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Higher education institutions play a crucial role in society as hubs of research, activism, and awareness. There is a general recognition of how their operation influences greenhouse gas emissions due to the facilitation of often necessary variables such as energy consumption, transportation, waste generation, and resource-intensive research activities. Through efforts taken by the University of North Carolina at Greensboro's (UNCG) Office of Sustainability, there is consistent tracking of emissions across campus through fragmented commitments to state and national organizations that recognize the efforts of higher education in sustainability. A more detailed purview of transportation within individual campus programs offers valuable insights to the university, shedding light on previously unexplored Scope 1 and 3 emissions. One program on UNCG's campus that has more-than-average travel among staff and students is the Outdoor Adventures program, which offers adventure trips and events to students utilizing a fleet of vans traveling on- and off-campus. A 10-year transportation analysis of this program was conducted using historical data extracted from transportation archives, a survey distributed among students, and the Sustainability Indicator Management and Analysis Platform (SIMAP). The results provided insight into greenhouse gas emissions released and avoided through offering vanpooling options, in addition to a stated preference by students of their commuting trends. UNCG Outdoor Adventures has generated a baseline of emissions that contributes to their own sustainability initiatives and influences the university to adopt similar tracking techniques towards other programs on campus that have more-than-average transportation use.

A DECADE OF MOBILITY: UNCG OUTDOOR ADVENTURES

TRANSPORTATION EMISSIONS ANALYSIS

(FY2013-2022)

by

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CHAPTER I: INTRODUCTION

Quantifying the environmental impacts of transportation on university campuses has become more commonplace as the climate crisis develops and more action is taken on the ground. However, there are gaps in the consistency of reporting transportation emissions for campus travel occurring mainly off-campus. To obtain a more detailed picture of the university's emissions, a thorough focus needs to be placed on Scope 1 emissions (those directly from campus operations, in this case vehicles operated by programs on campus) and Scope 3 emissions (those indirect from inputs and outputs, in this case resulting from the use of public shared transportation and commuters in automobiles). Transportation emissions are one the hardest avenues to cut due to the necessity of use for many programs (U.S. DOT 2010). Therefore, it is up to the institution to determine what response to take. The degree of transportation emissions tracking can demonstrate environmental dedication, and the possibility for more targeted solutions as universities pledge net carbon neutrality and support student activism.

There is an array of benefits to the university and to programs themselves through gathering their transportation data and determining any trends in the release of greenhouse gasses. At the University of North Carolina at Greensboro (UNCG), on-campus gasoline consumption data is gathered by the Office of Sustainability and collected for annual GHG inventory reports. However, there are some vehicles in the University fleets that have more-than average off-campus travel, such as the Outdoor Adventures (OA) vans which are used to commute students to various locations across the state and those surrounding for outdoor recreation purposes. OA is in a unique position as it promotes sustainability and furthers UNCG Health and Environmental Wellness goals but requires the use of conventionally gas-operated

vans for programming purposes, which lends a question of the quantitative impacts of the van fleet and if there are any avoided scope emissions by offering a vanpooling service to students. The main questions supporting the research are:

1) What are the greenhouse gas emissions released and avoided by UNCG Outdoor Adventures providing a fleet of shuttles that target student use and recreation?

2) What steps can UNCG Outdoor Adventures and UNCG both take to improve mobility and overall sustainability supported by the actions of other universities?

First, a brief introduction to "Sustainability" as a term, how UNCG embeds it into their operations, and how it unfolds on the ground can provide insight into the overall scope of environmental responsibility and accountability on campus. Higher education institutions (HEI) are often accredited for facilitating influential research, enhancing diversity, building up morals and values, and supporting interdisciplinary approaches (Bovea and Valls-Val 2021, 2524). Similarly, they deepen support for sustainability and environmental awareness through on-campus initiatives. The environmental stewardship and responsibility established in and out of classrooms enhances student capacity to make sound judgements about the world around them (Sandalow 1991). Next, an overview of emissions tracking at other universities and within the public sector is introduced to examine the capacity for alternative transit and mobility.

This section is followed by case studies of other universities implementing alternatives to reduce scope 1 and scope 3 emissions. Case studies help to generate a comparative analysis among UNCG and other decarbonization efforts. The accountability of emissions among other programs on campuses will justify and improve any solutions taken to decarbonize transportation. These dynamics are reinforced, but are often impeded by lackluster "organizational inertia, operational complexity, and regulatory requirements" (Filho et al. 2021,

2). The role of UNCG Outdoor Adventures is introduced, as it is the program being examined for its fleet emissions and the hub for outdoor recreation on campus. The methods for this research are introduced using OA shuttle logs, estimated population of van riders, a Qualtrics survey, and the Sustainability Indicator Management and Analysis Platform (SIMAP) to determine estimated greenhouse gas (GHG) emissions released, projected, and avoided from fiscal year 2013-2022.

Lastly, the results and discussion of the outcomes provide deeper insight into external impacts of transportation trends and justify the capability for diverse alternatives such as fleet electrification and the allocation of resources to enhance public transit and vanpooling use. The data in the research is specific to Outdoor Adventures, but the outline of methods taken can be applied to any program with simple adjustments. UNCG and Outdoor Adventures have a lot to gain from utilizing such reporting for other programs with similar emitting activities by considering the framework used in the research and recommendations provided.

Sustainability at UNCG

Sustainability at UNCG encompasses social equity, the environment, the economy, and aesthetics (UNCG n.d.). Universities primarily focus on research and teaching, but they also serve as esteemed demonstrators and catalysts for individuals who are passionate about creating change. An important aspect of UNCG's role involves nurturing environmental ethics within the campus community, a commitment shared by some programs, but not all of them. While sustainability is in the university's long-ranging plans, the term is applied more directly through faculty research, academic programs, and on-campus initiatives by the Office of Sustainability, clubs, and academic departments. A significant driver of on-campus efforts is through the Office of Sustainability, which assists in the determination of the UNCG Green Fund (a campus-wide

grant that supports student and staff proposals chosen for innovative projects). Initiatives such as these guide the university towards its otherwise ambitious goals of carbon neutrality by 2050.

At UNCG, the core themes of campus operations are Health and Wellness, Vibrant Communities, Global Connections, and the overall transformation of students, knowledge, and the region (UNCG 2023). The university emphasizes the merit of evaluating each of these qualities by applying a four-pronged sustainability perspective centered on aesthetics, social equity, environmental, and economic factors.

In a study performed on the importance of strategic plans in universities, it was found that a carefully considered and implemented strategic plan with inclusive input can impact the future and plays a vital role in maintaining "identity, image, and reputation" (Mahardhika and Raharja 2023, 1809). A positive management and direction of strategic plans helps integrate all stakeholders to deliver an intended vision from start to finish. The UNCG Strategic Plan informs overarching decisions across campus but does not offer much insight into how the university plans to continue sustainability initiatives long-term. There is an old Strategic Transportation Plan that the University adopted in 2012, that has since been remastered. However, in 2020, a revised Campus Master Plan was unveiled and offers comprehensive recommendations for various aspects of campus development and decarbonization. As related to transportation, the plan addresses these objectives by focusing on improvements to the campus fleet, enhancing walkability, and expanding commute accessibility (Sasaki 2020). The campus plan is quoted, "In support of the sustainability goals of the university, the overarching goal is to decrease transportation-related greenhouse gas emissions" (UNCG 2020, 107). Enhancing the accessibility and reliance of campus mobility develops student experience and overall livability while reducing overall emissions released and benefiting the regional environment.

The revised plan implements more bicycle routes and housing options to reduce the use of internal combustion engine (ICE) vehicles and increases the accessibility of campus corridors for efficient shuttle movement. At UNCG, the Scope 1 emissions are 32.6%, and account for university-owned vehicles burning of fossil fuels on-campus, while Scope 3 emissions, such as commuting and other indirect sources, is 29.2% (UNCG 2020, 126).

The university has reduced its GHG emissions by 14% since 2009, following the multitude of efforts taken in gathering campus-wide data, becoming members of the Advancement of Sustainability in Higher Education (AASHE), and committing to becoming carbon-neutral by 2050 (UNCG 2018, 5). In the U.S. around 1,000 campuses have used the STARS Reporting Tool, which is a voluntary self-reporting platform that has basic specifications (Chang et al. 2021, 1). The Executive Director of AASHE quotes UNCG's position by stating, "UNC Greensboro has demonstrated a substantial commitment to sustainability by achieving a STARS Silver Rating and is to be congratulated for their efforts" (AASHE 2023). The tool is a step towards consistent reporting and accountability but remains limited in its scope of identifying all buildings or features on campus. Other accolades at UNCG include being recognized as a Tree Campus by the Arbor Day Foundation and a Bicycle Friendly University by the League of American Bicycles (UNCG 2023). The University is in a unique position to narrow the gap of accounted emissions as it already has a strong foundation and the administrative support for innovative sustainability initiatives that contribute to the pre-existing efforts of emissions tracking.

The most extensive report of emissions on UNCG's campus is the 2009-2018 GHG inventory report generated by the Office of Sustainability. The GHG report is an elaborate analysis of the carbon footprint (CF) that UNCG produces by using SIMAP. The report covers

all scope emissions, such as transportation on and off campus, development, purchases, and energy usage. SIMAP was created in conjunction with academic institutions such as the University Of New Hampshire, and nonprofits, in the wake of needing a service that was specific to campus emissions tracking and accountability. SIMAP utilizes algorithms based on the GHG Protocol and "nearly two decades of work supporting campus inventories with the Campus Carbon Calculator, CarbonMAP, and the Nitrogen Footprint Tool" (SIMAP 2023), which was previously a complicated Excel spreadsheet. The SIMAP tool helped UNCG transition towards proper accountability and streamlined metrics. The UNCG GHG inventory was established in 2009 and outlined a base for which all following years could compare and generate baseline GHG totals. From 2009 to 2018, there was an 8% reduction in emissions (UNCG 2018, 5). As of 2022, there's been a 14% reduction in emissions, with totals at 66,203 metric tons equivalent of carbon dioxide (MTeCO2). The Office of Sustainability notes that there was a 22% increase in Scope 1 emissions since 2009 (UNCG 2023). Any other GHG Inventory Reports that follow continue to frame trends, past, current, and projected, and outline any next steps for the university to take to reduce emissions.

Sustainability at UNCG will continue to be a valued feature that supports decisions and strategies of innovation and forward-thinking among the community. A recent campus-wide solution to garnering collective action is the UNCG DRIVE (Drivers Reducing Individual Vehicle Emissions) program. The program encourages employees, students, and alumni to offset their emissions by contributing $15 per ton to a fund that will be invested in energy efficiency projects on campus to help reduce the University's carbon footprint. Ten percent of the funds raised will support a local non-profit that provides home weatherization repairs to local low-income homeowners (UNCG 2023). The program is unique given the fund is directly invested

into campus sustainability objectives, rather than going through a third-party, a major critique of offset programs. The solutions needed to curb emissions must be invested in, which makes the DRIVE fund a fundamental tool for UNCG to further its climate goals. The solutions funded by the DRIVE program could be targeted towards those that deter private commuting or increase public transportation, too. The Office of Sustainability releases a commuter survey annually and has access to on-campus gasoline consumption data, but the lens through which it can gather additional information is limited without the prior infrastructure or resources allocated to do so.

For UNCG, the commitment to sustainability is clear in some infrastructure, operations and the support of programs that educate future generations about environmental responsibility. Since there are no national requirements for standards and reporting through a certain threshold of emissions, there are often gaps in which programs are required to track, especially regarding transportation data (U.S. EPA 2015, 12). The Office of Sustainability has limited resources to work with when attempting to gather this data because it is not easily accessible or quantifiable without specific parameters in place to obtain it. It requires a multi-disciplinary collaboration to compile and gather such data for tracking among individual programs.

CHAPTER II: A REVIEW OF EMISSIONS TRACKING IN HEI AND THE PUBLIC SECTOR

In the United States, transportation accounts for 29% of all greenhouse gas emissions, with 16% stemming from cars, trucks, and SUVs (U.S. DOT 2010, 1). Decarbonizing the transportation sector requires broad strategies that address vehicle efficiency, lowers the carbon content of fuel sources, reduces miles traveled, and institutes more public transportation. Emissions tracking is currently the best practice for companies to report their data and support decarbonization through quantifying base-level greenhouse gasses which harm the ozone layer such as carbon dioxide (CO2), carbon monoxide (CO), methane (CH4), and nitrous oxide (NO) (U.S. DOT 2010, 1). While the history of CF began as a tactic to shift accountability from major oil corporations onto the everyday consumer (Supran and Oreskes 2021, 712), the practice is a tool to create baselines for companies and institutions that do have emissions undocumented.

The Greenhouse Gas Protocol is a vital framework within the United States for measuring and managing GHG emissions. Under this protocol, it is mandated that all public organizations, regardless of their governmental jurisdiction – be it local, state, or federal –report their Scope emissions. These emissions reporting requirements are a fundamental part of a fragmented commitment by states to monitor and reduce greenhouse gas emissions, thus contributing to broader climate change mitigation efforts (Russell and Sotos 2010, 25). The reporting tool does not require indirect emissions to be counted, including fleet emissions or any off-road equipment, which is complicated when applying to a campus perspective. The GHG Protocol for the U.S. Public Sector remarks a notable difference in the terms “base year” and “baseline” that are crucial in forming a basis for how carbon accounting plays a role in future decisions.

Base year emissions are actual emissions in a year identified as a reference year to which more annual emissions from other years will be compared. A baseline is a determined value for measuring and comparing the impact of reduction strategies in subsequent years. By addressing inconsistencies and ensuring all sectors of the organization are accounted for, institutions can better align their efforts with sustainability objectives (Klaaßen and Stoll 2021, 2).

Universities are in a unique position to report these variables given the pre-existing infrastructure that collects and reports data. Public HEI share some tracking measures with other entities in the public sector, while encompassing their own wide array of variables. Such differences include considerations of both on- and off-campus activities, diverse energy sources, and various departmental programs, all of which exert a significant influence on emissions. HEI function as integral components of the social fabric, often mirroring the prevailing norms and values of society. Within the sprawling campus, HEI comprise diverse structures, including multi-purpose buildings, student residences, and lush green spaces, all intertwined with common internal systems such as plumbing, HVAC, water supply, and electrical infrastructure. Some universities even have their own energy generation plants on campus (Mclaughlin and Pell 2022). This narrower perspective on emissions tracking highlights the interconnectedness of HEI with the surrounding community and the wider transportation network. The difference being, HEI can educate the public, generate action, and contribute to research, which expands those who support environmental and sustainability objectives.

Case Studies

A review of similar tracking at other universities is crucial for informing how HEI conduct assessments and measure their success in carbon footprint reduction. In a study that evaluated 20 universities worldwide for their carbon footprint and CO2 equivalencies efforts, researchers streamlined the data to calculate per capita emissions and carbon footprint per expenditure for comparison (Chang et al 2021, 2).[1] The findings revealed only one university approached net zero emissions, primarily using excess green energy to offset their emissions. This highlights the potential for emissions reduction in universities of all sizes and statuses. The University of Oulu in Finland, along with other European universities, have adopted a hybrid model for tracking that combines Life Cycle Analysis and Environmentally Extended Input-Output Analysis to achieve their carbon neutrality goals by 2030 (Hilli et al. 2023, 2). These universities emphasize the importance of referencing case studies as resources for optimal methodologies, with the hybrid reporting model being favored for its versatility in monitoring emissions and leveraging activity data compared to relying solely on financial accounting for emissions tracking. Previous research underscores the need for HEI to adopt a more uniform approach to track and mitigate greenhouse gas emissions on campuses.

GHG Protocol Standards are the most established procedure for calculating emissions, mostly measured in metric tons of carbon dioxide equivalence (MTCDE)[2] or pounds of CO2 (CO2 lbs.). There are different standards used internationally such as the Publicly Available Specification, and the standards created by the International Organization for Standardization.

[1] A carbon footprint is but one piece of an ecological impact assessment; some campuses have undertaken more specific analyses, such as nitrogen impact.

[2] Note: MTCDE and MTeCO2 can be interchangeable. They are the same variable in different notations. The SIMAP database uses MTCDE whereas UNCG uses MTeCO2.

On a national level, many universities have taken their approach to measuring CF through different databases that perform similar functions (Hilli et al 2023, 2). There is a gap in the effectiveness of the system since there have been increasing universities globally that have taken a step in tracking their emissions, yet there remains no mandated standard or inventory database for doing so (Bovea and Valls-Val 2021, 2525), and thereby, no consistency between universities or departments. More prompt standard procedures for organizations to follow given that tracking methods can be duplicated and formulated to account for the varying operations is a foundational piece to consistent tracking.

In the context of individual programs on campus, Texas Tech's Outdoor Pursuits program successfully demonstrated a carbon footprint for their outdoor center (Hayhoe and Lloyd-Strovas 2009, 157), albeit with methods that are challenging to replicate due to variations in tracking software and the metrics logged. This case study was influential in the research since it was one of the few carbon analyses of a campus outdoor program found in scholarly sources and journals. Their comprehensive overview encompassed aspects such as food, transportation, and gear purchasing. Notably, their approach to transportation emissions specifically examined adventure trip-related emissions, setting it apart from other scope 1 or 3 vehicle usage in the program. They calculated emissions based on individual vehicle and trailer metrics, distance traveled, and average carbon consumption. Their findings indicated that typical outdoor trips produced fewer emissions compared to students' individual commutes home, particularly when carpooling and extended time in the field were factored in (Hayhoe and Lloyd-Strovas 2009, 157-163). The more time spent in the field utilizing carpool effects, the more GHG were avoided.

Other university initiatives to reduce transportation emissions provides more discernment to the role of place, and how the campus environment impacts overall response. The University

of Illinois Urbana-Champaign recommends reducing transportation emissions by up to 20% through anti-idling techniques, environmentally friendly alternatives, and incentive programs (University of Illinois Urbana-Champaign 2023). Whereas a fellow UNC-system campus, UNC Asheville, conducted a university greenhouse gas (GHG) assessment using SIMAP, quantifying emissions over the years with activity-specific data for each scope (Hall 2021, 151). Their broad-ranging transportation metrics emphasize the need for more detailed data from programs to provide a comprehensive grasp of the university's environmental impact. Given the limitations of accounting in the public sector, more research on transportation decarbonization is essential to inform decisions that support meaningful reductions.

One major theme of each case study at other universities is the efforts to mitigate and reduce emissions using various techniques. Both employee and student commuting are being analyzed for ways to reduce individual vehicle miles travelled (VMT). Carpooling and vanpooling along with the addition of more connecting bus routes is the missing link. At Michigan State University, a focus group and survey were performed to analyze the state of preference for these alternatives. The outcomes suggested “modest economic incentives” would not have influence, but the purchase of carpool permits would (Kaplowitz and Slabosky 2018). Similarly, at Duke University an online platform was created to link users to car and vanpooling options, but the engagement has remained low (Alabaster et al. 2019). University vanpools can ultimately provide a solution to the ever-changing challenge of addressing transportation management on campuses.

Decarbonizing Transportation

In 2018, North Carolina transportation emissions accounted for 35.9% of the total emissions within the state. While the state has demonstrated a commitment to reducing emissions

back to 2005 levels by 2030, it's essential to critically examine the effectiveness and feasibility of the proposed plan (NCDOT 2023). The reliance on a tracking plan for hybrid and zero emissions vehicles includes registrations, sales, miles traveled, and equity metrics (NCDOT 2023, 3). North Carolina has many ongoing initiatives to accelerate the transportation plan, however the reliance on electric vehicle transitions is staggering. The increased use of electric medium and heavy-duty vehicle fleets, while a step in the right direction, could be hindered by both the slow adoption of electric vehicles in these categories and infrastructure challenges. Achieving such ambitious emissions reduction targets will likely require more comprehensive and aggressive measures, including broader public transportation investment and policies to reduce overall vehicle miles traveled, both of which appear to be briefly alluded to in the plan (NCDOT 2023, 4).

Several national models have been developed to aid in achieving environmental goals, including the Environmental Protection Agency's Motor Vehicle Emissions Simulator (MOVES), the Department of Transportation's Corporate Average Fuel Economy (CAFE) model, and the Department of Energy's Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) program (U.S. EPA 2023). Notably, the new CAFE standards for model years 2024-2026 promise to deliver up to 33% greater fuel efficiency in internal combustion engine (ICE) vehicles compared to 2021 models (NHTSA 2022). Simultaneously, the European Union is pushing forward with its plan to phase out ICE vehicles by 2035, emphasizing the need for more concrete standards, given an extension has been granted to the ban allowing ICE models burning e-fuels to be used after the intended deadline (Visnic 2023). These standards play a critical role in guiding short-term vehicle decisions as the transition towards a more sustainable, less gasoline-dependent future continues. It is essential to evaluate

each new vehicle purchase for its environmental effectiveness and conduct a cost-benefit analysis to determine if electric vehicles offer a superior long-term solution. While fuel efficiency standards serve as vital regulatory tools aimed at reducing greenhouse gas emissions, their true effectiveness hinges on a multitude of factors and comprehensive industry compliance (Bento 2020, 132).

Offset programs have been a large point of debate in the current state of attempts to curb emissions, with valid reasoning as they have not reduced emissions in significant terms, yet. There have been claims of greenwashing, misuse in carbon accounting, poor implementation, and overall market inefficiency (Dargusch and Thomas 2012; Miltenberger et al. 2021). Despite the issues, a market-based solution is seen as the tool needed today for climate success, even though long-term solutions may not be market-based. This perspective lends itself to recognize the issues of offset programs as issues in wait for solutions. The role of these carbon markets is anticipated to decrease over time as the reliance for non-renewables decreases. An increase in market innovation and participation gives insight to how the flaws of offset programs will reduce and adapt (Mittenberger et al. 2021, 5).

Capacity for Alternatives

Other aspects of decarbonization focus on the transition to reliance on renewables and the efficacy of long-term strategies to pursue other fuel sources. The National Renewable Energy Laboratory emphasizes “reshaping existing mobility” onto a system better equipped for future generations, resilient to change, and one that supports the climate future (NREL n.d.). Within the transportation sector, there are aggressive strategies taken to pursue a “multi-pronged” strategy of reliance on these other clean energy sources such as wind, solar, and bioenergy. The strategy taken by the NREL seeks to apply to industry stakeholders, communities, and individuals

through 3 main variables: Causal Factors of Mobility Behavior (sociodemographic, status factors, affordability, geography), Mobility Needs (work, entertainment, shopping, school), and Sustainable Transportation Modes to Meet the Needs of Individuals (aviation, vehicle, rideshare, transit). These variables are expansive but begin to network an energy ecosystem that can be referenced for decarbonization ventures (NREL n.d.).

Electric vehicles offer benefits but therein pose infrastructure and cost challenges, necessitating diverse decarbonization strategies. Life cycle analysis compares conventional, plug-in electric hybrid, and hydrogen fuel cell vehicles to inform sustainable choices. This assessment includes vehicle life cycle (assembly, maintenance, recycling) and fuel life cycle (extraction, processing, distribution, storage, use) (Gao and Winfield 2012, 1). Transitioning from decades of oil and gas reliance is multifaceted. Research explores various energy storage and capture methods to cut emissions in transportation. Low-carbon fuels were desirable for recycling and cross-sector use, as decarbonization can repurpose captured carbon into advanced materials and chemicals (NREL n.d.).

Within the U.S., EV were found to emit 60-68% less than gas vehicles and save a median of $770 annually, demonstrating the effect of financial and environmental savings. In Raleigh, NC, it can be even more, at $843, based on time-of-use rates (Bieker 2021; Union of Concerned Scientists 2017). While EV offer an accessible, individual climate solution, affordability and reliance on existing infrastructure remain a challenge. The life cycle of an EV will depend on the electricity used to charge it. In geographic locations with low-polluting energy sources, there is more of an advantage to the life cycle. Whereas in regions with conventional electricity generation, there is not as much of a strong lifecycle emissions benefit (U.S. DOE n.d.).

The future of EV must work alongside a rise in more public transportation or the per capita VMT will continue to increase and overshadow any alternatives (Mohsin and Woodhouse 2023). For more consumers to make the transition, there will need to be lower-cost energy plans to make the purchase affordable, more charging locations, and the implementation of federal and state purchase incentives to remain vital instruments in maintaining these sustainable solutions across the public sector (Union of Concerned Scientists 2017).

Decarbonizing University Fleets

Electrifying university fleets by transitioning vans from traditional ICE to EV is a progressive approach that institutions can consider developing the "feasibility of achieving net-zero-emissions" (Arnold et al. 2022, 8). More electric drivetrains are becoming available for light duty vehicle models and even some medium-high vehicles. In higher education settings, it may not be advantageous to electrify the vehicle fleets depending on low usage and little financial or emissions savings (Arnold et al. 2022, 14). There are concerns that while electrification of the vehicle will result in decreased emissions, there will be an increase in power generation, which ultimately links emissions reduction to the electrical matrix of the region (Sodre and Teixeria 2018, 375).

In a study done of two types of EV substitutions at a university, the electricity needed increased using both vehicles for the same distance traveled. In similar accordance, the electricity provided to the vehicles can be discharged back onto to the grid to "shave the peak demand of general usage" by the university (He and Yamamoto 2020). At Villanova University, a full fleet electrification analysis was performed that supported a 3% decrease of scope 1 emissions, and an overall reduction in 25% of emissions by 2024. While the size of the university is much smaller compared to UNCG, the clear savings from electrification, similar

pathways, and processes for outcomes can be used as a reference for other universities to follow in the future (Copsey 2022, 140). At the University of Tennessee, using an optimization model for total costs and travel mileage, all trips less than 100 miles were found the most optimal for electrifying the fleet (Cherry and Yoon 2018, 12). For outdoor programs, this can complicate the transition given travel to the mountains or hiking locations is often dependent on campus regional geography, but it does not negate the ability to do so. In the future of this research, outside the scope of this project, including into the analysis of EV replacement the variables of depreciation, disposal of surplus gas-powered vehicles, and the ownership cost of use are critical to consider the economic analysis for savings (Cherry and Yoon 2018, 14).

The future of the North Carolina energy mix and support of alternative practices can affect the efficacy of alternatives. While coal is being phased out of the state, the alternatives, such as solar, wind, etc. must be backed up by another on-demand resource like natural gas, which complicates the transition and reliance towards transportation solutions. In a recent study it was found that efforts to improve transportation energy sources have been critical for furthering the impression of environmental sustainability in policymaking yet have "been insufficient to decarbonize the economy" insofar as reliance on oil remains the preferred source (Marques and Neves 2021). North Carolina is on the right pathway to decarbonization, but importantly, the connection to how the energy source guarantees, to a certain extent, the magnitude of GHG emissions must be considered.

Public Transit Significance

Public transportation is an essential and environmentally responsible mobility choice (U.S. DOT 2010, 1). It reduces greenhouse gas emissions compared to an equivalent number of people driving private vehicles. The environmental benefits are greater when passenger vehicles or light rail systems maximize occupancy. In essence, adopting and promoting public transit systems represents a stride towards mitigating the environmental impact of individual transportation choices, and emphasizes the benefits of efficient and sustainable mass transit solutions (U.S. DOT 2010, 2). Even when factoring in emissions generated during the construction, manufacturing, and maintenance of public transit systems, they still exhibit lower greenhouse gas emissions per passenger mile when compared to individual car travel (U.S. DOT 2010).

The use of public transport crosses sectors of equity, health, mobility, livability, and substantially influences social outcomes. The sector is continuing to grow and become more sustainable following instituted mandates on fuel economy and standards, alongside the growing influence of hybrid, and electric vehicles, and deeper investments (NHTSA 2022). Public transportation continues to face an uphill battle as cities hold EV

to a higher standard than the strategies to improve this form of transit. The US has notoriously failed to compare to other countries when it comes to its investments in public transit infrastructure (Mohsin and Woodhouse 2023). The individual and collective landscape of decoupling from automobile reliance faces continued barriers as highway construction and car manufacturing are prioritized.

Public transportation and a university's fleet of vehicles share a common goal in connecting people to various destinations efficiently. In addressing emissions within the

transportation sector, universities often face challenges due to the predominant use of oil and gas and a lack of comprehensive mobility networks (Cherry and Yoon 2018). Nevertheless, by committing to improving the efficiency and sustainability of both public transit and the university's vehicle fleet, significant emissions reduction is attainable.

On campuses, there are avenues for both public transportation to various locations and van/carpooling to a single location. Many campuses have been concerned about their overall emissions regarding transportation and how to mitigate them. The increase of ridership among these avenues is the most supported way to limit private vehicle miles traveled. After the COVID-19 pandemic, transit ridership declined and has yet to improve. Meanwhile, vanpooling is on the rise and is expected to recover quicker because riders are familiar with each other and more comfortable sharing a space together (Feigenbaum 2021). At UNCG Outdoor Adventures, this was evident give the increase in participation on trips during this period. Vanpools have potential to replace locations where a fixed-bus service is not feasible and can re-connect riders back to the community.

To introduce a comparison between the outcomes of the transportation alternatives, the Activity, Modal Share, Energy Intensity, and Fuel (ASIF) equation can be used to determine GHG emissions of transport. The baseline scenario, such as the existing fleet emissions (whether using UNCG or individual program fleets like Facilities or OA) are determined. The total CO2 emissions, passenger travel in a predetermined distance metric (km or ton-km), the share of travel for each mode, and fuel type are all factors to consider in these equations (Arioli et al. 2020, 9). A university’s Sustainability Office should have access to this data if tracking is already occurring on external databases. The introduction of more vanpooling on-campus and EV purchasing as alternatives for the fleet can be calculated under the same parameters. The

emissions with and without the alternatives will ultimately highlight the case for reduction. There is additional potential to assess the number of vehicles on the road by looking at changes in the activity and modal shares. If the service is successful, it will result in more people using sharing transport avenues and less, individual cars on the road.

CHAPTER III: ROLE OF UNCG OUTDOOR ADVENTURES

Outdoor Adventures is the university's hub for campus outdoor recreation and adventure gear. The use of university-fleet vans supports the inherent programming of Outdoor Adventures on campus. There is a large benefit to providing access to outdoor spaces away from campus for students who wouldn't have chances otherwise. These characteristics of the program would not be possible without the use of shuttles in the way demonstrated. Outdoor Adventures is nestled under The Department of Recreation of Wellness, which is under the larger umbrella of The Division of Student Affairs. Outdoor Adventures aligns with the Division of Student Affairs' strategic plan, which follows the university strategic plan (with more targeted goals specific to the Division). OA influences students through on- and off- campus opportunities, including the climbing wall; Piney Lake; adventure trips, and student events. It originated as the Outing Club in 1966 at UNCG, providing outdoor experiences like rock climbing, kayaking, hiking, and caving. Over the years, it became part of the Department of Recreation and Wellness, which centralized its operations at a new recreation center in August 2016, marking continued growth in the programming.

Outdoor Adventures is founded around student participation, growth, and learning initiatives throughout these expeditions. In outdoor programs, the main awareness of environmental ethics is valued through the recognition and involvement of Leave No Trace policies. Leave No Trace is a meaningful tool for mitigating harmful environmental impacts, but there remain indirect ramifications through Scope 1 emissions from programs, such as the transportation, maintenance and operation of a vehicle fleet, and trailer travel with full vehicles (Hayhoe and Lloyd-Strovas 2009, 153). Many outdoor leaders and guides find themselves in a

unique position with their role in both providing a tailored student experience outdoors while maintaining sustainability and following the university's pledge for carbon reduction.

At UNCG Outdoor Adventures, from the fall to spring semesters, there are 19-20 recurring and 3-5 unique trips, with an average of 9 participants and 3 trip leaders on each adventure. More local trips often have community services, such as Adopt-a-Stream and the SPCA Dog Hike, which can accommodate up to 20 participants. Using the most recent Fall 2023 trip schedule as an example, only 6 out of 22 trips were out-of-state: 5 in Virginia and 1 in Tennessee. During the Spring semester, the out-of-state trips expand to include one trip to West Virginia for snowboarding and one trip to Florida for sea kayaking, as the ability to offer trips during warmer and colder temperatures varies. In the past, outlier trips have embarked to farther locations such as Wyoming and Utah. For the Fall 2023 semester example, out of 22 trips, only 4 trips were overnight: one 4-day trip, two 5-day trips, and one 2-day trip. All overnight trips longer than two days align with university instituted breaks for students.

CHAPTER IV: DATA AND METHODS

All Outdoor Adventure trips are staff-led, including food and transportation summed into the cost of attendance. From 2012-2022, there have been notable upgrades to the vehicle fleet to match the growing program and needs. From 2005-2014, there was only one vehicle used for the program's transportation needs: A 2005 Chevy Van, used for staff events, trip programming, and mobility around Greensboro for local tasks such as gear or food purchasing, and restocking. As the program increased in operation, budget, and participation, another vehicle was added to accommodate. From 2014-2016, the two vehicles in operation were the Chevy van and the recently acquired 2014 Ford StarCraft Minibus, both seating 14 individuals. Having two vehicles was beneficial to the program such that during one weekend, multiple trips can go out or various tasks can be done. From 2016-2018, a 2016 Ford Transit was added to the mix to accommodate the opening of Piney Lake and offering shuttles for students and staff to the property. Lastly, in 2018 a fourth vehicle was added to the fleet: a 2019 Ford Transit, as seen by Table 1.[3]

[3] A recent update to the program is the 2023 purchase of a 2022 Ford Transit van to replace the oldest van, the 2005 Chevy Van.

Table 1. Outdoor Adventures Active Van Fleet

Fiscal Year	Vehicle In Use			
	2005 Chevy Van	**2014 Ford StarCraft Minibus**	**2016 Ford Transit**	**2019 Ford Transit**
2013	x			
2014	x	x		
2015	x	x		
2016	x	x	x	
2017	x	x	x	
2018	x	x	x	
2019	x	x	x	x
2020	x	x	x	x
2021	x	x	x	x
2022	x	x	x	x

Note. Visual display of which vehicle was used for the following years.

There are four main components to the data results and its role in identifying greenhouse gas emissions released and avoided from the fleet of vehicles: shuttle logs indicating trip type

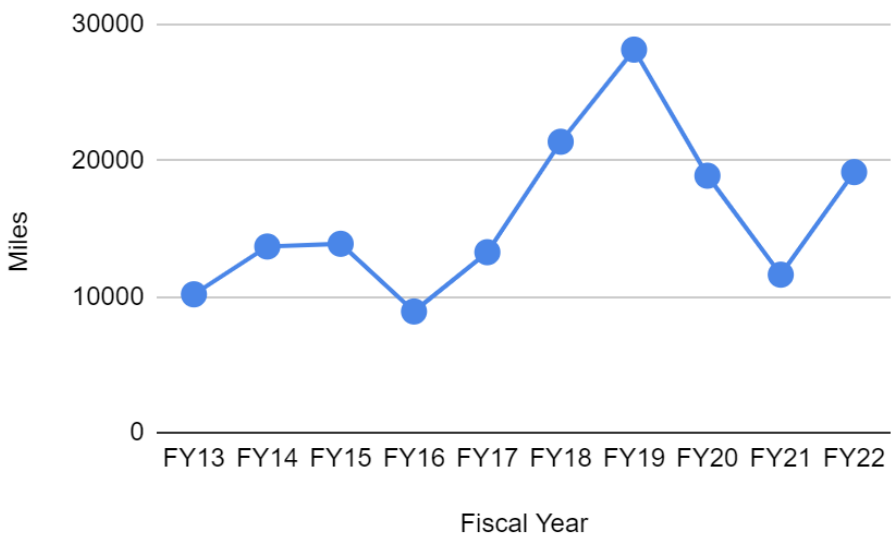
and use, estimated population during the period, the inputs needed for SIMAP, and the Qualtrics survey. [4]

UNCG Outdoor Adventures Shuttle Logs

Outdoor Adventures has been utilizing shuttle logs for the last ten years and files them within the Department of Recreation and Wellness' administrative storage as a new fiscal year begins. Every seven years, per the IRS limitation period, these documents can be shredded, which hindered gathering the physical shuttle logs for the years 2012-2015 (IRS 2023). Mileage data was being tracked for financial purposes which led to this information being obtained from a different avenue. The shuttle logs include the date in/out, the name of the driver, the in/out time of the vehicle, the odometer reading before and after the trip, and the total miles driven. This table is printed on a half sheet of paper and included in each vehicle's resource binder. Every trip taken is recorded in the log for program and gas purchasing accountability. The mileage information was crucial in visualizing usage trends over time and gathering the total mileage at the end of each fiscal year (Figure 1).

[4] Operating equipment at Piney Lake, such as gators, golf carts, and a truck using both diesel and gas, were excluded from this project due to less precise historical tracking and their recent transfer to the Facilities and Operations department.

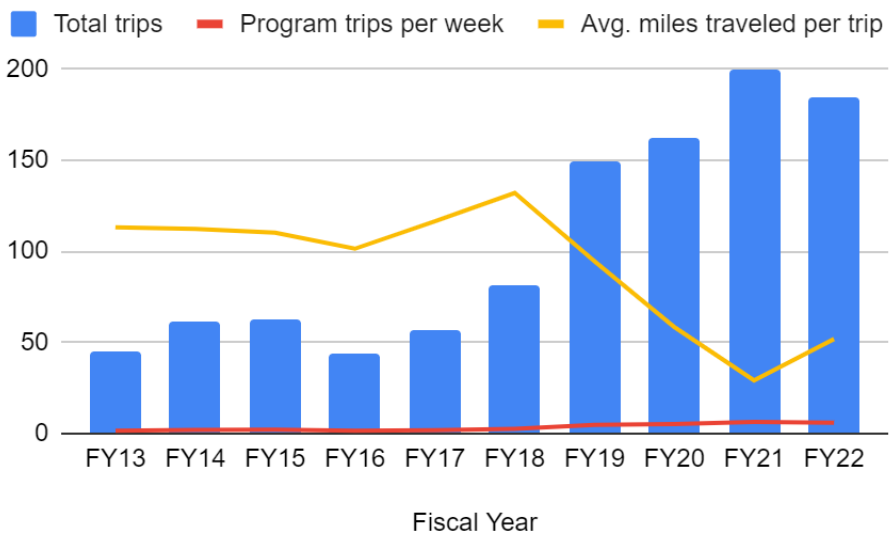
Figure 1. Total Vehicles Miles Traveled



Note. Total vehicles miles for all vans in the fleet annually.

The location field of the shuttle log was used to determine what type of trip was taken, which was broken into three categories that broadly represent program use: Adventure Trips Programming, Piney Lake, and Other. The "Other" region includes miscellaneous on-campus visits, Harris Teeter visits for food purchasing, or other informal uses of the vehicles, such as those a-typical to the program (See Table A1 in the appendix for the shuttle log raw data). Figure 2 demonstrates trends revealed in the program given the type of trip data. More visualizations can be generated from this data per each individual vehicle. For the research, visualizing the transportation trends in the program is most relevant.

Figure 2. Program Transportation Trends



Note. Y-axis represents number of total trips taken and average miles traveled per trip.

Program trends can provide deeper insight into the usual operation each vehicle is used for the most. Is there one van preferred for adventure trips and another for Piney Lake? The data reveals how the program fluctuates depending on broader circumstances, such as university operations, and staff abilities during that time. Trip distance has declined dramatically since 2018, explained by the increased frequency of Piney Lake trips and staff capacity impacted the outcome of the program. During 2018 and 2019, the program had more out-of-state trips but only during one period of the year. The rest of the trips were local and can explain the lower average miles traveled per trip. Additionally, the results were based on the shuttle logs which could demonstrate human error (not logging certain trips, therefore minimally skewing the results). The frequency of trips around Greensboro increased through 2020 as the COVID-19 pandemic affected travel policy and program participation. The program was not allowed to offer trips

which amounted to being in the vehicle longer than 15 minutes. The trend has since increased but has not reached previous levels.

Estimated Population

The population was both informed and assumed depending on the variable. For available adventure trip data, population numbers were accurate. For staff use of the vehicles, or outlier trips with the vans, assumed averages were used. For any Piney Lake events utilizing the shuttles, rider numbers were determined from previous logs. The rider use numbers were logged for each vehicle among each month from August 2012- July 2022.

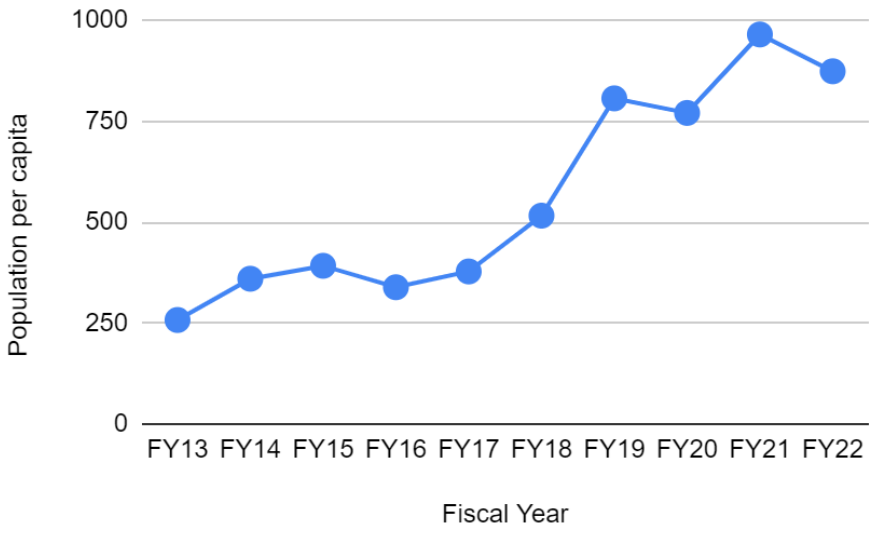
For each adventure trip, there are 3 trip leaders and on average 9 participants (some trips allowing up to 20). Some outlier trips may operate with only 2 trip leaders, and some trips will run with more, or less than 9 participants, depending on budgets. After each adventure trip, the trip leaders conduct a debrief that has a section for determining how many participants attended. This number was used for determining trips that were logged in the shuttle binders and were included in the reporting.

Programming for Piney Lake includes 1-2 staff members shuttling students from UNCG to Piney Lake and back on weekends, along with offered events and activities out at the property throughout the semester. Piney Lake has had inconsistent hours over the years as staffing capacity has changed. For example, in 2019, the lake was open weekly with staff attempting to offer shuttles during this time. More consistently, Piney Lake has only been open and offered shuttles on weekends. An average number of participants and staff were calculated from previously logged shuttle binders from Piney Lake operation. Only 1-2 vehicles were used for this weekend shuttling service, while the other vehicles would only go out to Piney for workdays

or staff use. For these factors, 2 was used as an average number for the number of riders at a time if staff were going out for workdays.

For the Other factor, the vehicle would be used for grocery trips, irregular tasks, and during the recent COVID-19 pandemic, offering shuttles back onto campus for students who were quarantining. If the location was Harris Teeter, 2 was used as the determination for population because it is the minimal staff needed for such task. Depending on the type of activity in the log, assumptions were made for other uses and those years prior for how many people were using the vehicle depending on previous program outings. Population over time is logged below in Figure 3.

Figure 3. Total Population Use of Fleet



Note. Total population of all program activities annually.

SIMAP

To obtain accurate results, the average miles traveled one way per trip, trips per week, and total commuting weeks were entered into the database. This data was obtained from the shuttle logs, total mileage of the vans, and population data for each month from August 2012-

July 2022. Each year reported had several Program Trips logged, and determined whether those trips were for Adventure Trip Programming, Piney Lake, or Other purposes. For example, in 2012 there was only one vehicle that accounted for 45 total program trips with an annual mileage of 10,180. The total number of trips divided by the annual mileage demonstrates the miles traveled per trip. With an average of 32 commuting weeks in a fiscal year, the number of Program Trips per week was calculated. The number of commuters, or population per capita having taken the shuttles is included to determine the GHG totals. These numbers were calculated for each year and input into SIMAP, demonstrated by Table 2 (below). The vehicles were combined to gather a full scope of program emissions, but each vehicle could have been input separately to determine which vehicles may emit more. Since all the vehicles are used for varying tasks, there was no need, for the goals of this research, to determine these independent emissions by vehicle.[5]

[5] See Table B1 in the appendix for SIMAP Raw Data

Table 2. Variables Input into SIMAP Database

Fiscal Year	Total miles traveled	Total trips	Total population use	Program trips per week	Avg. miles traveled per trip	Avg. miles per student
2013	10180	45	258	1.41	113.10	39.46
2014	13689	61	360	1.91	112.20	38.03
2015	13888	63	392	1.97	110.22	35.43
2016	8919	44	339	1.38	101.35	26.31
2017	13270	57	378	1.78	116.40	35.11
2018	21382	81	516	2.53	131.99	41.44
2019	28144	149	806	4.66	94.44	34.92
2020	18887	162	770	5.06	58.29	24.53
2021	11621	200	964	6.25	29.05	12.05
2022	19153	185	873	5.78	51.76	21.94

Note. The FY input into SIMAP was noted as FY33-FY42 to prevent overlap with current UNCG data. FY13=33, FY14=34, etc.

Qualtrics Survey

The Qualtrics survey was sent through an email chain of all patrons who swiped in at the climbing wall in 2021-2022, word of mouth survey, and release on social media. Noteworthy questions included in the survey and most valuable to the research were “Have you ever ridden in an OA vehicle for Piney Lake or the adventure trips program?”, and “Would you have driven

to these locations if you didn't have the shuttle service?", and "Where did you go?" (See Tables 3 and 4).

Table 3. Qualtrics Adventure Trip Preferences

Have you ever ridden in an OA shuttle for a trip?		**Would you have driven yourself to these locations if you had to?**	
Yes	40	Yes	10
No	61	No	15

Note. Specific to trips off-campus, not to Piney Lake.

Table 4. Qualtrics Piney Lake Trip Preferences

Have you ever ridden in an OA shuttle for Piney Lake?		**Would you have driven to Piney Lake if you had to?**	
Yes	43	Yes	17
No	58	No	1

Note. Specific to Piney Lake trips only.

The data informed the results of student preference to determine avoided emissions. The locations help to determine how many emissions could be prevented by continuing the trip shuttle service. The survey was released through Qualtrics and received a total of 139 responses that revealed patron preference when it comes to transportation options through the Outdoor Adventures program. There was a total of 101 unique responses in the survey by those who have taken the UNCG OA shuttles, whether for adventure trips, Piney Lake, or as staff members.

Table 5. Geographic Distribution of Qualtrics Responses

Distance from place of residence to OA	Number of Answers	Distance from place of residence to Piney Lake	Number of Answers
0-5	82	0-5	24
6-10	10	6-10	56
11-15	5	11-15	9
16-20	2	16-20	4

Note. The total number of answers to this question (98) is less than the total number of Qualtrics responses (101) due to human error in filling out the survey.

CHAPTER V: RESULTS AND DISCUSSION

The primary objective in this research was to assess the environmental impact of a university program's transportation fleet and determine the extent to which it contributes to and facilitates emissions reduction. The methods above were used to inform the results indicated by the SIMAP software and Qualtrics survey results combined.

The data trends illustrate seasonal fluctuations, with peaks and dips that can be linked to reduced or absent adventure trips during the summer months. It can also be noted that the trendlines for both miles driven and population are on an upward trajectory, supporting program growth. The growth is poised to result in increased emissions even with shorter trip distances, indicating both the need for potential emissions reduction tactics and the continued programming of campus outdoor recreation for its inherent benefits as supported by increased program use and preferences gauged.

SIMAP Results

SIMAP used the data to determine CO2 (kg), CO2 (MTCDE), CH4 (kg), CH4 (MTCDE), N2O (kg), N2O (MTCDE), and total GHG MTCDE. The results of all but CO2 rounded to 0 as the closest whole number. Therefore, for the purpose of this research, GHG MTCDE is mostly made up of CO2 MTCDE, converted to lbs. As seen by Table 6 are the emissions breakdowns total and per capita.

Table 6. Emissions per Fiscal year and per capita

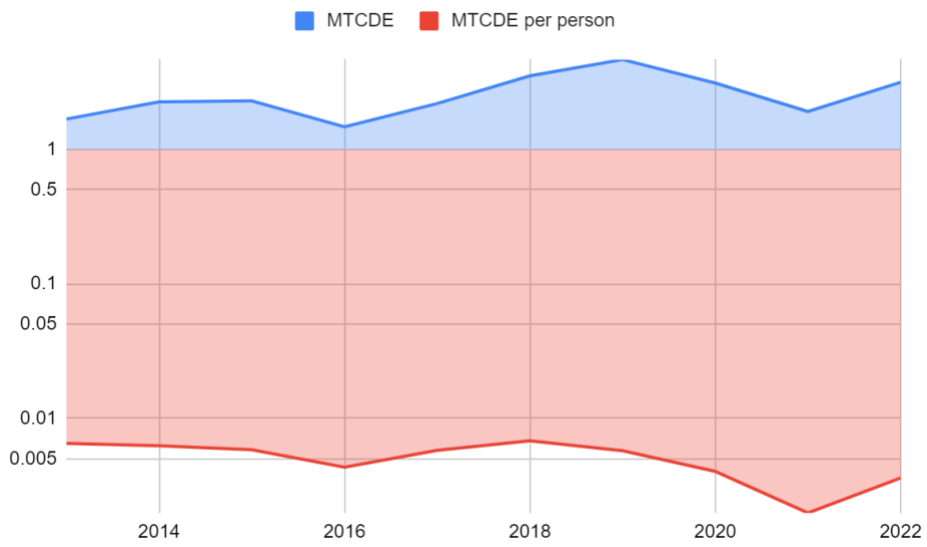
Fiscal Year	Total MTCDE	CO2 (lbs.)	Total Population Use	MTCDE per capita	lbs. CO2 per capita
2013	1.68	3360	258	0.00651	13.02326
2014	2.25	4500	360	0.00625	12.50000
2015	2.29	4580	392	0.00584	11.68367
2016	1.47	2940	339	0.00434	8.67257
2017	2.19	4380	378	0.00579	11.58730
2018	3.52	7040	516	0.00682	13.64341
2019	4.64	9280	806	0.00576	11.51365
2020	3.11	6220	770	0.00404	8.07792
2021	1.91	3820	964	0.00198	3.96266
2022	3.15	6300	873	0.00361	7.21649

Note. CO2 (lbs.) was determined outside the SIMAP outputs to generate comparison to UNCG and national averages.

The emissions per year help to indicate future recommendations based on how many tons are emitted. The MTCDE and CO2 per capita provide more insight into how programs fluctuate and reveal trends in usage by students and staff influencing emission outputs. Growth and more exposure of program activities are essential to Outdoor Adventures, as the goals are to educate and provide outdoor experiences to those who would otherwise not have the options. The expression per capita informs the program of van capacities and subsequent use.

Figure 4 shows the varying range in the emitted GHG per capita versus the total amounts annually. At UNCG, the average commuter releases 1 ton of emissions a year. In comparison, the OA vehicles are responsible for an average of 2.6 tons a year, while the use by students averages to .0051 tons a year.

Figure 4. Log Scale Indicating Variable Difference in Per Capita Emissions



Note. Log scale was used to visualize difference in ranges through the thousandth decimal.

The data reveals that fiscal year 2019 posed the highest for emissions, which correlates directly with the program offering more than average trips and events during that period. The staff capacity was higher and the ambitions to expand Piney Lake events and programming were taking effect. During this time from 2018-2019, Piney Lake was also open weekly which led to more program trips being taken. From 2013-2022, there was an 88% increase in GHG emissions which directly correlates to the 88% increase in miles traveled over the period. Whereas there was a 237% increase in the MTCDE per person per mile as both student use and the program has

grown. At OA, there was a 33% decrease in emissions from FY18 to FY19, largely due to transition in staffing the program saw, which was reflected in the trips and events programming.

The calculated total average miles driven before releasing 1 MTCDE GHG is about 6071, a small amount given the average miles traveled is only 15,913 a year. The results show that the per capita MTCDE has decreased over the last ten years. There have been both year-to-year fluctuations, most notably post-COVID when there were programming limitations; the emissions decreased 51%. The program resumed normalcy in 2022, as both the trip offerings and population began to recover. The increase in population coupled with Outdoor Adventures offering the same adventure trips over the years has led to reduced emissions per capita. These are trace amounts in the grand scheme of the university, but important to quantify. In comparison to the institution, from 2009-2021 at UNCG there was a 25% reduction in MTeCO2.[6] Pre-pandemic, UNCG had reduced its CF 14% and in FY18-19, there was a 5% reduction (UNCG 2021, 9).

Qualtrics Survey Review

The goals of the Qualtrics survey were to determine a quantitative and qualitative response to shuttle use from those on campus who utilize the OA program, whether for Piney Lake or recreation trips. The survey revealed that out of the 101 unique responses to the answers, 39.6% have taken the shuttles for an Outdoor Adventures trip program, and 42.6% have taken a shuttle to Piney Lake, for informal or formal programming. Out of the responses, for those who have been on adventure trips, 25% revealed that they would have otherwise driven to the trip locations stated. Out of the 10 “Yes” responses to willingness to drive to adventure trip locations,

[6] Noting that FY19-20 show substantial reductions due to the COVID-19 pandemic, also seen evident by the Outdoor Adventures results.

there were eight listed locations. As for Piney Lake, 17 respondents stated they would drive to Piney Lake if the shuttle option wasn't available.

Table 7. Stated Preference for Individuals Driving to Adventure Trip Locations

Location	Number of Answers	Round trip Distance from UNCG
UNCG Piney Lake, GSO	1	15.4
Pilot Mountain, NC	2	95.8
Pisgah NF	3	336
Lake Brandt, GSO	1	22.6
Local Horse Ranch, GSO	1	46.2
Catawba, VA	2	242
Snowshoe, WV	1	484
NC Coast	1	434
		1676 Miles Avoided

Note. Respondents were able to list multiple locations for the question.

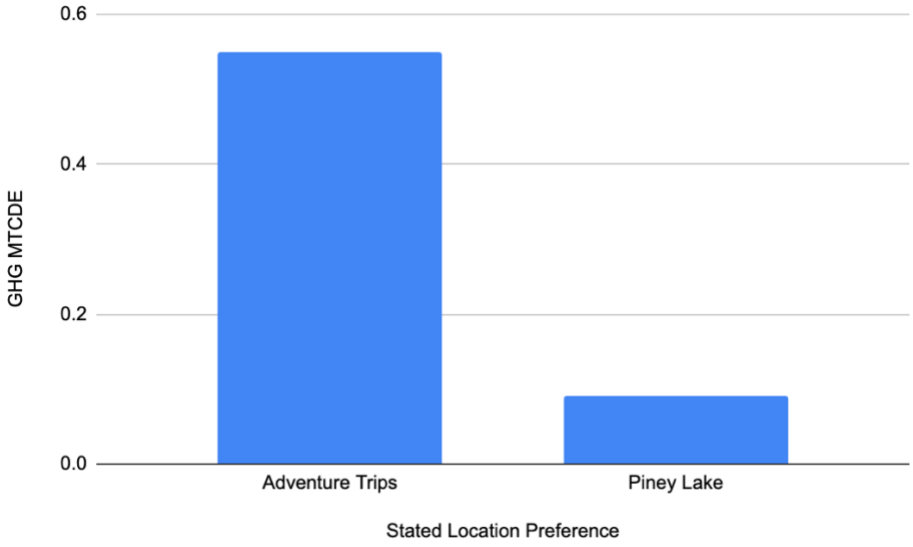
Table 8. Stated Preference for Individuals Driving to Piney Lake

Location	Number of Answers	Round Trip Distance from UNCG
Piney Lake	17	15.4
		261.8 Miles Avoided

Note. Some adventure trips have been at Piney Lake, but the distinction was made to keep the two separates for the purpose of the research.

The Qualtrics data reveals that some of the students and staff who utilize the OA shuttle services would rely on personal vehicles if the shuttle services were unavailable. By combining the roundtrip distance of all locations, if each participant traveled only once to these stated locations, the individual VMT would be about 1937.80 miles. There is an estimated 1937.80 miles avoided by offering forms of shared transportation. Due to the low recorded responses to the preference question, there is uncertainty in exact percentages for the avoidant emissions due to the response rate and questioned truthfulness of the responses (Hilli 2023, 7). The stated preference for travel was input into SIMAP to determine Scope 3 emissions avoided by offering the vanpooling service for program activities (Figure 5). For adventure trips, 0.55 MTCDE and .09 MTCDE for Piney Lake is prevented from release by offering the shuttle for student use each year. Over the last ten years, the savings have been approximately 6.4 metric tons.

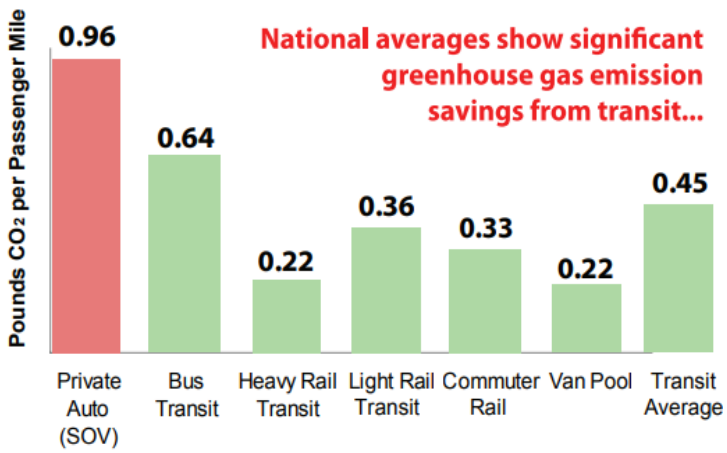
Figure 5. Annual Average Avoided GHG MTCDE from Qualtrics Responses



Note. This calculation assumes the stated preference and the students only drove one round trip in an ICE vehicle.

The data analysis supports the core hypothesis that a university's shuttle fleet can significantly contribute to emissions reduction. Public transit, including the university's shuttle services, serve as a vital mechanism for reducing the CF of the campus community. The chart below can be used as reference to how the UNCG OA fleet compares to national averages. The average pounds of CO2 per mile for the OA vehicles is 0.36, indicating more-than-average miles traveled compared to the national vanpool averages. The frequency of the trips, and the geographical limitation of Greensboro being in the Piedmont region is one reason for the disparity given that the distance to adventure locations, mostly the mountains or the beach, influences the averages.

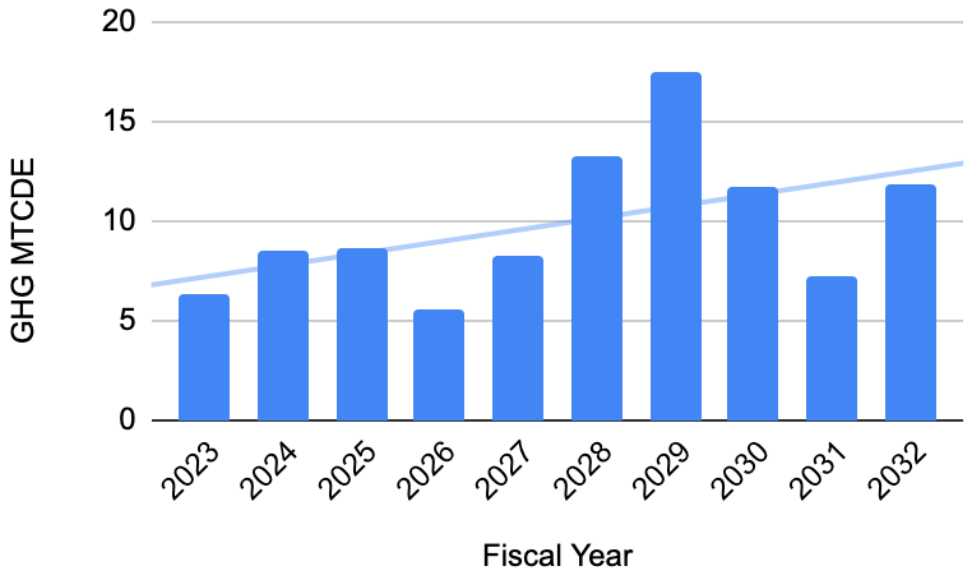
Example 1. Estimated CO2 Emissions per Passenger Mile for Transit and Private Autos



(U.S. Department of Transportation 2010, 2).

Determining the projected emissions given the 88% increase in GHG over the last ten years is essential to providing a baseline against which commitments can be measured. It can help the program set clear targets and track their progress towards becoming a more sustainable institution. A commitment to sustainability and transparent reporting of emission reduction efforts can enhance overall reputation and standing. While this research represents only one program, the tracking can attract environmentally conscious students, faculty, and funding, making the university a leader in environmental responsibility. Figure 6 shows the projected emissions over the next ten years considering the 88% increase in emissions from FY13-22.

Figure 6. Projected MTCDE Emissions FY23-32



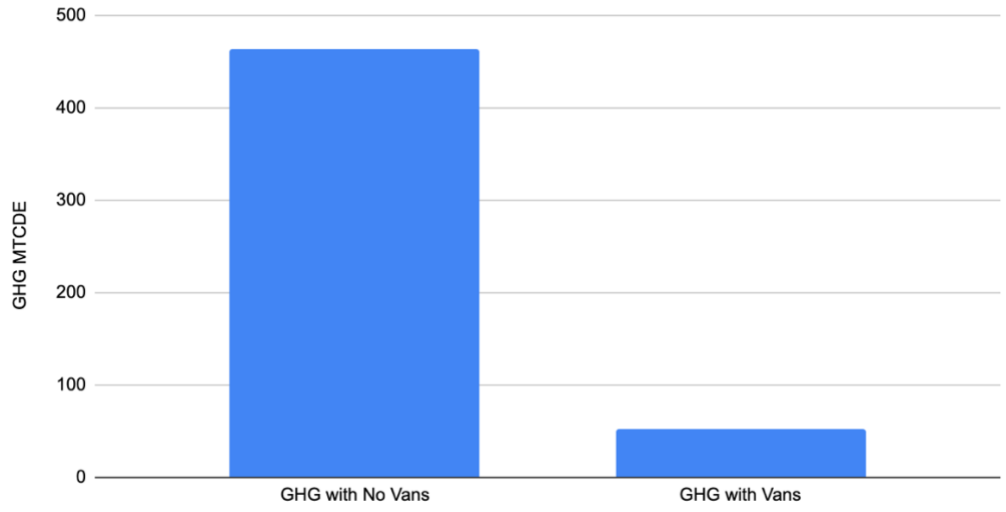
Note. This calculation assumes a constant annual percentage increase in emissions. If there are variations in the rate of increase over the next 10 years, the actual emissions may differ. This calculation provides a simplified estimate given that real-world emissions are influenced by various factors and policies.

Hypothetically, if the OA shuttle vans were not available for student use over the last ten years, the emissions would have been exponential. By broadly applying the stated preferences, it was determined that 75% of students would not have the chance to travel and experience these adventure trip offerings, as well as 60.5% of students, would not have had the chance to travel to Piney Lake (The on-campus public transportation not operated by OA, such as the Spartan Chariot fleet, does not travel to this property nor to outdoor adventure sites). Providing the shuttles is essential to program operations and increased student mobility.

Without the use of the vans by staff and students over the years, assuming each person drove a single occupancy vehicle and went on one trip, the emissions are almost 8.9x higher over

the last ten years than they were with the vans in use; A surprising amount that supports the recognition of vanpooling and campus public transit as resources for drastic emissions reduction.

Figure 7. Emissions Generated FY13-22 Assuming There Were No Vans for Student Use



Note. This calculation combines the preferences for adventure and Piney Lake trips over the ten-year timespan, and assumes each student drove one roundtrip in an ICE vehicle.

CHAPTER VI: RECOMMENDATIONS

Universities are hubs of innovation and imagination. With a university such as UNCG, that promotes becoming carbon neutral by 2050, there should be data available to account for base-level emissions in different programs and how the university is moving forward through a sustainable lens. The results highlight emissions avoided by providing such services. The cultivation of a stronger network of sustainable action and interaction with other campus programs advances three of the five Division of Student Affairs Strategic plan focus areas: Health and Wellness, Organizational Sustainability and Infrastructure, and Student Engagement. The inherent carbon neutrality goals of the University are enhanced by adoption of this research into other programs. Visualization of emissions and comparative resources between departments can justify any decisions put forward by the Office of Sustainability or those seeking change on campus. Through the lens of Outdoor Adventures, the future of the vehicle fleet will continue to rely on the vans. It is unlikely that another vehicle will be added onto the fleet unless to replace an old one that is functionally under-performing. The recommendations for future use can be broken into two parts: those relevant to Outdoor Adventures, and those relevant to UNCG as an institution.

Recommendations for UNCG Outdoor Adventures

Future Use of Vehicles

The program uses all the vehicles in the fleet a considerable amount and justifiably provides an impactful service to people in the process. An adoption of viewing the sustainability of vehicles in their life span can be a tool for continuing operations while emphasizing the potential for greener solutions. In this case, the future use of vehicles can be broken into three components: Travel, Maintenance, and Retirement. As the program continues, tracking the

maintenance and travel for each vehicle is important to gathering a life span for the vehicles. With this information, an analysis can be put together that would consider current trip budgets and vehicle costs/benefits to determine the efficacy of purchasing one new EV transit for the program when retiring an old vehicle and the revenue from the sale/retirement of that vehicle.

Program Policies

A policy that the data highlights as a potential unnecessary use of consumption and subsequent emissions is the trip requirements for meeting before trips. For example, if a commuter student wants to go on a Pilot Rock Climbing trip with the program, but lives in Winston Salem, they must meet the other participants and trip leaders at UNCG OA, in Greensboro, 28 miles (one-way) the opposite direction, to shuttle together. In this scenario, Pilot Mountain is closer to Winston Salem (23.6 miles away) versus the student driving out of their way to attend the program that will drive through the city they were originally in. While the occasion is rare when this occurs, it ultimately presents a scenario where the Scope 3 emissions are not justified, and individual VMT can be limited. This policy could remain as is to prevent unnecessary driving by those who would prefer to drive themselves but be presented on a case-by-case basis.

Another policy that could be implemented, either from the Division of Student Affairs or through the Kaplan Center and OA, would be the addition of an annual payment towards the UNCG DRIVE fund on a voluntary basis. The purchase of only $15 per ton of CO2 will offset annual emissions and go directly towards more sustainable solutions on-campus and a local housing non-profit. The program utilizes a flat fee which eliminates the pay scale in proportion to vehicle miles traveled on or to campus. For some, this flat fee would result in an excess payment towards the university because they do not drive often. For others who have been

working at the university longer, they are encouraged to offset their missions from previous years. For example, a payment of $75 is remarked to offset the last 5 years of emissions. As of May 2023, the program has been successful in raising $8,215 from 55 donors (MacInnes 2023). The offset program is a solution that recognizes the unsustainable technologies present and creates sustainable solutions to correct them. The university could be supporting these initiatives and funding them without the need to pool funds from students and employees, one of the larger criticisms of the program. Until broader solutions such as reduced car reliance, more decarbonization, and increased ridesharing through car and vanpooling can be met, the DRIVE program is a justifiable recommendation for supporting sustainable transportation on campus (UNCG n.d.).

Outdoor Adventures would not benefit from raising trip prices to facilitate the payment of this program. The raising of prices for trips have already been met with contention and feedback from students, even when the trip price was explained (Examples such as snowboarding or goat yoga ticket costs increasing is out of the program's control, as are food and gas cost increase, all of which influence trip cost per capita). The program could retroactively purchase $15 for each ton of emissions generated over the past ten years, which would total $786.45 through 2022. Any future emissions determined by continued tracking can thereby be purchased that year. In a similar notion, the program could align with the Office of Sustainability and use the allocations from the DRIVE program and the Green Fund to support an EV transit purchase for the program that would be used for more local trips, or those out to Piney Lake.

Recommendations for the University

EV Purchases for UNCG Fleets

As with many sustainable solutions, the benefits of EV grow when viewed in mass with all other instances of its use combined. UNCG has historically relied on vehicles using oil and gas for their operations. With small transitions to EV vehicles in programs that have more than average use, such as the on-campus bus systems, the OA vehicle fleet, club sports, and facility operations, there would be substantial cuts to overall emissions. The UNCG fleet has 209 gasoline powered vehicles, 62 that are 100% electric, and 17 powered with a locally produced, low-level biofuel (MacInnes 2022). The four vehicles that Outdoor Adventures uses are all light-duty and are good candidates to electrify given their usage.

In Greensboro, the larger city that UNCG is nestled into, major changes are taking place led by the Transit Agency to increase more frequent service and access to bus routes by city residents. These efforts are in response to the city embarking on a "car-optional" future (Melcher 2023). The integrated network of routes for public transit is critical, however, how to best alter the behavior of those already driving remains a challenge that both Greensboro and UNCG must start to unpack and address. UNCG already has a leg up with having effective modes of transportation and more avenues for mobility on campus. The anticipated next step is broadening the support for reducing reliance on vehicles that consume oil and gas.

Increase Accountability Measures

The University could facilitate adoption of specific standard procedures which can improve overall accountability and reporting consistency. Academic institutions can attempt to achieve more net carbon neutrality over time if all departments put as much emphasis on program emissions as the Office of Sustainability, or as this research has attempted. The efforts

taken in this project to calculate the number of greenhouse gas emissions can be duplicated and translated to other programs on campus to provide further insight and justifications toward sustainable transitions. Off-campus academic travel, sports travel, and more details about the university transit fleet can inform broader decisions about baselines and more trends highlighting overall performance. The statistics presented from this research enlighten both University stakeholders and individual programs about their emissions per capita, per trip, etc. to justify shuttle use and recommend actions that mitigate future emissions.

The Outdoor Adventures shuttle log is a simple, but effective tool that is meant for student accountability and annual mileage records. The data extracted from the log coupled with the information from gas receipts from trips was foundational to the research. The population numbers for this project were estimated, but with the adoption of this system to other programs, the addition of this data point can be added to the vehicle forms. Additionally, all gas receipts are kept for financial reporting back to the University anyways, thereby the addition of the gallons and cost from the receipts onto the anticipated spreadsheet during reporting would be minimal extra effort. Once the shuttle sheets (or digital logs via a form service) are in each University vehicle, a dedicated staff, student, or volunteer can log the data into a spreadsheet that tracks the mileage over time. This information can be overseen by the Office of Sustainability and input into the pre-existing annual coverage of greenhouse gasses. Another method would be to use or create a dashboard that combines all relevant climate visualizations, allowing stakeholders to monitor key metrics related to fleet usage, emissions, and environmental impact in real-time.

CHAPTER VII: RESEARCH LIMITATIONS

There are limitations in the scope of data gathering that have the potential to impact the number of trips reported in the initial quantitative assessments of the program. The shuttle logs are physical sheets of paper in a mini binder located in the vans. A field to report in the shuttle logs was “Odometer before” and “Odometer after”. In an ideal scenario, the End odometer reading for the previous trip would be the Beginning odometer reading for the current trip. Due to human error, some logs were missing, which can lead to a reporting bias from numbers in population and numbers of trips taken totals being skewed to a degree.

Additionally, the SIMAP database has limitations to the calculation of data. The input and output will vary depending on commuting weeks, one-way trips, and calculated population numbers. While SIMAP is continually making changes to accommodate these calculations, it was ultimately limiting for determining projected emissions given the lack of realistic data for future years.

Another caveat to the gathered research is the natural variation in fuel economy that is outside the scope of this project. Variables such as towing trailers with or without boats, how heavy the van was with gear or people, or weather conditions are too specific to include for the outcomes desired by this research. Additionally, the operation of Piney Lake is overseen by a grounds manager that was, until 2022, under the Department of Recreation and Wellness, and operated gas- and diesel-powered equipment. These features were not included in the total emissions or accounted for in any gas totals since the methods for tracking mileage were not consistent with the shuttle vehicles in the program.

CHAPTER VIII: CONCLUSION

Transportation emissions are the hardest to reduce globally. Universities are increasingly shifting their focus towards sustainability as a core of their strategic plans. At UNCG, there are programs and activities on campus that can record and track their emissions. Campus recreation as part of the UNCG Division of Student Affairs inherently plays a role in advancing the University's mission to provide opportunities for learning, discovery, and service. While the data pertains exclusively to the OA program, it constitutes a relatively small portion when considering the broader university emissions. This perspective underscores the usefulness of tracking emissions, as it not only identifies areas for potential reduction but also highlights the activities representing missed opportunities for emission mitigation. The adoption of new sustainable efforts such as EV purchases, more accountable tracking, purchasing campus offsets from the UNCG DRIVE program, and continuing to apply the quantitative and qualitative analysis done to other programs can significantly catapult student experience and recognition for these sustainability goals being met in unique and valuable ways. The DRIVE program could be used to fund additional EV purchases if the higher administration chooses not to develop an EV fleet until a later date.

The broader focus of recommendations should be on maximizing the benefits of on-campus shared transportation for emissions reduction. Public transportation, whether powered by gasoline or electricity, plays a pivotal role in achieving sustainability goals by reducing the overall number of single-occupancy vehicles. The data-informed analysis underscores how adopting a multifaceted approach to sustainable transportation planning is possible. The process is paramount to finding a balance between sustainability objectives and the practicality of transportation options. HEI, in many ways, function as microcosms of urban centers, akin to

small-scale cities. In essence, they demonstrate how a bustling urban environment can make meaningful strides toward greater environmental responsibility on a local scale. The broad range of services and assessments needed to be done on campuses leads to an inconsistency in reporting, whether through different software, different metrics, or self-reporting limitations. Efforts taken by other HEI can frame a picture for how a fleet of vehicles on-campus can be included in reporting.

The University should continue to invest in and promote shared modes of transportation and tracking as a means of reducing emissions and cultivating a culture of sustainability among its community. The data obtained from generating emissions totals from smaller programs on campus can lead to additional cost savings by optimizing use. There are more indirect benefits such as increased alumni and donor engagement in environmental causes, resilience to other environmental challenges supported by data-driven decisions, and overall, more engagement with students and the community through participation in such efforts. In doing so, the institution can continue to support sustainable transportation practices, reduce emissions, and uphold its commitment to environmental stewardship and community well-being.

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APPENDIX A: OUTDOOR ADVENTURES SHUTTLE LOG DATA

Table A 1. Number and Type of Total Vehicle Trips per Fiscal Year

	2005 Chevy Van	2014 StarCraft Minibus	2016 Ford Transit	2019 Ford Transit
FY 2013				
Total Number of Adventure trips	24	0	0	0
Total Number of Piney Lake trips	0	0	0	0
Total Number of Other trips	21	0	0	0
FY 2014				
Total Number of Adventure trips	29	5	0	0
Total Number of Piney Lake trips	0	0	0	0
Total Number of Other trips	23	4	0	0
FY 2015				

Total Number of Adventure trips	19	19	0	0
Total Number of Piney Lake trips	0	0	0	0
Total Number of Other trips	12	13	0	0
FY 2016				
Total Number of Adventure trips	10	18	7	0
Total Number of Piney Lake trips	1	1	0	0
Total Number of Other trips	7	0	0	0
FY 2017				
Total Number of Adventure trips	6	14	15	0
Total Number of Piney Lake trips	2	4	0	0
Total Number of Other trips	8	1	7	0
FY 2018				

Total Number of Adventure trips	6	18	21	0
Total Number of Piney Lake trips	10	0	3	0
Total Number of Other trips	10	2	11	0
FY 2019				
Total Number of Adventure trips	0	12	29	11
Total Number of Piney Lake trips	36	5	3	4
Total Number of Other trips	10	8	13	18
FY 2020				
Total Number of Adventure trips	0	11	16	20
Total Number of Piney Lake trips	27	4	6	2
Total Number of Other trips	9	7	32	28
FY 2021				

Total Number of Adventure trips	2	11	15	4
Total Number of Piney Lake trips	12	5	36	60
Total Number of Other trips	5	1	16	33
FY 2022				
Total Number of Adventure trips	0	14	10	30
Total Number of Piney Lake trips	1	4	40	28
Total Number of Other trips	0	1	25	32

APPENDIX B: SIMAP RAW DATA

Table B 2. SIMAP Raw Data

Fiscal Year	Start Date	End Date	Category	# of Commuters	Auto-mobile Miles	CO2 (kg)	CO2 (MTCDE)	CH4 (kg)	CH4 (MTCDE)	N2O (kg)	N2O (MTCDE)	GHG MTCDE
2033	7/1/2032	6/30/2033	Student Commuting	45	113.1	1,659.000	1.660	0.000	0.000	0.000	0.020	1.680
2034	7/1/2033	6/30/2034	Student Commuting	61	112.2	2,231.000	2.230	0.000	0.000	0.000	0.020	2.250
2035	7/1/2034	6/30/2035	Student Commuting	63	110.22	2,263.000	2.260	0.000	0.000	0.000	0.020	2.290
2036	7/1/2035	6/30/2036	Student Commuting	44	101.35	1,453.000	1.450	0.000	0.000	0.000	0.010	1.470
2037	7/1/2036	6/30/2037	Student Commuting	57	116.4	2,162.000	2.160	0.000	0.000	0.000	0.020	2.190

2038	7/1/2037	6/30/2038	Student Commuting	81	132	3,485.000	3.480	0.000	0.010	0.000	0.030	3.520
2039	7/1/2038	6/30/2039	Student Commuting	149	94.44	4,586.000	4.590	0.000	0.010	0.000	0.040	4.640
2040	7/1/2039	6/30/2040	Student Commuting	162	58.29	3,078.000	3.080	0.000	0.000	0.000	0.030	3.110
2041	7/1/2040	6/30/2041	Student Commuting	200	29.05	1,894.000	1.890	0.000	0.000	0.000	0.020	1.910
2042	7/1/2041	6/30/2042	Student Commuting	185	51.76	3,121.000	3.120	0.000	0.000	0.000	0.030	3.150