facilities has the potential to be sold to the grid to meet some of the requirements of North Carolina's Renewable Energy Portfolio Standard. Also, the amount of available biomass that the facility does not use should be incorporated into the table.
- Threats: The facilities within this database are subject to change during economic downturns and price changes in lumber.

Feature Dataset: Electricity Generators
Feature Classes: Operational_Landfill, and Potential_Landfill
Projection: NAD_1983_StatePlane_North_Carolina_FIPS_3200, in meters
Metadata: Yes
Synopsis: Methane capture from landfills is a renewable energy resource specified in the Renewable Energy portfolio Standard. All existing and potential landfill gas projects have been mapped for North Carolina. The data were generated by the EPA Landfill Methane Outreach Program in 2004 to assist governmental agencies and others in making management decisions through the use of a GIS. The spatial location of the operational and potential landfill gas projects provides important baseline data on the locations of facilities that are part of the program.
Process Description: The product was available as a free download from NC One Map, and the like attributes of existing and potential landfill gas projects were separated to create individual shapefiles. These shapefiles were then imported into the geodatabase.
Known Errors: The locations of the landfills in the database were obtained by latitude/longitude coordinates, physical address, or CGIA Solid Waste Facilities data. The locations of the landfills were then verified by using aerial photography.

- Strengths: City Planners and methane capture investors will find this data source particularly useful for determining future landfill gas projects.
- Weaknesses: An estimate of potential electrical generation output from potential landfill gas operations was not included in the table. The attribute tables contain basic information on the facilities and those interested in landfill gas projects will need to contact the EPA's Landfill Outreach Methane Program for more information.
- Opportunities: Update or obtain a new shapefile of landfill gas projects from the EPA when it is available.
- Threats: Updated data may not be available if EPA's Landfill Outreach Methane Program ceases to receive funding from the federal government.

Feature Dataset: Electricity Generators
Feature Classes: LFG_NCGreenPower, Small_HydroPower_NCGreenPower, Solar_NCGreenPower, Wind_NCGreenPower
Projection: NAD_1983_StatePlane_North_Carolina_FIPS_3200, in meters
Metadata: Yes
Synopsis: NC GreenPower is a statewide program that purchases renewable energy from program generators and supplies North Carolina's electrical grid with renewable energy. A shapefile of program generators was created to understand the distribution of renewable energy sites in North Carolina. This spatial dataset identifies areas where renewable energy development is lacking and where renewable energy policies or programs can be targeted. The

feature classes are also useful for locating potential sites where small renewable energy sites are most likely to occur.

Process Description: All data was obtained from NC Greenpower: http://www.ncgreenpower.org/resources/generators.php. An excel file was created during the summer of 2009 and participating generators were added to this database. Generator site locations were mapped using the latitude and longitude decimal degrees of the generators city location because the actual addresses of participating members are confidential. The excel file was then imported into ArcMap using the x; y coordinates to create a map layer. The like attributes of the feature classes listed above were selected to create new layers. The map layers were then exported to create separate shapefiles. The shapefiles were then imported into the geodatabase.

Known Errors: A high error tolerance exists due to the inaccuracy of site locations because NC GreenPower does not provide the physical addresses of the project locations

- Strengths: Provides the spatial distribution of program generators and the type of excess renewable energy that is being sold to the grid.
- Weaknesses: The exact location of generator sites is unknown. The dataset will require updates on a semi-annual basis and information will need to be extracted from the website and compared to existing data.
- Opportunities: Those interested in this program will need to contact NC Greenpower to obtain additional information. The service industry for installing and contracting renewable energy projects will find this information useful for market analysis on renewable energy demand in North Carolina.
- Threats: The usefulness of this data will depend on how often NC GreenPower's website is updated.

Feature Dataset: Wind_Potential
Feature Class: Wind_Potential
Projection: NAD_1983_StatePlane_North_Carolina_FIPS_3200, in meters
Metadata: Yes
Synopsis: The North Carolina State Energy Office[16] in the Department of Administration supported the NC Center for Geographic Information and Analysis to create a polygon shapefile that displays wind potential in North Carolina. The dataset was created to provide a resource tool for energy developers, government agencies, and others when determining the best location to site wind power. This feature class offers a great opportunity for the preliminary analysis of siting wind power facilities within North Carolina.

Process Description: A modified model developed for the State Energy Office by AWS Truewind, LLC of Albany, New York 2004, was used to develop a polygon layer of wind power potential in North Carolina. A wind power grid CD (floating point, 200 meter cells, UTM coordinates) provided by AWS True Wind, LLC, was copied by the NC Center for Geographic Information and Analysis (CGIA). CGIA then converted the raster to polygon using ArcGIS software's "simplify polygons" tool. The data was then reprojected to NC State Plane Coordinates: NAD_1983_StatePlane_North_Carolina_FIPS_3200, in meters. The US Department of Energy divides wind power potential into seven classifications based on Watts per square meter interval ranges. This classification was joined to the polygon attribute table.

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[16] http://www.windpoweringamerica.gov/maps_template.asp?stateab=nc

Metadata was then imported and the dataset copied. This shapefile was then imported into the geodatabase.

Known Errors: The source of the wind power data set is the State Energy Office with technical assistance from CGIA. The user must be sure to use the appropriate data set for the time period of interest. While efforts have been made to ensure that these data are accurate and reliable within the state of the art, CGIA cannot assume liability for any damages or misrepresentation caused by any inaccuracies in the data or as a result of changes to the data caused by system transfers (Source: NC State Energy Office, 20050908, onemap_prod.SDEADMIN.wndpwr: Renewable Energy Resources in North Carolina none, NC CGIA, Raleigh, NC).

- Strengths: The wind energy development industry, government agencies, and others will find this feature class particularly useful when making management decisions from a Geographic Information System.
- Weakness: This feature class does not take into account seabed geology, marine ecology, bird migration patterns, or restricted areas such as natural heritage sites.
- Opportunities: Those interested in wind power development will find this information useful for a preliminary investigation, but additional information such as census data will be necessary when determining the feasibility of supplying renewable energy to the grid. For specific areas of interest parcel data and zoning information will be necessary for the early stages of planning.
- Threats: This feature class is likely to change if new legislation bans wind power development on mountain ridge tops. If this occurs then the data will be need to be updated.

Supporting Documents to fulfill Map Requirements: These datasets are not evaluated for strengths, weaknesses, opportunities, or threats.

Feature Dataset: Population Centers
Feature Classes: NC_Cities, NC_County_Seat, NC_Major_City
Projection: NAD_1983_StatePlane_North_Carolina_FIPS_3200, in meters
Metadata: Yes
Source of Data: The original source of the data was created by the US Geologic Survey and was downloaded from:
http://coastalmap.marine.usgs.gov/GISdata/basemaps/usa/cities/citiesx020.zip.
Process Description: All cities located only in North Carolina were selected to create a map layer, and then exported to create a shapefile. Then using the NC_Cities shapefile, only the county seat cities were selected to create a map layer, then exported to create NC_County_Seat shapefile. Finally, the following major cities (Asheville, Charlotte, Durham, Fayetteville, Greensboro, Raleigh, Wilmington, and Winston Salem) were selected to create a map layer and then exported to create a shapefile. All shapefiles were then imported into the geodatabase.

Feature Dataset: County_Boundaries
Feature Classes: County_Boundaries, East, Charlotte, West, Northeast, Piedmont_Triad, Research_Triangle, Southeast
Projection: NAD_1983_StatePlane_North_Carolina_FIPS_3200, in meters
Metadata: Yes

Source of Data:
County Boundaries
The data was downloaded from the NC One Map website (http://www.nconemap.com/) and created by the NC Center for Geographic Information & Analysis.
Regions
The County_Boundaries shapefile above was the original source of data and economic regions were selected to create map layers, and then exported to create shapefiles.
Source of Economic regions: http://www.nccommerce.com/en/AboutNorthCarolina/Location/
Process Description:
County Boundaries
The original data was not altered. This shapefile was imported into the geodatabase.
Regions
Counties were broken down into regions by selecting the appropriate delineated counties and then the layers were exported to create shapefiles. The shapefiles were imported into the geodatabase.

Feature Dataset: Infrastructure
Feature Classes: NC_DOT_Roads, Pipelines_Other_Transmission, Railroads, NC_Ports
Projection: NAD_1983_StatePlane_North_Carolina_FIPS_3200, in meters
Metadata: Yes
Source of Data:
NC_DOT_Roads
The data was downloaded from the North Carolina Department of Transportation website, "Statewide Primary and Secondary Road Routes, LRS Routes Shapefile Format":
http://www.ncdot.org/it/gis/DataDistribution/DOTData/.
Pipelines_Other_Transmission
The layer name is "Transportation_Miscellaneous" and can be downloaded at:
http://www.nconemap.com/Default.aspx?tabid=286
Railroads
The layer name is "Railroads" and can be downloaded at:
http://www.nconemap.com/Default.aspx?tabid=286
NC_Ports
The excel file of port data can be downloaded at:
http://www.ndc.iwr.usace.army.mil/data/datapwd.htm
Process Description: The description for Ports will be described because it is the only dataset that was altered. Port facility data was downloaded as a .csv file from the US Army Corps of Engineers Navigation Data Center website. Port data for North Carolina was then extracted and columns were modified to either text or numeric fields, or deleted. A feature class from x, y data was created in ArcCatalog. The geographic projection was defined and then the data was projected to NAD_1983_StatePlane_FIPS_3200, in meters. Metadata was created using available information from US Army Corps of Engineers website:
http://www.ndc.iwr.usace.army.mil//metadata/Ports-met.html. The shapefiles were imported into the geodatabase.

4.3.2   Hardware and Software Used to Create the Geodatabase and Web Application

Hardware Description
Server: multiuser UNIX or Microsoft Windows server/workstations
CPU Speed: 1.6 GHz or higher
Memory/RAM: 2 GB
Display Properties: 24 bit color depth
Screen Resolution: 1024 x 768 or higher
Disk Space: 3.2 GB minimum

Software Description
Esri ArcInfo Desktop Version 9.3
Python for Geoprocessing
Internet Explorer 7.0
Windows Vista
ArcGIS Server

SECTION 5

DATABASE ASSESSMENT

5.1   Strengths

The creation of this database offers North Carolina a baseline inventory of renewable energy facility and resources as well as supplementary mapping data such as infrastructure and population centers. The database provides a preliminary analysis of rural areas and the potential to create green jobs. It also contains useful preliminary data for those interested in biogas projects from the swine and dairy industry. The potential to develop more landfill gas projects exists and the spatial location of these operations is included. Preliminary data to assess the feasibility of generating poultry litter and the location of proposed facilities is also provided.

The data are useful for determining large scale utility facilities that are capable of cofiring biomass or those that produce electricity from biomass exclusively. The data provide an overview of where the most electrical generation exists and the jurisdiction of energy providers. Useful data such as the amount of electricity produced at each plant as well as the percentage mixes of resources are provided within the attribute tables.

The spatial location of wood fired boilers provides useful information for the biomass industry and electrical companies in North Carolina and will facilitate a better understanding of the existing infrastructure of the woody biomass industry. These data will be useful for siting new facilities and identifying potential sources for densified biomass or processing residues.

The database contains biofuel data such as biofuel distributors, ethanol facilities, and construction waste and demolition facilities that produce boiler fuel. The data will be useful to biofuel industry and others who are interested in the availability of biofuel resources and facilities within North Carolina. Although the information contained within this biofuel feature dataset are not as extensive at the moment, the tables are flexible to incorporate more informative information as it becomes available.

The inclusion of NC GreenPower as a renewable energy program is important because it shows the distribution of participators and the type of excess energy that is being sold to the grid. The service industry for installing and contracting renewable energy projects will find this information useful for market analysis of renewable energy demand in North Carolina. The wind potential data set is helpful for those who wish to start a small scale generator and join this program. The wind potential data set also provides valuable information for siting large scale wind energy development sites.

5.2   Limitations

The greatest weakness for this database is that certain feature classes lack information that was not available during project research. Some of the data are lacking important information so it will be necessary to invest time and resources to gather additional existing data. It is also possible that desired data does not currently exist and will need to be created and placed into the geodatabase. Another weakness is that all information contained within this database is preliminary and at a relatively coarse scale and should be used only as an initial planning tool when assessing renewable energy resources and facilities within North Carolina.

The public web application does not provide models for analysis and is strictly set up as means to view a limited amount of the data within the geodatabase. This can viewed as a weakness to the web application user but analysis models have not been created at this time. Another limitation is that the web application can only be viewed when ArcServer is operating properly.

5.3   Opportunities

Many opportunities exist for enhancing the geodatabase such as creating models that will spatially analyze the data within the North Carolina Renewable Energy (NCRE) geodatabase. The flexibility to add more information to the feature datasets and edit existing data exists. A model that can calculate the potential biogas based on animal populations within a specified area would be useful for methane capture projects. Another opportunity for utilizing animal waste biomass data would be to create a model that can calculate the expected amount of electricity that a poultry facility can generate within a specified area. Models based on regional scales could also be incorporated into the database.

Additional data will be needed for each feature class when performing more site specific analysis of the data. The biofuel distributor's data set should be updated to include fuel type, fuel source, and yearly distributed amount to better assess the supply and demand for biofuels. The ethanol facilities should be updated to include proposed facilities as well as the source of feedstocks used to produce the fuel. The Construction and Waste Demolition Facilities data set needs information for all facilities in North Carolina that produce boiler fuel.

Other opportunities involve obtaining estimates on biomass resources such as agricultural crops, crop residues, and woody biomass. This is critical information that will need to be created based on estimates provided by the United States Agricultural Department. These data will also provide valuable information for creating new models that can estimate the amount of biomass available within the agricultural and forestry sectors.

5.4 Potential Problems

Data will need to be updated at least on an annual basis in order to be useful for encouraging economic growth to North Carolina. One difficulty faced, is obtaining updated data on a regular basis from government agencies and other sources. Data contained within the database will most be likely be a year or two old depending on how often it is updated. The most likely problem is lack of funding to hire a GIS Analyst or Technician which may result in a loss of data credibly.

A disclaimer is vital to ensure that interested parties are aware that the data contained within the dataset are for preliminary planning purposes only and may not reflect the current state of natural resources and facilities. Other perceived threats include technology mishaps such as database servers being down or lack of network privacy settings. Another perceived threat involves making decisions on what data should be available to the public and what data should be for internal assessment.

SECTION 6

RECOMMENDATIONS AND CONCLUSION

Cooperation between federal and state agencies, non-profit and private organizations is necessary to encourage renewable energy development within North Carolina. This consolidated spatial database was created to provide those interested in renewable energy development the ability to gain access to preliminary data in a timely manner. It is recommended that all renewable energy data for North Carolina continue to be consolidated into one spatial database and updated frequently in order to provide beneficial information for the following industries:

- Electrical power generation (public utilities, electric cooperatives, and potential private power plants)
- Transportation (production and distribution)
- Forestry and other manufacturing
- Renewable energy service industry and contractors
- Biofuels Industry
- Timber harvesting and feedstock supply
- Agriculture
- Feedstock harvesting specialists and processing facilities including pellet and torrefication plants

A spatial database will allow energy developers, investors, and policy makers the ability to obtain up-to-date information and ascertain whether the infrastructure and available resources can sustainably support a myriad of potential markets and energy projects.

The spatial database should be housed within an organization that will maintain and update the data and provide an interactive web application. The web application should provide spatial analysis tools that allow users to perform initial site assessments for their particular renewable energy interest. The ideal organization would be an extension service or an economic development department within a state commerce agency. The organization should have experience with performing spatial analysis with geographic information systems software.

A central database and web application will help expedite the planning process and allow developers to gain key contacts and information pertinent to the permitting process. The organization that will house the spatial database should perform partnerships with various state agencies, non-profit and private organizations, and universities. A partnership with all organizations involved with renewable energy development will provide interested parties with a wealth of information that will help developers make informed decisions regarding the sustainable use of natural resources within North Carolina.

The organization that will house the spatial database should be the primary contact that developers will consult with. This will help facilitate the planning process and provide a more consistent project relationship. By providing consulting services the energy developer will consult with one organization and in turn will receive guidance during the initial planning phase and important contacts and direction for other planning phases. This will help eliminate frustrations that developers face when a central agency for facilitating renewable energy development projects does not exist.

It is recommended that the spatial database incorporate agricultural crops, crop residues, sawmills without wood fired boilers and woody biomass to allow for more in depth analysis of biomass resources. Obtaining woody biomass data will prove difficult but it is a vital component that will need to be incorporated into the database. Models that allow for spatial analysis will also need to be incorporated into the database to answer questions that interested parties may have in a timely manner. It is also recommended that information resources such as county planning and state contacts be incorporated into the database.

It will be necessary to hire a project team consisting of a GIS analyst and technician to maintain and upgrade the database. A central server and network will also be necessary to house the data and the responsible organization will also need to make decisions on what information will be available to the public via the interactive web application.

The recommendations above were provided because the overall vision of this spatial database was to encourage more renewable energy development within North Carolina. Before the creation of this spatial database basic preliminary data such as infrastructure and existing renewable energy facilities and resources were scattered and buried within various federal and state agencies, and other sources. Other data simply did not have a spatial component associated with them. This spatial database, although preliminary, has the potential to become a powerful tool for assisting parties interested and involved in sustainable renewable energy development.

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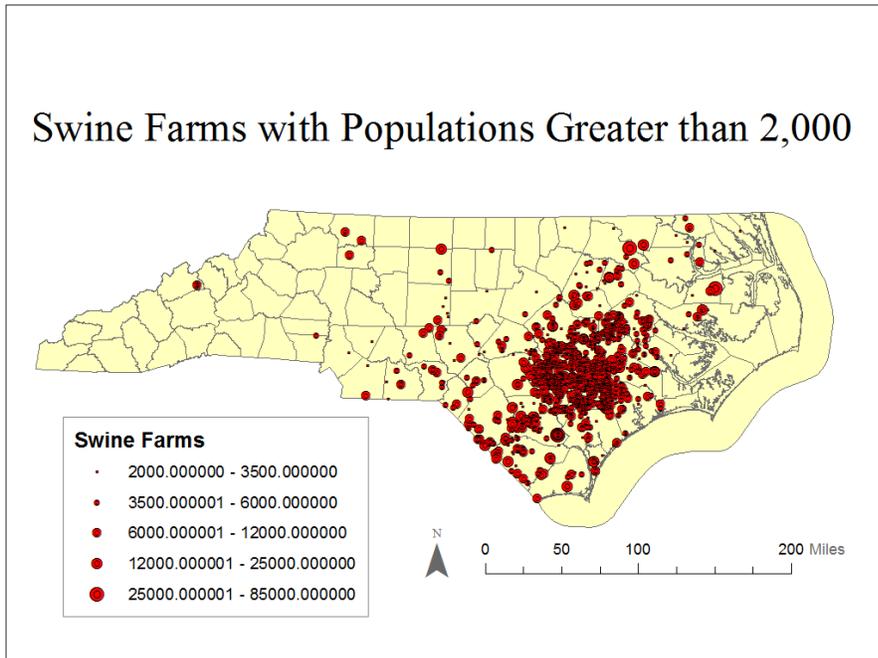
Appendix

Figure 1: Swine Farms
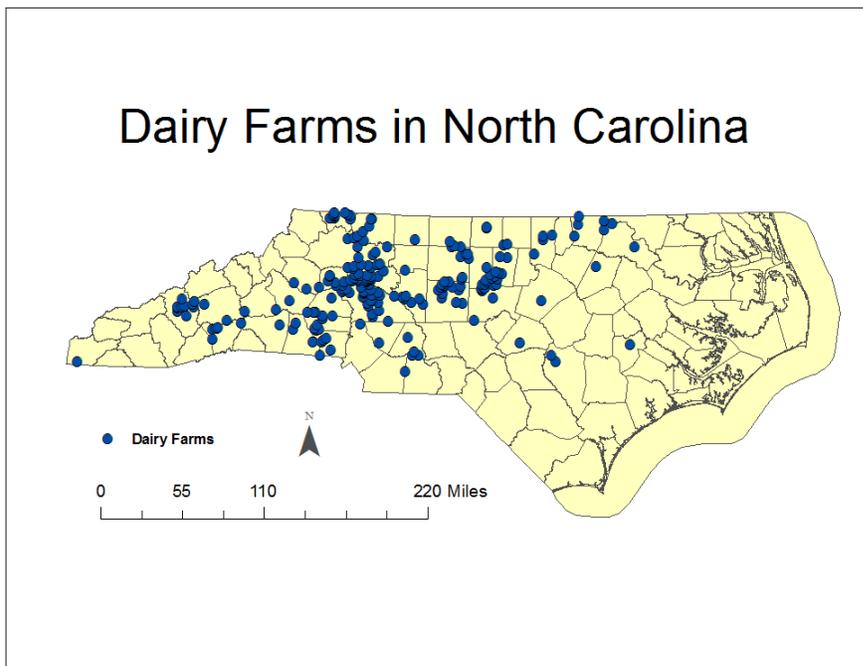

Figure 2: Dairy Farms

Figure 3: Poultry Farms

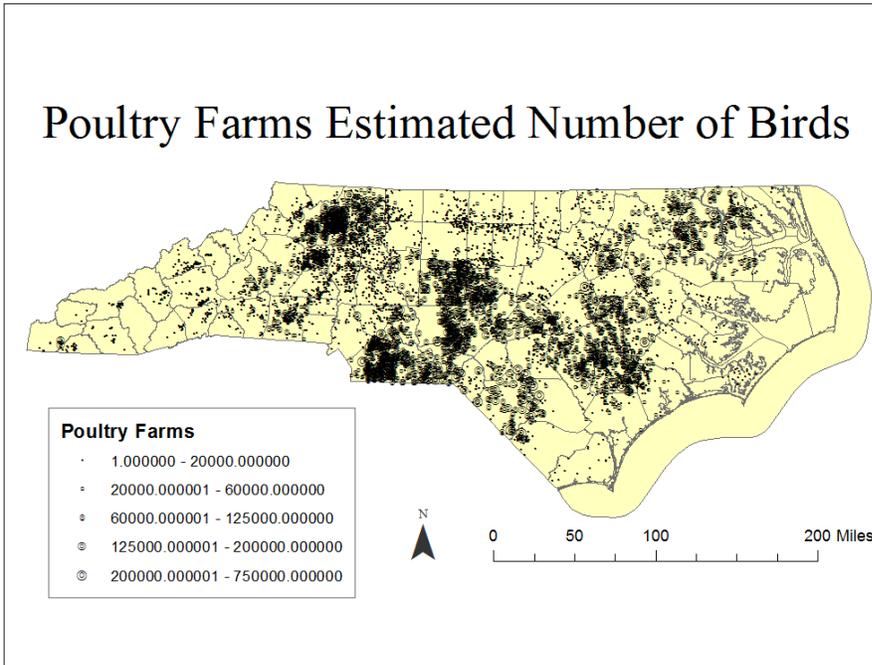
Figure 4: Proposed Poultry Waste Facilities
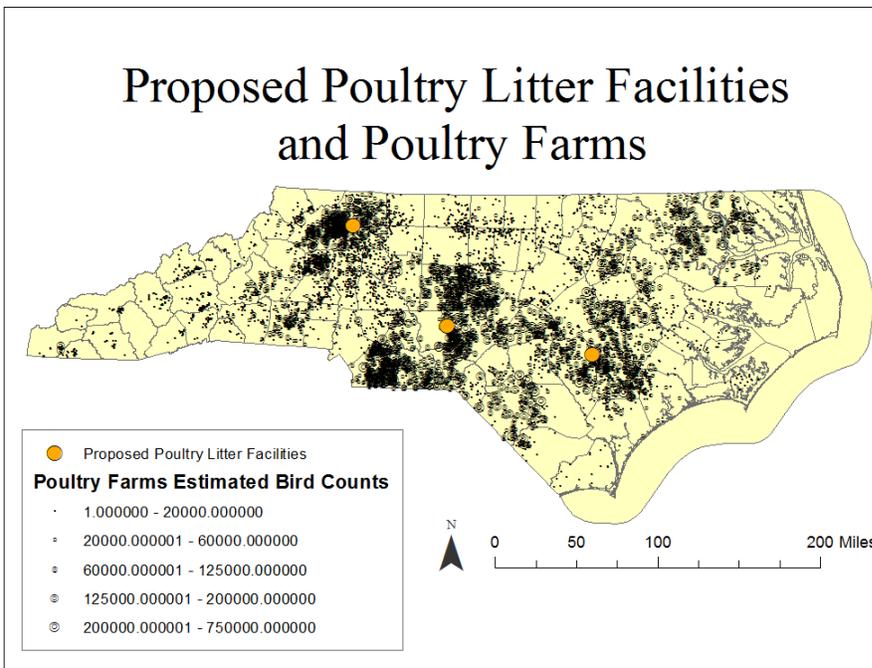
Figure 5: Processing Residues

Wood Fired Boilers

Figure 6: Biofuels

Biofuel Facilities and Distributors
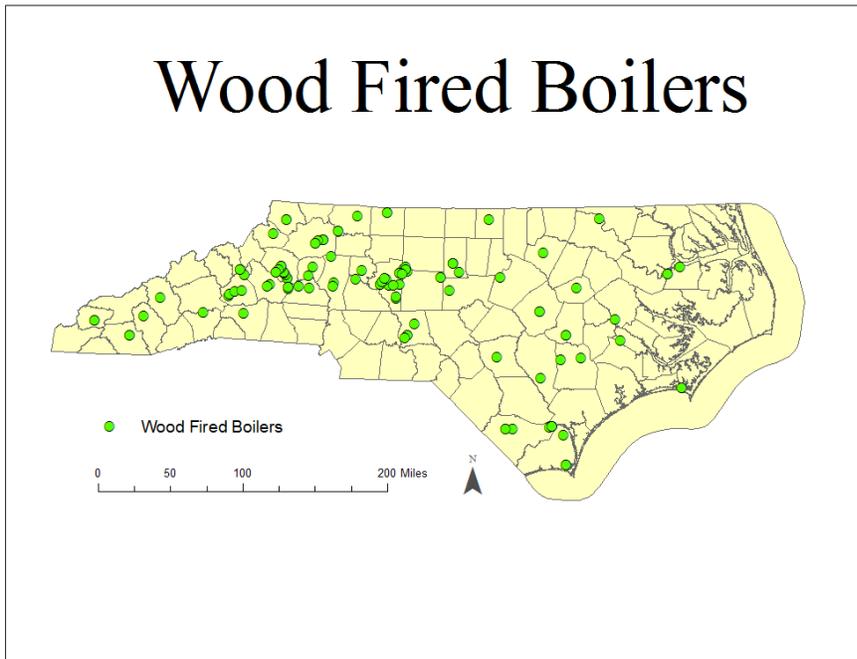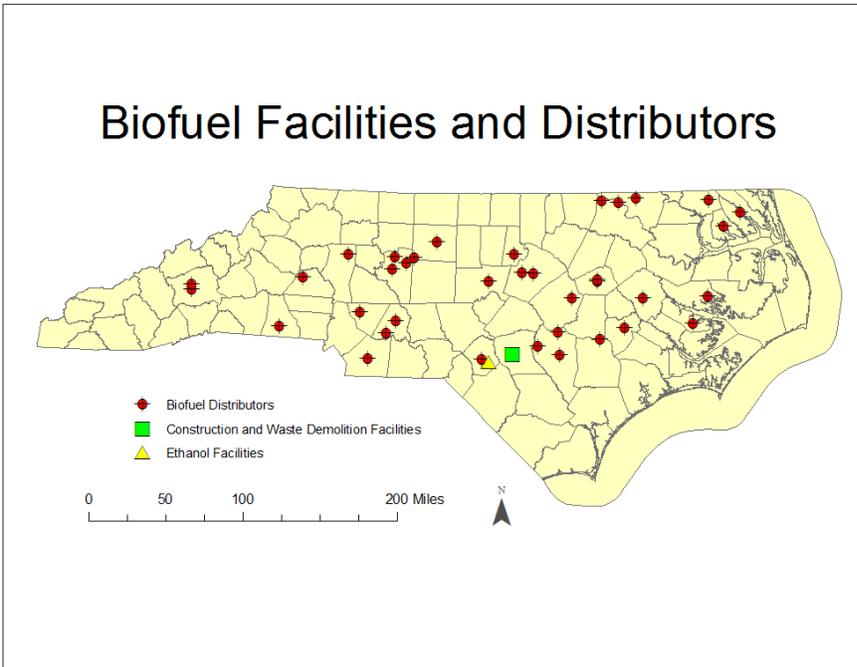
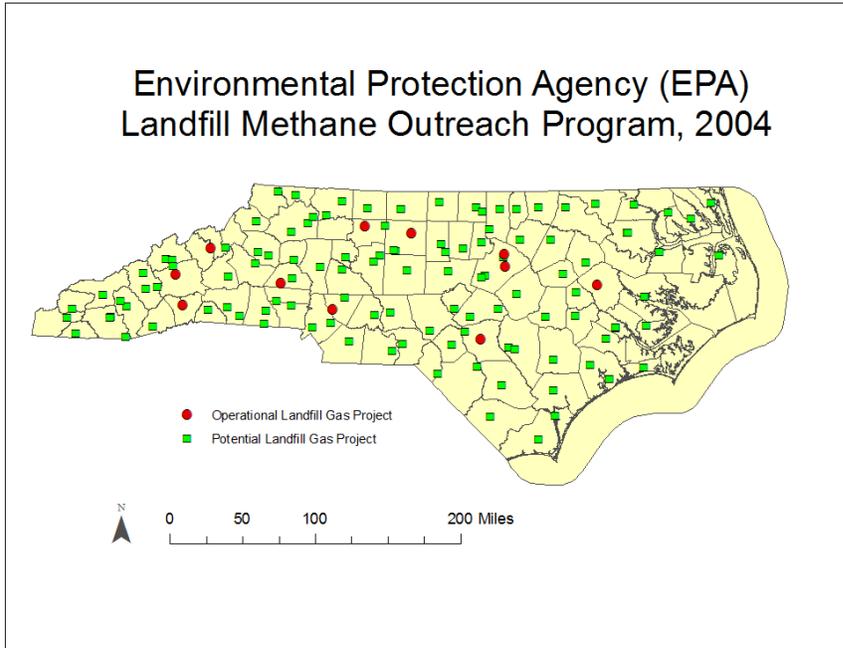Figure 7: Operational and Potential Landfill Gas Projects
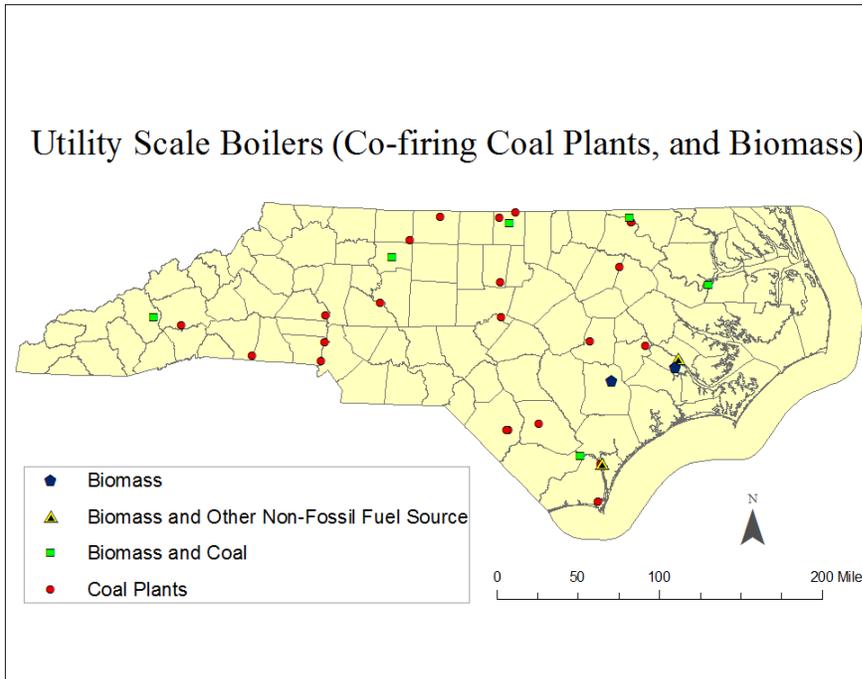

Figure 8: Utility Scale Boilers
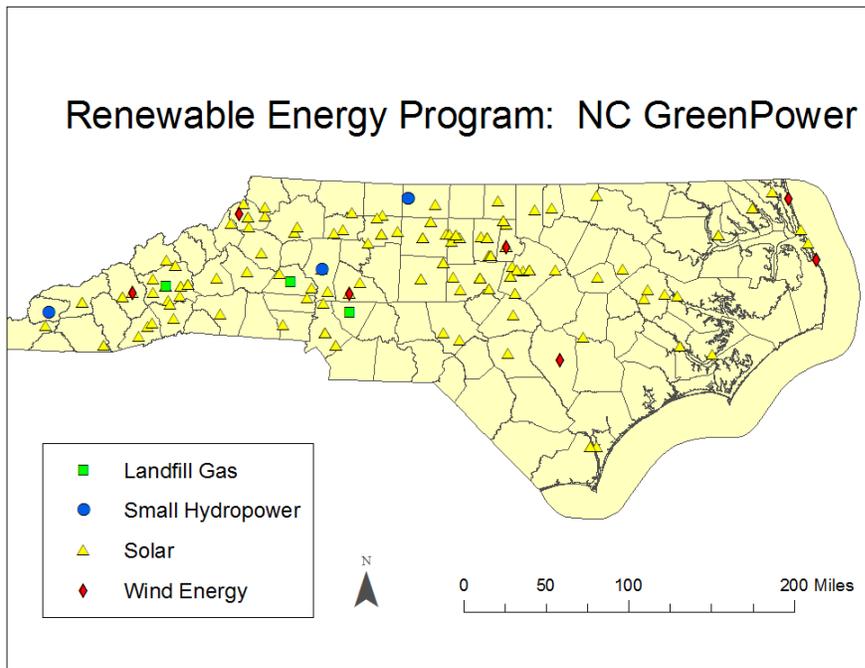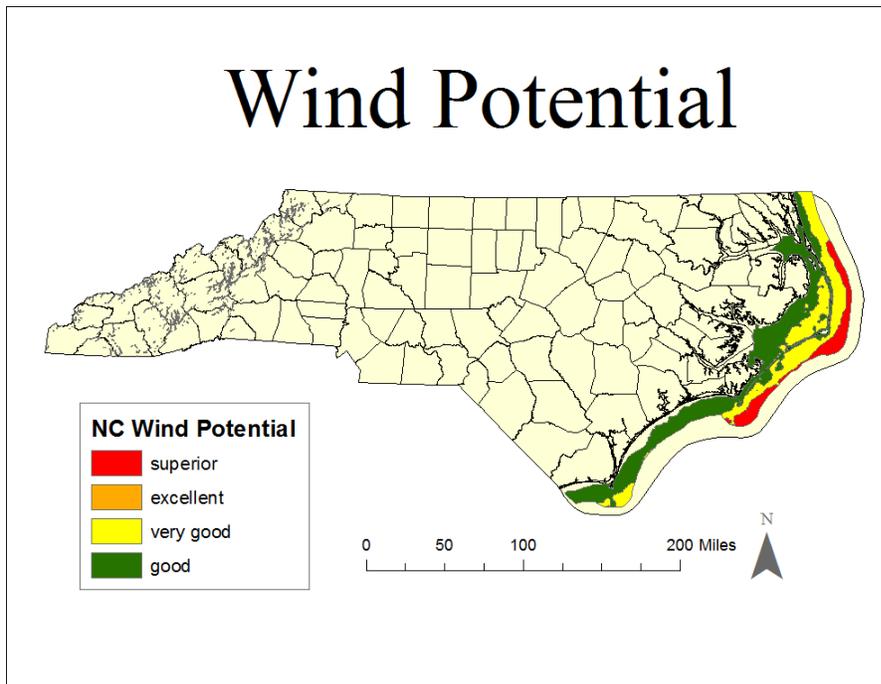
Figure 9: NC GreenPower

Figure 10: NC Wind Potential

Figure 11: Economic Regions and Major Cities

North Carolina Economic Regions and Major Cities

Major City
Charlotte
East
Northeast
Piedmont Triad
Research Triangle
Southeast
West

Winston-Salem
Greensboro
Durham
Raleigh
Asheville
Charlotte
Fayetteville
Wilmington

N

0   55   110   220 Miles