WALKING ON CAMPUS: CORRELATES AND WEB TOOLS

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Principal Investigator: Craig Zimring, PhD

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Introduction

The United States is experiencing an epidemic of disease related to inactivity and obesity. More than 50% of Americans do not achieve the Surgeon General's recommended 30 minutes of moderate activity on most days, resulting in some 200,000 unnecessary deaths per year due to stroke, cancer, obesity and diabetes (CDC, 2001; Jones et al., 2003; Kahn et al., 2002). The number of inactive Americans as a percent of the population has remained relatively constant at least since 1990, despite considerable investment in education and individual interventions (CDC, 2001). As a result, in addition to individual interventions, public health practitioners have also focused on environmental interventions aimed at increasing everyday activity such as walking. Walking burns calories, can increase self-efficacy about behavior change and can provide the moderate physical activity called for the surgeon general. However, in the age of the automobile many Americans live and work in settings that do not encourage, or permit, walking.

What factors influence everyday walking behavior is not is not entirely clear. While some people walk for instrumental reasons, such as to go to work or to reach transit or shopping, others choose to walk for recreation, or for a combination of reasons. Instrumental walking depends on having connected, safe, convenient sidewalks, with destinations nearby. (Americans will typically walk ¼-½mile depending on the type of destination.) However, while continuous sidewalks are necessary, they are not sufficient to encourage people to walk when they have a choice (Zimring, Joseph, Nicoll, & Tsepas, 2005).

Through this research project, we have attempted to answer the question, “is there a correlation between the physical attributes of walking paths and their use?” If there is such a relationship, and it is sufficiently causal in nature, policy makers may wish to expend funds or implement programs to increase incidental physical activity through the design or redesign of walking paths.

To conduct this study, we examined paths on the campus of the Georgia Institute of Technology in Atlanta, Georgia, and Sprint-Nextel’s corporate campus in Overland Park, Kansas. At each site we collected data about each path’s physical characteristics using an environmental audit tool and had participants report their walking behavior through a graphical, web-based, self-report tool called WebWalk. We then examined the data to see whether walking behavior was correlated with environmental characteristics.

Why Campuses?

Our focus on educational and corporate campuses can be explained by a variety of factors. To date, many private corporations, governments, and universities, have made large investments in walkability and physical activity opportunities on their campuses. In corporate settings, this movement has been fueled primarily by efforts to better employees’ health, with the desired end result of reducing insurance rates and improving productivity. On college campuses, the impetus has been primarily driven by the desire to reduce vehicle trips within campus and to eliminate distributed parking lots in favor of greenspace or campus building expansions. Educational institutions have also embraced activity-friendly campuses in an attempt to restore a sense of “campus community” through interpersonal interaction on walking paths and in shared gathering spaces.

There are many factors that make corporate, educational and governmental campuses a logical setting to focus on improved walking opportunities and increased physical activity:

1) Campuses offer the opportunity to influence a large number of people at a single location;

2) Campuses are often under the control of a single owner, which allows for centralized planning and administration over the whole campus;

3) This centralized land control and project funding make it easier to introduce targeted interventions, especially when compared to a neighborhood setting;

4) Campuses play a significant role in Americans' physical activity opportunities; Americans spend a majority of their day at work, and studies of activity patterns suggest that the workplace is second only to home as a base for activity trips (Wegman and Jang, 1998); finally,

5) Campuses create opportunity for intervention among special populations. College campuses, as an example, can provide early intervention opportunities with students, whose habits can carry with them through adulthood.

Overview of Literature

Even though most Americans spend the vast majority of their time within and around buildings, most previous studies exploring the impact of the physical environment on activity have looked at the larger urban and neighborhood scale. However, recent work at Georgia Tech by a core group of Active Living Researchers have focused on interventions at the site and building scale.

Although campuses provide many opportunities to study buildings and sites, a narrower focus on campuses adds theoretical and methodological challenges. Campuses are not generic, but are designed for and occupied by specific organizations who have special staff, customers, and visitors; each of these groups may have their own rules, histories, and cultures. Further, campuses' specific locations often have specific spatial connections. To better frame these complex interrelations, the Georgia Tech Active Living Research team developed a social-ecological model that links evidence to decisions that can be influenced through policy development and information dissemination (Zimring, Joseph, Nichol, & Tsepas, 2005).

This Socio-Ecological Model of influences is well suited to campus settings, as it addresses setting through a number of perspectives. The model considers Personal Factors, Organizational Factors, and Environmental Factors, as well as spatial scales, including building element design, building design, site selection and design, and urban design.

In this study, our focus on outdoor paths on campuses falls under the broader category of site selection and design. Site design involves the location and orientation of specific features, such as plazas, landscaping, parking and buildings as well as layout of the sidewalk system. Although there are few controlled studies looking at specific correlates at the site design level, when we assemble the available evidence with case studies and recommendations for pedestrian-oriented development, some plausible correlates emerge.

People are more likely to walk if they have destinations such as shopping, eating, and transit within ¼ to ½ mile of their workplace (O'Sullivan & Morrall, 1996;

Seneviratne, 1985; Vuori, Oja, & Paronen, 1994; Frank, Anderson, & Schmid, 2004.) The O'Sullivan & Morrall study recommends that designers locate facilities within pedestrian zone radial distances, ranging between 400 meters (Office) and 900 meters (Residential). These findings are consistent with other studies of walking distances (Seneviratne, 1985). The proximity of potential destinations, such as transit, shopping, or eating from a public building are predictors of the amount of walking people will do during their workday, as shown by the Atlanta SMARTRAQ (Frank, 2004).

The workplace is a base for walking trips in urban settings (Wegmann and Jang, 1998; Pushkarev and Zupan, 1975). Wegmann and Jang's study of trip chaining showed that the largest number of non-work related walking trips were made before, during, and after work, with the workplace as the base.

Locating parking away from buildings increases walking. Studies show that employees are willing to walk longer distances from parking than business visitors or shoppers *(Seneviratne, 1985;* Pushkarev and Zupan, 1975).

*Public transit increases walking behavior***.** Public transit is a primary consideration for increasing walking activity because transit is often paired with walking in a single trip (Department of Transportation Statistics, 1995) and people will walk longer distances from public transit, parking, and home, than other walking trips (O'Sullivan & Morrall, 1996; Seneviratne, 1985; Frank, Anderson, & Schmid, 2004).

Layout and configuration can predict walking behavior. Recent research on urban configuration patterns indicates a connection between street and path layout and pedestrian movement (Hillier, 1993; Peponis et al., 1989; Peponis, Zimring, & Choi, 1990; One Thousand Friends of Oregon, 1993). Specifically, researchers focused on a methodology called “Space Syntax” have developed well-established methods for mathematically describing layouts that are good predictors of the presence of people walking. The theory suggests that, if the built environment is considered as a circulation system to carry movement from every space to every other space within the system, the spaces that are more accessible in the system, will tend to attract higher densities of movement. Thus the distribution of “natural movement” could be seen as a function of spatial configuration (Hillier, 1993).

Path design and materials can increase walking behavior through affordance. A visible walking surface (sidewalk, path) is a fundamental provision for the promotion of pedestrian movement. On-site paths can be seen as connectors to other on-site paths or to off-site paths. According to Gibson’s ecological theory of perception (1979), ‘surface’ is the provider of possibility for movement. When engaging in natural movement, a person will guide him or herself towards available walking surfaces. Additionally, a ‘walkable’ surface provides affordance for further walkable surfaces (Turner & Penn, 2002). Visible connections and walking surfaces are key elements of Lynch’s concept of legibility (1960), in which the pedestrian uses visual cues to gain an understanding of the environment and organize it into coherent patterns; a pedestrian is not likely to be motivated to explore an environment that he or she cannot comprehend.

Presence of others and visual stimuli can increase walking behavior. Research suggests that pedestrians will move towards areas of more activity, or greater numbers of people, in their viewport (Beaumont et al., 1984; Peponis, Zimring, & Choi, 1990). Decisions about activity scheduling, activity area choice, and route choice are influenced by external factors such as presence of others, and stimulation in the environment

(Hoogendoorn & Bovy, 2002; Lynch & Atkins, 1998). Attractors and navigational landmarks can impact the route and distance a pedestrian travels (Lynch, 1960; Haas, 1970). Specific characteristics of stimuli may be important in motivating movement. Strength of the stimulus, its size, location, prominence, contrast against background, use, and symbolic significance are among these characteristics (Rapoport 1977; Gibson 1979; Appleyard 1969).

Imagery and aesthetics can increase walking behavior. Trips through pleasant and interesting places seem shorter than trips through dull areas (Rapoport, 1977). Pedestrians are drawn to attractive places, and often will choose attractiveness over distance. Imagery that supports culture, world-view, and values is a key aspect of perceived environmental quality, and thus, fundamental in environmental choice (Lynch, 1960; Martincigh, 2003). A study of pedestrians within a Montreal marketplace revealed that aesthetic and visual experience was fundamental in guiding movement beyond configurational aspects (Zacharias, 1997). In European PROMote Pedestrian Traffic (PROMPT) research, found that a variety of details and finishes are considered indicators of quality in the pedestrian environment (Martincigh, 2003). Kaplan and Kaplan (1982) suggest that preferred environments permit “involvement” and “making sense”. That is, they are diverse and interesting enough to create curiosity, yet all of the parts work together in a coherent way. Much of the Kaplans’ work has focused on the provision of nature in the environment. Through numerous studies, they have provided strong evidence supporting people’s preference towards natural elements in the landscape (Kaplan, 1975). Other elements that may impact an individual’s perception of environmental quality include public art, streetscaping, materials, style, colors, storefront displays, signage, and architecture.

Safety can influence walking behavior. Safety and human comfort, or rather the perception of such, are key determinants of mode choice (Forward, 2001). Safe and comfortable environments that include sidewalks, lighting, and traffic calming are more attractive to pedestrians. In a survey of minority women, sidewalks (80%) and street lights (71%) were highly endorsed as indicators of environmental quality (Lee et al, 2000). The fear of walking in the dark, especially by women, is a disincentive to walking (Lynch and Atkins, 1988; Forward, 1998a; Forward, 1998b). Appropriate levels of pedestrian lighting can promote walking by alleviating this fear. A pre and post-test study in Glasgow showed a significant increase in pedestrian activity after street and sidewalk lighting was introduced (Nair, 1994).

Evidence suggests that heavy automobile traffic is a deterrent to walking (Forward, 1998a; Forward, 1998b, Appleyard & Lintell,1972); in some cases, the perception of danger caused by such characteristics is greater than the actual risk as indicated by accident statistics (Forward, 2001).

Amenities may increase walking behavior. The inclusion of pedestrian amenities such as lighting, benches, water fountains, and bicycle racks on site can increase pedestrian activity. In a survey conducted as a part of the Louisiana Statewide Bicycle and Pedestrian plan, 30% of the respondents said they would walk more often if more benches and water fountains were available (State of Louisiana, 1998). In addition, amenities designed specifically to promote physical activity, such as walking/jogging paths and par courses have been implemented at several public facilities and reported as successful in a previous survey conducted by Georgia Tech researchers of State agencies (Tsepas and Zimring, 2004).

Audit Tool Background

While our broader research program exploring the role of buildings and sites in supporting walking behavior is based on a Social-Ecological model that explores the role of personal, organizational, social and physical environmental influences on the decision to be active, this project focused on understanding the role of measurable aspects of the physical environment. We approached the physical environment of buildings and sites in terms of three spatial scales:

1) Structural characteristics of site layouts, as determined by Space Syntax measures such as the overall integration and connectivity of routes on the site, as well as the availability of origins and destinations as they are connected to paths and the layout of origins and destinations.

2) Local path characteristics occur in a specific path or path segment, such as paving quality, availability of seating, presence of steps or other barriers, lighting, protection from the elements, aesthetic quality and perceived safety.

3) Relational qualities are those that reflect visibility of pathways and amenities, such as whether amenities can be seen by residents as they go about their daily business.

Prior to this study, there was no existing tool developed specifically for measuring environmental attributes in campus settings. Previous tools have focused primarily on neighborhood scales or sampling larger areas. We developed our measurement tool around two such previously tested audit tools, the Systematic Pedestrian and Cycling

Environmental Survey (SPACES) and the Irvine Minnesota Inventory, adapting them to the campus environment.

SPACES, developed by Terri Pikora and researchers at the University of Western Australia, rates 37 features of the built environment and is the most widely used environmental audit tool (Systematic Pedestrian and Cycling Environment Scan, 2007). The tool, which was developed primarily for auditing neighborhood settings, was not specifically developed for active living research purposes, however, it does achieve high inter-rater reliability (>75%).

The Minnesota Irvine Inventory was developed by researchers at the University of California Irvine and was further tested and developed by researchers at the University of Minnesota. This audit tool was designed to include a broader range of environmental features than the SPACES tool and was developed with an active living research focus (Day et al, 2006). The tool includes 54 segment level questions and is divided into four scales, or categories of factors that are believed to influence walking behavior: accessibility, pleasurability, comfort, and safety (Day et al, 2005).

The concepts of structural, relational and local environments can be linked to walking through these constructs. The evidence linking the environment with walking behavior suggests that the influence of some factors is limited to their immediate surroundings, while other factors are more wide-ranging in their influence. In the end, these concepts are operationally defined by grouping responses to audit questions and calculating a score for each of these categories.

• *Access* includes understanding how difficult or easy it is to get to destinations or resources and this is affected by configuration of the overall layout as well as local and relational cues. At the global scale, access involves ease with which origins and destinations can be located relative to paths of travel within the overall network of paths. At the relational scale, access involves ease of visual access to other parts of the environments from along the paths of travel that enable the individual to pick up cues about location of origins and destinations. Access at the local scale involves the ease with which local cues can be used to identify the presence of resources and amenities in the environment.

• *Pleasurability* relates to the need to provide an interesting and pleasing environment for walking. Pleasurability is primarily a local and relational environmental construct since it relates to the specific attributes of the path of travel and areas surrounding it.

• *Safety* relates to the need to provide a safe environment for walking, which includes safety from crime as well as safety from environmental hazards. Safety from crime involves providing an environment that supports surveillance – that is, ability to see and be seen by others (a relational factor). Safety from hazards involves providing an environment that is free from hazards that may result in incidents such as tripping, slipping or bumping as well as safety from traffic accidents.

• *Comfort* relates to the need to provide an environment for walking that is comfortable in that it provides support and is physiologically comfortable for walking. Comfort is predominantly a local path characteristic.

As noted previously, most active living research to date has focused on neighborhood settings. Although the Minnesota-Irvine study attempted to cover a number of other settings, such as transit-oriented developments and suburban entertainment centers, the tool was not tested in campus settings. The following were factors that lead to the modification of previous audit tool approaches in developing an audit tool focused on campuses.

1) Non-linear or mixed settings. Previous environmental audit tools generally focused on and were tested in 'linear' settings (Day et al, 2005). Linear settings are grid-like in nature and have relationships of buildings, lots, blocks, and streets. Campuses, however, can be both linear and non-linear. Both the SPACES and the Minnesota-Irvine tool approach the evaluation from the street rather than the footpath. The evaluation is based on what is happening on one side of the street versus the other side of the street. In a campus setting, many paths are not related to a street. Therefore, our unit of observation becomes the path segment itself, not a whole street segment. Therefore, even in cases where there are path segments on both sides of a street, they are analyzed as two different path segments.

2) Multiple path types. Unlike other audit tools, we designed our tool around different path types (paths next to streets, paths not part of street network, pedestrianized streets) and grouped questions that may be appropriate to some and not others. This way, whole groups of questions can be skipped if they do not apply to the path type. For example, there is no need to respond to sidewalk buffers when the path is not next to the street.

3) No sampling of paths. Since our study examines a smaller scale campus setting and is heavily focused on local path characteristics, we capture information about each path segment, rather than a sampling of paths in a larger neighborhood.

4) Campus environment vs. neighborhood environment. The audit had to include questions that were geared toward the wide range of environments and amenities found in college or corporate campuses, rather than the smaller range found in a residential neighborhood.

Audit Tool Development

The major methodological challenges to creating the audit tool were defining underlying concept, creating units of analysis and assembling and testing the environmental survey instrument. As previously mentioned, there were numerous factors that led the Georgia Tech research team to modify previous approaches to better suit campus settings. We also aimed to improve upon inter-rater reliability issues related to this type of research.

Paths

In order to conceptually divide the campus for both auditors and users, researchers distinguished between defined pathways and open spaces, and defined the term segment. These distinctions were key to the way the audit was completed and the way that users were presented with route choices when using the WebWalk tool.

A defined path is any pathway that is distinguished from the surrounding landscape through a change in material. For example, a defined path could be a concrete sidewalk that runs through a field of grass, or a mulched path that runs through a forest. Defined paths can be contrasted with open spaces. Open spaces are areas—usually made of grass or paving stone—which individuals can cross without choosing a specific path. Typical examples of open spaces are large plazas, or open fields.

In practice, however, these distinctions can be difficult. A pathway in an open field presents a particular (and common) challenge on campuses – pathways that are used so frequently that a manmade path has clearly been eroded into the ground should be treated as a defined path, while open areas that are used for transit and have no eroded paths are considered open space. It was not practical for these manmade paths to be considered defined paths in the study. Also, for the purposes of this study, street crossings, as indicated by changes in material, crossing lights and/or signs, or painted symbols or lines on the ground are also treated as defined paths. Finally, although such settings rarely occur, whenever a street intersects a single path, the implied crossing is treated as a defined path, even though it may not be distinguished by unique material or pavement markings.

Each defined path was further divided into segments. Segments represent the unit of analysis for the auditor and the finest detail of path selection for the participant. A segment is the portion of a defined path that lies between two decision points. Therefore, a path segment has no set metric length. A given segment can range from several feet to several hundred feet in length. The key concept is once participants decide to walk on a particular segment, they must complete the entire segment (or turn back) before moving to a new path, a new open space, or a new structure. Segments that were shorter than 10 feet (usually seen as the final entrance to the building) are called “stubs” and were not rated using the audit tool.

Environmental Survey

The environmental audit form used in the project draws on forms used in a number of previous studies; however, the unique aims of the current work required extensive modification of these previous instruments. The major steps in developing the environmental survey were:

1) compile a list of questions from SPACES and Minnesota Irvine Inventory that were both applicable to campus settings and plausibly related to walking behavior based on the available literature;

2) add questions based on the literature and/or based on input from the project's advisory panel of physical activity researchers;

3) reformat questions using the path-segment approach;

4) test the tool for interpreter reliability at multiple settings and revise questions as necessary;

5) develop a training manual; and,

6) perform final audits.

The WebWalk environmental audit form draws heavily on the Minnesota-Irvine Inventory and the SPACES tool. As noted, both of these tools were developed to rate paths through neighborhoods, rather than campus settings. To develop the present rating tool, researchers first took applicable questions from the Minnesota-Irvine and SPACES tool, and added additional questions suggested by the advisory panel. Three members of the research team then rated a small number of segments (n=15) to determine which questions needed refining due to unclear definitions or unanticipated circumstances.

These questions were further refined by revisiting the previously-rated segments as well as viewing additional path segments. Researchers then rated 300 segments on the Georgia Tech campus, including 50 segments which were used to test inter-rater reliability, using percent agreement and Cohen's (unweighted) Kappa. Measures which had poor inter-rater reliability were revised. Raters were then taken to 20 segments on the campus to rate physical attributes independently, and, where there was dissention, to reach a consensus on-site. Photographs were taken of these segments to be used in creating training material for future testers.

Inter-rater reliability remained poor (percentage agreement < 50%) for questions regarding vegetation. To solve this problem, raters were asked to independently rate 200 pictures of various vegetation states and to reach consensus on any divergent opinions.

After training and development of the tool was complete, raters assessed 52 segments at the Bellsouth Campus in midtown Atlanta and Sprint's corporate campus in Kansas City to measure inter-rater reliability (Appendix A). Both percent agreement and Cohen's Kappa measurements were generally high (percentage agreement was > 77% for all audit questions; Cohen's Kappa values were typically > .75).

While a useful measure of inter-rater reliability, particularly in the case where there are two raters, Cohen's Kappa has been criticized as providing values that are difficult to understand when measurements are taken out of context (e.g. a K value of .4 may be adequate in some studies, but poor in others) (Cohen, 1960; Gwet, 2001; Landis and Koch,1977). In general, Kappa values for inter-rater reliability were consistently high (> .75); however, in a few cases, the calculated values are misleading. For instance, a mathematical vulnerability in the test reduced Kappa to 0 in several cases where percent agreement was still extremely high (e.g. the xSignal, xIsland, xCurbExt, xBumps, xRumble, xParking, and segMaterial variables; variable names are listed at the end of Appendix "G"). Additionally, differences in coding between the raters made it difficult to compute valid Kappa values for segLandMaint, segBldMaint and TypeLandscape variables. Finally, for some variables, Cohen's Kappa was undefined, as there was no variation in the data set.

For the Georgia Tech portion of the study, members of the rating team worked independently, with an overlap of 10% of the segments (selected randomly) to ensure that raters' opinions continued to converge. Georgia Tech inter-rater reliability measurements met or exceeded the baseline standards achieved at the Bellsouth and Sprint campuses.

The WebWalk Tool

After evaluating the physical landscape of a given site, researchers sought information about walking behavior from individuals who worked at each site. These participants were recruited through mass emails to a headquarters-wide mailing list at Sprint and through departmental mailing lists at Georgia Tech. Because the WebWalk self-report requires the use of a computer, researchers accepted that there would be a small number of employees that would be excluded because of a lack of email addresses. Additional research may wish to focus on employees at corporate campuses that do not have access to email; however, the physical-labor aspects of these individuals' work are typically so significant that it may be impossible for them to recount their movements over the course of a day with any degree of accuracy. Other than access to email, researchers did not impose any limit or qualification to be in the study at Sprint; at

Georgia Tech, researchers required participants to be graduate students, faculty or staff, as they believed that the physical activity of these groups differed considerably from the activity of undergraduate students.

After registering for a user name and password, first-time users of the WebWalk self-report tool are presented with a 23-question demographic survey, and are provided with instructions on how to use the tool. The survey asks for demographic information that has been tied to physical activity levels in previous studies, such as age, race, etc. as well as information that the researchers believed might be correlated with on-the-job physical activity levels (e.g. a participant's position within the company or the type of job a participant performs). Additionally, the survey includes a shortened form of the International Physical Activity Questionnaire (IPAC) (The International Physical Activity Questionnaire, 2005), to determine participants' current level of physical activity. A copy of the survey and possible responses to multiple-choice questions can be found in Appendix B.

The self-report portion of the WebWalk tool is built using Scalable Vector Graphics (SVG), a relatively new technology that allows a computer programmer to describe graphical objects through the use of mathematical descriptors rather than storing graphics as rasterized bits of information. Because SVG objects are created by discrete statements, objects can be made to be interactive when paired with Javascript code—circles can increase in size, or lines can change color when the mouse is moved over them, or when the object is clicked.

WebWalk divides the screen into three areas (see Figure 1): the main map is the area in which a user selects the path that he or she has taken, the mini-map allows the user to shift the location of the main map to see a larger portion of the campus, and the information area provides the names of buildings and well-known path segments, as well as pictures of these areas.

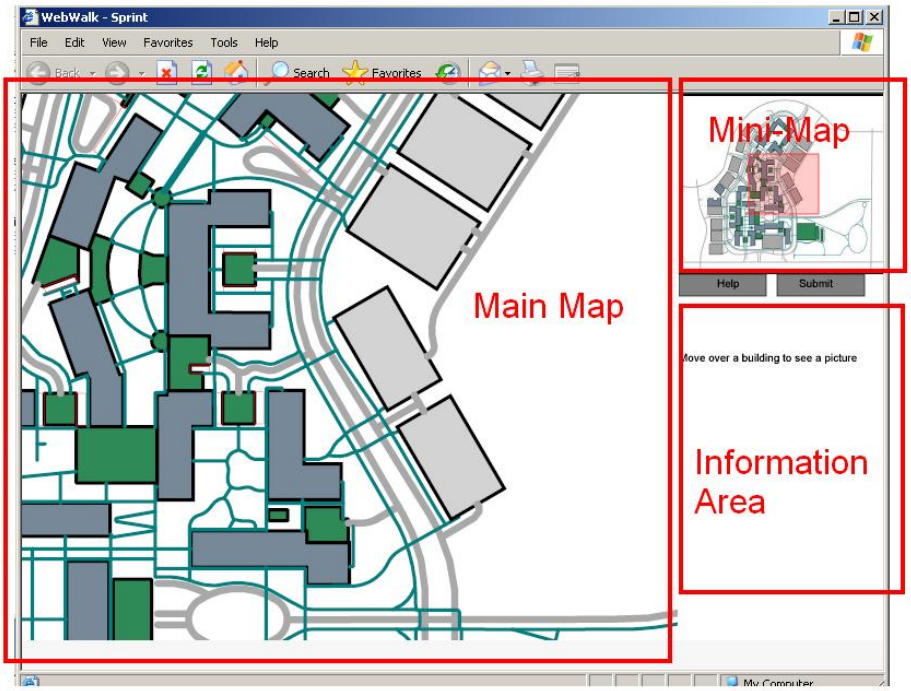

Figure 1: WebWalk Path Selection Screen

Participants use a mouse to click path segments, buildings and open spaces to trace the path that they took. After the user has entered a path, he or she clicks the “submit” button, and is presented with four multiple-choice questions about the path taken, including the date and approximate time trip was taken, the purpose of the trip and the speed of travel. The information is then transmitted to the WebWalk database, and is associated with the user name of the participant who entered it. A copy of the post-trip questions and possible answers to these questions can be found in Appendix C**.**

Users are free to enter data into WebWalk at any time during the day, however, in corporate settings, users have typically been asked to enter all of their trips at the end of their day to minimize the study's impact on their job.

The campus map is initially created in a geographic information system, where each path segment is defined as a separate line or curve, and where buildings and open spaces are defined as closed polygons. Research assistants then check the map against the campus by walking each path section and noting any variances. The map is revised, if necessary, and exported to .svg format. Where available, existing maps, surveys or aerial photography can be used to significantly reduce the amount of time needed to create the campus map. However, researchers should be sure to verify that such information is accurate. In the experience of the WebWalk team, many small changes to campus plans were never recorded on official plans, and aerial photographs were often out-of-date, especially in campuses that were undergoing high levels of construction.

Once the map is exported to .svg format, researchers embed additional code and javascript references into the .svg file that make the map interactive, and allow for interaction between the user and the database. Commented versions of the code as well as a. svg map form, which can be used to produce additional .svg maps are provided in Appendix D, Appendix E, Appendix F**.** Additionally, a table of the database structure is provided in Appendix G for users that wish to recreate the WebWalk system.

Data Analysis

How did people use the WebWalk tool?

The purpose of this descriptive analysis is to identify the pattern of use of the WebWalk tool by our subjects. In order to find out how people use the WebWalk tool, we asked the following questions: what are the total number of recorded trips each day, the number of people using the WebWalk tool each day, the average number of trips per person each day, and what is the number of people using WebWalk for 1 to 5 days,respectively.

In the case of Sprint, the number of trips recorded each day by WebWalk decreased from Monday to Friday (from 177 to 131 trips). The number of people using WebWalk each day also decreased in that period (from 54 to 27 users). Approximately 1/3 of people stopped using WebWalk after one day, and cumulatively half of people dropped out by the end of the period. In other words, half of the users actively used WebWalk throughout the whole study period. In the case of Georgia Tech, the same trend was revealed. Both the number of recorded trips and the number of users decreased each day from Monday to Friday (from 24 to 9 trips, from 5 to 2 users).

However, the number of trips per person each day increased over the week from 3.28 to 4.85 at Sprint. One implication of the results is that it is important to retain subjects using WebWalk tool. One way this might be accomplished is for the researchers to send a reminder email to all subjects one or two days into the study.

All the data obtained from field measures and the WebWalk tool was entered into SPSS 13. The data were then analyzed at three different and related levels: demographic level, path segment level and path level. Each level engages a different focus, purpose, and unit of analysis.

1. The contribution of demographic factors

The purpose of this analysis was to identify the demographic predictors of walking behavior in campus settings. The data were aggregated at the level of individual subjects. The independent variables constitute all demographic and health information which was obtained through an online survey completed by all subjects at the beginning of the study. The dependent variables constitute the number of trips, total walking distance and average walking distance per trip for each subject.

Exploratory factor analysis was employed at this stage. It is an analysis technique to identify groups or clusters of variables based on the correlation between variables. It can reduce the number of variables to a smaller set of factors while retaining as much of the original information as possible, identify the underlying variables (latent variables /factors), and eliminate the correlation between original predictors (Field, 2005). To conduct a factor analysis there needs to be a large sample size; one standard minimum size is 10-15 subjects per variable (Field, 2005).

In the case of Sprint, factor analysis revealed five underlying factors among all the demographic and health variables which can be grouped under the following terms: level of activity, level of walking, seniority, health condition, and time spent sitting (see Figure 2).

Rotated Component Matrix

	factor1 Level of activity	factor2 Level of walking	factor3 Seniority	Factor4 Health Condition	factor5 Time spent sitting
number of days doing vigorous physical activities per week	0.864				
time spent on vigorous physical activities on one of those days	0.869				
number of days doing moderate physical activities per week	0.724				
time spent on moderate physical activities on one of those days					
number of days walking for at least 10 minutes at a time per week		0.901			
time spent on walking on one of those days		0.816			
Gender					
level of education					
time having worked at current primary office			0.85		
time having worked at this campus			0.738		
Age			0.619		
Body Mass Index (BMI)				-0.836	
health condition				0.812	
time spent on sitting at work on a work day					0.802
time spent on sitting on a work day					0.761

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

Figure 2: Factor analysis of demographic and health information.

These five underlying factors were then entered into a regression to test against the dependent variables. People who are more active and healthier do walk longer. However, the statistical test is not significant, which may be accounted for by the small sample size.

The factor of seniority is nearly significant ($p=.059$) in predicting the number of days of using WebWalk. People who work on campus for more years and are older tend to use WebWalk for fewer days compared with the rest of the subjects. The amount of time spent sitting is nearly significant in predicting the total recorded walking distance ($p=.092$) as well as the average distance per trip ($p=.053$). Surprisingly, people who self reported to spend more time sitting in fact walked further distance in general.

At Georgia Tech, people who were more active and healthier tended to walk more. And people who self reported to spend more time on sitting also tended to walk more in the working environment. Due to the small sample size however, none of the above tests were statistically significant.

Our results indicate that factor analysis is a suitable method to reduce 15 variables to a manageable set of five underlying factors without losing important information among those variables. In general, the activity level and the health condition of an individual are positively related to their walking behavior. The self reported amount of time spent sitting can also predict walking on work campuses.

2. The path segment use

The purpose of this analysis is to identify the environmental predictors of path segment use. The data were aggregated at the level of path segments. The dependent variable then is the total number of times any one segment was used in our research period. The independent variables were obtained from field observations which were recorded using the environment audit tool.

Adopting path segment as the unit of analysis has a potential limitation. The use of one path segment is not independent from the use of the adjacent path segments. For example, if path segment A was frequently used, adjacent segment B may also be frequently used because it directly connects to A. This problem is referred to as spatial auto-correlation. To overcome this drawback, two methods were proposed: using the whole path rather than path segment as a unit of analysis, which is discussed in the following section, and taking random samples of certain portions of all path segments. An example of the second method was used by Foltete & Piombini (2007) who randomly drew 50% of the total path segments for their analysis to deal with spatial auto-correlation. Here, we used the same technique as Foltete & Piombini, by randomly sampling 50% of the total path segments for analysis.

In the analysis of both Sprint and Georgia Tech, factor analysis revealed three underlying factors among all environmental variables: pleasurability, safety, and comfort (Figure 3). The three factors generally confirm our theoretical constructs which are potentially linked to walking.

Rotated Component Matrix

	factor1 pleasurability	factor2 safety	factor3 comfort
segment condition			
segment slope			
landscape maintenance	-0.602		
surveillance from buildings		0.738	
surveillance from outdoor		0.661	
presence of lighting			0.715
segment width			
presence of stairs			
amount of protection from sun, rain etc.			0.769
amount of outdoor furnitures			
amount of visual attractions	0.654		
amount of nature features			
amount of parking spaces	-0.618		
amount of public spaces	0.798		

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

Figure 3: Factor analysis of environmental variables in Sprint.

For Sprint, the results of the regression analysis indicated that safety is a significant predictor of segment use (R=.191, p=.038). Thus, the extent to which a segment could be seen by people from either an indoor or outdoor area is positively linked to how often a path segment will be used. The more a segment is perceived as being safe, the more this segment will be used. Our two other factors, pleasurability and comfort, were also positively linked to segment use, but the statistical tests were not significant.

For Georgia Tech, all three latent variables: pleasurability, safety, and comfort were positively related to segment use, but they were not statisticaly significant, again, the lack of significant was likely due to small sample size.

We also explored whether the environment has a stronger impact on the recreational walking behavior than on instrumental trips. In order to resolve this issue, we categorized all segments based on primary use intentions into recreational and instrumental groups. If a segment was used more often for recreational purpose, it was placed into the recreational group. On the other hand, if the segment was more often used for work trips it was placed into the instrumental group. Then we tested whether those two groups differed statistically on environmental measures. The result indicates that the combination of the three factors better predicts the segment use in recreational group than that in instrumental group.

3. Path use

The purpose of the final analysis is to identify the environmental predictors of path use. The difference with the previous analysis is that the data were aggregated at the level of path, which is composed of one or more segments. The dependent variable is how often a path is used by the subjects, and the independent variables are the mean factor scores of all segments composing the path.

The result showed that none of the three factors was significantly associated with path use. Using the same technique we used previously, all paths were categorized into two groups: recreational and instrumental. We achieved similar result with path segment analysis, the combination of three factors better predict the path use for the recreational group than for the instrumental group. Combined with the previous results, this indicates that the environmental measures tend to exert more influence on recreational walking than instrumental walking. Safer, more pleasurable, and more comfortable environments tend to attract more walking compared with other paths.

Discussion and Future Direction

The tools and approaches used in this study pose several questions for future research. These questions can primarily be grouped into three categories: those related to the self-report tool itself; those related to the audit tool; and those related to the analysis of data.

The first category of questions relates to the reliability of the data produced by WebWalk. While informal interviews with participants revealed few problems with identifying buildings and locations using the birds-eye WebWalk map, it is possible that participants faced some difficulty in identifying starting points, pathways and destinations, and that they may, as a result have incorrectly recorded their behavior in the WebWalk system. Additionally, the authors are not aware of any research that examines the effect of the method of recording data as it relates to recall. It may be that the map used by WebWalk is more effective at priming memory than a journal approach; similarly, the computer-interface may be variously more intimidating or more intuitive to some users than a traditional pencil-and-map approach. Accordingly, future researchers may want to compare self-reported walking behavior using a tool such as WebWalk with pedestrian counts, accelerometer/GPS data, or traditional journal self-reported walking information to determine if the computer-based data is as reliable as other methods of tracking walking behavior. Additional future research could measure other presentation aspects of the data: for instance, would the reliability of the data change if the self-report was conducted using an avatar moving in a three-dimensional space, or if the program used more detailed or more abstracted representations of the campus setting?

Previous studies have generally relied on sampling path segments and applying those samples to larger regions where walking behavior could then be compared on a macro-level. In contrast, the present study aims to classify individual path segments (some as short as 10 feet) and determine the influence of both micro- and macro-level path phenomena on route choice. To do this, the study relies heavily on the audit tool.

The audit tool must deal with a number of competing goals, all of which are complicated by the irregular nature of campus paths. The tool must be comprehensive, but short enough to complete quickly; the tool must be objective, however, objectivity limits the tool’s sensitivity to previously-contemplated factors; additionally, objectivity requires strict measurements and categories, which limits the use of the tool to relatively well-trained auditors.

Many factors may play into an individual's decision to take a particular route; however, not all of these can reasonably be included in a brief audit instrument. For instance, views of mountains, wheat fields, or oceans might very well influence path decisions on campuses located near these features. However, the number of possible factors that could influence route choice is virtually infinite, and increasing the number of questions to address each possible feature would make the audit tool too unwieldy.

The time that it takes an auditor to rate a path is a significant consideration of the study. In a hypothetical example where the audit tool takes 5 minutes to complete per segment and there are 600 segments on campus, auditing the campus would take 50 manhours. While the elapsed time to audit the campus could be decreased by using multiple auditors, increasing the number of auditors also increases the noise in the data.

Other efforts to be comprehensive threaten the objectivity of the tool, as well as inter-rater reliability. Early versions of the audit tool included a question on the presence of “interesting or distinctive architectural features” of buildings. While it is plausible that the style of buildings influences route choice, even highly-trained raters were unable to agree on which buildings met this characteristic. Other judgment calls, such as whether or not a particular view is scenic, pose a similar problem. The audit tool has a comment section where auditors can note any exceptional characteristics of a path segment that are not otherwise addressed in the instrument, but at this point, such a comment is not included in the analysis of the data.

One of the hypotheses of the study is that paths that are “beautiful, comfortable and safe” would be used more heavily than other paths. However, decomposing these concepts into their constituent parts, particularly as they relate to beauty, is a daunting task, and one that has challenged aestheticians for centuries.

The attempt to decompose these characteristics to an objectively-measurable point dramatically increases the time to complete the audit instrument as well as the skill level of the auditors. Indeed, the task of classifying the variability of path characteristics on a campus can be compared to efforts of a skilled ethnologist trying to classify interview comments about a social phenomenon.

The characterization of plant-life presents a good example of this challenge. In the audit tool, plant life was classified either as: grass/lawn/groundcover, shrubs and other larger plants, or plants with variety and color. While it would be possible to exhaustively and objectively define each type of plant life (e.g. as being between certain heights, within certain ranges of color when viewed under a light of given color and intensity, and covering a given percentage of the land surrounding the path) such an analysis would be impossible with given time constraints. Instead, the variability found on campus paths meant that auditors were trained to classify plant life into one of the given categories by comparing the plant life with a wide range of photographs that had been classified by the research team. While these classifications could be objected to as subjective, the relatively high kappa scores for these questions suggest that there is at least high inter-rater reliability in these measurements.

Finally, the goals of comprehensiveness and objectivity are challenged by the impact of visual fields. For most in modern American life, vision is the most sophisticated and relied-on of the senses. One component of vision's power is the ability to sense phenomena at a greater distance than any of the other senses. Unfortunately for this study, that means that the comprehensiveness of the study is limited by excluding otherwise-relevant sights at a distance, or the objectivity of the study is limited by the number of questions that would need to be on the audit to effectively classify these sights.

As an example, assume that two paths are identical, except that one has a view of mountains in the far distance, and the other has a view of a dumpster within 500 feet. Likely, these characteristics would influence route selection, however, adding enough questions to the audit tool to effectively capture these differences is impractical. For that reason, the audit tool limits its contemplation of factors to those within 250 feet of any portion of the path segment, a distance where researchers believe that the impact of any such characteristic would be the strongest.

Finally, there are a number of opportunities for future research when it comes to analyzing participants' walking behavior. In many cases, the characteristics of the path may be confounded by issues related to designers' and individuals' walking behavior.

The most obvious hypothesis is that in most cases, individuals will act to minimize the distance that they travel. Thus, any "minimized" route should be excluded from analysis because, presumably, the path characteristics did not have any effect on route-selection behavior. Attempts to minimize route length may be actual or perceived. The most useful actual measure would be metric distance; however previous research suggests that perceived-minimization of route choice might be related to minimizing the number of turns that an individual might make, or minimizing the number of total degrees turned though (Peponis, Zimring, and Choi, 1990). More complicated experimental models might also suggest that lines of sight of the destination might also come into play (e.g. a route might be perceived as shorter when it allows for the destination to be seen from the origin, even though a shorter metric-distance path existed that hid the destination from view). These factors involve understanding human vision at a much higher level, and would need to account for factors such as the interference of three-dimensional objects.

Additionally, it is a well-known phenomenon that a subject's level of interest and the number of new sensations may make a walk seem longer or shorter than it really is. For example, the visual opportunities that pervade a walk down a New York avenue may make time appear to pass much more quickly than it actually does, and may make the subject feel that a distance is not as long as it actually is. (e.g. shorter perceived distance than a walk of similar length in a suburb, or featureless plain.) On the other hand, an overload of sensory factors may make an unaccustomed person feel that the path is much longer than it actually is. In sum, for any path between two areas, there might be several “shortest” paths. Future research should attempt to determine why individuals take more “comfortable, safe and beautiful paths”? Do individuals take them because they are, in fact, more pleasant, or because they appear to be shorter than paths that are less pleasing?

A conservative approach would suggest that designers are at least somewhat aware that their design choices could influence walking behavior. Additionally, they presumably expend their limited landscaping, budget in a way that would allow for the greatest effect for the greatest number of individuals (along with special exceptions such as paths near executive offices, near a main entrance, etc.).

In short, designers may have an intuitive feel for the most common paths that individuals will take, and will presumably spend the majority of their landscaping budget on these areas. Thus, a large amount of walking on paths that rate highly on these factors may be explained by a designer's superior predictive abilities.

One way to test this would be to design an experiment based on a campus where pedestrian-counts have already been obtained. Professional designers would then be asked to place a limited number of amenities on a map of this campus, which would be labeled with building functions, names, etc. If the designers placed these amenities on the highest-trafficked paths, it would provide some evidence that designers’ placement of amenities are based on underlying human-traffic patterns that are not necessarily changed by the presence or absence of such amenities. Such issues touch on issues of designs having inherent movement patterns, which, along with spatial autocorrelation and the effects of limited path choice, are discussed in the data analysis section, above.

Future researchers have a plethora of avenues to explore in further research; these avenues span disciplines, ranging from architecture, to cognitive psychology, to sociologists and medical professionals focusing on human activity. The environmental audit and the WebWalk tool presented here, as well as the ability to modify both, should be a useful starting point in exploring the many questions that still remain.

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Appendix A: Inter-rater reliability results in Bellsouth and Sprint

Interrater Reliability, Bellsouth and Sprint Tests (N=52)

Variable	Percent Agreement	Unweighted Kappa Value
segType	100%	1.00
roadLanes	100%	1.00
segLocation	100%	1.00
bufStrip	98%	0.92
bufTree	98%	0.93
bufFurn	100%	1.00
bufPark	96%	0.78
xZebra	100%	1.00
xColored	100%	1.00
xSignal	98%	-
xRaised	100%	1.00
xIsland	98%	-
xCurbExt	98%	-
xBumps	98%	-
xRumble	98%	-
xParking	98%	-
segMaterial	96%	-
segCondition	90%	0.83
segWidth	100%	1.00
segSlope	94%	0.83
segStair	100%	1.00
segLitter	90%	0.82
segLandMaint	77%	
segBldMaint	90%	
bldSurv	92%	0.80
outSurv	90%	0.75
segLighting	92%	0.85
segEmPhone	100%	Undefined
cvrWalkway	96%	0.78
Cvrcanopies	94%	0.68
cvrVegetation	90%	0.85
Cvrother	96%	0.48
amBench	94%	0.75
amBus	96%	0.93
amWater	98%	0.96
amBike	98%	0.96
amDirect	94%	0.90
amTrash	92%	0.88
amNewspaper	98%	0.96
amOther	94%	0.90
atArt	100%	Undefined
atFountain	100%	Undefined
atTrees	96%	0.38
atBridges	98%	0.96
atLandscape	88%	0.78

TypeLandscape	81%	
atRestaurant	100%	1.00
atOutDin	94%	0.89
atCoffee	98%	-
atVendors	100%	Undefined
atRetail	92%	0.80
atOther	96%	0.48
parkDeck	98%	0.96
parkLot	96%	0.89
outPark	92%	0.83
outSport	100%	undefined
outPlaza	94%	0.90
outGLawn	92%	0.72
outGolf	100%	undefined
natLake	100%	1.00
natWoods	94%	0.90
natStream	100%	1.00
exJogging	98%	0.93
OffPedestrian	100%	1.00
OffVehicular	100%	1.00
OffPublic	100%	1.00
OffShop	100%	1.00
OffService	100%	1.00
OffResidential	100%	1.00
minimum	77%	0.38
maximum	100%	1.00

Appendix B: Survey and possible responses to multiple-choice question

Thank you for registering with us. We will now ask you to complete a one-time survey regarding some basic information and your current exercise levels. We ask that you select the most appropriate answer below:

1. How many days per week do you usually work at your primary office?

   1

2. Which of the following best represents your job classification?

   - Managerial
   - Technical
   - Professional
   - Administrative
   - Other (please specify)

3. How long have you been working at **this campus**?

   - Less than 6 months
   - 6 months to 2 years
   - More than 2 years

4. How long have you been working at **your current primary office**?

   - Less than 6 months
   - 6 months to 2 years
   - 2 years or more

5. Would you say in general your health is...

   - Excellent
   - Very Good
   - Good
   - Fair

- ☐ Poor
- ☐ Don't Know/Not Sure

6. By yourself, and without using any special equipment, how difficult is it for you to walk a quarter of a mile (about 3 city blocks)?

- ☐ Not at all difficult
- ☐ Only a little difficult
- ☐ Somewhat difficult
- ☐ Very difficult
- ☐ Can't do at all

We are interested in finding out about the kinds of physical activities that people do as part of their everyday lives. The questions will ask you about the time you spent being physically active in the last 7 days. Please answer each question even if you do not consider yourself to be an active person. Please think about the activities you do at work, as part of your house and yard work, to get from place to place, and in your spare time for recreation, exercise or sport. In the questions below, we will ask about 2 types of physical activity: **vigorous** and **moderate**. When we ask about moderate physical activity, we'll ask about **walking** separately from other moderate activities. Think about all the **moderate** activities that you did in the **last 7 days**. Moderate activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal. Think only about those physical activities that you did for at least 10 minutes at a time.

7. During the **last 7 days**, on how many days did you do **moderate** physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? Do not include walking.

[0 ▾]

8. How much time did you usually spend doing **moderate** physical activities on one of those days?

[Not Applicable ▾]

Think about all **vigorous** activities that you did in the **last 7 days**. Vigorous physical activities refer to activities that take hard physical effort and make you breather harder than normal. Think only about those activities that you did for at least 10 minutes at a time.

9. During the last 7 days, on how many days did you do **vigorous** physical activities like heavy lifting, digging, aerobics, or fast bicycling?

   0

10. How much time did you usually spend doing **vigorous** physical activities on one of those days?

    Not Applicable

    Think about the time you spent **walking** in the **last 7 days**. This includes at work and at home, walking to travel from place to place, and any other walking that you might do solely for recreation, sport, exercise, or leisure.

11. During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time?

    0

12. How much time did you usually spend **walking** on one of those days?

    Not Applicable

    Think about how much time you spent **sitting** on **work days** during the **last 7 days**. Include time spent at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading, or sitting or lying down to watch television.

13. During the **last 7 days**, how much time did you spend **sitting** on a **work day?**

    Not Sure/Don't know

14. During the **last 7 days**, how much time did you spend **sitting at work** on a typical **work day**?

    Not Sure/Don't know

15. Over the past 7 days has your physical activity been significantly different from your customary and usual pattern?

    - Typical
    - Not typical (please specify)

16. Are you male or female?

- Male
- Female

17. What is your age?

20-29

18. What is the highest level of school that you have completed?

- Less than High School
- High School Graduate
- Some College/Associates Degree
- College Graduate (Bachelors)
- Graduate or Professional Degree
- Other (please specify)

19. Which of the following would you say best represents your race?

- American Indian or Alaska Native
- Asian
- Black or African American
- Native Hawaiian or other Pacific Islander
- White
- Other (please specify)

20. Are you Hispanic or Latino?

- Yes
- No

21. How much do you weigh without shoes? (please use whole numbers only; example: 154)

pounds

22. How tall are you without shoes? (please round up to the nearest inch)

4 feet 0 inches

23. Do you have any additional comments for us?

Submit

Appendix C: Post-trip questions and possible answers

Date of trip:

User selects month and day of trip from a drop-down menu.

Time of trip:

User selects “morning (6-10 am)”, “mid-day (10 am -2 pm)”, “afternoon (2 pm -6 pm)”, or “other” from a drop down menu.

Average intensity of trip:

User selects “normal pace walking,” “brisk or fast walking,” or “jogging or running” from a drop down menu.

Purpose of trip:

User selects “work-related,” “personal,” or “combination” from a drop down menu.

Appendix D : Source codes of base.svg

Following is an example of the .svg file used in the Georgia Tech portion of the study. This code could be used as the basis for another study using a different site. The .svg file also relies on functions that are defined in linecode.es and code.es, which also follow. Function descriptions appear as comments in the code.

```
	<?xml version="1.0"?>
	<!DOCTYPE svg PUBLIC "-//W3C//DTD SVG 1.0//EN"
"http://www.w3.org/TR/2001/REC-SVG-20010904/DTD/svg10.dtd">
	<!--Note that the entire svg file is hardwired for 800x600 resolution-->

	<svg
	xmlns="http://www.w3.org/2000/svg"
	xmlns:a3="http://ns.adobe.com/AdobeSVGViewerExtensions/3.0/"
a3:scriptImplementation="Adobe"
	width="790" height="500"
	zoomAndPan="disable"
	onload="initializeMap()">
	<title>WebWalk - Georgia Tech</title>

	<!--references the javascript/emacscript files that control the .svg file-->
	<script a3:scriptImplementation="Adobe" type="text/ecmascript"
xlink:href="code.es" />
	<script a3:scriptImplementation="Adobe" type="text/ecmascript"
xlink:href="linecode.es" />

	<!--SUB SVG MAIN MAP STATRS HERE-->
	<!--Note that viewbox below will depend on the measurements in the GIS
program that is used to export the .svg file-->
	<svg id="mainmap" width="600px" height="520px" preserve-aspect-
ratio="meet" viewBox="300000 -400000 310000 240000">

	<!-- Frame for Main map-->
	<rect x="0" y="0" width="600" height="520" stroke="black" fill="none" stroke-
width="1700" />
	<!--background color for main map-->
	<rect id="background" x="-2245" y="-701879" width="2991230"
height="1000000" />

	<!--Note that int the following, onmouseover, fill, and the like can generally be
defined in object groups, however
	  individual characteristics, like the id number of the object, the name, and
whether the object is used or not needs to be in the
	  individual object definition. Also, note that most fills, etc. can and will be
changed using the initialize map function in linecode.es-->
```

```
			<g id="bld" onmouseover="PolyHighlight(evt)"
onmouseout="PolyHighlight(evt)" onclick="PolySelected(evt)" fill="none"
stroke="black" stroke-width="398.7" stroke-linecap="round" stroke-linejoin="round" >
				<path id="git_bld_0" name="Klaus Advanced Computing
Building" status="normal" used="false" d="M651281.9 -379376.8l-16494.1 -
5880.5l1413 -3963.2l-9944 -3545.2l0 -37787.8l-29533.5 0l0 -13468.8l-3329.2 -
6090.4l31227.7" />
		<!--additional buildings would go here, with same fields as above-->
			</g>

			<g id="ops" onmouseover="PolyHighlight(evt)"
onmouseout="PolyHighlight(evt)" onclick="PolySelected(evt)" fill="none"
stroke="black" stroke-width="398.7" stroke-linecap="round" stroke-linejoin="round" >
				<path id="git_ops_0" status="normal" used="false"
d="M509736.7 -445759.3l4796.9 0l7461.9 7925.2l13724.6 0l0 9502.3l-7622.4 0l0
9031.8l-9119.9 0l0 6427.6l-9107.9 0l-133.2 -32886.9z" />
				<!--additional openspaces would go here, with same fields as
above-->
			</g>

			<g id="stu" stroke="black" fill="none" stroke-width="1" stroke-
linecap="round" stroke-linejoin="round" onmouseover="ChangeLineWeight(evt)"
onmouseout="ChangeLineWeight(evt)" onclick="LineSelected(evt)"	>
		<!--additional stubs would go here, with same fields as above-->
			</g>

			<g id="pkg" onmouseover="PolyHighlight(evt)"
onmouseout="PolyHighlight(evt)" onclick="PolySelected(evt)" fill="none"
stroke="black" stroke-width="398.7" stroke-linecap="round" stroke-linejoin="round">
				<path id="git_pkg_0" status="normal" used="false"
d="M380062.6 -440622.1l696.6 -85544.1l19136.2 -22.7l210.4 -6727.1l81132.6 1813.8l0
30244.3l-75653.6 -353.3l153.3 30286.2l-12.1 8594.8l-10455.1 -14.7l-30.1 21381.3l-
15178.2 341.4z" />
				<!--additional parking lots would go here, with same fields as
above-->
				</g>

			<g id="pkd" onmouseover="PolyHighlight(evt)"
onmouseout="PolyHighlight(evt)" onclick="PolySelected(evt)" fill="none"
stroke="black" stroke-width="398.7" stroke-linecap="round" stroke-linejoin="round" >
				<path id="git_pkd_0" name="Student Center Parking Deck"
status="normal" used="false" d="M354367.9 -187413.7l-11791.6 50583.3l-84662.4 -
15639.3l13084.2 -71831.6l48161.6 8772.7l-3826 21004.8l39034.2 7110.1z" />
		<!--additional parking lots would go here, with same fields as above-->
			/g>
```

```
			<g id="street"  fill="none" stroke="black" stroke-width="398.7" stroke-
linecap="round" stroke-linejoin="round" >
				<path id="git_str_0" d="M161135.2 -213631.4l12913.4 -32506.1l-
445.3 -13803.9l-18256.8 -22264.4" />
				<!--additional streets would go here, with same fields as above;
N.B. that the addition of events from above in the group will make streets selectable-->
				</g>

			<g id="seg" stroke="black" fill="none" stroke-width="1" stroke-
linecap="round" stroke-linejoin="round" onmouseover="ChangeLineWeight(evt)"
onmouseout="ChangeLineWeight(evt)" onclick="LineSelected(evt)" >
				<path id="git_seg_0" length_ft="107.92" status="normal"
used="false" d="M123534.8 -220119.9l26256.1 842.7" />
				<!--additional segments would go here, with same fields as above.
note that length_ft could be used to calculate the distance that an individual has walked,
either this trip or over multiple trips.-->
			</g>

		</svg>

		<!--SUB SVG (MINI-MAP) STATRS HERE-->
		<svg x="601" y="0" width="190" height="165" >

		<!--Minature map, created by resizing a .jpg image of the unmodified .svg file as
it comes from the GIS program.-->
		<g id="aerial2" visibility="visible" >
		<image xlink:href="tech_svg_map_small.jpg"
				x="1" y="0"
				width="187" height="165"/>
		</g>

		<!-- Frame for Mini map-->
		<rect x="0" y="0" width="189" height="165" stroke="black" fill="none" stroke-
width="4" />

		<rect id="mapbox" x="64" y="55" width="64" height="55" style="fill: red; fill-
opacity: .20; stroke: red;"
			onmousedown="initDrag(evt)" onmousemove="Drag(evt)"
onmouseout="endDrag(evt)" onmouseup="endDrag(evt)"/>

		</svg>

		<!--SUB SVG (INFORMATION AREA) STATRS HERE-->
		<svg x="601" y="165" width="190" height="355">
```

```
        <!--Code for buttons-->

        <g transform="translate(100,0)" onclick="countUsed()"
onmousedown="pressButton(evt, 'Submit')" onmouseup="releaseButton(evt, 'Submit')"
onmouseout="releaseButton(evt, 'Submit')">
         <rect id="Submit" x="0" y="0" width="80" height="20" fill="silver"/>
         <g id="Submit_highlight" fill="lightgray">
           <rect x="0" y="0" width="2" height="19"/>
           <rect x="0" y="0" width="80" height="2"/>
         </g>
         <g id="Submit_shadow" fill="darkgray">
           <rect x="2" y="18" width="78" height="2" />
           <rect x="78" y="2" width="2" height="18" />
         </g>
         <text x="25" y="13" style="visibility: visible; fill: black; font-family: San-Serif;
font-size: 10" pointer-events="none">Submit</text>
        </g>

        <g transform="translate(10,0)" onclick="openPopup('help.html',
'svgWindowTest','width=700,height=500,scrollbars,resizable')"
onmousedown="pressButton(evt, 'Help')" onmouseup="releaseButton(evt, 'Help')"
onmouseout="releaseButton(evt, 'Help')">
         <rect id="Help" x="0" y="0" width="80" height="20" fill="silver"/>
         <g id="Help_highlight" fill="lightgray">
           <rect x="0" y="0" width="2" height="19"/>
           <rect x="0" y="0" width="80" height="2"/>
         </g>
         <g id="Help_shadow" fill="darkgray">
           <rect x="2" y="18" width="78" height="2" />
           <rect x="78" y="2" width="2" height="18" />
         </g>
         <text x="30" y="13" style="visibility: visible; fill: black; font-family: San-Serif;
font-size: 10" pointer-events="none">Help</text>
        </g>

        <!--Code for picture of buildings/paths, etc.-->
        <text x="0" y="100" id="picText" style="visibility: visible; fill: black; font-
family: San-Serif; font-size: 10">Move over a building to see a picture</text>

        <image id="pic" xlink:href="" visibility="hidden"
         x="0" y="45" width="190" height="140"
         onmousedown="changePic(evt)"/>

        <!-- deprecated code for clear and enter path button, now done with page refresh
in javascript automatically after submission
```

```
	<rect id="Clear" x="0" y="25" width="170" height="20" style="fill: gray; stroke:
black;" onclick="refresh()"/>
	<text x="35" y="37" style="visibility: visible; fill: black; font-family: San-Serif;
font-size: 10" pointer-events="none">Clear and Enter New Path</text>
	-->

	<!-- deprecated code (very old) that could be used to toggle an arial photograph in
the background. Would need to update button style.
	<g id="togglebutton" transform="translate(0,0)" onclick="toggleAerial()">
	<rect id="toggleAerial" x="0" y="0" width="40" height="20" style="fill: gray;
stroke: black;"
		/>
	<text x="0" y="10" style="visibility: visible; fill: black; font-family: San-Serif;
font-size: 10" pointer-events="none">Toggle</text>
	</g>
	-->

	<!--Debugging text that is normally hidden. Reveal for debugging.
	<text x="0" y="90" id="Debug" style="visibility: hidden; fill: black; font-family:
San-Serif; font-size: 14"> </text>
	<text x="0" y="200" id="txtPolyName" style="visibility: visible; fill: black; font-
family: San-Serif; font-size: 14"> </text>
	-->

	</svg>
	</svg>
```

Appendix E: Source codes of linecode.es

```
//Linecode.es was created by Michael Herndon.
//This file was revised August 6, 2008
//The location of the file must be referenced in the .svg file.

//This file provides code that is used to control the user's intection with path segments.

//Terminology:
//Objects that users can interact with are named following the convention: SSS_OBJ_N
//where SSS is the ititials of the site, OBJ defines the type of object, and N is the number
of the object.
//OBJ can be BLD=Building; OPS=Open space; STU=Stub (pathway < 10 feet long, and
therefore not audited);
//PKG=Above ground parking; PKD=Parking deck; STR=Street; SEG=Audited path
segment > 10 feet.
//Therefore, git_bld_105 would refer to the Georgia Tech Campus, Building No. 105.

//Constants that determine color and size of items
//named colors are defined by .svg standards
//see http://www.december.com/html/spec/colorsvg.html for color examples

var BACKGROUND_COLOR = "white";             //background color of the map
var BUILDING_COLOR = "lightslategray";
var OPENSPACE_COLOR = "seagreen";
var PARKING_COLOR = "lightgray";        //color of above-ground parking structures
var PARKING_DECK_COLOR = "lightgray";       //color of parking deck
var STREET_COLOR = "darkgray";
var UNUSED_PATH_STROKE_COLOR = "teal";  //color of unused path segments
var UNUSED_POLY_STROKE_COLOR = "black ";//color of the border of unused
polygons (buildings, open space, parking, etc.)
var USED_PATH_STROKE_COLOR = "red";       //color of used path segments
var USED_POLY_STROKE_COLOR = "red";       //color of the border of used
polygons (buildings, open space, parking, etc.)
var BTN_SHADOW_COLOR = "darkgray"
var BTN_HIGHLIGHT_COLOR = "lightgray"
//***** Would be nice to define the original buttons with color here, and update them in
the init. function.

var NORMAL_PATH_STROKE_WIDTH = 1000;  //width of path segments normally
var NORMAL_POLY_STROKE_WIDTH = 1000;  //width of borders of polygons
normally
var BOLD_PATH_STROKE_WIDTH = 4000;       //width of path segments when
mouse moves over them
```

var BOLD_POLY_STROKE_WIDTH = 4000; //width of borders of polygons when mouse cursor moves over them
var STREET_WIDTH = 8000; //width of streets

//Reporting Constants
//These constants are used in determining which pathways and objects the user marked on his/her pathway.

var MAP_PREFIX = "git_"; //prefix of each object -- needs to be changed with new sites.
var WALKWAY_PREFIX = "seg_"; //letters used to identify segment objects. Should NEVER be changed. Some code may be hardwired, and cannot handle variable changes.
var STUB_PREFIX = "stu_"; //" " stub " "
var OPEN_PREFIX = "ops_"; //" " open space " "
var BLD_PREFIX = "bld_"; //" " building " "
var PARKLOT_PREFIX = "pkg_"; //" " above ground parking lots " "
var PARKDECK_PREFIX = "pkd_"; //" " parking deck " "

//Integer values should always be >= the actual number of objects of a given type.
//Integer values lower than the actual number of objects will result in user selections not being reported.

var MAX_WALKWAY_SEGMENTS = 1000; //minimum number of walkway segments in the .svg file
var MAX_STUBS = 500; //" " stubs " "
var MAX_BUILDINGS = 100; //" " buildings " "
var MAX_OPEN_SPACE = 50; //" " open space " "
var MAX_PKG = 30; //" " above ground parking lots " "
var MAX_PKD = 30; //" " parking decks " "

var strResult = ""; //Initial value of the result string, could be changed to add in necessary prefix information if necessary.

var pic = root.getElementById("pic"); //Identifies picture object. Should NOT be changed.

//Note that references to textstatus in the following code are for debugging purposes only,
//textstatus would need to be unhidden in the .svg file.

function initializeMap() {
//This function sets the color and width of buildings, open spaces, parking decks, streets, line segments and stubs.
//it is only run when the .svg file is loaded or reloaded.

```
	document.getElementById("bld").setAttribute("stroke",
UNUSED_POLY_STROKE_COLOR)
	document.getElementById("ops").setAttribute("stroke",
UNUSED_POLY_STROKE_COLOR)
	document.getElementById("pkg").setAttribute("stroke",
UNUSED_POLY_STROKE_COLOR)
	document.getElementById("pkd").setAttribute("stroke",
UNUSED_POLY_STROKE_COLOR)
	document.getElementById("seg").setAttribute("stroke",
UNUSED_PATH_STROKE_COLOR)
	document.getElementById("stu").setAttribute("stroke",
UNUSED_PATH_STROKE_COLOR)

	document.getElementById("stu").setAttribute("stroke-width",
NORMAL_PATH_STROKE_WIDTH)
	document.getElementById("seg").setAttribute("stroke-width",
NORMAL_PATH_STROKE_WIDTH)

	document.getElementById("bld").setAttribute("stroke-width",
NORMAL_POLY_STROKE_WIDTH)
	document.getElementById("ops").setAttribute("stroke-width",
NORMAL_POLY_STROKE_WIDTH)
	document.getElementById("pkg").setAttribute("stroke-width",
NORMAL_POLY_STROKE_WIDTH)
	document.getElementById("pkd").setAttribute("stroke-width",
NORMAL_POLY_STROKE_WIDTH)


	document.getElementById("bld").setAttribute("fill", BUILDING_COLOR)
	document.getElementById("ops").setAttribute("fill", OPENSPACE_COLOR)
	document.getElementById("pkg").setAttribute("fill", PARKING_COLOR)
	document.getElementById("pkd").setAttribute("fill",
PARKING_DECK_COLOR)

	document.getElementById("street").setAttribute("stroke-width",
STREET_WIDTH)
	document.getElementById("street").setAttribute("stroke", STREET_COLOR)

	document.getElementById("background").setAttribute("fill",
BACKGROUND_COLOR)
}

function ChangeLineWeight(evt) {
//higlights line if mouse moves over it
 var objLine = evt.target;
 var objLineWeight = objLine.getAttribute("status");
```

```
  if (objLineWeight == "normal")
  {
   objLine.setAttribute("stroke-width", BOLD_PATH_STROKE_WIDTH);
   objLine.setAttribute("status", "bold");
   //hack to identify line segments
   var oNum=objLine.getAttribute("id");
   //txtStatus.getFirstChild().setData(oNum);
 //  changePic(objLine); //could be used to show pictures of line segments.
  }
  else
  {
   objLine.setAttribute("stroke-width", NORMAL_PATH_STROKE_WIDTH)
   objLine.setAttribute("status", "normal");
   clearPic();
  }
}

function PolyHighlight(evt) {
//highlights polygon (building, open space, etc. when mouse cursor moves over it.
//also updates picture and displays name

 var objPoly = evt.target;
 var objPolyWeight = objPoly.getAttribute("status");
  var objText = document.getElementById("txtPolyName");

  if (objPolyWeight == "normal")
  {
   objPoly.setAttribute("stroke-width", BOLD_POLY_STROKE_WIDTH);
   objPoly.setAttribute("status", "bold");
  //describe the building
  var polyName = objPoly.getAttribute("name");
  objText.getFirstChild().setData(polyName);
  //change the picture
  changePic(objPoly)
  }
  else
  {
   objPoly.setAttribute("stroke-width", NORMAL_POLY_STROKE_WIDTH)
   objPoly.setAttribute("status", "normal");
  //hide the building name
  objText.getFirstChild().setData("");
  //hide picture
  clearPic()
  }
}
```

```
function changePic(obj, type) {
//determines which pictures should be displayed and displays it.
  //report that the function is running
  //txtStatus.getFirstChild().setData("changePic");
  //determine the name of the picture file to be loaded.
  var picname = obj.getAttribute("id");
  picname = "bld/" + picname + ".jpg";
  //display the picture file
  pic.setAttribute("xlink:href", picname);
  pic.setAttribute("visibility", "visible");
}


function clearPic() {
//hides picture of building/openspace when mouse leaves a polygon.
 pic.setAttribute("visibility", "hidden");
}


function pressButton(evt, btnName) {
//changes highlighting of a pressed button while the mouse is held down.
  var button = evt.target.getAttribute("id");
  var buttonPart = btnName + "_highlight"
  var buttonObject = document.getElementById(buttonPart);
  buttonObject.setAttribute("fill", BTN_SHADOW_COLOR);
  var buttonPart = btnName + "_shadow"
  buttonObject = document.getElementById(buttonPart);
  buttonObject.setAttribute("fill", BTN_HIGHLIGHT_COLOR);
}

function releaseButton(evt, btnName) {
//changes highlighting of a pressed button while the mouse is lifted.
  var buttonPart = btnName + "_highlight"
  var buttonObject = document.getElementById(buttonPart);
  buttonObject.setAttribute("fill", BTN_HIGHLIGHT_COLOR);
  var buttonPart = btnName + "_shadow"
  buttonObject = document.getElementById(buttonPart);
  buttonObject.setAttribute("fill", BTN_SHADOW_COLOR);
}

function LineSelected(evt) {
//changes color and status of selected line segments and stubs
 var objLine = evt.target;
 var objLineUsed = objLine.getAttribute("used");
   if (objLineUsed == "true")
   {
```

```
    objLine.setAttribute("stroke", UNUSED_PATH_STROKE_COLOR);
    objLine.setAttribute("used", "false");
   }
   else
   {
    objLine.setAttribute("stroke", USED_PATH_STROKE_COLOR);
    objLine.setAttribute("used", "true");
   }
}

function PolySelected(evt) {
//changes color and status of selected polygons (buildings, open space, etc.)
 var objPoly = evt.target;
 var objPolyUsed = objPoly.getAttribute("used");
   if (objPolyUsed == "true")
   {
    objPoly.setAttribute("stroke", UNUSED_POLY_STROKE_COLOR);
    objPoly.setAttribute("used", "false");
   }
   else
   {
    objPoly.setAttribute("stroke", USED_POLY_STROKE_COLOR);
    objPoly.setAttribute("used", "true");
   }
}

function countUsed(){
//Function determines which segments, buildings, etc. were marked "used" by the user,
passes that data to the database, opens the everytime survey and clears data.
//TEST FOR LINES
for(var i=0; i<=MAX_WALKWAY_SEGMENTS; i++) {
        var objTest = MAP_PREFIX + WALKWAY_PREFIX + i;
        //if element does not exist, move on; otherwise test if used.
 if (document.getElementById(objTest)!=null)
                {
                //following code ASSUMES that all lines have "used" attribute
                if (document.getElementById(objTest).getAttribute("used")=="true")
                        {
                        strResult = strResult + objTest + " ";
                        }
    }
}

//TEST FOR STUBS
for(var i=0; i<=MAX_STUBS; i++) {
        var objTest = MAP_PREFIX + STUB_PREFIX + i;
```

```
        //if element does not exist, move on; otherwise test if used.
 if (document.getElementById(objTest)!=null)
                {
                //following code ASSUMES that all elements have "used" attribute
                if (document.getElementById(objTest).getAttribute("used")=="true")
                        {
                        strResult = strResult + objTest + " ";
                        }
   }
  //window.alert(strResult)
}

//TEST FOR OPEN SPACE
for(var i=0; i<=MAX_OPEN_SPACE; i++) {
        var objTest = MAP_PREFIX + "ops_" + i;
        //if element does not exist, move on; otherwise test if used.
 if (document.getElementById(objTest)!=null)
                {
                //following code ASSUMES that all openspaces have "used" attribute
                if (document.getElementById(objTest).getAttribute("used")=="true")
                        {
                        strResult = strResult + objTest + " ";
                        }
   }
}

//TEST FOR BUILDINGS
for(var i=0; i<=MAX_BUILDINGS; i++) {
        var objTest = MAP_PREFIX + "bld_" + i;
        //if element does not exist, move on; otherwise test if used.
 if (document.getElementById(objTest)!=null)
                {
                //following code ASSUMES that all buildings have "used" attribute
                if (document.getElementById(objTest).getAttribute("used")=="true")
                        {
                        strResult = strResult + objTest + " ";
                        }
   }
}

//TEST FOR PARKING LOTS
for(var i=0; i<=MAX_PKG; i++) {
        var objTest = MAP_PREFIX + "pkg_" + i;
        //if element does not exist, move on; otherwise test if used.
 if (document.getElementById(objTest)!=null)
                {
```

```
                    //following code ASSUMES that all elements have "used" attribute
                    if (document.getElementById(objTest).getAttribute("used")=="true")
                              {
                              strResult = strResult + objTest + " ";
                              }
    }
}

//TEST FOR PARKING DECKS
for(var i=0; i<=MAX_PKD; i++) {
          var objTest = MAP_PREFIX + "pkd_" + i;
          //if element does not exist, move on; otherwise test if used.
 if (document.getElementById(objTest)!=null)
                    {
                    //following code ASSUMES that all elements have "used" attribute
                    if (document.getElementById(objTest).getAttribute("used")=="true")
                              {
                              strResult = strResult + objTest + " ";
                              }
    }
}

  postURL('postuser.php',strResult);
  //window.alert(strResult)      //Un-comment to have a messagebox show the content of
the variable passed to database.
  openPopup('pathinfo.php',
'svgWindowTest','width=300,height=300,scrollbars,resizable');       //allow user to input
additional data for every-time survey
  ClearData();  //Clears the data after it's been posted to the database.
}

function ClearData() {
//This function will mark each and every object as unused, and will reset path and
building colors to their default.
//Make sure that max values set in the constants are >= actual number of each type of
object

//CLEAR FOR SEGMENTS
for(var i=0; i<=MAX_WALKWAY_SEGMENTS; i++) {
          var objTest = MAP_PREFIX + WALKWAY_PREFIX + i;
          //if element does not exist, move on; otherwise test if used.
 if (document.getElementById(objTest)!=null)
                    {
                    document.getElementById(objTest).setAttribute("used", "false");
                    document.getElementById(objTest).setAttribute("stroke",
UNUSED_PATH_STROKE_COLOR);
```

```
                    document.getElementById(objTest).setAttribute("stroke-width",
NORMAL_PATH_STROKE_WIDTH);
                    document.getElementById(objTest).setAttribute("status", "normal");
    }
}

//CLEAR FOR STUBS
for(var i=0; i<=MAX_STUBS; i++) {
          var objTest = MAP_PREFIX + STUB_PREFIX + i;
          //if element does not exist, move on; otherwise test if used.
 if (document.getElementById(objTest)!=null)
                    {
                    document.getElementById(objTest).setAttribute("used", "false");
                    document.getElementById(objTest).setAttribute("stroke",
UNUSED_PATH_STROKE_COLOR);
                    document.getElementById(objTest).setAttribute("stroke-width",
NORMAL_PATH_STROKE_WIDTH);
                    document.getElementById(objTest).setAttribute("status", "normal");
    }
}

//CLEAR FOR OPEN SPACE
for(var i=0; i<=MAX_OPEN_SPACE; i++) {
          var objTest = MAP_PREFIX + OPEN_PREFIX + i;
          //if element does not exist, move on; otherwise test if used.
 if (document.getElementById(objTest)!=null)
                    {
                    document.getElementById(objTest).setAttribute("used", "false");
                    document.getElementById(objTest).setAttribute("stroke",
UNUSED_POLY_STROKE_COLOR);
                    document.getElementById(objTest).setAttribute("stroke-width",
NORMAL_POLY_STROKE_WIDTH);
                    document.getElementById(objTest).setAttribute("status", "normal");
          }
}

//CLEAR FOR BUILDINGS
for(var i=0; i<=MAX_BUILDINGS; i++) {
          var objTest = MAP_PREFIX + BLD_PREFIX + i;
          //if element does not exist, move on; otherwise test if used.
 if (document.getElementById(objTest)!=null)
                    {
                    document.getElementById(objTest).setAttribute("used", "false");
                    document.getElementById(objTest).setAttribute("stroke",
UNUSED_POLY_STROKE_COLOR);
```

```
			document.getElementById(objTest).setAttribute("stroke-width",
NORMAL_POLY_STROKE_WIDTH);
			document.getElementById(objTest).setAttribute("status", "normal");
		}
}

//CLEAR FOR PARKING LOTS
for(var i=0; i<=MAX_PKG; i++) {
	var objTest = MAP_PREFIX + PARKLOT_PREFIX + i;
	//if element does not exist, move on; otherwise test if used.
 if (document.getElementById(objTest)!=null)
			{
			document.getElementById(objTest).setAttribute("used", "false");
			document.getElementById(objTest).setAttribute("stroke",
UNUSED_POLY_STROKE_COLOR);
			document.getElementById(objTest).setAttribute("stroke-width",
NORMAL_POLY_STROKE_WIDTH);
			document.getElementById(objTest).setAttribute("status", "normal");
		}
}

//CLEAR FOR PARKING DECKS
for(var i=0; i<=MAX_PKD; i++) {
	var objTest = MAP_PREFIX + PARKDECK_PREFIX + i;
	//if element does not exist, move on; otherwise test if used.
 if (document.getElementById(objTest)!=null)
			{
			document.getElementById(objTest).setAttribute("used", "false");
			document.getElementById(objTest).setAttribute("stroke",
UNUSED_POLY_STROKE_COLOR);
			document.getElementById(objTest).setAttribute("stroke-width",
NORMAL_POLY_STROKE_WIDTH);
			document.getElementById(objTest).setAttribute("status", "normal");
		}
}
}

function openPopup (url, windowName, features) {
//by Zhengwei Li; opens everytime survey.
if (typeof browserEval != 'undefined') {
browserEval('window.open("' + url + '", "' + windowName + '", "' +
features + '");');
}
}
function refresh() {
  window.reload();
```

}

Appendix F: Source codes of code.es

```
//code.es was created by Michael Herndon.
//This file was revised August 6, 2008
//The location of the file must be referenced in the .svg file.


//This file provides code that deals with other aspects of the Webwalk experience.
//note that virtually all references to objects beginning with txt or text, or that call the
window.alert
//function are debugging tools only.

//Definitions of variables/constants
var root = document.documentElement;
//following variables are used in determining how dragging the minibox works.
var dragObject = null;
var dragStartPoint = root.createSVGPoint();
var dragEndPoint = root.createSVGPoint();
var offset = root.createSVGPoint();
var dragstate;

//the first variables in the viewbox origin
var minMapOrigin = root.createSVGPoint();
var pntMapBox = root.createSVGPoint();

minMapOrigin.x = -100;
minMapOrigin.y = -100;

//Values must be manually adjusted. They're related to values from the viewbox in the
main svg file
var mainMapOrigin = root.createSVGPoint();
mainMapOrigin.x = 300000;
mainMapOrigin.y = -400000;


//the following variables are used for debugging purposes only.
//ensure that these variables exist in your .svg file before uncommenting
//var txtStatus = document.getElementById("Debug");
//var txtStart = document.getElementById("startdata");
//var txtDrag = document.getElementById("dragdata");
//var txtMatrix = document.getElementById("matrix");

function refresh()
//refreshes the window.
{
    window.reload();
```

```
}

function toggleAerial() {
//depricated function that would allow the user to toggle between an arial photograph as a background for the map
//and the current, simplified view. Would likely need to be revised extensively before re-implementation.
 var obj = document.getElementById("aerial");
 var state = obj.getAttribute("visibility");
 if (state == "visible")
  {
        obj.setAttribute("visibility","hidden");
        //buildings
        var group = document.getElementById("bld");
        group.setAttribute("fill-opacity", "1.0");
        //open space
        var group = document.getElementById("ops");
        group.setAttribute("fill-opacity", "1.0");
        //parking decks
        var group = document.getElementById("pkd");
        group.setAttribute("fill-opacity", "1.0");
        //parking
        var group = document.getElementById("pkg");
        group.setAttribute("fill-opacity", "1.0");
  }
 else
  {
        obj.setAttribute("visibility","visible");
        var group = document.getElementById("bld");
        group.setAttribute("fill-opacity", ".60");
        var group = document.getElementById("ops");
        group.setAttribute("fill-opacity", ".60");
        var group = document.getElementById("pkd");
        group.setAttribute("fill-opacity", ".60");
        var group = document.getElementById("pkg");
        group.setAttribute("fill-opacity", ".60");
  }
}

function moveMapBox() {
 //Function that calculates how far the mapbox has been moved.
 //txtStatus.getFirstChild().setData("moveMapBox");
 var mouse = getMouse(evt);
 var obj = document.getElementById("mapbox");
 var matrix = obj.getCTM();
 var newpoint = root.createSVGPoint();
```

```
 newpoint.x = mouse.x - minMapOrigin.x;
 newpoint.y = mouse.y - minMapOrigin.y;
 //need to subtract the original x,y coordinates here.
 obj.setAttribute("transform",  "translate(" + newpoint.x + " " + newpoint.y+")");
 //window.alert(newpoint.x+","+ newpoint.y);
 }

function GetTransform() {
 //debugging function only. Determines transformation.
 var obj = document.getElementById("mapbox");
 var transform = obj.getAttributeNS(null, "transform");
 //window.alert(transform);
}

function initDrag(evt) {
  //Called when the dragging the mini map box begins. Transformations and the
interaction
  //between sub svgs make this messy.
  //report that the initDrag function has been called
  txtStatus.getFirstChild().setData("initDrag");
  //tell the object that it is being dragged
  dragstate = true;
  dragObject = evt.getTarget();
  //get current transformation matrix
  var matrix = dragObject.getCTM();
  //get mouse location - corrected for CTM
  var mouse = getMouse(evt);
  dragStartPoint.x = mouse.x-matrix.e;
  dragStartPoint.y = mouse.y-matrix.f;
  //report on the starting points.
  txtStatus.getFirstChild().setData("Start:" + dragStartPoint.x + "," + dragStartPoint.y);
  //Matrix.getFirstChild().setData("Matrix:" + matrix.e + "," + matrix.f)
  //dragObject.style.setProperty('pointer-events', 'none');
  //window.alert(matrix.e + "," + matrix.f);
}
//calculates how far it should be drug.
function Drag(evt) {
 //if dragstate = true
 if (dragstate) {
 //report that the drag function has been called.
  txtStatus.getFirstChild().setData("Drag");
  var mouse = getMouse(evt);
  var x = mouse.x - dragStartPoint.x;
  var y = mouse.y - dragStartPoint.y;
  txtStatus.getFirstChild().setData("Drag:" + x + "," + y);
  dragObject.setAttribute("transform", "translate(" + x + ", " + y + ")");
```

```
 getBoxData();
 }
}

function getBoxData() {
//constants in this code depend on map size and scaling. Calculated by determining
length/width ratio
//of svg file.
 var box = root.getElementById("mapbox");
 var matrix = box.getCTM();
 text = box.getCTM();
 //window.alert(box.getAttribute("y"));
 //This is a very awkward way of getting this data, but non-typed variables keep getting in
the way
 pntMapBox.x = box.getAttribute("x");
 pntMapBox.x += matrix.e;
 //It's not clear at all why the x coordinate needs to be corrected, but the y doesn't.
 pntMapBox.x = ((pntMapBox.x-64) * 3743.31); // essentially how far a move is
magnified
 //was 32.1578
 pntMapBox.y = box.getAttribute("y");
 pntMapBox.y += matrix.f * 3272.72; //how far a move is magnified
 //was 32.1578
 text = ("(" + pntMapBox.x + "," + pntMapBox.y +")");
 //window.alert(text);
 //changes where the large map focuses on.
 changeViewBox(pntMapBox.x+mainMapOrigin.x, pntMapBox.y+mainMapOrigin.y);
}

function changeViewBox(x1, y1) {
//changes where the large map focuses on.
 var mainmap = root.getElementById("mainmap");
 mainmap.setAttribute("viewBox", x1 + " " + y1 +" 310000 240000"); // how much the
magnification is - taken from last two variables of viewbox in the main .svg
}

function endDrag(evt) {
 //Depricated and unncessary now, EXCEPT FOR setting dragstate to null. Code left for
reference.
 //var mouse = getMouse(evt);
 //dragEndPoint.x = mouse.x;
 //dragEndPoint.y = mouse.y;
 //offset.x = dragEndPoint.x - dragStartPoint.x;
 //offset.y = dragEndPoint.y - dragStartPoint.y;
 //var transform = "translate(" + offset.x + "," + offset.y + ")";
 //window.alert(transform);
```

```
 // transform = "translate(-100,-100)";
 // dragObject.setAttribute("transform", transform);
 //txtStatus.getFirstChild().setData("endDrag");
 dragstate=null;
 //dragObject.style.setProperty('pointer-events', 'all');
}

function getMouse(evt) {
//determines position of map
 var position = root.createSVGPoint();
 position.x = evt.clientX;
 position.y = evt.clientY;
 return position;
}

function mouseData(evt) {
 //This function allows you to see where the mouse is.
 //debugging use only.
 var mouse = getMouse(evt);
 var strMouseData = "(" + mouse.x + ", " + mouse.y + ")";
 var text = document.getElementById("mouseText");
 //text.getFirstChild().setData(strMouseData);
}
```

Appendix G: Database structure

Table ‘path’

Field name	Data type	Description
pathID	integer	Index of each record
pathPerson	Varchar	User who input a path
pathMonth	varchar	At which month user walked
pathDate	varchar	At which date user walked
pathTime	Enum(1,2,3,blank)	Time of day for the walk 1 is morning 2 is mid-day 3 is afternoon Blank is other
pathSite	varchar	the campus at which user walks
pathPurpose	Enum(1,2,3)	Purpose of the walk 1. work-related 2, personal 3, combination
intensity	Enum(1,2,3,4)	Intensity of the walk 1. normal pace walking 2. brisk or fast walking 3. jogging or running
Link_path_route	integer	Link to the pathid in table’path_route’

Table ‘path_route’

Field name	Data type	Description
Path_id	integer	Index of path_route
segment	Varchar	the sequence of path(starting with the first site)
username	Varchar	User who walked this path

Table ‘users’

Field name	Data type	Description
username	varchar	Name of the user
password	varchar	Password of the user
sex	varchar	Sex of the user
site	varchar	Campus the user belongs to
time	timestamp	Time the user registered

Table ‘usersurvey’

Field name	Data type	Description
surveyid	integer	Index of this table
daysatbase	Enum(1,2,3,4,5,6,7)	How many days per week do you usually work at your primary office?

		1 is 1 day, 2 is 2 days, similarly to others
job	Enum(1,2,3,4,5)	Which of the following best represents your job classification? 1. Managerial 2. Technical 3. Professional 4. Administrative 5. Other
jobspecify	varchar	If job is 5, this is the description
Timeatco	Enum(1,2,3)	How long have you been working at this campus? 1.Less than 6 months 2. 6 months to 2 years 3. More than 2 years
timeatsite	Enum(1,2,3)	How long have you been working at your current primary office? 1.Less than 6 months 2. 6 months to 2 years 3. More than 2 years
health	Enum(1,2,3,4,5,6)	Would you say in general your health is? 1. Excellent 2. Very Good 3. Good 4. Fair 5. Poor 6. Don't Know/Not Sure
walkable	Enum(1,2,3,4,5)	By yourself, and without using any special equipment, how difficult is it for you to walk a quarter of a mile (about 3 city blocks)? 1.Not at all difficult 2. Only a little difficult 3. Somewhat difficult 4. Very difficult 5. Can't do at all
moderate	Enum(0,1,2,3,4,5,6,7)	During the last 7 days, on how many days did you do moderate physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? Do not include walking 0. 0 days. 1. 1 day 2. 2 days. similarly
moderatetime	Enum(1,2,3,4,5,6,7,8,9)	How much time did you usually spend doing moderate physical activities on one of those days? 1. Not Applicable

		2. 1-10 minutes 3. 11-20 minutes 4. 21-30 minutes 5. 31-45 minutes 6. 46-60 minutes 7. 1-2 hours 8. 2-3 hours 9. 3 hours or more
vigorous	Enum(1,2,3,4,5,6,7,8)	During the last 7 days, on how many days did you do vigorous physical activities like heavy lifting, digging, aerobics, or fast bicycling? 1. 0 days 2. 1 day 3. 2 days 4. 3 days 5. 4 days 6. 5 days 7. 6 days 8. 7 days
vigoroustime	Enum(1,2,3,4,5,6,7,8,9)	How much time did you usually spend doing vigorous physical activities on one of those days? 1. Not Applicable 2. 1-10 minutes 3. 11-20 minutes 4. 21-30 minutes 5. 31-45 minutes 6. 46-60 minutes 7. 1-2 hours 8. 2-3 hours 9. 3 hours or more
walking	Enum(1,2,3,4,5,6,7,8)	During the last 7 days, on how many days did you walk for at least 10 minutes at a time? 1. 0 days 2. 1 day 3. 2 days. 4. 3 days 5. 4 days 6. 5 days 7. 6 days 8. 7 days
walkingtime	Enum(1,2,3,4,5,6,7,8,9)	How much time did you usually spend walking on one of those days? 1. Not Applicable 2. 1-10 minutes 3. 11-20 minutes 4. 21-30 minutes 5. 31-45 minutes 6. 46-60 minutes 7. 1-2 hours 8. 2-3 hours 9. 3 hours or more

sittingtime	Enum(1,2,3,4,5,6,7,8,9, 10,11,12,13,14,15,16)	During the last 7 days, how much time did you spend sitting on a work day? 1. Not Sure/Don't know 2. Between 2-3 hours 3. Between 3-4 hours 4. Between 4-5 hours 5. Between 5-6 hours 6. Between 6-7 hours 7. Between 7-8 hours 8. Between 8-9 hours 9. Between 9-10 hours 10. Between 10-11 hours 11. Between 11-12 hours 12. Between 12-13 hours 13. Between 13-14 hours 14. Between 14-15 hours 15. Between 15-16 hours 16. 16 hours or more
sittingworktime	Enum(1,2,3,4,5,6,7,8,9, 10,11,12,13,14,15,16)	During the last 7 days, how much time did you spend sitting at work on a typical work day? 1. Not Sure/Don't know 2. Between 2-3 hours 3. Between 3-4 hours 4. Between 4-5 hours 5. Between 5-6 hours 6. Between 6-7 hours 7. Between 7-8 hours 8. Between 8-9 hours 9. Between 9-10 hours 10. Between 10-11 hours 11. Between 11-12 hours 12. Between 12-13 hours 13. Between 13-14 hours 14. Between 14-15 hours 15. Between 15-16 hours 16 hours or more
activity	Enum(0,1)	Over the past 7 days has your physical activity been significantly different from your customary and usual pattern? 0. Typical 1. Not typical (please specify)
actother	varchar	specify detailed activity if not typical
sex	Enum(0,1)	Are you male or female? 0. Male 1. Female
age	Enum(1,2,3,4,5)	What is your age? 1. 20-29 2. 30-39 3. 40-49 4. 50-59 5. 60 or over

edu	Enum(1,2,3,4,5,6)	What is the highest level of school that you have completed? 1. Less than High School 2. High School Graduate 3. Some College/Associates Degree 4. College Graduate (Bachelors) 5. Graduate or Professional Degree 6. Other (please specify)
eduother	varchar	specify detailed activity if not typical
race	Enum(1,2,3,4,5,6)	Which of the following would you say best represents your race? 1. American Indian or Alaska Native 2. Asian 3. Black or African American 4. Native Hawaiian or other Pacific Islander 5. White 6. Other (please specify)
raceother	varchar	specify detailed activity if not typical
hispanic	Enum(1,2)	Are you Hispanic or Latino? 1. Yes 2. No
weight	varchar	Unit: pounds
heightfeet	Enum(1,2,3)	Unit: feet 1. 4 2. 5 3. 6
heightinches	Enum(1,2,3,4,5,6,7,8,9, 10,11,12)	Unit: inch 1. 0 2. 1 3. 2 4. 3 5. 4 6. 5 7. 6 8. 7 9. 8 10. 9 11. 10 12. 11
thetext	varchar	comments
sysname	varchar	Name of the user

Table: ‘segment’

Filed Name	Data Type	Desciption
segmentID	integer	Index of each segment
segAuditor	Varchar	User who audit this segment
segType	Enum(1,2,3,4,5)	Q1. What is the path segment type? Check one and skip the questions indicated next to the response. 1, a pedestrian crossing (If ‘yes’, answer Q5,Q6 only) 2, alongside a vehicular street (If yes, skip Q5,Q6) 3, in a street or driveway (If ‘Yes’, skip Q3-6) 4, a pedestrianized street (If ‘Yes’, skip Q2-6) 5, within the landscape (If ‘Yes’, skip Q2-6)
roadLanes	Enum(1,2,3,4)	Q2. number of lanes for Cars: 1,1 lane 2,2 or 3 lanes 3,4 or 5 lanes 4,6 or more
segLocation	Enum(1,2,3)	Q3. Path location – how close is the path to the edge of the street/road? 1, Next to road 2, Within 4 feet of curb 3, More than 4ft from curb
bufStrip	Enum(1,2)	Q4a. landscape strip buffer present? 1, No 2, Yes
bufTree	Enum(1,2)	Q4b. street tree buffer present? 1, No 2, Yes
bufFurn	Enum(1,2)	.Q4c, street furniture buffer present? 1, No 2, Yes
bufPark	Enum(1,2)	Q4d. On street parking present? 1, No 2, Yes

xZebra	Enum(1,2)	.Q5a, Zebra or paving change present? 1, No 2, Yes
xColored	Enum(1,2)	Q5b. Pavers/color change present? 1, No 2, Yes
xSignal	Enum(1,2)	Q5c. Traffic signals present? 1, No 2, Yes
xRaised	Enum(1,2)	Q5d. Raised Crosswalk present? 1, No 2, Yes
xIsland	Enum(1,2)	Q6a. Median refuge and traffic island present? 1, No 2, Yes
xCurbExt	Enum(1,2)	Q6b. Curb extensions present? 1, No 2, Yes
xBumps	Enum(1,2)	Q6c. Speed Bumps/Humps present? 1, No 2, Yes
xRumble	Enum(1,2)	Q6d. Rumble Strips present? 1, No 2, Yes
xParking	Enum(1,2)	Q6e. parking at crossing present? 1, No 2, Yes
segMaterial	Enum(1,2,3,4,5,6,7,8,9)	Q7. what material is the path made of? 1, Concrete 2, Concrete w/ pavers 3, Majority Paving bricks 4, Gravel 5, Bitumen/Asphalt 6, Grass or sand 7, Mulch/Woodchips 8, Stone 9, Other (please specify)

segCondition	Enum(1,2,3)	Q8. is the path well maintained? Are the crossovers smooth? 1, Under repair/ Poor 2, Moderate 3, Good
segSlope	Enum(1,2,3)	Q9. how steep is the path? 1, Flat or gentle 2, Moderate slope 3, Steep slope
segLandMaint	Enum(1,2,3,4)	Q10. The quality of maintenance of Landscape ? 1, Good (More than 75% well maintained) 2, Moderate (50 –74% well maintained) 3, Poor (Less than 50% well maintained) 4, No landscape (with 30 ft)
TypeLandscape	Enum(1,2,3)	Q11. What is type of landscaping? 1, Grass/lawn/ Ground cover 2, Shrubs w/ plants 3, Variety & Color
segBldMaint	Enum(1,2,3,4)	Q12. The quality of the maintenance of the buildings? 1, Good (More than 75% well maintained) 2, Moderate (50 –74% well maintained) 3, Poor (Less than 50% well maintained) 4, No building (with 30 ft)
bldSurv	Enum(1,2,3)	Q13. The quality of Surveillance from buildings? 1, Excellent/Good 2, Poor 3, Not applicable
outSurv	Enum(1,2,3)	Q14. the quality of Surveillance from Outdoor, street etc? 1, Excellent/Good 2, Poor 3, Not applicable
segLighting	Enum(1,2)	Q15. Lighting over path present? 1, No 2, Yes

Cleanliness	Enum(1,2,3)	Q16. Can you see any litter, rubbish, graffiti, broken glass, discarded items? 1, Yes lots 2, Yes some 3, None or almost none
cvrWalkway	Enum(1,2,3)	Q17a. Covered Walkways present? 1, None/Few 2, Some 3, Many
Cvrcanopies	Enum(1,2,3)	Q17b. Canopies/Awnings present? 1, None/Few 2, Some 3, Many
cvrVegetation	Enum(1,2,3)	Q17c. Trees/vegitation present? 1, None/Few 2, Some 3, Many
Cvrother	Enum(1,2,3)	Q17d. Other protection present (please secify)? 1, None/Few 2, Some 3, Many
amBench	Enum(1,2)	Q18a. Benches present? 1, No 2, Yes
amBus	Enum(1,2)	Q18b. Bus stops present? 1, No 2, Yes
amWater	Enum(1,2)	Q18c. Drink fountains present? 1, No 2, Yes
amBike	Enum(1,2)	Q18d. Bike racks present? 1, No 2, Yes
amDirect	Enum(1,2)	Q18e. Maps present? 1, No 2, Yes
amTrash	Enum(1,2)	Q18f. Trash bins present? 1, No 2, Yes

amNewspaper	Enum(1,2)	Q18g. Newspaper carrels present? 1, No 2, Yes
amPhone	Enum(1,2)	Q18h. Emergency Phone present? 1, No 2, Yes
amOther	Enum(1,2)	Q18i. Other outdoor furniture present (please secify)? 1, No 2, Yes
atArt	Enum(1,2,3)	Q19a. Public Art present or visible? 1, Present 2, Visible 3, None
atFountain	Enum(1,2,3)	Q19b. Water Fountain present or visible? 1, Present 2, Visible 3, None
atTrees	Enum(1,2,3)	Q19c. Trees present or visible? 1, Present 2, Visible 3, None
atBridges	Enum(1,2,3)	Q19d. Bridges/Arch present or visible? 1, Present 2, Visible 3, None
atLandscape	Enum(1,2,3)	Q19e. Landscape Feature present or visible? 1, Present 2, Visible 3, None
natLake	Enum(1,2,3)	Q20a. Lake/pond present or visible? 1, Present 2, Visible 3, None
natWoods	Enum(1,2,3)	Q20b. Wooded areas present or visible? 1, Present 2, Visible 3, None

natStream	Enum(1,2,3)	Q20c. Stream/River present or visible? 1, Present 2, Visible 3, None
Jogging	Enum(1,2)	Q21. Marked/distinguished for jogging or exercise stations? 1, No 2, Yes
atRestaurant	Enum(1,2,3)	Q22a. Restaurant(s) present or visible? 1, Present 2, Visible 3, None
atOutDin	Enum(1,2,3)	Q22b. Outdoor Dining present or visible? 1, Present 2, Visible 3, None
atCoffee	Enum(1,2,3)	Q22c. Coffee Shop(s) present or visible? 1, Present 2, Visible 3, None
atVendors	Enum(1,2,3)	Q22d. Open air market(s) present or visible? 1, Present 2, Visible 3, None
atRetail	Enum(1,2,3)	Q22e. Retail present or visible? 1, Present 2, Visible 3, None
atOther	Enum(1,2,3)	Q22f. Other Gathering Places present or visible (please secify)? 1, Present 2, Visible 3, None
parkDeck	Enum(1,2,3)	a. Parking Deck present or visible? 1, Present 2, Visible 3, None

parkLot	Enum(1,2,3)	b. Parking Lot present or visible? 1, Present 2, Visible 3, None
outPark	Enum(1,2,3)	Q24a. Park/Garden present or visible? 1, Present 2, Visible 3, None
outSport	Enum(1,2,3)	Q24b. Playing/sport field present or visible? 1, Present 2, Visible 3, None
outPlaza	Enum(1,2,3)	Q24c. Plaza/square/courtyard present or visible? 1, Present 2, Visible 3, None
outGLawn	Enum(1,2,3)	Q24d. Great lawn present or visible? 1, Present 2, Visible 3, None
outGolf	Enum(1,2,3)	Q24e. Golf Course present or visible? 1, Present 2, Visible 3, None
OffPedestrian	Enum(1,2)	Q25a. connected to offsite pedestrian path ? 1, No 2, Yes
OffVehicular	Enum(1,2)	Q25b. connected to offsite vehicular path 1, No 2, Yes
OffPublic	Enum(1,2)	Q25c. connected to offsite public transportation? 1, No 2, Yes
OffShop	Enum(1,2)	Q25d. connected to offsite shopping / retail ? 1, No 2, Yes
OffService	Enum(1,2)	Q25e. connected to offsite services ? 1, No 2, Yes

OffResidential	Enum(1,2)	Q25f. connected to offsite residential? 1, No 2, Yes
segWidth	Enum(1,2,3,4)	Q26. What is the width of the path? 1, Less than 5 feet 2, 5.1 feet to 10 feet 3, 10.1 feet to 16 feet 4, Over 16 feet
segStair	Enum(1,2,3,4)	Q27. Does the path segment contain stairs? 1, None 2, Yes 1-4 risers 3, Yes 5-10 risers 4, Yes 10+ risers

Appendix H: Advisory Panel Participants

Alice Arthur
Emory University

Phil Dordai
Hillier Architecture

Julie Gazmararian
Emory University

Jeffrey Koplan
Emory University

Kenneth Powell
Emory University

Mahbub Rashid
University of Kansas

Phil Sparling
Georgia Institute of Technology