How can we alter our carbon footprint?
Estimating GHG emissions based on travel survey information

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ABSTRACT

The City of Montreal has taken recent initiatives to significantly reduce overall GHG emissions from the transport sector, and is making large investments in alternative transportation. In light of these recent plans, this study identifies with two objectives:

- First, to generate a clear methodology for estimating total GHG emissions generated by commuters to McGill University's downtown campus, and
- Secondly, to better understand who, how, and when each commuter to McGill generat.es travel-related GHG.

Mode split, distances, age, gender and status were uncovered by a 2011 travel survey that we conducted across the University, from which daily individual GHG emissions are estimated.

INTRODUCTION

McGill University has 32,900 commuters traveling to the downtown campus every day. In an effort to capture the travel behavior of the McGill population, an online travel survey was designed and administered to approximately 19,662 McGill employees and students, with a 5,016 (25%) response rate.

SURVEY DESCRIPTION

A large-scale online survey was conducted during the month of March and early April, 2011. The target population of the survey included all McGill students, staff, and faculty. The survey was also designed to capture differences in the respondents' transportation mode in winter and in fall. The survey asked respondents to:

- Describe their last trip to McGill.
- Indicate the postal code of their place of residence.
- Describe specific travel choices and trip "legs."
- To specify the train, metro or bus routes that were used.

After the data cleaning operations, a total of 4,362 entries were found to be suitable for use in calculating CO2 emissions. 1,038 (24%) indicated cycling or walking as the mode of their last commute, whereas 2,689 (62%) indicated public transit and 635 (14%) used a motorized vehicle. Of the public transit and car user entries, only 2,208 were complete and used for GHG emission calculations.

STUDY METHODOLOGY

Calculating travel-related GHG on a trip basis requires knowledge of the mode used to reach destination, speed, and distance traveled. GHG emissions are quantified only for the trip coming to the University but not for the trip back home.

- **Distances** - These were calculated using network analyst in a geographic information systems (GIS) environment. For individuals using a motorized vehicle, distances were modeled using the street centerline file, whereas transit trip distances were calculated based on the length of the specified metro, train or bus line using the transit network.
- **Speeds** - Car travel times were obtained from the Ministry of Transport Quebec (MTQ), based on origin-destination travel times derived from a travel demand model for all transportation analysis zones (TAZ) in the region. In this analysis, we used the travel time matrix for the morning peak period.
- **GHG Emission Factors** - Emission Factors for GHG were generated for each travel mode in grams of CO_2 equivalent per kilometer per passenger dependent on speed and vehicle type. The values for transit were based on the average speed and occupancy reported by the regional transit authorities.
- **Expansion Factors** - Two expansion factors were derived by dividing the total number students and employees in each borough by the number of students and employees residing in this borough in our sample to estimate a total carbon footprint for the entire McGill community.
- **Discounting for actual trips** - In recognizing that the number of individuals who commute to McGill varies every day, the sample size was discounted to only those respondents who indicated a trip was made the day before the survey was completed. Once these individuals were filtered, we are left with 85% of the original sample size.

Table 1: Emission Factors for Motorized Vehicles and Transit

Mode Type	Speed (Km/hr)	Emission Factor (g/Km/person)	Source
Passenger Car	<=4 - 90	1170 – 180*	MOVES
SUV	<=4 - 90	1380 – 230*	MOVES
Hybrid vehicle	<=4 - 90	100*	MOVES
Metro	40	0	STM
Bus	18	40	STM
Train	80	80	AMT
McGill Shuttle	40	50	MOVES

* Assuming single occupancy

RESULTS AND DISCUSSION

We estimate that on a single winter day, commuters to McGill's downtown campus generate around 31.1 tons of CO2 equivalent on their travel to McGill. During the fall, this amount decreases to 29.5 tons of CO2 equivalent.

During the winter season, faculty and staff generate 16,230 kg of CO2, while students generate 14,790 kg of CO2. For a commute during the fall, these numbers shift to 15,305 kg of CO2 for faculty and staff, and 14,098 kg of CO2 for students. The values used in this section are derived directly from the survey sample, without any expansions.

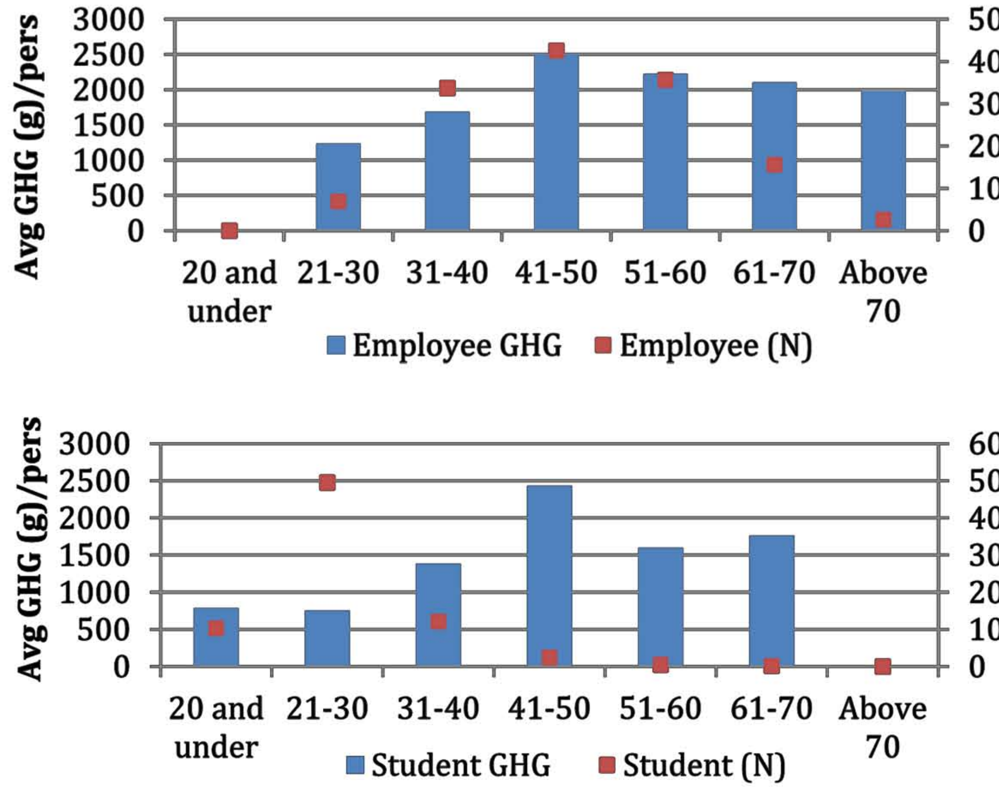

Figure 1: Average GHG for Employee/Student by age

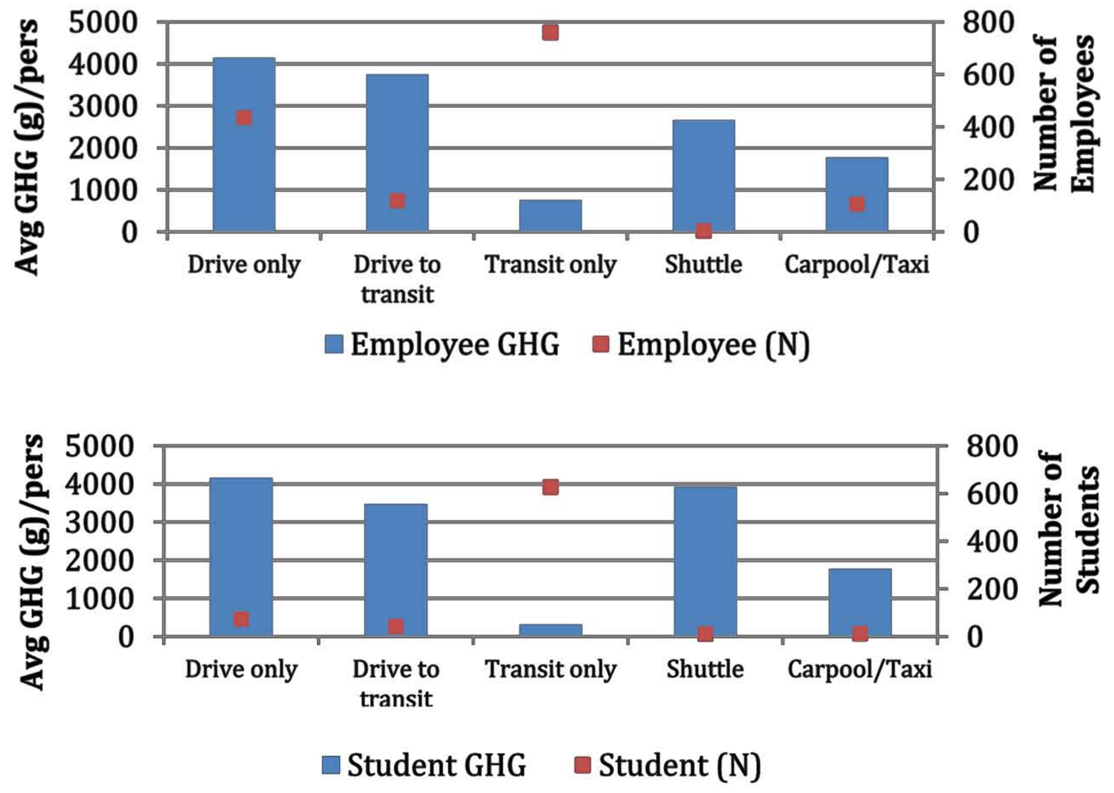

Figure 2: Average GHG for Employee/Student by mode split

EMISSION SCENARIOS

With a comprehensive understanding of who, how and when each individual generating emissions commutes to McGill, five alternative scenarios are presented.

- Base Case: Represents the average amount of CO2 that McGill commuters emit on a typical winter day, against which all further scenarios are compared against this average contribution.
- Scenario 1: Illustrates the potential emissions if all drivers, who indicated that they took transit at least once to reach McGill in the past year, switched to transit for their commute.
- Scenario 2: Represents viability, rather than irregularity. This scenario represents a shift towards modes that would either emit no CO2, or emit less CO2 than their original trip.
- Scenario 3: A combination of the opportunities from Scenario 1 (irregularity) and Scenario 2 (viability) are grouped together to represent a more comprehensive mode shift. This scenario is considered the best case in terms of a reduction in total CO2.
- Scenario 4: This scenario contrasts Scenario 3 by offering the worst outcome. This scenario assumes that if all survey respondents indicated they used a vehicle to commute from their home location to McGill's downtown campus in the past year.
- Scenario 5: This scenario models the emissions that would result if all commuters were required to be present on campus every day, highlighting the importance of flexibility in a work schedule.

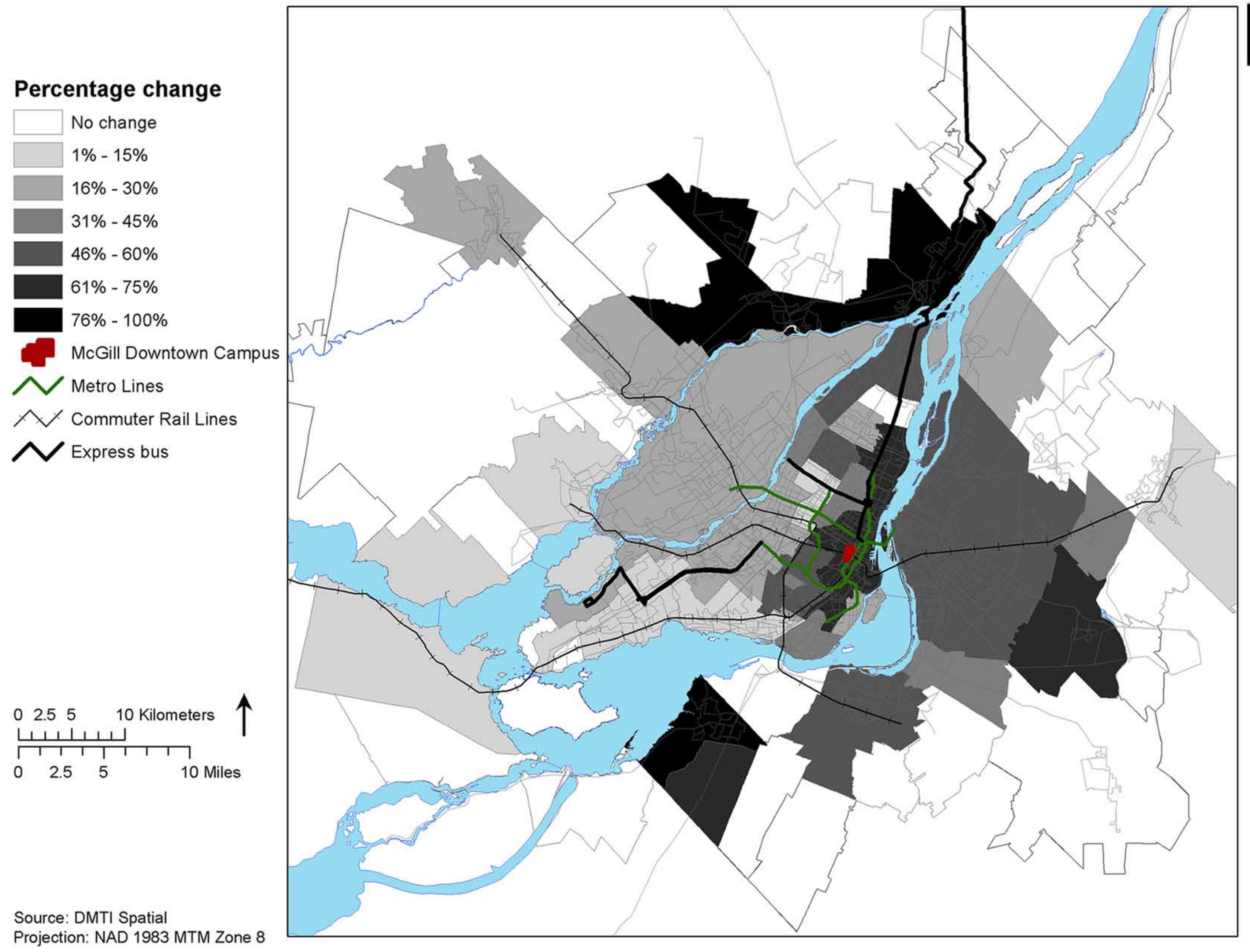

Figure 4: Percent change of emissions from Base Case to Scenario 3

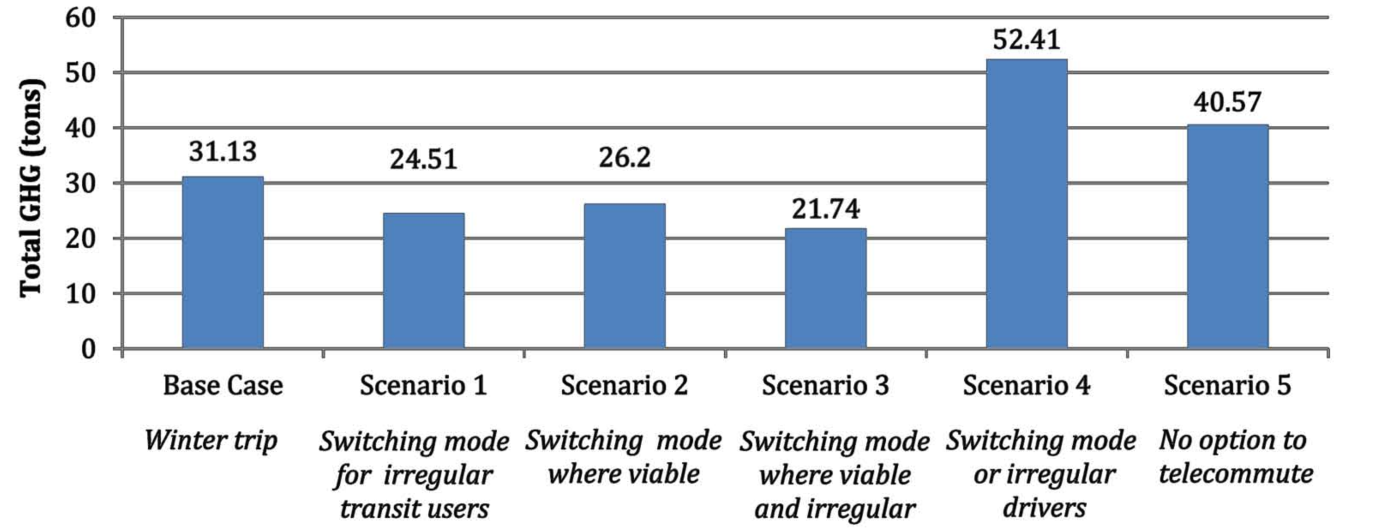

Figure 5: Total GHG (tons) by Scenario

CONCLUSION

The design of the survey allowed for certain pieces of information to be teased out: not only does this method involve multiple modes across a large sample region and individuals' sociodemographic characteristics, specific patterns such as seasonality help to further the analysis.

Scenarios were developed based on the analysis of the survey, and their implications are unique: they entail situations that could happen, and not necessarily what should or would happen.

Switching individuals from one mode to another was done by a careful evaluation of the opportunities present in the viability and irregularity of mode options. Although they represent reasonable alternatives, there are limitations to change.

The travel behavior of certain boroughs is resistant to mode shift, and regardless of these reasonable thresholds, not all individuals will take transit, or start cycling. Transit service and active transportation facilities will have to improve in order to attract riders to switch modes.

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