Project No. NCDOT 3205

TRIP MAKING PATTERNS OF NC'S UNIVERSITY STUDENTS

FINAL REPORT

Prepared for:

North Carolina Department of Transportation

Prepared by:

Joseph Huegy, AICP, P.I.

Chao Wang, Ph.D., P.E.

Bing Mei, P.E.

Daniel Findley, Ph.D., P.E.

Sarah Searcy

Institute for Transportation Research and Education

North Carolina State University

Joyendu Bhadury, Ph.D.

Bryan School of Business and Economics

University of North Carolina at Greensboro

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Trip Making Patterns of NC's University Students		5. Report Date July 29, 2015
		6. Performing Organization Code
7. Author(s) Joseph Huegy, AICP Joyendu Bhadury, Ph.D. Chao Wang, Ph.D.		8. Performing Organization Report No.
9. Performing Organization Name and Address Institute for Transportation Research and Education North Carolina State University Box 8601 Raleigh, NC 27695-8601		10. Work Unit No. (TRAIS)
		11. Contract or Grant No.
12. Sponsoring Agency Name and Address North Carolina Department of Transportation Research and Analysis Group 1 South Wilmington Street Raleigh, North Carolina 27601		13. Type of Report and Period Covered Final Report 8/16/2012 – 11/21/2014
		14. Sponsoring Agency Code NCDOT 3205
Supplementary Notes:		

16. Abstract

This report documents research undertaken as part of research project RP 2013-32 "Trip Making Patterns of NC's University Students." The project reviewed literature on surveys of university student travel behavior. A survey was designed to deliver to university students using the internet including self-geocoding of activity locations. The survey was pilot tested by Institute of Transportation Engineers Student Chapter members at NC State University and then was implemented at NC State University and UNC – Greensboro during the first year. During the second year, the survey was implemented at four other universities in North Carolina: UNC – Charlotte, Fayetteville State University, UNC – Wilmington, and Appalachian State University. The survey data was analyzed and models were prepared for trip generation, trip distribution, and mode choice. These models were designed to be included in existing travel forecasting models used in North Carolina in communities that have university campuses in order to better reflect the impact of university campuses on traffic patterns.

17. Key Words Planning, Surveys, Forecasting	18. Distribution Statement		
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 219	22. Price

Form DOT F 1700.7 (8-72) **Reproduction of completed page authorized**

DISCLAIMER

The contents of this report reflect the views of the author(s) and not necessarily the views of the University. The author(s) are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of either the North Carolina Department of Transportation or the Federal Highway Administration at the time of publication. This report does not constitute a standard, specification, or regulation.

ACKNOWLEDGMENTS

This project was made possible by the support of several people. In particular, for their assistance through the project, the research team expresses its gratitude to the following:

Michael Davenport, Office of Institutional Research, UNCG

Samuel Troy and Peyton Ford, Bryan School of Business & Economics, UNCG

Lisa Castellino and Albie Lange, University of North Carolina at Wilmington

Ivan Walker and Assad A. Tavakoli, Fayetteville State University

Nancy Whelchel, Office of Institutional Research and Planning, North Carolina State University

Peter Wachs, Ph.D., Institutional Research Assessment and Planning, Appalachian State University

Wayne Stone, Office of Institutional Research, University of North Carolina at Charlotte

John W. Kirby, Research Engineer

Office of Research, North Carolina Department of Transportation

Research Team for the project also included:

Mei Ingram, Institute for Transportation Research and Education, North Carolina State University

Jeffrey Chang, Institute for Transportation Research and Education, North Carolina State University

Bo Shao, Institute for Transportation Research and Education, North Carolina State University

Yijun Ma, Institute for Transportation Research and Education, North Carolina State University

Table of Contents

I. Executive Summary

The purpose of the research project was to collect survey data on the travel behavior of students from six public universities across North Carolina in order to support the development of travel models for communities that have university campuses. The objective was to assist the development of travel models for these communities to model student travel behavior more realistically, thereby improving their credibility.

This project was completed in two phases over a period of two years beginning in August 2012. Extensive data on student travel behaviors was collected via surveys performed at six universities in North Carolina. Universities were selected with their demographics in mind so that they were representative of the overall university and college system in North Carolina; primarily, from the standpoint of student impact on transportation in the vicinity of the selected campuses. After statistically analyzing the data, inferences were made about patterns of student travel; thereafter, the data were used to develop models of university student behavior. Two technical reports accompanying this report provide detailed documentation for the surveys: Technical Report A: Survey Documentation; and for the models developed for this project: Technical Report B: Model Development. It is suggested to consult these more detailed reports that have been prepared to stand on their own in order to make use of the survey data and models for further analysis and application.

Our primary recommendations based on the study are as follows:

1. Models can be used to assess the impact of university campuses on neighboring street systems based on the propensity for students to travel to and from the campus.
2. Key predictors of student travel are data that are readily available, such as number of students living on and off campus, and number of full time and part time students.
3. The key predictors of student travel can be based on local specific data to tailor university student models to the local context, making the data collected and the models developed for this project more transferrable.
4. For adding university students to travel models, for off campus students, it is suggested to add the crossing the university boundary trips and for on campus students to add both the crossing the university boundary trips and the outside the university trips.
5. A set of polynomial functions based on student residence distance from campus for each mode (walk, bicycle, auto, and transit) for total daily trips and home based university trips can be used in the absence of a travel demand model to understand the impact of university students on the road system adjacent to the campus.

II. Introduction

It is recognized that university students have a significant impact on the transportation network of the vicinity of the university campuses they attend. Under the assumption that student travel behaviors are similar to those of one-person low income households, the conventional norm in transportation research is to treat university students in the same manner as the general population. This assumption clearly has significant flaws. For example, university students have more mandatory trips to make, such as trips to classes. Also, with the availability of recreational facilities at subsidized prices on university campuses, students make more trips to or on campus for recreational purposes. Additionally, trip distance, activity duration, travel mode choices, and trip making time distribution of low income households and university students can be very different. For example, a large portion of university student trips are made on campus; therefore, the land-use characteristics of the University campus will significantly impact the travel patterns of the students. In summary, trip making patterns of university students are neither well understood nor well represented in travel demand models; therefore, it is challenging to plan for university student transportation.

North Carolina has an extensive system of 150 public and private universities and colleges across the entire state which serve as a bridge and diverse test bed to develop models of student travel behavior. For example, it can be expected that an urban campus such as that of University of North Carolina Charlotte (student enrollment is less than 2% of the surrounding population within a 50 minute driving distance) will have a very different impact on the transportation network of Charlotte than Appalachian State University (student enrollment is approximately 13% of the surrounding population within the 50 minute driving distance) will have on Boone. However, there is a dearth of information on travel patterns of university students in North Carolina - the sole significant survey was performed at North Carolina State University over a decade ago.

As a direct result of the limited information available on student travel patterns at state-supported universities, this research project was initiated with the intention of collecting data from a wide and representative sample of universities in North Carolina and to use that data to develop a realistic and reliable model of student travel behavior. The practical impact of this model is to allow transportation modelers to:

- investigate and resolve on- and off-campus transportation problems more systematically in order to improve campus transportation planning and operations; and
- facilitate transportation system modeling practices, such as university transportation models, MPO models, and even to improve the North Carolina Statewide Model and better traffic analysis studies of transportation related projects within or near universities.

This project was completed over a period of two years as a succession of 16 different tasks implemented in two phases. During this project, a substantial pool of data, over 3,700 samples, was collected through surveys conducted at the following six campuses in the University of North Carolina (UNC) system: North Carolina State University, University of North Carolina at Greensboro, University of North Carolina at Charlotte, University of North Carolina at Wilmington, Appalachian State University and Fayetteville State University. This makes the present study the largest ever conducted with a sample size almost twice that of the previous largest study conducted at Arizona State University in 2007. Each sample consisted of a detailed travel log by a given student over a specified period of time. Sample data was then validated to remove errors and then the revised data was used to estimate the parameters for model development. Thereafter, inferences were drawn and recommendations developed that are outlined in the remainder of the report. This report gives information about conducting the study and enough information to understand the results of the surveys and the models that have been prepared, but is not intended to

document the survey or to provide details needed to add the models to travel models. Detailed documentation of the surveys and models prepared are provided in two technical reports: A) Survey Documentation, and B) Model Development. The survey documentation technical report provides specific information for each campus survey to allow further analysis of the data sets and includes information on variables collected, sampling and sample weights, and tabulations of key variables. The model development technical report explains the development of models of university student travel behavior using the survey data, and provides guidance for including the models in local travel demand models including how to add them to models for areas where university students were not surveyed. In addition, a set of relationships are provided using the data to develop estimates of university trips without employing a travel demand model.

The next section provides background for the study, and a review of university student surveys that have been conducted in the United States prior to this study. The review provided important insights for the details of administering the surveys and results that could be used to set expected participation rates and trip rates to be obtained from the surveys.

III. Background Review

As background, a university student trip survey is similar to a household travel survey in that both collect the socioeconomic characteristics, demographic characteristics and travel behaviors (usually through travel logs). The instruments used in many university student travel surveys are modified versions of household travel surveys. On the other hand, a household travel survey typically uses households as samples, whereas a university student travel survey uses students. Compared to household travel surveys, university student trip surveys usually cover a much smaller area, use different survey techniques, and need to focus on problems that are important to University trips, such as parking constraints. The most prominent university student travel surveys conducted in the United States are summarized below.

Indiana University

The Indiana University Student Trip Survey was conducted in May of 1998 on the Bloomington campus [1]. Indiana University (IU) students attending the Bloomington Campus accounted for nearly 30% of the population of Monroe County. A total of 583 usable surveys were completed, representing about 1.7% of the total student population. These students generated 2,274 person trips on a typical day yielding 3.9 daily trips per person. This trip rate seemed reasonable considering that only inter-zonal trips were recorded. The motorized OD (Origin-Destination) matrix for student trips was obtained from the survey, and was used in the Bloomington metropolitan travel demand model [2].

North Carolina State University

In the 2001 North Carolina State University (NCSU) Student Activity Travel Survey, NCSU officials randomly selected 4,000 on-campus students and 4,000 off-campus students from the student registry for the spring, 2001 semester [3]. Students were asked to complete a travel diary for the pre-assigned “travel day.” This survey collected 843 valid student records, representing 3.2% of the total NCSU student population. The results show that undergraduate students and on-campus residents are engaged in more activities than graduate students and off-campus students. The student trip rate (6.35 trips/day) is significantly higher than the regional average of 4.06 trips/day recorded in the 2006 Triangle Regional Model (TRM) household travel survey [4].

Arizona State University

Arizona State University (ASU) has four campuses located in the Greater Phoenix Metropolitan Area and serves more than 60,000 students and 12,000 employees. The ASU Travel Demand Survey [5] was conducted in the spring of 2007 to collect travel data from students, faculty, and staff. The survey obtained detailed household and personal economic and demographic characteristics, class and work schedules for a typical week, "usual" characteristics of travel to and from ASU, and a travel log for all trips to and from ASU taken on the most recent day the individual traveled to campus. The survey also included a stated preference component to evaluate light rail usage. The total respondent sample size was 3,848 persons, which included 2,036 students. The rate of student trips to and from ASU was 2.50 trips/day (Note: This was not the overall daily trip rate, as trips that did not originate or end at ASU were not included in the computation). A trip generation model and a multinomial logit mode choice model were developed based on the survey to study the feasibility of the proposed light rail project.

Virginia Department of Transportation

Virginia Department of Transportation (VDOT) conducted university student surveys in 2009 at four Virginia public universities: Old Dominion University (ODU) [6], Virginia Commonwealth University (VCU), University of Virginia (UVA) and Virginia Tech (VT). These surveys were web-based and used a modified version of the National Household Travel Survey (NHTS) instrument to obtain travel behavioral data of university students [7]. In the first survey 5,000 students were sampled from each university with the goal of 1,000 completed samples. However, due to the excessive length of the survey, a substantial number of incomplete samples were observed in the sampling results. Therefore, another round of shorter and better-designed surveys was conducted at two universities (ODU and VT) in 2010 [8], which had more legitimate samples, higher response rate (see Table 1 for details), and more importantly, fewer underreported trips. Students reported 15% to 20% more trips in the second round of surveys, and the daily trip rates were 5.6 for ODU students and 5.8 for VT students, which were consistent with the North Carolina State University student survey (5.0-7.0 daily trips) [9].

Trip generation models were developed in this study to explore the connections between trip frequencies, and personal and travel characteristics of university students. Since the dependent variable, trip frequency, is a discrete variable, Poisson, zero-inflated Poisson and negative binomial regression models were tested [10]. The independent variables included working status, distance to campus (whether living near campus or far from campus), enrollment status (full time or part time, undergraduate or graduate), age, gender, number of vehicles, income, and whether the travel day was over the weekend. The insights gained from these models can serve as the basis for trip generation in regional travel demand models, where university dominated zones are treated as special generators.

The above are summarized below in Table 1.

Table 1 Summary of University Student Trip Surveys

University	Time	Campus Context	Sample Size	Response Rate	Distribution of Instrument	Note
Indiana University - Bloomington (IU-B)	1998	Suburban	583	11.7%	Web	Only record inter-zonal trips.
North Carolina State University (NCSU)	2001	Urban	843	10.5%	Mail	
Arizona State University (ASU)*	2007	Urban	2,036	3.4%	Web (SNAP)	Only record trips to or from ASU.
Old Dominion University (ODU)	2009	Urban	708	14.1%	Web (SNAP)	First round of VDOT surveys.
Virginia Commonwealth University (VCU)	2009	Urban	652	13.0%	Web (SNAP)	First round of VDOT surveys.
University of Virginia (UVA)	2009	Suburban	780	15.6%	Web (SNAP)	First round of VDOT surveys.
Virginia Tech (VT)	2009	Suburban	643	12.9%	Web (SNAP)	First round of VDOT surveys.
Old Dominion University (ODU)	2010	Urban	1,468	29.4%	Web (SNAP)	Second round of VDOT surveys.
Virginia Tech (VT)	2010	Suburban	1,128	22.6%	Web (SNAP)	Second round of VDOT surveys.

* The numbers for Arizona State University only consider the student samples.

The summary observations from these surveys above are as follows:

- University student trip surveys have been focused on public universities.
- The response rate varies from 10.5% to 29.4%, with the exception of the ASU survey whose response rate is only 3.4%. The ASU survey was conducted at the end of a spring quarter, which contributed to the much lower response rate. Incentives, good advertisement and less response burden seem important to increase the response rate.

- Both mail and web have been used to conduct the university student travel surveys.
- Depending on the model design, different surveys collected different travel information. For example, IU-B only collected inter-zonal trips and ASU only collected trips to or from ASU.

The next section explains how the surveys were designed and implemented in North Carolina. This started with designing the travel models to be developed, and then designing surveys to collect the data needed to develop the models.

IV. Project Implementation

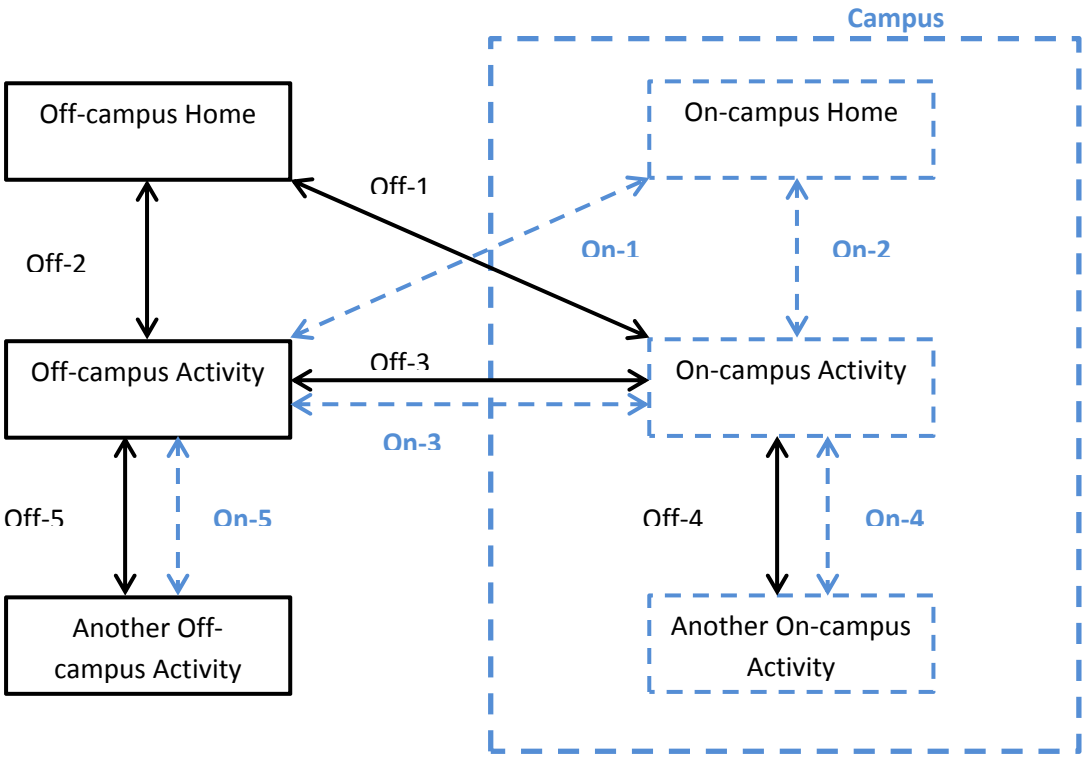
A. Model Design

The following criteria were used for developing the University student travel model. Based on extensive discussion with NCDOT, it was agreed that the proposed university student travel model will be used as a prototypical model that can be applied across North Carolina and have the following characteristics:

- an ability to reflect the major impact of university student trips on the road system around university campuses
- adequate representation of the unique travel behavior of university students
- easy to implement and incorporate into the current travel demand models across North Carolina and
- input data required by the model should be easy to collect.

The model begins with the basic premise that there are two types of university students, off-campus students and on-campus students. Off-campus students live off campus and live alone or live with family members or roommates. Off-campus students usually get sampled in household surveys. On the other hand, on-campus students live on campus and are not sampled in household surveys. These two groups make different types of trips, which are illustrated in Figure 1.

Figure 1 Illustration of Trips made by Off-campus and On-campus Students



In Figure 1, trip ends are represented as boxes: boxes with solid black borders for off-campus trip ends, and boxes with blue dashed line borders for on-campus trip ends. The lines linking these boxes represent the trips between these trip ends. The trips made by off-campus students are represented in solid black lines and on-campus students in dashed blue lines. Trips are numbered as Off-1 to Off-5, and On-1 to On-5 in Figure 1.

NCDOT indicated that university student trips that most affect the surrounding road system were of most interest. Based on the literature review, it was concluded that these would be trips that cross the university boundary, hence, the university student travel model focuses on modeling the following trips: Off-1, Off-3, On-1 and On-3.

With the above factors in mind, the proposed model was developed as follows. The proposed trip purposes for university students were defined as shown in Table 2.

Table 2 University Student Trip Purposes

ID	Trip Purpose	Off-campus Student	On-campus Student
1	HBU (Home Based University)	Off-1	On-2
2	HBO (Home Based Other)	Off-2	On-1
3	UBNH (University Based Non-home)	Off-3, Off-4	On-3, On-4
4	NHNU (Non-home Non-university)	Off-5	On-5

The highlighted trips, Off-1 under HBU, On-1 under HBO and Off-3 and On-3 under UBNH are the trips that cross the university boundary and therefore were the ones modeled by the proposed university student travel model.

Table 3 below summarizes the remaining attributes of the model chosen.

Table 3 Summary of the University Student Travel Model

Model Steps	**Sub-models**
Trips modeled	HBU (Off-1 by off-campus students), HBO (On-1 by on-campus students), and UBNH (Off-3 and On-3 by both off-campus and on-campus students).
Trip production	Take the university end as the production end for all modeled trips. Use a cross-classification model (stratified trip rates are multiplied by the number of students in a university by student stratification to calculate trip productions).
Trip attraction	Regression model.
Trip distribution	Gravity model (singly-constrained to productions, that is, the university ends).
Time of day	Fixed factors.
Mode choice	Logit model (borrow coefficients and calibrate constants) for regions that have or plan to develop a logit choice model for the general population, and factoring process for other regions.

Table 4 below summarizes the input data collected and used for the above model.

Table 4: Sources of the Input data used in the Proposed University Student Travel Model

	Source 1 **University student trip surveys**	**Source 2:** **The travel demand model that the proposed model is incorporated in**	**Source 3:** **New data collection**
Trip production	Student characteristics, and number of trips by trip purpose		Student enrollment by stratification
Trip attraction	Location of each trip end	Zonal characteristics, such as population, employment, median household income, whether close to transit routes, and whether apartments are present.	
Trip distribution	Location of each trip end	Highway travel time, transit travel time	
Time of day	Start and end time of each trip		
Mode choice	Travel mode of each trip	Highway travel time and cost, transit travel time and cost, walk time, and bicycle time	

B. Survey Design

In developing a survey to obtain planning data for college student travel behaviors, key survey dimensions and associated data were determined based on studies undertaken for universities in other states as well as utilizing existing data made available by University Planning and Analysis (UPA) at NCSU. Through reviewing the literature and discussing technical issues, a survey was initially drafted in early January of 2013.

Several criteria were used for designing the questionnaire. It was expected that the fully voluntary nature of the survey would require a simple short questionnaire requiring little time to complete. It was also anticipated that it would be easier for respondents to pin locations on a map than to type address text. These two overall criteria led the team to develop a web based tool that could capture information quickly and easily. A map was embedded in the survey instrument so that respondents could easily click on the places their activities took place. Both the questions and map together provided a complete description for activities and travel between locations without requiring a lot of time for respondents.

Concurrent with the development of a sampling plan, the survey was pilot-tested by distributing it to the Institute of Transportation Engineers (ITE) Student Chapter at NC State University in order to test survey language and respondent burden. Fourteen students completed the survey with an overall response rate of 24.5 percent. Completion of the pilot showed promise for success in the scheduled distribution of the actual survey. See Appendix A for a copy of the final survey deployed at NCSU.

C. Campus Selection

It is obvious that considerable attention must be paid to selecting the campuses where data was collected since the validity of the data pre-determines the validity of the model developed. For that purpose, the research team developed a set of criteria to assess the potential impact of a university on the local transportation systems.

- The first criterion was a measure of the role which the campus plays in the community called influence. It is the size of the campus population in relation to the population within a fifty minute drive time and it is expected that campuses at the high end of this measure will have a larger relative impact on the local infrastructure than campuses at the lower end of the measure.
- The second criterion is commuter or professional student population, measured as the percentage of part-time undergraduate students out of the total enrolled student population.
- The third criterion is geographic dispersion intended to insure that data is collected across the state - for this third criterion the state was divided into four regions: Mountains, Piedmont, Coastal plains, and Coastal; with the intention that no region of North Carolina be left unrepresented in the data collection process.

Table 5 below represents the campuses of the UNC system with regards to the University influence criteria. Table 6 below represents the same campuses with regard to the second criterion. Finally, Figure 2 visually represents the campuses according to both criteria so that the natural clusters become apparent.

Table 5: University Influence of UNC Campuses

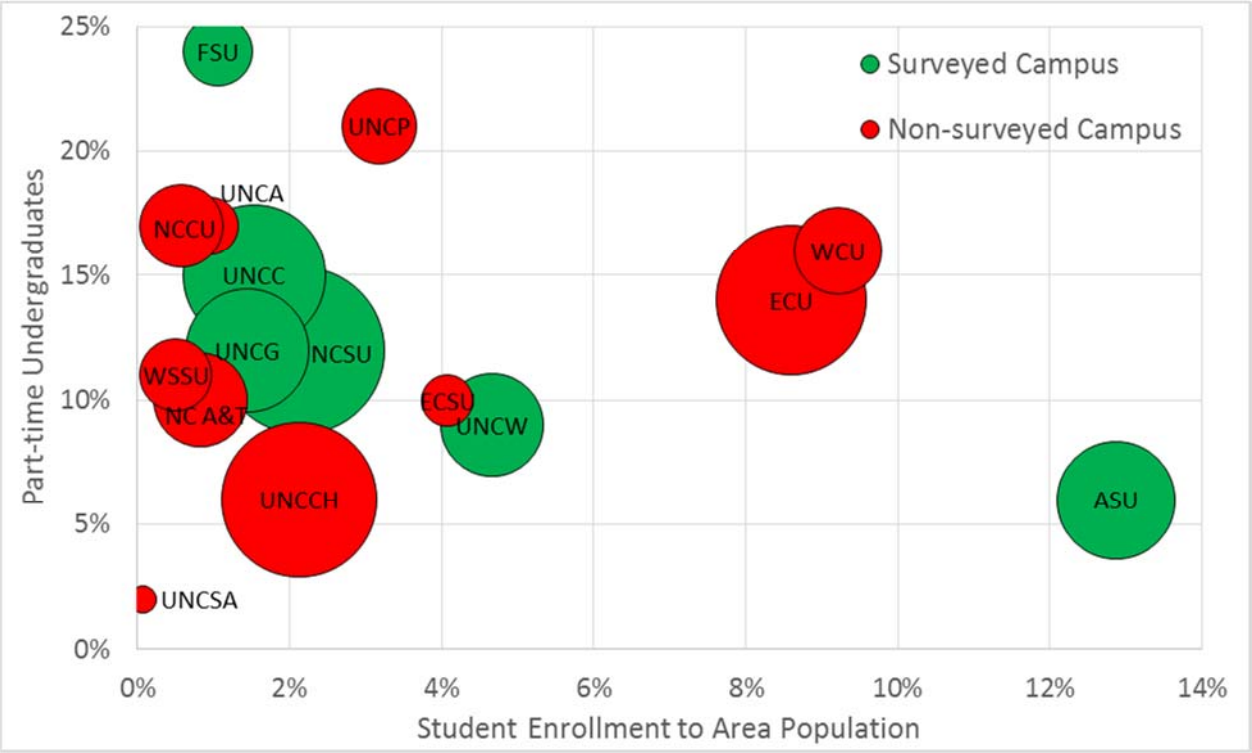
College/University	Student Enrollment to Area Population (%)	Population (50 Minute Drive Time)	Total Enrollment
University of North Carolina School of the Arts	0%	1,243,392	872
Winston-Salem State University	1%	1,249,053	6,333
North Carolina Central University	1%	1,489,956	8,645
North Carolina A & T State University	1%	1,294,099	10,795
University of North Carolina at Asheville	1%	414,103	3,967
Fayetteville State University	1%	546,344	5,781
University of North Carolina at Greensboro	1%	1,293,878	18,771
University of North Carolina at Charlotte	2%	1,630,289	25,063
University of North Carolina at Chapel Hill	2%	1,380,095	29,390
North Carolina State University at Raleigh	2%	1,598,842	34,376
University of North Carolina at Pembroke	3%	218,241	6,944
Elizabeth City State University	4%	81,092	3,307
University of North Carolina at Wilmington	5%	279,952	13,071
East Carolina University	9%	323,304	27,783
Western Carolina University	9%	102,190	9,407
Appalachian State University	13%	133,762	17,222

Table 6: Part-time Undergraduate Percentages UNC Campuses

College/University	Part-time Undergraduates (%)
University of North Carolina School of the Arts	2%
Appalachian State University	6%
University of North Carolina at Chapel Hill	6%
University of North Carolina at Wilmington	9%
Elizabeth City State University	10%
North Carolina A & T State University	10%
Winston-Salem State University	11%
North Carolina State University at Raleigh	12%
University of North Carolina at Greensboro	12%
East Carolina University	14%
University of North Carolina at Charlotte	15%
Western Carolina University	16%
North Carolina Central University	17%
University of North Carolina at Asheville	17%
University of North Carolina at Pembroke	21%
Fayetteville State University	24%

Figure 2: A Visual Representation of UNC Campuses by Criteria 1 & 2

(Size of a circle represents the enrollment of the campus)



List of university abbreviations in above figure 2

ASU: Appalachian State University	UNCC: University of North Carolina at Charlotte
ECU: East Carolina University	UNCCH: University of North Carolina at Chapel Hill
ECSU: Elizabeth City State University	UNCG: University of North Carolina at Greensboro
FSU: Fayetteville State University	UNCP: University of North Carolina at Pembroke
NC A&T: North Carolina A&T State University	UNCSA: UNC School of the Arts
NCCU: North Carolina Central University	UNCW: University of North Carolina at Wilmington
NCSU: North Carolina State University	WCA: Western Carolina University
UNCA: University of North Carolina at Asheville	WSSU: Winston-Salem State University

During the first year, two campuses were surveyed: NC State University (NCSU) and UNC Greensboro (UNCG). These campuses were chosen for their representativeness: NCSU is one of the largest campuses in the UNC system and located in a large metropolitan area and UNCG is a mid-tier university in the system that is located in a smaller urban area that draws upon students from surrounding rural counties. A total of 922 samples were collected from NCSU, of which 336 were complete and valid. The corresponding numbers for UNCG were 841 samples collected of which 383 were valid. Based on this experience, four more campuses were selected to be surveyed in the second year of the project. Starting in the western part of the state, the four campuses selected where as follows:

- Appalachian State University, Mountain Region - it combines the highest influence value with the second lowest part time percentage
- UNC Charlotte, Piedmont Region - it has an influence value similar to campuses already surveyed, but has a higher percentage of part-time under graduates
- Fayetteville State University, Coastal Plains Region - it has a low influence measure and the highest percentage of part-time undergraduates and further, is the only historically African-American institution in the survey plan
- UNC Wilmington, Coastal Region - it has a slightly higher than average influence measure and a lower percentage of part-time undergraduates.

D. Survey Deployment

As previously mentioned, the survey was deployed at six campuses of the UNC system over a period of two years. In order to maintain consistency, the same deployment process was used at each campus surveyed. The process is described in detail below for NCSU. A total of 6,021 students across the six campuses started the survey and 3,779 completed it, making this the largest survey of student travel done in the USA to date.

North Carolina State University Survey

The survey was deployed starting March 19, 2013 with 7,460 potential student participants (See Appendix B for a copy of the notification email sent to students who were being surveyed.) The sampling pool was divided into five equal panels of 1,492 randomized students with individual survey deliveries for each group Tuesday through Saturday (the survey requested information about activities on the day prior to receiving the invitation to participate). Students selected were sent an email message inviting them to participate in the survey with a link to the survey (see Appendix B). One to two weeks after the initial request for participation, a reminder email was sent on a different day of the week for each panel. The survey was closed on April 15, 2013, so as not to conflict with class evaluations and senior surveys conducted by other university offices. A total of 904 responses were recorded as surveys started with 396 surveys completed, yielding response and completion rates of 12.1% and 5.3%, respectively. This 5.3% rate of completion was lower than the hoped for 10% rate on which the sampling plan was designed.

University of North Carolina – Greensboro Survey

A total of 9,543 students were identified as potential participants by the Bryan School of Business and Economics at UNCG and the survey was deployed Tuesday, April 9, 2013 and closed on May 11, 2013. In addition to soliciting voluntary participation, incentives in the form of 15 $30 Amazon.com gift cards were offered to encourage students to take the survey. Of the sample, 841 participants started the survey and 442 completed it, yielding response and completion rates of 8.8% and 4.6%, respectively. This 4.6% rate of completion was lower than the hoped for 10% rate on which the sampling plan was designed.

University of North Carolina at Charlotte

A total of 24,114 students, essentially the entire student population enrolled in spring semester 2014, were contacted as survey participants starting on February 25, 2014. In addition to soliciting voluntary participation, incentives in the form of 15 $30 Amazon.com gift cards were offered to encourage students to take the survey. The survey was closed on May 5, 2014. 2,860 students started the survey and 1,492 completed it, yielding response and completion rates of 11.9% and 6.2% respectively.

University of North Carolina at Wilmington

A total of 13,064 students, essentially the entire student population enrolled in spring semester 2014, were contacted as survey participants starting on February 25, 2014. In addition to soliciting voluntary participation, incentives in the form of 15 $30 Amazon.com gift cards were offered to encourage students to take the survey. The survey was closed on April 21, 2014. 1,612 students started the survey and 917 completed it, yielding response and completion rates of 12.3% and 7% respectively.

Fayetteville State University

A total of 5,636 students, essentially the entire student population enrolled in spring semester 2014, were contacted as survey participants starting on February 25, 2014. In addition to soliciting voluntary participation, incentives in the form of 15 $30 Amazon.com gift cards were offered to encourage students to take the survey. The survey was closed on April 14, 2014. 539 students started the survey and 266 completed it, yielding response and completion rates of 9.6% and 4.7% respectively.

Appalachian State University

A total of 10,000 students were contacted as survey participants starting on March 18, 2014. The number of students contacted was slightly more than half the total student population at this university by the request of university officials. In addition to soliciting voluntary participation, incentives in the form of 15 $30 Amazon.com gift cards were offered to encourage students to take the survey. The survey was closed on April 27, 2014. 633 students started the survey and 266 completed it, yielding response and completion rates of 6.3 % and 3.3 % respectively. Thus, Appalachian State University had the smallest percentage of survey participants who started the survey and completed it.

E. Compiling Survey Responses

After the data were collected, the data were downloaded and prepared for analysis. To begin, the data were split into three files: a person file, a place file, and a trip file. The person file contains demographic and trip rate information. The place file has the type of place and location coordinates for all the places visited on the survey day. The trip file has trip information such as duration and mode used. The three files can be linked using the person ID or place ID. After the data files were prepared, they were checked and the data cleaned.

Several validation checks were performed on each sample and the dataset reduced to only the valid and complete samples. A complete and valid sample response is defined as one for which the survey software flagged as complete, and for which the number of reported survey trips are equal to or greater than one less than the number given by the respondent at the beginning of the survey. Some of the complete and valid samples were not used in the analysis, because they reported weekend travel, or the pattern of travel reported does not make sense. Incomplete and invalid sample records were reviewed in detail to determine if it is likely the respondent simply closed the web browser rather than continuing on to the last screen in the survey when the complete status flag is set. All analyses performed and stated in the remaining sections of this report were restricted to these final set of samples collected from each university campus.

In addition to reviewing the sample responses, key variables were also reviewed in detail and some corrected or imputed responses were provided as alternates to the responses. For trip purposes, if a response of “Other” was provided, but the description provided in the text response fit one of the categories of trip purpose, then this alternate response was separately recorded. In some cases the place type was used to modify the purpose response. Trip mode responses were translated into a mode variable

to be used for developing models. Some place types were corrected to be consistent with trip purpose reported. Home location coordinates were also checked (respondents could click on slightly different locations for home each time they used the map due to mouse placement). Finally, place types and the coordinates provided were checked to make sure they are consistent (an on-campus place type should have coordinates on campus).

After completing the checks and data cleaning, the data were weighted to adjust for non-response bias, and to represent the student population (expansion weights). Weights were developed based on three characteristics: residence location (on or off campus), education status (under graduate or graduate), and enrollment status (full or part time).

The next section highlights results of analyzing the survey data, and points to key insights. These insights informed the development of models for the project described in Section VI that follows.

V. Analysis of Results

This section describes characteristics of students at the universities and summarizes some of the data collected through the survey. All the data are weighted unless noted otherwise. More detailed results are presented in Technical Report A: Survey Documentation.

A. Demographics Characteristics Travel Behavior Characteristics

In addition to the model presented in the above section, several other observations may be drawn from the survey data that are of relevance to NCDOT when it comes to transportation planning around University campuses. Major observations are summarized below.

1) Trip rate
    a. The average trip rate for off-campus students range from 4.62 to 5.31, and for on-campus students from 4.51 to 7.46. These trip rates are consistent with estimates available from the other surveys.
    b. Most of the trips made by on-campus students are within the university. Within the university trips only account for a small portion of total trips made by off-campus students.
    c. Off-campus students make more trips that cross the university boundary than on-campus students. Off-campus students also make more trips outside the university than on-campus students.
2) Trip distribution
    a. In general, off-campus students travel farther than on-campus students. Off-campus students travel from 2.08 miles to 7.41 miles and on-campus students travel 0.62 miles to 2.59 miles.
    b. Differences in campus size and surrounding land use at the campuses surveyed explain the different average trip distances. ASU has the shortest trip distance of 0.62 miles for on-campus students and 2.08 miles for off-campus students. UNCC has the longest trip distance of 2.47 miles for on-campus students and 7.41 for off-campus students.
    c. Trips outside the university and trips crossing the university boundary have similar distances and both are longer than trips made within the university.

3) Mode share

   a. The dominant mode for on-campus students is walking, which accounts for 55% to 80% of total trips made by all students. The share of walking for off-campus students is only 6% to 27%.

   b. Drive alone takes the biggest share of the off-campus student trips varying from 39% to 78%. Together with shared ride, trips by auto are 14% to 92% of all trips by students.

   c. The transit shares at the campuses vary as follows: for off-campus students from 1.2% at FSU to 17% at ASU and NCSU, and for on-campus students from 0.7% at UNCW to 10.9% at NCSU. The difference is believed to be caused by the level of available transit service relative to the geographical spread of the buildings at each of the different universities.

   d. Trips within the university rely more on walking and available transit (both public and university provided); by contrast, trips outside of the university rely more on auto (drive alone plus shared ride).

4) Relationship between vehicle trips and distance to campus

The analysis that follows can be used to evaluate the impact of university students on the road system that surrounds a campus if a travel demand model is not available. It provides a sketch planning tool that is based on the survey data, and therefore can be used with confidence.

A regression analysis was performed to determine the relationship between student trip frequency by mode and distance to campus. The number of student trips served as the response variable, and was defined as either total number of home-based university daily trips or all daily trips. The independent variable was the distance of the student's residence from the university campus, in miles. This variable was measured as the geodesic distance between an off-campus student's home location and the first stop on campus of the student's university-bound trip. Student trips were analyzed based on their mode, whether walking, bicycling, driving an automobile, or riding transit.

In Stata®, regression fit plots (linear, quadratic, and fractional polynomial) were generated using the averaged data on each mode of interest to determine possible models of best fit. Fractional polynomial regressions appeared to fit best across all modes.

First described by Royston and Altman (1994), regression models based on fractional polynomial functions of a continuous covariate produce a wider range of curve shapes than linear and quadratic functions, and tend to be free of the unwanted artifacts that accompany cubic and higher-order curves. Unlike regular polynomials, fractional polynomials allow logarithms, non-integer powers, and repetition of powers. This increases the flexibility typically allowed by the family of conventional polynomial functions.

A fractional polynomial in x is written as

$$x^{(p_1,p_2,\ldots,p_m)t}\boldsymbol{\beta}$$

$x^{(p)}$ is written to mean a regular power except that $x^{(0)}$ is understood as meaning $\ln(x)$, not $x^{(0)} = 1$.

If there are no repeated powers in ($p1, p2, \ldots, pm$),

$$x^{(p_1,p_2,\ldots,p_m)t}\boldsymbol{\beta} = \beta_0 + \beta_1 x^{(p_1)} + \beta_2 x^{(p_2)} + \cdots + \beta_m x^{(p_m)}$$

Each time a power repeats, it is multiplied by another ln(*x*). For example, if a fractional polynomial has all-repeated powers, the equation is written as

$$x^{(p,p,\ldots,p)t}\boldsymbol{\beta} = \beta_0 + \beta_1 x^{(p)} + \beta_2 x^{(p)} \ln(x) + \cdots + \beta_m x^{(p)} \{\ln(x)\}^{m-1}$$

Fractional polynomial regressions were run on each travel mode of interest, and residual plots were examined in addition to p- and R squared values to evaluate significance and fit. Because fractional polynomial functions are subject to the restriction x>0, one-tenth of a mile was the minimum distance considered. The average numbers of trips for a distance zero were assigned to a distance of one-tenth of a mile. The maximum distance considered was ten miles. Two models were generated for each mode of interest: 1) a model where x=.1 to 10 for all daily trips, and 2) a model where x=.1 to 10 for home-based university daily trips.

Table 7 and table 8 provide the fractional polynomial functions for the four modes under consideration (walk, bicycle, vehicle, transit) for all daily trips and for home-based university trips, and includes R squared values. P-values were significant at <.05 for all modes on both trip categories except transit for home-based university daily trips.

Table 7: Fractional Polynomial Functions by Mode – All Daily Trips

Travel Mode	**All Daily Trips**	**R2**
Walk	$0.653794+0.66715*x^{(-2)}+0.2752161*x^{(-2)}*\ln(x)$	.9447
Bicycle	$-0.2321533-0.1704106*x^{(-1)}+0.6852585*x^{(-.5)}$	.8413
Vehicle	$0.1024407+3.719666*x^{(.5)}-0.8822391*x^{(1)}$	.8935
Transit	$0.7999186-0.4262231*x^{(-.5)}-0.2629771*\ln(x)$	.5079

Table 8: Fractional Polynomial Functions by Mode – Home Based University Trips

Travel Mode	Home-Based University Daily Trips	R2
Walk	$-0.0155588+0.3891592*x^{(-2)}+0.1618336*x^{(-2)}*\ln(x)$	.9611
Bicycle	$-0.1725628-0.1322248*x^{(-1)}+0.4868512*x^{(-.5)}$	.7982
Vehicle	$-1.190399+2.376443*x^{(.5)}-0.7010429*x^{(.5)}*\ln(x)$	.8504
Transit	$0.2996308+0.0044143*\ln(x)-0.0593218*\ln(x)$	.5385

The raw data obtained from the surveys and the estimated trips from the modeling process show an interesting relationship between the number of trips and the distance of students' residences from the university campus. Figures 1, 2, 3, and 4 present the total daily trips (all trips) by distance from the students' residences to their campus destination for each mode, while Figures 5, 6, 7, and 8 present only the trips between campus and their residence (home-based university trips). Generally, the shape of the model that fits all trips and home-based university trips was similar, although the magnitude differed since the all trips dataset comprised a larger numbers of trips. Walking trips were found to be common for students who live close to campus, with a large decrease in the average number of daily trips expected when a student lives further than one quarter mile from campus. Similar to walking trips, the average number of daily bicycling trips decline as students reside further from campus, although the decline is less precipitous than walking trips. Bicycling trips peak for students who live approximately one half mile from campus. Transit trips peak for students who live approximately four miles from campus and decrease slowly beyond that distance. Vehicle trips are low at short distances from campus and increase sharply over distances up to approximately two miles, after which predicted trips remain relatively flat.

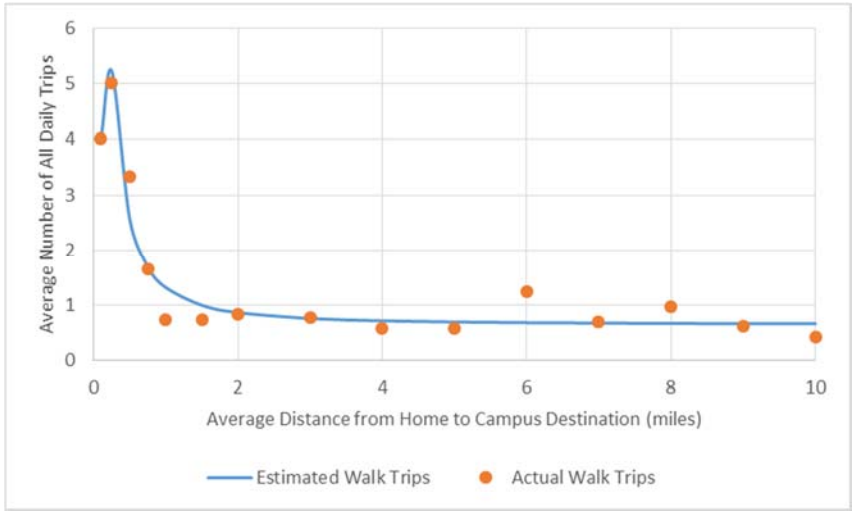


Figure 3: All Daily Walk Trips

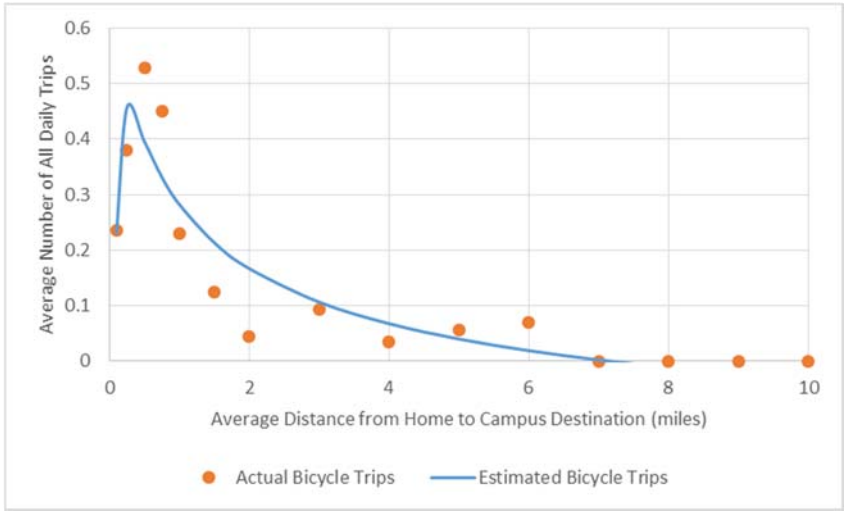


Figure 4: All Daily Bicycle Trips

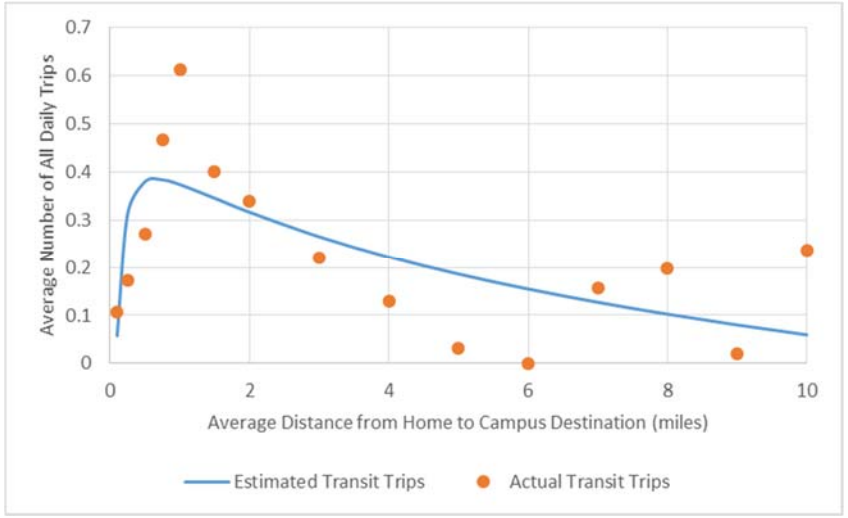


Figure 5: All Daily Transit Trips

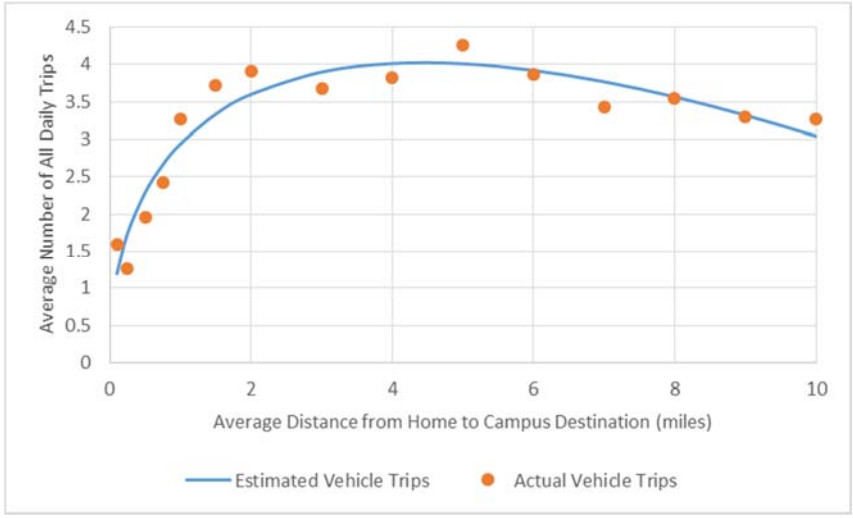


Figure 6: All Daily Vehicle Trips

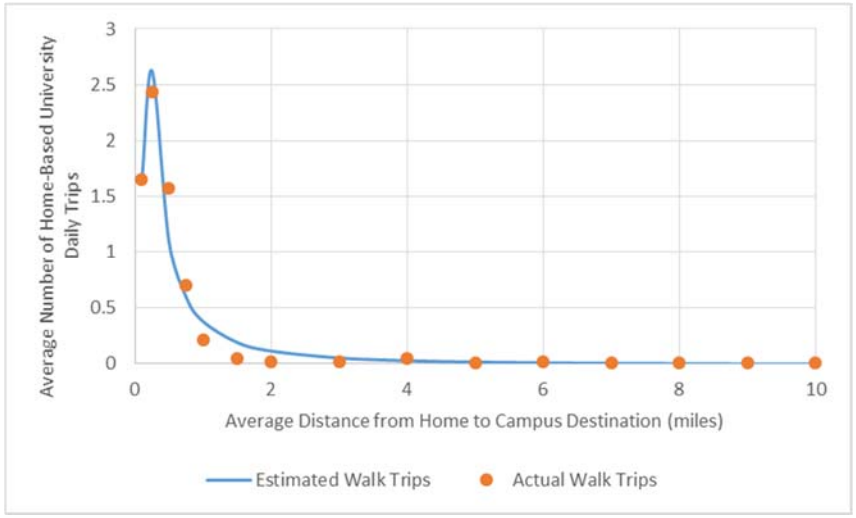


Figure 7: HBU Daily Walk Trips

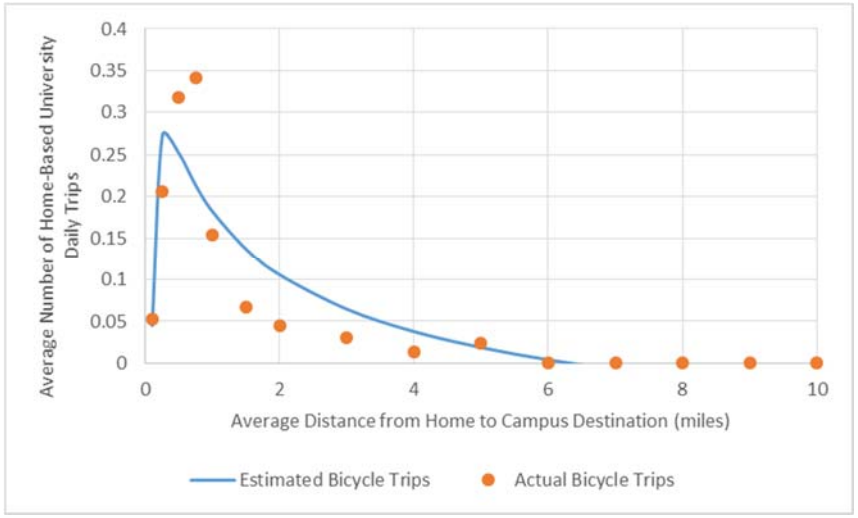


Figure 8: HBU Daily Bicycle Trips

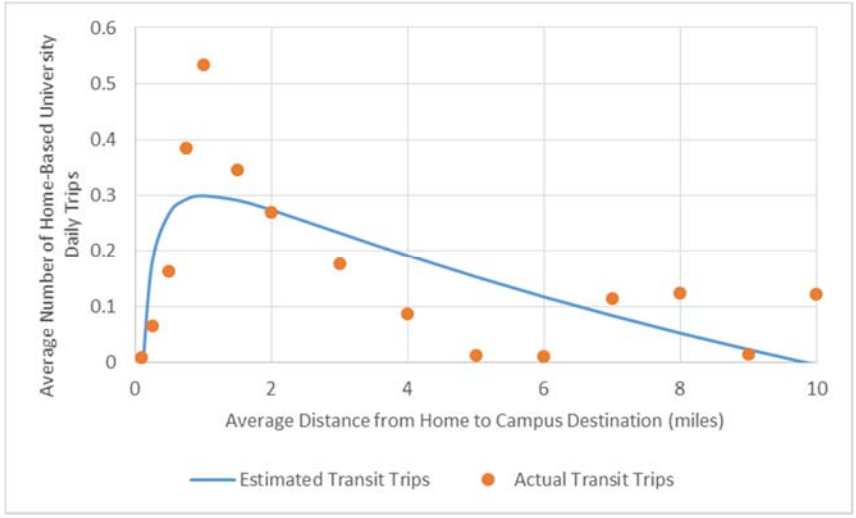


Figure 9: HBU Daily Transit Trips

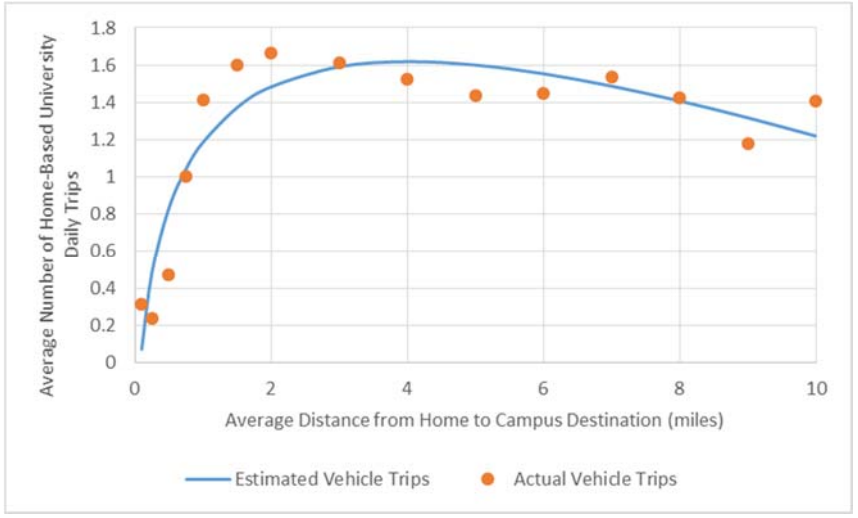


Figure 10: HBU Daily Vehicle Trips

Figure 11 and Figure 12 show the combined estimated trips for all modes (transit, vehicle, bicycle, and walk) for all daily trips and HBU daily trips, respectively. Walking trips comprise the majority of predicted trips at short distances from campus, while vehicle trips form the majority of trips at larger distances.

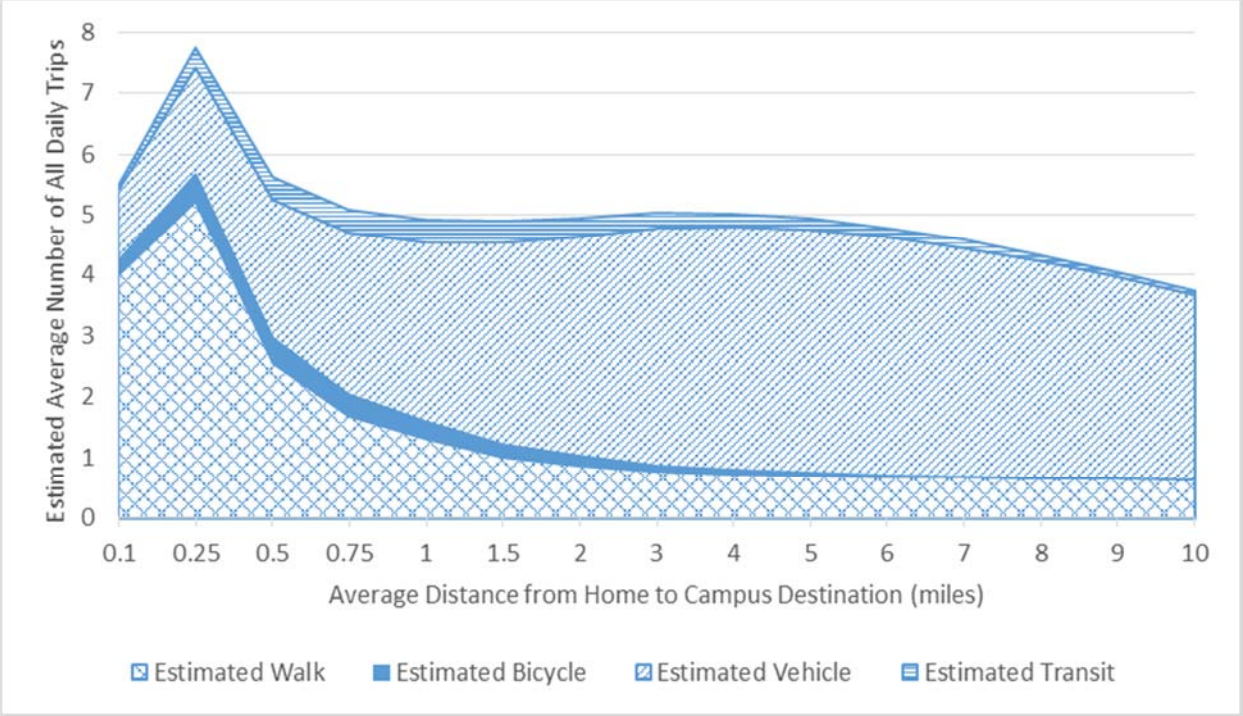


Figure 11: All Daily Trips

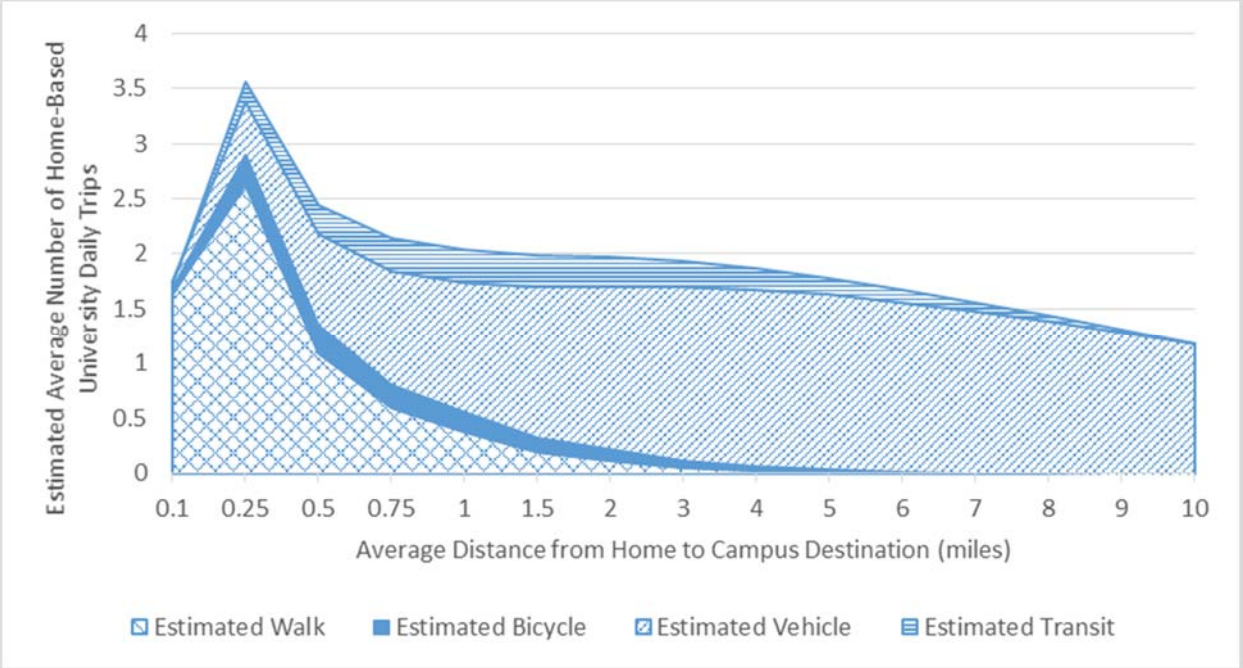


Figure 12: HBU Daily Trips

VI. Models of University Student Travel Behavior

This research project also has a goal of developing models that can be added to travel models for communities across North Carolina that have university campuses. The model design is described in section IV.A Model Design. The model design is deliberately flexible, so that it can be both added to existing models for communities with universities that were surveyed, and also can be added to models for communities with universities that were not surveyed. To facilitate transferring the models to communities with universities that were not surveyed, suggestions are provided for choosing an appropriate model to match the context of the university and community. To make it easier to add the models of university students to as wide a range of existing models as possible, they are designed as stand-alone models. The models developed are described below and follow the sequence of the trip based model from trip generation, to trip distribution, to mode choice. More detailed descriptions are presented in Technical Report B: Model Development. First, the definition of trips to be modeled will be described, then each model will be described.

An overall goal for this study is to focus on university student trips that most affect the road system surrounding university campuses. Both trips that do not leave campus and non-motorized trips were removed from the model development, because they do not affect the roads outside the university campus. The remaining (motorized) trips were classified into trips crossing the university campus boundary, and trips wholly outside the university. Trips were further classified by whether the students are living on-campus or off-campus. For each group of university student trips, models were developed for trip generation, trip distribution and mode choice. The output of the final mode choice step is the motorized origin to destination trip matrix by mode (auto and transit). These trip matrices can be added to the corresponding trip matrices from the local travel demand model for highway and transit assignment.

Some trips collected in the surveys were removed from the modeling efforts so that emphasis could be placed on the modeling of university student trips that most affect the surrounding road system. The trips removed include trips with both trip ends on campus, non-motorized trips and trips with at least one end outside of the region where the studied university is located. The remainder of the trips were further divided into four groups for modeling purposes:

1) crossing the university boundary trips made by students living off campus (called off- crossing trips);
2) outside of the university trips made by students living off campus (called off-outside trips);
3) crossing the university boundary trips made by students living on campus (called on-crossing trips); and
4) outside of the university trips made by students living on campus (called on-outside trips).

For each group of university student trips, models were developed for the steps of trip generation, trip distribution and mode choice. The final output is the motorized Origin Destination (OD) trip matrix by mode (auto or transit). These OD matrices can be added to the corresponding OD matrices from a local travel demand model for traffic assignment or transit assignment to evaluate the impact of university student trips.

A. Models of University Student Travel Developed in this Project

In trip generation, it is suggested to use a cross-classification model, in which stratified production rates are multiplied by the number of students enrolled in a university by student stratification to calculate the

control total of trip productions. The zonal trip production can be obtained by disaggregating the control total to each campus zone based on zonal characteristics for off-crossing and on-crossing trips; or to each non-campus zone based on its distance to campus and zonal characteristics for off-outside and on-outside trips.

In trip distribution, it is suggested to use a gravity model. For off-crossing trips, the six surveyed universities are divided into three groups based on the proportion of part-time students, and a Gamma function was developed for each group. For off-outside, on-crossing and on-outside trips, only one Gamma function was developed. The gravity model was singly constrained to productions for off-crossing and on-crossing trips, and was doubly constrained for off-outside and on-outside trips. The average trip distance and travel time were also summarized to be used as calibration targets.

To determine mode shares, it is suggested that a logit-based choice model be used for off-crossing trips. Several logit-based mode choice models were developed in this study from which one can be chosen. The chosen logit model should be calibrated based on an overall transit share before being applied for forecasting. The overall share can be estimated using a regression model developed in this study or can be chosen from a set of values derived from the surveys with adjustments as necessary. For on-outside trips, transit shares derived from the surveys can be employed with reasonable adjustments. On-crossing and off-outside trips can use either the more sophisticated off-crossing approach or the more straight-forward on-outside approach.

B. How to Fit University Student Travel Models in a Local Travel Demand Model

The university student travel models presented in this report include models of trip generation, trip distribution and mode choice for university students (stratified as off-campus students and on-campus students). The final output is the motorized Origin Destination (OD) trip matrix by mode (auto or transit). These OD matrices can be added to the corresponding OD matrices from a local travel demand model for traffic assignment or transit assignment to evaluate the impact of university student trips.

However, caution is needed to avoid double-counting the trips made by off-campus students. Off-campus students live off-campus, and they are counted as household population in the census. So in most travel demand models, they have already been counted in the zonal population in the socio-economic data, and their trips have already been modeled based on the assumption that the household characteristics and travel behaviors of off-campus students are the same as the non-student population. Therefore, if the off-campus student trips from the university student travel models are added to a local travel demand model, the trips made by off-campus students are doubly counted.

The ideal way to avoid double-counting the off-campus student trips is to separate the off-campus students from the non-student population before the step of trip generation, either by collecting data from the field, or by developing an off-campus student residence location model (such as is done in the Triangle Regional Model). However, this requires substantial effort and the improvement to the model might be marginal (especially for regions where university student trips are trivial).

An approximate way to address this issue is to keep all trips from a local travel demand model, but add some trips to better represent the trips made by off-campus students. As discussed in Section 2.1, the university student travel models will model “crossing the university boundary” trips and “outside of the university” trips for off-campus students. “Outside of the university” trips are trips with both trip ends outside of the university, and off-campus students’ travel behaviors are close to the non-student population for this trip classification. On the other hand, “crossing the university boundary” trips have

one trip end on campus, which are trips that the non-student population usually do not make. So "crossing the university boundary" trips are more likely to be the trips that are missed in a local travel demand model, and they should be added.

In summary, it is suggested to only add the "crossing the university boundary" trips to a local travel demand model for the off-campus students. However, this report presents the models for both "crossing the university boundary" trips and "outside of the university" trips, in case they are needed.

On-campus students live on campus, and they are counted as group quarters population in the census. Therefore, they are easy to separate from the non-student population. It is suggested to use the university student travel models in this report to model the "crossing the university boundary" trips and "outside of the university" trips for on-campus students, and add them to a local travel demand model.

For more details of the models developed from the survey data, please see Technical Report B: Model Development.

VII. Recommendations

The following recommendations are developed based on surveys of university students conducted at six campuses across North Carolina:

1. Models can be used to assess the impact of university campuses on neighboring street systems based on the propensity for students to travel to and from the campus.
2. Key predictors of student travel are data that are readily available, such as number of students living on and off campus, and number of full time and part time students.
3. The key predictors of student travel can be based on local specific data to tailor university student models to the local context, making the data collected and the models developed for this project more transferrable.
4. For off campus students, it is suggested to add the crossing the university boundary trips and for on campus students to add both the crossing the university boundary trips and the outside the university trips.
5. A set of relationships based on student residence distance from campus can be used in the absence of a travel demand model to understand the impact of university students on the road system adjacent to the campus.

VIII. References

[1] City of Bloomington, Technical Memorandum 3: Indiana University Travel Demand Survey Data Summary, City of Bloomington Metropolitan Planning Organization

[2] City of Bloomington, Technical Memorandum 4: Indiana University Travel Demand Model Components, City of Bloomington Metropolitan Planning Organization.

[3] Wilbur Smith Associates, Summary Report: North Carolina state University Special Generator Study, 2001, Capital Area Metrolitan Planning organization.

[4] NuStats, Greater Triangle Travel Study: Household Travel Survey Final Report, 2006, Capital Area Metropolitan Planning Organization, Durham-Chapel Hill-Carrboro Metropolitan Planning.

[5] Pendyala, R.M., *Analysis of Travel Demand and Mode Use Patterns for Arizona State University. Final Report*. 2007, Arizona State University, Department of Civil and Environmental Engineering.

[6] Khattak, A., et al., Old Dominion University Student Travel Survey, Final Report. 2011, Virginia Department of Transportation, Transportation & Mobility Planning Division.

[7] Khattak, A., et al., University Student Travel in Virginia: Is it different from the General Population? Transportation Research Record: Journal of the Transportation Research Board, Washington, D.C., 2011. 2255: p. 137-145.

[8] Khattak, A., et al., Comparative Analysis of Virginia University Student Travel Surveys. Final Report. 2012, Virginia Department of Transportation, Transportation & Mobility Planning Division.

[9] Eom, J.K., J.R. Stone, and S.K. Ghosh, Daily Activity Patterns of University Students. Journal of Urban Planning and Development, 2009. 135(4): p. 141-149.

[10] Wang, X., A. Khattak, and S. S., What Can We Learn from Analyzing University Student Travel Demand, in Accepted by TRB Annual Meeting. 2012: Washington, D.C.

[11] Institute for Transportation Research and Education, Trip Making Patterns of NC's University Students: Task 8 Survey Response Compilation, January 2014.

[12] Royston, P., and D. G. Altman. 1994. "Regression using fractional polynomials of continuous covariates: Parsimonious parametric modelling." Applied Statistics 43: 429–467.

[13] StataCorp. 2013. "Fractional Polynomial Regression." Stata 13 Base Reference Manual. College Station, TX: Stata Press.

IX. Appendix

A. Survey Deployed At NCSU

Q1 (Force Response) The Institute for Transportation Research and Education at NC State University has been tasked by NC Department of Transportation to conduct a travel survey of the state's university and college students. This survey should take approximately 8 - 10 minutes to complete. The answers you provide will be summarized so that your identity and specific information remains anonymous and undisclosed.

We hope that you can assist us with this survey, and if you are so inclined to do so, please agree to participate with the option to withdraw at any given point or reason.

Please contact Joe Huegy of NCSU (919-513-7378, jbhuegy@ncsu.edu) for any questions or comments.

- ❍ I Agree (1)
- ❍ I Disagree (2)

If I Agree is not selected, skip to End of Survey

Q2 (Force Response) What is your class status?

- ❍ Freshman (1)
- ❍ Sophomore (2)
- ❍ Junior (3)
- ❍ Senior (4)
- ❍ In a Master Program (5)
- ❍ In a PhD Program (6)
- ❍ Non-Degree Seeking (7)

- ❍ Co-op / Intern (8)
- ❍ Other (9) _____

Q3 (Force Response) How many credit hours are you enrolled in this spring semester?

- ❍ 0 (1)
- ❍ 1 (2)
- ❍ 2 (3)
- ❍ 3 (4)
- ❍ 4 (5)
- ❍ 5 (6)
- ❍ 6 (7)
- ❍ 7 (8)
- ❍ 8 (9)
- ❍ 9 (10)
- ❍ 10 (11)
- ❍ 11 (12)
- ❍ 12 (13)
- ❍ 13 (14)
- ❍ 14 (15)
- ❍ 15 (16)
- ❍ 16 (17)
- ❍ 17 (18)
- ❍ 18 (19)
- ❍ 19 (20)
- ❍ 20+ (21)

Q4 Usually on which weekdays do you come to the NCSU campus (select all that apply)?

- ❑ Monday (1)
- ❑ Tuesday (2)
- ❑ Wednesday (3)
- ❑ Thursday (4)
- ❑ Friday (5)
- ❑ Usually I don't come to the NCSU campus on weekdays (6)

Q5 (Force Response) Are you currently living on campus (i.e. residence halls, Wolf Village, Western Manor, ES King)? For the purpose of this study, fraternity and sorority houses are not counted as on campus residence.

- ❍ Yes (1)
- ❍ No (2)

Q6 (Force Response) Are you currently employed?

- ❍ Yes, on campus (1)
- ❍ Yes, off campus (2)
- ❍ Yes, both on and off campus (3)
- ❍ No (4)

Q43 Are you married or in a civil union / engaged?

- ❍ Yes (1)
- ❍ No (2)

Q44 Do you have children?

- ❍ No (3)
- ❍ Yes, under the age of 16 (1)
- ❍ Yes, age of 16+ (2)
- ❍ Yes, of all ages (4)

Q7 (Force Response) Do you have a vehicle to use (e.g. car, motorcycle, and other motorized/electric vehicles)?

- ❍ Yes (1)
- ❍ No (2)

Q8 (Force Response) Do you have a permit to park on campus or in university lots?

- ❍ Yes (1)
- ❍ No (2)

If Yes is selected for Q8, display Q45.

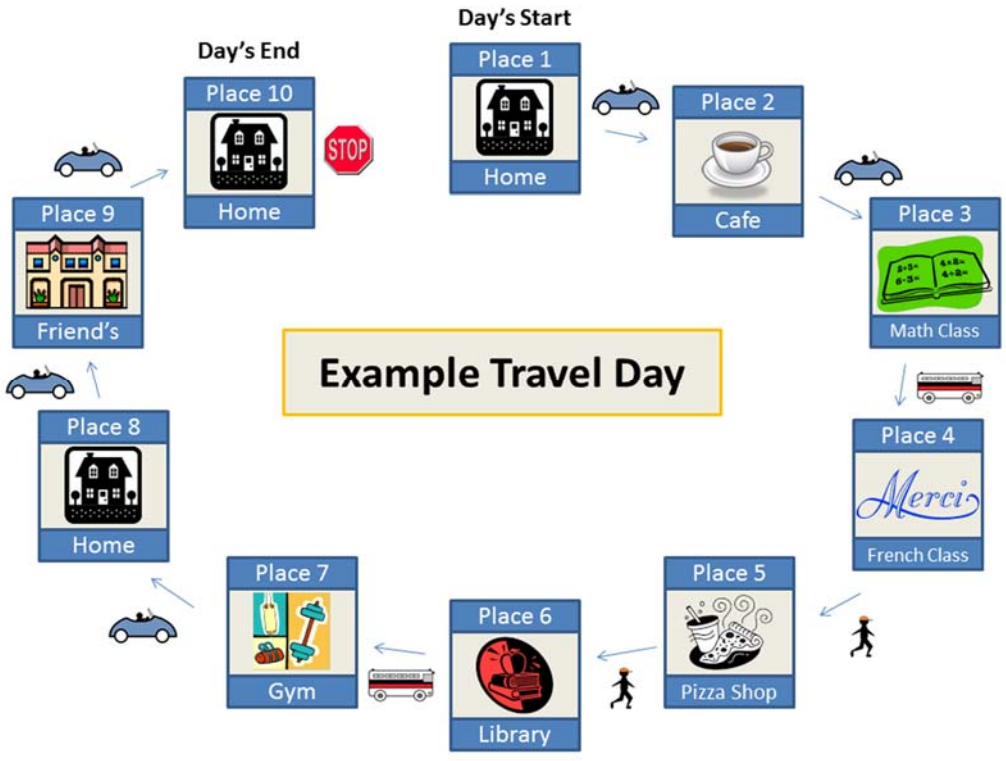
Q45 What type of parking permit do you have?

- ❍ CC (Centennial Campus Decks) (1)
- ❍ CD (Coliseum Deck) (2)
- ❍ DD (Dan Allen Deck) (3)
- ❍ L (Off Peak) (4)
- ❍ M (Motorcycle) (5)
- ❍ P (Perimeter) (6)
- ❍ RE (Resident East) (7)
- ❍ RP (Resident Perimeter) (8)

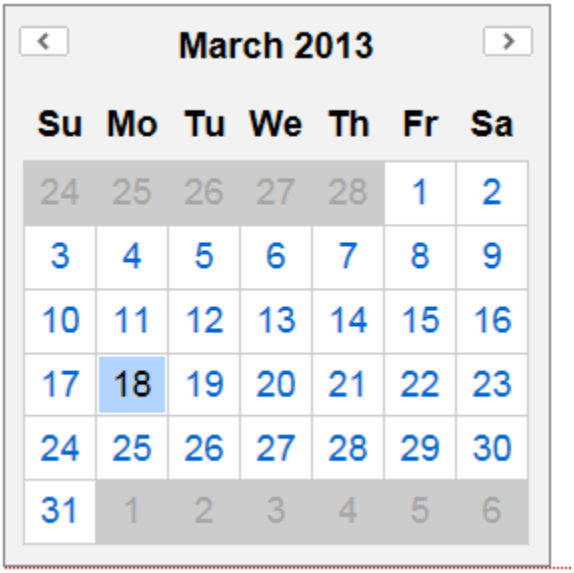
- RS (Resident Storage) (9)
- RW (Resident West) (10)
- SCP (Student Carpool) (11)
- V (Varsity Lot) (12)
- W (West Deck) (13)
- Other (14) _____

Q9 For the final part of the survey, please chronologically recall all the places you went yesterday. If yesterday was over the weekend, please use your most recent weekday. Places can be defined as (1) your starting location, (2) the destinations you traveled to, and (3) your ending location.

If you need to change or add any previous responses, please feel free to do so as your answers are saved. To back track, use the back feature at the bottom of each survey page as opposed to your browser's navigation button.



Q10 (Force Response) Please select the date you wish to describe.



Q11 Referring to the example above, how many places did you go on your selected travel day? Please be sure to include your start and end places for the day; in the example above, there are 10. If you went to a location twice, it is counted as two places.

- ❍ 1 (1)
- ❍ 2 (2)
- ❍ 3 (3)
- ❍ 4 (4)
- ❍ 5 (5)
- ❍ 6 (6)
- ❍ 7 (7)
- ❍ 8 (8)
- ❍ 9 (9)
- ❍ 10 (10)
- ❍ 11 (11)
- ❍ 12 (12)
- ❍ 13 (13)

- ❍ 14 (14)
- ❍ 15 (15)
- ❍ 16 (16)
- ❍ 17 (17)
- ❍ 18 (18)
- ❍ 19 (19)
- ❍ 20+ (20)

Q12 (Force Response) Where did you begin on {Selected date from Q10}?

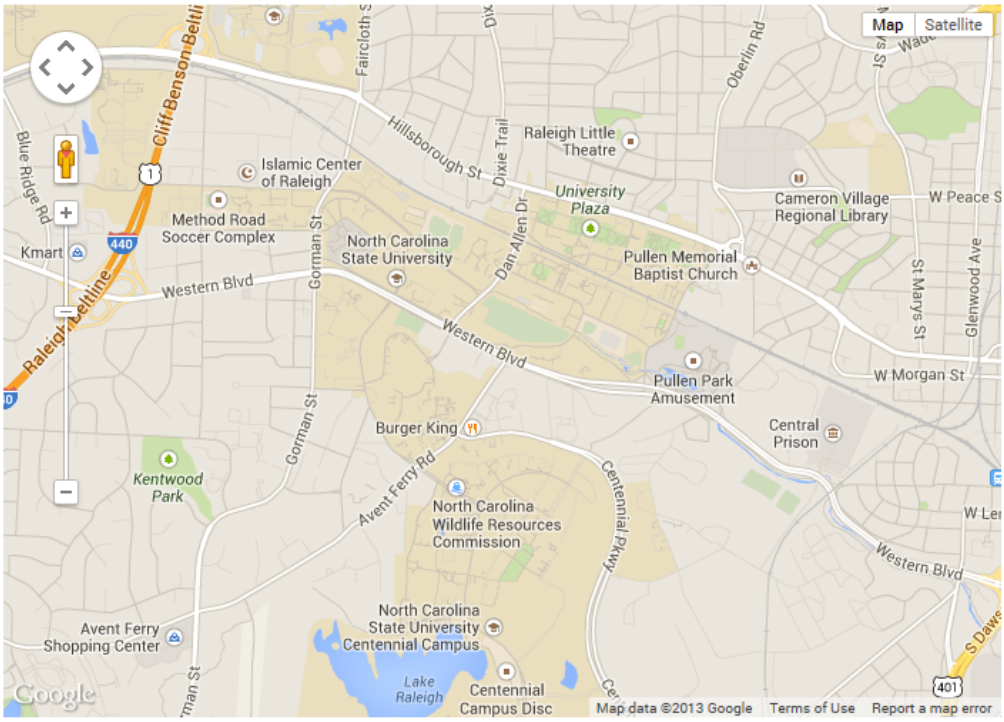
- ❍ Home (1)
- ❍ North Carolina State University (2)
- ❍ Off-campus Workplace (3)
- ❍ Other (4)

Q13 (Force Response) Where is this place? Please click it on the map shown below. You can zoom in, zoom out, and use the search box to help you find your place. Your click is successfully recorded when

you see a blue circle. If it did not show up, click a nearby place.

SAS Hall, Raleigh, NC

Find my Place



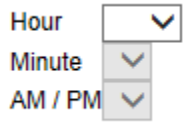
	Latitude	Longitude
Coordinates		

Q14 (Force Response) Did you leave this place on {Selected date from Q10}?

- ❍ Yes (1)
- ❍ No (2)

If Yes is selected for Q14, display Q15; if No is selected for Q14, display Q16.

Q15 What time did you leave this place? A rough estimate is OK.



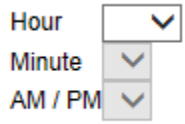
Q16 Please confirm you did not leave this place on your travel day. Select "No" will end this survey. Select "Yes" and click "Next" will continue this survey.

- ❍ Yes, I left this place and I want to record more of my trips. (1)
- ❍ No, I did not leave this place. Please exit the survey. (2)

If No is selected for Q16, skip to End of Survey

If Yes is selected for Q16, display Q17.

Q17 What time did you leave this place? A rough estimate is OK.



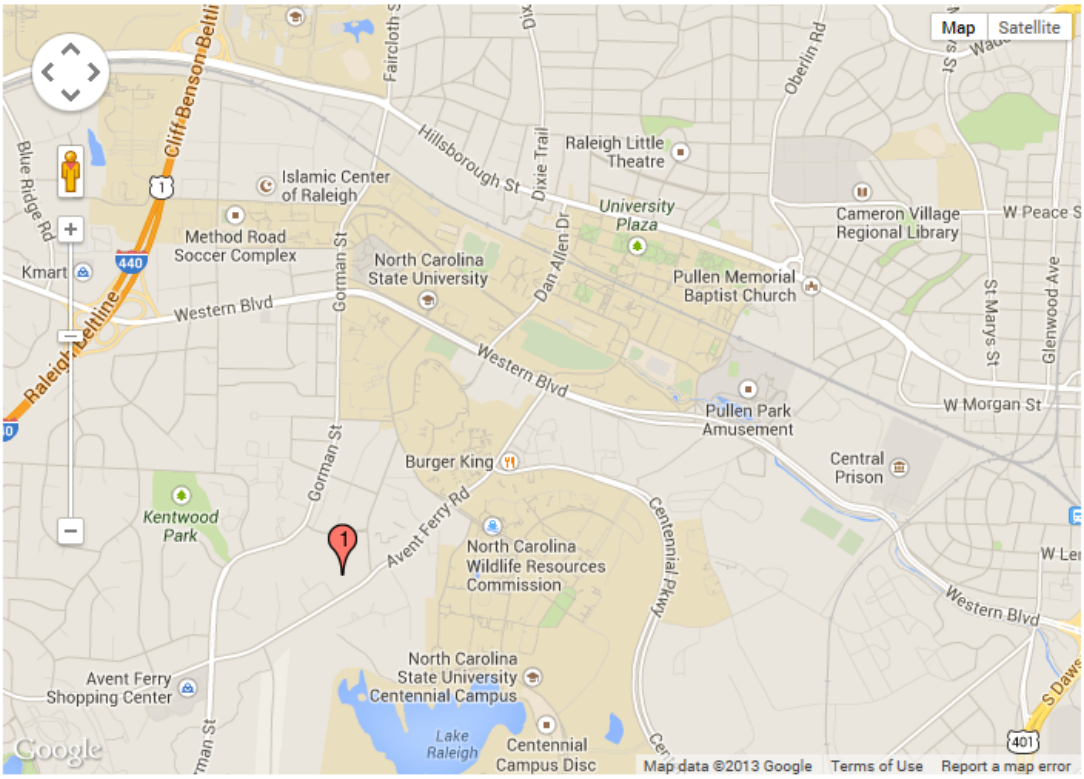
Q18 (Force Response) Where did you go next (the 2nd place of the day)?

- ❍ Home (1)
- ❍ North Carolina State University (2)
- ❍ Off-campus Workplace (3)
- ❍ Other (4)

Q19 (Force Response) Where is this place? Please point it out on the map shown below. You can zoom in, zoom out, and use the search box to help you find your place. Your first place has been marked on the map. Your click is successfully recorded when you see a blue circle. If it did not show up, click a nearby place.

SAS Hall, Raleigh, NC

Find my Place



	Latitude	Longitude
Coordinates		

Q20 (Force Response) What was your main purpose for traveling here (select one)?

- ❍ Go home (1)
- ❍ Attend Classes / Study / Research (2)
- ❍ Work (3)
- ❍ Dining / Shopping (4)
- ❍ Recreational / Social / Community Service / Personal (5)
- ❍ Other (10) _____

Q21 (Force Response) How did you get to this place (select all that you used)?

- ❑ Driver - Auto / Van / Truck (1)
- ❑ Passenger - Auto / Van / Truck (2)
- ❑ Motorcycle / Motorized Moped or Scooter (3)
- ❑ Public Bus / Private Shuttle (4)
- ❑ Bicycle (6)
- ❑ Walk (7)
- ❑ Other (8) _____

If "Driver - Auto / Van / Truck" or "Passenger - Auto / Van / Truck" is selected for Q21, display Q22. If "Public Bus / Private Shuttle" is selected for Q21, display Q23.

Q22 Including yourself, how many people were traveling in the vehicle?

- ❍ 1 (1)
- ❍ 2 (2)
- ❍ 3 (3)
- ❍ 4 (4)
- ❍ 5 (5)
- ❍ 6 (6)
- ❍ 7 (7)
- ❍ 8+ (8)

Q23 Which bus(es) did you take? Please select all that you used.

- ❑ Wolfline (NCSU Transit) (1)
- ❑ CAT (City of Raleigh Transit) (2)
- ❑ Triangle Transit (Regional Transit) (3)
- ❑ C-Tran (Town of Cary Transit) (4)

- ❑ Apartment Shuttle Bus (e.g. Wolf Creek Shuttle) (5)
- ❑ DATA (City of Durham Transit) (6)
- ❑ CHT (Town of Chapel Hill Transit) (7)
- ❑ Duke University Transit (8)

Q24 (Force Response) How many minutes did you take to get here? A rough estimate is OK.

Q25 (Force Response) Did you leave this place on {Selected date from Q10}?

- ❍ Yes (1)
- ❍ No (2)

If Yes is selected for Q25, display Q26; if No is selected for Q25, display Q27.

Q26 What time did you leave this place? A rough estimate is OK.

Hour
Minute
AM / PM

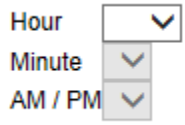
Q27 Please confirm you did not leave this place on your travel day. Select "No" will end this survey. Select "Yes" and click "Next" will continue this survey.

- ❍ Yes, I left this place and I want to record more of my trips. (1)
- ❍ No, I did not leave this place. Please exit the survey. (2)

If No is selected for Q27, skip to End of Survey.

If Yes is selected for Q27, display Q28.

Q28 What time did you leave this place? A rough estimate is OK.



Q29 (Force Response) Where did you go next {Your Place n[1]}?

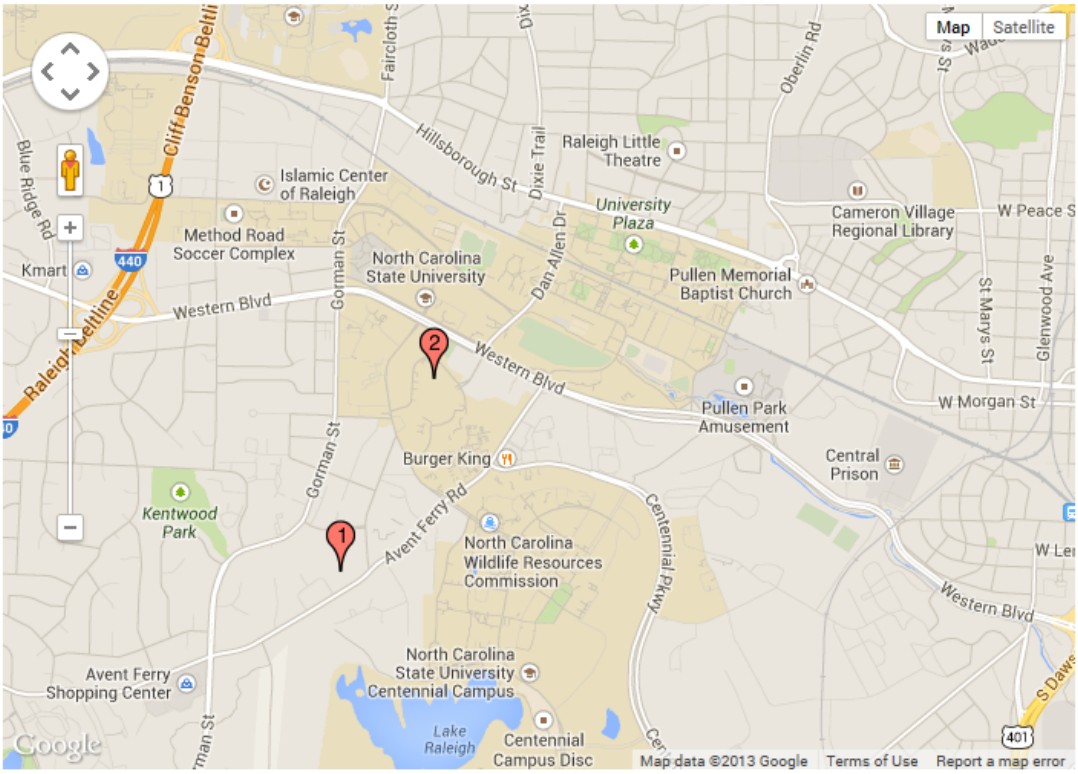
- ❍ Home (1)
- ❍ North Carolina State University (2)
- ❍ Off-campus Workplace (3)
- ❍ Other (4)

Q30 (Force Response) Where is this place? Please click it on the map shown below. You can zoom in, zoom out, and use the search box to help you find your place. Your first two places have been marked on the map. Your click is successfully recorded when you see a blue circle. If it did not show up, click a nearby place.

[1] n is used to track the number of places a respondent is reporting. Since the respondent has reported two places when he/she reaches Q29, n is equal to 3 when Q29 is displayed for the first time. Q29 to Q39 will be displayed over and over again, until the respondent selects "No" for Q36 and Q38, or they have reported 26 places. When Q29 is displayed for the second time, n is equal to 4, and so on. The maximum number of n will be 26.

SAS Hall, Raleigh, NC

Find my Place



	Latitude	Longitude
Coordinates		

Q31 (Force Response) What was your main purpose for traveling here (select <u>one</u>)?

- ❍ Go home (1)
- ❍ Attend Classes / Study / Research (2)
- ❍ Work (3)
- ❍ Dining / Shopping (4)
- ❍ Recreational / Social / Community Service / Personal (5)
- ❍ Other (10) _____

Q32 (Force Response) How did you get to this place (select <u>all</u> modes you used)?

- ❑ Driver - Auto / Van / Truck (1)
- ❑ Passenger - Auto / Van / Truck (2)
- ❑ Motorcycle / Motorized Moped or Scooter (3)
- ❑ Public Bus / Private Shuttle (4)
- ❑ Bicycle (6)
- ❑ Walk (7)
- ❑ Other (8) _____

If "Driver - Auto / Van / Truck" or "Passenger - Auto / Van / Truck" is selected for Q32, display Q33. If "Public Bus / Private Shuttle" is selected for Q32, display Q34.

Q33 Including yourself, how many people were traveling in the vehicle?

- ❍ 1 (1)
- ❍ 2 (2)
- ❍ 3 (3)
- ❍ 4 (4)
- ❍ 5 (5)
- ❍ 6 (6)
- ❍ 7 (7)
- ❍ 8+ (8)

Q34 Which bus(es) did you take? Please select all that you used.

- ❑ Wolfline (NCSU Transit) (1)
- ❑ CAT (City of Raleigh Transit) (2)
- ❑ Triangle Transit (Regional Transit) (3)
- ❑ C-Tran (Town of Cary Transit) (4)
- ❑ Apartment Shuttle Bus (e.g. Wolf Creek Shuttle) (5)

- ❑ DATA (City of Durham Transit) (6)
- ❑ CHT (Town of Chapel Hill Transit) (7)
- ❑ Duke University Transit (8)

Q35 (Force Response) How many minutes did you take to get here? A rough estimate is OK.

Q36 (Force Response) Did you leave this place on {Selected date from Q10}?

- ❍ Yes (1)
- ❍ No (2)

If Yes is selected for Q36, display Q37; if No is selected for Q36, display Q38.

Q37 What time did you leave this place? A rough estimate is OK.

Hour
Minute
AM / PM

Q38 Please confirm you did not leave this place on your travel day. Select "No" will end this survey. Select "Yes" and click "Next" will continue this survey.

- ❍ Yes, I left this place and I want to record more of my trips. (1)
- ❍ No, I did not leave this place. Please exit the survey. (2)

If No is selected for Q38, skip to End of Survey.

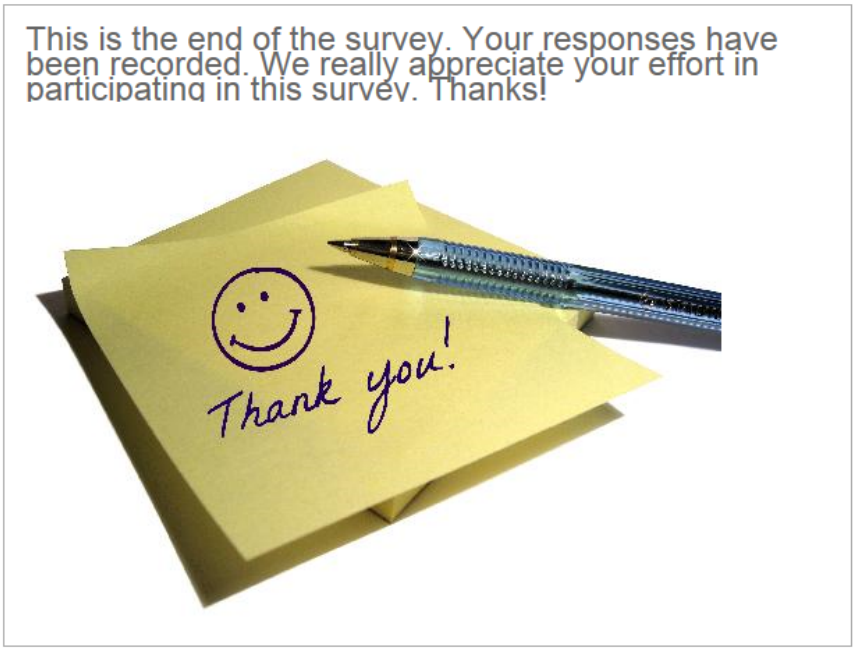
If Yes is selected for Q38, display Q39.

Q39 What time did you leave this place? A rough estimate is OK.

Hour
Minute
AM / PM

Q29 to Q39 will be displayed over and over again, until the respondent selects “No” for Q36 and Q38, or they have reported 26 places.

End of Survey



B. Survey Notification at NCSU and UNCG

The following message was sent to NCSU students inviting them to participate in the survey.

Students of NC State, greetings!

The Institute for Transportation Research & Education (ITRE) on Centennial Campus is conducting a study about the daily travels of our state’s university and college students. We would like to ask you to help us complete the following survey. Your answers will be anonymous and data will be summarized so as to keep the information you provide undisclosed. Please assist us by filling out a brief questionnaire through the link provided below. Our project aims to provide the NC Department of Transportation with more accurate planning models in order to better serve your transportation needs and improve the community’s transportation network!

[insert link]

If you have any questions regarding our work, please feel free to contact Joe Huegy at JBHuegy@ncsu.edu. Thank you for your interest and consideration!

Best,

The Team at ITRE