University of North Carolina Asheville
Journal of Undergraduate Research
Asheville, North Carolina
November 2020

Conducting a Greenhouse Gas Inventory of the UNC Asheville Campus and Operations

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Abstract

Global climate change poses a threat to ecological, social, and economic systems. UNC Asheville identifies sustainability as one of its three core values, and the university campus offers an opportunity to explore campus-level responses and solutions to the problem. In addition, the UNC System mandates a goal of carbon neutrality at UNC institutions by 2050. Through the summer of 2020, I collected data and collaborated with various departments across campus to complete a greenhouse gas inventory of the UNC Asheville campus and operations. The greenhouse gas inventory aims to guide and inform a campus Climate Action Plan and initiatives to decrease campus emissions. My main research questions were the following: What are UNC Asheville's campus greenhouse gas emissions, and what initiatives could UNC Asheville take to mitigate those emissions through a campus Climate Action Plan? I conducted a campus-wide greenhouse gas inventory, collecting and updating data from departments and offices across campus. Major findings from my research included the following: despite a fluctuating student body size and growing square footage of buildings on campus, electricity use per square foot has decreased. Scope 2 emissions, purchased electricity, were the largest portion of greenhouse gas emissions on campus. A coordinated campus-wide effort to update annual greenhouse gas inventories is needed in tandem with implementing the proposed Climate Action Plan.

1. Introduction

The 2019 report from the Intergovernmental Panel on Climate Change (IPCC)[1] concluded that warming over 1.5° C since pre-industrial levels will be catastrophic, and called for immediate action to cut global greenhouse gas (GHG) emissions by 2030. In order to mitigate climate change, it is necessary to reduce GHG emissions and support carbon sinks.[2] College campuses and universities are sites where GHG reductions can be pursued. According to Thomashow, "A campus is an ideal scale for experimenting with renewable energy and reporting on the results. It makes good sense that energy should be a central focus."[3]

The American College and University Presidents' Climate Commitment (ACUPCC), now called the Climate and Carbon Commitments, was launched in 2006.[4] Managed by the non-profit organization Second Nature, the Carbon and Climate Commitments provide an opportunity for colleges and universities to set targets and monitor progress on reducing emissions to combat the climate crisis, while also modeling climate solutions on campuses.

The greenhouse gas inventory that I completed involved collaborating with many departments on campus to estimate the amount of emissions coming from UNC Asheville's campus and operations over the past 10 years. Most of this reporting already existed within current departments and operations on campus, but my work aimed to gather this data and update it in order to prepare a comprehensive and accessible report. The goal of my research was to understand

a campus-level response to climate change and how the campus could address it, similar to the project by Bollier and Ormsby (2013), which outlines using a GHG emissions inventory to further sustainability initiatives and the Carbon Commitment at Eckerd College in Florida.[5] As Thomashow states, in order to implement GHG emission reductions, there must be effective planning in place, and to limit emissions, campuses have to measure them.[6]

1.1 Carbon Neutrality

Carbon neutrality and net-emissions are interchangeable terms referring to "a balance between emitting carbon and absorbing carbon from the atmosphere in carbon sinks. Removing carbon dioxide from the atmosphere and then storing it is known as carbon sequestration. In order to achieve net zero emissions...greenhouse gas emissions will have to be counterbalanced by carbon sequestration."[7] According to the UNC System Office's Sustainability policy on climate change mitigation and renewable energy, "The University shall develop a plan to become carbon neutral as soon as practicable and by 2050 at the latest, with an ultimate goal of climate neutrality."[8] Based on this mandate from the UNC System Office, it is recommended that 2050 be selected as the UNC Asheville campus carbon neutrality target date. As the university implements its Master Plan, which is also based on projects up to 2050, the timing of the proposed Climate Action Plan matches the Master Plan timeframe. A 2050 UNC Asheville campus carbon neutrality target date is consistent with the UNC System Office Sustainability Policy.

1.2 Emission Scopes

Scope 1, 2, and 3 emission categories define the various sources of GHG (Figure 1). I used these categories to measure GHG emissions from UNC Asheville's campus and operations: the emissions created due to the activities of UNC Asheville.

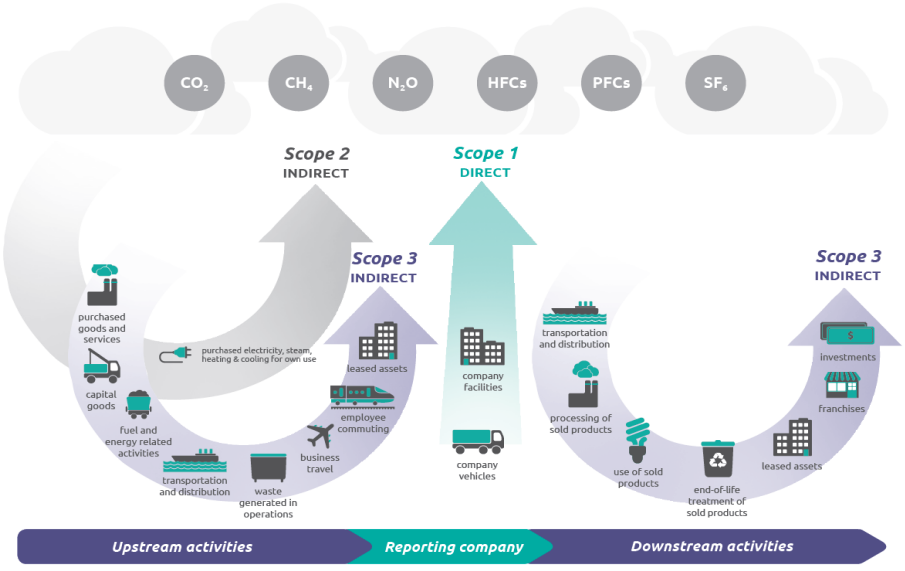

Figure 1. Diagram of Scopes and Emissions across the Value Chain[9]

Scope 1 emissions are defined as on-campus stationary sources. This includes emissions created by the combustion of fossil fuels for boilers, central heating plants, and on-campus power plants. This is energy generated on campus used to directly power campus buildings and operations. Scope 1 emissions also include gasoline and diesel used to fuel campus-owned fleet vehicles. Scope 1 emissions can also include refrigerants and chemicals that can leak from HVAC or refrigerant equipment on campus or on campus agricultural operations, such as activities for farms, gardens, or livestock management.[10] Campus fertilizer use is also considered Scope 1 emissions, as the production and

transportation of the chemicals are an energy-intensive process, and additionally, nitrogen, phosphorus, and potassium-heavy (NPK) fertilizers have significant carbon equivalencies.[11] Not only is fertilizer also one of the main causes of water pollution, but it also releases microbes that convert excess nitrogen into nitrous oxide (N2O). N2O is one of the six main greenhouse gases addressed by the United Nations Framework Convention on Climate Change.[12]

Scope 2 emissions, or indirect greenhouse gas emissions, are those that are purchased by an institution from an outside generator. UNC Asheville purchases electricity from Duke Energy. Scope 2 emissions are composed of purchased energy required by campus buildings and operations. They are a result of activities that happen on campus, but the emissions occur at another location owned and operated by a power company.[13]

Scope 3 emissions include all other indirect emissions caused by campus operations and activities. These greenhouse gas sources are not owned or controlled by UNC Asheville. Scope 3 includes emissions from the following: disposal of solid waste at the landfill or through incineration (mostly from methane emitted from landfills); campus water supply/use; student, faculty and staff commuting; and additional travel financed by an institution, such as study abroad.[14] Studies recently have emphasized the significance of greenhouse gas emissions tied to water usage and treatment in the United States. One report estimated that water-related energy use in the United States is responsible for about 5% of total greenhouse gas emissions.[15] This means that wastewater and associated emissions are an important portion of UNC Asheville's Scope 3 emissions.

1.3 Research Goals

My main research questions were the following: (1) What are UNC Asheville's campus greenhouse gas emissions? and (2) what initiatives could UNC Asheville take to mitigate these emissions through a campus Climate Action Plan?

Having a complete GHG inventory can inform elements of a campus Climate Action Plan (CAP) to reduce the campus carbon footprint.[16] The proposed CAP for UNC Asheville details various aspects of campus, offers background information, and proposes initiatives to mitigate emissions for elements in each scope category in the short, medium, and long term. Campuses are an important setting for the study of sustainability and to motivate change. In *The Nine Elements of a Sustainable Campus*,[17] Thomashow writes:

> "Higher education is embracing programs for water and energy conservation, renewable energy, waste minimization, recycling, green building and purchasing, alternative transportation, and local and organic food growing. In the United States, the student sustainability movement is well organized, extensive, and sophisticated; indeed, it may be the most significant student-initiated momentum since the civil rights and antiwar movements of the 1960s. Higher education's sustainability efforts are publicly visible to a degree that was unimaginable a decade ago."

2. Methodology

2.1 SIMAP and Data Collection

The Sustainability Indicator Management and Analysis Platform (SIMAP) was used to conduct a GHG inventory for UNC Asheville in the summer of 2020. SIMAP is managed by the University of New Hampshire Sustainability Institute in conjunction with Second Nature.[18] According to Second Nature, "SIMAP is a carbon and nitrogen-accounting platform that can track, analyze, and improve your campus-wide sustainability. Our proven algorithms, based on nearly two decades of work supporting campus inventories with the Campus Carbon Calculator, CarbonMAP and Nitrogen Footprint Tool, will help you:

- Create a baseline
- Benchmark your performance
- Create reports
- Set goals
- Analyze your progress year over year." [19]

The SIMAP sections for each emissions scope category are presented in Table 1.

Table 1. Scopes Tracked by SIMAP Defined[20]

On-Campus Stationary Sources	**Scope 1**
Direct Transportation (Mobile) Sources	**Scope 1**
Refrigerants and Chemicals	**Scope 1**
Agricultural Sources	**Scope 1**
Purchased Energy (e.g.: from Duke Energy)	**Scope 2**
University-Financed Travel	**Scope 3**
Commuting (Faculty, Staff and Students)	**Scope 3**
Study Abroad Travel	**Scope 3**
Solid Waste (Landfill and Recycling)	**Scope 3**
Wastewater (Septic Systems and Treatment Plants)	**Scope 3**

Much of the data collected for the GHG inventory had already been tracked by various departments on campus through the years, but was not all in one location and standardized for SIMAP entry. Thus, my aim was to collaborate with various campus departments to collect past data from multiple years to understand where data may have been missing, determine the level of confidence in accuracy of the data, and enter data into a master excel spreadsheet and then the SIMAP platform. Data collected and reported is only through fiscal year 2019, as most of the data for fiscal year 2020 was not yet available, and 2020 was unusual due to the COVID-19 pandemic. The start date of the different data items varied with scope, department, and additional factors.

The Environmental Protection Agency (EPA) Greenhouse Gas Equivalency Calculator[21] was used to determine the GHG emission equivalency of the therms of natural gas and kilowatt hours of electricity on campus. The My Climate Carbon Flight Calculator[22] was used to determine the GHG emissions equivalency of study abroad mileage. The Food Waste Greenhouse Gas Calculator[23] was used to understand the emissions equivalency of campus waste. Finally, the Greenhouse Gas Calculator from the City of Duluth, Minnesota[24] was used to calculate the emissions associated with campus wastewater.

2.2 Scope 1: Stationary Fuels

Stationary fuels include those used by UNC Asheville satellite properties, and generally include fuels used to power utilities, as well as emissions associated with the campus fleet. Data on annual therms of natural gas and propane used by campus operations were collected for this SIMAP entry. Annual reports for natural gas usage were available from fiscal years 2003 to 2019. Annual reports for propane were only available from 2006 to 2019 and reporting for 2013 and 2014 was missing. This annual data was provided by Dan Croisant, Project Manager, Facilities Mechanical Engineer, and Building Automation System (BAS) Administrator with Campus Operations.

Fertilizers used for landscaping are also a large producer of GHG emissions, and are an important component of the campus GHG inventory. Fertilizer at UNC Asheville is used almost exclusively for maintenance of athletic fields, and data on annual fertilizer usage was provided by Melissa Acker, Manager of Grounds Maintenance/Landscaping Design and Development with Campus Operations. Data was available from fiscal years 2010 to 2018, except for 2013 and 2014.

2.3 Scope 2: Utilities

Scope 2 emissions, or indirect GHG emissions, are those that are purchased by an institution from an outside energy provider. UNC Asheville purchases electricity from Duke Energy.[25] Scope 2 emissions are composed of purchased electricity required by campus buildings and operations. They are a result of activities that happen on campus, but the emissions occur at another location owned and operated by a power company. Scope 2 emissions can also include other forms of purchased energy by the campus, also operated and generated off site. The annual utilities consumption on campus is determined by campus utility bills, and is measured in kilowatt hours. Dan Croisant from Campus Operations provided annual reports for campus utility use from fiscal years 2003 to 2019. Utilities include all electricity purchased by UNC Asheville from Duke Energy.

2.4 Scope 3: Study Abroad, Wastewater, and Solid Waste

Scope 3 emissions include all other indirect emissions associated with campus operations and activities and are not owned or controlled by UNC Asheville. Scope 3 includes emissions from the following: disposal of solid waste at the landfill or through incineration; campus water supply/use; student, faculty and staff commuting; and additional travel financed by an institution, such as study abroad. In this study, the GHG inventory was completed for solid waste, wastewater, and study abroad. There are other dimensions of Scope 3 emissions that were not completed, including campus food systems. This work will be completed by the Student Environmental Center[26] employees in the near future.

Student and faculty study abroad travel is an important component of university travel emissions. The data for UNC Asheville faculty-led study abroad travel was collected from the Study Abroad Office at UNC Asheville in the Spring of 2020. Data was available for fiscal years 2010 to 2019, and the data only included UNC Asheville sponsored faculty-led trips; it did not include students who were abroad for a full semester or year. With information on the number of travellers and destinations, the total mileage was calculated, then My Carbon Climate Calculator[27] was used to calculate the emissions associated with each traveller individually. Mileage and total tons of CO_2 associated were combined to determine the annual emissions from UNC Asheville study abroad travel. Since UNC Asheville faculty take students on numerous trips around the world, the emissions associated with travel are significant to campus GHG emissions.

It is very important to consider water usage and management on the UNC Asheville campus because water processes, including the supplying and treatment of water, are energy-dependent, therefore are emissions-creating activities.[28] The energy required for the treatment, processing, and transportation of these water resources, mostly for use in buildings at UNC Asheville, is responsible for GHG emissions. Often, electricity is the largest cost and emissions driver of water processing and distribution activities.[29]

Wastewater data was collected for SIMAP entry from Dan Croisant in Campus Operations for fiscal years 2003 to 2019. The volume of wastewater generated onsite can be a proxy for the volume of water consumed. Additional information was required to learn what type of wastewater treatment is used by the local facility (anaerobic, aerobic, or aerobic digestion). The Metropolitan Sewerage District of Buncombe County wastewater treatment plant located on Riverside Drive in Asheville, North Carolina uses an aerobic digestion process for wastewater treatment.[30]

UNC Asheville has a long-standing ethic of waste reduction and recycling and implements responsible waste disposal programs to reduce the volume of waste shipped to the Buncombe County landfill. The Campus Operations staff conduct a campus-wide waste audit each semester to figure out how to improve waste reduction methods and participation and to track the campus waste streams. Data for these audits was provided for fiscal years 2015 to 2019 by Jackie Hamstead, Environmental Specialist with Campus Operations and Interim Co-Director of Sustainability.

2.5 Carbon Sinks: Compost, Solar, and Sequestration through Trees

SIMAP reporting also accounts for “carbon sinks” or carbon offsetting activities on campus, such as composting, renewable energy generation, and tree carbon sequestration. UNC Asheville’s composting diverts a substantial amount of waste from the landfill, which offsets campus emissions. On average, UNC Asheville composts approximately 242 tons of waste each year, as recorded from 2015 to 2019. Composting diverts organic matter, most often food and yard

waste, from the landfill and creates fertile soil for agricultural services.[31] UNC Asheville contracts services from industrial compost hauler Atlas Organics out of Greenville, South Carolina.[32] Data was provided by Jackie Hamstead, Interim Co-Director of Sustainability and Environmental Specialist with Campus Operations. Additional research was provided by Reilly Strong, Summer 2020 Intern with the Office of Sustainability.

There is a 24-kilowatt solar array on the Ponder Hall dorm, completed in 2012. Initial information on solar generation on campus through the Ponder Hall roof solar array was collected, however, the data is incomplete. The array consists of 112 individual panels and produces approximately 33,000 kilowatt hours per year.

3. Results

The results cover each component of SIMAP entry completed through my research. Each section is organized by emission scope and its associated individual SIMAP category data. Some years of data were missing or unavailable (e.g. transport fuels, refrigerants, renewable energy, commuting, business travel, student travel, food, and paper), so they are not represented in the graphs.

3.1 Scope 1: Stationary Fuels, Propane and Natural Gas

Propane is used for HVAC systems at the UNC Asheville properties at 24 and 25 Hyannis Drive. Annual gallons of propane used at UNC Asheville varied widely, with the lowest being 458 gallons in 2019 and the most 5,399 gallons in 2007.

Natural gas is used across campus for HVAC systems, water heating, generators, cooking, and fireplaces such as the fireplace at Roasted coffee shop in the Highsmith Student Union. Therms of natural gas were recorded ranging from 414,647 therms in 2003 to 680,077 therms in 2014. Natural gas therms are a non-SI unit of heat energy equal to 100,000 British thermal units.[35] Based on available data, the annual average of natural gas consumption was 543,801 therms (Figure 2); the annual average quantity of natural gas used on campus was 2,617 therms, which is equivalent to 13.8 metric tons of carbon dioxide emissions.

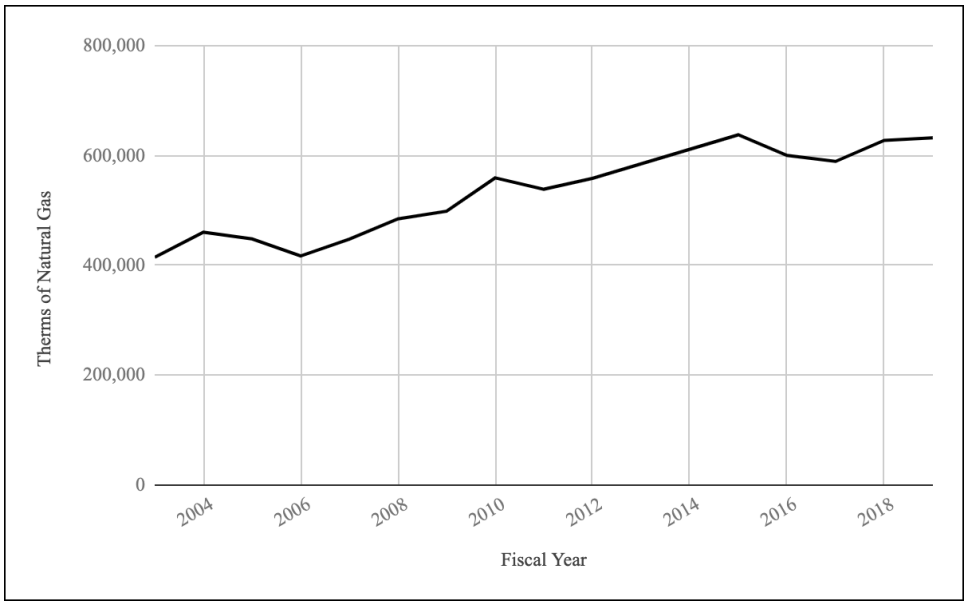

Figure 2. Annual Campus Natural Gas Consumption

3.2 Scope 1: Transport Fuels

Many departments on campus operate vehicles that are part of the campus fleet and require fuel. It was difficult to obtain complete information on the quantity of fleet vehicles. A partial list of departments with campus fleet vehicles includes:

- Academic Affairs: Information Technology: 1 electric vehicle and 1 utility vehicle.
- Athletics: 1 utility tractor, 1 gas-powered van, 3 mowers, 1 utility vehicle, 3 golf carts, 1 riding floor scrubber machine, 2 machines to smooth sand (dragger), 1 field mower, 1 sprayer.
- Dining Services (Chartwells): 1 van, 1 box truck, 1 utility vehicle.
- Student Affairs: Highsmith Student Union: 1 electric golf cart. Campus Recreation: 1 gasoline-powered SUV. Housing: 3 mule utility vehicles, 2 of which are electric powered, 5 gas-powered pickup trucks, 1 electric flatbed truck and 1 electric box truck. Transportation: 6 gas-powered shuttles, 1 electric UTV, 2 gas-powered ATVs, 3 gas-powered pickup trucks. University Police: 2 gas-powered SUVs and 3 sedans; Public Safety Motor Fleet: 10 gas-powered vehicles, large SUVs and vans, 3 electric vehicles; Trades: maintenance vehicles. Grounds and Campus Operations: 20 electric low-speed vehicles (LSVs), 20 mule utility vehicles, 17 commercial lawn mowers, 45 trucks and maintenance vehicles, 6 tractors, 1 chipper, 8 chainsaws, 15 weedeaters, 21 hand and backpack blowers, and other miscellaneous maintenance equipment. Mail, shipping, receiving: several mail vehicles including golf carts and cars.

The confidence level for this particular aspect of Scope 1 data is low. The data is incomplete and due to the numerous different departments with fleet vehicles, it is difficult to track annual fuel use. The annual average gasoline consumption was reported to be 19,247 gallons in 2012, equivalent to 171 metric tons of CO_2, and remained at 20,561 gallons, from 2013 to 2017, equivalent to 183 metric tons of CO_2 emissions, based on previous data entered into the SIMAP database.

3.3 Scope 1: Fertilizer

Fertilizer at UNC Asheville is used almost exclusively for maintenance of athletic fields. Data was not available for fiscal years 2013, 2014, or 2019. The annual average (removing null data values) of fertilizer used was 13,729 pounds, and annual use ranged from 2,800 pounds in 2011 to 25,550 in 2016 (Figure 3).

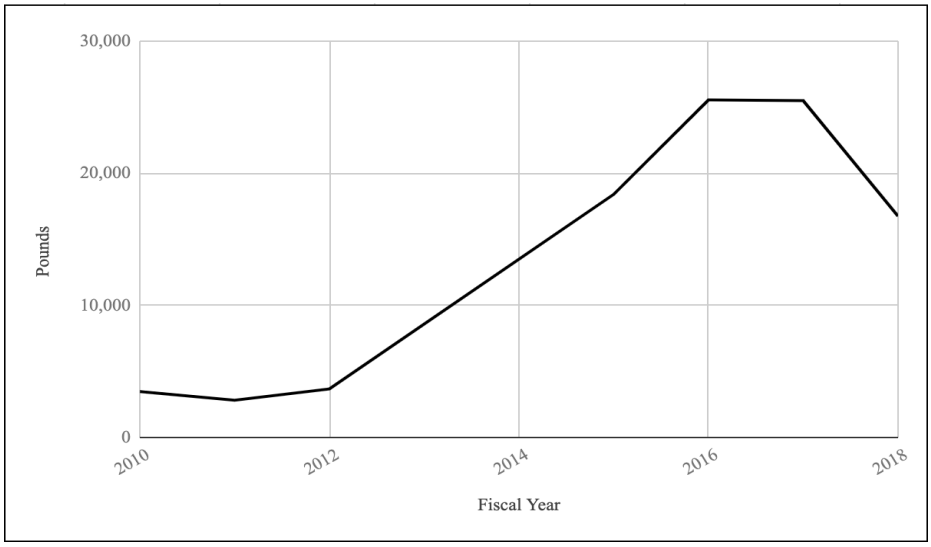

Figure 3. Annual Fertilizer Use

3.4 Scope 2: Utilities

Campus utility electricity consumption averaged 18,122,219 kilowatt hours annually between 2003 and 2019 (Figure 4). This is equivalent to 12,812 metric tons of carbon dioxide emissions annually on average. It is important not just to look at overall campus electricity consumption but also to consider electricity use per capita over time, as well as how electricity use changes per square foot as buildings are added to campus.

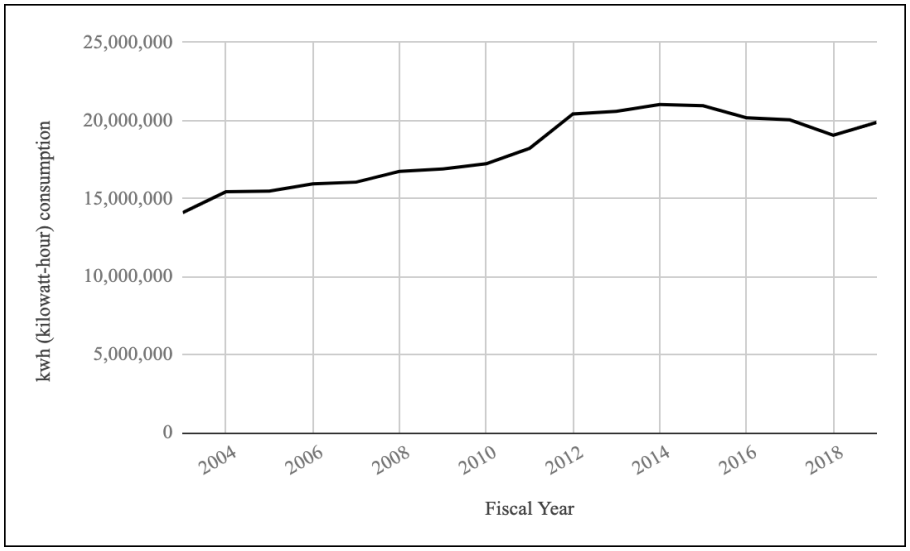

Figure 4. Annual Electricity Use by UNC Asheville for Campus Utilities

Figures 5 shows electricity use per capita on campus for fiscal years 2003 to 2019.

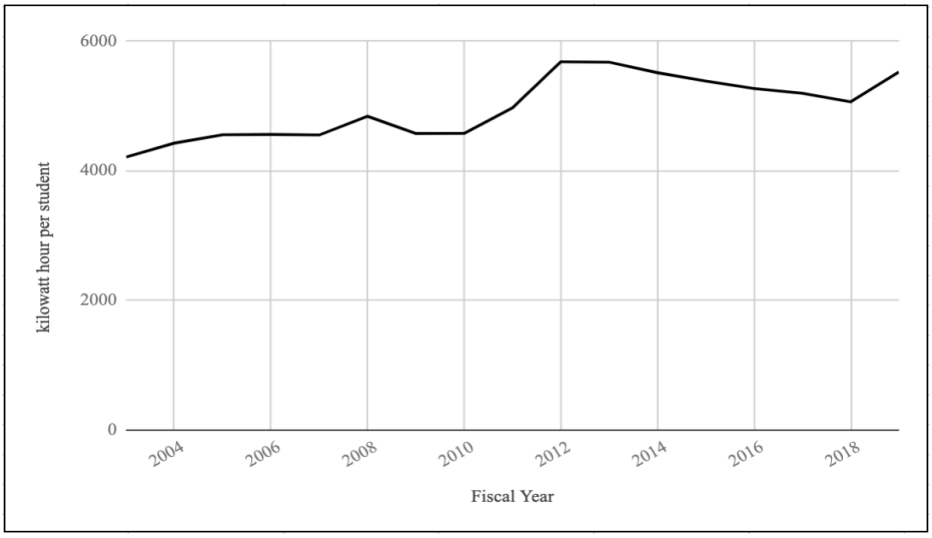

Figure 5. Electricity Use Per Capita (Per Student)

Figure 6 shows electricity use per square foot. UNC Asheville's built campus has grown throughout the years, thus increasing the gross square footage of campus buildings and the amount of electricity required for the space. The original campus buildings were constructed in the 1960's. The Highsmith Student Union was built in 1980, though a more recent update and expansion began in 2017 and was completed in 2019, adding the 6,000 square feet with the addition of the Blue Ridge Ballroom and new office and meeting spaces.[33] The Wilma M. Sherrill Center and Kimmell Arena was started in 2009 and opened in 2011. Ponder Hall was completed in 2012, and was previously called Overlook Hall. Rhoades-Robinson Hall underwent retrofitting in 2012 and is LEED Gold Certified. The Woods apartment-style residence halls opened in Fall of 2018. While UNC Asheville has added square footage due to new buildings, campus electricity use per square foot has declined, meaning that campus has become more efficient in its electricity use in buildings, which saves the university costs. UNC Asheville's gross square footage grew from 958,716 square feet in 2003 to 1,750,062 square feet in 2019.

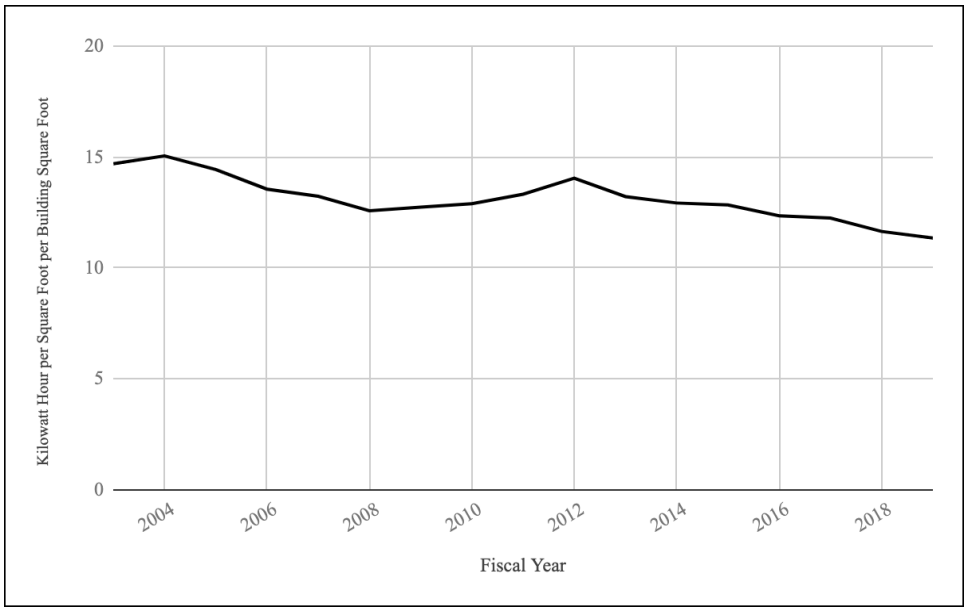

Figure 6. Campus Electricity Use by Building Square Foot

3.5 Scope 3: Study Abroad Travel

Student and faculty study abroad travel is an important contributor to university travel GHG emissions. UNC Asheville faculty take groups of students on numerous trips around the world each year. This adds up to a significant amount of miles travelled by airplane and emissions associated with that travel. Faculty-led study abroad trip annual mileage and associated emissions (all trips and travellers combined) ranged from 473,800 miles and 121.7 tons of carbon dioxide in 2014 to 1,026,800 miles and 277 tons of carbon dioxide in 2011 (Figure 7). The annual average carbon emissions associated with UNC Asheville study abroad travel is 196 tons.

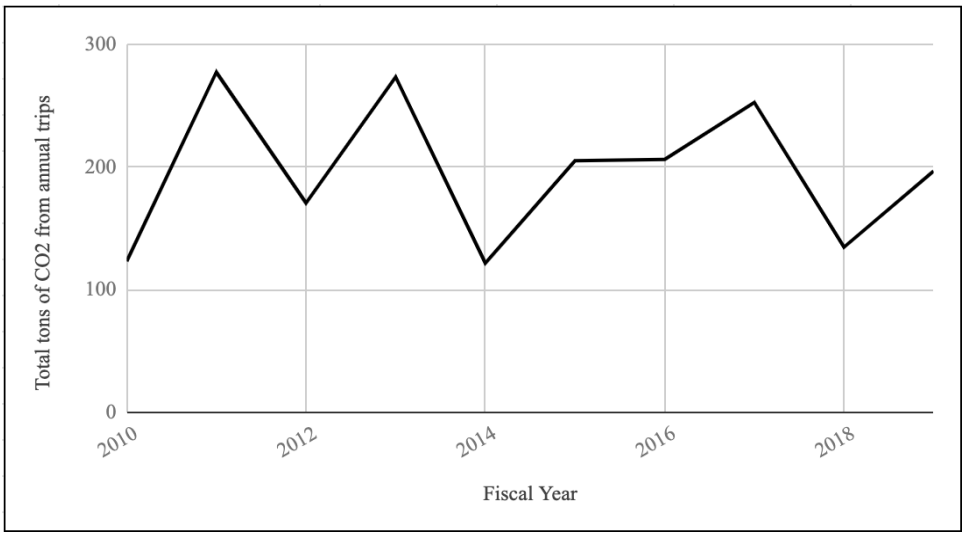

Figure 7. Annual Faculty-Led Study Abroad Travel CO_2 Emissions

3.6 Scope 3: Solid Waste and Wastewater

Campus waste that is not composted or recycled is taken to the Buncombe County landfill, located in Alexander, North Carolina. Buncombe County has operated a 53-acre landfill facility since 1997. In 2011, the landfill began installing 25 vertical walls inside of the facility in order to extract methane gas in order to produce energy. The walls direct methane to a generator on site. The generator produces approximately 1.4 megawatts of electricity annually.[34] This system is not standard for all landfill operations, and creates an energy offset to the GHGs caused by solid waste at the landfill. The annual average of landfill waste volume produced by UNC Asheville from 2015 to 2019 was 320.7 tons, which is approximately 609.3 metric tons of carbon dioxide emissions.

UNC Asheville wastewater is treated at the Metropolitan Sewerage District of Buncombe County site, using an aerobic digestion process.[35] The annual average volume of campus wastewater from 2003 to 2019 was 30,591 gallons (Figure 8).

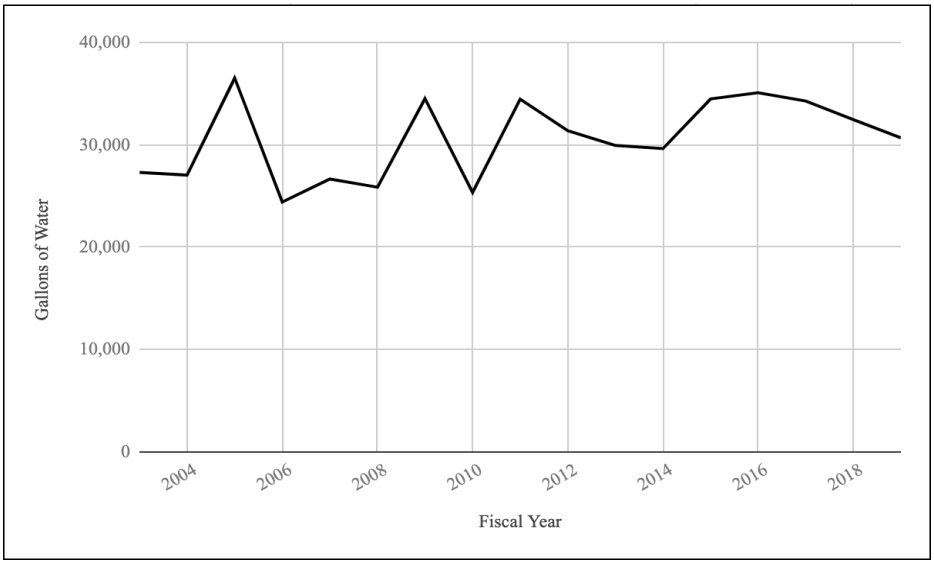

Figure 8. Annual Campus Wastewater Volume

3.7 Combined Results Summary

Comprehensive GHG inventory data was available only for 2015 to 2019. Partial data was available for previous years. Based on data from 2015 to 2019, the annual average GHG emissions for Scope 1 was 3,067 metric tons of CO_2 equivalency. The annual average for Scope 2 was 14,149 metric tons, and for Scope 3 was 808 metric tons (Table 2).

Table 2. Itemized Scope Greenhouse Gas Equivalencies (2015-2019)

Scope	Source	Annual Average	CO_2 Equivalency (Tons)	Source
Scope 1	Stationary Fuels (Natural Gas)	617,446 therms	3,267	EPA Greenhouse Gas Equivalency Calculator
Scope 2	Utilities	20,011,234 kwh	14,149	EPA Greenhouse Gas Equivalency Calculator
Scope 3	Study Abroad Travel	198.92 tons of CO_2 from annual trips	198.92	My Climate Carbon Calculator
Scope 3	Solid Waste (Landfill)	320.6 tons of waste	609.14	Food Waste Greenhouse Gas Calculator
Scope 3	Wastewater	33,397 gallons	0.08	City of Duluth, Minnesota Greenhouse Gas Calculator

Figure 9 presents combined Scope 1, 2 and 3 GHG campus emissions with available data for 2015 to 2019. Data for some GHG scope emissions was unavailable. Scope 2, campus utility consumption, was the largest GHG scope emitter.

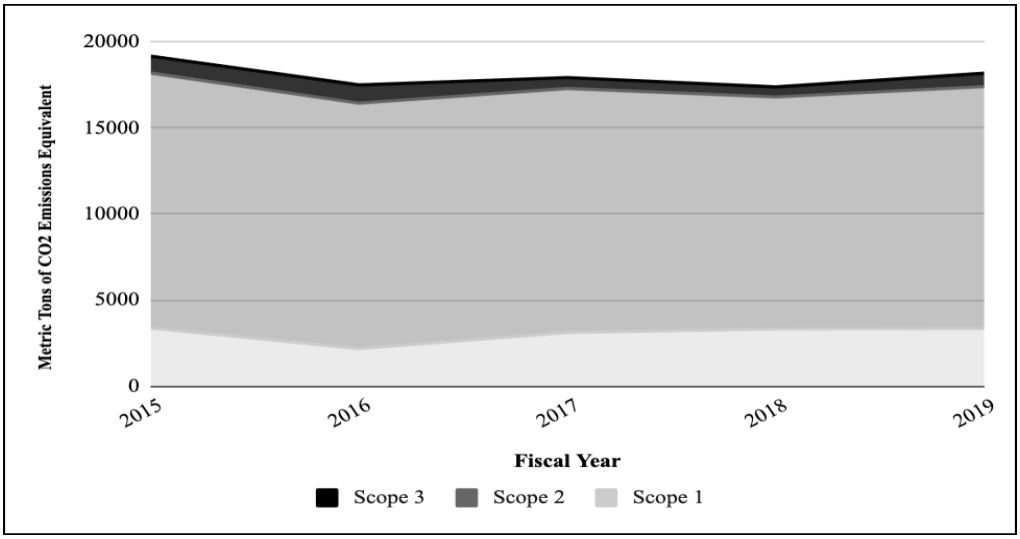

Figure 9. Average Annual Carbon Dioxide Emissions By Scope (2015-2019)

3.8 Climate Action Plan, Carbon Commitment, and Recommended Actions

Colleges and universities have been making commitments to climate action and mitigation for their campuses and operations. This includes completing campus GHG inventories and proposing Climate Action Plans (CAPs) to reduce campus GHG emissions.[36] Through a collaborative effort in spring and summer 2020, a UNC Asheville campus Climate Action Plan was drafted to compliment the findings from my research. The Climate Action Plan puts the GHG inventory findings into action by proposing short, medium, and long-term project goals by emission scope category to mitigate emissions.

The three pillars of sustainability are environmental, economic, and social.[37] The proposed UNC Asheville Climate Action Plan aims to incorporate all of these elements in the recommended Scope 1, 2, and 3 actions. The UNC Asheville CAP was drafted by Scope 1, 2, and 3 emissions, then short, medium, and long-term actions for each scope. Scope 1 recommendations include reducing campus fertilizer use by 5-10% in the short-term (2020-2030), improving fuel efficiency of the university-owned fleet in the medium-term (2030-2040), and adding several electric vehicle (EV) charging stations in the long-term (2040-2050). Scope 2 proposals include continuing the current practice of pursuing LEED standards, or a combination of other sustainable building standards, for all new campus buildings that are constructed in the short-term, installing green roofs and vegetative walls where feasible to increase energy efficiency of existing and new buildings in the medium-term, and installing solar arrays on additional buildings in the long-term. Finally, Scope 3 proposed actions include converting remaining fixtures and toilets to low-flow systems across campus in the short-term, creating an offset program for travel for faculty, staff, and students attending conferences in the medium-term, and implementing a plastic-free campus policy in the long-term. Creating an offset program would be an example of an economic-driven sustainability initiative. Installing a solar array would be an environmental sustainability project, and educational programs towards behavior change would be centered around social sustainability.

The CAP is one requirement of signing the Carbon Commitment. The Carbon Commitment has been adopted by colleges and universities in every state across the country, now totalling over 400 signatories between the Carbon and Climate Commitments. The Carbon Commitment is an opportunity for UNC Asheville to take measurable action to reduce GHG emissions. In North Carolina, the Commitments have been adopted by 13 schools in the state and five of the 17 UNC schools, including NC State, Appalachian State University, Fayetteville State University, UNC Charlotte, and UNC Chapel Hill. Table 3 represents peer institutions in North Carolina that have committed to climate action. Institutions in bold are members of the UNC System.[38]

Table 3. North Carolina Institutions Committed to Climate Action

Institution	Type	Date Signed
UNC System Schools		
UNC Chapel Hill	**Carbon Commitment**	**January 11, 2007**
North Carolina State University	**Carbon Commitment**	**January 30, 2008**
UNC Charlotte	**Carbon Commitment**	**October 14, 2009**
Fayetteville State University	**Carbon Commitment**	**April 22, 2010**
Appalachian State University	**Climate Commitment**	**January 4, 2016**
Other Colleges/Universities in NC		
Warren Wilson College	Carbon Commitment	January 11, 2011
Guilford College	Carbon Commitment	May 24, 2007
Catawba College	Carbon Commitment	June 12, 2007
Duke University	Carbon Commitment	July 24, 2007
Davidson College	Carbon Commitment	November 14, 2007
Wake Tech Community College	Carbon Commitment	April 22, 2010
Queens University of Charlotte	Carbon Commitment	April 19, 2010
Brevard College	Climate Commitment	August 31, 2017

Additionally, members of the Council of Public Liberal Arts Colleges (COPLAC),[39] made up of 30 members across the country, of which UNC Asheville is a member, have developed and enacted Climate Action Plans (Table 4). By signing the Carbon Commitment, UNC Asheville would be joining peer institutions both in North Carolina and across the country.

Table 4. COPLAC Institutions Committed to Climate Action

Institution	Type	Date Signed
Massachusetts College of Liberal Arts	Carbon Commitment	March 27, 2007
Fort Lewis College	Carbon Commitment	April 10, 2007
Keene State College	Carbon Commitment	April 12, 2007
University of Maine at Farmington	Carbon Commitment	May 7, 2007
SUNY Geneseo	Carbon Commitment	July 9, 2007
Ramapo College of New Jersey	Carbon Commitment	January 9, 2008
New College of Florida	Carbon Commitment	January 2008
University of Illinois at Springfield	Carbon Commitment	February 22, 2008
St. Mary's College of Maryland	Carbon Commitment	Spring 2008
University of Minnesota Morris	Climate Commitment	October 2, 2015
Sonoma State University	Climate Commitment	May 5, 2019

4. Discussion

Major findings of the research included the following: Despite a fluctuating student body size and growing square footage of buildings on campus, electricity use per square foot has decreased. Also, Scope 2 made up the largest portion of GHG emissions on campus with the categories from this study, followed by Scope 1, then Scope 3. In 2019, campus GHG emissions were estimated at 18,170 metric tons of CO2, slightly higher than the averages since fiscal year 2016. Finally, a coordinated campus-wide effort to conduct or update annual greenhouse gas inventories is needed in tandem with the Climate Action Plan. The GHG inventory serves to support and inform the university Climate Action Plan.

Institutions often publish their GHG inventories for public viewing, in addition to Second Nature SIMAP reporting. Appalachian State University's 2006-2016 GHG inventory found that the university's emissions were roughly made up of 40% transportation emissions, 27% natural gas emissions, and 33% electricity. Similarly to UNC Asheville, Appalachian State used a collaborative approach across campus departments to complete the inventory.[40] UNC Chapel Hill has been completing annual GHG inventories since 2007, when the institution signed the Commitment, and is also working toward an ultimate goal of carbon neutrality by 2050. In 2018, UNC Chapel Hill emitted 489,524 metric tons of carbon dioxide equivalency, a 2% decrease from 2017, and a 19% decrease from the initial 2007 report.[41] Over half of Chapel Hill's emissions are generated by stationary combustion sources, including the on-campus coal-fired power plant.[42] Chapel Hill's Office of Sustainability is the only one in the UNC System to follow a "3 Zeros" Model, centered around net zero water, net zero waste to landfills, and net zero GHG emissions.[43] North Carolina State University's most recent emissions report was released in 2017. Scope 1 emissions were reported to make up 39% of total emissions, Scope 2 made up 25%, and Scope 3 was 36% of campus GHG emissions. Reporting at the university has continued to improve and evolve throughout the different iterations of reports, released in 2008, 2010, and 2013, making it difficult to draw definitive comparisons of campus GHG emissions throughout the years since signing. The 2017 report will act as a new baseline for NC State's future climate reduction efforts.[44] UNC System institutions are all individually working toward a common goal of carbon neutrality by 2050, as per the UNC System mandate.[45]

UNC Asheville has made progress on many sustainability initiatives, including waste reduction and diversion programs, fossil fuel divestment, the establishment of the Student Environmental Center (SEC), implementation of

renewable energy sources, changes in landscape and fertilizer use practices, and community outreach and education programs.[46] However, the university can take further action by applying data gathered from the campus GHG inventory to continue implementing initiatives to mitigate emissions. Considering the scientific consensus regarding the severity of the global climate crisis, immediate action to reduce GHG emissions is required to avoid the tangible and severe repercussions of inaction. UNC Asheville has the potential to mitigate its emissions from the built campus and operations, while also solidifying its role as a leader on climate action. These actions can be facilitated and realized through UNC Asheville signing the Carbon Commitment and launching the proposed Climate Action Plan. Signing the Carbon Commitment and completing the necessary follow-through will make UNC Asheville a more competitive institution for prospective students and will allow UNC Asheville to be ranked in the Princeton Review sustainability ranking[47] and Sierra Club Cool Schools[48] lists.

Climate Action Plan (CAP) styles vary widely between institutions, and are greatly influenced by campus cultures and needs. For example, the University of North Carolina Charlotte's 2012 CAP is organized by short, medium, and long-term goals with integrated milestones.[49] Alternatively, Duke University's updated 2019 CAP is sectioned by Energy, Transportation, Carbon Offsets, Education, and Outreach and Communication.[50] The University of Colorado Denver's CAP focuses more on targets and phases to reduce emissions, and also feasibility assessments.[51]

Thus far, 11 of the 30 total COPLAC institutions[52] have signed the Climate or Carbon Commitment, as have 13 institutions in North Carolina, 5 of which are in the UNC System. Our peer institutions that have signed onto the Commitments have implemented initiatives that are offsetting and mitigating campus emissions. For example, Appalachian State University has implemented a Carbon Neutral Commuter Program, allowing students, faculty, and staff to pay a nominal fee along with their parking passes that go towards purchasing external carbon offsets that also contribute to Appalachian State's climate action plan.[53] UNC Chapel Hill has several renewable energy solar arrays located on campus, including a 2.7-acre pollinator garden with solar array,[54] a 24kW, 64-panel system on the Union,[55] and 172 solar thermal panels on the Morrison Residence Hall.[56] Thermal solar panels use sunlight to heat cylinders of water stored in the panel to generate energy.[57] North Carolina State has also integrated fully-electric grounds management equipment into their fleet, including mowers, some of which include an attached solar panel to extend the battery life, therefore decreasing direct emissions from NC State's campus operations.[58]

There were several limitations to my research. Due to the nature of institutional turnover, data was not consistent for all departments across all years of reporting. This was a major shortcoming of my research. Due to the fact that the first Sustainability Director, Environmental Specialist, and Building Automation System (BAS) Administrator all began at UNCA in Fall 2014, I only reported data from 2015 to 2019 because that was most complete and consistent. Data was incomplete or unavailable for some factors.

Future research and collaboration across campus departments will be required to complete and continue the GHG inventory. Filling gaps in the data are being pursued in collaboration with the new Student Environmental Center's Climate Analyst and the Building Automation System (BAS) Administrator within Campus Operations. The following categories require additional research:

- Scope 1: Transport Fuels, and Refrigerants and Chemicals
- Scope 2: Renewable Energy
- Scope 3: Commuting, Business Travel, Student Travel, Food, and Paper
- Any additional carbon sinks and/or offsets

5. Conclusion

UNC Asheville identifies environmental sustainability as one of its three core values. My research aimed to complete two components necessary for UNC Asheville to sign the Carbon Commitment, thereby creating an opportunity for UNC Asheville to monitor, evaluate, and act to reduce campus GHG emissions. The first component included collecting and updating data for a campus-wide GHG inventory. The second piece entailed revising and building on the working draft of the campus Climate Action Plan.

Major findings of the research included the following: Despite a fluctuating student body size and growing square footage of buildings on campus, electricity use per square foot has decreased. Also, Scope 2 made up the largest portion of GHG emissions on campus with the categories from this study, followed by Scope 1, then Scope 3. In 2019, campus GHG emissions were estimated at 18,170 metric tons of CO2, slightly higher than the averages since fiscal

year 2016. Finally, a coordinated campus-wide effort to conduct or update annual greenhouse gas inventories is needed in tandem with the Climate Action Plan. The GHG inventory serves to support and inform the university Climate Action Plan.

My research aimed to understand a campus-level response to climate change and consider how UNC Asheville could take steps to address its GHG emissions. My main research questions were the following: What are UNC Asheville's campus GHG emissions, and what initiatives could UNC Asheville take to mitigate those emissions through a campus Climate Action Plan? Major findings include that a coordinated campus-wide effort to conduct the annual GHG inventory is needed. Also, despite a fluctuating student body size and growing square footage of buildings on campus, electricity use per square foot has decreased. Students, staff, and faculty are continuing to revise the university Climate Action Plan and advocate for UNC Asheville to sign the Carbon Commitment in coordination with the UNC Asheville Office of Sustainability.

6. Acknowledgements

I would like to thank Dr. Alison Ormsby for her support and guidance throughout the research process. I'd also like to thank Jackie Hamstead, Dan Croisant, and all of the other campus departments that helped provide data and reporting for the greenhouse gas inventory. Thank you also to Dr. Evan Couzo for his support throughout the entire research and Climate Action Plan process.

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