1.0 Executive Summary

This report presents North Carolina's greenhouse gas (GHG) inventory, a detailed accounting of anthropogenic GHGs emitted or removed by key source categories from 1990 to 2017.[1] In addition, the inventory projects North Carolina's GHG emissions from 2018 to 2030 based on forecasted changes in fuel use, land use, population, historical trends, and other factors. GHGs are air pollutants as defined by a United States Supreme Court decision and subject to regulation by the U.S. Environmental Protection Agency (EPA) under the Clean Air Act.[2] In the report body, only select years are presented; however, estimated GHG emissions data for all analysis years, from 1990 to 2030, are summarized in Appendix A.

The methods used to prepare the North Carolina inventory are based on those used to prepare the Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2016 (U.S. Inventory), annually published by EPA.[3] The U.S. Inventory includes estimates of historic anthropogenic emissions of GHG sources and carbon sinks by source category, economic sector, and GHG pollutant type starting from 1990 for the entire country.[4] It is calculated using methodologies consistent with those recommended in the 2006 Intergovernmental Panel on Climate Change Guidelines for National Greenhouse Gas Inventories (IPCC Guidelines).[5] The use of consistent methodologies ensures that GHG inventories prepared by states and other entities are comparable.

1.1 Greenhouse Gases Included in the Inventory

The North Carolina historic and projected emissions inventory presented here estimates emissions of the six primary anthropogenic GHG pollutants listed below.[6]

- carbon dioxide (CO_2)
- methane (CH_4)
- nitrous oxide (N_2O)
- hydrofluorocarbons (HFCs)
- perfluorocarbons (PFCs)
- sulfur hexafluoride (SF_6)

[1] Anthropogenic emissions are the portion of emissions to the atmosphere that are produced directly by human activities, such as fossil fuel combustion, manufacturing, and waste management practices.

[2] *Massachusetts et al. v. Environmental Protection Agency et al*., U.S. Supreme Court, 549 U.S. 497, April 2, 2007, https://www.supremecourt.gov/opinions/06pdf/05-1120.pdf.

[3] Draft Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2016, EPA 430-P-18-001, U.S. Environmental Protection Agency, Washington, D.C., February 6, 2018.

[4] Carbon sinks are natural or artificial reservoirs that accumulate and store a carbon-containing chemical compound (generally CO_2) for an extended period, such as the growth of newly planted trees in a sustainably managed forest.

[5] 2006 IPCC Guidelines for National Greenhouse Gas Inventories, The National Greenhouse Gas Inventories Programme, The Intergovernmental Panel on Climate Change. Hayama, Kanagawa, Japan, 2006, https://www.ipcc-nggip.iges.or.jp/public/2006gl/.

[6] These six compounds are being reported under the U.S. GHG reporting program. For information on each compound, see https://www.epa.gov/ghgemissions/overview-greenhouse-gases.

Emissions of each GHG are reported using the common metric "CO2 equivalent emissions (CO2e)." This approach normalizes the emissions of the various GHGs to reflect the global warming potential (GWP) of each compound with CO2 as a baseline. Using a common metric allows the quantity of each GHG compound emitted to be compared on the same basis. It also allows emissions of each GHG compound to be summed together to show the total impact of GHGs. For instance, it allows CH4 emitted from landfills to be compared to the aggregate of CO2, CH4 and N2O emitted from power plants. Appendix B contains a discussion on GWPs.

1.2 Emission Sources Included in the Inventory

North Carolina's GHG emissions inventory covers all GHG sources and carbon sink categories that are included in the national inventory prepared by EPA and are representative of activities occurring in our State. This includes emissions from Combustion Processes, Industrial Processes, and Waste Management activities. It also includes fugitive emissions from Natural Gas Transmission and Distribution systems, Agriculture Operations, and from Land Use activities such as fertilization and forest fires. Lastly, the emissions inventory includes estimates of the emissions associated with Imported Electricity consumed in North Carolina but generated outside the State. North Carolina's GHG inventory does not include coal, oil, and gas production, cement manufacture, lime manufacture, ammonia production, nitric acid production, adipic acid production, magnesium production, and the production of the refrigerant chlorodifluoromethane (HCFC-22) because these activities do not occur in the State.

Fuels derived from biomass sources, such as wood, ethanol, and landfill gas, are treated differently than fossil fuel sources in the inventory. CO2 emissions from the combustion of biomass are not included because they are considered carbon neutral under EPA and IPCC Guidelines. Under this approach, CO2 emissions from the combustion of biomass are offset by CO2 sequestered in the growth of new vegetation, resulting in zero net CO2 emissions. Some inventories report these emissions separately as "biogenic emissions;" however, this report, in keeping with the Guidelines, does not report biogenic CO2. There is considerable debate over the assumption that a biomass fuel is carbon neutral, and future inventories should include CO2 emissions from biomass combustion as a separate category of "biogenic CO2 emissions." Appendix C provides additional discussion on the treatment of CO2 emissions from biomass combustion. Note that emissions of CH4 and N2O from biomass combustion are reported in the inventory as part of gross GHG emissions since these human-induced emissions are not considered carbon neutral.

Changes in the growth, decay, storage, and use of the carbon-based stocks on North Carolina's managed lands, often referred to as carbon flux, are estimated for both the historic and projected emissions inventory. For most years, North Carolina's land use changes and forestry management practices result in a net sequestration of carbon and are reported as a carbon sink. (See Section 2.9.)

1.3 GHG Emissions Estimation Methods

Both the historic and projected GHG emissions are calculated primarily using the "State Inventory and Projection Tool (SIT)," a spreadsheet-based tool developed by EPA to assist state agencies in preparing state-level GHG inventories and projections.[7] The SIT automates the estimation procedures used by EPA to prepare the national GHG inventory for use in preparing state-level GHG inventories.

The SIT includes default data for North Carolina and other states supplied by EPA. The default data are generally publicly available information from various federal agencies such as the U.S. Department of Energy (DOE), U.S. Department of Agriculture (USDA), Federal Highway Administration (FHWA), U.S. Geological Survey (USGS), U.S. Census Bureau, and EPA. These data are frequently used by state and local agencies to develop air pollutant emissions inventories. A limited number of source categories contained in the SIT (e.g., fertilizer application) utilize data obtained from third party vendors. Where default data were unavailable or considered inferior relative to other information sources, data obtained from state agencies is used in the SIT to provide more accurate emissions estimates for North Carolina. Examples of state-specific refinements include: (1) replacing the default CH_4 emission factor for natural gas compressor stations to reflect the average emissions of North Carolina compressor stations that report to EPA's GHG Reporting Program; (2) adding North Carolina poultry production data obtained from NC Department of Agriculture and Consumer Services where no default data are included in the SIT Wastewater Module; and (3) using waste in place data from the North Carolina Division of Waste Management. The data sources used to estimate emissions are documented in Section 3.0 of this report.

Uncertainty associated with the default data available in the SIT tool is located in each SIT module under the tab labeled "Uncertainty."[11] A discussion of the uncertainty associated with the data and methodology used outside of the SIT tool is available upon request. .

Table 1-1 summarizes the estimates of North Carolina's historical and projected GHG emissions and carbon sinks from 1990 through 2030.[8] Some important details about the table are listed below.

- Emissions are presented in million metric tons as CO_2 equivalent emissions (MMT CO_2e).
- CO_2 emissions from biomass combustion activities are not included.
- The inventory is presented as both gross emissions and net emissions (emissions minus carbon sinks) since targets for GHG emissions reductions are generally expressed as net emissions.
- Emissions reductions are presented for a base year of 2005 out to 2025, which corresponds with the baseline and projection years specified by the Paris Agreement, an

[7] State Inventory and Projection Tool, US Environmental Protection Agency, https://www.epa.gov/statelocalenergy/download-state-inventory-and-projection-tool accessed January 3, 2018.

[8] The data for all years are presented in Appendix A.

agreement within the United Nations Framework Convention on Climate Change (UNFCCC) dealing with greenhouse-gas-emissions mitigation, adaptation, and finance.[9]

Based on the estimated emissions in Table 1-1, North Carolina's gross GHG emissions in 2017 are about 148 MMT CO_2e.[10] Accounting for carbon sinks, North Carolina's net GHG emissions in 2017 are estimated at 114 MMT CO_2e and are projected to decrease to 104 MMT CO_2e by 2025. Using a base year of 2005, North Carolina reduced its net GHG emissions by 25% between 2005 and 2017. North Carolina's projected net GHG reductions for 2025 are 32%, which is below the U.S. commitment to reduce GHG emissions by 26% to 28% by 2025 under the Paris Agreement.[11]

Table 1-1: North Carolina GHG Emissions Inventory by Source Sector (MMT CO_2e)

Sector	1990	2005	2012	2015	2017	2020	2025	2030
Electricity Use	**54.57**	**79.37**	**66.85**	**58.48**	**52.60**	**45.74**	**40.59**	**42.46**
Electric Power Generation	46.28	73.27	55.95	51.10	45.32	38.34	32.99	34.70
*Imported Electricity**	8.29	6.10	10.90	7.37	7.28	7.39	7.60	7.76
Residential/Commercial/Industrial Combustion**	**26.77**	**26.02**	**18.66**	**21.15**	**20.92**	**22.52**	**23.26**	**23.92**
Industrial	17.59	14.21	10.00	9.97	9.93	11.32	12.16	12.62
Commercial	3.79	5.06	4.17	5.76	5.72	5.84	5.76	5.93
Residential	5.39	6.75	4.48	5.43	5.28	5.36	5.35	5.38
Transportation	**40.24**	**55.26**	**46.57**	**48.29**	**46.43**	**43.75**	**40.37**	**38.91**
Gasoline & Diesel Highway	35.14	48.19	41.70	43.26	41.35	38.50	34.88	33.20
Non-Highway	5.07	6.97	4.74	4.90	4.92	5.05	5.23	5.45
Alternative Fuel Vehicles	0.03	0.09	0.12	0.12	0.15	0.20	0.25	0.26
Agriculture	**7.06**	**10.65**	**10.56**	**10.38**	**10.53**	**10.51**	**10.47**	**10.44**
Manure Management	2.59	6.02	5.63	5.90	6.05	6.06	6.09	6.11
Agricultural Soil Management	2.87	2.74	3.18	2.74	2.84	2.82	2.78	2.75
Enteric Fermentation	1.60	1.89	1.74	1.73	1.64	1.63	1.60	1.58
Burning of Agricultural Crop Waste	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Waste Management	**6.39**	**8.52**	**9.09**	**8.44**	**8.77**	**9.29**	**10.17**	**11.07**
Municipal Solid Waste	5.47	7.23	7.52	6.82	7.09	7.52	8.26	9.00
Wastewater	0.92	1.29	1.57	1.61	1.68	1.77	1.92	2.06
Industrial Processes	**1.04**	**3.83**	**5.39**	**6.03**	**7.18**	**8.84**	**11.31**	**12.73**
Natural Gas and Oil Systems	**0.86**	**1.17**	**1.28**	**1.32**	**1.35**	**1.40**	**1.47**	**1.55**
Gross Emissions	**136.92**	**184.81**	**158.39**	**154.08**	**147.79**	**142.04**	**137.65**	**141.07**
Net Carbon Sinks - LULUCF***	-35.64	-32.66	-33.97	-34.16	-34.03	-34.03	-34.03	-34.03
Net Emissions	**101.28**	**152.14**	**124.42**	**119.92**	**113.76**	**108.02**	**103.62**	**107.04**
Percent Reduction in Net Emissions from 2005					**25%**		**32%**	

Note: Totals may not equal exact sum of subtotals shown in this table due to independent rounding.
* Assumes all electricity generated in North Carolina is consumed in-state and includes emissions from Imported Electricity use that occur outside North Carolina.
** Represents emissions associated with on-site fuel combustion activities in the Residential, Commercial, and Industrial sectors.
*** Land Use, Land Use Changes and Forestry

[9] https://treaties.un.org/pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXVII-7-d&chapter=27&clang=_en
[10] 2015 is the last year of historic GHG emissions data. 2017 is a short-term projection of GHG emissions and is treated as historical data for this analysis.
[11] Cover Note INDC and Accompanying Information, UNFCCC http://www4.unfccc.int/submissions/INDC/

1.4 Reference Case Projection

The projection of the GHG inventory includes all sectors that were estimated for the historic inventory. The projection represents a single reference case for future GHG emissions. No future year scenarios are included in the projections since potential scenarios have not been quantified at this time. This reference case projection will be used to evaluate the impact of future scenarios with policies, programs, or rules that increase or decrease emissions.

There is uncertainty in this reference case projection due to EPA's potential replacement of several regulations involving GHG emissions including; 1) fossil fuel power plant CO_2 emissions, 2) landfill CH_4 emissions 3) corporate average fuel economy (CAFE) standards for vehicles, and 4) phasedown of HFCs under the Montreal Protocol.[12,13] The reference projection still includes the emissions reductions from these regulations, except for Electricity Generation. The Electricity Generation projection does not include any regulation of CO_2 emissions in the future since this regulation has already been removed from the forecast for this sector. Future inventories will incorporate any final regulatory changes.

As stated above, future decreases in GHGs through various mitigations strategies that may be employed by North Carolina are not included. Mitigation strategies are being developed along with their impact to net GHG emissions in order to evaluate their potential as cost-effective policies to reach the GHG reduction target in 2025. Examples of mitigation strategies being evaluated include; 1) increase in the use of renewable energy, energy efficiency, and storage, 2) increase in use of electric vehicles, 3) livestock manure management, and 4) sequestration of carbon by natural and working lands.

1.5 Key Findings from Development of the GHG Inventory

Listed below are key findings from both the GHG emissions inventory and from the analysis of the data used to develop the emissions for each source sector. Additional detail is provided in Section 2.0 Trends in Greenhouse Gas Emissions. Emissions reductions are generally expressed as the percent change in gross GHG emissions, unless otherwise stated, from the baseline year of 2005 to 2017.

- **North Carolina's Gross and Net Emissions**
  - North Carolina reduced gross GHG emissions by 20% and net GHG emissions by 25% since 2005.
  - During this same time period, North Carolina's population and real Gross State Product (GSP) grew by 18%.
  - By 2025, net GHG emissions are projected to decrease by 32% from the 2005 baseline, indicating North Carolina can achieve the U.S 2025 reduction target of 25% to 28%.

[12] The Montreal Protocol's charter is to save the upper atmosphere ozone layer that protects from the sun's ultraviolet rays that cause skin cancer (see U.S. Department of State, "The Montreal Protocol on Substances That Deplete the Ozone Layer," https://www.state.gov/e/oes/eqt/chemicalpollution/83007.htm, accessed May 2018.)
[13] https://www.epa.gov/laws-regulations/epa-deregulatory-actions

- **GHG Compounds**
  - Carbon dioxide emissions currently account for approximately 81% of the total GHG emissions.
  - The primary source of CO_2 emissions is fossil fuel combustion.
  - GHG emissions from fossil fuel combustion have decreased by 25% since 2005. This is due to both a shift in fuel use, from coal to natural gas, and increased energy efficiency.
  - Methane emissions (CO_2e) currently account for approximately 11% of the total GHG emissions
  - The primary sources of methane are Waste Management and Agriculture.
  - Emissions from Waste Management and Agriculture have not changed significantly since 2005, even with a growing population and economy.
- **Electricity Sector**
  - Electricity Generation is the largest emissions sector and represents 36% of all GHG emissions.
  - GHG emissions from Electricity Generation have decreased by 34% since 2005.
  - North Carolina's Electricity Generation sector has undergone a transformation since 2009 including;
    1) retirement of over 3,000 megawatts (MW) of coal fired power plants, which is 25% of the NC coal fleet.
    2) increased use of efficient natural gas combined cycle plants
    3) North Carolina legislation to promote renewable energy
  - Solar, hydro and wind power now represent 9% of North Carolina's Electricity Generation.
  - Avoided GHG emissions due to renewable energy power are estimated at 4 MMT CO_2e for 2017.
- **Transportation**
  - Transportation is the second largest emissions sector and represents 31% of all GHG emissions.
  - Emissions from the Transportation sector have decreased by 16% from 2005 to 2017.
  - Gasoline represents 71% of the energy input into Transportation while diesel represents 21%.
  - Projections for gas and diesel vehicle emissions under the current CAFE and GHG standards indicate a 20% decrease in GHG emissions. However, the last phase of these standards are currently being proposed to be relaxed, suggesting projected emission reductions may be lower than reported here.
- **Residential Commercial and Industrial**
  - Residential, Commercial and Industrial emissions represent over 20% of all GHG emissions.
  - Residential sector emissions from total energy use have decreased by 22% since 2005, while North Carolina's population grew by 18% over that time.
  - GHG emissions from fuel combustion in the Commercial sector have increased by 13% due to shifts in the economy. This is offset by a 29% decrease in emissions from Electricity Use by this sector.
  - Industrial fuel combustion emissions have decreased by 30% since 2005.
  - GHG emissions from Industrial Processes have doubled since 2005.
- **Land use, Land Use Changes and Forests**

- Forests, natural lands, and agricultural lands sequestered an estimated 35 MMT of CO_2 and offset gross emissions by 25% in 2017.
- These carbon sinks are primarily due to increases in forest stocks and storage of carbon in wood products, reflecting North Carolina's increasing sustainable management of its forests and their economic uses.

➢ **Landfills**

- Many large landfills in North Carolinaare now collecting methane and using the captured biogas as energy, resulting in 561,000 MWh of Electricity Generation and an additional 149,000 million British thermal units (MMBtu) of heat input in 2017.
- There has been a 25% reduction in GHG emissions from this sector since 2005, despite a large growth in population. This is primarily due to the energy recovery discussed above.

1.6 Structure of the Report

The remainder of this report is divided into two sections. The first section is an analysis of the key economic sectors and a discussion of the trends in North Carolina's GHG sources and sinks. The second section discusses the methodologies and data sets used to prepare the estimates, including key assumptions and limitations.