UAA INVENTORY:
GREENHOUSE GAS EMISIONS FROM TRANSPORTATION

prepared for:

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1. Introduction

As a signatory of the American College and University Presidents Climate Commitment, UAA has agreed to conduct an inventory of its greenhouse gas (GHG) emissions. This inventory serves as a baseline against which to measure the effectiveness of GHG emissions reduction projects. To fulfill the Commitment UAA agreed to conduct an inventory of its Scope 1 and 2 emissions, as well as some Scope 3 emissions. In addition to signing the Presidents Climate Commitment, UAA signed the Talloires Declaration in April 2004. The Talloires Declaration is a statement of principles and practices for using higher education to promote sustainability.

Scope 1 emissions are defined as direct GHG emissions occurring from sources that are owned or controlled by the institution. Scope 2 emissions are indirect emissions generated in the production of energy purchased by the institution. Scope 3 emissions are indirect emissions that are the consequence of the activities of the institution, but occur from sources not owned or controlled by the institution.

Pursuant to the Commitment, this study estimates the levels of two types of Scope 3 GHG emissions – commuting by students and employees, and university-funded air travel. Scope 1 and Scope 2 GHG emissions are being estimated in a separate study. Two models were developed and used: a UAA commuter model and a UAA air travel model.

2. UAA Air Travel GHG Emissions Inventory

GHG emissions created by any air travel paid for by UAA must be included in a baseline GHG emissions inventory in order to meet the requirements of the American University and Colleges Presidents Climate Commitment. Air Travel GHG emissions were estimated using data from Travel Expense Reports (TERs). TERs include information on each leg (segment) of a flight paid for by the university. A sample of 14% of all FY07 TERs was used to estimate total emissions attributed to air travel.

Athletic Department travel – including travel by numerous student-athletes -- is included in TER records, but a sample of the TERs would probably not accurately represent this travel. Therefore, we have calculated athletics travel separately using the department's internal records. A description of the how TER and Athletic Department is used in the UAA air travel model is found in Appendix A.

2.1 Results

UAA air travel was responsible 3,582 metric tons of CO_2 emissions in FY07. This is equivalent to 2.32 metric tons of CO_2 per UAA employee (1,525 full time equivalent employees)[1]. The total CO_2 and CO_2 emissions per employee account for all air travel funded by UAA. This includes employee and athletic travel. Results of the UAA's air travel inventory are in Table 1.

Table 1. Air travel (athletic and TER) results summary

	UAA	Per trip	Per employee
Total miles flown	14,653,793	4,993	9,499
kg CO2	3,581,638	910	2,322
Metric tons CO2	3,582	0.91	2.32

2.2 UAA air travel model

The UAA air travel model estimates GHG emissions by summing the GHG emissions of individual flight segments. The model determines the geographic coordinates for each airport code listed in the TERs. It then converts each successive pair of airport codes into a distance in miles. The number of miles is then multiplied by a GHG multiplier to determine the emissions from that segment. Each segment is categorized by its length: long, medium or short. Due to the high energy cost of takeoff relative to additional miles at cruising altitude, different segment lengths are associated with different levels of average GHG emissions per mile traveled. Table 2 shows the emissions multipliers used in the model.

[1] UAA employees data from: UA in Review.
http://www.alaska.edu/swoir/publications/uar_docs/uar08/uar08_docs/uar08_Chapter_3.

Table 2: Air Travel Emissions Factors[2]

	Max Distance (miles)	Multiplier, kg CO2 per mile
Short Haul	281	0.2897
Medium Haul	994	0.2028
Long Haul	None	0.1770

Because the model utilizes information about the length of each segment of the journey it is more accurate than a model that only uses the total distance between origin and final destination airports.

Athletic Department air travel data

Athletic travel was modeled separately from other university travel due to sampling concerns related to the fact that a single TER might cover a great many travelers. We utilized the Athletic Department's internal records to calculate their travel. Athletic records include information on the number of passengers and the departure airport/final destination only. Intermediate flights were estimated based on TER data. Additional information including an example of how a trip is entered in the UAA air travel model can be found in Appendix A.

Because athletic travel is recorded in both TERs and Athletic records, it was necessary to take precautions against double counting athletic travel. For this reason, all Athletic travel in the TERs was calculated for a single traveler regardless of the reported number of travelers. The Athletic model subtracted one passenger from each trip to account for the single passenger counted in the TER data.

TER Data

The TERs contain records on approximately 2,800 trips in FY07 funded by UAA that include air travel. The TERs are sorted alphabetically by the last name of the person traveling. Flight information from the first seventh of the TERs was used to estimate the GHG emissions of UAA air travel.

[2] World Resource Institute, CO2 Emissions from Mobile Sources. http://www.ghgprotocol.org/

2.3 Recommendations

- Future GHG inventories should also include emissions associated with UAA funded auto travel. Emissions from UAA funded auto travel are different from commuting emissions because they are reimbursed on a per mile bases. Data on UAA funded auto travel is stored in TERs and could be entered along with air travel data.
- Future GHG inventories would benefit from TER data recorded electronically. Preferably, each trip paid for by the University would be added to a spreadsheet identifying each airport visited and the number of travelers. This would increase the accuracy of calculations, eliminate the need for a separate Athletic Department calculation and allow the model to calculate figures for the entire population rather than just a sample.
- Future GHG inventories should make some effort to account for air travel by UAA employees for university business that is not funded by UAA. If a UAA employee's travel is paid for out of pocket or by another institution it is not accounted in the TER data. Emissions from this type of travel may still be attributable to UAA.

3. UAA Commuter GHG Emissions Inventory

GHG emissions created by students and employees commuting to and from UAA are included in a baseline GHG emissions inventory in order to meet the requirements of the American University and Colleges Presidents Climate Commitment.

3.1 Results

Each year the average UAA commuter releases between 1.10 and 1.91 metric tons of CO2, yielding a total of between 11,203 and 19,451 metric tons for the entire university. The results are presented as a range because emissions were estimated under low, medium and high scenarios. Estimated GHG emissions for each scenario can be seen in Table 5.

Parking permit data was used to estimate the GHG emissions attributable to UAA commuters using the UAA commuter model. In addition to the parking permit data, the UAA commuter model uses assumptions made for seven parameters.

The first five parameters address commuting patterns, the sixth addresses fuel efficiency and the seventh addresses UAA commuters who do not purchase parking permits. Table 3 matches the parameter number with the parameter name. Different assumptions about the parameters were used to create three scenarios. The assumptions used for each parameter for the three scenarios can be seen in Table 4. A discussion of these parameters is in Section 3.3.

Table 3. Parameter names

Parameter number	Parameter name
1	Portion of commutes with multiple purposes
2	Multiple purpose emissions attribute to UAA
3	Commuters from outside Anchorage
4	Average round trips per week
5	Average weeks per year
6	Alaska efficiency decrease
7	Off campus multiplier

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Table 4. Parameter assumptions

Parameter	High scenario		Medium scenario		Low scenario	
number	Student	Employee	Student	Employee	Student	Employee
1	0.00	0.00	0.05	0.05	0.15	0.05
2	1.00	1.00	0.75	0.75	0.50	0.50
3	1	1	0.9	1	0.8	1
4	5	5	5	5	4	5
5	32	50	32	50	32	50
6	0.9	0.9	1.0	1.0	1.0	1.0
7	1.1	1.1	1.0	1.0	1.0	1.0

The three scenarios produce a wide but reasonable range of annual GHG emissions and miles driven from UAA commuters. The fundamental uncertainty stems from the fact that we have no direct data on actual commuter travel. We only have data on the potential for such travel – the numbers and zip code of origin of vehicles that park at UAA. Survey research would be needed to determine actual travel and its relationship to parking permit ownership patterns. These surveys are outside the scope of this study.

Table 5. Commuter results summary

	Metric tons of CO2 for all UAA	Metric tons of CO2 per commuter	Miles driven for all UAA	Miles driven per commuter
High scenario	19,451	1.91	16,318,571	1,600
Medium scenario	14,783	1.45	14,782,958	1,449
Low scenario	11,203	1.10	11,474,973	1,125

3.2 UAA commuter model data

Data for the UAA commuter model was provided by UAA Parking Services. UAA Parking Services provided information on each of the 10,202 parking permits sold in FY07 for the UAA main campus. For each permit sold a data record contains the following information:

- **Order number**
- **Bar code**
- **Permit type**
- **Payment method**
- **Vehicle make and model**
- **ZIP code**

Parking permit data was used to determine important characteristics of UAA commuters. Most importantly, information on fuel efficiency, distance of commute and type of commuter for each commuter was obtained through analysis of the permit data.

Fuel efficiency

The fuel efficiency is calculated for the first vehicle reported by each commuter in the parking permit application. Fuel efficiency data for each make and model of automobile sold in the U.S. was downloaded from the US Department of Energy[3]. Fuel efficiency often varies from year to year for most vehicle models. In order to account for these changes, the average fuel economy for each model was used. This average was obtained by averaging the efficiency reported in each even year from 1994 through 2008 for each make and model of vehicle. A detailed description of the method used to calculate fuel efficiency is found in Appendix B.

[3] United States Department of Energy, Fuel Efficiency. www.fueleconomy.gov

The parking permits are individually matched with the appropriate fuel efficiency based on the make and model of the vehicle reported on the permit application. This process is done on a spreadsheet outside of the model. The fuel efficiency figures for each parking permit are entered into the UAA commuter model.

Distance of commute

There are 32 ZIP codes within a reasonable commuting distance of UAA, extending from Girdwood to Houston. The driving distance from each ZIP code to campus was determined using Mapquest (www.mapquest.com). Mapquest provides driving directions and distances from one street address to another. When ZIP codes are entered instead of street addresses Mapquest will use the population centriod of the ZIP code as the starting point. The average driving distance for all residents of a ZIP code is best estimated using the driving distance from the population centriod of that ZIP code.

Less than 1% of parking permits reported zip codes outside of a reasonable commuting distance (e.g., Seattle). These parking permits were assigned the weighted average of all ZIP code distances.

Type of commuter

The parking permit data included information on payment method. Permits that were paid for with payroll deductions were assumed to be purchased by UAA employees. All other permits were assumed to be purchased by UAA students. This method of separating employees from students likely underestimates the number of commuting employees and overestimates the number of commuting students. The likely result is that the GHG emissions attributed to employees is underestimated and the emissions attributed to students are overestimated. When the two estimates are combined it is likely that the total GHG emissions from all commuters are accurate. This report only presents estimates on total GHG emissions from UAA commuters. With the available data it is inappropriate to estimate student and employee emissions separately.

3.3 UAA commuter model assumptions

In addition to the data described above the UAA commuter model uses seven parameters for which assumptions must be supplied. Each parameter is applied separately to employees and to students in order to account for their different commuting patterns.

The values used for each parameter for the high, medium and low scenarios for both students and employees are reported in Table 4 and Appendix C.

1. Portion of commutes with multiple purposes

This parameter reflects the portion of trips to UAA that are also used to travel to other destinations such as the grocery store. Since UAA is not the only commute destination it should not be responsible for all of the GHG emissions associated with these trips.

2. Multiple purpose emissions attribute to UAA

This variable determines the portion of the GHG emissions that are attributed to UAA for those trips with multiple destinations in addition to campus.

3. Commuters from outside Anchorage

The impact of this parameter can be interpreted as making two corrections to the model. First, the fuel efficiency data uses city mpg but a portion of the commute for those living outside the city takes place on the highway. Second, commuters from farther away probably attempt to arrange their class and meeting schedules so that they make fewer trips to campus than other commuters. This parameter reduces the GHG emissions of commuters outside of Anchorage but within a reasonable commuting distance to more accurately reflect reality.

4. Average round trips per week

This parameter accounts for the number of round trips from home to campus a commuter makes in an average week while working or attending classes at UAA.

5. Average weeks per year

Students only commute to campus while classes are in session, generally during the spring and fall semesters with some also attending summer classes. Employees are assumed to continue their commuting patterns throughout the year net a few weeks for time off. This parameter determines the number of weeks per year that a commuter is driving to campus.

6. Alaska efficiency decrease

This variable is used to decrease the fuel efficiency of the vehicles being driven to campus. Conditions exist in Anchorage in the winter than might cause vehicles to have lower fuel efficiencies than reported to the EPA. The original fuel efficiency values associated with each parking permit could over estimate fuel efficiency by not accounting for miles being driven in four wheel drive or for time spent warming a car before driving. This parameter attempts to correct that problem

7. Off campus multiplier

Not every student or employee commuting to UAA purchases a parking permit. Examples include employees or students working or taking classes in UAA buildings off the main campus, commuters who only take night classes and do not come onto campus until parking enforcement ends at 7:30 pm, or commuters who park off campus or use parking meters or garages when they do park on campus.

3.4 Recommendations

- Future GHG inventories would benefit from more accurate estimates of the seven parameters. This could be obtained using a survey administered by UAA Parking Services. We suggest a discount on the cost of a parking permit if applicants answer a short survey.
- Future GHG inventories should include estimates of emission attributable to student travel on public transportation. Students are allowed free transportation on the Municipality of Anchorage's People Mover bus system through the U-Pass program.
- Future GHG inventories should include estimates of UAA Pay and Park use. Pay and Park offers commuters the opportunity to pay for short term parking on campus without having to purchase a parking permit.

4. Comparisons with other universities

When looking at emissions data it is important to draw comparisons with other universities. According to the medium estimate, UAA's 10,202 commuters contribute 14,783 metric tons of carbon each year. This represents 1.45 metric tons of carbon per commuter per year. How does this compare to other universities? The answer is: often unfavorably. The University of New Hampshire, for example has an emissions per commuter figure of just 0.49[4], one fourth that of UAA's. Portland State University also has figures significantly lower than UAA's. Their 15,915 students on average contribute 0.40 metric tons of C02 each year[5]. Tulane University's 6,533 students contribute a total of 4,867 metric tons, or approximately 0.74 tons per person per year[6]. Yale University has a total emissions figure of 16,000 metric tons per year[7]. Yale's emissions per student are 1.42. Detailed analysis of UAA commuter related GHG emissions compared with that of other universities can be found in Table 6.

Table 6. Comparison of emissions with other universities (in metric tons of CO2)

	Commuter emissions	Number of commuters	Emissions per commuter	Number of students	Emissions per student
University of Alaska Anchorage	14,783	10,202	1.45	10,064	1.95
University of New Hampshire	3,337	6,800	0.49	11,523	0.28
Portland State University	6,411	22,153	0.29	15,915	0.40
Yale University	16,000			11,250	1.42
Tulane University	4,867			6,533	0.74

In some ways these results should not be surprising. The University of Alaska is traditionally regarded as a commuter school. Furthermore, the extreme weather in Alaska often makes alternative forms of transportation, such as walking or biking, unfavorable. Anchorage has a less developed transit system than most of the institutions named above. These factors may contribute to UAA's high per capita emissions figures.

Future studies would benefit by making direct comparisons with UAA's Peer Institutions. Efforts were made in this study to do so, but GHG emissions inventories were not readily available at the time of the study.

[4] New Hampshire: http://www.sustainableunh.unh.edu/climate_ed/greenhouse-gas-invnt/1990-2003_UNH_GHG_Report.pdf
[5] Portland State: https://www.oregon.gov/Gov/2007_Legislative_Session/Correspondence/OUS_GHG_Inventory.pdf
[6] Tulane: http://www.tulane.edu/~eaffairs/PDFs/ghg_inventory5282.PDF
[7] Yale: http://www.epa.gov/ttn/chief/conference/ei14/session3/buttazzoni.pdf

Appendix A: Notes to UAA air travel model

The greenhouse gas (GHG) emissions associated with UAA air travel was estimated in two parts: staff/faculty travel and athletics travel. The GHG emissions generated by staff/faculty air travel was estimated using data collected from a sample of UAA Fiscal Year 2007 Travel Expense Reports (TERs). TERs contain information on flight destinations and connections for each UAA financed trip.

Air travel attributable to the Athletics department is recorded in the TERs but a. sample of TER data would not have provide an accurate estimation of athletic travel. Due to team travel there a few Athletic Department TERs with very large amounts of associated travel. It is not reasonable to assume that the TERs with team travel would be evenly distributed throughout the TERs. To accurately account for team travel the GHG emissions associated with the UAA Athletic Department was estimated separately and is discussed later.

Both staff/faculty and Athletic Department GHG emissions were estimated using the same model. The model is structured so that its inputs are airport codes for each airport associated with a trip. For example, a roundtrip to Detroit from Anchorage with a connecting flight in Seattle would be entered:

ANC SEA DTW SEA ANC

Within the UAA air travel model each airport code is matched with its geographical coordinates. Using these coordinates the distance between each airport is calculated using the haversine formula. Each flight distances is classified as a short, medium or long haul trip. Based on these classifications, the GHG emissions of each flight was calculated using a conversion table supplied by World Resource Institute.

Airport codes and geographical coordinates

Airport codes were downloaded from Global Airport Database[8], a free online database created by a private individual. This database was supplemented by airport codes copied from the Orbitz website[9].

A significant share of the UAA air travel was to remote Alaskan communities. Many of these smaller communities were not listed in the Global Airport Database. Alaska airport codes were downloaded from Explore North[10]. Geographic coordinates were downloaded from the State of Alaska, Alaska Community Database[11].

This collection of different airport data was compiled into one list of data. The data was compiled in the excel file "airport codes worksheet.xls."[12] The compiled list of airport data was copied from this file into the UAA air travel model and each airport entered into the model was checked to ensure that its geographical coordinates was included in the airport data.

TER sample data

TER flight information is stored aphetically in hard copy by the UAA travel department. It is stored in seven shelves. Each shelf has roughly the same number of TERs. We used a sample population of one shelf as an input in the UAA air travel model. The calculated GHG emissions of the first shelf were multiplied by seven to estimate the GHG emissions of all UAA travel.

Athletic Department

The UAA Athletic Department records its travel in the UAA TERs as well as keeping its own travel records. Both sources were used to estimate the Athletic Department GHG emissions. Travel by athletic teams is only recorded as one TER entry under the coach's name and this causes two problems. First, team travel is likely unevenly distributed throughout the TERs so a sample of TERs is not likely to accurately

[8] Global Airport Database. http://www.partow.net/miscellaneous/airportdatabase/
[9] Orbitz. http://www.orbitz.com/App/global/airportCodes.jsp
[10] Explore North. http://explorenorth.com/library/aviation/ak-aircodes.html
[11] State of Alaska, Alaska Community Database.
http://www.commerce.state.ak.us/dca/commdb/CF_COMDB.htm
[12] Available via special request from author: Nick.Szymoniak@uaa.alaska.edu

represent the amount of team travel. Second, team travel is listed in the TERs as a single travel record with multiple travelers. This creates the risk of accidently not accounting for the multiple travelers during data entry.

To mitigate these potential problems the Athletics Department GHG emissions were estimated using both sources of information. When Athletic Department travel was found in the TERs it was entered in the model as one traveler even if it was for a full team. Then one traveler was subtracted from each entry in the Athletic Department data. This meant that the first traveler for each Athletics Department travel was counted in the TER data and each additional traveler was counted in the Athletic Department data. The two combined represent an accurate estimate of total UAA travel but neither accurately estimate Athletic Department travel. It is possible to estimate Athletic Department GHG emissions but this was not investigated.

The Athletics Departments travel is recorded in the file "FY07 Athletics Travel Log.xls"[13] The Athletic Department records the number of travelers and the destination for each trip. It does not record the flight legs of each journey. The airports used for flight connections were estimated and entered into the model. For example, the data indicated a trip to Detroit; we assumed that they stopped in Seattle both on the way there and on the way back. This data was entered into the model in the same manner as TER data.

[13] Available vie special request from author: Nick.Szymoniak@uaa.alaska.edu

Appendix B: Fuel efficiency estimates

Data used to estimate the fuel efficiency for UAA commuters was downloaded from the US Department of Energy website, www.fueleconomy.gov.

The parking permit data did not included the year of vehicle reported and the fuel efficiency is understood to sometimes change from year to year for a particular make and model. Also, some vehicles reported in the permit data are no longer in production. To solve this problem the fuel efficiencies for every reported make and model of automobile for each even year between 2008 and 1994 were downloaded and used to estimate an average fuel efficiency for each type of automobile reported in the parking permit data.

Parking permit applicants reported their own vehicle make and model so sometimes the vehicle name in the permit did not match up perfectly with the official name in the fuel efficiency data.

This was corrected in two ways. First, the name of some of the models listed in the downloaded data was changed so they would match the parking permit names. The most common change was for GM trucks. The fuel efficiency data had the most common model as K1500 while the parking permits often listed them as 1500 or Silverado. By making an entry in the fuel efficiency data for 1500 or Silverado that had the fuel efficiency of the K1500 most of the missed lookups were now associated with at least a very similar vehicle.

In order to make sure that the most important vehicles had an appropriate lookup, the parking permit data by sorted by count. Each vehicle with over 20 entries was manually checked to make sure that it was given the correct fuel efficiency.

Less than 1% of vehicles reported in the permit data did not have a corresponding efficiency in the downloaded data. These vehicles were given a fuel efficiency of 18 which is approximately the mean efficiency for reported vehicles.

Each parking permit was matched with its appropriate fuel efficiency and copied in the UAA commuter model. The original fuel efficiency data and work can be found in the “Vehicle_eff.xls”[14] excel file.

[14] Available via special request from author: Nick.Szymoniak@uaa.alaska.edu

Appendix C: UAA commuter model details

High Scenario Saved Results

	Students	Employees
Portion of Commutes with Multiple Purposes	0	0
Multiple Purpose Emmissions attributable to UAA	1	1
Out of City Commuters	1	1
Average round trips per week	5	5
Average weeks per year	32	50
Alaska Efficiency Decrease	0.9	0.9
Off Campus Multiplier	1.1	1.1

Model Results

Total Fuel Burned in One Round Trip	11,215	702
Fuel per week	56,074	3,510
Fuel per Year	1,794,360	175,512
Total Miles in One Round Trip	92,799	5,883
Miles per week	463,995	29,414
Miles per Year	14,847,852	1,470,718
kg of CO_2 per Year	**17,507,573**	**1,712,467**
Metric Tons of CO_2 per Year	**17,508**	**1,712**

Total

kg of CO_2 per Year	**19,450,734**
Metric Tons of CO_2 per Year	**19,451**
Miles per Year	**16,318,571**

Medium Scenario Saved Results

	Students	Employees
Portion of Commutes with Multiple Purposes	0.05	0.05
Multiple Purpose Emmissions attributable to UAA	0.75	0.75
Out of City Commuters	0.9	0.9
Average round trips per week	5	5
Average weeks per year	32	50
Alaska Efficiency Decrease	1	1
Off Campus Multiplier	1	1

Model Results

Total Fuel Burned in One Round Trip	9,367	592
Fuel per week	46,835	2,962
Fuel per Year	1,498,735	148,122
Total Miles in One Round Trip	86,063	5,513
Miles per week	430,313	27,565
Miles per Year	13,770,031	1,378,269
kg of CO2 per Year	**13,293,779**	**1,313,846**
Metric Tons of CO2 per Year	**13,294**	**1,314**

Total

kg of CO2 per Year	**14,782,958**
Metric Tons of CO2 per Year	**14,783**
Miles per Year	**15,148,300**

Low Scenario Saved Results

	Students	Employees
Portion of Commutes with Multiple Purposes	0.15	0.15
Multiple Purpose Emmissions attributable to UAA	0.5	0.5
Out of City Commuters	0.8	0.8
Average round trips per week	4	5
Average weeks per year	32	50
Alaska Efficiency Decrease	1	1
Off Campus Multiplier	1	1

Model Results

Total Fuel Burned in One Round Trip	8,668	554
Fuel per week	34,672	2,772
Fuel per Year	1,109,504	138,589
Total Miles in One Round Trip	79,580	5,155
Miles per week	318,320	25,775
Miles per Year	10,186,248	1,288,725
kg of CO2 per Year	**9,841,304**	**1,229,289**
Metric Tons of CO2 per Year	**9,841**	**1,229**

Total

kg of CO2 per Year	**11,203,471**
Metric Tons of CO2 per Year	**11,203**
Miles per Year	**11,474,973**