

Wellesley Student Transportation Analysis (Short Distances)

INTRODUCTION

This report will analyze short distance transportation use by Wellesley students and suggest policies that Wellesley could use to make our short distance transportation use more sustainable. We analyze where Wellesley students go, how often, how they get there, and how much gasoline/fuel is consumed by their transportation needs. We will take the results of this research to suggest policies that could significantly reduce greenhouse gas emissions and gasoline use without severely increasing monetary costs.

To find this information we constructed a survey, distributed randomly online among Wellesley students. We received 264 responses. The survey was designed to elicit information on Wellesley students' use of cars, the exchange bus, the Senate bus, Zipcars, CWS vehicles, the escort van, Wellesley sports vehicles, and long-distance travel.

We hope that Wellesley administration will take advantage of our research and policy suggestions

MAJOR SHORT DISTANCE TRANSPORTATION BY WELLESLEY STUDENTS

We will attempt to provide a snapshot of present transportation options and costs to a typical Wellesley student. This information is also intended to make our analysis comprehensible to non-Wellesley readers.

Wellesley College contracts with Peter Pan Bus Company to provide local transportation. The Senate and Exchange Bus transport students to and from Boston and Cambridge. The Senate Bus costs \$2 per ride to Wellesley students and provides transportation from Friday night to Sunday night, while the Exchange shuttle is free and operates from Monday morning until Friday afternoon. The Natick Mall shuttle operates only on Saturdays, costs \$2 round trip, and transports students to the nearby Natick Mall

Sophomores, juniors, and seniors may also register for on-campus parking permits. Wellesley charges \$135 for a full-year parking permit for a resident student and \$100 for a commuter student. Students may also enroll in the Wellesley Zipcar program, which is

discounted from the regular Zipcar program. Wellesley students with a valid driver's license may join Zipcar for only \$25 per year and then pay \$8 per hour or \$60 per day for use of a Zipcar. Gas, insurance and parking are included for this price. Students may also pool rides via the online Rides conference, which matches students needing transportation with those able to provide it.

Wellesley is generally walkable, or at least cyclable. Campus police has two student-worker operated vans that give rides to students after dark, students living at the French House and disabled or injured students.

Wellesley students have access to several vehicles of the Wellesley fleet. These vehicles all run on unleaded gas. There are three CWS vehicles which are available for the use of students needing transportation to volunteer work or internships for credit. Gas is paid for by the CWS. The CWS also allocates Zipcars to students. The Athletics department owns their own vehicles which transport sports teams to games and tournaments. Certain academic departments on campus, (like Biology) have their own vans for student academic trips.

TRANSPORTATION DECISIONS AT OTHER EDUCATIONAL INSTITUTIONS

While some nearby campuses may not have transportation policies marketed as sustainable, their decisions may inadvertently influence students into taking more sustainable transportation decisions.

Boston College shares Wellesley's relative proximity to Boston. It is located about six miles west from the city of Boston, and is accessible by the T, the Boston subway system. Significantly for our purposes, parking permits at BC are only available to commuting students, junior and senior undergraduates and graduates. They cost \$400 per semester.¹

Mount Holyoke is an ideal college for comparison to Wellesley. Both are single sex colleges located within the vicinity of other colleges at which the students cross register. Mount Holyoke provides a fleet of hybrid vehicles that tested and approved students can reserve and use. On weekends, vans take students directly to nearby

¹ According to WC Parking Questions at parking@wellesley.edu, "The amount [Wellesley] students pay for parking is average in comparison to other colleges in the area, but way below average in comparison to colleges located in Boston"

shopping areas. Elements of Mount Holyoke's transportation policy, particularly the hybrid fleet and the van, could be implemented comfortably by Wellesley to improve our sustainability rating.

ASSUMPTIONS

Firstly, we assume that the data collected from our survey is representative of the student body².

We disregarded student use of the Boston T, taxis and academic department vans. We also do not consider the Olin Shuttle, as no established vehicle is used at all times.

A Wellesley student is defined as one who is currently enrolled and registered full time. Cross registered students from other colleges and post-baccalaureate students are excluded in our analysis.

We calculate an average of 34 weeks in the school year. Wintersession and summer school are excluded from the analysis. For certain forms of transportation that we were unable to determine the number of miles driven per year, we assume that in the 34 weeks that we are analyzing, 9000 miles is driven³.

We assume that the costs of gas, diesel and biodiesel are constant over the time analyzed.

Some students seemed to misunderstand the questions in our survey. We could only catch glaring errors⁴ and cannot specify how many less obvious errors might have slipped into our data.

WELLESLEY STUDENT'S ENVIRONMENTAL FOOTPRINT FROM SHORT DISTANCE TRANSPORTATION

Our aim is to break down the Wellesley college short-distance transportation carbon footprint in various ways in order to more accurately pinpoint the areas where policies could produce the greatest aggregate effect.

² Z-statistics show that, by class, our survey sample actually includes more first-years and sophomores than is statistically likely at the 5% level (see appendix F)

³ Official Energy Statistics from US Government, www.eia.com

⁴ Examples: reported purchase of 80 gallons of gas for 5-6 hours driving; reporting using a plane to reach Worcester MA (a 30 mile distance).

The carbon footprint of the typical Wellesley student is the representation of the average effect on the climate in terms of the total amount of greenhouse gases produced, measured in units of carbon dioxide. The carbon footprint of each student from short distance transportation varies depending on the type of vehicle used, the distance and the frequency of travel. From our research, the total carbon emitted annually through short distance transportation by Wellesley students is 1423.512 tons. This is equivalent to 33,113 tree seedlings grown for 10 years. Below is a breakdown of the emissions by vehicle (Figure 1).

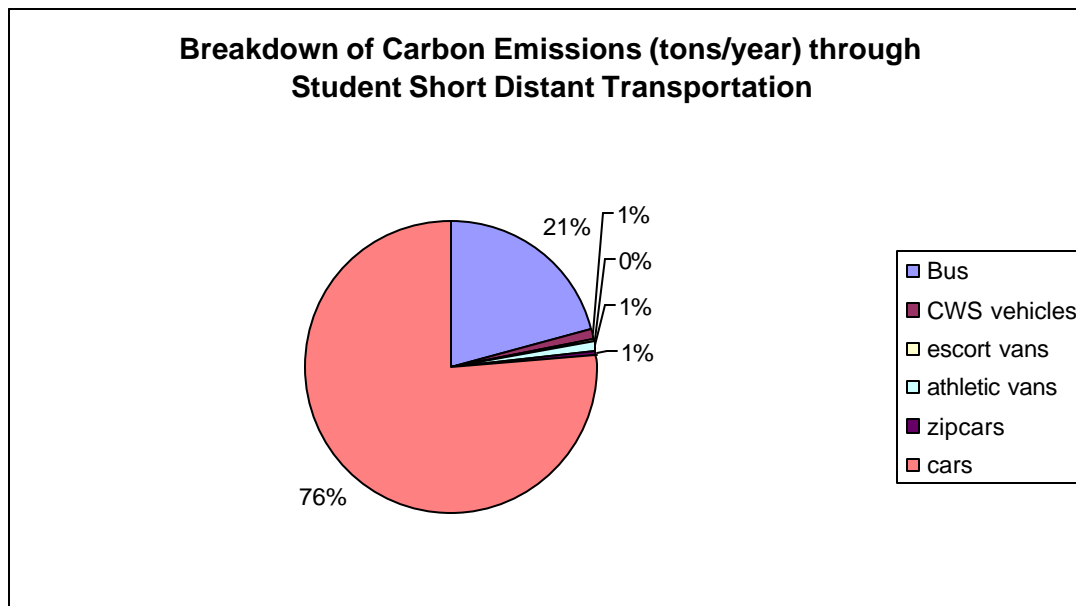


Figure 1: The estimated breakdown of carbon emissions (tons/year) by student short distant transportation in the school year 2006-2007 (from survey data)

PETER PAN BUSES

Wellesley’s contracted Peter Pan buses sit 55 passengers each, run on diesel and get 5mpg⁵. Two Exchange Buses are provided during weekdays, running constantly from 7:30 AM until 1:40 AM. Each round trip is 35.59 miles and there are 18 round trips per day (Appendix B). Thus, in a year 100,436 miles are driven, which requires 20,088 gallons of gas. The Senate Bus runs from Friday afternoon to the early hours of Monday morning. It takes two routes, one of which is 35.62 miles per round trip, and the alternate

⁵ The ES 300 report recommended that a smaller bus be used at certain times. The Peter Pan Information Service said that a smaller bus also gives 5mpg. This shows that there is no reason to switch to a smaller bus.

route is 37.5 miles per round trip. Depending on demand, the number of buses running at any one time varies from two to five. In a year, 64,672 miles are driven which requires 12,936 gallons of diesel. The Natick Movie-Mall Shuttle runs constantly on Saturdays from 11am until midnight. Each round trip is 11.57 miles and there are 7 seven round trips each Saturday. In a year, 2574 miles are driven which requires 551 gallons of diesel. Totaling the gallons of diesel required to run these buses in the 34 weeks, 33,573 gallons are required which produces 294.772 tons of carbon dioxide annually (Appendix A1). Bus use is the second largest carbon polluter in Wellesley's short-distance transportation, accounting for 21% of the total short-distance carbon footprint.

We suggest that Wellesley pressure Peter Pan to switch to biodiesel blend B-20. Considering that Wellesley accounts for a significant proportion of Peter Pan's business in Boston, pressure by the Wellesley administration should result in some action on Peter Pan's side. The biodiesel group found that based on March prices, B-20 is \$0.07/gallon cheaper than diesel. Using this estimation, Peter Pan will save \$2350.11 per year. Based on the most expensive estimate of B-20 in literature, which is \$0.10/gallon more expensive than diesel Peter Pan will have an added cost of \$3357.30. However, as the biodiesel group found, the price of biodiesel is likely to fall in the future, rather than rise.

A possible problem with this plan is Peter Pan might be unwilling to switch to bio-diesel. Some engine manufacturers may void the warranty if bio-diesel is used. Also, bio-diesel is not available at every gas pump.

CWS Vehicles

As mentioned above, CWS has three vans available for student use. There is a 1997 7-passenger Dodge Caravan, a 1998 7-passenger Dodge Caravan, and a 2006 7-passenger van. In order to estimate the amount of carbon emitted per year from these vehicles, we estimated that each vehicle has a fuel efficiency of 17 to 21 mpg (Appendix C). In a year, these vehicles emit 13.497 tons of carbon (Appendix A3).

In our survey, we asked students how many people were in the van when they last used it and on average. Only 20% responded that there were six people or more in the van last time they used it (Figure 2). Thus, the vans are being used inefficiently approximately 80% of the time, as a smaller car can seat five or less people more fuel-efficiently.

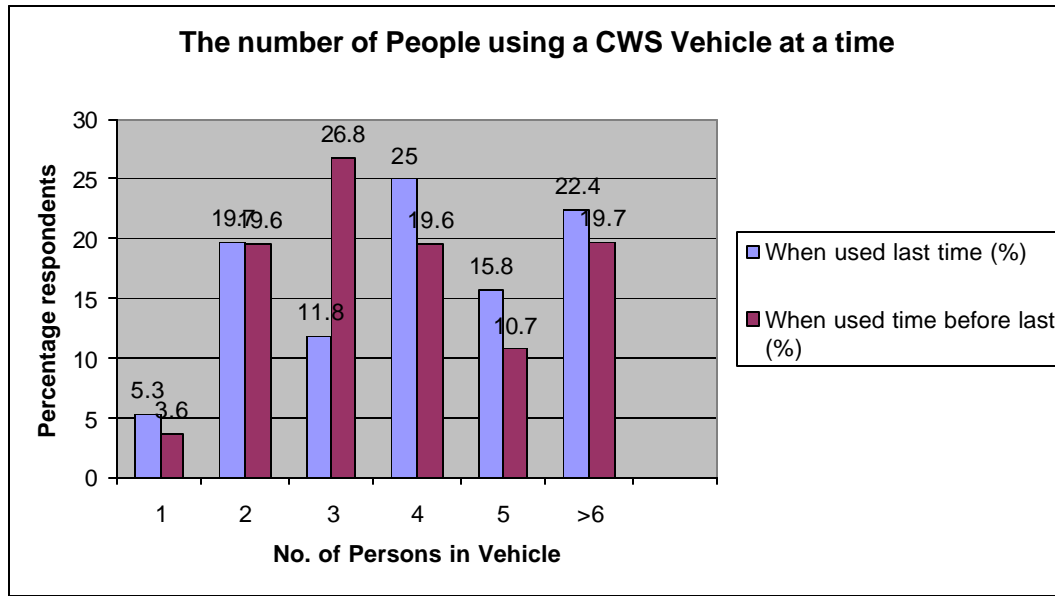


Figure 2: The chart shows the number of persons in a CWS vehicle from respondents of the survey

In order to correct for this, we suggest that when there are fewer than six people in the vehicle at any one time, CWS should allocate students to Zipcars. Our research showed that there is a fall in cost to the college when Zipcars are used instead of owning a car⁶. If one takes into consideration the cost of depreciation, maintenance, insurance, parking and finance charges, it is estimated that CWS would save \$3604 a year (Appendix D). This recommendation is by no means a difficult policy to implement.

However, Zipcar has certain restrictions and so there is still a need for CWS vans. It is also important to have a 7-passenger van for times when there are six or more people in a vehicle. We suggest that only the newest van, the 2006, 7-passenger van, be maintained. The other two CWS vans are getting older and we suggest that they be phased out and hybrid cars or vans be introduced. The cost of a hybrid car is estimated to be about \$2500 to \$3000 more expensive than a non-hybrid car.⁷ However, a hybrid car has an estimated fuel efficiency of 50mpg while a non hybrid car gives 20mpg (Appendix C). In a year, a hybrid car would only require 180 gallons of gas while a non-hybrid car

⁶ AAA Your Driving Costs 2007 Ed.

<http://www.aaexchange.com/Assets/Files/20073261133460.YourDrivingCosts2007.pdf>

⁷ www.edmunds.com/advice/fueleconomy/articles/103708/article.html

requires 450 gallons. Assuming that the price of gas is \$2.73⁸, CWS would save in costs of gas by \$737.10. The payback time per hybrid car that CWS buys is 3.5 to four years. Considering that gas prices are likely to rise in the future, it is possible that the payback time will be less than we have estimated.

ESCORT VANS

There are two escort vans on campus and we estimated that they each give 20mpg (Appendix C). This results in an annual carbon emission of 4.499 tons (Appendix A3).

Our research showed that only one van runs at any one time. These vans are old, that is, about nine to ten years old. Also, although 60% of students who responded to our survey said that they have in the past used the escort vans, on a typical day most students do not use the van.

The escort vans are an important feature in the Wellesley Fleet. Since Motor Pool is considering changing them in the near future⁹, we recommend that they switch to hybrid vans. The costs analysis of this policy is identical to the cost analysis of switching the CWS vans to hybrid cars.

ATHLETIC VANS

There are 13 teams on campus who have access to the athletic vehicles which includes a Ford 15-passenger van and 2 GMC 15-passenger mini-buses. Although only 10% of Wellesley students are athletes, the vehicles are used on a regular basis and are usually used for medium distance travel. We assume that the minibuses have an estimated fuel efficiency of 17mpg each and the 15-passenger van gives 20mpg (Appendix C). In a year, they emit an estimated total of 15.085 tons of carbon (Appendix A3). We found that the minibuses are three years old and the department will not be changing them in the near future. The van is also used minimally because of safety concerns. Thus, we will not be recommending any changes to these vehicles.

⁸ Information from George Reebe at Motor Pool

⁹ Ibid

ZIPCARS

There are three Zipcars on campus, a Mazda 3 “Maria”, a Toyota Matrix “Martha” and a Scion xB “Beverly”¹⁰. Since they are small vehicles, we estimate that their fuel efficiencies are 26mpg (Appendix C). In a year, these cars give a total of 9.12 tons of carbon (Appendix A1).

From our survey, we found that approximately 10% of the student body is enrolled in the program. From the data, we constructed a table (Figure 3) to see how often each car is used in a day. We found that each car is used between six to ten hours a day¹¹.

	Total Hours all cars are in use, per week	Total hours per week cars are in use, per car	Total hours per day cars are in use, per car
Average Hours Used Per Week	171.189	57.063	8.15
Hours Used Last Week	129.85	43.28	6.18
Hours Used Week Before Last	199.65	66.55	9.51

Figure 3: The table shows the hours per day each Zipcar is used on average, last week and the week before last

Our survey also showed that 47.6% (120 students) of respondents indicated that they would join ZipCar or use ZipCars more if more were available on campus. We have already shown that CWS vehicles are used inefficiently, that is, they are often used when fewer than six people are in the vehicle. Thus, we propose that several additional ZipCars become available on campus. Instead of using CWS vehicles, CWS should subsidize ZipCar use for students going to volunteer work/internships.

STUDENT CARS

50 students with cars responded to our survey. We assume that they are a representative sample of the 651 students with parking permits¹². From the information

¹⁰ www.zipcar.com

¹¹ Peter Eastment, the Director of Housing and Transportation estimated that each car is used 8-10 hours per day

that they provided, we formed a breakdown of types of cars students use (Figure 4.1). We also observed the breakdown of the top places students drive to (Figure 4.2).

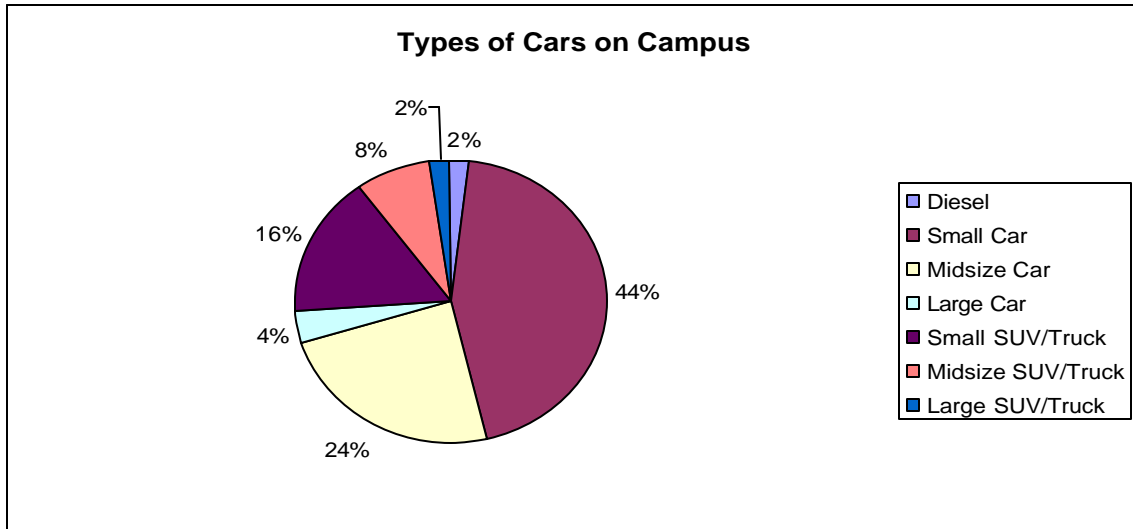


Figure 4.1: The breakdown of the cars Wellesley students keep on campus for the school year of 2006-2007

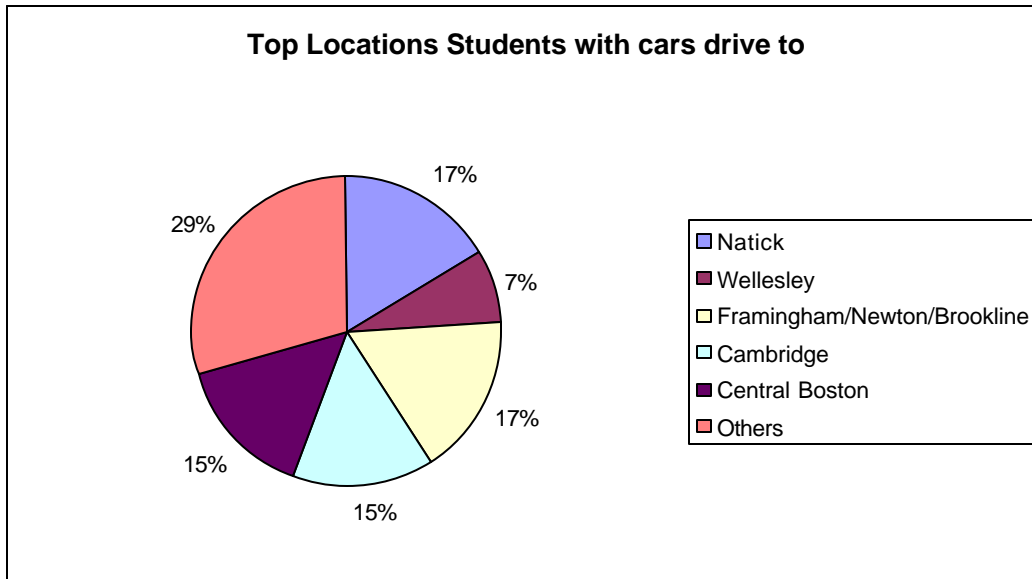


Figure 4.2: The top locations Wellesley students with cars drive to in the school year 2006-2007

¹² Statistical analysis shows that a statistically significant (at the 1% level) fewer number of car-owning students answered our survey. This might be due to the large number of first-years in the sample (see appendix F).

In our survey, we asked students with cars questions about the type of car they own, the top three places they drive to, the number of hours they drive in a week, and the amount of gas their car uses in a week. We then separated our analysis to fuel efficient and non-fuel efficient cars. We disregarded the diesel cars assuming that very few students use diesel cars. We defined a fuel efficient car as one that is small, midsize or hybrid and estimated that they give 30mpg (Appendix C). A non-fuel efficient vehicle is a large car or an SUV and we estimated that they give 20mpg (Appendix C). From our analysis, we found that while students with non-fuel efficient cars buy more gas than students with fuel efficient cars, students with non-fuel efficient cars drive fewer hours than students with fuel efficient cars (Figure 5 & 6). While zero number of students with non-efficient cars responded that they drive more than ten hours in a week, 7 students with fuel efficient cars say that on average they drive more than 10 hours a week¹³.

Non-Fuel Efficient Cars (15 cars)

	0	1-2	3 -4	5 -6	7 -9	10+
Average Hours per Week Driven	1	3	5	3	3	0
Last Week Hours per Week Driven	0	5	4	2	4	0

Fuel Efficient Cars (34 cars)

	0	1- 2	3- 4	5- 6	7 -9	10+
Average Hours per Week Driven	1	11	6	8	1	7
Last Week Hours per Week Driven	4	9	7	6	3	5

Figure 5: The average hours students say they drive per week and the actual hours students say they drove the previous week for fuel efficient and non-fuel efficient cars

¹³ The ES 300 report recommended charging students with non-fuel efficient vehicles a higher permit price. As our analysis has shown, such students are responding to rising gas prices by driving less per week. Also, given short-term inelasticity of the car market, the permit price would have to be quite high to influence behavior in any way.

Non-Fuel Efficient

	total	per car
Average Gallons per Week Bought	121.5	8.1
Gallons Bought Last Week	143	10.21

Fuel-Efficient

	total	per car
Average Gallons per Week Bought	250	7.35
Gallons Bought Last Week	299.5	8.81

Figure 6: The average gallons of gas students say they buy per week and the actual gallons they bought the previous week for fuel efficient and non-fuel efficient cars

We also assumed that the average speed Wellesley students drive at is 35 miles/hour. Using the information about fuel efficient and non-fuel efficient cars, we found that just from this sample, the total carbon emitted for the sample is 83.19 tons per year. From this, we estimated that 1081.4 tons of carbon is emitted per year by all student cars (Appendix A2).

Student-owned cars are the greatest contributor to Wellesley's short-distance transportation carbon footprint. Therefore, it is crucial that effective policies be introduced to improve student transportation sustainability. Carbonfund.org carbon offset costs \$5.50 per metric ton. We suggest increasing permit prices by \$10 per car per year and using the proceeds to buy these carbon credits. Just this increase will make Wellesley students' car use carbon-neutral.

Another policy that could reduce carbon emission through student owned cars is by increasing the coordination of shared rides. While an online rides conference exists, few students make regular use of it. 21.7% of survey respondents report they were not aware of its existence. Among complaints about the conference are the inconvenience, bad response time, unreliable drivers and offers not taken up.

We suggest better organization of the conference. Sub-conferences for airport rides, local rides (Whole Foods, Cambridge, Natick, Babson, etc), and long distance rides

should be included. Clear rules and regulations should also be provided to ease use of conference. There should also be pooled information on drivers as presently, there is imperfect information on which drivers are reliable. Ride-givers and ride takers should have a safe space conference where they are allowed to discuss their experiences (ideally anonymously). Wellesley students would volunteer to control this conference in return for being able to put the position on their resume, so there would be no costs to this change.

Furthermore, there should also be more broadly disseminated information about the conference. The existence of the conference should be made known to incoming students during the first year sustainability workshop.

FURTHER ANALYSIS (Long Distances)

We found that long distance travel accounts for 87% of total annual carbon emissions for all travel.

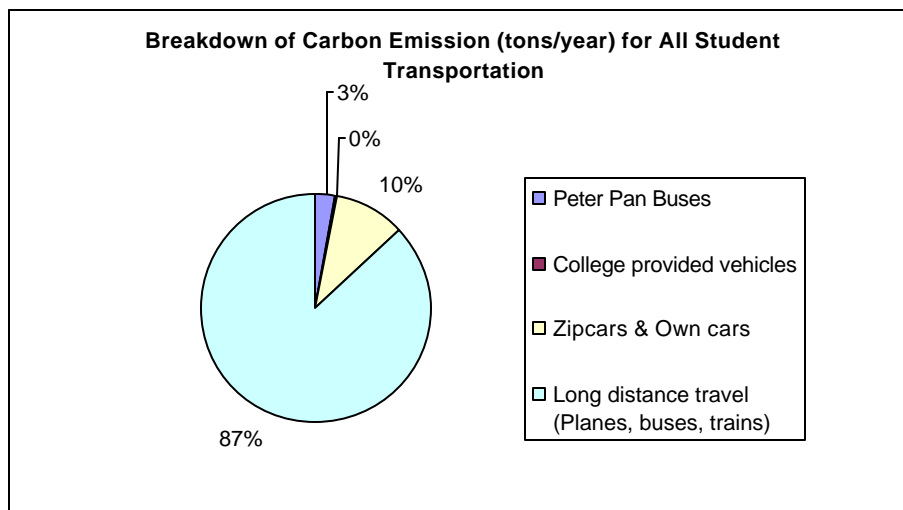


Figure 7: The estimated breakdown of carbon emissions (tons/year) by all student transportation in the school year 2006-2007

We define long-distance transportation as transportation to and from Wellesley to homes and vacation spots. We attempted not to include semester-abroad trips in our count. We attempted to include no trips except the first trip away from Wellesley to the primary destination. There are four major forms of long-distance transportation: bus, car, plane, and train.

In our survey, we asked students where they were from, which vacations they had gone home for that year, and what other trips out of the Boston area they had made. We then asked them their form of transportation and reason for travel and used this data to calculate Wellesley's long-distance transportation carbon count. We found 9315 tons of carbon per year is Wellesley College students' long-distance carbon footprint.

Although 264 students responded to our survey, only 225 responded with usable information for this sector. Breaking them down by region of origin¹⁴, 8% were of international origin, 18% from the Pacific/Mountain region, 20% from New England, 23% from the Mid-Atlantic region, 16% from the South, and 16% from the Central US. The average distance from home for each student increased from approximately 50 miles for the New England students to 5700 miles for the international students. We noted that the average number of times this year that each student had traveled home¹⁵ had a strong inverse relationship with distance to home. For example, New England students traveled home an average of 3.9 times this year¹⁶, whereas international students traveled home an average of 1.7 times this year.¹⁷ Using a carbon counter¹⁸, we found that the total carbon count for travel home for all Wellesley was 5212 tons. Broken down by region, we find that the largest aggregate polluters are actually not international students, but Pacific/Mountain region students, who produce 39% of the travel-home carbon footprint¹⁹. New England students, predictably, produced the least aggregate carbon pollution, account for 0.9%²⁰ of the total.

We then opened up long-distance travel to non-home travel. 4103 tons of carbon were produced through non-home long-distance travel. The top three reasons given for

¹⁴ We ran a z-test using the 2010 statistics (<http://www.wellesley.edu/admission/admission/statistics.html>), using class of 2010 as a proxy for geographic breakdown across the school, and found that our sample was statistically the same (at the 10 % confidence level) regionally except for the Central region, which had a z-value of -2.7)

¹⁵ "Home" is identified as the place the student listed when asked where "home" was – obviously there is room for skew in broken homes, childhood homes where parents no longer live, etc.

¹⁶ This value is arguably actually smaller than the actual value because most students reporting homes in Boston, Cambridge, Wellesley, and neighboring suburbs did not report how many times per year they returned home as trips "outside Boston".

¹⁷ See Appendix E, Table 1

¹⁸ www.nativeenergy.com/travel

¹⁹ International students are still however the largest per-capita polluters for travel home.

²⁰ See Appendix E, Table 2 (To calculate full-school carbon count, we assumed that our sample was representative of the college, although we know that the Central Region is not perfectly representative)

this sort of travel were visiting friends, athletics, and visiting family²¹. 29% of trips were made to the Mid-Atlantic area, driven largely by bus-trips to New York. However, this only made up 6% of the carbon footprint of non-home travel – the vast majority of carbon, 60%, was emitted by international trips. 96% of international trips were reached via plane, whereas only 1% of New England trips were plane travel.

Plane use in New England produced 0.0014 tons of carbon per mile and plane use in the mid-Atlantic region produced 0.0010 tons of carbon per mile, whereas plane use in all other (further) regions produced 0.0007 tons of carbon per mile. This supports our research²² finding that plane use is most polluting in short-distance hops, due to the large carbon expenditure in take-off and landing relative to length of flight.

Bus use uniformly produced an average of 0.0003 tons of carbon per mile, car (assumed small) use produced an average of 0.0006 tons of carbon per mile, and train use produced an average of 0.0006 tons of carbon per mile. Bus use was the least-polluting option, although we were not able to find a value for fully occupied cars.

Our final carbon footprint for all long-distance travel was 9315 tons of carbon per year, based on 2007 survey measures. We found that 27% of all travel was by bus, 19% by car, 49% by plane, and 6% by train. 28% of travel was within New England, 27% of travel to the Mid-Atlantic region, 12% of travel to the Central region, 12% of travel to the South, 10% of travel to the Pacific/Mountain region, and 10% of travel international. Students used more cars and buses and trains for distances under 250 miles, then car and bus and train use virtually disappeared and plane use became dominant. For more details, see appendix E, table 5.

39.2% of 176 survey respondents reported that even if exciting, interesting trips and/or activities had been offered on campus, they would still have chosen to travel. Only 2.3% reported that they would have forgone their trip, while 58.5% responded that it would depend on the activity.

We suggest that during the first-year sustainability seminar, students be informed of the relative carbon footprints of cars, buses, trains, and planes, in the hopes that, better informed, they will make more ecologically friendly choices.

²¹ See Appendix E, Chart 1

²² www.nativeenergy.com/travel

CONCLUSION

All in all, the policies we have recommended here result in an additional cost to the college of \$5447.60 in the first year but savings of \$3604 in each subsequent year. This assumes that the college changes both the escort vans and the 1997 and 1998 CWS vans to hybrid vehicles all in the first year. Assuming this, there is a payback time of 1.5 years. There is also a maximum additional cost to students of \$35 per year, which considers a student with a car on campus also registered with Zipcar. However, most students will choose only one alternative and a reasonable estimate of the additional cost to a student is either \$10 or \$25.

The policies we have suggested that Peter Pan takes on result in no additional cost to the college other than the effort of pressuring Peter Pan to introduce green policies. Depending on the cost of biodiesel, Peter Pan could incur additional costs of \$3357.30 or savings of \$2350.11 per year. However, as mentioned earlier, the price of biodiesel is likely to fall in the future as opposed to a likely increase in the price of diesel. Thus, Peter Pan should save more than we have estimated.

There is also a further possibility of using the savings each year to purchase carbon credits. This could make Wellesley student's transportation use carbon neutral. This subject of carbon credits is analyzed by another group.

Our analysis has shown that indeed it is possible to introduce more sustainable student transportation without incurring a significant cost and with much ease. Furthermore, there could be an improvement in the budget in the long term as these policies are more efficient.

Appendix A1

To calculate the number of gallons required in a year by the vehicles, we took the total number of miles driven and divided it by the actual or estimated fuel efficiency (mpg). Next, to calculate the total emission of carbon annually, we took the quotient obtained above, multiplied it by 19.36 which is the amount of pounds of carbon emitted as a result of burning one gallon of gasoline. The product is then divided by 2205, the number of pounds in a metric ton.

Appendix A2

We faced some problems in calculating the amount of carbon emitted from cars. Initially, we used the total amount of gallons the students reported buying per week but the value that we got was unbelievable more than the one in the ES300 report. We suspect that this could be a fault in our survey.

In order to get a plausible value, we assumed that the average speed students drive at is 35 miles/hour. We then multiplied 35 by the total hours per week driven by the sample of students we considered. We then multiplied this quotient by the inverse of the estimated fuel efficiency to get the total gallons of gas used per week.

Appendix A3

We used a carbon calculator we found online to measure the total annual carbon emitted. The website is www.nativeenergy.com/travel. While the calculations method used by the website is identical to ours, they added a 15% mileage addition factor to account for the non-linear nature of roads.

Appendix B

To calculate the number of miles in a round trip, we obtained the respective bus schedules from <http://www.wellesley.edu/Transportation/index.html>. Using the information from this schedules, we found the number of round trips the buses take. We then used www.mapquest.com to determine the exact number of miles per round trip.

Exchange Bus

Wellesley to Building N52
16.82 Miles
Building N52 to building 34
0.38 Miles
Building 34 to Kendall Square
0.55 Miles
Kendall Square to Building E40
0.13 Miles
Building E40 to Building 44
0.59 Miles
Building 44 to 77 Mass Ave
0.22 Miles
77 Mass Ave to Commonwealth
0.75 Miles
Commonwealth to Wellesley College
16.15 Miles

SENATE BUS

Wellesley to Harvard Square
16.77 Miles
Harvard Square to MIT Kresge
2 Miles
MIT Student Center to Commonwealth Ave
0.8 miles
Comm Ave to Wellesley
16.15 miles
TOTAL MILEAGE: 35.72 Miles

Alternate Route

Wellesley to Harvard Square
Harvard Square to MIT Kresge
MIT Student Center to Commonwealth Ave
Commonwealth Ave to MFA
MFA to Wellesley
TOTAL MILEAGE: 37.5 Miles

Appendix C

For vehicles that we were unable to determine the fuel efficiency, we used the information below as an estimation of miles per gallon.

Vehicle	Estimated fuel efficiency (mpg)
Hybrid passenger car	50
Hybrid truck / hybrid SUV	25
Diesel car	35
Small car	26
Mid-size car	24
Large car	22
Small SUV / small truck	21
Mid size SUV / midsize truck	20
Large SUV / large truck	17
Van	20
Motorcycle	50
No specific classification	21

<http://www.carboncounter.org/offset-your-emissions/calculations-explained.aspx>

Appendix D

The cost savings from using a Zipcar instead of owning a car was estimated by comparing the two alternatives. Using the guidelines in the AAA Your Driving Costs 2007 edition, we estimated the following costs:

<i>Car Ownership</i>	<i>Cost/month</i>
Car payment (including depreciation)	\$287
Finance Charges	\$62
Insurance	\$75
Gas	\$123
License, registration, taxes	\$46
Maintenance & tires	\$71
Total	\$664

Total cost/vehicle in 34 weeks to college: \$5644

Total cost for three vehicles in 34 weeks to college: **\$16,932**

We assume that CWS allocates Zipcars to students for approximately 7 hours each day.

<i>Zipcar</i>	<i>Cost/week</i>
Start-up cost to college	0
Cost/hour driven	\$392
Total	\$392

Total cost in 34 weeks to college: **\$13,328**

Savings/year: **\$3604**

APPENDIX E

TABLE 1

TRIPS HOME								
Student's Home Region	# students	Avg distance home	Avg # times home/yea r	% home summer	% home Thanksgiving	%home winter holidays	% home spring break	# additional trips home/person
New England	45	50.27	3.87	64.44%	71.11%	84.44%	64.44%	1.02
Mid-Atlantic	51	256.27	3.53	66.67%	84.31%	92.16%	56.86%	0.53
Central	36	1062.50	3.03	80.56%	61.11%	91.67%	58.33%	0.11
South	35	1239.14	2.74	74.29%	62.86%	94.29%	42.86%	0.00
Pacific/Mountain	41	3075.6	2.32	75.61%	26.83%	95.12%	34.15%	0.00
International	17	5667.6	1.69	82.35%	5.88%	58.82%	11.76%	0.00

TABLE 2

TRIPS HOME					
Student's Home Region	# students	average carbon count per person	total carbon count - SURVEY	total carbon count - WELLESLEY	% carbon count by region
New England	45	0.11	4.80	48.66318	0.93%
Mid-Atlantic	51	0.49	24.98	253.4828	4.86%
Central	36	2.18	78.36	795.0485	15.25%
South	35	2.31	80.83	820.1005	15.73%
Pacific/Mountain	41	4.90	201.06	2040.079	39.14%
International	17	7.28	123.68	1254.893	24.08%

CHART 1 (Non-Home Trips)

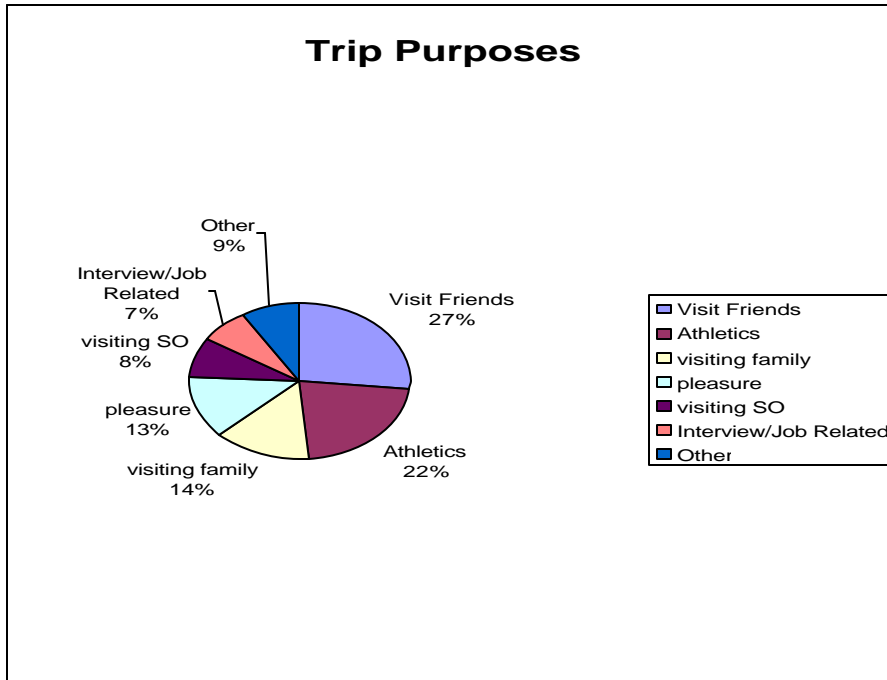


TABLE 3

TRIPS NOT-HOME (by region)							
	TOTAL	New England	Mid-Atlantic	Central	South	Pacific/Mountain	International
Total # trips:	522	31	149	35	52	31	96
% total trips		5.94%	28.54%	6.70%	9.96%	5.94%	18.39%
Avg Carbon Count per Trip (tons):	0.77	0.05	0.16	0.68	0.80	2.13	2.52
Total Carbon Count in tons:	404.34	7.71	23.26	23.69	41.48	66.10	242.11
% total carbon		1.91%	5.75%	5.86%	10.26%	16.35%	59.88%
% bus trips	27.97%	43.40%	45.64%	2.86%	15.38%	0.00%	0.00%
% car trips	21.26%	46.54%	20.13%	2.86%	1.92%	3.23%	4.17%
% plane trips	44.64%	1.26%	22.15%	94.29%	82.69%	96.77%	95.83%
% train trips	6.13%	8.81%	12.08%	0.00%	0.00%	0.00%	0.00%

TABLE 4

SOUTH	# trips	% of total	total carbon count	avg carbon count	avg distance	carbon count/mile
total	52	9.96%	41.48	0.798	1211.11	0.0007
by bus	8	15.38%	3.26	0.407	1100.00	0.0004
by car	1	1.92%	0.70	0.703	1300.00	0.0005
by plane	43	82.69%	37.52	0.873	1220.00	0.0007
by train	0	0.00%	0.00	0.000	0.00	0.0000

PACIFIC/MOUNTAIN	# trips	% of total	total carbon count	avg carbon count	avg distance	carbon count/mile
total	31	5.94%	66.10	2.132	2936.84	0.0007
by bus	0	0.00%	0.00	0.000	0.00	0.0000
by car	1	3.23%	1.29	1.293	2300.00	0.0006
by plane	30	96.77%	64.80	2.160	2972.22	0.0007
by train	0	0.00%	0.00	0.000	0.00	0.0000

New England	# trips	% of total	total carbon count	avg carbon count	avg distance	carbon count/mile
total	31	5.94%	7.71	0.048	92.89	0.0005
by bus	69	43.40%	2.29	0.033	100.63	0.0003
by car	74	46.54%	4.48	0.061	90.74	0.0007
by plane	2	1.26%	0.25	0.123	85.00	0.0014
by train	14	8.81%	0.68	0.049	86.00	0.0006

Mid-Atlantic	# trips	% of total	total carbon count	avg carbon count	avg distance	carbon count/mile
total	149	28.54%	23.26	0.156	285.41	0.0005
by bus	68	45.64%	5.42	0.080	293.75	0.0003
by car	30	20.13%	4.04	0.135	259.23	0.0005
by plane	33	22.15%	10.84	0.328	333.33	0.0010
by train	18	12.08%	2.97	0.165	262.86	0.0006

International	# trips	% of total	total carbon count	avg carbon count	avg distance	carbon count/mile
total	96	18.39%	242.11	2.522	3667.10	0.0007
by bus	0	0.00%	0.00	0.000	0.00	0.0000
by car	4	4.17%	0.74	0.185	330.00	0.0006
by plane	92	95.83%	241.37	2.624	3778.33	0.0007
by train	0	0.00%	0.00	0.000	0.00	0.0000

Central	# trips	% of total	total carbon count	avg carbon count	avg distance	carbon count/mile
total	35	6.70%	23.69	0.677	1000.63	0.0007
by bus	1	2.86%	0.26	0.256	800.00	0.0003
by car	1	2.86%	0.41	0.411	700.00	0.0006
by plane	33	94.29%	23.03	0.698	1036.43	0.0007
by train	0	0.00%	0.00	0.000	0.00	0.0000

TABLE 5

WHOLE-SCHOOL TOTALS		Carbon Count (tons)				
Trips Home		5212.267				
Trips Not-Home		4102.71				
TOTAL CARBON COUNT		9314.98				
By Region	TOTAL trips	% by region	% by bus	% by car	% by plane	% by train
Total	12223.56		26.77%	19.11%	48.39%	5.54%
New England	3378.84	27.64%	43.40%	46.54%	1.26%	8.10%
Mid-Atlantic	3338.253	27.31%	45.64%	20.13%	22.15%	12.08%
Central	1461.12	11.95%	2.86%	2.86%	94.29%	0.00%
South	1501.707	12.29%	15.38%	1.92%	82.69%	0.00%
Pacific/Mountain	1278.48	10.46%	0.00%	0.79%	99.21%	0.00%
International	1265.163	10.35%	0.80%	0.80%	98.47%	0.00%

CHART 2

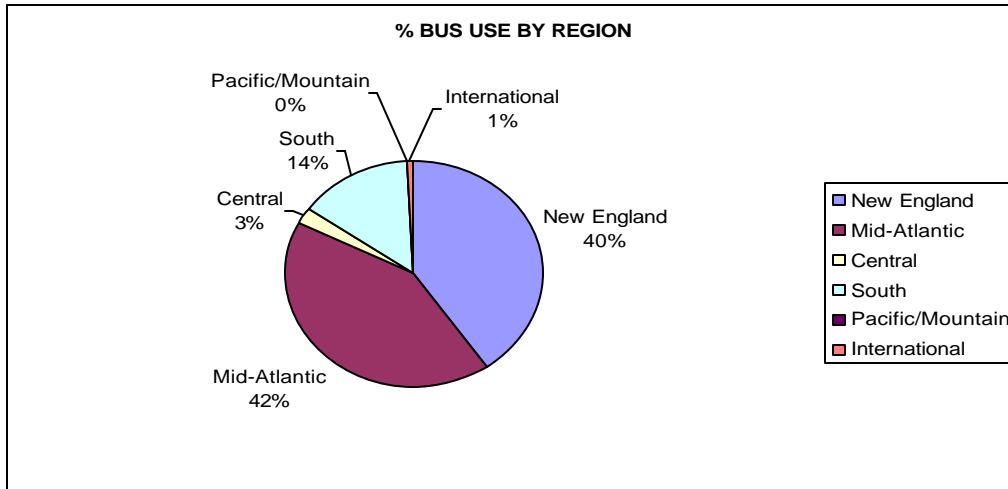


CHART 3

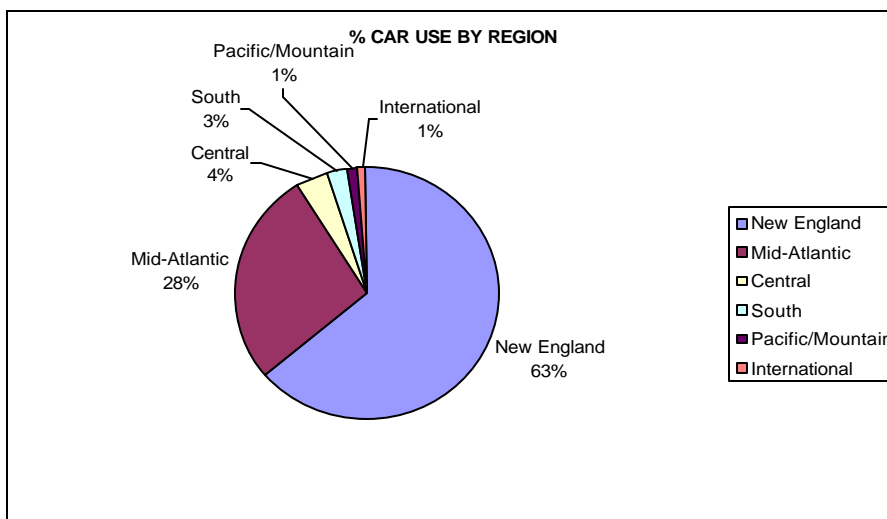


CHART 4

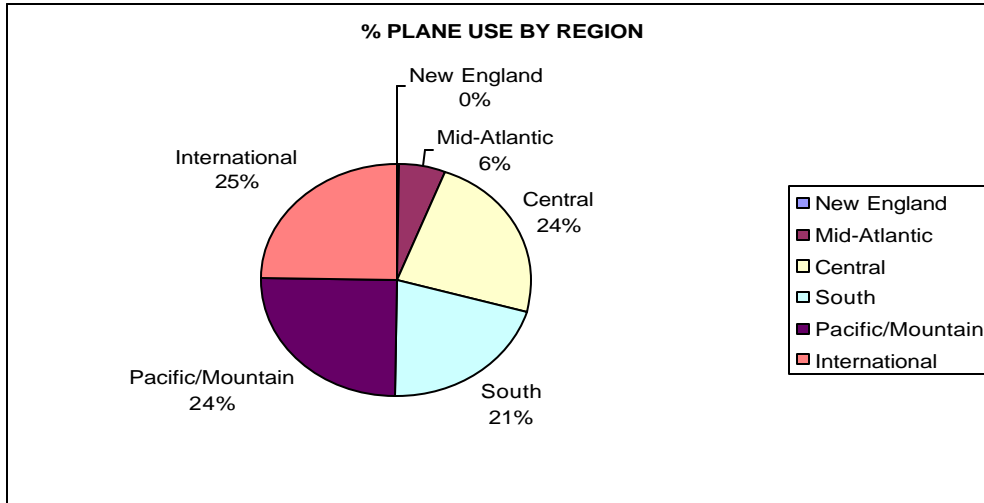
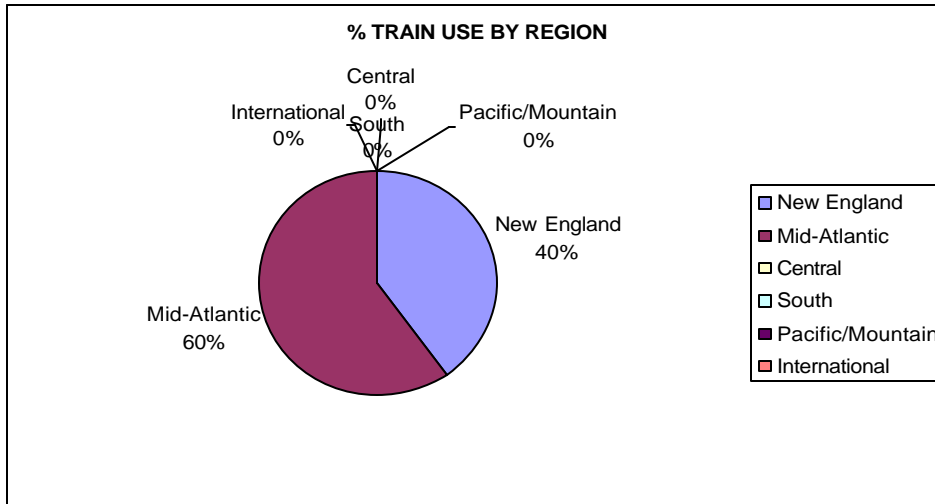


CHART 5



APPENDIX F

Statistical Analysis

z value	p hat	x 1	n 1	p hat 1	x 2	n 2	x 2	YEAR
-1.96237	0.259419	579	2283	0.253614	82	265	0.309434	<i>First-Year Students</i>
-2.02797	0.257849	575	2283	0.251862	82	265	0.309434	<i>Sophomore Students</i>
0.424768	0.175432	403	2283	0.176522	44	265	0.166038	<i>Junior Students</i>
1.274324	0.223312	518	2283	0.226894	51	265	0.192453	<i>Senior Students</i>
-1.82556	0.011381	23	2283	0.010074	6	265	0.022642	<i>Davis Scholars</i>

CAR OWNERSHIP

z value	p hat	x 1	n 1	p hat 1	x 2	n 2	x 2	CAR OWNERS
3.32877	0.275118	651	2283	0.285151	50	265	0.188679	<i>CAR OWNERSHIP</i>

Bibliography

Stacy Sneeringer, Assistant Professor, Economics, Wellesley. Advised us on the project

Ben Hufford, green architect. Advised us on the project

ES300 Audit of Wellesley College's Greenhouse Gas Emissions,
<http://www.wellesley.edu/EnvironmentalStudies/Prospectives/assessment.html>

Online survey, www.surveymonkey.com

Carbon calculator, www.nativeenergy.com/travel

Wellesley Bus Schedules, <http://www.wellesley.edu/Transportation/index.html>.

Maps, www.mapquest.com

Peter Pan hotline (1-800-343-9999). Provided information about the buses Peter Pan serves Wellesley college

Estimation of fuel efficiency, <http://www.carboncounter.org/offset-your-emissions/calculations-explained.aspx>

Costs of buying a hybrid car,
www.edmunds.com/advice/fueleconomy/articles/103708/article.html
Zipcar information, www.zipcar.com

Costs of Driving 2007,
<http://www.aaaexchange.com/Assets/Files/20073261133460.YourDrivingCosts2007.pdf>

Official Energy Statistics from US Government, www.eia.com

Peter Eastment, Director of Housing and Transportation, Wellesley. Provided estimate of how often Zipcars are used per day.

Melissa Hawkins, Director of Service & Stipend Programs, Center for Work and Service, Wellesley. Provided information about CWS vehicles.

George Reebe, Garage Mechanic A, Motor Pool, Wellesley College. Provided information about all vehicles in the Wellesley Fleet and mentioned the possibility of buying new escort vans. Gave an estimation of the price of unleaded gas at Motor Pool

Bridget Belgiovine, Director of Athletics, Physical Education, Recreation & Athletics, Wellesley. Provided information on athletic vehicles and referred us to George Reebe at Motor Pool.

Statistics of Student Majors, <http://www.wellesley.edu/Directory/>

Statistics of Class of 2010, <http://www.wellesley.edu/admission/admission/statistics.html>

Wellesley Spring 2007 College Count,

<http://www.wellesley.edu/Registrar/spr2007colcount.html>

Boston College Student Parking Permits,

<http://www.bc.edu/offices/transportation/parking/student/>

Mount Holyoke College transportation,

<http://www.mtholyoke.edu/offices/es/10712.shtml>

Carbon credits, www.carbonfund.org

Lauren Gritske, Heather Hausladen & Anli Yang, Biodiesel Group, Wellesley. Provided information about the cost of biodiesel and diesel

WC Parking Questions at parking@wellesley.edu, Provided information about Wellesley college parking permits, permit money use, and prices.