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# The State of Sustainable Transportation at Union College: A Transportation Audit of Union College Students and Faculty

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# The State of Sustainable Transportation at Union College

*A Transportation Audit of*
*Union College Students and Faculty*

By

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**ABSTRACT**

Union College has established a Climate Action Plan with the goal of carbon neutrality by 2060 as part of its commitment to sustainability. A significant component of Union's carbon footprint, however, is student and faculty transportation. The purpose of this research was to analyze the transportation behavior of students and faculty to determine the carbon emissions that result from the use of various transportation methods. Two campus-wide surveys were conducted; one was distributed to students and the other targeted faculty. For comparison purposes, survey questions were designed to be compatible with, but more focused than, those of a survey conducted in 2007-08 by the students taking an Introduction to Environmental Science course. The surveys asked students and faculty about the modes of transportation utilized, and parking and travel habits. Using standard formulas, transportation carbon emission analysis determined that a typical faculty member emitted 824 and 1020 kg of carbon in 2011 and 2007, respectively. Similar calculations showed that a typical student emitted 998 and 784 kg of carbon in 2011 and 2007, respectively. By compiling the data related to the type of cars students drive, as well as carpool and trolley participation habits, the study proposes recommendations to improve the transportation culture on campus to make it more sustainable.

## DEDICATION

While the origins of this thesis officially began in the spring of 2011, it was inspired in the mid-1990s by a challenge offered to me by my father. As we drove home from a family vacation, my father asked me to guess on a map where we were making a surprise visit; it took me less than thirty seconds to guess the right answer: Dinosaur State Park, located off Interstate 91 in Rocky Hill, Connecticut. My interest in public infrastructure, transportation, and urban design stems from a short moment in my parents' old station wagon.

I dedicate my thesis to my family, who have supported me throughout my academic pursuits and let me "borrow" copious amounts of white-out for homemade maps and Lego creations. I also dedicate my thesis to all my teachers, who have demanded excellence from me throughout my academic pursuits, and my friends, who have always let me talk for hours about the societal impact of infrastructure as well as the infamous planner, Robert Moses.

My thesis is also dedicated to my aunt, for without, I would have never spent four wonderful years in Schenectady finding my life passion.

**ACKNOWLEDGEMENTS**

This thesis was the result of many hours of brainstorming and discussions with my professor, thesis advisor, mentor, and friend, Ashraf Ghaly. Professor Ghaly has always helped me do my best and has always been excited to talk about infrastructure and transportation with me. His assistance and encouragement throughout the thesis process gave me the opportunity to do a project that I was thoroughly interested in.

I also must acknowledge the professor who let me into his already over-sized Introduction to Environmental Science class during my freshman year. Professor Jeffery Corbin further opened my eyes to the world of environmental science and sustainability, which ultimately led me to changing my major to Environmental Science. I thank Professor Corbin for giving me guidance throughout my thesis project and for giving me access to his previous transportation survey and data.

I would also like give thanks to the Union College Facilities Services Department, including Loren Rucinski and Fred Puliafico, who provided me with information regarding the history of parking, transportation, and circulation at Union College.

# TABLE OF CONTENTS

ABSTRACT....ii
DEDICATION....iii
ACKNOLEDGEMENTS....iv
LIST OF FIGURES....vii
LIST OF TABLES....ix
LIST OF MAPS....ix
INTRODUCTION....10
Background of Union College....10
Background of Schenectady, New York....11
Current Transportation in the Capital Region....12
Background of the Union College Climate Plan....13
Reasons for a Transportation Study at Union College....14
Goals of the Current Transportation Survey....16
SURVEY IMPLEMENTATION AND RESULTS....18
2011-2012 Faculty Survey Methods and Questions....18
2011-2012 Faculty Survey Graphs....24
2011-2012 Student Survey Methods and Questions....33
2011-2012 Student Survey Graphs....43
2007-2008 Faculty Survey Graphs....63
2007-2008 Student Survey Graphs....67
Faculty Survey Comparison: 2007-2008 and 2011-2012....71
Student Survey Comparison: 2007-2008 and 2011-2012....75
CARBON EMISSIONS ANALYSIS....80
Introduction to Carbon Emission Conversion Factors....80
Introduction to Student Car Emissions....81
Student Weekly Car Travel Emissions....82
Student Emissions from Traveling Home....82
Introduction to Student Emissions from Public Transportation....83
Student Emissions from Trains and Buses....84
Student Emissions from Airplanes....85
Student Emissions Summary....86
Faculty Car Emissions....87
DISCUSSION AND RECOMMENDATIONS....90
Introduction to Recommendations....90
Educating the Campus Community....92
Improving Campus Governance....98
Reducing Student Vehicle Emissions....99
Campus Bus/Trolley Usage....100
Introduction to Reducing Transportation Emissions....105
Reducing Emissions via Biking....105

Reducing Emissions via Walking……108
The Impact of Weather on Biking and Walking……112
Introduction to Vehicles on Campus……114
Parking Sites and Regulations……115
Ride Share Programs……120
Car Share Programs……122
Union-Schenectady Relations: Connecting to Schenectady……124
CONCLUSION……129
REFERENCES……131
APPENDICES……USB Stick
APPENDIX A- World Resources Institute –$CO_2$ Inventory Report For Calendar Year 2008……USB Stick
APPENDIX B- 2011-2012 Faculty Survey……USB Stick
APPENDIX C- 2011-2012 Faculty Survey Data……USB Stick
APPENDIX D- 2011-2012 Student Survey……USB Stick
APPENDIX E- 2011-2012 Student Survey Data……USB Stick
APPENDIX F- 2007-2008 Faculty Survey Data……USB Stick
APPENDIX G- 2007-2008 Student Survey Data……USB Stick

## LIST OF FIGURES

Figure 1. 2011-2012 Faculty Distance Between Union College and Residence……..24/71
Figure 2. 2011-2012 Number of Days Per Week Driving Alone to Campus, % of Faculty……25/71
Figure 3. 2011-2012 Number of Days Per Week Carpooling Other Faculty, % of Faculty……25/73
Figure 4. 2011-2012 Number of Days Per Week Carpooling in Another Faculty's Car, % of Faculty.....26/73
Figure 5. 2011-2012 Number of Days Per Week Biking to Campus, % of Faculty……26/71
Figure 6. 2011-2012 Number of Days Per Week Utilizing Public Transportation, % of Faculty……27/72
Figure 7. 2011-2012 Number of Days Per Week Walking to Campus, % of Faculty……27/72
Figure 8. 2011-2012 Faculty Transportation Modes to Campus, % of Faculty……28/72
Figure 9. 2011-2012 Faculty Vehicle Use……28
Figure 10. 2011-2012 Faculty Cars Registered by Campus Safety……29
Figure 11. 2011-2012 Faculty Vehicle Model Year……29/73
Figure 12. 2011-2012 Faculty Vehicle Types……30
Figure 13. 2011-2012 Faculty Parking Locations……30
Figure 14. 2011-2012 Faculty Reasons for Parking Locations……31
Figure 15. 2011-2012 Reasons to be More Likely to Carpool or Use Public Transportation, % of Faculty……31
Figure 16. 2011-2012 Would Consider Carpooling or Public Transportation, % of Faculty……32/74
Figure 17. 2011-2012 Student Survey Participants by Class Year……43
Figure 18. 2011-2012 Student Total Car Ownership……43/75
Figure 19. 2011-2012 Percentage of Students with Cars……44
Figure 20. 2011-2012 Student Cars Registered with Campus Safety……44
Figure 21. 2011-2012 Student Car Parking Locations……45
Figure 22. 2011-2012 Reasons for Parking Location, % of Students……45
Figure 23. 2011-2012 Student Car Types……46
Figure 24. 2011-2012 Student Average Vehicle Model……46
Figure 25. 2011-2012 Student Average Miles Per Gallon……47
Figure 26. 2011-2012 Are Driving Habits Impacted by Gas Prices?, % of Students……47
Figure 27. 2011-2012 Student Gas Payment Source……48
Figure 28. 2011-2012 Student Average Miles Driven Weekly……48
Figure 29. 2011-2012 Student Average Trips Home Per Term via Own Car……49
Figure 30. 2011-2012 Student Average Trips Home Per Term via Carpool……49
Figure 31. 2011-2012 Student Average Trips Home Per Term via Personal/Family Car……50
Figure 32. 2011-2012 Student Average Trips Home Per Term via Airplane……50
Figure 33. 2011-2012 Student Average Trips Home Per Term via Train……51
Figure 34. 2011-2012 Student Average Trips Homer Per Term via Bus……51
Figure 35. 2011-2012 Student Average Distance Between Home & Union College, including Airplanes.....52/75
Figure 36. 2011-2012 Student Average Distance Between Home & Union College, excluding Airplanes....52/75
Figure 37. 2011-2012 Overall Student Transportation Modes Home……53/76
Figure 38. 2011-2012 Freshmen Transportation Modes Home……54
Figure 39. 2011-2012 Sophomores Transportation Modes Home……54
Figure 40. 2011-2012 Junior Transportation Modes Home……54

Figure 41. 2011-2012 Senior Transportation Modes Home……54
Figure 42. 2011-2012 Student Weekday Travel Destinations……55
Figure 43. 2011-2012 Student Weekend Travel Destinations……55
Figure 44. 2011-2012 Overall Student Travel Destinations……56
Figure 45. 2011-2012 Student Trolley Usage……56
Figure 46. 2011-2012 Student On-Campus Trolley Usage, On Average Per Week……57/76
Figure 47. 2011-2012 Student On-Campus Trolley Usage, Time of Day……57
Figure 48. 2011-2012 Student Off-Campus Trolley Usage, Time of Day……58
Figure 49. 2011-2012 Student On-Campus Trolley Usage, Destinations……58
Figure 50. 2011-2012 Student Off-Campus Trolley Usage, Destinations……59
Figure 51. 2011-2012 Carpooling Other Students in Your Car, % of Students……59/77
Figure 52. 2011-2012 Carpooling with Other Students in Their Car, % of Students……60/77
Figure 53. 2011-2012 Student Carpooling Destinations……60
Figure 54. 2011-2012 Reasons to be More Likely to Use the Trolley, % of Students……61
Figure 55. 2011-2012 Reasons to be More Likely to Carpool, % of Students……61
Figure 56. 2007-2008 Faculty Distance Between Union and Residence……63/71
Figure 57. 2007-2008 Number of Days Per Week Driving Alone to Campus, % Faculty……63/71
Figure 58. 2007-2008 Number of Days Per Week Carpooling, % Faculty……64/73
Figure 59. 2007-2008 Number of Days Per Week Biking, % Faculty……64/71
Figure 60. 2007-2008 Number of Days Per Week Utilizing Public Transportation, % Faculty……65/72
Figure 61. 2007-2008 Number of Days Per Week Walking, % of Faculty……65/72
Figure 62. 2007-2008 Faculty Transportation Modes to Campus……66/72
Figure 63. 2007-2008 Faculty Vehicle Model Year……66/73
Figure 64. 2007-2008 Would Consider Carpooling or Public Transportation, % of Faculty……67/74
Figure 65. 2007-2008 Student Transportation Modes Home……67/76
Figure 66. 2007-2008 Student Total Car Ownership……68/75
Figure 67. 2007-2008 Student Overall Average Trips Home Per Term……68
Figure 68. 2007-2008 Student Average Distance Between Home & Union College, including Airplane……69/75
Figure 69. 2007-2008 Student Average Distance Between Home & Union, excluding Airplane……69/75
Figure 70. 2007-2008 Student Campus Trolley Usage, On Average Per Week……70/76
Figure 71. 2007-2008 Student Carpooling Usage……70/77
Figure 72. Faculty MPG Comparison between 2007-2008 and 2011-2012……74
Figure 73. Student MPG Comparison between 2007-2008 and 2011-2012……78
Figure 74. Student Vehicle Model Year Comparison between 2007-2008 and 2011-2012……78
Figure 75. Student Average Weekly Miles Driven Comparison between 2007-2008 and 2011-2012……79
Figure 76. Student Overall Average Trips Home Per Term Comparison between 2007-2008 & 2011-2012……79
Figure 77. Union College Sustainability Website Screenshot……96
Figure 78. Union College Geology Department Sustainability Website Screenshot……97
Figure 79. U-Sustain Website Screenshot……97
Figure 80. Union College Trolley Tracker Website Screenshot……103
Figure 81. Walking Distance Map of the Union College Campus……109

Figure 82. Map of Northwestern University Walking Zone……110
Figure 83. Map of the intersection at Union Street and Nott Terrace……112
Figure 84. Engineering Drawings of Raised Crosswalks, Center Islands, and Bump Out Sidewalks……127
Figure 85. Engineering Drawings of Road Striping Designs for Bike Lanes……128

## LIST OF TABLES

Table 1. 2007 Emission Conversion Factors……80
Table 2. 2008 Emission Conversion Factors……81
Table 3. 2007-2008 Student Emissions by Mode of Transportation……86
Table 4. 2011-2012 Student Emissions by Mode of Transportation……87
Table 5. 2007-2008 Faculty Emissions From Personal Vehicle Use……89
Table 6. 2011-2012 Faculty Emissions From Personal Vehicle Use……89
Table 7. Impact of Weather on Bicycle Commuting on College Campuses……114
Table 8. Summary of Past Union College Parking and Comprehensive Campus Planning Studies……116
Table 9. Parking Summary of Six Northeastern Liberal Arts and Engineering Colleges and Universities……120

## LIST OF MAPS

Map 1. Map of New York State highlighting Schenectady County and Union College……11
Map 2. Buffer Map of the United States Indicating Faculty Distance Between Residence and Union……32
Map 3. Buffer Map of New York State Indicating Faculty Distance Between Residence and Union……33
Map 4. Buffer Map of the United States Indicating Student Distance Between Residence and Union……62
Map 5. Buffer Map of New York State Indicating Student Distance Between Residence and Union……62

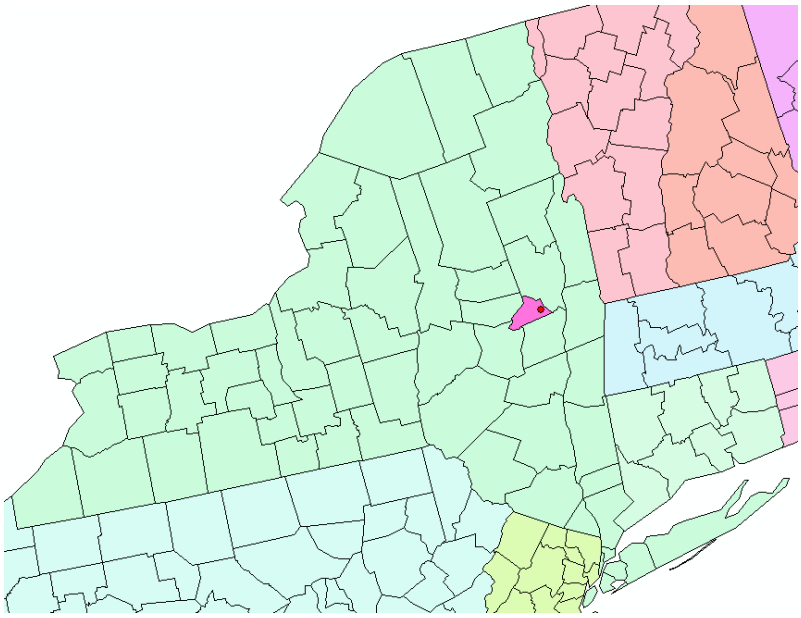
## INTRODUCTION

### *Background of Union College*

Union College is an independent liberal arts college located in Schenectady, New York in the Capital Region of Upstate New York. Established in 1795, it was the first college chartered by the Board of Regents of the State of New York. In 1812, the fourth President of Union College, Eliphalet Nott, purchased approximately 300 acres of land outside of the Downtown Schenectady and hired French architect and landscape planner Joseph Jacques Ramée to design the grounds on which Union College continues occupy (Somers 2003, 135). The Union College campus, which was the first comprehensively planned campus in the United States (Turner 1996, 190), currently occupies approximately 130 acres. Since the "Union College Campus Plan for the eighties" was developed, Union has been a walking campus as vehicular traffic and parking has been developed along the periphery of the campus (Somers 2003, 615).

As of the Fall 2011 academic term, there were 2,170 degree-seeking students (1,155 men; 1,015 women), all undergraduates, enrolled in the College (Union College Institutional Studies 2011). Students from throughout the United States and abroad are enrolled at Union College; 868 students are from New York State (40%), 801 students are from the New England States (36.9%), 234 students are from the Mid-Atlantic States, excluding New York State (10.8%), 161 students are from the Central, South, West, and U.S. Territories combined (7.3%), and 105 International students (4.8%) (Union College Institutional Studies 2011). Union College is a residential college that offers various styles of student housing arrangements. 87% of students live in college-owned, operated, or

affiliated housing while 13% of students live off campus or commute (Union College Institutional Studies 2011). During the same academic term, the College employed 202 full-time faculty members and 35 part-time faculty members.



Map 1: This is a map of the location of New York State (green) in the Northeastern region of the United States. Union College is situated in Schenectady County, New York, and the campus' exact location in the City of Schenectady is indicated by a red dot.

### *Background of Schenectady, New York*

Schenectady, New York, the city in which Union College operates in, is located in the Capital Region of New York State, approximately 18 miles northwest of the State Capital, Albany. Throughout its history, Schenectady's location has been an asset in terms of economic development and transportation. Since the Capital Region is located at the intersection of the Hudson and Mohawk Rivers, Albany and Schenectady have been a natural gateway to the north and west. Besides the natural water routes connecting Schenectady to the rest of the state, the turnpike system was one of the first overland

transportation systems in New York (Eisenstadt et al. 2005, 1588). The opening of the Erie Canal in 1825, which, through Schenectady, is the present-day Erie Boulevard, improved transportation between Albany and the Great Lakes (Eisenstadt et al. 2005, 46). Six years later, transportation to Schenectady further improved with the operation of the Mohawk and Hudson Railroad (Eisenstadt et al. 2005, 46).

During the twentieth century, Schenectady was known as "The City that Lights and Hauls the world" because the innovation and technology that was being developed in the headquarters of General Electric and the American Locomotive Company (ALCO) (Eisenstadt et al. 2005, 1363). On July 11, 1946, the State of New York accommodated and further increased the use of the personal automobile and large tractor-trailers when construction crews began building the New York State Thruway (Eisenstadt et al. 2005, 1101). Today, the 570-mile New York State Thruway is a mode of travel between various regions and states, making it an integral component of the state's modern-day transportation network. Additionally, as early as 1913, inter-city bus lines were established with connections between various urban areas, including Schenectady and Albany, in New York State (Eisenstadt et al. 2005, 779).

### *Current Transportation in the Capital Region*

Today, Schenectady continues to be connected to the state transportation network that links the geographically spread out regions of New York State. As a result, students and faculty members traveling to Union College have various modes of transportation to the campus at their disposal. The campus is accessible via personal automobile by utilizing the Interstate Highway routes I-87, I-90, and I-890. The campus is also accessible via public

transit that stops regularly in Schenectady by utilizing the Amtrak train service (the Schenectady stations services five different lines), the Greyhound Bus Service, and the Adirondack Trailways bus service (Amtrak 2012) (Greyhound 2012) (Trailways 2012). Union College is also accessible internationally via the Albany International Airport, located 9 miles southeast of the campus. The Union College Campus Safety Department operates an on and off-campus bus service, known as the Union College Trolley. The on-campus trolley system makes a loop around the perimeter of the college grounds and the off-campus trolley system travels between the College and the Crossgates Mall in Albany, New York, the Mohawk Commons shopping center in Niskayuna, New York, and Wal-Mart in Glenville, New York (Union College Campus Safety Department 2012).

### *Background of the Union College Climate Plan*

Union College is committed to sustainability and improving the environment. By signing the American College and University Presidents Climate Commitment in 2007, Union College President Stephen C. Ainlay made sustainability and the reduction of climate emissions a significant goal for the college (Union College News 2007). As a result of this commitment, Union College agreed to take two steps with the eventual goal of climate neutrality. The first step mandated the creation of a long-term comprehensive climate plan to "achieve climate neutrality as soon as possible." In preparation for the development of a climate plan, Union College needed to create an inventory of campus greenhouse gasses, including emissions from electricity, heating, commuting, and air travel (American College & University Presidents' Climate Commitment 2012). The second step required the College to employ two or more actions to reduce greenhouse gases while the long-term plan was

being developed. In order to reach this requirement, Union College began purchasing 15% of its electricity resources from wind power and agreed to use sustainability practices in it new buildings (Union College News 2007).

In June 2010, Union College produced a Climate Action Plan that was designed to be a guide to reduce carbon emissions on campus. The plan established milestones in order to reach carbon neutrality by the year 2060 (Union College Climate Plan 2010). In terms of transportation by Union College students and faculty members, the plan has two goals (Union College Climate Plan 2010, 8):

1. To reduce miles driven by employees and students
2. To encourage each employee to drive alone to campus one day less per week, and to end student driving between campus points.

The plan also indicated that there are three campus projects and initiatives (Union College Climate Plan 2010, 8):

1. Establish three preferred parking spaces for carpools
2. Bikeshare program
3. Trolley transports students to points on campus and off.

Future projects indicated by the campus action plan included (Union College Climate Plan 2010, 8):

1. Expand number of spots for preferred parking spaces as demand requires
2. Trolley Tracking Program to provide real-time, web-based location of trolley to increase usage
3. Development of a web-based carpool finder system to increase carpooling by employees and students.

### *Reasons for a Transportation Study at Union College*

The Union College community is responsible for its impact on the environment. This study was conducted to determine the impact of students and faculty members on the

environment through travel emissions. As a signatory of the American College and University Presidents' Climate Commitment, Union College has committed to achieve climate neutrality "as soon as possible" (American College & University Presidents' Climate Commitment 2012).

The first official statement by administrators in higher education was the Talloires Declaration. The plan, which was established in 1992, consisted of a ten-point plan to take actions to improve environmental conditions. The declaration was important because it recognized the role colleges and universities have in terms of the environment. The declaration states, "Universities have a major role in the education, research, policy formation, and information exchange necessary to make [the goals of reversing the negative environmental trends] possible" (Association of University Leaders for a Sustainable Future 2008). As a result, it is important to study the travel behaviors of students and faculty members because transportation has a significant impact on the environment. Some researchers state that educational institutions are particularly important in the future of the environment, "The daily movement of people back and forth to campus in automobiles burning fossil fuels is one of the largest impacts a typical educational institution imposes on the life support systems of the planet" (Toor and Spencer 2004, 1). In addition to negative environmental consequences as a result of vehicle emissions, there are also serious health implications. The EPA estimated that air pollution, as a result of vehicle emissions, caused between 20,000 and 46,000 cases of chronic respiratory illness (United States Environmental Protection Agency 2001).

Transportation is an important aspect of global carbon emissions because society, and colleges in particular, rely on it for everyday activities. In the United States, personal vehicles are the dominant forms of transportation; between 1980 and 1997, total vehicle miles of travel increased by 63%, or at an average rate of 3% per year (greater than the yearly population growth) (U.S. Energy Information Administration 2012). In actual total annual vehicle miles, travel increased from 1 trillion miles in 1970 to 2.6 trillion miles in 1998 (Toor and Havlick 2004, 1). As a result of the large amount of transportation occurring, approximately 2/3 of all petroleum consumed in the United States is used for transportation (U.S. Energy Information Administration (2012). Carbon dioxide emissions are a consequence of vehicle miles traveled the consumption of petroleum; transportation accounts for 32 percent of U.S. carbon dioxide emissions" (Toor and Spencer 2004, 2). Therefore, in order to reduce carbon dioxide emissions, both total vehicle miles traveled and the consumption of petroleum need to decrease.

### *Goals of the Current Transportation Survey*

This study analyzes the transportation behaviors of Union College students and faculty members as well as various factors that impact these behaviors. While a similar study was conducted by Union College students as class work in the 2008 Introduction to Environmental Science class, the purpose of the current study is to determine if transportation emissions and travel behavior has changed over the course of the past four years. This report aims to calculate the average annual $CO_2$ emissions, by transportation mode, as a result of weekly travel and trips between permanent residences and the Union College campus. The study will compare transportation emissions and transportation mode

utilization from the result of the 2007-2008 study. Through an analysis of survey responses, this study will also report on where, when, and why students travel. Further, using the data gathered, this study will provide various policy recommendations to assist Union College in attaining a carbon-neutral campus environment.

## SURVEY IMPLEMENTATION AND RESULTS

### *2011-2012 Faculty Survey and Results*

The faculty survey was conducted via an online survey using the Google Documents survey feature. The survey consisted of a maximum of 21 questions, though answers were not required by all questions since some may not have been applicable to all faculty respondents (Appendix B). Engineering Professor Ashraf Ghaly distributed the survey through the Union College Faculty listserv and was receiving responses from October 19, 2011 to November 23, 2011. There were 168 responses by Union College faculty members over this time period, accounting for a 70.89% response rate among all faculty members.

1. Approximately, how many miles (round trip) do you travel to and from campus each day?

This question was included in the survey to determine how many miles faculty members travel between Union College and their homes each day. In order to calculate the total carbon emissions from faculty travel, it was necessary to determine their mileage traveled each day. Faculty members were able to enter their roundtrip mileage through a fill-in text box.

2. On average, how many days per week do you drive alone to get to campus?

This question was designed to determine personal vehicle usage among faculty members to get to campus. Faculty members responded to this question by selecting one of the following answers by selecting the corresponding radio button: Never, 1, 2, 3, 4, 5, or other (with a text box).

3. On average, how many days per week do you carpool using your car to get to campus?

This question was designed to determine carpooling usage among faculty members who own their own vehicles to get to campus. Faculty members responded to this question by selecting one of the following answers by selecting the corresponding radio button: Never, 1, 2, 3, 4, 5, or other (with a text box).

4. On average, how many days per week do you carpool with a coworker in his/her car to get to campus?

This question was designed to determine carpooling usage among faculty members who do not own a personal vehicle to get to campus. Faculty members responded to this question by selecting one of the following answers by selecting the corresponding radio button: Never, 1, 2, 3, 4, 5, or other (with a text box).

5. If applicable, how many days per week (on average) do you ride your bicycle to get to campus?

This question was designed to determine bicycle usage among faculty members to get to campus. Faculty members responded to this question by selecting one of the following answers by selecting the corresponding radio button: Never, 1, 2, 3, 4, 5, or other (with a text box).

6. On average, how many days per week do you take public transportation to get to campus?

This question was designed to determine public transportation usage among faculty members to get to campus. Faculty members responded to this question by selecting one of

the following answers by selecting the corresponding radio button: Never, 1, 2, 3, 4, 5, or other (with a text box).

7. On average, how many days per week do you walk to get to campus?

This question was designed to determine walking among faculty members to get to campus. Faculty members responded to this question by selecting one of the following answers by selecting the corresponding radio button: Never, 1, 2, 3, 4, 5, or other (with a text box).

8. Please specify other modes of transportation you use to get to campus

This question was included to identify other modes of transportation faculty members utilized to get to campus. Faculty members were able to respond to this question by filling in a textbox.

9. How many days per week do you use the mode of transportation stated in the above question?

This question was designed as a follow-up prompt to question number 8 to determine how often the other modes of transportation were utilized. Faculty members responded to this question by selecting one of the following answers by selecting the corresponding radio button: Never, 1, 2, 3, 4, 5, or other (with a text box).

10. If you travel by car, is your car registered with campus safety?

This question was attempting to determine how many faculty members registered their vehicles with campus safety. This is an important indicator in understanding whether faculty members are willing to pay an annual fee to park on-campus. Faculty members who

owned cars on campus responded to the question by selecting either a “Yes” or “No” radio button.

11. If you travel by car, where do you park your car? (Check all that apply)

This question was included to determine where faculty members who owned a car on-campus parked their car. Understanding the parking behaviors of faculty members is important for analyzing on-campus parking as well as the impact of Union College on the surrounding neighborhoods. The question was answerable by faculty members who owned a car on-campus by clicking on a checkbox stating “Union on-campus parking lot” or “Off-campus street parking.” Faculty members were able to check as many as applied to their behavior.

12. Your decision of where you park your car depends on:

Determining the reasoning behind faculty member parking behavior is important in understanding what the faculty car owners value while picking a parking location. This question was designed as a follow up question to the previous question to better comprehend its results. Faculty members who owned a car on-campus were able to answer the question by clicking on as many checkboxes that applied to them. The available answer choices were: Convenience, availability, walking distance, weather, safety, and other (with a text box).

13. If you travel by car, what type of car is it?

This question was included to provide information regarding the class of cars faculty members brought to campus. An analysis of the vehicle fleet can be determined by

understanding what types are being operated. Faculty members who drove to campus responded to the question by selecting a radio button for either: Small, mid-size, minivan, SUV, pick-up truck, or other (with a text box).

14. If you travel by car, what model year is it?

Faculty members who drove a car to campus were asked to provide their vehicle model year to further analyze the faculty vehicle fleet. Through this information, the study was able to determine the average model year. The question was answerable through a fill-in text box.

15. If you travel by car, how many miles do you get per gallon?

This question was designed to determine the average miles per gallon faculty members' vehicles are able to obtain. The individual miles per gallon obtained by each vehicle was used in determining the quantity of carbon dioxide emitted. Faculty members who drove a car to campus were able to respond to the question through a fill-in text box.

16. If applicable, how many other people ride in your carpool when using your car?

This question was included to understand the popularity of carpooling among faculty members. The results to this question would help determine how many faculty members are commuting to campus via a personal vehicle with a carpool. Faculty members were able to respond to this question by selecting a radio button indicating, 1, 2, 3, 4, 5, or other (with a text box).

17. If applicable, how many people other than yourself ride in your carpool when using a coworker's car?

This question was designed to determine the popularity of carpooling by faculty members in colleague's personal vehicle. The results to this question would help determine how many people rely on someone else to get to campus. Faculty members were able to respond to this question by selecting a radio button indicating, 1, 2, 3, 4, 5, or other (with a text box).

18. Would you consider carpooling or using public transportation to commute to campus in order to reduce carbon emissions? If not, please explain in the box below.

This question was designed to determine the willingness of faculty members to carpool or use public transportation to commute to campus. The results of this question can help the College understand how many people would be willing to use alternative methods of transportation and how to proceed with investments in this area in the future. Faculty members were able to respond by checkbox indicating "Yes," "No," or "Other."

19. What would make you more likely to carpool or use public transportation?

This question was included to understand why faculty members would be more likely to carpool or use public transportation in the future. The answers to this question would help in recommending improvements to the current personal transportation situation at Union College. All faculty members were able to respond to this question by clicking on as many checkboxes that applied to them. The available answers were: Monetary or in-kind incentives by the college, An earned credit or a thank you reward (meal, coffee, drink, etc.), A service provided by the college to connect carpool matches, and other (with a text box).

20. Are your driving habits impacted by gas prices?

This question was included in the survey to examine whether gas prices impacted car travel decisions. Faculty members who owned a car on-campus were able to respond to the question by selecting either a "Yes" or "No" radio button.

21. Comments, Questions, Concerns

The final question of the survey was an open-ended textbox that provided faculty members with the ability to share their comments, questions, and concerns about the survey, transportation options at Union College, or the overall study.

***2011-2012 Faculty Survey Graphs***
(Appendix C)

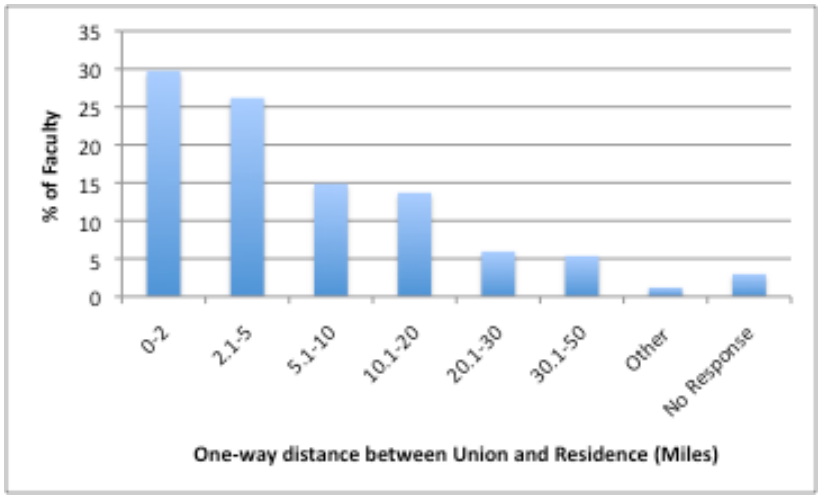



Figure 1: This figure shows the one-way distance between Union College and the homes of faculty members, by percentage. Most faculty members stated that they live within 0 to 2 miles (30%). Many faculty members also stated that they live between 2.1 and 5 miles away from Union College (26%). A lesser number of faculty members indicated that they live between 5.1 and 10 miles away (15%) and 10.1 and 20 miles away (14%). A low percentage of faculty members indicated that they live beyond 20 miles away from Union College; 6% lived between 20.1 and 30 miles away and 5% lived between 30.1 and 50 miles away. 1% stated "other," including a faculty member who lives 180 miles from Union College.

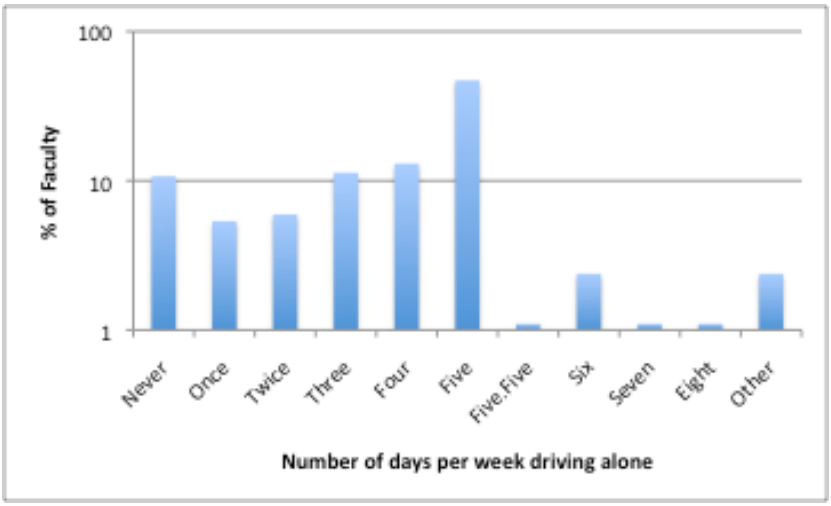



Figure 2: This figure indicates the average number of days per week faculty members drive alone in their personal vehicle, on a logarithmic scale. A large number of faculty indicated that they drive alone all five days during the week (47%). The second highest answer recorded by faculty was four days per week (13%). Conversely, 11% of faculty stated that they never drive alone to get to campus.

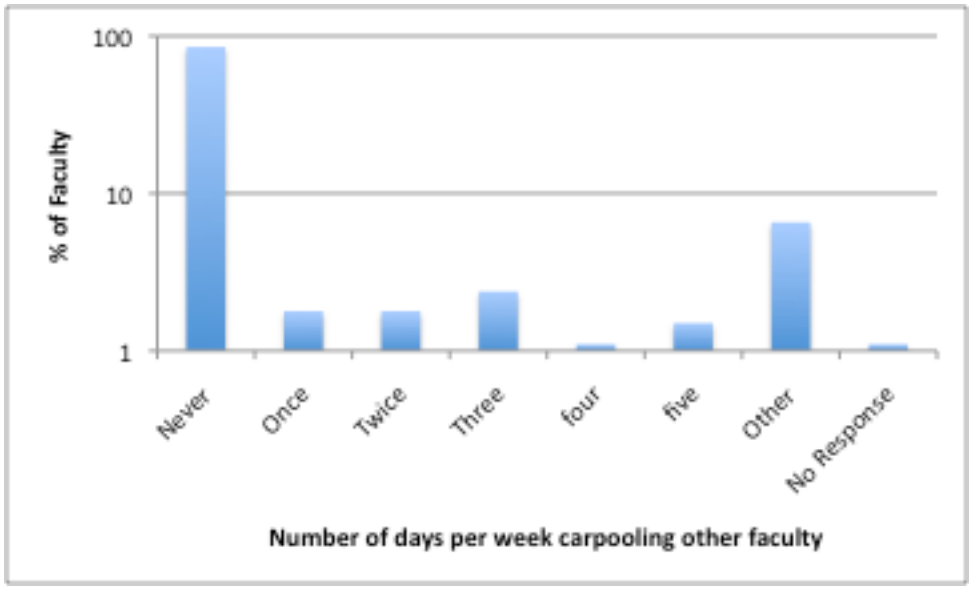



Figure 3: This figure shows how many days per week, on average, do faculty members carpool using their vehicles to get to campus, on a logarithmic scale. The majority of faculty members stated that they never use their vehicle to carpool other faculty members to campus (85%). Approximately 8% of faculty members indicated that they carpool using their car between once and five times a week. Other (6.5%) responses included "once or twice a month" and "occasionally."

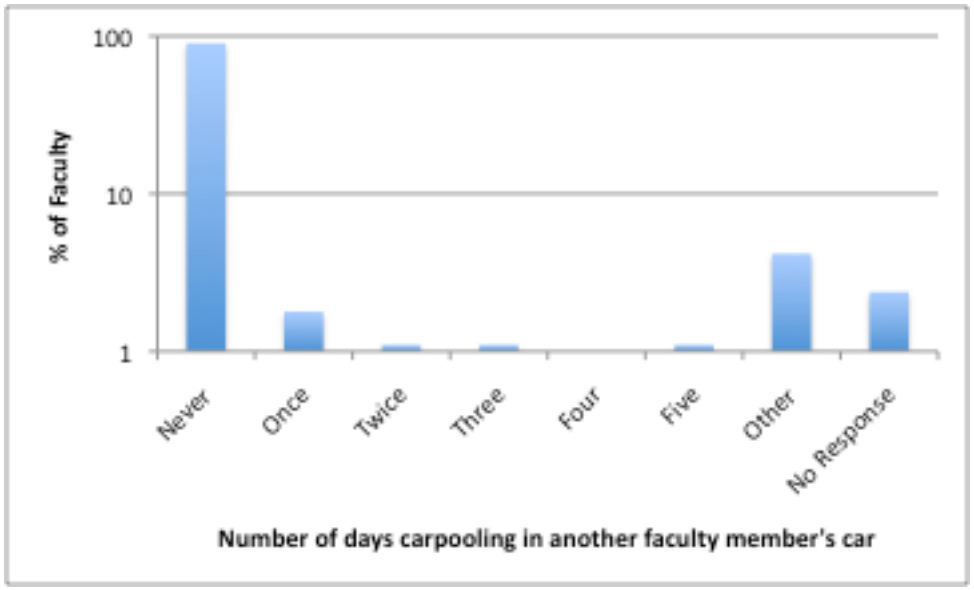



Figure 4: This figure shows how many days per week, on average, do faculty members carpool in another faculty member's vehicle to get to campus on a logarithmic scale. The majority of faculty members stated that they never carpool with another faculty members in their vehicle to get to campus (90%). Approximately 4% of faculty members indicated that they carpool in another car between once and five times a week. Other (4%) responses included "with family" and "occasionally."

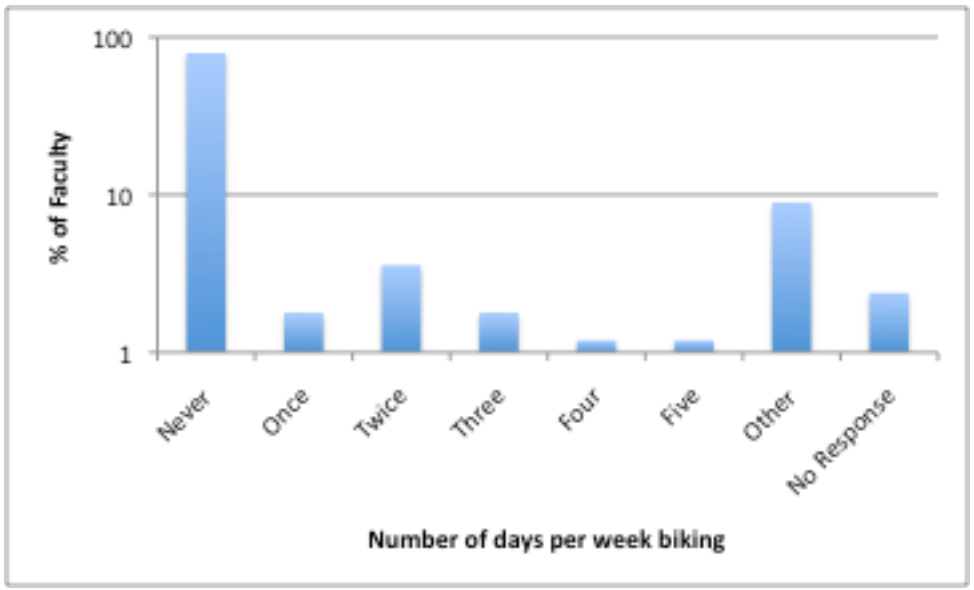



Figure 5: This figure illustrates how many days per week, on average, do faculty members bike to get to campus on a logarithmic scale. The majority of faculty members indicated that they never bike to campus (80%). Approximately 9.5% of faculty members said they biked to campus between once and five times a week. Other (9%) responses included "on occasion," "weather permitting," and "in the summer."

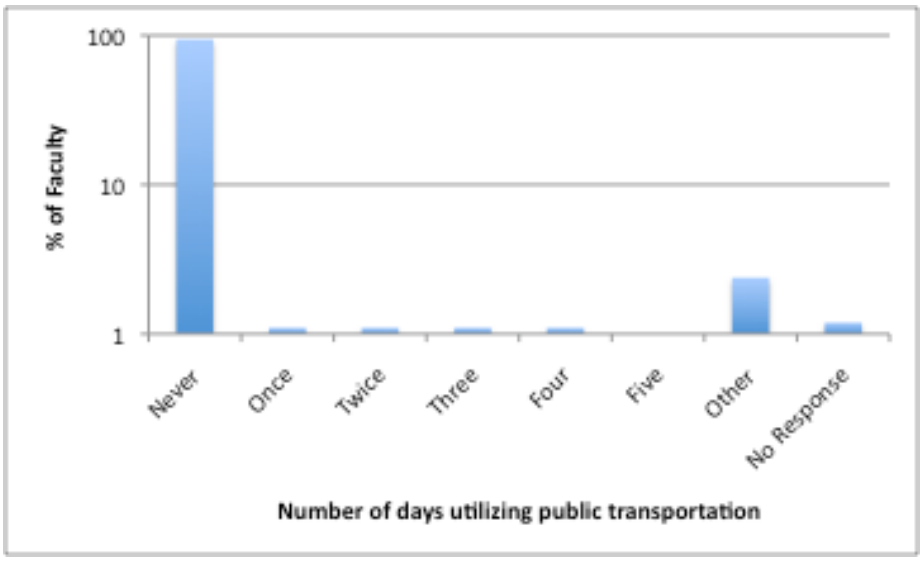



Figure 6: This figure shows how many days per week, on average, do faculty members utilize public transportation to get to campus on a logarithmic scale. The majority of faculty members stated that they never use public transportation to get to campus (94%). Approximately 2.4% of faculty members indicated that they use public transportation to get to campus between once and five times a week. Other (2.4%) responses included "often in winter," "occasionally and in bad weather," "a couple times a year," and, as a bike user stated, "on days of heavy snow and rain."

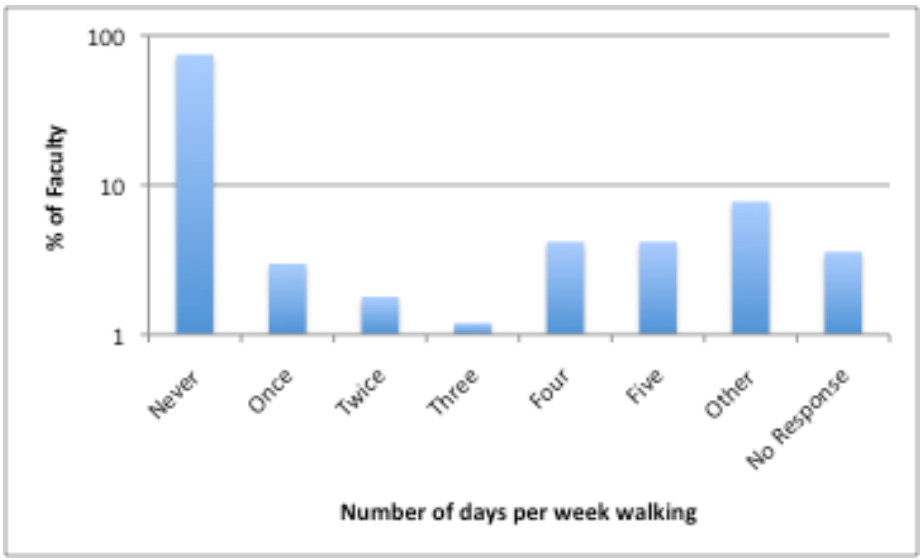



Figure 7: This figure shows how many days per week, on average, do faculty members walk to get to campus on a logarithmic scale. The majority of faculty members indicated that they never walk to campus (74%). A greater percentage of faculty stated that they walk four (4.2%) and five (4.2%) days per week to get to campus than those who indicated that they either walk once (2.9%), twice, (1.7%), or three (1.2%) times a week. Other (8%) responses included "always, I live just a few blocks away from campus," "on occasion," and "during the winter when there was a lot of new snow."

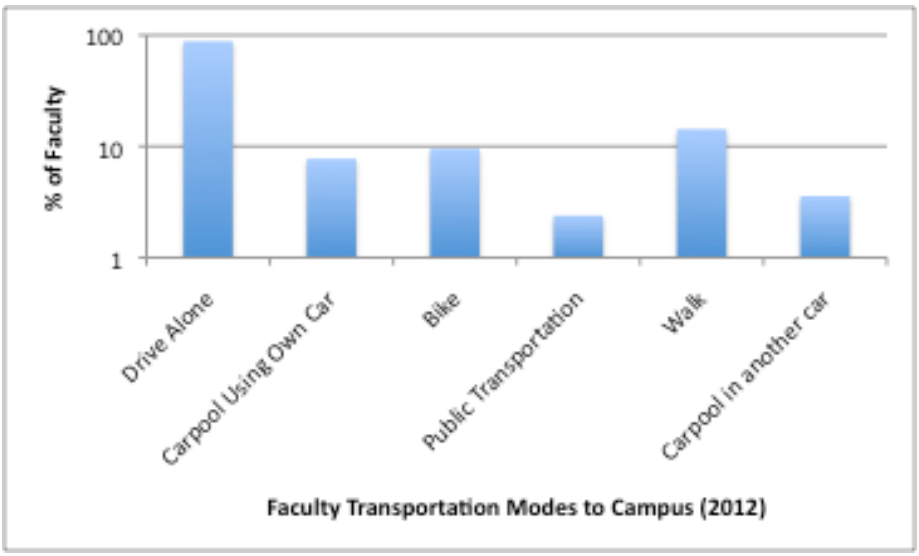



Figure 8: This figure indicates how faculty members commute to the Union College campus, by percentage on a logarithmic scale. The majority of faculty members stated that they drive alone to campus (88%), with walking (14%) and biking (9.5%) a distant second and third choice, respectively. Carpooling other faculty members in a personal vehicle (8%) and carpooling in another faculty member's vehicle (4%) were both unpopular choices. Public transportation was the least utilized mode of transportation (2.3%).

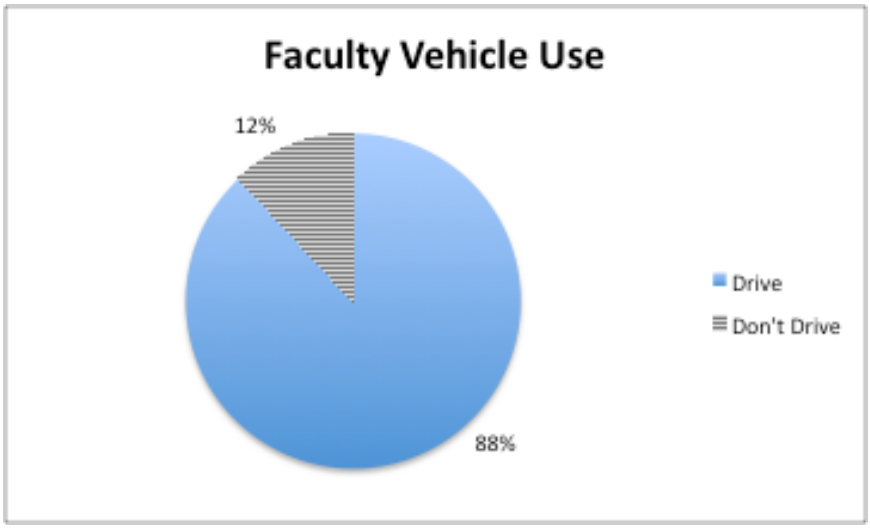



Figure 9: This figure indicates the percentage of vehicle use to commute to the Union College campus among faculty members. The striped lines are the percentage of faculty members who do not drive to campus and the solid color indicates the percentage of faculty members who do drive to campus. The survey concluded that more Union College faculty members do drive to campus (88%) than do not drive to campus (12%).

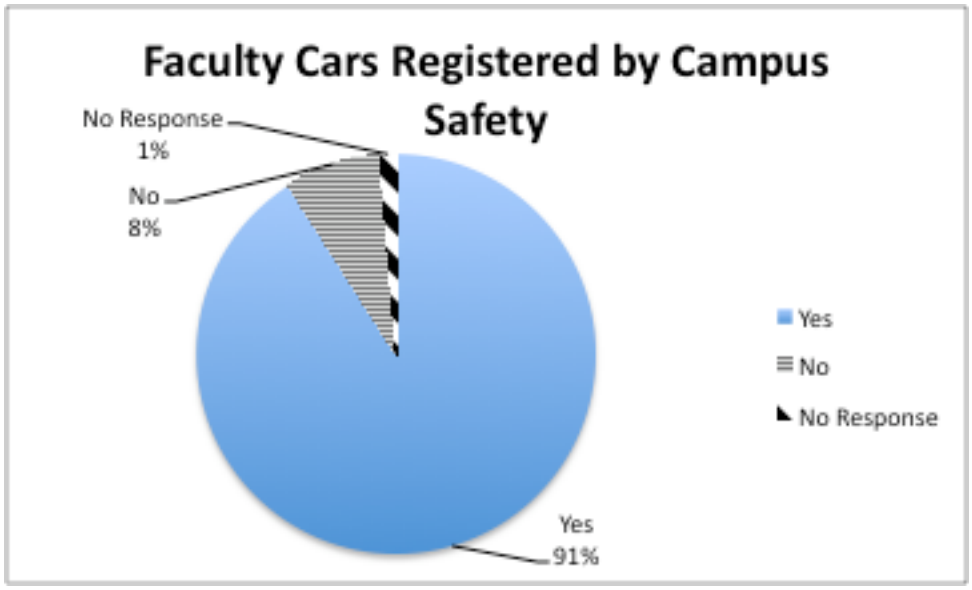



Figure 10: This figure shows the percentage of faculty members that drive to the Union College campus who registered their vehicle with the Union College Campus Safety Department in 2011. The majority of faculty members who drove to campus registered their vehicles with Campus Safety (91%) while a small amount of faculty members stated that they had not registered their vehicle with Campus Safety (8%).

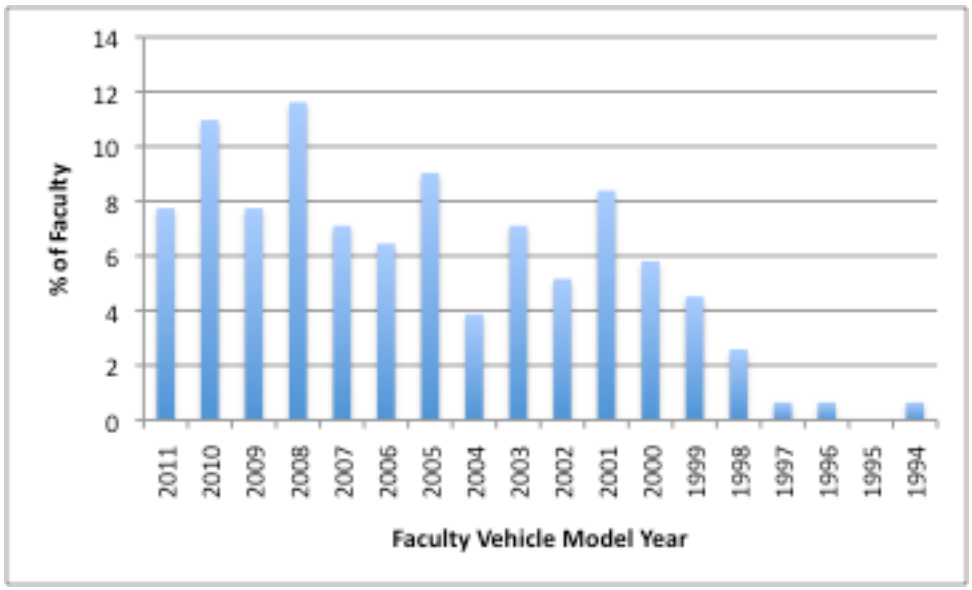



Figure 11: The figure above illustrates the age of the vehicle fleet of faculty members who drive to campus. The greatest percentage of faculty own vehicles produced in 2008 (11.6%) and 2010 (11%). The overall average model year for faculty vehicles is 2005.37, which made the average vehicle approximately six years old. 60.6% of vehicles owned were about the fleet average while 39.4% of the vehicles owned were below the fleet average.

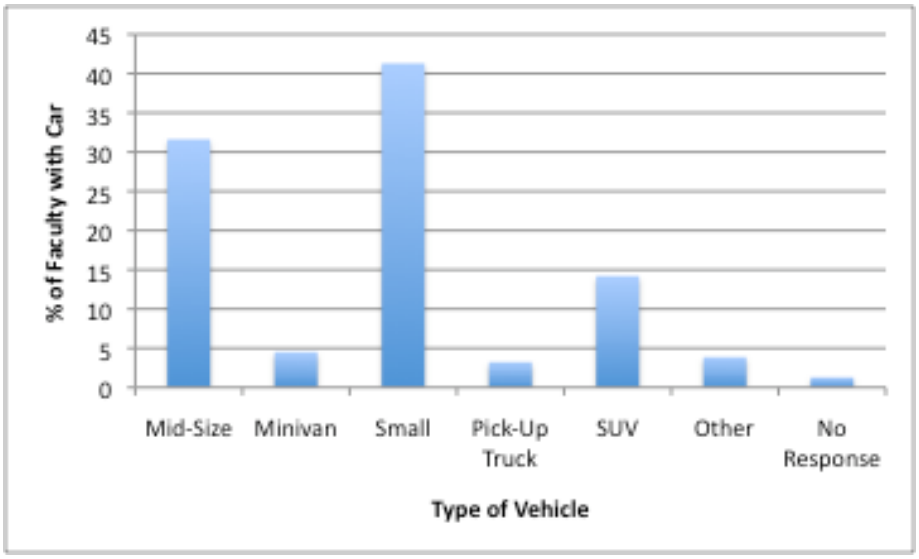



Figure 12: This figure shows the types of vehicles faculty members used to commute to campus. For the most part, faculty members indicated that they either owned a small (41%), mid-size (31%), or SUV (14%). Pick-up trucks (3%) and minivans (4.5%) were lesser-owned vehicles. 4% of faculty members stated that they drove a vehicle not listed in the survey. Faculty members who responded with "other," for the most part, described their vehicles as wagons and station wagons. The results indicate that more faculty members drive smaller vehicles than larger SUVs, minivans, and pick-up trucks.

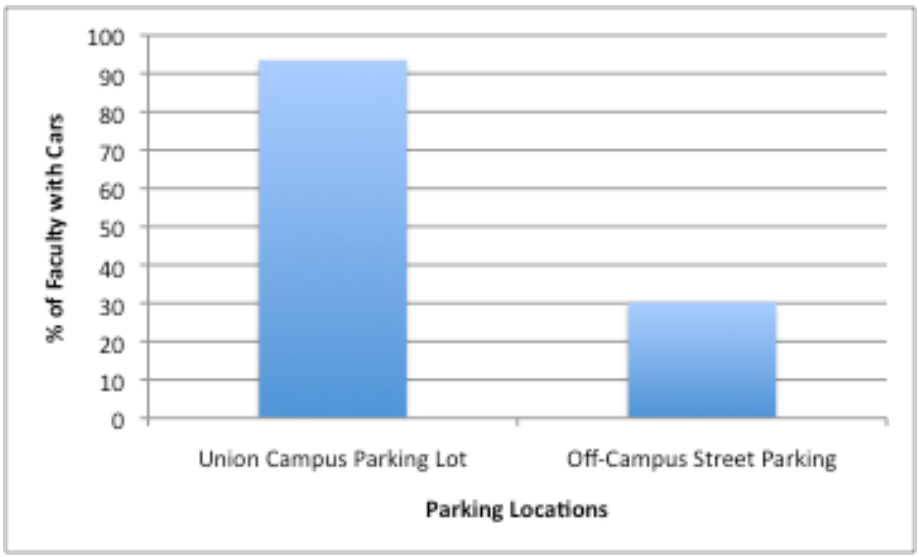



Figure 13: This figure indicates where faculty members who drive a car to the Union College campus park their vehicles, by percentage. 94% of faculty members reported that they se Union College on-campus parking lots while 30% stating they parked their cars on streets located off-campus. The percentages do not add up to 100% because faculty members were permitted to select as many answers as applicable. This shows that the majority of faculty members are choosing to park their vehicles on-campus instead of parking the surrounding neighborhood.


Figure 14: This figure illustrates the reasons faculty members who commute to campus by car park where they do. Parking convenience and availability were the top reasons at 58% and 79%, respectively. Walking distance (40%) was also important to many faculty members. Faculty members were less concerned with weather (24%) and safety (19%) while deciding where to park. The percentages do not add up to 100% because students were permitted to select as many answers as applicable.

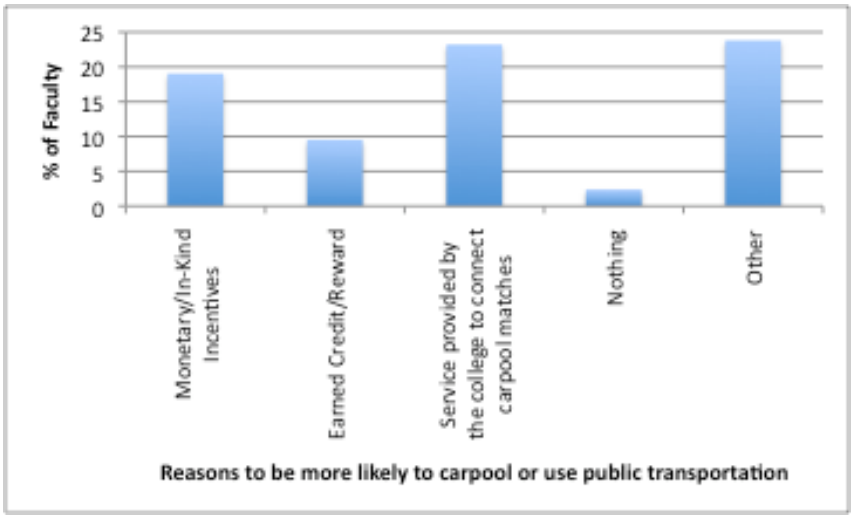



Figure 15: This figure shows the reasons faculty members would be more likely to carpool or use public transportation in the future, by percentage. The most chosen answer, "Other" (24%) offered various alternative reasons to increase carpooling or public transportation usage. Faculty members stated that they would be more likely to use these methods if the availability of public transit, specifically buses, was improved, if there were better parking spaces for carpools, if both were more convenient to their homes, and if there was more schedule compatibility between coworkers. A service provided by the college to connect carpool matches (23%) and monetary/in-kind incentives (19%) were the most common choices among faculty. An earned credit/reward (10%), however was a less popular incentive. Additionally, 2.3% of faculty stated nothing would make them use these modes.

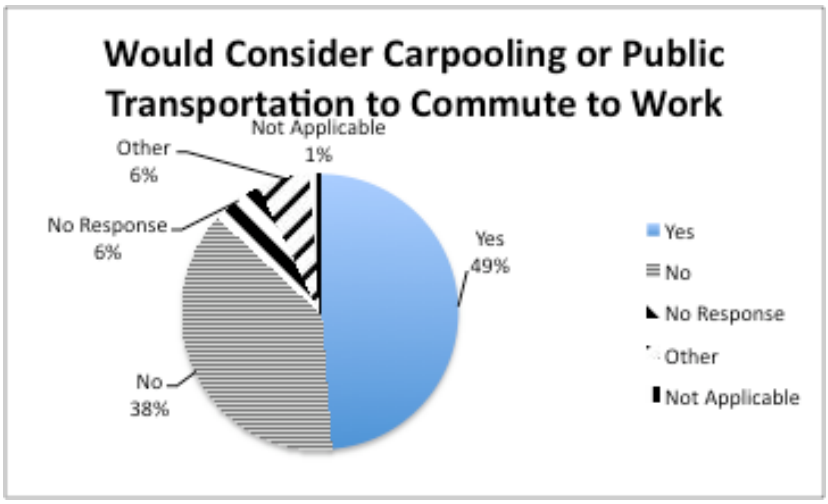
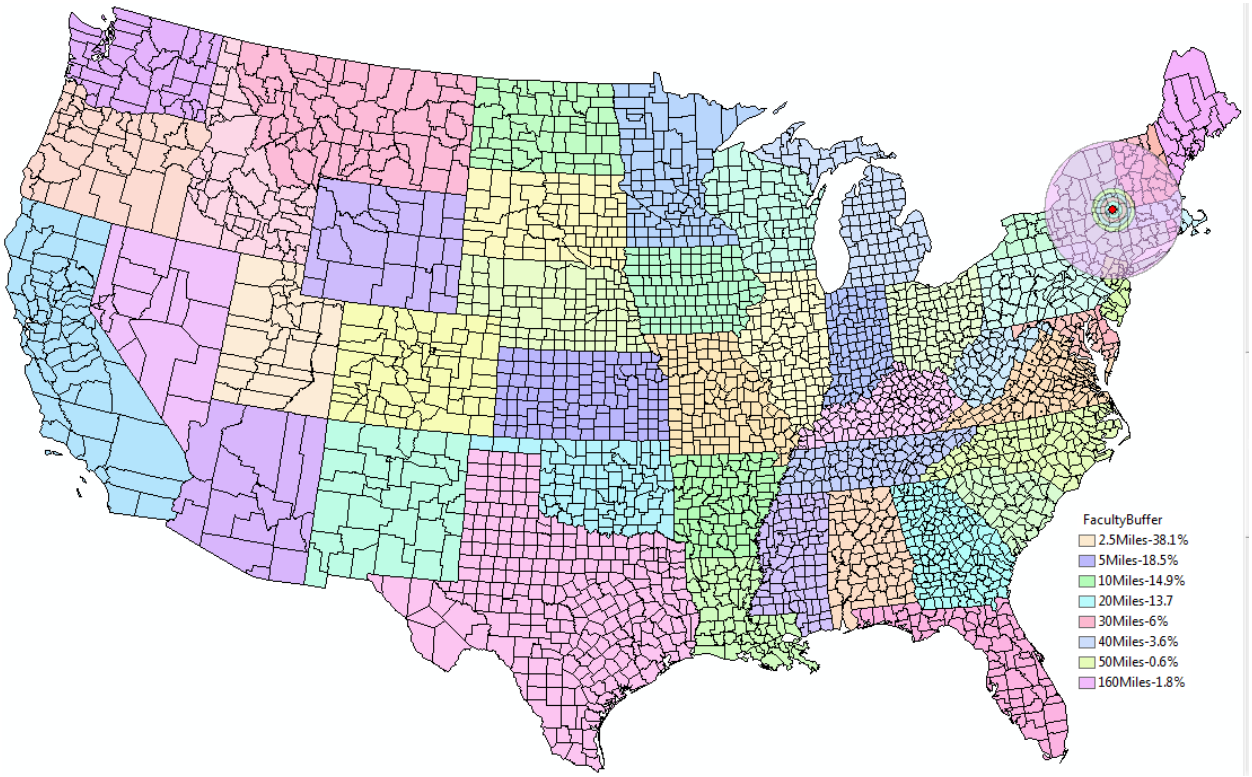
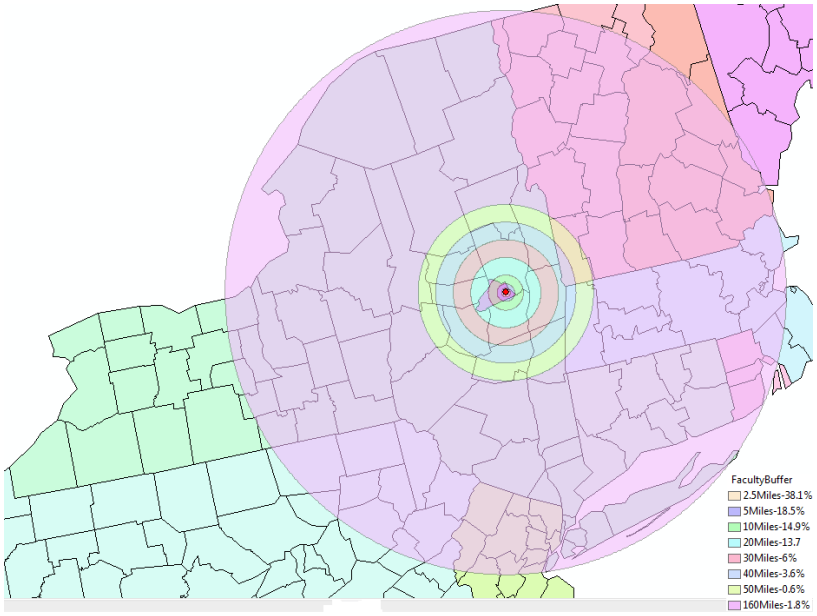



Figure 16: This figure describes whether faculty members would consider carpooling or utilizing public transportation to commute to work. Almost half of faculty stated that they would consider using these modes of commuting to work (49%) while 38% stated that they would not consider carpooling or using public transportation. The 6% of faculty members who indicated "other," responses included "public transit takes more time," "I'm more interested in walking," and "no options where I live."




Map 2: This is a buffer map of the United States using GIS to indicate the distance, in miles, that Union College faculty members travel between their residences and the Union College. Most faculty members live within 2.5 miles of the Union College campus (38.1%).



Map 3: This is a buffer map of New York and its neighboring states using GIS to indicate the distance, in miles, that Union College faculty members travel between their residences and the Union College campus. Most faculty members live within 2.5 miles of the Union College campus (38.1%).

### *2011-2012 Student Survey Methods and Questions*

The student survey was conducted via an online survey using the Google Documents survey feature. The survey consisted of a maximum of 29 questions, depending on if they owned a vehicle on campus and if they ever used the Union College trolley. The survey was distributed by campus email through the Dean of Students office and was receiving responses from October 31, 2011 to November 20, 2011 (Appendix D). There were 338 responses by students over this time period, accounting for 15.58% of the entire student body.

1. All of my questions have been answered and I wish to participate in this research study.

The Union College Human Subjects Review Committee required this question. The committee indicated that the survey was required to obtain informed consent. All

respondents who completed the survey clicked a radio button indicating that they "agreed" to the statement of informed consent prior to taking part in the survey.

2. What is your class year?

This question was included to understand the transportation behaviors by class year. The question was answerable by selecting one of four radio buttons. All students responding to the survey were asked to indicate their class year.

3. Do you own a car on campus?

The third question in the survey was designed to determine the percentage of students who owned a car on-campus. The question was answerable by selecting either a "Yes" or "No" radio button. If the student selected "Yes," he/she was automatically directed to questions four through twelve, all of which were based on vehicle ownership.

4. Is your car registered with campus safety?

The survey was attempting to determine how many students registered their vehicles with campus safety. This is an important indicator in understanding whether students are willing to pay an annual fee to park on-campus. Students who owned cars on campus responded to the question by selecting either a "Yes" or "No" radio button.

5. Where do you park your car?

This question was included to determine where students who owned a car on-campus parked their car. Understanding the parking behaviors of students is important for analyzing on-campus parking as well as the impact of the Union College student population on the surrounding neighborhoods. The question was answerable by students who owned

a car on-campus by clicking on a checkbox stating “Union on-campus parking lot” or “Off-campus street parking.” Students were able to check as many as applied to their behavior.

6. Your decision of where you park your car depends on:

Determining the reasoning behind student parking behavior is important in understanding what the student car owners value while picking a parking location. This question was designed as a follow up question to the previous question to better comprehend its results. Students who owned a car on-campus were able to answer the question by clicking on as many checkboxes that applied to them. The available answer choices were: Convenience, availability, walking distance, weather, safety, and other (with a text box).

7. What type of car do you own?

This question was included to provide information regarding the class of cars students brought to campus. An analysis of the vehicle fleet can be determined by understanding what types are being operated. Students who owned a car on-campus responded to the question by selecting a radio button for either: Compact, midsize, large, minivan, SUV, pick-up truck, or other (with a text box).

8. What model year is your car?

Students who owned a car on-campus were asked to provide their vehicle model year to further analyze the student vehicle fleet. Through this information, the study was able to determine the average model year. The question was answerable through a fill-in text box.

9. How many miles do you get per gallon?

This question was designed to determine the average miles per gallon students' vehicles are able to obtain. The individual miles per gallon obtained by each vehicle was used in determining the quantity of carbon dioxide emitted. Students who owned a car on-campus were able to respond to the question through a fill-in text box.

10. Are your driving habits impacted by gas prices?

This question was included in the survey to examine whether gas prices impacted car travel decisions. Students who owned a car on-campus were able to respond to the question by selecting either a "Yes" or "No" radio button.

11. Who is paying for gas?

Understanding the economics behind travel decision-making is important in analyzing the campus community's vehicle usage behavior. This question was designed to be a follow-up to the previous question to learn whether or not students are impacted by prices because they using their personal funds or guardian's funds. Students who owned a car on-campus responded to this question by clicking on as many checkboxes that applied to them. The available choices were: Credit Card bill that goes to guardian(s) and personal funds.

12. How many miles to you drive in a week (including weekends, but not including trips home).

This question was included in the survey to find out how many miles a week students drove off-campus. Students were asked this question in order to determine student carbon emissions as a result of weekly driving. Respondents who owned a car on-campus were asked to estimate their weekly driving mileage. This question was answerable through a fill-in text box.

13. On average, how many times do you go home each term?

In order to calculate the total carbon emissions from student travel, it was necessary to determine how many times students traveled home each term. The question assumed that students did not count their trip before and after each term when responding. All respondents were asked this question and were able to choose one of the following answers by selecting the corresponding radio button: 0, 1, 2, 3, or other (with a text box).

14. Approximately, how many miles is it from Union to your home?

This question was also necessary in calculating the total carbon emissions from student travel since it is a variable in determining amount of fuel consumed. The question assumed that students only entered a one-way mileage total (rather than a round-trip mileage total). All respondents were asked this question and were able to enter this distance in miles through a fill-in text box.

15. How do you travel home?

This question was included in the survey to understand how students travel between their homes and the Union College campus. Because each mode of transportation utilizes different types and amounts of fuel, determining how each student traveled home was necessary. All students were able to answer this question by clicking on as many checkboxes that applied to them. The available answers were: Personal Car, bus (MegaBus, Greyhound), train (Amtrak), airplane, carpooling using your car, carpooling in a friend's car, other (with a text box).

16. What are some common locations to which you travel during the week?

This question was designed to understand the travel behaviors of students specifically during the week. The results of this answer help in determining where students travel the most during the week and where there could be improvements to the on and off-campus transportation systems in the future. All students were able to answer this question by clicking on as many checkboxes that applied to them. The available answers were: Supermarket, Wal-Mart, Crossgates Mall, Mohawk Commons, Downtown Schenectady (State St./Proctors area), Bank, Albany, Saratoga, Alumni Gym-Union Campus, and other (with a text box).

17. What are some common locations to which you travel during the weekends?

This question was designed to understand the travel behaviors of students specifically during the weekends. The results of this answer help in determining where students travel the most during the weekends and where there could be improvements to the on and off-campus transportation systems in the future. All students were able to answer this question by clicking on as many checkboxes that applied to them. The available answers were: Supermarket, Wal-Mart, Crossgates Mall, Mohawk Commons, Downtown Schenectady (State St./Proctors area), Bank, Albany, Saratoga, Alumni Gym-Union Campus, and other (with a text box).

18. Have you ever used the campus trolley?

This question was designed to determine the effectiveness of the campus trolley by asking students if they ever utilized it. Understanding this mode of transportation's usage is helpful in analyzing the entire transportation system at Union College. In retrospect, this question should have been divided into two questions for the on-campus trolley and the

off-campus trolley. All students were able to respond to this question by selection either a "Yes" or "No" radio button.

19. On average, how often (per week) do you use the on-campus trolley?

This question was designed to determine how often students used the on-campus trolley. This question was only presented to students who stated in question 18 that they used the campus trolley. The results of this question illustrate the effectiveness of the on-campus trolley among actual users. Students who indicated that they use the trolley were able to select the following answers through a radio button: 1, 2, 3, 4, or other (with a text box).

20. What time of the day do you use the on-campus trolley?

This question was included to understand at what time of day is the on-campus trolley most effective. This question was only presented to students who stated in question 18 that they used the campus trolley. The results of this question help indicate when on-campus trolley service is most used. Students who indicated that they use the trolley responded to this question by clicking on as many checkboxes that applied to them. The available answers were: 6pm, 7pm, 8pm, 9pm, 10pm, 11pm, 12am (midnight), 1am, and 2am. In retrospect, the available answers should have also included 3am and 4am on weekend nights.

21. What time of the day do you use the off-campus trolley?

This question was designed to determine how often and when students utilized the off-campus trolley. This question was only presented to students who stated in question 18 that they used the campus trolley. Students who indicated that they use the trolley

responded to this question by clicking on as many checkboxes that applied to them. The available answers were: 6:45pm Wed, 8pm Wed, 9pm Wednesday, 1pm Saturday, 2:20pm Saturday, 3:30pm Saturday, 6:15pm Saturday, and 9:15pm Saturday.

22. Where do you go when you use the on-campus trolley?

The results of this question provide information regarding where students travel to using the on-campus trolley. Since the on-campus trolley has a set route around the Union College campus, the study wanted to find out what stops were the most useful for students. This question was only presented to students who stated in question 18 that they used the campus trolley. Students who indicted that they use the trolley responded to this question by clicking on as many checkboxes that applied to them. The available answers were: Alumni Gym-Union Campus, College Park Hall-Union Campus, Davidson/Fox Hall-Union Campus, Beuth/Golub House, Old Chapel, Reamer Campus Center, and other (with a text box). In retrospect, the Lenox Road/Frat Row stop on the on-campus trolley should have been included in the answer choices.

23. Where do you go when you use the off-campus trolley?

The results of this question provide information regarding where students travel to using the off-campus trolley. Since the off-campus trolley has predetermined destinations around the Capital Region, the study wanted to find out what locations were the most useful for students. This question was only presented to students who stated in question 18 that they used the campus trolley. Students who indicted that they use the trolley responded to this question by clicking on as many checkboxes that applied to them. The available answers were: Crossgates Mall, Mohawk Commons, SUNY Albany, and other (with a text box). In

retrospect, the question should have also included the special Wal-Mart shuttle that runs only on Wednesdays.

24. Do you ever use your car to carpool other students?

This question was included in the survey to gauge carpooling at Union College. While this question was only applicable to students who owned cars on-campus, all students were able to answer. This caused some irregularities in the data collection, though it gave a fairly good representation of carpooling by students who own cars on-campus. Respondents answered the question by selected either a "Yes" or "No" radio button.

25. Do you ever carpool with other students in their cars?

This question was included in the survey to gauge carpooling at Union College by all students. Respondents answered the question by selected either a "Yes" or "No" radio button.

26. If you carpool, where do you travel?

This question was designed as a follow-up question to the previous questions regarding carpooling. It asked students to state where they traveled to using via a carpool. This is important in understanding the traveling behaviors of students who take part in carpooling. Students responded to this question by clicking on as many checkboxes that applied to them. The available answers were: Supermarket, Wal-Mart, Crossgates Mall, Mohawk Commons, Downtown Schenectady (State St./Proctors area), Bank, Albany, Saratoga, Alumni Gym-Union College, other (with a text box).

27. What would make you more likely to use the campus trolley?

This question was included to understand why students would be more likely to use the trolley in the future. The answers to this question would help in recommending improvements to the current transportation system. All students were able to respond to this question by clicking on as many checkboxes that applied to them. The available answers were: More trolley hours (specify in "other" below), More trolley stops (specify in "other" below), High Gas Prices, and other (with a text box).

28. What would make you more likely to carpool?

This question was included to understand why students would be more likely to carpool in the future. The answers to this question would help in recommending improvements to the current personal transportation situation at Union College. All students were able to respond to this question by clicking on as many checkboxes that applied to them. The available answers were: A service provided by the college to connect carpool matches, High Gas Prices, Sharing cost by carpoolers, Common destination of potential carpoolers, and other (with a text box).

29. Comments, Questions, Concerns

The final question of the survey was an open-ended textbox that provided students with the ability to share their comments, questions, and concerns about the survey, transportation options at Union College, or the overall study.

***2011-2012 Student Survey Graphs***

(Appendix E)

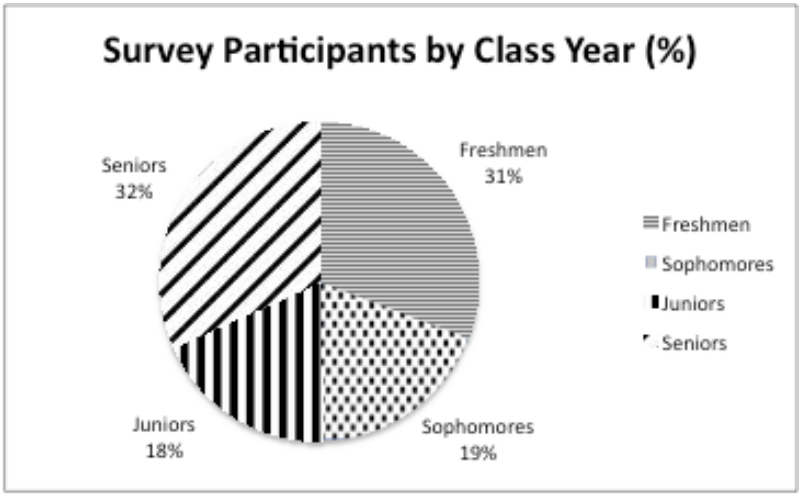



Figure 17: This figure indicates the survey participants by class year by percentage. The survey was a good representation of the Union College student body; 338 students out of a total of 2,170 (15.6%) completed the survey. The responses by class year are also fairly representative, with more freshmen (31%) and seniors (32%) responding than sophomores (19%) and juniors (18%).

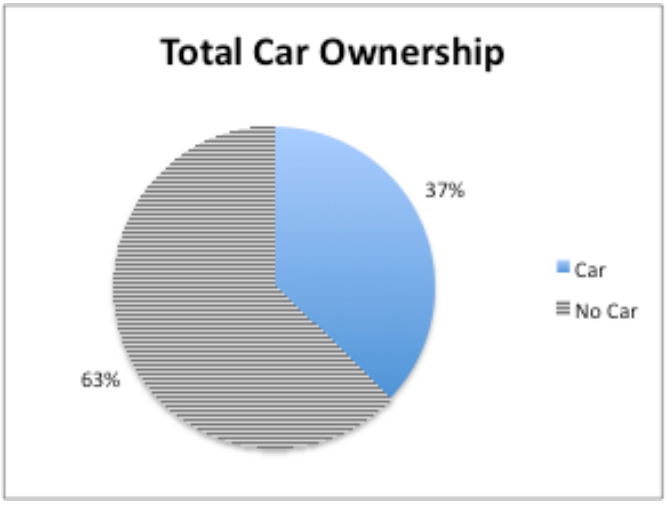



Figure 18: This figure indicates the percentage of car ownership among students in 2011. The striped lines are the percentage of students who do not own a car on campus and the solid color indicates the percentage of students who do own a car on campus. The survey concluded that more Union College students do not own a car on-campus (63%) than do own a car on-campus (37%). In total, 126 of 338 students reported that they owned a car on-campus.

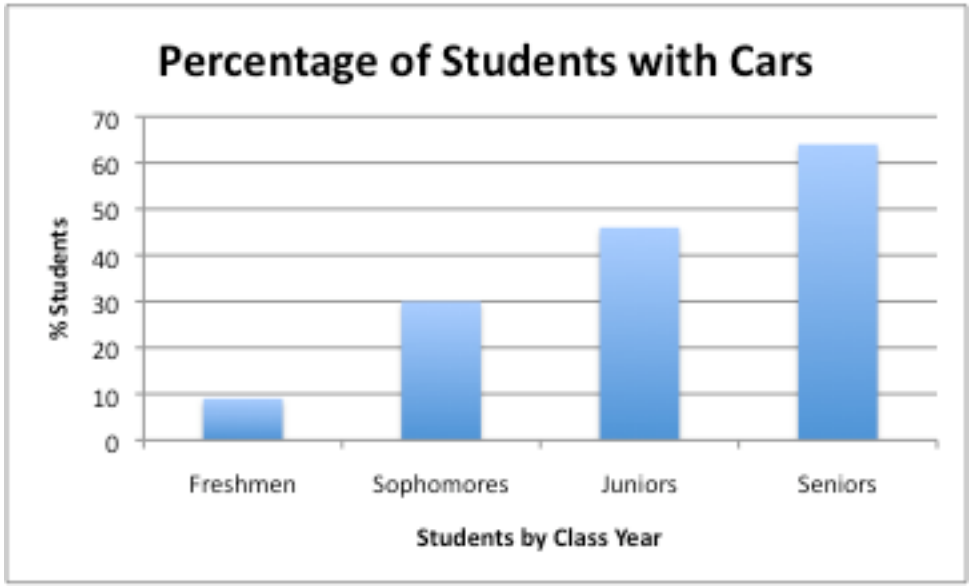



Figure 19: This figure shows the percentage of students who owned cars on-campus at Union College in 2011. The survey found that as students increased in class year, they were more likely to own a car on-campus. Freshmen had the lowest percentage of on-campus car ownership at 9%, sophomores indicated that 30% of their class year owned a car on-campus, juniors increasingly owned a car at 46%, and seniors had the highest percentage of car ownership at 64%. Freshmen car ownership is artificially low since they can only own a car on-campus if they receive a waiver from the Office of the Dean of Students.

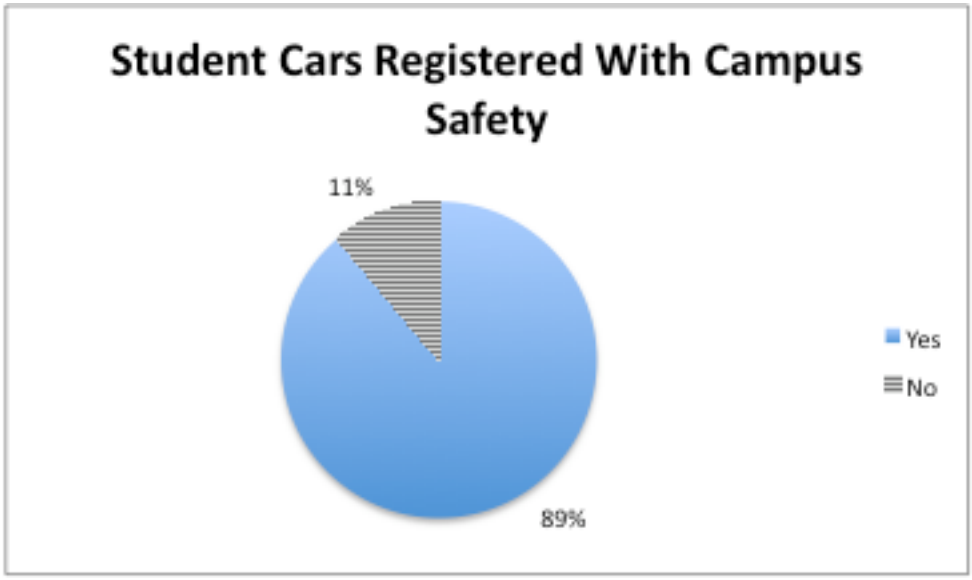



Figure 20: This figure shows the percentage of students that own a car on-campus who registered their vehicle with the Union College Campus Safety Department in 2011. The majority of students who owned cars on-campus registered their vehicles with Campus Safety (89%). 100% of freshmen and juniors stated that they registered their vehicles, compared to 95% of sophomores and 81% of seniors.

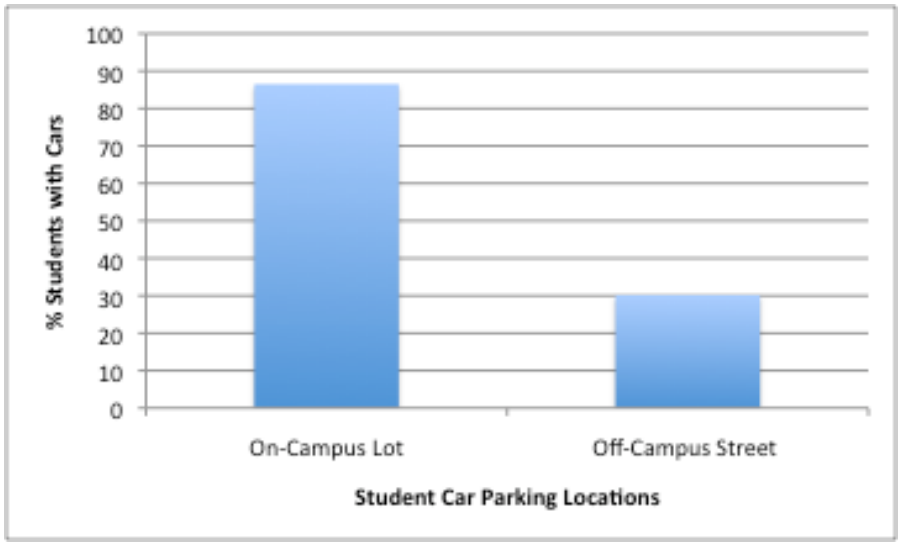



Figure 21: This figure indicates where students who own a car on-campus park their vehicles, by percentage. 87% of students reported that they use Union College on-campus parking lots while 30% stated they parked their cars on streets located off-campus. The percentages do not add up to 100% because students were permitted to select as many answers as applicable. This shows that the majority of students are choosing to park their vehicles on-campus instead of parking in the surrounding neighborhood.

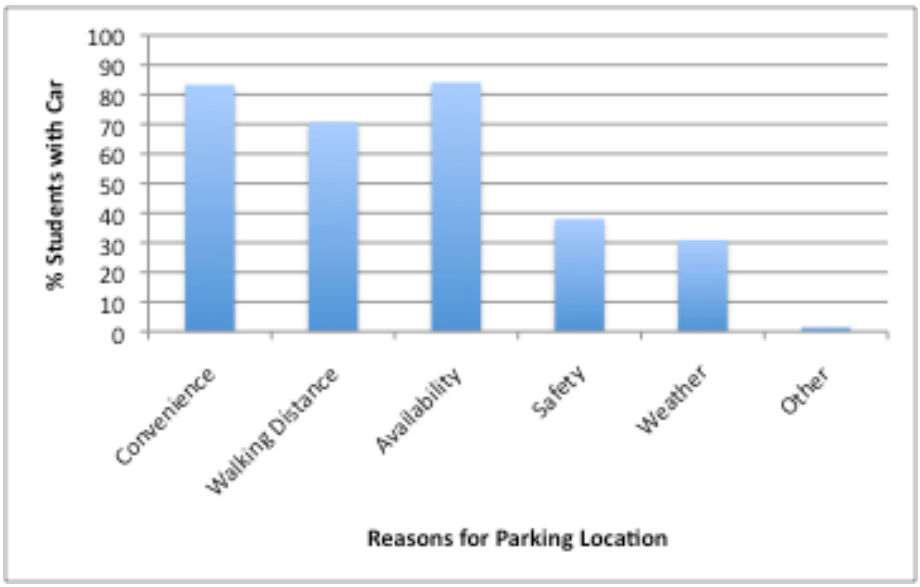



Figure 22: This figure illustrates the reasons students who own cars on-campus park where they do. Parking convenience and availability were the top reasons at 83% and 84%, respectively. Walking distance was also important to the majority of students with 71%. Students were less concerned with safety and weather while deciding where to park with 38% and 30% indicating it was important, respectively. The percentages do not add up to 100% because students were permitted to select as many answers as applicable.

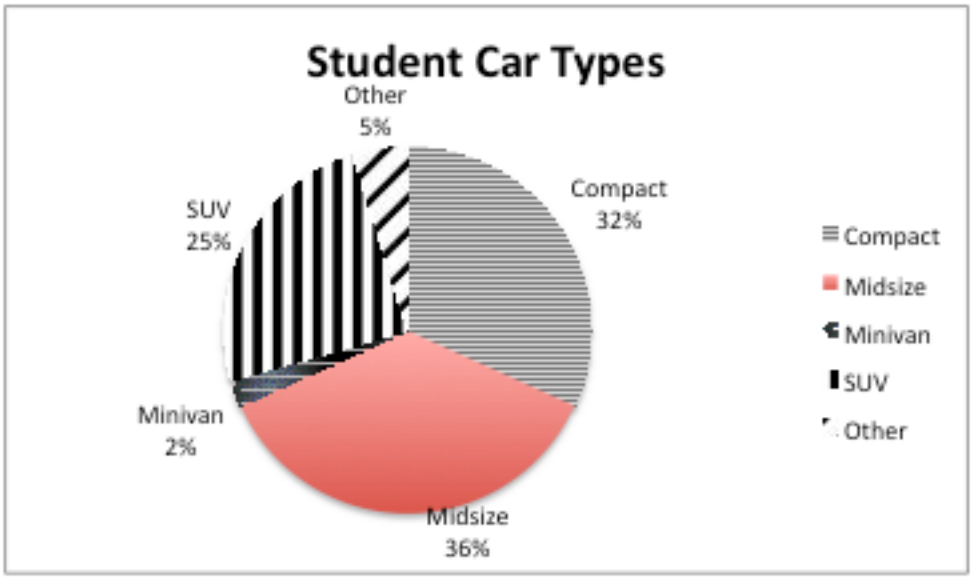



Figure 23: This figure shows the types of vehicles students own on-campus. For the most part, students indicated that they either own a midsize (36%), compact (32%), or SUV (25%). More students stated that they drove a vehicle not listed in the survey (5%) than stated they drove a minivan (2%). The results indicate that more students drive smaller cars than larger SUVs and minivans. Students who responded with "other" described their vehicles as sedans, a station wagon, a sports car, and large.

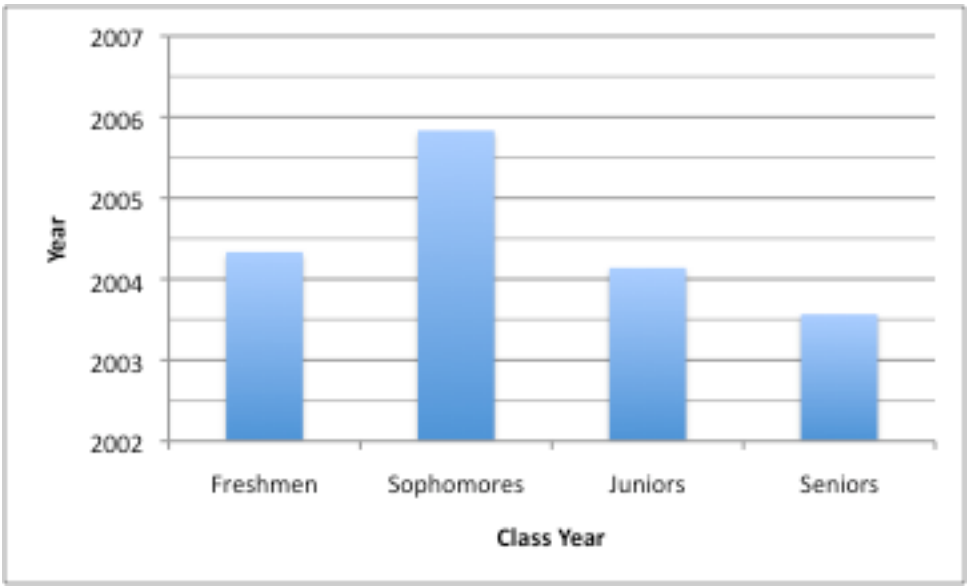



Figure 24: This figure indicates the average vehicle model year for students who owned a car on-campus in 2011. The total average model year for the student vehicle fleet was 2004.47. Sophomores owned the newest vehicles at an average year of 2005.83. Freshmen (average year=2004.33), juniors (average year=2004.14), and seniors (average year=2003.57) owned vehicles below the average model year. This indicates that, excluding, freshmen, model year decreases as class year increases.

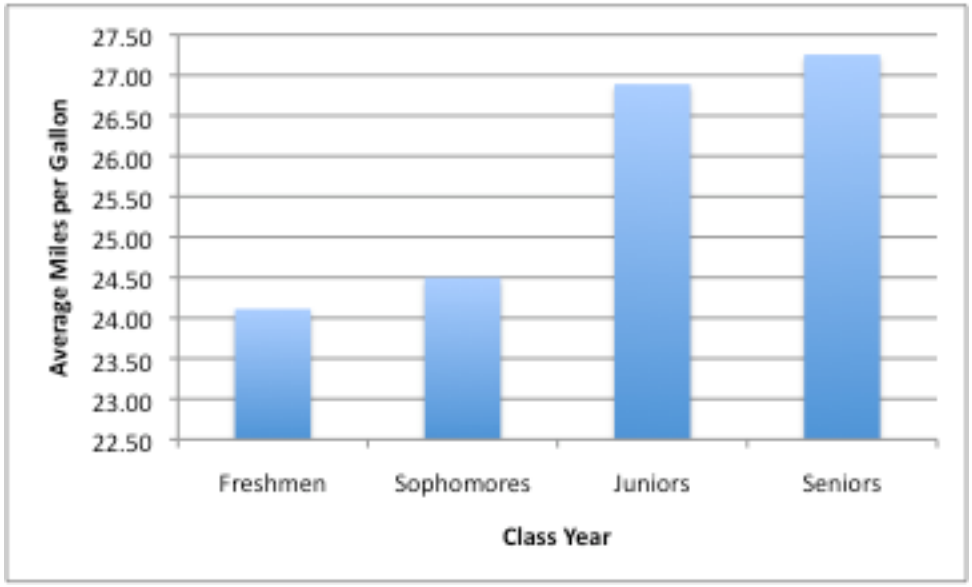



Figure 25: This figure shows the average miles per gallon (MPG) on-campus student-owned vehicles obtain during use in 2011. The total average MPG achieved for the entire student vehicle fleet was calculated to be 25.69 MPG. Freshmen and sophomores reported that they own less fuel-efficient vehicles than the overall student average at 24.11 and 24.50 MPG, respectively. Juniors and seniors reported owning more fuel-efficient vehicles than the total student average at 26.89 MPG and 27.26 MPG, respectively.

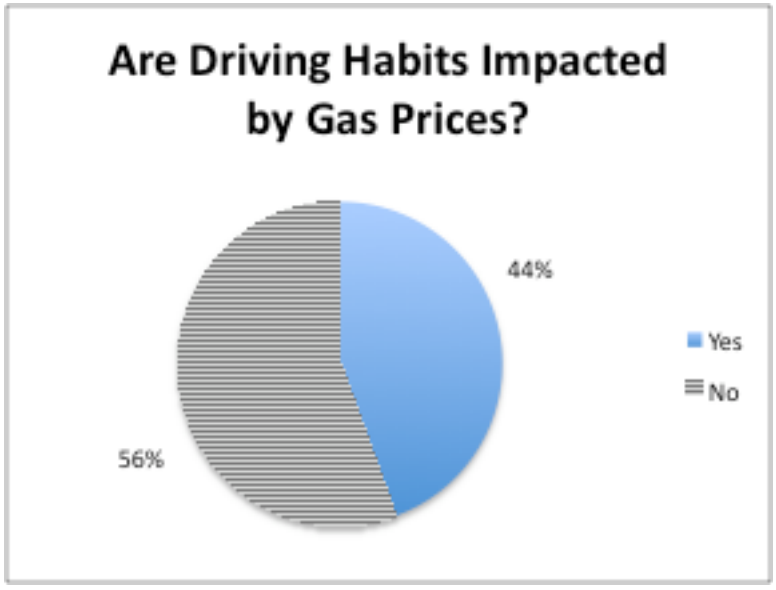



Figure 26: The figure above describes how students who own cars on-campus are impacted by automobile gasoline prices. More students with cars on-campus stated that their driving habits were not impacted by gasoline prices (56%) than students who stated that gasoline prices impacted their driving habits (44%). This indicates how gasoline prices do not affect the majority of students with cars on-campus.

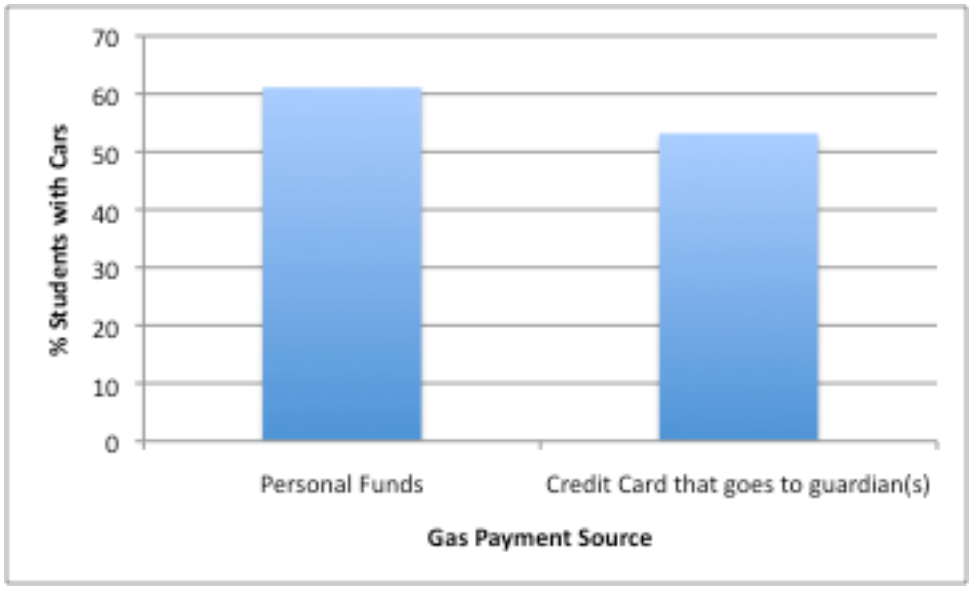



Figure 27: This figure indicates the payment methods that students with cars on-campus use to pay for their automobile gasoline, by percentage. More students indicated that they paid for their gasoline with their personal funds (61%) than indicated that they paid for their gasoline with a credit card that goes to their guardian (53%). The percentages do not add up to 100% because students were permitted to select as many answers as applicable.

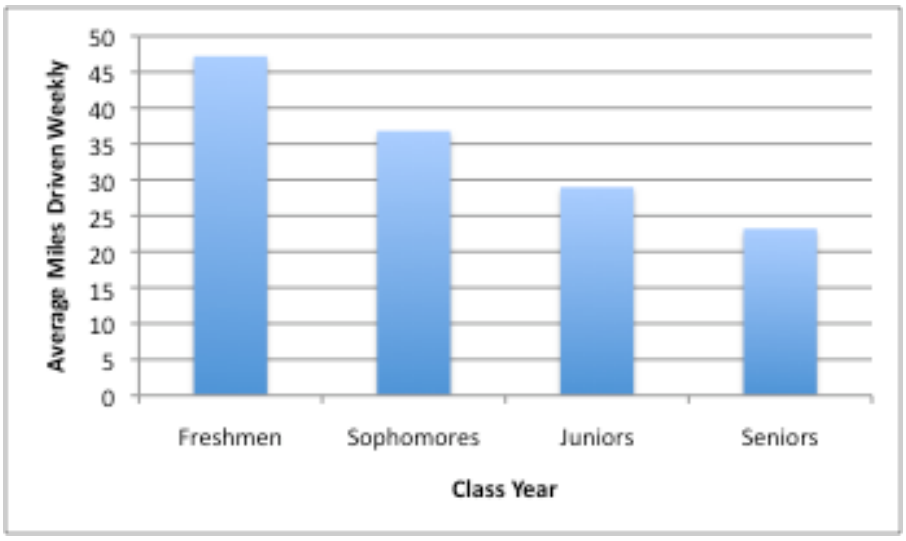



Figure 28: This figure shows the average miles driven per week by students who own a car on-campus. The average for freshmen (47.2 mi) is artificially high because there were only nine respondents who were on-campus car owners. Despite the irregularity, average miles driven per week decreases as class year increases. The overall average miles driven weekly for the entire vehicle fleet is 34.1 miles per week. Freshmen and sophomores (36.8 mi) had above average weekly mileage while juniors (28.97 mi) and seniors (23.2 mi) had below average weekly mileage.

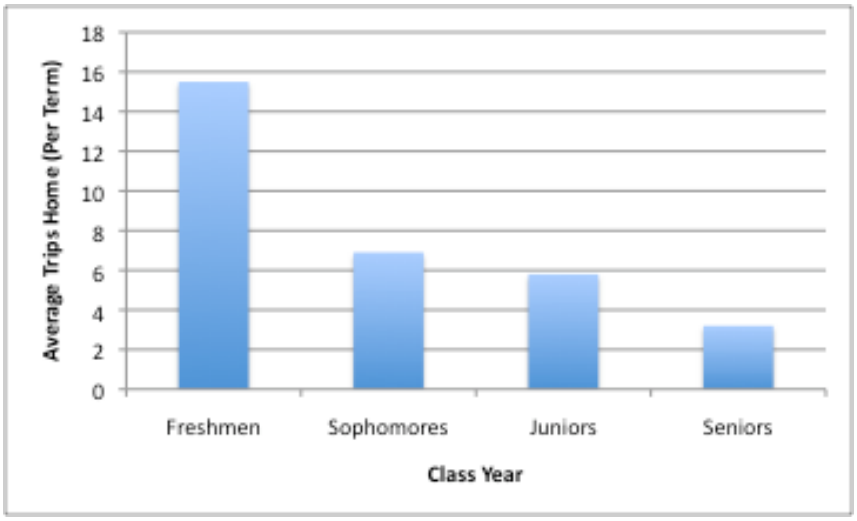



Figure 29: This figure shows the average number of trips home per term by students who use their own car to travel home. Because it was assumed that students did not count their trip before and after each term when responding, one trip was added to each respondent's total. The average for freshmen (15.5) is artificially high because there were only nine respondents who were on-campus car owners. Including freshmen, the overall average number of roundtrips was 7.9 while, without them, it was 5.3. Sophomores (6.9) and juniors (5.8) were above the latter average while seniors were below (3.2). As class year increased, the average total number of trips home decreased.

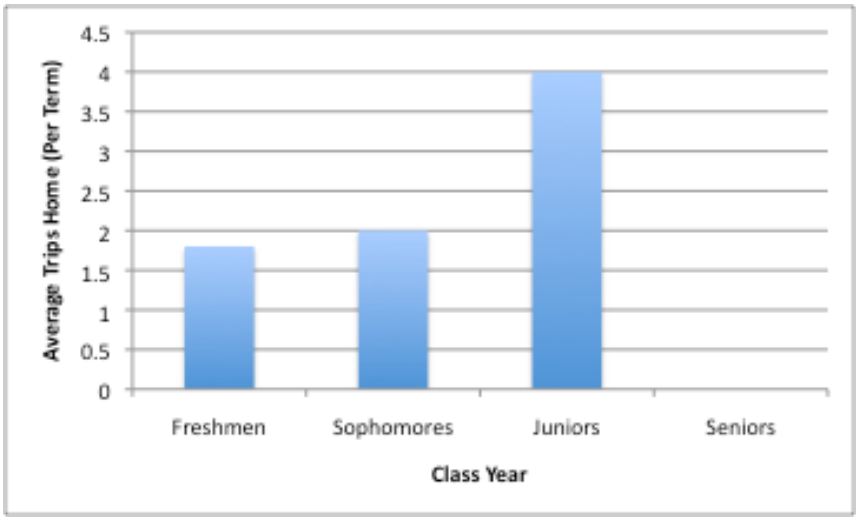



Figure 30: This figure shows the average number of trips home per term by students who carpooled to travel home. Because it was assumed students did not count their trip before and after each term when responding, one trip was added to each respondent's total. The overall average number of roundtrips was 2.6. Freshmen (1.8) and sophomores (2) were below the average while juniors (4) were above the average. No seniors reported carpooling home. Excluding seniors, as class year increased, the average total number of trips home via carpool increased.

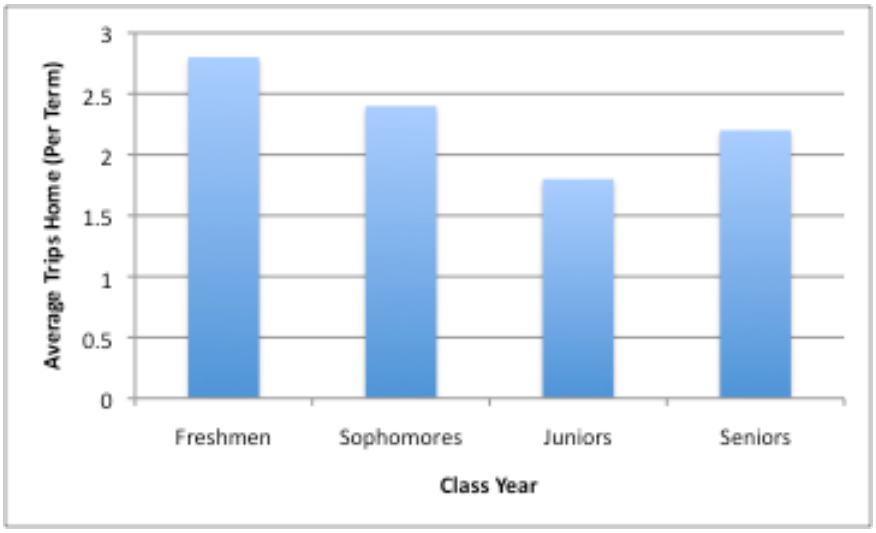



Figure 31: This figure shows the average number of trips home per term by students who utilized a family/personal (non on-campus) car to travel home. Because it was assumed students did not count their trip before and after each term when responding, one trip was added to each respondent's total. The overall average number of roundtrips was 2.3. Freshmen (2.8) and sophomores (2.4) were above the overall average while juniors (1.8) and seniors (2.2) were below the average. The average number of trips home decreased as class year increased, except in the case of the senior class.

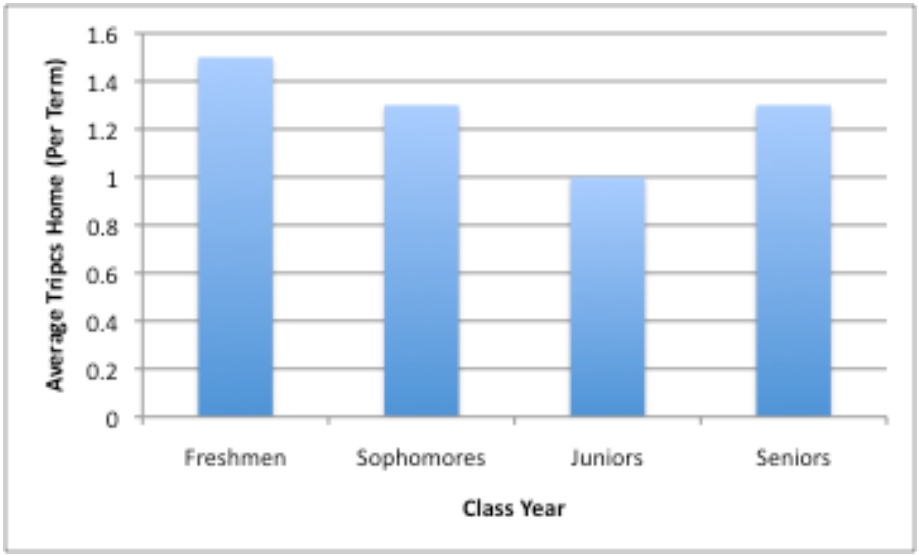



Figure 32: This figure shows the average number of trips home per term by students who took an airplane to travel home. Because it was assumed students did not count their trip before and after each term when responding, one trip was added to each respondent's total. The overall average number of roundtrips was 1.28. Freshmen (1.5), sophomores (1.3), and seniors (1.3) were above the overall average while juniors (1) were below the average. The average number of trips home decreased as class year increased, except in the case of the senior class.

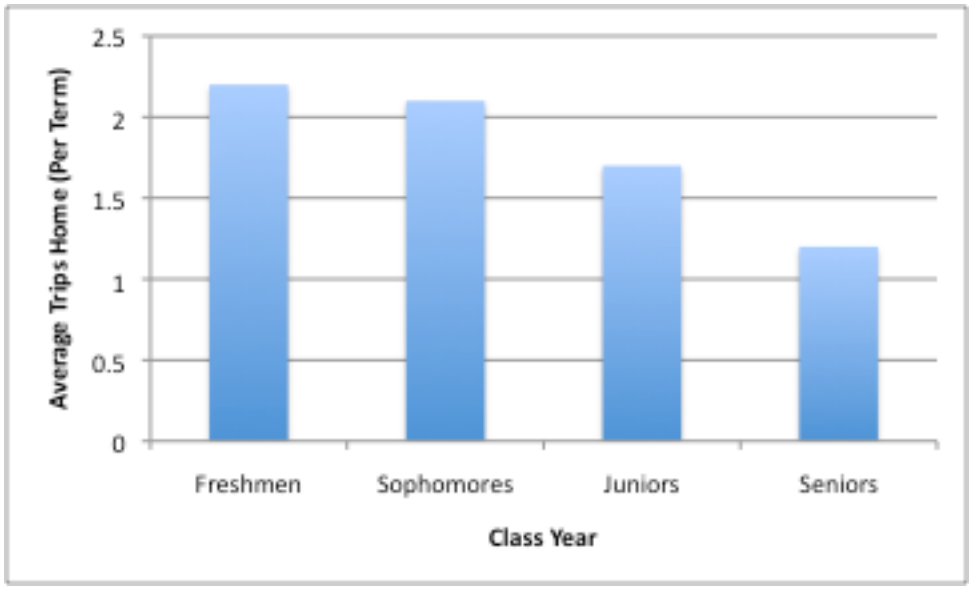



Figure 33: This figure shows the average number of trips home per term by students who took a train to travel home. Because it was assumed students did not count their trip before and after each term when responding, one trip was added to each respondent's total. The overall average number of roundtrips was 1.8. Freshmen (2.2) and sophomores (2.1) were above the overall average while juniors (1.7) and seniors (1.2) were below the average. As class year increased, the average number of trips home decreased.

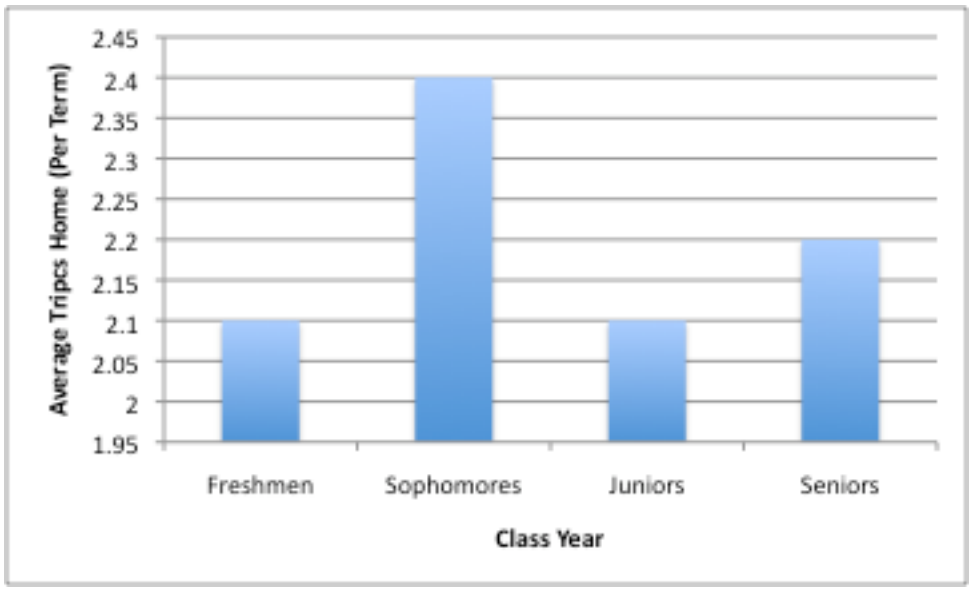



Figure 34: This figure shows the average number of trips home per term by students who took a bus to travel home. Because it was assumed students did not count their trip before and after each term when responding, one trip was added to each respondent's total. The overall average number of roundtrips was 2.2. Sophomores (2.4) were above the overall average, freshmen (2.1) and juniors (2.1) were below, and seniors (2.2) were at the average. Average trips home per term varied significantly between class years.

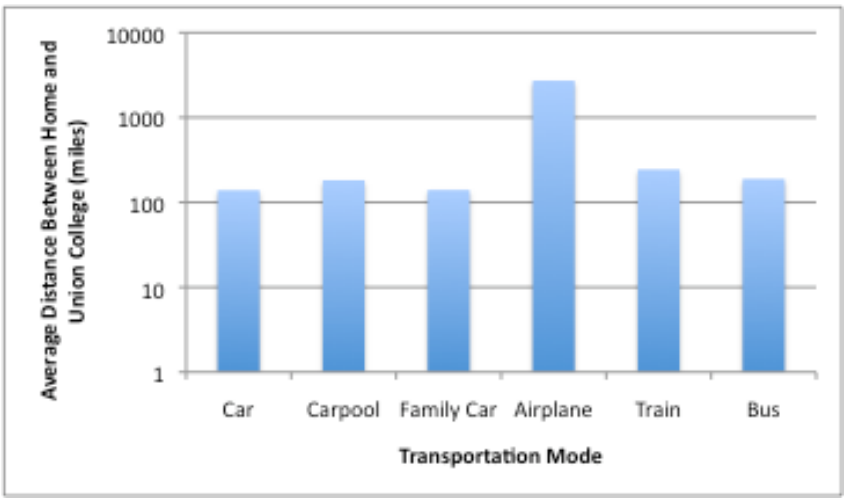



Figure 35: This figure indicates the average distance in miles for students between home and Union College on a logarithmic scale. The overall average distance between a permanent residence and Union College was 602 miles, however, those who utilize an airplane distorted that average. Students who utilized an airplane had the highest average distance between their permanent residence and Union College (2715.56 miles). Besides those who utilized an airplane, the average distance between home and Union College was fairly flat, as shown in Figure 20.

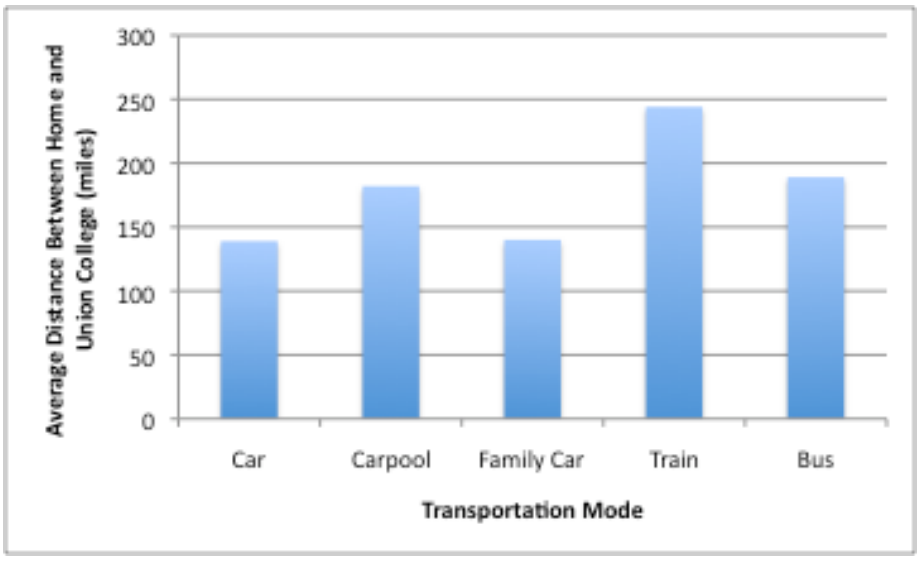



Figure 36: This figure describes the average distance in miles for students between home and Union College, excluding airplane use. The overall average distance between a permanent residence and Union College when excluding airplane use was 179 miles. The utilization of trains (244 mi), buses (189 mi), and carpools (182 mi) occurred when students lived above the average distance while on-campus car (139 mi) and family car (140 mi) usage occurred when students lived below the average distance.

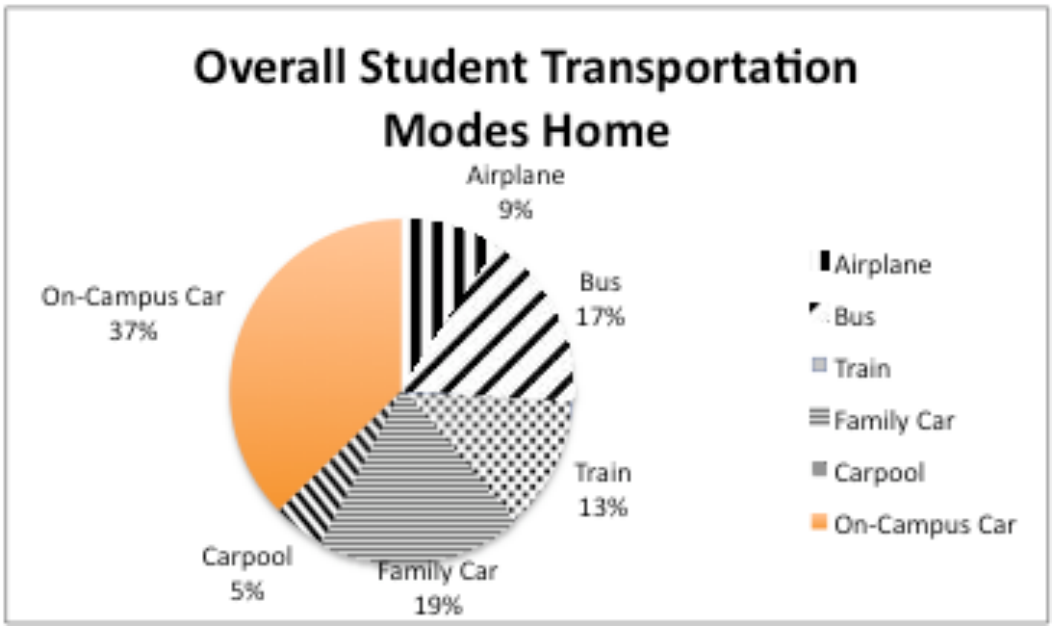



Figure 37: This figure describes the overall breakdown of the modes of transportation students use to travel home in 2011. All 338-student respondents answered this question, which was important in determining how students traveled between their permanent homes and Union College. The most utilized mode of transportation by students was via the car they owned on-campus (37%). The second most utilized mode of transportation by students was a personal/family car (19%). These respondents were students who answered the survey question with "Personal Car" but did not own a car on-campus. Bus (MegaBus and Greyhound) was the most utilized public mass-transportation option (17%) with the train (Amtrak) a close second, and fourth overall (13%). Airplane was the least utilized public transportation option, which could be attributed to the close proximity of Union College to most of its students (87.7% of students live either in a New England or Mid-Atlantic State). The least utilized transportation option home was carpooling (5%). Figures 22-25 analyze transportation mode selection into greater detail by specific class year.

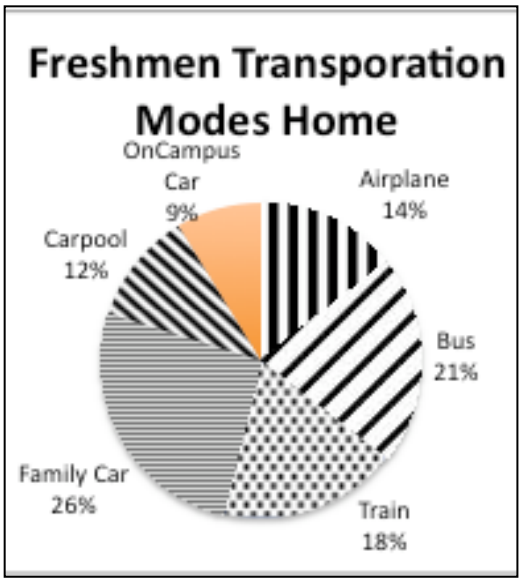



Figure 38

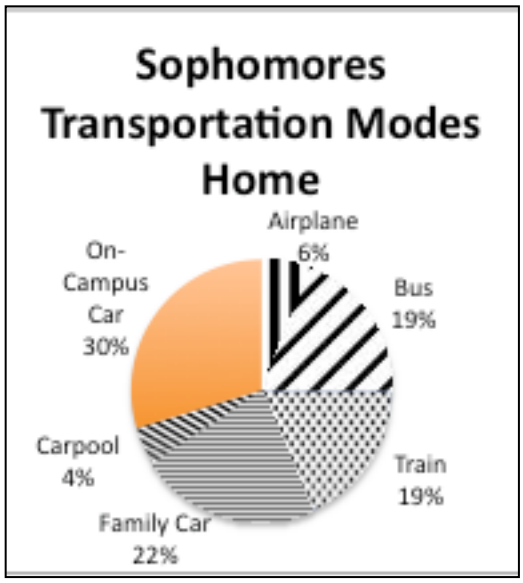



Figure 39

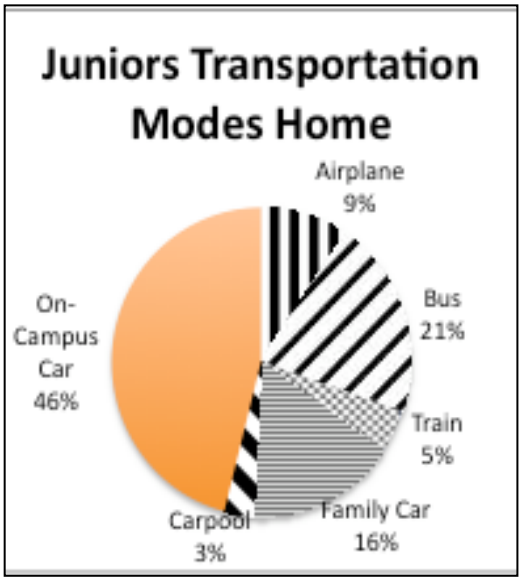



Figure 40

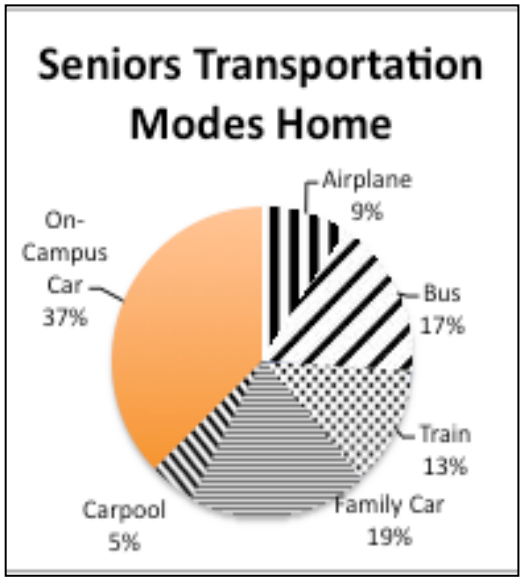



Figure 41

Figures 22-25: The above figures show the breakdown by which each class year travels between Union College and their permanent home. The usage of on-campus cars to travel home increases steadily (from 9% to 46%) until it drops for seniors (37%). Train usage is flat during freshmen (18%) and sophomore (19%) year, though decreases greatly during junior year (5%) before rising again for seniors (13%) Airplane usage is fairly flat all four years, ranging from 6% to 14%. Bus usage is also fairly flat all four years, ranging from 17% to 21%. The utilization of a family car for transportation is highest during the first two years (26% and 22%, respectively) before dropping to 16% for juniors and 19% for seniors. Carpooling also drops in usage immediately after freshmen year (12%) as it is barely used by sophomores (4%), juniors (3%), and seniors (5%).

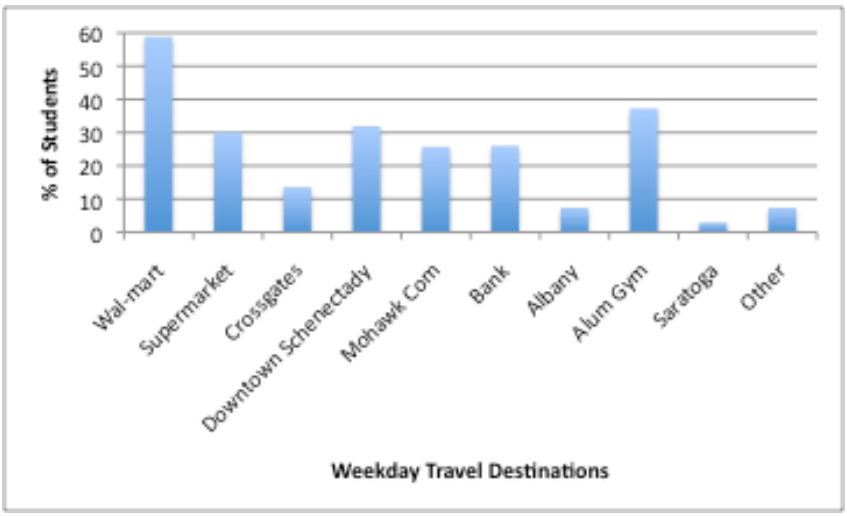



Figure 42: This figure shows the distribution of weekday travel destinations of students, by percentage. The most popular destination for students during the week was to Wal-Mart (59%). Alumni Gym, located on the Union College campus, was the second most visited destination by students (37%). Downtown Schenectady (32%), the local supermarket (30%), the bank (26%), and Mohawk Commons in Niskayuna, NY (26%), were also frequently visited destinations by students. Less visited destinations include the Crossgates Mall in Albany, NY, (14%), Albany, NY (7%), and Saratoga, NY (3%). Other answers (7%) included "home," "off-campus job," "Starbucks," "Troy," and "Frat Row" (Lenox Road).

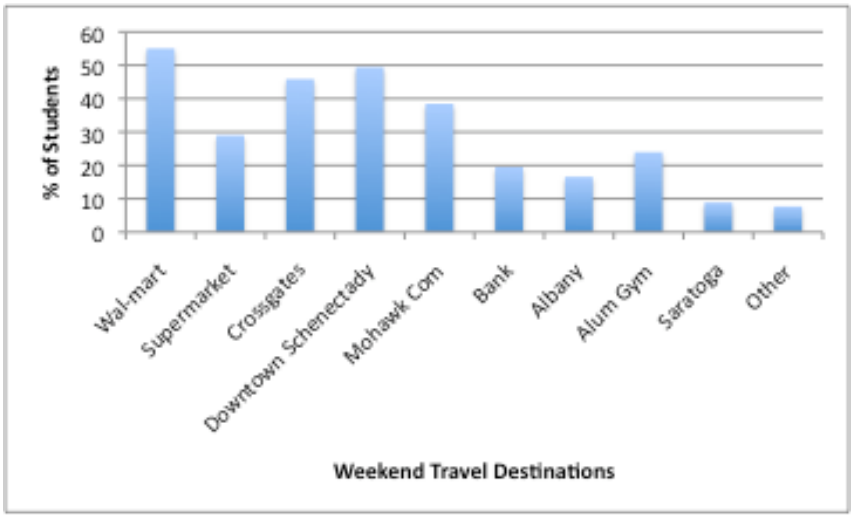



Figure 43: This figure shows the distribution of weekend travel destinations of students, by percentage. The most popular destination for students during the weekend was to Wal-Mart (55%). Downtown Schenectady (49%), the Crossgates Mall in Albany, NY (46%), Mohawk Commons in Niskayuna, NY (38%), and the local supermarket (29%) were also frequently visited destinations by students. Alumni Gym at Union College (24%), the bank (20%), and Albany, NY (17%) were moderately visited destinations while Saratoga, NY (9%) was the least visited destination. Other answers (8%) included "Frat Row" (Lenox Road), "Starbucks," and "Food Places."

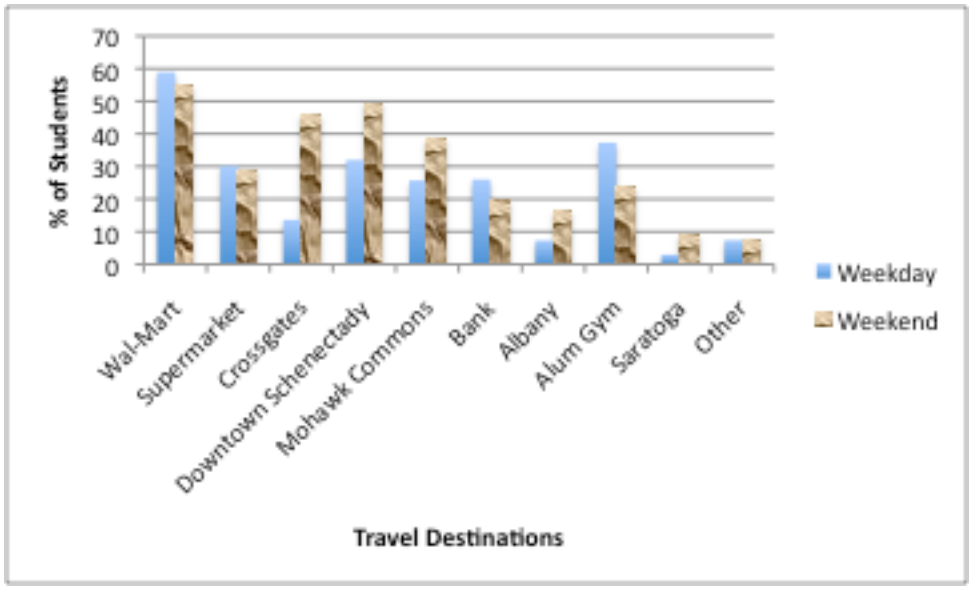



Figure 44: The figure above shows the common locations students travel to during weekdays and weekends on the same axes, by percentage. Wal-Mart is consistently the most popular destination during both weekdays (59%) and weekends (55%). The percentage of students traveling to the local supermarket is level during both weekdays (30%) and weekends (29%). While student travel to the bank and Alumni Gym, student travel to Crossgates Mall, Downtown Schenectady, Mohawk Commons, Albany, NY, and Saratoga, NY increase in percentage from weekdays to the weekend. This indicates that students are more likely to shop at malls and spend time in city centers during the weekend.

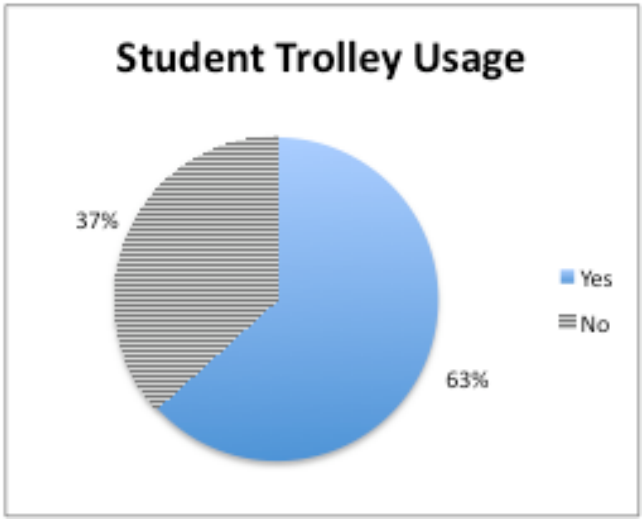



Figure 45: This figure describes Union College Trolley usage in 2011 among all students who responded to the survey. The striped lines are the percentage of students who have not used the Union College Trolley and the solid color indicates the percentage of students who have used the Union College Trolley. A majority of students stated that they have used the Union College Trolley (63%) than have not used the Union College Trolley (37%).

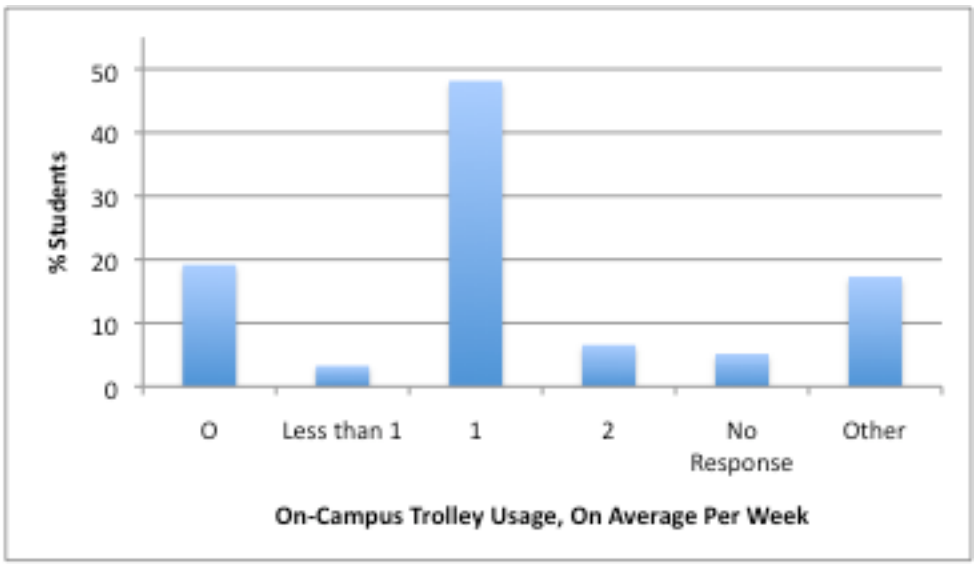



Figure 46: This figure illustrates average on-campus trolley usage per week, by percentage. Of the students who stated that they used the College Trolley, most stated that on average, they utilize it once a week (48%), however, only 7% stated that they used the trolley twice a week, on average. The second highest response was an average of zero times a week, or almost never (19%) in addition to the 3% who stated they use it less than once a week, on average. Other (17%) answers included "not often," "maybe once," and "since the trolley tracker stopped working, I haven't used it." 5% of students who stated that they use the trolley did not respond.

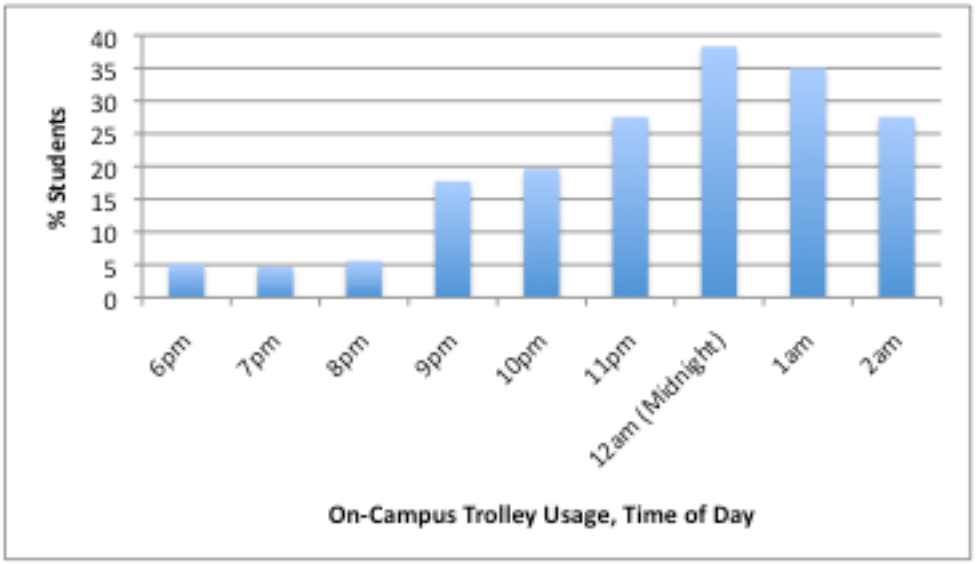



Figure 47: This figure describes the average time of day students utilize the on-campus trolley, by percentage. Between 6pm and 8pm, student usage is flat, ranging from 4.7% to 5.6%. From 9pm (18%) to 12am (38%), on-campus trolley usage consistently increases. While usage during 1am (35%) and 2am (28%) decreases from the highpoint at 12am, on-campus trolley usage is still much greater during these hours than from 6pm to 8pm.

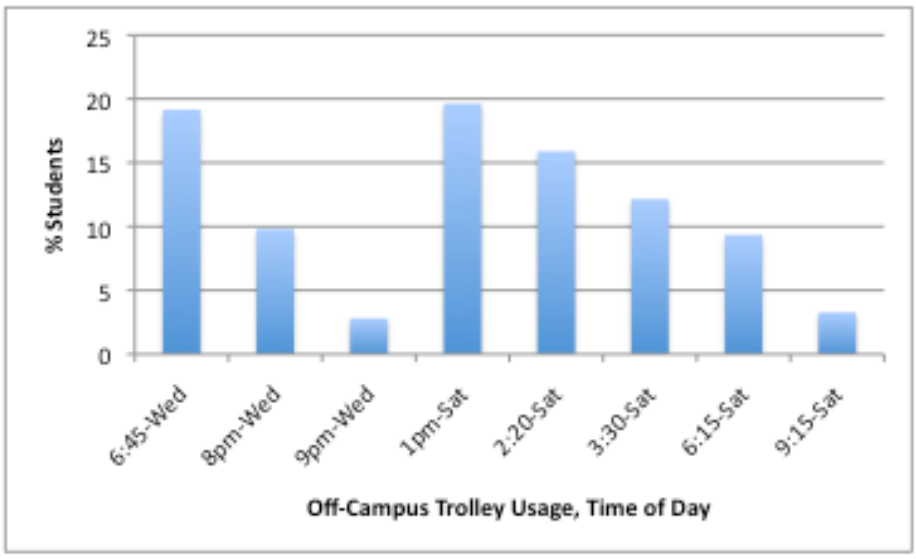



Figure 48: This figure illustrates the time of day that students who stated they utilize the trolley, on average, use the off-campus trolley, by percentage. Students indicated that they more often use the trolley earlier in the day on both Wednesdays and Saturdays. The greatest percentage of students utilized the trolley on Saturday afternoons at 1pm (19.6%) and on Wednesday night at 6:45pm (19.1%). Trolley usage on both service days decreases consistently after the first run of the trolley and is lowest during the nine o'clock hour.

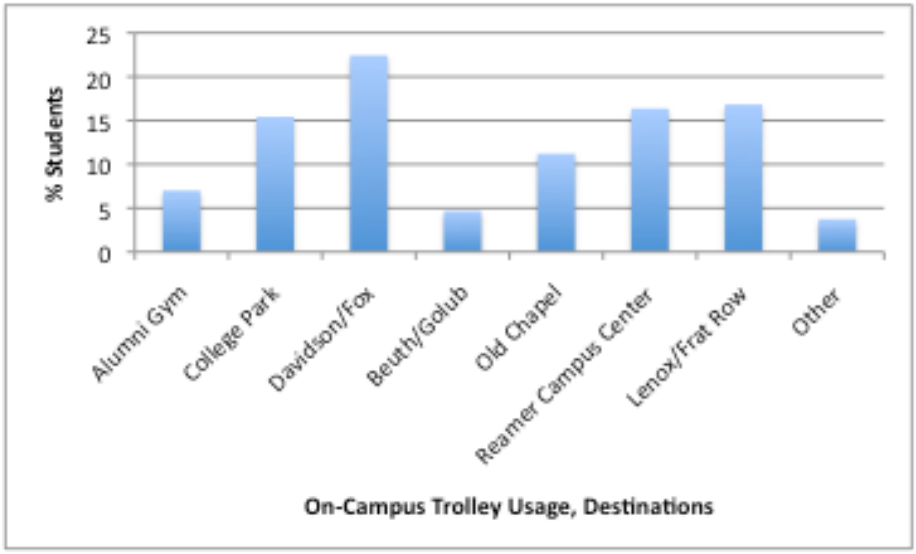



Figure 49: This figure describes what stops students utilize while traveling on the on-campus trolley, by percentage. The Davidson and Fox dormitory complex (22%) was the most used stop. The second most utilized stop, Lenox/Frat Row (16.8%), was often written in "other," though it warranted its own bar on the figure. Reamer Campus Center (16.3%), College Park Hall (15%), and Old Chapel (11%) were also frequently used on-campus trolley stops. Students, however, were less likely to use the on-campus trolley when traveling to Alumni Gym (7%) and Beuth/Golub (5%). Other responses (4%) included "off-campus house," "anywhere near Union Avenue," and "all over."

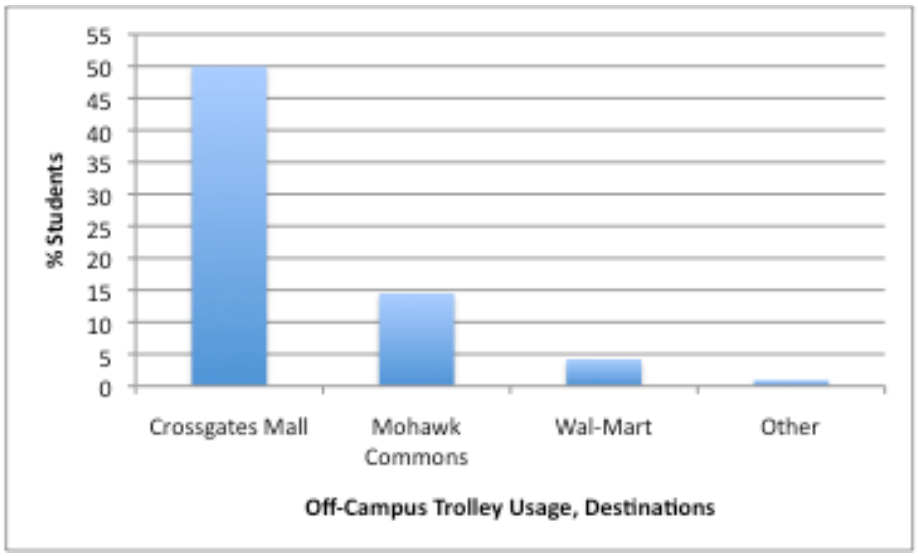



Figure 50: This figure shows what stops students utilize while traveling on the off-campus trolley, by percentage. Students who indicated that they used the trolley responded that Crossgates Mall in Albany, NY, was the most utilized off-campus trolley destination (50%). Mohawk Commons in Niskayuna, NY, was the second most utilized destination (14%) while Wal-Mart was the lowest (4%). Wal-Mart may have been the lowest since it was not an answer choice in the survey. Other answers (1%) included "SUNY Albany" and "school sponsored events at the bowling alley."

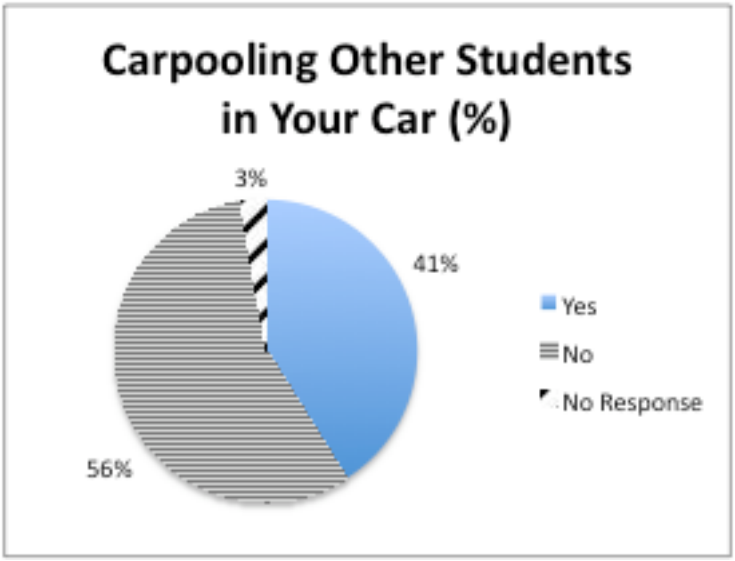



Figure 51: This figure describes carpooling by students who own a car on-campus in 2011 among all students who responded to the survey. The striped horizontal lines are the percentage of students who do not use their vehicle to carpool other students (56%), the solid color indicates the percentage of students who do use their vehicle to carpool other students (41%), and the striped diagonal lines are students who did not respond to the question (3%). More students stated that they do not use their vehicle to carpool other students than those who stated that they do use their vehicle to carpool other students.

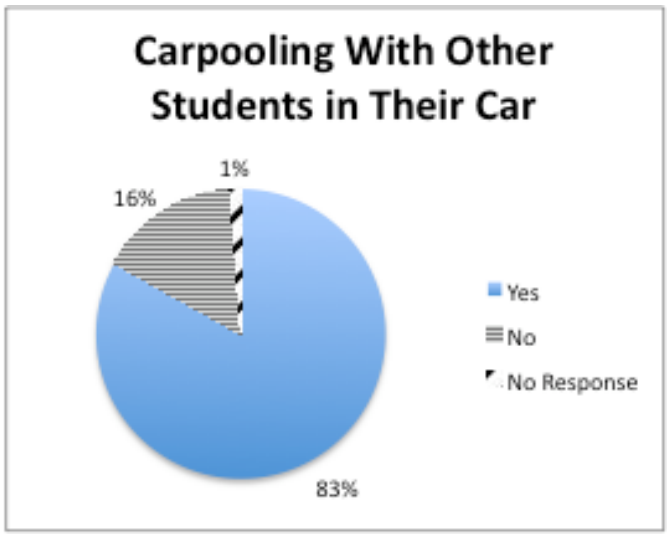



Figure 52: This figure describes carpooling by students in another student's vehicle in 2011 among all students who responded to the survey. The striped horizontal lines are the percentage of students who do not carpool in another student's vehicle (16%), the solid color indicates the percentage of students who carpool in another student's vehicle (83%), and the striped diagonal lines are students who did not respond to the question (1%). More students stated that they do carpool in another student's vehicle than those who stated that they do not car pool in another student's car.

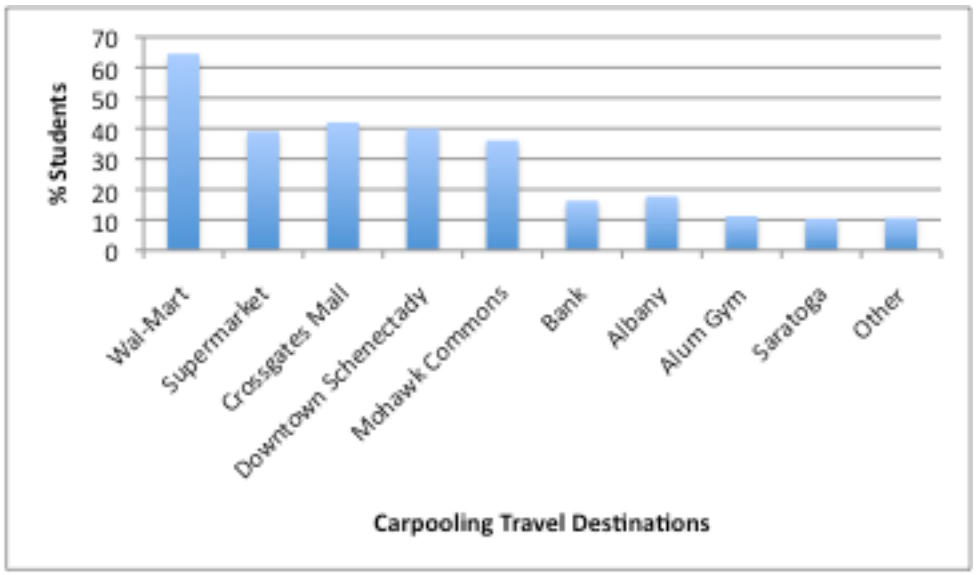



Figure 53: The figure above illustrates the destinations to which students travel to via a carpool, by percentage. Most students indicated that, while carpooling, they travel to Wal-Mart (64%). Other destinations well visited by carpools were the Crossgates Mall (42%), Downtown Schenectady (40%), the local supermarket (39%), and Mohawk Commons (36%). Destinations lesser visited by carpools included Albany, NY (18%), the bank (16%), Alumni Gym (11%), and Saratoga, NY (10%). Other (11%) responses included "home," "RPI," "Clifton Park," "food places," and "Union Graduate College."

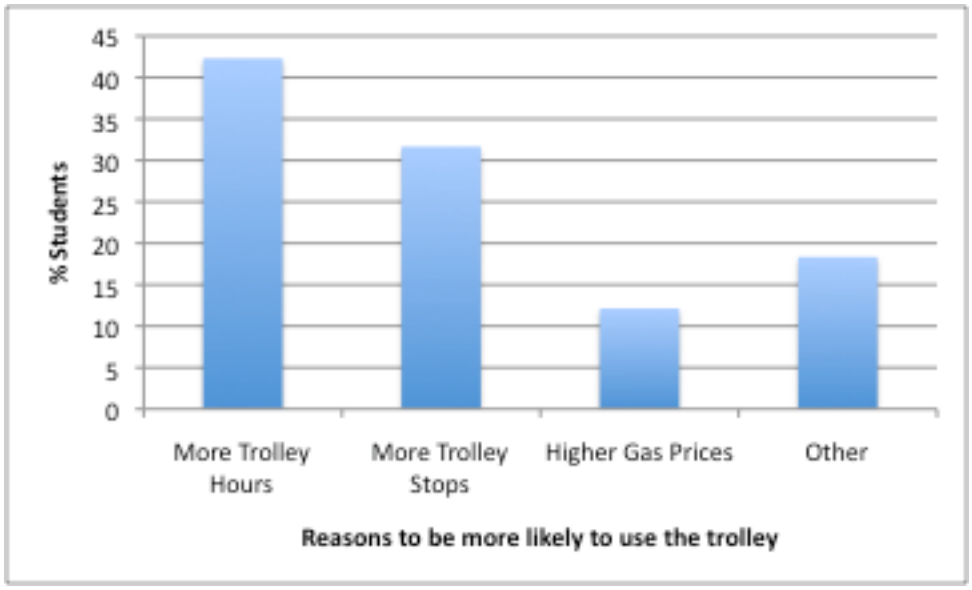



Figure 54: This figure shows the reasons students would be more likely to use the campus trolley in the future, by percentage. "More Trolley Hours" received the most responses by students (42%), followed by "More Trolley Stops" (32%). 12% of students indicated that higher gas prices would increase their trolley usage. Other (18%) responses included "a trolley tracker system that works," "knowledge and info of how it works," "more frequent trolley pickups," "less stops (express)," and "other nights for Wal-Mart trips."

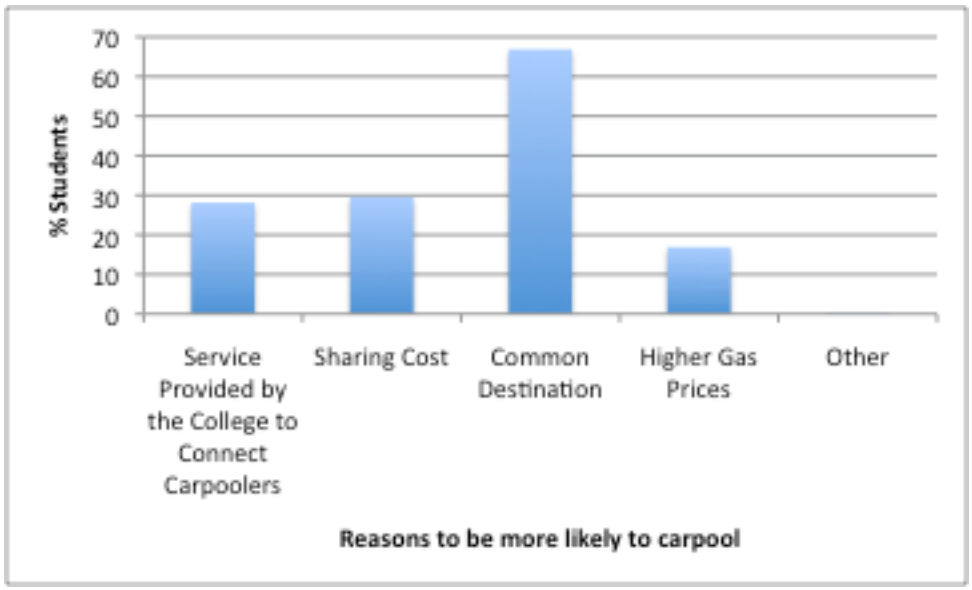
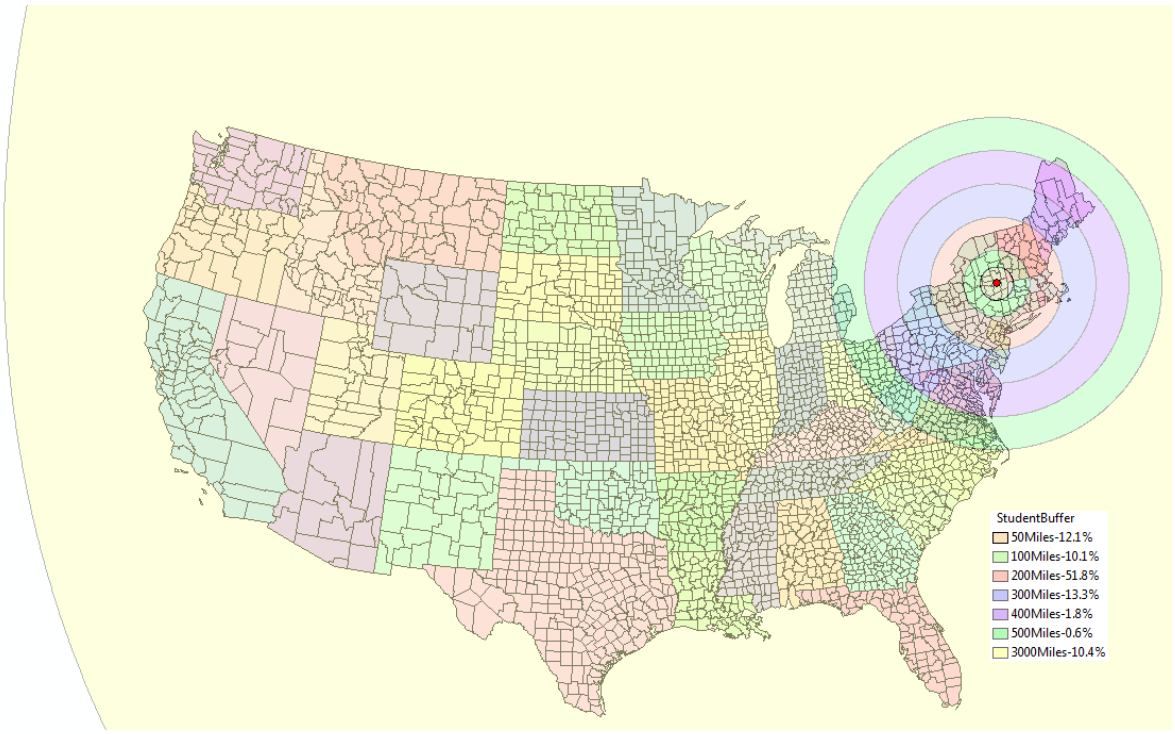
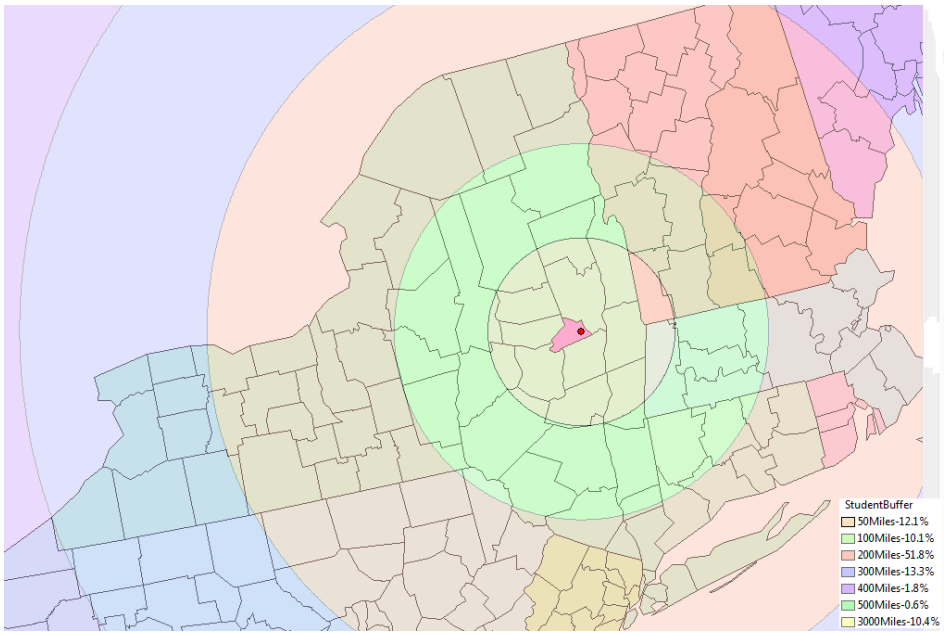



Figure 55: This figure shows the reasons students would be more likely to carpool in the future, by percentage. The majority of students indicated that a common destination (67%) would increase their carpooling. Sharing cost (30%) and a service provided by the College to connect carpoolers (28%), however, were less of an incentive to increase carpooling. Additionally, higher gas prices received the least support by students (17%).




Map 4: This is a buffer map of the United States using GIS indicating the distance, in miles, students travel between their residences and Union College. The cream buffer (>500 miles) indicates students who reside in distant locations in the United States or abroad. Most students (51.8%) live between 101 and 200 miles away from Union College (2012).




Map 5: This is a buffer map of New York and its neighboring states using GIS indicating the distance students travel between their residences and Union College. Most students (51.8%) live between 101 and 200 miles away from Union College (2012).

***2007-2008 Faculty Survey Graphs***

(Appendix F)

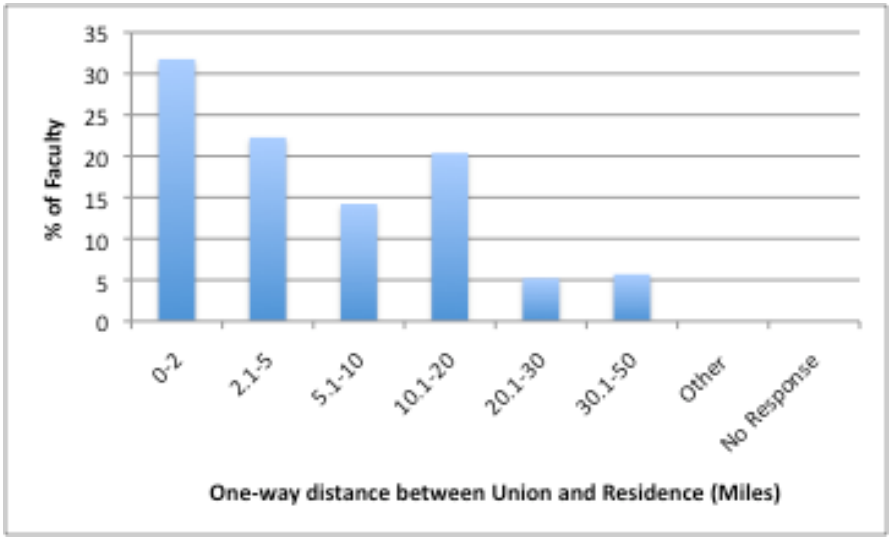



Figure 56: This figure shows the one-way distance between Union College and the homes of faculty members, by percentage. Most faculty members stated that they live within 0 to 2 miles (32%). Many faculty members also stated that they live between 2.1 and 5 miles away (22%) and between 10.1 and 20 miles away (20%). A lesser number of faculty members indicated that they live between 5.1 and 10 miles away (14%) and beyond 20.1 miles away from Union College; 5% lived between 20.1 and 30 miles away and 6% lived between 30.1 and 50 miles away.

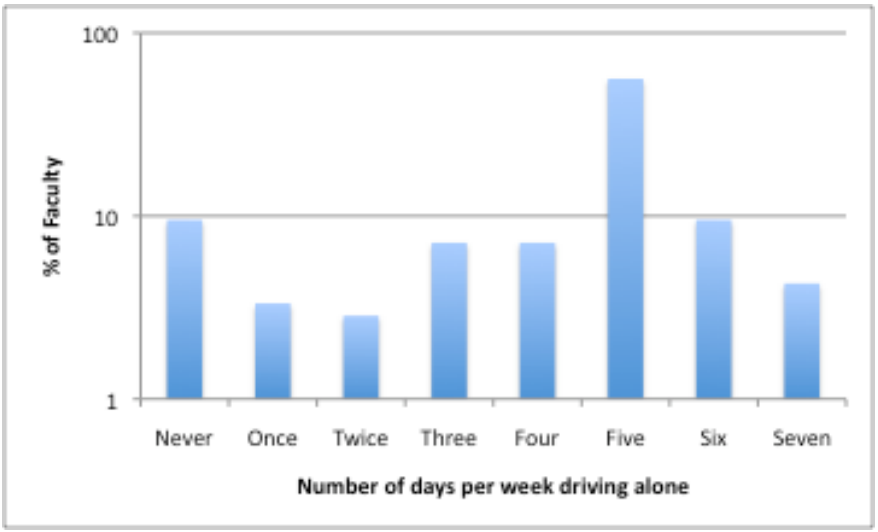



Figure 57: This figure indicated the average number of days per week faculty members drive alone in their personal vehicle on a logarithmic scale. The majority of faculty indicated that they drive alone to campus all five days during the week (56%). The second highest answers recorded by faculty were Never (10%) and six days per week (10%). Driving alone one (3%), two (3%), three (7%), four (7%), and seven (4%) days a week was less common.

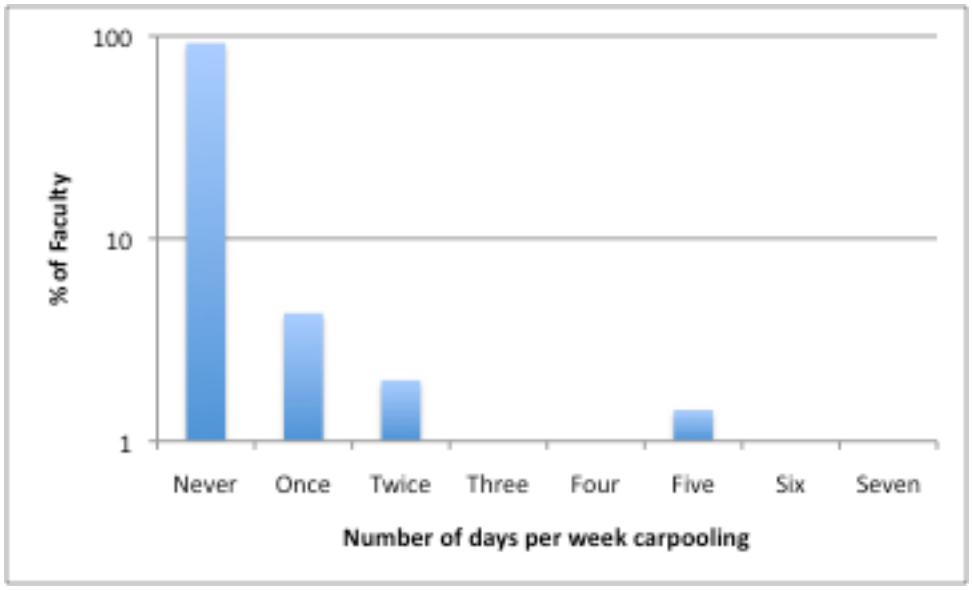



Figure 58: This figure shows how many days per week, on average, do faculty members carpool to the Union College campus on a logarithmic scale. The majority of faculty members stated that they never carpool to campus (92%). The percentage of faculty carpooling on a particular day between one and seven days of the week never exceeded 2% daily.

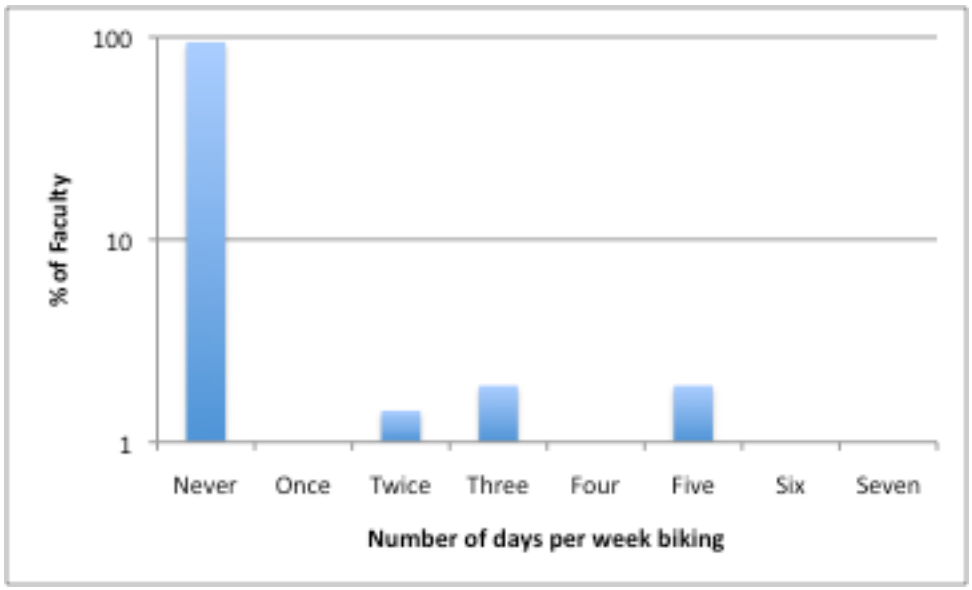



Figure 59: The figure shows how many days per week, on average, do faculty members bike to the Union College campus on a logarithmic scale. The majority of faculty members stated that they never carpool to campus (94%). The percentage of faculty biking on a particular day between one and seven days of the week never exceeded 2% daily.

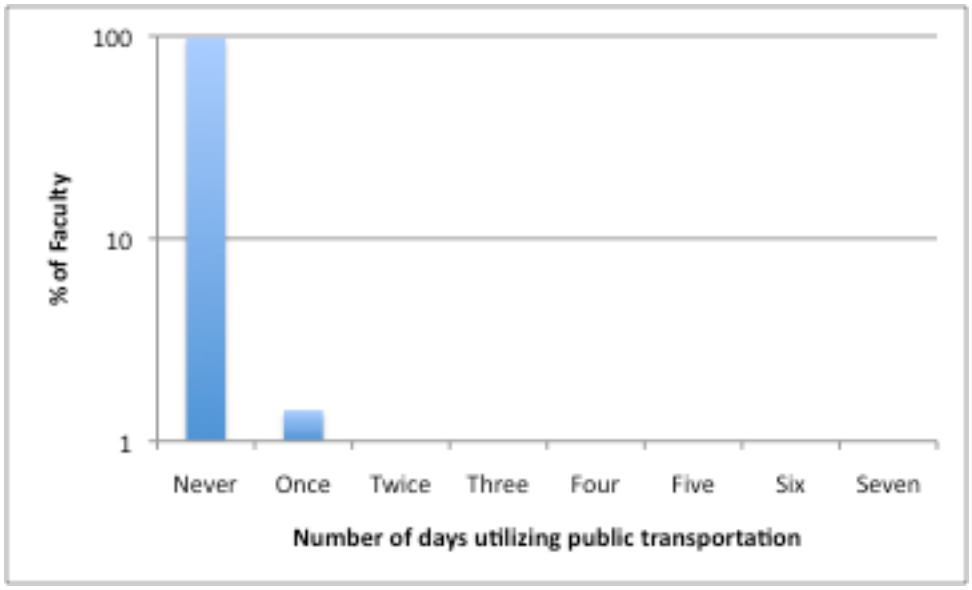



Figure 60: The figure shows how many days per week, on average, do faculty members utilize public transportation to the Union College campus on a logarithmic scale. The majority of faculty members stated that they never utilize public transportation to campus (98.1%). The percentage of faculty utilizing public transportation on a particular day between one and seven days of the week never exceeded 1.4% daily.

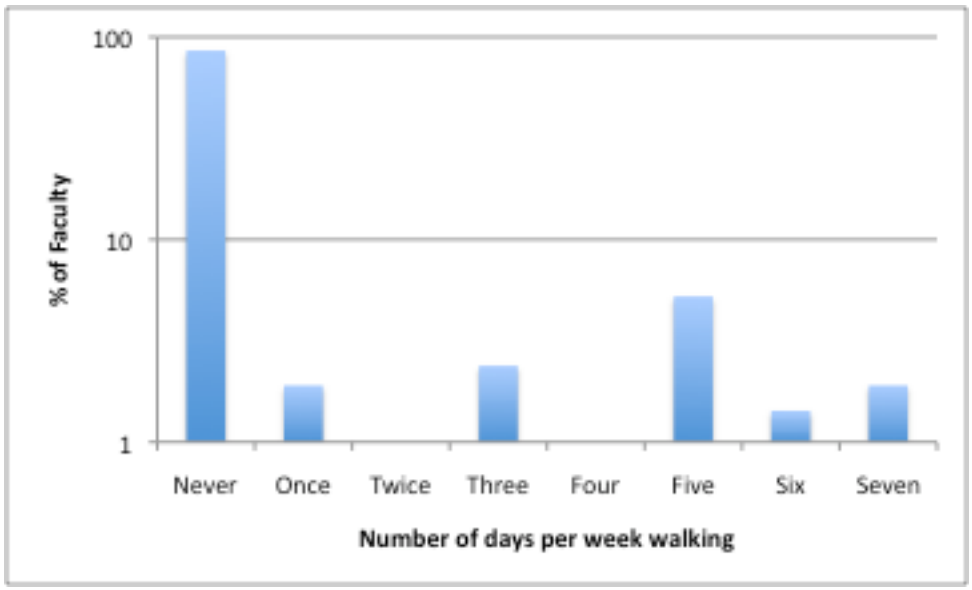



Figure 61: The figure shows how many days per week, on average, do faculty members walk to the Union College campus on a logarithmic scale. The majority of faculty members stated that they never walk to campus (86%). 5% of faculty members indicated that they walk to campus all five days during the week. Besides walking five days a week, the percentage of faculty walking to campus on a particular day between one and four days as well as six and seven days of the week never exceeded 2% daily.

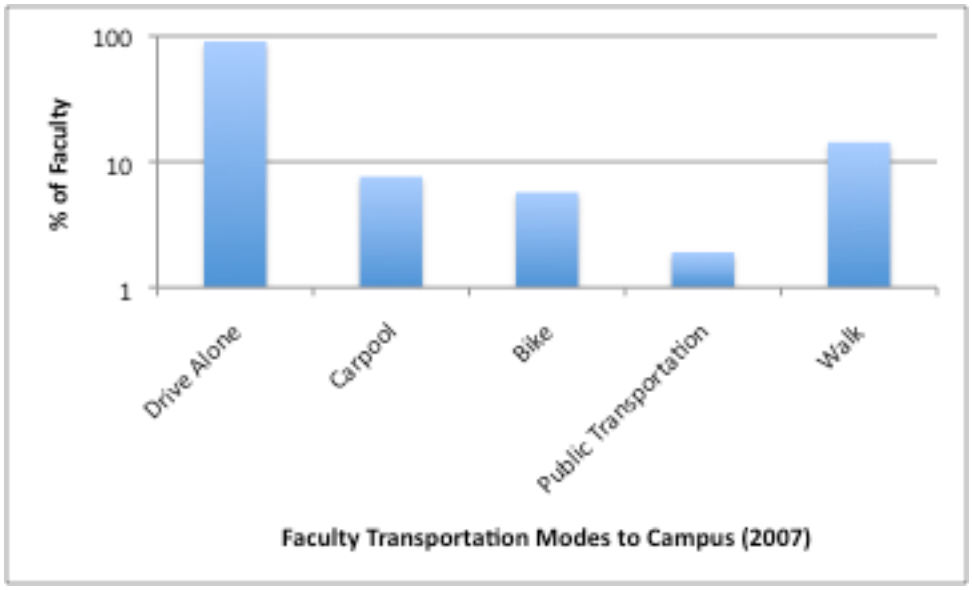



Figure 62: This figure indicates how faculty members commute to the Union College campus, by percentage on a logarithmic scale. The majority of faculty members stated that they drive alone to campus (90%), with walking (14%), carpooling (8%), and biking (6%) well behind driving. Public transportation was the least utilized mode of transportation (2%).

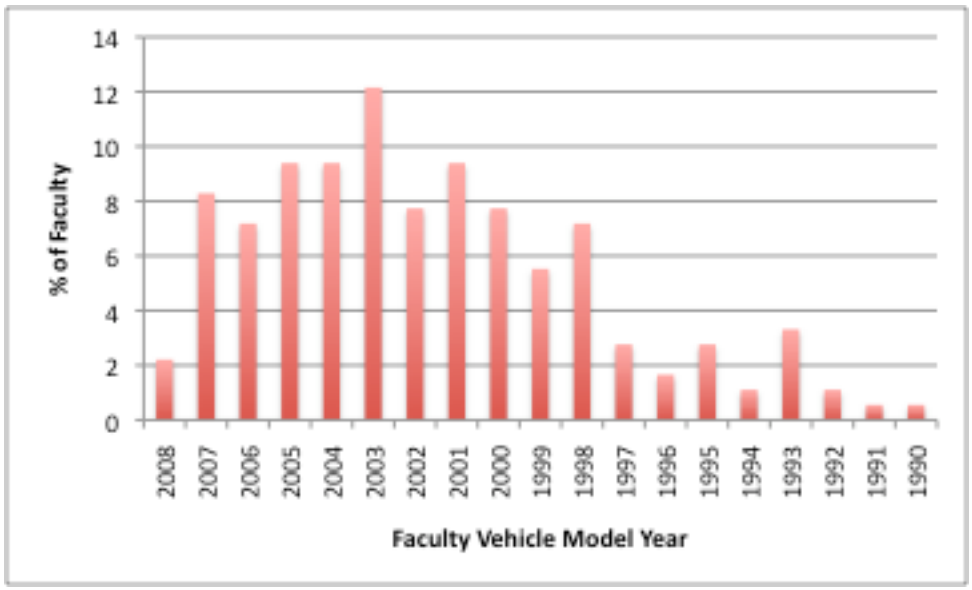



Figure 63: The figure above illustrates the age of the vehicle fleet of faculty members who drive to campus. The greatest percentage of faculty own vehicles produced in 2003 (12.2%) and in 2005 and 2004 (9.39%). The overall average model year for faculty vehicles is 2001.67, which made the average vehicle approximately seven years old. 56% of vehicles owned were above the fleet average while 44% of the vehicles were below the fleet average.

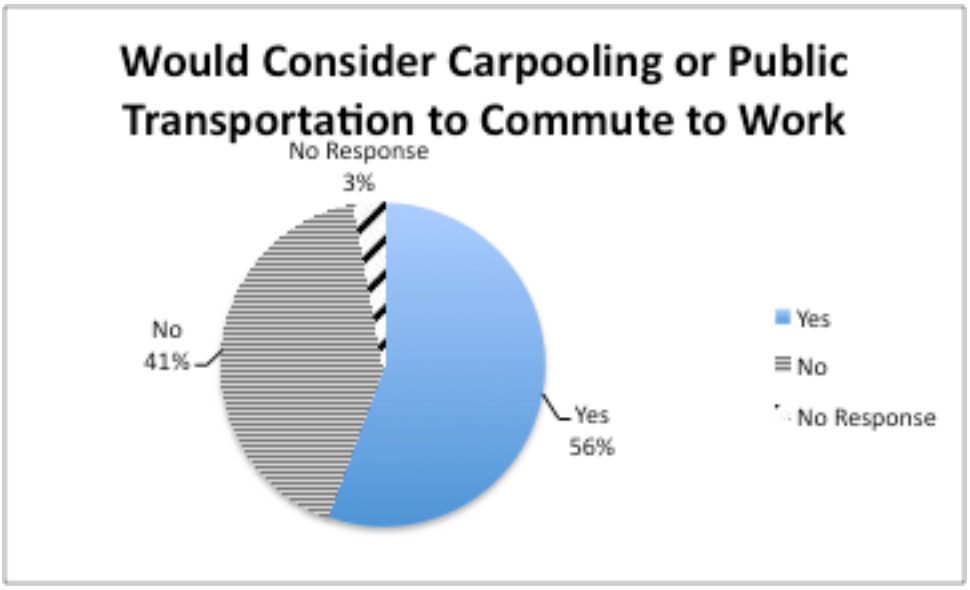



Figure 64: This figure describes whether faculty members would consider carpooling or utilizing public transportation to commute to work. Over half of the faculty states that they would consider using these modes of commuting to work (56%) while 41% stated that they would not consider carpooling or using public transportation. Additionally, 3% of the faculty did not respond to the question.

***2007-2008 Student Survey Graphs***

(Appendix G)

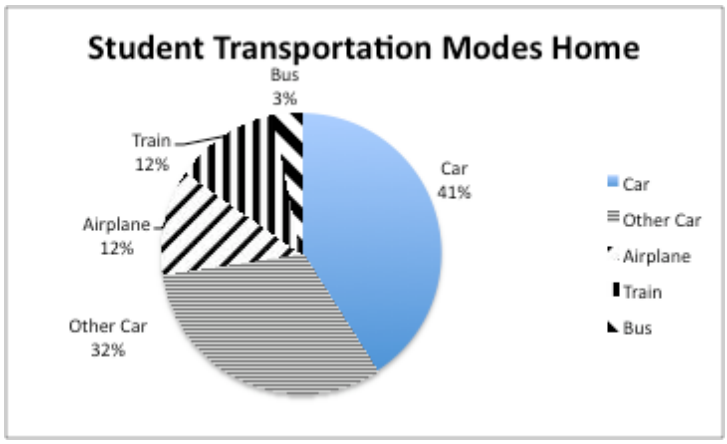



Figure 65: This figure describes the breakdown of the modes of transportation students use to travel home in 2007, by percentage. All 405-student respondents answered this question. The most utilized mode of transportation by students to travel home was via the car they owned on-campus (41%). The second most utilized mode of transportation by students was "Other Car," which could either be the use of a family car or a carpool (32%). These respondents were students who answered the survey with "Personal Car" but did not own a car on-campus. Train (12%) and airplane (12%) were the most utilized public transportation options. Bus was the least used public transportation, as well as the least used option overall (3%).

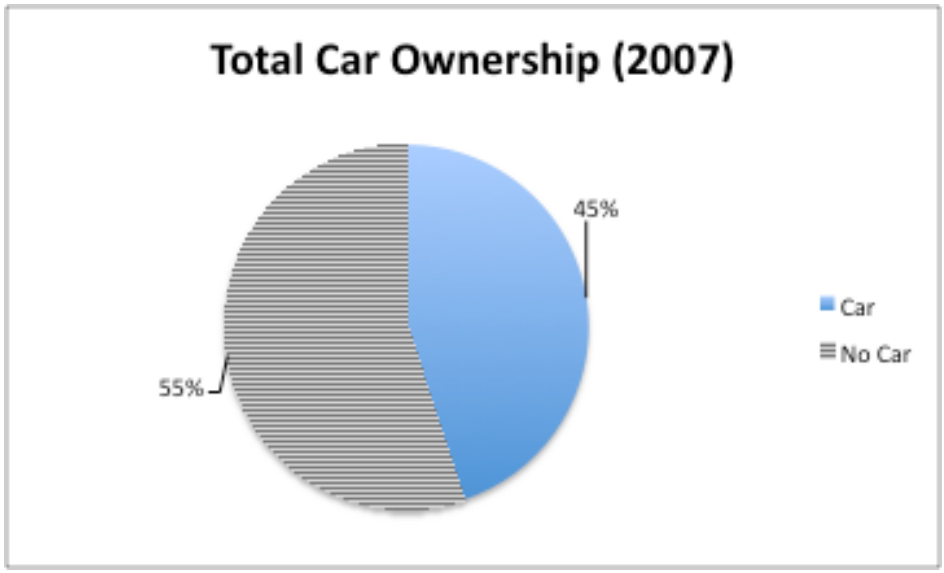



Figure 66: This figure indicates the percentage of car ownership among students in 2007. The survey concluded that more students do not own a car on-campus (55%) than do own a car on-campus (45%). Not all students who stated they had cars on-campus used them to drive home. In total, 182 of 405 students reported that they own a car on-campus.

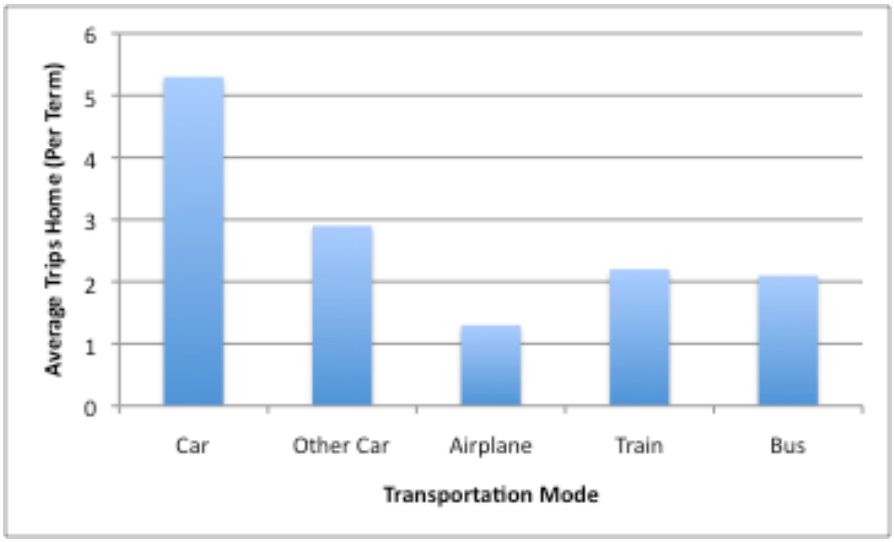



Figure 67: This figure shows the average number of trips home per term by students. Because it was assumed that students did not count their trip before and after each term when responding, one trip was added to each respondent's total. Students who travel home via car, on average took the most trips home per term (5.3). Those who responded with car but did not own a car on-campus were designated as "Other Car" for either traveling home in a family car or carpool (2.9). Trips home per term via train and bus were similar at 2.2 and 2.1 times per term, respectively. The lowest number of trips home was via an airplane (1.3).

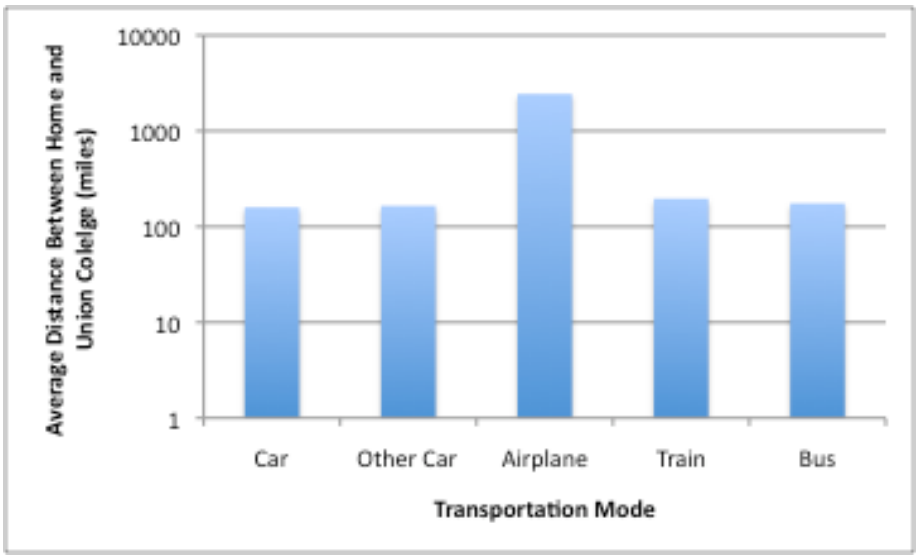



Figure 68: This figure indicates the average distance in miles for students between home and Union College on a logarithmic scale. The overall average distance between a permanent residence and Union College was 626 miles, however, those who utilize an airplane distorted that average. Students who utilized an airplane had the highest average distance between their permanent residence and Union College (2434 miles). Besides those who utilized an airplane, the average distance between home and Union College was fairly flat, as shown in Figure 69.

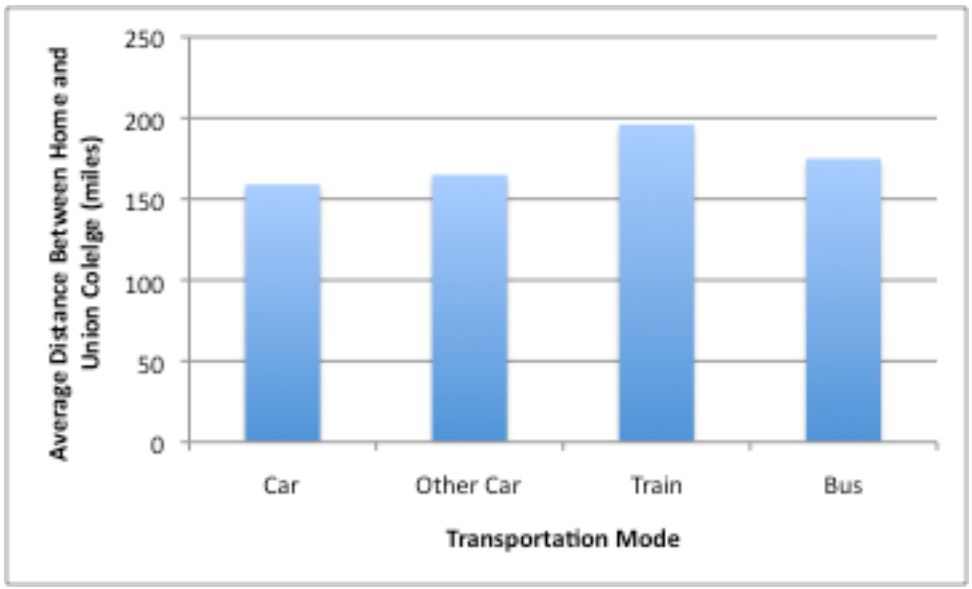



Figure 69: This figure describes the average distance in miles for students between home and Union College, excluding airplane use. The overall average distance between a permanent residence and Union College when excluding airplane use was 174 miles. The utilization of trains (196 mi) and buses (175 mi) occurred when students lived above the average distance while on-campus car (159 mi) and "Other Car," family car/carpool (165 mi) usage occurred when students lived below the average distance.

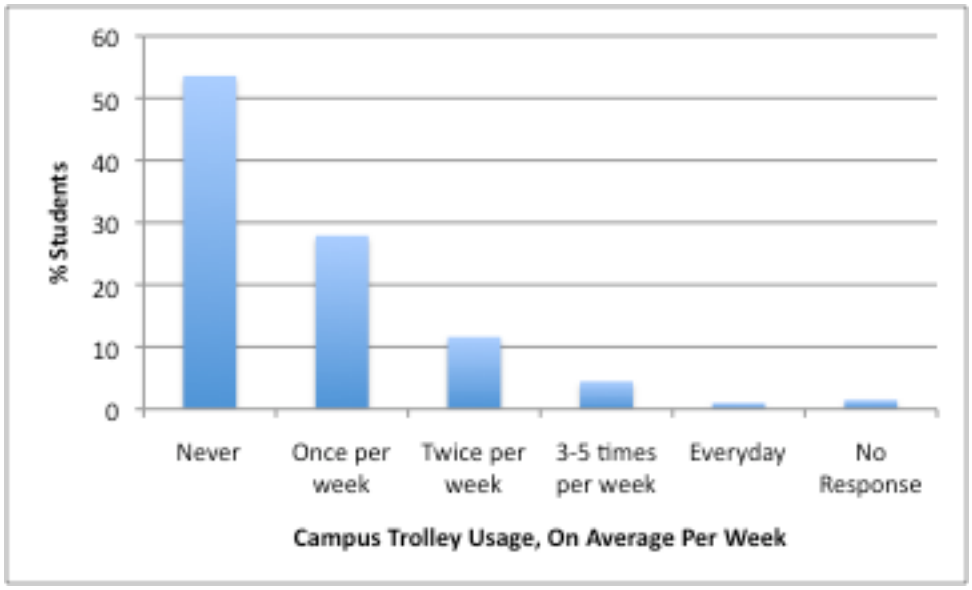



Figure 70: This figure illustrates average campus trolley usage per week, by percentage. The majority of students indicated that they never use the trolley (54%). For those that did use the trolley, they stated that they use it once per week (28%). Trolley usage greater than once per week was low as 12% indicated they used it twice per week, 4% indicated 3-5 times per week, and 1% indicated everyday. 1.5% of students did not respond to the question.

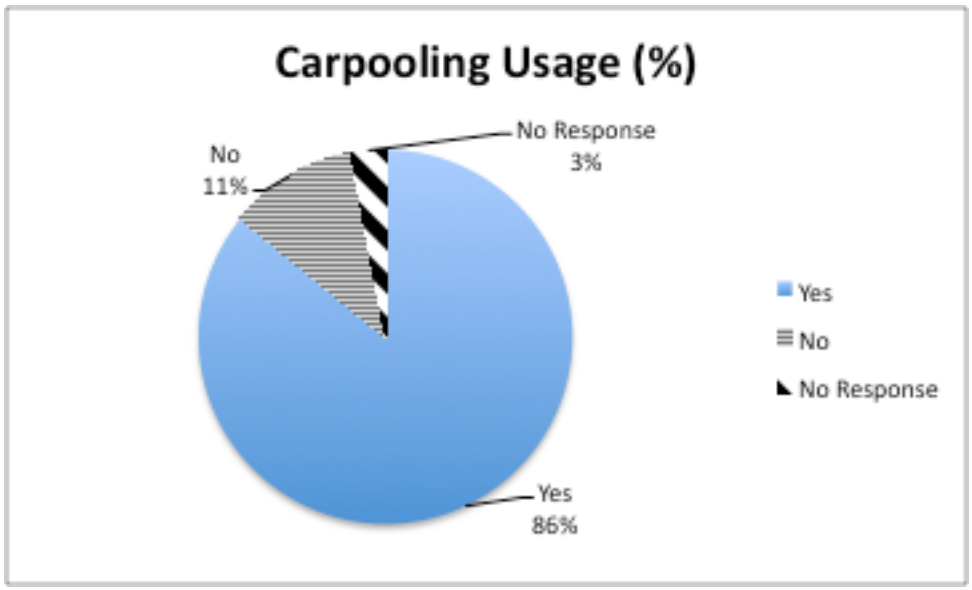
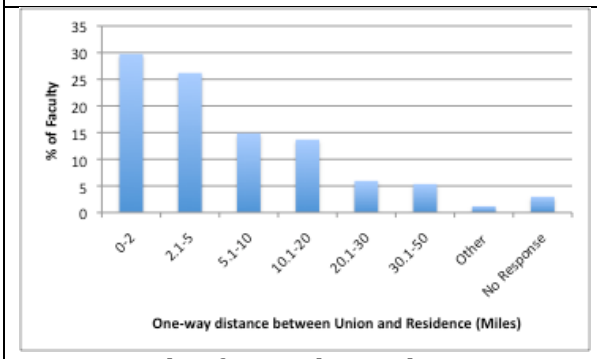
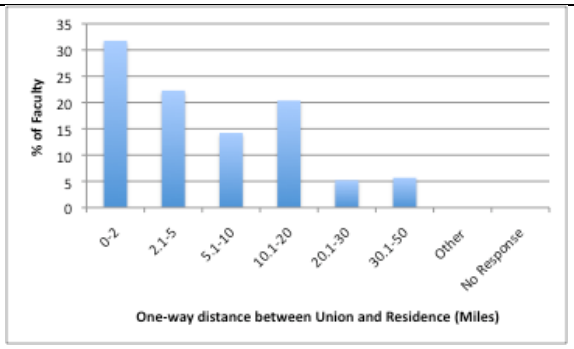
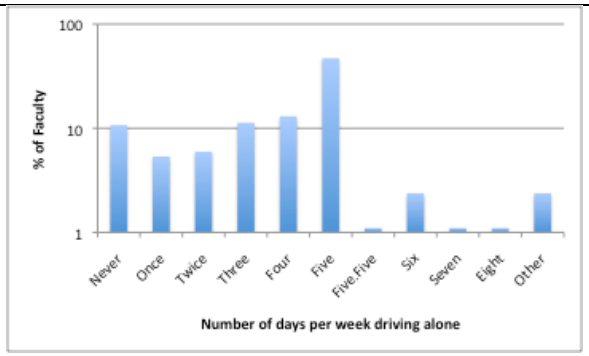
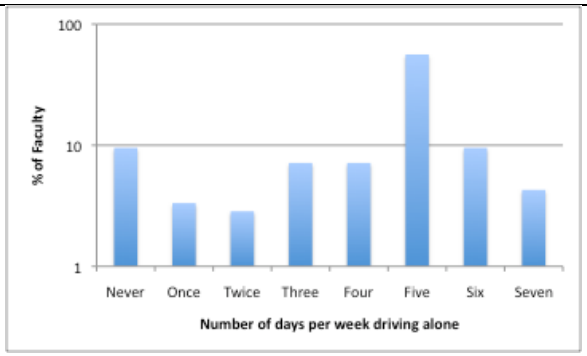
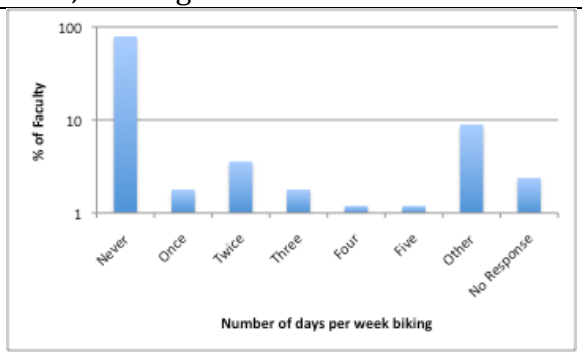
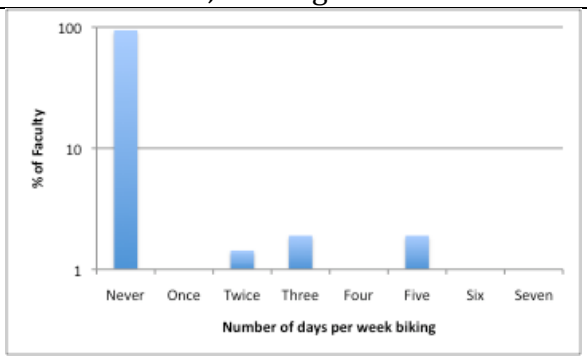



Figure 71: This figure describes carpooling by students among all students who responded to the survey, by percentage. The striped horizontal lines are the percentage of students who do not carpool (11%), the solid color indicates the percentage of students who do carpool (86%), and the striped diagonal lines are students who did not respond to the survey (3%). More students stated that they do carpool than those who stated that they do not carpool.

## *Faculty Survey Comparison: 2007-2008 and 2011-2012*

| 2011-2012 | 2007-2008 |
|---|---|
|  |  |
| Figure 1: This figure shows the one-way distance between Union College and the homes of faculty members in 2011, by percentage. | Figure 56: This figure shows the one-way distance between Union College and the homes of faculty members in 2007, by percentage. |
|  |  |
| Figure 2: This figure indicates the average number of days per week faculty members drive alone in their personal vehicle in 2011, on a logarithmic scale. | Figure 57: This figure indicated the average number of days per week faculty members drive alone in their personal vehicle in 2007, on a logarithmic scale. |
|  |  |
| Figure 5: This figure illustrates how many days per week, on average, do faculty members bike to get to campus in 2011, on a logarithmic scale. | Figure 59: The figure shows how many days per week, on average, do faculty members bike to the Union College campus in 2007 on a logarithmic scale. |

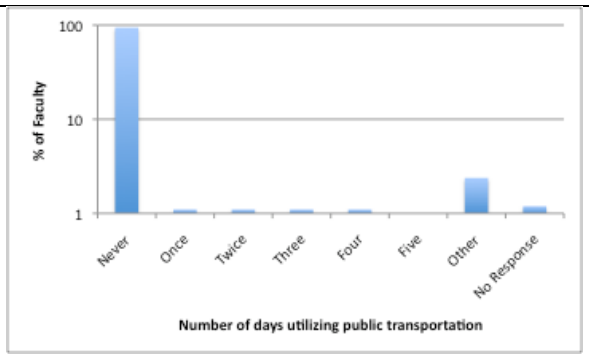



Figure 6: This figure shows how many days per week, on average, do faculty members utilize public transportation to get to campus in 2011, on a logarithmic scale.

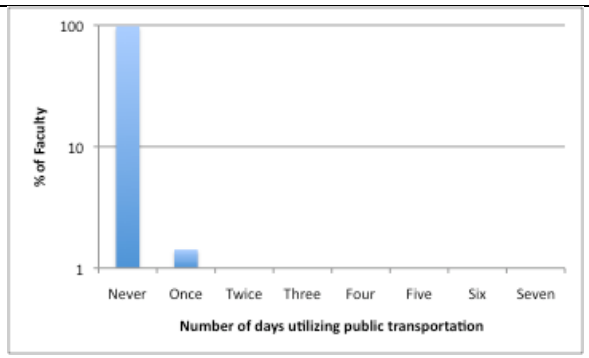



Figure 60: The figure shows how many days per week, on average, do faculty members utilize public transportation to the Union College campus in 2007 on a logarithmic scale.

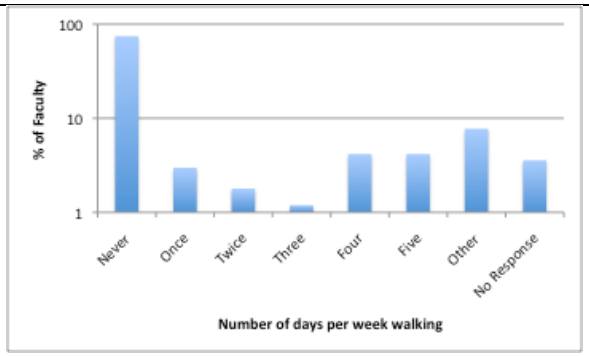



Figure 7: This figure shows how many days per week, on average, do faculty members walk to get to campus in 2011, on a logarithmic scale.

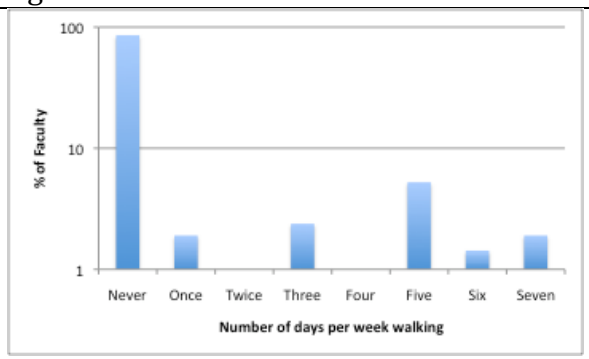



Figure 61: The figure shows how many days per week, on average, do faculty members walk to the Union College campus on a logarithmic scale.

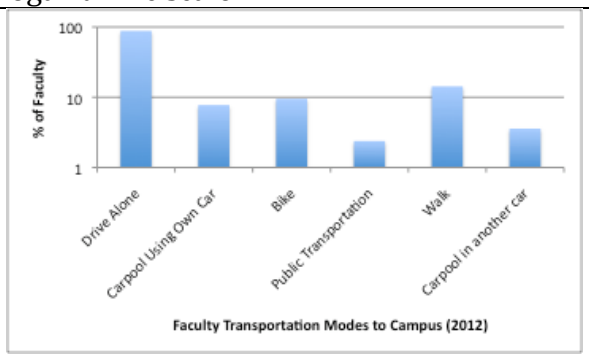



Figure 8: This figure indicates how faculty members commute to the Union College campus in 2011, by percentage on a logarithmic scale.

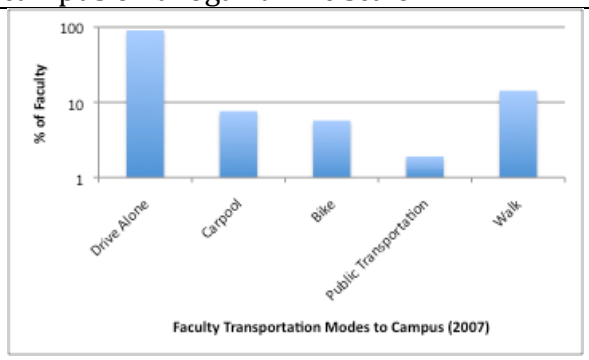



Figure 62: This figure indicates how faculty members commute to the Union College campus in 2007, by percentage on a logarithmic scale.

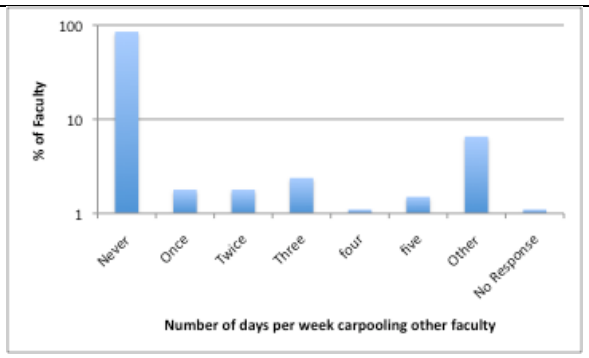



Figure 3: This figure shows how many days per week, on average, do faculty members carpool using their vehicles to get to campus in 2011, on a logarithmic scale.

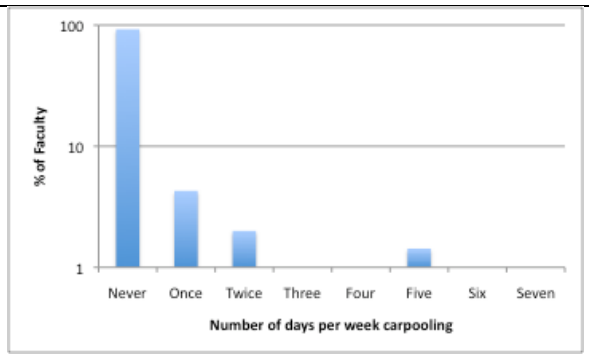



Figure 58: This figure shows how many days per week, on average, do faculty members carpool to the Union College campus in 2007 on a logarithmic scale.

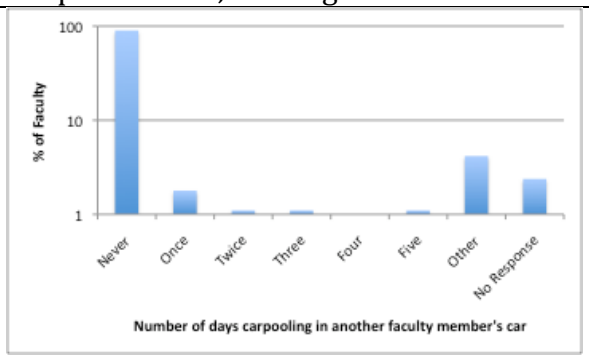



Figure 4: This figure shows how many days per week, on average, do faculty members carpool in another faculty member's vehicle in 2011 to get to campus, on a logarithmic scale.

No similar data was available from the 2007-2008 faculty survey.

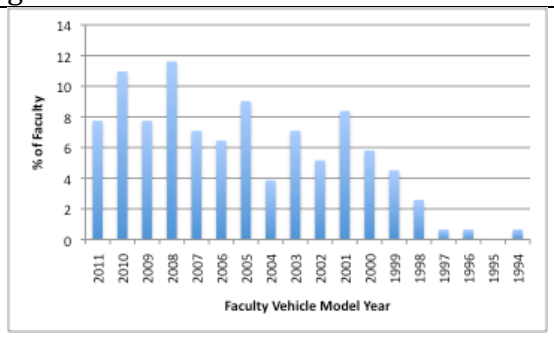



Figure 11: The figure above illustrates the age of the vehicle fleet of faculty members who drive to campus in 2011.

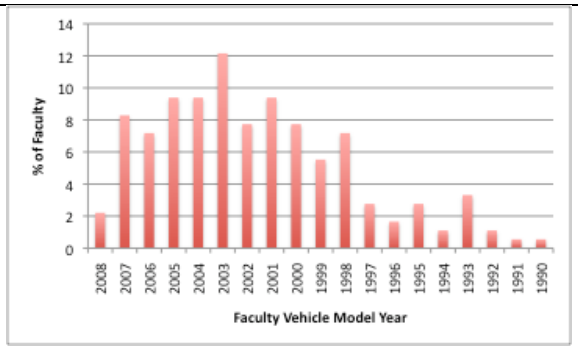



Figure 63: The figure above illustrates the age of the vehicle fleet of faculty members who drive to campus in 2007.

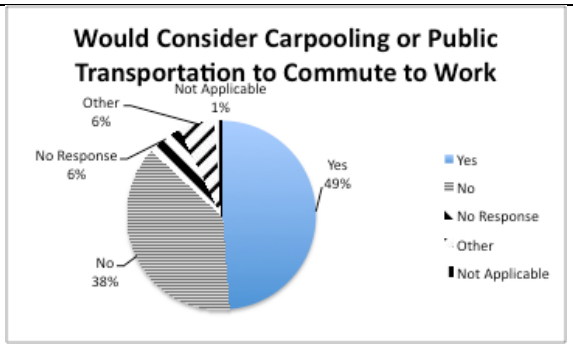



Figure 16: This figure describes whether faculty members in 2011 would consider carpooling or utilizing public transportation to commute to work.

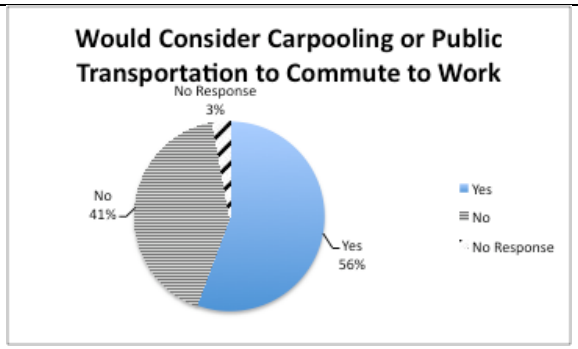



Figure 64: This figure describes whether faculty members in 2007 would consider carpooling or utilizing public transportation to commute to work.

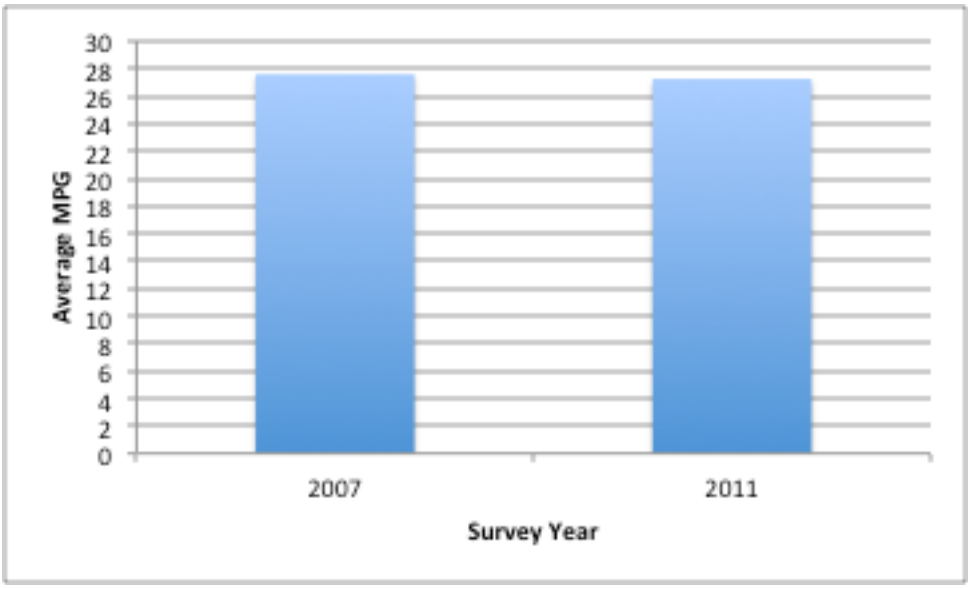
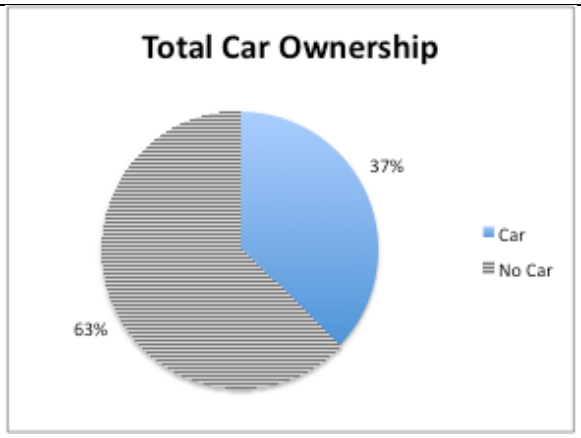
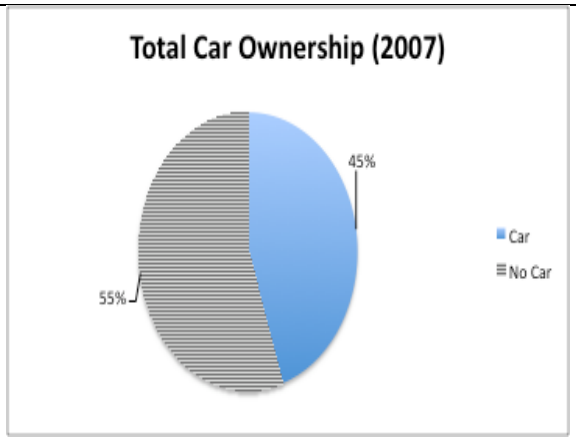
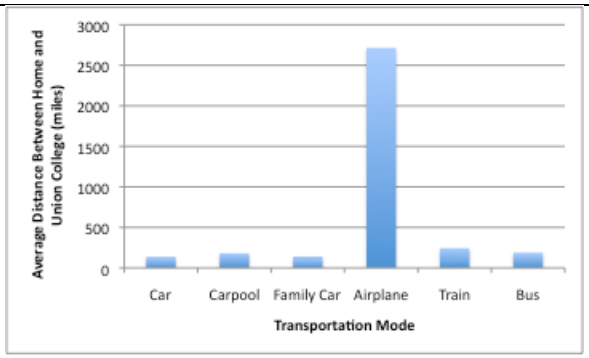
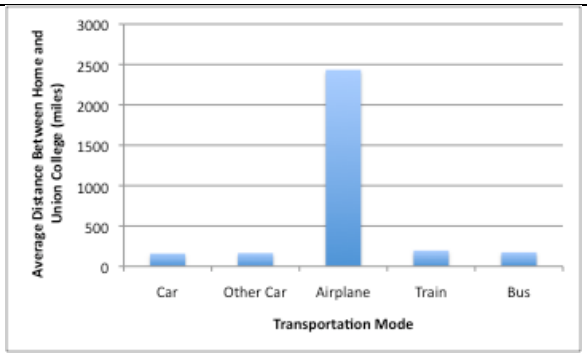
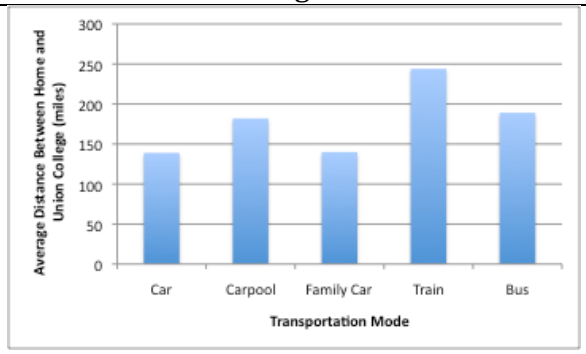
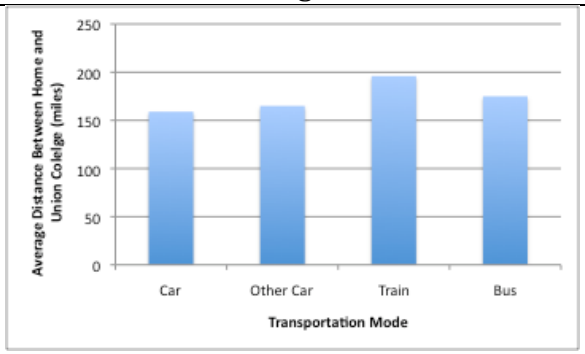



Figure 72: This figure shows the average MPG of the faculty vehicle fleet in 2007 and 2011. The average vehicle MPG for faculty members decreased slightly from 27.6 MPG in 2007 to 27.26 MPG in 2011.

***Student Survey Comparison: 2007-2008 and 2011-2012***

| 2011-2012 | 2007-2008 |
|---|---|
|  |  |
| Figure 18: This figure indicates the percentage of car ownership among students in 2011. | Figure 66: This figure indicates the percentage of car ownership among students in 2007. |
|  |  |
| Figure 35: This figure indicates the average distance in miles for students between home and Union College. | Figure 68: This figure indicates the average distance in miles for students between home and Union College. |
|  |  |
| Figure 36: This figure describes the average distance in miles for students between home and Union College, excluding airplane use. | Figure 69: This figure describes the average distance in miles for students between home and Union College, excluding airplane use. |

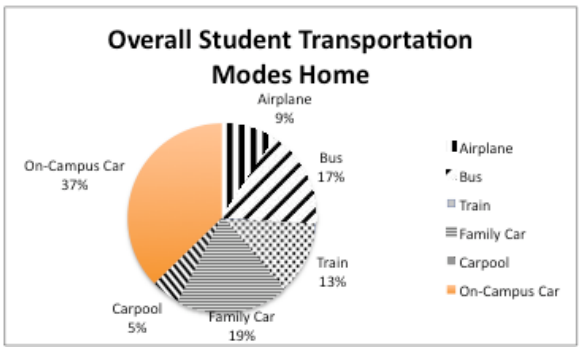



Figure 37: This figure describes the overall breakdown of the modes of transportation students use to travel home in 2011, by percentage.

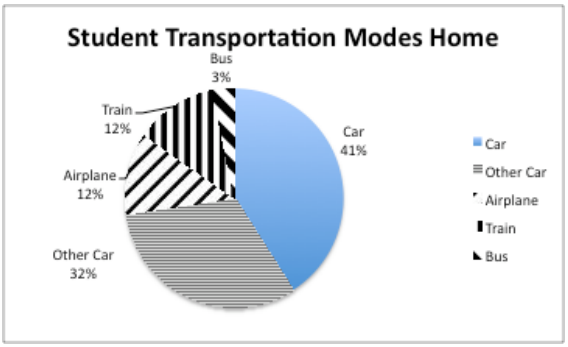



Figure 65: This figure describes the breakdown of the modes of transportation students use to travel home in 2007, by percentage.

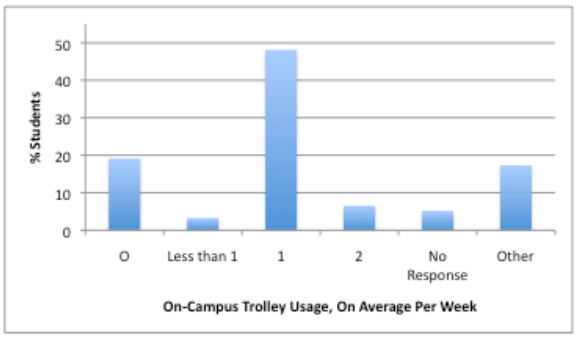



Figure 46: This figure illustrates average on-campus trolley usage in 2011 per week, by percentage.

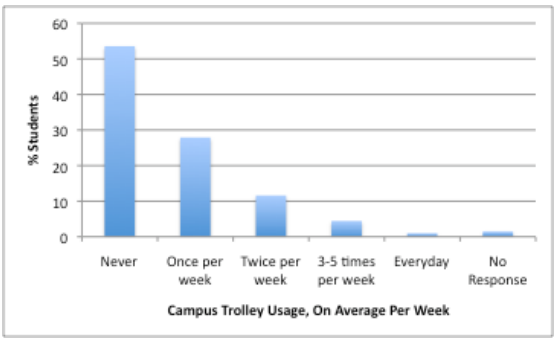



Figure 70: This figure illustrates average campus trolley usage in 2007 per week, by percentage.

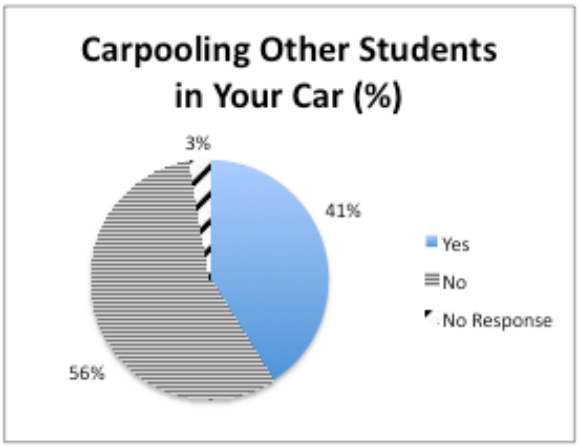



Figure 51: This figure describes carpooling by students who own a car on-campus in 2011 among all students who responded to the survey.

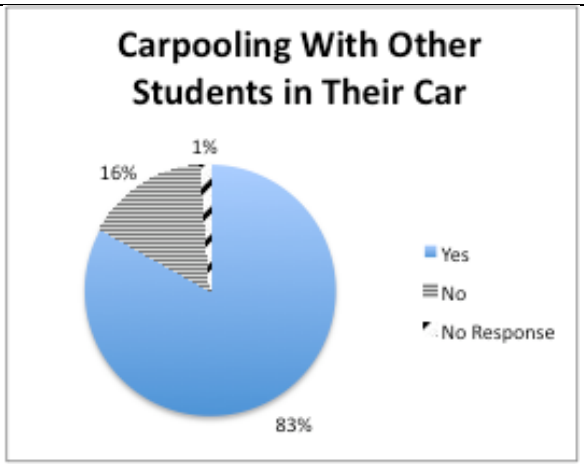



Figure 52: This figure describes carpooling by students in another student's vehicle in 2011 among all students who responded to the survey.

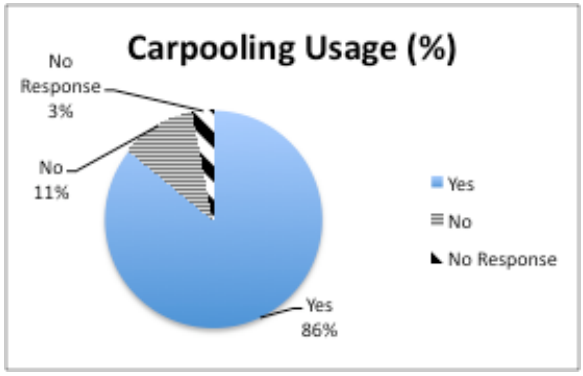



Figure 71: This figure describes carpooling by students among all students in 2007 who responded to the survey, by percentage.

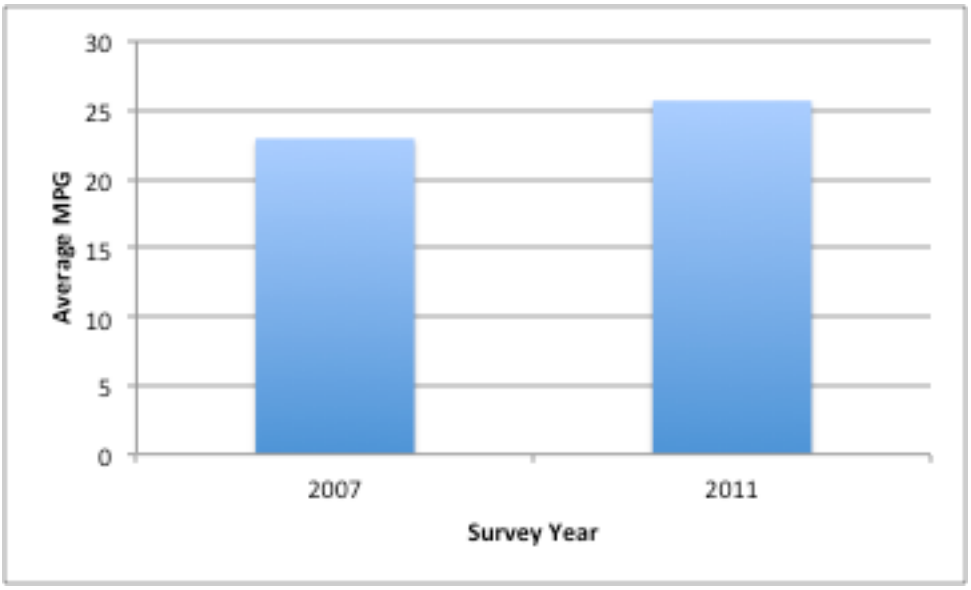



Figure 73: This figure shows the average MPG of the student vehicle fleet for 2007 and 2011, respectively. Average MPG increased from 22.95 MPG in 2007 to 25.69 MPG in 2011, an increase of 11.94%.

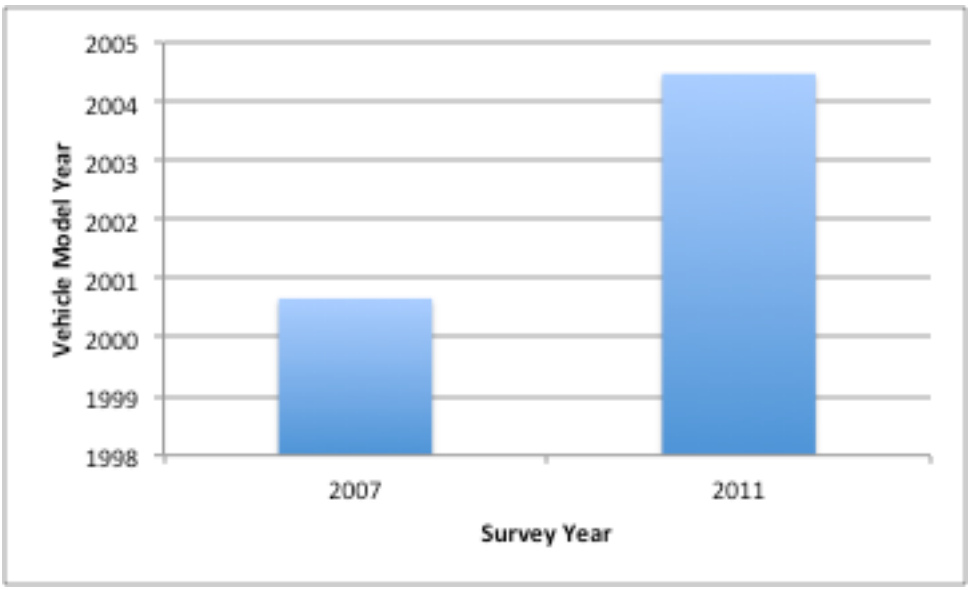



Figure 74: This figure shows the average vehicle model year for students in 2007 and 2011. While average model year increased from 2000.66 in 2007 to 2004.47 in 2011, the average relative age of the vehicle fleet increased from approximately six years old in 2007 to seven years old in 2011.

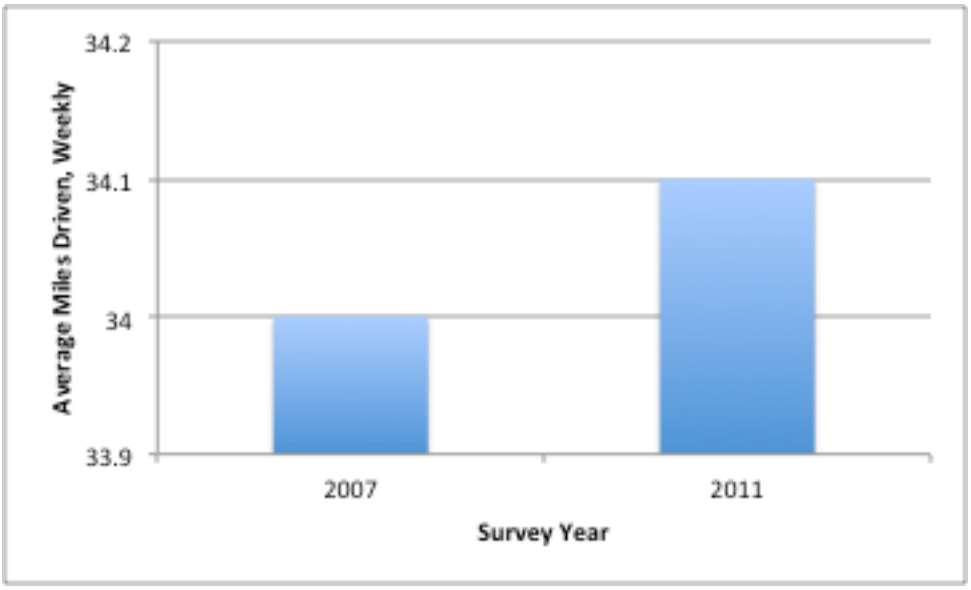



Figure 75: This figure indicates the average miles driven weekly by students in 2007 and 2011. The average miles driven per student weekly increased slightly from 34 miles to 34.1 miles between 2007 and 2011.

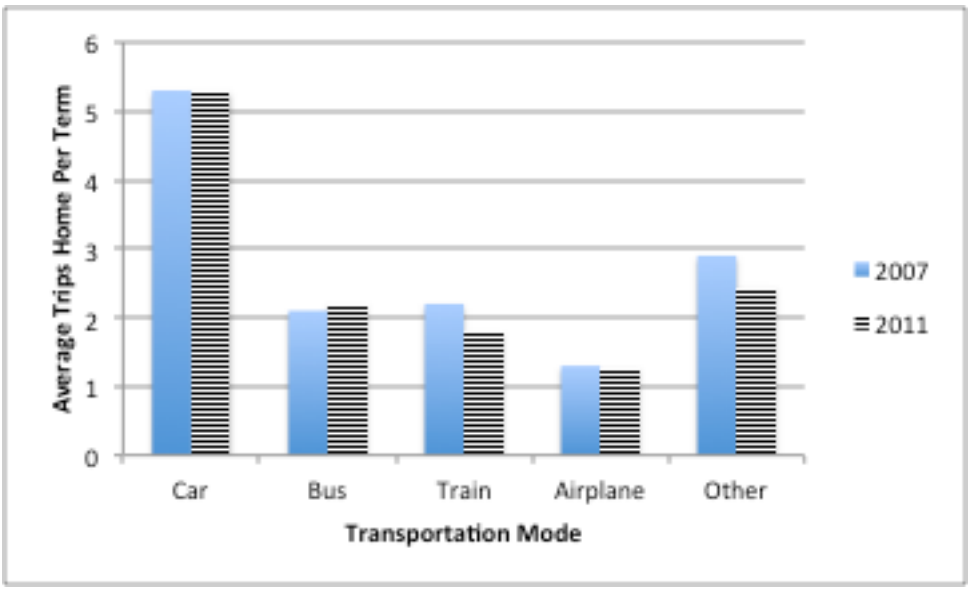



Figure 76: This figure shows the average trips students traveled home per term, separated by transportation mode. Average trips home via personal vehicle was flat at 5.3 for both years. The average trips home per term increased between 2007 and 2011 for bus transportation from 2.1 to 2.2 trips. The average number of trips home via train (2.2 to 1.8) and airplane decreased (1.3 to 1.28) between 2007 and 2011. Other was designated as those who either carpooled or used a family vehicle to travel home. This designation was created because the 2007 survey did not separate them in the data set. The average trips home per term using these transportation modes decreased from 2.9 in 2007 to 2.45 in 2011.

## CARBON EMISSIONS ANALYSIS

### *Introduction to Carbon Emission Conversion Factors*

The movement of Union College students between their permanent homes and the Union College campus has a significant impact on the environment. In order to determine the carbon dioxide emissions, numerous calculations specific to the various modes of transportation were performed. Since the fuel efficiency and usage varies depending on the mode of transportation, an emission conversion factor was incorporated into the formulas to convert miles traveled, kilometers traveled, gallons of gasoline used to kg $CO_2$. The 2007-2008 study conducted by the 2008 Intro to Environmental Science Class used the most up-to-date emissions conversion factors, at that time, as shown in Table 1. Since that study, more accurate emissions conversion factors have been released, as shown in Table 2. The latest emission guide improves the conversion factors by reflecting modern improvements in fuel efficiency and technology, especially in trains and cars. This study recalculated the amount of $CO_2$ emissions for the 2008 Intro to Environmental Science Class dataset in addition to calculating the amount of $CO_2$ emissions for the current survey.

| Mode of Transportation | Base Unit | Conversion Factor | End Unit |
|---|---|---|---|
| Train | Miles | .31 | kg $CO_2$ |
| Bus | Miles | .08 | kg $CO_2$ |
| Airplane | Miles | .19 | kg $CO_2$ |
| Cars | Gallons of Gasoline | 20.7085 | Lbs $CO_2$ |

Table 1: The 2007 emission conversion factors used to determine the amount of carbon emitted by various modes of transportation (These are the factors the 2008 Introduction to Environmental Science Class work used. Car information was found at Dickinson 2007. The other data used was from www.ghgprotocol.org by was not retrievable in the course of this study.)

| Mode of Transportation | Base Unit | Conversion Factor | End Unit |
|---|---|---|---|
| Train | Miles | .185 | kg $CO_2$ |
| Bus | Miles | .107 | kg $CO_2$ |
| Airplane | | | |
| Short Flights <483 km | km | .19 | kg $CO_2$ |
| Medium Flights <1126 km | km | .10 | kg $CO_2$ |
| Long Flights >1126 km | km | .09 | kg $CO_2$ |
| Cars | Gallons of Gasoline | 19.4227 | Lbs $CO_2$ |

Table 2: The 2008 emission conversion factors used to determine the amount of carbon emitted by various modes of transportation (Damassa 2010).

### *Introduction to Student Car Emissions*

To determine the amount of carbon emitted by students via the cars owned on-campus, the study calculated both the amount of travel and emissions as a result of weekly driving as well as driving between Union College and their permanent residences. While the previous study used 20.7085 as a conversion factor from gallons of gasoline to pounds of $CO_2$, the current study utilized the new conversion factor of 19.4227 gallons of gasoline to pounds of carbon. For cars, the formulas to determine $CO_2$ emissions included .45359 kg to convert from pounds to kilograms. When a student reported that they owned a car on-campus and either used it to drive home or drive to local places during the week but did not state their vehicle's MPG, the average MPG of the students who did report was used in their place. The average MPG of student owned cars on-campus was 22.95 miles per gallon in 2007-2008. The average MPG of student owned cars on-campus was 25.69 miles per gallon in 2011-2012. The average MPG of student owned cars on-campus increased by 11.94% between 2007 and 2011.

### *Student Weekly Car Travel Emissions*

The amount of carbon emitted by students during the week via their on-campus vehicle was calculated using the formula below (2008 Introduction to Environmental Science class):

(# of miles per week * 10 weeks * 3 academic terms) x (1/MPG) x (Emissions Conversion Factor) x (.45359 kg)= kg of $CO_2$ emitted

The formula first calculated the distance students traveled in an academic year by multiplying the number of miles driven per week by the ten weeks that consist of a term by three academic terms. This distance was then divided by the vehicle's MPG and multiplied by the emissions conversion factor. The final answer, in pounds of $CO_2$ was then converted to kilograms by multiplying by .45359 kg. This calculation used the total number of miles driven per week as well as the average MPG to determine the average yearly $CO_2$ emissions as a result of weekly driving by students.

In 2007-2008, the average $CO_2$ emitted per academic year by a student, as a result of weekly student driving, was (using the 2008 emissions conversion factors) 394.61 kg while in 2011-2012 the average $CO_2$ emitted per academic year as a result of weekly student driving was (using the 2008 emissions conversion factors) 289.31 kg. Between 2008 and 2012, the average $CO_2$ emitted as a result of weekly student driving decreased by 26.68%.

### *Student Emissions from Traveling Home*

The amount of carbon emitted by students by traveling between their permanent residences and Union College via their on-campus vehicle was calculated using the formula below (2008 Introduction to Environmental Science class):

(Distance home in miles * 2 trips) x (# of trips home per term * 3 terms) x (1/MPG) x (Emissions Conversion Factor) x (.45359 kg)= kg of $CO_2$ emitted

The formula calculated the number of miles driven by multiplying distance by two to account for a roundtrip travel distance. This number was then multiplied by the number of trips made in an academic year. The survey assumed that students did not include their trip before and after each academic term so one was added to the number of trips traveled home per term. The quantity of trips was determined by multiplying the adjusted number of trips by three academic terms. This distance was then divided by the vehicle's MPG and multiplied by the emissions conversion factor. The final answer, in pounds of $CO_2$ was then converted to kilograms by multiplying by .45359 kg.

In 2007-2008, the average $CO_2$ emitted per academic year by students as a result of driving home using their personal vehicle was (using the 2008 emissions conversion factors) 1,048.88 kg. The average $CO_2$ emitted per academic year by students as a result of driving home using their personal vehicle was (using the 2008 emissions conversion factors) 787.81 kg in 2011-2012. Between 2008 and 2012, the average $CO_2$ emitted as a result of driving home decreased by 25.90%.

### *Introduction to Student Emissions from Public Transportation*

For students who do not own a car on-campus, do not carpool, or do not travel home in a family car, there are three forms of public transportation available, train, bus, and airplane to travel between Union College and their permanent residences. Each method of transportation has a different emissions conversion factor that converts distance to kilograms of carbon.

### *Student Emissions from Trains and Buses*

The previous study used .31 as a conversion factor for trains to convert miles to kilograms of $CO_2$ and .08 as the conversion factor for buses to convert miles to kilograms of $CO_2$. The current study utilized the new conversion factor of .185 for buses to convert miles to kilograms of $CO_2$ and .107 for buses to convert miles to kilograms of $CO_2$.

The amount of carbon emitted by students by traveling between their permanent residences and Union College via train and bus was calculated using the formula below (2008 Introduction to Environmental Science class):

(Distance home in miles * 2 trips) x (3 of trips home per term * 3 terms) x (Emissions Conversion Factor) * (.45359 kg)= kg of $CO_2$ emitted

The formula calculated the number of miles each student traveled between Union College and their respective homes by multiplying distance by two to account for a roundtrip travel distance. This number was then multiplied by the number of trips made in an academic year. The survey assumed that students did not include their trip before and after each academic term so one was added to the number of trips traveled home per term. The quantity of trips was determined by multiplying the adjusted number of trips by three academic terms. The distance was then multiplied by the appropriate emissions conversion factor.

In 2007-2008, the average $CO_2$ emitted per academic year by students as a result of train usage was (using the 2008 emissions conversion factors) 452.95 kg. The average $CO_2$ emitted per academic year by students as a result of train usage was (using the 2008 emissions conversion factors) 422.33 kg in 2011-2012. Between 2008 and 2012, the average $CO_2$ emitted as a result of train usage decreased by 6.76%.

In 2007-2008, the average $CO_2$ emitted per academic year by students as a result of bus usage (using the 2008 emissions conversion factors) was 227.41 kg. The average $CO_2$ emitted per academic year by students as a result of bus usage (using the 2008 emissions conversion factors) was 260.54 kg in 2011-2012. Between 2008 and 2012, the average $CO_2$ emitted as a result of bus usage increased by 14.57%.

### *Student Emissions from Airplanes*

The previous study used one conversion factor, .19, for all lengths of flights to convert miles to kilograms of $CO_2$. This study, however, utilized the new emission conversion factors for airplanes, which consisted of three factors, depending on flight length. Short flights (less than 483 km) utilized a factor of .19 to convert kilometers to kilograms of $CO_2$. Medium flights (less than 1126 km) utilized a factor of .10 to convert kilometers to kilograms of $CO_2$ while long flights (greater than 1126 km) utilized a factor of .09 to convert kilometers to kilograms of $CO_2$.

The amount of carbon emitted by students by traveling between their permanent residences and Union College via airplane was calculated using the formula below (2008 Introduction to Environmental Science class):

> (Distance home in miles* 1.609km * 2 trips) x (3 of trips home per term * 3 terms) x (Emissions Conversion Factor) * (.45359 kg)= kg of $CO_2$ emitted

The formula calculated the number of miles each student traveled between Union College and their respective homes by multiplying distance by two to account for a roundtrip travel distance. The distance was converted from miles to kilometers by 1.609.

This number was then multiplied by the number of trips made in an academic year. The survey assumed that students did not include their trip before and after each academic term so one was added to the number of trips traveled home per term. The quantity of trips was determined by multiplying the adjusted number of trips by three academic terms. The distance was then multiplied by the appropriate emissions conversion factor, depending on flight distance.

In 2007-2008, the average $CO_2$ emitted per academic year by students as a result of airplane usage (using the 2008 emissions conversion factors) was 1,797.66 kg. The average $CO_2$ emitted per academic year by students as a result of airplane usage (using the 2008 emissions conversion factors) was 3,229.83 kg in 2011-2012. Between 2008 and 2012, the average $CO_2$ emitted as a result of airplane usage increased by 79.66%.

***Student Emissions Summary***

| Mode of Transportation | Average $CO_2$ Emissions, 2007 Conversion Factors (kg) | Average $CO_2$ Emissions, 2008 Conversion Factors (kg) |
|---|---|---|
| Car (Traveling Home) | 1,118.31 | 1,048.88 |
| Car (Weekly Travel, excluding trips home) | 420.72 | 394.61 |
| Bus | 170.03 | 227.42 |
| Train | 758.99 | 452.95 |
| Airplane | 3,767.86 | 1,797.66 |
| | | |
| Total Car Average | 769.51 | 721.75 |
| Total Overall Average | 1247.32 | 784.30 |

Table 3: Student emissions by mode of transportation, 2007-2008.

| Mode of Transportation | Average $CO_2$ Emissions, 2007 Conversion Factors (kg) | Average $CO_2$ Emissions, 2008 Conversion Factors (kg) |
|---|---|---|
| Car (Traveling Home) | 839.99 | 787.81 |
| Car (Weekly Travel, excluding trips home) | 308.46 | 289.31 |
| Bus | 194.79 | 260.54 |
| Train | 707.692 | 422.33 |
| Airplane | 4,418.44 | 3,229.83 |
| | | |
| Total Car Average | 574.23 | 538.56 |
| Total Overall Average | 1293.87 | 997.96 |

Table 4: Student emissions by mode of transportation, 2011-2012.

### *Faculty Car Emissions*

The majority of faculty members utilize their personal vehicle to commute from their homes to Union College. To determine the amount of $CO_2$ emitted by faculty members as result of their car usage, the total distance driven in an academic year and vehicle MPG were utilized. Both the 2007-2008 and the 2011-2012 survey did not determine the annual average public transportation use. The study utilized the same $CO_2$ emissions factors as used for student vehicles. When a faculty member reported that they drove a car to commute to campus but did not state their vehicle's MPG, the average MPG of the faculty members who did report was used in their place. The average MPG of faculty vehicles was 27.6 miles per gallon in 2007-2008. The average MPG of faculty vehicles was 27.26 miles per gallon in 2011-2012. The average MPG of faculty vehicles decreased 1.23% from 2007 to 2011.

The amount of carbon emitted by faculty members traveling between their permanent residences and Union College via their personal vehicles was calculated using the formula below (2008 Introduction to Environmental Science class):

(# of days per week faculty drive) x (roundtrip distance in miles to campus each day) x (36 weeks per year) x (1/MPG) x(Emissions Conversion Factor) x (.4535 kg)= kg of $CO_2$ emitted

The formula calculated the number of miles each faculty member traveled between Union College and their respective homes by multiplying the number of days per week they drove by the roundtrip distance traveled. This distance was then multiplied by 36 weeks to determine the distance traveled via car during an entire academic year. 36 weeks was used to account for the ten weeks during the academic term as well as the week before and after each term. This distance was then divided by the vehicle's MPG and multiplied by the emissions conversion factor. The final answer, in pounds of $CO_2$ was then converted to kilograms by multiplying by .45359 kg.

In 2007-2008, the average $CO_2$ emitted per academic year by faculty members as a result of driving between their home and Union College using their personal vehicle was (using the 2008 emissions conversion factors) 1,020.50 kg. The average $CO_2$ emitted per academic year by faculty members as a result of driving between their home and Union College using their personal vehicle was (using the 2008 emissions conversion factors) 824.14 kg in 2011-2012. Between 2008 and 2012, the average $CO_2$ emitted as a result of driving between their home and Union College decreased by 19.24%.

| Mode of Transportation | Average $CO_2$ Emissions, 2007 Conversion Factors (kg) | Average $CO_2$ Emissions, 2008 Conversion Factors (kg) |
|---|---|---|
| Car | 1088.1 | 1020.50 |

Table 5: Faculty emissions from personal vehicle use, 2007-2008.

| Mode of Transportation | Average $CO_2$ Emissions, 2007 Conversion Factors (kg) | Average $CO_2$ Emissions, 2008 Conversion Factors (kg) |
|---|---|---|
| Car | 878.7 | 824.14 |

Table 6: Faculty emissions from personal vehicle use, 2011-2012.

## DISCUSSION AND RECOMMENDATIONS

### *Introduction to Recommendations*

The sustainability efforts in regards to lessening the emissions from transportation sources at Union College have had mixed results over the past four years. Since 2007-2008, Union College students are emitting, for the most part, less carbon dioxide as a result of personal vehicle and train use. However, since 2007-2008, emissions of $CO_2$ by Union College students have increased through airplane and, to a lesser extent, bus use. As a result of these increases in $CO_2$ emission from airplane and bus transportation, the overall average $CO_2$ emissions per student annually has increased from 784.30 kg to 997.96 kg, an increase of 27.24%. While overall average $CO_2$ emissions per student annually has increased over this time period, the overall average $CO_2$ emissions per student in terms of personal vehicle use has decreased by 25.38% (Figure 3 and 4).

The mixed emissions results and the data gathered regarding Union College trolley usage, carpooling, and traveling behavior suggest that the College is not portraying a clear sustainability message to the greater campus community. In order for policy recommendations to reduce emissions to be successful, particularly in the transportation sector, there needs to be campus-wide understanding and involvement of the plan. Union College has two active environmental organizations on campus, U-Sustain and the Environmental Club, as well as an environmentally conscious theme house, Ozone House. In addition, Union College President Stephen Ainlay's Presidential Green Grant program has contributed funding to campus projects and studies with the overall goal of reducing Union College's environmental impact.

Despite the efforts of these organizations and opportunities on the Union College campus, the survey results do not indicate that there is a widespread effort to consciously reduce carbon emissions by students or faculty members. When asked what would make you more likely to carpool or use public transportation, one faculty member stated, "The expression of serious dedication to the reduction of carbon emissions by the college." Considering such sentiment, the organizations on campus that are active in environmental issues, as well as the Union College Administration, should take a closer look at how students and faculty members travel on and off-campus. This study proposes various policy recommendations to create a reduced carbon transportation system. While there is little support or incentive behind reducing automobile use, it is important to remember that just because it does not exist, does not mean it can't successful in the future as Toor and Havlick suggested, "No college or university campus is an island. The degree to which the college community uses alternate modes of transportation is influenced by the availability of transportation options other than an automobile" (Toor and Havlick 2004, 26). However, if there is no student or faculty interest among environmentalists on campus in the future, it will be hard to get the support of the greater campus community to level where the College could study or implement new systems.

While Union College has a small campus population, students and faculty can have a large impact on both the campus community as well as Schenectady. A study conducted by Balsas argues that colleges must be instrumental in sustainable transportation development, "Due to their pro-active educational milieu, college campuses are privileged places to communicate sustainability and to help reshape society's transportation patterns"

(Balsas 2003, 36). Furthermore, these institutions should be aware of their impact on society today and in the future in terms of sustainability practices due to their educational responsibilities, "the college's potential to affect not only the transportation behavior of the campus population in the present but also the transportation habits and environmental awareness that students will develop in the long term as 'they will progress to occupy influential roles in government, companies, or other organizations" (Balsas 2003, 37).

Sustainable transportation involves various systems of transit, including, but not limited to, personal vehicles, buses, trains, bicycles, and walking. Transportation systems can be deemed as sustainable if they can be effective over a long period of time, "…one that satisfies current transport and mobility needs without compromising the ability of future generations to meet their own" (Balsas 2003, 37). In this chapter, various problems and their corresponding policy recommendations will be presented. These recommendations vary from being shovel-ready (projects that can take place immediately) to occurring in the future with the proper support.

### *Educating the Campus Community*

In order to sustainable transportation systems to be successful at Union College, the campus community needs to be better informed of the different options available. Many students indicated that they do not use the campus trolley system because they do not understand how it works and when it works. Furthermore, both students and faculty stated that they would be more likely to carpool if there were a common destination between

individuals or a service to connect carpool matches. Solutions to these situations will be discussed later, however, these issues are information-based.

A higher level of education and awareness can be achieved though increased advertising on campus. Transportation should be as heavily promoted on campus as recycling is currently. There are numerous reminders of the importance of recycling through visuals (recycling bins), special events (the Environmental Club's annual trash audit), and information (signs indicating what is recyclable). Throughout the winter 2012 term, there has been a focus on the negative impact of bottled water in which there have been special events, visuals, and informational posters. Extending this strategy to transportation through constant reminders of sustainable transportation practices, what types of transportation the College offers, and why it is important to reduce transportation emissions would be significant if it resulted in an impact similar to past environmental campaigns on-campus.

Transportation options would be more easily understood if there were clear and direct routes to popular and important destinations. One study stated that students often indicate that they need a car on-campus to travel to destinations, however, if there were easy to read maps and materials, more students would take an alternate mode of transportation as indicated by Toor and Havlick, "If easily read maps show how to walk, bike, or take the bus to a local attraction, a large number of students and staff will use alternate modes in good weather" (Toor and Havlick 2004, 143). Currently, if students or faculty members want to acquire information regarding alternative transportation modes, they need to make an effort search for it via the Union College website.

If Union College is serious about improving sustainability awareness and alternative transportation programs, then the College should ensure that the programs have a significant presence both on-campus and on the College's website. Currently, transportation information, including the trolley schedule and route can be found on the Union College Campus Safety website while sustainability information can be found on a community information sub-listing on the main website. The sustainability page, however, was a static page that lacked information about what is occurring on a daily basis to reduce environmental impacts (Figure 77). There is also a sustainability sub-page on the President's page on the main Union College website (Union College Presidential Initiatives 2011). In addition, the Environmental Science, Policy, and Engineering program (ESPE) maintains a website highlighting sustainability efforts at Union, as early as 2009 (Figure 78). This page links to another sustainability page hosted by U-Sustain (Figure 79). In order to make sustainability as simple and easy to understand and access as possible, there should be one, central location where a member of the Union College community can get real-time information and continuous feed.

An improved sustainability website should include the College's Climate Action Plan, a list of on-going sustainability projects on campus, information regarding transportation both on and off-campus, and maps. It should also contain the goals set forth by the College as well as data regarding energy and transit use. The website should be an interactive portal where students and faculty members can learn more about various campus initiatives and how they can get involved. With the widespread use of smart phones today,

an app (application) specifically developed to supply sustainability information on hand-held devices can make a difference and help further sustainability efforts on campus.

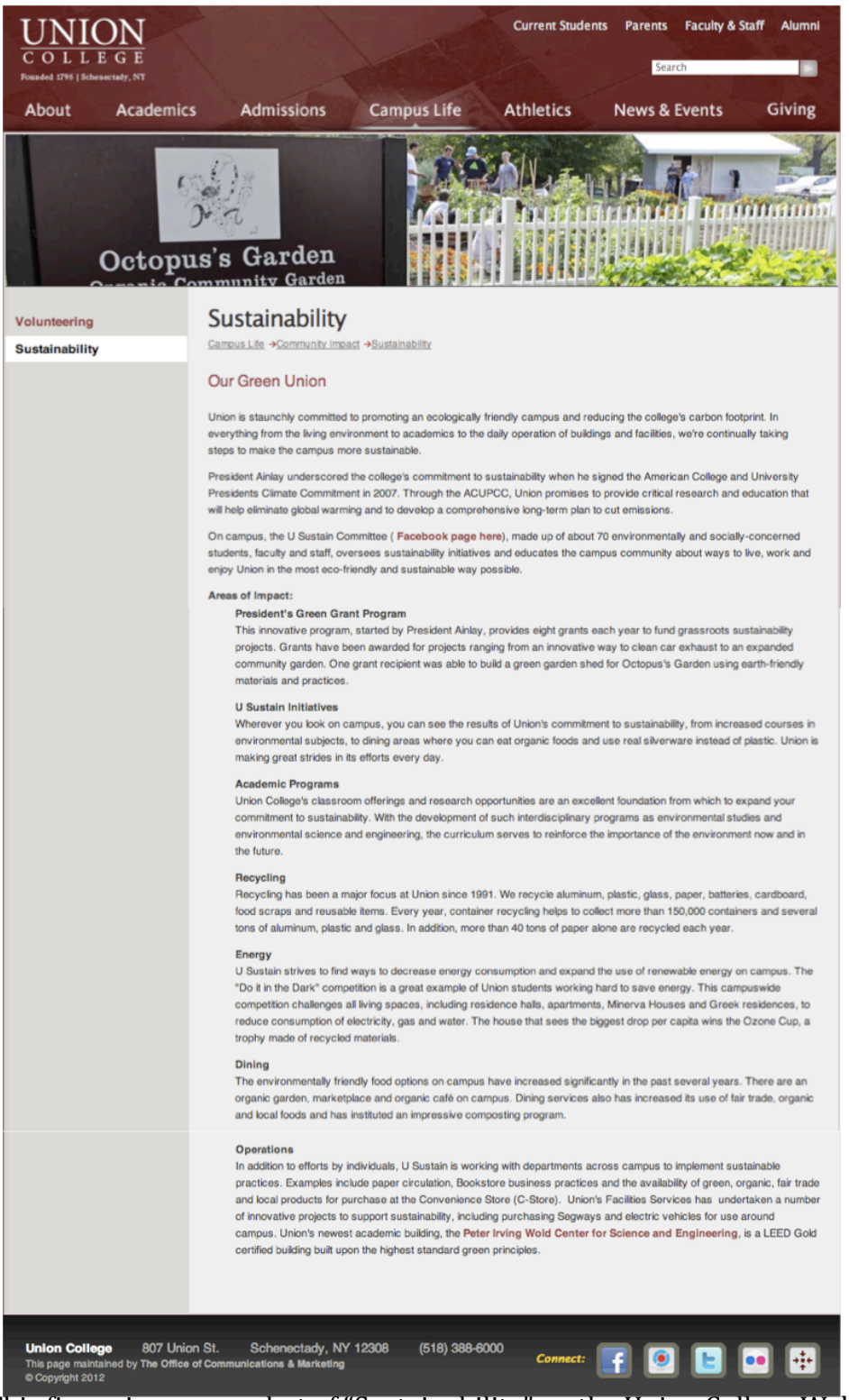


Figure 77: This figure is a screenshot of "Sustainability" on the Union College Website (http://www.union.edu/campus/community/sustainability/index.php) that is maintained by the Office of Communications and Marketing.


Figure 78: This figure is a screenshot of "Sustainability at Union College" (minerva.union.edu/env/sustainability.html), a website maintained by the Union College Geology Department.

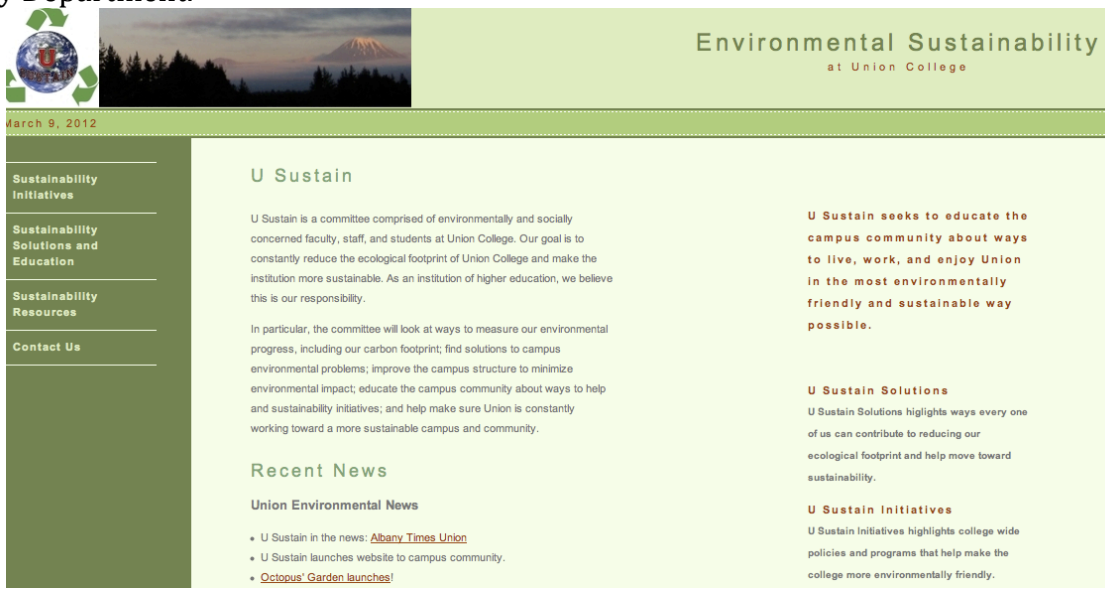



Figure 79: This figure is a screenshot of "U-Sustain" (http://www.vu.union.edu/~sustain/), the website describing the group's news and activities.

### *Improving Campus Governance*

In order for the proposed recommendations to be successful, campus student and faculty leaders need to make an effort to support projects that reduce the College's carbon emissions. It is in Union College's best financial and health interest to support no and low-carbon initiatives. Because many of the proposed solutions require a change in transportation culture on campus and may be unpopular, campus leaders should be looking toward the future while considering transportation on and off-campus as stated by Toor and Havlick, "[An] important factor that influences transportation choices and policy is the philosophy of transportation priorities held by student leadership and the governing body of the institution. If a campus student council or other student leadership group…demonstrates the need for more efficient mobility, the faculty and administration can be encouraged to support changes" (Toor and Havlick 2004, 24).

In order to decrease vehicle emissions, Union College should consider walking and biking as more important than traditional single-occupancy travel methods, "College administrators rarely consider bicycle and pedestrian planning to its full extent, and that more can be done to integrate nonmotorized modes in the alternative transportation package" (Balsas 2003, 36). Students, faculty, and administrators can deem pedestrians and bicyclists a greater priority by providing both financial and logistical support. These groups need to lead by example and push fellow students and colleagues to change their transportation behavior. Unfortunately, over the past four years, little has been accomplished in lowering vehicle use on-campus. Union College is fortunate that vehicle efficiency and technology have improved, thus increasing the average MPG.

Aside from the environmental and financial aspects of no and low-carbon emitting transportation planning, students, faculty, and administrators should treat transportation as an educational opportunity. These interest groups enter the college environment with prior transportation knowledge, but through education, they can all learn about the alternatives, as suggested by Louis Roscoe, "The idea that 'a student's education is the sum of his experiences in and out of the classroom,' a tenet of the last fifty years, has been used to lobby for improved residential life, social interactions and extracurricular activities" (Roscoe 2000, 2).

### *Reducing Student Vehicle Emissions*

Student vehicle emissions, on average, decreased between 2007-2008 and 2011-2012, however, weekly miles driven did not change. Emissions only decreased as a result of improved technology in vehicles leading to a higher average MPG. In order to decrease automobile emissions, there needs to be multiple solutions.

Union College, like numerous other colleges, bans first-year students from having a vehicle on–campus. Currently, first-year students are not permitted to own a vehicle on-campus unless they have a waiver from the Dean of Students. One solution to decrease total emissions from student vehicles is to reduce the number of vehicles traveling to Union College. A first step in lessening the number of vehicles on-campus would be eliminating sophomore-owned vehicle on-campus. Sophomores make up 15% of the vehicles on-campus while first-year students make up 7% of the vehicles on-campus. While an unpopular solution politically, the Union College Administration would be able to decrease student vehicle emissions by 15% in a short amount of time. One study suggests that first

and second year students should not own a vehicle on-campus because they are still getting accustomed to college, "Normally the first- and second-year student is overwhelmed making educational, social, and financial adjustments to college life" (Toor and Havlick 2004, 25).

Vehicle bans that extend after a student's first-year are somewhat rare, however, there are high-profile institutions that do enforce such a policy. Tufts University in Medford, Massachusetts, the University of North Carolina at Chapel Hill, and The College of William and Mary in Williamsburg, Virginia, all enforce a ban on first and second-year students (Association for the Advancement of Sustainability in Higher Education, Car Bans, 2012). First-year, sophomores, and juniors who live on campus at Northwestern University in Evanston, Illinois are not permitted to bring vehicles to campus (Northwestern University 2012).

Despite the unpopularity of a sophomore vehicle ban, students may be more willing to agree to a ban on these vehicles if there were more alternative modes of transportation. Student vehicle emissions can be also be decreased through the use of car sharing and rideshare/carpool programs. These programs, which are discussed below, can either be implemented with or with out a ban on sophomore vehicles.

### *Campus Bus/Trolley Usage*

The Union College Campus Safety Department operates two trolley systems, one that travels a circular route around the campus and another that travels to various shopping areas in the Capital Region. While over 60% of students stated that they use at

least one of the trolley systems, average usage is around once per week. Many students, when asked about the campus trolley, said they either did not know much about it or they used to ride it until the on-line trolley tracker stopped working. Currently, faculty members have no reason to use either campus trolley, but 49% did express interest in using public transportation to commute to campus. Studies indicate that public transportation infrastructure must be attractive and dependable, "Frequency, reliability, and amenities are important factors for sustaining transit ridership" (Dittmar and Ohland 2004, 125). Another survey indicated that improving bus service would result in less people using their personal vehicles for short-distance trips, especially if the cost of the service was less than the cost associated with a vehicle (Mackett 2001, 300). The campus trolleys are valuable assets to the campus community and can improve short distance travel at and around Union College, however, they need to improve in order to be successful for the college practically and financially.

Many students who took part in the survey expressed their frustrations with the campus trolley system. Students stated that it was hard to use because it was often never on time or they had to wait in the cold for a long time, both problems that had been raised in the past and solved through the implementation of the Union College Trolley Tracker. In fact, many students indicated that they would be more willing to use the trolley if there was a consistently functioning trolley tracker.

Electrical Engineering major, Isaac Rodgers '10, developed the trolley tracker in response to various campus surveys that suggested trolley usage would increase with an on-line trolley tracker. Studies have shown that GPS transportation tracking is an effective

method of communication between transit and community members on college campuses as stated by Miller, "Real-time schedule information available to users on their computers is one [Advanced Public Transportation System] application that seems ideally suited for the campus transit environment, because of the high rate of access and use of the Internet by students, faculty, and staff" (Miller, J. 2001, 26).

Currently, the Union College Trolley Tracker is accessible via the website on both computers and smart phones (Union College Trolley 2011). The project website states that a cell phone text message system is under development for students without smart phones. Additionally, the website mentions a past advertising plan, "In 2010-2011 [the web page and text communication system] will be widely publicized to promote more use of the trolley and less use of personal cars on campus" (Union College Trolley 2011). However, throughout the fall 2011 term, the trolley tracker website, trolley.union.edu, was not consistently functioning. Nonetheless, the website, while currently active, is hard to find when accessing the Union College website as it is not located on either Campus Safety's trolley page or on the sustainability page.

In order to increase usage of the campus trolley, an improved website page dedicated to both the on-campus and off-campus trolleys. Additionally, the trolley tracker program should be expanded to include the off-campus trolley. Students would gain from knowing as much as they can about the campus trolleys so that they can make an informed transportation decision. Further information on the website and around campus should include detailed trolley schedules and route maps.

Figure 80: This figure is a screenshot of the Union College Trolley Tracker website. The bolded line indicates the route of the campus trolley and the "T" marker indicates the real-time location of the campus trolley (Union College Trolley 2011).

This information should result in a trolley page that is prominently displayed on the main Union College sustainability website. The website, in conjunction with improved visual advertising on campus, would give students the information they need in deciding whether or not to use the trolley. Because off-campus trolley usage has a set schedule and set destinations, it is important for the sustainability coordinator to conduct surveys to determine if the routes need to be adjusted. Operation of the trolley system cannot be static since behaviors rapidly change.

Despite the lack of information regarding the trolley, the survey indicated that most students use the on-campus trolley during the late evening and early morning hours between 9pm and 2am. The University of Florida, albeit a much large institution than Union College, operates a similar late-night campus bus system called "Later Gator." The program

at Florida has three goals: 1) extend transit operations into the late evening hours; 2) Reduce frequency of driving under the influence of alcohol by connecting residential areas with night club areas and bars; and 3) Alleviate severe parking shortages in the "primary districts of late night activity" (Bond and Steiner 2006, 137). Union College can improve late-night on-campus trolley service by setting similar goals. This service could result in a culture shift on-campus since additional students would be more willing to travel to Downtown Schenectady, Albany, or Saratoga late at night on the weekends.

In addition to improving trolley service for students, the current system should provide a benefit for faculty members. Since most faculty members live within two miles of campus and do not prefer to walk to commute to campus, they could use the on-campus trolley. A plan incorporating faculty utilization of the campus trolley would require a service increase from current levels. Currently, the on-campus trolley does not operate in the morning or early afternoon hours. If a faculty trolley were implemented, the system would have to operate early enough to pick up faculty members in the morning as well as to drop them off in the afternoon. The faculty would also need to be equipped with a trolley tracker to determine its location.

Before establishing a faculty trolley system, future study needs to be conducted to determine whether faculty would use the on-campus trolley and where they would like a morning or afternoon route to travel through. This would make up for the lack of useful Capital District Transit Authority (CDTA) routes around campus. The CDTA bus route number 351 (Van Vranken Ave-Broadway) bounds the west side of campus along Seward Place. The current bus stop on Seward Place borders the main campus and therefore is not

an effective mode of transportation for faculty members who live in the Stockade area, Park Place, or on the eastern or southern borders of campus, such as University Place or the GE Reality Plot (CDTA 2012). A commuter trolley program for faculty members would need to include a route pattern and level of bus frequency that meet the needs of the faculty.

### *Introduction to Reducing Transportation Emissions*

Transportation emissions can be quickly eliminated through the use of transportation modes that do not emit any carbon and do not rely on fossil fuels. Two methods of transportation that fit these criteria are biking and walking. These transportation modes are different in their infrastructure and administration, however, both need the support of campus leadership to succeed. A survey of transportation patterns at eight campuses indicated that six of eight have bike and pedestrian committees and two have transportation advisory committees (Balsas 2003, 41). Some schools also have a bicycle and pedestrian coordinator, which could be incorporated into the duties and responsibilities of Union College's new sustainability coordinator. This employee would be expected to conduct regular surveys across years and seasons to determine the improvements that could be implemented on an on going basis. In order to promote these alternative methods of transportation, various programs can be implemented, as discussed below.

### *Reducing Emissions via Biking*

Riding a bicycle is often considered something children and young teens do, however, bike usage has increasingly become popular throughout the world for commuting

to work and running errands. According to a study bike ownership is growing larger than vehicle ownership as reported by Balsas, "In recent years more bicycles have been sold annually than automobiles, with total bicycle ownership in 1999 at over 120 million units in the United States." (Balsas 2003, 38) Bicycle programs are successful in reducing $CO_2$ emissions because they do not negatively impact the environment. Union College would benefit from a bicycle program because it is a small campus located in an urban setting. A college biking study concluded that bikes are beneficial for these unique environments as suggested by Balsas, "The bicycle offers riders speed and flexibility over short distances. It produces no pollution, uses no energy, is silent, can be accommodated with relatively little space, it fast and cheap, and is accessible to many people who cannot drive" (Balsas 2003, 38). A successful bike program would provide students and faculty members with incentives to bike on and off-campus. However, Union College has experienced the failures of an unsuccessful bike program.

In 2009, two students established a program entitled, "Free Cycles For U" in which students paid a $1 deposit to receive a key that would unlock a bike located anywhere on-campus (Union College News 2009). In addition to receiving a key, students also had access to a bike shop in the Richmond House basement. However, after the spring term, the program ceased to exist as the bikes were either damaged or stolen. In order to have a successful bike program, there needs to be an investment in bike infrastructure by the college, otherwise the system will not be sustainable over a long period of time and will not be worth it financially to the campus community.

Bicycle infrastructure would consist of storage and maintenance facilities. Currently, there are some pieces of infrastructure supporting the Union College biking community such as 24/7 locker rooms in the basement of the Science and Engineering Building and outside bike racks. The locker rooms, which include a shower and ventilated lockers, were renovated as part of a Presidential Green Grant in 2010. (Union College News 2011) The locker rooms were once again granted a Presidential Green Grant in 2011 to improve the showers. Students and faculty members can access the locker rooms in the basement of Science and Engineering 24 hours a day, 7 days a week with their Union ID card. Because the Union College campus is designed to benefit the pedestrian and forces cars to the periphery of campus, bike lanes or general campus road improvements are not necessary.

While the current biking infrastructure is sufficient for the individuals who currently bike on and off-campus, faculty may be more willing to bike to work and students may be more willing to bike off-campus if there were additional services and incentives provided by the College. The 2009 bike program had many flaws, but it did have a key component of a biking system, a bike maintenance station. The Union College Administration would be making a statement to the campus community if it invested in a campus bike station. While the economy can currently be considered lack-luster, a bike station would provide bicycle users proper facilities to maintain their bike. The station could have an office hours-based system where bike riders could bring their bike for free maintenance, compressed air, and access to tools. The bike station could also have short and long-term rentals that students and faculty members could utilize. Unlike the previous bike program, in order for students and faculty to take care of the rental bike, the renter

would need to take responsibility for the general condition of the bike. The bike station would provide a safe and secure facility to store bicycles as well as parking in bad weather, however the more secure the bike, the more expensive the project (Forester 1994, 281).

If Union College were unwilling to fully invest in this project, a bike station would be a good opportunity for the College to reach out to local communities members who share an interest in bicycling. Many communities across the United States are developing bike rescue programs. Albany and Troy each have bike rescue shops at which community members of all ages can learn how to properly maintain and fix a bike as well as volunteer to help others with their bike maintenance (Albany Bike Rescue 2012). Both groups have programs in which community members, if they put in a certain number of hours at the shop, can get a bike for free. In Troy, people can also "adopt" refurbished bicycles for a donation, depending on how much work was put into the bike (Troy Bike Rescue 2012). Developing a Union-Schenectady bike rescue would help both the Union College community as well as its neighbors.

### *Reducing Emissions via Walking*

The Union College campus' design was revolutionary in that it created lots of open space and architectural balance within an academic environment. Even though the original campus plan will celebrate its 200th anniversary next year, it is important that Union College maintain the pedestrian-only presence within the central campus. Since most students live and park within the boundary of the 130-acre campus, walking to the campus center, the athletic facilities, and the residential halls should be second nature. According to

the latest comprehensive campus plan from 2008, it is a five-minute walk from Seward Place (on the western side of campus) and Abbe Hall (on the eastern side of campus) to the center of campus, Schaffer library (Figure (Dober, Lidsky, Craig, and Associates, Inc. 2008, 21).


Figure 81: This figure is a map of the Union College Campus with a printed circle indicating a 5-minute walk from the center (Schaffer Library) to the edge, based on a rate of 3 miles per hour (Dober, Lidsky, Craig, and Associates, Inc. 2008, 21).

Walking is not only environmentally healthy, but also physically and financially healthy as Balsas concluded, "Walking is fast, direct, and has no costs" (Balsas 2003, 38). While walking is not a reasonable alternative long-distance transportation solution, it is effective for the college community in that most students and many faculty members live either on-campus or just beyond the College grounds. Union College could eliminate vehicles driving to campus by abolishing parking for students and faculty members who live within a certain distance of campus. At Northwestern University, students and faculty who live within a certain distance surrounding the campus are considered to be in the "Walking Zone." Those who live in the walking zone are not eligible to receive a parking pass (Northwestern University 2012). This is a viable option for reducing emissions for Union College because of the high percentage of faculty and students who live on or close to the campus. This would force those who currently drive to campus to use an alternative, and less environmentally unfriendly, mode of transportation to commute to campus.

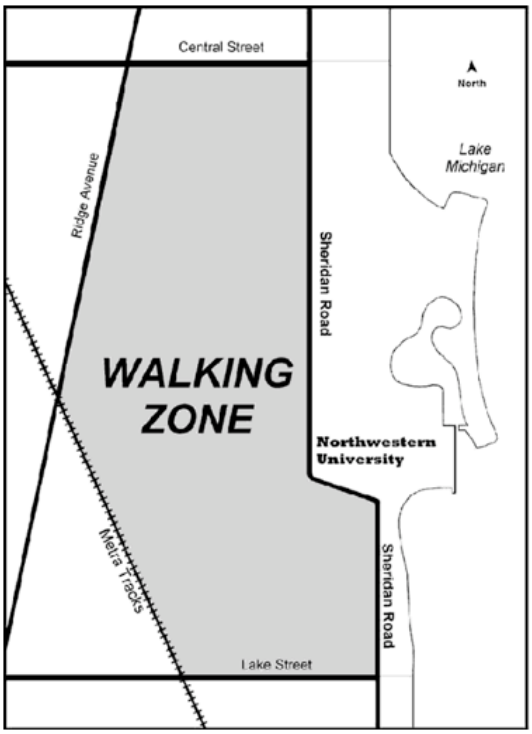



Figure 82: This figure shows a map of the walking zone instituted by Northwestern University. Students and faculty members who live within the shaded walking zone area are not allowed to get a parking pass (Northwestern University 2012).

If Union College expects more people to walk to campus and the surrounding business districts, then it should continue to improve the surrounding infrastructure for

walkers as well as create a "Pedestrian Bill of Rights." The college has started to improve walking infrastructure on the western side of campus by paying for textured crosswalks across Seward Place (Goot 2011). These types of crosswalks better distinguish the walking path for both pedestrians and drivers as one study indicated, "Motorists are alerted effectively to a student crosswalk when that zone is slightly elevated and well-marked. A different color pavement or a different texture paving material helps the motorist to see the pedestrian crosswalk more clearly" (Toor and Havlick 2004, 140). Textured crosswalks are also used at the intersection of Union Street and Nott Terrace. The College and the City of Schenectady should continue to work together to implement these types of crosswalks in the Union-Schenectady area to improve safety and promote walking.

If the College and City are willing to invest in pedestrian infrastructure, a pedestrian bill of rights for students, faculty, and communities members can help create and guide transportation projects in the area. The goal of a policy document such as this one is to ensure that the rights of pedestrians are not forgotten in a car-dominated culture (Toor and Havlick 2004, 139). A sample pedestrian bill of rights created by Toor and Havlick include statements such as, "The right of the campus pedestrian to have the right of way at all pedestrian crosswalks…," "The right of the campus pedestrian not to be impeded by vegetation or structural barriers…," and "The right of the campus pedestrian to be safe and well separated from roadways…" (Toor and Havlick 2004, 139-140). Pedestrian bills of rights are important in setting expectations for both the pedestrian and the agencies constructing and maintaining the walkways.

Figure 83: This figure shows a map of Union College at the intersection of Union Street and Nott Terrace. The circles indicate textured crosswalks adjacent to the Union College campus and the arrow is pointing to the "Blue Gate." (Google.com/maps)

### *The Impact of Weather on Biking and Walking*

One of the main obstacles preventing the increase of biking and walking on and around a college campus is weather. Union College is located in upstate New York where there are significant shifts in weather patterns across seasons. Albany, New York, Schenectady's eastern neighbor, has an average temperature of 47.4 °F. Additionally, annually, on average, there are 8 days at or greater than 90 °F, and receives 53% of all possible sunshine. Albany has 69 clear days, 111 partly cloudy days, 185 cloudy days, and 135 days with at least 0.01 inches of precipitation on average per year (Climate Zone 2012). Mackett's study found that biking and walking decrease as weather conditions worsen, "A significant factor that deters people from walking and cycling is bad weather" (Mackett 2001, 304). Another study conducted by Aultman-Hallb investigated adults who commute greater or equal to 2 miles each way. The study showed that the likelihood of

bicycle use increased with higher temperatures and no rain and decreased with snow and wind (Aultman-Hallb et al. 2012).

Despite Union College's often cold and wet climate, biking and walking for commuting can still be still be successful. Commuter biking in other cold climates has been successful with proper infrastructure. Northern Europe has been successful despite similar climate conditions to Union College. One study suggests that climate does not impact bicycle use as often believed; "Yet the effect of climate on cycling may be exaggerated. In spite of mostly cloudy days and frequent rain and drizzle, northern Europe has the highest cycling levels, far higher than in southern Europe, where it is drier, sunnier, and warmer" (Pucher et al. 1999). Additionally, other cities with academic institutions in the United States have had success with bicycle commuting. Schenectady's mean high temperature is 57.75 °F, which is in-line with cities such as Boulder, Eugene, Madison, and Seattle, all of which have been able to use infrastructure improvements and incentives to increase bicycle commuting among students and faculty members (Table 7) (The Weather Channel 2012). Union College's trimester calendar is beneficial for bikers concerned about weather since there is no need to travel to campus during the month of December nor do bikers need to travel in the dark between the months of March and June.

While bicycle commuting volume would be expected to decrease in very bad weather, it is believed that as the volume of commuter biking increases, the effect of weather on this transportation mode will decrease (Forester 1994, 75). Forester's study suggests that in addition to the implementation of bicycle infrastructure, the habit of biking in general results in greater individual use for commuting, "Most American cyclists start

out as short-distance fair weather recreationalists. But they learn to handle the weather that they face" (Forester 1994, 74). Weather should not be an obstacle to increasing biking and walking at Union College, but rather should be considered as healthier, cleaner, and inexpensive modes of transportation.

| City | Mean high temperature (°F) | Rain Days | Bicycle commute percent for the campus |
|---|---|---|---|
| Boulder | 65.3 | 51 | 12% |
| Eugene | 63.3 | 123 | 12% |
| Madison | 56.1 | 18 | 15% |
| Seattle | 59.7 | 158 | 5% |
| (Balsas 41) | | | |
| Schenectady/Albany | 57.75 | 135 | Range: 0% to 9% (Figure 5) |

Table 7: This table shows the impact of climate on bicycle commuting on college campuses. Union College, which was not included in the original study (Balsas 41), has similar climate conditions as other campuses with bicycle programs (The Weather Channel 2012).

### *Introduction to Vehicles on Campus*

Union College was established prior to the dominance of the personal vehicle and has had to adjust to the shift in transportation modes throughout its history. While the original campus plan favors pedestrians over automobiles, many students and faculty members bring their personal vehicles on-campus. 88% of faculty members commute to campus via automobiles while a lesser percentage of students, 37%, own a vehicle on-campus (Figures 9 & 18). The majority of both students (89%) and faculty members (91%) who bring vehicles to campus register their vehicles with the Union College Campus Safety Department (Figures 10 & 20). Additionally, a larger percentage of both students (87%) and faculty members (94%) tend to park in on-campus parking lots over off-campus street parking (Figures 13 & 21). Additionally, Balsas, a transportation planner described

automobile use as "expensive and inefficient over short distances and is a major contributor to global warming" (Balsas 2003, 37). In order to reduce $CO_2$ emissions and promote alternative modes of transportation, Union College needs to create policies and regulations to persuade students and faculty members from traveling to campus via a personal vehicle. The recommendations below describe various solutions to decreasing the quantity of vehicles driven and parked on campus.

### *Parking Sites and Regulations*

Since 1983, the abundance of parking spaces on the Union College campus has increased by almost 43% while the student population has only increased by approximately 6.5% (Table 8). While much of the increase in parking spaces can be attributed to the development of the College Park Hall and Seward/Hull Place areas (232 spots at College Park Hall and 45 spots in the Seward/Hull Place area), the abundance of parking encourages personal vehicle use. As of the last comprehensive campus plan conducted in 2008, there are a total 1,369 spaces (Dober, Lidsky, Craig, and Associates, Inc. 2008, 19).

Both students and faculty members indicated that on-campus parking behavior depended on parking availability and convenience. If the campus population continues to stay somewhat level, the college should not increase parking capacity, and instead make it harder to find a parking spot on-campus. Despite the unpopularity of such a plan, it would force students and faculty members to take a closer look at how they travel to and from Union College.

| Year | Number of Parking Spots | Proposed Future Number of Parking Spots | Other Notes | Source |
|---|---|---|---|---|
| 1983 | 960 | N/A | Study indicated, "adequate capacity exists" with new Nott/Seward Lot. Enrollment: ~2,000 students | Parking: (Saratoga Associates 1983) Enrollment: (Somers 2003) |
| 1984 | 990 | 1,215 | | (Saratoga Associates 1984) |
| 1989 | 1,042 | 1,247 | | (Saratoga Associates 1989) |
| 2008 | 1,369 | N/A | Enrollment: 2,130 students | (Dober, Lidsky, Craig, and Associates, Inc. 2008) |
| % Difference | +42.6% | N/A | Enrollment: +6.5% students | |

Table 8: This table is a summary of past Union College parking studies and comprehensive campus planning studies.

In addition to an abundance of parking at Union College, there are no incentives to stop driving to campus. In order to reduce the number of vehicles driven to and parked on the Union College Campus, personal vehicle use could be discouraged through changes to the campus parking regulations. Currently, those who are not visitors and wish to park a vehicle on-campus must register their vehicle with the Union College Campus Safety Department (Union College Campus Safety Department 2012).

Vehicle registration at Union College costs $15 a year for students and faculty members. In comparison to other schools, Union College students and faculty members pay less to park per year (Table 9). If a student drove from their home to campus and never took their car out of a parking lot, he or she would be paying less than .01¢ (.0029¢) an hour

to park on-campus. If a student left campus for four hours a day, he or she would still be paying less than .01¢ (.0036¢) an hour to park. If faculty members park their vehicles on-campus for an average of nine hours a day, they would also be paying less than .01¢ (.0079¢) an hour to park on-campus. Because parking fees are so inexpensive, there is no disincentive to drive and park on-campus.

Since there is little off-campus street parking available, students and faculty members are forced to park on-campus if they have a car and therefore are required to register their vehicle with Campus Safety. A study concluded that people are more likely to drive alone if there are no incentives to do otherwise, "Free and ample parking at the workplace encourages single-occupant driving. In urban areas where parking is a commodity and charged at market prices, transit ridership is dramatically higher than in the suburbs where there are large amounts of free parking" (Dittmar and Ohland 2004, 124). Like other services on-campus, parking rates should match market demand. As a result, it is possible that faculty members would bike, walk, carpool, or use a campus trolley system if they had to pay a substantial amount to park on-campus. The same study indicated that "employees who paid for parking drove alone 33% less and used transit 25% more than those who did not pay for parking or whose parking was subsidized" (Dittmar and Ohland 2004, 124). In addition to recommending that Union College increase the on-campus vehicle registration rates, the College should give drivers the ability to pay for parking registration on a term-by-term basis to give drivers the ability to switch to different transportation modes. The current annual registration system encourages drivers to drive all year long, regardless of whether other options exist.

Some institutions offer faculty members the choice to opt-out of on-campus parking. These programs, often called, "parking cash-out programs," pay faculty members to not drive to campus. While this could be expensive, it could be combined with a parking registration fee increase to balance costs. Smith College in Massachusetts has slightly more students and faculty members than Union College, though operates a cash-out program. Smith pays eligible employees to travel to and from work if they agree to not travel to campus in a vehicle alone. As part of the program, faculty members cannot bring their car on-campus between 7am and 5pm. The amount faculty members are paid for not driving to campus depends on how far from campus they reside. If a faculty member lives one mile from center of campus, he or she is paid $150 per year and if a faculty member lives outside of the one-mile radius, he or she is paid $400 per year (Smith College 2012).

Additionally, faculty members who take part in the program receive 18 free parking passes each year to park in case of emergency. Furthermore, a faculty member can choose to only participate in the program for half the year, if their schedule permits it and are paid $75 if they live within one mile of campus or $200 if they live outside the one-mile radius. Those who participate in a carpool are also eligible to participate in the cash-out program. Because faculty member parking registrations cost $50 per year at Smith, participants receive an economic benefit of $450 as well as a benefit from not spending money on gas or vehicle repairs. Some faculty members stated in the current survey that they would not want to be on-campus without their vehicle in case they needed to go home for an emergency. In order to give faculty members who share this opinion a sense of comfort, it would be recommended that the College provide an option for a reimbursed ride home in

the case of an emergency. A cash-out program similar to the one at Smith College could be effective in reducing faculty vehicle emissions as well as promoting alternative transportation methods.

For those who do park on-campus, the campus parking lots are open for all registered vehicles; faculty members can park in any faculty lots while students can park in either student-only or student/faculty/staff lots, depending on the day and time. Campus Safety should implement parking zones on campus, restricting where people can park depending on what building they work in and if they live on-campus. This will decrease student trips made via personal vehicle to on-campus locations such as the Reamer Campus Center, Alumni Gym, and between College Park Hall and the main campus. Parking zones should restrict all on-campus residents from parking near Alumni Gym and restrict College Park Hall residents from long-term parking areas on the main campus. Removing the ability to park in strategic areas will force students to use alternative modes of transportation, such as the on-campus trolley, bicycles, and walking, to travel short distances around campus.

| School | Number of Students | Number of Faculty | Student Price | Faculty Price | Car share Program | Parking Restrictions |
|---|---|---|---|---|---|---|
| Union College | 2,170 | 237 | $15/year | $15/year | No | No 1st Years |
| Amherst College | 1,795 | 236 | $60/year | $0 | ZipCar | No 1st Years |
| Smith College | 2,750 | 285 | $150/year | Alone: $50/year Carpool: $10/year | ZipCar | No 1st Years |
| Hamilton College | 1,812 | 219 | $100/year $50/semester | $0 | ZipCar | No 1st Years |
| RPI | 7,521 | 496 | Resident Students: $135/year Commuters: $80/year Parking Garage: $375/year | General: $135/year Restricted Lots: $170/year Parking Garage: $375 Department-Restricted Lot: $310 | No | No 1st Years |
| Vassar | 2,446 | 328 | $50/semester | $0 | ZipCar | No 1st Years on Central Campus |

Table 9: This table shows costs, restrictions, and car share services for six northeastern liberal arts and engineering institutions.
Sources: (Union College Campus Safety Department 2012), (Amherst College 2012), (Smith College 2012), (Hamilton College Campus Safety 2012), (RPI Parking and Transportation 2012), (Vassar College Safety and Security 2012)

### *Ride Share Programs*

Ride share, or carpool, programs help reduce $CO_2$ emissions and dependence on fossil fuels by removing vehicles from the road. Filling all the seats in a car makes driving a more efficient mode of vehicle transportation, "Putting more people in the same car makes

a lot of sense as a more efficient use of existing infrastructure (Poinsatte and Toor 1999, 37.) Ride share programs are becoming increasing popular on college campuses throughout the United States (Abell 2009). These programs give people the opportunity to socialize and reduce travel costs. Ride sharing is beneficial for families, people who live and work near each other, people who shop at common businesses, and people who are traveling long distances to the same geographic area. As a result, ride-sharing programs can be successful for students traveling between Union College and their permanent homes as well as for short trips for errands. Additionally, ride-sharing programs can be successful for faculty members who live near each other and have similar schedules.

While ride share programs seem to be a natural transportation solution for college communities, studies indicate that people are not willing to drive with other people if there are no incentives to do so. Poinsatte and Toor stated, "Simply leaving people to their own devices, however, will usually result in few carpools; the occasional housemates or spouses who happen to have similar schedules might ride together…Getting strangers to arrange ride sharing is a more difficult task, one that is encouraged by an outside 'helping hand'" (Poinsatte and Toor 1999, 36). There are various types of programs, though they are similar in that they are online-based and connect people traveling to the same location.

Cornell University's ride sharing programs are good examples of how it can be used for faculty and students. Cornell provides the campus community with a service called Zimride (Zimride 2012). This program is an online-based system that connects members of the campus community and is accessible using the Cornell network username and password to ensure privacy. Outside of the Cornell Zimride program, people can use the

website by logging into the public ride share system using their Facebook accounts. Drivers are able to post how many available seats they have in their vehicles and set a fee for a ride. Passengers are able to book a ride online and pay by credit card via the Zimride website. The Zimride social network removes the anonymity of strangers traveling together since both the driver and passenger are able to base their traveling decisions on each other's social network profiles.

In addition to providing students and faculty members with a system to connect ride share matches, colleges need to be financial incentives and benefits to promote increased carpooling. At Cornell University, carpooling increased from 5% to 15% in the early 1990s because of financial incentives, discounts, and parking rebates (Toor and Havlick 2004, 49). Besides from offering reduced priced parking registrations and preferential parking to ride share vehicles, the college should offer a reward system (giveaways, raffles, contests, gas cards, food coupons, or bookstore coupons) based on how often one carpools. Union College should promote ride sharing by implementing a modern ride board and providing both students and faculty members with enough incentives not to drive alone to campus.

### *Car Share Programs*

Car share programs are effective in reducing the number of vehicles on-campus as well as decreasing the number of miles driven between campus and students' permanent homes. These types of programs are not for everyday vehicle use, but rather for a member of the campus community who only drives occasionally a stated by Toor and Havlick, "These are programs designed to serve students or staff who do not own vehicles and those

who choose not to bring an automobile to campus because of environmental or financial reasons" (Toor and Havlick 2004, 50). Many cars on campus brought by students are rarely used to travel off-campus and remain idle in on-campus parking lots. Because students and faculty members need to plan ahead and pay when using a car share service, there is an incentive to reduce vehicle use (Toor and Havlick 2004, 50).

A company called Zipcar operates a major car share program throughout the United States and is becoming increasingly popular on college campuses (Zipcar 2012). Zipcar is located on over 100 college campuses including those similar to Union College such as Colgate, Hamilton, Amherst, Williams, Holy Cross, Vassar, and Hobart and William Smith. Institutions have invested in car share programs to reduce the number of cars on campus as well as to reduce emissions as a result of student driving. Zipcar states that each car takes 15 personal vehicles off the road. Schools are able to control the types of vehicles students and faculty members use to travel off-campus through a car share program, ensuring that this type of travel will fuel efficient and somewhat environmentally friendly. Institutions usually initially introduce two Zipcar vehicles, ranging from hybrids to pick-up trucks, and can increase the number of campus vehicles depending on demand (Fuchs 2011). Students and faculty members can purchase an annual Zipcar membership (ranging from $25 to $50 a year), which gives them 24 hours, 7 days a week access to the car share vehicles. Members must be at least 18 years old to use a campus-based Zipcar and at least 21 years old to use any Zipcar in the country. Participants in the program receive a Zipcar electronic card that, when swiped over a Zipcar's windshield, unlocks the vehicle.

Once registered, members can log onto their school's homepage on the Zipcar website to see vehicle availability and to make vehicle reservations. A vehicle can be reserved for a short as an hour or as long as multiple days (up to 180 miles per day). In addition to the annual membership fee, users pay as low as $8 per hour or $66 per day. This fee includes vehicle insurance and gas. The Zipcar card also works as a gas payment card at any gas station.

Utilizing a car share program, such as Zipcar, would create an affordable way for students and faculty members to travel around Schenectady and the rest of the Capital District. Additionally, it would provide international students with vehicles that they can use, especially during the winter and summer vacation periods. However, car share programs require a level of investment, often undertaken by a college's transportation department or student government. Some schools generate additional revenue through car share programs if rental fees are higher than fees paid to the car share company. Union College should implement a car share program so that students and faculty members can use a car for short-distance travel instead of always bringing a vehicle to campus.

### *Union-Schenectady Relations: Connecting to Schenectady*

The Union College community has the benefit of being within walking, biking, and trolley distance of a downtown commercial district. While Schenectady is not known as a "college town," it is important for both Union College and Schenectady to work together to improve access between the two. The 2001 National Household Transportation Survey determined that "50% of all trips in metropolitan areas are three miles or less and 28% of

all metropolitan trips are one mile or less – distances easily traversed by foot or bicycle. Yet 65 percent of trips under one mile are now made by automobile" (National Complete Streets Coalition 2012). The survey suggests automobile use is so high for use in short trips because incomplete streets make walking, biking, and transit dangerous.

Despite the conflicts between the two entities, Union College is just as important to Schenectady as Schenectady is important to Union College. A higher percentage of students indicted that they carpool to local places in Schenectady than to other areas of the Capital Region, including Albany and Saratoga. Schenectady already has key attractions for Union College students: a pharmacy, restaurants, hair stylists, a health club, recreational facilities (three parks), a bus terminal, an Amtrak station, and entertainment, which includes a multi-screen movie theater and Proctors Theater. In order to promote walking, biking, and trolley usage between Union College and Downtown Schenectady, it is important that both work together to create an environment conductive to these forms of low-emission transportation.

Union College and Schenectady need to continue the work they have done to improve access to the downtown area. Projects such as textured crosswalks and timed crossing signals give priority to pedestrians in traditionally automobile-domination environments. The Seward Place reconstruction project is a good example of using grassy medians and textured crosswalks to create a pedestrian-friendly environment. Additionally, the College should continue to create access points that provide students with gateway options, such as the recently improved Blue Gate at the intersection of Union Street and Nott Terrace near Davidson Hall (Figure 83). The gate was equipped with an ID

card reader that allows students to enter or leave campus by swiping their ID card. This type of infrastructure gives pedestrians and bikers a clear path to the greater Schenectady area and should be expanded further to connect Union College to the central business district on State Street, “A system of walkways needs to be direct, well connected, safe and visually interesting. Streetscape, urban design, building orientation and public places all influence the decision to walk” (Dittmar and Ohland 2004, 124).

A complete streets program in Schenectady would improve conditions for automobiles, pedestrians, and bicyclists. An example of a complete streets plan in an urban environment is New Haven, Connecticut. In 2010, the City of New Haven developed a complete streets plan that requires safety and convenience among all groups, primarily pedestrians, bicyclists, and transit users, prioritizes walkability, traffic calming, and pedestrian-based urban economic development (City of New Haven 2010, 11). In Schenectady, traffic calming devices such as intersection bump outs and center medians with raised or textured crosswalks (Figures 83 and 84) would help slow down traffic as well as provide non-motorized modes of transportation with safe routes. Traffic calming provides psychological and physical deterrents to driving fast and, if successful, makes a route less attractive than other routes (Forester 1994, 258).

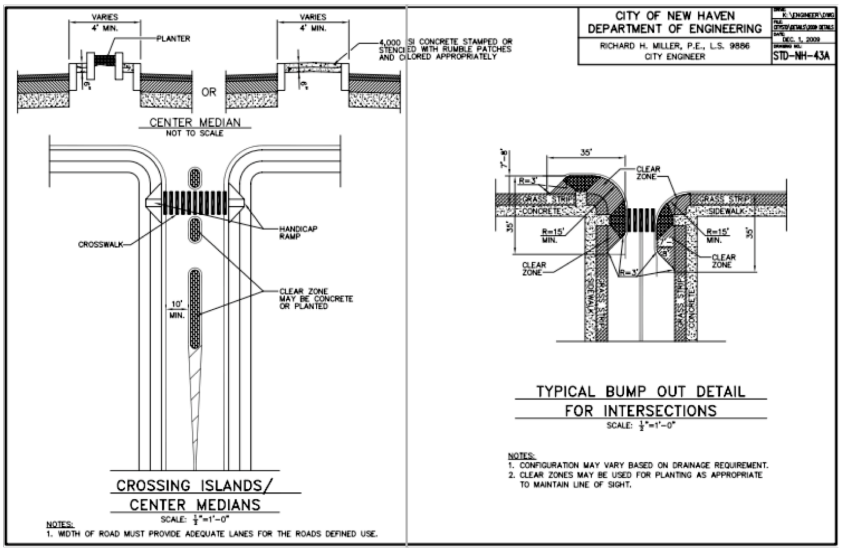


Figure 84: This figure shows designs of raised crosswalks and islands (left) and bump out sidewalks at intersections in New Haven, Connecticut (New Haven 2010).

Complete streets change the current transportation system of an area by no longer concentrating on automobile-dominated travel routes. The National Complete Streets Coalition states that benefits of complete streets include improving safety because they promote better sidewalks, traffic-calming devices, walking and bicycling for health, and stronger communities, while considering climate change and oil dependence (City of New Haven 2010, 23-24). This would be beneficial in creating a designated pedestrian/bike route between the Union College Campus and Downtown Schenectady, especially near City Hall, Jay Street, and Union Street.

A complete street plan between Union College and the City of Schenectady should also provide community members with an increased level of safety while traveling off-campus. Both groups need to create a safe and easy-to-use transportation system that gets people to their destinations efficiently. One study suggests that non-motorized transportation usage will not increase until a proper infrastructure consisting of designated and signed routes for bikes and pedestrians is established as Balsas describes,

"The level of bicycle use, though, is dependent upon the availability of various facilities and services such as bike paths and lanes, proper signage, bike parking, measures to be taken to deal with safety issues, and the level of cooperation between the school and the town or city in which it is located" (Balsas 2003). At the minimum, bike and pedestrian infrastructure could simply be striping existing roads for bikes (Figure 85). A bike or pedestrian route, even if not separated from vehicle traffic, can result in a safe route between the two areas of the city by creating a designated, well-signed and well-lit route. Additionally, the Union College Campus Safety Department could give route users an additional level of safety and comfort by lining the potential route between the College and the Downtown Area with the Code Blue safety light system that is used as an emergency intercom system on-campus.

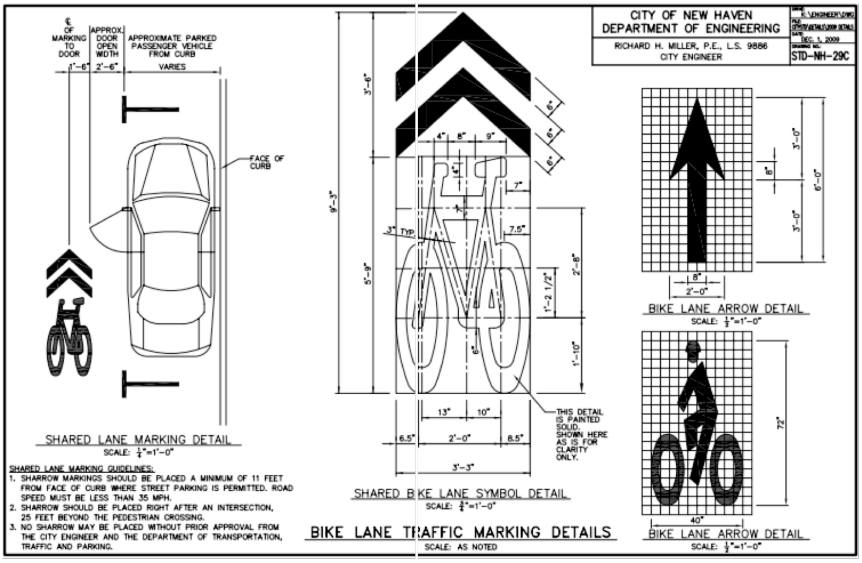


Figure 85: This figure shows road striping designs for bike lane traffic on previously existing roads in New Haven, Connecticut (New Haven 2010).

As a result, the campus community should work closely with the local Schenectady government to promote the idea of a complete street network to connect the Union College

area to the Downtown Schenectady business district. Union College and Schenectady need to create goals to develop a complete solution to livable streets. While the funding may not be available or in place at time of planning, it is important to have data and designs ready when grants and other sources of funding become available. Bike and pedestrian routes used by both Union College community members and Schenectady community members should be maintained through a maintenance program that shares costs between the City and the College (Toor and Havlick 2004, 151).

## CONCLUSION

This transportation audit of travel habits of Union College students and faculty members reported in this study provides the College and its community with information and recommendations to achieve the administration's declared goal of carbon neutrality by 2060. This study showed that, while the typical student and faculty member currently emits less carbon than four years ago, there is much work to be done to further decrease carbon emissions. The potential to improve the state of sustainable transportation at Union College is tremendous since, at present, many students and the majority of faculty members rely on their personal vehicle (by themselves) to travel to the Union College campus, which is less-than-ideal. In order to decrease carbon emissions, the College needs to adopt creative solutions and implement enticing incentives. The results of the survey indicated that many people were willing to take part in carbon emission-reducing programs, though such programs are currently unavailable. Transportation at Union College is often overlooked in terms of sustainability, but through the work of the

administration, student, and faculty governance systems, the opportunity exists for Union College to become a leader in transportation sustainability. As a first step, the College is encouraged to use the findings and recommendations of this report to structure a sustainable transportation program that appeals to a large segment of students and faculty. Although a perfect program that addresses every need may not exist, any developed program should always be considered a work in progress that needs to be retooled and adjusted to respond to the needs that may arise upon implementation.

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# World Resources Institute
# Carbon Dioxide ($CO_2$) Inventory Report
# For Calendar Year 2008

Thomas Damassa

February, 2010

WORLD
RESOURCES
INSTITUTE

## Summary

This report presents WRI's carbon dioxide ($CO_2$) inventory for calendar year 2008. It summarizes emission sources included in the inventory, calculation methodologies, and trends, and highlights WRI's role in the completion of a green roof space at our Washington, DC office building. Previous reports are available online at http://www.wri.org/project/wri-co2-commitment.

WRI's total emissions for 2008 were 1,263 metric tons of $CO_2$. This represents a 29% increase above our (recalculated) 2003 base year emissions (see below). WRI has committed to offset its emissions to achieve its goal of a "net zero" emissions balance every year. For 2008, WRI purchased credits compliant under the Clean Development Mechanism of the Kyoto Protocol, known as certified emission reductions (CERs). These credits were sourced from three different projects in China and India. Details of WRI's offset purchases for 2008 can be found on page 7.

This report is available online on WRI's website, http://www.wri.org. For more information about WRI's $CO_2$ commitment and our outreach activities, please contact Tom Damassa at 202-729-7783, tdamassa@wri.org.

## Introduction

The World Resources Institute (WRI) – a nonprofit policy and research organization working at the intersection of environment and human needs – recognizes global climate change as one of the most pressing challenges and opportunities of our time. Indeed, one of WRI's core goals is to "protect the global climate system from further harm due to emissions of greenhouse gases and help humanity and the natural world adapt to unavoidable climate change." Although our work seeks viable strategies to mitigate and adapt to climate change, we also acknowledge our own contribution to the problem.

As a result, in 1999, WRI committed to "walk the talk" by reducing its carbon dioxide ($CO_2$) emissions balance to zero (WRI has achieved its "net zero" goal each year since 2000), and publicly report its progress. The emission sources included in this goal are indirect emissions from the generation of purchased electricity, business air travel, and employee commuting. Through this project WRI gains direct experience in developing an annual $CO_2$ inventory and devising emissions mitigation strategies. WRI uses this first-hand knowledge to help others understand climate change and identify actions they can take to effectively measure, manage, and reduce their $CO_2$ emissions.

WRI conducts a $CO_2$ inventory each year to track our emissions and performance. The inventory follows the guidance in *Hot Climate, Cool Commerce: A Service Sector Guide to Greenhouse Gas Management* (see http://www.wri.org/publication/hot-climate-cool-commerce), which is based on and consistent with the WRI/WBCSD *Greenhouse Gas Protocol Corporate Accounting and Reporting Standard, Revised Edition* (GHG Protocol). A copy of these documents can be downloaded from the GHG Protocol website, http://www.ghgprotocol.org.

This report presents a summary of WRI's emissions for calendar year 2008. WRI issues a full report every two years and a summary report in the intervening years. For additional information, please refer to the last full report—WRI's $CO_2$ Inventory Report for Calendar Years 2006 & 2007. A full report will also be released next calendar year (2011) when WRI reports its CY2009 $CO_2$ inventory.

### *New in 2008: Opening a China Office and Joining the Climate Registry*

In mid-2008, WRI established an office in Beijing, China. With fewer than five full-time staff members initially, operation of the Beijing office currently makes a relatively small contribution to WRI's total global $CO_2$ "footprint". Nevertheless, we have started to account for our Beijing operations in our annual $CO_2$ inventory, particularly since there are likely to be increases in staff air travel to and from China.

WRI also became a founding member of The Climate Registry—a nonprofit collaboration among North American states, provinces, territories and Native Sovereign Nations that sets consistent and transparent standards to calculate, verify and publicly report greenhouse gas emissions into a single registry. As a voluntary reporter to The Climate Registry, our 2008 annual inventory is now also publicly available on The Climate Registry's website (http://www.theclimateregistry.org) and our reported Scope 2 emissions (emissions from the consumption of electricity) for 2008 have been verified by a third-party and successfully Climate Registered™. For more information on WRI's participation in The Climate Registry, please see the full press release.

## Emissions for Calendar Year 2008

WRI's total $CO_2$ emissions for calendar year 2008 are reported in Table 1.[1]

Emissions from the generation of purchased electricity (Scope 2) for WRI's Beijing office and business air travel (Scope 3) for staff based at the Beijing office for all relevant months (Jul-Dec, 2008) are reported separately in Table 1. Emissions from employee commuting for China-based staff are not included in WRI's inventory due to the uncertainty or unavailability of appropriate emissions factors. Future inventories will attempt to expand the source coverage and improve the quality of calculations for WRI's Beijing office.

A summary methodology, relevant activity data, and emission factors used in WRI's calculations are detailed in Appendices I & II.

**Table 1:** WRI's $CO_2$ emissions for calendar year 2008

| **CATEGORY OF EMISSIONS** | | **2008 EMISSIONS (IN METRIC TONS OF $CO_2$)** |
|---|---|---|
| SCOPE 1 (DIRECT) | | 0 |
| SCOPE 2 (CONSUMPTION OF PURCHASED ELECTRICITY) | DC Office | 511 |
| | Beijing Office | 4* |
| SCOPE 3 (BUSINESS AIR TRAVEL) | DC Staff | 635 |
| | Beijing Staff | 1* |
| SCOPE 3 (EMPLOYEE COMMUTING)** | | 112 |
| **TOTAL $CO_2$ EMISSIONS:** | | **1,263** |

**Total is for July – December, 2008 only.*
*** Total is for DC office staff only; excludes Beijing office staff.*

### *Excluded Sources of Emissions*

While WRI incorporates all major sources of $CO_2$ emissions from its business-related activities into its annual inventory, some minor sources are excluded due to data and/or systems constraints. These include:

- *Non-U.S. and non-China-based staff* – Currently WRI has a small number of full-time staff members and contracted employees who work remotely in India, Turkey, Central Africa, and Indonesia. While we recognize that these individuals contribute to WRI's overall "footprint," we currently do not have sufficient systems or relevant emissions factors to make robust calculations of their $CO_2$ contribution possible. While it is likely that this contribution is small, WRI hopes to incorporate these data into its inventory in the future.

[1] To facilitate comparability between 2008 totals and previously reported (historic) emissions we have included $CO_2$ emissions only in this report. However, as required by The Climate Registry's *General Reporting Protocol*, WRI also calculated estimates of methane ($CH_4$) and nitrous oxide ($N_2O$) emissions associated with our Scope 2 emissions (emissions from the consumption of purchased electricity). These emissions totaled three (3) metric tons of $CO_2$-equivalent and are reported at http://www.theclimateregistry.org.

- *HFC Emissions from HVAC –* Fugitive emissions of hydrofluorocarbons (HFCs) derive from building air heating, cooling, and refrigerant usage. While we hope to be able to report estimates of HFC emissions in the future, to date we have been unable to obtain any data from our landlord regarding building usage or WRI-specific activity data. In addition, pursuant with Ch.15.3 in the Climate Registry's *General Reporting Protocol*, because WRI leases space within a building and cooling generation units are outside of our organizational boundary, these emissions are considered optional (Scope 2) to report.

- *$CO_2$ Emissions from Paper Use –* Since 2004, $CO_2$ emissions from the use of paper (office paper, checks, and publications) has been reported in WRI's annual inventory, but totals have not been associated with WRI's "net zero" goal. While WRI believes that it is important to continue to leverage paper reduction opportunities, at present, WRI is no longer reporting emissions from paper in its annual inventory report. This is largely due to two factors: 1) many uncertainties are inherent in the calculation methodology for paper (i.e., appropriate emissions factors are largely unavailable); 2) WRI is currently considering new procedures to better track and manage data on our own paper use. We hope to be able to incorporate emissions from paper use into our annual inventory in a more robust way in the future.

## Emissions Trends (2003 – 2008)

### *Introduction*

In 2008, emissions factors for all of WRI's Scope 3 emission sources (business air travel and employee commuting) were revised based on the latest publications from the UK Department for Environment, Food, and Rural Affairs (UK DEFRA) and the U.S. Environmental Protection Agency (US EPA)—see Appendix I. In aggregate, these changes constituted a significant (> 5%) change in total reported emissions (compared to previous years' totals) and made comparisons with previously reported annual totals difficult.

WRI has therefore chosen to revise estimates of $CO_2$ emissions from reported sources for previous years using the latest (2008) emissions factors. Readers should bear in mind that the figures presented here may not be the same as those reported in previous WRI $CO_2$ inventory reports.

To ensure optimal comparability between annual estimates and provide a robust set of trend data, WRI has also established a new base year—2003. Calendar year 2003 was chosen for two reasons:

- Certain activity data (i.e., short-, medium-, and long-haul flight distances) are unavailable prior to 2002.

- Prior to CY2003, WRI reported its $CO_2$ inventory on a fiscal year (October-September) basis.

Therefore CY2003 is the earliest year for which comprehensive calendar year activity data exist. Unadjusted emissions totals for 2000-2002 (as published in previous $CO_2$ inventory reports) are presented in Appendix III.

### *Analysis*

In 2008, WRI's total emissions were 29% higher than its base year (2003) emissions. This growth in emissions is largely attributable to an increase (approximately 30%) in the number of WRI staff during 2005-2008 and a subsequent rise in travel-related emissions associated with business travel. Growth in emissions from electricity use in 2007-2008 is a result of WRI expanding its Washington, DC office

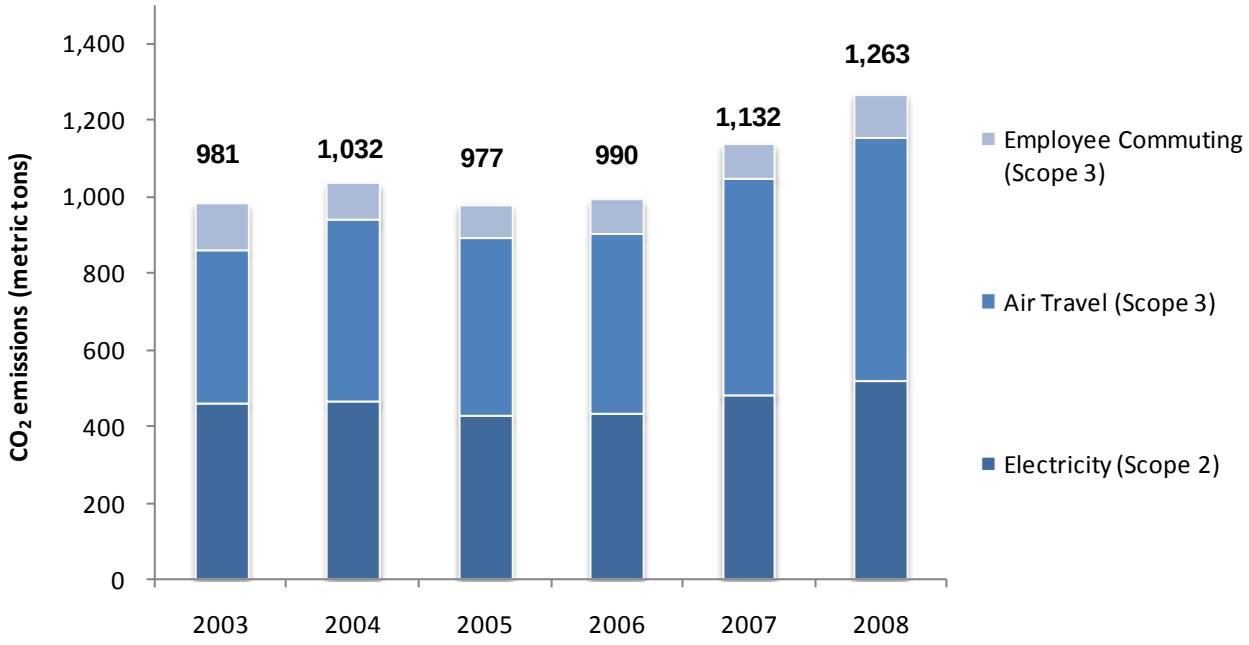
space (see WRI's $CO_2$ Inventory Report for Calendar Years 2006 & 2007). Table 2 and Figure 1 illustrate WRI's emissions performance from 2003 through 2008, by source.

Table 2 also includes estimates of WRI's annual per capita (per person) emissions. Per capita emissions in 2008 were approximately 2% lower than in 2003, but since 2005 WRI's estimated per capita emissions have increased 10%. This increase is, in part, due to the expansion of WRI's office space in 2007. It is also largely a result of increasing staff business air travel, which is a consequence of both a greater number of staff being required to travel and more frequent trips made between distant locations (for example, Washington, DC and Beijing).

**Table 2:** WRI total $CO_2$ emissions, by source, 2003 – 2008

| All emissions shown in metric tons of $CO_2$ | | | | | | |
|---|---|---|---|---|---|---|
| | **2003 (base year)** | **2004** | **2005** | **2006** | **2007** | **2008** |
| **Scope 2**<br>*Electricity* | 459 | 461 | 423 | 431 | 479 | 515 |
| **Scope 3**<br>*Air travel*<br>*Employee commuting* | <br>400<br>122 | <br>474<br>97 | <br>464<br>90 | <br>468<br>91 | <br>566<br>87 | <br>636<br>112 |
| **Total Emissions** | **981** | **1,032** | **977** | **990** | **1,132** | **1,263** |
| *Per Capita Emissions*<br>(metric tons per person) | 7.55 | 7.59 | 6.74 | 6.83 | 7.08 | 7.42 |

**Figure 1:** WRI total $CO_2$ emissions, by source, 2003-2008



## Investing in GHG Offsets[2]

WRI has sought to maximize efficiency opportunities in its business operations (for example, see Box I), however, WRI's annual goal is to achieve a "net zero" emissions balance, and to reach this target we must offset all emissions we have not been able to reduce through internal activities.

### *Offset purchases*

To offset our 2008 $CO_2$ emissions, WRI purchased Certified Emission Reduction (CER) credits.[3]

WRI procured CERs from three projects: the 4MW renewable energy (biomass co-generation) project by Sri Kalyani Agro Products & Industries Ltd. in Andhra Pradesh state, India; the Nanjing Tianjingwa (China) landfill gas to electricity project; and the 6.75MW small scale grid connected wind electricity generation project in Tamil Nadu, India. CERs for all projects were procured through EcoSecurities, Ltd. (http://www.ecosecurities.com), an independent broker that specializes in sourcing, developing, and trading emission reduction credits. Details of these projects are available at the UNFCCC website:

*Sri Kalyani biomass co-gen:* http://cdm.unfccc.int/Projects/DB/DNV-CUK1163564754.57/view

*Nanjing landfill gas to energy:* http://cdm.unfccc.int/Projects/DB/DNV-CUK1129289693.13/view

*Tamil Nadu wind power:* http://cdm.unfccc.int/Projects/DB/DNV-CUK1175246467.05/view

We hope our own experience and insights navigating the purchase of offset credits may provide guidance to companies, peer non-profits, and other organizations as they consider various offset options. For more information, please contact Tom Damassa (tdamassa@wri.org).

[2] An offset is an activity or project that reduces or sequesters greenhouse gas (GHG) emissions and takes place outside the inventory boundary of an organization. Companies and organizations can invest in these projects to counteract or "offset" the GHG emissions from their own operations. GHG offsets can be used to meet emission reduction targets, especially when the cost of internal reductions is high or opportunities for internal reductions are limited.

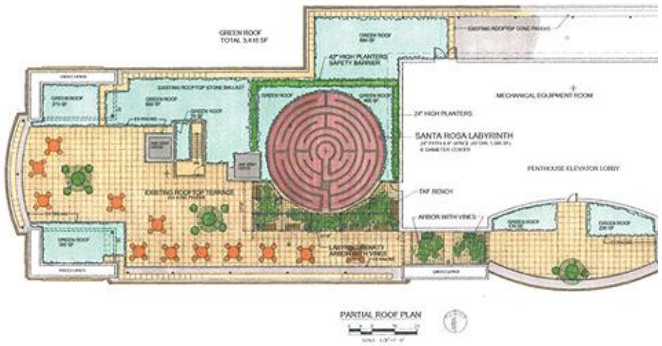
[3] CERs are a fungible commodity with 1 CER equivalent to 1 metric ton of $CO_2$. They are produced under the Clean Development Mechanism (CDM), an arrangement within the United Nations Framework Convention on Climate Change (UNFCCC) that allows industrialized countries with a greenhouse gas reduction commitment under the Kyoto Protocol (called Annex I countries) to invest in projects that reduce emissions in developing countries as an alternative to more expensive emission reductions in their own countries (a viable strategy since the effect of greenhouse gases is global, rendering the point of reduction irrelevant). The CDM is a compliance market and CERs are compliance credits.

**Box 1. The Green Roof at 10 G Street, NE**

Adapted from "Greening the Urban Rooftop" by Nancy Kiefer

In real estate-scarce cities, commercial property owners nationwide are turning roof space into green space. In 2008, WRI and the property owner, the American Psychological Association, completed work on a 3,000 square foot green roof and labyrinth on its 8-story office building near Union Station in Washington, DC.

Green roofs are advantageous not just for their aesthetics and the improvement they make to the urban landscape. Commercial property is a major energy consumer, and in the United States is responsible for 10 percent of greenhouse gas emissions. And considering the amount of time most people spend at work, environmental improvements to the workplace equate to better human health and well-being.




Here are a few green roof benefits:

- Green roofs are, in effect, a second roof. They reduce wear on the roof structure, extending its life by as much as 50 years. They improve insulation and reduce energy costs year-around. One study estimated that green roofs on all Chicago city buildings would save 720 megawatts annually (equal to several coal plants or one small nuclear plant) for a cost savings of $100 million.
- Green roofs also provide acoustic insulation, and can reduce noise pollution by as much as 50 decibels.
- Green roofs produce oxygen, absorb air pollutants and greenhouse gases, and reduce water loss due to run-off. 1,000 square feet of green roof provides enough oxygen for 110 people, and removes 41 pounds of airborne particles a year.
- Urban rooftops can reach 175 degrees Fahrenheit in the summer. Green roofs can lower ambient air temperatures and reduce the heat island effect.
- Square footage is a valuable urban commodity. Green roofs reclaim space for personal use and relaxation, and provide habitats for wildlife.
- Green roofs can counteract "big box development" to make retail and commercial properties more valuable and attractive. In 2006, Wal-mart built a 67,000 square foot, self-irrigating green roof on top of one of its Chicago stores.

The 10 G Street project is a partnership between APA and WRI, with funding and support from the TKF Foundation and the Chesapeake Bay Foundation.

- Read WRI's Press Release

## WRI Emissions Balance Sheet

WRI's emissions balance for 2008 (total emissions less purchased CERs) is presented in Table 3. This table also includes historic data, including WRI's purchases of carbon financial instruments (CFIs) – the offset or allowance credit for the Chicago Climate Exchange (CCX). Table 4 presents WRI's historic purchases of renewable energy credits (RECs).[4] A complete discussion of WRI's previous investments in different carbon reduction credit types, as well as RECs, can be found in WRI's $CO_2$ Inventory Report for Calendar Years 2006 & 2007 and earlier inventory reports.

**Table 3:** Emissions balance summary, including the purchases of offsets. All data reported in metric tons of $CO_2$.

| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|
| **Scope 1 (Direct)** | **0** | **0** | **0** | **0** | **0** | **0** |
| **Scope 2 (Purchased electricity)** | **459** | **461** | **423** | **431** | **479** | **515** |
| **Scope 3 (Air travel and commuting)** | **522** | **571** | **554** | **559** | **653** | **748** |
| $CO_2$ offsets purchased | 0 | 0 | 0 | 0 | 1,132 | 1,263 |
| CCX offsets/allowances purchased | 1,100 | 1,200 | 1,100 | 1,200 | 0 | 0 |
| *CERs Applied* | *0* | *0* | *0* | *0* | *-1,132* | *-1,263* |
| *CCX carbon financial instruments applied** | *-1,100* | *-1,200* | *-1,100* | *-1,200* | *0* | *0* |
| **WRI $CO_2$ Emissions Balance**** | **0** | **0** | **0** | **0** | **0** | **0** |

** The Chicago Climate Exchange (CCX) requires members to purchase an amount of carbon financial instruments or CFIs (with 1 CFI = 1 metric ton $CO_2$) equivalent to a company's total net emissions, rounded up to the nearest hundred.*

*** Readers should note that because emissions totals for 2003-2007 were revised in 2008 (as described in this report), WRI's $CO_2$ emissions balance will not sum to zero for years in which CCX allowances were purchased (2003-2006). Nevertheless, we report a net emissions balance of zero, because we did meet our "net zero" $CO_2$ reduction commitment for each year.*

**Table 4:** WRI Renewable Energy Credit (REC) purchases.

| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|
| *WRI REC Purchases (Megawatt hours)* | *230* | *232* | *214* | *0* | *324* | *0* |

[4] RECs are environmental commodities intended to provide an economic incentive for the generation of electricity from renewable energy sources. A REC is created when 1,000 (net) kilowatt-hours (kWh) of electricity is generated from an eligible renewable energy resource. Typically, RECs are unbundled and sold separately from the underlying electricity generated.

## Appendix I: Calculation Methodology Summary and Inventory Adjustments CY2008

### *Calculation methodology*

The formula used to calculate all $CO_2$ emissions in WRI's inventory is:

| Activity data | X | Emissions factor | = | $CO_2$ emissions |
|---|---|---|---|---|

Activity data = quantification of an activity of emissions source (e.g., air miles traveled, kWh of electricity used, etc.).

Emissions factor = A factor relating activity data and absolute emissions. The source-specific or published emissions factor is used to convert activity data to an emissions value.

For more information, please see the full description of WRI's accounting methodology, available in WRI's $CO_2$ Inventory Report for Calendar Years 2006 & 2007.

### *Emissions adjustments*

As our knowledge and experience in inventory development grows, we may develop improved calculation methodologies and tools. When this happens, previous years reported emissions are adjusted according to the new methodology.

Adjustments are also made when new emission factors are published that more closely reflect actual emissions than those available at the time the original calculations were made. These adjustments allow our emissions accounting to be as accurate and consistent from year to year as possible. However, in the case where adjustments are relatively insignificant or do not reflect a change in calculation methodology, recalculations are not performed for previous years' emissions.

For the CY2008 inventory, emission factors for all Scope 3 sources (business air travel and employee commuting), as well as the distance designations for air travel legs (i.e., short-, medium-, and long-haul) were updated based on recent publications by the UK Department for Environment, Food, and Rural Affairs (UK DEFRA) and the U.S. Environmental Protection Agency (US EPA). Cumulatively, these changes were significant enough to warrant revising calculations of emissions totals for previous years (as described on page 5 of this report). Table 5 presents a summary of the changes from 2007 to 2008.

Note that while the emissions factor used to calculate $CO_2$ emissions from purchased electricity (Scope 2) changed from 2007 to 2008, because this change was a result of fluctuations in the composition of regional fuel mix (as opposed to improved accuracy), estimates for previous years' Scope 2 emissions were *not* recalculated.

**Table 5:** 2008 Emission Factor Adjustments

| | 2007 EMISSION FACTORS | 2008 EMISSION FACTORS* |
|---|---|---|
| **PURCHASED ELECTRICITY** | | |
| **ELECTRICITY (RFCE REGION)** | 1,098 LBS. $CO_2$/MWH | 1,139 LBS. $CO_2$/MWH |
| **BUSINESS AIR TRAVEL** | | |
| **AIR TRAVEL, SHORT FLIGHTS** | DISTANCE: <500 KM | DISTANCE: <483 KM |
| | 0.15 KG $CO_2$/KM | 0.19 KG $CO_2$/KM |
| **AIR TRAVEL, MEDIUM FLIGHTS** | DISTANCE: <1600 KM | DISTANCE: <1126 KM |
| | 0.12 KG $CO_2$/KM | 0.10 KG $CO_2$/KM |
| **AIR TRAVEL, LONG FLIGHTS** | DISTANCE: >1600 KM | DISTANCE: >1126 KM |
| | 0.11 KG $CO_2$/KM | 0.09 KG $CO_2$/KM |
| **EMPLOYEE COMMUTING** | | |
| **BUS** | 0.30 KG $CO_2$/MILE | 0.107 KG $CO_2$/MILE |
| **SUBWAY (METRO)** | 0.17 KG $CO_2$/MILE | 0.163 KG $CO_2$/MILE |
| **U.S. COMMUTER RAIL (E.G., AMTRAK)** | 0.31 KG $CO_2$/MILE | 0.185 KG $CO_2$/MILE |
| **CAR** | 8.87 KG $CO_2$/GALLON GASOLINE | 8.81 KG $CO_2$/GALLON GASOLINE |

**See Appendix II for emission factor sources. Note: Emissions factors for air travel presented here are rounded, and represent "economy class" values for all designations. For more precise factors, see http://ghgprotocol.org.*

## Appendix II: 2008 Activity Data, Emission Factors, and Sources

### Scope 2 Information

- *Electricity*. WRI's Washington, DC office occupies one complete floor and, as of 2007, most of another floor in an eight story building. This space is not separately metered therefore annual electricity use by WRI must be estimated. The formula used is:

| (area of WRI's space ÷ total building area) | X | Total building usage of electricity | = | WRI's estimated electricity use |
|---|---|---|---|---|

WRI's Beijing office occupies a small portion of a multi-story building. Direct reporting of electricity usage data is available and maintained by the Beijing office manager.

**Table 6:** WRI's 2008 Scope 2 emissions. (Appropriate unit conversions are applied to achieve data in metric tons of $CO_2$).

| | | Source of emissions | Activity data | Emission factor | Metric tons of $CO_2$ |
|---|---|---|---|---|---|
| **Scope 2** *(electricity)* |  | *Purchased electricity – DC Office* | *989,358 kWh* | *1.139 lbs of $CO_2$/kWh* | *511* |
| | | *Purchased electricity – Beijing Office* | *4,831 kWh* | *1.737 lbs of $CO_2$/kWh* | *4* |
| | | | | **Total** | **515 t$CO_2$** |

Emission factor source: For DC office - U.S. EPA E-Grid database (eGRID2007 Version 1.1), 2005 data for RFCE region. See http://www.epa.gov/cleanenergy/energy-and-you/how-clean.html. For Beijing Office - IEA, 2008. *$CO_2$ Combustion from Fossil Fuels*. Paris, France: OECD/IEA. Available at: http://www.iea.org/w/bookshop/add.aspx?id=36. © OECD/IEA [2008].

### Scope 3 Information

- *Business Air Travel.* Two methods are used to obtain activity data for air miles traveled:

  1. Air miles for travel booked through WRI's travel agency are automatically compiled and are available for download through the travel agency's website.

  2. Staff are required to complete a travel authorization form for each trip taken. A section has been added to this form for staff to complete with information about miles traveled if the trip is not booked through WRI's travel agency.

Since emissions per mile are higher for short flights than for long flights, data on air miles traveled is further broken down in to short, medium, and long flights as defined in the GHG Protocol mobile combustion tool and a unique emissions factor is applied to each.

**Table 7:** WRI's 2008 Scope 3 emissions from air travel. (Appropriate unit conversions are applied to achieve data in metric tons of $CO_2$).

| | | Source of emissions | Activity data | Emission factor | Metric tons of $CO_2$ |
|---|---|---|---|---|---|
| **Scope 3** *(air travel)* | | *Air travel, short flights* | *71,531 km* | *0.19 kg of $CO_2$/km* | *14* |
| | | *Air travel, medium flights* | *318,758 km* | *0.10 kg of $CO_2$/km* | *33* |
| | | *Air travel, long flights* | *6,689,357 km* | *0.09 kg of $CO_2$/km* | *588* |
| | | | | **Total** | **635 $tCO_2$** |

Emission factor source: UK DEFRA. *Notes:* Emissions factors for air travel presented here are rounded values. For more precise factors, see http://ghgprotocol.org. UK DEFRA defines flight legs as "domestic", "short haul", and "long haul"; these have been (conservatively) re-categorized here as "short", "medium", and "long", respectively. In all cases, an emissions factor for economy class is used when available.

- *Employee commuting*

WRI surveys its staff once each year to obtain information about average commuting habits. The information gathered is used to extrapolate average annual commuter miles traveled by all staff via various modes of transport. For a sample copy of WRI's commuter survey, please contact Tom Damassa at tdamassa@wri.org.

**Table 8:** WRI's 2008 Scope 3 emissions from employee commuting. (Appropriate unit conversions are applied to achieve data in metric tons of $CO_2$).

| | | Source of emissions | Activity data | Emission factor | Metric tons of $CO_2$ |
|---|---|---|---|---|---|
| **Scope 3** *(employee commuting)* |  | *Bus* | *42,142 miles* | *0.107 kg of $CO_2$/mile* | *4* |
| |  | *Metro* | *250,181 miles* | *0.163 kg of $CO_2$/mile* | *41* |
| |  | *Commuter rail* | *144,190 miles* | *0.185 kg of $CO_2$/mile* | *27* |
| |  | *Car* | *4,522 gallons of gas* | *8.81 kg of $CO_2$/gallon* | *40* |
| |  | *Walk/bike* | *37,712 miles* | *0* | *0* |
| | | | | **Total** | **112 $tCO_2$** |

Emission factor sources: UK DEFRA & U.S. EPA.

## Appendix III: WRI Reported $CO_2$ Emissions, 2000-2002

Emissions totals presented in this appendix represent data for years preceding WRI's (re-established) base year—2003. Data presented in Table 9 have not been adjusted using 2008 emissions factors (as documented in Appendix I). These data have previously been reported in WRI's 2002, 2003, 2004-2005, and 2006-2007 $CO_2$ inventory reports (see http://www.wri.org/publication/co2-inventory-report) and represent an important historical record of WRI's $CO_2$ accounting practices.

**Table 9:** WRI's $CO_2$ emissions, 2000 – 2002

| | 2000 | 2001 | 2002 |
|---|---|---|---|
| **Scope 2**<br>*Electricity* | 431 | 503 | 535 |
| **Scope 3**<br>*Air travel*<br>*Employee commuting* | <br>535<br>98 | <br>598<br>104 | <br>529<br>94 |
| **Total Emissions** | **1,064** | **1,205** | **1,158** |

Appendix B: 2011-2012 Faculty Survey

Page 1: All Faculty

## Union College Faculty/Staff Transportation Survey

Dear Faculty/Staff member,
Please fill out this survey regarding transportation habits at Union College. The results from this survey will help me analyze transportation options as part of my Environmental Science thesis. Names and emails will not be recorded at any point during the survey. Thank you, Benjamin Engle '12

**Approximately, how many miles (round trip) do you travel to and from campus each day?**

**On average, how many days per week do you drive alone to get to campus?**

- Never
- 1
- 2
- 3
- 4
- 5
- Other:

**On average, how many days per week do you carpool using your car to get to campus?**

- Never
- 1
- 2
- 3
- 4
- 5
- Other:

**On average, how many days per week do you carpool with a coworker in his/her car to get to campus?**

- Never
- 1
- 2
- 3
- 4
- 5
- Other:

**If applicable, how many days per week (on average) do you ride your bicycle to get to campus?**

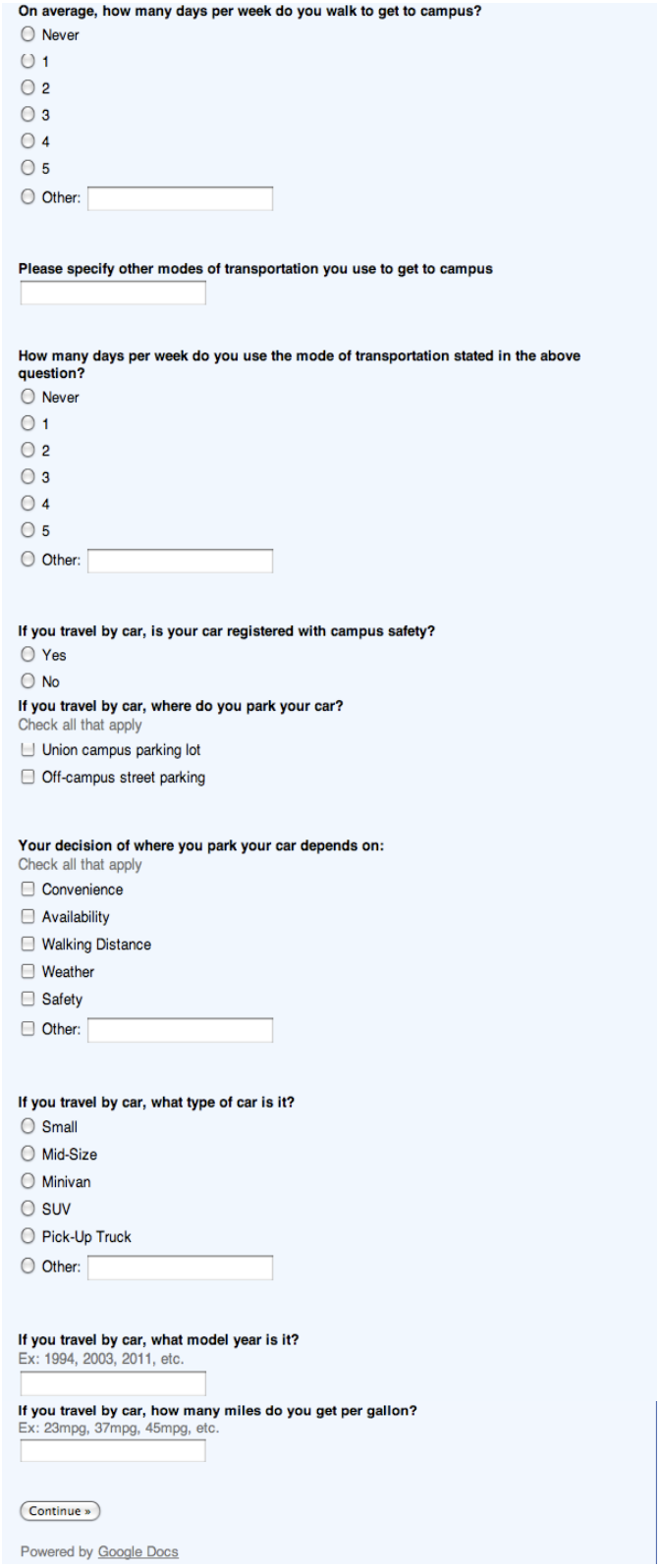
- Never
- 1
- 2
- 3
- 4
- 5
- Other:

**On average, how many days per week do you take public transportation to get to campus?**

- Never
- 1
- 2
- 3
- 4
- 5
- Other:

# Appendix B: 2011-2012 Faculty Survey

## Page 1 (Continued): All Faculty



**On average, how many days per week do you walk to get to campus?**

- ○ Never
- ○ 1
- ○ 2
- ○ 3
- ○ 4
- ○ 5
- ○ Other:

**Please specify other modes of transportation you use to get to campus**

**How many days per week do you use the mode of transportation stated in the above question?**

- ○ Never
- ○ 1
- ○ 2
- ○ 3
- ○ 4
- ○ 5
- ○ Other:

**If you travel by car, is your car registered with campus safety?**

- ○ Yes
- ○ No

**If you travel by car, where do you park your car?**

Check all that apply

- ☐ Union campus parking lot
- ☐ Off-campus street parking

**Your decision of where you park your car depends on:**

Check all that apply

- ☐ Convenience
- ☐ Availability
- ☐ Walking Distance
- ☐ Weather
- ☐ Safety
- ☐ Other:

**If you travel by car, what type of car is it?**

- ○ Small
- ○ Mid-Size
- ○ Minivan
- ○ SUV
- ○ Pick-Up Truck
- ○ Other:

**If you travel by car, what model year is it?**

Ex: 1994, 2003, 2011, etc.

**If you travel by car, how many miles do you get per gallon?**

Ex: 23mpg, 37mpg, 45mpg, etc.

Continue »

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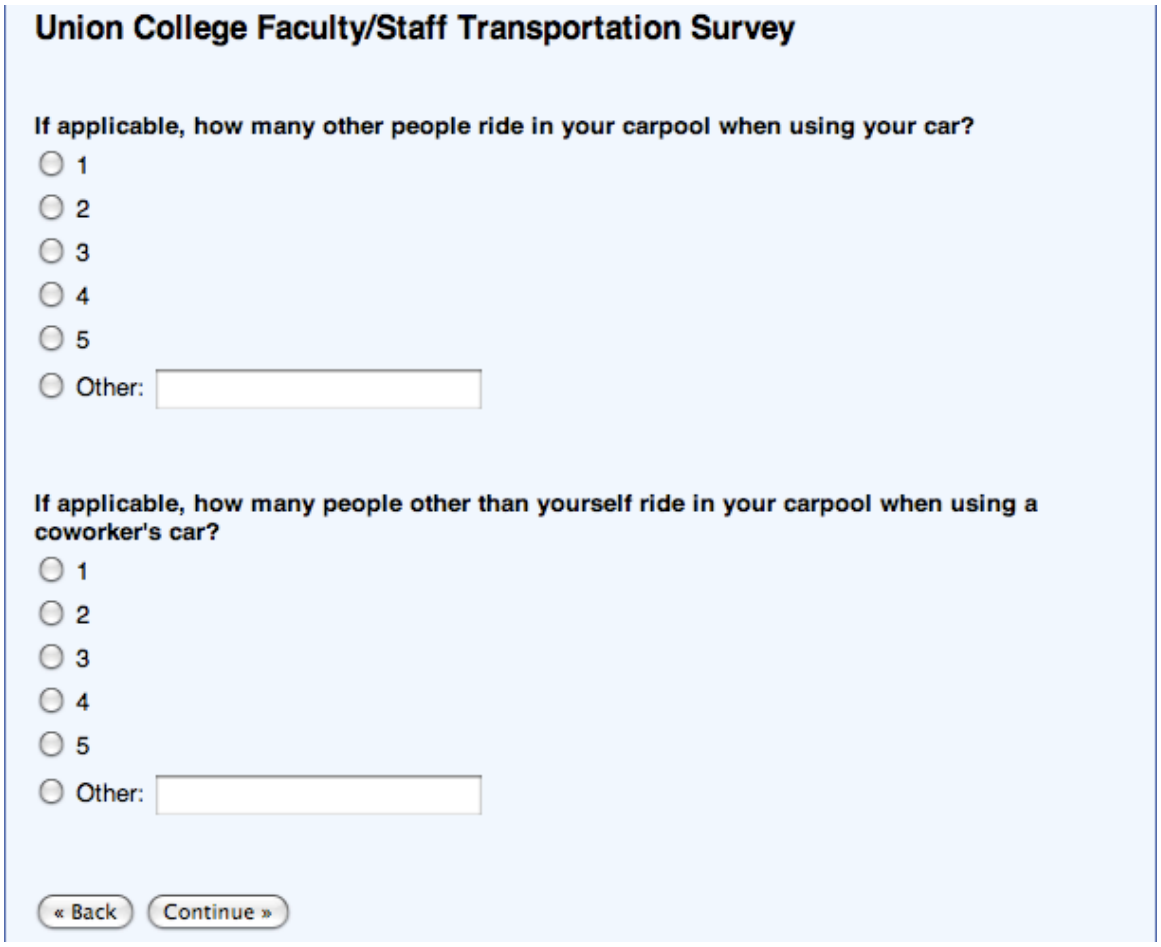
Appendix B: 2011-2012 Faculty Survey

Page 2: All Faculty



**Union College Faculty/Staff Transportation Survey**

**If applicable, how many other people ride in your carpool when using your car?**

- ○ 1
- ○ 2
- ○ 3
- ○ 4
- ○ 5
- ○ Other:

**If applicable, how many people other than yourself ride in your carpool when using a coworker's car?**

- ○ 1
- ○ 2
- ○ 3
- ○ 4
- ○ 5
- ○ Other:

« Back  Continue »

Appendix B: 2011-2012 Faculty Survey

Page 3: All Faculty

**Would you consider carpooling or using public transportation to commute to campus in order to reduce carbon emissions? If not, please explain in the box below.**

- ☐ Yes
- ☐ No
- ☐ Other:

**What would make you more likely to carpool or use public transportation?**

- ☐ Monetary or in-kind incentives by the college
- ☐ An earned credit or a thank you reward (meal, coffee, drink, etc.)
- ☐ A service provided by the college to connect carpool matches
- ☐ Other:

**Are your driving habits impacted by gas prices?**

- ○ Yes
- ○ No
- ○ Other:

**Comments, Questions, Concerns**

« Back Submit