An Examination of Commuting Patterns to McGill University

Results of the 2011 McGill Transportation Survey

Submitted to

Office of Sustainability
McGill University

Prepared by

Cynthia Jacques, Vincent Chakour, Anais Mathez, Kevin Manaugh, Guillaume Barreau, Marianne Hatzopoulou, Naveen Eluru, Ahmed El-Geneidy

Final Report

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L'Analyse des Déplacements à l'Université McGill :

Résultats du Sondage de Transport de McGill en 2011

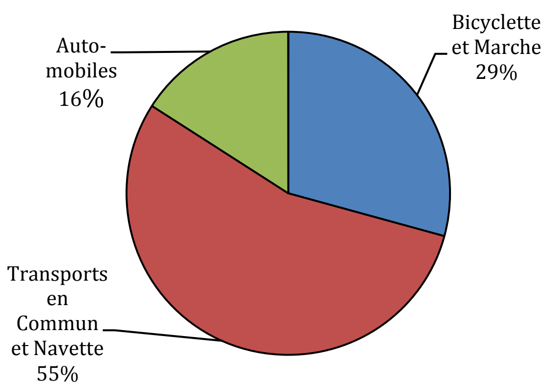
La communauté de l'Université McGill comporte plus de 30,000 individus et contribue fortement à la demande du transport routier. Les données recueillies par le sondage de transport de McGill en 2011 ont été rassemblées et analysées afin d'examiner le déplacement d'une portion de la communauté de McGill.

Taux de Réponses

Au total, 19,622 invitations au sondage ont été envoyées aux étudiants, aux professeurs et aux membres du personnel de McGill par courriel. **Un total de 5,016 réponses a été reçu avant la date limite exigée par le sondage, correspondant à un taux de réponse de 25.5%**. Parmi les répondants, 56% sont des employés (professeurs et personnel), 43% sont des étudiants, et 1% sont classés "autres" (étudiants ou professeurs en visite).

Modes de Déplacement

La répartition actuelle des déplacements est la suivante pour la population de McGill:

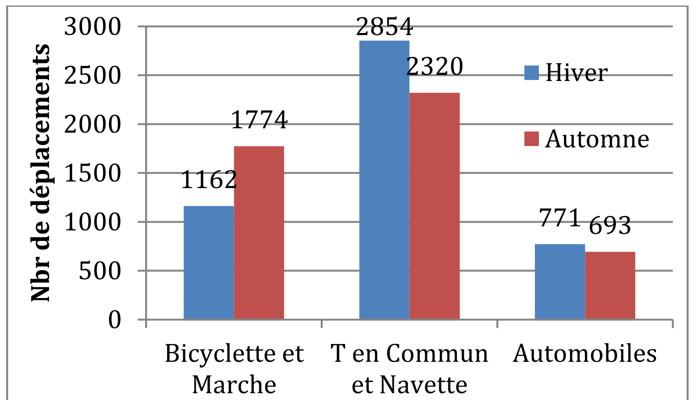


Le transport actif (vélo et marche) et le transport en commun représentent 84% des déplacements, indiquant une tendance vers les modes de transport durable. L'emploi des véhicules motorisés est davantage présent au campus Macdonald tandis que les deux autres modes l'emportent au campus du centre-ville.

Distances et Saisonnalité

La plupart des individus résident entre 7 et 11 kilomètres d'un des campus de McGill, ce qui correspond à la distance optimale parmi ceux qui choisissent d'utiliser le transport actif ou en commun. Le taux d'utilisation de la voiture reste relativement constant avec l'augmentation de la distance, suggérant ainsi que l'accès à un véhicule en incite l'usage, malgré la distance.

La saisonnalité exerce un effet important sur les modes de déplacements; l'usage du transport en commun augmente pendant les mois d'hiver de Montréal, alors que l'usage du transport actif augmente de façon importante pendant les saisons plus douces.

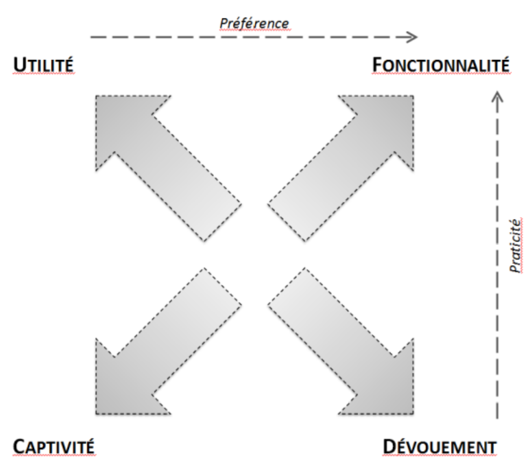


Les Émissions des Gaz à Effet de Serre

On estime que les **déplacements <u>vers</u> le campus du centre-ville produisent 31,1 tonnes de CO_2-eq. pour une journée <u>d'hiver,</u> et 29,5 tonnes pour une journée <u>d'automne</u>**. En terme d'émissions par voyageur pour une journée d'hiver (d'automne), un employé émet 1,8kg CO_2-eq (1,7kg) et un étudiant émet 0.78kg CO_2-eq (0.68kg).

Types de Voyageurs

L'analyse des types de voyageurs à McGill (pour les deux campus) a démontré qu'il existe **quatre sections extrêmes du marché :**



On suppose que les individus se dirigent le long d'un continuum de choix en direction des différents extrêmes, dépendamment des circonstances affectant leur choix de mode. L'idéal serait que les individus se dirigent vers un choix de trajet préféré plus durable.

Commentaires et Soucis

Les commentaires et soucis des voyageurs sont essentiels pour comprendre leurs choix de déplacement et pour améliorer les trajets, parfois longs et coûteux. Les commentaires et soucis clés sont présentés ci-dessous:

Commentaires et Soucis des Cyclistes:

- Améliorer la sécurité des cyclistes en créant plus de pistes cyclables et en entretenant les voies existantes.
- Inciter les étudiants à s'inscrire à Bixi et/ou à acheter des vélos de seconde main.
- Aménager des installations pour cyclistes, tels que: douches, casiers et stationnements abrités et sûrs, hors de danger.

Commentaires et Soucis des Piétons:

- Améliorer l'environnement de marche; trottoirs, bancs, auvents ou couvertures sous les arbres pour l'abri.
- Améliorer le nettoyage de la neige sur les trottoirs et escaliers extérieurs.
- Réorganiser la signalisation aux intersections dangereuses telles Milton/Université, et ajouter des traverses piétonnes, en particulier sur l'Avenue des Pins et la Rue Dr. Penfield.

Commentaires et Soucis des Utilisateurs de Transport en Commun:

- Offrir une réduction aux étudiants de plus de 25 ans.
- Améliorer la sécurité et augmenter la fréquence de la ligne 144 (Avenue des Pins) ainsi qu'augmenter la fréquence des trains de banlieues AMT en soirée.
- Améliorer l'accès aux stations pour les personnes à mobilité réduite (ajout d'escaliers roulants et d'ascenseurs).

Commentaires et Soucis des Utilisateurs de la Navette McGill:

- Augmenter la fréquence et la capacité des navettes pour diminuer le temps d'attente et l'encombrement et prévoir des aubettes aux arrêts et du chauffage dans les navettes.
- Simplifier l'achat des billets pour les membres du personnel et offrir une carte de type "opus" pour simplifier l'embarquement.
- Promouvoir la navette à travers des affiches publicitaires et en ligne, ainsi qu'afficher les horaires de bus.
- Introduire une navette qui joint d'autres établissements de McGill, tels les hôpitaux.
- Incorporer des navettes express vers le campus Macdonald et des autobus locaux qui effectueraient plusieurs arrêts.

Il est essentiel de satisfaire les utilisateurs du transport en commun et d'améliorer leurs déplacements car ceux-ci comptent pour plus de deux tiers de la totalité des déplacements à McGill. En outre, c'est en entretenant l'infrastructure, en améliorant la conception et en introduisant des mesures de circulations anti-stressantes que la sécurité augmentera et qu'une ambiance de respect entre piétons, cyclistes et automobilistes se créera.

Préparé par:
Cynthia Jacques, Vincent Chakour, Anais Mathez, Kevin Manaugh, Guillaume Barreau, Marianne Hatzopoulou, Naveen Eluru, et Ahmed El-Geneidy

An Examination of Commuting Patterns to McGill University – *Results of the 2011 McGill Transportation Survey*

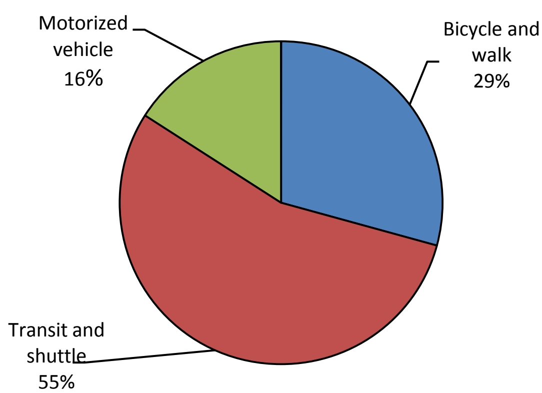
McGill University, comprising of over 30,000 affiliates, contributes significantly to the transportation network. The data collected by the 2011 McGill Transportation Survey has been compiled for analysis in order to examine commuting behaviour patterns of a cross-section of the McGill community.

Response Rate

A total of 19,662 survey invitation emails were sent out to McGill students, faculty and staff. A total of **5,016 responses were received by the closing date of the survey, yielding a survey response rate of 25.5%.** Of these responses, 56% are employees (including faculty and staff), 43% are students, and 1 % falls into the category of 'other', including visiting students and professors.

Mode Split

The current commuting mode split among McGill-affiliated individuals is as follows:

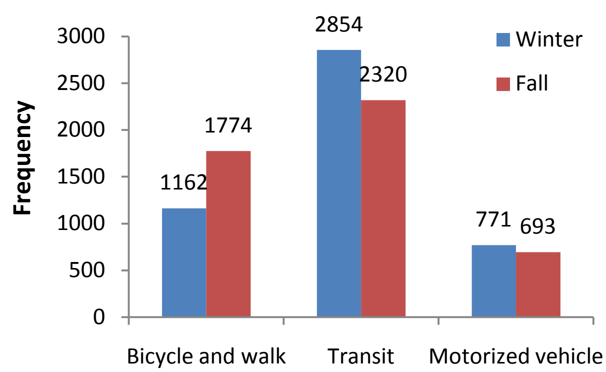


Active transport and public transit combined make up 84% of transportation to and from McGill campuses indicating a culture of sustainable transportation among McGill affiliates. Motor vehicle use accounts for a higher proportion of trips to and from Macdonald campus, whereas active and public transit outweighs car use on the Downtown campus.

Distances and Seasonality

The majority of individuals live within 7-11 kilometers of a McGill campus, which corresponds with the optimal distance at which individuals choose to use active transport or public transit. Rates of car use stay relatively constant as distance increases, suggesting that access to an automobile encourages use, regardless of distance.

Seasonality greatly affects mode split; transit use increases during Montreal's harsh winter months, while rates of active transport increase significantly during the warmer months.

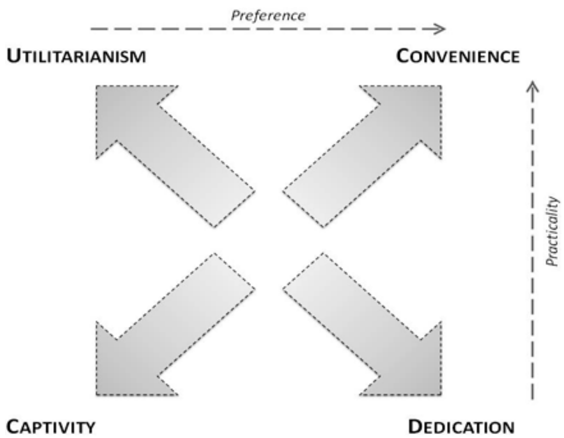


Greenhouse Gas Emissions

It is estimated that **commuters to McGill's Downtown campus generate 31.1 tons of CO_2 equivalent on their trip <u>to</u> McGill on a single <u>winter</u> day, and 29.5 tons of CO_2 equivalent on a <u>fall</u> day.** Translated into emissions per commuter per trip to the Downtown campus, on average, on a typical winter (fall) trip an employee emits 1.8 kg CO_2 (1.7 kg) and a student emits 0.71 kg CO_2 (0.68 kg)

Types of Commuters

The analysis of types of commuters at McGill (for both campuses combined) yielded **four market segment extremes, each with a varying level of trip preference and practicality: captivity, utilitarianism, dedication or convenience**.



Individuals are considered to moving along a continuum of choice toward the various extremes as their circumstances change, thus affecting their travel behaviour choices. Ideally, individuals would move toward a preferred and more practical travel choice.

Comments and Concerns

Comments and concerns are vital to understanding the motivations for certain trips, and alleviating the burden of lengthy and costly commutes. Key comments and concerns are grouped into well-defined categories:

Cycling Comments and Concerns:

- Enhance commute safety by creating more bicycle lanes and maintaining existing ones.
- Offer incentives for students to purchase Bixi memberships or used bicycles.
- Introduce facilities for cyclists such as showers, lockers, and sheltered or secure parking.

Walking Comments and Concerns:

- Enhance walking environment, such as sidewalks, benches, adequate lighting, and tree canopy cover.
- Improve efficient snow removal of sidewalks and outdoor stairs.
- Reorganize traffic signaling at problematic intersections, such as Rue Milton and Rue University, and add crosswalks, especially at Avenue des Pins and Rue Dr. Penfield.

Public Transit Comments and Concerns:

- Offer a school-wide discounted transit pass to circumvent the age cap of 25 for reduced fares.
- Improve the reliability and frequency of bus route 144 (Avenue des Pins) and the frequency of the AMT commuter trains during evenings.
- Improve access to transit stations for the mobility impaired (i.e., escalators and elevators).

Shuttle Service Comments and Concerns:

- Increase shuttle frequency and capacity to overcome long wait times and overcrowding while providing adequate shelter at bus stops and heating in the buses.
- Introduce a streamlined system to simplify the purchase of passes for staff, and an ID-swipe machine for students boarding buses.
- Promote the shuttle service through informational posters, online media, posted schedules, and clearly marked bus stops.
- Incorporate a shuttle that connects other McGill facilities, such as hospitals.
- Incorporate express buses to Macdonald campus and local buses that make several stops.

It is paramount to maximize the satisfaction of the commute for transit users, where feasible, as they account for over two thirds of total trips made to and from McGill campuses every day. Additionally, by maintaining infrastructure, improving design and introducing traffic-calming measures, overall safety will augment, creating a culture of respect among pedestrians, cyclists and motorists.

Prepared by
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TRAM
TRANSPORTATION RESEARCH AT McGill

Sustainability Projects Fund

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Section I – *Report Introduction*

Increasingly, higher education institutions such as universities and colleges are recognizing the impact that their operations have on the environment, particularly with regard to the effects of numerous students, faculty and staff commuting to and from campus on a regular basis. According to Tolley (1996), commuting accounts for the greatest proportion of the environmental impact of academic institutions. In addition to the potential environmental impacts, commuting patterns at such institutions greatly influence the use and quality of the campus space; for instance, a campus that has a high proportion of automobile commuters will likely have a large amount of space dedicated to parking lots, which can result in a somewhat unwelcoming campus environment. Consequently, efforts have been made in recent years to implement strategies to promote more sustainable modes of travel to college and university campuses, which include walking, cycling and public transit.

In order to effectively manage commuting patterns and encourage a shift toward more sustainable modes of transportation to travel to and from campus, it is first necessary to have a clear picture of the prevailing commuting trends at the institution. A common approach to obtaining this sort of information is through detailed commuting surveys distributed to individuals in the academic community, including students, faculty and staff (as applied in Cotnoir 2004, Cotnoir & Chénier 2008, Páez & Whalen 2010, Shannon et al. 2006, among others). A benefit of this approach to data collection is that it not only allows for the collection of mode share data, but also allows for questions that will provide a greater understanding of the motivation behind individuals' mode choices as well as the identification of barriers to the use of more sustainable modes.

McGill University is a sizable institution comprising of two main campuses (the Downtown campus in the heart of Montreal and the Macdonald campus in Sainte-Anne-de-Bellevue), as well as several teaching hospitals located across the city. Over 35,000 individuals, as students, faculty or staff, make regular trips to and from McGill campuses from all over the Montreal Metropolitan Region, thus having a considerable environmental impact. Observing the number of individuals walking and cycling to McGill, it is clear that a study is needed to better understand the transportation needs of those using active modes of transportation. In addition, some students, faculty and staff continue to use private automobiles to travel to McGill campuses, which is an issue that requires a greater examination in order to achieve a significant reduction in the number of automobile trips to McGill. Further, the variety of public transit services offered throughout the region presents an opportunity to limit other energy-intensive modes used to commute to McGill campuses.

In 2004, when McGill University, in partnership with the Agence Métropolitaine de Transport (AMT), first signed on as a participant in the Allégo program to promote viable alternatives to the one-car-one-driver commuting paradigm, a survey was conducted on existing commuting habits. This 2004 survey received 2,000 responses from members of the McGill community on their travel behaviour and preferences, although most respondents were students.

Much has changed in the last seven years both in the recognition of the importance of sustainable transportation practices, as well as in infrastructure and policy supporting sustainable transportation. For example, the orange line of the metro has been extended off the Island of Montreal to Laval, the commuter train line north to St-Jerome has been implemented, separated bicycle paths have been constructed on both Boulevard de Maisonneuve and Rue University, and the BIXI system has been implemented with several stations just steps from campus. At McGill's Downtown campus, McTavish Street and the lower section of campus have been transformed into pedestrian zones, with no parking and extremely limited vehicular circulation, as well as the implementation of a no cycling on campus policy for pedestrian safety. In addition, construction has begun on the new Glen campus of McGill University. It is likely that some of these changes have had a noticeable impact on the travel patterns of McGill students, faculty, and staff. This study will provide an update to the 2004 study, establishing a new baseline that can help the McGill Sustainability Office to measure future success in promoting more sustainable travel behaviour in the coming years.

To better understand the level of environmental impact associated with travel to and from McGill campuses, and to better harness opportunities for the use of more sustainable modes, the Transportation Research at McGill (TRAM) research group[1], in collaboration with the McGill Sustainability Office, undertook a project beginning in December 2010 to assess the travel behaviour of McGill University students, faculty and staff.[2] The objective of this project was to understand how University members commute to McGill campuses, and how they use the various transportation services and incentives offered by the City of Montreal and McGill University as part of their travel. A second objective of the project was to quantify the environmental impact of travel to McGill and increase awareness of these impacts among the McGill community.

The potential benefits of this research project are numerous, and include: an increase in the awareness of the importance of travel behaviour in an overall sustainability framework; a better understanding of the level of use of sustainable transportation among McGill-affiliated individuals and existing barriers associated with the use of these modes; an opportunity to bring to the attention of the City and Regional transit authorities the main transportation issues related to travel to the McGill campuses, such as inter-campus travel and coordination between the different transit agencies; and an opportunity to explore the "walkability" and "cyclability" of McGill campuses and their surroundings, as well as the impact of other campus sustainability projects, such as the Greening Lower Campus initiative. Moreover, the results of this study can support the University's submission for a rating from the Association for Sustainability in Higher Education (AASHE)'s Sustainability Tracking, Assessment and Rating System (STARS), which requires information about student and staff commute modal split.

[1] TRAM is a multidisciplinary team including faculty members and students mainly from the School of Urban Planning, Faculty of Engineering, McGill University.

[2] The project is funded through the McGill Sustainability Projects Fund.

This report provides a detailed account of the results of this research project, beginning with a description of the survey design and methodology. This is followed by a detailed analysis of the survey results, complemented by other data obtained from McGill's Human Resources Department, to generate detailed mapping and statistical analysis of travel demand for both McGill campuses. In addition, the level of greenhouse gas emissions generated by the university community as a result of commuting is estimated, to provide a better understanding of the university's environmental impact. The report also explores the types of commuters that make up the McGill community, to provide a better understanding of what influences their travel choices, as well as the level of satisfaction individuals have with their trip, to better guide future action to promote sustainable transportation to university campuses. Finally, this report explores the comments and concerns raised by survey respondents related to improving sustainable transportation options to McGill campuses, and offers a few concluding remarks to highlight the important findings of the project.

Section II – *Survey Description*

SURVEY DESIGN

To gather the data required to accurately model travel behaviour patterns among individuals of the McGill community and to quantify the environmental impact of travel to McGill campuses, a large-scale online survey was conducted during the month of March and early April, 2011. The target population of the survey included all McGill students, staff, and faculty, with the goal of capturing representative data for both of the main campuses and other McGill establishments (such as teaching hospitals). The survey was designed and carried out by the TRAM research group, in consultation with faculty specialists in transportation planning and travel behaviour, members of the Office of Sustainability of McGill Campus and Space Planning, and Daniel Schwartz from the McGill IT Office with whom the TRAM research group has a very close relationship in building online surveys. The survey underwent a series of revisions and pilot testing with these stakeholders before being launched to the McGill community (see Appendix I for the final version of the survey). Standard approval procedures were followed, including approval from the Office of the Provost and approval of a human subject review application made to the Research Ethics Board Office.

To minimize potential for survey abandonment by respondents, the online survey was designed with a question filtering mechanism which instantly modified the series of questions based on the respondent's previous answers, so that only relevant questions were asked. In addition, some questions were designated as 'required' and other as 'optional' to ensure that essential questions were answered while other could be avoided if time was a constraint. For example, although the specification of vehicle type is useful for more accurate transportation emissions calculations, it is not necessary for identifying the mode of travel.

The survey asked respondents to describe their last trip to McGill through a series of guided questions. In order to accurately model the trips, respondents were asked to indicate the postal code or the nearest intersection to their place of residence while working/studying at McGill, as well as the campus (or area of campus if downtown) at which they spend the majority of their time while at McGill. The survey also included questions regarding specific travel choices and trip "legs" (the various pieces that make up a single one-way trip to campus, which in many cases involves more than a single mode of transportation). In addition, to ensure that trip modelling could be as accurate as possible, respondents were asked to specify the train, metro or bus routes that were used if they indicated the use of public transit as part of their trip, which allowed for the identification of multimodality. These types of questions were important for quantifying mode share values and also the level of greenhouse gas (GHG) emissions resulting from travel to McGill campuses. To adjust for seasonality in mode choice, the survey was designed to capture differences in the respondents' transportation mode used for various times of the year, in cases which this applied.

The survey also included a series of questions which aimed to identify motivations and barriers related travel choices. These types of questions were particularly important for gaining insight into ways that existing barriers to the use of sustainable transportation could be removed, as well as to gain an understanding of why some individuals in the McGill community use private motorized vehicle to arrive at campus. These questions were also helpful in identifying potential improvements that could be made to transit services or active transportation facilities to further encourage the use of these modes to travel to McGill campuses. Similarly, there were four more open-ended questions included in the survey where respondents were invited to provide any comments they had regarding particular topics.

SURVEY DISSEMINATION

An invitation to participate in the survey was distributed electronically via email, providing individuals with a link to the online survey (see Appendix II). This link was customized using a unique "token" number which allowed for personalized survey distribution, and also enabled us to track which individuals completed the survey and send out reminder emails only to those who did not complete the survey. All personal information was removed from the collected data before it was released for analysis, to ensure the anonymity of the respondents. Only the survey administrator, Daniel Schwartz, had access to this personal information for administrative purposes, such as sending out personalized survey invitations and reminder emails.

An email list of all faculty, staff and students working/studying at McGill was obtained from the Provost's Office. Email invitations were distributed to all faculty and staff that had a McGill email address (8,493). For those staff members that do not have a McGill email address, such as maintenance staff, a postcard inviting them to go online and take the survey was mailed to their McGill work location. These postcards were sent out to a total of 200 staff members without access to a McGill email address (See Appendix III).

Ideally, the survey would have been distributed to the entire McGill student population in order to have the largest possible number of completed responses (since participation was voluntary, and therefore not everyone would complete the survey). However, there were issues with overloading students with email requests, and therefore the number of invitations that could be sent to students was restricted to 11,000, or approximately 30% of the McGill student population. Given this restriction, it was important to ensure that the invitations sent out to students would yield a representative sample of responses of students attending both of the main McGill campuses, as well as a representative sample of students commuting from different parts of the region. Therefore, students were randomly selected within each borough and municipality in the Montreal Metropolitan Region, with the goal of obtaining responses from 5% of the total McGill student population residing in each borough or municipality (see Figure X for the actual sampling rate achieved).

To ensure that the online survey was not overloaded, the invitations to participate in the survey were sent out in batches over the first few days that the survey was active. The survey remained active for a total of 35 days during the month of March and the beginning of April, 2011, during which a total of 19,662 survey invitation emails were distributed among the McGill community. After the first week, a reminder email was sent out to individuals who had not yet completed the survey (Appendix IV). Various prizes were offered as an incentive for survey participation.

SURVEY RESPONSES

Of the 19,662 surveys distributed among the McGill community, 5,016 responses were obtained by the closing date of the survey. This yielded an overall response rate of 25.5%, which is similar to the results of other comparable studies such as Páez & Whalen (2010). Following a series of data cleaning operations, through which incomplete and nonsensical survey responses were removed, a total of 4,698 entries were found to be suitable for use in subsequent analyses of the survey results, giving rise to a sampling error of plus or minus 2% at a 99% confidence interval. Of these useable entries, 2,616 respondents (56%) are McGill employees (which include both faculty and staff), 2,032 respondents (43%) are McGill students, and the remaining 50 respondents (1%) fell into the category of 'other', which includes visiting students and professors. The overrepresentation of employees is the result of the restriction placed on the number of students to whom the survey invitation could be distributed (discussed in the previous section). For future surveys of this nature, it would be best to eliminate such a restriction so as to ensure a more accurate representation of the McGill community. Of the 200 postcards that were sent out to staff members that do not have a McGill email address, only three individuals completed the online survey.

The majority of the survey respondents (4,638 or 99%) reside within the Montreal Metropolitan Region; Figure 1 illustrates the distribution of their home locations throughout the region. It is apparent that the majority of the survey respondents reside on the Island of Montreal itself, with a high concentration around the Downtown McGill campus in the centre of the Island and a concentration around the Macdonald campus in the western portion of the Island. This is due to the fact that a large proportion of McGill students live close to either of the main McGill campuses. A fair amount of respondents also reside in Laval just north of the Island of Montreal, and in Brossard on the South Shore. In addition, 60 survey respondents (1%) indicated that they commute to McGill from outside of the Montreal Metropolitan Region; for example, a few respondents commute to McGill from Ottawa, Ontario (approximately a two-hour trip) a few days a week.

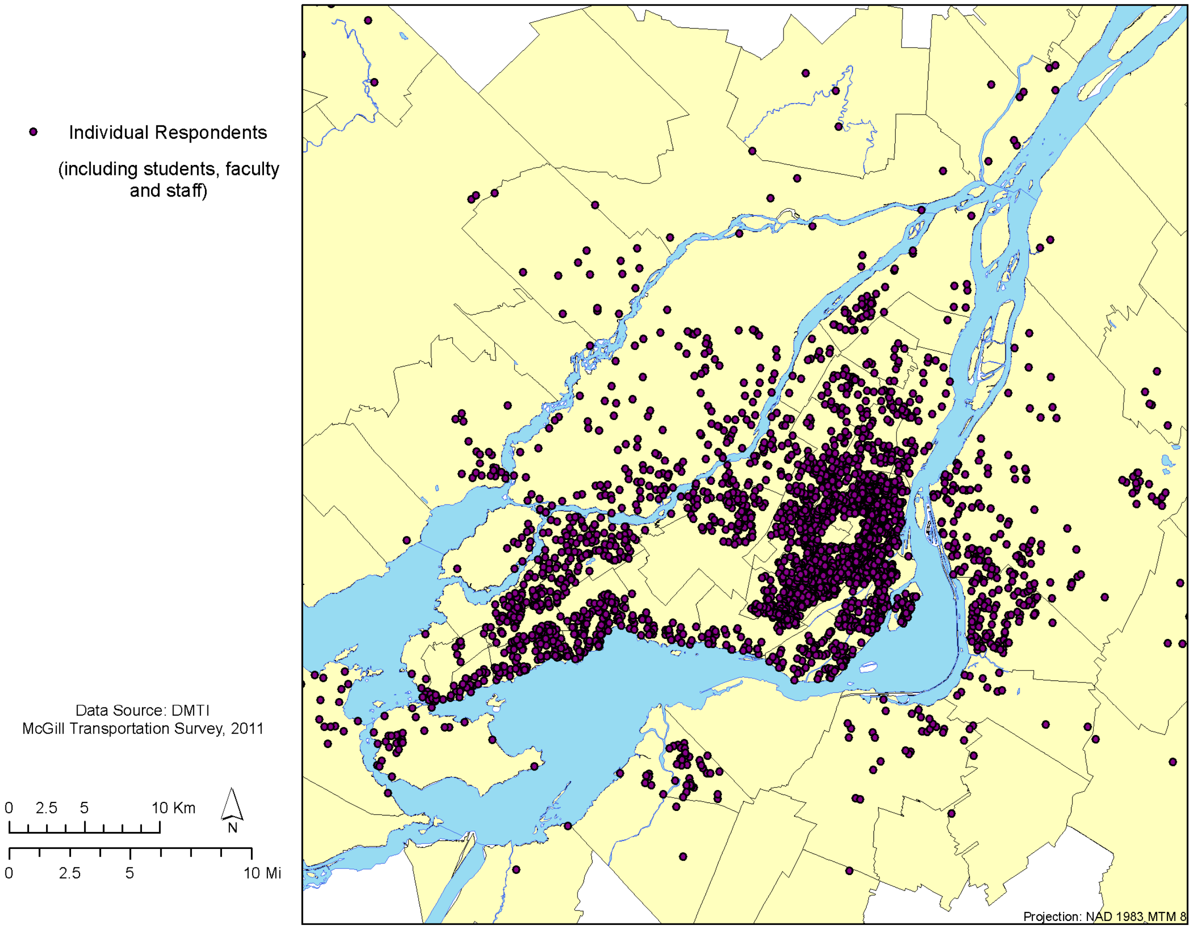

Figure 1. Spatial distribution of the home location of all survey respondents, including students, faculty and staff

Figures 2 and 3 illustrate the sampling rate of McGill employees (including all faculty and staff) and McGill students, respectively, within each of the boroughs and municipalities in the Montreal Metropolitan Region. This sampling rate was determined by examining the number of survey respondents that live in each borough and municipality within the Region (as determined by geocoding the home location of respondents using the postal code or nearest street intersection provided by survey respondents for accurate trip modelling), compared to the total number of McGill employees and student living in each borough or municipality within the Region.

The color gradient in Figures 2 and 3 depicts the sampling rate, while the numbers indicated directly on the map represent the actual number of employees and students included in the sample for each borough or municipality. Although it appears that the sampling rate for some boroughs or municipalities is very high (such as the areas represented in orange and red in Figures 2 and 3), the number of individuals surveyed is actually quite low (only a few individuals). The elevated sampling rates are therefore the result of the fact that very few McGill employees and students reside in these areas.

Overall, the results in Figures 2 and 3 illustrate that the survey respondents provide a good representation of employees and students, respectively, commuting to McGill from all over the region, with the exception of a few outlying areas. For McGill faculty and staff (Figure 2), a sampling rate of 9% or higher was obtained for the majority of the boroughs and municipalities in the Region. For McGill students (Figure 3), a sampling rate of 5% or higher was obtained for most boroughs and municipalities, thus achieving the goal set forth in the methodology section to ensure representative sampling of students despite the limitation set on the number of students that could be sent the survey invitation.

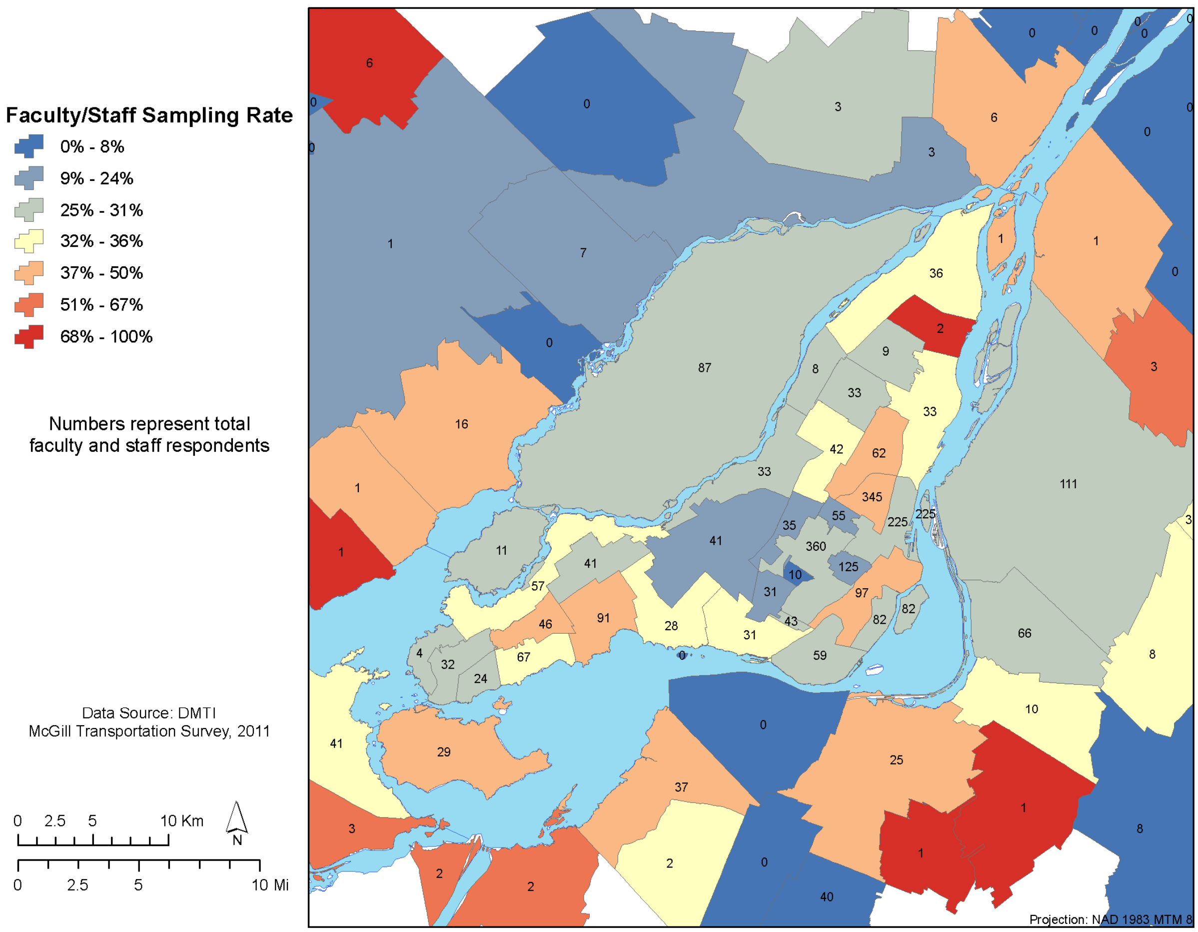

Figure 2. Sampling rate of faculty and staff by borough or municipality in the Montreal Metropolitan Region

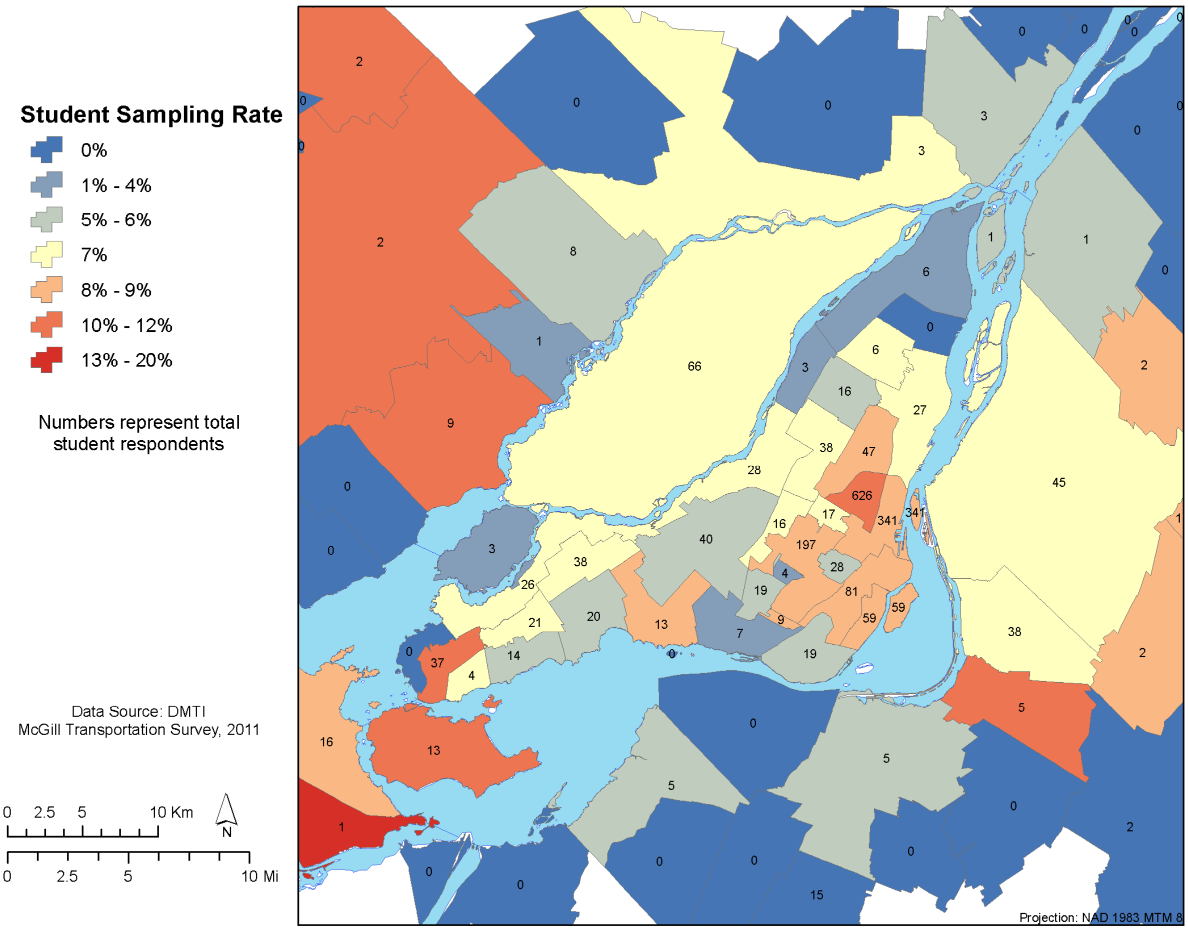

Figure 3. Sampling rate of students by borough or municipality in the Montreal Metropolitan Region

Section III – *Summary Statistics*

MODAL SPLIT

Modal split illustrates the proportion of individuals who choose one form of transportation over another to arrive at their destination. Various modes of transportation define the commuting patterns within the McGill community, some of which are more weighted than others. In terms of these commuting patterns, modal split is categorized into three types of travel: those who use active transport, those who use public transit and those who use motorized vehicles. Each category can be further classified to specify the type of public transportation, active transportation and motorized vehicle used. These subdivisions would include: biking or walking as a means of active transport; using the bus, metro, commuter train or McGill shuttle to define public transit; and taxis, private cars, two-wheeled motor vehicles, or carpooling to characterize the use of motor vehicles.

For the purpose of providing a basic context, the three main categories generate a simple framework in which to demonstrate the overall mode share of the survey sample population. The mode split of the survey sample population is illustrated in Figure 4. The use of motorized vehicles makes up less than a quarter of the mode split of the surveyed population, whereas active transport and public transit modes make up the bulk of McGill's commuting patterns. When combined, active transport and public transit make up 84% of the primary mode of transportation used to travel to and from McGill campuses.

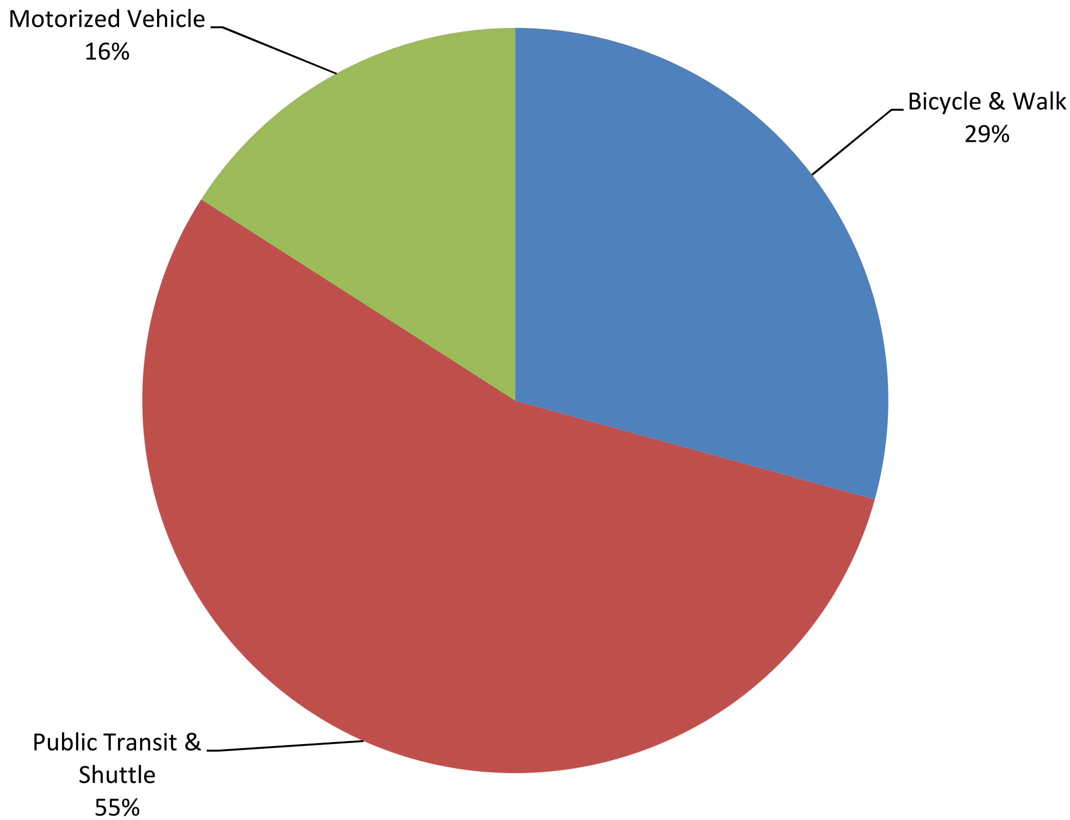

Figure 4. Total mode split based on the results of the 2011 McGill Transportation Survey

For comparative purposes, Figure 5 provides the mode split for all work and school trip to downtown Montreal, based on the Montreal Origin-Destination survey. Relative to the Montreal Metropolitan Region as a whole, the McGill community fairs quite well in terms of the use of sustainable modes of transportation for commuting purposes. McGill has over three times as many users of active modes (29% for McGill versus 9% for the Region), three times fewer individuals commuting by motorized vehicle (16% for McGill versus 48% for the Region), and a slightly higher proportion of individuals commuting by public transit than the Region overall (55% for McGill versus 43% for the Region).

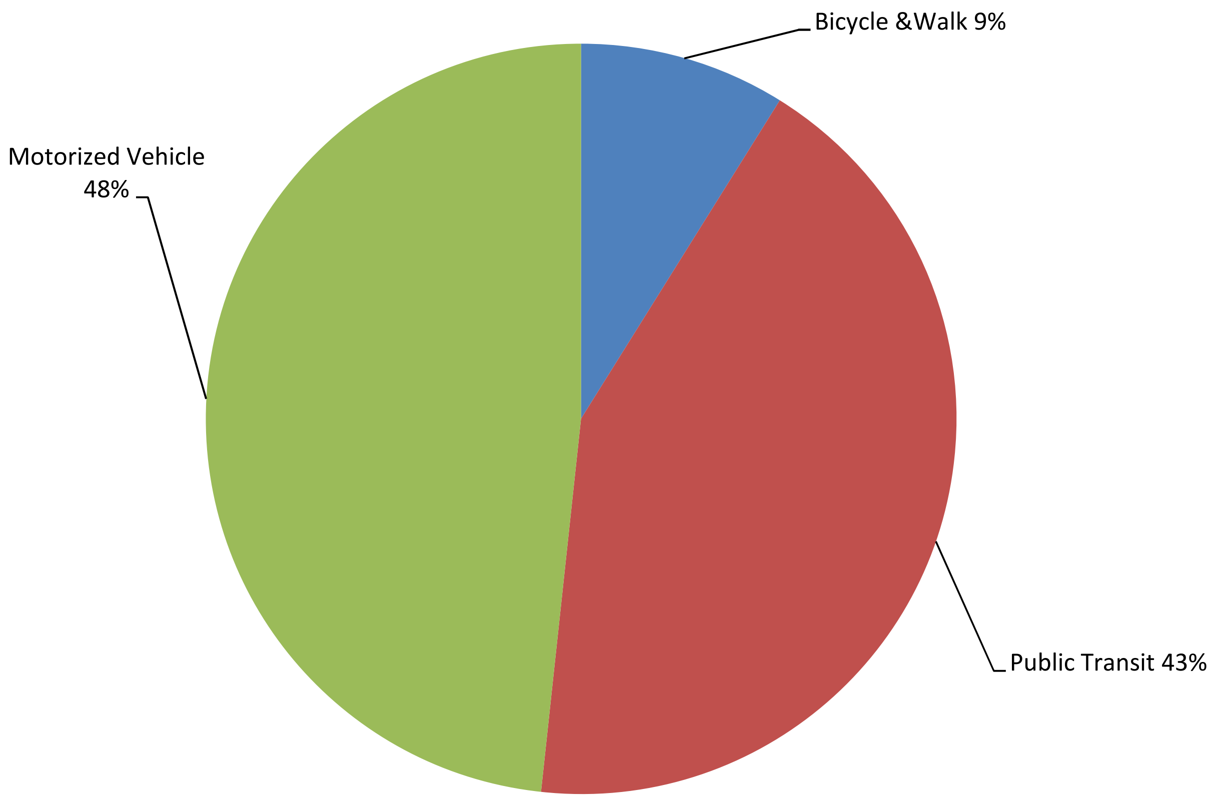

Figure 5. Mode split for all work and school trips to downtown based on the results of the Montreal Metropolitan Region Origin-Destination Survey

In an attempt to further characterize this mode split, the sampling rate can be divided by age, status at McGill, and campus destination. Figure 6 defines an individual's status at McGill and the frequency at which each status participates in all three mode shares. The share of motorized vehicle use is relatively higher for employees (academic, secondary, administrative, and other staff) than for students (undergraduate, graduate, continuing education, and post-doctoral students). Alternatively, larger shares of students choose active transport (walking and cycling) to access campus than employees. Influential factors for this divergence may include higher salaries and steady incomes for employees, as well as priorities more common to these individuals, such as family and children, which may restrict choice of residence to the urban fringes. As 34.3% of the population aged 20-34 with a university certificate, diploma or degree lives in downtown Montreal, it is assumed that students may tend to live closer to campus for convenience and cost.[3] Finally, transit accounts for 55% of the total mode split, and shares the majority of trips across all status groups.

[3] *Statistics Canada. 2002. 2001 Community Profiles. Released June 27, 2002. Last modified: 2005-11-30. Statistics Canada Catalogue no. 93F0053XIE.* http://www12.statcan.ca/english/Profil01/CP01/Index.cfm?Lang=E (accessed June 9, 2011).

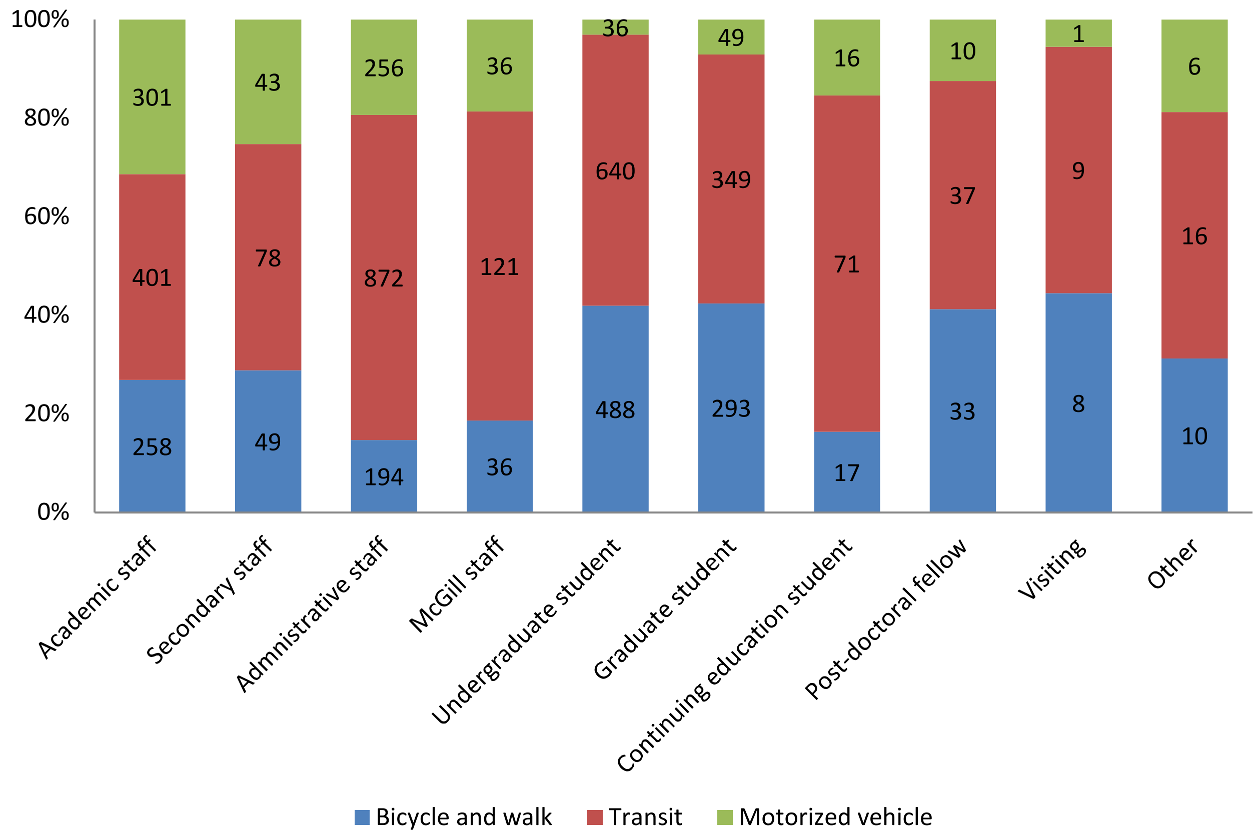

Figure 6. Mode split by status

Several trends appear when mode share is split according to the reported age of the sampling rate. The use of motorized vehicles steadily increases with age, whereas both active transport and public transit decrease gradually with age (Figure 7). However, the most prevalent mode continues to be public transit. Rates of transit use stay relatively constant among different age brackets. The only two age groups in which transit share does not exceed 50% are those under 20 years old, and those 65 to 69 years old. Transit accounts for over 50%, and nearly 60% of the mode share in all other age brackets.

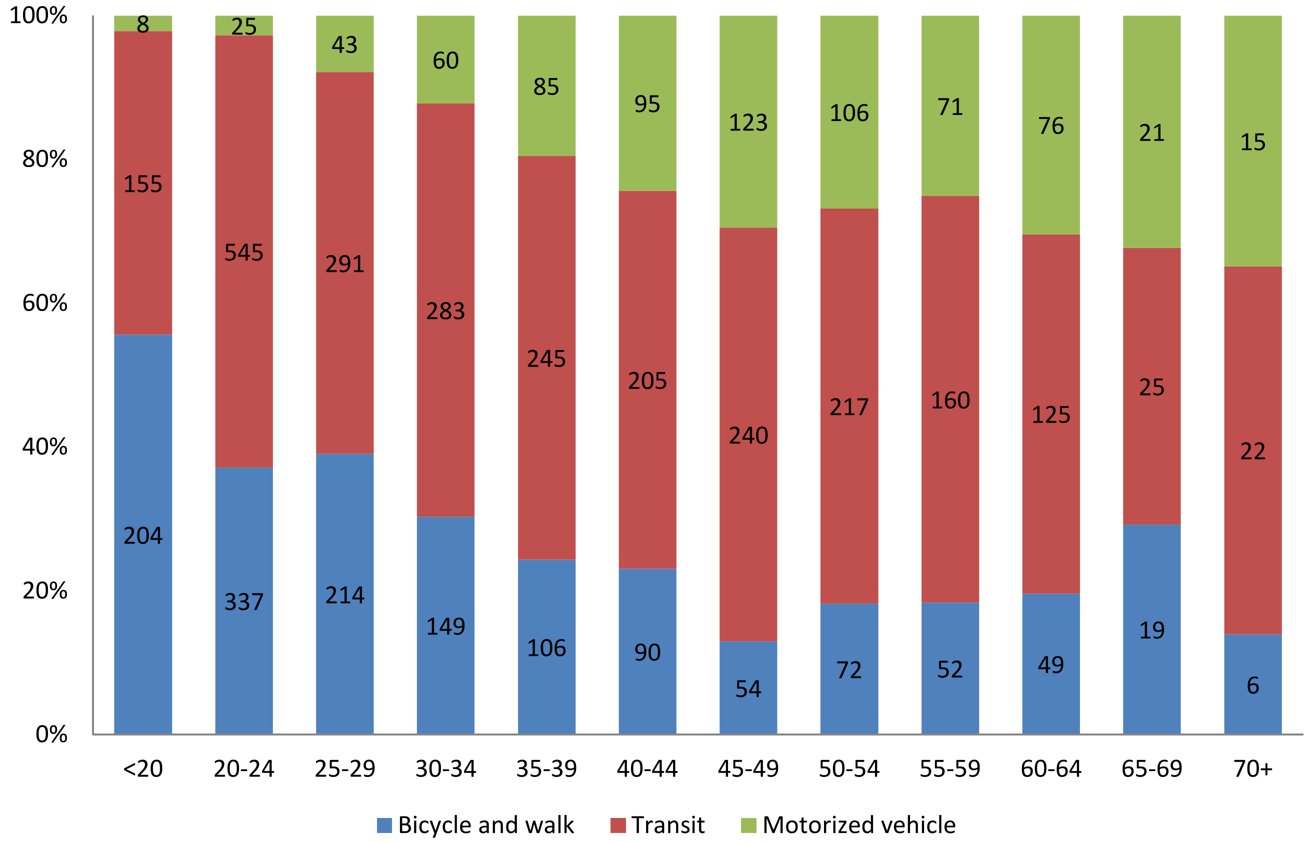

Figure 7. Mode split by age

Although motorized vehicle share increases as age increases, a slight decrease in the share is observed from 50-59 years old. Whereas age may be associated with reduced mobility, awareness of the health indicators of an active lifestyle may become more acute; by adopting more active transportation methods, health and lifestyle benefits may increase.

However, the general trend illustrates that the share of bicycling and walking decreases with age. Accounting for 55% for those less than 20 years old, this mode share reaches its minimum at 13% for those aged 45-49. As seen in the previous figure, 90% of students either cycle, walk or take transit, as confirmed by the younger individuals in Figure 7 who are most likely students.

Finally, mode share has been characterized by destination: the upper, middle, or lower section of the Downtown campus, Macdonald campus, and other McGill institutions, such as hospitals, constitute the survey destinations (Figure 8).

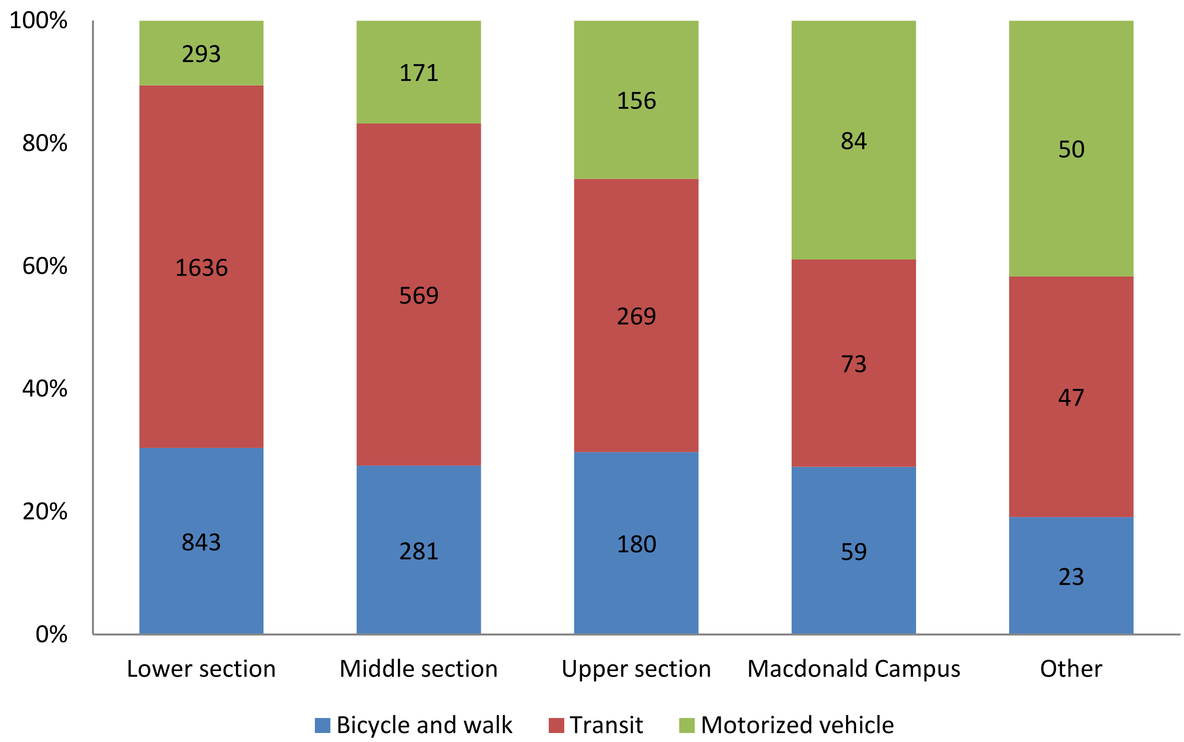

Figure 8. Mode split by destination

The discussion of these three categories of mode share will be supported by maps to illustrate these patterns based on two main destinations: the Downtown campus, and the Macdonald campus.

Active transport methods remain fairly constant for all three sections of the Downtown campus. In general, the Downtown campus sees a higher proportion of individuals walking and cycling to campus. Bicycle and pedestrian infrastructure is highly developed around the downtown core, facilitating the movement of people by these active means. Whereas the Macdonald campus has a significantly less dense population, active transport methods are limited to those who are within reasonable walking and cycling distance of Macdonald. The small town of Ste. Anne de Bellevue may not have the same extensive network of pedestrian paths and cycling facilities as the urban core, and the spread of residences is far greater around the urban fringe, as the density is much higher in the downtown area. Figure 9 and 10 illustrates those respondents who claim to use active transport methods to reach their destination, whether Macdonald or the Downtown campus (See Appendix V, Figure 52 for the distribution of respondents using active transportation to reach McGill by borough).

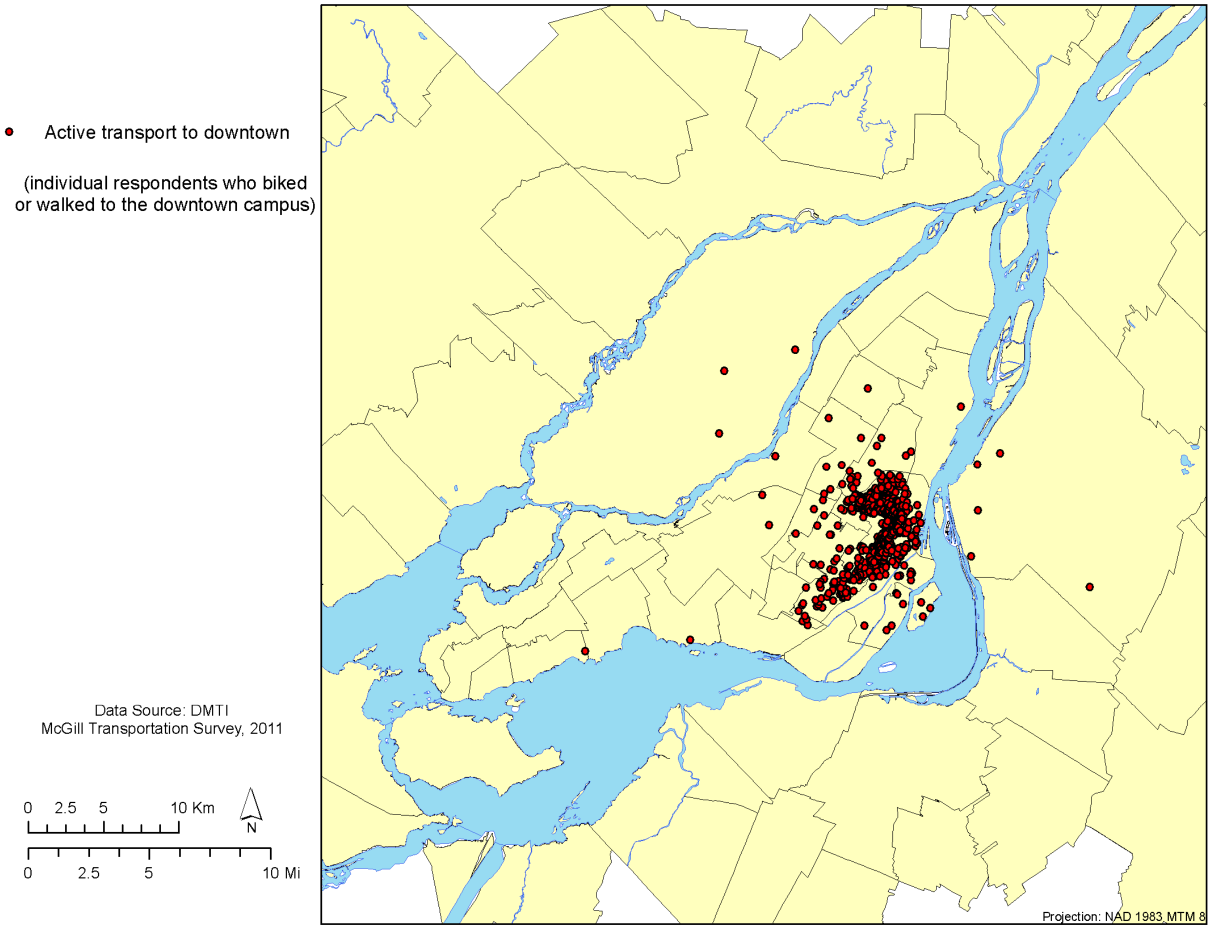

Figure 9. Home location of respondents who use active transportation to reach the Downtown McGill Campus

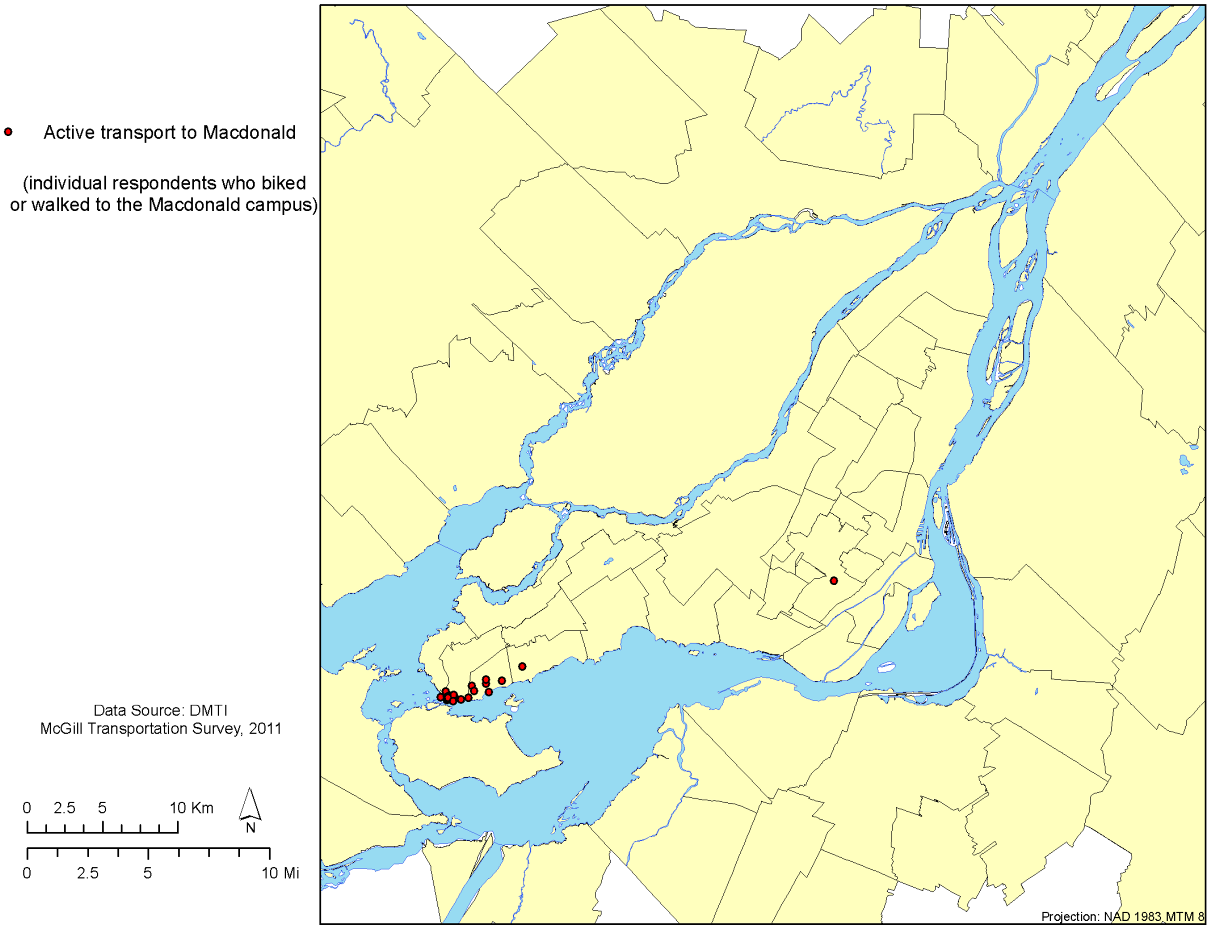

Figure 10. Home location of respondents who use active transportation to reach the Macdonald Campus

The highest levels of transit rates are found among those that travel to the Downtown campus, most notably the lower and middle sections. Due to the proximity of the McGill metro station to the lower end of campus, as well as the frequency of several buses on the main arteries that pass by the lower section, transit users may be expected to be highest for these areas. The upper section of campus, located on a steeper portion of the Mont-Royal Mountain, has less direct access to public transit, with few bus lines that run frequently, which may translate into a reduced share of transit. This may be especially true during the winter months, when the hazards of snow accumulation and cold weather discourage the sharp climb from the metro and bus lines that link downtown Montreal. This decrease in transit is compensated in an increase in motorized vehicle share, especially with the presence of an underground parking garage in the McIntyre Medical Building located on the upper campus. More broadly, the Downtown campus as a whole experiences a higher frequency of transit users (Figure 11) than the Macdonald campus. In the downtown core, the network can accommodate and expand due to the higher density of the areas that public transit services. Of those respondents who travel to the Macdonald campus (Figure 12), the intercampus shuttle may explain the rates of transit users, as the service ferries students and staff between both campuses, facilitating the amount of trips that can be taken between these two locations (see Appendix V, Figure 53 for the distribution of respondents using public transportation to reach McGill by borough).

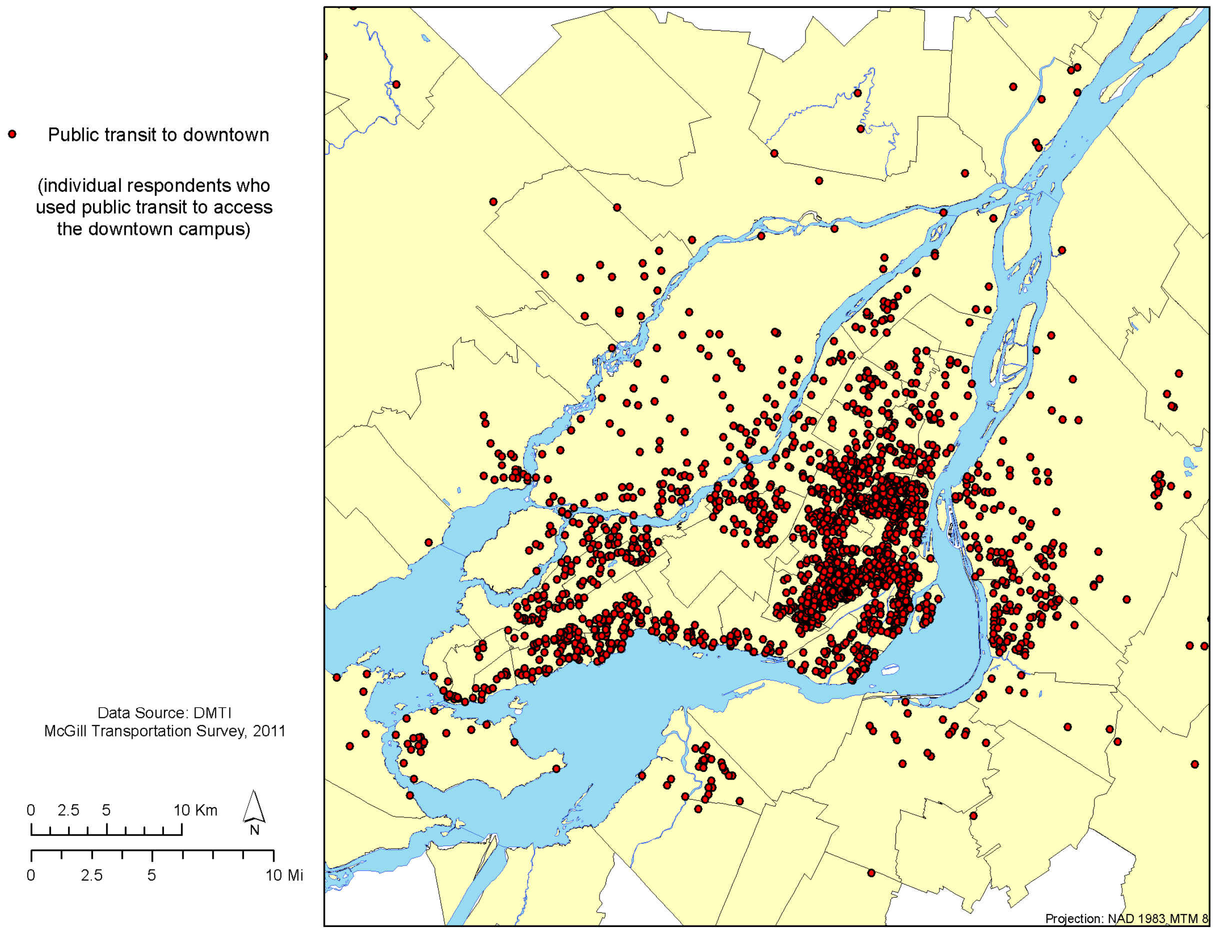

Figure 11. Home location of respondents who use public transportation to reach the Downtown McGill Campus

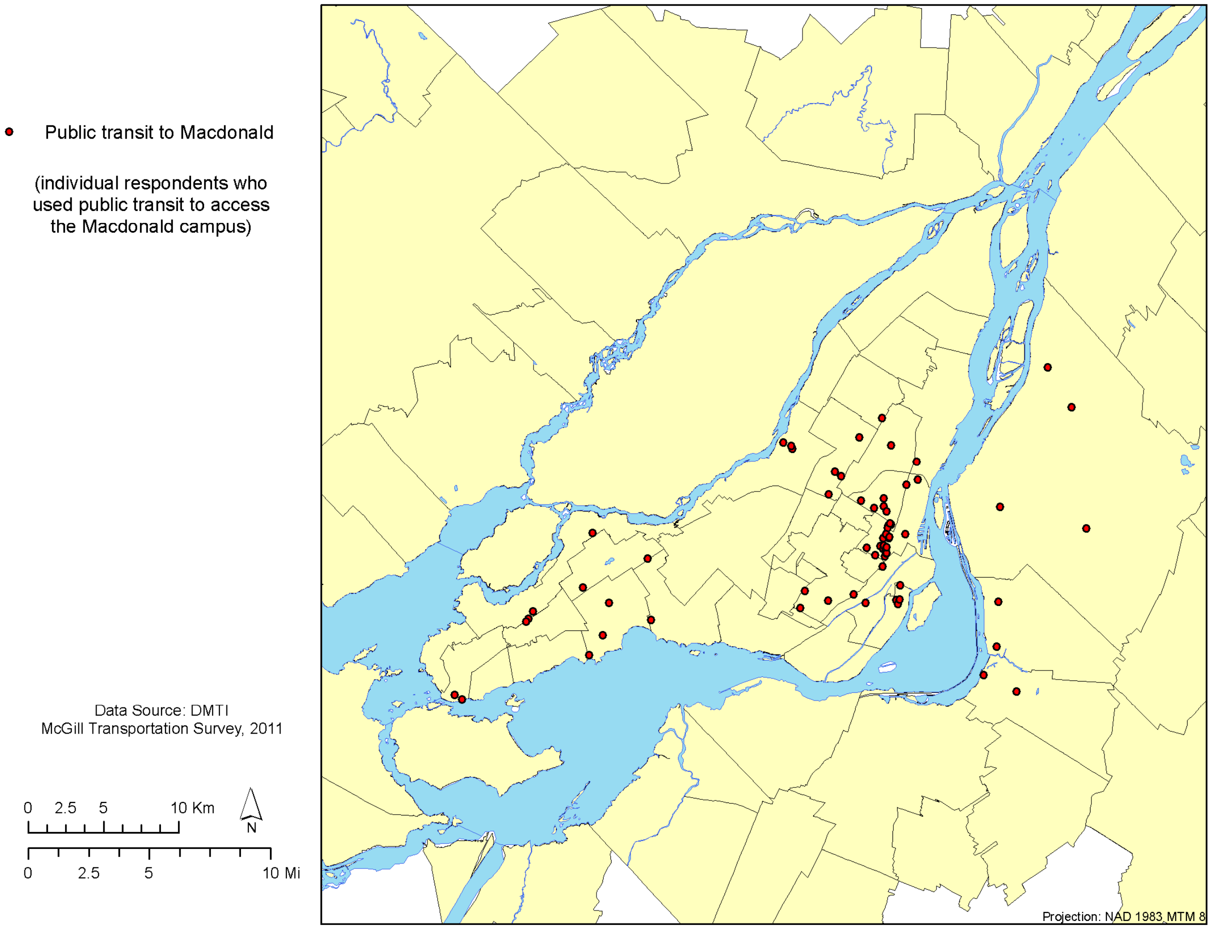

Figure 12. Home location of respondents who use public transportation to reach the Macdonald Campus

As Figure 8 previously explained, of those who drive to either campus, Macdonald campus (with the exception of "other"), consequently shares a larger proportion of motorized vehicles to access the campus. With its location on the far end of the West Island, the area is significantly less dense in population, and thus has a less extensive transit network. As mentioned above, the commuter train, the McGill shuttle bus, and few bus lines service the town of Ste. Anne de Bellevue, but the decreased density of residences reduces the viability of these options. While walking and cycling are feasible when individuals' origins are near the Macdonald campus, the spread of these origins is large enough to require the use of an automobile by default. Although the Downtown campus still sees a high rate of car users (Figure 13), motorized vehicles account for a larger proportion of trips to and from Macdonald campus, as illustrated in Figure 14 (see Appendix V, Figure 54 for the distribution of respondents using public transportation to reach McGill by borough).

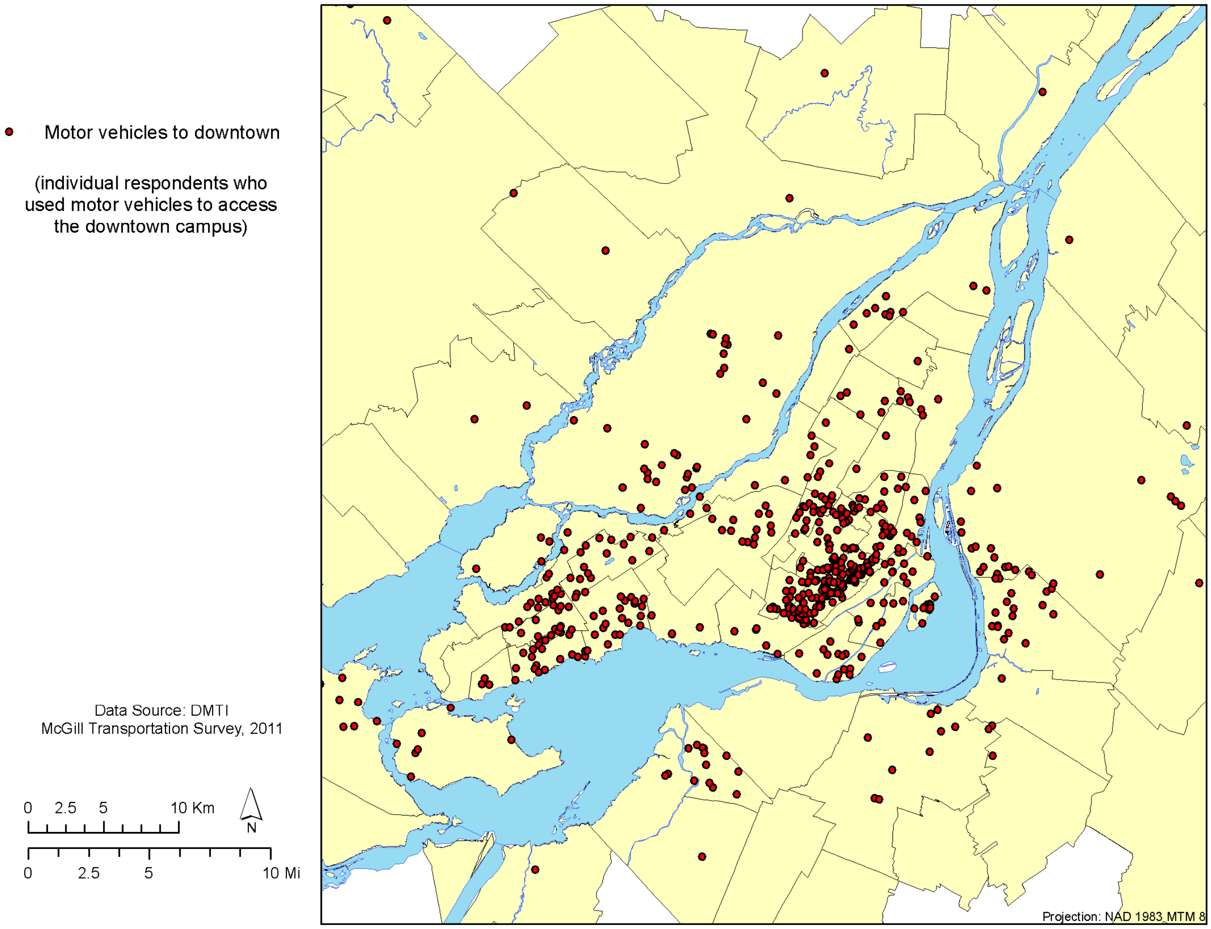

Figure 13. Home location of respondents who use motorized vehicle to reach the Downtown McGill Campus

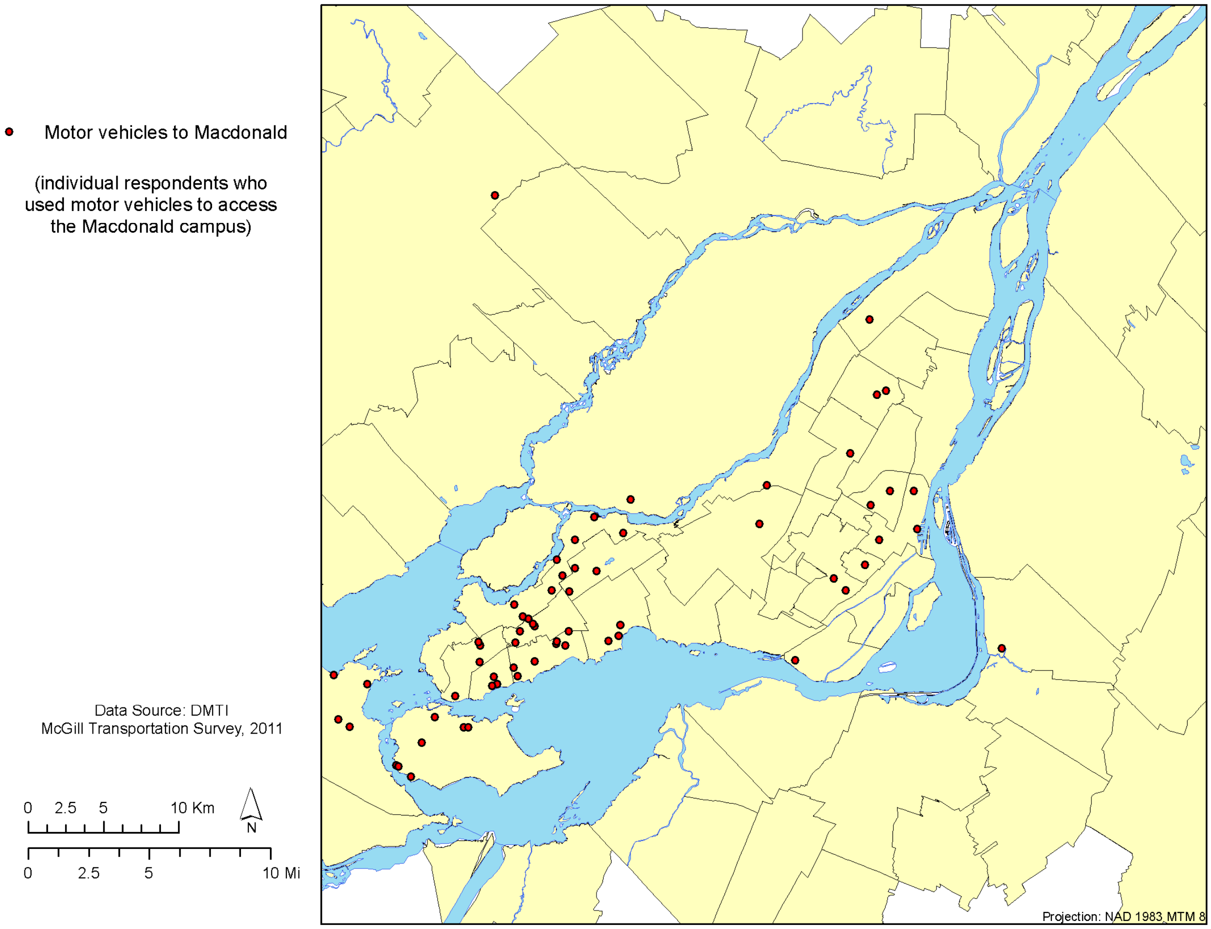

Figure 14. Home location of respondents who use motorized vehicle to reach the Macdonald Campus

Finally, the sample indicated the category of "other" as destinations such as McGill-affiliated hospitals. Many hospital staff indicated frequent travel between these locations on any given day, and stressed the utmost importance of maximum flexibility for these trips. Commuting by car allows for this efficiency, and dedicated parking at all hospitals facilitates this mode of transport. The transit share indicates that there are other viable options, though the location of some of these facilities is spread across enough of a distance to require multiple transfers, augmenting total travel time and diminishing time efficiency.

Further analysis related to mode split which uses multinomial logit models to understand the factors that dissuade individuals from commuting by transit, as well as to understand the transit route choice decision of those individuals that commute by transit can be found in Appendix VI.

DISTANCES

The sampling rate identified a frequency of over 1,600 individuals travelling approximately seven kilometres from origin to destination (OD) (Figure 15). The frequency of individuals decreases exponentially as distance travelled to a McGill campus increases, marked with a cluster of 150 to 400 users travelling between 20 and 40 kilometres.

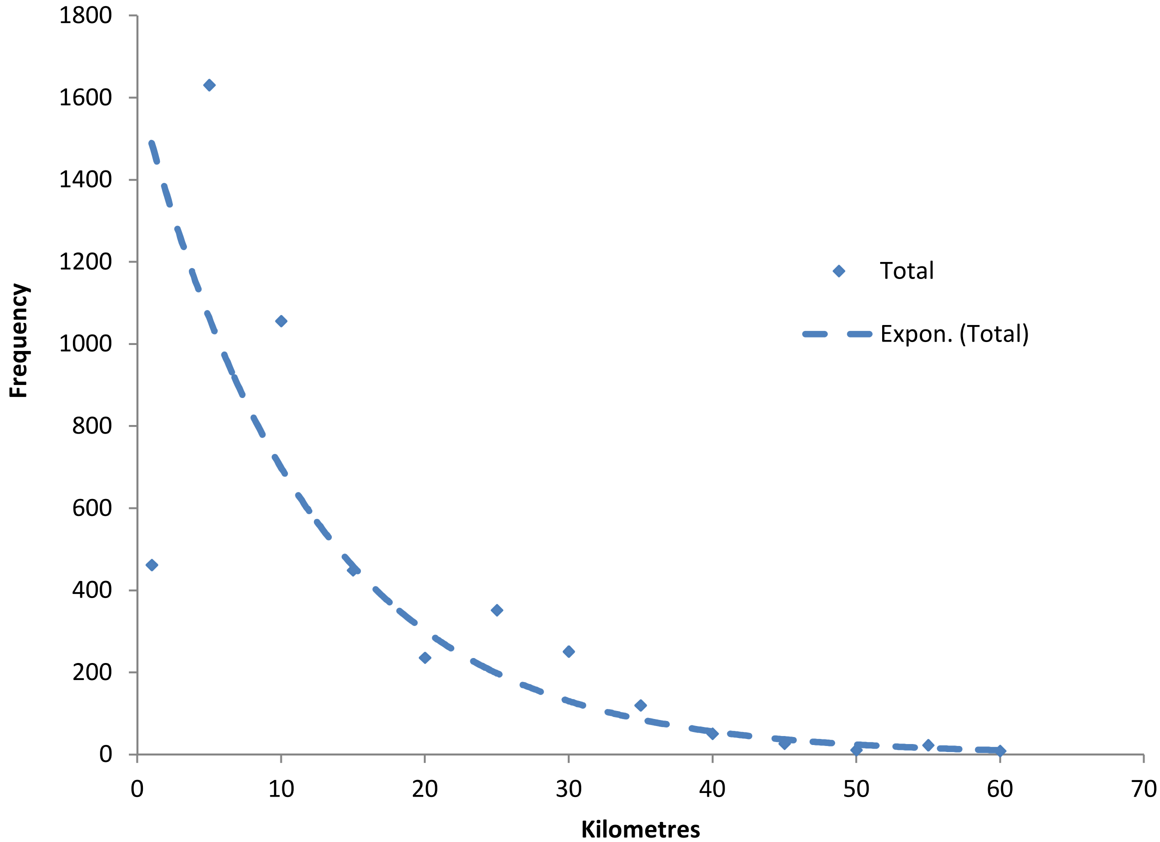

Figure 15. Distance OD for all McGill

This OD distance significantly impacts choice of mode. Figure 16 illustrates the percentage of use of different modes of transportation by distance. Rates of cycling and walking can be expected to decrease as distance travelled increases; this is confirmed by the blue curve, suggesting that the vast majority of cyclists and walkers live within a close distance to campus. More than 1,200 active transport users live within 5 kilometres of a McGill campus, but this frequency decreases to nearly 16 individuals within a distance of 10 to 15 kilometres.

Conversely, the highest numbers of transit users are those that live within 8 kilometres of a McGill campus, though a cluster of 100 to 250 individuals take transit for a distance of 20 to 35 kilometres. In the case of McGill commuters, as OD distance travelled increases, the frequency of the use of transit (red curve) decreases at approximately the same rate as the use of motorized vehicles (green curve). This suggests that individuals of the McGill community who take transit are travelling as far as individuals who use private motorized vehicles. The rate of decrease in the use of transit and motorized vehicle is relatively constant (no sharp drops at a certain distance threshold), and decreases much less rapidly than for active modes of transportation.

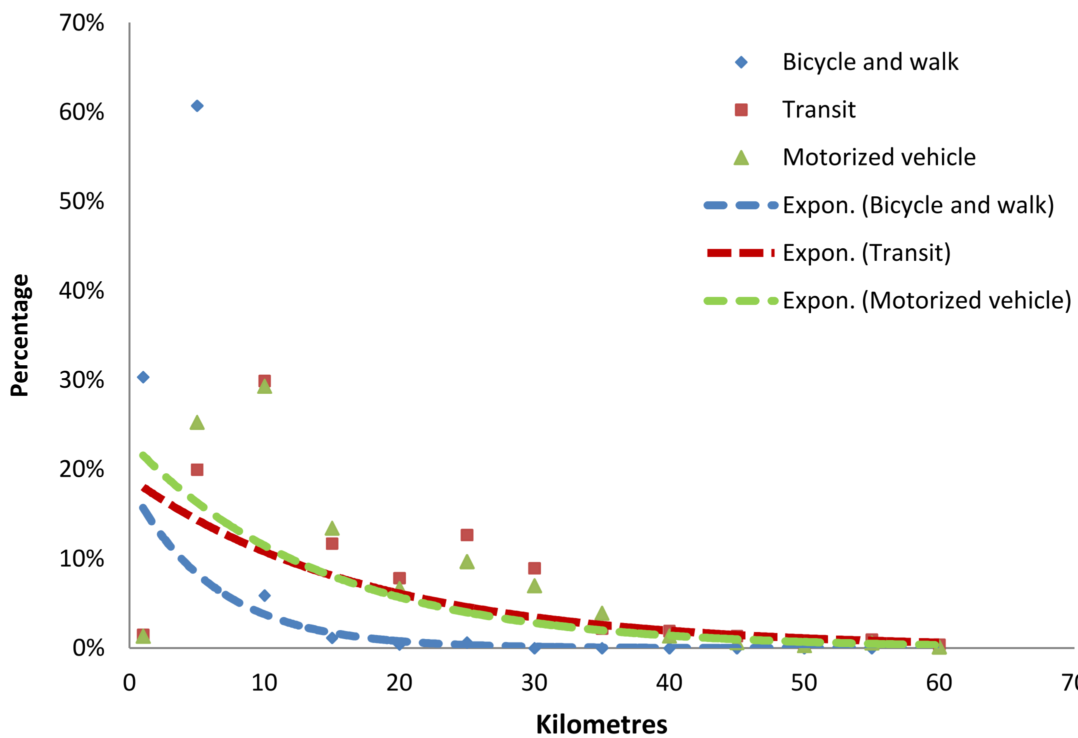

Figure 16. Distance from origin to destination for different transportation modes based on the results of the 2011 McGill Transportation Survey

Figure 17 illustrates the percentage of use of different modes of transportation by distance for all work and school trip to downtown Montreal, based on the Montreal Origin-Destination survey. This allows us to evaluate how the impact of distance on mode choice for McGill commuters differs from that of commuters across the Montreal Region. For the Montreal Metropolitan Region as a whole, some different patterns emerge. The use of active transportation (blue curve) is highest at distances below 10 kilometres, with only a very small proportion of users at greater distances. The rate of decrease in the use of active modes with increasing distance travelled is still much more rapid compared to transit of motorized vehicle. Similarities do exist when comparing the active transportation curves in Figure 16 and Figure 17.

What is quite different from the pattern seen among the McGill community is the impact of distance on the use of transit (red curve) and motorized vehicle (green curve). Rather than following a very similar rate of decrease in use with increasing distance travelled, now we see a much more rapid decrease in the use of transit with increased distance travelled, than we do with motorized vehicle (the use of transit significantly drops off at distances around 20 kilometres). This therefore suggests that individuals commuting to McGill take transit for much longer distances than other individuals commuting in the Region. This could stem from the fact that many individuals commuting to McGill are students and therefore may not have access to a vehicle for this commuting trip, or they may not have their drivers licence. Nevertheless, we are seeing a stronger tolerance to increases in distance travelled and the continued use of sustainable modes among the McGill community than in the rest of the Region.

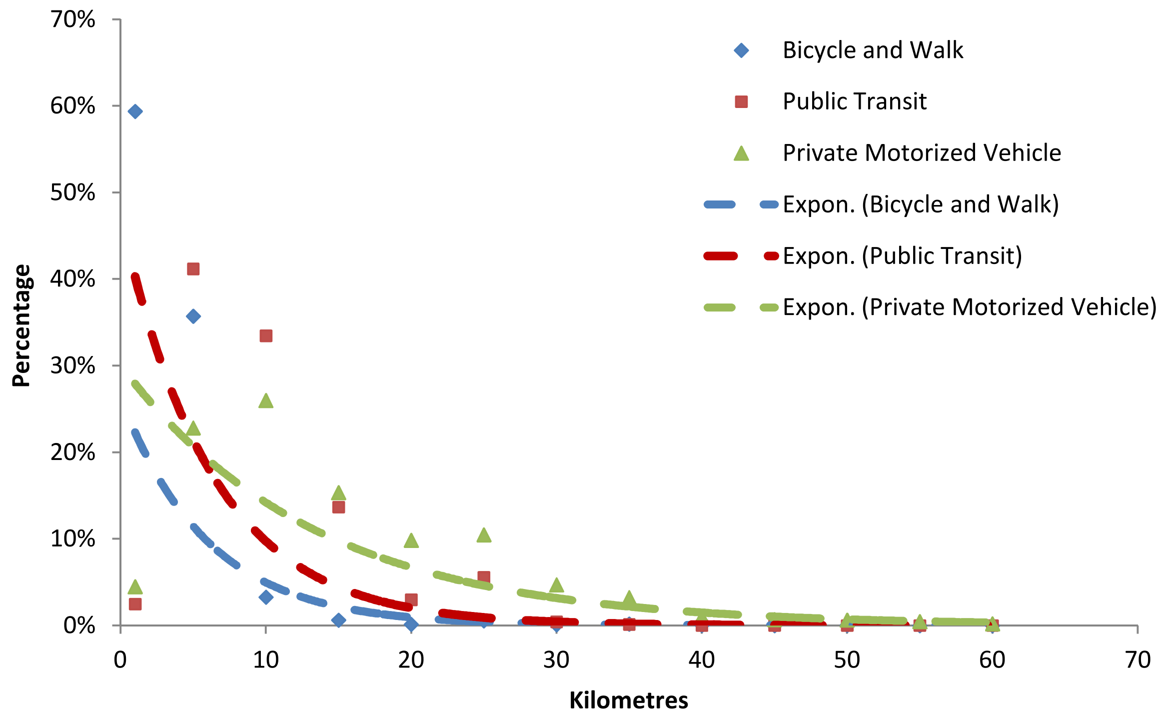

Figure 17. Distance from origin to destination for different transportation modes for all work and school trips to downtown Montreal based on the results of the Montreal Metropolitan Region Origin-Destination Survey

In further subdividing the sampling rate by status, distance travelled affects the mode decisions made by students in the same manner for employees (Appendix V, Figure 55). The choice of transit between these two groups follows similar exponential curves, with increased OD distance resulting in less frequency of individuals using transit.

Distance travelled may also be characterized by the choice of residence, and the factors influencing this decision (Appendix V, Figure 56). Amenities of a neighbourhood, housing quality and cost and proximity to areas of interest all impact mode split, and by consequence, the distance travelled from origin to destination.

Individuals who chose their residence based on proximity to areas of interest, whether this is near friends or family, near key transit nodes, or places of work and recreation, are less likely to choose motorized vehicle as their primary mode of transportation. Alternatively, those who chose their residence based on housing quality and costs tend to share a larger proportion of automobile use. Appendix V, Figure 57 illustrates these correlations and the mode share among these different factors.

SEASONALITY

Montreal is prone to drastic temperature changes, resulting in severe winters and humid summers. Snow, ice and freezing temperatures may heavily impact commuting patterns during the winter months, whereas modest temperatures in the fall allow for more viable active transportation options, which increase overall travel activity. Figure 18 confirms this increase in active transport users in the fall, with a corresponding decrease in transit. An increase in public transit users occurs in the winter, where other options can be limited by weather. Automobile rates, though slightly lower in the fall, stay relatively constant, regardless of the fluctuations in seasons. The reduced numbers of individuals that take transit or drive cars corresponds to the augment of cycling and walking, and is able to account for most of this increase in active transportation on a nice fall day.

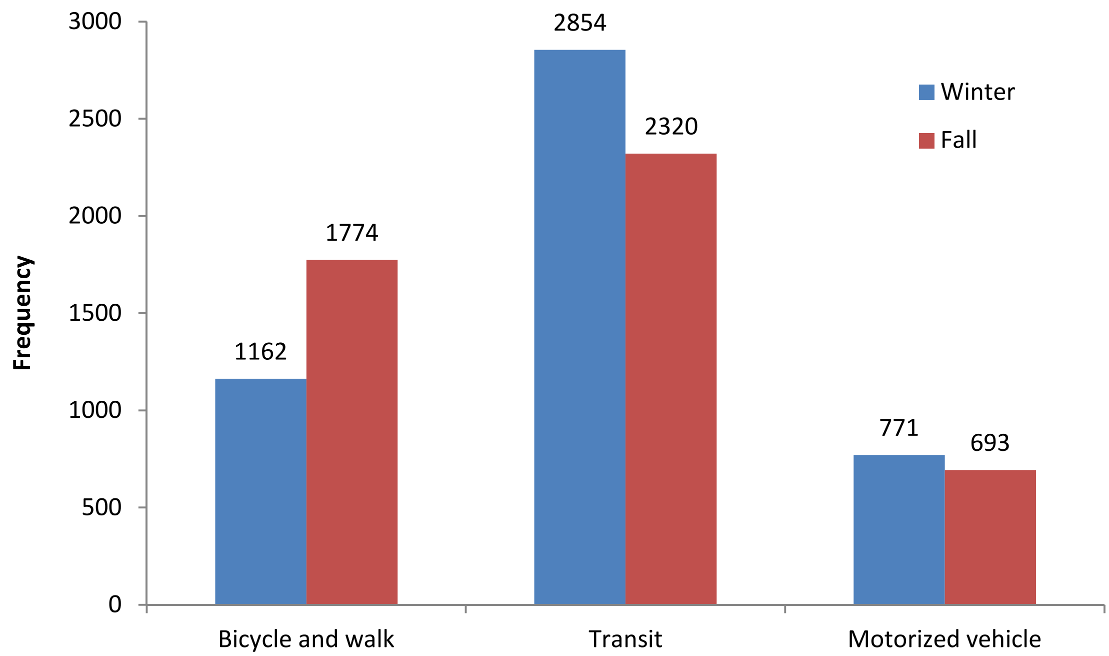

Figure 18. Frequency of respondents using each mode by season

Within the sampling rate, only 10% of individuals who cycled or walked during the winter months reported a different type of trip on a nice fall day (Figure 19). Variation exists in this decision within this active transport mode; those who may walk during the winter may choose to cycle in the fall, when ice and snow accumulation do not affect the trip to campus. Of transit users, 27% employ a different trip on a fall day, indicating the possibility that more active transport options are considered. More favourable weather conditions encourage cycling and walking, if the distance is not too far. Conversely, trip behaviour for motor vehicles users alters only 16% in the fall, strengthening the proposition that access to an automobile encourages regular use, regardless of season or distance.

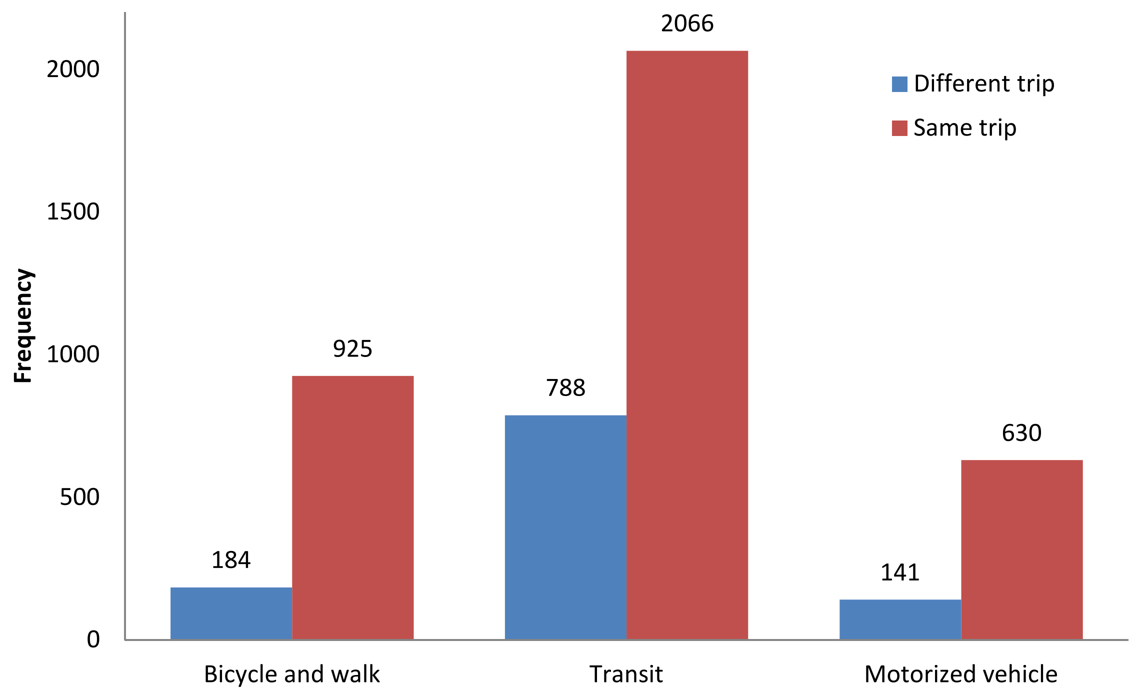

Figure 19. Seasonality of mode share

MOTIVATIONS

Whereas distance, choice of residence, season, age or destination may influence the decision to take one mode of transport over another, the motivations for each of these categories may explain more clearly the nuances present in this decision-making process. These factors are directly attributed to the specificity of the mode share, whereas the aforementioned are prone to underlining the more descriptive elements of a decision. Motivations for transit, active transport, or the use of a car reflect these elements, but provide further validation

Transit

As stated by the primary motivation behind the use of public transit, nearly 1,600 respondents cited greater convenience as a main incentive. The response rate for all other motivations is significantly less among individuals. However, the second most important motivation is proximity, but shares similar response rates that are split between the environment, convenience and lack of access to a car. For those who cited issues of proximity to their destination as their first or second motivation, their transportation mode may be reconsidered if their origin was closer to their destination. Similarly, those who identified lack of access to a car may opt to drive rather than commute by transit if they had the opportunity to travel by automobile.

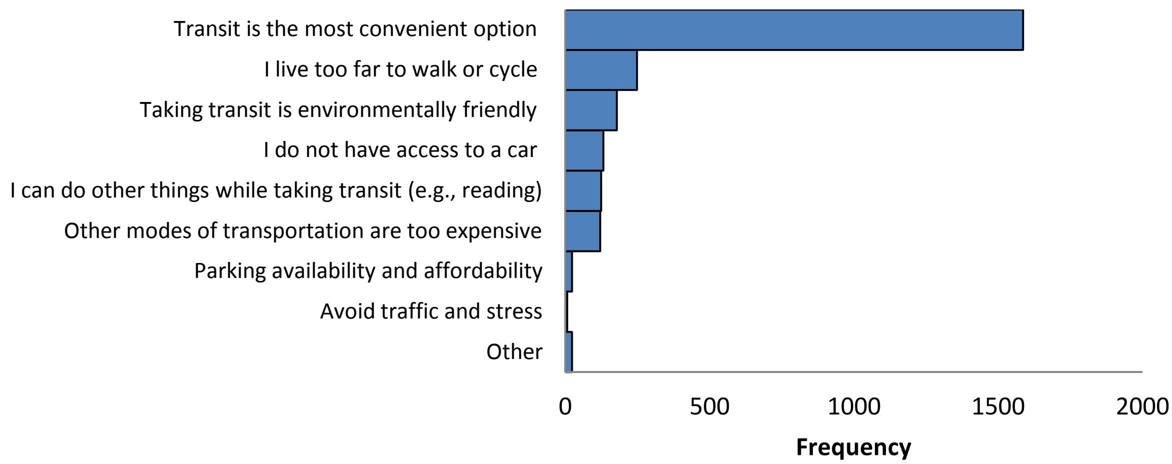

Figure 20. First motivation to use public transit

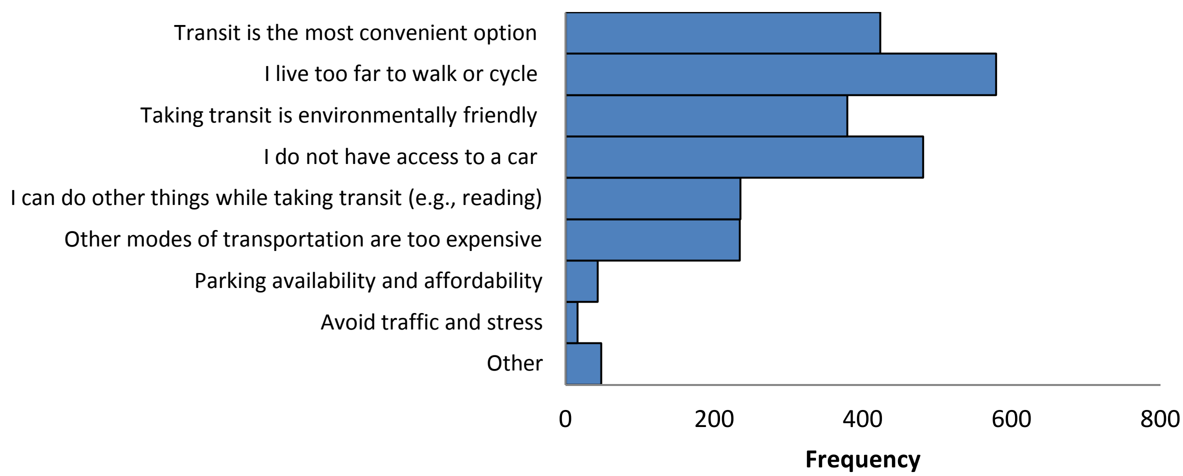

Figure 21. Second motivation to use public transit

Walking

Proximity is the listed as the main motivations for individuals to walk to their destination. The convenience of walking and the form of exercise it provides ties in response rates as the most important secondary factor to choosing this type of active transport. If these individuals lived further from their destination, or if it was less convenient to walk, the probability of choosing another mode of transportation is much higher, regardless of environmental concern, cost, or any other factors regarding the decision.

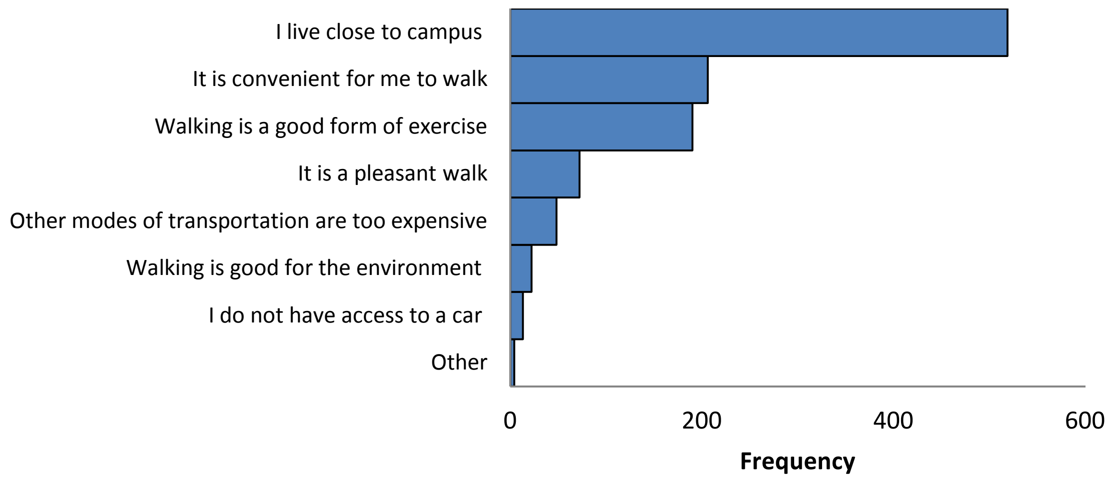

Figure 22. First motivation to walk

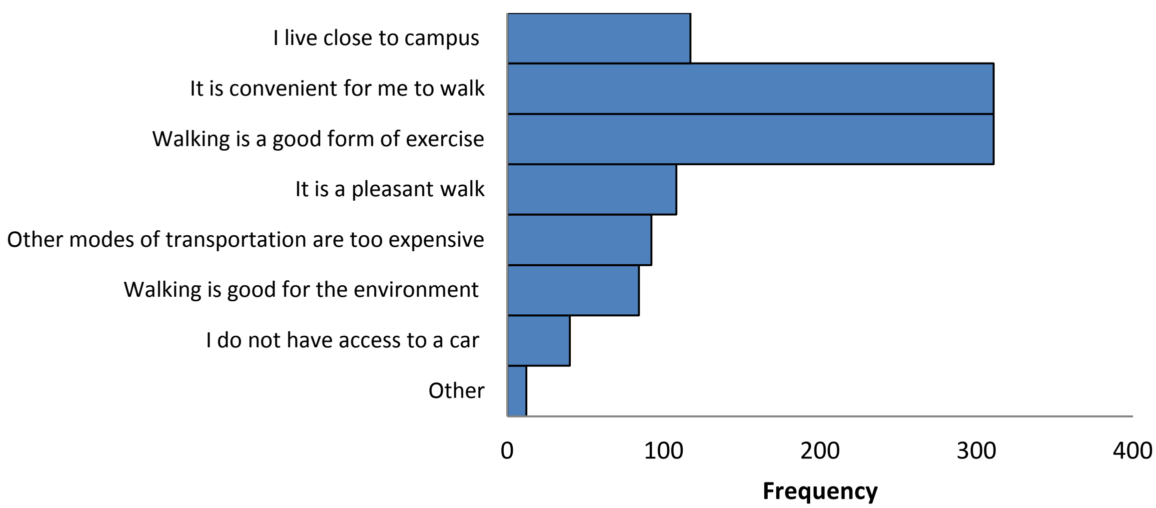

Figure 23. Second motivation to walk

Cycling

Unlike those who choose to walk, individuals who cycle are not motivated primarily because of their proximity to their destination, but rather because of the rapidity, convenience and exercise that cycling offers. If considering the second motivation, the response rate for cycling as a faster method of transportation, as a form of good exercise, and because of environmental concerns, is much higher. The distance travelled from origin to destination by public transit may be comparable to the distance one is willing to travel by bicycle, suggesting that these two modes of transportation share synonymous motivations.

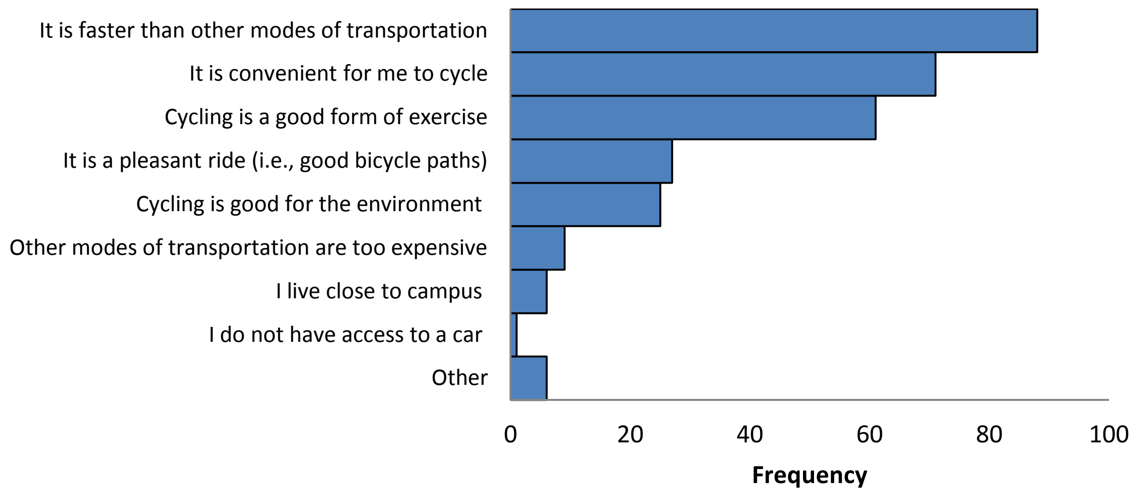

Figure 24. First motivation to cycle

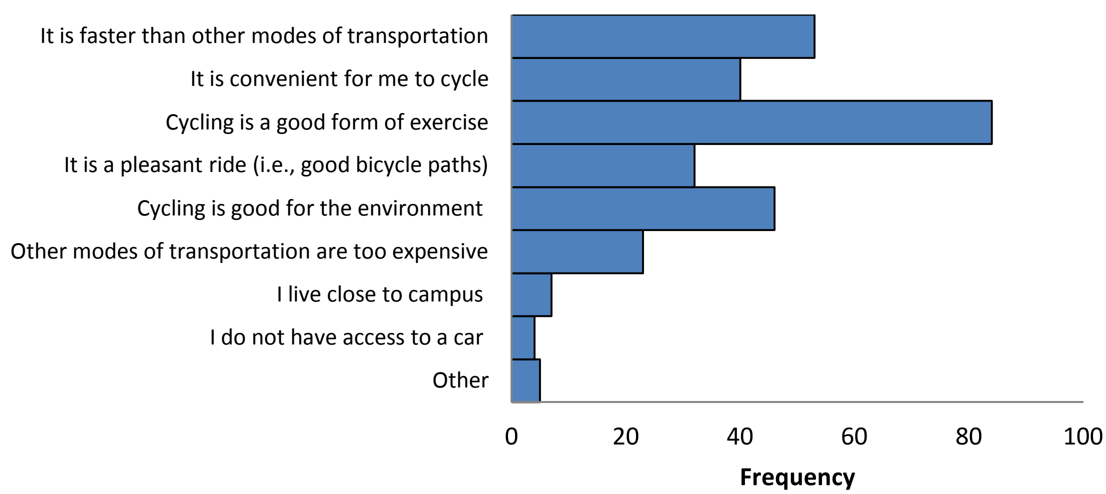

Figure 25. Second motivation to cycle

Motorized Vehicle Use

Theoretically, access to an automobile insinuates unprecedented freedom and flexibility, which explains why convenience may be cited as the primary motivation behind the use of a car. For the other majority behind primary motivation, access to a vehicle offers the fastest option to reach a destination. When considering a second motivation, the frequency of those citing the car as the fastest option outweighs convenience, but only marginally. Few other factors garner much response: recognition that a great origin-destination distance renders other modes of transportation impractical is a minor motivation behind use of the car. This may suggest that although a portion of individuals are aware of other options, regardless of the feasibility, the incentive to explore these alternatives is overshadowed by the expediency of the automobile.

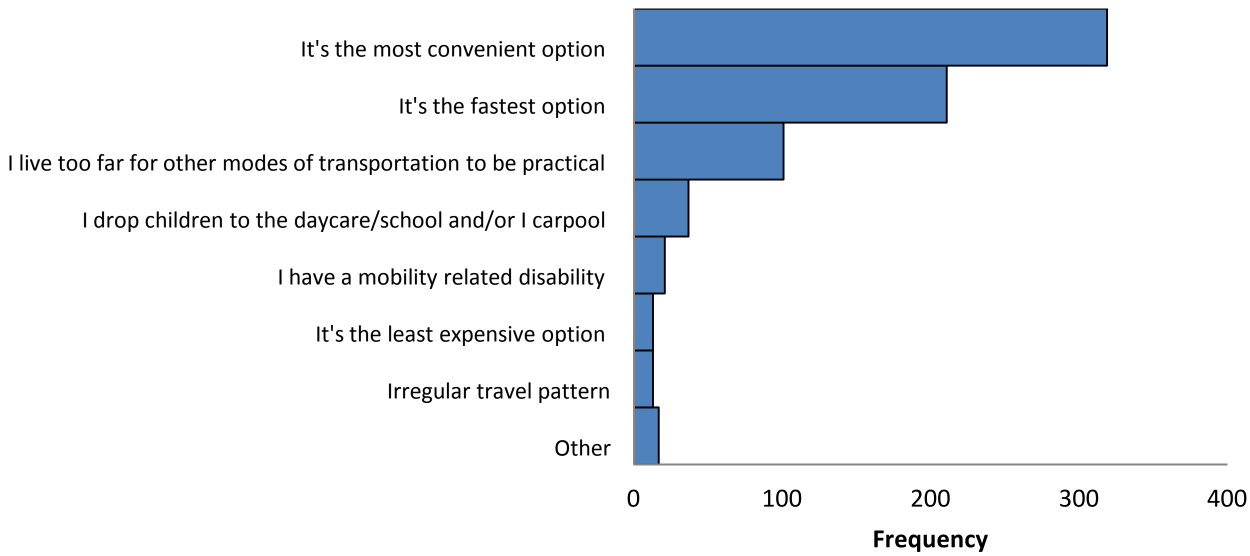

Figure 26. First motivation to use the car

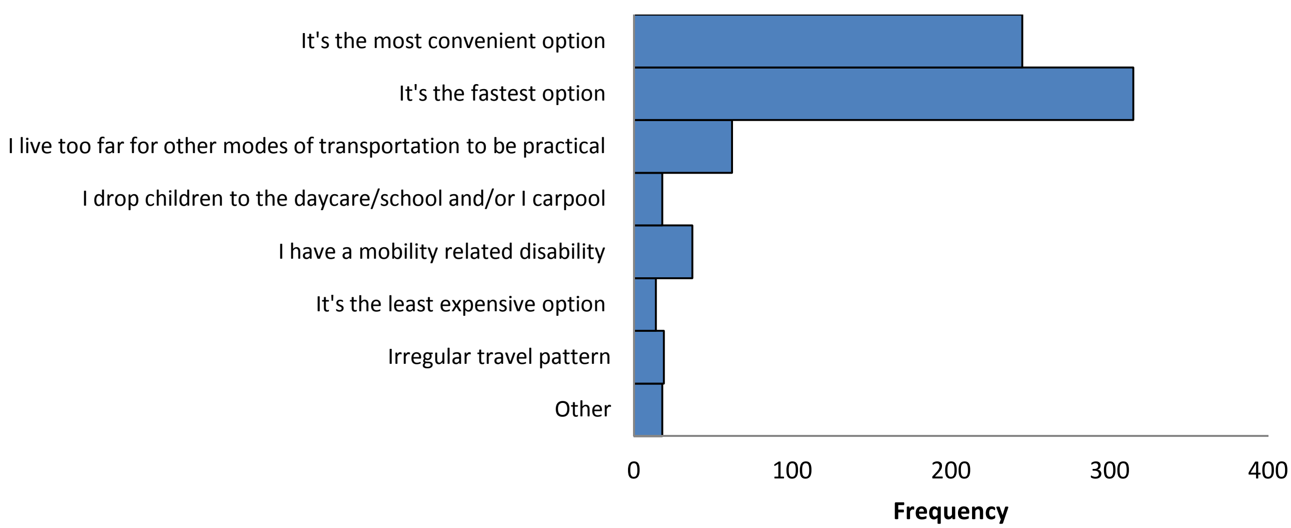

Figure 27. Second motivation to use the car

Car Ownership

Car ownership can be correlated with higher rates of usage. Where a household shares two cars, rates of active transport and public transit begin to decrease significantly, and rates of motorized vehicle use are highest. While modest rates of active transport are reported in households with one vehicle, those households lend to significant transit use. This can be attributed to households that share a vehicle between two or more individuals, resulting in one car trip to a one destination for one transit trip to another destination.

Table 1. Car ownership by primary mode

Number of Vehicles	Bicycle and Walk	Transit	Motorized Vehicle	Total
None	830	728	5	1563
1 vehicle	413	1098	297	1808
2 vehicles	105	610	365	1080
3 vehicles	20	106	65	191
4 vehicles	12	42	16	70
5+ vehicles	6	10	6	22
Total	**1386**	**2594**	**754**	**4734**

For those who do use a vehicle to access their destination, lack or difficulty in parking, whether on-site or on-street, may discourage car use. The high response rate for those being dropped off at their destination suggests that a number of individuals choose to carpool (Figure 28). Of those who do use a car, the majority of those individuals have access to on-campus parking, particularly for the underground parking lot of the McIntyre Medical building. If on-campus parking is not available, other means such as garage rental or metered parking are used, though the share of these individuals diminishes as parking options become less favourable.

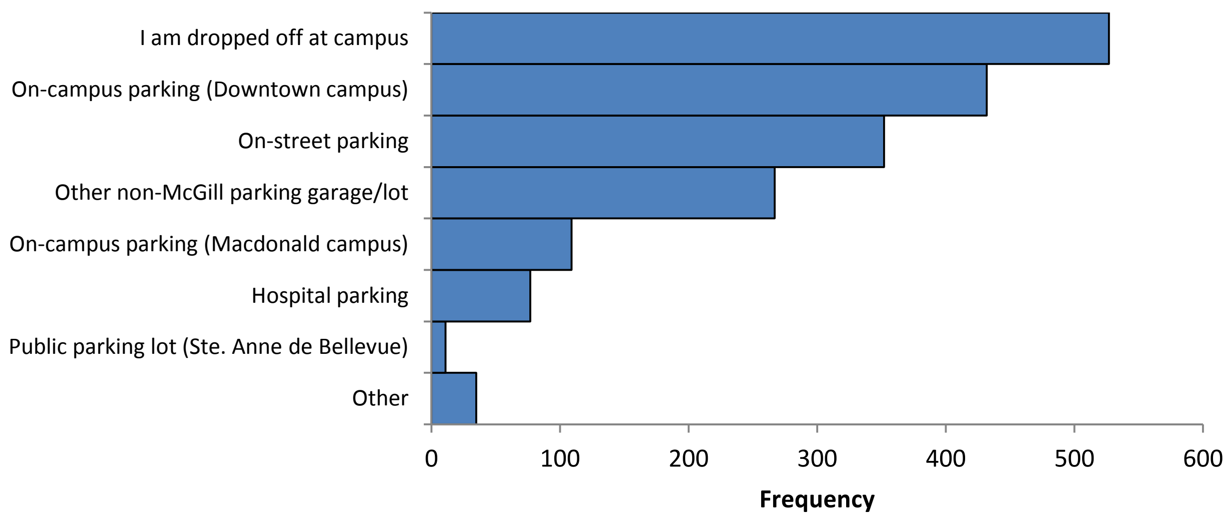

Figure 28. Where individuals who have taken the car to campus in the past month usually park

MCGILL INTERCAMPUS SHUTTLE

McGill's intercampus shuttle provides transportation between the Downtown campus and Macdonald campus for students, faculty and staff, with up to 16 round trips a day during the academic school year. As defined by the university, the primary purpose of the intercampus shuttle service is to transport students who are taking courses on both campuses and for faculty and staff who have administrative or academic university-related business on both campuses (McGill University, 2011). The shuttle carries up to a maximum of 48 students per trip, though passengers are warned of long waiting times and overcrowding during peak hours and exam periods. Access to the shuttle requires confirmation of registration at McGill in order to receive a pass. For faculty and staff, individual tickets may be purchased electronically for one-way trips, and are not reusable. Visitors may also board the shuttle with a letter providing proof of McGill or Macdonald affiliation.

A total of 262 survey respondents indicated that they use the McGill intercampus shuttle as part of their commute. Of the 262 respondents who use the shuttle, 61 respondents (23%) indicated that they use the shuttle as their primary mode of commuting, thus replacing their need for other forms of transit. Motivations to ride the shuttle are based primarily on convenience. For students with limited or no access to vehicles, the intercampus shuttle is the only option for the commute between both campuses. The shuttle makes no stops on its route and provides efficient service, though subject to construction and road delays. Convenience is cited as the primary motivation for use of the service, with a significantly higher response rate than any other option (Figure 29). Secondary motivations include the ability to engage in other activities during the trip, such as reading, which renders the trip more productive with the time spent commuting. This is closely followed by convenience, lack of access to a car, and the greater distance that eliminates the option to walk or cycle (Figure 30).

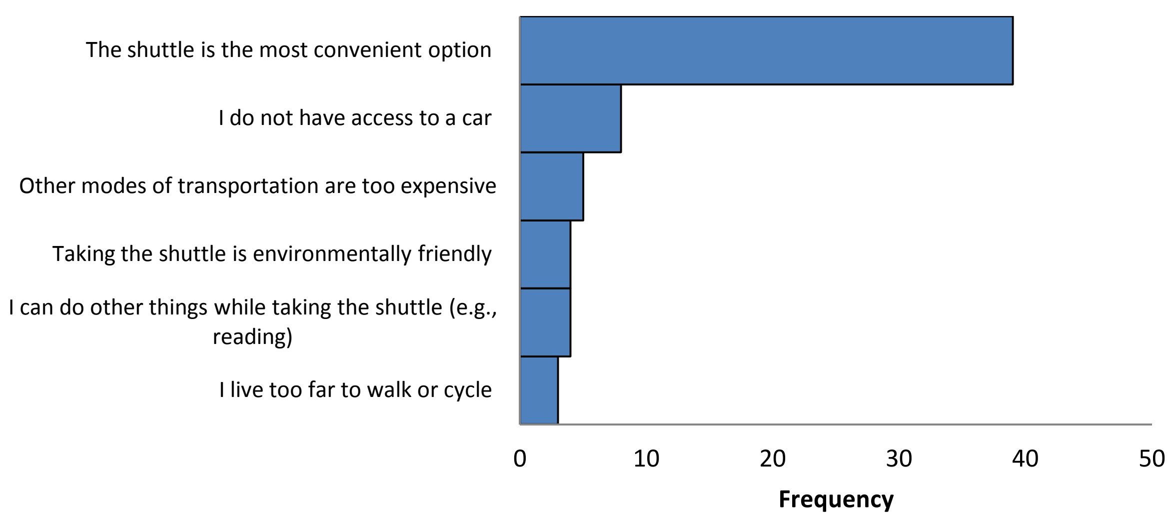

Figure 29. First motivation to use the McGill shuttle

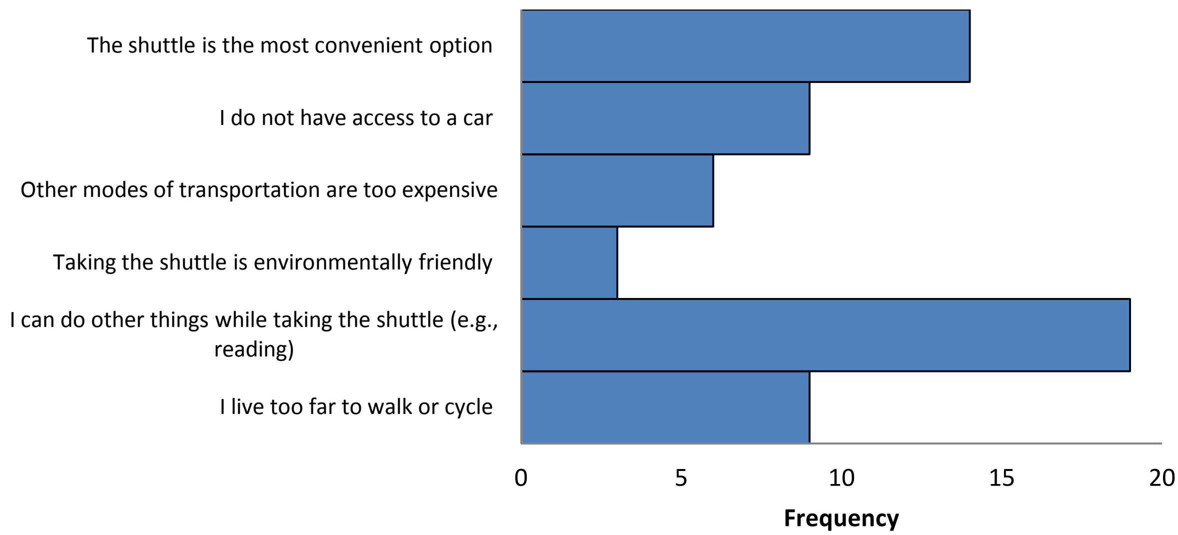

Figure 30. Second motivation to use McGill shuttle

Figure 31 confirms that the main use of the intercampus shuttle complies with what is defined as its primary purpose by the university. The service can ferry over 700 individuals in a day, whether these individuals are regular or occasional users. If a student or faculty's primary activities reside at the Macdonald or Downtown campus, the probability of a residential choice being made with this location in mind may explain why the response rate is relatively low for those who replied that the service was their main means of transport to access the majority of their daily activities.

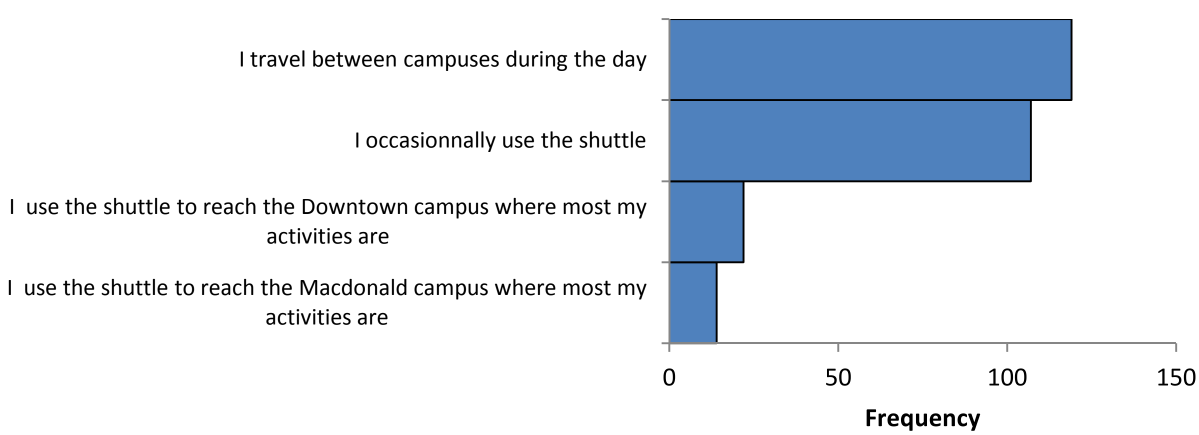

Figure 31. Reasons for using the McGill intercampus shuttle

WORKING FROM HOME

Telecommuting is an arrangement that eliminates the need to travel to an office or classroom, replaced by telecommunication links. Email, phone, video conferencing, and lecture recording enable individuals to connect to their workplace or classroom throughout the day, while eliminating the need to commute. However, the nature of the work may restrict this option, as many activities require a physical presence or the use of materials found on location. Telecommuting is especially lucrative for those who must otherwise travel greater than average distances every day. The option to telecommute is an attractive idea, though half of students and staff telecommute only once a month. Of the 3,211 individuals who identified that they are unable to work from home, 2,209 expressed interest if the nature of their work allowed for telecommuting.

Figure 32 provides a breakdown of the current rate of telecommuting among the different statuses of individuals at McGill. The greatest proportions of individuals who telecommute at least half of the time are academic staff, graduate students and post-doctoral fellows. The lowest proportions of those who telecommute are administrative and secondary staff, as well as continuing education students. Approximately 25% of undergraduate students work from home.

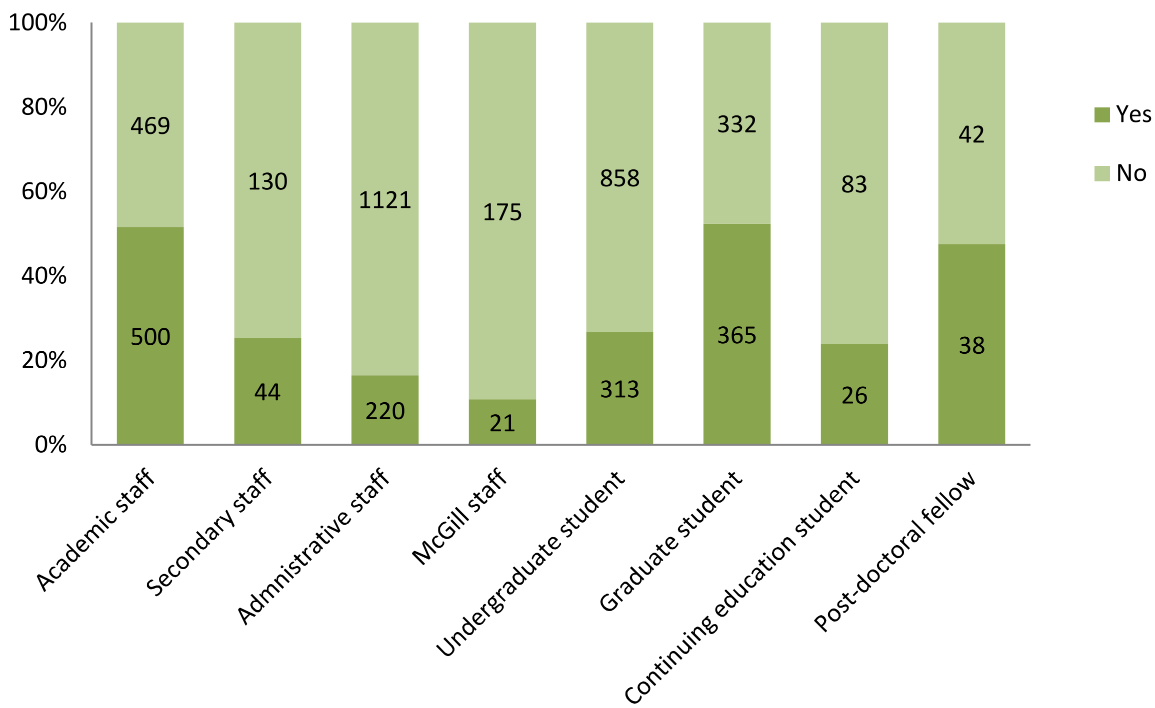

Figure 32. Telecommuters by status

Most of the academic staff telecommutes less than 5 days a month (Appendix V, Figure 58). The variety of tasks that a member of the faculty needs to undertake may not easily be done at home, such as meetings or lectures. Few faculty members telecommute over 20 days a month, indicating that their activities or research may specifically differ from the nature of work for other academic staff.

While the majority of graduate students telecommute 5 days or less per month (Appendix V, Figure 59), approximately half of this majority telecommutes between 6 and 20 days a month. Graduate students may experience more flexibility in their work hours, as the nature of their education is more autonomous than that of an undergraduate. Resources, classes and meeting require travel to and from campus, but these activities are generally more independent.

The majority of the sampled undergraduate students, though less self-governing in their academic activities, telecommute 1-5 days a month (Appendix V, Figure 60). Particularly for first-year level courses, individuals are often found in large classes that record lectures, which may be reviewed from home at a later date.

The frequency of telecommuters for employees and students with respect to the number of kilometres between their origin and destination decreases with distance (Figure 33). However, the two exponential curves follow one another closely, suggesting that both employees and students who telecommute live at the same distance from campus. The motivations to telecommute can imply similarity between these two groups of individuals in choosing to work productively off-location.

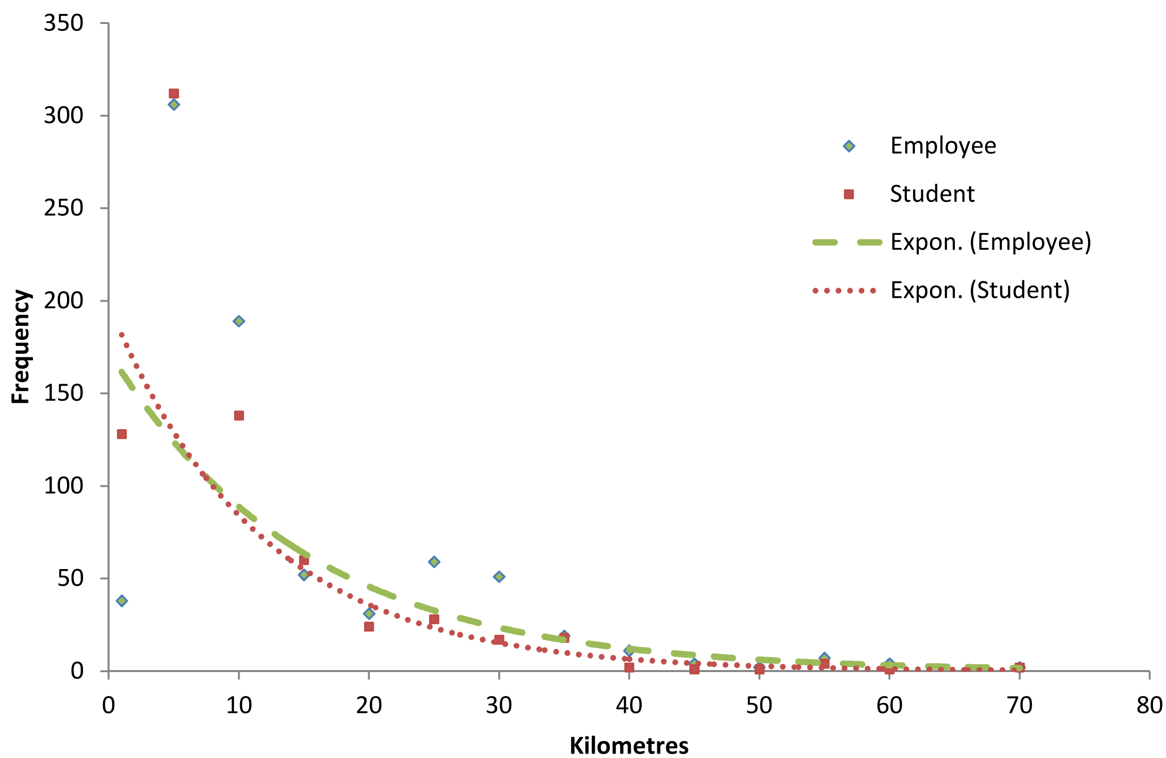

Figure 33. Distance OD McGill employees and students for telecommuters

Section IV – *Greenhouse Gas Emissions*

CONTEXT

The significant contribution of transportation to greenhouse gas emissions (GHG) is a subject that has received much attention. The literature swells with recent research demonstrating the role and potential of urban transportation in the reduction of anthropogenic GHG emissions. In 2005, transportation was responsible for 23% of world carbon dioxide (CO_2) emissions from fuel combustion, of which the road sector held the greatest share. This global trend points to increased car use, of which urban areas in Canada are no exception, both in terms of vehicle ownership and vehicle kilometres traveled (VKT). The pressure to decrease GHG emissions from the transport sector has pushed large metropolitan areas to heavily invest in transit infrastructure and promote the use of active transportation.

Many governments are aiming for major reductions in GHG generated from transport. This goal was clearly reflected in a declaration made by the City of Montreal, during the United Nations Climate Change Conference in 2005, to achieve a reduction of 30% of the community's GHG emissions by 2020. In the province of Quebec, the transport sector is responsible for 38% of total GHG production. In 2003 alone, transportation emitted nearly 14 million tons of GHG throughout the Montreal metropolitan area (Division du developpement des transports, 2008). The intent of the 2008 Montreal Transportation Plan is to significantly reduce its dependence on cars through massive investment in various forms of public transit and active transportation, including the metro, bus, train, as well as pedestrian and cycling facilities. As part of the strategy to attain these goals, the City has called upon all institutions and businesses to further the objectives of the Transportation Plan by encouraging active transportation and public transit, as well as more appropriate uses for cars such as carpooling, carsharing, and taxi service.

In light of the growing momentum behind sustainable transport initiatives in Montreal, McGill University, located right in the downtown core and one of the largest employers in the region, shares an equal concern for its carbon footprint, especially with 32,900 commuters traveling to the Downtown campus every day. In an effort to capture the travel behaviour of the McGill population, an online travel survey was designed and administered to approximately 19,662 McGill employees and students. The survey response rate reached 25%, which is comparable to previous surveys conducted in a university context (Páez & Whalen, 2010). The main goal of this study is twofold: first, to propose a methodology for estimating total GHG emissions generated by the McGill population during their daily commute to the Downtown campus, and secondly, to better understand who, how, and when each individual generating GHG commutes to McGill. We then demonstrate the value of this information in the evaluation of a range of policies and their impact on the carbon footprint of a large employer.

This section of the report commences with a review of recent research in conducting travel-related GHG emission inventories, and then continues with a discussion of data used and methodology. The results summarizing the segmentation of GHG emissions among commuters are presented, followed by a discussion supported by a scenario-based analysis of GHG reduction opportunities for McGill commuters. Finally, this section concludes with a presentation of policy recommendations.

TRANSPORTATION GHG EMISSION INVENTORIES: RECENT EVIDENCE

While GHG emission inventories are compiled at different scales (countries, cities, communities and organizations) on a regular basis, their scope and breadth, in both methodology and analysis, varies dramatically. The majority of these inventories include GHG generated from various sectors, such as infrastructure, electricity, waste and transportation. Transportation is one of the most rapidly growing sources of carbon emissions (Schipper, Marie-Lillu, & Gorham, 2000). In Canada, transportation GHG emissions have increased by 35% between 1990 and 2007 (Terefe, 2010).

Within the transportation sector, a considerable focus has been placed on comparisons of CO_2 emissions between motorized and non-motorized trips, with particular emphasis on cycling habits (Walsh, Jakeman, Moles, & O'Regan, 2008), and assessing the energy implications of such modal shifts (Lovelace, Beck, Watson, & Wild, 2011). While early works have established broad correlation between urban density and energy consumed for commuting (Newman & Kenworthy, 1988), travel-based surveys are the most effective way of highlighting the complexity of energy consumption and capturing the emissions associated with daily travel made by individuals. Ko and Park (Ko, Park, Lim, & Hwang, 2011) used travel diary surveys to identify the largest producers of CO_2 emissions in the Seoul metropolis, revealing strong associations between modal intensities and distance traveled with emitter's socioeconomic characteristics. Independent of mode of travel, location and unit of analysis, it is echoed that variables of economic and social structure significantly influence emission levels (Brand & Boardman, 2007). Regardless, no scenarios are offered to explore ways in which emissions could be reduced.

It is important to note that standard travel behaviour surveys are not always designed to capture the GHG emitted by individuals in an accurate manner. Precise estimations can only be done when travel behaviour surveys are constructed with specific questions that help generate GHG estimations for cities or large employers. A common approach to obtaining a comprehensive overview of the prevailing commuting trends, particularly for universities and institutions, is through detailed commuting surveys distributed to individuals in the academic community (as applied in (Cotnoir, 2004; Cotnoir & Chénier, 2008; Páez & Whalen, 2010; Shannon et al., 2006), among others). However, emissions calculations are largely excluded from data analysis.

Since GHG inventories continue to expand and the relationship between particular variables and high emission profiles is widely recognized, this study contributes to the literature by providing evidence for a substantial, yet overlooked niche. An online survey was designed to capture the commuting habits of the McGill population, and was specifically constructed in a way that allowed GHG estimations to become one of the main goals of the study. Accordingly, several questions were added to the survey to help accurately quantify emissions for every commuter to McGill. The use of detailed survey responses reflect the robustness of this methodology for calculating CO_2 emissions, and the alternative scenarios that are developed in the study help rationalize ways in which this carbon footprint can be reduced. The following section provides details about the survey design and the collection of information that is necessary for accurate estimations of GHG emissions.

METHODOLOGY

Following an additional series of data preparation operations, a total of 4,362 entries were found to be suitable for use in calculating CO_2 emissions for each trip. Of these useable entries, 1,038 (24%) indicated cycling or walking as the mode of their last commute (which generate no GHG emissions), whereas 2,689 (62%) indicated public transit and 635 (14%) used a motorized vehicle. Of the public transit and car user entries, only 2,208 were complete with the necessary variables that allowed for accurate GHG emission calculations. The following section will provide details of the methods used to estimate GHG emissions for these 2,208 individuals.

Calculating travel-related GHG on a trip basis requires knowledge of the particular characteristics of each trip. These characteristics include: mode used to reach destination, speed, and distance traveled. Since respondents were only asked to describe the last trip to McGill, GHG emissions are quantified only for the trip coming to the University but not for the trip back home. In the following section we will discuss the steps taken by the research team to estimate total GHG emissions generated by each individual commuting to the McGill Downtown campus.

Distances

For all 2,208 trips included in the total emission calculations, the home postal code and destination postal code were used to determine trip distance. These were calculated using network analyst in a geographic information systems (GIS) environment. For individuals using solely a motorized vehicle for their commute, distances were modeled between their home location and the McGill Downtown campus using the street centerline file as the base for the network. For individuals making transit trips, distances were calculated based on the length of the specified metro, train or bus line using the transit network. For individuals using a combination of transit and motorized vehicles (park and ride), methodologies were combined and adapted to account for distances associated with each mode of the trip. Whereas car distances are measured to the nearest transit station along the transit line that the individual reported, transit distance is measured from this point until the end of the trip along the transit network.

Speeds

Car travel times were obtained from the Ministry of Transport Quebec (MTQ), based on origin-destination travel times derived from a travel demand model for all transportation analysis zones (TAZ) in the region. In this analysis, we used the travel time matrix for the morning peak period. Every trip origin and destination was assigned a TAZ to determine speed.

For individuals using a combination of motorized vehicles and transit (park and ride), speeds were compiled for each leg of the trip where the modes differed. For the car portion of the trip, speed was derived from the travel time between their TAZ of origin and the TAZ where they boarded the first transit line that they reported in the survey. The boarding point is defined as the nearest transit stop along the reported transit line to the home location. In some cases, an individual's origin and destination fell within the same TAZ. Accordingly, travel time within a TAZ was derived based on average speed observed between the TAZs.

Meanwhile, transit travel times were derived by entering the origin (home postal code) and destination (McGill's postal code) into GoogleMaps to obtain a set of transit alternatives for every trip. These alternatives were then matched to the route that the individual reported to have used to reach the McGill campus. These matches were made by running a java script that captured travel times along the different transit modes (metro, bus and train). Correspondingly, the speeds for each type of transit mode (metro, bus and train) are based on both the GoogleMaps transit travel times, and the average values obtained from the regional transit bodies, the Societe de Transport de Montreal (STM) and Agence Metropolitaine de Transport (AMT). While the metro and train have relatively stable speeds (40 k/hr and 80 km/hr, respectively), buses are reported to travel an average of 18 km/hr.

GHG Emission Factors

Emission Factors for GHG were generated for each travel mode in grams of CO_2 equivalent per kilometre per passenger dependent on speed and vehicle type. Whereas car speeds vary by trip, the analysis is based on the assumption that buses, trains and metros run at an average speed, as given by the STM and AMT.

For motorized vehicle users, the survey asked each individual to report the type of vehicle used for the commute and the number of individuals in the vehicle, allowing the total emission of a car to be divided by the reported occupancy, where applicable. Emission factors for motor vehicles were derived from the MOVES model developed by the USEPA, and fitted with input data reflecting the Montreal vehicle fleet. Emission Factors for passenger cars were found ranging from 180g per Km.vehicle at a speed of 90 Km/hr to 650g per Km.vehicle at a speed around 6Km/hr. Emission Factors for SUVs were higher, varying between 230g/Km.vehicle and 770g/Km.vehicle.

The values for transit were based on the numbers reported by the regional transit authorities. The STM buses emit around 1,600 g/Km, divided by an average occupancy of 40 people, resulting in 40g/person.Km. The AMT trains emit around 80g/person.Km. Meanwhile, the metro, by utilizing hydroelectric power, is reported to emit 0g/Km. The McGill intercampus shuttle, a converted school bus, emits around 2,000g/Km and is divided by an average load of 40 people, resulting in a value of

50g/person.Km. The following table compiles these emission factors for all modes taken by survey respondents:

Table 2. Emission Factors for Motorized Vehicles and Transit

MODE TYPE	SPEED (KM/HR)	EMISSION FACTOR (G/KM.VEHICLE)	SOURCE
Passenger Car	<=4 - 90	1170 - 180	MOVES
SUV	<=4 - 90	1380 - 230	MOVES
Hybrid vehicle	<=4 - 90	100	MOVES
Metro	40	0	STM
Bus	18	40	STM
Train	80	80	AMT
McGill Shuttle	40	50	MOVES

Expansion Factors

Since the sample size of the survey does not correspond with the real number of individuals commuting to McGill, the number of respondents was expanded to represent the entire population. During the survey process, McGill provided the research team with the postal code associated to each student (graduate and undergraduate) and employee (faculty and staff). This information was used to select the random sample of students to whom the survey was distributed. This information was grouped by Montreal borough. In the survey, students and employees were asked to report their home postal code. This information was linked in GIS to the borough. Two expansion factors were derived by dividing the number students and employees in each borough by the number of students and employees residing in this borough in our sample. This expansion factor was also based on the bias that is present in our sample between students and employees, since more employees were sampled than students. New CO_2 totals were computed based on the expansion factors of these individuals to estimate a total carbon footprint for the entire McGill community.

Discounting for Actual Trips

In recognizing that the number of individuals who commute to McGill varies every day, it would be wrong to assume that the entire sample took a trip to McGill on the same day. Part-time employees, flexible student schedules, and the option to telecommute all affect the real number of commuters per day. To justify this, the sample size was discounted to only those respondents who indicated a trip was made the day before the survey was completed. For example, if one individual finished the survey on the 10^{th} of April and reported his last trip to be on the 8^{th} of April, he was excluded from the total GHG calculations. The only exceptions were for those who completed the survey on a Sunday (or up until 9 am on Monday), in which case the last trip could have been two days prior to the completion of the survey. Once these individuals were filtered, we are left with 85% of the original sample size.

RESULTS AND DISCUSSION

Recall that the survey was conducted in March and April, which in Montreal characterize typical winter months. We estimate that on a single winter day, commuters to McGill's Downtown campus generate around 31.1 tons of CO_2 equivalent on their travel **to** McGill. During the fall, this amount decreases to 29.5 tons of CO_2 equivalent. These values can be further divided between types of commuters: during the winter season, faculty and staff generate 16,230 kg of CO_2, while students generate 14,790 kg of CO_2. For a commute during the fall, these numbers shift to 15,305 kg of CO_2 for faculty and staff, and 14,098 kg of CO_2 for students. These values can be translated into emissions per commuter to McGill's Downtown campus. On average, an employee emits around 1.8 kg/ CO_2 and a student emits 0.71 kg/ CO_2 on a typical winter trip. During the fall, an employee would produce in average 1.7 kg/ CO_2 and a student would produce 0.68 kg/ CO_2 in their daily commute to McGill's Downtown campus. Note that these emissions per commuter reflect lower than average values because they are normalized for all commuters, including cyclists and pedestrians who do not produce any GHG during their commute.

Who is Emitting?

The goal of this section is to understand who is emitting the most among the different groups commuting to McGill's Downtown campus to help in generating policies that can target the highest GHG emitters. Accordingly, the values used in this section are derived directly from the survey sample, without any expansions. When generating averages, cyclists and pedestrians are excluded from the following analysis, leaving only the commuters who contribute to the total carbon footprint. It is important to note that the reported values are relatively conservative: the travel times for a morning commute to McGill's Downtown campus are based on a travel time matrix (TAZs) where the average speed is around 24 km/hr. Cars travelling at this speed have higher emission factors (313 g/Km for passenger cars, and 374 g/Km for SUVs).

Gender

While the highest emitters, on average, tend to be among employees, further variables can be used to describe these individuals. A male faculty or staff contributes an average of 2,175 g per day when commuting to McGill's Downtown campus, while a female would contribute 2,058 g. Among the students, however, a female contributes 977 g and a male contributes 835 g per trip.

Age

Figure 34 shows the age distribution for McGill's employees and students on the X-axis and the average GHG emitted by individuals in this age group on the Y-axis. A secondary Y-axis is included to show the number of respondents from the McGill survey who falls in this age category. The average age of the highest emitters falls into the same age category for both employees and students. Individuals between the ages of 41-50 emit an average of 2,431 and 2,504 g for students and employees, respectively.

However, only 24 students fall into this age bracket, compared to the 425 employees aged 41-50 in our sample. The majority of students fall between the ages of 21-30 (495 respondents), yet a student commuting to McGill's Downtown campus in this age category only contributes an average amount of 752 g.

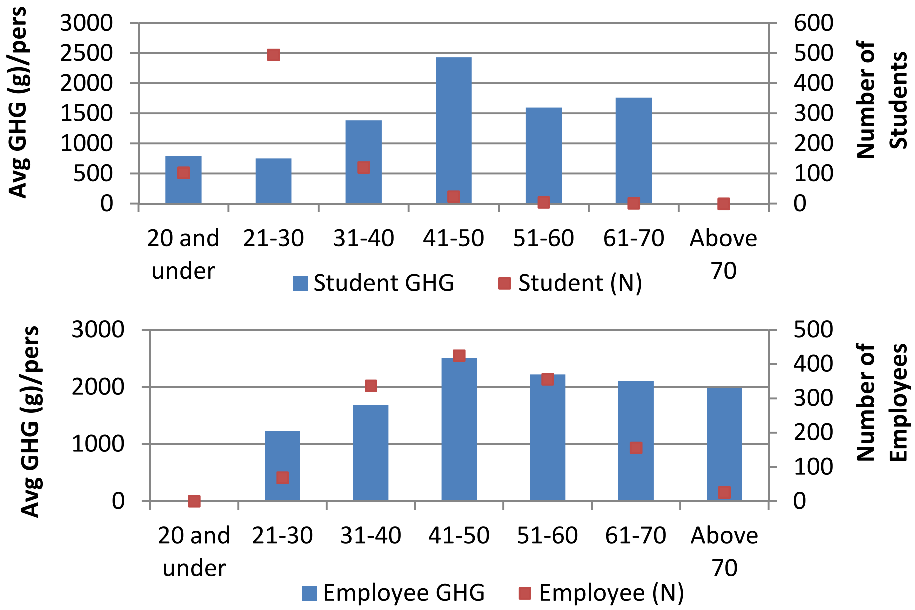

Figure 34. Average GHG for Employee/Student by age

Status

Out of all employees, security maintenance personnel have the greatest average emissions 2,965g/person. The second two groups that have the highest emissions per commuter are adjunct faculty and continuing education students, with CO_2 emissions around 2,000 g/person for both. Post-doctoral students contribute around 767 g/person, whereas undergraduate and graduate students contribute around 850 g/person. However, the higher contribution of emissions by faculty and staff may be explained by the larger share of users who park and ride, or use motorized vehicles, which emit 3,746 g/person and 4,137 g/person respectively.

How Are They Emitting?

Mode Choice

Figure 35 shows the mode split for McGill's employees and students on the X-axis and the average GHG emitted by individuals using this particular mode on the Y-axis. A secondary Y-axis is included to show the number of respondents from the McGill survey who fall into each mode of transport. The average GHG per person based on mode split follows a similar pattern for both employees and students. As expected, drivers emit the most CO_2, and transit users emit the least. With average GHG emissions that are almost comparable to drivers, park and ride individuals heavily outweigh their savings in emissions by taking transit with the use of their car to access transit. This difference in savings is particularly stark, as transit emits significantly less CO_2 than any other mode (751 g/person and 308 g/person for employees and students, respectively). McGill operates a shuttle bus between its two campuses, and several students and employees that reside near one of the two campuses use the McGill shuttle to commute between campuses. The Macdonald campus, located at the tip of the island of Montreal, is less than 40 km away from the downtown core. The shuttle bus in operation is a retrofitted school bus. For shuttle users, students are far more likely to use the service, as the intercampus shuttle is severely limited to faculty and staff, which explains the larger quantity of CO_2 produced by students on the shuttle, as compared to employees utilizing this service.

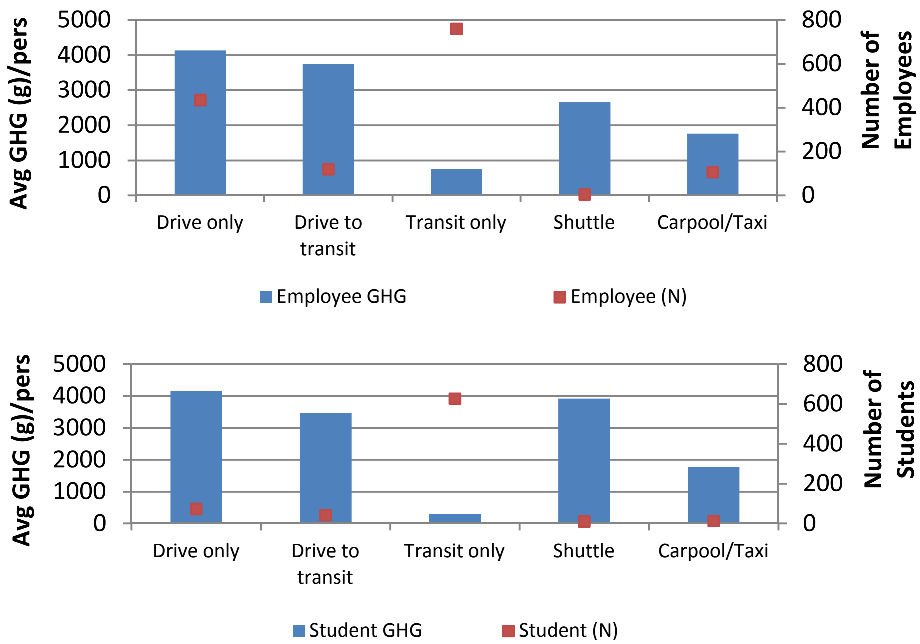

Figure 35. Average GHG for Employee/Student by mode split

When are they emitting?

Emissions by Season

Montreal's long winters often create difficulties for commuters, particularly after large snowfalls and during below-freezing temperatures. The expanded total of emissions during a winter commute is 31.1 tons, whereas a fall commute emits an average of 29.5 tons, resulting in a drop of over 1.5 tons of CO_2 between seasons. For GHG emitters, the difference in the contribution of CO_2 among students is less than 1 ton (692,199 g) between seasons (14.8 tons and 14.1 tons in the winter and fall, respectively). Meanwhile, faculty and staff see a slightly larger difference of nearly 1 ton (925,374 g) between seasons. However, if active transport users are included in the sample size and then expanded to the entire McGill community, a winter trip would emit 1,797 g per-employee, versus 1,694 g for a fall trip. Emissions per-student are significantly less, resulting in 714 g for a winter trip and 680 g for a fall trip.

While the difference per-employee is about 100g, the per-student value has a difference of around 40 g. Overall, this may explain that active transport users are severely limited by the harsh climate, signifying a shift towards transit or motorized vehicles during these conditions.

Emissions by Season and Mode Choice

Based on expanded numbers, the variation of emissions based on season can be further dissected to analyze the differences in mode choice among students and faculty/staff. As shown in Table 2, all emissions are lower in the fall compared to the winter season. The most notable shift is in the difference of CO_2 emitted from employees who choose a motorized vehicle for their commute. Winter CO_2 emissions from this mode increase by over 0.5 tons per day. Meanwhile, a shift in transit emissions is only marginal for employees.

Table 3. Seasonal emissions among employees and students by mode choice

	TRANSIT ONLY	DRIVE ONLY	DRIVE TO TRANSIT	CARPOOL/TAXI	SHUTTLE
EMPLOYEES					
Expanded GHG Winter (t)	2.78	10	2.287	1.144	0.017
Expanded GHG Fall (t)	2.634	9.494	2.102	1.056	0.177
STUDENTS					
Expanded GHG Winter (t)	4.4	5.452	3.597	0.607	0.733
Expanded GHG Fall (t)	4.243	5.249	3.415	0.574	0.616

For students, the largest difference in CO_2 emissions is for those who primarily drive to McGill, closely followed by those who use a combination of transit and motorized vehicles. The seasonality of these emissions can also be observed spatially. Figure 36 shows the percentage change in the total CO_2 emitted from commuters to McGill's Downtown campus from different boroughs, comparing winter to fall seasons. It is clear that the largest change in emissions occurred on the island of Montreal, while commuters coming from the far suburbs generally do not deviate from their typical mode, resulting in a contribution of the same amount of GHG emissions over the year.

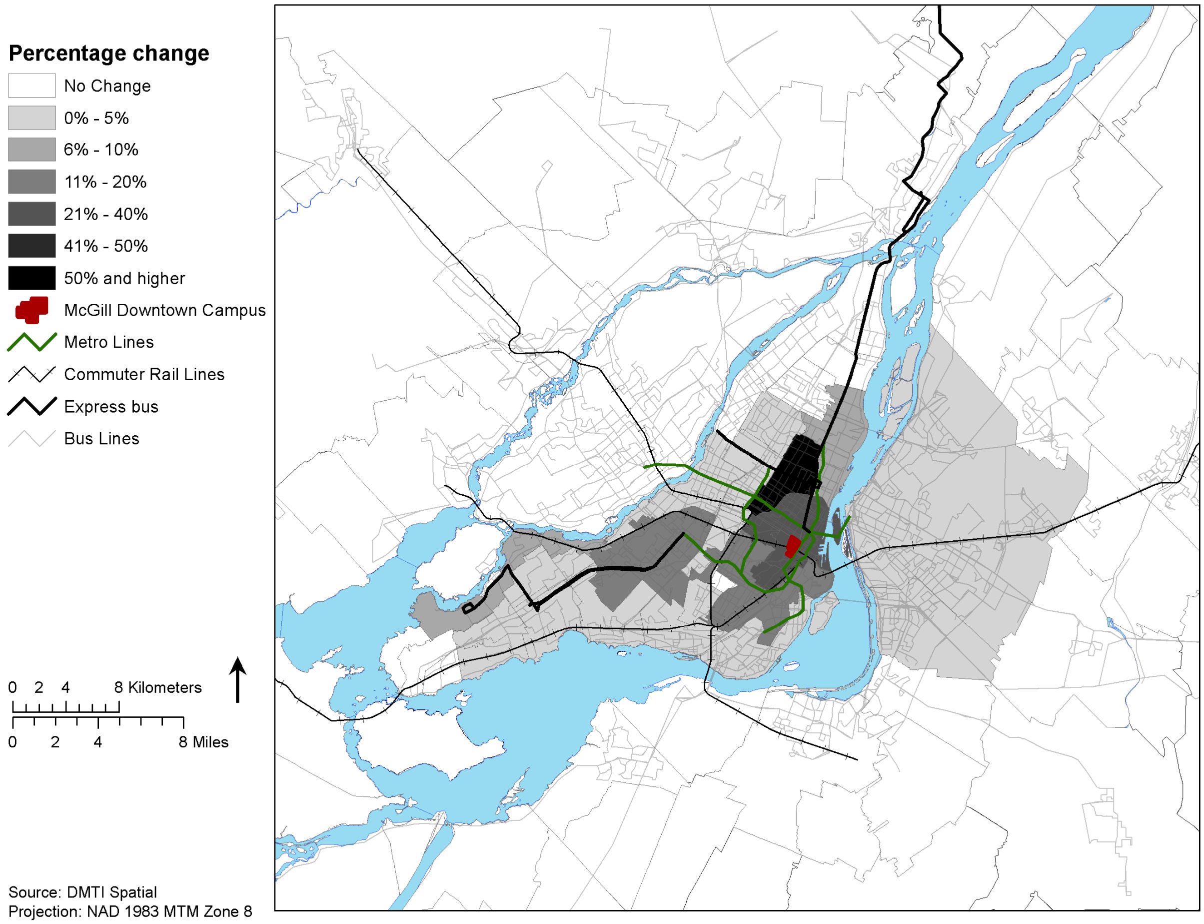

Figure 36. Percentage changes in seasonal CO_2 emissions from commuters to McGill's Downtown campus from different boroughs

Emission Scenarios

With a comprehensive understanding of who, how and when each individual generating emissions commutes to McGill, five alternative scenarios are presented to offer large institutions, like McGill, pragmatic approaches that could help reduce the community's carbon footprint. These scenarios are based on specific information collected by the survey to determine the viability of a mode shift among certain groups of individuals in reducing total GHG emissions.

Base Case: Represents the average amount of GHG that McGill commuters emit on a typical winter day when commuting the Downtown campus, which is estimated at 31.13 tons of CO_2. All further scenarios are compared against this average contribution.

Scenario 1: Illustrates the potential emissions if all drivers, who indicated that they took transit at least once to reach McGill in the past year, switched to transit for their commute. These typical drivers could be seen *as irregular transit users*, indicating that a transit option is available, whether or not the driver makes use of it, and can be repeated again. This scenario totals 24.51 tons of CO_2, saving around 6.62 tons of CO_2.

Scenario 2: Represents viability, rather than irregularity. Viability is defined by a commute that falls within a threshold of travel time that is reasonable enough to convince individuals to switch modes. To determine this threshold at which another mode option is practical, the average time a transit user spent in transit was divided by the average time a driver spent in a car, resulting in a ratio of 1.3, indicating that a transit user's trip is on average 30% longer than a driver's trip. In order to convince drivers to switch to transit, a commute done by transit could not exceed the typical time a driver spent to reach McGill: while a 30% longer trip is ambitious, a 20% longer trip is a more conservative threshold for encouraging this mode shift. A threshold was also determined for the viability of switching to active transportation: if an individual could reach campus with a 15 minute bicycle ride or a 20 minute walk from their home location, active transportation is considered feasible. Thus, Scenario 2 represents a shift towards modes that would either emit no CO_2, or emit less CO_2 than their original trip. All drivers for whom it is viable to cycle or walk were switched, followed by drivers who can take a viable transit trip, and then followed by all transit users for whom it is viable to use active transportation. This scenario totals 26.2 tons of CO_2, saving around 4.93 tons of CO_2.

Scenario 3: A combination of the opportunities from Scenario 1 (irregularity) and Scenario 2 (viability) are grouped together to represent a more comprehensive mode shift. This means all drivers who are irregular transit users switch to transit, and all other individuals switch to the next best viable alternative, whether that means drivers take transit or use active transportation, and transit users switch to active transportation, wherever it is feasible. This scenario totals 21.74 tons of CO_2, and saves around 9.39 tons of CO_2. Because this scenario is considered the best case in terms of a reduction in total $CO_{2,}$ the spatial distribution of this scenario can be of interest to decision makers. Figure 37 shows the spatial distribution of the percentage decrease in total CO_2 emitted by commuters from every borough to McGill's Downtown campus. The percent decrease in emissions is compared to the base case.

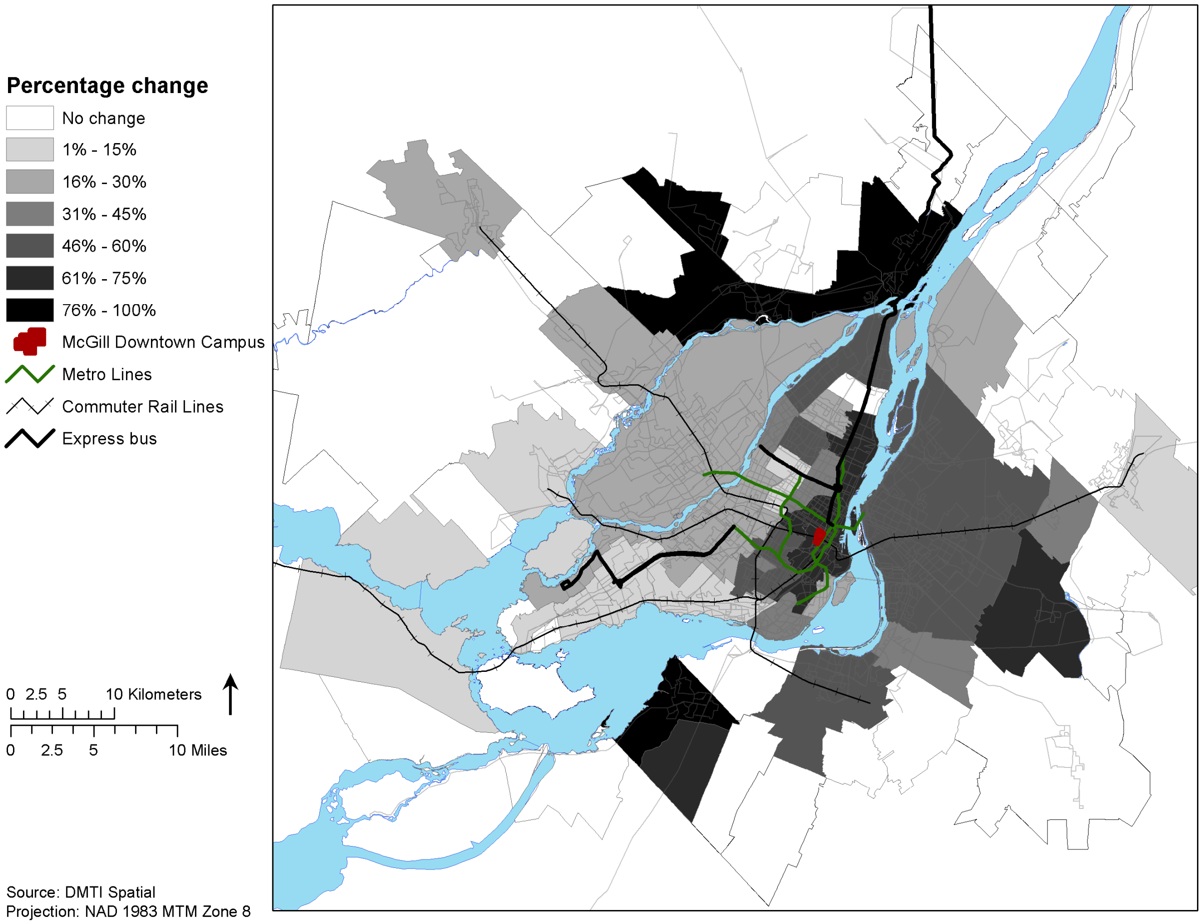

Figure 37. Percent change of emissions from Base Case to Scenario 3

Scenario 4: This scenario contrasts Scenario 3 by offering the worst outcome. This scenario assumes that if all survey respondents indicated they used a vehicle to commute from their home location to McGill's Downtown campus in the past year, they could switch to this mode. These individuals would be *irregular drivers* who become regular drivers, as opposed to Scenario 1, where all individuals that are drivers and *irregular transit users* become regular transit users. This scenario would amount to 52.41 tons of $CO_{2,}$ adding around 21.28 tons of CO_2 to the base scenario.

Scenario 5: It must be recognized that the number of individuals who commute to McGill varies by day, implying that we cannot assume the entire sample commuted to campus on the same day. Yet if this was the case, and all McGill Downtown campus commuters were required to be present on campus, emissions would amount to 40.57 tons of CO_2. This scenario adds around 9.44 tons of CO_2 per day to the base scenario. However, option to telecommute is available to most of the McGill community. Students can have flexible schedules, and many employees are part-time. This scenario highlights the importance of flexibility in a work schedule, and considers the choice to work from home as a valuable opportunity that should be recognized by the University.

Figure 38 shows a comparison between the different scenarios generated in this section. Whereas scenarios can often be mistakenly hypothesized, these alternatives are unique because a pragmatic approach was used in their design, resulting in all scenarios representing reasonable outcomes. The worst case scenario was specifically refrained from modeling situations where all individuals in the sample drive, regardless if they live within a 2 minute walking distance. The strength of these scenarios lies in our calculation of all travel times and distances for all individuals using all types of modes, which allows us to determine the number of respondents who realistically *could* use a mode that differs from the one they reported.

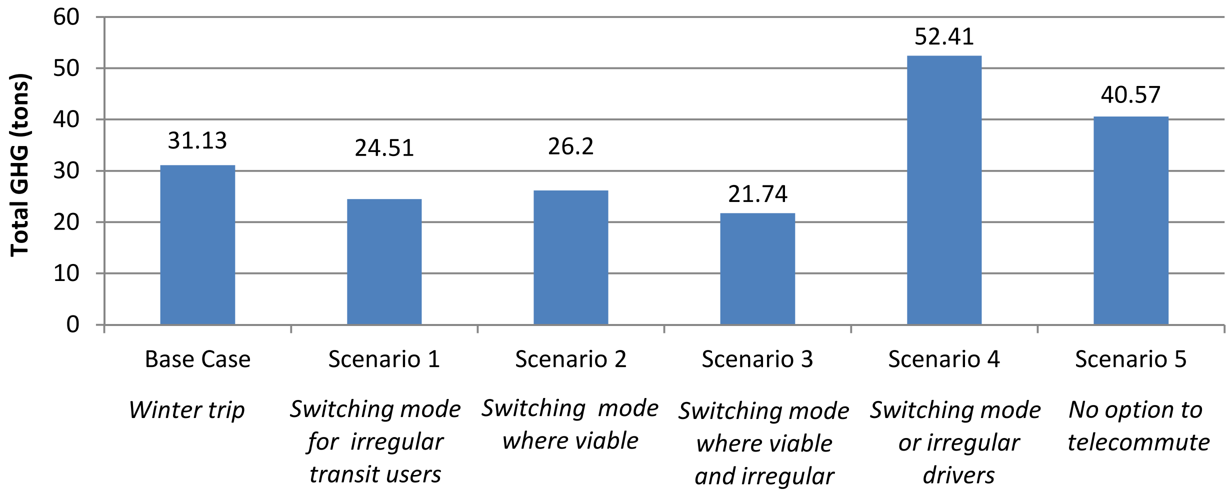

Figure 38. Total GHG (tons) by Scenario

CONCLUSION

This study first set out to calculate CO_2 emitted by individuals commuting to McGill's Downtown campus. In order to harness the variations in modes and distances among the community, a methodology was developed to account for these effects. The design of the survey allowed for certain pieces of information to be teased out: not only does this method involve multiple modes across a large sample region and individuals' sociodemographic characteristics, specific patterns such as seasonality help to further the analysis. Seasonality holds particular weight, as Montreal endures below-freezing temperatures and longer than average winters. Supporting variables add to the explanation of who, how and where commuters access McGill's Downtown campus. Whereas there is little variance in gender, status and mode split differ among survey respondents.

Scenarios were developed based on the analysis of the survey, and their implications are unique: they entail situations that *could* happen, and not necessarily what should or would happen. Although they represent reasonable alternatives, there are limitations to change. The travel behaviour of certain boroughs is resistant to mode shift, and regardless of these reasonable thresholds, not all individuals will take transit, or start cycling. Transit service and active transportation facilities will have to improve in order to attract riders to switch modes. Nonetheless, the pragmatism of these scenarios is reflected in the calculations made for every individual using all variations of mode split. Switching individuals from one mode to another was done by a careful evaluation of the opportunities present in the viability and irregularity of mode options. In addition, an alternative was modeled to reflect the importance of flexibility in a work schedule, particularly for large employers like McGill: if the entire community had to travel to the Downtown campus every day, an additional 9.44 tons of CO_2 would be emitted per day.

Finally, the context of this study is pertinent to initiatives of the Montreal Transportation Plan. Through massive investments in infrastructure and service, the city is reimagining its transportation network in order to achieve the goal of a 30% reduction in this sector's share of GHG emissions by 2020. However, the Transportation Plan underlined the need for cooperation and leadership among all stakeholders, particularly large businesses and institutions, if these goals are to be met. Large employers have significant leverage for encouraging a shift in travel behaviour. By developing a robust methodology and critically analyzing its results, we have identified and explored these commuting patterns, and thus contributed to McGill's efforts to react and reduce, as called upon by the city of Montreal.

Section V – *Types of Commuters*

CONTEXT

To effectively encourage the use of sustainable modes of transportation for commuting trips to campus, it is important to first gain a concrete understanding of the prevailing types of commuters. Previous literature has focused primarily on the reasons behind travel behaviour, with only a few attempts to classify types of travelers into different transport market segments. The prevailing approach to transport market segmentation has defined two types of users: “captive” and “choice”. This paradigm have been widely used and accepted as a means of categorizing and understanding mode choice and travel behaviour for well over thirty years.

Despite their widespread use, the meaning of the terms captive and choice as descriptors for travellers is rather ambiguous, and can result in conflicting interpretations, especially from the point of view of a transit agency versus an individual user. A transit agency, for example, is concerned with ridership and therefore perceives captive riders as a means to guarantee profit. This may create a situation where captive users are “taken for granted” by transit agencies since it is assumed that these individuals will always use transit no matter the quality of the service provided (Beimborn, Greenwald, & Jin, 2003). Moreover, even captive users potentially have a choice in the long-term if their situation happens to change; for example, if they acquire the resources to purchase an automobile (Beimborn, et al., 2003; Morison, 1982). However, the policy implications of these conflicting interests have been largely overlooked and unquestioned.

Conventional market segmentation approaches have been primarily concerned with whether or not individuals have an alternative choice, but ignore whether these alternatives are more practical or enjoyable than the chosen mode or route. This could contradict the notion of captivity or choice. For instance, an individual can have limited travel options but enjoy the mode they use, thus rendering the term captive irrelevant or misleading. In addition, these approaches have focused primarily on public transit and automobile users while ignoring active modes such as walking and cycling, leaving a considerable gap in existing transportation literature and our understanding of types of travelers.

Using a combination of statistical clustering techniques, this analysis uncovers different market segments that are applicable to the four main modes of transportation observed in the results of the 2011 McGill Transportation survey: walking, cycling, public transit, and private automobile. The resulting classification of travelers will prove useful for the University’s future endeavours to promote the use of sustainable modes of transportation through targeted efforts. In addition, the resulting understanding of commuter types will be largely applicable to other contexts, thus filling a gap in existing transportation research and policy.

DATA & METHODOLOGY

Data Preparation

For the purpose of this study, additional data cleaning was required to remove entries that were missing information relevant to the study or that were not representative of the modes examined. Removed entries include: individuals living outside of the Montreal metropolitan region (such as those commuting from Ottawa, Ontario); individuals identifying themselves as “visitor” and “other”; individuals commuting by motorcycle, scooter, taxi or the McGill intercampus shuttle, as there were far too few individuals to warrant clustering for these modes; and entries for which the age or sex were not indicated.

The modes of transportation examined in this analysis are walking, cycling, public transit (bus, metro and commuter train), and motorized vehicle (drive and carpool). To ensure that trip satisfaction and transit trip details were included for each respondent, their “primary mode" was matched to either of the detailed trips described by the survey respondent (either the fall or the winter trip). In cases where the indicated primary mode did not match the mode described in either of the detailed trips, the entry was excluded from the analysis. For walkers, additional entries were removed when they were found to have indicated unrealistic walking distances or the respondent lived on campus.

Trip distances were measured along the network using geographic information system (GIS) software, linking the home postal code to the campus destination indicated by the survey respondent. This distance was then used to generate the travel time for each respondent. Past research has proposed an average speed of 5.47 km/h and 15.94 km/h for walking and cycling trips, respectively (El-Geneidy, Krizek, & Iacono, 2007; Horning, El-Geneidy, & Krizek, 2007). These speeds were used to generate approximate travel times. Car and carpool travel times were obtained from the Ministry of Transport Quebec (MTQ), using speeds derived from a travel demand model measuring speeds between transportation analysis zones (TAZ). In this analysis we used the travel time matrix for the morning peak period. Every trip origin and destination was assigned to a TAZ to determine the trip speed. This method of travel time derivation was chosen over using the free-flow speeds derived from GIS software to avoid any under estimations in travel time calculations.

A set of transit alternatives was obtained by entering the home postal code as well as the postal code of their destination (section of the campus) into the Google Maps transit application. For transit users, these alternatives were then matched to the transit trip routes reported by the respondent. This was done by running a java script which captured all of the pieces associated to the travel time along the different transit modes (bus, metro or commuter train) including in-vehicle time, walking time, and waiting time. Several studies have shown that the out-of-vehicle times have more influence on individual’s decision to use transit than simply the in-vehicle travel time; therefore, the inclusion of these times better represents the way individuals perceive the overall transit travel time (Beimborn, et al., 2003; Morison, 1982). Only individuals that walked to transit could be matched to the Google routes, therefore park-and-ride users were excluded from this analysis. For individuals using a mode other than transit as their primary mode, the shortest transit trip option was used to generate the hypothetical transit travel times.

Once the data preparation operations were complete, a total of 3,002 observations were found to be suitable for this analysis, including 1,193 transit users, 254 cyclists, 928 walkers, and 627 automobile users.

Mode-Based Cluster Analysis

A two-step cluster analysis was performed for each of the four modes of transportation examined in this study. The two-step cluster was chosen for these mode-based analyses, as it is a recognized clustering method for dealing with both categorical and continuous variables (Norusis, 2010). The goal of these cluster analyses was to identify distinct groups of individuals within each mode category, using several key variables from the survey results. Table 4 provides a list of the variables included in the analysis for each of the four modes examined.

The number of years an individual has been involved with McGill was used as an indicator of familiarity with the transportation options available to arrive at their destination, such as transit route or cycling lanes and paths. Age was inputted primarily to make the important distinction between a young active student who walks or cycles and an older person who is likely to have other options and/or is less likely to engage in physically demanding transportation. The travel time was included to get a sense of the distance which individuals travelled between their home location and a McGill campus; higher than average walking or cycling times could indicate dedication to the particular mode. The year-round variable was used as an indicator for dedication and practicality, an important variable given the region's harsh winters. Trip satisfaction, an important distinction of this dataset, is used in the analysis to show the level of enjoyment the individual derives from their current trip.

Trip utility is meant to capture the level of practicality for each trip taken compared to the most realistic alternative for the same trip. For cycling and walking trips, transit was used as the alternative, since it is less likely that an individual using an active mode of transportation would travel by automobile rather than taking transit because they do not own a car, or for environmental, practicality or cost reasons. Similarly, transit was used as the next alternative for automobile trips, since it is unlikely that individuals traveling by automobile would switch to an active mode due to potentially long travel distances. For transit trips, the automobile was used as the next alternative, since some individuals using transit may live too far to realistically commute by active transportation. Several trip utility variables were tested, and it was found that the selection of transit as the trip alternative yielded a similar output to including other trip utility variables for every alternative mode. As the relationship between hypothetical walking and cycling times is constant, this value added nothing to the analysis. Accordingly, using transit alternative as the base for measuring trip utility enabled a reduction in the number of variables included in the cluster analyses.

Trip utility was calculated as the ratio between the travel time of the alternative trip option and the travel time for the mode actually used for the trip. Values above one indicate that the chosen mode has a higher utility (is faster) than the alternative mode, whereas values below one indicate that the alternative mode has a higher utility (is faster) than the mode chosen. For example, a utility value of 2 indicates that the mode chosen is twice as fast as the next best alternative mode, and a utility of 0.5 indicates that the chosen mode is half as fast as the alternative mode.

For transit users, a series of additional variables describing the details of their transit trip were included in the cluster analysis, to provide an indication of the complexity or simplicity of the transit trip. For automobile users, a dummy variable indicating whether or not individuals carpool is included in the analysis.

Table 4. List of Variables in the Cluster Analysis for Each Mode Examined

VARIABLES	VARIABLE TYPE	DATA SOURCE
WALKERS		
Age	Continuous	Survey response
Years actively involved with McGill	Continuous	Survey response
Walking travel time (minutes)	Continuous	DMTI Inc., Survey response
Trip utility (walking versus transit trip)	Continuous	DMTI Inc., Survey response
Year-round	Categorical; 0=seasonal, 1=year-round	Survey response
Trip satisfaction dummy	Categorical; 0= "Neutral", "Unsatisfied" or "Very Unsatisfied", 1= "Satisfied" or "Very satisfied"	Survey response
CYCLISTS		
Age	Continuous	Survey response
Years actively involved with McGill	Continuous	Survey response
Cycling travel time (minutes)	Continuous	DMTI Inc., Survey response
Trip utility (cycling versus transit trip)	Continuous	DMTI Inc., Survey response
Year-round	Categorical; 0=seasonal, 1=year-round	Survey response
Trip satisfaction dummy	Categorical; 0= "Neutral", "Unsatisfied" or "Very Unsatisfied", 1= "Satisfied" or "Very satisfied"	Survey response
TRANSIT USERS*		
Age	Continuous	Survey response
Years actively involved with McGill	Continuous	Survey response
Total transit travel time (minutes)	Continuous	DMTI Inc., Survey response
Trip utility (transit versus driving trip)	Continuous	DMTI Inc., Survey response
Number of transfers	Continuous	Google Maps, Survey response
Walking time to transit (minutes)	Continuous	Google Maps, Survey response
Time in bus (minutes)	Continuous	Derived from transit schedules
Time in metro (minutes)	Continuous	Derived from transit schedules
Time in train (minutes)	Continuous	Derived from transit schedules
Walking time in transit (minutes)	Continuous	Google Maps, Survey response
Walking time from transit (minutes)	Continuous	Google Maps, Survey response
Total waiting time (minutes)	Continuous	Google Maps, Survey response
Year-round	Categorical; 0=seasonal, 1=year-round	Survey response
Trip satisfaction dummy	Categorical; 0= "Neutral", "Unsatisfied" or "Very Unsatisfied", 1= "Satisfied" or "Very satisfied"	Survey response
AUTOMOBILE USERS		
Age	Continuous	Survey response
Years actively involved with McGill	Continuous	Survey response
Automobile travel time (minutes)	Continuous	DMTI Inc., Survey response
Trip utility (automobile versus transit trip)	Continuous	DMTI Inc., Survey response
Carpool	Categorical;0=no, 1=yes	Survey response
Year-round	Categorical; 0=seasonal, 1=year-round	Survey response
Trip satisfaction dummy	Categorical; 0= "Neutral", "Unsatisfied" or "Very Unsatisfied", 1= "Satisfied" or "Very satisfied"	Survey response

*Park and ride users are not included in this analysis; only individuals who walked to transit are included here

Final Cluster Analysis

To uncover the types of market segments, a k-means clustering analysis was performed on all twenty-one mode-based clusters resulting from the two-step cluster analysis. Although there are no defined standards for the minimum sample size for a cluster analysis, other studies have performed cluster analyses on samples with as few as ten observations (Dolnicar, 2002); therefore, our sample of twenty-one observations (the initial mode clusters) was thought to be appropriate for such analysis. This clustering was based on the mean trip utility and trip satisfaction for each of the initial clusters, since we hypothesized that the practicality of a mode could be the most important factor affecting mode choice for some individuals, while others may value their enjoyment of a certain mode regardless of the level of practicality that it offers.

RESULTS

Initial Mode-Based Clusters

The two-step clusters yielded distinct groups of individuals for each of the four modes of transportation examined in this study. A total of twenty-one clusters were defined: five each for walkers, cyclists and automobile users, and six for transit users. The percent variation of the mean cluster values for each of these analyses is presented in Figure 39. Detailed descriptions of the clusters for each mode are provided below.

Walkers

The cluster analysis for walkers revealed five distinct groups of individuals. The percent variation of the mean cluster values is presented in Figure 39A. Trip utility for walkers compares the walking travel time to the hypothetical transit travel time for the same trip. The resulting clusters can be described as follows:

Cluster W1: Young, year-round walkers whose walking trip is slightly longer than taking transit. They do not enjoy this walking trip and it is less practical than taking transit; perhaps they walk to save money on transit fares.

Cluster W2: Young, seasonal walkers who walk out of practicality, but do not enjoy it.

Cluster W3: Older, year-round, satisfied walkers who have a relatively long walk that is longer than taking transit. They walk for enjoyment and other benefits rather than for practicality. They walk year-round even though it is not practical.

Cluster W4: Young, year-round walkers with a short, somewhat practical trip with which they are quite satisfied.

Cluster W5: Seasonal, average aged walkers who have a relatively long walking trip that is much longer than taking transit. They likely walk for enjoyment rather than practicality.

Cyclists

The cluster analysis for cyclists yielded five distinct groups. The percent variation of the mean cluster values is presented in Figure 39B. Trip utility for cyclists compares the cycling travel time to the hypothetical transit travel time for the same trip. It should be noted that all cycling clusters in this analysis resulted in a utility value of one or more, indicating that the cycling travel time is faster than the transit times for the same trip (although this is not necessarily true for each individual observation). The average utility for cycling clusters was 1.8, therefore, it is important to consider how the utility value for each cluster varies from the mean for all cluster groups. The resulting clusters are summarized as follows:

Cluster C1: Young, year-round, satisfied cyclists with short travel time and an average trip utility, indicating that this group cycles both for practicality and enjoyment.

Cluster C2: Slightly older, long cycling trip which some individuals do year-round, high satisfaction with their trip despite the fact that is has a lower than average utility and long travel time. Although this trip is more practical relative to transit, the fact that it has a long travel time and some individuals do this trip year-round indicates dedication on the part of the cyclist.

Cluster C3: Young, seasonal, satisfied cyclists who cycle a relatively short distance and whose cycling trip is much faster than transit (more so than all of the other clusters).

Cluster C4: Young, seasonal cyclists whose trip is relatively short and satisfying but not as practical as some of the other groups of cyclists, although it is still faster than taking transit.

Cluster C5: Unsatisfied, year-round cyclists with an average travel time and trip utility. Given the negative input for years at McGill, they may be unfamiliar with the cycling facilities between their home and destination at McGill, which may contribute to their dissatisfaction.

Transit Users

The cluster analysis for transit users yielded six distinct groups. The percent variation of the mean cluster values is presented in Figure 39C. Trip utility for transit users compares the transit travel time to the hypothetical automobile travel time for the same trip. Transit observations have more elaborate findings as additional variables were included in the analysis (waiting time, time in different modes and number of transfers). The clusters are summarized as follows:

Cluster T1: Transit users who have a short, simple trip which they take year-round, is nearly as fast as driving, and with which they are satisfied.

Cluster T2: Commuter train users with a long walk to and from the station. They are quite satisfied, which could be explained by both the short waiting time and high trip utility value.

Cluster T3: Transit users who have a complex transit trip with a below average utility, but nonetheless they are satisfied and take this trip year-round. Their higher than average age and years of involvement with McGill suggests that they are familiar with their travel options, but remain dedicated transit users.

Cluster T4: Somewhat satisfied, seasonal transit users that have a relatively short transit trip with a below average trip utility, and they are somewhat satisfied.

Cluster T5: Year-round bus users with a relatively simple although not very practical transit trip with which they are not satisfied.

Cluster T6: Similar to cluster T3, these transit users have a complex transit trip with a below average utility, which they take year-round. In contrast, however, these individuals are not satisfied with their commute.

Automobile Users

The cluster analysis for automobile users yielded five distinct groups. The percent variation of the mean cluster values is presented in Figure 39D. Trip utility for automobile users compares the automobile travel time to the hypothetical transit travel time for the same trip. It should be noted that all automobile clusters resulted in a utility value which indicated that the automobile travel time is faster than the transit times for the same trip (although this is not necessarily true for each individual observation). The average utility for automobile clusters was 1.7; accordingly, it is important to consider how the utility value for each cluster varies from the mean for all cluster groups. The resulting clusters can be summarized as follows:

Cluster A1: Seasonal, somewhat satisfied automobile users, some of whom carpool, with a relatively short travel time but below average trip utility.

Cluster A2: Year-round, unsatisfied drivers, with an average trip utility but longest travel time.

Cluster A3: Year-round carpoolers, with a slightly higher than average driving time, but the highest trip utility (much more time efficient to drive). Despite the high utility, this group is only somewhat satisfied; this could be due to issues related to carpooling.

Cluster A4: Younger, year-round, satisfied automobile users with an average travel time and trip utility. They drive both because it is preferred and it is more practical than taking transit. They may be unfamiliar with their transit options or may not have found carpool partners since they have been at McGill only a short time.

Cluster A5: Older, year-round, satisfied automobile users with an average travel time and trip utility. They drive both because it is preferred and it is more practical than taking transit.

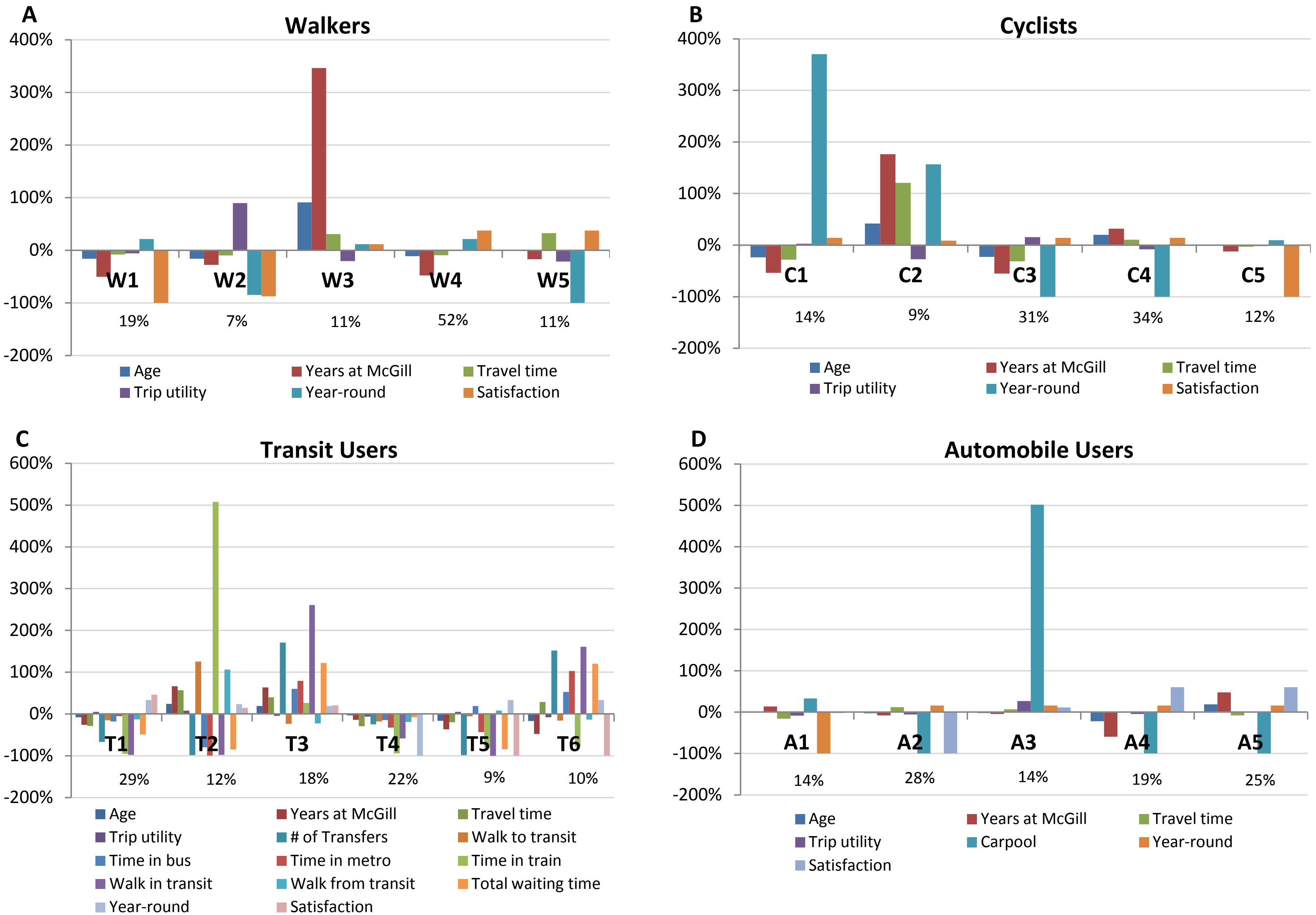

Figure 39. Percent variation of mean cluster values for (A) walkers, (B) cyclists, (C) transit users, and (D) automobile users

Final Clusters

The final cluster analysis based on the mean trip utility and satisfaction revealed four groups. Other numbers of clusters were tested, but resulted in clusters with only one observation or difficult-to-interpret outcomes. Four clusters gave the clearest results. Figure 40 provides a visual representation of the final clusters, through a scatter plot of the trip utility versus the level of satisfaction for each of the twenty-one initial mode-based clusters. The scatter plot alone illustrates clear trends, as the four resulting clusters are already quite apparent. The k-means cluster analysis further confirms the presence of four clusters, which are highlighted by circle outlines in Figure 40. A description of each of the resulting clusters is provided below.

Lower-left cluster: Individuals that have a low trip utility (not practical), as well as a low level of preference for their trip, suggesting that these individuals face some level of constraint or captivity related to their trip. This cluster represents 13.6% of our sample.

Upper-left cluster: Individuals that have a low level of preference, but a high level of practicality in their current trip. Therefore, these individuals take a very utilitarian approach to their travel decisions, favouring the level of practicality with a given trip, over their own preference. This cluster represents 9.0% of our sample.

Lower-right cluster: Individuals that have a low trip utility, but who are satisfied with their trip, suggesting that they base their travel decisions on their level of enjoyment of the trip rather than the practicality. This group therefore demonstrates a certain level of dedication to their trip. This cluster represents 55.7% of our sample.

Upper-right cluster: Individuals who have both a high level of trip utility and a high level of preference for their trip, thus representing individuals with a convenient trip. This cluster represents 21.7% of our sample.

A large proportion of our sample is represented in the “dedicated” cluster; this is likely the result of the unique setting at an urban university campus. Although we might expect to see a different distribution of individuals in other samples, the strength of this approach is that it can be universally used to describe people in other contexts and geographic locations.

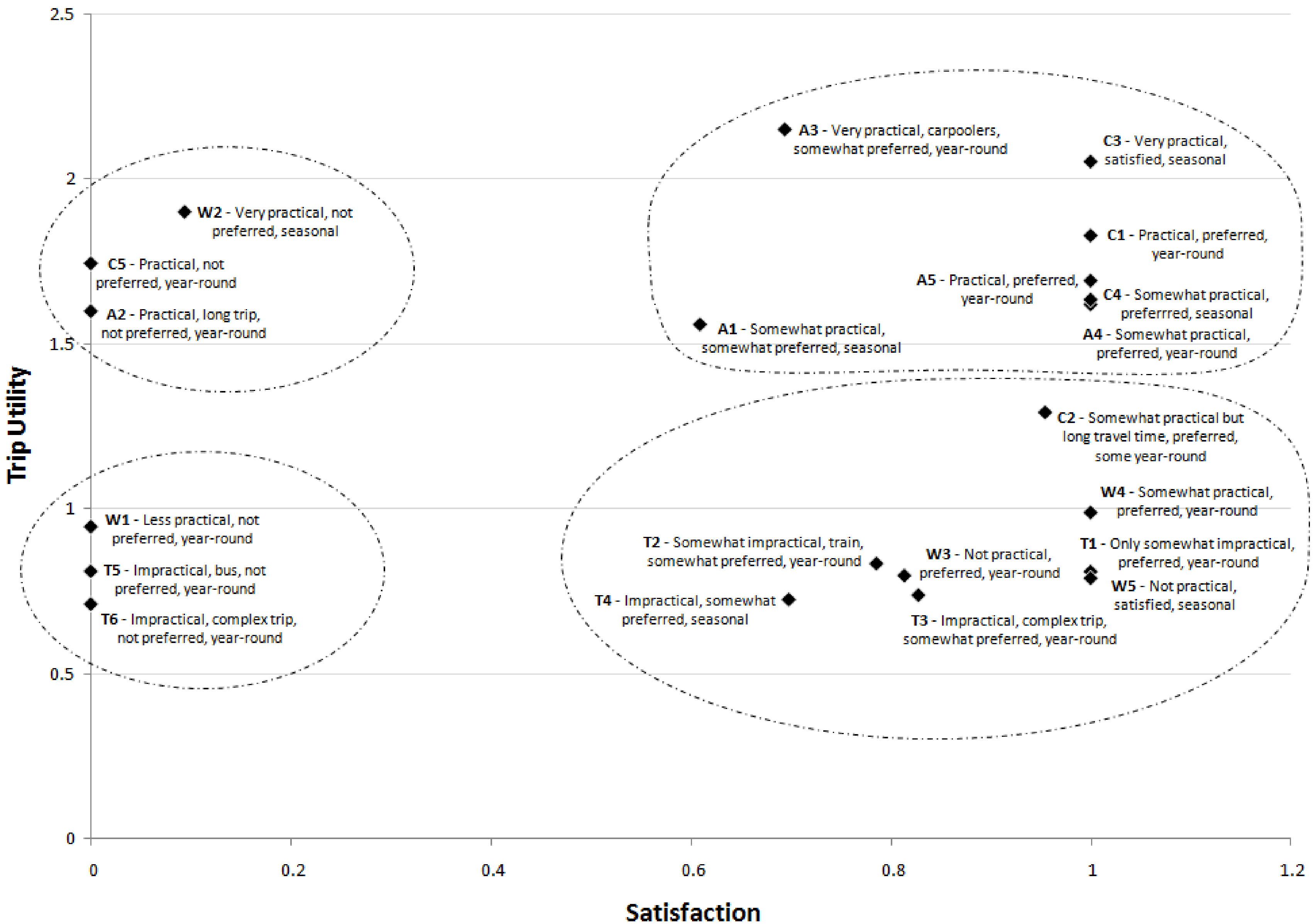

Figure 40. Visualization of the clusters resulting from the k-means cluster for satisfaction and trip utility

Discussion

From the viewpoint of the conventional segmentation paradigm, the lower-left cluster presented in Figure 40 would describe “captive” users. In such a case where an individual is regularly making a trip that is both impractical and not their preferred choice, it is likely that they could feel “captive”. One criticism of the prevailing transport market segmentation approach, however, is that it tends to imply that captive users are unlikely to switch modes for any reason. In this sense, the term captive may have a positive connotation from the perspective of a transit agency, for example, who may perceive captive riders as guaranteed and permanent ridership and profit regardless of the quality of the service. On the other hand, it would very likely have a negative connotation from an individual’s perspective.

In this analysis, the term captive is used to describe one of the final resulting clusters (lower-left cluster). Here, however, we acknowledge the negative connotations associated with this terminology, and use it in a manner that is intended to highlight this situation that the individuals in this cluster find themselves in: making an unpleasant, impractical trip. In this sense, the term can be used from the perspective of both a transit agency and an individual in a mutually understood rather than a contradictory way.

Further, the term captivity as it is applied here, does not necessarily imply that the individuals in this group are captive to or do not enjoy a particular mode. For instance, someone may enjoy walking, but not enjoy their walking trip to a particular destination or along a given route. Therefore, the term captivity here is meant to emphasize the need for improvements to increase their level of satisfaction with or the practicality of their trip (although this may mean changing modes for some individuals).

Another criticism of the current terminology is the lack of a consistent definition for captive and choice, which results in several ambiguities. For instance, the traditional use of the term captive, in many cases, fails to distinguish between those individuals who are making a particular trip because they truly have no other options for reasons beyond their control, and those who have to make a certain trip due to conscious choices that they have made (such as choosing not to purchase a vehicle even though they have the means to). The clusters resulting from this analysis redefine these latter individuals as dedicated rather than captive, since they are choosing to take a less practical trip because find it more preferable (for instance, they may prefer to take transit for environmental reasons, even though it is less practical than driving).

Similarly, individuals in the top-right cluster would most likely have been described as choice users under the traditional paradigm, but here they are described as having a convenient trip that is both practical and preferred. Likewise, someone that does not enjoy their trip even though it is practical (the upper-left cluster) does not fit easily into the captive or choice description. These individuals may be making a conscious decision to make this trip even though it is not their preferred, but simply because it is practical; therefore, this cluster is said to have a utilitarian approach to their travel choices.

The distribution of the observations within circles delineating the four individual clusters effectively demonstrates the varying level of preference and practicality which could be found within a single group of individuals; observations A3, A1 and C2 are good examples (see their descriptions in the previous section). This stresses the importance of recognizing that no two individuals face the exact same circumstances, constraints or resources. Accordingly, caution should be taken when defining transport market segments to not imply that individuals are indefinitely confined to a specific group. In fact, these results suggest that such market segments should perhaps be viewed as continuums along which individuals move, rather than static grouping.

The four final clusters in this analysis of McGill commuters inspired the development of an alternative approach to transport market segmentation which has been conceptually presented in Figure 41. The arrows in this diagram signify a movement toward, rather than a static presence in, a certain market segment, four of which have been defined here: captivity (trip is neither practical nor preferred), utilitarianism (trip is practical but not preferred), dedication (trip is preferred but not practical) and convenience (trip is both practical and preferred). The peripheral arrows symbolize the varying degrees of preference and practicality within each category, acknowledging that individuals are not indefinitely confined to a particular segment, as their circumstances are constantly changing and affecting their travel behaviour choices. The overall concept is one of a continuum of travel choice, along which individuals move toward various extremes of travel options and preferences. Viewing individuals' travel choices in this way could have substantial policy implications.

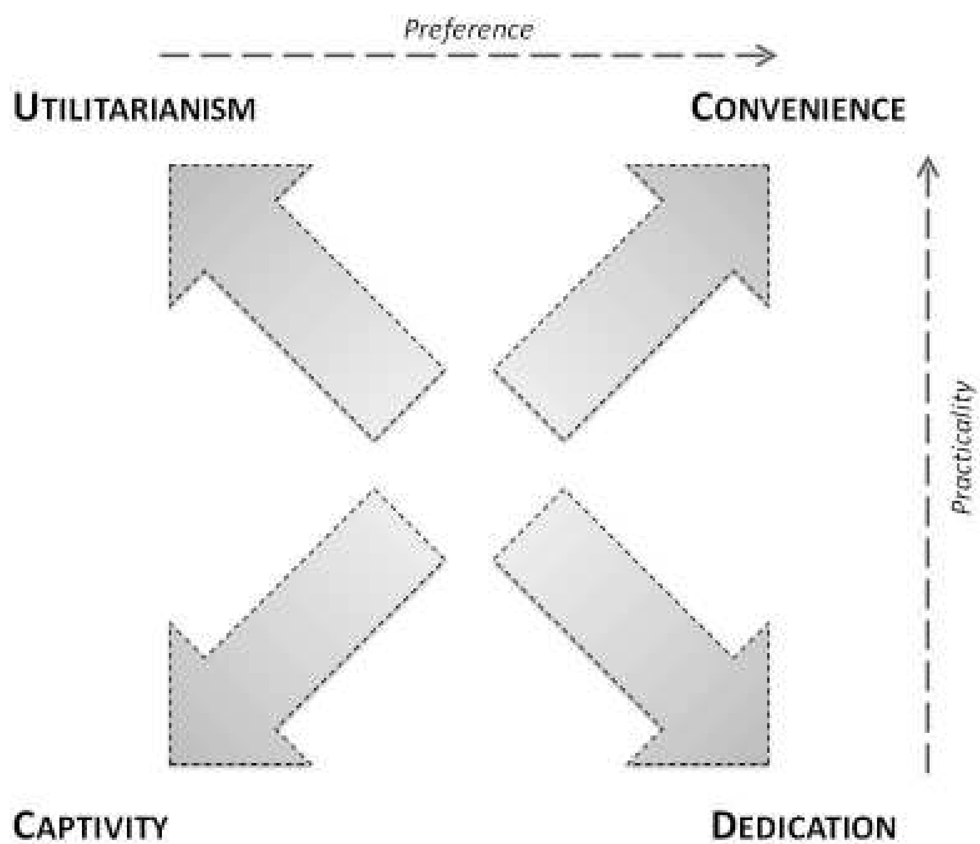

Figure 41. Conceptualization of an alternative approach to transport market segmentation

CONCLUSIONS & IMPLICATIONS

This section of the report used clustering techniques to derive transport market segments which describe the various types of commuters at McGill University. The resulting approach can be applied to the four main modes of transportation observed (walking, cycling, public transit and private automobile), and can be used by users, agencies and municipalities alike to better guide the development of transport policies. The main factors considered in this analysis are the level of trip satisfaction and practicality.

The results of this analysis yielded four final clusters, each with a varying level of trip preference and practicality, resulting in the transport market segments of McGill commuters presented in Figure 41. In this approach, individuals move along the continuum of choice toward various market segment extremes: captivity, utilitarianism, dedication or convenience. This model does not presuppose that individuals are static with their respective segment, but rather is designed to guide transport policy to move individuals toward a preferred and more practical travel choice. This approach focuses on the individual's trip rather than their mode, recognizing that an individual's lack of preference for a particular trip does not necessarily imply a lack of preference for a particular mode.

Ideally, individuals would move individuals along the continuum illustrated in Figure 41, toward a more preferable and more practical realm of choice ("up" and to the "right" in the conceptual diagram). For instance, individuals who lack the financial—or physical—means to change modes and are therefore headed toward captivity could be provided faster, more comfortable service which could lead to increased trip enjoyment and efficiency. Such efforts would move these individuals away from "captivity" and toward a more favourable segment such as "convenience", without having to change modes. Similarly, "utilitarian" trips could be made more enjoyable through increased comfort and safety, while "dedicated" trips could be made more efficient, through improved transit service, more bike lanes, and so on.

Although not every mode is present within each of the resulting clusters depicted in Figure 41, it does not suggest that certain modes are excluded from particular segments. For instance, it is possible to have a transit trip that is both pleasant and more practical than driving, despite the lack of observed transit users in either of the upper clusters in Figure 41 (practical trips). The lack of transit in these clusters may have to do, in part, with the fact that the transit travel time derived for this analysis included the total walking and waiting time in addition to the total in-vehicle travel time, to better represent the perceived practicality of a transit trip. If the in-vehicle time had been considered alone, transit would most certainly have been more practical than driving in many cases. Similarly, if the level of practicality of an automobile trip accounted for parking and gasoline costs, the trip utility might have resulted in transit being more practical in some cases. Considering the value that some individuals associate with being able to have extra time to read or relax while taking transit or the added stress of driving in traffic would also affect the perceived utility of a trip. The effect of such factors should be considered further in future research.

Section VI – *Trip Satisfaction*

Commuting patterns are most enjoyable when disturbances are minimized and efficiency and convenience are maximized. The trade-offs to maximize or minimize these factors include travel time, cost, season, among others. The impetus to adopt higher commuting costs may coincide with the onset of harsh temperatures, while the convenience of walking may be reconsidered if shorter travel time can be attained through another mode. Trip satisfaction is a balancing act between these various issues, all of which finely tune the daily commute.

SEASONALITY

Weather severity can be a forceful determinant of mode share. Disturbances caused by seasonality affect trip satisfaction, particularly during colder months. Although cyclists and walkers may feel the direct effects of snow accumulation, ice and cold, users of active modes were found to have the highest rates of satisfaction, with more than 70% of travelers stating either that they are “satisfied” or “very satisfied”. Transit and private automobile users are generally less satisfied with their commute, as weather delays can affect entire network operations. Users of active modes are independent of these road or transit networks, and therefore they may have more control over their trip even in bad weather. This may play a role in the degree of satisfaction among active mode users during the winter months relative to transit and automobile users. However, transit and automobile users both have a satisfaction rate of 60%, indicating that nonetheless there is a majority that are generally satisfied with their daily commute during the winter (Figure 42).

Conversely, trip satisfaction improves significantly during warmer seasons (Figure 43). Cyclists and walkers report an overall satisfaction rate of 90%, while transit and car users are nearly 20% more satisfied during the fall than during the winter months. Of those that are very unsatisfied with their mode of transport, factors that impede efficiency, cost and convenience may be viable explanations. Frequent road congestion, especially during peak hours, poorly maintained bicycle infrastructure, as well as heavy construction that restricts sidewalk use are all cited as critical factors.

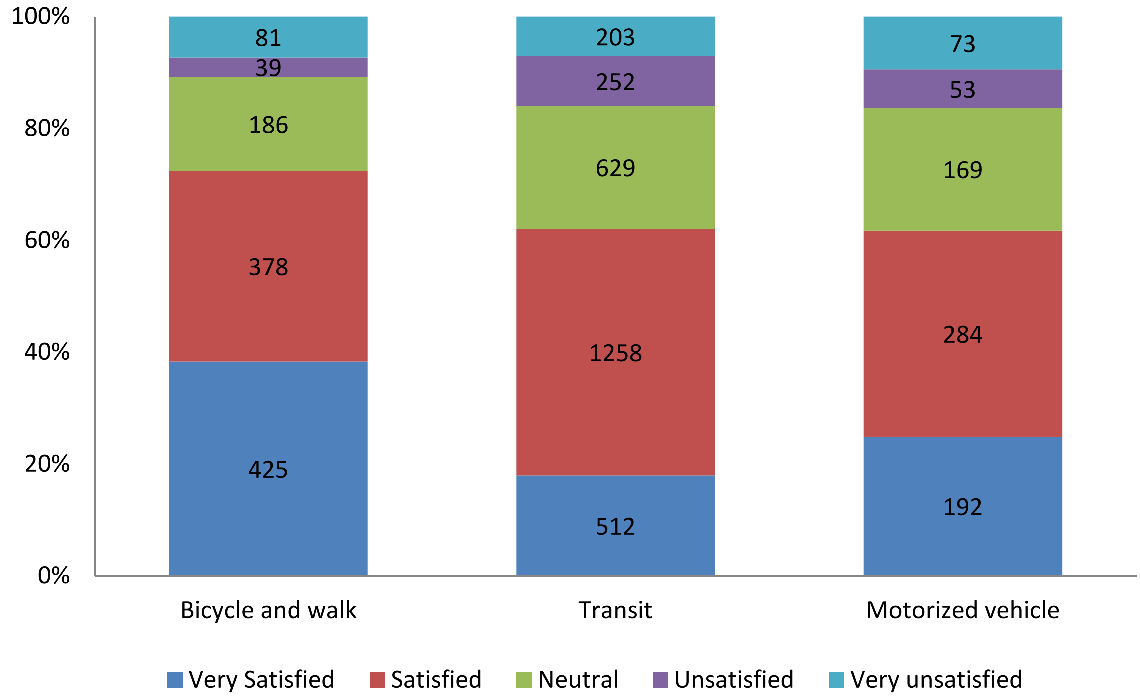

Figure 42.Trip satisfaction by mode (winter)

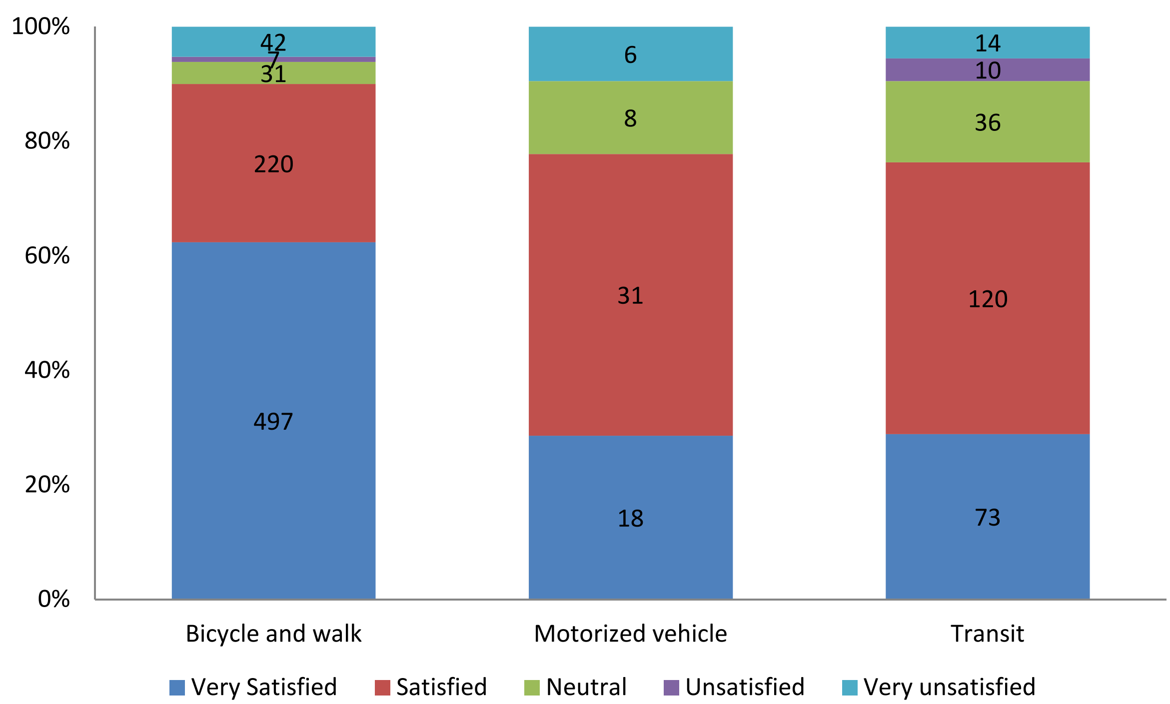

Figure 43. Trip satisfaction by mode (fall)

TRAVEL TIME

The burden of lengthy commute times manifests directly into general dissatisfaction with overall trips. On average, Canadian commuters spend 63 minutes a day making the round trip between their place of residence and their workplace. In 2005, the round-trip for people in the census metropolitan area of Montreal commuted for 76 minutes on average, up from 62 minutes in 1992 (Statistics Canada, 2006). The travel time for trips made to McGill destinations averaged 30-44 minutes for the majority of all survey respondents (Figure 44). This frequency is followed by a slightly shorter travel time of 15-29 minutes. Average commute time varies between employees and students. Employees generally travel farther distances than students, with a large proportion spending 30-44 minutes in travel time. Conversely, students report an average commute time of 15-20 minutes, closely followed by those who spend 30-44 minutes for each trip. However, a much greater share of students travel less than 15 minutes to reach their destination than employees (Appendix V, Figure 61 and 62).

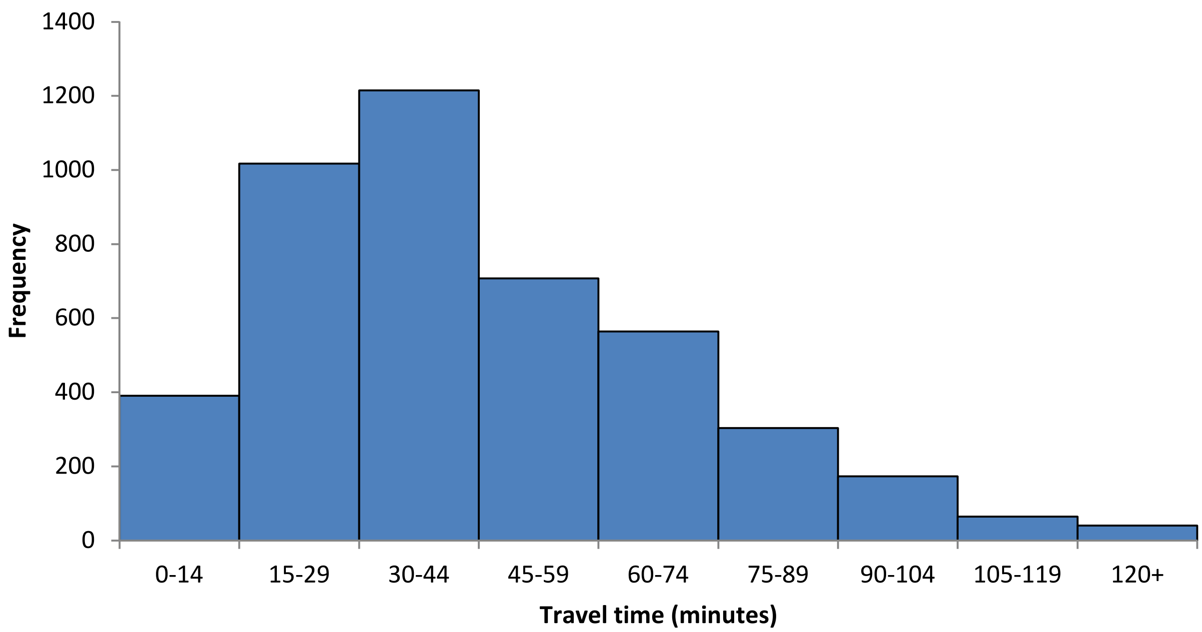

Figure 44. Travel time histogram for McGill

Figure 45 illustrates that satisfaction by trip time steadily decreases as travel time increases, from 75% to nearly 30%. Whereas only 10% of individuals whose trips are less than 15 minutes are either unsatisfied or very unsatisfied with their trip, 30% report dissatisfaction when the trip reaches between 105 and 120 minutes. Neutrality about the satisfaction of the origin-destination commute also increases as time increases, possibly due to fewer trips made more often if a respondent is part-time, or has the option to telecommute. The enjoyment of longer trips may also be attributed to the mode in which they commute: the commuter train or other transit options offer the chance for other activities, such as reading, which relieve the burden of time spent commuting.

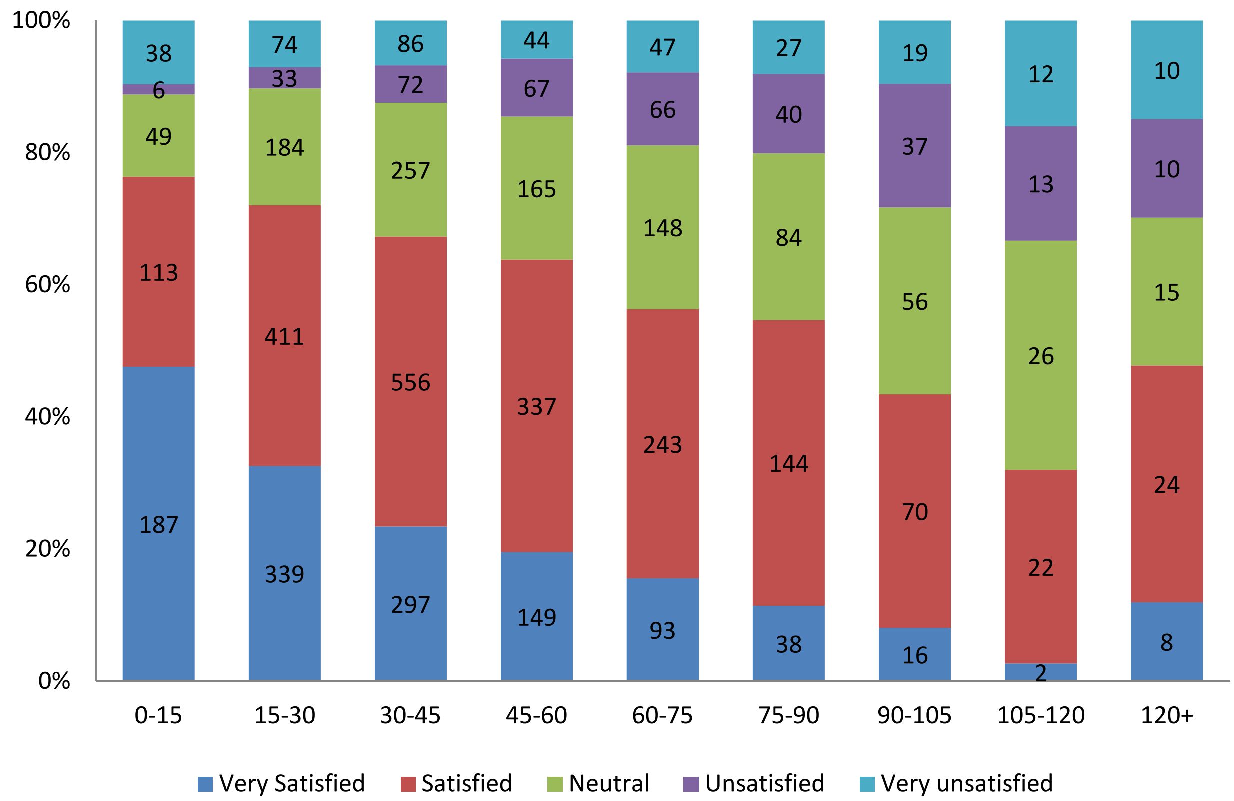

Figure 45. Trip satisfaction by travel time

VALUES AND MOTIVATIONS

Two important aspects of mode choice are often overlooked in both research and policy context related to transportation planning: traveler motivations and satisfaction. Attitudes towards, exercise, social interaction, and the environment are central to an individual's choice of mode, while trip satisfaction is a complex and important—yet rarely explored—element that has important ramifications for understanding travel behaviour. The 2011 McGill Transportation Survey is quite unique in that it captures traveler motivation, trip satisfaction, and elements of residential choice. Appendix VII provides a detailed analysis which uses clustering techniques, to stratify respondents who walk to campus into one of five distinct groups based on values and motivations. Statistical tests are used to examine the variance in behaviour and satisfaction across groups. Among other findings, it is observed that people who are most concerned with environmental issues and physical activity are walking longer distances and are on average much more satisfied with their commute. Future research using the results of the 2011 McGill Transportation Survey should focus on conducting similar analyses for other modes of transport, particularly public transit.

Section VII – *Comments and Concerns*

Detailed analysis of the results of the 2011 McGill Transportation Survey, as presented above, has revealed various areas for improvement in facilitating and promoting the use of sustainable transportation to and from McGill campuses for all students, faculty and staff. This section summarizes the comments, concerns and suggestions provided by the survey respondents for each mode of sustainable transportation to McGill campuses. The survey included four open-ended questions which allowed respondents to elaborate on their thoughts regarding improvements to various modes and ways by which the use of sustainable modes of transportation could be further facilitated. The responses to these questions provided great insight into the different barriers to the use of specific modes of transportation and ways by which these barriers could be eased or eliminated.

Figure 46 illustrates the feedback obtained from survey respondents when asked for suggestions on how the use of sustainable transportation could be further encouraged for commuting to McGill campuses. This question generated a great diversity of suggestions pertaining to different modes. Suggestions related to public transportation make up the majority of the comments received, with 21% of the comments suggesting improvements to the transit service, infrastructure or vehicles, and 19% suggesting lower transit fares. This is not surprising since public transit makes up over half of the mode share for McGill (see Figure 4), and it is the best sustainable transportation option for a wide variety of individuals travelling in from all over the Montreal Metropolitan Region. Thus, from the point of view of the McGill community, the best way to encourage and facilitate the use of sustainable transportation is to improve the public transit system.

To elaborate, the respondent- suggested transit improvements are numerous and include: adaptation of the transit system for the mobility-impaired; increased transit frequency and extended service hours to meet the need of student, faculty and staff who arrive at or leave McGill campuses during non-standard hours; an extension of the transit network, particularly to and from the West Island; increased reliability; additional parking at metro and train stations; and additional bicycle racks on transit vehicles and at transit stations. The following quote from a survey respondent highlights the issues surrounding the use of public transportation for the mobility-impaired:

> *"In the case of persons with disabilities, mainly mobility impairments, there should be more shuttle buses to help us navigate the campus. If you want to encourage persons with disabilities to use adapted transportation, maybe you could negotiate with them to give priority to the students, professors and staff. In paper, school is a priority, but not every taxi driver or buses of the STM of Montreal are aware of the fact that we have to be on time to teach or study. I tried once to get to McGill by bus, and I had to give up after 5 buses stopped and told me either the driver did not know how to use the*

elevator, the elevator did not work, or there was room only for one person with a disability and there was already one in the bus. There is also a rule that wheelchair users are not allowed to use public buses during rush hours. About the metro, there are groups advocating for the implementation of elevators in Metro stations, but their demands do not deserve the attention they should. Maybe McGill could join the advocacy efforts and ensure that the nearest station be adapted as soon as possible. We are talking of no less than 80 years for this to happen, but maybe if significant actors like universities join the advocacy efforts, the metro will be an option to get to the campus soon."

Reductions in transit fares were another major concern among survey respondents. Of particular concern is the fact that students over the age of 25 have to pay full price for their transit pass, regardless of the fact that these students do not necessarily have the budget for this since they are still living on a student income. Therefore, allowing all full-time students a reduced fare, regardless of age, may increase user satisfaction with the transit system. Some specific suggestions offered by survey respondents regarding reduced fares include the implementation of a "UPass" system, where the University negotiates a deal with the transit service providers to have a transit pass included as part of tuition fees. Such a scheme was implemented recently by the Université de Montreal, through negotiations with the STM. An important note of caution with such an initiative is that it should be recognized that not all students use the STM; there are many individuals who travel in from various parts of the region which have their own transit service providers (for instance, the AMT for the commuter trains, the transit authorities on the South Shore and Laval). Therefore, it may be rather complicated to implement such a plan, although it would likely send a strong message about McGill University's encouragement of the use of public transit for commuting. The quote from a survey respondent highlights the advantages of implementing such a pass:

"Consider a university wide transit pass, like a lot of Ontario schools have. By making it mandatory for everyone to get a pass as a part of student fees, the monthly cost of a transit pass is significantly reduced. This not only encourages student to use STM to get to school, but for any other time they travel around Montreal. I've always thought university transit passes were a genius idea, because even if you live close to campus and you walk to school you can and will use the metro or bus to get to clubs or movies or museums or parks or SOMETHING. You'll end up using it for sure."

Although such a scheme would help with reducing transit costs for students of all ages, it does not solve the problem for faculty and staff. Some survey respondents suggested that McGill, as a major employer, should follow the lead of other major employers in the region and strike a deal with transit authorities for some sort of discounted rate, as described in the quoted comment below:

"Students have discounted Opus cards. A large company like McGill should have worked out some deal with the STM to offer Opus card discounts to McGill employees - discounted monthly passes (1 per valid McGill ID card). This is pretty standard for

companies in the United States - even those smaller than McGill. Perhaps there is such an incentive available - if so it needs to be advertised more. The net result would be less automobile use even on weekends! . . ."

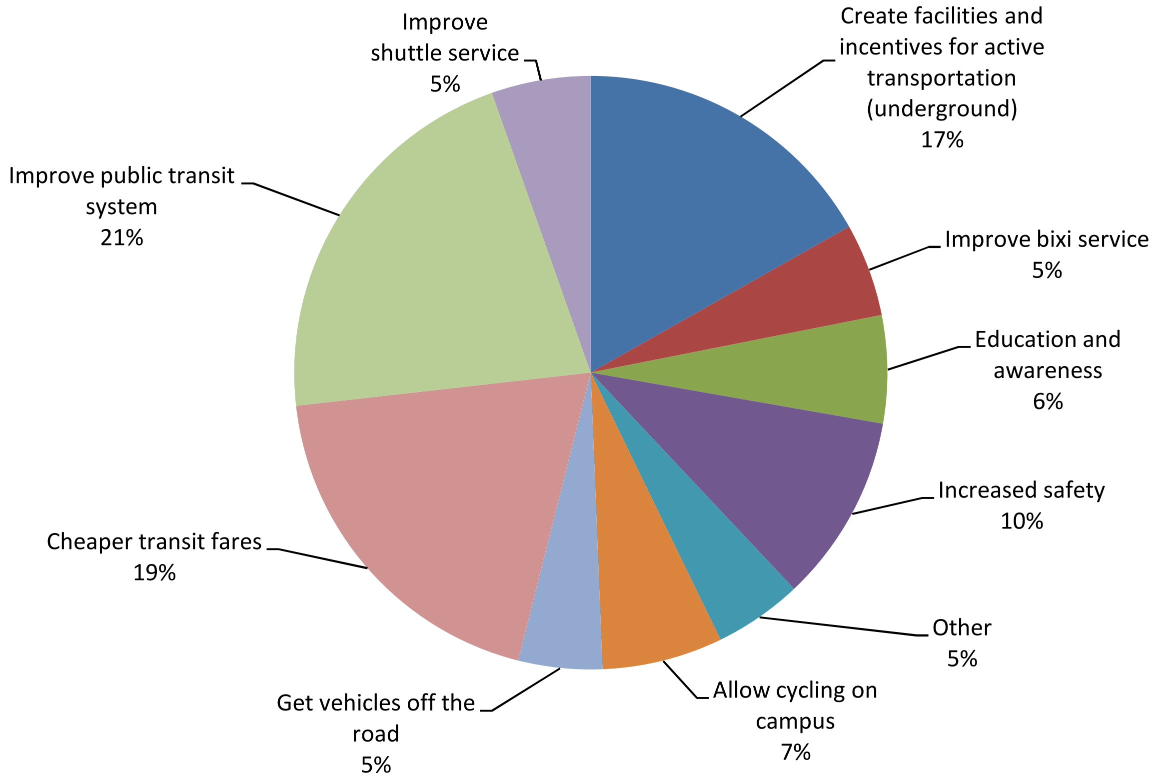

Figure 46. Respondents' suggestions to encourage the use of sustainable transportation to McGill campuses

Following improvements and fare reductions for public transit, a significant proportion of survey respondents indicated that they feel McGill should provide more active transportation facilities and incentives to further encourage the use of sustainable transportation to McGill campuses. Specific comments were related to: showers in some buildings on campus to allow individuals to freshen up after cycling or walking to campus; additional and improved bicycle lanes around campus, particularly the Downtown campus; secure bicycle parking; more Bixi stations around campus; and an underground tunnel connecting the McGill metro station to the Downtown campus (see the quote below). Some of these suggested improvements may be realistic and achievable within the foreseeable future, while others would involve a great deal of planning, cost and infrastructure to be put into place.

"As mentioned earlier in the survey, SECURE parking for bicycles should be a priority. It's my main mode of transportation in good weather, both for the exercise and because it is cost efficient. I've had two bicycles stolen from the bicycle racks immediately outside my building. It has made me very reluctant to take my bicycle to work. I used to work in an

office where I was able to bring my bicycle in with me. I have moved to another work space where this is not permitted (although faculty members are allowed to bring their bicycles in - this double standard is very disappointing). The Montreal Jazz Fest organizers have established secure bicycle parking facilities during the festival. It's an outdoor area of bicycle racks enclosed by a fence with security staff ensuring the security of the bicycles. McGill should provide something like this for staff/students. It should be accessible with a valid McGill ID card and should be FREE in order to encourage sustainable transportation and for the health benefits of biking (i.e. better work productivity as a result of exercise). There is certainly space on the Downtown campus for such a place and it would only require one staff member to monitor the station, so the staffing expense would be minimal. I hope McGill will seriously consider this solution."

Other survey respondents feel that increasing safety in and around campus for both cyclists and pedestrians is necessary. There is great concern regarding snow removal during the winter months, which makes it very difficult to get around the campus, and therefore may be an impediment to the use of more sustainable modes of transportation. Particular issues with snow removal and safety during the winter months are found primarily in the upper portion of the McGill Downtown campus, moving up the hill from Doctor Penfield, as highlighted in the quote below. In addition, there appears to be a general lack of respect for cyclists by drivers and vice-versa. Some survey respondents go as far as saying that the number of cars should be reduced considerably, if not banned, by introducing taxes, tolls, and closing off roads to discourage car users. Others feel that bicycles should be allowed on campus again.

*". . . As for snow clearing, working on all of the hills and steps should be a big priority. I teach on the lower campus, but my office is on the upper campus. It feels like a death-defying risk to get to my office throughout the winter. I simply cannot imagine how a less physically active person would be able to cope with the situation at McGill. Even among the young student population, I notice an impact. When my office was on the lower campus, I *always* had students coming to my office hours. On the upper campus...never! If they can't safely walk up the hill, one can't blame them for not taking advantage of all educational opportunities."*

Finally, some respondents' comments suggest that educating the population on the benefits and advantages of active transportation may have a considerable impact on travel behaviour, as per the quotes below. It can be less expensive, faster, and even more enjoyable than riding a car to campus.

"Have some fun campaigns to encourage people to celebrate using sustainable transportation. Maybe reach out to people about health benefits and make a friendly challenge (they can win a bicycle) if they start coming by bicycle a set # of times. Encourage people to take public transit and maybe let them know that they could commute to an express bus stop, park and then take the bus the rest of the way. They can save on parking fees, still have a manageable commuting time and use their car less

(would need to pin point where parking is okay and the commute time is close to what they would spend in the car plus how much they can save). Thanks for the survey - good luck!"

"I travel with my husband and it gives us extra quality time together. It's all about the way we look at things. I'm now helping the environment and at the same time it benefits my relationship. Enjoying Public Transit, I would suggest it to anyone living in the West Island."

This question yielded various other suggestions for improving the use of sustainable transportation to McGill campuses (see Figure 46). The following subsections highlight some of the more specific comments and suggestions provided by survey respondents for encouraging cycling, walking and the use of public transit as a means of commuting to McGill campuses.

CYCLING

The City of Montreal has been making great strides in recent years trying to promote the use of cycling as a viable mode of transportation, through the construction of numerous bicycle lanes and paths, and the widespread implementation of the Bixi bicycle-sharing system. To gain insight into ways that cycling to campus could be improved and further encouraged, one of the open-ended questions in the survey asked respondents to provide suggestions on how McGill could facilitate cycling to campus. The resulting comments are summarized in Figure 47. The most notable suggestions offered by survey respondents include increased bicycle parking, improving and maintaining infrastructure, and allowing cyclists through the Downtown campus, which combined account for more than half of the comments.

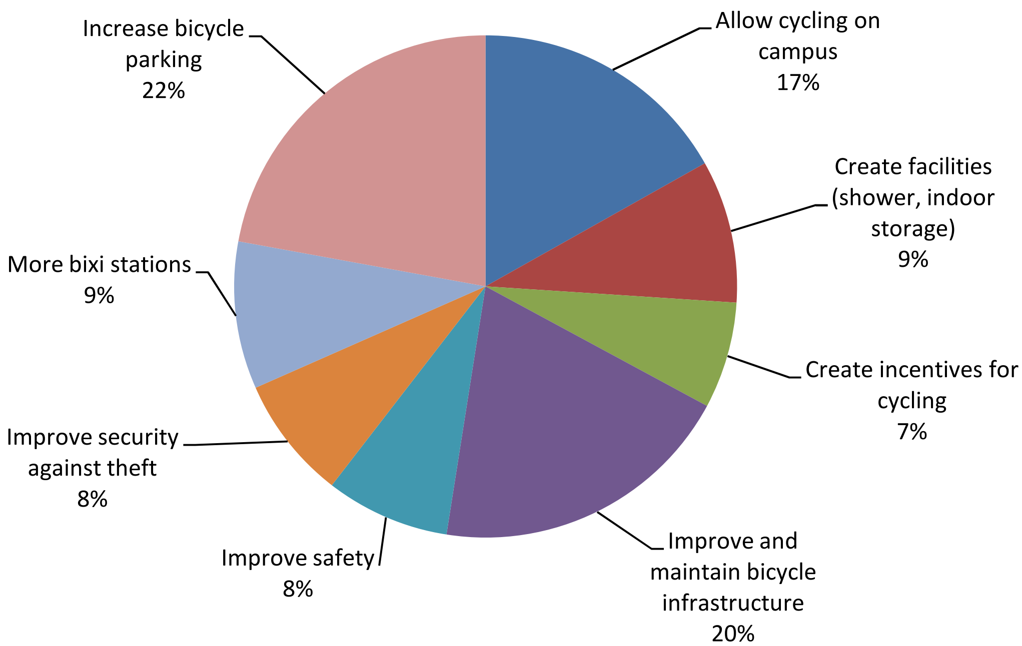

Figure 47. Respondents' suggestions to facilitate commuting by bicycle to McGill campuses

The raised most often is this issue of available bicycle parking, which has several consequences. Firstly, inadequate parking may force individuals to lock up their bicycles on fences, ramps, trees, and other undesirable or unsuitable areas. For instance, security must repeatedly cut locks off of bicycles that are attached to mobility ramps at the entrance of most buildings on campus. Inadequate parking may also mean insecure parking. This equally discourages travelers from commuting to campus by bicycle for fear that they will not be able to find a secure place to lock up their bicycle that is close enough to their final destination (see Appendix V, Table 5 for rates of bicycle theft by campus). Solutions proposed by survey respondents include: creating space to add more bicycle racks throughout the campus, introducing new designs for racks that enhance security; and creating indoor storage facilities to minimize bicycle clutter in offices, as declared in the quote below.

> *"McGill should create a "bicycle locker" similar to what is used at the Jazz Fest. It's an enclosed, outdoor space where you can lock your bicycle, but there is a security guard on duty. It should be accessible with a valid McGill ID and should be FREE. I would be much more likely to ride my bicycle to work if I knew my bicycle was secure. Both of my bicycles were stolen directly in front of my building (New Music Building) in broad daylight (between 9:00am and 12noon)."*

Cycling safety, which relies primarily on the soundness of cycling infrastructure, was also raised as an issue by survey respondents. When bicycle lanes are present and well maintained, the perception of safety is increased, which may encourage individuals to cycle. Knowledge and education may also heighten this sense of safety, as increased awareness is crucial for creating a respectful dynamic among cyclists, pedestrians and automobiles. The following quote highlights the issue of problematic intersections around campus, which may be require infrastructure improvements, as well as increased awareness among mode users to increase safety.

> *"Coming from North East of the city, the last leg of the ride is very dangerous (taking Avenue des Pins from the cycle path on Parc to Peel to reach Stewart Biology). I dread this moment anytime, but even more during rush hour. Actually, I had to switch to a different route that is a detour (down the cycle path to main campus, then walking beside my bicycle to cross the whole pedestrian area and up the hill on Peel to reach Stewart Biology, pfiu!). I wish I could take des Pins with my bicycle without feeling close to dying!"*

The maintenance of existing infrastructure is also crucial for both the safety and feasibility of a commute. Survey respondents feel that cycling lanes should be cleared in the same manner as streets, and that connections and thoroughfares are not overly compromised if construction is present. Investment in and maintenance of bicycle lanes, bicycle racks, Bixi stations, and all other services, may help to increase the appeal of cycling to campus.

Lastly, numerous comments and suggestions have revolved around the recent ban on cycling through campus. In this open-ended question, many survey respondents expressed their discontent with this new rule, indicating that it forces cyclists to take unsafe routes around the campus, as described in the quotes below.

> *"It could include bicycle routes on campus! I feel very strongly that the campus is large enough to accommodate some lanes through campus, especially now that the cars are gone. Having to walk all the way from the gates on University Avenue to McTavish is a huge waste of time and very awkward. The money spent telling people to get off their bicycles would be better used making good signs reminding people to bicycle carefully and respectfully (which they usually do through campus). Also, it would be great if des Pins had a bicycle route added to it (shuttling you to the St. Urbain route). I think a lot of faculty and students would benefit from that."*

> *"Although I understand the rationale for no longer allowing cycling through campus, I find this impractical, and safe alternative cycle paths are not available. I work in the Stewart Biology building, and would logically take des Pins to arrive at work. However, as it's too dangerous, I park outside the Milton gates and walk up to my work (10 min walk at a good clip!). McGill could lobby the city for a bicycle path on des Pins."*

Finally, the importance of awareness and education are reiterated by survey respondents in the belief that cohesion and respect between cyclists and pedestrians is paramount in creating a positive relationship. The following suggestion provided by a survey respondent highlights that there is room for improvement to encourage these dynamics:

"I am in favor of cycle paths on campus: it is important that pedestrians and cyclists respect each other and encourage each other as both value the environment [by adopting these] means of transport."

Sustainable, livable communities are enhanced when the movement of people is harmonized. This should be considered when implementing policies aimed to address the different types of traffic flow. Encouraging active transport wherever possible underlines the University's mission for a healthy, environmentally-conscious and forward-thinking institution.

Comments and Concerns for Cycling:

- **Increase parking for bicycles and introduce secure rack designs.**
- **Enhance the safety of the commute by creating more bicycle lanes and maintaining existing ones. Implement smart street signage and increase awareness campaigns.**
- **Create incentives for students to purchase Bixi memberships or used bicycles.**
- **Revisit the ban on cycling through the Downtown campus or offer safe, alternative ways of accessing campus buildings by bicycle.**
- **Introduce facilities for cyclists such as showers, lockers, and sheltered or security-monitored parking.**

WALKING

Figure 48 illustrates the frequency of responses for various suggestions for improving walking as a viable means of commuting to campus. Improvements to the walking environment - which includes the condition and maintenance of sidewalks, adequate linkages, as well as the addition of benches, tree canopy, and lighting - are cited most frequently over the other options listed in the survey question. Improving the walking environment may also encompass many of the other suggested walking improvements listed in Figure 48, such as improvements to crosswalks, reduced speed limits, and increased traffic awareness.

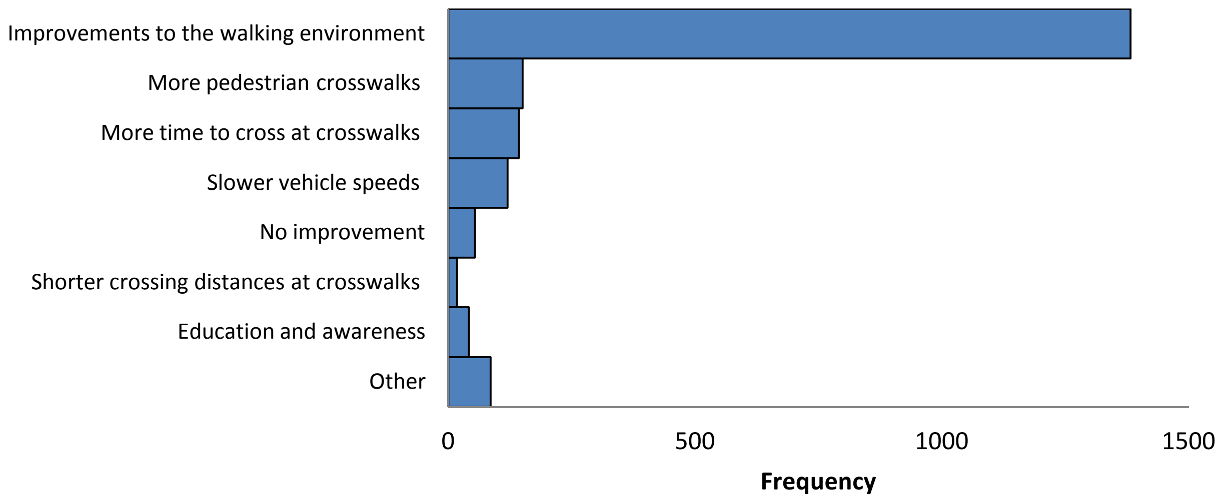

Figure 48. Frequency of responses for suggested improvements to walking

Moreover, comments by survey respondents suggested the expansion of tunnels and underground thoroughfares to conveniently connect campus buildings to the underground mall in downtown Montreal, as well as two central metro stations:

> *"Many people work on the Main Campus (the buildings between McTavish-Sherbrooke-University-Pine) - it would be nice, as Concordia has done at Guy metro, to have the metro pedestrian tunnels extend up to campus into one of the buildings nearby (i.e. Burnside) so that people wouldn't have to walk outside and just use the tunnel to get up to campus when they exit McGill metro. I think this would encourage people, particularly those who fear walking on the icy sidewalks, to use public transit instead of driving."*

Once again, the issue of snow removal and the winter hazards that significantly degrade walking conditions are of particular concern among survey respondents. While a majority of comments and suggestions are aimed towards more efficient snow removal, the addition of paved paths that create connections and allow for better accessibility across campus is also suggested by respondents. The quote below highlights these points.

> *"... My big suggestion to a group trying to improve transportation at McGill would be to make it a convenient walk from Strathcona to Thompson House across that reservoir: 1. Make a cross-walk from those stairs that end at Dr. Penfield to the entrance of the park, 2. Get rid of that perpetually closed gate and little muddy gap, 3. Make a paved walk through the park from the east entrance to the west entrance, 4. Regularly plow it in winter, 5. Make another cross-walk across McTavish at the West Entrance. A lot of people use this commute--it would be a welcome change. Thanks for reading!"*

Comments and Concerns for Walking:

- **Enhance walking environment by resurfacing sidewalks, adding benches, installing adequate lighting, and increasing tree canopy.**
- **Improve efficient snow removal of sidewalks and outdoor stairs.**
- **Create shortest-route footpaths to establish linkages between buildings and existing infrastructure, especially across Rutherford Park.**
- **Construct an underground tunnel connecting the McGill campus with the McGill/Peel metro station and the rest of the downtown underground network.**
- **Reorganize traffic signalling at problematic intersections, such as Rue Milton and Rue University, and add crosswalks, especially at Avenue des Pins and Rue Dr. Penfield.**

PUBLIC TRANSIT

Figure 49 illustrates the frequency of responses when survey respondents were asked to identify the most important improvements that could be made to public transit. More than 1,000 survey respondents feel that a reduction in the cost of transit would be the best improvement for transit. Individuals citing "reduced transit wait times" or "less crowded transit vehicles" as important transit improvements are both pointing out the need for increased transit frequency. Finally, 600 respondents felt that more reliable transit service is also of great importance.

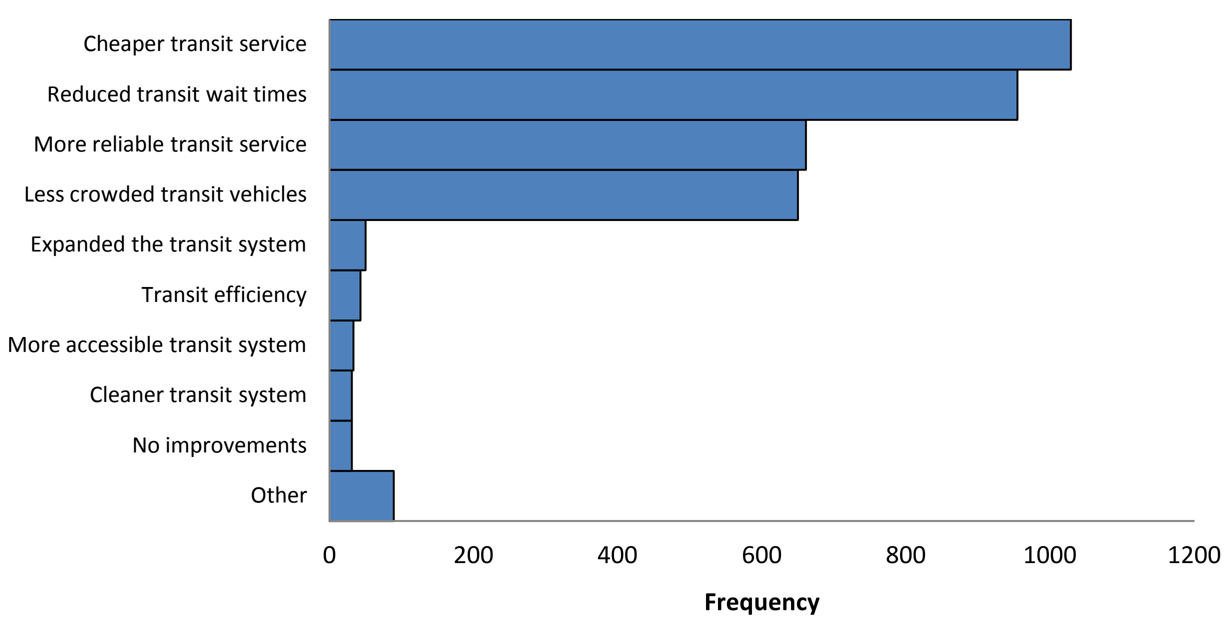

Figure 49. Frequency of responses for suggested improvement to transit

In addition, public transit received much attention in the open-ended comment questions in the survey, in which survey respondents highlighted issues such as: the difficulties of transit use for individuals with reduced mobility, high transit fares, unreliable and inconsistent service on the commuter train lines, as well as the frequency and dependability of several bus routes, notably the 144 along Avenue des Pins.

As mentioned previously, transit fares are of major concern, especially for those students that exceed the age limit for a student discount transit passes. Likewise, the onset of the UPass adopted by the Université de Montreal, with Concordia University to follow, has sparked debate over the idea of a school-wide transit pass, as illustrated in the following quote.

> *McGill should come up with some way to make it that all students have a bus pass. This is currently done at many schools in Canada where your student fees cover the cost of a bus pass and this makes it cheaper, and gives a lot of money to the transit system. It is also way less hassle. This would also encourage people to not use their cars to get to campus if they already have a bus pass in their possession.*

Furthermore, individuals with reduced mobility often cite the many barriers and obstacles that make their commutes to campus and within campus tedious and stressful. Many metro stations lack elevators or working escalators, and not all buses provide adequate handicap services, as illustrated in the following quote.

> *"In the case of persons with disabilities, mainly mobility impairments, there should be more shuttle buses to help us navigate the campus. I tried once to get to McGill by bus, and I had to give up after 5 buses stopped and told me either the driver did not know how to use the elevator, the elevator did not work, or there was room only for one person with a disability and there was already one in the bus. There is also a rule that wheelchair users are not allowed to use public buses during rush hours. As for the metro, there are groups advocating for the implementation of elevators in Metro stations, but their demands do not deserve the attention they should. Maybe McGill could join the advocacy efforts and ensure that the nearest station be adapted as soon as possible. Maybe if significant actors like universities join the advocacy efforts, the metro will be an option to get to the campus soon."*

Complaints regarding the reliability, efficiency and wait times of the AMT commuter rail were numerous. This was particularly pertinent to the timing of rush-hour trains and the lack of trains leaving downtown Montreal during irregular hours:

> *"There needs to be more frequent train service on the Montreal-Vaudreuil line, particularly between 5-9 p.m. There also needs to be more parking spaces available at the train station. If get there after 7:30 now there is nowhere to park!"*

Lastly, comments concerning bus routes touched upon various issues with reliability, wait-times, and connections between different routes. There was repeated concern for bus route 144 that travels along Avenue des Pins. The following quote provides a good example of the concern with this route. Although service for this route is in high demand (it serves four hospitals, two of which are MUHC), the buses are infrequent during peak periods and even more so during off-peak periods, and this route encounters significant delays. Individuals have reiterated the importance of this route, as it connects to a significant number of McGill buildings and offices.

> *"The bus service to the downtown McGill campus is not very good. The bus route 144 is not very frequent at all and during bad weather, in winter especially, it is really, really bad. Sometimes, several buses do not come at all. The wait time at the Metro stations becomes much too long for comfort. More frequent bus services to the campus, not only bus route 144, would definitely encourage the use of public transport."*

Comments and Concerns for Public Transit:

- **Offer a school-wide discounted transit pass to circumvent the age cap of 25 for a reduced fare on an OPUS card.**
- **Improve the reliability and frequency of bus route 144 (Avenue des Pins).**
- **Construct adequate facilities such as escalators and elevators in metro stations for those with reduced mobility.**
- **Increase the overall frequency of the commuter train (AMT) during the evenings, and improve the reliability and efficiency of the commute.**

McGill Intercampus Shuttle

The McGill intercampus shuttle service is a vital link between the two main McGill campuses; it serves to ferry a significant number of individuals to and from lectures, meetings, and other academic or institutional events. Concerns about shuttle capacity, frequency, costs, network range, and knowledge of such service are the most frequently cited in the comments. This important service must be well managed in order to capture all its benefits. Figure 50 illustrates the various comments received from survey respondents, as suggestions to improve the McGill shuttle service.

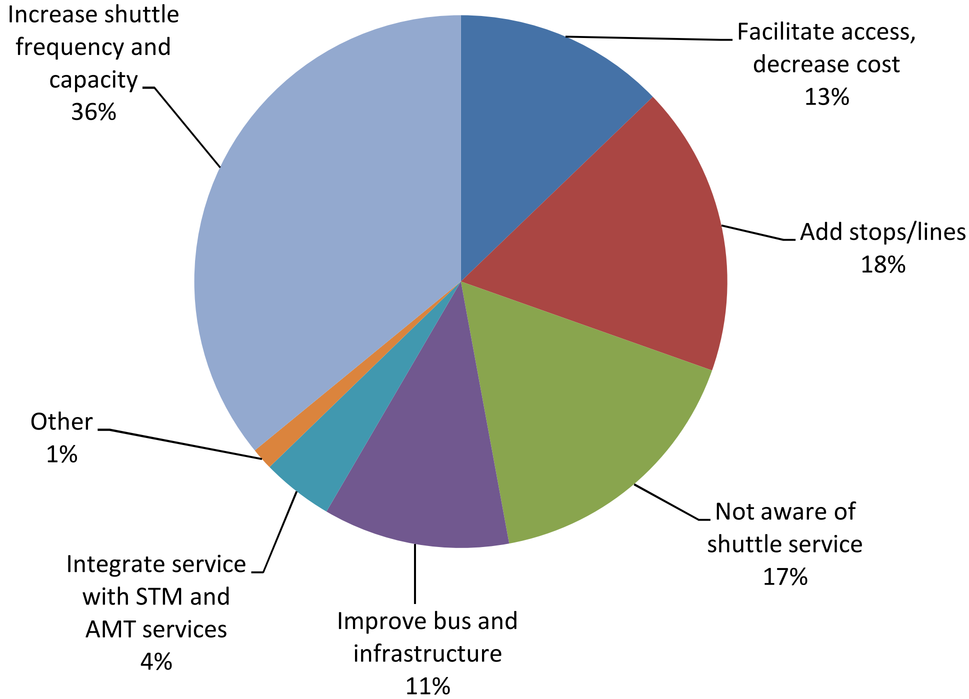

Figure 50. Respondents' suggestions to improve the McGill intercampus shuttle service

More than a third of respondents have put forth suggestions regarding the frequency and capacity of the McGill shuttle service. Survey respondents remarked that boarding the shuttle involves long wait times, overcrowded buses, and anxiety over being punctual for commitments. Survey respondents feel that the frequency of shuttles should be increased, and that service hours should be extended beyond peak travel hours, as highlighted in the quotes below.

> *"We need a more logical schedule: add an earlier bus, add a later bus, and reduce mid-day buses. Perhaps use smaller buses during non-peak times."*

> *"More shuttles in the morning because there is not enough room for everybody that uses it! Even when arriving 40 minutes before the shuttle leaves at 7:20 you may not be able to take it and you will have to wait for the next one at 7:45 (which, in the middle of the semester-particularly in the fall-may be too full to board)."*

> *"In terms of necessary improvements: there need to be more buses at peak times (between 7 and 9am, and from 4 to 6pm, and the service should be easily be accessible to ALL students (not just those who study on the Mac Campus) and staff... this will facilitate interaction between the campuses (i.e. students engaging in joint activities and events, staff collaborating on projects)."*

It is alarming to note that 17% of respondents are not aware of the McGill intercampus shuttle service; this suggests a clear need for increased promotion and awareness of the McGill intercampus shuttle service, as noted in the following quotes. While some individuals may be aware of the existence of the shuttle, they may not be familiar with the shuttle schedule, fare or route, as noted in the following quotes.

> *"Get more promotion, I didn't even know there was an intercampus shuttle service available!"*

> *"More awareness of it would be useful and details on how it works would encourage those who are interested in using the service."*

> *"I've never known the schedule of the intercampus shuttle service and have no idea of the whereabouts of the bus stop to take it. Is it possible to make some obvious signs around the campus just like the one that STM's using?"*

Although details regarding the shuttle service, fare and schedules are posted on the McGill website, students and staff would benefit from increased promotion of the service and alternative communication outlets, such signage indicating schedules and stops, as well as posters and flyers.

Furthermore, 18% of the survey respondents indicated a need for additional shuttle stops and lines, which would provide riders with the possibility of boarding or disembarking the bus closer to their destination, or linking their shuttle ride with a metro or bus stop (see the quotes below). Such an initiative would require integrating the shuttle service with city-wide and regional public transit (STM and AMT).

> *"The shuttle could run its current 16 departures between Macdonald and Lionel-Groulx to maximize efficiency (by collaborating with STM to take advantage of existing Green Line Metro to Peel/McGill stops). Ultimately, McGill could eliminate its shuttles and partner with the STM to extend their very successful 747 Express Buses out to Macdonald Campus (i.e. sustainable, 24 hour express service between Macdonald, Dorval circle, Lionel-Groulx, and Berri-UQAM) - maximizing public transit service for McGillians between West Island and Montreal Est using their existing monthly OPUS/TRAM passes.***"***

> *"Make interim stops at points on the highway along the route (i.e. Beaconsfield, Pointe Claire, Dorval). This would make it much more convenient for staff and students to use.*
> *"Those of us who work slightly off campus are completely forgotten when it comes to any type of service or activity. For instance, I do not have enough time to walk or commute to the main campus for a conference or any other activity. If shuttles were organized to accommodate us, it would certainly enhance our McGill experience."*

A potential solution to meet survey respondents' concerns for higher shuttle frequency and extended service hours could be met with a mix of express and local shuttle buses. Direct (express) shuttle buses to Macdonald campus could be nonstop, whereas additional “local” shuttle buses could make two or three brief stops at major metro or commuter train stations along its route. In addition, the need for shuttle service connecting the main McGill campuses and other McGill institutions, such as hospitals and off-campus laboratories was also expressed by survey respondents.

Anxiety about fares and shuttle passes suggest that respondents would like pass procedures to be fair and simple. Students indicated that they would like to be able to only show their ID to access the shuttle, and staff indicated their discontent with the fact that they are required to pay one day in advance using a FOAPAL number. In addition, some faculty and staff expressed discontent about not being permitted to board the shuttle. The following quotes highlight these raised issues.

> *“Staff should be allowed to ride the shuttle for free, or at the very least it should be simpler to buy tickets. The current system for purchasing tickets is quite a hassle.”*

> *“We were advised that McGill staff is no longer able to take the shuttle. Mac Campus refused to sell me a parking pass for the last few months. However, I know for a fact there are a select few that still take the shuttle. So either ALL staff should be permitted or NO staff should be permitted.”*

> *“I regularly need to travel between campuses in order to attend meetings or events. The new policy whereby staff may only purchase tickets using a FOAPAL number means that I now must ask my unit to absorb the cost of my travel. This is unreasonable, as our department does not pay for anyone else's travel. I understand that the shuttle is costly, though I believe that it is an important service, both to students and staff. Macdonald campus is isolated, and often overlooked in decision-making. The shuttle is an easy way to ensure that the campuses are linked. I am not sure how the shuttle is currently funded, but it seems unreasonable that the cost should be shouldered by Macdonald campus alone.”*

The physical infrastructure of the shuttle service was another area of concern which arose frequently in the comments from survey respondents. Providing adequate shelter at shuttle stops, as well as proper heating of the buses, were cited as ways of making the shuttle commute much more favourable. Not only would minor improvements such as shelters benefit waiting passengers, but they would also provide a visual reference for others to promote awareness of the service.

> *“A place to wait that is protected by the rain and does not interfere with other pedestrians. If this is not possible, then allow buses to sit at the stop and let students sit in the bus.*

> *“Have better heating on the buses in the winter: often ice forms on the inside of the windows!*

Comments and Concerns for Shuttle Services:

- **Significantly boost shuttle frequency and capacity to cut long wait times and overcrowded buses.**
- **Allow the shuttle to be universally used by faculty and staff.**
- **Integrate several stops at major metro or train stations to create transit connections. Consider incorporating express buses to Macdonald campus and local buses that make several stops.**
- **Introduce a streamlined system to simplify buying passes for staff, and an ID-swipe machine for students boarding buses.**
- **Promote the shuttle service by disseminating information through informational posters and online media, posted schedules, and clearly marked bus stops.**
- **Provide adequate shelter at bus stops and heating in the buses.**
- **Incorporate a shuttle that connects other McGill facilities, such as hospitals and off-campus laboratories.**

OTHER COMMENTS AND CONCERNS

To ensure that all comments and concerns of the survey respondents were captured adequately, an additional open-ended question was included at the end of the survey to allow respondents to elaborate on any additional comments or concerns that were not within the scope of other questions or that are very important to them. Figure 51 illustrates the comments and concerns brought forward by survey respondents in this question regarding commuting to McGill campuses. The comments are rather diverse and touch upon all modes of transportation to campus. Some of the comments are similar to those discussed in the previous sections dealing with mode-specific comments and concerns, such as concerns with public transit and bicycle infrastructure, thus stressing the importance of these concerns and suggestions from the viewpoint of McGill commuters.

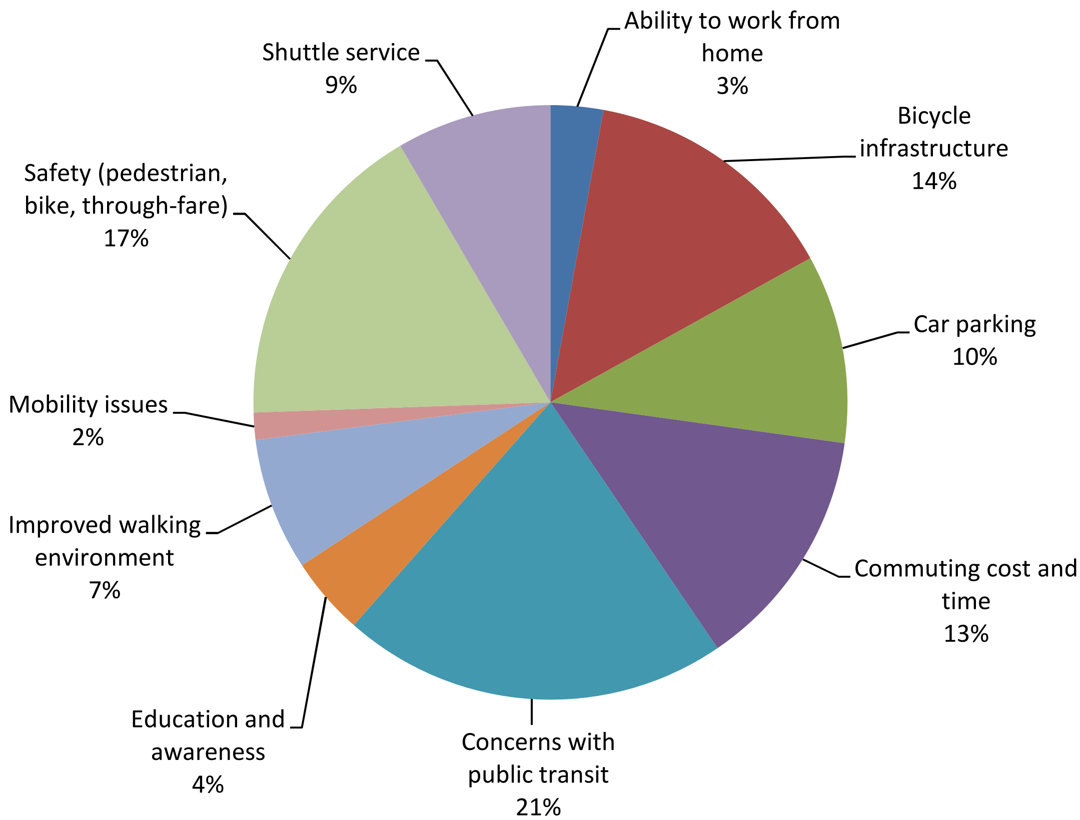

Figure 51. Respondents' other comments or concerns regarding commuting to McGill campuses

Concerns about safety for non-motorized trips comprise a large proportion of the comments raised in this question (17%). A lack of respect between pedestrians, drivers and cyclists manifests when road signs and regulations are disobeyed or inconsistent with actual traffic flows and patterns. Moreover, adequate snow removal and improved streetscapes enhance safety against the natural elements, thus encouraging individuals to take advantage of walking and cycling infrastructure. Likewise, survey respondents cycling to campus feel that cleared bicycle lanes in and around campus may eliminate the impeding threat of automobiles. Sharing the street is a way of life in most cities, and proper reinforcement of the rules of the road, as well as respect for pedestrians and cyclists are crucial for encouraging the use of active modes. It is necessary to address the ongoing dilemma of vehicular traffic and give priority to active transport users, whenever feasible.

> *"Recent anti-bicycle policy on campus: it's ineffective and destructive to campus morale and unnecessarily pits pedestrians against cyclists. I think McGill could better address the expressed concerns of select individuals (who have over-generalized their perception of that bicycles are dangerous) through innovative design interventions in the space shared by cyclists and pedestrians. Remember all cyclists are also pedestrians, so to vilify them in support of pedestrians is moot. The intersections adjacent to campus are dangerous for pedestrians and cyclists alike. The traffic signalization along University is*

especially problematic and should be reviewed and altered - pedestrians and cyclists should have priority at all intersections that feed into and border the campus. The speed and volume of motor vehicle traffic along University, Milton, and Hutchison is disconcerting. I'd like to see traffic calming measures along these streets. Due to the high volume of bicycle traffic along the bicycle routes on Milton and University (during the spring, summer, and fall in particular) these streets should become bicycle priority streets. They could accommodate local car and truck traffic, but drivers would be informed that the street right-of-way is always first to pedestrians and second to cyclists."

It must be emphasized that transit users represent more than half of the total McGill commuters. Therefore, maximizing their satisfaction may prove to be beneficial to sustainable transportation initiatives at McGill. Although satisfaction rates for transit users are relatively stable, there are some particular concerns that need to be addressed. The most recurring concern and suggestion from survey respondents related to transit is a decrease in the transit fare, or a student fare based on status and not on age. Another recurring concern and suggestion from survey respondents is an increase in frequency of service, which translates into shorter wait times, as well as less crowded transit vehicles. Certain areas of the metropolitan region, such as the West Island, the North Shore and the South Shore, are cited by respondents as lacking sufficient transit options and flexibility (see the quote below, for example). Forging more dynamic partnerships with the STM and the AMT may prove to be advantageous to both the McGill community and Montreal transportation authorities.

"I chose to never use a car to travel downtown. It seemed ludicrous to me. While the metro system is amazing, the bus transportation should be improved. More buses are definitely needed, as given the smaller capacity of the newer buses, they are almost painfully crowded. Having the metro extend further into LaSalle/Lachine/Dorval would be absolutely great, along with the improvement to the train service from further beyond Dorval."

Lastly, users of private motorized vehicles have contributed their own comments and suggestions. Of greatest concern among these individuals is the issue of sufficient parking. Motorists generally participate in this mode of transportation simply because other options cannot compete with the flexibility that the car offers. In addition, individuals with reduced mobility must rely on their vehicles to transport them safely to and from their destination. Some survey respondents feel that the procedure for reserving parking spaces is highly inefficient, and that the procedure for determining priority for spaces remains relatively inconsistent. If McGill wishes to further introduce measures to eliminate vehicles on campus, it must supplement these disincentives with initiatives to ease the transition and channel motorized vehicle users into other sustainable modes of transport. Campaigns to promote carpooling among those groups for who the automobile is the only viable transportation mode (given their family status or reduced mobility) may help in this regard. The following quote highlights these issues.

"My suggestion would be to give parking spaces first to staff with young children (0-until end of secondary school). Second to those who carpool. Third, by age group (may be more difficult to bicycle or walk at a certain age). Strangely, you get a parking spot right away if your address is far away from campus. This is so illogical. One of my colleagues, who used to live downtown and walk to work, recently bought a house on the South shore. Right away he was given a parking spot, even if he is single and relatively young. The reason: if you live far, you can take your car. So, if you live near and carpool thus using very little oil to come to work, you are denied a parking, If you live far, use a lot of oil, you are rewarded with a parking space. Where is the incentive for living near and encouraging sustainable transportation?"

Other Comments and Concerns:

- **Maximize the satisfaction of the commute for transit users: they account for over two thirds of total trips made to and from McGill campuses every day. These improvements will be most beneficial to a majority of individuals.**
- **Create a culture of respect among pedestrians, cyclists and motorists to augment overall safety by maintaining infrastructure, improving design and introducing traffic-calming measures.**
- **Standardize the procedure for the procurement of parking spaces for motor vehicles on campus. Offer priority parking passes for seniors, disabled individuals, and those with young children.**
- **Encourage active transport by amending the ban on cycling through campus or offering safe, alternative routes around the campus.**

These comments are paramount to understanding the daily commuting patterns of McGill's thousands of students, faculty and staff. Alleviating the burdens associated with commuting by actively seeking partnerships, collaborating on projects, and spearheading initiatives can potentially enhance McGill's commitment to providing incentives to use sustainable means of transportation. Montreal, a city widely recognized for its *liveability*, provides a structurally sound framework for these ideas to take root. McGill should be at the forefront of these changes if it wishes to take a serious step towards environmental stewardship.

Section VIII – *Conclusion*

The current report, based on the results of the 2011 McGill Transportation Survey, is a comprehensive analysis of the commuting patterns among the McGill University community. Detailed information is provided with regard to various topics, including: the survey design and dissemination; the analytical methodologies employed; various demographic and choice statistics; an estimate of the level of greenhouse gas emissions generated by the university as a result of commuting; the types of commuters that make up the McGill community; the level of satisfaction that individuals have with their current commute; and finally, the various comments and concerns raised by survey respondents related to improving sustainable transportation options to McGill campuses. The results presented in this analysis provide valuable insight into the various factors that influence individuals' travel choices, as well as a better understanding of the university's environmental impact. This information is essential for guiding future action to promote sustainable transportation to university campuses.

Based on the findings detailed throughout this report, the TRAM research group has generated a few recommendations to guide McGill University's next steps in their endeavour to further encourage the use of sustainable modes of transportation for commuting to and from the various campuses. For one, it is recommended that McGill explore the viability of implementing a special, reduced student rate for public transit, since the current age cut-off for reduced rates is 25 years despite the fact that many students (particularly graduate students) are above this age. The Université de Montréal has just negotiated such a discount with the STM; enquiring on the details and challenges of their negotiations may prove very helpful to McGill in assessing the viability of such an initiative. An additional recommendation related to public transit is to conduct further studies to address some of the issues raised regarding bus route 144, which may help to identify ways to improve this route.

Within the context of the University, attention has been brought to particular services, policies and infrastructure on campus. The McGill Intercampus Shuttle is an essential service that is well used by the McGill community as a means of traveling between the two main campuses. It is recommended that McGill undertake a study to investigate the feasibility of increasing shuttle frequency and comfort, as per the suggestions obtained from the survey respondents. In addition, it may be wise to revisit the cycling ban on campus, as many respondents indicated that they feel this policy is a deterrent to the use of sustainable transportation, or sends a negative message regarding McGill's support for sustainable transportation. Perhaps this misconception can be resolved through further informational campaigns stressing the rationale behind this policy and the resulting benefits and challenges. It is also recommended that further attention be paid to maintaining sidewalks and paths, particularly during the winter months, to ensure that individuals are not discouraged from walking to and on campus.

In order to effectively track changes in travel behaviour as new initiatives or projects encouraging and facilitating the use of sustainable transportation are implemented, it is recommended that a study investigating the commuting patterns and impacts of the McGill community, similar to this current study, be conducted every two to three years. Further research in this area, however, would greatly benefit from ensuring a more representative proportion of students, faculty and staff in the survey sample of the McGill population (and to avoid an oversampling of McGill employees, as in this current survey), as this will give rise to an even more accurate estimation of the mode share and environmental impact of commuting to and from McGill campuses.

The high level of responses from individuals primarily attending the Downtown McGill campus made it difficult to accurately and meaningfully summarize travel behaviour and commuting impact from other McGill campuses and facilities. Further research should be undertaken to estimate the level of greenhouse gas emissions generated from the Macdonald campus, as this current report only examines the emissions for the Downtown campus. Additional studies should also ensure a fair sample size from the Macdonald campus, as well as other McGill-affiliated facilities (such as teaching hospitals and laboratories), to understand the commuting patterns to and from these facilities in greater depth, so that future initiatives to encourage sustainable transportation can be tailored to the travel needs of the individuals attending these campuses and facilities.

Moreover, future research in this area would also benefit from gathering further data on those who choose to drive to campus, the reasons why they choose this mode and how they could be persuaded to use alternative, more sustainable modes whenever realistic options are available. Additional analyses examining the level of satisfaction that individuals have with their current commute (such as that found in Appendix VII for walkers) would be beneficial for other modes, particularly cycling and public transit, as this may help to better understand how the use of these modes could be improved and further promoted. Finally, it would also be potentially interesting to expand the survey to explore the extent that an individual's commute affects their level of involvement in extracurricular activities and campus life.

Overall, the McGill University community travels to and from campus in a sustainable manner. Additional efforts to facilitate and encourage the continued use of sustainable modes of commuting would greatly benefit the University and its community. Given the large population of the University and the various campus and facility locations it holds across the city, these efforts are paramount to minimizing the institution's environmental impact and contributing to the sustainability of the region as a whole.

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Section X – *Appendices*

APPENDIX I – FINAL SURVEY

2011 McGill Transportation Survey

The inter-disciplinary research group, Transportation Research at McGill (TRAM) is currently undertaking research aiming to assess the environmental impact of travel to and from McGill University and to develop recommendations on how to further encourage the use of sustainable transportation for commuting to McGill. The target population of the survey includes all McGill students, staff, and faculty. Your participation is greatly appreciated. The project is led by Cynthia Jacques and Jacob Mason, Master of Urban Planning candidates, under the supervision of Ahmed El-Geneidy, Assistant Professor with the School of Urban Planning, Naveen Eluru and Marianne Hatzopoulou, Assistant Professors with the Department of Civil Engineering.

This short survey will take approximately 10 to 15 minutes to complete. Participation is voluntary, and you may exit the survey at any time. Completing the survey indicates consent to participate in this study. The findings of the survey may be presented to the City of Montréal and to the Société de transport de Montréal (STM). Other research resulting from the survey may be published in various academic journals and at conferences. All survey responses will remain confidential, stored on password-protected computers, and participants will not be identified in any publications or reports. The data may be kept for future research purposes. All participants will automatically be entered into a drawing for various prizes. The drawing will occur on TBD, and prizes will include:

- One night accommodation in Signature Club room with buffet breakfast for two at the Signature Club Lounge at the Delta Montreal (1 prize; odds of winning 1:2000)
- McGill Bookstore $20 gift card (5 prizes; odds of winning 1:400)
- McGill Athletics 3-month or summer membership (1 prize; odds of winning 1:2000)
- Macdonald Campus Athletics membership for Fall 2011 (1 prize; odds of winning 1:2000)
- Faculty Club $25 gift certificate (1 prize; odds of winning 1:2000)
- Lunch for two at Tadja Hall, Macdonald Campus Faculty Club (1 prize; odds of winning 1:2000)
- McGill Food and Dining Services $15 gift certificates (5 prizes; odds of winning 1:400)
- One -year Bixi membership (5 prizes; odds of winning 1:400)
- iTunes $15 gift cards (4 prizes; odds of winning 1:500)
- Second Cup $10 gift certificates (5 prizes; odds of winning 1:400)

Many thanks to Kathleen Ng, Environmental Officer with the McGill Office of Sustainability, for her support in carrying out this project and for coordinating exciting prizes. We would also like to thank the McGill Sustainability Projects Fund for funding this research project and contributing to graduate research.

If you have any questions of concerns regarding this research project, please send an email to TRAM@mcgill.ca. If you need urgent assistance, you may call TRAM at 514-398-4058.

If you have any questions or concerns regarding your rights or welfare as a participant in this research study please contact the McGill Research Ethics Officer at 514-398-6831 or lynda.mcneil@mcgill.ca.

PART I – GENERAL INFORMATION

Question 1

Are you a... ?

Choose one of the following answers

- ○ McGill academic staff (faculty)
- ○ McGill adjunct faculty
- ○ McGill administrative staff
- ○ McGill staff (e.g., security, maintenance)
- ○ McGill undergraduate student
- ○ McGill graduate student
- ○ McGill continuing education student
- ○ McGill post-doctoral fellow
- ○ Visitor (e.g., visiting scholar)
- ○ Other: ______________________

Question 1.2

Are you at McGill... ?

Choose one of the following answers

- ○ Full-time
- ○ Part-time

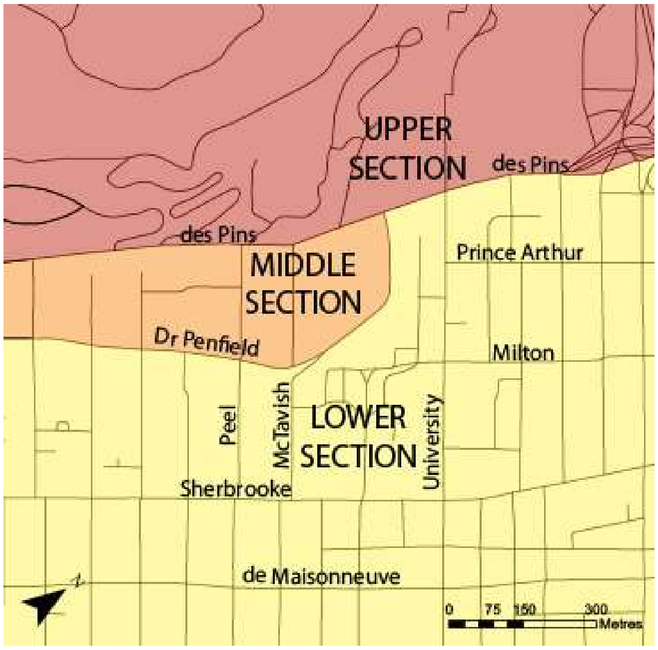
Question 2

For how many years have you been actively involved with McGill? _________________ years

Question 3

When at McGill, you spend the majority of your time at:

Choose one of the following answers



- ○ Macdonald Campus
- ○ **Lower section**, McGill Downtown campus (south of Dr. Penfield)
- ○ **Middle section**, McGill Downtown campus (between Dr. Penfield and des Pins)
- ○ **Upper section**, McGill Downtown campus (north of des Pins)

<u>Question 4</u>

Describe your typical work schedule at campus.

- ○ I'm on campus for standard hours (for example 9am – 5pm) _______ days per week
- ○ I'm on campus for nonstandard hours ________ days per week

<u>Question 5</u>

To best examine travel behaviour, McGill is interested in **your home location** while working/studying at McGill. Would you prefer to provide...?

- ○ Postal code
- ○ Nearest intersection

If 'Postal code' go to question 5.1. If 'Nearest intersection', go to question 5.2.

<u>Question 5.1</u>

What is your current **home** postal code while at McGill? (Please enter in the form: XXX XXX)

____

Question 5.2

What is the nearest intersection to your **home**?

Example: Rue Sherbrooke and *Avenue du Parc*

Street #1: ___________________________

Street #2: ____________________________

PART II - COMMUTING HABITS

Question 6

In general, what is your **primary** mode of travel when commuting to McGill?

Choose one of the following answers

- ○ Walk
- ○ Bicycle
- ○ Carpool
- ○ Automobile
- ○ Bus
- ○ Metro
- ○ Commuter train
- ○ McGill intercampus shuttle
- ○ Motorcycle / scooter
- ○ Taxi
- ○ Other: ____________________

If 'Walk', answer questions 6.1a & 6.1b
If 'Bicycle', answer questions 6.2a & 6.2b
If 'Bus', 'Metro', or 'Commuter train', answer questions 6.3a & 6.3b
If 'Automobile' or 'Motorcycle / scooter', answer questions 6.4a & 6.4b & 6.5
Otherwise, go to question 7.

Question 6.1a
What is the ***most*** important factor in your choice to **walk**?
Choose one of the following answers

- ○ Walking is a good form of exercise

- Walking is good for the environment
- I live close to campus
- I do not have access to a car
- Other modes of transportation are too expensive
- It is convenient for me to walk
- It is a pleasant walk
- Other ____________________

Question 6.1b

What is the ***second most*** important factor in your choice to **walk**?

Choose one of the following answers

- Walking is a good form of exercise
- Walking is good for the environment
- I live close to campus
- I do not have access to a car
- Other modes of transportation are too expensive
- It is convenient for me to walk
- It is a pleasant walk
- Other ____________________

Question 6.2a

What is the ***most*** important factor in your choice to **cycle**?

Choose one of the following answers

- Cycling is a good form of exercise
- Cycling is good for the environment
- I live close to campus
- I do not have access to a car
- Other modes of transportation are too expensive
- It is faster than other modes of transportation
- It is convenient for me to cycle
- It is a pleasant ride (i.e., good bicycle paths)
- Other ____________________

Question 6.2b

What is the ***second most*** important factor in your choice to **cycle**?

Choose one of the following answers

- Cycling is a good form of exercise
- Cycling is good for the environment
- I live close to campus
- I do not have access to a car
- Other modes of transportation are too expensive
- It is faster than other modes of transportation
- It is convenient for me to cycle

- It is a pleasant ride (i.e., good bicycle paths)
- Other ____________________

Question 6.3a

What is the ***most*** important factor in your choice to use **transit**?

Choose one of the following answers

- Taking transit is environmentally friendly
- Transit is the most convenient option
- I can do other things while taking transit (e.g., reading)
- I do not have access to a car
- I live too far to walk or cycle
- Other modes of transportation are too expensive
- Other ____________________

Question 6.3b

What is the ***second most*** important factor in your choice to use **transit**?

Choose one of the following answers

- Taking transit is environmentally friendly
- Transit is the most convenient option
- I can do other things while taking transit (e.g., reading)
- I do not have access to a car
- I live too far to walk or cycle
- Other modes of transportation are too expensive
- Other ____________________

Question 6.4a

What is the ***most*** important factor in your choice to commute by **motorized vehicle**?

Choose one of the following answers

- It's the most convenient option
- It's the least expensive option
- It's the fastest option
- I have a mobility related disability
- I live too far for other modes of transportation to be practical
- Other ____________________

Question 6.4b

What is the ***second most*** important factor in your choice to commute by **motorized vehicle**?

Choose one of the following answers

- It's the most convenient option
- It's the least expensive option
- It's the fastest option

- I have a mobility related disability
- I live too far for other modes of transportation to be practical
- Other ____________________

Question 6.5

What factors discourage you from carpooling?

Check any that apply

- My schedule is too variable/irregular
- Distance between home and McGill
- I can't find anyone to carpool with
- Prefer to drive alone
- I have to bring my children to/from school/daycare
- I run errands before/after work/school
- Other: _________________

Question 7

Question 7.1

Describe the sequence of your **most recent trip to McGill** by answering the following questions:

- First, I:

Choose one of the following answers

- Walked to transit
- Walked
- Bicycled: Bixi? Yes or No
- Carpooled, with _____people (including the driver) in the car.

Which type of car?

- Passenger car (compact, mid-size, or large sedan)
- Small SUV or small pickup
- Minivan or compact SUV (e.g. Explorer)
- Intermediate SUV (e.g. Land Cruiser)
- Larger SUV (e.g. Expedition)
- Other _____________

With whom did you carpool?

- Family members
- Neighbours
- Friends
- Colleagues at McGill

- Other: ________________

- Drove: Which type of car?
  - Passenger car (compact, mid-size, or large sedan)
  - Small SUV or small pickup
  - Minivan or compact SUV (e.g. Explorer)
  - Intermediate SUV (e.g. Land Cruiser)
  - Larger SUV (e.g. Expedition)
  - Other ______________
- Took the bus route ___________
- Took the metro ____________ line
- Took the commuter train ___________ line
- Took the McGill intercampus shuttle
- Rode a motorcycle / scooter
- Took a taxi
- Other: __________________

- Second, I

Choose one of the following answers

- Reached campus
- Made a stop on my way to campus

  What was the purpose of the stop?
  - Drop children off at school/daycare/etc.
  - Shopping
  - Buy coffee/meal
  - Stop at the bank
  - Go to the gym
  - Other: ___________________
- Walked to transit
- Walked
- Bicycled: Bixi? Yes or No
- Carpooled, with _____people (including the driver) in the car.

  Which type of car?
  - Passenger car (compact, mid-size, or large sedan)
  - Small SUV or small pickup
  - Minivan or compact SUV (e.g. Explorer)
  - Intermediate SUV (e.g. Land Cruiser)
  - Larger SUV (e.g. Expedition)
  - Other ______________

  With whom did you carpool?
  - Family members
  - Neighbours
  - Friends
  - Colleagues at McGill

- Other: ________________

- Drove: Which type of car?
  - Passenger car (compact, mid-size, or large sedan)
  - Small SUV or small pickup
  - Minivan or compact SUV (e.g. Explorer)
  - Intermediate SUV (e.g. Land Cruiser)
  - Larger SUV (e.g. Expedition)
  - Other ______________
- Took the bus route ___________
- Took the metro ____________ line
- Took the commuter train ___________ line
- Took the McGill intercampus shuttle
- Rode a motorcycle / scooter
- Took a taxi
- Other: __________________

- Third, I

Choose one of the following answers

- Reached campus
- Made a stop on my way to campus

  What was the purpose of the stop?
  - Drop children off at school/daycare/etc.
  - Shopping
  - Buy coffee/meal
  - Stop at the bank
  - Go to the gym
  - Other: ___________________
- Walked to transit
- Walked
- Bicycled: Bixi? Yes or No
- Carpooled, with _____people (including the driver) in the car.

  Which type of car?
  - Passenger car (compact, mid-size, or large sedan)
  - Small SUV or small pickup
  - Minivan or compact SUV (e.g. Explorer)
  - Intermediate SUV (e.g. Land Cruiser)
  - Larger SUV (e.g. Expedition)
  - Other ______________

  With whom did you carpool?
  - Family members
  - Neighbours
  - Friends

- Colleagues at McGill
- Other: ________________

- Drove: Which type of car?
  - Passenger car (compact, mid-size, or large sedan)
  - Small SUV or small pickup
  - Minivan or compact SUV (e.g. Explorer)
  - Intermediate SUV (e.g. Land Cruiser)
  - Larger SUV (e.g. Expedition)
  - Other ______________
- Took the bus route ___________
- Took the metro ____________ line
- Took the commuter train ___________ line
- Took the McGill intercampus shuttle
- Rode a motorcycle / scooter
- Took a taxi
- Other: __________________

- Fourth, I

Choose one of the following answers

- Reached campus
- Made a stop on my way to campus

  What was the purpose of the stop?
  - Drop children off at school/daycare/etc.
  - Shopping
  - Buy coffee/meal
  - Stop at the bank
  - Go to the gym
  - Other: ___________________
- Walked to transit
- Walked
- Bicycled: Bixi? Yes or No
- Carpooled, with _____people (including the driver) in the car.

  Which type of car?
  - Passenger car (compact, mid-size, or large sedan)
  - Small SUV or small pickup
  - Minivan or compact SUV (e.g. Explorer)
  - Intermediate SUV (e.g. Land Cruiser)
  - Larger SUV (e.g. Expedition)
  - Other ______________

  With whom did you carpool?
  - Family members
  - Neighbours

- Friends
- Colleagues at McGill
- Other: ________________

- Drove: Which type of car?
  - Passenger car (compact, mid-size, or large sedan)
  - Small SUV or small pickup
  - Minivan or compact SUV (e.g. Explorer)
  - Intermediate SUV (e.g. Land Cruiser)
  - Larger SUV (e.g. Expedition)
  - Other ______________
- Took the bus route ___________
- Took the metro ____________ line
- Took the commuter train ___________ line
- Took the McGill intercampus shuttle
- Rode a motorcycle / scooter
- Took a taxi
- Other: __________________

- Fifth, I

Choose one of the following answers

- Reached campus
- Made a stop on my way to campus

  What was the purpose of the stop?
  - Drop children off at school/daycare/etc.
  - Shopping
  - Buy coffee/meal
  - Stop at the bank
  - Go to the gym
  - Other: ___________________
- Walked to transit
- Walked
- Bicycled: Bixi? Yes or No
- Carpooled, with _____people (including the driver) in the car.

  Which type of car?
  - Passenger car (compact, mid-size, or large sedan)
  - Small SUV or small pickup
  - Minivan or compact SUV (e.g. Explorer)
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  - Larger SUV (e.g. Expedition)
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  - Other ______________
- Took the bus route ___________
- Took the metro ____________ line
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  - Buy coffee/meal
  - Stop at the bank
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- Other ______________

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- Other: ________________

- Drove: Which type of car?
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  - Larger SUV (e.g. Expedition)
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- Took the commuter train ___________ line
- Took the McGill intercampus shuttle
- Rode a motorcycle / scooter
- Took a taxi
- Other: __________________

- Ninth, I

Choose one of the following answers

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  What was the purpose of the stop?

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  - Buy coffee/meal
  - Stop at the bank
  - Go to the gym
  - Other: ___________________
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- Bicycled: Bixi? Yes or No
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  Which type of car?

  - Passenger car (compact, mid-size, or large sedan)
  - Small SUV or small pickup
  - Minivan or compact SUV (e.g. Explorer)
  - Intermediate SUV (e.g. Land Cruiser)

- Larger SUV (e.g. Expedition)
- Other ______________

With whom did you carpool?

- Family members
- Neighbours
- Friends
- Colleagues at McGill
- Other: ________________

- Drove: Which type of car?
  - Passenger car (compact, mid-size, or large sedan)
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  - Larger SUV (e.g. Expedition)
  - Other ______________
- Took the bus route ___________
- Took the metro ____________ line
- Took the commuter train ___________ line
- Took the McGill intercampus shuttle
- Rode a motorcycle / scooter
- Took a taxi
- Other: __________________

- Tenth, I

Choose one of the following answers

- Reached campus
- Made a stop on my way to campus

  What was the purpose of the stop?

  - Drop children off at school/daycare/etc.
  - Shopping
  - Buy coffee/meal
  - Stop at the bank
  - Go to the gym
  - Other: ___________________
- Walked to transit
- Walked
- Bicycled: Bixi? Yes or No
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  Which type of car?

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  - Small SUV or small pickup
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- Intermediate SUV (e.g. Land Cruiser)
- Larger SUV (e.g. Expedition)
- Other ______________

With whom did you carpool?

- Family members
- Neighbours
- Friends
- Colleagues at McGill
- Other: ________________

- Drove: Which type of car?
  - Passenger car (compact, mid-size, or large sedan)
  - Small SUV or small pickup
  - Minivan or compact SUV (e.g. Explorer)
  - Intermediate SUV (e.g. Land Cruiser)
  - Larger SUV (e.g. Expedition)
  - Other ______________
- Took the bus route ___________
- Took the metro ____________ line
- Took the commuter train ___________ line
- Took the McGill intercampus shuttle
- Rode a motorcycle / scooter
- Took a taxi
- Other: __________________

Question 7.2

On this most recent trip to McGill, what time did you leave your house and what time did you arrive at McGill? Please use 24-hour time.

Time you left your house? ____ : ____

Time you arrived at McGill? ____ : ____

Question 7.3

On what date did this most recent trip to McGill take place (dd/mm/yyyy)? ____________

Question 7.4

How would you rate your satisfaction with this commute?

Choose one of the following answers

- Very unsatisfied
- Unsatisfied
- Neutral
- Satisfied
- Very Satisfied

PART III - FALL COMMUTING HABITS

Question 8

Would your commute to McGill that you just described be the same **on a nice fall day**?

- Yes
- No

If 'No' go to questions 8.1 and 8.2. If 'Yes' go to question 9.

Question 8.1

Describe the sequence of your last trip to McGill **on a nice fall day** by answering the following questions:

- First, I:

Choose one of the following answers

- Walked to transit
- Walked
- Bicycled: Bixi? Yes or No
- Carpooled, with _____people (including the driver) in the car.

  Which type of car?

  - Passenger car (compact, mid-size, or large sedan)
  - Small SUV or small pickup
  - Minivan or compact SUV (e.g. Explorer)
  - Intermediate SUV (e.g. Land Cruiser)
  - Larger SUV (e.g. Expedition)
  - Other ______________

  With whom did you carpool?

  - Family members
  - Neighbours
  - Friends
  - Colleagues at McGill
  - Other: ________________
- Drove: Which type of car?
  - Passenger car (compact, mid-size, or large sedan)

- Small SUV or small pickup
    - Minivan or compact SUV (e.g. Explorer)
    - Intermediate SUV (e.g. Land Cruiser)
    - Larger SUV (e.g. Expedition)
    - Other ______________

- Took the bus route ___________
- Took the metro ____________ line
- Took the commuter train ___________ line
- Took the McGill intercampus shuttle
- Rode a motorcycle / scooter
- Took a taxi
- Other: __________________

- Second, I

Choose one of the following answers

- Reached campus
- Made a stop on my way to campus

    What was the purpose of the stop?

    - Drop children off at school/daycare/etc.
    - Shopping
    - Buy coffee/meal
    - Stop at the bank
    - Go to the gym
    - Other: ___________________
- Walked to transit
- Walked
- Bicycled: Bixi? Yes or No
- Carpooled, with _____people (including the driver) in the car.

    Which type of car?

    - Passenger car (compact, mid-size, or large sedan)
    - Small SUV or small pickup
    - Minivan or compact SUV (e.g. Explorer)
    - Intermediate SUV (e.g. Land Cruiser)
    - Larger SUV (e.g. Expedition)
    - Other ______________

    With whom did you carpool?

    - Family members
    - Neighbours
    - Friends
    - Colleagues at McGill
    - Other: ________________

- Drove: Which type of car?
    - Passenger car (compact, mid-size, or large sedan)

- Small SUV or small pickup
- Minivan or compact SUV (e.g. Explorer)
- Intermediate SUV (e.g. Land Cruiser)
- Larger SUV (e.g. Expedition)
- Other _______________

- Took the bus route ____________
- Took the metro _____________ line
- Took the commuter train ____________ line
- Took the McGill intercampus shuttle
- Rode a motorcycle / scooter
- Took a taxi
- Other: ____________________

- Third, I

Choose one of the following answers

- Reached campus
- Made a stop on my way to campus

  What was the purpose of the stop?

  - Drop children off at school/daycare/etc.
  - Shopping
  - Buy coffee/meal
  - Stop at the bank
  - Go to the gym
  - Other: _____________________
- Walked to transit
- Walked
- Bicycled: Bixi? Yes or No
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  Which type of car?

  - Passenger car (compact, mid-size, or large sedan)
  - Small SUV or small pickup
  - Minivan or compact SUV (e.g. Explorer)
  - Intermediate SUV (e.g. Land Cruiser)
  - Larger SUV (e.g. Expedition)
  - Other _______________

  With whom did you carpool?

  - Family members
  - Neighbours
  - Friends
  - Colleagues at McGill
  - Other: _________________
- Drove: Which type of car?

- Passenger car (compact, mid-size, or large sedan)
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- Larger SUV (e.g. Expedition)
- Other ______________

- Took the bus route ___________
- Took the metro ____________ line
- Took the commuter train ___________ line
- Took the McGill intercampus shuttle
- Rode a motorcycle / scooter
- Took a taxi
- Other: __________________

- Fourth, I

Choose one of the following answers

- Reached campus
- Made a stop on my way to campus

What was the purpose of the stop?

- Drop children off at school/daycare/etc.
- Shopping
- Buy coffee/meal
- Stop at the bank
- Go to the gym
- Other: ___________________

- Walked to transit
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- Took the metro _____________ line
- Took the commuter train ____________ line
- Took the McGill intercampus shuttle
- Rode a motorcycle / scooter
- Took a taxi
- Other: ____________________

- Fifth, I

Choose one of the following answers

- Reached campus
- Made a stop on my way to campus

    What was the purpose of the stop?

    - Drop children off at school/daycare/etc.
    - Shopping
    - Buy coffee/meal
    - Stop at the bank
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- Reached campus
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Choose one of the following answers

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- Other: ________________

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○ Took the commuter train ___________ line

○ Took the McGill intercampus shuttle

○ Rode a motorcycle / scooter

○ Took a taxi

○ Other: __________________

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What was the purpose of the stop?

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- Buy coffee/meal
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- Other: ___________________

○ Walked to transit

○ Walked

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- Other: ________________

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- Took the metro ____________ line
- Took the commuter train ___________ line
- Took the McGill intercampus shuttle
- Rode a motorcycle / scooter
- Took a taxi
- Other: __________________

- Tenth, I

Choose one of the following answers

- Reached campus
- Made a stop on my way to campus

  What was the purpose of the stop?
  - Drop children off at school/daycare/etc.
  - Shopping
  - Buy coffee/meal
  - Stop at the bank
  - Go to the gym
  - Other: ___________________
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With whom did you carpool?

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- Neighbours
- Friends
- Colleagues at McGill
- Other: ________________

- Drove: Which type of car?
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  - Minivan or compact SUV (e.g. Explorer)
  - Intermediate SUV (e.g. Land Cruiser)
  - Larger SUV (e.g. Expedition)
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- Took the bus route ____________
- Took the metro _____________ line
- Took the commuter train ____________ line
- Took the McGill intercampus shuttle
- Rode a motorcycle / scooter
- Took a taxi
- Other: ___________________

Question 8.2

How would you rate your satisfaction with this commute?

Choose one of the following answers

- Very unsatisfied
- Unsatisfied
- Neutral
- Satisfied
- Very Satisfied

PART IV – MCGILL INTERCAMPUS SHUTTLE

Question 9

Do you use the McGill intercampus shuttle?

- Yes
- No

If 'Yes' go to question 9.1. If 'No' go to question 9.4.

Question 9.1

How do you use the McGill intercampus shuttle?

Check any that apply

- I travel between campuses during the day
- I live near Macdonald campus and use the shuttle to reach the Downtown campus where most my activities are
- I live near Downtown campus and use the shuttle to reach the Macdonald campus where most my activities are
  Other: ___________________

Question 9.1a

What is the ***most*** important factor in your choice to use the McGill intercampus shuttle?
Choose one of the following answers

- Taking the shuttle is environmentally friendly
- The shuttle is the most convenient option
- I can do other things while taking the shuttle (e.g., reading)
- I do not have access to a car
- I live too far to walk or cycle
- Other modes of transportation are too expensive
- Other______________________

Question 9.1b

What is the ***second most*** important factor in your choice to use the McGill intercampus shuttle?
Choose one of the following answers

- Taking the shuttle is environmentally friendly
- The shuttle is the most convenient option
- I can do other things while taking the shuttle (e.g., reading)
- I do not have access to a car
- I live too far to walk or cycle
- Other modes of transportation are too expensive
- Other______________________

Question 9.2.a

What would be the ***best*** way to improve the McGill intercampus shuttle?

Choose one of the following answers

- ○ Reduced wait times
- ○ Less crowded vehicles
- ○ More reliable shuttle service
- ○ Cleaner shuttle
- ○ Other______________________

Question 9.2.b

What would be the ***second best*** way to improve the McGill intercampus shuttle?
Choose one of the following answers

- ○ Reduced wait times
- ○ Less crowded vehicles
- ○ More reliable shuttle service
- ○ Cleaner shuttle
- ○ Other______________________

Question 9.3

How often do you typically use the McGill intercampus shuttle?

_________ time(s) per week / month / semester

Question 9.4

How satisfied are you with the McGill intercampus shuttle service?

Choose one of the following answers

- ○ Very unsatisfied
- ○ Unsatisfied
- ○ Neutral
- ○ Satisfied
- ○ Very Satisfied

Question 9.5

What suggestions do you have for how the McGill intercampus shuttle service can be improved?

____
____
____
____

PART V – WORKING FROM HOME/TELECOMMUTING

<u>Question 10</u>

Do you have the option to work from home or telecommute for your work/studies at McGill?

- ○ Yes
- ○ No

If 'Yes' go to question 10.1. If 'No' go to questions 10.2 & 10.3.

<u>Question 10.1</u>

For the current semester, roughly how often do you work/study from home/telecommute?

_________ day(s) per week / month

<u>Question 10.2</u>

What factors discourage you from working from home/telecommuting?

Check any that apply

- ○ Working from home/telecommuting is not encouraged
- ○ Current work policy does not permit working from home/telecommuting
- ○ The nature of my work/studies does not allow me to work from home/telecommute
- ○ I prefer not to work from home/telecommute
- ○ Other: _________________________

<u>Question 10.3</u>

If the option was available to you, would you work/study from home/telecommute rather than traveling to McGill campus some days of the month?

- ○ Yes
- ○ No

PART VI - PARKING

Question 11

Have you driven or been driven to campus in the past month?

- ○ Yes
- ○ No

If 'Yes' go to question 11.1. If 'No' go to question 12.

Question 11.1

Where do you typically park?
Choose one of the following answers

- ○ I am dropped off at campus
- ○ On-campus parking (Downtown campus)
- ○ On-campus parking (Macdonald campus)
- ○ On-street parking
- ○ Public parking lot (Ste. Anne de Bellevue)
- ○ Other non-McGill parking garage/lot
- ○ Other: ____________________

If you selected 'I am dropped off at campus', go to question 12.

Question 11.2

How much do you typically spend on parking?

- ○ I don't pay for parking
- ○ $_______ per day / week / month

PART VII - BICYCLE USE

Question 12

What type of bicycle, if any, do you have access to?

Choose one

- ○ I do not have access to a bicycle

- ○ Personal bicycle
- ○ Bixi
- ○ Personal bicycle & Bixi
- ○ Other: ____________________

Question 12.2

Do you ever ride a bicycle to campus?

- ○ Yes
- ○ No

If ‘Yes’ go to questions 12.3 & 12.4. If ‘No’ go to question 13.

Question 12.3

Where do you typically park when cycling to campus?

Choose one of the following answers

- ○ Bicycle racks at the campus gates
- ○ Bicycle racks on campus
- ○ Off campus
- ○ Bring my bicycle inside my building
- ○ Parking garage
- ○ Bixi station
- ○ Other: ____________________

Question 12.4

Do you have difficulty finding bicycle parking near campus?

Choose one of the following answers

- ○ Never
- ○ Sometimes
- ○ Usually
- ○ Always

Question 13

How many bicycles, if any, have you had stolen **at campus** within the past year?

- I have not had a bicycle stolen while at campus
- 1
- 2
- 3
- 4+

Question 13.1

At which campus did this occur?

- Downtown campus
- Macdonald Campus

Question 14

How could McGill make it easier to commute by bicycle to campus?

____
____
____
____

PART VIII - TRAVEL CHOICE INFORMATION

Question 15

Question 15.1

Do you have a monthly transit pass?

- Yes
- No

If 'Yes' go to question 15.2. If 'No' go to question 16.

Question 15.2

What type of monthly transit pass do you have?

- TRAM monthly pass from the AMT
- STM monthly pass (reduced fare)
- STM monthly pass (regular fare)
- Other: ___________________

Question 16

Select ***all*** the following that apply to you:

- I have a driver's license
- I have a Communauto membership
- I have had a Bixi membership/subscription in the past year
- I have used the Allego carpooling service in the past year

Question 17

How many vehicles are owned by your household?

- None
- 1 vehicle
- 2 vehicles
- 3 vehicles
- 4 vehicles
- 5+ vehicles

If you selected 'none', skip to Question18, otherwise proceed to Question 17.1

Question 17.1

What type of vehicles are these?

Check any that apply

- Passenger car (including compact, mid-size, or large sedan)
- Small SUV or small pickup
- Minivan or compact SUV (e.g., Explorer)
- Intermediate SUV (e.g., Land Cruiser)
- Larger SUV (e.g., Expedition)
- Other: ________________

<u>Question 18</u>

Select ***all*** that apply in the past year.
Check any that apply

- ○ I have walked from my home to campus in the past year
- ○ I have cycled from my home to campus in the past year
- ○ I have taken transit (bus, metro, commuter train) from my home to campus in the past year
- ○ I have driven or been driven to campus in the past year

If you selected 'walked', answer questions 18.1a, 18.1b, & 18.1c
If you selected 'cycled', answer questions 18.2a, 18.2b, & 18.2c
If you selected 'transit', answer questions 18.3a, 18.3b, & 18.3c

<u>Question 18.1a</u>

What would be the ***best*** way to improve your walk to campus?
Choose one of the following answers

- ○ Slower vehicle speeds
- ○ More pedestrian crosswalks
- ○ More time to cross at crosswalks
- ○ Shorter crossing distances at crosswalks
- ○ Improvements to the walking environment (sidewalks were clean, snow free, more trees, etc.)
- ○ Other_________________________________

<u>Question 18.1b</u>

What would be the ***second best*** way to improve your walk to campus?
Choose one of the following answers

- ○ Slower vehicle speeds
- ○ More pedestrian crosswalks
- ○ More time to cross at crosswalks
- ○ Shorter crossing distances at crosswalks
- ○ Improvements to the walking environment (sidewalks were clean, snow free, more trees, etc.)
- ○ Other_________________________________

<u>Question 18.2a</u>

What would be the ***best*** way to improve your bicycle ride to campus?
Choose one of the following answers

- Slower vehicle speeds
- More bicycle paths/lanes
- More bicycle parking
- Secure bicycle parking
- More Bixi stations
- Better maintained bicycle paths/lanes (cleaner, snow free, etc.)
- Other________________________________

Question 18.2b

What would be the ***second best*** way to improve your bicycle ride to campus?
Choose one of the following answers

- Slower vehicle speeds
- More bicycle paths/lanes
- More bicycle parking
- Secure bicycle parking
- More Bixi stations
- Better maintained bicycle paths/lanes (cleaner, snow free, etc.)
- Other________________________________

Question 18.3a

What would be the ***best*** way to improve your transit trip to campus?
Choose one of the following answers

- Reduced transit wait times
- Cheaper transit service
- Less crowded transit vehicles
- More reliable transit service
- Cleaner transit system
- More accessible transit system (e.g. for the mobility impaired)
- Other________________________________

Question 18.3b

What would be the ***second best*** way to improve your transit trip to campus?
Choose one of the following answers

- Reduced transit wait times
- Cheaper transit service
- Less crowded transit vehicles

- More reliable transit service
- Cleaner transit system
- More accessible transit system (e.g. for the mobility impaired)
- Other________________________________

Question 19

How long have you lived at your current residence?

Choose one of the following answers

- less than one year
- 1 year
- 2 years
- 3 years
- 4 years
- 5 years
- 6 years
- 7 years
- 8 years
- 9 years
- 10+ years

Question 20a

Which of the following factors had the ***most*** influence on your choice of residence?

- This decision was out of my control
- Proximity to public transit
- Walkability of neighbourhood
- Amenities of neighbourhood (shops, parks, attractive houses)
- Housing qualities (space, yard etc…)
- Ability to cycle to campus
- Ability to walk to campus
- Being near friends and family
- Crime and safety
- Cost of housing
- Quality of schools
- Other______________________________

Question 20b

Which of the following factors had the ***second most*** influence on your choice of residence?

- ○ Proximity to public transit
- ○ Walkability of neighbourhood
- ○ Amenities of neighbourhood (shops, parks, attractive houses)
- ○ Housing qualities (space, yard etc…)
- ○ Ability to cycle to campus
- ○ Ability to walk to campus
- ○ Being near friends and family
- ○ Crime and safety
- ○ Cost of housing
- ○ Quality of schools
- ○ Other_______________________________

PART IX – PERSONAL PROFILE

Question 21

Are you:

- ○ Male
- ○ Female
- ○ Prefer not to answer

Question 22

What year were you born in?

____

PART X – FURTHER THOUGHTS

Question 23

Do you have any suggestions to encourage the use of sustainable transportation (cycling, walking, and public transit) to McGill?

____
____
____

Question 24

Do you have any other comments or concerns about traveling to McGill?
____
____
____
____

THANK YOU!

Thank you for your participation in the 2011 McGill Transportation Survey! Your name will automatically be included in a drawing for various exciting prizes. Transportation Research at McGill (TRAM), in collaboration with the McGill Office of Sustainability, will use the results of this survey to assess the environmental impact of travel to and from McGill University and to develop recommendations on how to further encourage the use of sustainable transportation for commuting to McGill.

The project is led by Cynthia Jacques and Jacob Mason, Master of Urban Planning Candidates, under the supervision of Ahmed El-Geneidy, Assistant Professor with the School of Urban Planning, Naveen Eluru and Marianne Hatzopoulou, Assistant Professors with the Department of Civil Engineering. If you have any questions or concerns regarding this research project, please send an email to TRAM@mcgill.ca.

Many thanks to Kathleen Ng, Environmental Officer with the McGill Office of Sustainability, for her support in carrying out this project and for coordinating exciting prizes. We would also like to thank the McGill Sustainability Projects Fund for funding this research project and contributing to graduate research.

APPENDIX II - INVITATION EMAIL

Dear *[insert name]*,

Transportation Research at McGill (TRAM), in collaboration with the McGill Sustainability Office, is presently conducting research on the travel behaviour of McGill University students, faculty and staff. In this research, we wish to examine how University members commute to McGill and how they use the various transportation services offered by the City of Montreal and McGill University as part of their travel. Your participation in this survey will allow us to determine the environmental impact of travel to McGill and will guide the development of recommendations to further encourage the use of sustainable transportation to commute to the University. Please visit our website to share your views and experiences in a short survey, and have the chance to win great prizes, including McGill bookstore gift certificates, McGill Fitness Centre memberships, Bixi memberships, and much more!

Click here to participate in the survey. This link is intended specifically for you so that you can be entered in the prize drawing.
<< https://surveys.mcgill.ca/limesurvey/index.php?sid=85522&lang=en>>

If you have any questions of concerns regarding this research project, please send an email to TRAM@mcgill.ca. If you need urgent assistance, you may call TRAM at 514-398-4058.

If you know anybody who is interested in participating in this survey, please have them contact TRAM@mcgill.ca.

The project is led by Cynthia Jacques and Jacob Mason, Master of Urban Planning candidates, under the supervision of Ahmed El-Geneidy, Assistant Professor with the School of Urban Planning, Naveen Eluru and Marianne Hatzopoulou, Assistant Professors with the Department of Civil Engineering. We would like to thank the McGill Sustainability Projects Fund for funding this research project and contributing to graduate research. The survey is being distributed by TRAM with the approval of McGill University.
TRAM is a multidisciplinary team including faculty members and students mainly from the School of Urban Planning, Faculty of Engineering, McGill University. TRAM members have developed a particular interest in the travel behaviour of University students. A University travel behaviour survey was conducted during 2004 to learn more about McGill University members' traveling habits and preferences.

APPENDIX III - POSTCARD TO STAFF WITHOUT EMAIL

Dear *[insert name]*,

Transportation Research at McGill (TRAM), with the McGill Sustainability Office, is presently conducting research on the travel behaviour of McGill University students, faculty and staff. Your participation will allow us to determine the environmental impact of travel to McGill and will guide the development of recommendations to improve transportation to the University. Please visit our website below to share your views and experiences in a 10 to 15 minute survey, and have the chance to win great prizes, including McGill Fitness Centre memberships, Bixi memberships, and much more!

tram.mcgill.ca/survey.htm

On the website, you will be asked to enter the following token code:

This code is intended specifically for you so that you can be entered in the prize drawing.

If you have any questions of concerns regarding this research project, please send an email to TRAM@mcgill.ca. If you need urgent assistance, you may call TRAM at 514-398-4058.

APPENDIX IV - REMINDER EMAIL

Dear *[insert name]*,

This is a reminder to please complete the short 2011 McGill Transportation Survey online. Transportation Research at McGill (TRAM), in collaboration with the McGill Sustainability Office, is presently conducting research on the travel behaviour of McGill University students, faculty and staff through the online survey. Your participation in this survey is greatly appreciated and will help to improve transportation options for commuting to and from McGill campuses. Please visit our website to share your views and experiences and have the chance to win great prizes, including McGill bookstore gift certificates, McGill Fitness Centre memberships, Bixi memberships, and much more!

Click here to participate in the survey. This link is intended specifically for you so that you can be entered in the prize drawing.
<< https://surveys.mcgill.ca/limesurvey/index.php?sid=85522&lang=en>>

If you know anybody who is interested in participating in this survey, please have them contact TRAM@mcgill.ca.

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TRAM is a multidisciplinary team including faculty members and students mainly from the School of Urban Planning, Faculty of Engineering, McGill University. TRAM members have developed a particular interest in the travel behaviour of University students. A University travel behaviour survey was conducted during 2004 to learn more about McGill University members' traveling habits and preferences.

Appendix V - Additional Tables and Figures

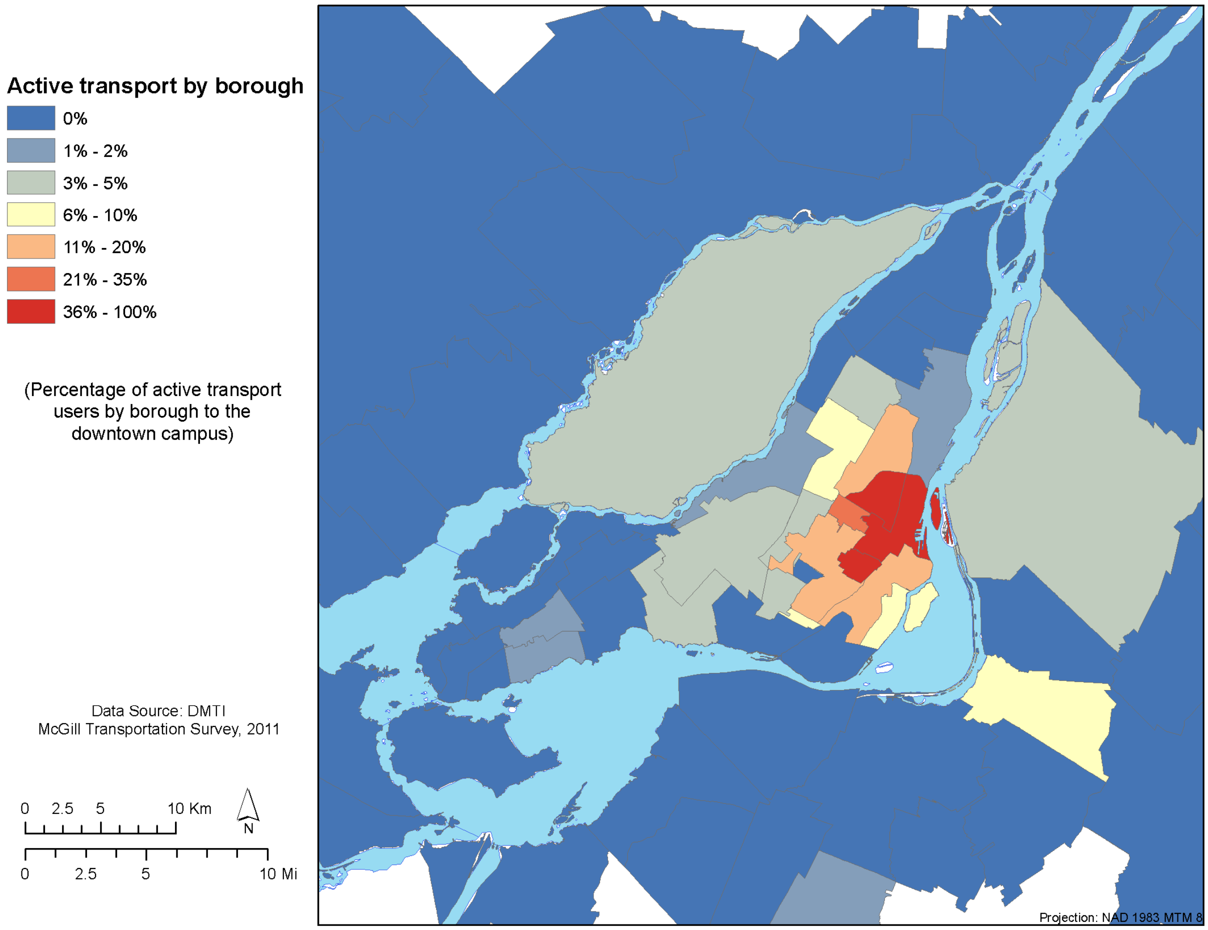

Figure 52. Distribution of respondents using active transportation to reach McGill campuses by borough

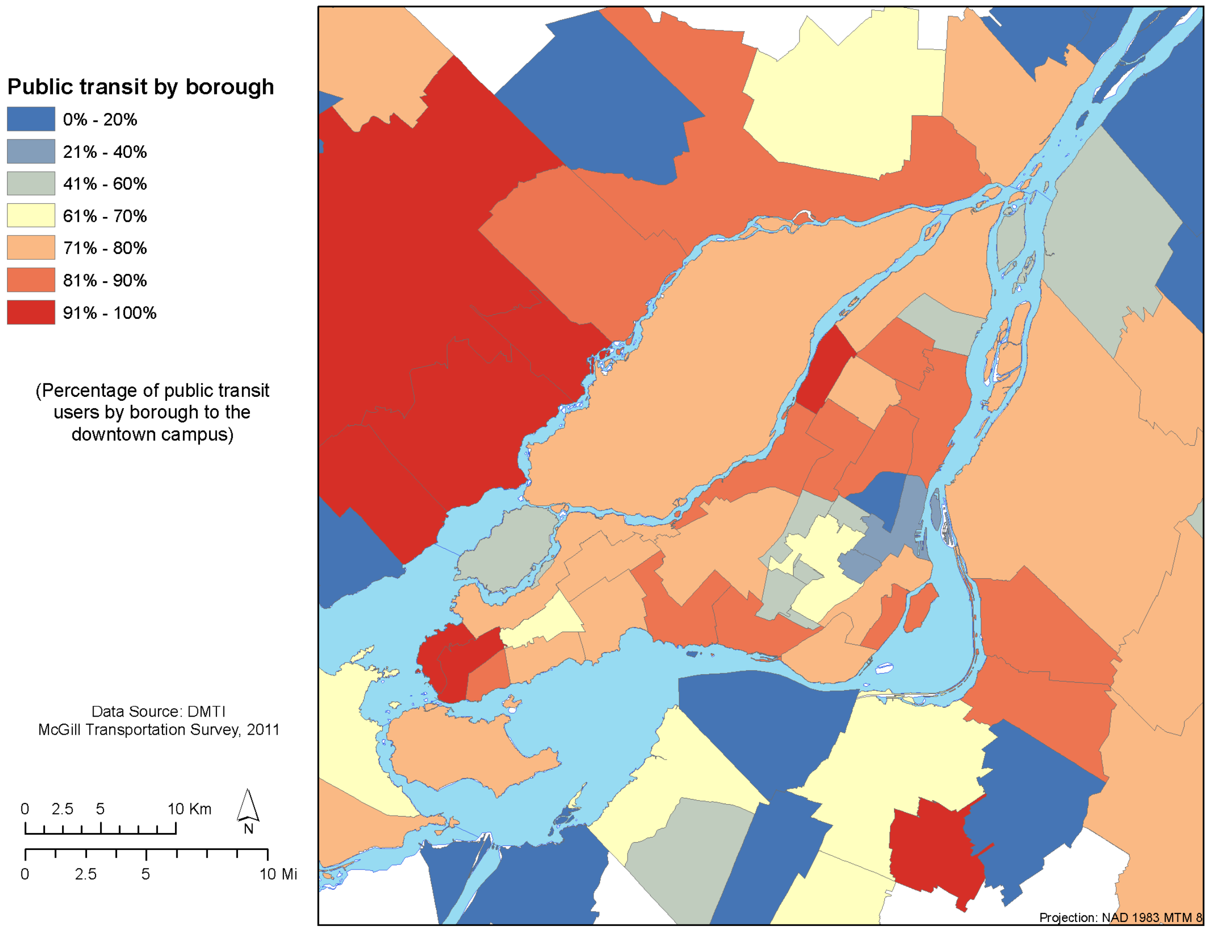

Figure 53. Distribution of respondents using public transportation to reach McGill campuses by borough

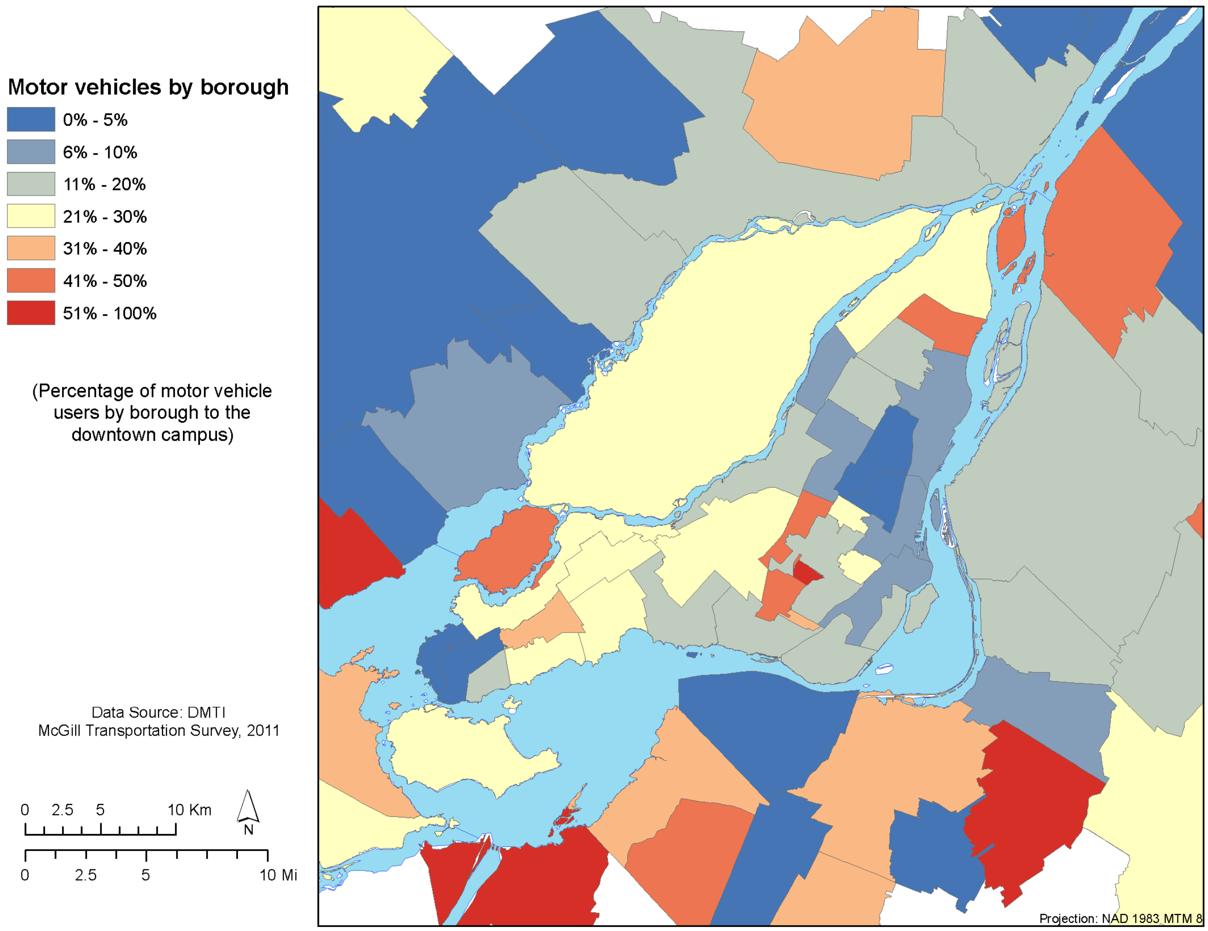

Figure 54. Distribution of respondents using motorized vehicle to reach McGill campuses by borough

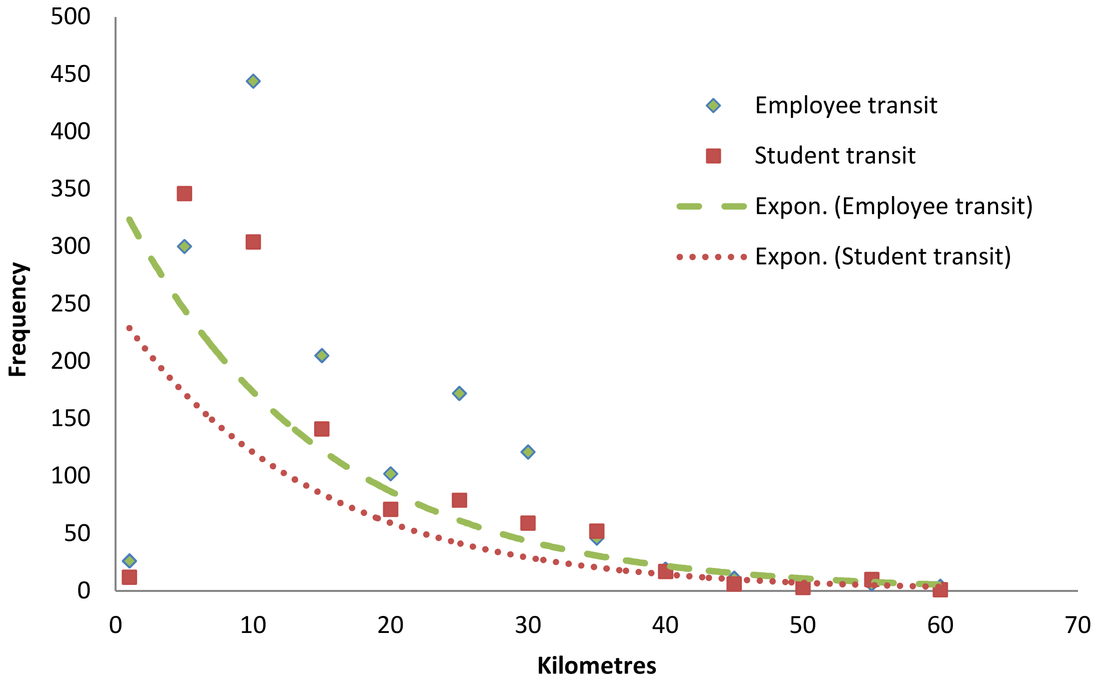

Figure 55. Distance OD McGill employees and students for transit

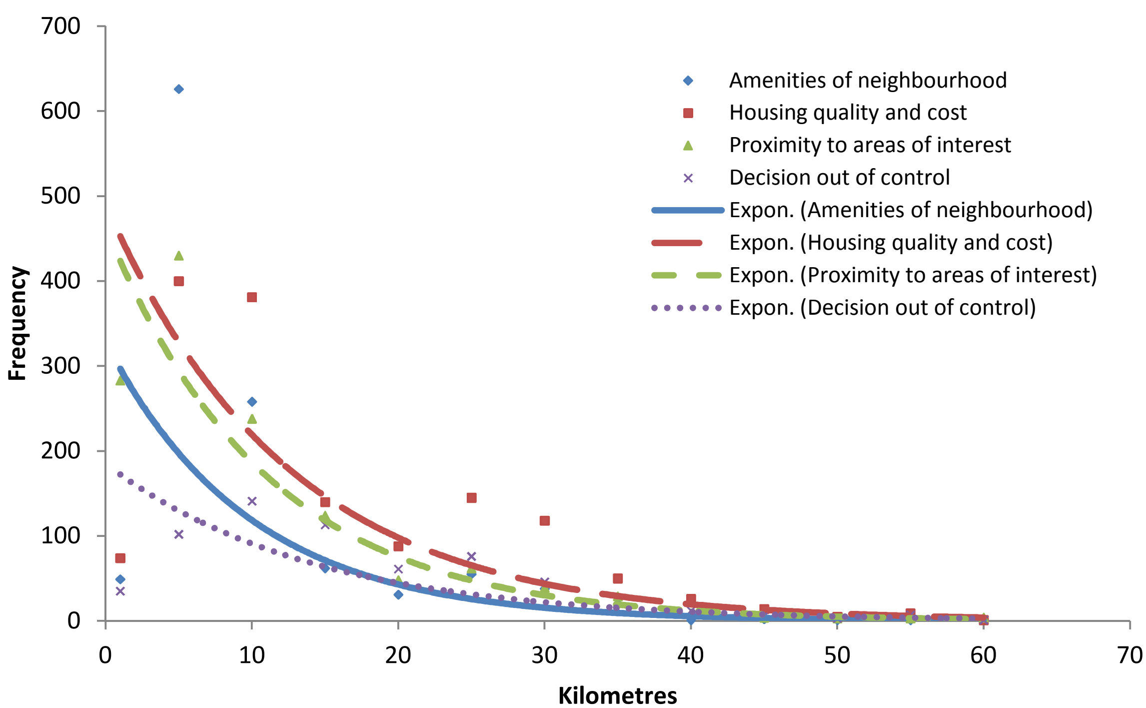

Figure 56. Distance OD for choice of residence

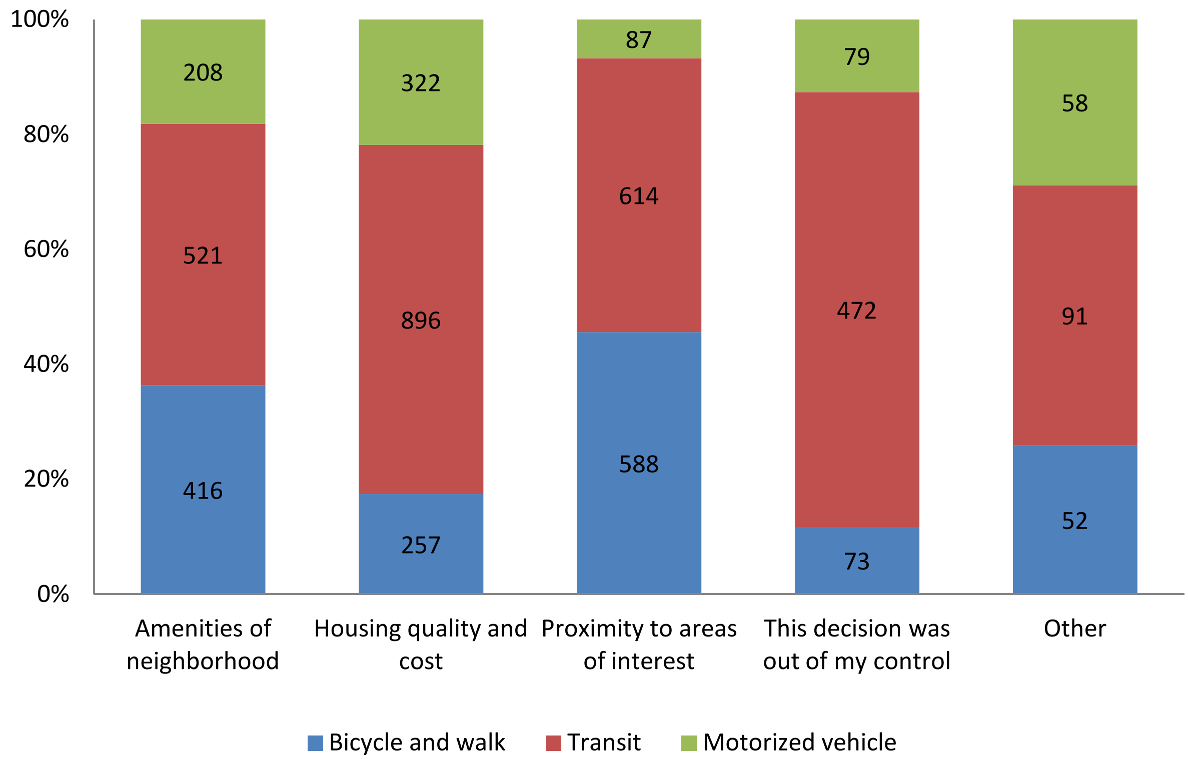

Figure 57. Mode by residential selection

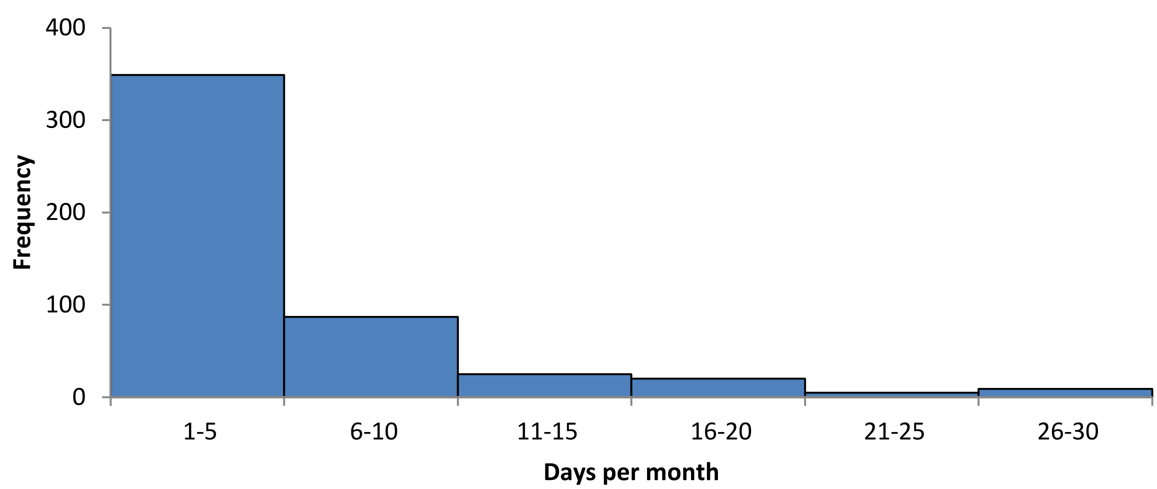

Figure 58. Telecommuting histogram for academic staff

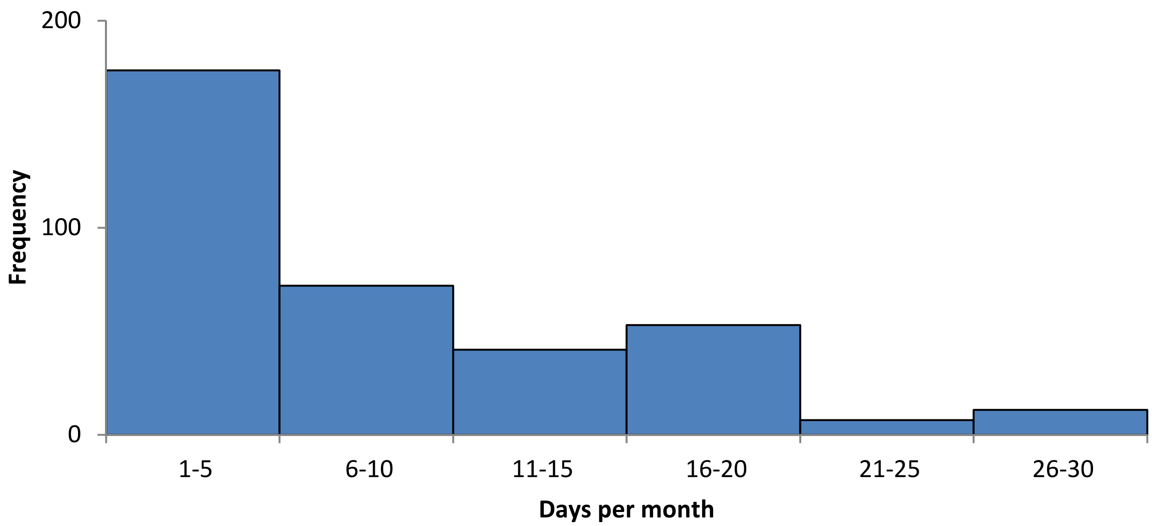

Figure 59. Telecommuting histogram for graduate students

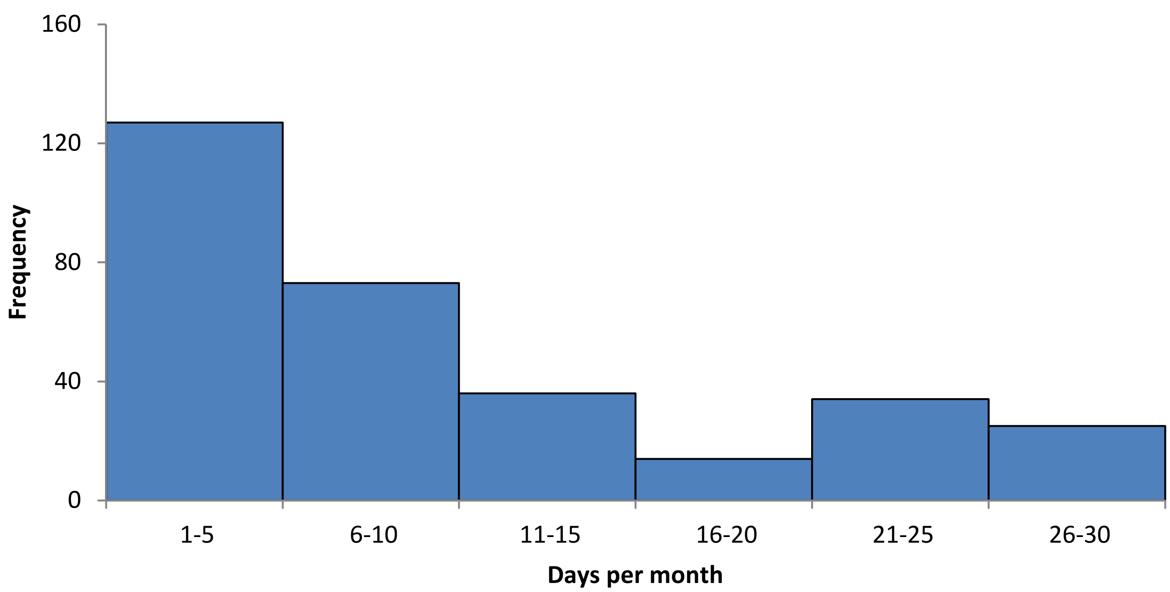

Figure 60. Telecommuting histogram for undergraduate students

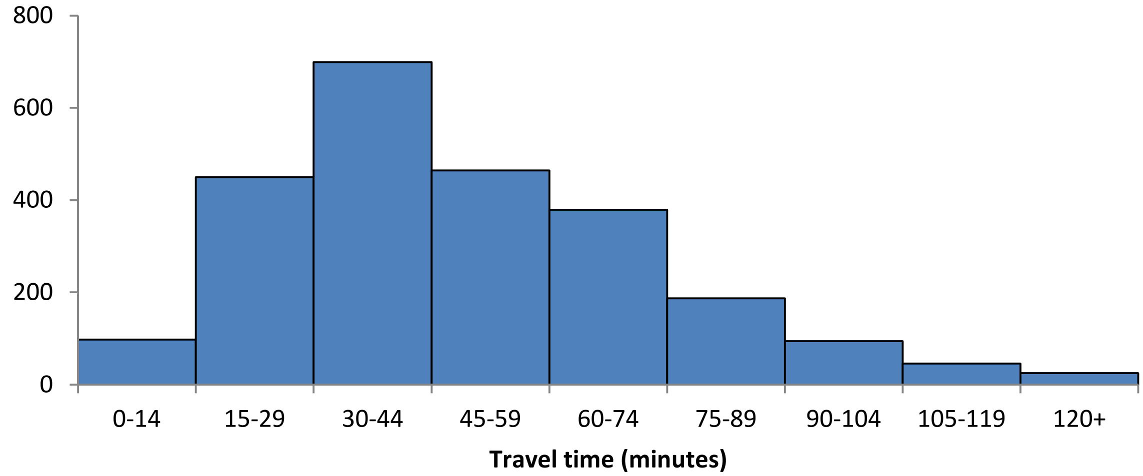

Figure 61. Travel time histogram for McGill employees

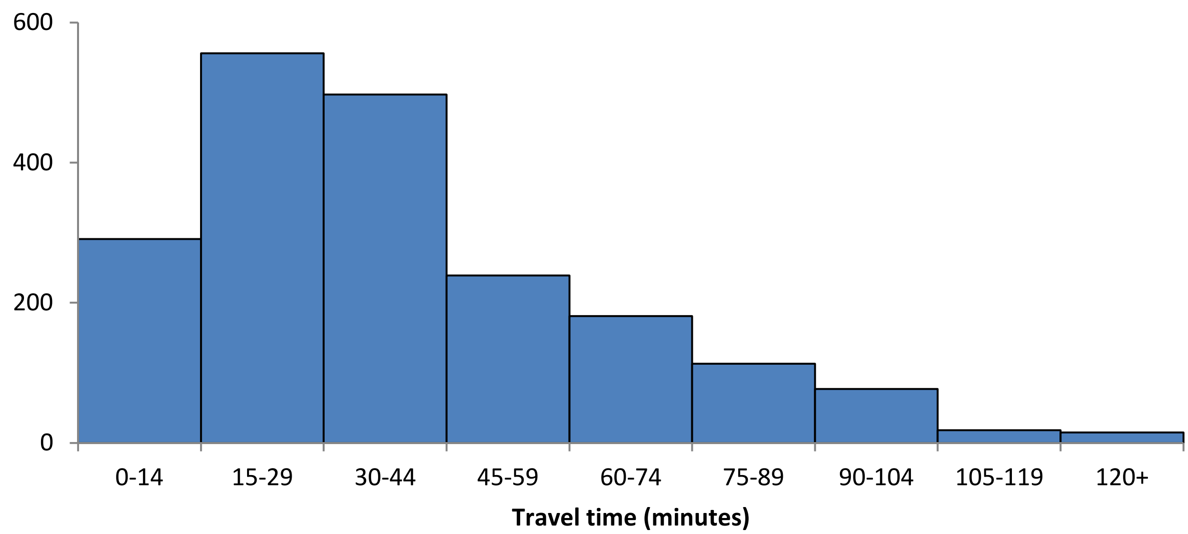

Figure 62. Travel time histogram for McGill students

Table 5: Bicycle theft by campus

Frequency of Bicycle Thefts	Downtown campus	Macdonald Campus	Total
1	80	2	82
2	14	1	15
3	0	0	0
4+	1	0	1
Total	**95**	**3**	**98**

Appendix VI - Research on Mode and Route Choice

Travel Mode Choice and Transit Route Choice Behaviour in Montreal: Insights from McGill University Members Commute Patterns

Naveen Eluru*
Assistant Professor
Department of Civil Engineering and Applied Mechanics
McGill University
Suite 483, 817 Sherbrooke St. W.
Montréal, Québec, H3A 2K6
Canada
Ph: 514 398 6823, Fax: 514 398 7361
Email:naveen.eluru@mcgill.ca

Vincent Chakour
Department of Civil Engineering and Applied Mechanics
McGill University
Suite 483, 817 Sherbrooke St. W.
Montréal, Québec, H3A 2K6
Canada
Ph: 514 398 6823, Fax: 514 398 7361
Email:vincent.chakour@mail.mcgill.ca

Ahmed M. El-Geneidy
Assistant Professor
School of Urban Planning
McGill University
Suite 400, 815 Sherbrooke St. W.
Montréal, Québec, H3A 2K6
Canada
Ph.: 514-398-8741, Fax: 514-398-8376
E-mail: ahmed.elgeneidy@mcgill.ca

*corresponding author

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ABSTRACT

In developed countries such as Canada and United States, a significant number of individuals depend on the automobile as the main mode of transportation. The high auto dependency, in turn, results in high auto travel demand on highways. There has been a stronger push towards analyzing traveler behaviour at the individual level so that transportation agencies can formulate appropriate strategies to reduce auto dependency. Towards this pursuit of enhancing our understanding on travel behaviour, we examine individual home to work or school commute patterns in Montreal, Canada with an emphasis on the transit mode of travel. The overarching theme within the research effort is to provide affordable and efficient alternatives to automobile use in Montreal. We investigate two specific aspects of commute mode choice: (1) the factors that dissuade individuals from commuting by transit i.e. use the automobile to commute and (2) for individuals commuting by transit we analyze their transit route choice decision. This research study employs a unique survey conducted by researchers as part of the McGill University Sustainability project. The survey collected information on commuting patterns of students, faculty and staff from McGill University along with residential and socio-demographic information. The analysis is undertaken using classical multinomial logit model for both travel mode choice component and transit route choice component. The estimation results are employed to undertake policy sensitivity analysis that allows us to provide recommendations to public transportation and metropolitan agencies.

MOTIVATION

In developed countries such as Canada and United States, a significant number of individuals depend on the automobile as the main mode of transportation. This dependency on the automobile can be attributed to high auto ownership affordability, inadequate public transportation facilities (in many cities), and excess suburban land-use developments. The high auto dependency, in turn, results in high auto travel demand on highways. At the same time, the ability to build additional infrastructure is limited by high capital costs, real-estate constraints and environmental considerations. The net result has been that traffic congestion levels in metropolitan areas of Canada and United States have risen substantially over the past decade (see Schrank and Lomax, 2005). The increase in traffic congestion levels not only causes increased travel delays and impacts stress levels of drivers, but also adversely affects the environment as a result of rising air pollution and GHG emissions. The increasing auto travel, and its adverse environmental impacts, has led, in the past decade, to the serious consideration and implementation of travel demand management (TDM) strategies (for example, evaluating and enhancing existing public transportation services, building new services such as light rail transit and promoting car sharing schemes). The main objective of these TDM strategies is to encourage the efficient use of transportation resources by influencing travel behaviour. TDM strategies offer flexible solutions that can be tailored to meet the specific requirements of a particular urban region. Along with this emphasis on demand management there has also been a stronger push towards analyzing traveler behaviour at the individual level so that transportation agencies can formulate appropriate strategies to reduce auto dependency (Eluru, 2010).

Towards this pursuit of enhancing our understanding on travel behaviour, we examine individual home to work or school commute patterns in Montreal, Canada with an emphasis on the transit mode of travel. The overarching theme within the research effort is to provide affordable and efficient alternatives to automobile use in Montreal. Specifically, the thrust in our analysis is on evaluating existing transit infrastructure, identifying important attributes that affect transit usage and providing recommendations towards enhancing transit services in general and for commuting purposes in particular. This research study employs a unique survey conducted by researchers as part of the McGill University Sustainability project. The survey collected information on commuting patterns of students, faculty and staff from McGill University. McGill University, located in downtown Montreal, has a workforce of about 50,000 individuals thus providing us a unique opportunity to examine travel behaviour of a large proportion of individuals travelling to downtown Montreal.

In the current paper, we investigate two specific aspects of commute mode choice. First, we examine the factors that dissuade individuals from commuting to work or school by transit (i.e. use the automobile to commute). The analysis will enable us to suggest recommendations that will allow us to enhance the attractiveness of transit mode to commuters. Second, for individuals commuting to work by transit we analyze their transit route choice decision. Montreal with its unique multimodal public transportation system consisting of bus, metro and commuter train offers multiple route alternatives to individuals commuting to downtown. The examination of individual transit route choice behaviour will allow us to identify important attributes that influence route choice decisions thus allowing us to provide recommendations to transit agencies on enhancing transit services in the urban region. The analysis is undertaken using multinomial logit model for both travel mode choice component and transit route choice component. The estimation results are employed to undertake policy sensitivity analysis that could offer insights to public transportation and metropolitan agencies.

The rest of the paper is organized as follows. Section 2 positions the current research effort in context while providing a brief review of earlier research. Section 3 provides details about the survey and outlines data assembly procedures. Section 4 briefly outlines the econometric methodology employed in estimating the different models. Section 5 presents the results while discussing their implications through a host of sensitivity analysis. Section 6 concludes the paper.

LITERATURE REVIEW AND CURRENT STUDY CONTEXT

The objectives of the research effort are two-fold. First, we investigate individual's decision framework to choose between transit and car mode of transportation for commuting to McGill University. Second, for individuals choosing to commute by transit, the decision process of finalizing the transit alternative to commute is examined.

The first objective has received wide attention within the transportation research community in general and travel behaviour research community in particular. Travel mode choice behaviour has been extensively examined over the last five decades. Transportation researchers have made giant strides in formulating advanced behaviour-oriented frameworks and developing enhanced data collection strategies to accurately model travel mode choice decisions. A comprehensive review of earlier literature examining mode choice decisions is beyond the scope of the current paper. We present a brief summary of the most important characteristics of earlier research efforts investigating travel mode choice decisions.

Earlier research has clearly shown that individual and household socio-demographics exert a strong influence on travel mode choice decisions. Specifically, gender, income, car ownership, and employment status effect travel mode decisions (Bhat, 1997; Bhat and Sardesai, 2006). Researchers have identified that tour complexity influences the mode choice substantially, such that individuals with more complex commute tours (possibly with multiple stops) prefer to employ the auto mode of transportation (Stratham and Dueker, 1995; Ye et al., 2007). Residential location, neighbourhood type and urban form play a prominent role in determining the favoured travel mode for commute (Vanwee and Holwerda, 2003; Pinjari et al., 2007; Frank et al., 2008). Individuals with inclination to commute to work by public transportation locate themselves in neighbourhoods with adequate access to transit. There has also been extensive focus on evaluating the willingness to pay (i.e. amount of money travellers are willing to pay to reduce their travel time by unit time) towards reducing travel time (Bhat, 1997; Bhat and Sardesai, 2006). In more recent research studies, reliability of travel time is also incorporated within the framework to compute the value of travel time (Noland and Polak, 2002; Small et al., 2005; Bhat and Sardesai, 2006; Li et al., 2010). Other attributes that influence travel mode choice include travel distance

(Scheiner, 2010), and constraints such as picking up or dropping a child tend to constrain travel mode options.

Advanced modelling frameworks including the mixed multinomial logit model and the generalized extreme value (GEV) models (see Bhat et al., 2008) have been adopted to investigate travel model choice behaviour.

On the other hand, the second objective of our research study, has received very little attention. There has been no empirical work within the public transportation community to examine transit route choice behaviour from an individual perspective. To be sure, there have been research efforts examining transit route choice within the traffic assignment context. Liu et al., 2010 conduct an extensive review of literature on transit route choice. The paper classifies transit choice literature into three groups: (1) studies that employ shortest-path heuristics, random utility maximization frameworks of route choice within a user equilibrium-based assignment (for example, Marguier and Ceder, 1984; Lam and Xie, 2002; Cepeda et al., 2006), (2) studies that consider intra-day dynamics within transit route choice, and dynamic traffic assignment (for example, Nuzzolo and Crisalli, 2004; Hamdouch and Lawphongpanich, 2008), and (3) emerging studies that incorporate day-to-day dynamics, and real-time dynamics in transit route choice behaviour (Coppola and Rosati, 2009; Wahba and Shalaby, 2009).

The approaches discussed so far focus on transit route choice behaviour from the system perspective, such that the focus is on routing transit users based on transit network system pricing, level of service (LOS) measures and network congestion attributes. The individual user behaviour is incorporated into the model indirectly. However, there has been little research that examines transit route choice from the individual's perspective. Bovy and Hoogendoorn-Lanser (2005) is the only study that has investigated transit route choice decisions. However, the focus of the study was on examining the influence of route choice with train as the primary mode of transportation with a combination of walking, bicycling and car modes. The study conducted in the Rotterdam–Dordrecht region in Netherlands examined the influence of travel time, waiting time, number of transfers (between trains) and walking time on individual route choice. The study developed a hierarchical generalized extreme value model to examine the choice of combination of transit route choice and choice of railway station types. The study was conducted using a small sample of records (235 observations) and considers only one public transportation mode (train).

Current Study

The reader would note that it is possible that urban residents have transit route alternatives that involve more than one public transportation mode. Consider an urban region where an individual is faced with the following options to commute by transit: (1) Walk – Bus – Metro – Walk, (2) Walk – Metro – Bus – Walk, (3) Walk – Train – Walk, and (4) Walk – Train – Bus – Walk. The transit alternatives proposed could differ in terms of travel time, travel cost, transfers, walking times, and waiting times. Further, it is also possible that individuals have intrinsic preferences towards a particular transit mode. Some individuals might prefer the commuter train because it is faster and is often less congested compared to the metro alternative. To elaborate, it is possible that individuals residing in urban regions with multiple transit route alternatives to commute face an important decision. Understanding this decision framework will allow public transportation agencies to better coordinate among each other to deliver enhanced transit service to urban residents. In spite of this there has been very little work undertaken to behaviourally examine how transit users choose among such multiple alternatives (except Bovy and Hoogendoorn-Lanser, 2005). The current research extends Bovy and Hoogendoorn-Lanser's (2005) research by considering multiple modes of public transportation (bus, metro and train). Further, the current research is based on a larger sample of transit road users.

Study Region

A very good reason for the lack of empirical work is the lack of well-connected multimodal public transportation systems. Montreal, Quebec with its unique multimodal system provides us with a test bed to examine transit route choice behaviour. Montreal is the second most populous metropolitan region in Canada with 3.7 million residents. According to the 2008 Montréal origin-destination (OD) survey (Agence métropolitaine de transport 2003), 67.8% of trips are undertaken by car, 21.4% by public transit, and 10.8% by active transportation (walking and bicycling). Montreal with its well-connected public transportation system (bus, metro and train) contributes to the relatively high share of transit ridership (for a North American city). Montreal metropolitan organization and other public transportation agencies are currently focussing their energies on further enhancing the transit ridership. The current research effort is focussed on providing recommendations to increasing public transit ridership in Montreal.

DATA SOURCE AND ASSEMBLY

Data Source

The data employed in the current study is drawn from a web-based survey of the McGill community members (students, staff and faculty) conducted during the months of April and May 2011. The survey collected information on the community members' socio-demographic information (age, gender, vehicle ownership), and McGill University experience (in years). Further, the survey gathered details on community members' regular commuting patterns. In particular, the respondents were requested to provide the sequence of their regular commute to McGill with information on their start time to work, arrival time to work, transportation mode, and detailed transit route information for transit users. A screenshot of the web-based survey requesting the commuting pattern information is provided in Figure 1. The figure provides the sequence of questions for a respondent who has walked to the metro station, travelled by metro and then walked to reach campus. Information on the metro line is also collected. In addition to the above information, origin and destination postal codes were obtained for all respondents through a McGill internal employee and student database.

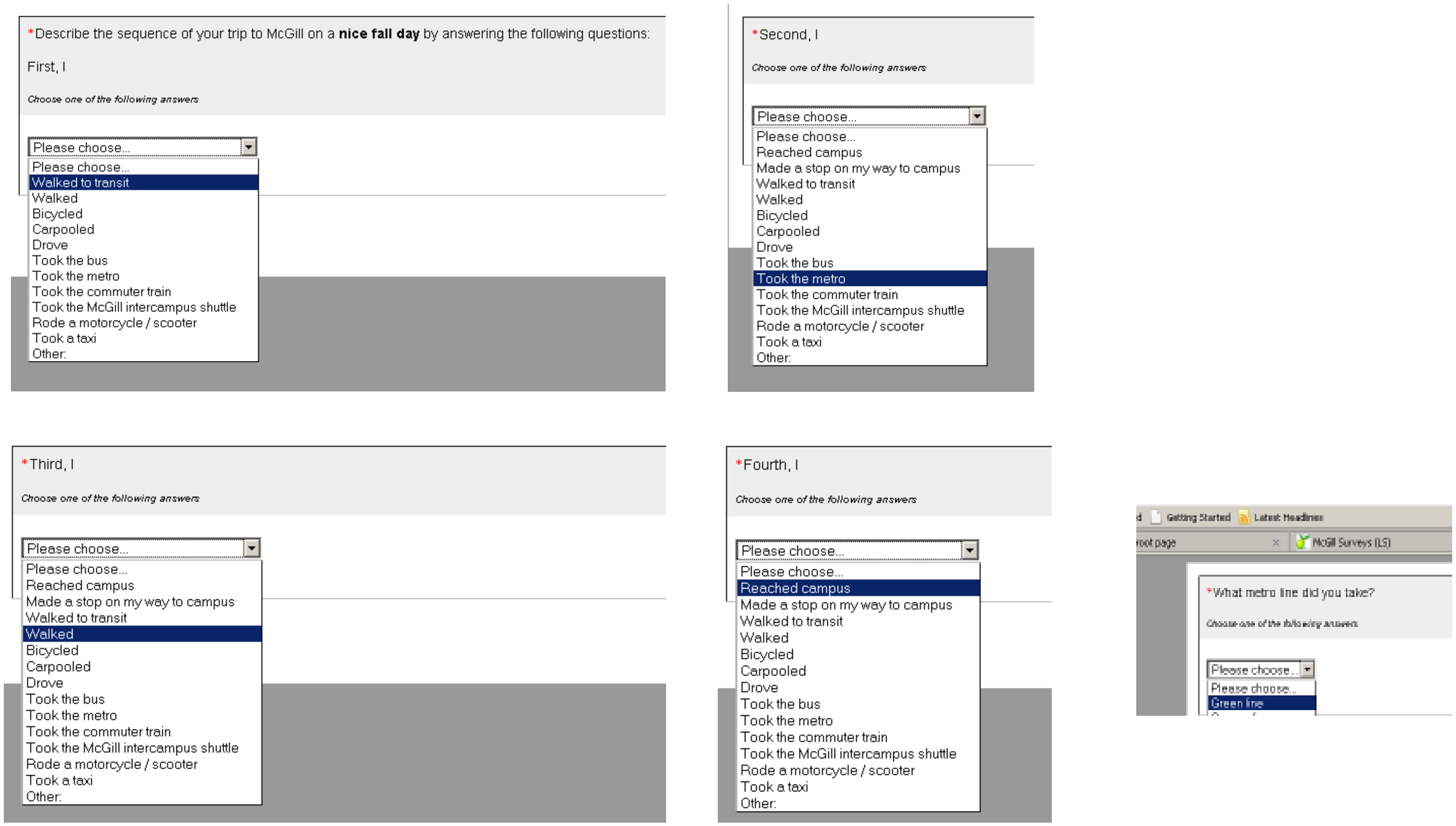

Figure 63. Screenshots of Commuter sequence questions in the Web-based Survey

The web-survey was hosted and administered internally within the McGill University. A total of 19,662 surveys were distributed among the McGill community members. The survey administered elicited 5,016 responses prior to the closing date. The data thus collected was thoroughly examined for consistency and erroneous reporting and the inconsistent records were eliminated from the database. The resulting sample consisted of 4,698 entries. Of these records 2,616 respondents (56%) are McGill employees (which includes both faculty and staff), and 2,032 respondents (43%) are McGill students, and the remaining 50 respondents (1%) included exchange students, and visiting professors. The reader would note that the web-based survey intentionally oversampled the employee community relative to the student community. For our analysis, we limited ourselves to community members commuting to the Downtown campus.

Data Set Assembly for Analysis

The dataset preparation involved two distinct components. The initial part of the data assembly process focussed on compiling the travel mode choice dataset for the car versus transit model. The subsequent part of the data assembly was targeted at generating all transit alternatives for the individuals' choosing to commute by transit. The following discussion provides more details of the data assembly process for each component individually.

Travel mode choice data set requires assembly of LOS attributes for all modes under consideration. The analyst is only aware of the LOS attributes for the chosen alternative. We need to generate LOS attributes for the competing modes. In our empirical case, we are interested in examining why the automobile users are not commuting to work by transit. So, we select only those commuters that employ either the car mode or the transit mode in our analysis. The sample consists of 1845 records. Of these 1291 (70%) respondents commute using transit while 554 (30%) respondents commute by car. For these respondents we need to generate the LOS attributes for both modes. The research team employed two sources for generating this information. First, car in-vehicle travel times for all individuals (irrespective of their choice) were generated using LOS matrices for postal code origin and destinations. Second, Google Maps were employed to generate the best transit alternative available to the individuals using car at the time of his/her departure to work. The respondent provided transit route information was compiled for respondents who chose transit.

The second component of the data assembly process generated alternative transit routes for the transit commuters. The alternative generation was achieved using a Google Maps procedure that identifies unique alternative transit routes between the respondent's origin and destination. The routes obtained thus are compared with the respondent's transit commute route and the chosen alternative is tagged. The transit alternatives for respondents varied from one to six in the following proportions: 5.8%, 33.2%, 32.0%, 22.8%, 5.6% and 0.6%. Clearly, a larger proportion of transit users (88%) have between two to four alternatives to commute to work. This statistic clearly highlights that transit commuters to Montreal downtown region have multiple alternatives to choose from.

Sample Statistics

Descriptive statistics for the samples for travel mode choice and transit route choice are presented in Table 1. The sample statistics for travel mode choice dataset are presented in the top part of the table followed by the statistics for transit route choice dataset.

Table 6. Database summary statistics

TRAVEL MODE CHOICE DATASET	
Mean travel time by transit (min)	17.8
Mean in-vehicle travel time by car (min)	36.1
Gender	
Males	39.0
Females	61.0
Age	
<25	20.5
25-45	42.7
45-65	33.9
>65	2.9
Employment Type	
Part-Time	12.0
Full-Time	88.0
Vehicles Ownership	
0	25.9
1	42.9
2	25.7
3	3.9
4+	1.6
Number of transfers for the transit alternative	
0	50.9
1	32.7
2	14.6
3	1.7
4	0.1
TRANSIT ROUTE CHOICE DATASET	
Mean Travel Time	23.8
Mean Total Walking Time	17.4
Mean Total Waiting Time	3.7
Transit route alternatives comprising	
Bus	69.3
Metro	49.0
Train	15.6
Average travel time by mode (min)	
Bus	21.54
Metro	10.24
Train	24.84

Travel Mode Choice

The average travel time values for transit and car modes are substantially different. It is not surprising that travel times by transit are superior especially given the large share of proportion of transit users. The sample consists of a larger share of females compared to men. The majority of the respondents are in the age groups of 25-45 and 45-65. A majority of the respondents are full-time McGill community members. The vehicle ownership analysis indicates a large proportion on 0 vehicle and 1 vehicle households in the sample. The number of transfers for transit varies from 0 through 4. The proportion of 0 and 1 transfers (~83%) highlights the well-connected public transportation system in Montreal.

Transit Route Choice

The average travel time is about 24 minutes for transit alternatives which is higher than the 18 minutes reported earlier because this dataset involves the chosen as well as not chosen transit alternatives thus resulting in an increase in average travel time values., The average walking time for transit alternatives is about 17 minutes, while the average waiting time is only 3.7 minutes

METHODOLOGY

A classical Multinomial Logit (MNL) model is employed to examine (a) travel mode choice and (b) the transit route choice behaviour. The modeling framework is briefly presented in this section. Let q be the index for commuters (q = 1, 2, ..., Q) and i be the index for travel mode or transit route alternatives. With this notation, the random utility formulation takes the following familiar form:

$$u_{qi}^{*} = \beta' x_{qi} + \varepsilon_{qi} \quad (1)$$

In the above equation, u_{qi}^{*} represents the utility obtained by the q^{th} commuter in choosing the i^{th} alternative. x_{qi} is a column vector of attributes influencing the choice framework. β is a corresponding coefficient column vector of parameters to be estimated, and ε_{qi} is an idiosyncratic error term assumed to be standard type-1 extreme value distributed. Then, in the usual spirit of utility maximization, commuter *q* will choose the alternative that offers the highest utility. The probability expression for choosing alternative *i* is given by:

$$P_{qi} = \frac{\exp(\beta' x_{qi})}{\sum_{i} \exp(\beta' x_{qi})} \quad (2)$$

The log-likelihood function is constructed based on the above probability expression, and maximum likelihood estimation is employed to estimate the β parameter. The modeling framework is similar for both decisions frameworks. The reader would note that the travel mode choice model with two alternatives collapses to the conventional binary logit model. Further, in the mode choice model we can estimate alternative specific coefficients. However, in the transit route choice model, alternative specific variables do not make sense and hence appropriate interactions with LOS attributes are computed to incorporate the effect of individual socio-demographics on route choice preferences.

EMPIRICAL ANALYSIS

The empirical analysis in the paper involves the estimation of the travel mode choice model (binary logit model) and the transit route choice model (multinomial logit model). Several variables were considered in the empirical analysis, including individual and household socio-demographics - age, gender, driving license, employment status, vehicle ownership, and LOS attributes - travel time, travel time by mode, walking time, waiting time, number of transfers, and time of day. We also considered several interaction effects among the variables in both the mode choice and transit route choice model. The specification process was also guided by prior research and intuitiveness/parsimony considerations. The final specification was based on a systematic process of removing statistically insignificant variables. We should also note here that, for the continuous variables in the data (such as age, travel time, walk and waiting times), we tested alternative functional forms that included a linear form, and a square term. In the subsequent discussion, we present the results from model estimations.

Travel Mode Choice

In this model we examine the influence of factor influencing respondents' inclination to use the Transit mode. The mode choice component offers intuitive results. Travel mode choice binary logit model estimation results are presented in Table 2. The car mode of transportation is considered to be the base alternative for all variables except for the travel time variable where we estimate a generic travel time coefficient.

Table 7. Binary logit model results for Home-Work commute mode choice

ATTRIBUTES	PARAMETER	T-STATS
(Car alternative is the base)		
Constant	9.4983	8.975
Age	-0.2461	-6.261
Age squared	0.0023	5.657
Respondent status		
Staff member	0.5099	3.332
Student	0.8231	3.054
Full time member of the community	0.3494	1.791
Driver license status	-1.3592	-3.900
Household car ownership	-1.0847	-12.127
In-vehicle Travel time	-0.0540	-6.584
Transfers	-0.8906	-10.031
Walk time	-0.0652	-2.537
Walk time square	0.0012	2.524
Departing time period is AM peak	0.2689	1.754
Log-likelihood at Convergence	-718.644	
Log-likelihood at constants	-1127.47	
McFadden rho-square	0.35	

Model Fit

The log-likelihood value at convergence for the binary logit model is -718.6. The log-likelihood value at constants is – 1127.5. The hypothesis that the variables in the model do not offer any statistically significant improvement in model fit is rejected at any level of significance. The McFadden's adjusted rho-square value for the model is computed. It is defined as $\bar{\rho}^2 = 1 - \frac{L(\beta)-M}{L(C)}$ where $L(\beta)$ represents log-likelihood at convergence for the model, $L(C)$ represents log-likelihood at sample shares and M is the number of parameters in the model (Windmeijer, 1995). The travel mode choice model has a rho-square value of 0.35 denoting that the model explains travel behaviour adequately.

Model Parameters

The constant corresponding to the transit mode is significantly positive indicating the inherent preference of transit mode among respondents. Individual and household socio-demographics attributes influence the choice process. Age exerts a significantly negative influence on choosing the transit mode. This is expected because younger individuals of the McGill community (students and younger employees) are more likely to use the public transportation mode compared to older members (who possibly might have access to parking at the university) of McGill community. The result is further supported based on the influence of the role of the respondent. The adoption of transit is the highest among students followed by staff members compared to faculty members. Among the employees, full-time employees and students are more likely to commute by transit compared to part time employees and students. The full-time members have a more definite work schedule, making it easier for them to commute to work. The license status of the individual significantly affects the choice between transit and car. Within the student community it is possible a number of individuals do not have driver licenses and are captive to the public transportation mode. Household car ownership also has a strong negative effect on the choice of commute mode. Households with more cars are least likely to commute to work by transit.

LOS attributes including travel time, walking time, number of transfers and departure time, significantly influences the choice between auto and transit modes. Specifically, increasing travel time reduces the likelihood of choosing the alternative (see Pinjari and Bhat, 2006, Bhat and Sardesai, 2006 for similar results). The increase in the amount of walking within the transit alternative significantly reduces the likelihood of the respondent using transit for commuting. In fact, the relationship between transit usage and walking time is non-linear with statistically significant linear and square terms. Further, increase in the number of transfers for travelling by transit reduces the likelihood of using transit substantially. The departure time period influences the mode choice. Individuals travelling during the AM peak period are more likely to commute by transit mode. It is heartening for transportation agencies that an increased frequency of transit service during the peak periods contributes to increased transit usage.

Transit Route Choice Model

The multinomial logit model of transit route choice evaluates the propensity for choosing the transit route alternatives based on route LOS attributes and their interactions with a host of individual and household socio-demographics,. The results of the estimation are presented in Table 3.

Table 8. Multinomial logit model results for transit route choice

ATTRIBUTE	PARAMETER	T-STATS
Transit alternative has bus	-0.9465	-6.614
Transit alternative has metro	-0.9737	-5.040
Transit alternative has train	-2.4695	-5.816
The alternative is the shortest route	0.2238	2.297
The alternative will allow the respondent to reach earliest	0.3949	4.952
Travel time in metro for the alternative	-0.1306	-3.890
Travel time in bus for the alternative	-0.1991	-7.099
Travel time in Train for the alternative	-0.1368	-4.281
Total Walking time for the alternative	-0.2177	-8.657
Total Walking time squared for the alternative	0.0022	6.972
Total Waiting Time for the alternative	-0.1721	-8.618
Total travel time interactions with Socio-demographics		
Female	0.039	2.671
Age	0.0014	2.224
Staff	-0.0192	-0.964
Faculty	-0.0493	-2.078
Log-likelihood at Convergence	-877.196	
Log-likelihood at Equal shares	-1301.11	
McFadden rho-square	**0.31**	

Model Fit

The log-likelihood value at convergence for the multinomial logit model is -877.2. The log-likelihood value at equal shares is – 1301.1. The hypothesis that the variables in the model do not offer any statistically significant improvement in model fit is rejected at any level of significance. The McFadden's adjusted rho-square value for the model is 0.31. The adjusted rho-square denotes that the model describes the route choice behaviour satisfactorily.

Model Parameters

The transit route alternatives in the choice set are a combination of bus, metro and train alternatives. Hence, it is possible to evaluate the intrinsic preferences of respondents towards commuting by each public transportation alternative. The results indicate a clear preference for alternatives involving bus and metro mode relative to alternatives involving train mode. The intrinsic preferences is inherently accounting for the expensive monthly pass required for train users compared with other public transportation models.

Prior to examining the influence of travel time on transit route choice, we evaluate the influence of two overall route characteristics on route choice: (a) shortest travel time route and (b) route that allows the respondent to arrive earliest. Individuals are likely to evaluate routes based on these characteristics and hence are considered in the model. These variables are essentially dummy variables that are set to 1 for the route alternatives that satisfy the characteristics of interest. The influence of these variables is along expected lines. The respondents exhibit a strong preference for alternatives that allow them to travel efficiently and arrive at the earliest time.

The travel time coefficients indicate the negative propensity towards travel for respondents. A closer examination of the travel time results leads to interesting insights. In the model, we introduced travel time by mode. The coefficient on each of these modes provides the sensitivity to travel time for respondents by that mode. The results indicate that individuals find travel time on the bus mode the most onerous while they are similarly sensitive to travel time on metro and train. Public transportation agencies should investigate the reasons for this apparent discomfort and propose remedial measures to alter this. The influence of walking time is along expected lines. Specifically, transit route alternatives with smaller walk times are preferred. The model results indicate the presence of a non-linear relationship (linear and square terms) with a downward parabola. The total waiting time in a route has a negative effect on the likelihood of the alternative being chosen. Obviously, individuals' prefer alternatives with the least amount of walking and waiting time.

In a route choice model, it is not possible to evaluate the effect of socio-demographics directly. Hence, we evaluate their influence by estimating interactions terms with LOS attributes. In the model we consider interactions of gender, age, employment status with total travel time (sum of travel time by all modes in a route). The results offer interesting findings. Travel time interacted with female gender results in a positive coefficient indicating that females are less sensitive to travel time compared to males. To be sure, the overall sensitivity to travel time for females is still negative. However, it is lower than the sensitivity of travel time for males. The results corresponding to the interaction variable involving age and total travel time indicate that with increasing age of the respondent, there is a marginal reduction in the sensitivity of travel time. The result might seem counter-intuitive and requires more detailed future analysis. The interaction of total travel time variable with the role of McGill community members provides intuitive effects. Staff and faculty members are more sensitive to travel time compared to the student respondents. Further, faculty members are significantly more sensitive to travel time compared to the staff members.

POLICY SENSITIVITY ANALYSIS

The exogenous variable effects presented in Tables 2 and 3 do not directly provide the magnitude of the impact of variables on the choice process at work. To do so, we compute the aggregate level "elasticity effects" of variables. Thus, we conduct a sensitivity analysis of attribute effects on travel mode choice and transit route choice models.

Travel Mode Choice

The objective of the policy sensitivity analysis is to investigate the influence of exogenous variables on transit usage. The aggregate "elasticity effects" computation involves the following steps: (a) binary logit model results at convergence presented in Table 2 are used to compute the base probabilities for all respondents in the dataset using the attribute levels as reported; (b) the attribute of interest is chosen and new attribute levels for all respondents are computed in a pre-defined manner; (c) the new attribute computed is employed in the place of the base attribute along with the other base attributes and new probability measures are generated; and (d) percentage change in probabilities relative to the sum of base aggregate shares is computed.

The scenarios considered for analysis include: (a) reduced travel time by transit - five and ten minutes; (b) increased travel time by car– five and ten minutes; (c) reduce walking time for transit – five and ten minutes; (d) reduce transit transfers by 1; and (e) reduce vehicle ownership by 1. The percentage change in mode share for transit and car for the above scenarios are provided in Table 4.

Table 9. Policy sensitivity analysis of the travel mode choice model

ATTRIBUTE	CAR	TRANSIT
Travel time by Transit reduced by 5 minutes	-10.95	4.67
Travel time by Transit reduced by 10 minutes	-20.65	8.80
Travel time by Car increased by 5 minutes	-11.04	4.70
Travel time by Car increased by 5 minutes	-21.45	9.14
Walking time to transit reduced by 5 minutes	-5.94	2.53
Walking time to transit reduced by 10 minutes	-17.98	7.66
No. of transfers (for transit) reduced by 1	-21.53	9.17
Household vehicle ownership reduced by 1	-37.44	15.95

The following observations can be made based on the results. First, the results clearly indicate that travel mode shares are very sensitive to level of service attributes i.e. by enhancing the public transportation modes we can encourage more travellers to use the transit mode. The changes in travel times by mode provide intuitive results. Second, we see that a change in transit (reduction) or car (increase) travel time lead to similar percentage changes in the overall aggregate share. Third, the influence of walking time on travel mode is marginally lower than the effect of travel time on mode choice. Public transportation agencies must recognize that reducing walking time by increasing accessibility of public transportation mode is less expensive than reducing transit transportation time financially. Hence, adequate resources need to be allocated to identify urban pockets that have inadequate transit accessibility (bus, metro or train) and improve accessibility in these urban pockets either by increasing the number of stations or improving feeder services to metro and train stations. Fourth, the reduction in transit number of transfers by 1 would increase transit share by 9.17%. The results indicate that each transfer that individuals are faced with has an effect similar to that of a reduction in travel time by 10 minutes. In other words, individuals consider every transfer that they have to make along their route to be a little more than about 10 minutes. The result clearly highlights the need for public transportation agencies to investigate the possibility of developing more direct services between downtown and rest of Montreal. Finally, the effect of vehicle ownership is also staggering on the travel model choice. Even a reduction of household vehicle ownership by 1 might change the share of transit ridership by about 16%. Policy makers need to consider incentives to residents in Montreal towards altering vehicle ownership because it might lead to a significant increase in transit ridership.

Transit Route Choice

The approach employed to undertake sensitivity analysis for the transit route choice model is very similar to the approach described for the travel mode choice except for one small change. In the route choice context, however there are no alternative specific coefficients as the case was in the travel mode choice model. Hence changes to attribute levels do not capture the change in probability adequately. Instead, we focus on changes to attributes based on the presence of different transit modes within the alternative. For instance, for alternatives with bus mode we reduce the travel time by bus by five minutes while the alternatives that do not have bus are not altered.

The scenarios considered for analysis include: (a) reduced travel time by bus, metro and train - five and ten minutes, (b) reduced walking time for alternatives involving bus, metro and train - five and ten minutes, and (c) reduced waiting time for alternatives involving bus, metro and train - five and ten minutes. The change in transit route choice probabilities for all the scenarios is provided in Table 5.

Table 10. Policy sensitivity analysis of the transit route choice model

REDUCTION IN ATTRIBUTE BY	BUS		METRO		TRAIN	
	5 minutes	10 minutes	5 minutes	10 minutes	5 minutes	10 minutes
Travel Time	19.77	32.73	12.07	20.42	8.21	14.34
Walking Time	17.54	32.38	14.47	30.48	5.78	11.87
Waiting Time	7.34	9.11	11.37	17.25	4.69	7.42

The following observations can be made based on the results. First, change in travel time by bus has the most positive effect, i.e. if alternatives involving bus mode can be improved to reduce travel times the likelihood of individuals choosing that alternative increases substantially. The public transportation agencies and metropolitan organization for Montreal city need to coordinate and develop a dedicated bus priority signalization and or exclusive bus lanes in order to improve transit ridership. Second, reduction in travel time by train has the least influence indicating that respondents using trains are relatively satisfied with current train speeds. Third, changes to walking time are likely to affect alternatives with bus and metro substantially, whereas alternatives with trains are only marginally affected by improving accessibility to trains. Finally, waiting time reductions indicate that alternatives with metro will benefit substantially if waiting times on metro lines are reduced. The public transportation agencies need to review opportunities to reduce waiting times for metros.

CONCLUSIONS

A significant number of individuals depend on the automobile as the main mode of transportation in developed countries. The high auto dependency, in turn, results in high auto travel demand on highways. As transportation professionals, there is need for us to investigate the reasons for this automobile usage and suggest recommendations to encourage more people to employ transit for their travel. Towards this end, we examine two specific aspects of commute mode choice. First, we study the factors that dissuade individuals from commuting to work or school by transit i.e. use the automobile to commute. Second, for individuals commuting to work by transit we analyze their transit route choice decision. Montreal with its unique multimodal public transportation system consisting of bus, metro and commuter train offers multiple route alternatives to individuals commuting to downtown. The data employed in the current study is drawn from a web-based survey of the McGill community members (students, staff and faculty) conducted during the months of April and May 2011. The survey collected information on the community members' socio-demographic information (age, gender, vehicle ownership), and McGill University experience (in years). Further, the survey gathered details on community members' regular commuting patterns. The analysis is undertaken using multinomial logit model for both travel mode choice component and transit route choice component.

The travel mode choice results clearly highlight the role of travel time, walking time, number of transfers on the propensity to choose transit. Further, the results also indicate that faculty members are least likely to choose the transit mode for commuting compared to staff and students. The policy sensitivity analysis conducted using the convergence results for travel mode choice indicates that changes to travel times by transit mode will result in increase in the proportion of riders using transit. Hence, public transportation agencies must consider the possibility of exclusive bus lanes or bus prioritized signals to improve transit times within the Montreal region. The results also highlight the role of walking time while choosing commute mode. Longer walking times act as deterrents to choosing transit mode. Hence, it is necessary for public transportation agencies to increase bus accessibility as well as provide better feeder access (through bus) to metro and train stations.

The transit route choice results provide interesting insights. The results indicate that individuals find travel time on the bus mode the most onerous while they are similarly sensitive to travel time on metro and train. Public transportation agencies should investigate the reasons for this apparent discomfort and propose remedial measures to alter this. The influence of gender on route choice indicates that women are less sensitive to travel time compared to men. Within the McGill context, faculty are likely to be more sensitive to travel time compared to staff and faculty. The policy analysis conducted indicates that reducing travel time by bus increases the likelihood of such alternatives being chosen substantially. So, public transportation agencies need to enhance bus travel times either through bus priority signalization or exclusive bus lanes. The policy results also indicate that routes with bus and metro alternatives are more sensitive to walking time. Hence, it is imperative that public transit agencies consider means to reduce passenger walk times to metro and bus.

The research presented in the study effort is not without limitations. The authors recognize that the survey is conducted for a single work place. However, the large size of McGill University provides us with a relatively large sample to eliminate any intrinsic biases. The modeling approach employed in the study is a classical multinomial logit model. In future research efforts more advanced mixed multinomial logit models can be employed. Overall, the research effort provides promising insights on increasing transit ridership in Montreal.

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Appendix VII - Research on the Satisfaction of Walkers

Does Distance Matter? Exploring the links among values, motivations and satisfaction in walking trips

Kevin Manaugh
PhD Candidate
School of Urban Planning
McGill University
Suite 400, 815 Sherbrooke St. W.
Montréal, Québec, H3A 2K6
Canada
Tel.: 514-398-4075
Fax: 514-398-8376
E-mail: kevin.manaugh@mail.mcgill.ca

Jacob Larsen
PhD Student
School of Urban Planning
McGill University
Suite 400, 815 Sherbrooke St. W.
Montréal, Québec, H3A 2K6
Canada
Tel.: 514-398-4075
Fax: 514-398-8376
E-mail: jacob.larsen@mail.mcgill.ca

Ahmed M. El-Geneidy
Assistant Professor
School of Urban Planning
McGill University
Suite 400, 815 Sherbrooke St. W.
Montréal, Québec, H3A 2K6
Canada
Tel.: 514-398-8741
Fax: 514-398-8376
E-mail: ahmed.elgeneidy@mcgill.ca

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ABSTRACT

Despite a proliferation of interest in planning for active transportation, two important aspects are often overlooked in both research and policy contexts: traveller motivations and satisfaction. Attitudes towards, exercise, social interaction, and the environment are central to an individual's choice of mode, while trip satisfaction is a complex and important—yet rarely explored—element that has important ramifications for understanding travel behaviour. This research utilizes a large-scale travel survey that captures traveller motivation, trip satisfaction, and elements of residential choice. Using clustering techniques, respondents are stratified into one of five distinct groups based on values and motivations. Statistical tests are used to examine the variance in behaviour and satisfaction across groups. Among other findings, it is observed that people who are most concerned with environmental issues and physical activity are walking longer distances and are on average much more satisfied with their commute. By not assuming that all travellers display a consistent response to components of a trip such as travel time, distance, and slope, this research adds to the burgeoning debate surrounding how various aspects of travel can best be measured, conceptualized and modelled for better public policy.

Key words: Walking, travel behaviour, satisfaction, utility, active transportation, residential self-selection

INTRODUCTION

In recent years, researchers have focused on exploring the effect of the built environment on physical activity and active forms of transportation. Researchers in the domains of urban planning and transportation, as well as public health, have begun exploring how to increase utilitarian walking and cycling, and identifying individual or built environment characteristics associated with these desired behaviours. These studies, though often based on extensive travel surveys, rarely account for the personal motivations or preferences of travellers which may vary dramatically in terms of attitudes towards physical activity and exercise, environmental awareness, or preferences related to transportation or housing location choices.

Self-selection, too, is a prickly issue that undermines the causal link that many researchers have posited between the built environment and individuals' travel choices. Various studies have thus attempted to understand whether the built environment actually prompts certain forms of travel, or whether individuals who prefer those forms of travel simply locate in places in order to adopt certain behaviour. Failure to account for these and other oft-ignored factors may result in the attribution of a disproportionate significance to the physical environment as a predictor of the decisions to use active transportation (Alfonzo, 2005). As recent research has shown, individuals of various socio-economic groups respond differently to the same built environment factors, often assumed to uniformly promote walking trips (Manaugh & El-Geneidy, 2011). A related concern is whether a person decides to walk because of a comfortable, inviting pedestrian environment or simply as a result of having no other viable options due to financial or other constraints.

In addition to failing to account for motivations behind individuals' travel and housing decisions, rarely does active transport research explore the level of satisfaction derived by an individual for a particular trip. This may be due to the growing preoccupation with active transportation as a solution to the problems of obesity and climate change, where policy goals are limited in their scope. While GHG emissions reductions are commonly translated into economic terms *(Hoffman, 2005)*, issues of personal satisfaction derived from transportation decisions and other quality-of-life issues are typically more difficult to quantify and are often ignored. By paying greater attention to these aspects among those making active transportation trips, researchers can develop a more nuanced understanding of the different types of individuals who adopt these practices, and their diverse reasons for doing so. Central to this research is the recognition that individuals walk for a host of different reasons, including but not limited to exercise, concern for the environment, convenience or simply out of necessity (because other options are either not affordable or available).

To explore the question of how personal motivations affect travel behaviour, an analysis was performed of individuals' satisfaction of trips to a downtown university campus. Data collected in the winter of 2011 documented motivation for using the chosen mode as well as overall satisfaction with the commute. Additional analysis in GIS allowed for the calculation of distance, slope and other trip and neighbourhood-level characteristics. It is hypothesized that people with a professed motivation of personal exercise or environmentalism may demonstrate not only different travel behaviour but may rate their satisfaction with a walking trip differently than those who walk out of necessity. A person who chooses to walk out of a conscious effort to limit GHG emissions may be much more tolerant and satisfied with a long walk to his desired destination. Likewise, a person who walks in order to fulfill a desire for physical activity or exercise may in fact prefer a route with a large elevation gain, for example. This paper argues for the incorporation of individuals' motivations into research on active transportation behaviours. This can best be achieved using a socio-ecological framework, which recognizes the dynamic relationship between an individual and her environment (Stokols, 1992). Moreover, the inclusion of personal motivations in discussions about transportation leads directly to a reconsideration of a central tenet of utility maximization, which assumes that minimizing the cost of transportation is a factor that contributes to all decisions (McFadden, 2001). Increasingly, the assumption that a single objective can be applied to all travel decisions made by all individuals is coming under increasing scrutiny. Just as various destinations hold different levels of utility for different people, so too is travel experienced differently by different individuals or groups.

To address these issues, this research draws on the response from over 900 walkers and sets out to: 1) examine (self-reported) motivations for choosing to walk; 2) explore how the correlation among trip characteristics such as distance, slope and trip satisfaction varies among groups; and 3) explore issues of self-selection by examining how the characteristics of walking trips and the satisfaction derived is related to decisions related to housing locations.

LITERATURE REVIEW

The present research forms part of a growing body of work that seeks to question and expand the view that travel by active modes follows patterns that can be generalized across different populations and in multiple contexts. This assumption stems from a core tenet of transportation studies and policy: travel time and/or distance is a type of disutility that all rational decision-makers aim to minimize (McFadden, 2001). In the context of active transportation, researchers have sought to identify standard walking distances that people are willing to walk to certain services, such as transit stations (Alshalalfah & Shalaby, 2007; O'Sullivan & Morral, 1996; Zhao, Chao, Li, Ubaka, & Gan, 2003). Other research has expanded the scope of this type of analysis, seeking to understand how far individuals will walk or cycle to access different types of destinations, including work, shopping and leisure (Greenwald & Boarnet, 2007; Iacono, Krizek, & El-Geneidy, 2008; Larsen, El-Geneidy, & Yasmin, 2010). In general these studies have all presumed that travel time and distance are elements of a journey to be minimized.

However, there is growing evidence that travelers of both active and motorized modes do not always make transportation choices that conform to this principle. For one, travel time appears to have remained relatively constant over time, despite the opportunities presented by technological progress for households to reduce this by adjusting their home and work locations (Levinson & Kumar, 1994; Marchetti, 1994). Indeed, there is growing evidence that commuters enjoy a certain minimum travel time between their home and work or school destination, especially when active modes of transport are employed (Paez & Whalen, 2010). One major shortcoming in utility-maximizing frameworks is that cultural factors, notably feelings of freedom and independence often associated with travel, are rarely incorporated. While these cultural values are often associated with the United States and its 'love affair with the car', this concept is certainly not exclusive to that country, nor that mode of travel (Marsh & Collett, 1986; Sachs, 1992; Wachs & Crawford, 1992). In addition to independence, travel has been associated with providing therapeutic benefits and physical exercise, satisfying curiosity, raising one's social status, and providing a sense of adventure *(Ory & Mokhtarian, 2005)*. In short, the associations identified with different types of travel are multiple and overlapping; failure to account for this in transportation research may lead to over-simplistic transport policies.

Socio-ecological model

These frequently-ignored distinctions highlight the need for a more dynamic approach to understanding the trips people undertake, and how their personal abilities, sensitivities and beliefs interact with the environment in which the trip is made. These dynamic interactions are at the center of the socio-ecological approach to transportation research, which situates the decision-maker in a series of interrelated and nested contexts. This includes such aspects as cultural and national norms, family obligations and customs, neighbourhood standards, religious practices, as well as personal expectations and desires. This approach is inherently dynamic and multivariate: that is, the specific array of factors at play ensures that their effects are differentially experienced. (Sallis et al., 2006). In contrast to many studies of active transport, Alfonso (2005) explores these social and physical factors as mediating or moderating elements, rather than as predictive, independent variables. According to this perspective, even the decision-making process follows a nested model: in order for walking to occur, basic feasibility must be ensured (eg. is this person mobile?) before secondary and tertiary criteria such as accessibility, safety, comfort and pleasurability are considered. While feasibility is a basic prerequisite for all walks, individuals will differ in the importance ascribed to subsequent criteria, depending on a host of mediating factors identified above.

Measuring Satisfaction

Research in the transport field has drawn on some key concepts from work on consumer satisfaction in the fields of marketing and psychology, notably the distinction between positive or negative effect, or the satisfaction with a discrete transaction with some sort of transportation service, and cumulative satisfaction with transportation services over a longer period of time *(Friman & Gärling, 2001).* Studies relating to the former category are by far the most common, likely due to the relative ease of cross-sectional data collection (Ettema, Gärling, Olsson, & Friman, 2010). The traditional model of customer satisfaction presumes the customer's psychology to be an essentially unknowable element acting on the satisfaction outcome. More involved behavioural models have attempted to explain what happens in this black box. The most important theory which has been posited to explain customer satisfaction has been the expectancy disconfirmation model, in which satisfaction is defined as a comparison of pleasant past-purchasing experience *(Oliver, 2010; Oliver, Balakrishnan, & Barry, 1994)*. The expectancy disconfirmation model, as well as Fornell's satisfaction model have been used in econometric analysis of customer satisfaction, primarily through structural equations model that links different customer satisfaction measures (e.g. expectations, loyalty, complaints, etc.) with specific and predefined formulas

(Fornell, 1995; Johnson & Fornell, 1991). Other types of satisfaction measurement approaches identified are statistical and data analysis techniques, the quality approach method, and consumer behavioral analysis (Grigoroudis & Siskos, 2009).

Satisfaction studies have sought to explore the importance of service reliability, frequency, comfort and short commutes, all attributes which adhere to the assumptions of utility maximization of public transit users (Cantwell, Caulfield, & O'Mahony, 2009; Tyrinopoulos & Antoniou, 2008; Weinstein, 2000). However, other non-instrumental variables such as cleanliness, privacy, safety, convenience, stress, social interaction and scenery have also been found to contribute to transportation-specific satisfaction (Stradling, Anable, & Carreno, 2007). While many studies have used aesthetic elements of the walking environment to predict mode choice, few have attempted to measure walking satisfaction with the same factors.

Even attributes of travel usually considered as disutilities have been shown to be enjoyed by travelers. Active transportation users, for example, have been shown to respond differently to travel characteristics typically viewed as disutilities. In a recent study of university students traveling to a central campus, Páez and Whalen (2010) found that active commuters were most satisfied with their commutes and in fact, most often desired longer journeys to their destinations. In their study of commuters' liking for travel in the San Francisco Bay area, Ory and Mokhtarian *(2005)* examined commuter's liking for travel stratified between long and short distance trips. For short distance trips, they found that those using active modes were most likely to like or strongly like their short commutes (66%), followed by private vehicle drivers (58%), rail transit passengers (31%) and finally bus passengers (8%). Personal motivations, such as environmentalist beliefs were shown to have a positive effect on the liking for active modes and rail use.

Since transportation aims to provide opportunities for people to participate in activities that are deemed to be important, and thus contribute to the fulfillment of life goals, questions of how transportation satisfaction contribute to cumulative subjective well-being have been posed *(Ettema, et al., 2010)*. However, despite the theoretical connection between the cumulative effect of multiple positive experiences of transportation and overall life satisfaction, few studies have explored this connection (Jakobsson Bergstad et al., 2009), leaving this field of research wide open for further study.

DATA AND STUDY CONTEXT

The data used in this research is taken from a large-scale travel behaviour survey carried out at McGill University in Montreal, Quebec, Canada in consultation with members of the Office of Sustainability of McGill Campus and Space Planning, as well as members of the McGill IT Office. With a total population of 36,000 staff, faculty and students, split between a major Downtown campus and a much smaller suburban campus, McGill is a major activity generator. The Sustainability Office has a vested interest in reducing the GHG emissions of the McGill community by limiting commuting by car as well as encouraging active commuting. Recent initiatives have attempted to reduce the space devoted to parking and make the campus more pedestrian friendly.

The target population of the survey included all McGill students, staff, and faculty. An invitation to participate in the survey was distributed via email, providing recipients with a link to the online survey. While most people associated with McGill have access to a computer and a valid email address, for those staff members that did not have a McGill email address, a postcard inviting them to participate in the survey was mailed to their McGill work location. The survey remained active for a total of 35 days during the month of March and the beginning of April, 2011, during which a total of 19,662 survey invitation emails were distributed among the McGill community. Various prizes were offered as an incentive for survey participation.

Due to a restriction placed on the number of students to whom the survey invitation could be distributed, there is an overrepresentation of employees (this is discussed further in the analysis section). Responses for those who indicated that they walked to the university in either the winter or the fall were analyzed. Of the roughly 5000 survey responses, this study is based on the responses of 935 walkers for whom complete data was available. This sample included 17.4% faculty, 14.2% staff, and 68.3% students. The decision to select only those walkers traveling to the Downtown campus (and not those traveling to the university's suburban campus) permitted us to control for unobserved effects of the walking environment. In addition, by keeping both the trip purpose and location consistent, there are less issues of respondents conflating satisfaction with the trip itself and the destination; which would be an issue if, for example, one were to compare a leisure trip and a work trip to the same location. Satisfaction with walking trips was gauged using a single, Likkert-type question where respondents rated their trip at one to five levels from 'very unsatisfied' to 'very satisfied'. Table 1 shows the level of satisfaction by status by percentage.

In addition, respondents were asked about their motivations for walking to campus, as well as their reasons for choosing their current home location. This question was structured so the respondent could list the first most important thing that motivated her to walk to campus. Then the respondent was asked about the second most important motivation. The list of motivations included an *other* category for people who had a different response than what was listed in the survey. Similarly two questions on residential choice were included. Table 1 includes the percentages associated with the first and second motivation for walking as well as for selecting the current home location.

Table 11. Satisfaction by Status and Responses to Motivation and Residential Choice Factors

	VERY UNSATISFIED	UNSATISFIED	NEUTRAL	SATISFIED	VERY SATISFIED
Faculty	6.7%	1.2%	9.8%	28.8%	53.4%
Staff	10.5%	0.8%	9.0%	31.6%	48.1%
Student	6.4%	4.5%	21.3%	36.3%	31.5%
Overall	7.1%	3.4%	17.5%	34.3%	39.8%

MOTIVATIONS FOR WALKING	FIRST	SECOND
I live close to campus	48.4%	11.1%
It is convenient for me to walk	19.5%	29.9%
Walking is a good form of exercise	17.1%	29.0%
It is a pleasant walk	7.0%	10.3%
Other modes of transportation are too expensive	4.5%	8.3%
Walking is good for the environment	2.4%	7.5%
I do not have access to a car	1.1%	3.3%
RESIDENTIAL CHOICE FACTORS		
Ability to walk to campus	44.2%	19.4%
Amenities of neighbourhood (shops, parks, attractive houses)	14.8%	26.5%
Walkability of neighbourhood	11.0%	14.9%
Cost of housing	8.1%	11.9%
Housing qualities (space, yard etc)	7.9%	8.9%
This decision was out of my control	6.3%	0.0%
Being near friends and family	2.7%	7.1%
Proximity to public transit	2.0%	6.7%
Crime and safety	0.6%	2.1%

For geocoding purpose, respondents were asked to indicate the postal code or the nearest street intersection to their place of residence while working/studying at McGill, as well as the area of campus at which they spend the majority of their time while at McGill. The home locations of those who walked to the Downtown campus, in addition to the campus itself, are shown in Figure 1. As Montreal's climate has such a large impact on the possibility of active modes, questions were asked to capture differences in the respondents' transportation mode in various times of the year. While people commuting to the McGill Downtown campus are not representative of the population at large, this sub-population is vital to understand, especially in light of current world-wide campus sustainability efforts.

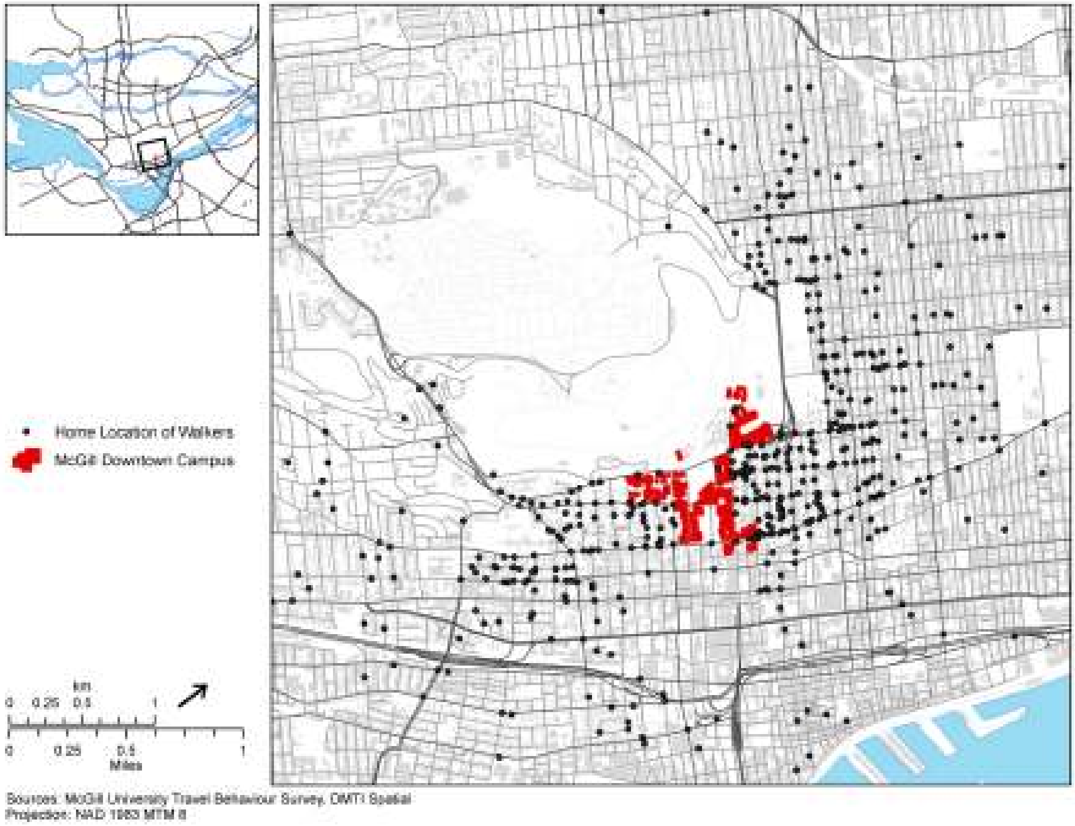

Figure 64. Context Map with home locations of all respondents

METHODOLOGY

As the primary intent of the research was to understand the relationships among trip elements such as slope, travel distance and individual characteristics such as environmental values, several methods were used to gain an insight into these issues. As seen in Figure 1, each respondent's home location was mapped in a GIS. Network analyst in Esri's ARGIS was used to calculate the shortest route from each residence to the area of campus that the respondent reported as their most common destination. Measuring the shortest path generates a line along the network connecting each origin and each destination. Since McGill is located on the lower slope of Mount Royal (which can be seen in Figure 1 as the large, mostly street-less area north of campus), depending on the location of the origin and the destination, a trip may require a significant elevation gain. Accordingly the line connecting each origin and destination was then tested against changes in topographic contour to determine slope and total elevation change for each trip. As these two elements—distance and slope—are the most obvious disutilities of a walking trip, preliminary analysis of these aspects in relation to trip satisfaction was the first step. The inconclusive nature of the results led to adopting a clustering approach to further explore these correlations.

The central hypothesis of this research is that a person who chooses to walk *because* they cannot afford transit will have a very different response to elements of their trip than someone who is consciously seeking an active lifestyle or making an effort to limit GHG emissions. In order to explore the motivations of different types of campus users, a two-step clustering process was employed, which grouped the sample of walkers into five distinct categories. The clustering process examined only responses to the questions related to traveller motivations. The possible responses were environmental awareness ("it is environmental friendly to walk"), physical exercise, convenience, affordability, proximity, "because it is pleasant" or because the respondent does not own a vehicle. These responses were designed to elicit variance in traveller values. No other personal characteristics of the respondent were inputted into the clustering process. Post-tests evaluated whether the different age, gender, or status make up had an effect on the clustering outcomes.

Distance-decay curves were generated by cluster in order to explore how different groups varied in their walking distances. ANOVA and chi-square analysis are used to confirm and understand statistical significance of the variance between groups. In order to visualize these relationships, a figure plotting satisfaction by distance decile is constructed. Finally we tested the relationship between the clusters against reasons for selecting home location. This part of the analysis will help in better understanding the self-selection phenomena among walkers.

FINDINGS

The average distance walked by individual to campus was 1,436 meters. No clear patterns were found between total walking distance, elevation change and satisfaction levels. For example, there was no significant difference between the distance walked between the most and least satisfied individuals, for example. Differences in terms of gender, age, and work status were also inconclusive, though staff members were slightly more likely to be satisfied than others; this certainly did not explain all of the variance. These findings suggested the value of looking at motivations and values of travellers to gain a greater insight into how these important aspects may relate to travel outcomes and individual responses. This section highlights important findings, beginning with the results of the clustering.

Cluster Membership

Figure 2 graphs the z-scores for each different motivation by group, where a value of +/- 1 represents one standard deviation from the average frequency at which a particular motivation was cited by respondents on the whole. This figure reveals that the different groups are quite distinct, with certain motivations for walking shared between groups and others that vary dramatically.

The first group cited the largest number of reasons for walking, including the environment, cost, the pleasantness of the experience and the fact that they do not own a car. As seen in Figure 2, this group is the most heterogeneous group in terms of motivations, and seems to be balancing several concerns. However, the clearest difference from the other groups is their mention of lack of car ownership and cost. These factors were mentioned by this group only, suggesting that monetary constraints played a factor in their decision to walk. In addition this group has a much lower than average value for exercise.

This group was, therefore called the ***"cost minimizers"***. *The second group* is characterized by high values for exercise and convenience; they were termed the ***"active convenience-seekers"***. Interestingly, this group did not cite proximity to campus as a motivation, suggesting that the convenience of walking to campus may be related to other factors, such as avoiding the aggravation of parking a vehicle or allowing multiple stops to be easily done on the way to and from the campus. *The third group* was motivated by proximity and convenience, in other words, it appears that this group walks largely because they lack constraints, rather than due to positive motivations. Accordingly this group is known as the ***"convenience walkers."*** *The fourth group* has high values for exercise and proximity, a combination which seems at first somewhat contradictory, but may simply reflect a strong desire to exercise and multiple time constraints. So this group includes individuals who are generally ***"close and active."*** The fifth and final group has strong values for environmental motivation, as well as exercise and appreciating the pleasant experience of walking. This group was named the ***"active environmentalists."***

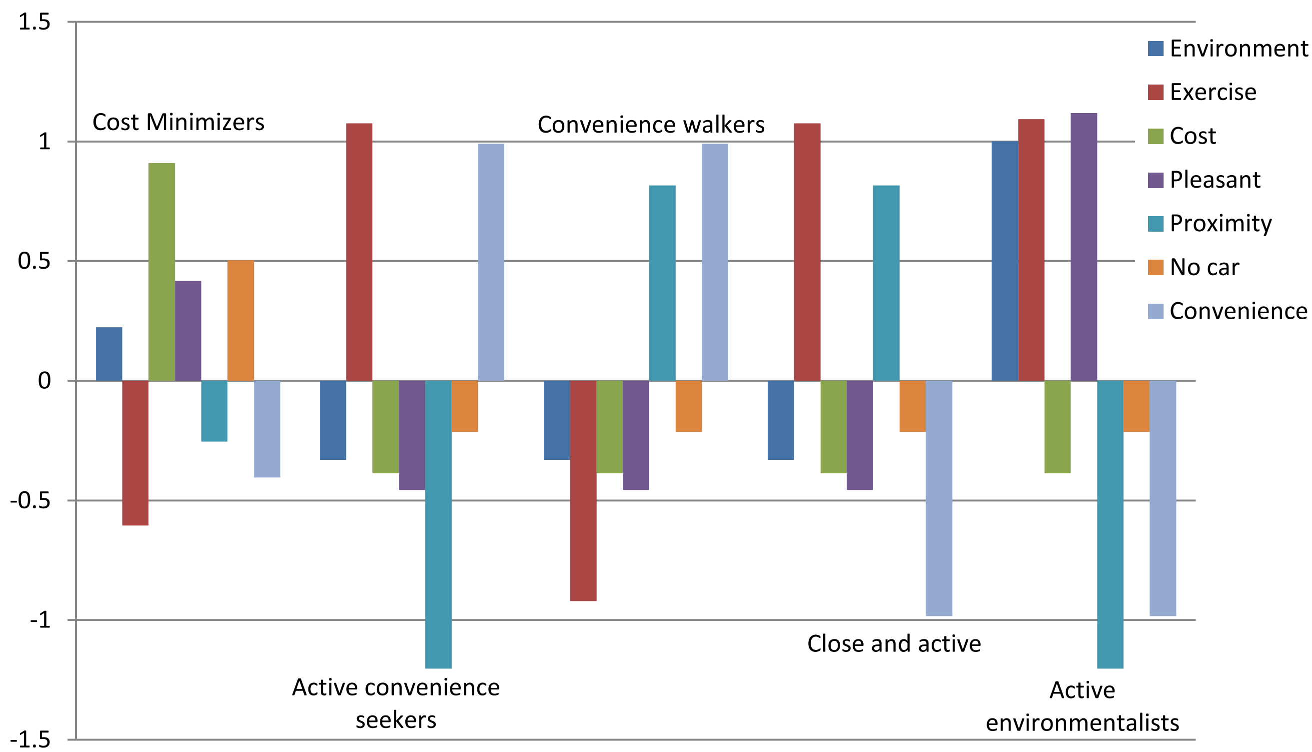

Figure 65. Cluster Membership Z-scores of average cluster values

We next examine walking distance and average elevation change of each group in greater detail, with regards to their levels of satisfaction. Taking a closer look at the individuals in the five clusters, we see that not only do their motivations for walking differs dramatically, but so too do their objective travel characteristics. Interestingly, cluster 5, which has both the longest average distance and highest average elevation change, is also the ***"most satisfied"***. This can be contrasted with cluster 1 and 3 especially which show much shorter travel distances and elevation change yet significantly lower satisfaction rates. In order to ensure that oversampling of faculty and staff did not affect the outcome of our study, satisfaction levels were checked both with and without this group included; this had nearly no effect on the results. In addition, the groups are made up of slightly different percentages of age categories; however, testing for this effect also did not drastically affect the overall results. It is important to reiterate that the clusters were run entirely on responses to questions relating to motivations and values and not on any attributes of the trip itself. The fact that distance and satisfaction varies so drastically by cluster is in itself an initial confirmation of the usefulness of the technique.

Table 12. Average distance, slope and satisfaction by cluster membership

CLUSTER	COUNT	ELEVATION CHANGE (M)	DISTANCE (M)	VERY SATISFIED (%)
Cost Minimizers	279	49.1*	1553.9**	31.9%***
Active, Convenience Seekers	114	53.4*	1845.8**	37.7%***
Convenience Walkers	270	27.7*	877.4**	40.0%
Close and Active	156	33.5*	1083.6**	45.5%****
Active Environmentalists	116	67.2	2528.6	56.0%****
Average		**43.1**	**1436.6**	**40.02%**

*Statistically significant (ANOVA) F(4,930) = 45.11, p < .05
** (ANOVA) F(4,930) = 97.48, p < .05
***Chi-square (4, N = 935) = 22.22, p = .004, lower than expected value
**** Chi-square (4, N = 935) = 22.22, p = .004, higher than expected value

Chi square and ANOVA were used to understand the variance between the groups. Results are shown in Table 2. For ease of presentation in the ANOVA results, the asterisks refer to cluster 5 as a reference category. All combinations of clusters are statistically significantly different except ***"convenience walkers"*** and ***"close and active"*** whose slope and distance values are quite similar. The "very satisfied" column shows the percentage of respondents who report being "very satisfied" with their commute. Both the ***"active environmentalist"*** and ***"close and active"*** groups have a much higher percentage of satisfied individuals than would be expected if satisfaction was randomly distributed throughout each cluster.

To further explore how satisfaction varies over distance by different groups Figure 3 was constructed. While distance decay curves typically highlight the diminishing attractiveness (or utility) of increasingly distant destinations, figure 3 plots the average satisfaction reported by each group against the decile of distance for each respective group. Deciles were used for comparative purposes, since the distances walked by each group differed so dramatically. Plotted this way, we see that the traditional assumptions about the disutility of distance holds true only for cluster 3. For the ***"convenience walkers"***, who walk because of proximity to campus and convenience in general, the percentage of respondents reporting they are satisfied with their commutes clearly declines as distances increase. For the ***"active convenience-seekers"*** and ***"close and active"*** walkers, it appears that satisfaction increases with distance, then declines at a certain point, which may be considered a threshold for each group. The ***"Active environmentalists"***, show an upward level of satisfaction with their walking trips as distance increases. The clusters who valued factors related to cost (group 1) show no clear pattern of increasing or decreasing satisfaction with the distance they walk, though this is not entirely surprising.

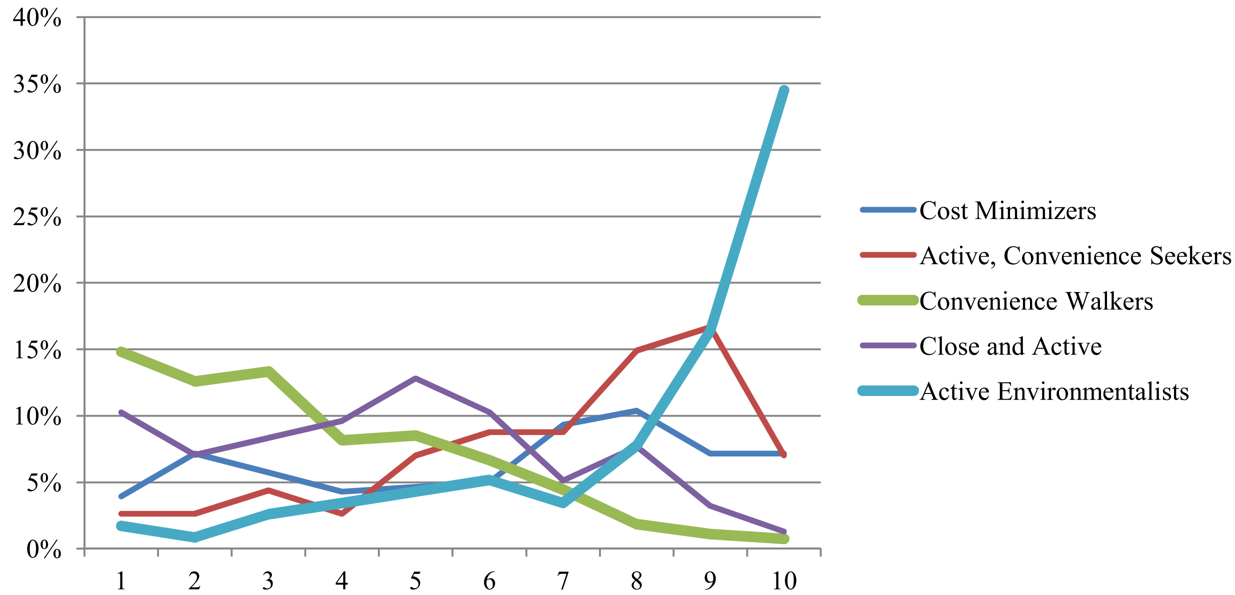

Figure 66. Satisfaction with trip plotted against distance travelled by decile

Perhaps as another way to interpret Figure 3, it may be helpful to consider that only in the ***"convenience walkers"*** cluster are people who are most likely to be satisfied in the lowest 2 deciles. In all other groups the pattern is quite different with a spike in satisfaction at a much higher distance. For ***"close and active"*** this spike begins at 1,151 metres. For the ***"active convenience seekers"*** and the ***"active environmentalists"*** the spike is much higher, at 1,997 metres and—a surprising—2,883, respectively. These values are useful in understanding potential "thresholds" for satisfaction among different populations; even the most active and environmentally aware people will of course have a limit that they will happily choose to walk.

The motivations that individuals have for walking are a strong predictor of the level of satisfaction they are likely to derive from it. As hypothesized, those who walk for environmental or fitness reasons not only tend to walk longer distances but also be more satisfied by their commute. The ***"convenience-seeking walkers"***, which values proximity to their destination and overall convenience, displays more "normal" distance decay curves as well as expected distance/satisfaction relationship. Although this group only represents 28% of all walkers in our study, most research, and indeed policy, seems to use this group as the standard model for pedestrians. Most measures and assumptions in the walking literature are generated based on the understanding of the behaviour of this group, which is mainly reliant on utility maximization.

Residential Choice

Much discussion has focused on the interaction between the built environment and the extent to which it influences peoples' travel decisions. This question was addressed in the present survey by asking respondents for their primary reason for choosing their current home location. Responses by cluster are reported in Table 3, showing the two most common responses by cluster and the percentage of each. Interestingly, the most common response for members of clusters 1 through 4 was that it permitted them to easily walk to their destination. "Ability to walk to campus" was the first or second choice for well over 50% of the respondents in each cluster. However, for the ***"active environmentalists"***, the group which on average walked the longest distance and derived the greatest satisfaction from their walking, the ease of walking to McGill's Downtown campus was not the primary reason behind their choice in housing location. Rather, this group cited convenience to other amenities.

Table 13. Reasons for choosing current place of residence by Cluster membership

	FIRST CHOICE	%	SECOND CHOICE	%
Cost Minimizers	Ability to walk to campus	36.6%	Amenities of neighbourhood	24.7%
	Walkability of neighbourhood	10.8%	Ability to walk to campus	20.1%
Active, Convenience Seekers	Ability to walk to campus	29.8%	Amenities of neighbourhood	23.7%
	Walkability of neighbourhood	17.5%	Ability to walk to campus	20.2%
Convenience Walkers	Ability to walk to campus	58.9%	Amenities of neighbourhood	20.7%
	Walkability of neighbourhood	6.3%	Ability to walk to campus	17.0%
Close and Active	Ability to walk to campus	53.8%	Amenities of neighbourhood	28.2%
	Walkability of neighbourhood	9.6%	Ability to walk to campus	10.9%
Active, Environmentalists	Amenities of neighbourhood	36.2%	Amenities of neighbourhood	27.6%
	Ability to walk to campus	22.4%	Ability to walk to campus	21.6%

While it was hypothesized that the cross-cluster response to the residential selection questions might shed some light on these issues, overall the response was remarkably consistent for all clusters. Even in the ***"convenience"*** cluster, which appeared to simply be walking out of a lack of better alternatives, they do seem to value the chance to engage in active transportation. While initially somewhat surprising, this seems in fact to confirm our hypothesis that these people value the *convenience* of walking less than the actual experience of walking. Interestingly, and somewhat contradictory to our initial hypothesis, almost all walkers seem to be making a conscious decision to walk and in fact rate this as their primary criteria for their residential choice. Our sample is therefore in some ways "self-selected"; most people consciously chose their home location based on the desire to be able to walk to school or work. It is only in the ***"active environmentalist"*** cluster that the pattern is slightly different. This finding confirms the importance of concerns related to self-selection bias that plays an important role in travel behavior and should be accounted for in any future research related to walking.

DISCUSSION AND CONCLUSIONS

A considerable amount of past research has been dedicated to understanding how far people will travel to certain types of destinations; however, there has been significantly less study of the satisfaction derived from travel, as well as what motivates different types of travel. This is especially true for those who travel by active modes, which past research suggests do not conform to the assumptions of utility maximization *(Ory & Mokhtarian, 2005; Paez & Whalen, 2010)*. Other work questioning the accepted "derived demand" nature of travel is also relevant to this study.

This study aimed to understand the satisfaction levels and motivations of walkers traveling between their homes and a shared destination: McGill University's Downtown campus. The hypothesis that satisfaction with travel is simply a function of distance walked was eliminated, prompting the categorization of walkers into clusters based on motivation. Incorporating travelers' motivations resulted in the identification of five clusters with dramatically different walking patterns and satisfaction levels. The group of walkers motivated by a desire for exercise, environmental awareness and an appreciation of the aesthetic elements of their journey walk over 1 km farther than the average. This group is characterized by a higher overall level of satisfaction than all other clusters; furthermore, for this group, satisfaction is positively associated with distance. The greatest contrast was found between this group and group 3, which was characterized by an inverse relationship between distance and satisfaction. This group, motivated to walk by convenience and proximity, walked nearly 600 m shorter than the average. A key importance of this research is simply in distinguishing between the distance that one is "willing" to walk, and the distance that one is "happy" to walk. Observing that this varies among groups adds to this value.

The direct policy implications of these results are not obvious. The finding that some people enjoy longer walks certainly does not imply that distances between homes and destinations should be increased. Rather, these findings tend to support rethinking the assumption of the universality of utility-based models of decision-making, a central assumption in the planning and research of transportation networks. While the standard utility model may hold true for many people, a wider set of evaluative measures could be developed and utilized to assess the success of transport policies. While transportation planning goals often focus on modal split and reduction of GHG emissions, this paper argues for the importance of measuring traveler—and in particular, pedestrian—satisfaction. This paper calls on planners and researchers to adopt a broader set of evaluative measures in order to understand the various aspects that contribute to peoples' satisfaction with travel, and the diverse motivations behind it. Much research, and indeed policy direction, seems to be geared toward increasing the modal share of active modes. This research confirms the suspicion that not all people will rate or experience a similar trip in a similar manner. Simply counting the number of pedestrians in a given neighbourhood could overstate the "walkability" of the area. Knowing whether people are walking out of a conscious choice—as opposed to response to their barriers—and are enjoying their travel is arguably a vital aspect.

In addition, these findings also confirm the usefulness of socio-ecological models of walking behaviour that take into account personal and social characteristics of neighbourhoods, households, and individuals in addition to built environment factors. Future work could build on these findings to expand standard concepts of neighbourhood walkability. Responses to the questions of residential choice decisions suggests that the vast majority of our sample values the chance to engage in active transportation and in fact makes this is an important part of the residential-decision making process. These findings confirm the importance of understanding self-selection in active transportation studies. Virtually every respondent listed the ability to walk to their destination as a primary reason for choosing to live in their current residence. This directly calls into question any attempts to link changes in built environment factors and behaviour. However, future work should test how this relationship persists outside of a sample from a University setting.

One important limitation of this research is that the survey on which it is based included only one question concerning overall satisfaction with travel. Yet, in order to explore the issue of travel satisfaction in sufficient detail, future research should devote greater attention to the various aspects of satisfaction, both in terms of specific trips and commuting over time. Issues such as safety, comfort, privacy, sociability, travel time and aesthetic experience would be worthwhile to explore in this regard. It is important to note that questions regarding these aspects are rarely present in most large-scale travel behaviour surveys. It is our contention that the inclusion of these types of questions could greatly improve both research and policy outcomes.

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