We appreciate the opportunity to share with you some background on this project while providing you with a copy of the draft McMaster University Travel Demand Management Plan 2016.

In 2013, the University engaged the McMaster Institute for Transportation to review travel demand and campus needs. The draft report was received in 2016, delayed somewhat by the unforeseen and unfortunate changes in the leadership of the Institute and remained as an incomplete draft research project.

Over the past several years, the University has taken many steps to improve the campus transportation and enhance transit sustainability.

We have worked with our students and faculty to reclaim the area around Coldwater Creek from existing parking and construct a riparian buffer protecting the creek from the parking area.

The University has also reclaimed some surface parking spots for new campus developments while introducing underground parking for faculty, students, staff and visitors.

We've invested in new walkways and sidewalks to improve walkability. McMaster has worked closely with the Social Bike Network (SoBi) to help encourage use of that system. The station located at the Sterling entrance is among SoBi's most active and popular terminals. The University is also a major sponsor of the Hamilton Bike Share initiative, which makes bikes more readily available in our neighbourhoods.

The University is working to make transit a more attractive option for our community by investing in infrastructure, creating programs to increase demand in transit and most importantly, by working with key partners to improve transit.

We're engaged with the City of Hamilton and Metrolinx to help advance and support the LRT project – including planning a significant new Transit Hub at Main Street and Cootes Drive that will expand the current GO Transit station, which currently serves approximately 3,000 daily passengers. The hub includes plans for a covered multi-bay HSR bus station on campus. It will be connected to the LRT station and helping ensure a convenient connection point between for train and bus passengers.

The University has taken a balanced and holistic approach to Travel Management and planning. Thank you for your interest in the draft report and for considering this update.

McMaster University Travel Demand Management Plan 2016

January 2016

A Draft Report Prepared for Parking and Security Services

McMASTER INSTITUTE FOR
TRANSPORTATION
& LOGISTICS

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Executive Summary

Managing travel demand has become a core competency in most transportation programs and represents a shift in thinking: from building infrastructure for long-term growth to effectively managing existing infrastructure and judiciously investing in new services while focusing on encouraging more sustainable transportation options. This report assesses the travel conditions at McMaster University to explore how travel demand management can accommodate university growth expected by 2025.

Existing travel patterns and public input on travel services are analyzed and future travel demand is forecasted based on several potential policy scenarios. Study findings demonstrate that by improving walking, bicycling, and public transit options in concert with a 30% increase in the price of parking and a 30% faculty and staff transit subsidy, future travel demand can be better accommodated. These measures will also lead to a financially beneficial outcome, and establish McMaster University as a leader in sustainability and an integrated approach to transportation system management. While a policy approach based on consistently providing more parking can accommodate future travel demand, this approach does not meet goals such as environmental stewardship or financial soundness.

What Travel Demand Management means for McMaster University

Travel demand management represents an approach to program management and not simply a finite and planned set of actions. TDM is not a "to-do" list; it is a philosophy which is constantly re-engaged to manage new and changing circumstances. Common travel demand management programs are organized around the principles of:

1. Improving the transportation system efficiency,
2. Improving environmental sustainability,
3. Reducing dependence on the automobile,
4. Promoting walking, bicycling, transit, and other commuting alternatives, and
5. Minimizing the role of capital infrastructure investments by focusing on making the best use of existing infrastructure.

Universities are well suited for the development of TDM plans for three key reasons:

- First, TDM can immediately lead to benefits in managing the University's daily activities
- Second, a TDM can enable universities to be leaders in reducing greenhouse gas emissions, facilitating sustainable modal choices, and benefitting the broader community.
- Finally, a university TDM provides an opportunity for learning about environmental stewardship and the role of transportation and travel in being socially responsible.

Four key issues provide challenges for McMaster University in accommodating travelers to access the campus over the next ten years. These are growth, finite physical space, the low price of driving, and limited alternate transportation service options. Both McMaster University's student and faculty/staff populations have historically grown by approximately 2.5% annually and this growth is expected to continue into the future. In the last five years, student enrollment has increased by approximately 300 undergraduate students and 100 graduate students per year, while the faculty and staff complement has increased by 190 between 2009 and 2013. Managing auto demand and supporting reasonable alternatives is key to best using available resources and encouraging socially and environmentally sustainable options. This travel demand management plan is designed to:

- catalogue the existing state of travel and transportation services at McMaster University
- explore what these conditions mean for the future (a ten-year horizon)
- identify strategic actions and outcomes which can better enable members of the McMaster University community, focusing on those commuting to main campus, to continue engaging in a productive way in campus life and work without sacrificing life quality.

Evaluative Criteria

Guidance from the McMaster University Campus Plan and previous studies is distilled into five core principles to which this study adheres in its recommendations:

1. Future services should meet expected future demand to accommodate core university functions,
2. Future services should encourage less auto travel and more travel by transit, walking, or bicycling,
3. Actions should resonate with input from the public involvement process,
4. Actions should lead to a lower environmental footprint in the future, and
5. Actions should be financially sound - not only from a transportation program management perspective but also from the perspective of managing the entire university.

Study Approach

This travel demand management (TDM) plan is organized by characterizing current travel to McMaster University, by estimating the outlook of various factors to better managing travel, and by identifying those transportation program management decisions with the best outlook for success using alternate policy scenarios.

Existing Conditions - A survey was administered to McMaster University faculty and staff (15% sample) and students (5% sample) to identify current travel patterns, choices, and preferences.

Compared with a survey from 2010, these results indicate that the share of students, faculty, and staff has not materially changed. Parking utilization data indicate that fall semester parking regularly exceeds 80% of the on-campus parking capacity, while spring parking demand is significantly lower. Peak on-campus parking currently exceeds 95% of total capacity on only two days of the year.

A public meeting was held on January 20, 2015 in which members of the McMaster community provided input for the purposes of designing the travel demand management plan. Most agree that there is a need for services to change but there is disagreement among various members of the public on what changes are most needed. While most assert that improvements to the pedestrian environment and bicycling experiences should be advanced, others emphasize the need to access campus by car. Most attendees indicated that transit services were of very low quality and, among faculty and staff, transit was expensive relative to parking permits.

Exploring Alternate Scenarios - Using the travel survey data, models are built in which travel demand is estimated to 2025 in response to several factors, including available parking, service levels, land use patterns, and other socio-demographic characteristics. The following scenarios are evaluated:

1. No Action Alternative – no policy actions are taken to accommodate future travel demand
2. Build Parking Alternative – parking is constructed proportionately to campus growth under current service levels
3. Improved Transit Alternative – transit improves and no other actions are taken to accommodate future travel
4. Full Travel Demand Management Alternative – transit, walking, and bicycling services are improved to meet future needs

Each of these four alternatives are estimated assuming two alternative pricing scenarios:

1. No real changes in real the price of parking or transit
2. Parking prices increase 30% over ten years and faculty/staff transit passes are subsidized by 30%

Discrete choice models indicate that the four most critical components to materially shifting travel demand are constraining parking supply, shifting the price of parking, balancing the price of transit uses for faculty and staff, and providing and actively managing reasonable alternatives to driving. When comparing scenarios with the five key evaluative objectives, results strongly indicate that the Full Travel Demand Management Scenario should be engaged to accommodate future travel demand, which entails improvements to walking and biking experience, a cap on parking supply, 30% higher real parking costs, a 30% subsidy on faculty and staff transit fares, and improved transit services. Build Parking Scenarios represent the polar opposite policy approach and while meeting future travel demand, this approach would not meet other evaluative policy objectives.

Financial models which estimate year-over-year costs and revenues to McMaster University from alternate scenarios indicate that the Full TDM Scenario is financially sound and its revenue benefits accrue over the long-term. When focusing strictly on the short-term (e.g. only a five-year horizon), the TDM Scenario is less favorable than the Build Parking Scenario, while the TDM Scenario becomes even more financially attractive when focusing on time horizons longer than ten years. In short, while program management costs through the TDM Scenario accrue in the next five years, the lack of costs due to parking construction or operations over the longer term balances softer short-term investments.

Recommendations

Based on input from the McMaster community and forecasts of parking demand based on several potential scenarios, key recommendations address five types of actions:

1. Institutional
    a. Parking Services is recommended to be renamed to Transportation Services to signal the broader range of transportation options which are managed within the division.
    b. A TDM Manager should be hired by the newly renamed McMaster Transportation Services to direct day-to-day operations, including an $80,000 marketing budget and a new $200,000 annual operations and infrastructure budget.

2. Project Recommendations
    a. Coordinate with the City of Hamilton and Hamilton Street Railway to secure 30% faculty and staff transit discounts and transit service improvements.
    b. Implement 30% real increases in parking prices on campus (which need to be adjusted for inflation). Assuming a 1.5% normal rate of inflation, the nominal price of parking would go up by just over 50% in total[1], or 4.2% annually[2].
    c. Establish regular procedures for discussing TDM policies, efforts, and sources of financial support from the City of Hamilton, Metrolinx, and Hamilton Street Rail.
    d. To reduce the negative environmental impacts of single occupancy vehicular travel and to promote cleaner travel, consider preferential parking location and/or parking discounts for those who commute with electric vehicles.

3. Infrastructure
    a. As a principle, refrain from adding parking supply beyond current levels.

1 0.51 = 1.015^10 * 1.3 – 1

2 0.042 = 1.51^(1/10)-1

b. Improve pedestrian sidewalks and crosswalks to improve pedestrian safety.
c. Provide bicycle lanes and identify design improvements which can create a safer setting for bicyclists; safety is paramount.
d. Add bicycle racks and storage facilities - e.g. at McMaster Innovation Park.
e. Identify how and where bicycle riders can access showers and change rooms to enable the full cycling experience to meet the needs of users.
f. The Hamilton Light Rail Transit line, funded by Metrolinx, should be supported to identify how to generate the highest transit service benefits on campus.

4. Information and Marketing
   The travel demand management program should engage in a multi-directional information and marketing campaign to encourage TDM. Information should follow the following trajectories:
   a. <u>TDM Program to User</u> - Regularly communicate the key objectives of the travel demand management plan to inform McMaster University faculty, staff, and students on project goals and objectives. Moreover, insofar that the peak travel periods are constrained to very specific times, information should be communicated to users on the nature of these most intense travel period and potential solutions should be suggested.
   b. <u>User to TDM Program</u> - Regularly solicit direct input into the TDM process from members of the McMaster University community. Hearing from transportation system users in an open dialogue is critical to filling transportation service gaps which otherwise may never be identified.
   c. <u>User-to-User</u> - Identify student-led competitions or collaborations which could encourage better real-time information sharing. For example, almost ten percent of users used a different mode to depart from campus than how they arrived - implying the potential for on-the-fly carpooling. Incentivizing students to create Apps or other platforms for information sharing could represent low-cost, high-yield actions.
   d. <u>McMaster Management to McMaster Management</u> - identify, evaluate, and strengthen information sharing procedures regarding large events or travel patterns which could influence TDM program management.

5. Evaluation

   Regularly monitor parking demand and travel choices to McMaster University using formal and informal techniques. While parking utilization can be formally monitored continuously through the office of the TDM Manager, formal travel surveys should be conducted every five years to identify significant changes in McMaster University transportation system user choices and experiences. Likewise, the TDM Manager should regularly engage members of the McMaster community to evaluate how transportation services are meeting the needs of users.

Background

1.1 Introduction

Managing travel demand has become a core competency in most transportation programs. The era of "predict and provide" and the model of building more parking and more roads is increasingly coming to an end in an environment with finite land and financial resources, and an increasing priority given to environmental sustainability. As such, travel demand management represents a shift in thinking: from building infrastructure for long-term growth to effectively managing existing infrastructure and investing in new services while focusing on encouraging more sustainable transportation options.

This leap in thinking is particularly relevant for a university for three reasons:

1. Managing travel behaviour plays a key role in accommodating travel to enable core university functions.
2. Managing university travel influences how much money, land, and resources are available to fulfill the university's core education and research missions.

3. Universities have a moral obligation as models in educating the public and promoting sustainability, livability, and environmental stewardship.

Effectively educating and promoting sustainable travel demand management rests not just on identifying a course of action, but also re-evaluating and adjusting on a regular basis. This is an approach which must be sustained and is not a single actionable solution. In short, travel demand management strategies must be identified, institutionalized, and integrated into existing functions.

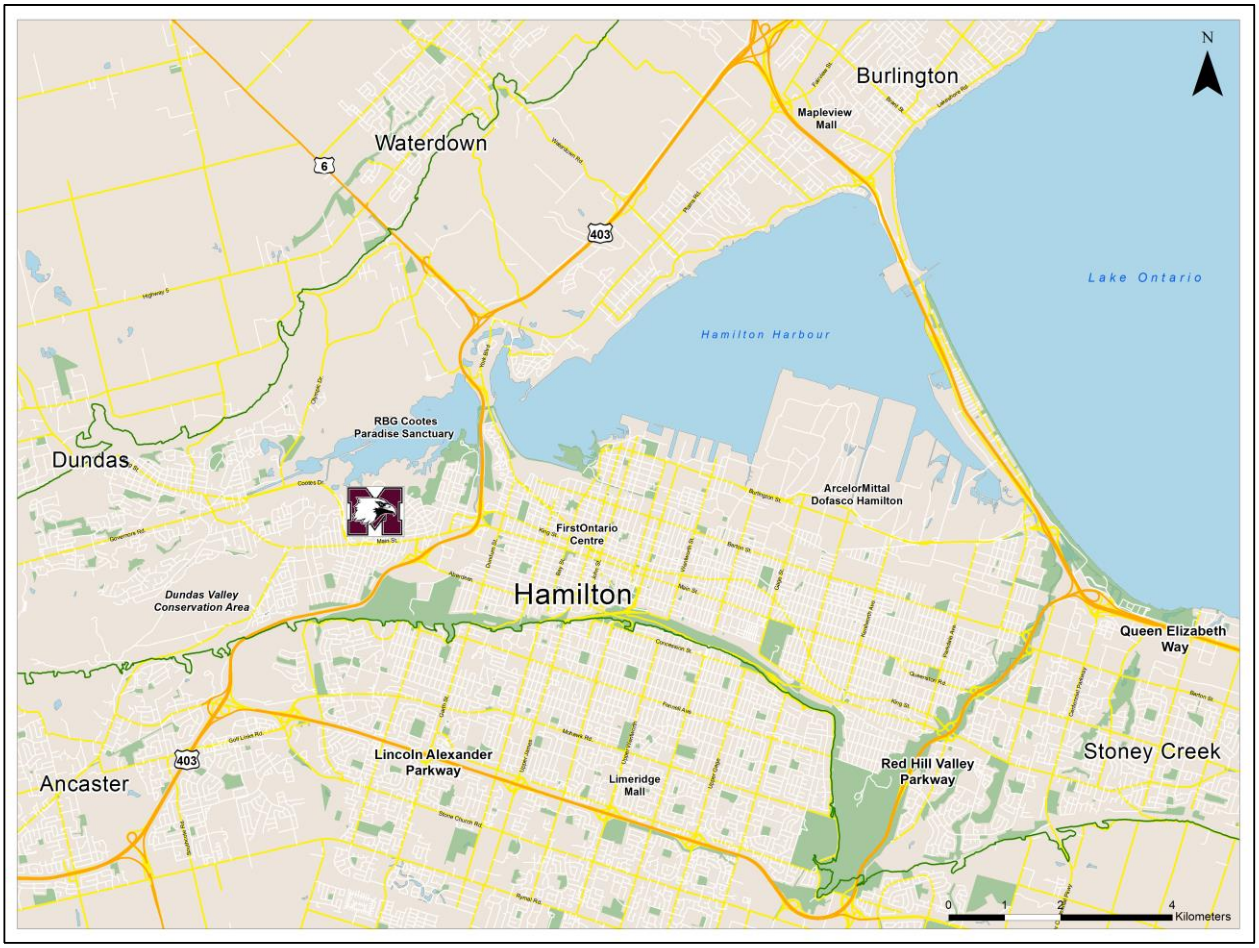

Figure 1: McMaster University Main Campus in Hamilton, Ontario

McMaster University is a public research university that offers a wide range of undergraduate and graduate degrees to thousands of students each year. Based on past trends, the University is expected to grow by approximately 400 students and 190 faculty and staff per year over the next ten years - leading to significant growth primarily on the main campus. As seen in Figure 1, the Main Campus is found in the west end of Hamilton, the fourth largest city in Ontario. The area around the University is called Westdale Village, and is bordered by Cootes Paradise, the Royal Botanical Gardens, and the shores of Lake Ontario. Physical space, land, and financial resources are finite, so effective management of increasing travel demand to McMaster University is critical for its capacity to function efficiently in the future.

This study focuses on travel demand management for McMaster University in an effort to both sustain an approach to managing travel as an integrated system and to formally institutionalize how travel by all modes and all users should be programmed from within McMaster University.

1.2 What is Travel Demand Management?

Automobility has resulted in significant social benefits to users, enabling complex daily activity patterns, fast mobility, and freedom. Despite these social benefits, public policy contexts which have historically favored automobility have led to auto dependence and traffic congestion, as well as environmental, social and economic consequences which are now being managed in efforts to holistically improve the transportation system. Increasing the supply of roads and parking spaces in congested areas is not always a viable approach to transportation program management. Instead, transportation planners and public officials have begun pursuing strategies to decrease the demand for single occupancy vehicle use, make better use of the valuable auto-oriented services available, and by encouraging commuters to use alternate modes.

Travel Demand Management (TDM) is an approach to the growing concern of traffic congestion, pollution, and parking shortages (Watterson, 2011). For the purposes of this report, TDM is defined as an approach to transportation planning and program management which focuses on:

- increasing transportation system efficiency and environmental sustainability by reducing dependence on cars and improving alternate modes (e.g. walking, bicycling, transit)
- making the best use of the system while sparingly making (frequently expensive) capital infrastructure improvements.

The historic auto-oriented policy approach has led to significant environmental consequences and social consequences (leaving out those without cars), and has ignored the opportunity cost of using scarce financial and land resources for other more productive uses. Auto travel is critical to enabling urban function, but remedying both its direct consequences and potential inefficiencies due to its subsidization over other uses has been a focus of many corrective policy actions in university settings (Balsas, 2003; Watterson, 2011; IBI Group, 2011).

1.3 TDM in a University Context: the Need

TDM plans are initiated in the university setting for a multitude of reasons, the most important of which are the following:

- a valuation of environmental sustainability
- a reaction to a current or pending parking strain
- and/or traffic congestion in the campus vicinity

This plan serves to establish McMaster as a leader both in environmental action and education.

Universities have social responsibilities to lead efforts to encourage environmental sustainability both through multimodal education and by promoting positive environmental stewardship. The Stockholm Declaration on the human environment in 1972 highlighted intra- and intergenerational equity amongst humans. It offered 24 principles to encourage environmental sustainability, noting that nations must "improve the human environment for present and future generations. . . a goal to be pursued together with, and in harmony with, the established and fundamental goals of peace and world-wide economic and social development" (UNESCO World Heritage Centre, 2005). The Tibilisi Declaration of 1977 made the principles of environmental sustainability concrete in university contexts, highlighting both environmental action and equal access to environmental education using different modes as keys to improving environmental sustainability (Wright, 2002).

The McMaster University Office of Sustainability has been established to focus on linking sustainable management principles with educational outreach. In Canada, transportation accounted for approximately one-quarter of greenhouse gas (GHG) emissions in 2011 and Canada accounts for approximately two percent of global CO_2 emissions from fuel combustion (Environment Canada, 2013).

Universities are well suited for the development of TDM plans for three key reasons.

- First, TDM can immediately lead to benefits in managing the University's daily activities – improving commuting experiences, effectively managing competing budget objectives, and making the best use of scarce land.
- Second, a TDM can enable universities to be leaders in reducing greenhouse gas emissions, facilitating sustainable modal choices, and benefitting the broader community through lower traffic volumes, safety improvements, and a reduced environmental footprint. These benefits accrue beyond the confines of the university – extending both to future generations (e.g. in improving environmental stewardship) and into other realms of the urban fabric (e.g. the broader community).

- Finally, completing a university TDM provides an opportunity for learning about environmental stewardship and the role of transportation and travel in being socially responsible.

1.4 Reviewing TDM Principles

Travel demand management represents an approach to program management and not simply a finite and planned set of actions. TDM is not a "to-do" list; it's a philosophy which is constantly re-engaged to manage new and changing circumstances. Within the TDM approach, there are many tools. Common travel demand management programs, plans, and projects are organized around the principles of:

1. Improving the transportation system efficiency,
2. Improving environmental sustainability,
3. Reducing dependence on the automobile,
4. Promoting walking, bicycling, transit, and other commuting alternatives, and
5. Minimizing the role of capital infrastructure investments by focusing on making the best use of existing infrastructure.

Since travel demand management is integrative, the transportation program management tasks of transitioning towards TDM can begin in different contexts such as: out of necessity; out of financial constraints; out of environmental priorities; or out of social values of livability. Six elements feature prominently in travel demand management initiatives.

1. A TDM plan, such as this one, can provide a vision of how demand management may influence transportation program management and user experiences in both short and medium-term timelines. Plans provide the context, identify the need, and establish a general framework through which the strategic tasks of program management can be implemented.

2. An institutionalized program establishes the mechanism through which a TDM plan can be implemented in practice. To effectively elevate a plan to a program, regular updating is required, dedicated staff with specific mandated objectives are needed, and resources are necessary to monitor, communicate, implement, and evaluate practices in short and longer-term timeframes.

3. Projects are specific tangible actions that should be carried out to effectively manage travel demand. These efforts can be discretely identified within the broader program management objectives. Capital projects can include investing in new pedestrian facilities

while operating projects can include implementing new communication systems, prices or fare structures, and implementing new regulations.

4. A minimalist approach towards infrastructure investments is often inherent in travel demand management programs. On the basis of realigning historic incentives which encourage automobility, infrastructure investments in TDM primarily focus on less costly pedestrian, bicycling, and transit improvements but not on higher-cost auto infrastructure improvements.

5. Marketing and information provision also play key roles in encouraging a more efficient use of the full transportation system. Marketing strategies include providing the public with information about options about which they may not know, communicating the broader social and environmental consequences of travel and transportation policy, communicating program successes in improving travel conditions, marketing new alternatives, and identifying needs communicated by the public.

6. Evaluation features strongly in travel demand management, providing an effective mechanism through which performance objectives are regularly re-assessed and successes and shortcomings are identified, remedied or reevaluated. Evaluation provides the mechanism through which successes and shortcomings in the TDM program can be identified, assessed, and improved.

McMaster University Transportation Context

Four key issues provide challenges for McMaster University in accommodating travelers to access the campus over the next ten years. These are growth, limited physical space, the low marginal price of automobility, and limited alternate transportation service options. With a growing university population, the pressures of automobility on the use of land and the use of university funds and resources is significant. Managing auto demand and encouraging choices is key to best using available resources and encouraging socially and environmentally sustainable options. This plan is designed to:

- catalogue the existing state of travel and transportation services at McMaster University
- explore what these conditions mean for the future (a ten-year horizon)
- and identify strategic actions and outcomes which can better enable members of the McMaster University community, focusing on those commuting to main campus, to continue engaging in a productive way to campus life and work without sacrificing quality of life.
-

2.1 Past and Projected Growth in Students, Faculty and Staff

Both McMaster University's student (2005 to 2015) and faculty/staff (2009-2013) populations grew by approximately 2.5% annually. In the last five years, student enrollment has increased by approximately 300 undergraduate students and 100 graduate students per year (see Figure 2), while the faculty and staff complement has increased by 190 between 2009 and 2013. As shown in Figure 3, most recent growth in faculty members has occurred in the Faculty of Health Sciences while other faculties have remained largely stable (McMaster University, 2010). As such, while student growth has slowed moderately over the last ten years, faculty, or staff are added to McMaster University's already large community, leading to pressures on the existing transportation and broader services.

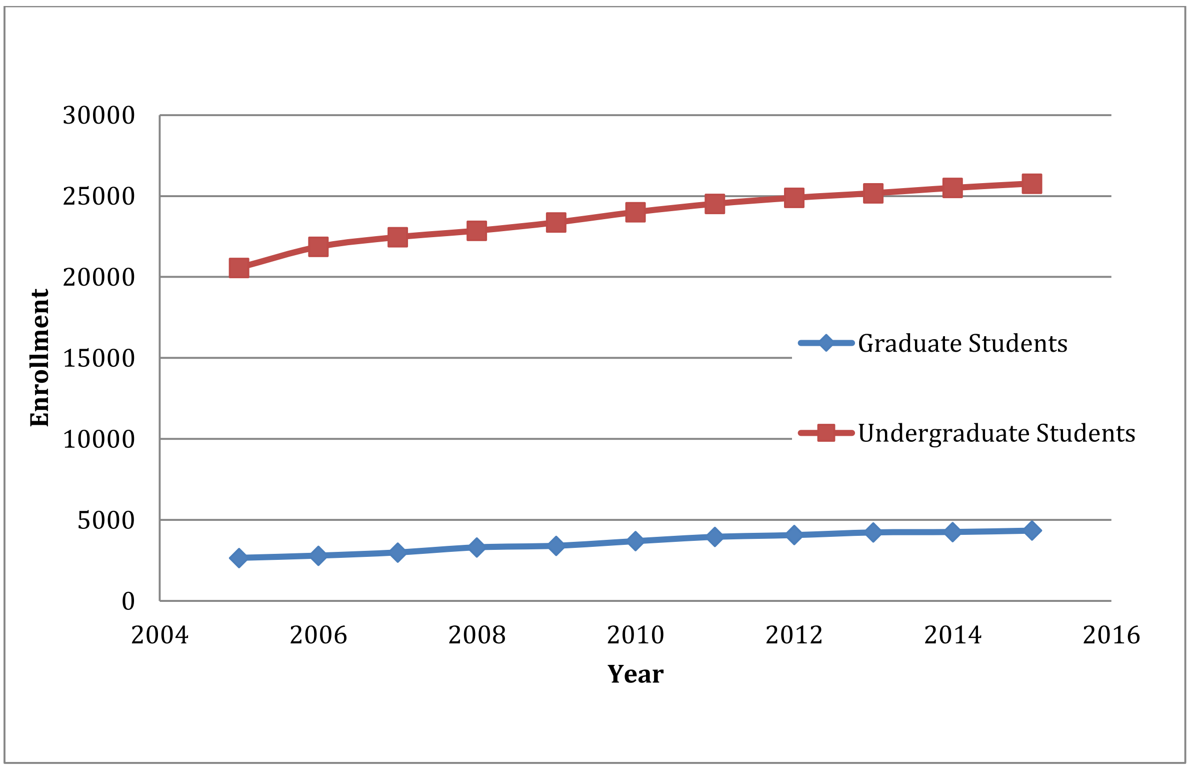

Figure 2. Growth in Student Enrollment (2005-2015)

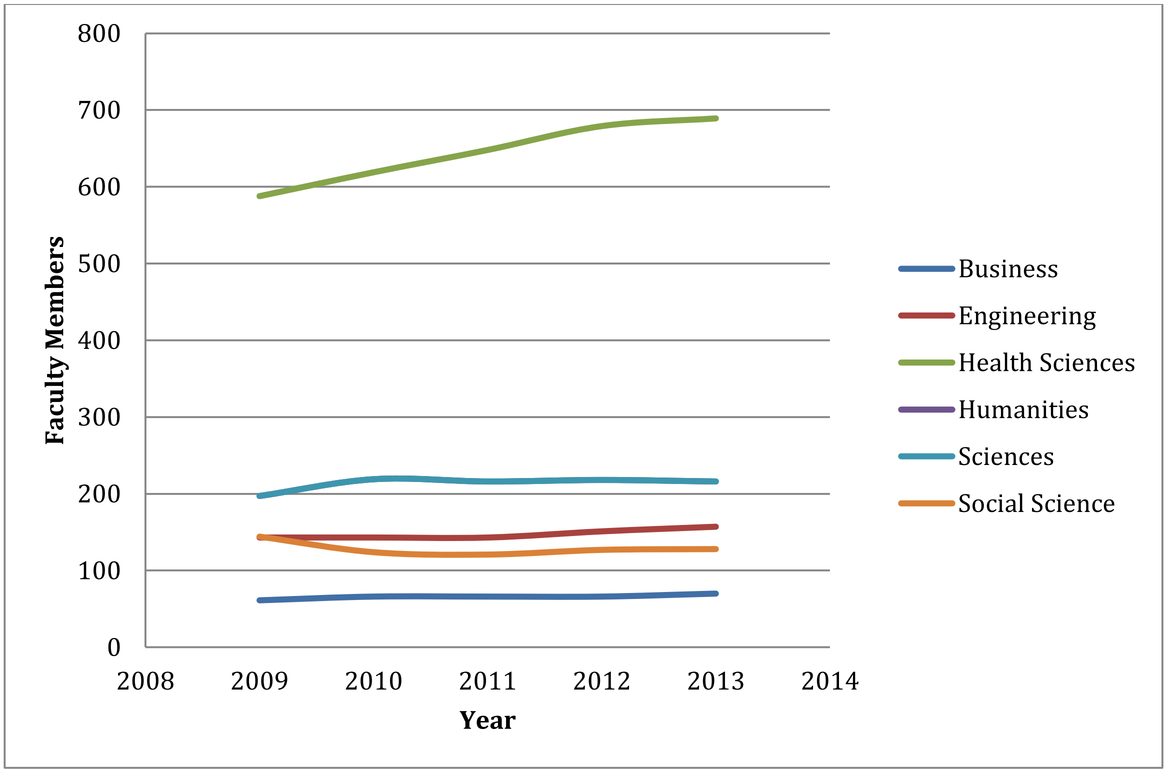

Figure 3. Growth in McMaster University Faculty (2009-2013)[3]

Growth is projected for all McMaster University faculty, staff, and students and this is done for two groups: the total university population and secondly for those primarily traveling to the main campus. Expected linear growth rates based on the data above and are displayed in Table 1 for the entire university and in Table 2 for the main campus (Root, 2015).

Faculty/staff and student increases of 30% and 13% respectively are expected for the main campus, creating significant potential for growing travel demand. The program management and economic implications of accommodating these additional individuals are potentially significant. With this projected growth, demand for land and other resources will increase in order to accommodate core university functions such as research, administration, leadership, teaching, and learning. With limited space on main campus, it is critical to make the best use of scarce land and financial resources for diverse potential uses, including both the university's core functions and the accommodation of travel to campus.

3 (McMaster University, 2010)

Table 1. Projected Growth in University Population

	2015	2025	Growth /Yr	10-year Growth Rate (%)
Students	30,117	34,117	400	13
Faculty and Staff (full and part-time)	5,895	7,795	190	32
Total	36,012	41,912	590	16

Table 2. Projected Growth in Main Campus Population

	2015	2025	Growth /Yr	10-year Growth Rate (%)
Faculty & Staff, full-time equivalents (FTEs)	3,303	4,283	98	30
Students, Faculty and Staff FTEs	33,420	38,400	498	15

2.2 Previous Policies Guiding Travel Demand Management

While this travel demand management plan represents a new opportunity to manage forecasted travel demand growth effectively and in an environmentally sustainable manner, previous campus policy documents have provided guidance on strategic priorities related to transportation policy. These plans include: the McMaster University Campus Master Plan (Updated in 2008), the McMaster Transportation Demand Management Strategy (2002), and the McMaster University Capacity Study (2011). The master plan provides key principles which guide campus planning decisions while previous transportation studies focus on cataloging the existing state of conditions.

The McMaster University Campus Master Plan (2008) identifies six core principles which guide university planning activities. Those principles include (Urban Strategies, Inc., 2008) that:

- future growth should be on Main Campus,
- the plan is a living document which should regularly be reassessed in light of new conditions,

- the campus should be accessible and pedestrian focused,
- the campus setting and image should be enhanced,
- campus activities encourage sustainability and environmental stewardship, and
- McMaster University function as a village and partner in surrounding community

These principles are important in outlining the strategic priorities in managing travel demand to McMaster University. First, these priorities indicate the importance of McMaster's main campus and its destination as a community focus which is accessible by all modes and with priorities to non-auto users. Second, the principles underscore the value given to environmental sustainability and a positive relationship with others beyond the campus border.

While the McMaster Campus Plan highlights these principles as guiding features, specific recommendations for travel options are sometimes at odds with general principles. For example, some recommendations (Chapter 5, p. 46) suggest that five potential additional parking structures would be needed in addition to conversions of undeveloped land to surface parking (Urban Strategies, Inc., 2008). In contrast, other TDM recommendations propose a 10% reduction in vehicle mode share. These would be achieved through measures which would reduce transit fares, increase parking prices, and improve services available to non-auto modes (Urban Strategies, Inc., 2008). Hence, while the campus plan highlights sustainability and diversion away from automobiles as critical priorities, their potentially conflicting policy actions remain part of the suite of recommendations - most critically, adding significant parking capacity and encouraging alternate modes.

The McMaster Capacity Study (2011) highlights the need for land and financial resources to be prioritized in meeting the needs both of on-campus buildings and transportation - providing a vision in which physical buildings, activity space, and pedestrianized amenities take priority over vehicular uses. When focusing on the building needs of McMaster University based on the McMaster Capacity Study (2011), the expected future growth of university facilities is expected to be on main campus and particularly on west campus (Urban Strategies Inc., Rickes Associates Inc., MMM Group Ltd., 2011). Based on the 30-year vision, many current parking lots are expected to be transformed to buildings - meaning that priorities will have to be made when using existing developed land for transportation uses or buildings or redeveloping additional land.

Moreover, the 30-year vision proposes significant parking infrastructure investment, including repurposing western lots for buildings, converting undeveloped land north of the Cootes Drive baseball fields to parking lots, and constructing a parking structure in the northeast corner of Cootes Drive and Main Street (currently Lot I). Each of these interventions entails a calculated environmental impact (e.g. redeveloping land), an economic cost (constructing buildings and parking facilities), and includes social implications. The McMaster Capacity Study further highlights vehicular capacity constraints at intersections, primarily along Main Street, at which additional capacity for growth is not available. The McMaster Capacity Study further recommends pursuing TDM strategies to alleviate peak vehicle trips - presumably to reduce congestion on city streets - and to partner with the city to provide sustainable mobility options. This implies a vision of McMaster considering both its own city service needs and relying on the city to meet critical transit gaps.

The 2008 McMaster Sustainability Assessment (McMaster University, 2008) likewise sets McMaster University's policy direction as prioritizing the needs of non-auto users and decreasing the relative role of automobiles in accommodating travel demand. Recommendations highlight the MAC Cycle Co-Op, the Alternative Commuting and Transportation (ACT) Office, an office to encourage use of non-auto modes (which has subsequently become part of the Office of Sustainability), and the Cycling Committee. Specific objectives highlighted are increasing transit use, walking, and bicycling; decreasing auto use, reducing transit fares for faculty and staff; and partnering with the city to improve HSR services.

2.3 Existing University Travel Options

When commuting to McMaster University, several travel options are available but are not all equally provided to potential users, including those on main campus, the McMaster Innovation Park, and the Ron Joyce Centre. The availability of travel options stems from the actions of multiple agencies: Security and Parking Services manages on-campus infrastructure and parking; the City of Hamilton manages city arterials, sidewalks, and bicycle infrastructure; Hamilton Street Rail (HSR) manages bus transit options within the City of Hamilton; GO Transit manages regional transit services in the Greater Toronto-Hamilton Area; and various other non-profit (e.g. SoBi) and for-profit entities (e.g. Zipcar) provide other transportation services.

Consequently, understanding and managing the entire array of travel options does not rest with any one entity -- the planning and provision of travel services includes many actors, several potential partnerships, and possible competing objectives.

2.3.1 Main Campus Travel Options

Parking

McMaster University has 17 on-campus parking lots, including one that is located off campus on Ward St. (see Figure 4.) The daily and monthly parking rates among these lots vary and can be observed in Table 3 and Table 4.

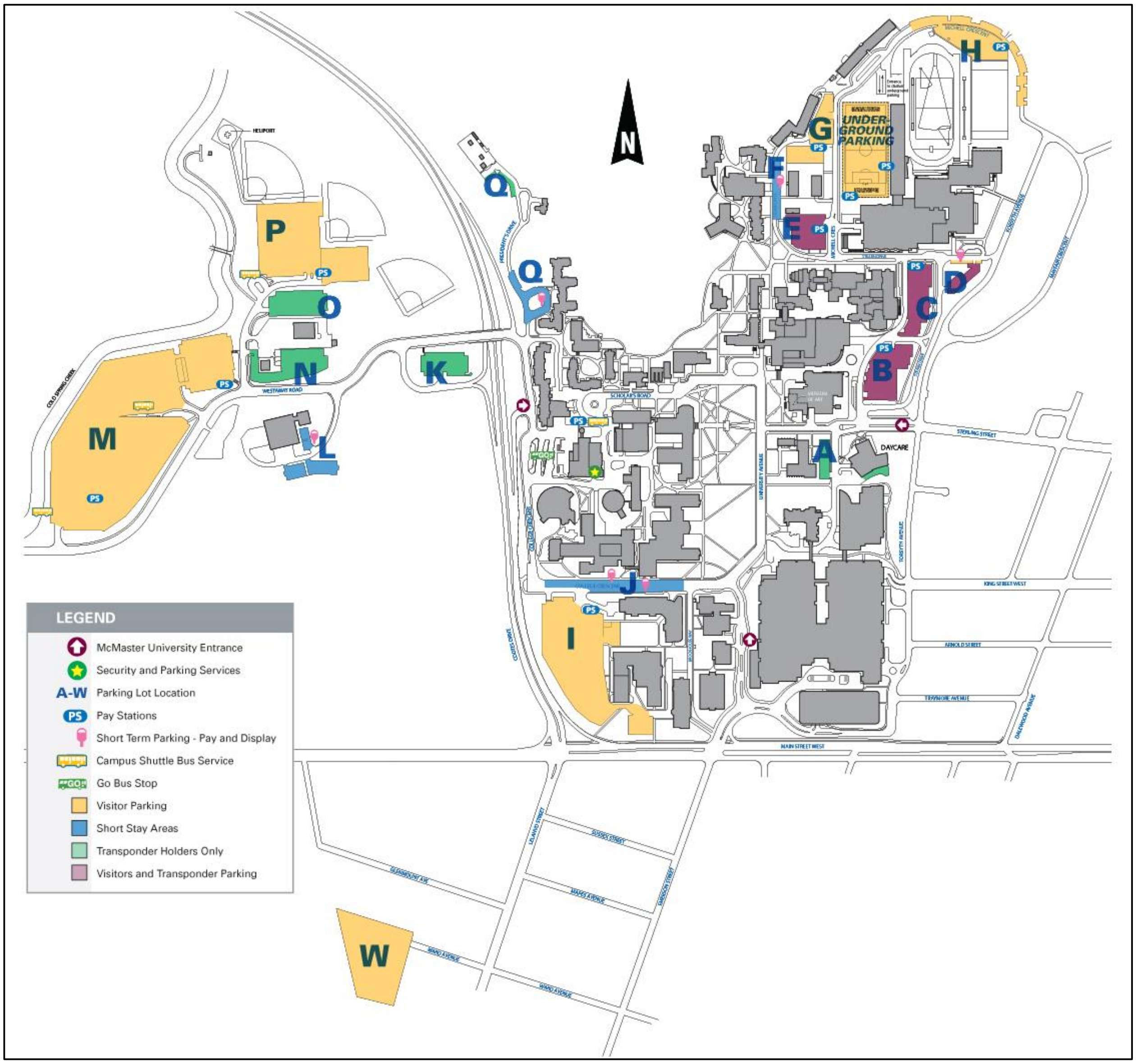

Figure 4: McMaster University Main Campus Parking Lots[4]

4 Source: McMaster (2015)

McMaster University offers several types of parking permits to students, staff and faculty. Some of the parking permits include: Shift Permits, Evening Permits, Main Campus Permits, and West Campus Permits.

- Shift Permits are issued to McMaster employees who have a valid permit for Lot M, N, O or P and work shifts that extend outside the shuttle bus hours of operation.
- Evening Permits allow drivers to park after 4pm Monday to Friday and all weekend on the main campus, with the exception of Lot A and the Stadium Lot.
- Main Campus Permits authorize parking only in the lot assigned to the permit between 7:30am and 4:30pm Monday through Friday. Outside of this time block, drivers with Main Campus Permits are able to park in any lot except for Lot A and Stadium parking.
- West Campus Permits authorize parking only in the lot assigned to the permit between 7:30am and 7:30pm Monday through Friday. Outside of this time period drivers with a West Campus Permit can park in any lot except for Lot A and Stadium parking.

Due to the distance between the West parking lots and the main campus, the University provides a shuttle bus service connecting the two locations. Regular shuttle service hours are between 6:30am and 11:00pm Monday through Thursday, and 6:30am to 7:00pm on Fridays. There is no shuttle bus service on weekends or statutory holidays.

Table 3: Monthly Parking Rates[5]

PARKING LOT	MONTHLY RATE
A (Divinity College)	$86.00
B,C,D,E, F, G, I and Q	$86.00
H, K and L	$68.00
M, N, O, P	$46.00
Stadium	$101.00
Ward	$50.00
Accessible[6]	$46.00
Evening	$46.00
Motorcycle	$17.00
Commercial	$106.00
All	$86.00

5 Rates before September 1, 2015 (McMaster University Parking Services, 2015)

6 Accessible parking refers to parking designated for individuals with specific accessibility needs, such as special mobility needs or wheelchair accessibility.

Table 4: Daily Parking Rates[7]

Lots A, B, C, D, E, G, H, I and Stadium	Duration	Rate
Monday-Friday 7:30am - 4:00pm	No charge within the first 15 minutes of the first hour, then first hour and all additional hours	**$5.00/hr$20.00**
Monday-Friday After 4:00pm	No charge within the first 15 minutes of the first hour, then Flat Rate	**$7.00**
Saturday-Sunday and Statutory Holidays	No charge within the first 15 minutes of the first hour, then Flat Rate	**$7.00**
Lots M, N, O and P	**Duration**	**Rate**
Monday-Friday 7:30am - 4:00pm	No charge within the first 15 minutes of the first hour, then Daily Flat Rate	**$7.00**
Monday-Friday After 4:00pm	No charge within the first 15 minutes of the first hour, then Daily Flat Rate	**$3.00**
Saturday-Sunday and Statutory Holidays	No charge within the first 15 minutes of the first hour, then Daily Flat Rate	**$3.00**
Lots F, J and Q Short-term meter		
Monday-Sunday 7:30am - 9:00pm	1 Hour Maximum	**$7.00**
DISABLED - Lots A, B, C, D, E, I, Stadium, MDCL, IWC and Mills Library		
Monday-Sunday and Statutory Holidays	Daily Flat Rate	**$7.00**
DISABLED - Short term metered parking lots F, J & Q		
Monday-Sunday 7:30am - 9:00pm	Daily Flat Rate	**$7.00**

7 Rates include HST, before September 1, 2015 (McMaster University Parking Services, 2015)

Alternate Parking Services

McMaster Parking Services offers additional parking permit options for those who choose to drive to campus to encourage either carpooling or the use of parking services on only the most critical days. A Carpool Permit can be purchased and shared between two or more individuals who travel together at least three times a week and live at least 1.5 kilometers away from campus. There are designated parking spaces for carpool permit holders in some parking lots to make it easier for those individuals to find a parking space in a shorter period of time. The carpool group is also eligible for a limited number of reduced-rate parking vouchers to be used on days when one member needs to take their own vehicle to campus. To further support carpooling, Smart Commute, a program of Metrolinx, has created the “Smart Commute tool”, a website that was designed to help individuals find a carpool partner who travels to the same destination and lives along a common route. It helps them to explore their travel options, match their trips based on travel preferences, and see the impacts of their transportation choices.

Another sustainable commuting option is the Flex Pass. The Flex Pass was created to encourage staff, faculty and students to switch to a sustainable mode of transportation but retain the option of driving during times of extreme need. In addition, Parking Services can put a monthly parking permit on hold for up to 12 months without the risk of an individual losing their parking space. The cost is $90 for 10 entry/exits per month, and expires after 12 months from the date of purchase. The Flex Pass is valid for all gated lots with the exception of Lot A, Lot B, and Lot D. The applicant is not able to have any other parking permit except for a carpool permit at the same time as the Flex Pass.

Cycling

Cycling is a very affordable option for commuters who live within a reasonable distance to campus. The bicycling services available on campus are provided by different entities, including Facility Services, MACycle Co-op, SoBi, and Start the Cycle. There are more than 1,963 spaces on bike racks on main campus, representing approximately one bicycle spot for every 17 full-time equivalent student, faculty, or staff members. McMaster University also maintains CycleSafe bike lockers which are available for rent by members of the McMaster community for $40 per semester or $100 per year. Lockers are in three key locations: on the north side of the E.T. Clarke Centre, between the John Hodgins Engineering Building and Burke Science Building (south campus), and north of Togo Salmon Hall (north campus). For $5 per term, McMaster also offers secure bike storage facilities for up to 48 bicycles on the west side of Chester New Hall. Bicycle repair stations have also been installed throughout campus.

The MACycle Co-Op, McMaster's non-profit bicycle repair shop, is run by the McMaster Student Union. They are located at the North end of Ron Joyce Stadium, under the bleacher seating. With a purchase of a yearly membership for $5, members of the McMaster community can have access to tools, cheap parts, and the expertise of their staff. MACycle Co-op is a do it yourself bike repair shop with staff available for basic guidance. MACycle is also in a partnership with the City of Hamilton to save bikes that are headed for the landfill. The group collects them, fixes them up and sells them at affordable prices to the McMaster community.

The City of Hamilton recently launched a new bike-share program in March 2015. Social Bicycles in Hamilton (SoBi) is the non-profit local operator which provides 750 bicycles and 105 stations for the Hamilton community. There are 7 SoBi hub locations found around the McMaster Main campus, and several others in the surrounding neighbourhoods and Westdale area. The bike share program is another option for students who may not own their own bicycle, or would like to be able to use a bicycle occasionally to get to their destinations (SoBi, 2015).

Finally, Start the Cycle (www.startthecycle.ca) is a non-profit program initiated by McMaster University community members (Charles Burke and Justin Hall) which enables individuals to rent bicycles from either the McMaster University library or the Mohawk College library. This program encourages better access to bicycles, the encouragement of physical activity, and early and sustained education about the importance of bicycling and physical activity.

Public Transit

Transit commuters to McMaster University have two options: the GO system, a regional transit system which primarily services the Hamilton-Toronto corridor, and the Hamilton Street Railway (HSR), Hamilton’s municipal transit system for local trips. The bus routes that service the University are the 10 Beeline, 5 Delaware, 1 King, and 51 University. All of these routes stop near the MacNab Transit terminal, where transfers can be made to bus routes accessing other parts of the city.

While HSR provides a discounted bus pass, the U-pass, to full-time students, no such program is currently available to faculty and staff. In the 2014/2015 school year, graduate students paid approximately $180 in their supplementary fees for service from September to August. As of September 2015, the undergraduate students are also now offered service for the whole year for approximately $140 as part of their student fees as a result of a vote at the time of the Student Union Presidential Elections. Students voted to add expanded service and create a 12 month pass for an additional $12.50 per year. Prior to this, their passes were only valid from September to April, and summer students had the option of purchasing discounted transit passes for the summer months. This is a revenue neutral program, and the cost per student is determined by

HSR. Based on the ridership statistics from the previous years, HSR monitors how often students make use of the HSR system to determine how much they will charge the University for the student bus passes. There is no marginal cost to the students for transit use because transit passes have already been included within their supplementary fees.

Carsharing

Carsharing has been a growing travel alternative for those with infrequent or irregular need of a vehicle[8]. Carsharing programs are alternatives to personal auto ownership for those who irregularly need access to a vehicle. Users can borrow a carshare vehicle from specified locations under specified pricing schemes. Carsharing enables access to vehicles without the costs of car ownership. Insofar that carsharing can fill a mobility market which enables more people the choice to live without or with fewer cars, it can help reduce a driver's ecological footprint by driving less and using more active forms of transportation.

Three separate carsharing programs serve the broader Hamilton area and provide services in relatively close proximity to the McMaster University main campus. Rate structures and driving restrictions vary between each of these carsharing programs and should be verified independently. First, Community CarShare is Hamilton's non-profit car-sharing co-operative and it has placed a carsharing vehicle in the parking lot at the corner of Forsyth and Sterling (Community CarShare, 2015). Second, Student CarShare provides carsharing services and hosts carsharing locations on key corridors near McMaster University. At least three carsharing stations are within a kilometer of McMaster University's main campus: near Main Street West and Osler Drive, Main Street West and Cootes Drive, and in Westdale South (Student CarShare, 2015). Third, Zipcar provides carsharing services and hosts one carsharing location within one kilometer of the McMaster University main campus on Cline Avenue South (Zipcar, 2015).

2.3.2 McMaster Innovation Park Travel Options

Parking

Parking capacity at the McMaster Innovation Park (MIP) site is 500 vehicles. All of the parking lots are signed regarding the permits and rates to ensure clarity for the tenants and visitors to the campus. A map of the parking lots at MIP can be seen in Figure 5. Tenant employees are eligible to apply for a parking permit at MIP in Lot 2, Lot 3, Lot 4 and Underground for a monthly fee of $60 (as of January 1, 2015).

8 Carsharing has grown significantly over the last years and we expect that the inventory of car sharing programs available for members of the McMaster community to be expanding rapidly.

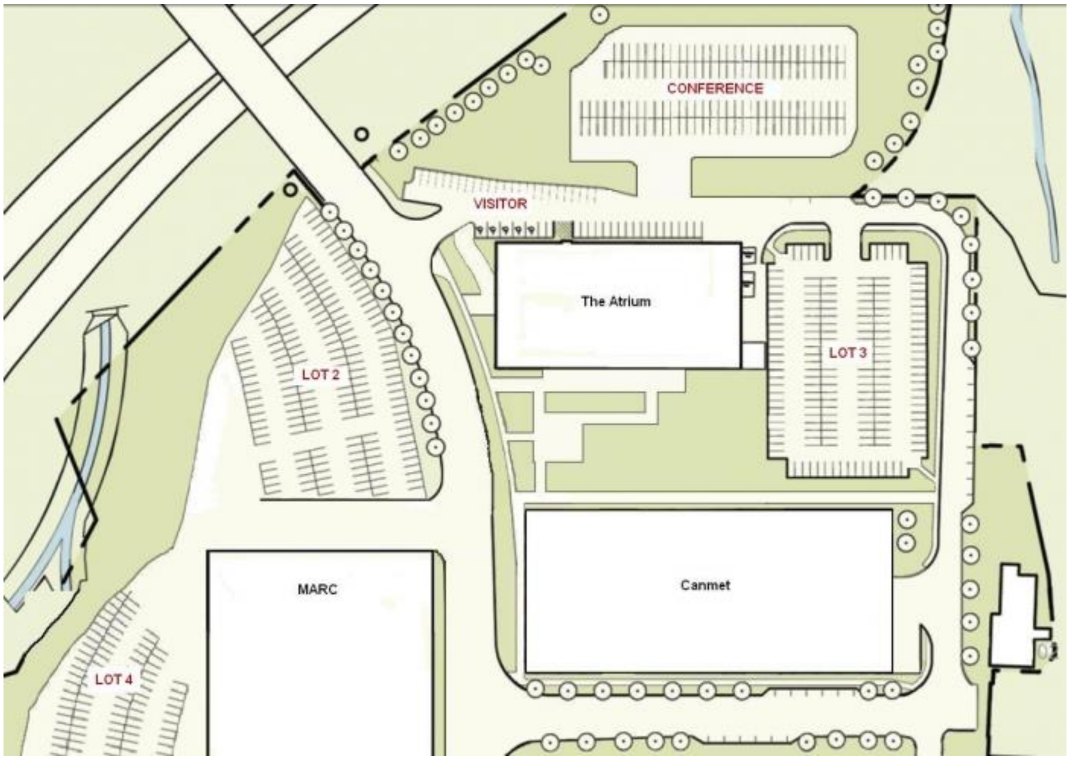

Figure 5: Map of parking lots at McMaster Innovation Park[9]

Cycling

Some cycling facilities are available at McMaster Innovation Park, including bike racks, bike lanes, and a SoBi bike station. Bike lanes are available along Longwood Rd. from Aberdeen Ave. to the Royal Botanical Gardens and on Aberdeen Ave. from Longwood Rd. to Dundurn St.

Public Transit

McMaster Innovation Park is served by the HSR but is not directly served by GO. Bus routes around this area with frequent services include the 6 Aberdeen, 5 Main West/Delaware, 1 King, 5 West Hamilton, 10 Beeline, and 51 University bus routes.

2.3.3 Ron Joyce Centre Travel Options

Parking

9 Source: McMaster Innovation Park (2011)

The Ron Joyce Centre (RJC) has 275 parking spots, 260 of which are allocated to permit holders. Parking permit costs for the Ron Joyce Centre can be seen in Table 5. The parking passes can be purchased on a monthly and term basis. The Ron Joyce Centre also offers visitor parking rates.

Table 5: Parking permit costs at Ron Joyce Centre[10]

Ron Joyce Centre	Total (incl. HST)
Per Term (4 months)	$113
Per Month	$35.00
Evenings & Weekends	$3.50
Day rates after 4 hours	$7.00
Day rate up to 4 hours	$3.50

Public Transit and Shuttle Service

Public transit to the Ron Joyce Centre is currently available through two means: a shuttle which connects the RJC with the Appleby GO Station and a shuttle which connects the RJC with main campus. Neither Burlington Transit nor HSR provide direct service to the RJC; the current closest Burlington Transit stop is at Appleby and Harvester (1.5 kilometers away). As the RJC is located approximately two kilometers from the Appleby GO Station, a shuttle provides a connection with GO and departs approximately every 20-40 minutes during peak periods and every hour during off-peak periods. Similarly, as the RJC is approximately 20 kilometers from the McMaster main campus, a shuttle service similarly connects the two, departing approximately every 90 minutes in either direction.

10 Source: McMaster University Ron Joyce Centre (2014)

Methodology

This travel demand management (TDM) plan is organized firstly by characterizing current travel to McMaster University's main campus, secondly by estimating the outlook for various salient travel factors, and thirdly by identifying those transportation program management decisions with the best outlook for success.

To translate the fundamental guidance from the campus plan and previous transportation studies into actions in this study, previous guidance is distilled into five core principles to which this study adheres in identifying and making recommendations:

1. Future services should meet expected future demand to accommodate core university functions,
2. Future services should encourage less auto travel and more travel by transit, walking, or bicycling,
3. Actions should resonate with input from the public involvement process,
4. Actions should lead to a lower environmental footprint in the future, and
5. Actions should be financially sound - not only from a transportation program management perspective but also from the perspective of managing the entire university.

Both quantitative and qualitative data are employed. Quantitative data was collected from a University-wide travel survey completed in the spring of 2015. The survey results capture various descriptive elements of current travel patterns to the University. Using the survey data, travel demand models were estimated to identify the actions with the greatest potential to manage demand. Using these demand models, forecasts were derived to explore the most likely parking demand estimates based on available information. The travel behavior survey was conducted by the research team in conjunction with Research Now, a private firm that specializes in the design of online surveys. Qualitative input was also collected through a public information and involvement campaign. Members of the McMaster community were engaged during the winter and spring of 2015 to both provide them with information on the study and to seek their guidance and input on those issues of most interest to McMaster University faculty, staff, and students. The two data collection efforts are discussed below.

3.1 Travel Survey Description

A travel survey was administered to all McMaster students (undergraduate and graduate), faculty, and staff through the McMaster University faculty association, Human Resources, and the Office of the Registrar. The underlying population is estimated to be approximately 36,012, of which 1,550 students and 892 faculty and staff completed the online survey. Following cleaning and pre-processing, the survey data represented approximately 5% of students (1,550/30,117) and approximately 15% faculty and staff (892/5,895).

The survey included questions relating to how individuals traveled to and from McMaster University, the characteristics of the survey participants, attitudes towards travel, and (for a sub-set of survey participants) a series of questions asking respondents to select from among alternative hypothetical travel choices. The latter part of the survey is known as *stated preferences*, as opposed to the former part which is usually referred to as *revealed preferences*. An example of a question from the stated preferences section of the survey can be observed in Appendix 6.2.

The survey was administered between March 11, 2015 and April 17, 2015. Survey participants were recruited by email through authorized student, faculty, and staff list-servers on campus. One initial email recruitment letter was sent to participants and was followed by three reminders. As list-servers were employed for recruitment and the survey panel was not directly accessed by the research team, each potential participant received the survey multiple times: one initial recruitment letter and three subsequent reminders. Comments about the survey were submitted both to the research team and to members of the McMaster University Ethics team and questions and identified problems were addressed.

Survey participation increased after each reminder email was sent, leading the survey rate to change in a non-linear pattern (see Figure 6). The cumulative completions increase dramatically after each email recruitment letter before leveling off, indicating the importance of survey reminders.

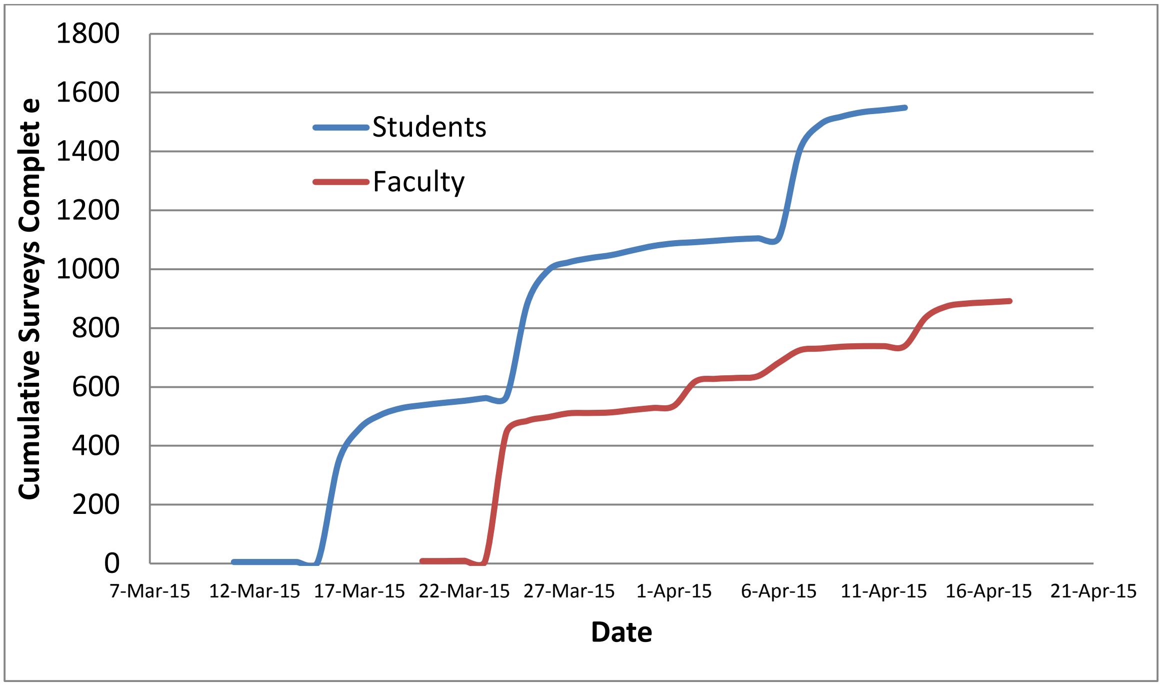

Figure 6. McMaster University 2015 Travel Survey Cumulative Completions over Time

To reflect the travel patterns of the overall McMaster population, survey data were employed to categorize current travel patterns and attitudes towards travel of the McMaster University community. Basic descriptive statistics were used to characterize travel patterns and compare between faculty/staff (combined) and students. Beyond survey questions designed to identify the characteristics of current system users and how they travel to McMaster, additional survey questions were posed to users who self-identify as most likely to use other modes.

3.2 Projections and Forecasting

To explore policies with the greatest prospect for success in managing travel demand, several modeling approaches were employed to forecast travel demand under a range of future scenarios. Forecasts and plausible alternate travel demand management policy scenarios were developed using university faculty, staff, and student growth forecasts and in five subsequent stages. As discussed previously, data on past and current student enrollment and faculty and staff levels, forecasts were developed to estimate the increases in future (2025) enrollment and staffing levels. These university population growth forecasts (of faculty, staff, and students) establish the basic foundation through which parking forecasts were developed.

1. Baseline Parking Utilization - First, parking utilization data was collected from the McMaster Parking Services department and used to characterize "typical" parking utilization levels in both the spring and fall (2014). Data on current parking utilization levels were used as a baseline from which forecasts of future parking utilization were developed.

2. Estimating Parking Demand - Discrete choice models of modal split were estimated using the 2015 McMaster Travel Survey data. These estimations were used to identify predictors of current and future mode choice and parking behavior.

3. Forecasting Parking Utilization - Using alternate policy choice scenarios, future parking utilization levels were estimated using information on baseline parking utilization and predictors of mode choice and parking demand.

4. Estimating Price Sensitivity - Using the stated preference component of the travel survey, parking price sensitivity was estimated independently for students and for faculty and staff to explore parking demand responses to changes in parking price.

5. Forecasting Parking Utilization based on Priced Scenarios - In addition to the scenarios developed using revealed preference data on travel behavior decisions, stated preference data was used to estimate price sensitivity and prospective parking decisions. The sensitivity of parking behavior with respect to parking price was incorporated into forecasts for the purposes of estimating future demand.

3.3 Qualitative Input in Public Forum

A public event was hosted on January 20, 2015, titled, "Tell Us About Your Commute!" and was hosted at the CIBC Room of the McMaster University Student Centre. The key themes and findings from this public involvement effort are identified in Section 4.2 while a full list of comments collected at this event is included in Appendix 6.6. A further description about the logistics of the event is presented immediately below.

Advertisements for the public forum were posted online on the Parking Services website, on the McMaster Institute for Transportation and Logistics website, on student union screens, at bus shelters, and in several buildings. Over 40 participants attended the event and gave feedback on the various elements of the transportation system. The room was divided into four primary section: one devoted to discussing auto services to McMaster University, one devoted to discussing public transit services to McMaster University, one devoted to discussing walking and bicycling services to McMaster University, and one at which a formal presentation was given.

Upon arriving, participants were asked to sign in, have some food, hear about the study effort at the central station, and visit the other three stations to further discuss McMaster transportation services with the study team. Each station was equipped with pens, paper, maps, and diagrams on which participants were invited to draw, write, or comment as they chose. At least one member of the study team was present at each station and each was directed to facilitate discussions on elements of the transportation system that individuals liked, disliked, viewed as needing improvement, or viewed as being a challenge. As participants visited each station, discussions expanded far beyond each individual mode - often resulting in very comprehensive discussions in small groups of individuals who considered many elements of travel, many users beyond themselves, and the challenges of integrating each of these elements of the transportation system to improve users' full experiences.

Results

This chapter begins with a descriptive overview of outcomes from the 2015 McMaster travel survey. To identify the travel demand management policies with the greatest potential for success, models of travel behavior were estimated to identify expected user responses to changes in various factors (e.g. price of transit, price of parking). Moreover, the analysis is supplemented with findings from public meetings that explored elements of the transportation system not captured in the survey. This study focuses primarily on the conditions at McMaster University's main campus, where most anticipated growth in faculty and students is expected to occur.

4.1 Survey Descriptive Statistics

Initially, the locations of survey respondents are considered. A scatter map of faculty/staff origins is shown in Figure 7 and a similar map for students is provided in Figure 8. Corresponding tabular presentations of counts and their percentage distributions are provided in Table 6 and Table 7. Note that these maps and tables consider only those respondents who are associated with the main campus. The results suggest that students are much more likely to live close to the campus than faculty/staff. Visual inspection of the two maps shows that the clustering of students in neighbourhoods adjacent to the campus is much more intense than for faculty/staff.

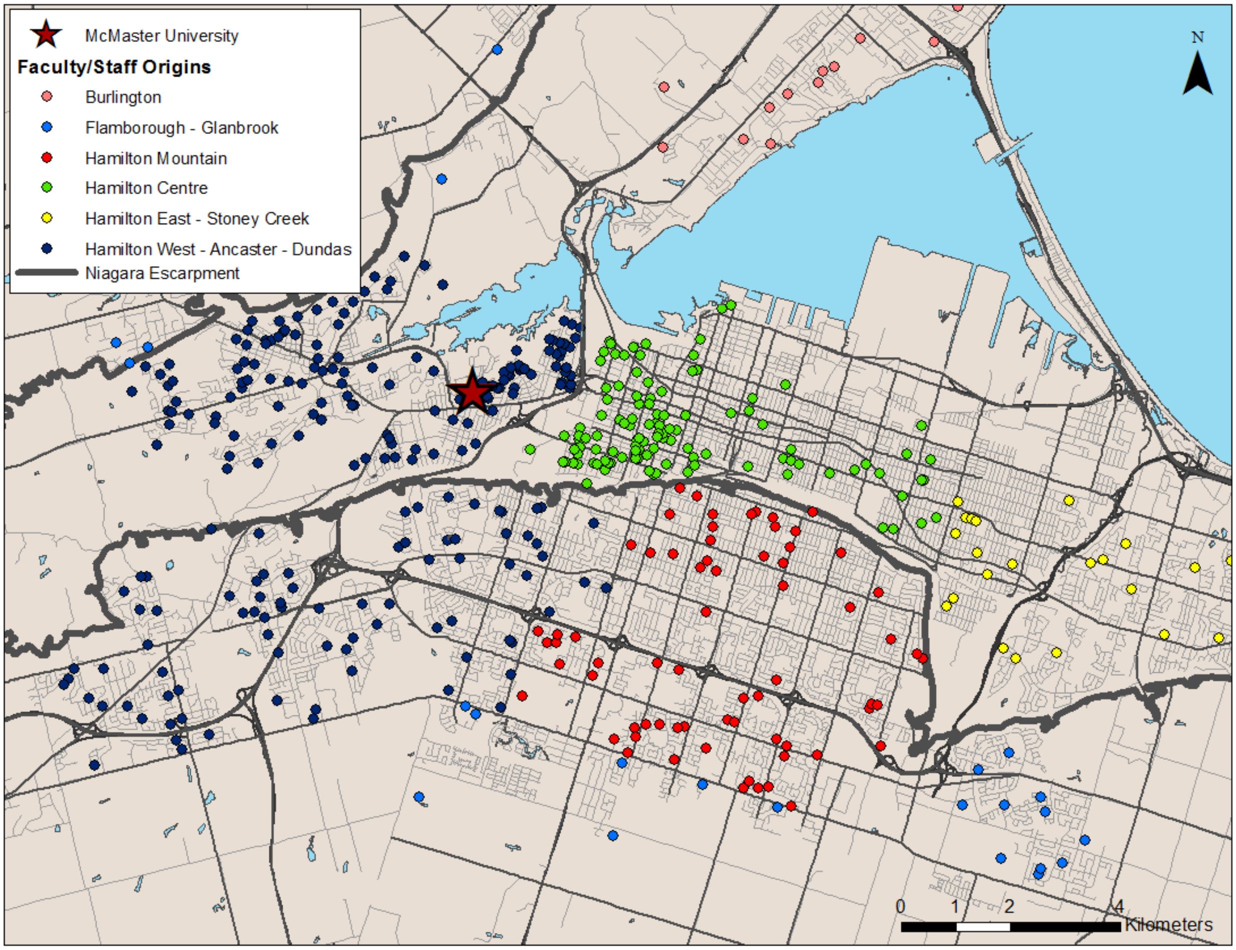

Figure 7. Origins of Main Campus Faculty/Staff

The “other” percentages for both classes are just under 20% so there is little difference in the shares of students versus faculty/staff that travel from further afield. Within the Hamilton/Burlington regions however, faculty/staff are more dispersed. It stands to reason then, that TDM measures discouraging single occupancy vehicle travel will be relatively more influential on faculty/staff. Further details about the travel patterns of respondents and relevant geographical classifications are provided in Appendix 6.2.

Table 6. Distribution of Main Campus Faculty/Staff by Federal Electoral District

District	Count of Faculty/Staff	%
Hamilton West - Ancaster - Dundas	239	32.6
Hamilton Centre	123	16.8
Hamilton Mountain	74	10.1
Flamborough - Glanbrook	50	6.8
Burlington	45	6.1
Hamilton East - Stoney Creek	38	5.2
Niagara West	15	2.0
Oakville	15	2.0
Milton	1	0.1
Other	133	18.1
Total	**733**	**100.0**

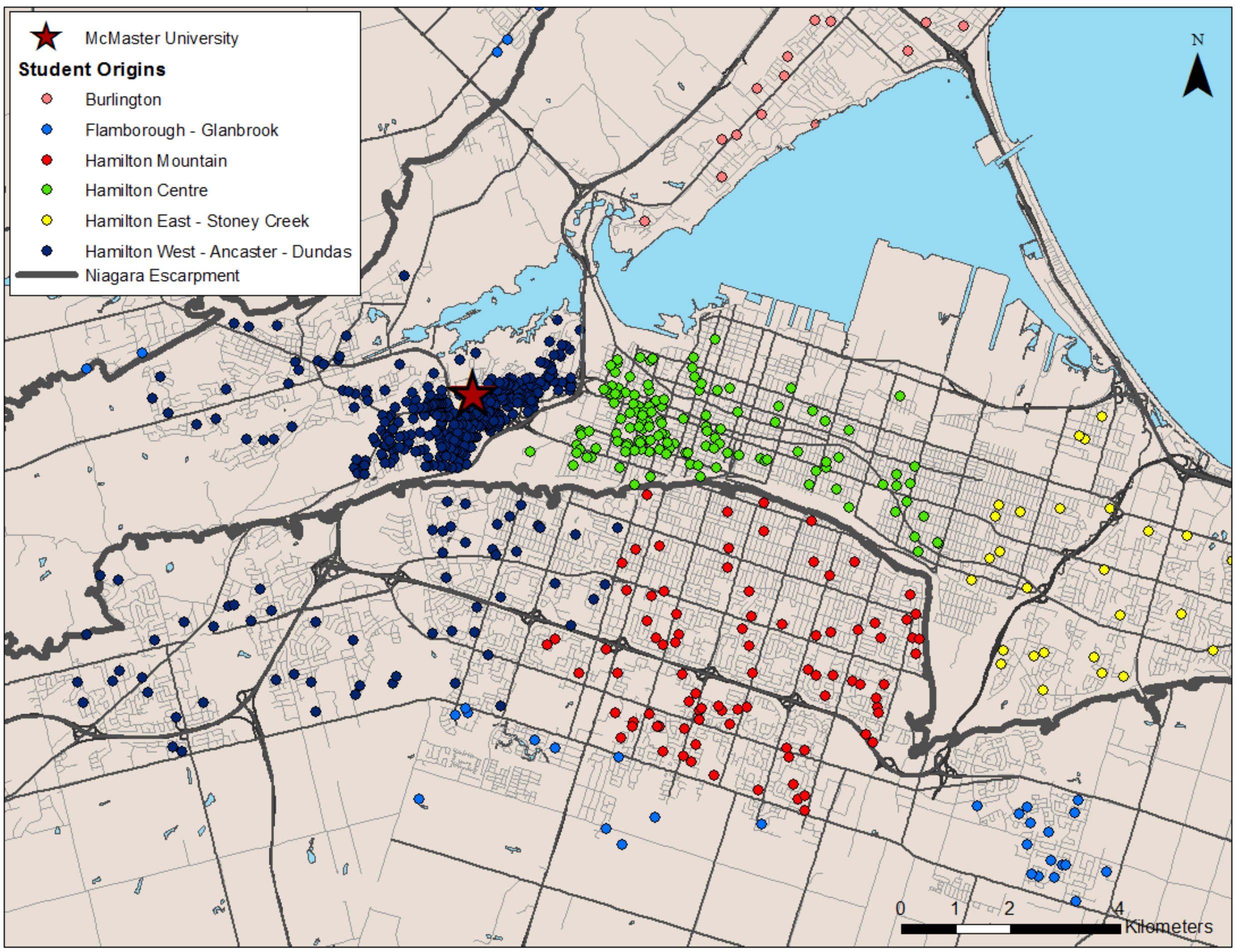

Figure 8. Origins of Main Campus Students

Table 7. Distribution of Students by Federal Electoral District

District	Count of Students	%
Hamilton West - Ancaster - Dundas	745	50.0
Hamilton Centre	171	11.5
Hamilton Mountain	91	6.1
Flamborough - Glanbrook	73	4.9
Hamilton East - Stoney Creek	55	3.7
Burlington	47	3.2
Oakville	13	0.9
Niagara West	6	0.4
Other	290	19.5
Total	**1491**	**100.0**

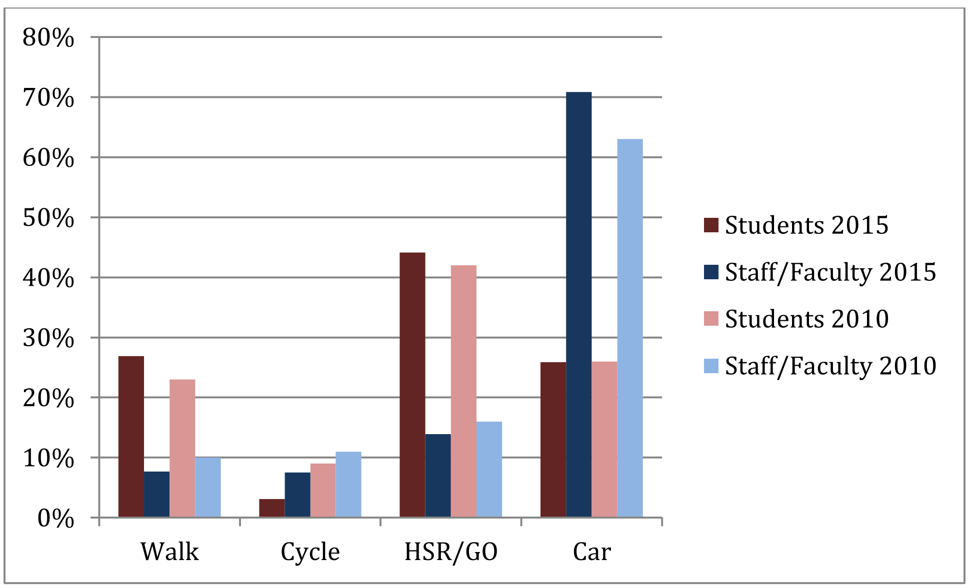

Figure 9. McMaster University Typical Mode Shares (2010-2015)

In Figure 9, mode shares are shown that compare the March 2015 survey to the previous survey from the fall 2010. Results suggest that:

- the shares of travelers using each of the different transportation modes remain essentially unchanged;
- faculty and staff continue to travel by car more than students. Accordingly, the survey indicates that student travel times are on average longer than faculty and staff
- Cycling shares are considerable lower in 2015 likely reflecting seasonal differences

4.1.1 Current Travel Choices

Data on student, faculty, and staff arrival and departure times illustrated that while faculty and staff largely conform to traditional work hours (approximately 9am to 4pm), students' on-campus work schedules were much more complex. As shown in Figure 10, typical student arrival times cluster primarily during the morning before 10am, significant shares of the student population arrive in the middle of the day, during the dinner hour, and late at night. Student departure times vary even more - indicating very flexible work schedules among students which extend deep into the night and early morning hours.

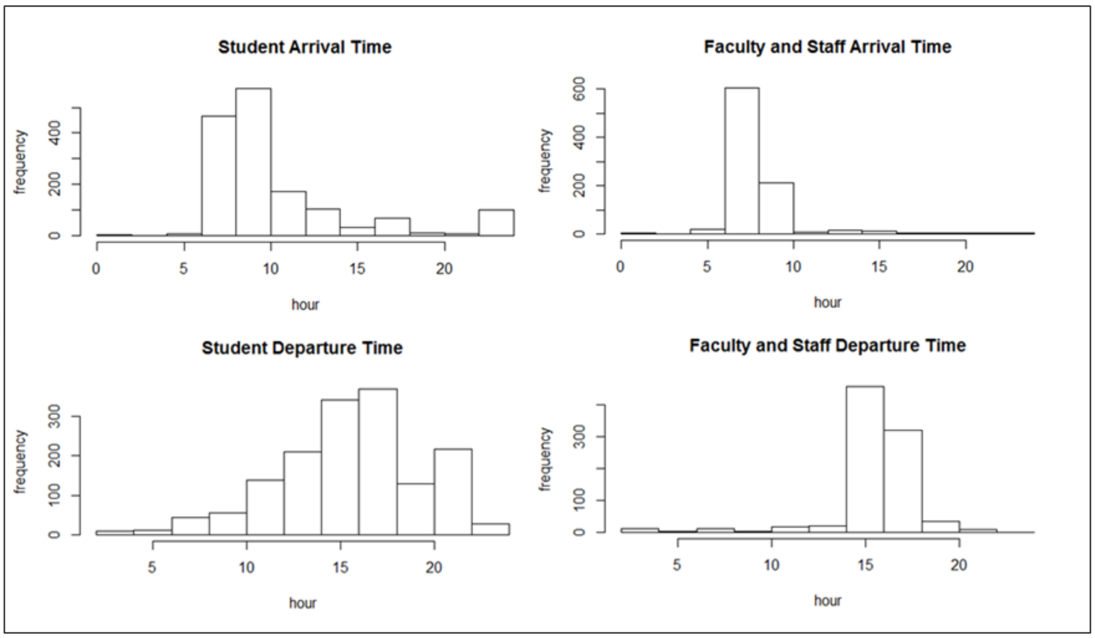

Figure 10. Typical Arrival and Departure Times among Students, Faculty and Staff

Qualitative information on teleworking indicated that only 11% telework at least once per week, 9% telework during occasional part days, and approximately 70% of faculty and staff telework less than once per month, if even at all (see Figure 11). In sum, this suggests that despite potential stereotypes of university faculty and staff as having significant flexibility to work from home, regular telecommuting (once or more per week) is only occurring for approximately one in ten faculty and staff members.

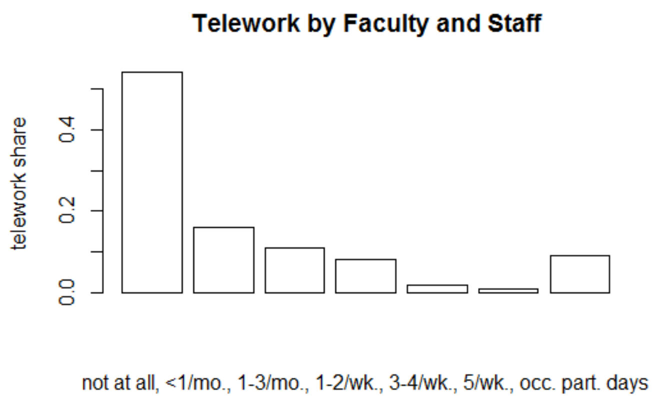

Figure 11. Teleworking by Faculty and Staff

4.1.2 Motivating and Barrier Factors

In this section, both the motivations for auto use are identified and the barriers (among auto users) to transit, walking, or bicycling are identified.

Auto Use Motivations - Students, faculty, and staff were asked of their primary motivations for auto use. Among respondents, the factors most frequently listed are shown in Table 8. Differences between students, faculty, and staff were small, so the table refers to all respondents.

Table 8. Motivations for Auto Use

Motivation for Car Use	Share
Fast	40.7%
Convenient	38.6%
Other	19.5%
day care	2.4%
no alternative	9.5%
transit service is bad	2.5%
No Motivation	3.0%
Need car for work	15.6%
Need car for shopping	14.6%
Chauffeuring people	9.7%
Health Reasons	1.9%

In general, results suggest that people use cars because they are fast, convenient, and accommodate their complex lives. Since one of the main goals of TDM is to shift travel to the non-automobile modes to the extent possible, auto use is examined based on what motivates it while the other modes are assessed based on barriers to more use. The survey respondents were asked to determine their largest barrier to transit, walking and cycling. Many other barriers could be selected as desired, and several options were given for each:

Transit Barrier Options

- I need a car to chauffeur other household members
- Trip travel time of transit
- Unreliability of transit services
- Transit stop quality
- Walk to transit stop
- Price of transit
- Transit vehicle crowding
- Weather
- My health or the physical strain
- Other ____________

Walking Barrier Options

- I need a car to chauffeur other household members
- Travel time of service
- Walking is not safe because of cars
- Walking is not safe because of bicycles
- Weather
- Lack of walking signals to cross streets
- Streets are too wide and difficult to cross
- My health or the physical strain
- Lack of sidewalks
- Other ____________

Cycling Barrier Options

- I need a car to chauffeur other household members
- Travel time of service
- Cycling is not safe because of cars
- Lack of bicycle lanes
- The areas through which I cycle are not safe.
- Parking/storage of bicycle
- Weather
- My health or the physical strain
- Other _______________

Charts of Barriers to Adoption of Alternative Models

The following half dozen full-page figures capture barriers that automobile drivers perceive in considering alternative modes for travel to and from McMaster. Only students, faculty, and staff that arrive to and depart from campus by car are included in the following descriptive statistics. These charts are worthy of some careful review and study. The first two figures capture obstacles to transit use and this is done separately for students and for faculty/staff. The subsequent two figures do the same for walking and the final pair address barriers to adoption of cycling.

In each of these figures there are eight mini-charts that detail how the given barrier was ranked by respondents (1 is the most severe barrier and 8 implies the minimal level of importance). Below each figure, the share of respondents who identified the factor as a barrier is noted. In general, it can be seen that travel time is the barrier that has the least dispersed distribution (i.e. many people identified it as a #1 or #2 barrier). Following the presentation of the charts, some further discussion of results is offered.

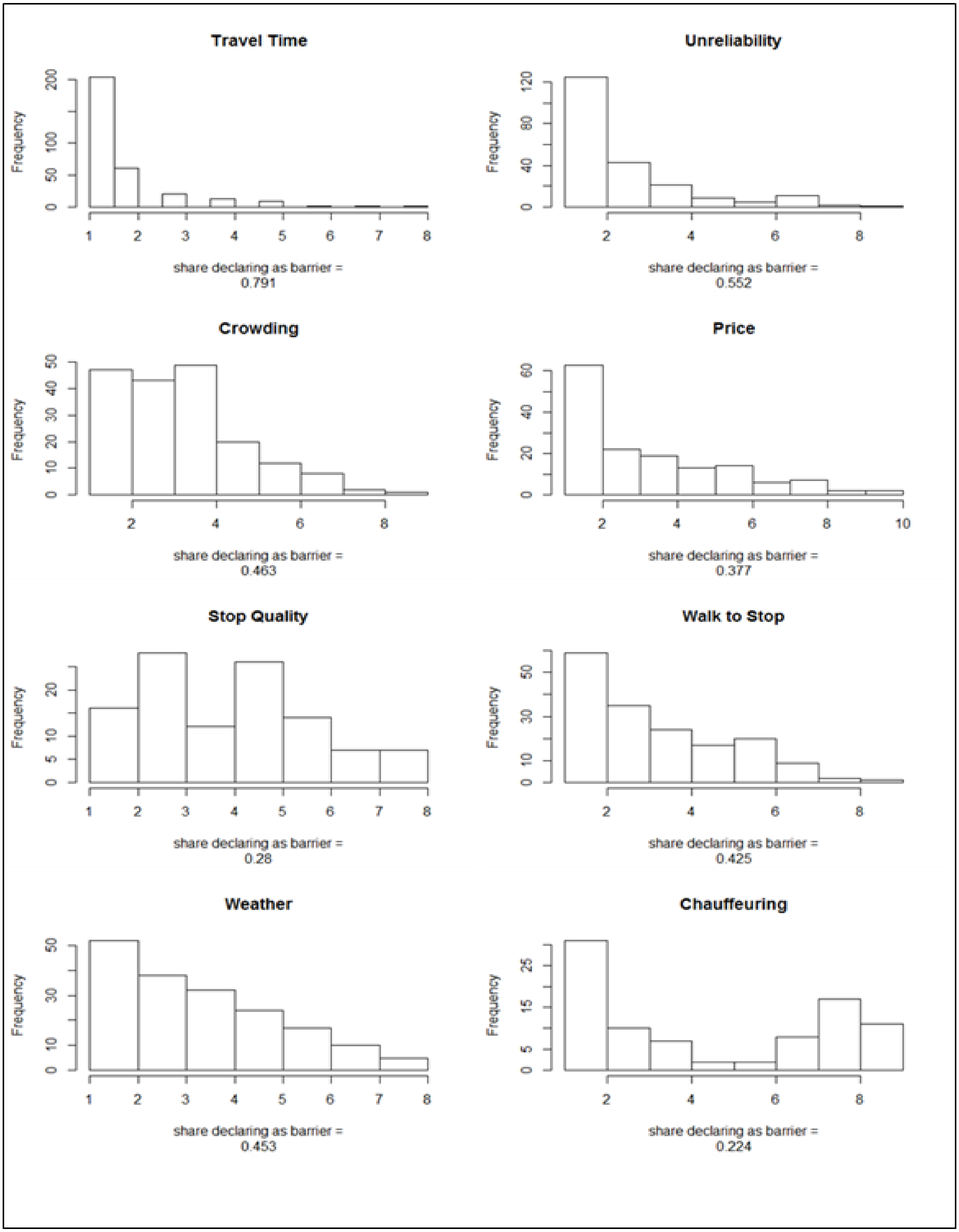

Figure 12. Student Drivers' Barriers to Transit Use

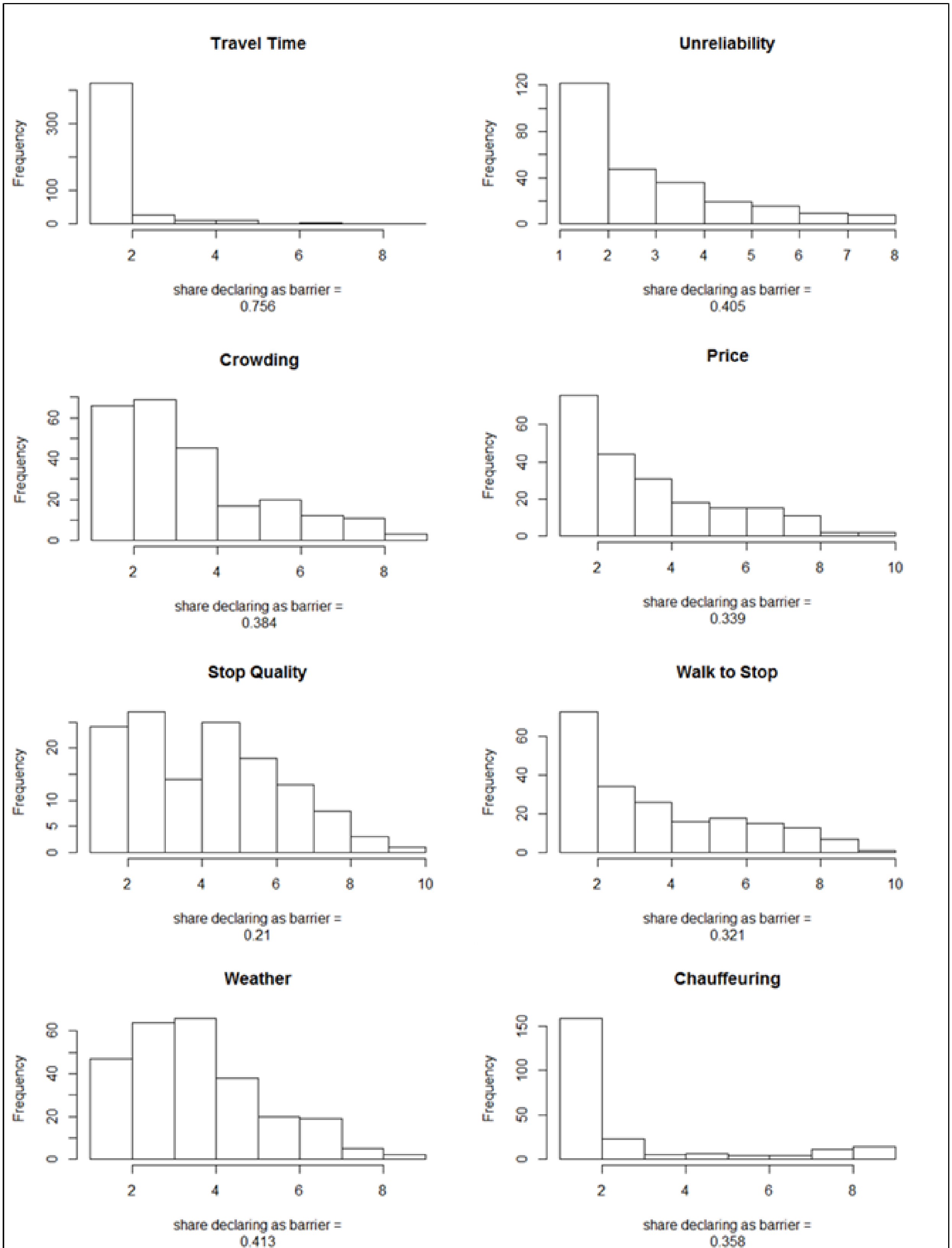

Figure 13. Faculty/Staff Drivers' Barriers to Transit Use

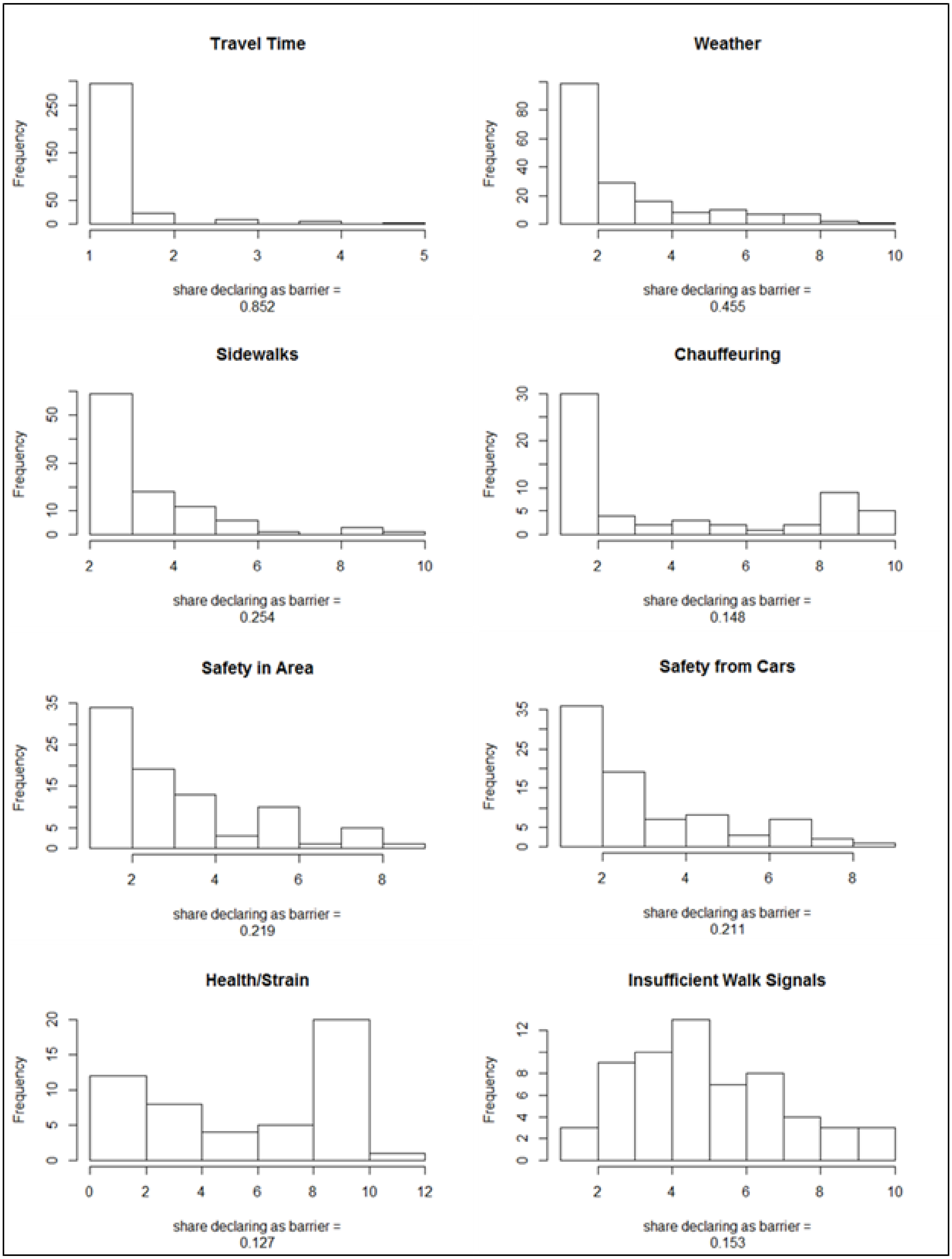

Figure 14. Student Drivers' Barriers to Walking

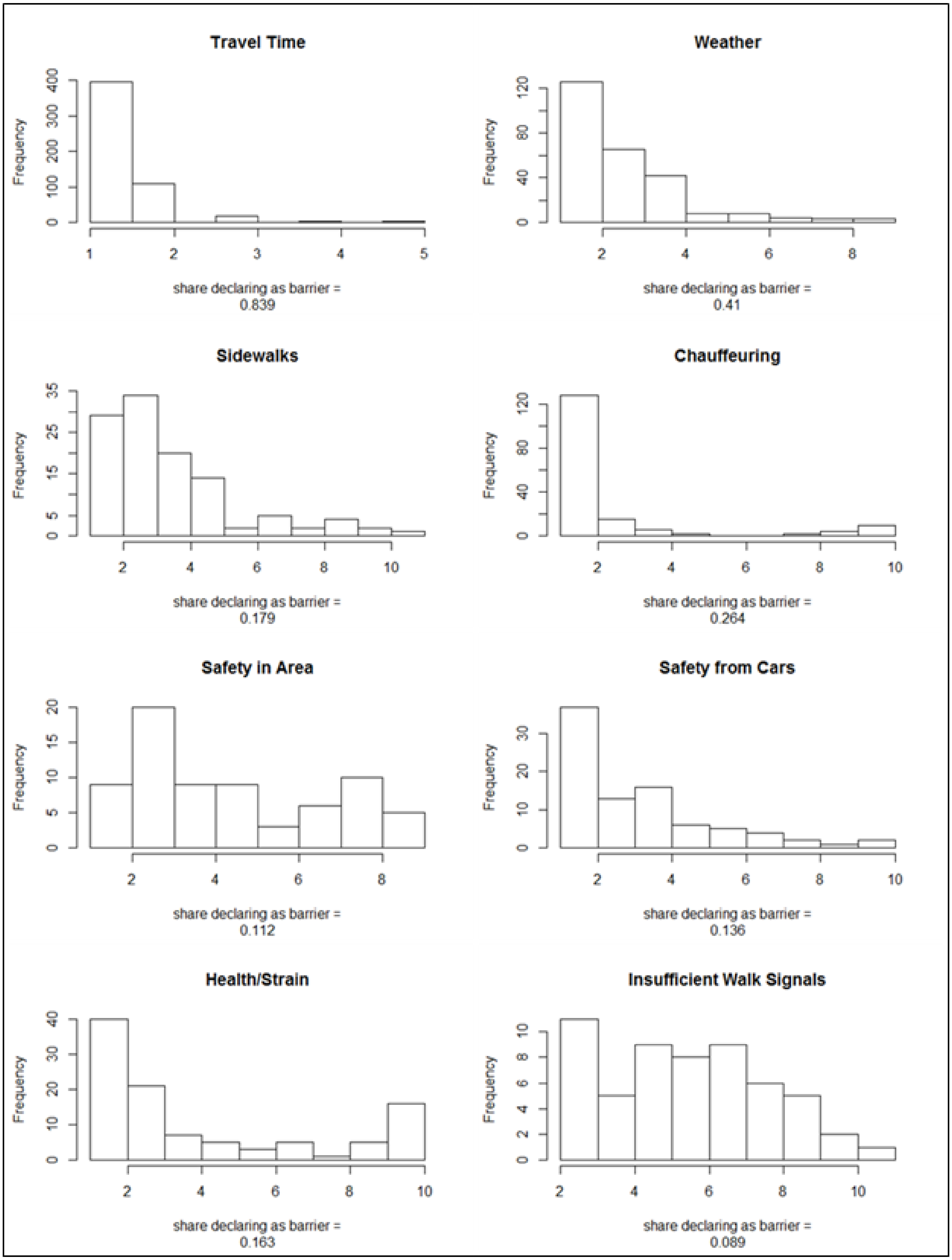

Figure 15. Faculty/Staff Drivers' Barriers to Walking

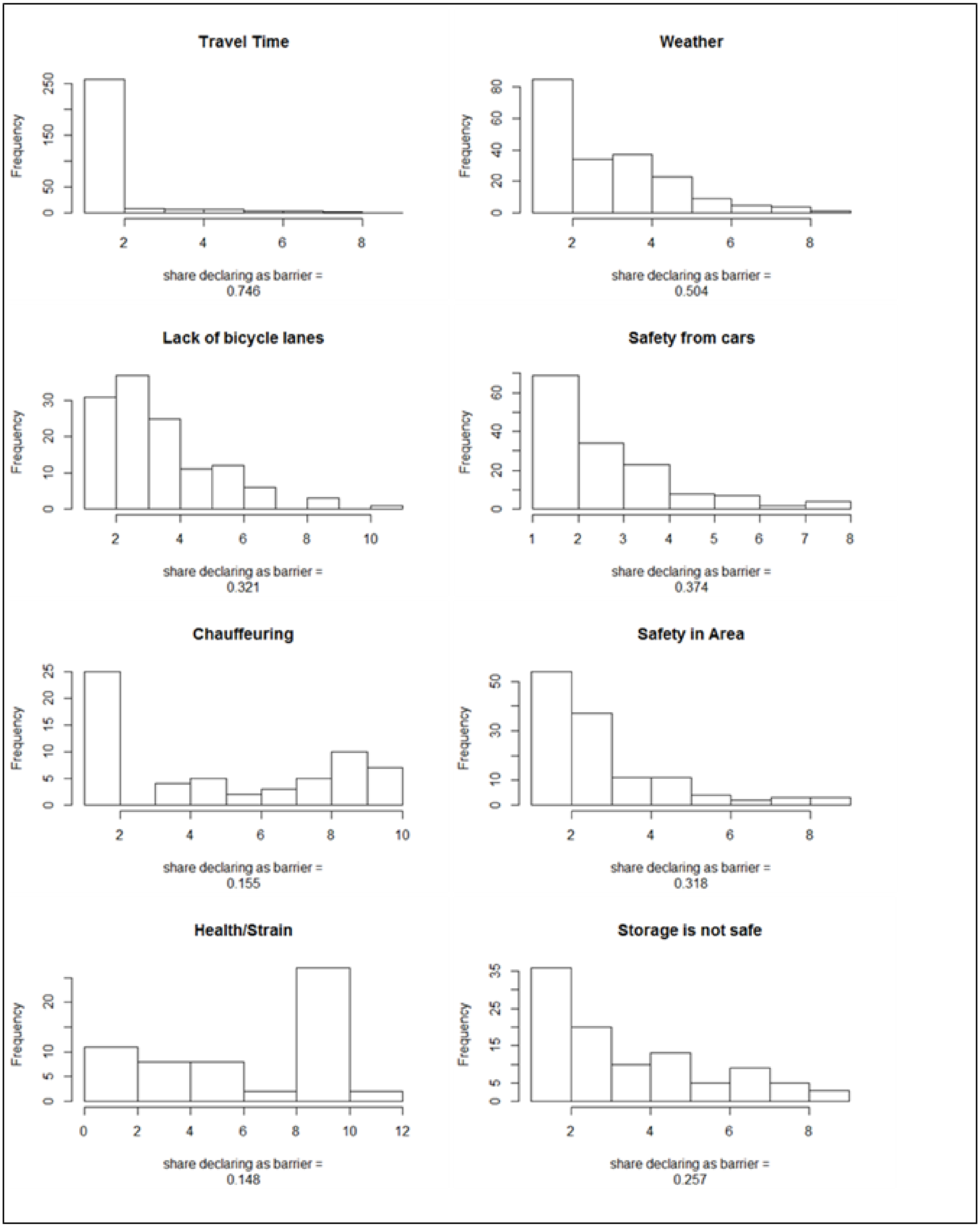

Figure 16. Student Drivers' Barriers to Cycling

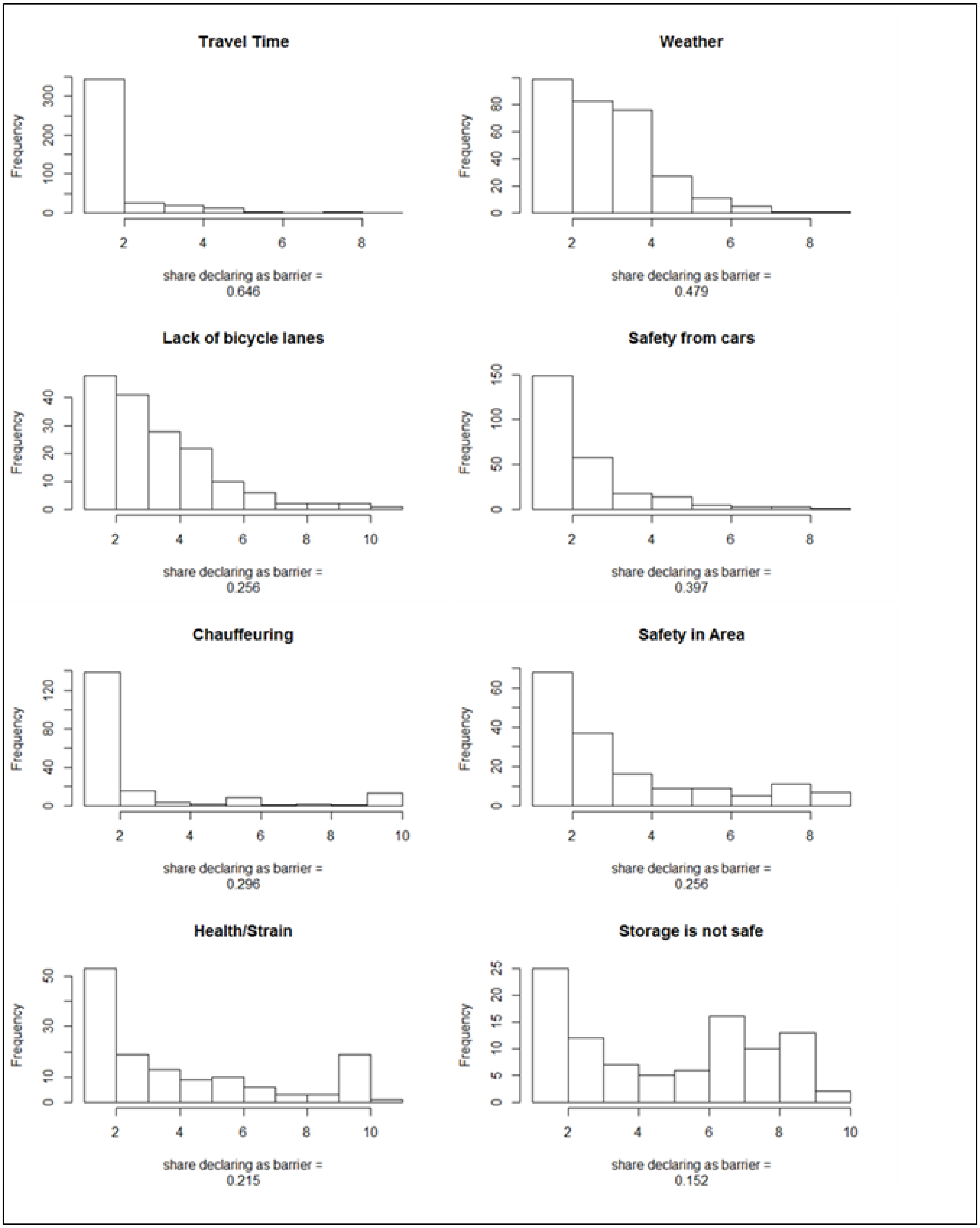

Figure 17. Faculty/Staff Drivers' Barriers to Cycling

Transit Barrier Results - As shown in Figure 12, student drivers stated that the largest barriers to transit use were travel time (79% provided this answer), unreliability (55%), crowding (46%), and weather (45%). Of these, travel time and unreliability were listed in a majority of the cases as being among the top three barriers. Similarly, faculty and staff drivers listed travel times (76%), weather (41%), unreliability (41%), and crowding (38%) as their chief barriers to transit use, shown in Figure 13. Travel times were most frequently listed among the top two barriers, while stop quality was listed infrequently (21%). Strain and health concerns were transit barriers for 15.7% of faculty and staff drivers and this was overwhelmingly a bottom-order (most frequently ranking as the 9th most important reason).

Walking Barrier Results - Similar to student drivers' barriers to transit use, travel time features as the most important barrier to walking, seen in Figure 14. More than 85% of student drivers list travel times as a barrier and in almost all those cases, it was the single most important factor. Weather was the second most frequently listed barrier to walking (46%), while the lack of sidewalks, area-wide safety, and safety from cars were the only other barriers listed by 20% or more of drivers. In short, long-travel times and weather are key barriers to students while the lack of sidewalks, general safety, and safety for cars are barriers for student sub-markets. Both safety from bicycles (9%) and the street width (14.5%) were much less common reasons given by student drivers.

Like students, faculty and staff drivers most frequently list travel times (84%) and weather (41%) as barriers to walking as observed in Figure 15. However, only one other reason is mentioned by more than 20% of faculty and staff drivers: chauffeuring - likely because of the higher child care responsibilities in comparison with students. Safety from cyclists and street width are listed by only seven percent or less of respondents.

Cycling Barrier Results - Student drivers stated largest barriers to bicycling are also related to travel time (75%) and weather (50.4%). However, potential issues of local policy intervention appear to be barriers to cycling as well. These include lack of bicycle lanes (32%), safety from cars (37%), general safety (32%), and safety in the vicinity of storage areas (26%) as shown in Figure 16.

Likewise, faculty and staff drivers' largest barriers to bicycling are travel times (65%) and weather (48%), observed in Figure 17. Opportunities for local policies to improve bicycling options include improving safety from cars (40%), bicycle lanes (26%), and area safety (26%). However, in contrast to students, the role of chauffeuring appears to be a potential significant barrier listed for 30% of faculty or staff drivers and identified as one of the top two barriers to bicycling. Approximately 15% noted storage was not safe, but it was a middling reason.

Overall, barriers to using other modes mirror motivations for auto use. While travel times feature as barriers to public transit, walking and cycling, there are other reasons become more significant. These barriers include: unreliability, crowding, and weather for transit; weather, sidewalks, and chauffeuring for walking; and bicycle lanes, area safety, and safety from vehicles for cycling. In sum, these results indicate that while travel time improvements are significant, improving safety and providing more sidewalks, bicycle lanes, and supportive infrastructure (e.g. showers, information, changing areas), significant barriers to transit, bicycling, and walking could be better managed.

As will become clear in the subsequent development of mode choice models, there is another very significant barrier to the use of the non-auto modes and this is possession of a parking permit to park on campus. People who have a parking permit are very much less likely to consider active modes or transit.

4.2 Public Forum Results

Findings from the January 20th, 2015, public forum indicate that each transportation system user had their own values, priorities, and experiences in the existing transportation system. While some emphasized the importance of environmental sustainability, others emphasized the value of bicycling or active transportation as a lifestyle and the moral imperative of prioritizing such modes. Others still focused on the utility of the system, commenting on the challenges of paying for travel costs and the challenges of using transit during off-peak periods. Each user emphasized different perspectives and different potential solutions to the elements of the system with which they were most familiar.

Despite the variety of voices, several themes emerged in conversations about different modes. Specific comments for each of the modes can be found in Appendix 6.6

4.2.1 Bicycling Comments

Comments on bicycling services to and around McMaster focused on inadequate infrastructure, safety, and the role of weather in shaping how existing infrastructure can accommodate bicycling. First, many respondents voiced concern over bicycling and pedestrian infrastructure available on the eastern side of the main campus, near King and Sterling. Some recommended customized delineation of bicycle lanes (e.g. in green), while others highlighted challenges in visibility (of cyclists by pedestrians or of pedestrians by cyclists) which made some participants feel less safe.

Second, many suggested that a clearer role for cyclists on campus would be beneficial. While current signs prohibit cyclists from riding in pedestrian areas, some contend that dismounting is less realistic or feasible than ceding priority to pedestrians. Moreover, cyclists contend that while cycling is discouraged on campus, if it is to be a feasible transportation mode to campus, its benefits for travel on or through campus should not be discouraged; instead signage and bicycle lane designations should be encouraged.

Third, some contend that insufficient bicycle racks are available on main campus and that those that are available are challenging to use when near capacity (e.g. when using the side of the rack) or are anchored in soil, making them muddy during inclement weather. Several noted that McMaster Innovation Park bicycle racks are full during summer months.

4.2.2 Driving Comments

Comments on driving and parking on campus were very diverse: while some wanted the role of parking to be reduced in light of ecological and environmental priorities, others focused on the inconvenience of existing services. Some contended that parking - particularly in the west side of main campus- takes space from environmentally sensitive ecosystems. Others noted that accessing parking - particularly on west campus via Cootes or to the Stadium parking from Sterling Street was a burden due to on-foot travel distance or due to many pedestrians and cyclists competing for the same road space

4.2.3 Walking Comments

Comments on walking to and on campus highlighted the joy from walking in green space and also the challenges of navigating streets, parking lots, and paths with unclear designation for pedestrians. For example, crossing Main Street at many locations was highlighted as challenging. Similarly, accessing main campus from the west or from the east through parking lots in each respective location was identified as challenging - indicating a conflict between locating parking exclusively at the edge of the university and simultaneously creating a parking barrier with surrounding communities.

4.2.4 Transit Comments

Finally, comments on transit focused on five core issues: crowded buses, lack of information, poor services (connections, speeds, and service times), high costs, and safety. First, many participants noted that buses were very crowded - primarily at student-oriented station stops near the university campus. While participants noted that crowding primarily impacted students who couldn't get on the bus or who needed to wait for a different bus in the inbound direction, participants highlighted the challenges of full outbound buses from students and faculty which subsequently affected the potential for other riders in the City of Hamilton to use these services at other points along the routes. In short, inadequate capacity currently influences both students and other prospective system users both at McMaster University and in the surrounding community.

Second, many participants complained about the lack of information on bus arrivals or departures. Many discussed the challenges of getting out of class to find that their bus had just departed and that information on the next departing bus was unavailable. More generally, many highlighted the challenges of getting sufficient information on transfer options during non-traditional commuting hours. Other participants noted a lack of information was not only a problem for system users but also for system managers. While students are regular bus patrons, ridership data may undercount students because they simply show their passes and board, rather than having a documented monthly pass or purchased trip.

Third, many identified HSR service deficiencies which significantly impacted their capacity to engage in campus life. For example, many living on Hamilton Mountain highlighted the severe inconvenience of transferring one or more times to access McMaster University. They emphasized that each transfer exacerbated issues of unreliability. Moreover, both staff and students noted that HSR services were not available during key times at which they were needed. One student noted that they had to frequently stay on campus overnight because their activity schedule extended into night hours during which no buses were running. Similarly, staff (such as those involved in coordinating special events) highlighted the challenges of commuting by transit during non-traditional times.

Fourth, while students were generally satisfied with their subsidized transit passes, faculty and staff highlighted the challenges of deciding to pay a higher monthly fee to take transit than to pay for on-campus parking. At the time of the event, the cost of a HSR transit pass was $87 per month while a monthly parking pass to western main campus lots was $46 per month. Faculty and staff generally viewed transit as prohibitively expensive - particularly in comparison with the price of driving.

Finally, some participants highlighted safety near HSR services as a concern. While some noted that conditions did not feel as safe during the night, others noted that crowding often led to a sense of unsafe conditions.

4.3 Projections and Forecasting

By pairing travel survey data and parking utilization data, models are estimated to forecast future travel behavior decisions by McMaster University faculty, staff, and students. As objectives of travel demand management center both on improving the experiences of users, on making better use of the system, and on improving the sustainability of travel choices, this study explores system usage rates and models of mode choice.

4.3.1 University Growth Projections

McMaster University has grown by approximately 600 students, faculty, and staff members per year since 2009, with two-thirds being growth in the student body. Projections were based on linear trends of past growth, shown in Figure 2 and 3, and compiled from different sources, including the McMaster University Office of Institutional Research and Analysis and the Unifor Local 5555 (a union representing staff, parking, transit services, and security services). Both 2015 estimates and 2025 estimates were based on annual linear growth rates which were estimated by the study team - yielding an average of approximately 590 additional individuals (400 students and 190 faculty and staff) each year between 2015 and 2025. This represents 13% total growth in students and 32% total growth in faculty and staff, as shown in Table 1 - of which all student growth is projected to occur on main campus and most faculty and staff growth is projected to occur on main campus.

4.3.2 Baseline Parking Utilization

Data from the Parking Services Department for spring and fall of 2014 was employed to characterize current parking utilization levels on McMaster's Main Campus. These parking utilization rates describe the existing conditions and establish the benchmark from which future forecasts were developed. When these parking utilization data were collected, the full capacity of the parking system was 3,543. These data were employed to derive estimates of not only the peak parking demand for a typical day, but also those of the distribution of peak utilization rates over the course of each of the two semesters. The difference is important: although peak utilization is critical from a system performance perspective, building infrastructure with the objective of servicing these peaks implies allocating resources to address the most critical one or two days of the year that do not necessarily reflect typical use patterns.

Parking utilization data was cleaned to eliminate statutory holidays and weekends - thereby illustrating the chief weekday trends during the 2014 winter and fall semesters. Maximum parking utilization was estimated for each individual day - generally during the 1pm hour. These maxima, illustrated in Figure 18 and Figure 19, show significant seasonal variations. Fall parking utilization was significantly higher and for two days in September 2014 exceeded 95% (3,366 used spaces). Moreover, between September 4 and October 14, 2014, utilization exceeded 85% (3,012 used spaces) of on-campus capacity for 14 weekdays.

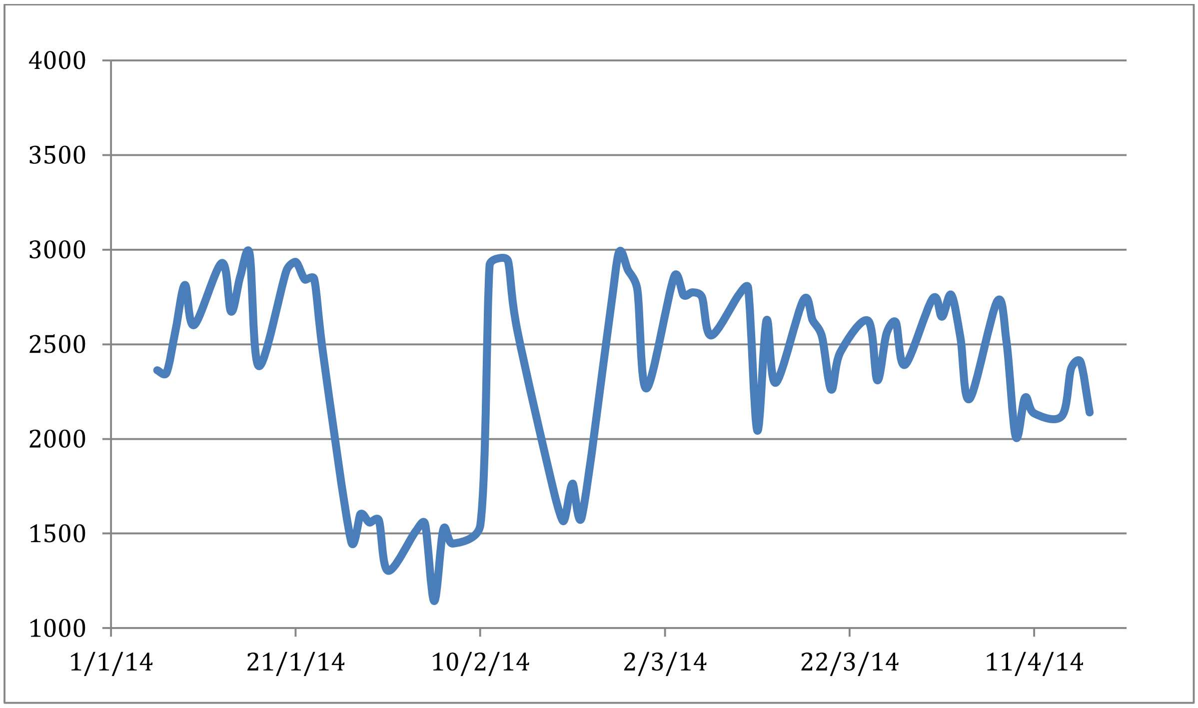

Figure 18. Winter 2014 Parking Utilization (Capacity is 3,543)

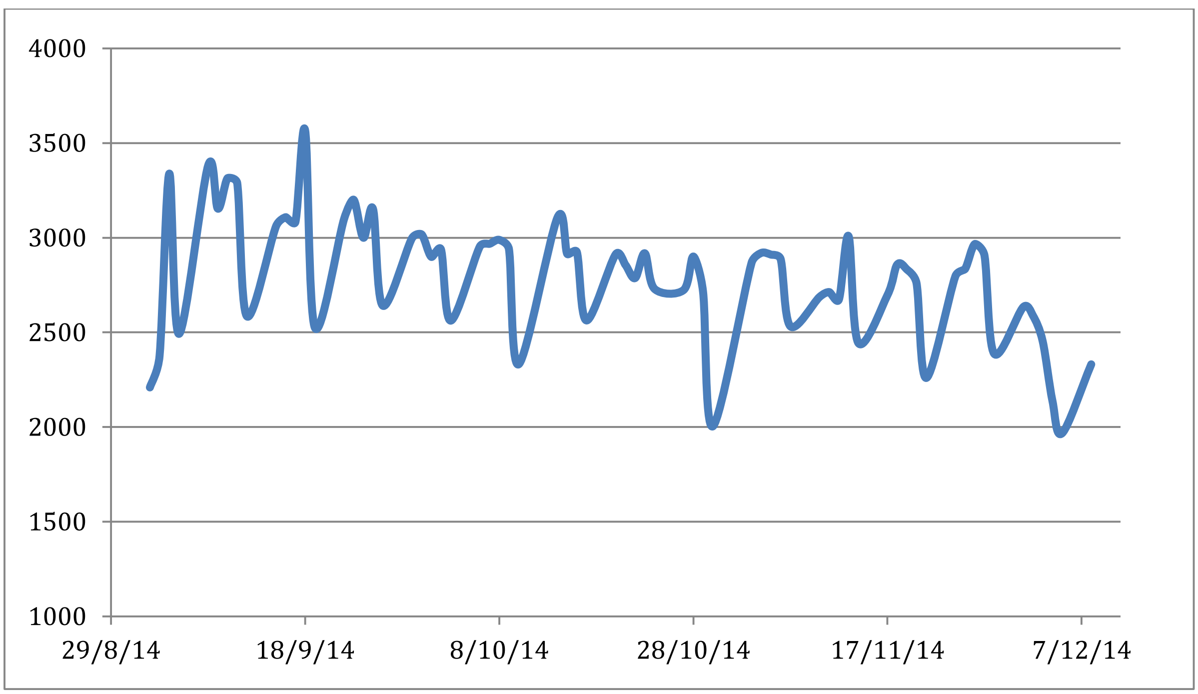

Figure 19. Fall 2014 Parking Utilization (Capacity is 3,543)

Parking utilization results indicate that while the on-campus parking supply regularly exceeds 85% of capacity during September, 50th percentile highest weekday utilization rates in the winter are 2,542 and in the fall 2,863 used spaces. As these utilization rates are respectively 72 and 81 percent of capacity, parking utilization rates during the fall semester appear to be regularly very close to the effective capacity but excess capacity remains throughout the winter semester.

4.3.3 Estimating Travel Demand

The design of policies that will influence effectively travel demand to McMaster University must be based on solid evidence. This study makes use of the 2015 McMaster University travel survey to identify, through econometric estimation, the predictors that have a significant effect on the mode of travel selected by survey respondents. Models used in this type of analysis, known as discrete choice models of travel behavior, are critical in exploring how travel demand can be most effectively managed. While many studies use typical relationships between policy variables and outcomes of interest (e.g. the elasticity of travel demand with respect to commuting cost), this study estimates behavioral sensitivities based on the specific characteristics of the sampled population of interest.

As the travel behavior and general circumstances of students were significantly different from those of faculty and staff, each of these two user groups was analyzed independently. From the family of discrete choice models, multinomial logistic regression models were estimated to explore predictors for the following travel choices (modes): **a) driving to work alone, b) driving or riding to work with someone else (either a formal or informal carpool), c) taking transit (either GO or HSR), d) walking, or e) bicycling.**

Travel mode choice decisions are fundamentally a function of six types of predictors:

- the service level of a given mode and other modes,
- the relative prices of different alternatives,
- individuals' socioeconomic and demographic characteristics,
- access to resources,
- trip characteristics, and
- land use characteristics.

Broadly, each of these predictors matters, but some are more significant than others, depending on the circumstances. For example, pedestrian or transit-oriented land uses and transportation services may independently influence travel behavior, but this effect is strongest when the time price (congestion) or the monetary price (road tolls or parking fees) of auto travel is sufficiently high (Chatman, 2008).

Student, and faculty and staff mode choice models were estimated as a function of mode-specific service levels (travel time and transfers), socioeconomic characteristics (age, sex, household size, the presence of children under 15, and the number of days going to campus), access to resources (parking permits, vehicle ownership, and bicycle ownership), and land use characteristics (job density at residential location). Trip-specific characteristics were omitted as each trip represents a trip from the survey respondent's location of residence to McMaster University. For the purposes of estimating predictors of mode choice, only those respondents who regularly travel to the McMaster University main campus and do not park in the hospital were included. In selecting the final preferred models, several controls were sequentially eliminated from either the student model or the faculty and staff model (or both) - depending on statistical significance.

Final models are shown in Appendix 6.4 and are consistent with theoretical expectations. Beyond the direction of influence between model explanatory variables and the mode choice outcome, the magnitudes and non-linear characteristics of these relationships are central to identifying how changes in transportation services (e.g. the service quality of alternatives or the availability of on-campus parking) impact travel demand.

For students, the basic findings are as follows:

- Longer travel times reduce the utility of walking
- The optimal travel times for single occupancy vehicles (SOVs), transit, carpooling, and bicycling are 21 minutes, 29 minutes, 11 minutes[11], and 28 minutes respectively
- Transit transfers reduce the attractiveness of taking transit
- Older students are more likely to use single occupancy vehicles
- Owning a parking permit and having a car makes one less likely to use non-SOV modes
- Owning a bicycle is associated with a higher likelihood of cycling to McMaster.

For faculty and staff, the basic findings are as follows:

- The optimal travel time for transit and walking are respectively 20 minutes and 10 minutes
- Transit transfers feature into the likelihood of choosing transit.
- Bicycle ownership and the age among faculty and staff are unassociated with mode choice
- Owning a parking permit and having a car makes one less likely to use non-SOV modes
- The optimal population density for the purposes of using transit is 216 residents per square acre

11 We expect the optimal carpool travel time of 11 minutes, a relatively short commute, to be because students who often walk or take transit frequently catch a ride with a friend living in close proximity.

4.3.4 Forecasting Parking Demand

Using the existing parking utilization rates for the fall and winter semesters of 2014 and the mode choice model results, scenarios are designed to forecast future parking utilization rates. The forecasts are based on assumptions that certain elements of travel behavior identified with the help of the 2015 Travel Survey continue into 2025 (see Table 9). As observed in 2015, this study assumes that 30% of students and 12% of faculty and staff drivers continue to park off campus. Likewise, based on the arrival and departure patterns of students, faculty, and staff, it is expected that a higher share of faculty/staff are on campus at the peak periods and that faculty/staff come to campus more frequently.

Table 9. Key Assumptions Informing Forecasts

Assumption	Students	Faculty and Staff
Share of vehicles parked during peak hour (1pm)	67%	96%
Mean Days Spent on Campus	4	4.7
Share of Vehicles Using Off-Campus Parking Spaces	30%	12%
Carpool Occupancy[12]	2.1	2.1

To estimate parking demand, the growth in mode-specific users was estimated using faculty and staff and student growth projections and the forecasted mode-shares based on several scenarios using the mode choice models. The student population is expected to grow by 13% in 10 years (400 students annually) and the full-time equivalent faculty and staff populations are expected to grow by 30% in 10 years (190 faculty and staff annually). These growth rates were important in estimating changes in parking demand. Forecasts of growth in parking demand were then estimated by adjusting the share of each type of user who is on-campus during peak periods, the number of days spent on campus, the share of vehicles which select off-campus parking spaces, and the occupancy of carpool vehicles.

Forecasts were developed for four distinct scenarios, as described below:

Alternative 1. No Action - according to this scenario, no changes would be made to the existing transportation system. Key assumptions are as follows:

1. The number of parking spaces and the number of permits being sold remain constant, implying a decline on a per potential user basis
2. The price of parking permits remains constant and indexed to inflation (1.5% per year)
3. HSR Services, congestion, walking services, and bicycling services remain stable

12 The assumption of two individuals per carpool vehicle is very conservative, as it assumes that one carpool in ten has more than two occupants

4. When demand exceeds capacity, mean auto travel times are increased by five minutes due to additional searching time for parking or walking from further-lying locations. Otherwise, auto travel times increase by 1% by 2025 due to background increases in traffic congestion[13]

Alternative 2. Build Parking - according to this scenario, the same parking services would be provided on a per person basis as currently provided. Key assumptions include the following:

1. Parking capacity on campus is expanded such that the rate of parking passes within the faculty, staff, and student populations remains the same in the future at the current levels.
2. Additional parking is constructed proportionately to increases in parking permits and the geographic distribution of this additional parking is such that it remains approximately at the current levels(e.g. on west campus, north campus, central campus, etc.).
3. The price of parking permits remains constant and indexed to inflation.
4. HSR Services, congestion, walking services, and bicycling services remain stable.
5. Mean auto travel times are not increased (in order to search for parking or walk from further-lying locations) because incremental parking is constructed. This assumes that city traffic is managed such that no congestion-induced increases in auto travel times are incurred.

Alternative 3. "Transit Improves"

1. Transit services (both GO and HSR) improve in a way that on average there is a 10% decrease in transit travel times and 10% of potential transit trips would entail exactly one connection less than before.
2. The number of parking spaces and the number of permits being sold remain constant (and therefore decline on a per potential user basis)
3. The price of parking permits remains constant when indexed to generalized inflation (approximately 1.5% per year)
4. Congestion, walking services, and bicycling services remain stable
5. When demand exceeds capacity, mean auto travel times are increased by 5 minutes due to additional searching time for parking or walking from further-lying locations. Otherwise, auto travel times increase by 1% by 2025 due to background increases in traffic congestion.

13 Based on regional travel demand forecasts, (HDR, 2008) and more detailed studies from within the Greater Toronto-Hamilton Area (Sweet, Harrison & Kanaroglou, 2015), a one percent increase in travel times due to congestion is perhaps a lower bound on what is most likely over the next ten years.

Alternative 4. "Full TDM" Scenario

1. Transit services (both GO and HSR) improve such that on average there is a ten-percent decrease in transit travel times and 10% of potential transit trips would entail exactly one connection less than before.
2. The number of parking spaces and the number of permits being sold remain constant (and therefore decline on a per potential user basis)
3. The price of parking permits remains constant and indexed to generalized inflation (approximately 1.5% per year)
4. The amenities, convenience, and safety improvements to walking, bicycling, and carpooling services increase proportionally to a ten-percent decrease in travel times.
5. When demand exceeds capacity, mean auto travel times are increased by an additional 5 minutes due to additional searching time for parking or walking from further-lying locations. Otherwise, auto travel times increase by 1% by 2025 due to background increases in traffic congestion

The expected mode-specific travel times, availability of parking permits, and presence of transfers for the underlying sample were adjusted based on each of the scenarios to simulate alternate mode shares and develop parking demand.

There are only moderate differences between each of the modeled student alternatives. As can be seen in the mode shares forecasted for students in Table 10, the Build Parking Scenario (with some rounding based on model calibration) represents the effective mode shares under which there are no changes in mode shares from 2015 to 2025 and represents the highest proportion of single-occupancy vehicles (SOVs) and carpoolers. In the No Action Scenario, according to which there are no additional permits or parking spaces sold, 0.5% of commuters switch from SOV to transit and little else changes. Next, in the Transit Improvement Scenario, 0.9% of commuters switch from SOV and 0.7% switch to transit while 0.3% switch to walking. Finally, based on the Full TDM scenario, SOV mode share is reduced by 1.2% from the Build Parking Scenario, transit use increases by only 0.4%, walking increases by 1.2%, and biking mode share decreases by 0.2%.

The action with the highest impact in managing the auto mode share among students is not building additional parking: no other single action impacts SOV mode share by more than 1% (of a total FTE-equivalent Main Campus population of more than 30,000). In addition user travel behavior decisions to switch modes illustrate the extent to which users substitute transit, walking, and cycling for one another. Improvement in non-auto services redistribute active and transit mode shares and do not simply yield net reductions in SOV mode shares.

Table 10. Student Forecasted Mode Shares in 2025 (%)

	Alternative. No Action	Alternative 2. Build Parking	Alternative 3. Transit Improves	Alternative 4. Full TDM
Single-Occupancy Vehicle	18.4	19.0	18.0	17.8
Walk	26.8	26.9	27.3	28.1
Transit	44.7	44.1	44.8	44.4
Carpool	6.9	6.9	6.7	6.7
Bike	3.2	3.1	3.2	2.9

Faculty and staff mode shares vary more significantly than those of students between different scenarios, as observed in Table 11. As over 70% of faculty and staff arrive on campus via car, there is a greater share of vehicle travel to divert to alternate modes. For example, simply by not building parking capacity proportional to current capacity, the auto mode share would be expected to decrease by 10%, leading to modest increases in walking of 0.5%, carpooling by 2.5%, and cycling by 1.4%, and a large increase in transit mode share by 5.5%. Improving transit services would be expected to shift travel behavior moderately while implementing the Full TDM Scenario could achieve transit mode shares of 19%, a bike mode share of 11%, a walking mode share of about 9%, and a carpool mode share of 18%.

Table 11. Faculty and Staff Forecasted Mode Shares in 2025 (%)

	Alternative 1. No Action	Alternative 2. Build Parking	Alternative 3. Transit Improves	Alternative 4. Full TDM
Single-Occupancy Vehicle	48.0	58.1	46.8	43.2
Walk	7.7	7.0	7.9	8.9
Transit	18.4	12.9	18.9	18.9
Carpool	16.3	13.8	16.3	18.1
Bike	9.6	8.2	10.2	10.8

Using the expected mode shares and projected growth in students, faculty, and staff, parking demand change between 2015 and 2025 was forecasted under the four different scenarios. As shown in Table 12, growth in parking demand is most significant for the faculty - regardless of alternative.

Table 12. Forecasted Percentage Growth in Parking Demand (2015-2025)

Scenario	Students	Faculty	Total
Alternative 1. No Change	10.5	12.4	11.3
Alternative 2. Build Parking	13.3	30.3	20.0
Alternative 3. Transit Improves	8.1	9.9	8.8
Alternative 4. Full TDM	6.8	4.5	6.0

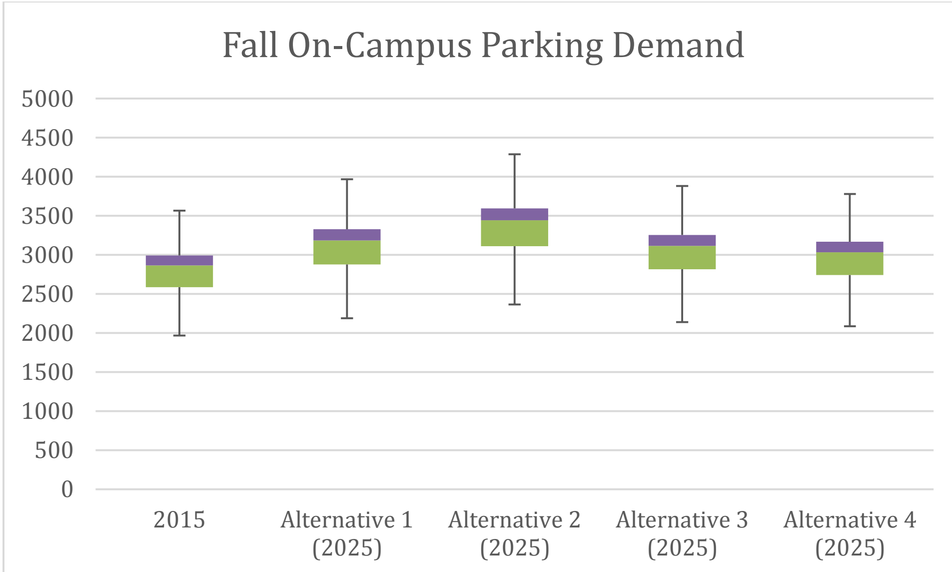

Figure 20. Weekday Distribution of Fall On-Campus Parking Demand for Base (2015) and Scenarios 1-4 (2025) – Capacity is 3,543

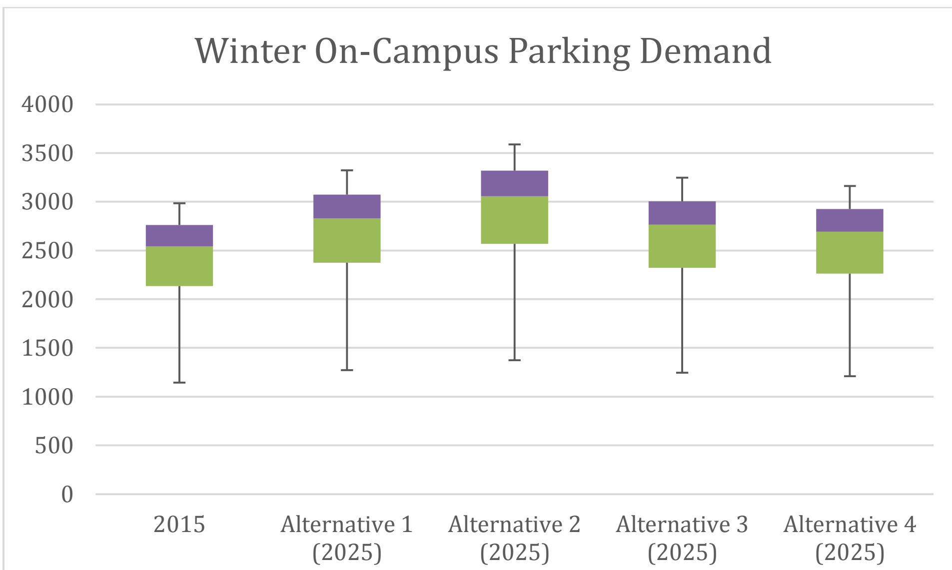

Figure 21. Weekday Distribution of Winter On-Campus Parking Demand for Base (2015) and Scenarios 1-4 (2025) - Capacity is 3,543

Using the observed 2014 winter and fall data on parking utilization and adjusting it modestly for 2015, the distribution of peak parking demand levels were forecasted to 2025 using each of the four proposed scenarios. The outcome for fall is shown in Figure 20 and for winter in Figure 21. These are "box and whisker" plots where the distribution of daily parking demand is separated into quartiles. The median level of demand in each case is defined by the boundary between the green and purple areas. Half of the daily observations are included in the overall boxed area. The first and fourth quartiles, associated with the top and bottom “whiskers” cover a wider range of more extreme parking demand outcomes. Results suggest that Alternative 2, the Build Parking scenario, is associated with the highest level of parking demand in both fall and winter. The results also show far more variability in winter parking than fall parking.

4.3.5 Estimating Price Sensitivity

While the previous forecasts of future parking demand assume that the price of on-campus parking remains stable, adjusting the price of parking can be a mechanism to better manage the utilization of valuable parking resources. To maximize our understanding of how McMaster commuters respond to changes in the price of parking, stated preference scenarios were presented to respondents who would then choose their preferred option based on the scenario.

Options for students were constrained to taking active transportation, transit, parking on west campus, parking at the stadium, or parking at Ward. Options provided to faculty and staff likewise included active transportation, transit, and parking on west campus, but also included the option of parking on central main campus. Expected transit and walking travel times varied from respondent to respondent while parking lot price and (in the case of faculty/staff) transit fare price was varied for each question posed to survey participants. By identifying the typical price points at which faculty, staff, or students become significantly more likely to change their choices, price sensitivity can be estimated for each user group.

Multinomial logistic regression models were used to estimate system users' sensitivity to the price of parking. Results are shown in more detail in Appendix 6.5.

For students, the findings were as follows:

- No differences in price sensitivity were identified across alternatives: higher prices are linked with a lower likelihood of choosing a particular travel option.
- The links between travel times and the likelihood of choosing alternatives relative to active transport is non-linear and unequal across all options.
- Being on campus more is associated with a higher likelihood (relative to active transport) of parking at Ward or taking transit.
- Students are least likely to choose non-active modes if they live in neighbourhoods with residential densities between 290 and 350 people per square kilometer

For faculty and staff, the findings are:

- No differences in price sensitivity were identified across alternatives: higher prices are linked with a lower likelihood of choosing a particular travel option and the effect becomes stronger non-linearly as prices increase.

- The links between travel times and the likelihood of choosing alternatives relative to active transport is non-linear and unequal across all options.
- Being older makes one more likely to take active travel alternatives.
- Most frequently spending time on north campus is associated with a lower chance of using non-active modes.
- Most frequently spending time on south campus is associated with a higher chance of transit use.
- Spending more time on campus is associated with a lower probability of using non-active modes.
- Larger households are associated with a higher chance of using non-active modes.

4.3.6 Forecasting Parking Demand with Price Variations

Using the estimated stated preference models, parking utilization forecasts for the original four scenarios were re-estimated based on a 30% increase in the price of parking and a 30% decrease in the price of a transit pass for faculty and staff between 2015 and 2025. Net changes from the existing conditions are shown in Table 13.

Table 13. Forecasted Parking Demand Under Un-Priced and Priced Scenarios (2015-2025)(%)

	Un-priced Scenarios	30% Pricing Scenarios*
Alternative 1. No Change	11.3	5.2
Alternative 2. Build Parking	20.2	13.5
Alternative 3. Transit Improves	8.8	2.8
Alternative 4. Full TDM	6.0	0.2

*30% pricing scenarios assume that inflation-adjusted parking prices increase by 30% and that the faculty/staff inflation-adjusted price of a transit pass decreases by 30%

Based on 30% Priced Scenarios, parking demand would increase 13% in the Build Parking Scenario, but would increase by no more than 3% from existing parking demand and in some cases decrease in the other three alternatives. Table 14 illustrates the current monthly parking rates for the main campus parking lots, and the future parking costs assuming the 30% increase scenario.

Table 14. Current Parking Rates Compared to 30% Priced Scenario Parking Rates

	MONTHLY PARKING RATE	
LOT	**2014/2015 RATES**	**REAL 30% INCREASE**
A (Divinity College)	$86	$112
B,C,D,E, F, G, I and Q	$86	$112
H, K and L	$68	$89
M, N, O, P	$46	$60
Stadium	$101	$132
Ward	$50	$65
Accessible	$46	$60
Evening	$46	$60
Motorcycle	$17	$23
Commercial	$106	$138
All	$86	$112

Using the forecasted changes in parking demand based on the 30% change in prices, the expected variation in peak daily demand is estimated for the fall and spring semesters. As can be seen in Figure 22. Fall 2025 Parking Demand Under 30% Priced Scenarios, the peak parking demand is constrained very close to existing levels in each of the priced scenarios.

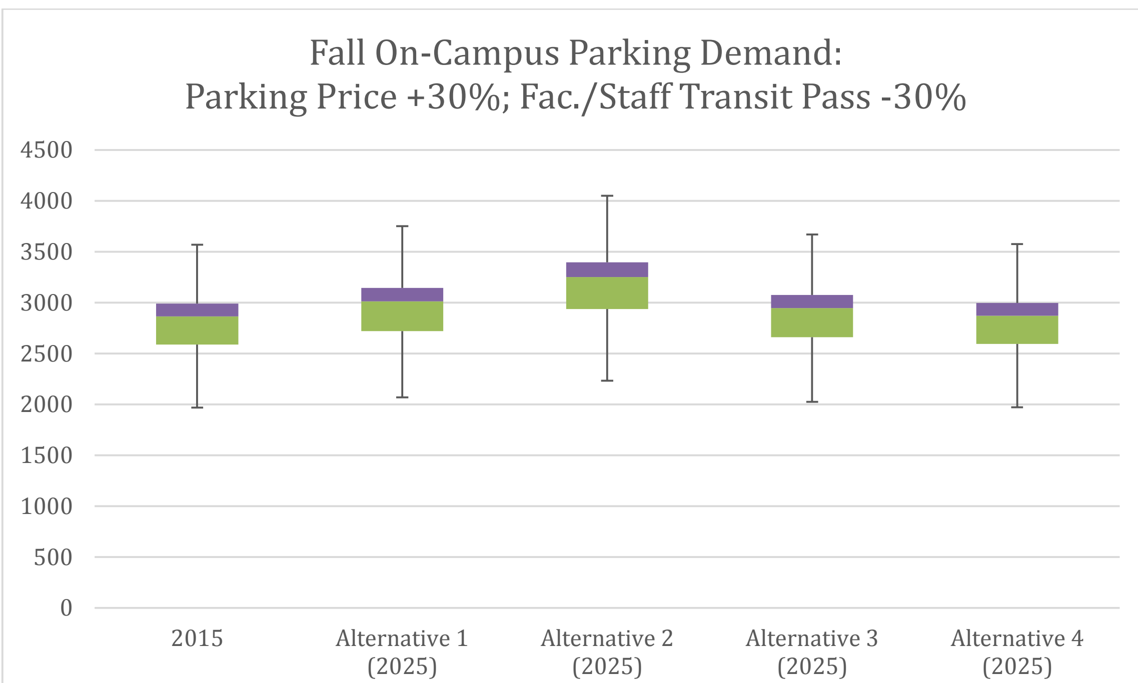

Figure 22. Fall 2025 Parking Demand Under 30% Priced Scenarios

On the basis of these results, if modest TDM and transit service improvement measures are undertaken, a 30% real increase in the price of parking and 30% decrease in the price of a faculty/staff transit permit can constrain future on-campus parking demand to effectively no change in total parking demand on campus. A 0.2% increase in parking demand would not change the number of days on which the system exceeds 95% capacity. Even if transit improvements do not materialize and TDM improvements are delayed, a 30% increase in the price of parking and a 30% decrease in faculty and staff transit passes can constrain 2025 peak period parking demand to 5.2% growth from current conditions. This would mean that during the first two weeks of September 95% of the system capacity would be exceeded for six days rather than two days (as currently).

4.4 Scenario Comparisons

Each of the eight future alternatives are compared on the basis of four of the evaluative criteria and two are further compared on the basis of the fifth evaluative criterion: financial soundness. As discussed above, the five evaluative criteria are:

1. reasonably meeting future travel demand
2. increasing transit, walking, and bicycling and reducing auto use
3. reflecting the public involvement process
4. reducing McMaster's environmental impact
5. financial responsibility

Because present parking demand is very close to parking capacity during the highest utilization days of the year, no parking demand growth strictly represents the notion of reasonably accommodating future travel demand. To accommodate parking demand, two broad approaches are appropriate:

1. building more parking
2. engaging in progressively higher combinations of a) incentives to use other modes (the Full TDM alternatives) combined with b) changes in parking and transit prices.

As shown in Table 15, only three of the eight alternatives (4 main alternatives * 2 pricing types) fully accommodated future demand (zero parking demand growth or less) while only one of these three was associated with parking demand increases of 3% or less. Only the Build Parking alternative met future parking demand among both scenarios. No other alternative met parking demand in the unpriced scenario, while the 30% priced scenario represented parking demand growth of 5% or less. Other than the Build Parking alternatives, only the Full TDM alternative met all demand in the 30% pricing scenario.

Table 15. Alternative Comparisons Using Evaluation Criteria

<table>
<tr><th rowspan="2">Alternative</th><th rowspan="2">Pricing Scenario Type</th><th colspan="4">Evaluation Criteria*
Achievement: (Yes, Maybe, or No)</th></tr>
<tr><th>Criterion 1. Meets Future Travel Demand</th><th>Criterion 2. Less Driving, More Transit, Walk, Bike</th><th>Criterion 3. Reflects Public Input</th><th>Criterion 4. Minimize Environmental Footprint</th></tr>
<tr><td>No Action</td><td rowspan="4">No Price Changes</td><td>11.3% unmet</td><td>Yes.</td><td>No.</td><td>Yes.</td></tr>
<tr><td>Build Parking to Meet Demand</td><td>Yes.</td><td>No.</td><td>Maybe.</td><td>No.</td></tr>
<tr><td>Transit Improves</td><td>8.8% unmet</td><td>Yes.</td><td>Maybe.</td><td>Yes.</td></tr>
<tr><td>Full TDM</td><td>6.0% unmet</td><td>Yes.</td><td>Maybe.</td><td>Yes.</td></tr>
<tr><td>No Action</td><td rowspan="4">Parking Prices Increase 30%;

Faculty/Staff Transit Prices Decrease 30%</td><td>5.2% unmet</td><td>Yes.</td><td>No.</td><td>Yes.</td></tr>
<tr><td>Build Parking to Meet Demand</td><td>Yes.</td><td>No.</td><td>Maybe.</td><td>No.</td></tr>
<tr><td>Transit Improves</td><td>2.8% unmet</td><td>Yes.</td><td>Maybe</td><td>Yes.</td></tr>
<tr><td>Full TDM</td><td>Yes.</td><td>Yes.</td><td>Maybe</td><td>Yes.</td></tr>
</table>

** Evaluation Objective 5, financial soundness, is omitted from this table as it is further discussed below for two select alternatives.*

While the Build Parking alternatives meet Criterion 1 in accommodating future travel demand, these alternatives do not meet Criteria 2 (less driving, more alternate modes) or 4 (reducing environmental footprint). Moreover, qualitative feedback during public input processes generally suggest that McMaster students, faculty, and staff do not simply want more available parking and therefore the alternative would not meet Criterion 3 either. Build Parking alternatives would both lead to more driving and less transit, walking, or biking - thereby leading to a higher environmental footprint. In contrast, all other alternatives score much more favorably on Criteria 2 and 4.

The only alternatives which would not have been endorsed based on public input were the No Action alternatives. Overwhelmingly, the feedback suggested that actions were desired and necessary to improve transportation services to the university, but there remained disagreements on what actions might be most beneficial. While it appeared that the public support for improving transit, walking, and bicycling may have been strongest, some auto users likewise indicated that changing prices or service levels would not be desirable.

Based on the forecasts, there are two fundamental approaches to meeting future travel demand: building more parking or engaging in various elements of travel demand management. Of these, all four initial criteria were met by only one alternative: the full TDM alternative with 30% changes in pricing.

Differences between the two approaches are illustrated by comparing the financial soundness of two specific alternatives: the Build Parking Scenario (according to which parking capacity increases by 30% and prices remain stable) and the Full TDM Alternative under the 30% Price Change Scenario (according to which the real price of parking increases 30% over ten years and the price of transit decreases by 30% over ten years).

To estimate financial impact in terms of net present value, a ten-year program is designed which considers costs or revenues which are unique to each of the two scenarios. As the scenarios are modeled on the basis of identifying how current conditions influence travel demand in 2025, intermediate years are assumed to reflect a linear trend between 2015 and 2025. Changes in parking capacity, transit prices, and parking prices are assumed to incrementally be changed to target 2025 levels. This approach allows one to see differences in net financial impact when focusing on different time horizons. Most notably, when focusing on short-term time horizons, the Build Parking Scenario has a more positive financial impact whereas when focusing on 8-10 year time horizons, the Full TDM Scenario with 30% changes in prices is more financially beneficial.

4.4.1 Build Parking Scenario

First, the financial impact of the Build Parking Alternative is estimated. In terms of costs and revenue accruing to McMaster University, the Build Parking Scenario under high-cost assumptions would lead to significant growth in program costs, while under the low-cost assumptions would be competitive with the Full TDM Scenario - at least over the short term. This approach would also lead to an increase in McMaster's environmental transportation-related impact because it would not shift mode shares from automobiles to other modes. Total parking demand would increase by 20% and total greenhouse gas emissions would likewise increase by up to 20% - assuming future McMaster student, faculty, and staff members' residences are distributed similarly to existing conditions.

Annual costs for the Build Parking Scenario are estimated to 2025 based on the following calculations:

> <u>Parking space capital costs</u>: approximately 106 parking spaces are expected to be constructed each year over ten years (1,063 in total, a 30% increase over ten years) at a cost of between \$20,000 and \$40,000 per space. Annual construction costs are assumed

to equal the average interest rate (between 3% and 6% annually) times the number of new spaces (compared to currently) times the cost per space (between $20,000 and $40,000)[14].

Parking operating costs are expected to be between $200 and $800 per space per year[15]and are likewise applied to the additional 106 spaces each year over ten years.

The annual projected capital and operating costs from constructing the 1,063 new spaces by 2025 (160 per year) are shown in Table 16 assuming a 3% interest rate and $500,000 in monthly revenues in 2015.

Table 16. Build Parking Scenario Expected Capital and Operating Costs

Year	Add'l Spaces from 2015	Capital Costs (High Est.)*	Cap. Costs (Low Est.)*	Op. Costs (High Est.)**	Op. Costs (Low Est.)**
2015	0	$0	$0	$0	$0
2016	106	$127,200	$63,600	$84,800	$21,200
2017	212	$254,400	$127,200	$169,600	$42,400
2018	318	$381,600	$190,800	$254,400	$63,600
2019	424	$508,800	$254,400	$339,200	$84,800
2020	530	$636,000	$318,000	$424,000	$106,000
2021	636	$763,200	$381,600	$508,800	$127,200
2022	742	$890,400	$445,200	$593,600	$148,400
2023	848	$1,017,600	$508,800	$678,400	$169,600
2024	954	$1,144,800	$572,400	$763,200	$190,800
2025	1063	$1,275,600	$637,800	$850,400	$212,600

** High and low capital cost estimates are based on 3% interest rates and, respectively, $40,000 or $20,000 construction costs per parking space.*

*** High and low operating costs are based on costs of $200-$800 per parking space per year.*

Revenue from the Build Parking Scenario is expected to accrue from additional parking ticket sales.

14 Low-end estimates of capital costs assume $20,000 in construction costs per space while upper-end estimates assume $40,000 per space. Annual construction costs are estimated using an assumed annual interest rate of between 3% and 6%. Based on a 30% increase in parking supply, this would equal 0.3 * 3,543 spaces = 1,063 additional spaces. Based on the 6% interest rate, the annual cost of constructing a single parking space would range between $1,200 (0.06 * 20,000) and $2,400 (0.06 * 40,000). Thus, the annual cost of providing the additional 1,063 spaces would be between approximately $1.3 million ($1,200 cost per space * 1,063 new spaces = $1.275 million annually) and $2.6 million (2,400 cost per space * 1,063 new spaces = $2.551 million annually) in 2025.

15 These rates of parking operating costs are adapted from Litman (2013). While Litman's operating cost estimates for a staffed multi-story urban parking deck are as high as $2,500 annually, the range of operating cost estimates here are capped at $800 per space annually based on a different context.

<u>Additional parking ticket sales</u>: Current monthly revenue for the twelve months of the year ranges between $400,000 and $500,000 per month.[16] As parking demand is expected to increase by 20% over the ten years (see Alternative 2,

Table 13), it is assumed that parking demand increases by 2% over current levels each year. This translates into 2% increases in monthly permits, 2% increases in parking fines, and 2% in visitor revenue. Thus, annual revenue growth is estimated as the share of new ticket sales (beginning at 2% and increasing to 20% in 2025) times the current mean monthly revenues ($400,000 to $500,000) times the interest rate (3% to 6%). Expected Revenues are shown in Table 17. The fiscal impact of the high cost estimates are negative and become significantly more negative over time due to the high capital and operating costs incurred by new parking facilities. In contrast, based on the low cost estimates of average parking spaces costing only $20,000, one would expect an annual return almost $350,000 annually by 2025.

Table 17. Build Parking Scenario Expected Revenue and Fiscal Impact Based on High and Low Cost Estimates

Year	All Costs (High Est.)	All Costs (Low Est.)	Growth In Parking Use	New Revenue*	Fiscal Impact (High Est.)	Fiscal Impact (Low Est.)
2015	$0	$0	0%	$0	$0	$0
2016	$212,000	$84,800	2%	$120,000	-$92,000	$35,200
2017	$424,000	$169,600	4%	$240,000	-$184,000	$70,400
2018	$636,000	$254,400	6%	$360,000	-$276,000	$105,600
2019	$848,000	$339,200	8%	$480,000	-$368,000	$140,800
2020	$1,060,000	$424,000	10%	$600,000	-$460,000	$176,000
2021	$1,272,000	$508,800	12%	$720,000	-$552,000	$211,200
2022	$1,484,000	$593,600	14%	$840,000	-$644,000	$246,400
2023	$1,696,000	$678,400	16%	$960,000	-$736,000	$281,600
2024	$1,908,000	$763,200	18%	$1,080,000	-$828,000	$316,800
2025	$2,126,000	$850,400	20%	$1,200,000	-$926,000	$349,600

4.4.2 Full Travel Demand Management with 30% Price Changes

For the Full TDM Scenario with 30% changes in the price of parking and the price of transit, there are new annual costs associated with a TDM manager and budget, pedestrian and bicycling infrastructure, and the 30% faculty and staff transit subsidy, while new revenue is generated through the phasing in of 30% higher parking prices. A new TDM manager with a program budget should be phased in and is expected to cost $200,000 annually by 2025. Approximately $200,000

16 Based on parking metrics reports from McMaster Parking Services (2015), revenues from parking passes and visitors equal almost $500,000 per month.

should be budgeted immediately for pedestrian and bicycle infrastructure. All other costs and revenues are phased in over the ten-year period. Costs include:

TDM Manager with Program Budget: This role can be phased in over the first 5 years and in fact this is assumed in the financial scenario. Assume that $60,000 is allotted for a new TDM staff member in years 1-5. The TDM efforts of Transportation Services and this new staff member can be supported with a marketing budget of $40,000 per year in years 1-5. In subsequent years (i.e. 6 to 10), a senior TDM manager can be hired – for which $120,000 would be budgeted for salary + benefits. In this latter period a full TDM marketing budget of $80,000 can be made available. The ultimate amount of $200,000 that is set aside for marketing and implementing TDM does not seem unreasonable considering that the McMaster community consists of approximately 40,000 faculty, students and staff.

Bicycle and Pedestrian Infrastructure: approximately $200,000 per year to add bicycle lanes, provide additional bicycle racks, and provide or modify sidewalks and signalization.

Table 18. Projected Real Faculty and Staff Transit Pass Subsidy (30%)

Year	Transit Mode Share	Total Faculty and Staff	Transit Pass Holders	Real Annual Subsidy*
2015	0.137	5,895	810	$253,000
2016	0.146	6,085	890	$278,000
2017	0.155	6,275	970	$304,000
2018	0.164	6,465	1,060	$331,000
2019	0.173	6,655	1,150	$360,000
2020	0.182	6,845	1,240	$389,000
2021	0.190	7,035	1,340	$420,000
2022	0.199	7,225	1,440	$451,000
2023	0.208	7,415	1,540	$484,000
2024	0.217	7,605	1,650	$517,000
2025	0.226	7,795	1,760	$552,000

* Transit Subsidy = 30% * $87 (monthly price) * 12 months/year * Transit Pass Holders

Transit Subsidy to Faculty and Staff:

Model results indicate that the transit mode share on main campus would be approximately 22.6% in 2025. Based on 7,795 faculty and staff who are expected to be members of the McMaster University community in 2025, approximately 1,760 faculty and staff will purchase transit passes at that time. For the purposes of conservatively estimating transit subsidy costs, transit mode shares at other locations beyond main campus are expected to shift commensurately with main campus transit mode shares. If each of these transit passes were $87 in real dollars and there were a 30% discount, one would expect the price of the faculty/staff transit subsidy to equal the number of transit pass holders times 30% of the monthly transit pass. The ten-year schedule of expected transit subsidy expenses is shown in Table 18.

Revenue from higher parking prices are expected to yield more revenue over time as the price increases are implemented. As with transit mode share changes, the changes in parking revenue are assumed to be linearly phased into the transportation program - meaning that the real (2015) increase in parking revenue in the first year is approximately $180,000, while in the tenth year, the real increase in revenue would be equivalent to $1.8 million.

Table 19. Projected Revenue from Higher Parking Prices in TDM Scenario*

Year	Revenue Growth % (from 2015)	Real Annual Revenue*	Real Annual Revenue Growth
2015	0	$6,000,000	$0
2016	0.03	$6,180,000	$180,000
2017	0.06	$6,360,000	$360,000
2018	0.09	$6,540,000	$540,000
2019	0.12	$6,720,000	$720,000
2020	0.15	$6,900,000	$900,000
2021	0.18	$7,080,000	$1,080,000
2022	0.21	$7,260,000	$1,260,000
2023	0.24	$7,440,000	$1,440,000
2024	0.27	$7,620,000	$1,620,000
2025	0.3	$7,800,000	$1,800,000

* Assumes existing parking revenues are approximately $500,000 per month.

As can be seen, based on the Full TDM Alternative with the 30% price change scenario, most of the net revenue is generated further in the future. The key benefit and cost elements of the Full TDM Alternative with the 30% changes in parking and transit fares is shown below.

Table 20. Annual Surplus-Deficit for Full TDM Alternative with 30% Price Changes[17]

Year	Additional Parking Revenue	Faculty/Staff Transit Subsidy	TDM Marketing & Infrastructure Program	Surplus-Deficit
2015	$0	0	0	0
2016	$180,000	$278,000	$300,000	-$398,000
2017	$360,000	$304,000	$300,000	-$244,000
2018	$540,000	$331,000	$300,000	-$91,000
2019	$720,000	$360,000	$300,000	$60,000
2020	$900,000	$389,000	$300,000	$211,000
2021	$1,080,000	$420,000	$400,000	$260,000
2022	$1,260,000	$451,000	$400,000	$409,000
2023	$1,440,000	$484,000	$400,000	$556,000
2024	$1,620,000	$517,000	$400,000	$703,000
2025	$1,800,000	$552,000	$400,000	$848,000

4.4.3 Direct Comparison of Build Parking Scenario and Full TDM Scenario

To directly compare the financial implications of the two scenarios, each is modeled on a year-over-year basis, as above, using different assumptions about current revenue to calculate the net present value (NPV) of future costs and revenues. The net present value calculation yields different results depending on the specific future years that are included in the calculation. In general, NPVs associated with Build Parking show their most favourable results when fewer years into the future are used and Full TDM performs better when the calculation includes more years into the future. The net present value of each is estimated using an assumed discount rate of 4% reflecting the fact that a given dollar cost or revenue incurred in the future is less impactful than that same cost or revenue incurred now.

[17] Note that the totals in the surplus-deficit column are not discounted to the present. In Figures 23 and 24, amounts are discounted at 4% for the NPV calculations. So the $848,000 surplus associated with the year 2025 translates into $563,778 when discounted back to 2015.

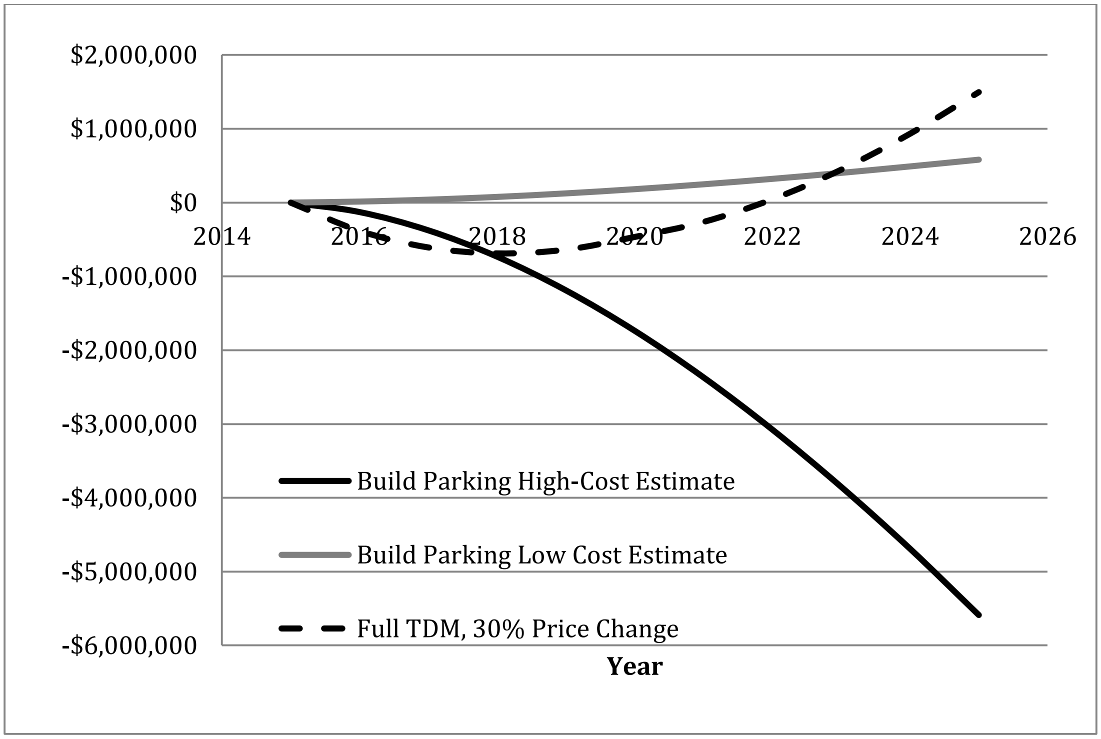

Figure 23. 2015 NPV by time span using 4% interest rate and $500,000 monthly parking revenue in 2015.

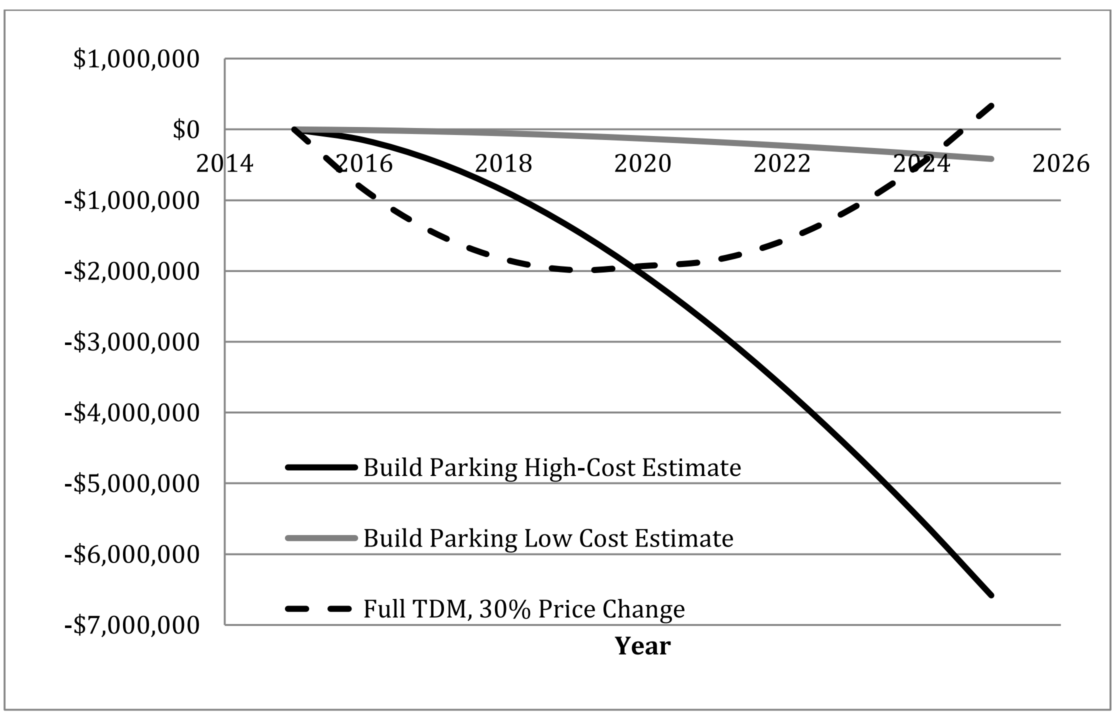

Figure 24. 2015 NPV by time span using 4% interest rate and $400,000 monthly parking revenue in 2015.

Three different scenarios are compared: the Full TDM Scenario, the Build Parking Scenario (using high cost assumptions) and the Build Parking Scenario (using low cost assumptions). Although the high-cost and low-cost Build Parking Scenarios are treated as different courses of action, they should be interpreted as the range of possible financial impacts of a single scenario: choosing to accommodate future travel demand by building more parking. As such, differences between these two capture uncertainty in the price of parking space construction and operating costs and should be interpreted simultaneously.

The sensitivity of the relative financial impact of each of the scenarios are compared with respect to the current monthly revenues from McMaster Parking Services (values used are $400,000 or $500,000 per month). Cumulative net present value is estimated for each of the Build Parking Scenario, High-Cost Estimate; the Build Parking Scenario, Low-Cost Estimate; and the Full TDM Scenario under different assumptions about parking revenues.

Important observations that can be made based on a comparison of Figure 23 and Figure 24 are as follows:

- The high-cost parking scenario is unfavourable regardless of what time periods are included and what assumption is made about parking revenue
- At $500K monthly revenue the build parking scenario always yields positive NPVs whereas at $400K it always yields negative NPVs
- The full TDM scenario is always in a net negative position when only the earlier years are included in the calculation but this net negative is much worse at the lower $400K per month parking revenues.
- At $500K parking revenue per month, the full TDM begins to outperform the Build Parking scenario when years including and beyond 2023 are included in the NPV calculation. More years have to be included for full TDM to pay off with $400K revenues.

In sum, the Full TDM Scenario always outperforms the High-Cost Build Parking Scenarios and outperforms even the most optimistic financial impact of the Build Parking Scenarios if we look far enough into the future. While the most optimistic assumptions for the Build Parking Scenarios are competitive over the short-term, the per year benefits of the Full TDM Scenario are significant between 2019 and 2025. The positive results for TDM in those years eventually overcome the annual deficits from the earlier years.

5

Recommendations

Travel demand management at McMaster University hinges on a multimodal approach which focuses on balancing core university priorities, finite resources, and a moral responsibility to lead in environmental sustainability. While much has already been done to encourage non-auto modes among students, the existing policy environment continues to encourage auto use among faculty and staff (e.g. for some lots monthly parking is no more than half the cost of a monthly transit pass), so effectively managing travel demand growth relies on reorienting incentives and improving alternate services. Quantitative statistical models used to forecast future parking demand and qualitative public input from McMaster University faculty, staff, and students both highlight the key role of maintaining high-quality services for the automobile while focusing the majority of the effort on improving transit, walking, and bicycling services.

The primary alternate option to travel demand management, significantly expanding parking supply, is both financially more costly, consumes more natural land, and would change the character of the McMaster community. Embracing existing mode shares and accommodating existing parking demand into the future would entail 20% more vehicle trips than currently. In comparison, with the recommended Full Travel Demand Management Alternative (modest improvements in transit and active modes), a 30% real increase in the price of parking prices, and a 30% real decrease in the price of transit, university parking demand is expected to remain flat into the future. In short, at stake are a 20% difference in auto mode share, a 30% difference in parking capacity, and the difference between a more financially sound program under the recommended Full TDM Alternative and a likely budget deficit under most assumed conditions for the Build Parking Alternative. To implement such a vision, several steps are necessary.

5.1.1 Institution

First, Parking Services should be renamed Transportation Services. Current travel demand management efforts are coordinated from within the division and its name and official mandate should be adjusted to formalize this new role: providing transportation services, not just parking.

Second, a TDM staff member should be hired under newly named McMaster Transportation Services to focus on the day-to-day operations of the TDM program. The cost for the staff member and associated marketing budget might total $100,000 in early years but be ramped up to $200,000 in later years. In these later years the TDM staff position might be replaced by a TDM Manager to direct implementation. In each year an approximate $200,000 budget for capital improvements to pedestrian, bicycling, or transit-supportive services could be defined. This approach as described is what has been used in the Net Present Value Scenario calculations of Section 4.4.3 of this report.

By institutionalizing travel demand management within the core responsibilities of the Transportation Services division, this will be a sustained focus on managing auto services, providing transport alternatives, and adjusting policies to changing contexts.

5.1.2 Project Recommendations

The reconfigured Transportation Services team should engage in three specific projects:

- Coordinate with the City of Hamilton and Hamilton Street Railway to secure a) 30% faculty and staff transit discounts and b) transit service improvements.
- Implement 30% real increases in parking prices on campus (which need to be adjusted for inflation). Assuming a 1.5% normal rate of inflation, the nominal price of parking would go up by just over 50% in total[18], or 4.2% annually[19].

18 0.51 = 1.015^10 * 1.3 – 1

19 0.042 = 1.51^(1/10)-1

- Establish regular procedures for discussing TDM policies, efforts, and sources of financial support from the City of Hamilton, Metrolinx, and Hamilton Street Rail.

As is consistent with the philosophy of TDM, the primary focus in this report has been on the benefits to be gained from moving people from single vehicle occupancy travel to other modes such as transit, walking, cycling and carpooling. Due to the specific circumstances of many McMaster commuters, however, there will remain a large share of travelers who are dependent on single occupancy vehicle travel. Given that preservation of the environment is one of the important elements of a McMaster TDM plan, we recommend that the University should encourage the transition to zero-emission vehicles to help reduce the impact of the remaining large numbers of single-occupant vehicles travelling to the campus. Commuters who travel in zero-emission or plug-in hybrid vehicles could be entitled to preferred parking locations and/or rates. Such incentives may accelerate the adoption of clean vehicles by the McMaster Community.

5.1.3 Infrastructure

As the approach of travel demand management represents a minimalist approach to infrastructure construction, infrastructure construction should follow the following recommendations:

- Constrain parking supply to current levels. As a principle, refrain from adding parking supply.
- Improve pedestrian sidewalks and crosswalks to improve pedestrian safety.
- Provide bicycle lanes and identify design improvements which can create a safer setting for bicyclists from motorists; safety is paramount.
- Add bicycle racks and storage facilities - particularly at McMaster Innovation Park.
- Identify how and where bicycle riders can access showers and change rooms to enable the full cycling experience to meet the needs of users.
- Although construction of the proposed Hamilton Light Rail Transit line on Main Street West is expected to be funded by Metrolinx, the project should be supported to identify how to generate the highest transit service benefits on campus.

5.1.4 Information and Marketing

The travel demand management program should engage in a multi-directional information and marketing campaign to encourage TDM. Information should follow the following trajectories:

<u>TDM Program to User</u> - Regularly communicate the key objectives of the travel demand management plan to inform McMaster University faculty, staff, and students on project goals

and objectives. Moreover, insofar that the peak travel periods are constrained to very specific times, information should be communicated to users on the nature of these most intense travel period and potential solutions should be suggested.

User to TDM Program - Regularly solicit direct input into the TDM process from members of the McMaster University community. Hearing from transportation system users in an open dialogue is critical to filling transportation service gaps which otherwise may never be identified.

User-to-User - Identify student-led competitions or collaborations which could encourage better real-time information sharing. For example, almost ten percent of users used a different mode to depart from campus than how they arrived - implying the potential for on-the-fly carpooling. Incentivizing students to create Apps or other platforms for information sharing could represent low-cost, high-yield actions.

McMaster Management to McMaster Management - identify, evaluate, and strengthen information sharing procedures regarding large events or travel patterns which could influence TDM program management.

5.1.5 Evaluation

Regularly monitor parking demand and travel choices to McMaster University using formal and informal techniques. While parking utilization can be formally monitored continuously through the office of the TDM Manager, formal travel surveys should be conducted every five years to identify significant changes in McMaster University transportation system user choices and experiences. Likewise, the TDM Manager should regularly engage members of the McMaster community to evaluate how transportation services are meeting the needs of users.

6

Appendices

6.1 References

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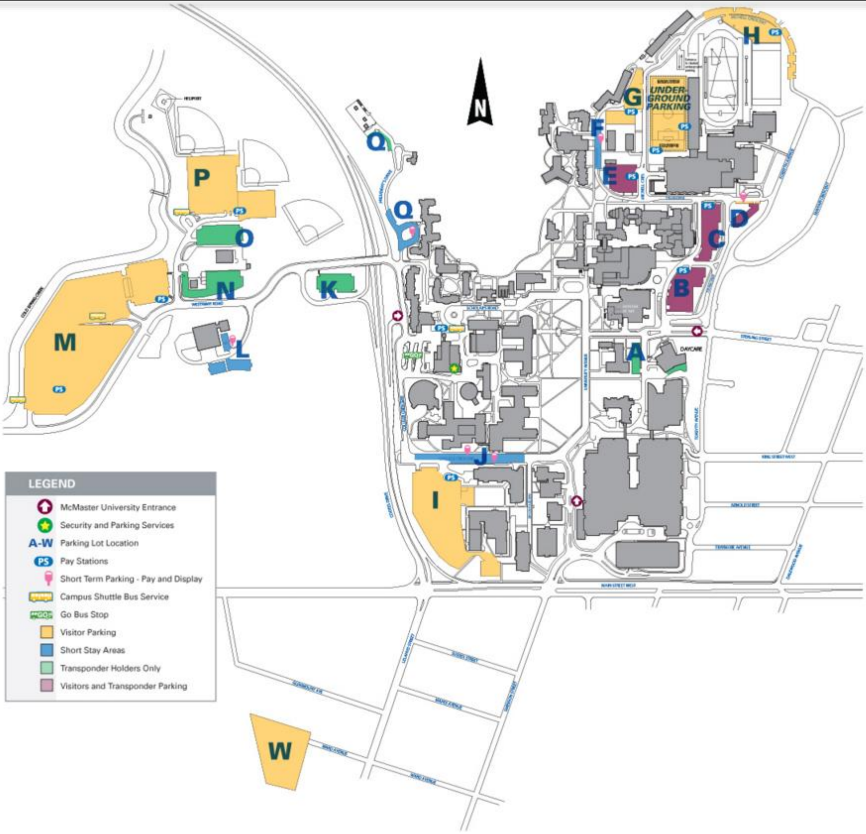
6.2 Travel Survey Questions



What would you choose for regular commuting given the following options?

	Auto	Auto	Auto	Walk or Bike	Transit
Travel Time	12 min	12 min	12 min	1 hour 20 min	46 min
Monthly Price	$46	$86	$56	$0	$0
Shuttle	Shuttle bus to Main Campus (every 5min)	n/a	Shuttle bus to Main Campus (every 15min; 6-10am and 3pm-8pm)	n/a	n/a
Lot	West Campus (Lots M, N, O or P)	Main Campus: Stadium Underground	Ward	n/a	n/a
	●	●	●	●	●

Figure 25. Example Stated Preferences Question from the 2015 Travel Survey

6.3 Survey Respondent Results

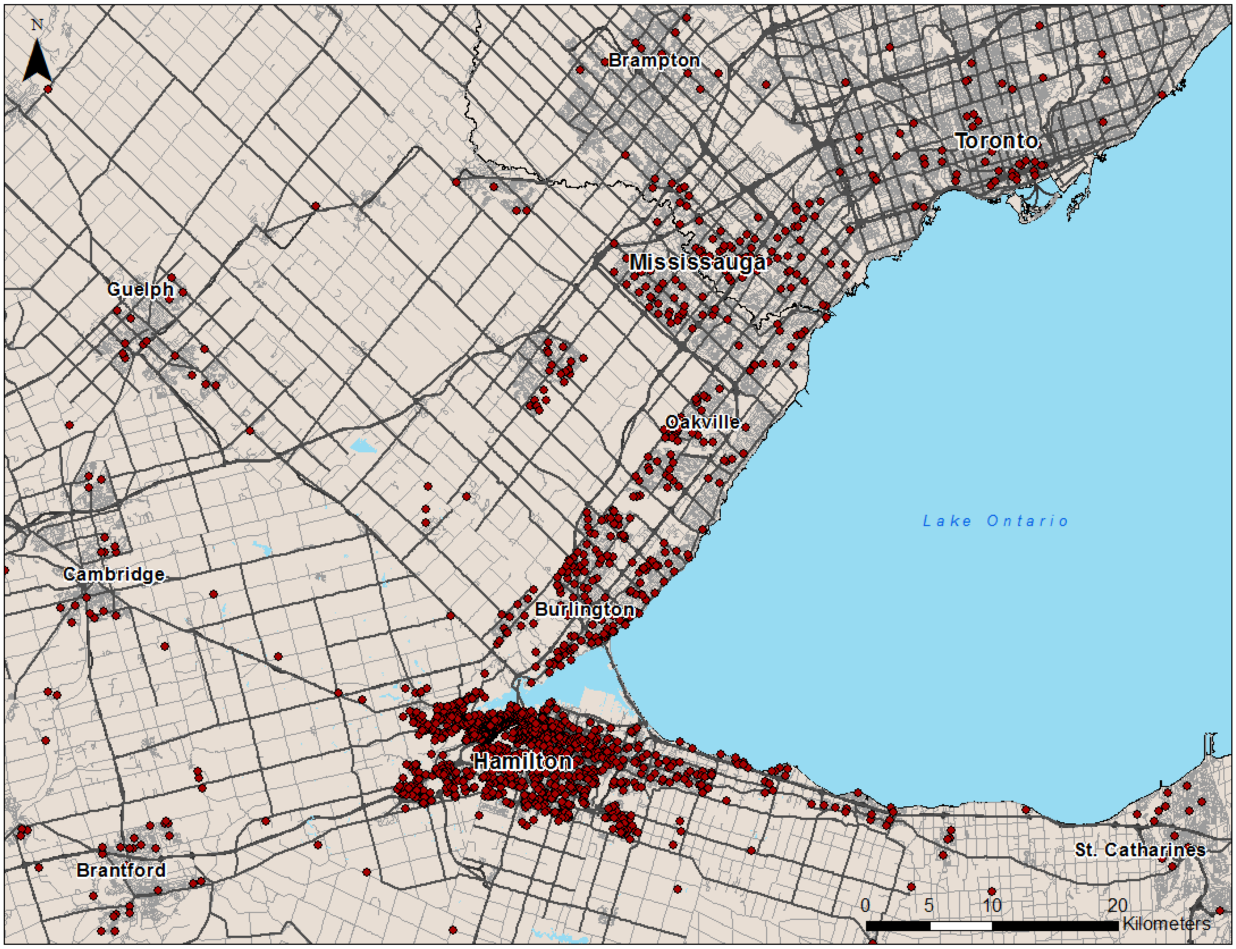


Figure 26. Where the student, staff and faculty survey respondents live

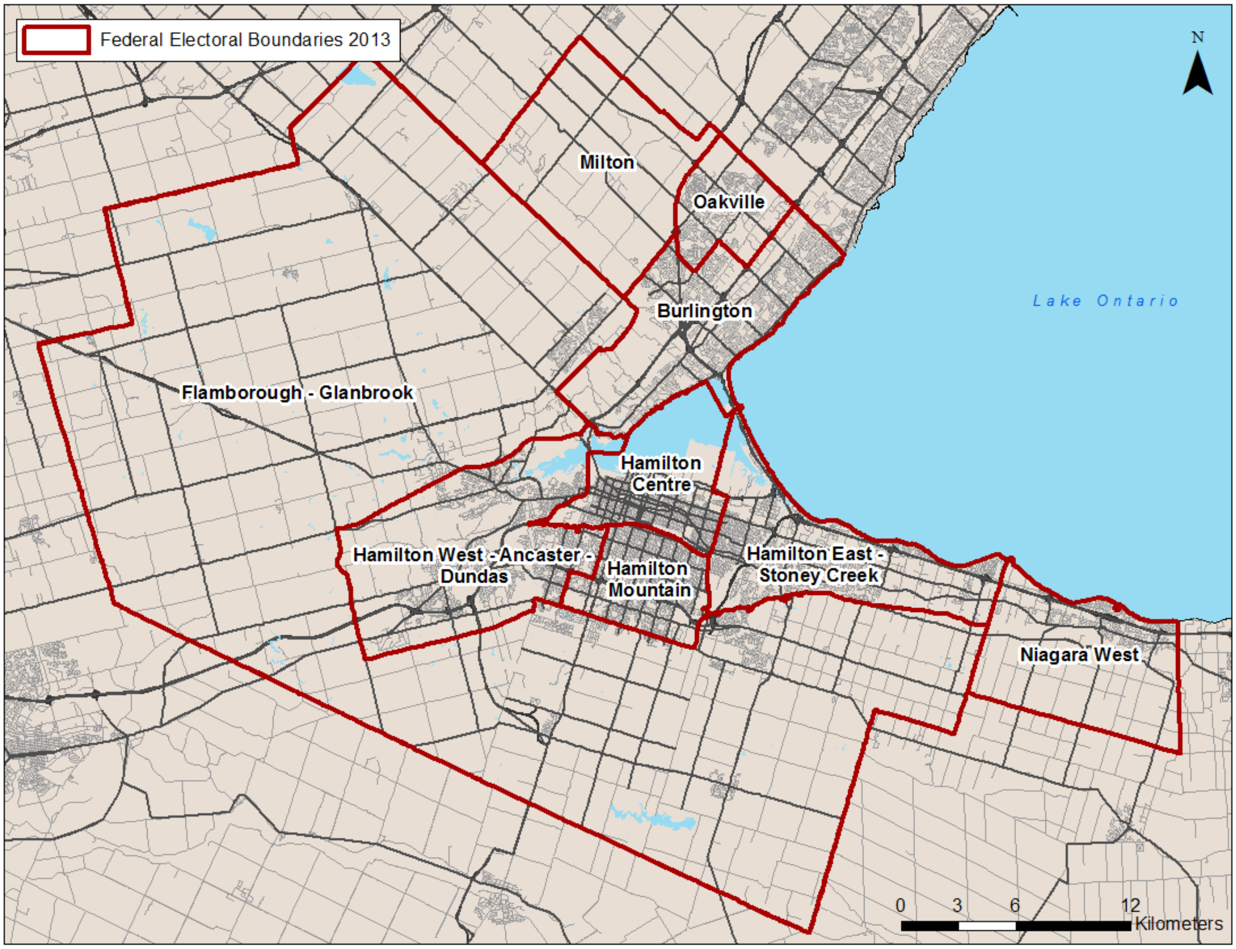


Figure 27. Hamilton Census Metropolitan Area Federal Electoral Boundaries (2013) that were used to describe which areas of Hamilton the survey respondents reside in

Table 21. The origins of the McMaster Main Campus Commuters

Federal Electoral Boundary	Commuters to McMaster Main Campus	
	Number of Students	Number of Faculty/Staff
Beaches - East York	1	
Brampton Centre	2	
Brampton East	3	
Brampton North	5	1
Brampton South	4	
Brantford - Brant	9	26
Burlington	47	45
Cambridge	7	10
Davenport		2
Don Valley East	1	
Don Valley North	2	
Don Valley West	2	

Dufferin - Caledon		1
Eglinton - Lawrence	4	
Etobicoke Centre	4	
Etobicoke - Lakeshore	2	1
Etobicoke North	1	
Flamborough - Glanbrook	74	50
Guelph	6	6
Haldimand - Norfolk	9	23
Hamilton Mountain	91	74
Hamilton Centre	171	123
Hamilton East - Stoney Creek	55	38
Hamilton West - Ancaster - Dundas	745	239
Humber River - Black Creek	1	
King - Vaughan	1	1
Kitchener Centre	3	1
Kitchener - Conestoga	2	3
Kitchener South - Hespeler	2	2
London Centre North	1	1
Markham - Stouffville	1	
Markham - Unionville	1	1
Milton	18	4
Mississauga Centre	23	2
Mississauga - Erin Mills	18	
Mississauga East - Cooksville	16	1
Mississauga - Lakeshore	12	6
Mississauga - Malton	16	
Mississauga - Streetsville	15	1
Niagara Falls	1	1
Niagara - Centre	2	
Niagara - West	15	18
Oakville	19	5
Oakville North	35	20
Oxford	4	1
Parkdale - High Park	1	5
Peterborough - Kawartha	1	
Pickering - Uxbridge		1
Richmond Hill	1	
Scarborough - Agincourt		1
Scarborough - Guildwood	1	
Scarborough Southwest	1	
Spadina - Fort York	6	3

St. Catharines	3	6
Thornhill	2	
Toronto Centre	3	1
Toronto - St. Paul's	1	2
University - Rosedale	3	
Vaughan - Woodbridge	1	
Waterloo	2	
Wellington - Halton Hills	5	3
Whitby	1	1
Willowdale		1
York - Simcoe	2	
York South - Weston		2

6.4 Mode Choice Model Results Using Revealed Preference

Table 22. Student Mode Choice Results (Multinomial Logit; Drive Alone is the reference alternative)

	Driving, SOV		Walking		Transit		Carpool		Bicycling	
Explanatory Variable	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.
Intercept	n/a		-0.94	0.937	-6.26	0.201	-4.61	0.101	1.997	0.782
Number of Transfers	n/a		0.079	0.672	-0.46	0.061	0.036	0.692	-0.35	0.284
Sex: Female Status	n/a		-1.14	0.025	-0.97	0.011	0.211	0.427	-2.03	0
Respondent Age (ln)	n/a									
Mode-Specific Travel Time (ln)	1.75	0.03	8.303	0.002	7.468	0.001	1.456	0.112	1.346	0.423
Mode-Specific Travel Time Squared (ln)	-0.66	0	-1.79	0	-1.25	0	-0.61	0.002	-0.56	0.039
Parking Permit (binary)	n/a		-2.98	0	-5.03	0	-1.34	0	-2.98	0.999
Vehicle Ownership (binary)	n/a		1.496	0.254	-1.84	0.002	0.607	0.451	-1.69	0.025
Bike Ownership (binary)	n/a		-0.17	0.508	-0.27	0.178	-0.23	0.36	4.038	0
Days on Campus	n/a		-0.05	0.896	0.604	0.021	0.255	0.2	-0.22	0.455
Job Density (ln)	n/a		-1.41	0.643	-1.87	0.032	0.535	0.46	0.319	0.857
Job Density Squared (ln)	n/a		0.12	0.556	0.174	0.006	-0.03	0.616	0.009	0.939
Household Size (ln)	n/a		-0.22	0.318	0.1	0.498	0.089	0.363	0.382	0.037
N = 1480 students										

McFadden R-Squared: 0.419

Table 23. Faculty and Staff Mode Choice Results (Multinomial Logit; Drive Alone is Reference)

	Driving, SOV		Walking		Transit		Carpool		Bicycling	
Explanatory Variable	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.
Intercept	n/a		-10.6	0.296	4.378	0.054	2.207	0.364	-8.36	0.485
Number of Transfers	n/a		-0.36	0.03	-0.25	0.015	0.074	0.375	-0.81	0.05
Sex: Female Status	n/a		omitted							
Respondent Age (ln)	n/a		-0.07	0.018	-0.05	0.001	-0.03	0.085	-0.11	0.041
Mode-Specific Travel Time (ln)	2.721	0	-1.35	0.017	2.189	0	2.225	0.004	1.748	0.05
Mode-Specific Travel Time Squared (ln)	-0.45	0.001	0.071	0.322	-0.33	0	-0.46	0.003	-0.26	0.067
Parking Permit (binary)	n/a		-2.94	0	-3.71	0	-0.86	0.001	-2.94	0.999
Vehicle Ownership (binary)	n/a		-2.34	0	-2.65	0	-1.44	0.01	-2.97	0
Bike Ownership (binary)	n/a		omitted							
Days on Campus	n/a		0.674	0	0.391	0	0.195	0.091	0.298	0.222
Job Density (ln)	n/a		5.994	0.027	-0.7	0.25	-0.23	0.74	3.018	0.33
Job Density Squared (ln)	n/a		-0.44	0.02	0.076	0.098	0.018	0.731	-0.22	0.309
Household Size (ln)	n/a		-0.47	0.013	0.17	0.014	0.174	0.036	-0.89	0.034
N = 676 faculty and staff members										
McFadden R-Squared: 0.420										

6.5 Mode Choice Model Results Using Stated Preferences

Table 24. Student Mode Choice Results Using Stated Preference Data (Active Transportation is the reference alternative)

	Active Transportation		Drive & Park West Campus		Drive & Park at Stadium		Drive & Park at Ward		Transit	
Explanatory Variable	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.
Intercept	n/a		25.90	0.12	20.67	0.22	20.38	0.23	15.34	0.37
Price (ln)	n/a		-3.37	0.00	-3.37	0.00	-3.37	0.00	-3.37	0.00
Age (ln)	n/a		2.00	0.32	1.76	0.39	3.65	0.08	0.67	0.75
Travel time (ln)	-3.34	0.52	1.98	0.00	3.11	0.00	-1.20	0.15	-3.77	0.03
Travel time (ln) squared	0.28	0.60	-0.28	0.09	-0.64	0.00	0.41	0.04	0.38	0.08
Household members <15	n/a		-1.92	0.03	-1.19	0.18	0.16	0.86	-1.41	0.13
On Main Campus (dummy)	n/a		-1.72	0.01	-1.65	0.02	-0.37	0.62	-1.35	0.08
Days on Campus	n/a		0.52	0.05	0.46	0.11	0.97	0.00	1.61	0.00
Residential Density (ln)	n/a		-4.98	0.13	-2.78	0.40	-5.79	0.08	-8.75	0.01
Resid. Density (ln) squared	n/a		0.43	0.11	0.26	0.34	0.51	0.06	0.75	0.01
Household Size	n/a		0.27	0.70	-0.18	0.80	-0.24	0.75	0.48	0.50
			N = 176 students; 8 questions each; 5 potential alternatives each							
			McFadden R-Squared: 0.167							

* Preferred models do not attribute price as alternative specific and instead reflect the average price sensitivity.

Table 25. Faculty and Staff Mode Choice Results Using Stated Preference Data (Active Transportation is Reference)

	Active Transport		Drive & Park West Campus		Drive & Park at Main Campus		Transit	
Explanatory Variable		n/a	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.
Intercept		n/a	5.89	0.18	13.46	0.00	-8.58	0.29
Price (ln)		n/a	-0.31	0.00	-0.31	0.00	-0.31	0.00
Price (ln) squared		n/a	-0.22	0.00	-0.22	0.00	-0.22	0.00
Age (ln)		n/a	-3.35	0.00	-3.81	0.00	-4.02	0.00
Travel time (ln)	-2.07	0.30	3.52	0.17	0.08	0.98	12.61	0.01
Travel time (ln) squared	-0.02	0.92	-0.98	0.06	-0.37	0.47	-2.05	0.00
Household members <15		n/a	omitted					
On Main Campus, South (dummy)		n/a	-0.19	0.77	-0.15	0.82	1.08	0.13
On Main Campus, North (dummy)		n/a	-0.55	0.25	-1.22	0.01	-0.37	0.50
Days on Campus		n/a	-0.78	0.01	-0.75	0.02	-1.20	0.00
Residential Density (ln)		n/a	omitted					
Resid. Density (ln) squared		n/a	omitted					
Household Size		n/a	1.37	0.01	1.33	0.01	1.88	0.00
N = 172 faculty and staff; 8 questions each; 4 potential alternatives each								
McFadden R-Squared: 0.130								

* Preferred models do not attribute price as alternative specific and instead reflect the average price sensitivity.

6.6 Specific Comments from Public Involvement Event (January 20, 2015)

The following bullet points characterize information written on maps and diagrams of McMaster University and its vicinity which were provided to participants of the January 20, 2015 public involvement forum.

6.6.1 Biking

- Adding bike lanes/widen sidewalks on Main St.
- East downtown → McMaster, Charlton → Aberdeen → Rail Trail → McMaster – good scenic routes but minimal bike lanes
- More bike racks at MIP – they get full in the summer
- Dangerous dip in road for cyclists on Osler before it turns into Main St.
- York/Queen is a tough intersection to navigate on a bike – cars don't like you there
- Hectic for biking – connecting Cannon to McMaster
- At Paradise and King – terrible transition when traveling east attempting to get to bidirectional path
- Dangerous timing and blind spots at Main and Emerson McMaster entrance
- Forsyth and King St. – hard to navigate on a bike, lots of cars turning
- Some covered bike racks would be nice for rain/snow
- Parking hut on Sterling St. entering McMaster creates blind spot
- Impact of Mills bike library
- Sterling St. entrance – bike lane ends entering campus and very tricky transition with cars turning/terrible surface – conflicts with buses, cars and pedestrians
- Biking lanes should be widened leading into McMaster (near Sterling)
- More bike racks needed at either end of the student center
- Space for cycling clothes storage – need space for winter riders without offices
- Improved lighting along Scholars Road (on campus)
- Better security in front of BSB, JHE – video recorders – bike was stolen
- SoBi bikes near west parking lots?
- King's Walk – no proper way to get in or out on bike: awkward interactions with cars
- There is a sign near LSB saying "walk bikes". Why? No one obeys…why not "cyclists yield to pedestrians"
- Sterling Gate – bike lanes going west leaves cyclists to right of traffic going to parking lots – cyclists need to be on the left
- Sterling Gate – place for a bike storage facility?
- Sterling Gate – leaving campus the bike lane aligns with the right-turn lane
- Bike racks – too few, too tight, often bordering muddy earth, overall message: a half-assed attempt
- Bike repair: pump station is a great idea, but pump has never worked and it flattens tires, and is also far away if you live in residence and have a flat tire
- CO-OP – not many people know where it is
- Sterling St. into campus is confusing for cyclists – going around into lot or straight into campus
- Ward 1 used to have winter maintenance but not sure if it does anymore?
- Some buildings don't have as many bike racks as others

- Sanders Blvd – people not following bike rules: correct side of street, stopping at stop signs, wearing black and headphones and no light at night – I think there needs to be more education
- Sanders Blvd – people walking in bike lanes on this street

6.6.2 Walking

- Sidewalk curb too high off the road at Westaway Rd bridge
- Walking path off of Grant Blvd could be improved to facilitate walking from this area
- Crossing Main St. at Westbourne/Rifle Range Rd is really scary
- Love the green spaces on campus, places to sit and hangout
- Getting from TSH to Sterling means going through two parking lots

6.6.3 Driving

- Baseball diamonds – car windshields – not always a good combination – lack of cameras and protection - $500 repair
- Designated parking for hybrids, plug-in hybrids, battery-electric?
- Explore.smartcommute.ca
- Carpool for students?
- More consistent shuttle service
- Reduce untreated waterflow into creeks
- Changes to make 30m buffer from creek
- Create a path from lot P across baseball fields to path next to Cootes Drive and then onto campus instead of having to walk down to Westaway Rd and then over
- Decrease speed on Cootes – turtles/wildlife crossing
- Valuing the restoration of ecologically sensitive areas affected by urbanization – Ancaster Creek – Lot M buffer restoration
- People need to stop for cars in front of DBAC
- Getting to underground stadium parking from Sterling and University is a grey-hair inducing event

6.6.4 Public Transit

- 5c Meadowlands is always packed at Sterling and University. The drivers only let people on who are going to Ancaster even though the bus goes through the same route as the 51.
- It seems there are fewer buses heading west from campus than there are heading east
- When is the bus coming? No know knows? GPS tracking for live times?
- Transit from the mountain is long
- Do not feel safe taking the bus at night
- More express buses – fewer stops
- But what if there is no express busway stop near my house? Is convenience more important than travel time?
- Unreliable buses leave early, easily miss bus because you get there on time
- Mountain car park with shuttle to McMaster

- More creativity in bus aesthetics, not just advertising – Art? Less decals on windows to see out window
- No bus lane unless it's absolutely needed (LRT)
- Heaters in bus shelters
- LRT! Merging west and east Hamilton
- Infrequent north-south service
- Nicer employees
- Reduced HSR pass for faculty and staff – monthly parking pass about the same price as a bus pass
- Sterling and University Ave – only one bus shelter on the south side – need one on the north side
- Lack of data – not recording student ridership – only flash student card
- Dundas – very close to campus, fewer students in the area because of limited housing. Should have a shuttle to and from Dundas downtown to campus
- Dundas – HSR route from there is not direct, (ie. Cootes Dr.) and Main St. bus is crowded
- Electric clean bus given environmental concerns in Cootes
- Real-time bus data
- More B-line service after 7pm
- Increase HSR transfer time → currently 2 hours
- People not taking the right bus for their destination and crowding other bus routes
- Reduced service during off peak hours – what about the students with night classes or work evenings?
- Sitting next to someone with a cold, people with strollers not sitting in correct seats
- Mac-Mohawk shuttle for joint programs
- Bigger/warmer bus stops
- People not utilizing buses correctly – not moving back, people not sitting down, taking their backpacks off
- Debit tap machines at pay shelters – the machines are too slow right now especially when you have to wait in the cold
- HSR running hours don't accommodate evening work – city of Toronto Blueline