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Greenhouse Gas Assessment of Daily Commutes at Radford University

Fall 2016 Independent Study

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Introduction

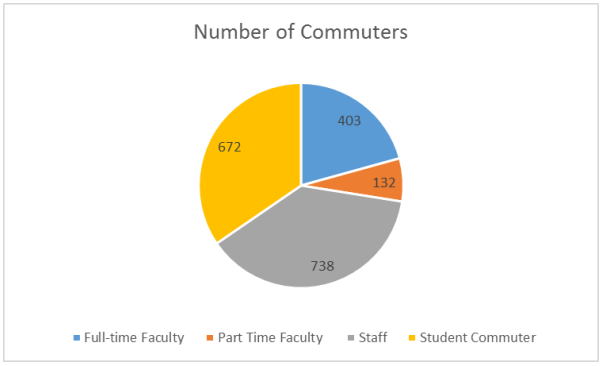
As part of Radford University's commitment to further its efforts in the reduction of environmentally harmful emissions, the President of the university signed a commitment to take the necessary steps to pursue carbon neutrality. As a result of this agreement a Climate Action Plan was created in October of 2009, the university has pledged to become carbon neutral by the year 2040. As a part of this commitment, the university is asked to perform an annual greenhouse gas assessment in order to track how the campus is making progress in its effort to reduce its carbon footprint. The first greenhouse gas assessment was performed in 2010 and covers the time period of July 1, 2009 through June 30, 2010 and was intended to serve as a baseline for future assessments. A greenhouse gas assessment is intended to examine the annual greenhouse gas emissions for the university. This includes items like purchased electricity, directly financed travel, and faculty/staff commuting. In an effort to determine an accurate number for the amount of pollution emitted each of the possible forms of pollution are broken into three separate scopes. Scope I examines emissions that are contributed from activities that occur directly on campus. This includes stationary and mobile fuel usage, refrigerants, and fertilizer. Scope II examines emissions that do not directly come from campus but are linked to campus operations such as purchased electricity, steam, and chilled water. Scope III examines what is referred to as "upstream" emissions. That is, directly financed travel, commuting, and solid wastes such as paper or plastic. This report examines the scope III emissions that are attributed to faculty, staff, and student commuting. In the past, scope III emissions were calculated by Dr. Charles Manyara using a GIS software called ArcMap. Using the number of commuters, fuel efficiency (MPG), and, weekly commuters, Dr. Manyara was able to determine the total number of miles driven each year and the associated carbon emissions. As a student enrolled in the Geospatial Science Department who is familiar with the same program, I utilized the many tools that ArcMap has to offer in order to determine emissions in a similar method.

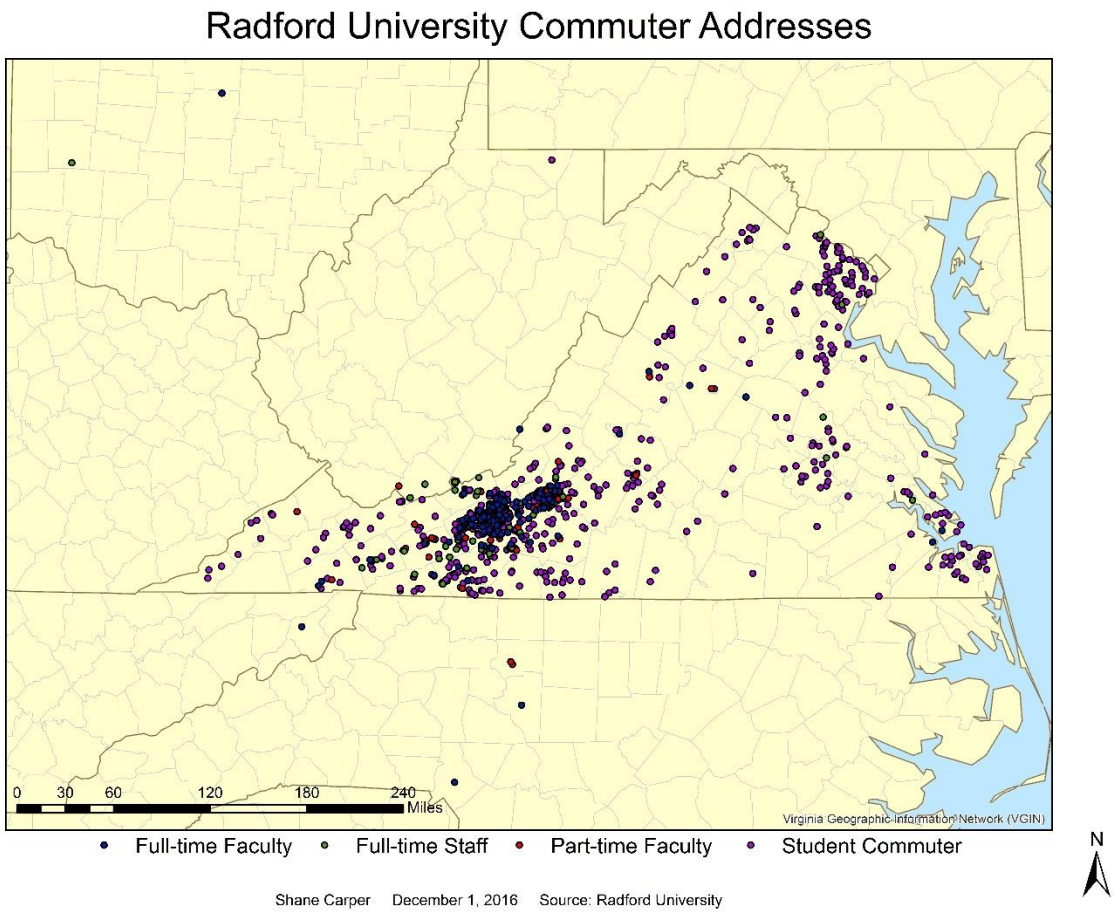
Methods

In order to determine an accurate number for the amount of emissions that are attributed to faculty, staff, and student commuting an excel spreadsheet of addresses was obtained from Radford University's Director of Institutional Research, Reporting, and Assessment Dr. Eric Lovik and members of the Parking and Transportation facilities with the help of the department head of the geospatial science department Dr. Richard Roth and Sustainability Manager, Joshua Nease. Within the spreadsheet were a list of addresses consisting of house number, street name, city, and zip code. The list of addresses that was included consisted of full-time faculty and full-time staff, part-time faculty, and student commuters. All names and forms of identification were excluded in order to honor the privacy of those who were included in the list. The spreadsheet was then further broken into four separate categories similar to how Dr. Manyara separated the values in his report in 2009: full-time faculty, part-time faculty, staff, and student commuters.

Mapping Commuters

Of the original list of 2205, commuters, 1945 addresses were used and mapped using the esri software ArcMap. The sample of addresses used consisted of 403 full-time faculties, 132 part-time faculties, 738 full-time staff, and 672 student commuters. When the original 2,205 addresses were mapped, some of the points were found in separate states including West Virginia, Tennessee, North Carolina, and Maryland. These addresses were excluded during the analysis because it was assumed that these individuals were not traveling over 200 miles round trip every day for work. 3 full-time faculties, 2 staff, 2 part-time faculties, and 253 student commuters were omitted from the analysis due to the fact that individuals would be traveling in excess of 90 miles one-way.



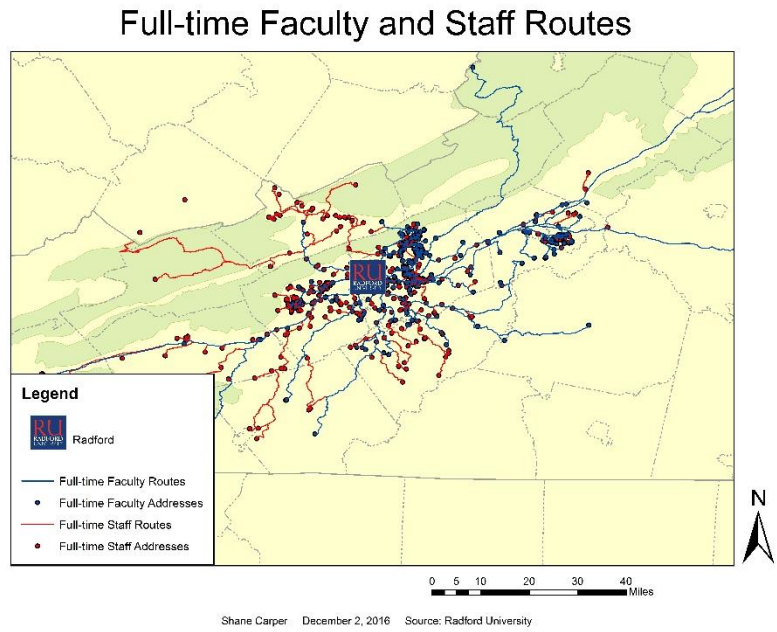


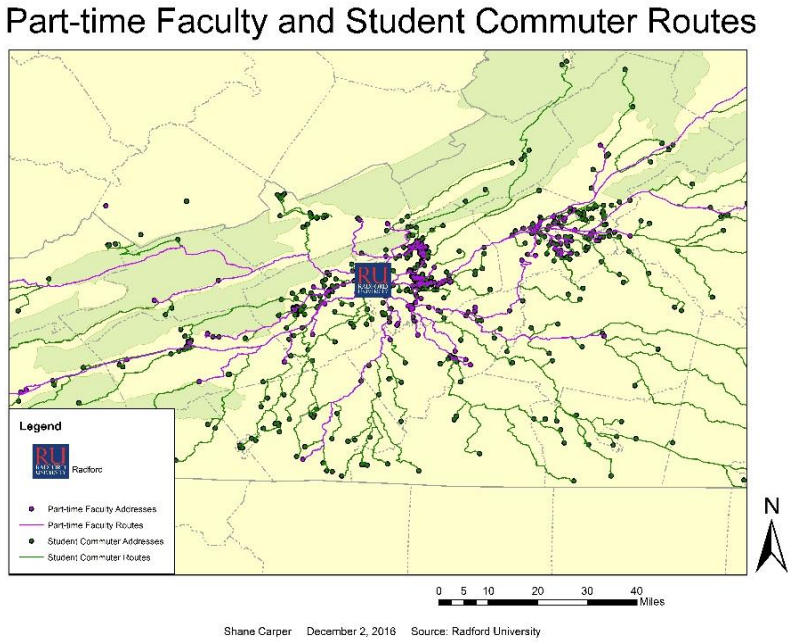
In ArcMap the spreadsheet of commuter addresses was mapped through the method of geocoding using the VGIN Composite Address Locator. Geocoding is the process of transforming a

description of a location such as an address to a location on the earth's surface. By adding multiple addresses at once in a table the resulting locations are output as geographic features with attributes that can be used to make further analysis. When geocoding in ArcMap, the user inputs a spreadsheet of addresses much like the one that was provided. When you enter these addresses the geocoding engine converts the input addresses into pieces such as street name, city, state, and zip code. Each address is searched in the address locator and is compared to each address element. A score is generated based on how well the addressed matched, and then each point is added to the map to the location with the best score.

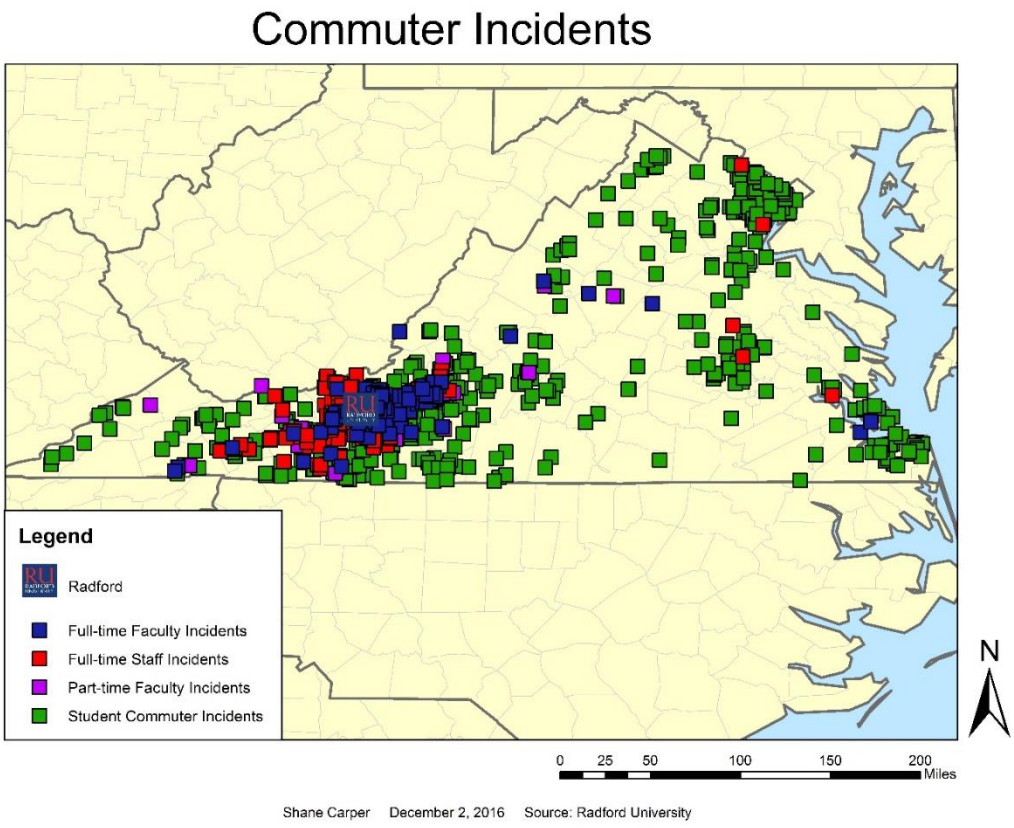
Finding Routes

Using ArcMap's Network Analyst toolset any individual can determine the distance from one point to another. A network in a GIS is a system of interconnected elements, such as edges (lines) and connecting junctions (points) that represent one possible route to another. By modeling potential routes with a road network it's is possible to find the shortest distance between two objects or a list of multiple addresses. Using a detailed street map obtained from an open source GIS data center, (United States Census Bureau, 2016) a network dataset was created in order to determine routes. Since simply adding street centerlines to the map, the user cannot begin to solve routes because the lines don't necessarily know what they are connected to and that the streets are actually a network of connected turns and junctions. If one wanted to find the nearest location from one point to another they must first create a network dataset. Using the network dataset wizard, one can accomplish this after defining a few parameters first. Using the network dataset wizard and the geometry of the road centerlines, the tool establishes connectivity between the lines. In the interest of finding total distances for all commuters,





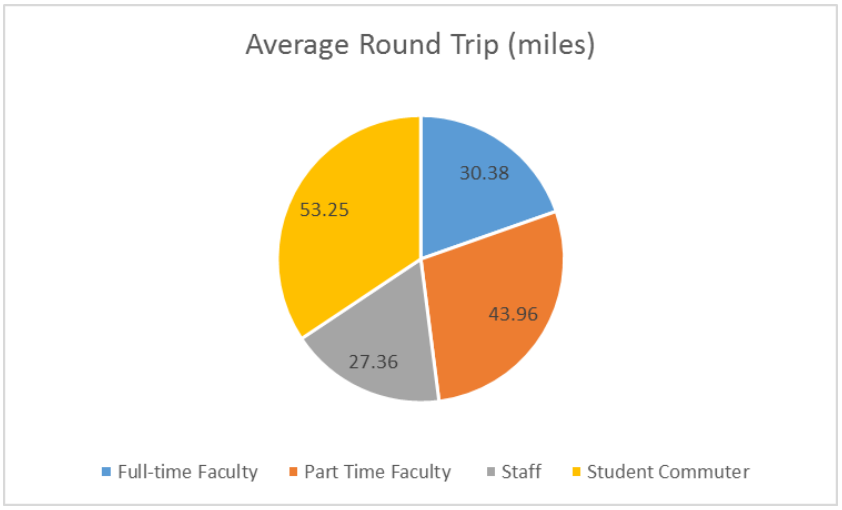
each address was added to the Virginia road network created using the “add locations” tool. The add locations tool in the network analyst toolset adds network analysis objects to the network analysis layer. In this case the commuter addresses were used as the network analysis objects. Using the “closest facility” tool in the network analysis layer, all addresses were added as well as a single point that represented Radford University using the add locations tool. The closest facility analysis measures the distance and cost of traveling between two points or a set of multiple points. After creating a closest facility layer six network analysis classes are added: Facilities Incidents, Routes, Point Barriers, Line Barriers, and Polygon Barriers. The facilities class stores the network location and serves as the end point in this report. The incidents class also stores the network locations and serves as the starting point in this analysis. Radford University was added as a facility and the commuter address points were added as incidents.



The routes class stores the resulting route that was found by the network. Within the output field of the routes class is a field named “Total_(Impedance)”. There are a number of options the user may choose from such as minutes but, since we were interested in finding the distance of the routes, the impedance was configured to output the route in miles and was stored in the attribute table. Once the closest facility layer was configured the network was solved and the routes from each address to Radford University were created. Within the routes layer attribute table, is a field that contains the distance of the route in miles. These distances were used to calculate the total number of miles traveled by Radford University employees and students.

Calculating Distances

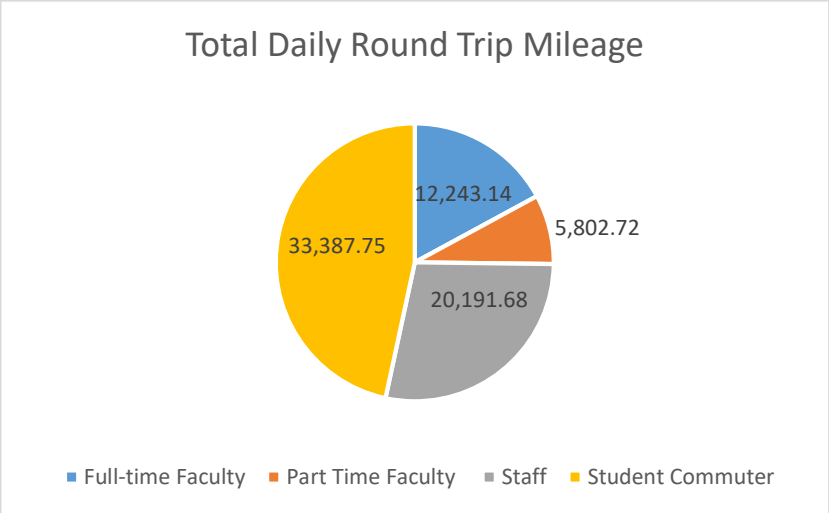
Once the network analyst found the shortest routes for each intended address, the distances from the route layer attribute table were exported into an excel spreadsheet. Using Microsoft Excel, the total number of miles attributed to faculty, staff, and student commuters were totaled in their respective categories using the SUM function. In order to determine the average daily commute for each individual (round trip), the one-way trip distances were determined by averaging the driving distance of each individual address to Radford University's campus and then multiplying the results by two. The calculated average (mean) round trip for full-time faculty was 30.38 miles, 43.96 miles for part-time faculty, 27.36 miles for full-time staff, and 53.25 miles for student commuters.



Due to the lack of detailed knowledge of how faculty, staff, and students commute to campus each year, the following assumptions were made when deriving the total commuter mileage:

1. Full-time faculty members commuted to campus an average of 5 times per week for a total of 150 days out of the year. Based off of the notion that there are 30 instructional weeks per year (15 per semester).
2. Non-teaching full-time staff members commuted to campus five days a week for 48 weeks for a total of 240 days per year.
3. Part-time faculty members commuted to campus three times a week for 30 weeks of the year totaling to 90 days out of the year.
4. Student commuters were assumed to travel to campus five days per week for each 15-week semester (30 weeks) for a total of 150 days per year.
5. Lastly, it was assumed that each commuter drove individually without carpooling and only made one single round trip each day.

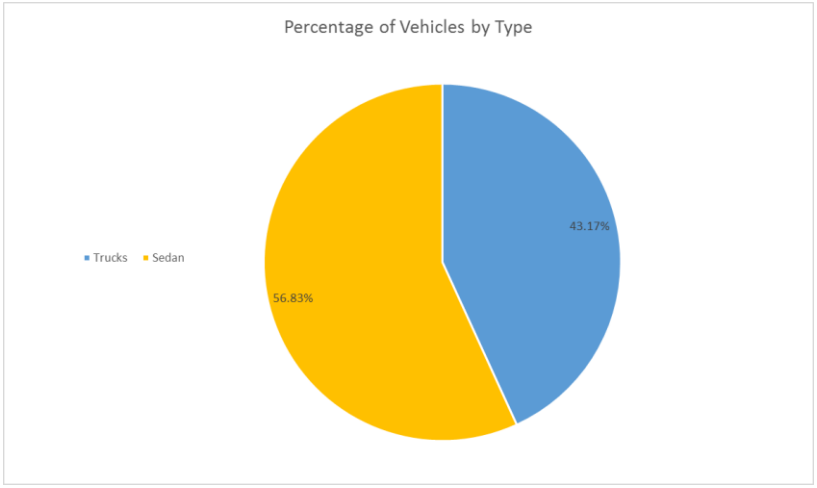
Total round-trip mileage per day was calculated by multiplying the average daily commute and the total number of individuals in each corresponding category. 403 full-time faculty members traveled 30.38 miles on average each day they commuted to work. 132 part-time faculty members travelled an average of 43.96 miles per day, 738 full-time staff members commuted an average of 27.36 miles per day, and 672 students commuted an average of 53.25 miles each day. Once the total daily round-trip mileage was calculated for each category, the number of miles was multiplied by the total number of days each employee commuted to Radford University's campus. A total of 12,546,759 miles was calculated.



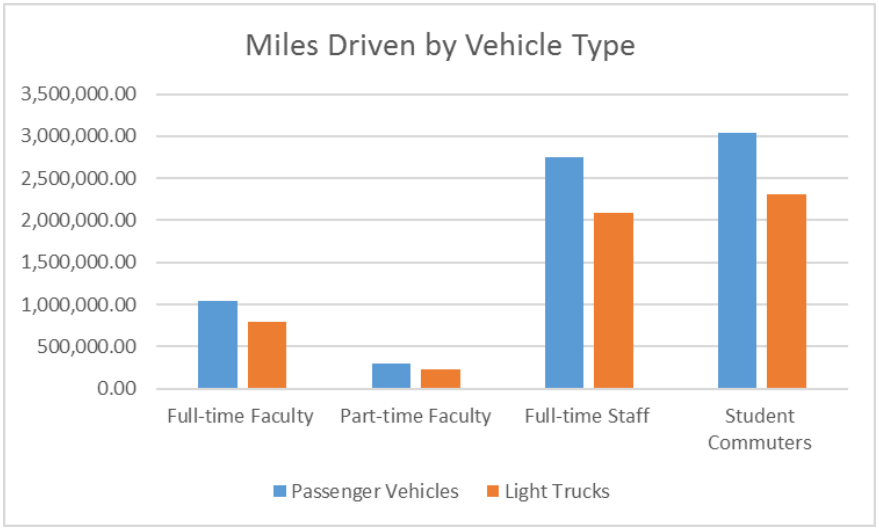
	Number of Commuters	Average Round Trip	Total Round Trip Mileage	Total Miles x Number of Days
Full-time Faculty	403	30.38	12,243.14	1,836,471.00
Part Time Faculty	132	43.96	5,802.72	522,244.80
Staff	738	27.36	20,191.68	4,846,003.20
Student Commuter	672	53.25	33,387.75	5,342,040
Total	1945			12,546,759.00

Carbon Footprint Calculations

In order to determine an accurate amount of carbon dioxide that is being emitted by Radford University commuters, the total number of miles driven each year was multiplied by the average fuel consumption of cars and light trucks. According to the Department of Transportation, the average fuel consumption of light trucks in 2014 was 26.3 MPG and the average fuel consumption of passenger vehicles was 36.4 MPG. With this knowledge, a sample of Radford University vehicle types was performed in order to determine the ratio of light trucks and passenger vehicles that are driven by Radford commuters. Parking lots DD located on Fairfax Street and lots N, HH, and M found on Jefferson Street were surveyed on November 30, 2016 at 11:30 am. A total of 315 vehicles were sampled from the Radford population. 136 vehicles were recorded as light trucks and 179 vehicles were recorded as passenger vehicles. Out of the 315 vehicles sampled, light trucks accounted for 43.17% of the total and passenger vehicles accounted for the other 56.83%. These percentages were

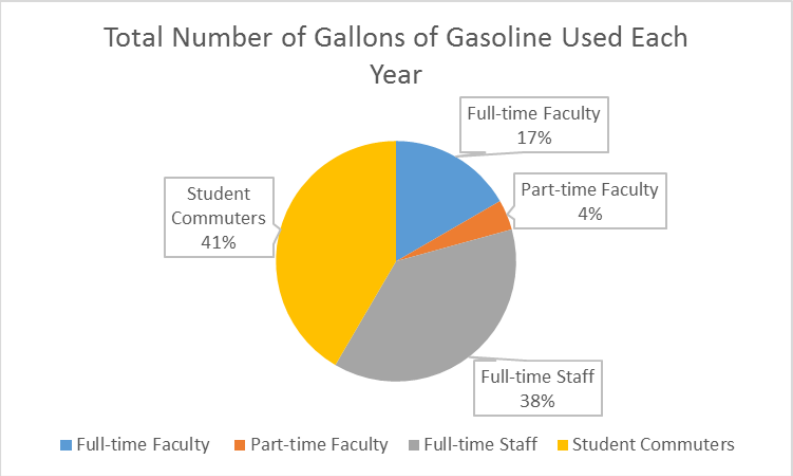


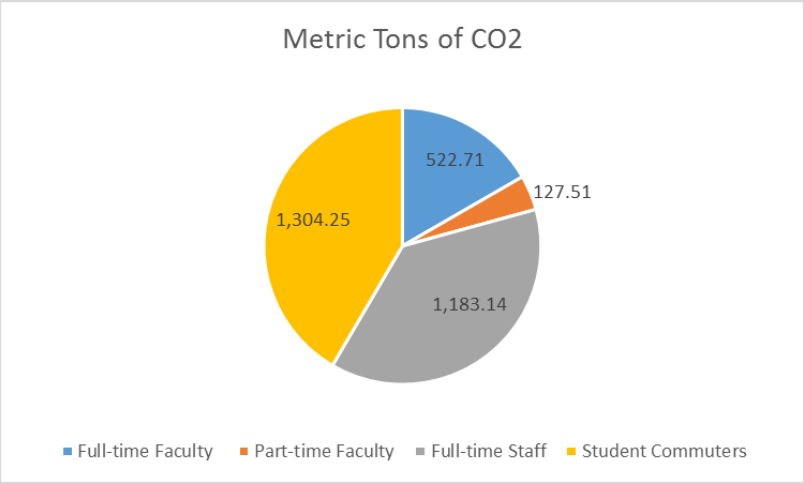
then applied to the total number of miles for each section of commuters. Of the 1,836,471 total miles driven by full-time faculty, 1,043,666.47 miles were driven using a passenger vehicle and 792,804.53 miles were driven using a light truck. Of the 522,244.80 total miles driven by part-time faculties, 296,791.72 were driven using a passenger vehicle such as a four door sedan and the other 225,453.08 miles were driven using a light truck. Of the 4,846,003.20 miles driven by full- time staff members, 2,753,983.62 miles were driven in passenger vehicles and 2,092,019.58 miles were driven in light trucks such as a sport utility vehicle. Lastly, of the 5,342,040.00 miles driven by student commuters, 3,035,881.33 miles were driven in a small passenger vehicle and 2,306,158.67 miles were driven in light trucks. The number of miles traveled by each corresponding vehicle type were then divided by their matching fuel efficiency standards of 36.4 MPG for passenger vehicles and 26.3 MPG for light trucks provided by the Department of Transportation. This calculation was performed in order to achieve the total number of gallons of gasoline used each year. After performing this task, it was determined that full-time faculty members used approximately 58,816.81 gallons of gas each year, part-time faculty members used 14,347.38 gallons of gasoline each year, full-time staff members used about 133,131.96 gallons of gas each year, and students that commuted to campus used approximately 146,759.3407 gallons of gasoline each year for a total of 353,055.50 gallons of gas used each year.



	Full-time Faculty	Part-time Faculty	Full-time Staff	Student Commuters
Number of Gallons (Passenger)	28,672.16	8,153.62	75,658.89	83,403.33
Number of Gallons (Light Truck)	30,144.66	8,572.36	79,544.47	87,686.64
Total Number of Gallons	58,816.81	14,347.38	133,131.96	146,759.34

The next step in the process to find out how much carbon dioxide is being emitted by Radford University commuters was to see how much CO_2 a single gallon of gasoline releases into the atmosphere. According to the Environmental Protection Agency, "to obtain the number of grams of CO2 emitted per gallon of gasoline combusted, the heat content of the fuel per gallon is multiplied by the kg CO2 per heat content of the fuel. In the preamble to the joint EPA/Department of Transportation rulemaking on May 7, 2010 that established the initial National Program fuel economy standards for model years 2012-2016, the agencies stated that they had agreed to use a common conversion factor of 8,887 grams of CO2 emissions per gallon of gasoline consumed" (Federal Register 2010). Using the number of gallons of gasoline consumed through Radford commuters each year and the EPA's figure for carbon dioxide at 8,887 grams per gallon consumed, the total carbon dioxide emissions were calculated by multiplying gallons of gasoline by 8,887 grams for each commuter category. After calculating each individual commuter type, using this method, it was determined that Radford University emits the equivalent of 3,137.60 metric tons of carbon dioxide each year as a result of full-time faculty and staff, part-time faculty, and students that commute to Radford regularly. 1,304.25 metric tons can be attributed to student commuters, 522.71 metric tons can be attributed to full-time faculty, 127.51 metric tons of carbon dioxide can be attributed to part-time faculty, and 1,183.14 metric tons are generated from the daily commutes of full-time staff members.





Conclusion/Discussion

With the increasing and recent activism for Radford University's sustainability practices, and pressures from various other collegiate organizations to out-perform, the university will continue to lead the way for sustainability amongst its competitors. Every single bit of information is crucial to know when any organization is attempting to reduce its impact on the environment. With this report, the purpose is to give insight into how much of an impact commuting individuals have on the environment and inspire ways to reduce that impact. With this knowledge, we can employ various strategies that will facilitate the university in reaching its ultimate goal of carbon neutrality in the upcoming years and possibly motivate other organizations to follow in our footsteps.

Acknowledgements

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