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Abbreviations and acronyms

ART	Auckland Regional Transport Model
BU	business trips
CBD	central business district
CTM	Christchurch Transport Model
CTS	Christchurch Study Transport Model
CV	commercial vehicle
DfT	Department for Transport, UK
DTLR	Department for Transport, Local Government and the Regions, UK
GDP	gross domestic product
HBEd	home-based education
HBO	home-based other
HBSh	home-based shopping
HBW	home-based work
HIS	household interview survey
ITE	Institute of Transport Engineers, United States
LCBD	lower central business district
LTSA	Land Transport Safety Authority (now NZ Transport Agency)
MoT	Ministry of Transport, New Zealand
MUA	main urban area
NHB	non-home-based
NTS	National Travel Survey
NZHTS	New Zealand Household Travel Survey
NZTA	New Zealand Transport Authority
RA	rural area
RTA	Road Transport Authority, Australia
SUA	secondary urban area
TDB	Trips Database Bureau, New Zealand
TDM	travel demand management
UCBD	upper central business district

Contents

Executive summary **7**

Abstract **9**

1 Introduction **11**

1.1 Background 11

1.2 Research objective 11

1.3 Report structure 12

2 Survey procedure **13**

2.1 Data description 13

2.2 Weights 14

2.3 Filters 15

2.4 Definitions of trips and purposes 15

3 Literature review **17**

3.1 Definition of trip chains and tours 17

3.2 Existing trip generation resources 19

3.3 Key trends established from international household travel surveys 21

3.4 Existing New Zealand strategic transport models 24

3.5 Vehicle ownership 29

3.6 Use of household travel surveys for predictive purposes 29

3.7 Summary 30

4 Trend analysis 2003–10 ..... **31**

4.1 Treatment of data 31

4.2 Change in trip rates over time 32

4.3 Changes in morning departure times 34

4.4 Mode split of trip chains 37

4.5 Trip chain complexity 45

4.6 Trip chain duration 50

4.7 Travel trends for all purposes 53

4.8 Home to education travel 54

5 Use of NZHTS data in a predictive context and other uses **61**

5.1 Household trip generation 61

5.2 Other uses for the NZHTS models 67

6 Discussion **75**

6.1 Trend analysis 75

6.2 Use of NZHTS data in a predictive context 79

6.3 Daily profiling 83

7 Summary and recommendations **84**

7.1 Changes in travel behaviour over time 84

7.2 Travel behaviours in relation to area type 84

7.3 Use of NZHTS data in a predictive context 85

7.4 Applications 86

7.5 Recommendations 87
8 References **89**
Appendix A: Daily travel profiles **92**

Executive summary

This research project extended the work presented in *NZ Transport Agency research report 353* 'National travel profiles part A: description of daily travel patterns' (Abley et al 2008), which assessed the trip leg patterns associated with the 2003–06 New Zealand Household Travel Survey (NZHTS). The earlier work has now been expanded with the inclusion of four more years of data, analysis of travel in terms of trip chains and analysis of travel behaviour on the basis of a wider range of area types that distinguish between main urban areas (MUAs) and the major MUAs of Auckland, Wellington and Canterbury.

The main objective of this research was to maximise the value of the travel information held within the NZHTS. This was done by examining changes in travel behaviour over time and identifying travel behaviours such as journey times, trip complexity, mode choice and trip generation rates particular to the area types tested. This report describes a method used to extract and arrange the NZHTS data into a series of interactive models found at www.abley.com/NZHTSmodels and at www.nzta.govt.nz/resources/research/reports/467/index.html. These allow practitioners to quickly undertake a range of enquiries based on user-specified variables such as car ownership and household compositions to reveal area-specific travel behaviours.

The use of the NZHTS data in a predictive manner was found to be limited for a range of reasons. A key limitation relates to the fact the data does not contain information that responds to issues affecting future travel choice such as improvements to public transport, direct changes to fuel prices, traffic congestion or the relative costs of transport modes. However the manner in which the data has been arranged provides a useful starting point for explaining current trip generation rates and travel behaviour in response to changes in demographic structures.

The research revealed that the following changes in travel behaviour had occurred between 2003 and 2010:

- There was some evidence that trips per household had declined over time.
- For the major MUAs of Wellington and Canterbury there was some indication that for the period between 2003 and 2010, commuters started their morning commute at an earlier time.
- There was no evidence that commuting distances were constantly increasing over time for the major MUAs in contrast with the other MUAs and SUAs, which did show consistent increases in commute distances over time.
- Trip durations for drivers in the major MUAs of Wellington and Canterbury had increased during the period tested.
- Trends showed marginal but consistent increases in vehicle driver mode share for the Auckland MUAs, while the opposite trend occurred in the Wellington MUAs with no consistent trends in vehicle mode share observed for the Canterbury MUA.
- There was no consistent pattern of change in trip complexity for the areas tested.
- The Auckland MUAs showed marginal decreases in commute distances over time.

The research revealed the following distinctions in travel behaviours for the different areas tested:

- Higher shares of public transport use were related to larger urban areas.

- The major MUA of Wellington had the highest proportion of travel from home to work and education by public transport and walking.
- The most complex trip chains were associated with travel by motorised forms of transport, particularly where public transport was used, with the least complex trip chains undertaken as walk trips.
- The major MUA of Wellington showed the highest amount of complex trip chains, which reflected high public transport use.
- The major MUAs showed higher vehicle driver journey times than the other main and secondary urban areas, indicating higher levels of congestion in the major centres.
- For pre-school and primary schools, the predominant mode of travel was as a vehicle passenger.
- Cycling to school, while representing a low proportion of trips, was most prevalent in secondary urban areas (SUAs).
- In the major MUA of Wellington, a quarter of all school-related travel was undertaken by bus, which was almost double that of the major MUAs of Auckland and Canterbury.
- The variability in mode splits between the areas tested was greatest for non-car-owning households.

Applications

Through the course of this research several new applications of the NZHTS data were identified, including the development of a school trip generation model and a household person trip generation model providing a first-cut estimate of person trip rates to a range of destination activities. The NZHTS data can also be used to profile travel movements by mode throughout the day enabling public transport service providers to plan services around times of peak demand and assisting transport demand management (TDM) measures to be directed towards specific road user groups. The findings of this report can also be used to test a number of conventional wisdoms associated with travel behaviours.

Recommendations

In increasing the value of the NZHTS while preserving the value of continuity within it, the following potential refinements have been proposed:

- Introduce an enquiry field that asks for reasons why a particular mode of travel was used for journey to work purposes or alternatively extend the question of parking availability to all transport mode users.
- Explore the potential for supplementary methods of data collection including smart phone applications that are capable of measuring travel for all transport modes with growing accuracy.
- Amend an existing question to gather journey purpose information from passengers as well as drivers to assist in determining vehicle occupancy levels.

Future work

An area that would merit further investigation when more data has been collected is public transport transfer times between trip segments. Such work could reveal transfer penalties and assist public transport service providers in planning for services that rely upon a series of transfer points to provide service coverage over a wider area. In addition travel behaviour associated with food and non-food shopping may be significantly different therefore further refinement of the shopping journey purpose may add additional understanding of shopping trips. Where more data becomes available the models established in this research can be expanded to include more journey purposes.

Abstract

Using data held within the New Zealand Household Travel Survey (NZHTS), this research examined changes in travel behaviour between 2003 and 2010 and sought to determine whether travel behaviours such as journey times, mode choice, trip complexity and trip generation rates differed by area type and region. A key aim of the research was to unlock further value from the data for the benefit of transport planners and engineers. The research explored the extent to which NZHTS data could be used in a predictive context and examined a method to extract and arrange the NZHTS data into a form that would allow practitioners to quickly undertake a range of enquiries based on user-specified variables such as car ownership and household compositions to reveal area-specific travel behaviours.

The research provided an additional reference source for policy makers by allowing them to view changes in travel behaviours over time that might be attributed, in part, to past and present transport policy. The research findings offer an addition to multi-modal trip generation resources for the benefit of traffic engineers and can also assist travel planning coordinators to achieve the most effective use of existing transport resources.

1 Introduction

1.1 Background

The New Zealand Household Travel Survey (NZHTS) is a series of travel surveys designed to provide a databank of personal travel information for New Zealand. It is part of a continuous survey that began in 2003 and is useful in enabling the identification of long-term travel trends. This databank will continue to be an important source of information for influencing government policies and monitoring transport and safety performances. The Ministry of Transport (MoT 2007) states 'the aim of this survey is to increase our understanding of travel behaviour by people in New Zealand, including travel by car as a driver or passenger, walking and cycling'. This research analysed NZHTS data recorded between 2003 and 2010.

The continuous survey ensures the availability of up-to-date travel data to formulate new transport and road safety policies. *NZ Transport Agency research report 353* 'National travel profiles part A: Description of daily travel patterns (Abley et al 2008) investigated travel behaviour from the NZHTS on a trip leg basis and recommended further work be undertaken to explore trends in travel behaviour using a larger data set, arranged in terms of trip chains and with further analysis on a regional basis.

1.2 Research objective

This report is an extension to *NZ Transport Agency research report 353*. The work undertaken in part A has been expanded by including four more years of data, and analysing travel in terms of trip chains and on the basis of more discrete areas of the nation. The main objective of this research was to maximise the value of the travel information held within the NZHTS database, by arranging the data into an accessible form which could be used for transportation and regional planning studies and research. In particular, an understanding of the predictors of travel demand by mode and purpose was sought for a range of variables including car ownership, region type, area type, year group and household composition.

The intention was, in examining the expected trip rates and mode of travel associated with these variables on a temporal basis, the capability of the NZHTS data to be used in a predictive context for transportation planning would be better understood.

The analysis included an examination of the changes in travel over time expressed in trip chains for a range of journey purposes and modes of travel. It also included a comparison of travel behaviours between different area types including the major urban areas within Wellington, Auckland and Canterbury regions as well as other main urban areas (MUAs), secondary urban areas (SUAs) and rural areas (RAs).

The travel behaviours examined included:

- changes in morning departure times
- modes splits for different journey purposes
- trip chain complexity
- trip chain durations
- travel associated with education purposes.

The information used within the research related to land use, travel mode and trip purpose relationships and in particular focused on person and vehicle trip generation at the household level.

The capability of the NZHTS to predict school travel in terms of mode choice and vehicle trip generation was also examined.

In exploring the predictive capability of the NZHTS data, limitations of the data were identified. This was intended to assist in highlighting the merits of arranging more targeted questions within the survey to enhance the value and benefit of future information while maintaining the basic structure of the survey to ensure comparability with its earlier versions.

As part of increasing awareness of transport issues and making such data more available to professionals, an output of the research was to arrange the NZHTS data into a form that could be made available electronically for the benefit of transport practitioners in the regions.

1.3 Report structure

The remainder of this report is structured as follows:

- Chapter 2 explains the NZHTS survey procedure and defines the terms of trip legs, trip purposes and trip chains.
- Chapter 3 considers the definition of trip chains as established elsewhere and describes existing trip generation sources. Aspects of New Zealand strategic transport models are also reported along with the key transport outputs from a small selection of household travel surveys undertaken elsewhere in the world.
- Chapter 4 examines differences and changes in travel behaviours occurring over time and between different area types such as major MUAs, other MUAs, SUAs and RAs. The different travel behaviours for a range of land uses explored include trip chaining behaviour, journey to work departure times, mode splits for different land uses and trip chain characteristics.
- Chapter 5 explores the use of the NZHTS in a predictive context and examines the use of different trip production variables such as household type and car ownership for a range of area groupings. This section also explores the potential use of the NZHTS data as a trip generation model for educational activities.
- Chapter 6 provides a discussion of the trend analysis and the outputs of the NZHTS models introduced in the previous section.
- Chapter 7 summarises our conclusions and provides recommendations for the application of our findings and potential further research.

2 Survey procedure

The NZHTS dataset analysed in this report includes travel by approximately 40,000 people from some 22,000 households in sample areas throughout New Zealand between 2003 and 2010. The NZHTS is administered through an independent contract on behalf of the Ministry of Transport (MoT).

Households are selected and an initial letter is sent from the MoT to each household together with a pamphlet briefly describing the aims and content of the survey. The interviewer then calls at the address to gather household information, explain the purpose of the survey, and inform the household which 'travel days' should be diarised. The 'travel days' are collected as a 48-hour sample for which the household records all travel. An even spread by day of week is maintained by systematic allocation of travel days. The survey includes trips beginning between 4am on the first day to 3.59am on the third day. A memory jogger is left with the respondents to use for recording travel. Participation in the survey is voluntary.

The households to be sampled are drawn from within randomly selected census meshblocks. Over a five to seven year period every household within the meshblock will be invited to participate in the survey; after which a new meshblock will be selected for sampling.

Strategic transport models reflect the expected level of mode change in response to a number of factors. While the ability of the NZHTS data to be used in a predictive context is limited, there is value in providing a readily accessible opportunity for people without access to such models to undertake their own analysis or scenario testing through the models that have been developed as part of this research. The arrangement of the NZHTS data undertaken as part of this study allows for some limited scenario testing that provides a starting point for explaining travel behaviour in response to changes in demographic structures. NZHTS methodology can be found on the MoT website: www.transport.govt.nz/research/Pages/TravelSurvey-Method.aspx.

2.1 Data description

This research relied on household travel surveys undertaken in 14 local government areas within New Zealand. Between July 2003 and June 2010, 40,160 people from 21,587 households were interviewed. The data supplied by the MoT was dated 25 February 2011. In general, the collected data was divided into the categories shown in table 2.1. This research project only focused on analysing household, person and trip data to achieve the stated objectives. The variables supplied by the MoT can be found in the downloads section of the MoT website: www.transport.govt.nz/research/Pages/TravelSurvey-Method.aspx.

Table 2.1 Main data categories and descriptions

Main data category	Description
Household	Details about the household and its response to the survey
Person	Details about people in the household (information such as age, sex, driving/cycling experience, accident totals, occupation, income, driving, work and school locations)
Trip	Purpose, mode, destination, date, time, duration and distance of each trip leg, and vehicle information
Vehicle	Type, make, model, year, engine size and owner information for vehicles driven during the survey
Alcohol	Drinking session times and locations
Accident	Accident involvement over the last two years
Address	Text description of trip destinations
Accident locations	Text description of accident locations
Trip geocoding	Trip location (map references) and geocoded distance estimates

2.1.1 Stratification

The sample strata and substrata were geographically based on Statistics New Zealand definitions for the 1996 Census of Population and Dwellings.[1] The strata was based on the 14 local government regions, further stratified into major and main urban areas (at least 30,000 population), secondary urban areas (population between 10,000 and 30,000) and rural (including minor urban areas with population less than 10,000 and all other rural areas).

2.1.2 Eligibility

All household members, including babies, were included in the survey. Travel by household members aged nine and under was reported by a parent or caregiver.

2.1.3 Off-road travel

Off-road travel, such as on off-road tracks or around private property (eg farms), were excluded from the survey. All on-road travel, including farmers' work travel, was included.

2.2 Weights

Since the sample was not a random sample of the population, a simple total of the survey observations was not appropriate for estimating population travel statistics. Weighted values for trips, persons and households were used, where the weights were approximately equal to the reciprocals of the probability of selection of the respondents. Weights also reduced the bias of non-response.

[1] See glossary at www.stats.govt.nz/surveys_and_methods/methods.aspx

The appropriate weights provided by the MoT in the datasets have been applied in the calculation of all the travel profiles contained in this research report.

2.3 Filters

'Filters' were applied to select households, people and trips by people with full responses only. Filters applied to the 'household', 'person' and 'trip' datasets provided by MoT are presented in table 2.2.

Table 2.2 Filters used with each dataset

Dataset	Filter	Description
Household	hhrespstat=1	Households with full response only
Person	perespstat=1	People in the survey with full responses
Trip	perespstat=1	Trips by people with full responses

2.4 Definitions of trips and purposes

The definition and classification of 'trip legs', 'trip chains', 'modes' and 'trip purposes' can often vary between countries. Furthermore, the level at which travel is considered can vary between different analyses. For example, the *Travel survey report 1997/1998* (LTSA 2000) used trip legs to understand New Zealanders' travel behaviour, while O'Fallon and Sullivan (2005) used 'trip chains'. These terms are defined in the remainder of this section, allowing practitioners to understand how the travel profiles are generated and to allow comparison with other national and international research.

2.4.1 Trip legs

The trip dataset contains 281,812 rows, each representing a single surveyed trip leg. The MoT defines a trip leg thus:

> *A trip leg is a section of travel by a single mode with no stops. Thus if one walks to the bus stop, catches the bus to town and walks to his/her workplace, he/she has completed three trip legs (home-bus stop, bus stop 1 to bus stop 2, bus stop 2-work).*

2.4.2 Trip leg purpose

Each trip leg has a trip leg purpose; the activity that is performed at the trip leg destination. For this research, to ensure we considered purposes relevant to the trends being analysed and maintained sufficient sample sizes, we limited our analysis to the following trip purposes, which in some instances are combinations of purposes initially coded by the MoT (as stated below):

- Home: where the person is travelling to their permanent or temporary place of residence.
- Employment: these are trip legs to a fixed work address and all work-related stops to other than a fixed work address. Employed or self-employed people without a fixed place of work (eg plumber) are included in this category. This is a combination of all the MoT purposes regarding employment ('work – main job', 'work – other job' and 'work – employer's business').

- Education: this includes travel as a student to institutions such as primary and secondary schools, colleges of advanced education, technical colleges and universities. It also includes school-related activities that are not conducted at school, eg school outings, school patrol or sports within school time. Sports activities during the weekend or after school are coded to recreation. To better understand travel trends to particular school types, respondent age groupings have been applied to stratify the responses in some parts of the analysis.
- Shopping: this describes any trip leg ending at premises which sell goods or hire goods out for money. Premises which provide services only (eg solicitors, banks) or repairs only (eg appliances or shoe repairs) should be coded as 'personal business/services'. Shopping is defined as any time the respondent enters a shop, whether or not a purchase is made.
- Social visits: these include visits to a private home; visits to a non-private dwelling (eg visiting a friend in hospital, visiting a friend staying in a hotel); pre-school activities such as kindergarten, crèche, day-care, kohanga reo or nursery school; and all entertainment activities occurring in a public or private place. Such entertainment activities include dining out, clubs, hotels, concerts, religious meetings, and off-road driving or motocross. Walking or cycling for social purposes involve exercise and are therefore coded as 'recreational'.
- Recreational: this includes participation in sporting activities and travelling to sporting or recreational activities (eg driving to the park to go jogging). It excludes watching someone else play sport, which is a 'social visit'; and off-road driving or motorcycling, which are coded as 'social visits' as these have no exercise component.
- Other: this includes any other trip leg purposes not defined by any of the trip leg definitions above. In some cases 'shopping', 'social visits' and 'recreational' purposes have all been combined into this category.

2.4.3 Trip chains

Trip legs, in some cases, are not the most appropriate level at which to understand travel. For some analyses it is desirable to link travel into trip chains. A trip chain is defined as a series of trip legs where no stop between legs exceeds a specified time, either 30 or 90 minutes. This research report retains the 90-minute definition of trip chains as used in the Abley et al (2008) report. For example, a trip from work to home with a stop at shopping for 40 minutes is a trip chain. The main travel purpose of a trip chain is identified by the purpose of the final chain segment; the travel mode of the chain is defined by the mode of the segment covering the greatest distance. For example, a trip chain involving walking 500m to a bus stop, riding the bus 3km to a shop, shopping for 40 minutes then walking 400m to work would have a trip purpose of work by bus as the main mode.

3 Literature review

A review was undertaken of international literature on trip generation resources, the trends in travel behaviour derived from household travel surveys and the trip rate inputs to existing strategic transport models in New Zealand. The function of the literature reviewed in this section is four-fold:

- to clarify the definition of trip, trip legs and trip chains
- to assess the extent and quality of existing trip generation resources available
- to provide a context for travel behaviour trends as established from other household interview surveys (HIS)
- to explain the key variables and corresponding trip rates used in existing strategic transport models.

The literature review is divided into four parts. The first part is a review of the definition of trips, trip chains and tours. The second part is a review of existing trip rate databases commonly used in New Zealand and elsewhere. The third section of the review describes the findings of household travel survey data found in other countries. The final section describes aspects of transport models developed in New Zealand which are based on local household travel survey data.

3.1 Definition of trip chains and tours

3.1.1 New Zealand study

O'Fallon and Sullivan (2005) defined a trip chain as 'a series of one or more segments [trip legs] defined by starting a new chain whenever:

- the segment [trip leg] is the first one recorded in the respondent's travel diary (excluding trip legs by plane)
- the starting point of the segment [trip leg] is home or their workplace
- the origin of the trip is neither home nor work, but the respondent has been at that location for more than 90 minutes (and the purpose of the immediately preceding segment [trip leg] was not mode change).'

A trip chain is effectively a one-way trip from an origin to a destination. O'Fallon and Sullivan (2009) developed the trip chain concept further to define a 'tour' as 'a series of segments [trip legs] that starts from home and ends at home' this being a return trip that completes the life cycle of a trip. O'Fallon classed tours into 10 different types as shown in table 3.1.

Table 3.1 Classification of tours (O'Fallon and Sullivan 2009)

Tour description	Sequence
Simple work	h-w-h
Multi-part work	h-w-(-w-)-w-h
Composite to work	h-psl/e-(-psl/w/e-)-w-h
Composite from work	h-w(-psl/w/e-)-psl/e-h

Tour description	Sequence
Composite to and from work	h-psl/e-(-psl/w/e-)-w-(-psl/w/e-)-psl/e-h
Composite at work	h-w-(-psl/w/e-)-psl/e-(-psl)/w/e-)-w-h
Simple/multi-part education	h-e-(e)-h
Composite education and non-work	h-psl-e-(-psl-)-h and h-(-psl-)-e-psl-h
Simple non-work/non-education	h-psl/ne-h
Multi-part non-work/non-education	h-psl-psl-(psl)-h

Where the bracketed terms represent additional segments that may be in the tour, psl is personal travel (includes personnel business/services, medical/dental and social welfare), shopping and leisure travel (includes social, leisure and recreational purposes), ie neither work nor education.

The O'Fallon and Sullivan (2009) research reported that respondents in the 2004–07 NZHTS averaged 2.4 trip chains per day, which was a slight increase over the 2.3 trip chains per day calculated on the basis of the 1997–98 NZHTS.

3.1.2 Australian study

Primerano et al (2007) defined a trip chain to be 'the linking of secondary activities to a primary activity through travel that is made from when an individual leaves home to when they return home. It is a schedule that individuals will follow (or create as they proceed through the day) from the moment they leave home to the moment they return home'.

Primerano et al (2007) adopted three activities that drive the trip chaining process, which was proposed by Stopher et al (1996). These activities are classified into three categories:

- mandatory activities, which have frequency (typically daily), location and timing that are all fixed (eg work and school)
- flexible activities, which are performed on a regular basis but have some characteristics (eg timing or location) that can vary (eg shopping for convenience goods or banking)
- optional activities, which are discretionary and for which all characteristics may vary. In particular, frequency may be zero in a given time period (eg social and recreational activities).

It appears the trip chain definition proposed by Primerano et al (2007) is similar to the 'tour' defined by O'Fallon and Sullivan (2005) in that a trip chain starts and ends at home.

3.1.3 US study

The Federal Highway Administration's operational definition of a trip chain is 'a sequence of trips bounded by stops of 30 minutes or less'. A stop of 31 minutes or more defines the terminus of a chain of trips, and that chain of trips is considered a tour. McGuckin and Nakamoto (2004) used the following definitions to describe the trip chaining process:

- anchor – a primary or substantial trip destination
- direct trip – a trip that travels directly between two anchor destinations, such as a trip from home to work

- chain – a series of short trips linked together between anchor destinations, such as a trip that leaves home, stops to drop a passenger, stops for coffee and continues to work
- intervening stop – the stops associated with chained trips
- tour – total travel between two anchor destinations, such as home and work, including both direct trips and chained trips with intervening stops. Note that it is possible to have the two anchor destinations in the same location, as in a home-to-home or work-to-work tour.

3.2 Existing trip generation resources

When travel demand is expressed in terms of trip chains this provides a closer equivalence to trip rates – a key building block for modelling travel behaviour. When expressed as a trip chain, the NZHTS data can complement trip generation sources that are currently available to transport practitioners in New Zealand. There are typically four main international trip generation databases that are used in New Zealand: the New Zealand Trips, Parking Database Bureau which is now called the Trips Database Bureau (TDB), TRICS® from the United Kingdom, Roads and Traffic Authority (RTA) of Australia and the Institute of Transportation Engineers (ITE) Trip Generation of the United States. The features of each of these are described in the following sections.

The trip rates included in the following databases differ in nature from those commonly used in transport modelling as the former represent measured arrival and departure movements recorded from empirical surveys of land-use activities. Trip rates used in transport modelling represent trip attractions and trip productions measured at the 'gate' of development activities. Household trip generation rates can also be derived from NZHTS data by determining the vehicle trip generation through trip legs:

- grouped by household vehicle ownership
- made by vehicle drivers that originated or terminated at home.

3.2.1 TDB database

The TDB database is a New Zealand-based resource and was first published as *Transfund NZ research report 210* (Douglass and McKenzie 2001) 'Trips and parking related to land use. Volume 2: Trip and parking surveys database'. This report has been superseded by regular releases and upgrades of the database.

The current TDB database (version August 2010) contains approximately 700 New Zealand sites and 300 Australian sites from the RTA. The information is retained at individual site-by-site levels. The database is supplied to members as a Microsoft Excel spreadsheet on a CD which is updated annually. Other TDB research documents, survey methodology, technical notes and similar aids to the understanding of the database are available on request as well as the website www.tdbonline.org. Typical vehicle trips associated with residential activities range from 2.6 trips per day for retirement units up to 10.7 trips per day for large family dwelling houses. Although the type of dwelling and the number of people within a dwelling are linked, it is the number of people within a household that determines the amount of travel.

3.2.2 TRICS database

The TRICS database is a UK trip generation and parking resource and contains traffic count information for over 3199 individual sites, 5746 days of survey counts and 110 land-use sub-categories. The database was formed in 1989 and had 301 organisations holding licences when TRICS 2011(a) v 6.7.2 was issued. TRICS is the most comprehensive database available and now has two versions available. Members of TRICS can interrogate the database on a site-by-site basis via an online version that can be accessed via the TRICS website www.trics.org and an offline version that can also be downloaded via the TRICS website. Individual site details stored in either version can be imported into a Microsoft Excel spreadsheet for further data manipulation.

New Zealand and Australian members of TDB have 'inquiry access' to these TRICS databases through nominated representatives in each of the main cities. Typical household vehicle trip rates from the TRICS database range from 1.56 trips for a retirement dwelling and up to 7.6 trips for a dwelling house.

3.2.3 ITE database

The ITE (2008) *Trip generation* handbook is an American publication and consists of two data volumes with land-use descriptions, trip generation rates, equations and data plots. Data is included from more than 4800 sites and 162 land uses. The survey information is merged and analysed together for land-use groups rather than being retained at an individual site-by-site level. The most recent (8th) edition was published in 2008. The ITE database is produced in book format and there is also a software version available. Trip Generation by Microtrans software calculates traffic generation on the basis of the ITE database and has been updated with each new edition of the ITE report.

Typical household vehicle trip rates from the ITE database range from 2.52 trips for a retirement unit and up to 9.57 trips for a dwelling house.

3.2.4 RTA database

The RTA database is an Australian publication that contains vehicle trip rates and parking rates information for nine main land uses. The document only provides an average trip rate by grouped land-use activities. Site-by-site details of each land-use activity are not included within this document. Many of the trip and parking rates are based on surveyed data from the 1990s; however, surveys of large bulk retail stores and senior housing were added in 2009. Collaboration between the TDB and RTA has resulted in the latest TDB database, dated August 2010, including RTA data.

3.2.5 Multi-modal survey data

Data on modal split and variations between inner, suburban, small town and rural situations is now deemed of great importance as this supports the national and regional strategies which seek greater modal integration and increased use of sustainable transport.

One of the most important elements in determining the effects of travel-generating activities is the collection of relevant data. In most situations where new developments are proposed there will be only limited sources of information about the particular site or activity. While a major shopping centre, for example, will generate trip making and parking demand patterns similar to equivalent centres, there will always be modal split variations and catchment influences which surveys at other sites do not reveal.

In seeking to apply the principles of 'sustainable transport', practitioners require an increased awareness of the contribution to the total transport system of public transport, pedestrian and cycle trips, and the extent of car passenger as well as car driver travel. More effort is being applied to multi-modal surveys, which is reflected in current NZTA research such as Pike (2011).

A comparison of the national and the international databases by multi-modal information is shown in table 3.2.

Table 3.2 Summary of databases by multi-modal information

Database content	TDB	TRICS	ITE	RTA
Multi-modal data available	Yes	Yes	Light and heavy vehicle trip rates only.	Yes
Total number of surveys	692	3419	4800	192
Number of multi-modal surveys	90	720	Nil	109
Formal multi-modal survey methodology	No	Yes	No	No
Surveyed modes	Car driver, car passenger, goods driver, goods passenger, pedestrian, cyclist, bus passenger	Vehicles, pedestrians, public transport users, cyclists, occupants, public service vehicles, goods vehicles, taxis	Vehicles and trucks	Car driver, car passenger, goods driver, goods passenger, pedestrian, cyclist, public transport
No. of surveyed activities (multi-modal)	12	84	Nil	5

As can be seen from table 3.2 there is still a limited number of New Zealand multi-modal surveys for informing transport practitioners in New Zealand of modal splits and there is no data on variations of modal choice over time. While efforts are being made to increase the number of multi-modal survey results, the database relies upon the good will of transport consultants to offer data they have collected. This reliance on voluntary contributions explains the slow growth of multi-modal samples within the TDB database.

3.3 Key trends established from international household travel surveys

The trends established from an analysis of the household travel surveys of other countries provide a basis of comparison with New Zealand, and changes in travel behaviours observed elsewhere could be a signpost for changes in New Zealand.

3.3.1 UK National Travel Survey

The UK National Travel Survey (NTS) is a continuous survey of personal travel. The survey is designed to monitor long-term trends in personal travel in Great Britain. The survey collects information on where, how, why and when people travel, as well as factors which affect personal travel such as car availability, driving licence holding and access to key services.

It provides the Department for Transport (DfT), Local Government and the Regions (DTLR) with data to answer a variety of policy and transport research questions and is used to provide trip rates for the

National Trip End Model. The survey has been running continuously since 1988. Like the NZHTS, the NTS is a travel diary which samples household members over consecutive days.

The DfT produces a series of travel fact sheets periodically that contain key statistics relating to personal travel. Such data includes details on a range of issues including school travel, car occupancy, commuting and business travel, and travel in urban and rural areas. The following findings are of key interest for the purposes of this report:

- Average length of commuting trips increased by 5% between 1995/97 and 2009.
- People in rural locations travel furthest to work.
- Average journey time to work is steadily increasing (18% increase between 1997 and 2009).
- On average: commuting trips by foot take 18 minutes, by cycling 22 minutes, by car 24 minutes and by bus 41 minutes.
- The average number of trips made per person each year by public transport increases with the size of the urban area.
- Fewer trips by foot to school occurred in 2008 compared with 1995/97.
- In rural areas more children travel by car or private bus than in urban areas and fewer walk to school (19%) than the national average (44%).
- There has been a steady falling trend in trip rates since 1995/97. Average distance travelled per person per year remained relatively stable until 2007, but has declined slightly over the last three years.
- In 2010, there was an average of 960 trips per person per year – the lowest level since the mid-1970s.
- Between 1995/97 and 2010, overall trip rates fell by 12%. Trips by private modes of transport fell by 14% while public transport modes increased by 8%.
- Most of the decline in overall trips rates between 1995/97 and 2010 can be accounted for by a fall in the number of trips to shopping and to visit friends.
- Trips by car (as a driver or passenger) accounted for 64% of all trips made and 78% of distance travelled in 2010.

The 2010 NTS indicated that travel for all trip purposes for all age types averaged 960 trips per person per year, equating to 2.63 trips per person per day.

3.3.2 The Sydney Household Travel Survey

Household travel surveys are used as inputs to transport and land use planning and policy making at the regional as well as national level. The Transport Data Centre of New South Wales undertakes a continuous household travel survey focusing on the greater metropolitan area of Sydney to provide data on current and future demographic, employment and travel patterns.

Summarising data from the 2009 Sydney Household Travel Survey and journey to work data collected through the census of population and housing every five years in Australia, it was found that:

- Both residential and employment locations had moved further away from the Sydney central business district (CBD).
- Public transport share for the journey to work was declining.
- Public transport mode share was around 10% for travel to non-centre locations.
- The average trip length was increasing over time, closely related to the noticeable land use pattern changes.
- In 2008/09 Sydney residents made 16.3 million trips on an average weekday and 14.7 million on an average weekend day. Weekday trip growth slowed over the past year to 0.2%, despite population growth of 1.5% for the same period.
- In the 12 months to 2008/09 there was a growth in public transport and walk trips and vehicle passengers while the proportion of travel as a vehicle driver declined.
- 54% of respondents cited parking problems as a reason for commuting by public transport
- The drop in car trips was not reflected in levels of household vehicle ownership, which grew at 2.8%. Despite growth in vehicle ownership, people appeared to be more selective about how often they used the car.
- Average travel time remained steady. The average time spent travelling each day was 81 minutes per person. The average duration of a work trip was 34 minutes and the average duration of a non-work trip was 18 minutes.

The Sydney Household Travel Survey presents data on personal travel expressed as linked trips which is defined as a journey from one activity to another, ignoring changes of mode and where a linked trip may comprise one or more unlinked trip legs. Trip rates presented in the Sydney HTS are 3.6 trips per day per person and 10.2 trips per day per household.

3.3.3 US National Household Travel Survey

The US National Household Travel Survey is undertaken by the Federal Highway Administration in the USA showing daily vehicle trips per driver of 3.56 trips and person trips of 4.18 trips. Use of regional or state household travel surveys can reveal travel patterns that are unique to a particular area. The following example was reported by Milone in a presentation to the Travel Forecasting Subcommittee in 2009 in relation to the Metropolitan Washington Area Household Travel Survey. In comparing the 2004 and 2009 data for the Washington area Milone reported that:

- within the study area, daily household vehicle trip rates declined from 8.8 to 8.3
- the share of home-based work (HBW) trips, as a percentage of all trips, continued to decline, from 21% to 18.5%
- the public transport mode share increased from about 6.3% to 7.3%
- car occupancies increased from 1.28 to 1.38
- time-of-day distributions indicated slightly less travel in the peak periods and slightly more midday travel.

A further finding of the US travel survey was that commuting trips (HBW) might not be the dominant contributor to peak hour traffic demand on the road network. This issue was also highlighted by McGuckin et al (2005) who supported the proposition, in relation to the survey, that it was the growth of non-work trips embedded in commute trips that added to traffic congestion during peak times.

3.3.4 Trip complexity

While not a primary output of the household travel survey analyses, trip chain complexity is an important key output. In their research on travel time competitiveness of cycling in Sydney, Ellison and Greaves cited many studies that focused on the relationship between trip chain complexity and mode choice. The general message from the research was that the use of alternative modes was likely to decrease as the complexity of trip chains increased. Hensher and Reyes (2000) supported this general finding and added an additional dimension that the complexity of trip chains was likely to increase as a result of an increase in the number of children and other changes in family structures.

3.4 Existing New Zealand strategic transport models

3.4.1 Wellington

Greater Wellington developed its transport strategy model in 2003 using the 2001 Wellington Region Household Survey data, timed to align with the 2001 census. The model has been updated to a 2006 basis. The household data comprises three separate files: a household file, a person file and a stop (or trip) file. Six trip end models (productions and attractions) were produced for the following purposes:

- home-based work (HBW)
- home-based education (HBEd)
- home-based shopping (HBSh) – including personal business
- home-based other (HBO) – combined home-based other and home-based social
- non-home-based other (NHBO)
- business trips (BU) – combining home-based and non-home-based employer’s business

There are different variables within the household survey data that best predict each of the six trip end models. The final trip rate variables used are summarised in table 3.3.

Table 3.3 Trip end predictors for the Wellington Region Transport Model

Trip end model	Production	Attraction
HBW	Fixed hours	Retail employment
	Flexible hours	Transport & communications employment
	Rostered shifts	Services employment
	Works from home	Other employment
	Paid employee	Manufacturing employment
	Self-employed – no others employed	Other + manufacturing employment
	Self-employed and employer or people	Retail + transport & communications + services employment
	Family business	
HBEd	Primary school age (5–10 yrs)	No. of households
	Secondary school age (11–16 yrs)	No. of households with no tertiary enrolments
	Young adult (17–25 yrs)	Secondary school enrolments with no tertiary enrolment
	Adult (26+ yrs)	Tertiary enrolments
HBSh	Children (6–16 yrs)	No. of households
	Young adult (17–25 yrs)	Other employment
	Adult (26–65 yrs)	Other employment in non-SC sectors
	Older adults (66+ yrs)	Manufacturing employment
		Manufacturing employment in non-SC sectors
		Transport & communications employment
		Transport & communications employment in non-SC sectors
		Retail employment
		Retail employment in non-SC sectors
		Retail employment in UCBD sectors
		Services employment
		Services employment in non-SC sectors
		Services employment in UCBD sectors
		Services employment in non-SC and non-UCDB sectors
HBO	Children (6–16 yrs)	Other employment
	Young adult (17–25 yrs)	Manufacturing employment
	Adults (26–65 yrs)	Transport & communications employment
	Older adults (66+ yrs)	Services employment
	With 1 vehicle	Retail employment
	With 2+ vehicles	Retail employment in LCBD (2)
	Household size 2+	Retail employment not in LCBD (1)
	Household income (000's)	Retail employment in UCBD
		Retail employment in Petone
		Retail employment in LCBD (2)

Trip end model	Production	Attraction
		No. of households No. of households in sector not in LCBD
NHBO	Children (6–16 yrs) Young adult (17–25 yrs) Adults (26–65 yrs) Older adults (66+ yrs) Locations not in Wellington city With 1 or more vehicles	No. of households Retail employment Retail employment in Petone Manufacturing employment Other employment Transport & communications employment Services employment
BU	Fixed hours Flexible hours Rostered shifts Works from home Part-time workers	No. of households Other employment Manufacturing employment Transport & communications employment Services employment Retail employment Retail employment in the CBD Retail + transport & communications employment Retail + transport & communications employment in Porirua and Kapiti District Retail + transport & communications employment not in Porirua and Kapiti District

non-SC = non-shopping centre
UCBD = upper central business district
LCBD = lower central business district

3.4.2 Auckland

Auckland Regional Council commissioned Sinclair Knight Mertz to develop a regional transport model in 2008 using the 2001 Auckland Region Household Survey data. The household data comprises three separate files, a household file, a person file and a stop (or trip) file. Six trip end models (productions and attractions) were produced for the following purposes:

- home-based work (HBW)
- home-based education (HBEd)
- home-based shopping (HBSh)
- home-based other (HBO)
- employer's business (EB)
- non-home-based other (NHBO).

There are different variables within the household survey data that explain each of the six trip end models. The variables in each of the production and attraction models are summarised in tables 3.4 and 3.5.

Table 3.4 Trip production variables

Variable	HBW	HBE	HBSh	HBO
Employment type	✓			
Work arrangements	✓			
Full-time/part-time	✓			
Person types		✓	✓	✓
Household types			✓	✓
Regional growth areas	✓			
Urban/rural		✓		✓
Car ownership	✓	✓	✓	✓

Table 3.5 Trip attraction variables

Variable	HBW	HBE	HBSh	HBO	EB (private vehicle)	EB (public transport)	NHBO (private vehicle)	NHBO (public transport)
Employment type	✓		✓	✓				
Household types				✓				
Educational rolls		✓						
HB attractions (car)					✓		✓	
HB attractions (public transport)						✓		✓
CBD adjustment	✓	✓		✓		✓		✓
Shopping zones			✓					

As part of the process of building the model, extensive work was done to determine the significance or otherwise that some variables had on trip generation rates. Where variables had little effect these were combined into more significant variable categories. This reduced the extent of the variables that needed to be considered. For instance it was found that different household characteristics such as larger households, or non-working households, or young persons, or older non-working persons all displayed similar trip rates. Therefore such variables were combined.

Person type and to a lesser extent household type are variables associated with car ownership, which is a variable that features strongly in all purposes relating to trip production. Person and household types are also used to a lesser extent as trip production variables. Car ownership effects were found to be more significant for active modes with active mode trip rates reducing with increasing car ownership.

3.4.3 Christchurch Transport Model

The Christchurch Transport Model (CTM) is a replacement of the vehicle driver-based Christchurch Transport Study Model (CTS). It is a person-based multi-modal transportation model that includes public transport passengers and other non-car modes. The model uses household interview survey (HIS) data collected on the basis of a stratified random sampling procedure by area, the distribution of households by household type categories and by vehicle availability, and has been subjected to a form of stratified expansion process.

The expansion was initially carried out based on vehicle availability and household type categories according to the 2006 Census data. Major special generators including the airport and the University of Canterbury are included in the model. The model adopts a category analysis for trip generations.

The model validation report indicates that as the model reflects total travel, previous difficulties from vehicle trip rates possibly changing over time were addressed. In the previous CTS model, income as an explanatory variable for trip generation was investigated but found to be explained by the household and vehicle categories.

As a refinement to the category-based, trip rate approach, area-specific trip rates were included in the model to represent proximity to activity areas, or conversely, lower accessibility in rural areas. The model contains a mechanism for explaining geographic differences in trip rates enabling issues such as the lower trip rate revealed for certain parts of the district to be incorporated. Following adjustments for under-reporting in the HIS, the model produced a trip production rate of 12.5 daily person trips per household.

3.4.4 Waikato Regional Transportation Model

The Waikato Regional Transportation Model was the first to be built in New Zealand that included both a major urban area and an extensive rural area. There was a degree of unease at the outset as to whether the approach would work, but in the event, there was found to be insufficient difference in the travel patterns of urban and rural dwellers for separate models to be required.

The model contains the Hamilton, Rotorua, Taupo and Tauranga areas at a coarse level with the Hamilton area modelled as a four-stage sub-area including public transport, travel demand management (TDM) and the option of a parking model. The existing models of Rotorua, Taupo and Tauranga remain unchanged three-step models, except that flows by trip purpose at the boundaries interface with the higher level regional model.

HIS data was collected by face-to-face interviewers with laptop computers that included custom written software. Interviewee responses were entered as they were given and the software simultaneously performed the range and logic tests on the data. This process was said to ensure the integrity of the data, and was reported as instrumental in removing the need for a correction for under-reporting that was evident in the Auckland and Christchurch HIS surveys.

The model produced a trip rate of 11.06 person trips per household.

3.4.5 Tauranga Transport Model

For the Tauranga Transport Model, future trip productions are modelled by multiplying the numbers of households in each category with their trip production rates (which are assumed to remain constant). The future number of households and people in each area has been estimated by Tauranga City Council. The number of future trip productions at the model level is made by factoring the base-year car ownership level with the future car ownership level. For each area, the total number of cars is distributed to future household numbers in 16 categories, taking into account the change in households, persons per household and cars per person.

The adopted methodology assumes that growth in vehicle availability is not significantly influenced by geographic, economic or demographic differences. However, the model builders recognise that higher-density urban zones positioned near public transport could exhibit lower levels of car ownership than other areas.

The trip generation models comprise a 24-hour private-vehicle trip production model and trip attraction model. Trip productions and attractions are produced separately for four trip purposes – home-based work (HBW), home-based shopping (HBS), home-based other (HBO) and non-home-based (NHB). A separate model is used to forecast commercial vehicle (CV) generation.

The production model estimates daily trip rates for households classified by car ownership level and household size. The numbers of households in each category and geographical area are obtained for the base year from the 1996 Census of Population and Dwellings.

The final daily vehicle trip rates adopted for the Tauranga Transport Model range from 2.8 vehicle trips per day for one person, one vehicle households up to 11 vehicle trips per day for households with more than four persons and more than two vehicles available to the household.

3.5 Vehicle ownership

A key variable in the models described above relate to vehicle ownership. In recent research on vehicle ownership in New Zealand, Conder (2009) reported:

- The number of cars per person increased almost every year between 1970 and 1996.
- Since the 1950s, New Zealand car ownership per person has closely matched Canada and Victoria (Australia, and was equal to 0.49 cars per person in 1995.
- The average annual changes in cars per person were strongly correlated with changes in GDP per person and real car prices.
- Auckland had the highest level of vehicles per household in 1996; however, not the highest level of vehicles per person which was in Nelson/Marlborough.
- Households with a greater number of adults tended to have more vehicles per household.
- Households with retired people tended to have fewer vehicles per household.

3.6 Use of household travel surveys for predictive purposes

As part of the process of establishing trip generation rates for the models described above, different variable categories are tested to establish the most appropriate trip rates. It is noted here that the level of disaggregate data used to determine the model trip rates is not available for the NZHTS and therefore regression has not been done as part of this study.

While the relative disaggregation of the Auckland and Wellington data, which includes some special variation, does not allow for direct comparisons of trip rates it does provide a useful demonstration of the significant variables in the Wellington region for trip production and attraction.

The 'goodness of fit' for the regression carried out in the Auckland and Wellington modelling demonstrated the predictive ability of the final selected variables which included the key variables of household type and availability of a vehicle to the household.

As with all transport models, the data used in their construction relates, to some extent, on inputs collected in the past. Therein lays an inherent assumption that inputs such as trip generation rates remain valid into the future. While there is little evidence showing changes in person trips over time, UK research undertaken in 2004 on behalf of TRICS assessed the validity of historic site survey data in relation to vehicle trip generation.

The research concluded that for some land uses, historic data remained valid while for others this was not so. The results of the study, which recommended setting cut-off dates for using particular land-use categories, were applied to the TRICS database. The brief descriptions of the models given in this review reveal there is some acknowledgement of the potential for change in vehicle trip rates to occur over time while others assume that vehicle trip rates remain constant.

One significant advantage of the NZHTS is the ability to look at temporal trends both nationally and regionally to establish changes in travel behaviours over time and to determine the influence that key variables have on trip rates and transport mode choice.

3.7 Summary

The literature reviewed in this section provided supplementary information regarding trip generation and travel trends within New Zealand and around the world. Additionally, it provided commentary on the findings of other household travel surveys and how data from these surveys reflected the trip generation inputs associated with strategic transport models in New Zealand.

The findings of this literature research were used to guide the selection of the most significant variables for testing the NZHTS data in a predictive context. The review also provided an understanding of the definitions of the units of travel for a non modelling audience.

The relevance of the review of the transport models was twofold: first it provided a brief summary of the models for the understanding of non-modellers and second by reporting the trip generation rates used in these models (where available), it provided a guide for the person and vehicle trip rates derived from the analysis of the NZHTS data.

Reference to traffic engineering trip rate resources along with a sample of the range of trip generation rates associated with residential households provided a point of reference and comparison between the equivalent trip rates derived from the analysis of the NZHTS data.

The review of international household travel surveys provided useful context in terms of recent personal travel behaviours and trends in trip making and allowed comparisons between international travel behaviour and New Zealand. The issues revealed from the international household travel surveys provided guidance on whether such insights could be gathered from the NZHTS in its current form. By consulting outputs generated internationally, we were able to ensure both the survey and subsequent analysis of the results were in line with international methods for investigating travel behaviour.

4 Trend analysis 2003–10

4.1 Treatment of data

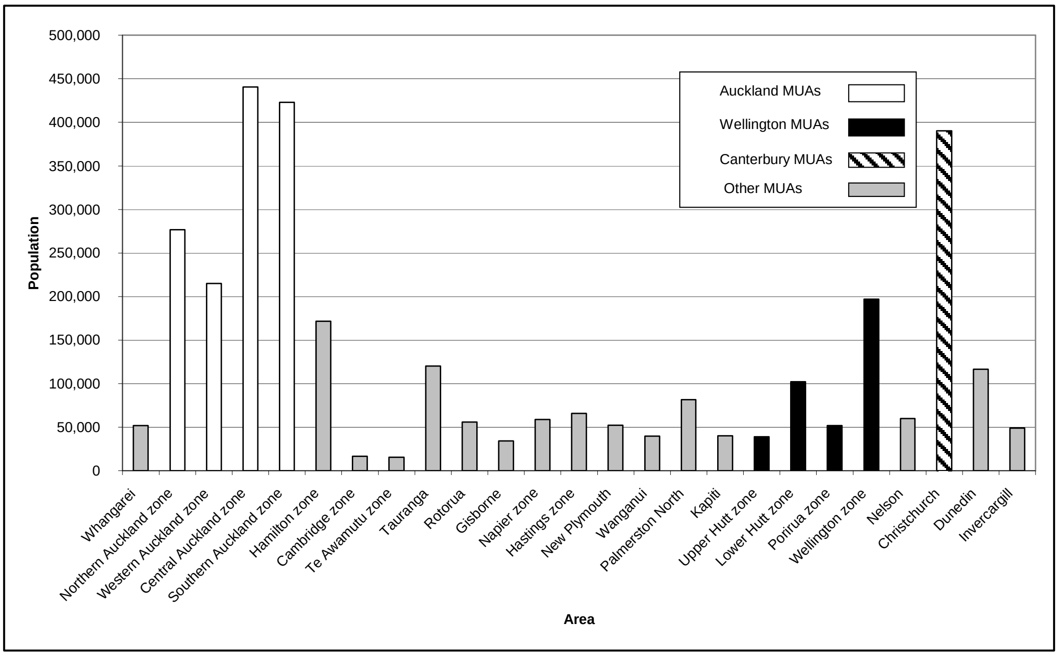
The following analysis was based on trip chains from the data set 2003–10. Trip chains describe how people link their travel between 'significant' locations such as home, work or education, and other activities. For this report, a trip chain consists of a sequence of segments (trip legs) bounded by stops of 90 minutes or more. The main travel purpose of a trip chain is identified by the purpose of the final chain segment; the travel mode of the chain is defined by the mode of the segment covering the greatest distance.

The analysis focused on a comparison of regional areas. The data was separated into the following discrete groups for comparative purposes:

- MUAs located within the regions of Auckland, Wellington and Canterbury (collectively termed 'major MUAs')
- other MUAs
- secondary urban areas (SUAs)
- rural areas (RAs).

The MUAs located within the regions of Auckland, Wellington and Canterbury were separated from MUAs located in other regions. This was done in recognition of the fact that while, for example, Wellington city and Dunedin city are both classified as MUAs, their population and transport infrastructure provision are significantly different thus potentially resulting in different travel behaviours. The population sizes associated with MUAs and the urban areas to be included in the MUAs as defined by Statistics New Zealand are shown in figure 4.1.

Figure 4.1 MUA populations – June 2010



Although the data is recorded within survey years, the conditions of use stipulate the data must be aggregated into groups of no smaller than two survey years when reviewing regional trends. Consequently, the groupings of 2003 through to 2006, 2006 to 2008 and 2008 to 2010 were applied when assessing changes in travel over time. As the earlier years have fewer samples and the total number of sample years is uneven the first three years were aggregated. Table 4.1 sets out the sample sizes associated with each of the groupings.

Table 4.1 Sample sizes

Year grouping	2003–06	2006–08	2008–10
Trips sampled	88,000	57,000	140,000
Trip chains sampled	38,000	24,000	58,000
Trip chains represented*	8,300,000,000	5,700,000,000	5,400,000,000
Household samples	4000	2600	6200
Person samples	11,000	7,000	17,000

* Trip chains represented is the expanded trip chain sample following application of the MoT weightings

It can be seen that the amount of data used to describe the wider population for the 2006–08 period is lower than in the other year groups. The results established from the other year groups therefore present higher levels of confidence and may explain instances where outputs associated with the 2006–08 period sometimes did not follow the general trends established from the other year groups.

For a large part of the analysis, comparisons were made between data that was expressed in proportions or percentages. For this comparison chi-squared tests were undertaken to determine whether the differences between the proportions were statistically significant. Where comparisons were made between values not represented as proportions, t-tests were applied to evaluate the statistical significance. Sample standard errors were calculated using the bootstrap resampling method with 4000 repetitions. All differences that had been statistically tested were reported as being either significant or not significant to the 95th percentile confidence level.

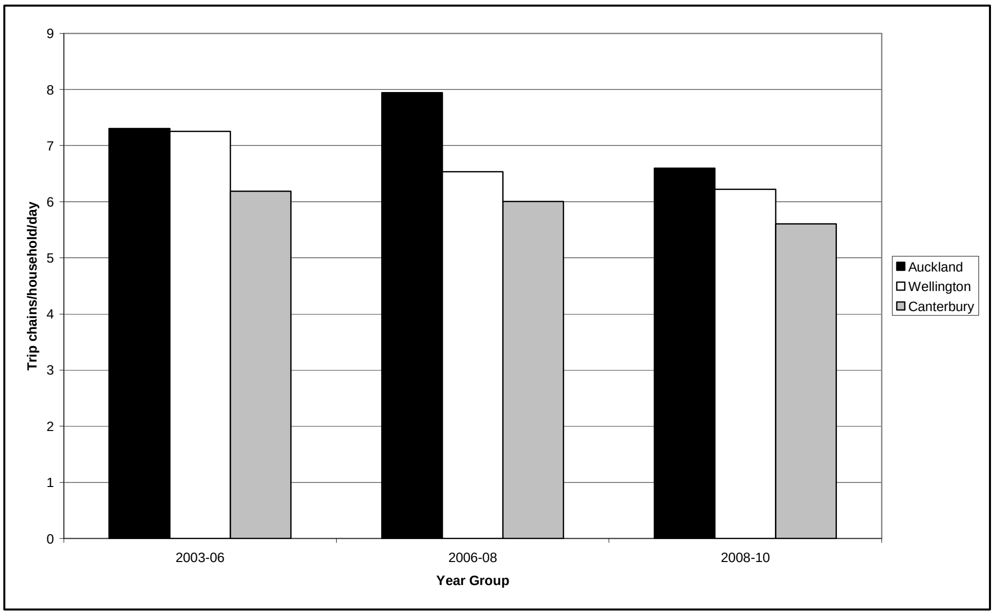
The data was filtered to remove 'professional driver' trips, which includes persons such as taxi drivers, as the inclusion of such trips could bias the output where such an individual may undertake an unrepresentatively high number of trips. The data was also filtered to remove incomplete survey responses.

The following analysis considers travel behaviour in terms of trip chains. Throughout this report trip chains are described as trips and should be read as having the same meaning.

4.2 Change in trip rates over time

As set out in chapter 3, household travel surveys have recently recorded declining person and vehicle trip rates in the UK and vehicle trip rates in the USA and Australia. A significant advantage of the NZHTS is that it is possible to look at temporal trends to assist in determining whether trip rates are declining in New Zealand. Figure 4.2 examines daily trip chain rates at the household level, across the major urban areas for three-year periods.

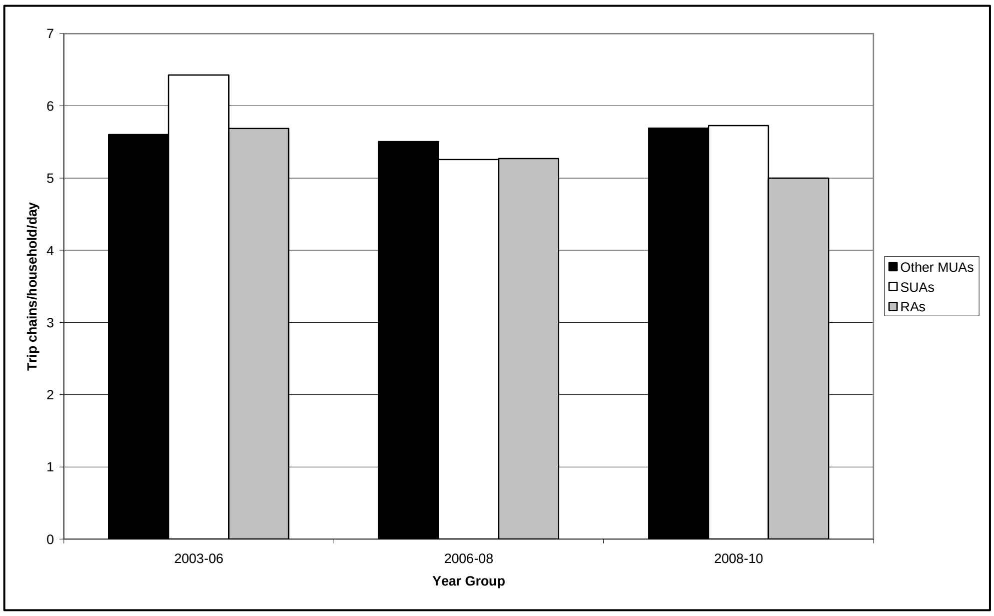
Figure 4.2 Temporal analysis of person trip rates per household: 2003–10 within major MUAs



The following observations can be made from figure 4.2:

- In general, and with the exception of the Auckland data corresponding to the 2006–08 period, there appears to be a decline in trips per household over the period tested. The difference between the 2003 and 2010 periods is significant for all areas.
- The largest decline in trips per household between 2003 and 2010 occurs in the major MUA of Wellington (13%). The major MUA of Canterbury experiences a net decrease of 9% over the same period.
- The apparent increase in trips for Auckland in the 2006–08 period may be attributed to sampling error.

Figure 4.3 Temporal analysis of person trip rates per household: 2003–10 in other area types



The following observations can be made from figure 4.3:

- There is no consistent trend across all area types tested.
- The MUAs display a slight decline then increase over the period tested.
- SUAs show a sharp decline in trips per household before increasing in the period 2006–08 to 2008–10.
- RAs show a continuous decline in trips per household declining 8% between 2003 and 2008, and then 9.5% between 2006 and 2010.

4.2.1 Summary findings of changes in trip rates over time

In general, and with the exception of the Auckland data corresponding to the 2006–08 period, there appeared to be a decline in trips per household in major MUAs over the period tested.

In relation to the major MUAs, the largest decline in trips per household between 2003 and 2010 occurred in the major MUA of Wellington (13%). The major MUA of Canterbury experienced a net decrease of 9% over the same period. The trip rates per household for the other area types did not share a general trend in the period tested.

4.3 Changes in morning departure times

This analysis explored the morning work departure times of respondents to determine whether there was any evidence that such trips were occurring earlier, which could be explained by urban sprawl, road network congestion, or increased trip chaining etc. The analysis, derived by area and specified survey year groupings, provided the mean, 20th percentile and 80th percentile departure times for the first morning departure trip to work. Increasing peak spreading would be evidenced as a growing gap between the 20th and 80th percentiles.

4.3.1 Morning work departure times by vehicles – MUA

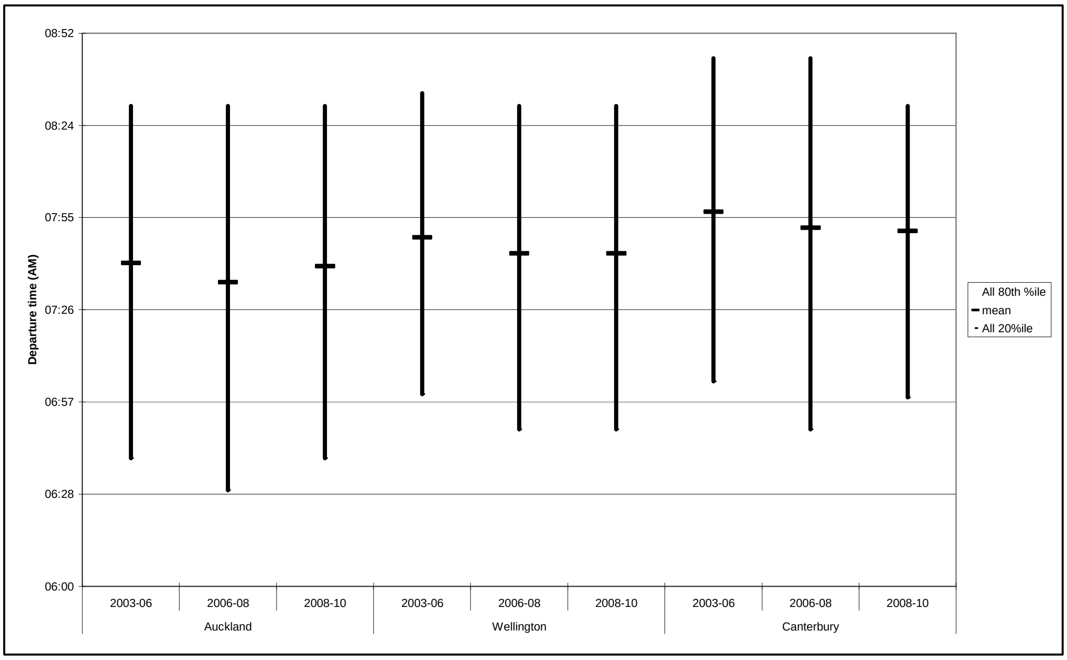
Values were mean weighted by trip weights within the sample by the formula shown in equation 4.1. The expressions used in the formula were taken directly from those provided within the NZHTS data. Only vehicle trips were counted if the greatest distance segment of the chain was as a vehicle driver or vehicle passenger.

$$departureTime_{Area,Year} = \frac{1}{n}\sum_{i=1}^{n} departureTime_i \cdot \left(\frac{tripwgt\_ann_i}{\frac{1}{n} \cdot \sum_{i=1}^{n} tripwgt\_ann_i} \right) \quad \text{(Equation 4.1)}$$

where *i…n* are the dataset rows for each combination of *area* and *year* and *mode type*.

The pattern of work-related morning departure times for vehicles was established from the above formula.

Figure 4.4 Temporal analysis of morning work departure time by vehicle within major MUAs



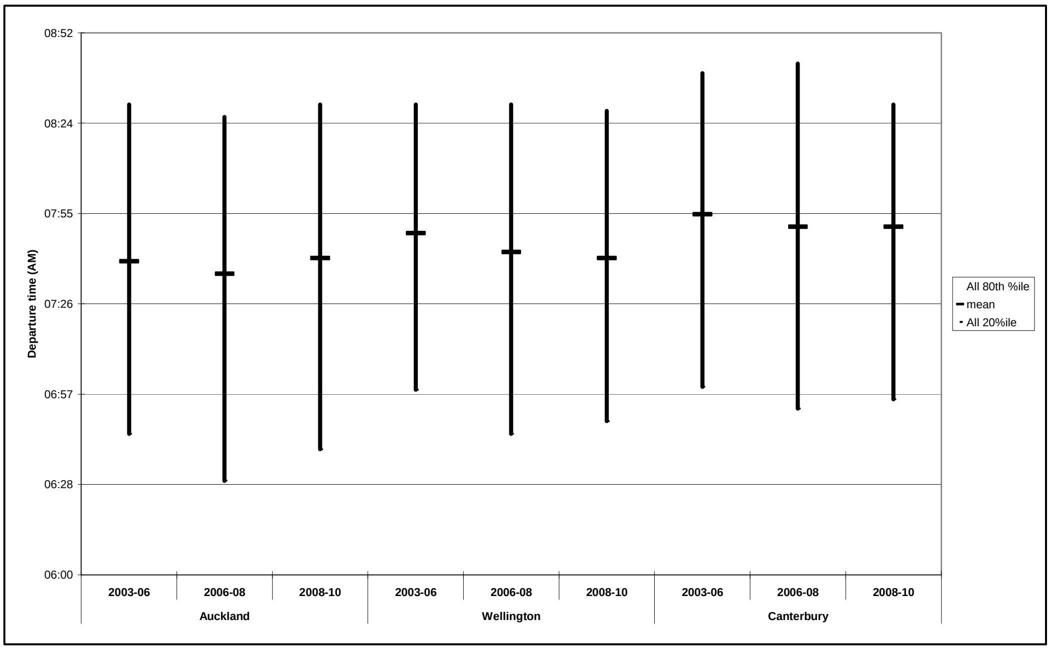
The following observations can be made from figure 4.4:

- Commuters in the Auckland MUAs depart significantly earlier than in the MUAs of Wellington and Canterbury.
- Commuters in the Canterbury MUA depart at a later time, potentially reflecting the lower levels of congestion on the road network in this region compared with Auckland and Wellington.
- Between the year groups 2006–08 and 2008–10 all of the MUAs show earlier departure times in comparison with the departure times associated with the 2003–06 year group.
- Generally, the changes in departure times from one year group to the next are not significant.
- Differences between the departure times of Christchurch and Wellington for all years are not significant.
- With the exception of the Auckland MUAs in the year group 2008–10, the departure times are progressively earlier for the other main MUAs.
- Wellington MUAs show the least amount of variation about the mean.

4.3.2 Morning work departure times by all modes – MUA

The data was examined for commuters' departure time associated with all modes of transport.

Figure 4.5 Temporal analysis of morning work departure time by all modes within major MUAs

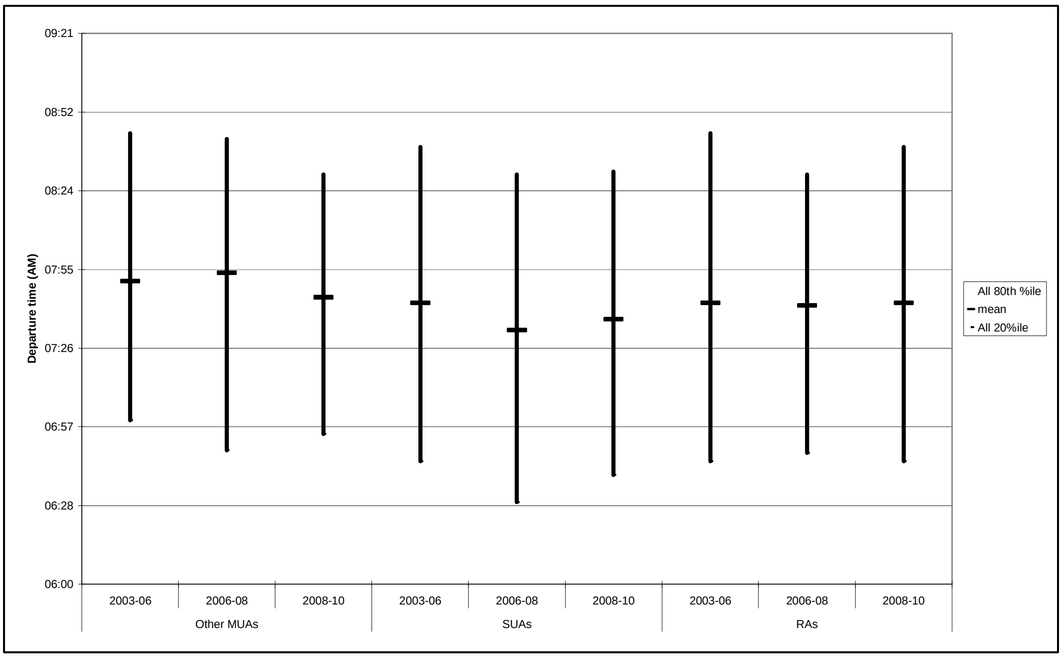


A comparison between figures 4.4 and 4.5 indicates there are negligible differences in the departure times associated with vehicles or all modes of travel. From this comparison it is apparent the departure times and departure time patterns occurring over time are largely governed by private motor vehicle use. Therefore, only the departure times associated with home to work trips by vehicle were analysed further.

4.3.3 Morning work departure times by vehicles – other MUA, SUA, rural

Figure 4.6 illustrates the morning work departure times associated with the other area types.

Figure 4.6 Temporal analysis of morning work departure time by vehicle within other area types



The following observations can be made from figure 4.6:

- Comparison of the three area types shows there is no consistent pattern emerging between them.
- The other MUAs depart later than the SUAs and RAs.
- Departure times associated with the RAs are broadly consistent between each year group, which may be a function of lower congested routes within the rural road network.
- Generally, the changes in departure times from one year group to the next are not significantly different.

An analysis of journey times associated with home to work was undertaken for the 2003 to 2010 periods. While the analysis confirmed work arrival times remained unchanged, the results failed to show any statistically significant change in the home to work journey time over the period analysed. It was therefore considered the sample sizes were too small to assert that peak spreading took place.

4.3.4 Summary findings of morning departure times

For vehicle drivers, the start time for the journey to work appeared to be significantly earlier for people within the Auckland MUAs in comparison with the other area types analysed, which could be attributed to the more dispersed nature of Auckland and the dominance the car has had in shaping the region to date. For the Wellington and Canterbury MUAs there was some indication that throughout the period between 2003 and 2010, commuters were starting their morning commute at an earlier time. There was no evidence to show commuting distances were constantly increasing over time for these MUAs, therefore the earlier departure times for the Wellington and Canterbury areas may be attributed to higher levels of road congestion. Journey to work departure times were predominantly related to the vehicle trip as opposed to other travel modes. Of the area groups tested, the earliest start times were associated with the SUAs and RAs, potentially reflecting the higher commuting distances for these areas.

4.4 Mode split of trip chains

This section of the analysis examines the mode split of trip chains ending at the following main destinations:

- employment
- education
- shopping
- social visits
- recreation
- home.

The following analysis examines the mode split of chains by area and year, displayed as the percentage of weighted trips. The mode for the trip chain is defined as the mode of the trip leg covering the greatest distance within the chain. The mode splits were derived with the following equation.

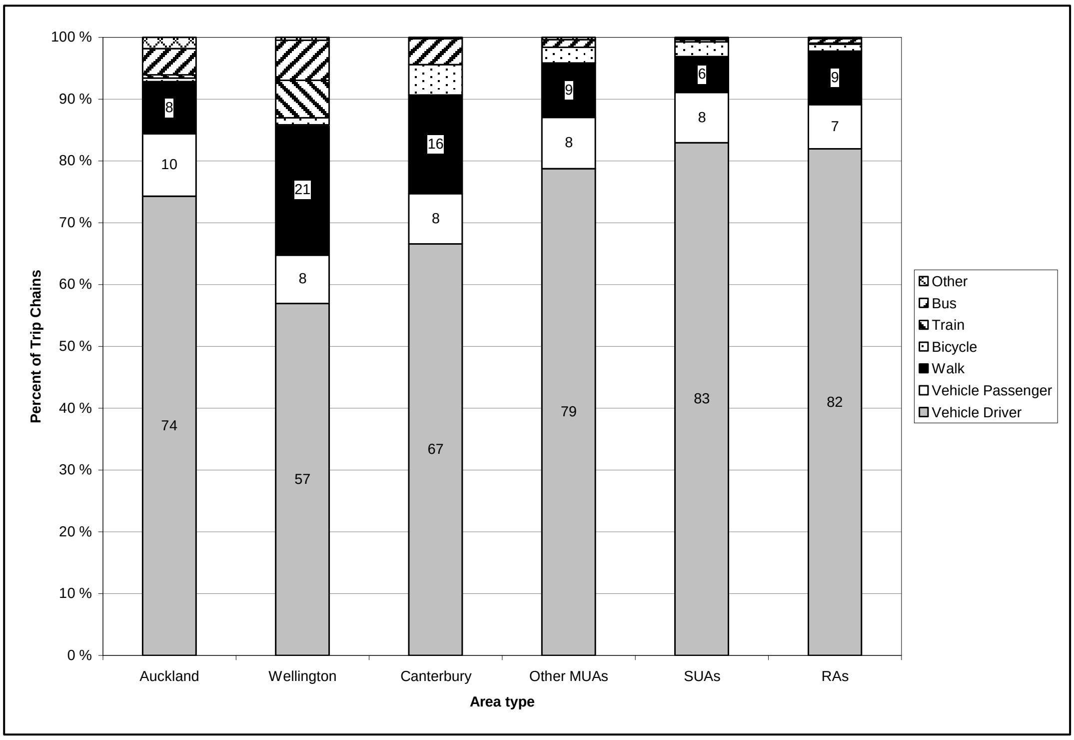
$$\%Mode_{Destination,Area,Year} = 100 \cdot \frac{\sum_{j=1}^{m} tripwgt\_ann}{\sum_{i=1}^{n} tripwgt\_ann} \quad \text{where Modej = Mode} \qquad \text{(Equation 4.2)}$$

and where *i…n* are the dataset rows for each combination of *destination*, *area* and *year*

The following mode split patterns for the main destinations were established from the above formula.

4.4.1 Mode split of trip chains to employment

Figure 4.7 Mode split of trip chains to employment



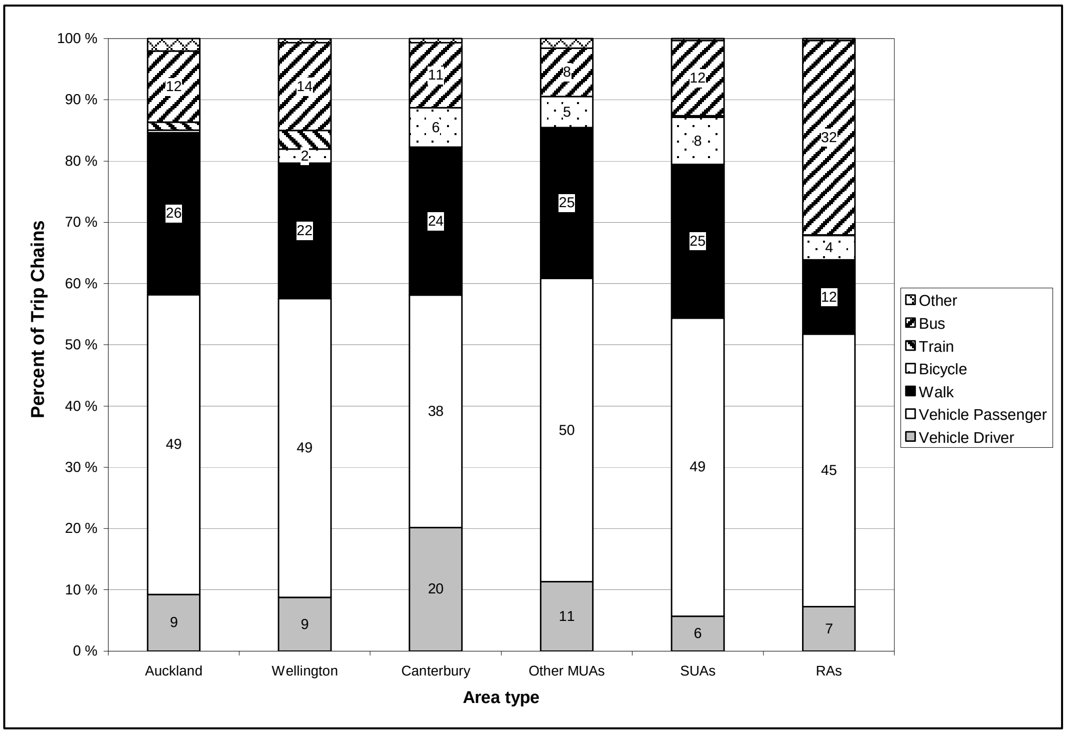
The following observations can be made from figure 4.7:

- The predominant mode of travel is by vehicle for each area type.
- Among the main MUAs, Auckland shows the highest share of vehicle drivers (74%) followed by Canterbury (67%) then Wellington (57%).
- The highest percentages of vehicle drivers can be found in SUAs (83%), RAs (82%) and other MUAs (79%).
- SUAs display the highest proportion of vehicle driver (83%).
- The difference in the proportion of vehicle passengers between areas is generally statistically significant, despite being broadly consistent across all area types (7% to 10%).
- Wellington MUAs accommodate the highest share of non-car travel with walking (21%), bus use (6.5%) and train (6%).

- Bus holds 4% mode share for MUAs in both Auckland and Canterbury.
- In the major MUAs Canterbury shows the highest share of bicycle travel (4.9%), followed by Wellington (1%).

4.4.2 Mode split of trip chains to education

Figure 4.8 Mode split of trip chains to education

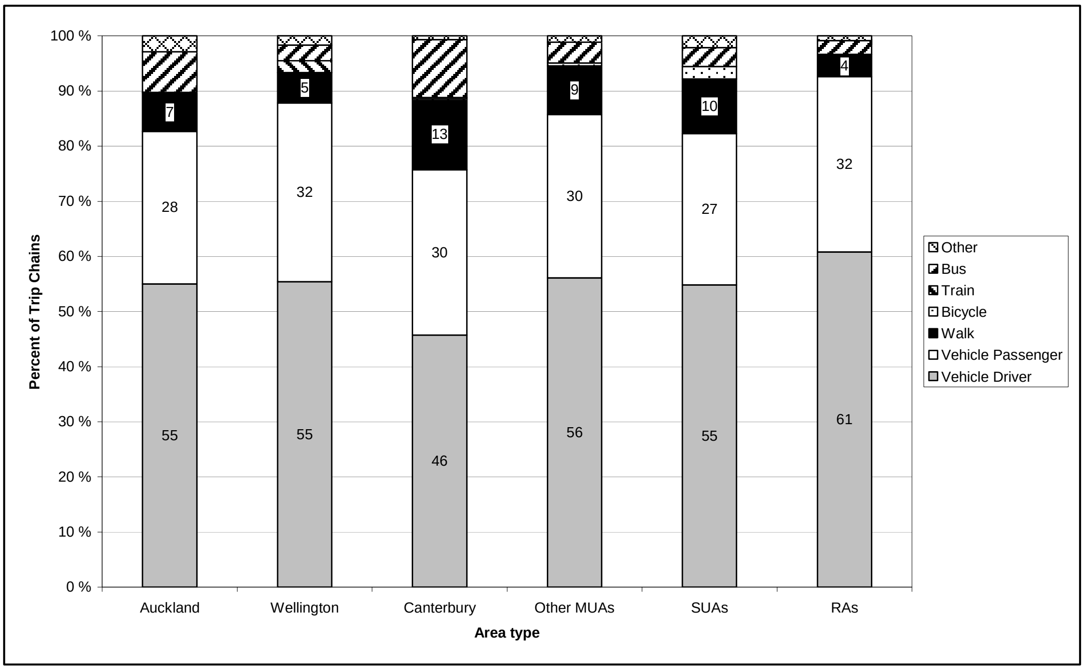


The following observations can be made from figure 4.8:

- The predominant mode for education trips in all areas is vehicle passenger.
- Canterbury vehicle driver mode share is more than double that of Auckland and Wellington. This is probably a consequence of the high number of trips to tertiary education sampled in this region, and the location of the University of Canterbury within the suburbs, which places it further from denser residential areas and public transport routes, and the high availability of parking within and around the campus.
- With the exception of the Canterbury MUA, which shows a vehicle passenger share of 38%, the vehicle passenger mode share of around 49% is broadly consistent across all other area types.
- With the exception of RAs which show a lower walking share of 12%, a walking share of between 22% and 26% occurs over all other area types.
- RAs present the highest share of bus use (32%) which is more than double that of any of the other area types.
- With the exception of the Auckland MUAs where the cycle mode share is less than 1%, cycle mode share for other area types ranges from 2% to 8%.

4.4.3 Mode split of trip chains to shopping

Figure 4.9 Mode split of trip chains to shopping

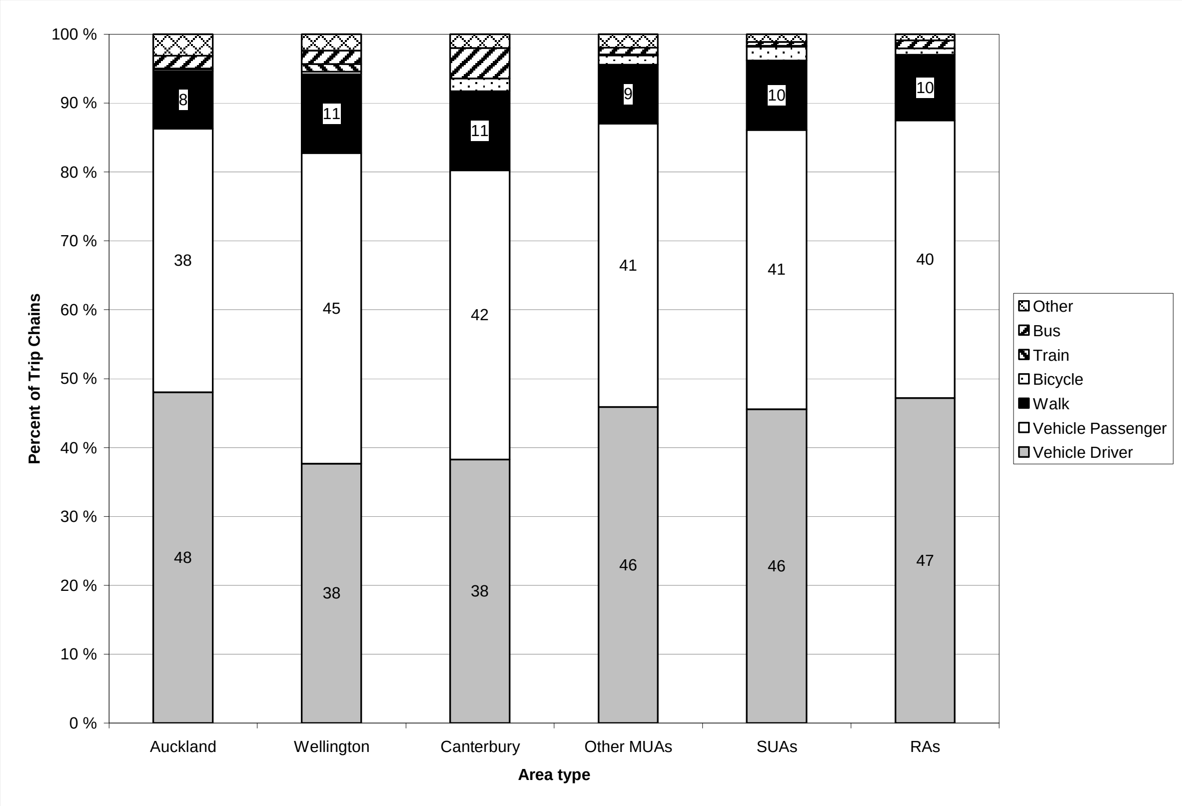


The following observations can be made from figure 4.9:

- The predominant mode share s vehicle driver (46% to 61%).
- RAs present the highest share of vehicle drivers (61%) and the Canterbury MUA shows the lowest proportion of vehicle drivers (46%).
- The Canterbury MUA presents the highest share of walking (13%).
- In the Wellington MUAs just under 3% of shopping travel is undertaken by train.
- Canterbury enjoys the highest bus mode share (13%). Bus use occurs in all area types.
- Travel by bicycle does not feature highly for shopping trips with the highest use, at 2%, occurring in SUAs.
- While the differences between the area types for mode of travel as a vehicle passenger are statistically significant this mode share is comparatively consistent across all area types at around 30%.

4.4.4 Mode split of trip chains to social visits

Figure 4.10 Mode split of trip chains to social visits

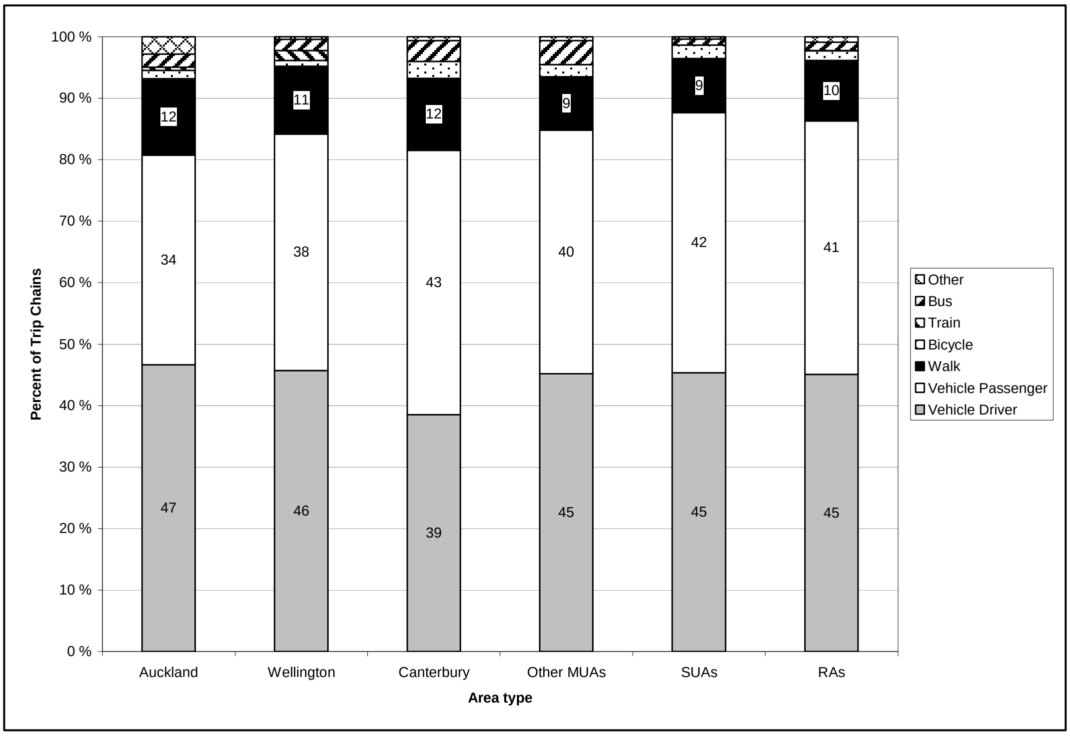


The following observations can be made from figure 4.10:

- Wellington and Canterbury MUAs have the lowest vehicle driver mode share of 38%.
- While the difference in vehicle driver share between Auckland MUAs and the non-major MUA area groups is statistically significant, the actual difference between these area groups is slight (46% to 48%).
- Bus use occurs in all area types with the largest bus mode share occurring in the Canterbury MUA (6%).
- The proportion of walk mode is reasonably consistent across all the area types (8% to 11%).

4.4.5 Mode split of trip chains to recreation

Figure 4.11 Mode split of trip chains to recreation

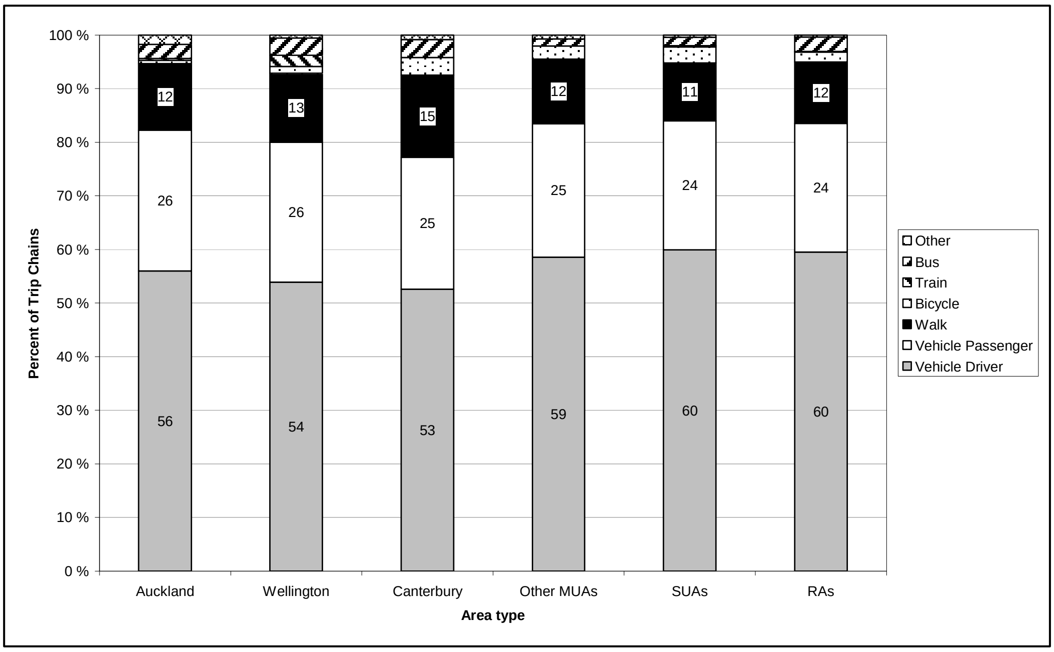


The following observations can be made from figure 4.11:

- With the exception of the Canterbury MUA (39%), the mode of vehicle driver is broadly consistent across all other area types (45% to 47%).
- Bus use is undertaken across all area types ranging from 1% in SUAs to 4% in other MUAs.
- Cycle use occurs across each area type, with maximum cycle use in Canterbury (2.7%).
- Walk mode is consistent among the major MUAs (11% to 12%) and ranges between 9% and 10% for all other area types.

4.4.6 Mode split of trip chains to home

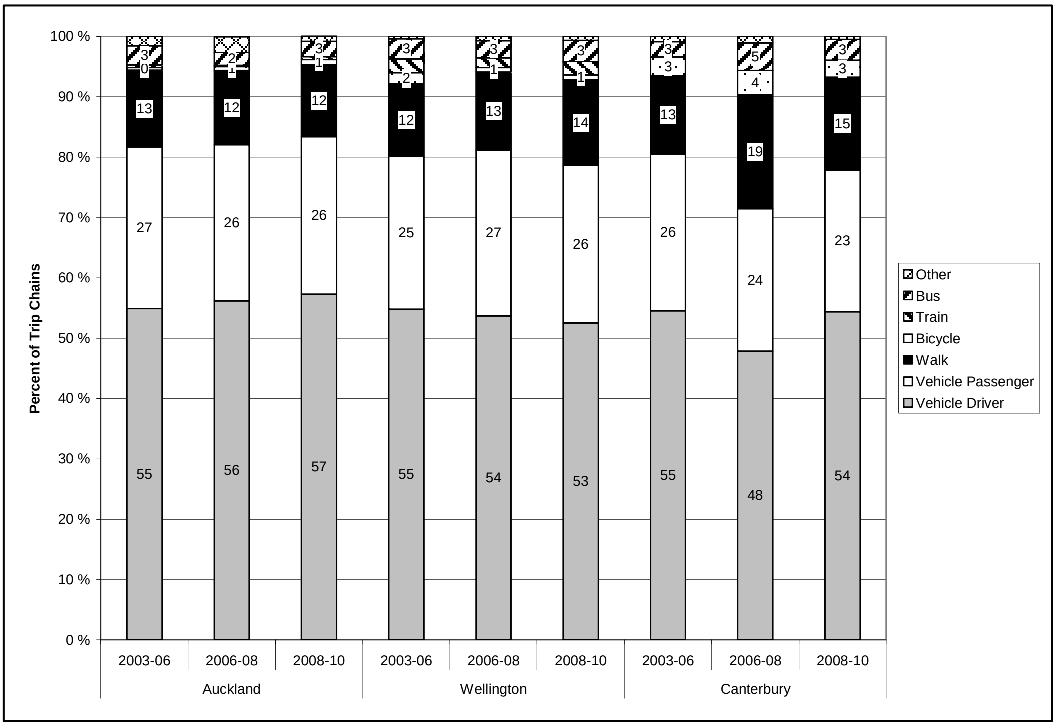
Figure 4.12 Mode split of trip chains to home



The following observations can be made from figure 4.12:

- The predominant mode of travel to home is by private vehicle.
- The lowest share of private car use occurs in the main MUAs.
- The Canterbury MUA presents the highest proportion of trips by walking (16%).

Figure 4.13 Temporal analysis of trip chain mode split to home within major MUAs



The following observations can be made from figure 4.13:

- Comparison between each major MUA reveals there is no common trend in the change of mode split occurring.
- Over the period 2003–10, the mode share for vehicle drivers increases in Auckland MUAs (55% to 57%) while Wellington MUAs show a decrease in the share of vehicle drivers (55% to 53%).
- The Canterbury MUA shows a higher mode share for cycling than their Auckland and Wellington counterparts.
- For the Canterbury MUA, the year group 2006–08 sees a noticeable drop in vehicle driver mode share although this may be attributed to the lower sample size for this year group.

4.4.7 Key findings of mode split of trip chains

Employment activities generated the highest proportion of vehicle drivers among the land uses tested. Travel as a vehicle driver was the dominant mode choice for travel to work. For home to work trips, the largest proportion of vehicle driver mode was associated with the SUAs and RAs reflecting the more dispersed relationship between residential and employment land use activities in these areas. The lowest vehicle driver share was found in the major MUAs, with the remaining MUAs showing a significantly higher share of vehicle drivers for employment purposes, again reflecting the more compact urban forms and greater choice of alternative ways to travel within those areas located in the major regions.

Education trips in major MUAs showed Canterbury vehicle driver mode share was more than double that of Auckland and Wellington, which may be a result of the spatial location of the University of Canterbury. It may have been further influenced by the high number of trips to tertiary education sampled in this region, and the availability of parking within and around the Canterbury University campus. The greatest amount of bus mode share occurred in RAs due to the more dispersed residential locations relative to school locations.

For shopping trips from home, RAs presented the highest share of vehicle drivers, with the Canterbury MUA showing the lowest proportion of vehicle drivers in comparison with the other area groups tested. The lower vehicle driver share for Canterbury can be attributed to the higher share of bus use and walking in this area for shopping purposes. In the Wellington MUAs, just under 3% of home to shopping travel was undertaken by train. Travel by bicycle did not feature highly for shopping trips with the highest use at 2% occurring in SUAs. While the differences between the area types for mode of travel as a vehicle passenger were statistically significant, this mode share was comparatively consistent across all area types at around 30%.

There was significant similarity between mode splits for home to recreation trips and home to social visit trips which were dominated by travel as a vehicle driver and passenger. Of the land uses investigated, recreational and social visits attracted the highest proportion of vehicle passengers.

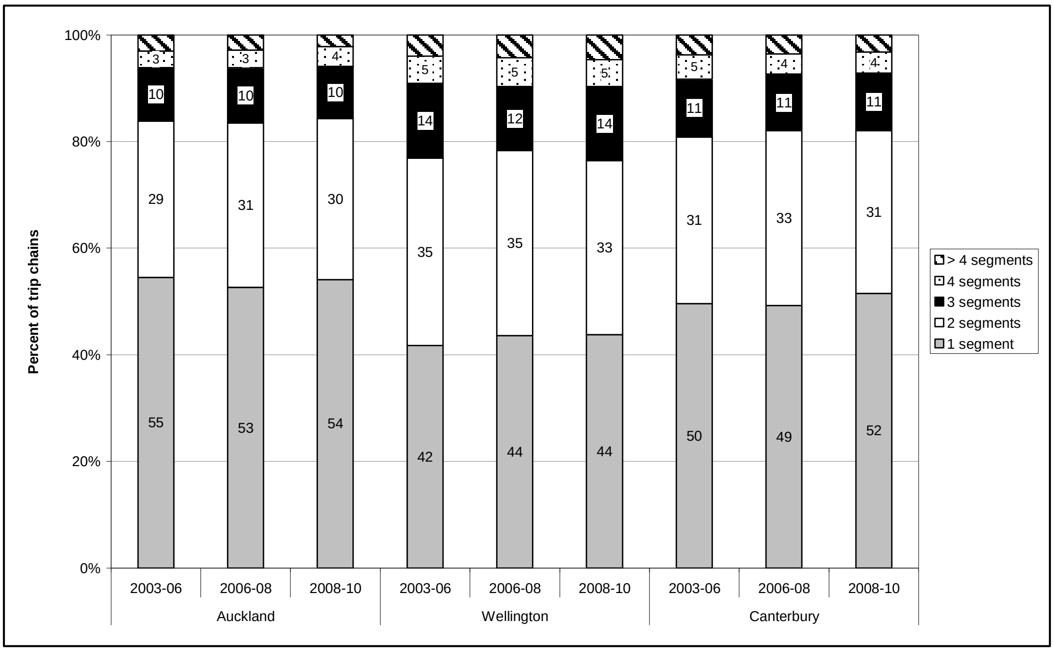
For home-bound travel, which included travel from all journey purposes, the vehicle driver mode share for the major MUAs was lower in comparison with other MUAs as well as the SUAs and RAs. In general the mode of travel was broadly consistent across all area types. Trends over time showed marginal but consistent increases in vehicle driver mode share for the Auckland MUAs, while the opposite trend occurred in the Wellington MUAs with no consistent trend observed for the Canterbury MUA.

4.5 Trip chain complexity

This section examines the complexity of trip making over time throughout the area types. This is done by identifying the number of trip legs per chain, and is expressed as a weighted frequency histogram with the output displayed as a percentage of all trip chains. The analysis is shown first for all trip purposes by year group, then by work trips.

4.5.1 Change in trip complexity over time for all purposes – major MUAs

Figure 4.14 Temporal analysis of trip chain complexity for all purposes in major MUAs

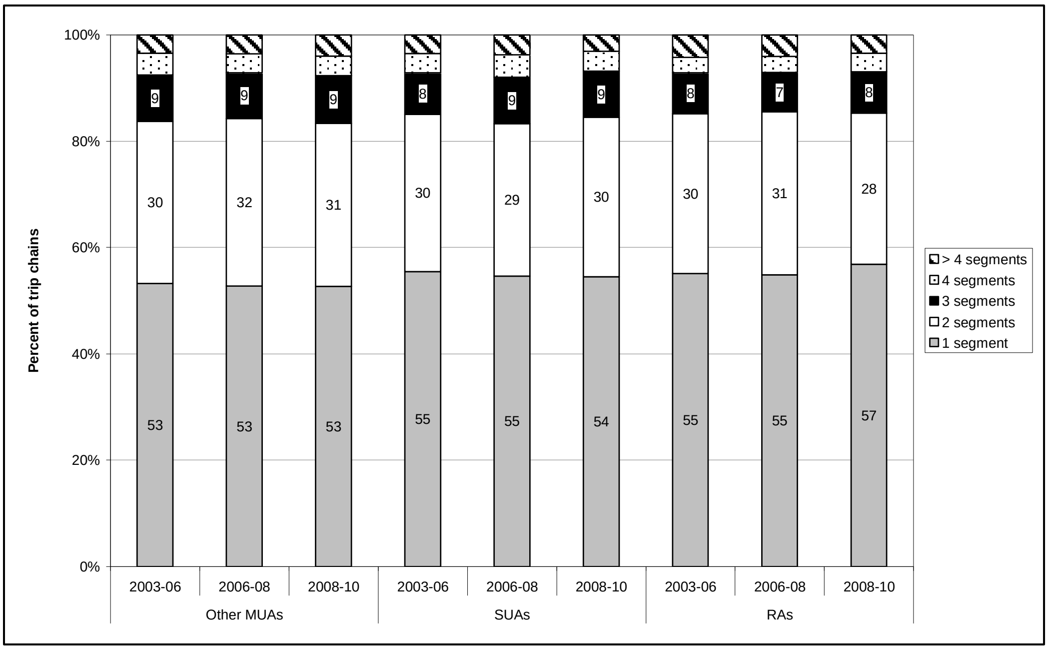


The following observations can be made from figure 4.14:

- Small, but statistically significant changes of between 1% and 2% within each of the major MUAs occur over the year groups.
- Comparisons between each MUA group indicate Wellington MUAs have consistently lower proportions of one-trip leg trip chains than Canterbury and Auckland MUAs. This difference is statistically significant.

4.5.2 Change in trip chain complexity over time for all purposes other areas

Figure 4.15 Temporal analysis of trip chain complexity for all purposes in other area types

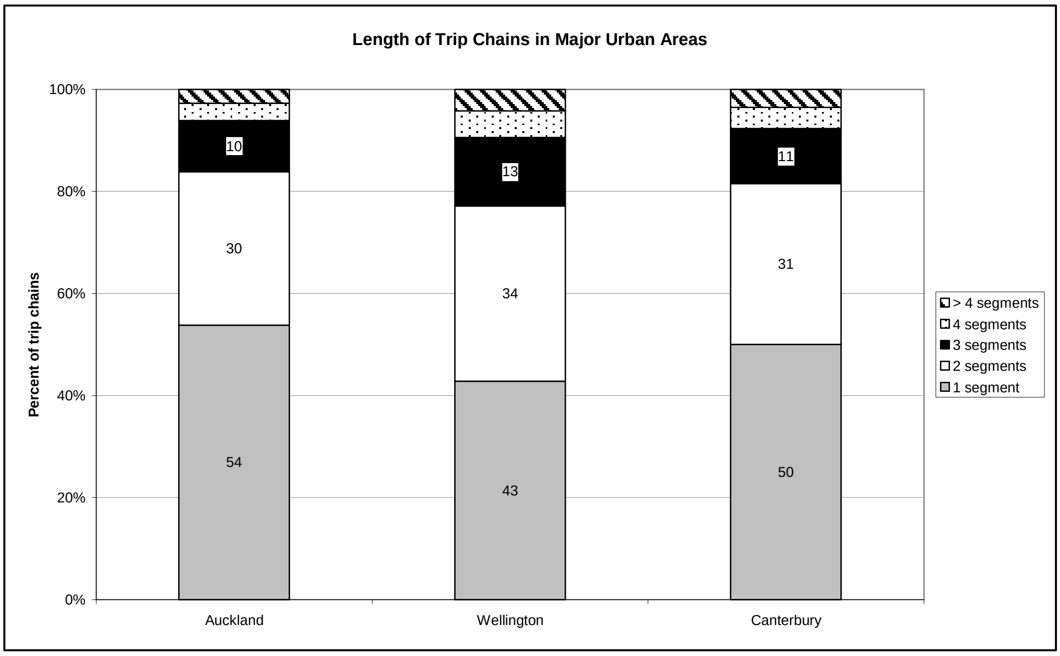


The following observations can be made from figure 4.15:

- In general, no more than a 2% change occurs between one year group and the next for each of the above area groups.
- Single leg trip chains represent the predominant trip chain type throughout each non-major area group.

4.5.3 Trip chain complexity for all purposes – major MUAs 2003–10

Figure 4.16 Complexity of trip chains for all purposes in major MUAs

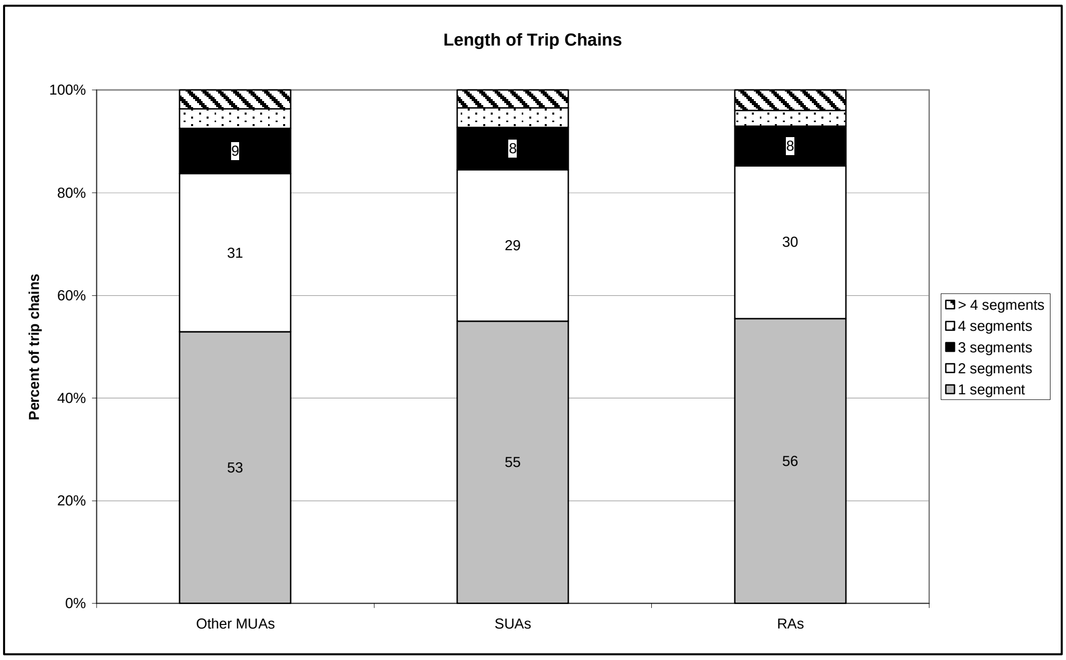


The following observations can be made from figure 4.16:

- Auckland MUAs have the highest share of one-leg trip chains (54%) followed by Canterbury (50%).
- Wellington MUAs show the lowest share of one-leg trip chains at 43%.

4.5.4 Trip chain complexity for all purposes – other areas 2003–10

Figure 4.17 Complexity of trip chains for all purposes in other area types



The following observations can be made from figure 4.17:

- Single-leg trip chains represent the predominant trip chain type for all area groups.
- RAs display the highest share of one-leg trip chains (56%).
- Variation in trip chain type is no more than 3% for all the area types.

4.5.5 Trip chain complexity and mode choice for all purposes

Table 4.2 Relationship between trip chain complexity and mode choice

Area type	Average number of segments for trip chains by mode				
	Walk	Bicycle	Vehicle driver	Vehicle passenger	Bus & rail
Auckland	1.60	1.47	1.73	1.66	2.67
Wellington	1.75	1.48	1.96	1.85	3.28
Christchurch	1.65	1.44	1.86	1.75	3.06
MUAs	1.63	1.47	1.83	1.78	2.29
SUAs	1.58	1.38	1.79	1.77	1.96
RAs	1.60	1.55	1.78	1.83	1.67

The following observations can be made from table 4.2:

- Bicycle journeys show the least number of trip segments.

- Journeys by public transport show the highest average number of trip legs.
- Trips undertaken as a car driver and passenger are more complex than those undertaken by active modes.

4.5.6 Home to work trip chain complexity

Figure 4.18 Complexity of trip chains to work in major MUAs

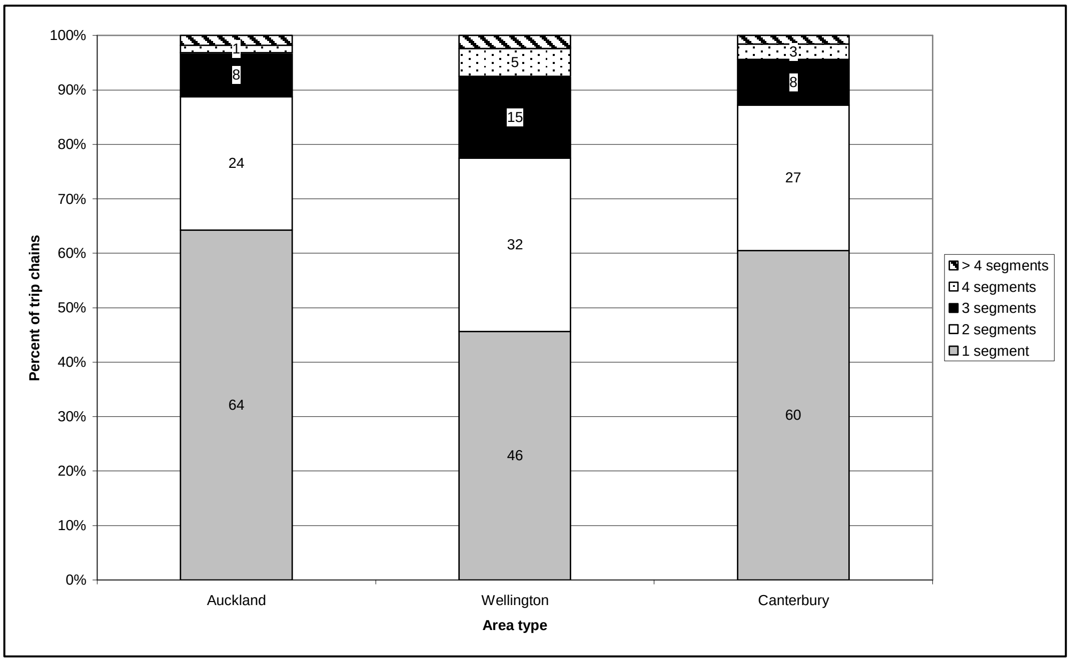
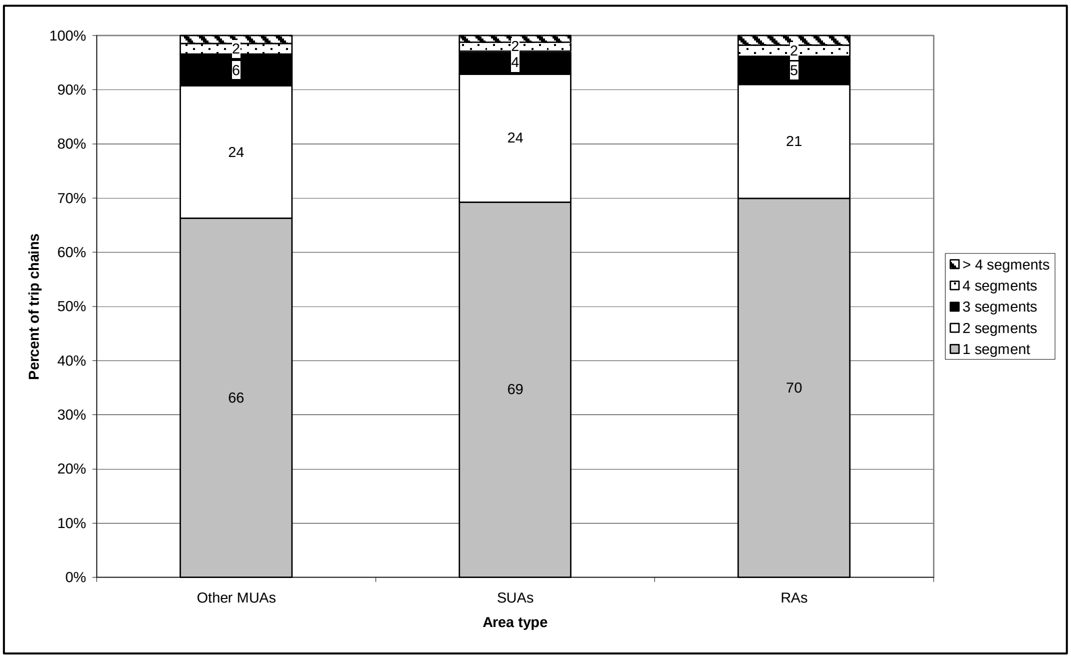


Figure 4.19 Complexity of trip chains to work in other area types



The following observations can be made from figures 4.18 and 4.19:

- With the exception of the Wellington MUAs, which show 45% of work trip chains are undertaken as a one-leg trip chain, all other areas show a higher proportion one-leg trip chains; between 60% and 70%.
- Conversely, Wellington MUAs display the highest proportion of multi-leg trip chains.
- The multi-leg trip chains in Wellington MUAs, of two or more segments, constitute a significantly higher proportion of trips chains in comparison with the other area types.
- For all area groups, excluding Wellington MUAs, between 20% and 30% of work trip chains consist of two-leg trip chains.
- The major MUAs show marginally more complex trip chains than other area types.

4.5.7 Summary findings of trip chain complexity

For journeys to work, the proportion of single-segment trip chains is significantly less in Wellington MUAs than for other area groups. This may be attributed to the higher utilisation of bus and train modes for journey to work trips in this area.

For all observed area groups, there is no consistency with regard to the direction of change in trip complexity over time, and the variations that have been observed are no more than 2% of the total.

While less complex trip chains are undertaken by active modes, public transport trip chains are the most complex, which can be attributed to the necessary segments associated with travelling to and from the public transport facility.

4.6 Trip chain duration

The following section explores regional and temporal variations in the duration of trip chains, by different modes. The trip chain times have been examined in minutes for each area type and analysed by year group. The values are mean weighted by trip weight within the sample by the formula shown in equation 4.3. The main mode has been identified as the mode by which the greatest distance segment was conducted.

$$duration_{Area,Year,Mode,Destination} = \frac{1}{n}\sum_{i=1}^{n} duration_i \cdot \left(\frac{tripwgt\_ann_i}{\frac{1}{n} \cdot \sum_{i=1}^{n} tripwgt\_ann_i} \right) \quad \textbf{(Equation 4.3)}$$

where *i…n* are the dataset rows for each combination of *area*, *year and mode.*

4.6.1 Trip chain durations – all area types 2003–10

Table 4.3 Trip chain duration of whole trip (minutes) for all area types 2003–10 average

Area type	Walk	Bicycle	Vehicle driver	Vehicle passenger	Bus & rail
Auckland	20.6	30.2	28.6	27.4	55.0
Wellington	24.2	25.5	28.3	27.2	57.7
Canterbury	19.9	27.1	25.5	26.2	46.5
Other MUAs	22.1	23.3	22.7	25.5	58.1
SUAs	22.1	21.6	20.7	25.2	-
RAs	18.8	23.6	26.5	31.8	47.7

'-' indicates that sample size was below the minimum sample size specified by the MoT terms of use for the dataset

The following observations can be made from table 4.3:

- Wellington MUAs show the highest duration for walking trips (24.2 mins) with RAs showing the lowest duration (18.8 mins).
- There is a wide range of walk durations throughout all area types.
- For modes by vehicle driver the major MUAs within Auckland and Wellington display higher trip durations than other area types.
- The major MUAs show higher vehicle driver and passenger trip duration than the other main and secondary urban areas.

4.6.2 Trip chain durations for all purposes – MUAs by year group

Bicycle mode has been omitted from tables 4.4 and 4.5 due to insufficient sample sizes when the data was broken down into year groupings.

Table 4.4 Trip chain duration for whole trip (minutes) for major MUAs of Auckland, Wellington and Canterbury regions

Area	Mode											
	Walk			Vehicle driver			Vehicle passenger			Bus & rail		
	2003-06	2006-08	2008-10	2003-06	2006-08	2008-10	2003-06	2006-08	2008-10	2003-06	2006-08	2008-10
Auckland	21.2	18.0	22.5	28.8	27.9	28.8	29.4	26.3	25.7	51.3	-	59.6
Wellington	22.6	23.5	26.8	26.5	29.2	30.4	25.6	28.5	28.4	57.2	53.1	62.1
Canterbury	21.3	17.0	21.3	24.8	25.5	26.2	24.3	28.2	26.6	-	-	52.9

The following observations can be made from table 4.4:

- Wellington MUAs show the longest duration walk trips in comparison with their Auckland and Canterbury counterparts.

- Auckland and Canterbury MUAs share a pattern of decreasing walk durations, but increasing in 2008–10.
- Trip duration for drivers in the Wellington and Canterbury MUAs increases over the period tested.
- Trip chain durations, in general, are completed within a time budget of between 20 and 30 minutes for the private transport modes.

4.6.3 Trip chain durations for all purposes – other area types

Table 4.5 Trip chain duration for whole trip (minutes) for other MUAs, SUAs and rural

Area	Mode											
	Walk			Vehicle driver			Vehicle passenger			Bus & rail		
	2003-06	2006-08	2008-10	2003-06	2006-08	2008-10	2003-06	2006-08	2008-10	2003-06	2006-08	2008-10
Other MUAs	21.2	23.6	22.0	22.5	22.0	23.6	25.7	24.2	26.4	65.7	-	58.4
SUAs	20.7	23.7	22.8	21.1	20.9	19.9	25.8	28.6	21.9	-	-	-
RAs	18.5	17.8	20.4	26.8	26.5	26.0	31.0	34.9	30.1	46.7	44.5	52.2

The following observations can be made from table 4.5:

- RAs show the longest vehicle driver and passenger durations for each year group.
- Trip chain durations for drivers in SUAs decrease over time while trip chain durations for rural drivers remain relatively static over the period tested.

4.6.4 Trip chain distances for home to work journeys – all area types

Table 4.6 Commute distance (km) by private vehicle (AM peak period)

Year	Auckland	Wellington	Canterbury	Other MUAs	SUAs	RAs
2003–2006	12.74	15.53	9.07	10.35	12.38	19.45
2006–2008	12.31	19.77	8.90	10.89	12.98	17.18
2008–2010	12.14	15.55	10.23	10.97	15.74	17.44
2003–2010	12.44	16.77	9.37	10.69	13.50	18.21

The following observations can be made from table 4.6:

- There is no common direction of change in commuting distances occurring across the area groups.
- The Auckland MUAs show marginal decreases in commute distances over time.
- The lowest average commuting distance is presented by the Canterbury MUA (9.37km) and the highest commute distance occurs in rural areas (18.21km).
- Of the major MUAs, Wellington shows the highest average commute distance (16.77km).
- Other MUAs and SUAs show consistent increases in commute distance over time.

4.6.5 Summary findings of trip chain durations

The major MUAs showed higher vehicle driver trip durations than the other main and secondary urban areas. Trip durations for drivers in the Wellington and Canterbury MUAs increased during the period tested. Auckland and Wellington MUAs shared a pattern of increased walk and vehicle driver trip chain durations for the period 2006–08 to 2008–10.

The Auckland MUAs showed marginal decreases in commute distances over time, potentially reflecting changes in road infrastructure. The lowest average commuting distance was presented by the Canterbury MUA (9.37km) with rural commute distances representing almost double that of the Canterbury MUA.

Of the major MUAs, Wellington showed the highest average commute distance of around 16km. Other MUAs and SUAs showed consistent increases in commute distances over time.

4.7 Travel trends for all purposes

This section explores three aspects of travel behaviour for all modes and travel purposes between 2003 and 2010. The aspects explored relate to:

- trip legs per person per year
- travel hours per person per year
- km travelled per person per year.

Equations for these trends are shown in equations 4.4, 4.5 and 4.6:

$$nLegs_{year} = \frac{\sum_{i=1}^{n} tripwgt\_ann_i}{\sum_{i=1}^{n} peweight_i}$$ (Equation 4.4)

where *i…n* are the dataset rows for each year

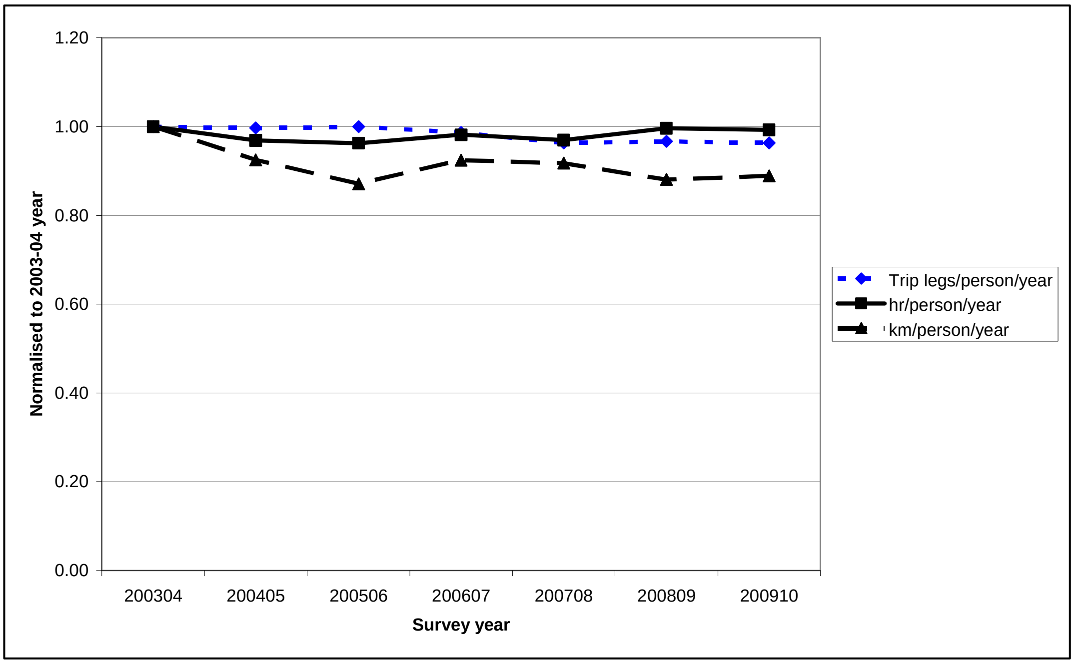
$$dist_{year} = \frac{\sum_{i=1}^{n} tripwgt\_ann_i \cdot dist_i}{\sum_{i=1}^{n} peweight_i}$$ (Equation 4.5)

where *i…n* are the dataset rows for each year

$$time_{year} = \frac{\sum_{i=1}^{n} tripwgt\_ann_i \cdot time_i}{\sum_{i=1}^{n} peweight_i}$$ (Equation 4.6)

where *i…n* are the dataset rows for each year.

Figure 4.20 Travel pattern changes between 2003–04 and 2009–10



The following observations can be made from figure 4.20:

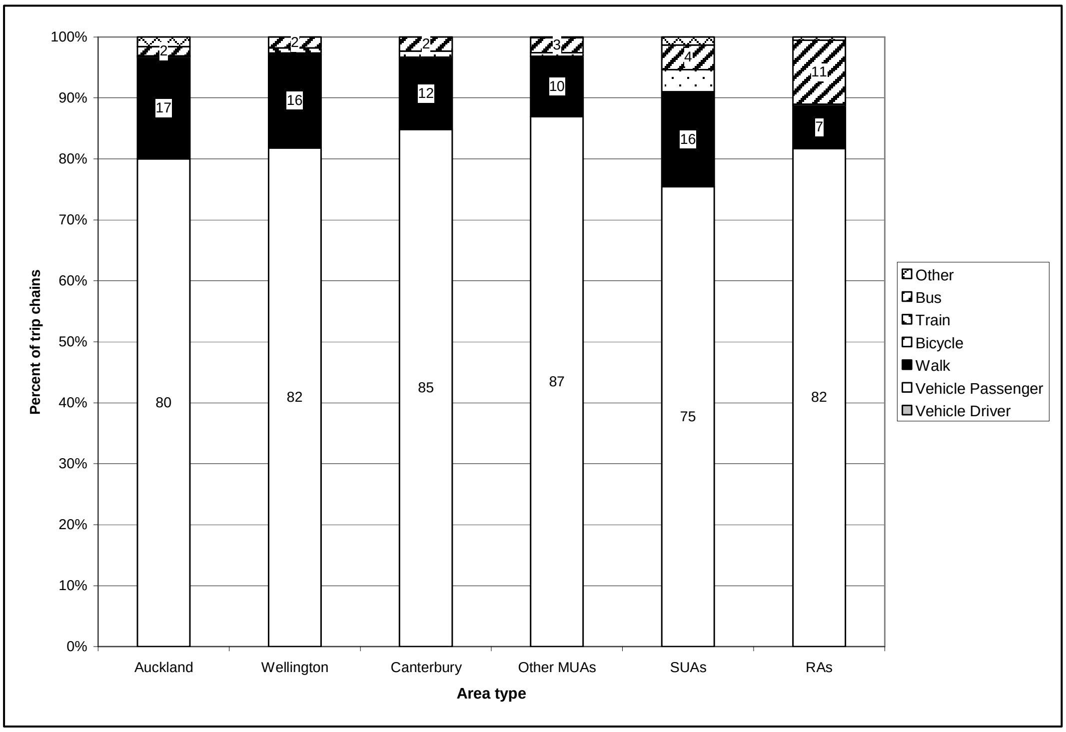
- Trip legs per person per year peak during the 2005–06 period before declining thereafter. While the year on year change is not always statistically significant the overall change between 2003 and 2010 is statistically significant.
- The sharpest decline in all of the travel aspects examined occurs during the period 2006–07.
- Travel hours per person per year peak during the period 2006–07.
- All of the travel aspects have lower values in 2010 than in 2003 with km/person/year seeing the greatest drop of 9% over the period of analysis.
- Although the hours/person/year statistics show statistically significant changes within the periods tested, the overall change from 2003 to 2010 is not statistically significant.
- The transport statistics for trip legs per person per year and km per person per year show significant overall changes between 2003 and 2010.

4.8 Home to education travel

This section examines the travel characteristics associated with education related trip chains, which also includes trips coded as 'social visits' for children under five years of age.

4.8.1 Preschool (age group 0–4 years)

Figure 4.21 Preschool modal split of chains for all area types

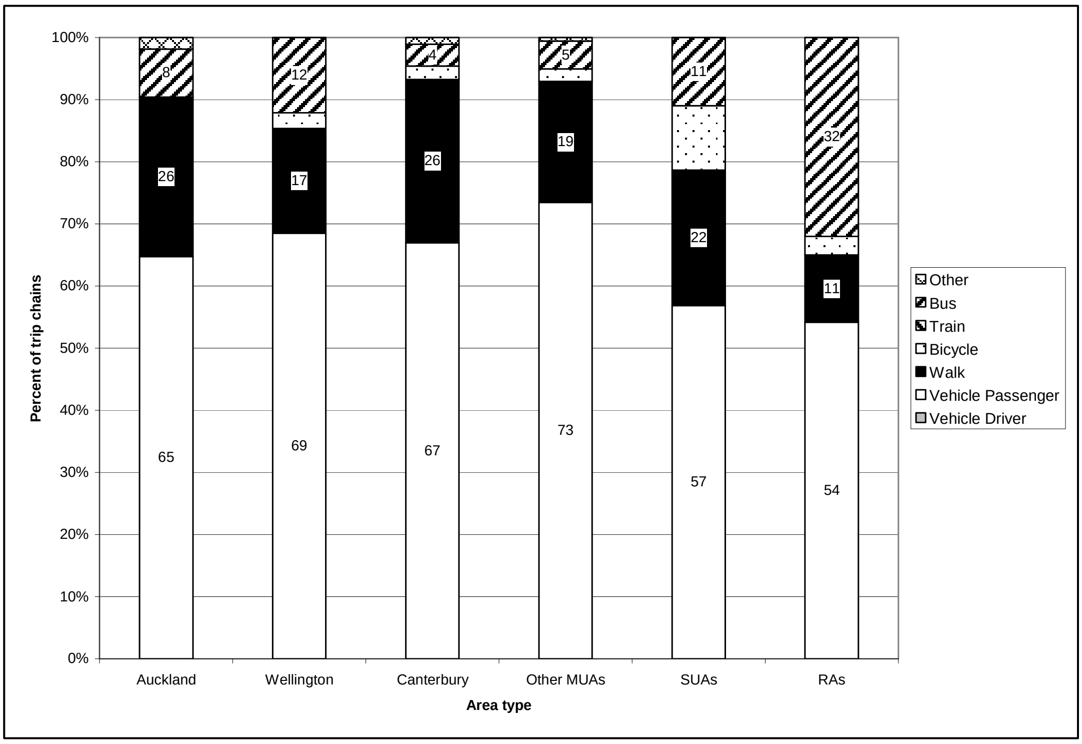


The following observations can be made from figure 4.21:

- The predominant mode of travel is as a vehicle passenger for all area types.
- Other MUAs show the highest vehicle passenger share (87%) with SUAs showing the lowest proportion (75%).
- The highest walk share was in Auckland MUAs (17%) followed by Wellington MUAs and SUAs (16%).
- The highest bicycle share can be found in SUAs (3.6%) followed by the Canterbury MUA (1%), with all other area types showing bicycle use of less than 1%.
- The highest share of bus use can be found in RAs (11%).

4.8.2 Primary school (age group 5–10 years)

Figure 4.22 Primary school modal split of chains for all area types

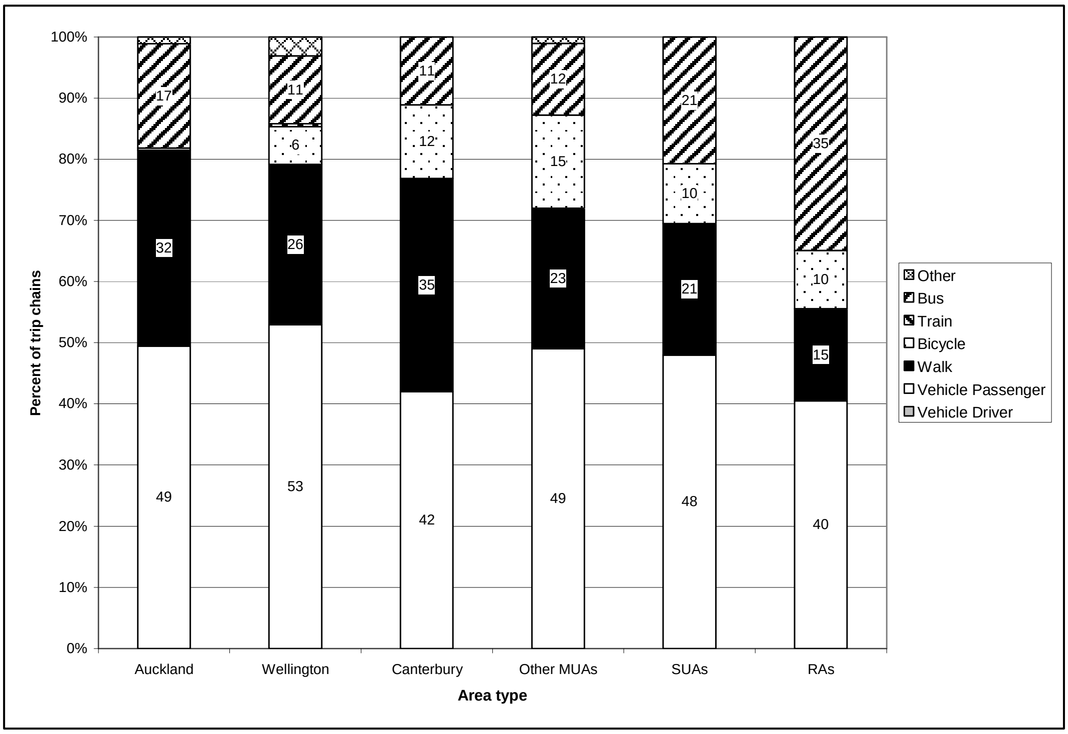


The following observations can be made from figure 4.22:

- The predominant mode of travel is as a vehicle passenger for all area types, ranging from 54% to 73%.
- Other MUAs show the highest proportion of vehicle passengers (73%).
- SUAs and RAs show the lowest proportion of vehicle passenger trips (54% to 57%).
- The highest walk mode of 26% is shared by both Auckland and Canterbury MUAs.
- The highest bus mode share occurs in rural areas (32%) and the lowest bus mode share occurs in the Canterbury MUA (4%).
- Wellington MUAs present a bus mode share that is three times greater than Auckland MUAs and double that of the Canterbury MUA.
- With the exception of Auckland, which has a bicycle mode share of less than 1%, bicycle use in all other area types ranges from 2% to 10%.

4.8.3 Intermediate school (age group 10–13 years)

Figure 4.23 Intermediate school modal split of chains for all area types

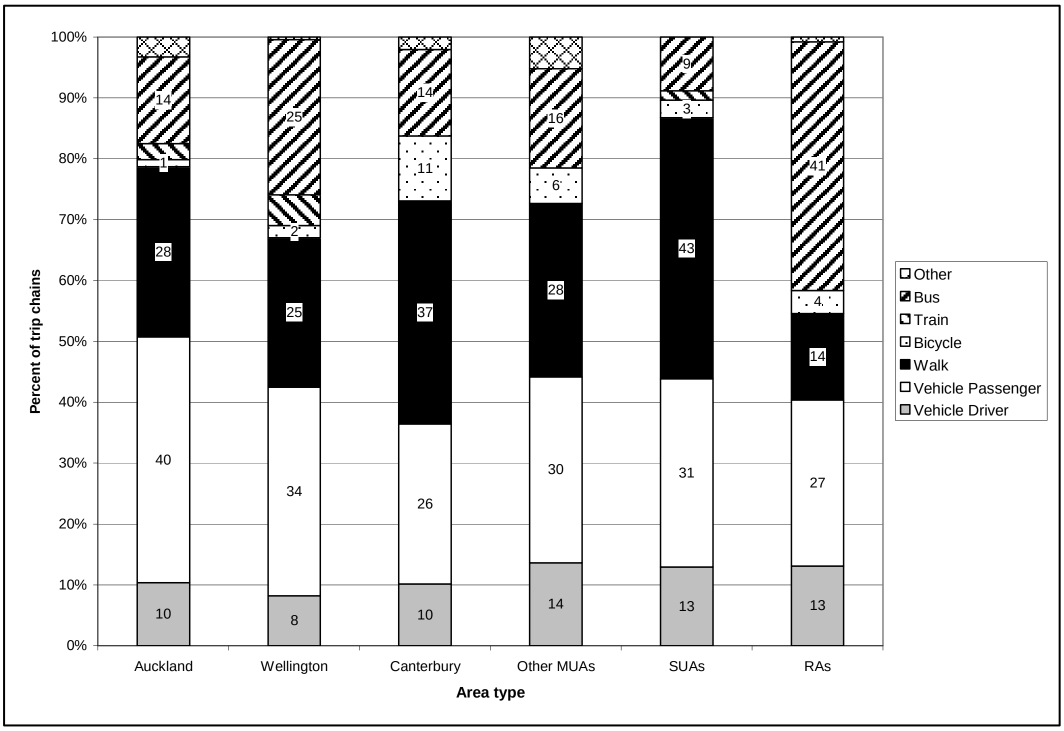


The following observations can be made from figure 4.23:

- The predominant mode of travel in all area types is as a vehicle passenger.
- The highest walk mode share occurs in the Canterbury MUA (35%) with the lowest walk mode share occurring in RAs (15%).
- With the exception of Auckland MUAs, which show a bike use of less than 1%, bike use ranges between 6% for Wellington and up to 15% for other MUAs.
- Bus use is represented in each area type; the lowest share occurs in Wellington and Canterbury MUAs at 11%.
- The highest bus mode share within the major MUAs is represented by Auckland MUAs (17%), with Canterbury and Wellington MUAs showing a bus mode share of 11%.
- The highest bus mode share occurs in RAs (35%).

4.8.4 High schools (age group 13–17 years)

Figure 4.24 High school modal split of chains for all area types

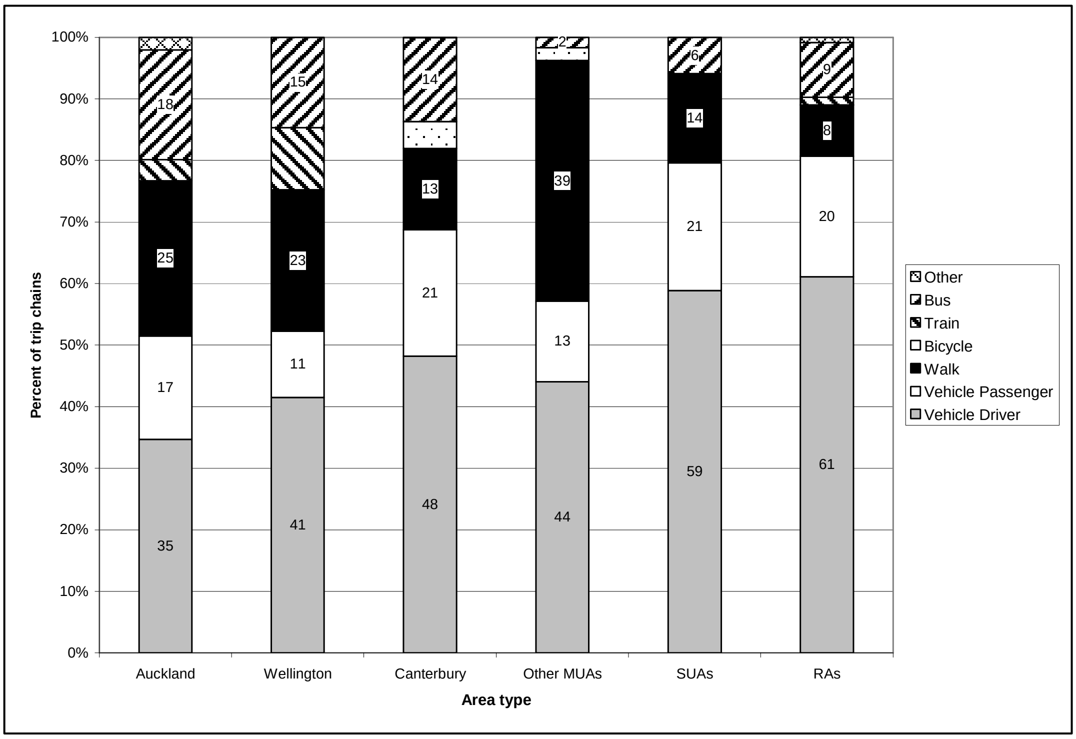


The following observations can be made from figure 4.24:

- The highest share of vehicle driver mode is found in other MUAs (14%) followed by SUAs and RAs at 13%.
- The lowest vehicle driver share can be found in Wellington MUAs (8%), followed by the other major MUAs within Auckland and Canterbury (10%).
- The highest vehicle passenger mode share can be seen in Auckland (40%).
- The major MUAs show higher vehicle passenger share than other area types.
- There is a large variation in walk mode share, ranging from 14% in RAs to 43% in SUAs.
- Among the major MUAs, walking is the most prominent mode in Canterbury (37%). In Auckland, 28% of trips are by walking, and in Wellington the figure is 25%.
- Train use occurs in Wellington (5%) Auckland (2.6%) and SUAs (1.5%).
- Cycle use occurs in all areas with Canterbury showing the highest share of 11%, and Auckland MUAs showing the lowest cycle mode share of 1%.
- Bus use occurs in all areas with RAs representing the highest use of 41% and SUAs the lowest at 9%.

4.8.5 Tertiary education (age group over 18 years)

Figure 4.25 Tertiary education modal split of chains for all area types



The following observations can be made from figure 4.25:

- Vehicle driver is the predominant mode of travel in all areas.
- Between the area types, RAs and SUAs feature the highest percentage of vehicle drivers, while Auckland and Wellington MUAs feature the lowest.
- The highest walk share of 39% occurs in other MUAs.
- Train use occurs in Wellington MUAs (10%), Auckland MUAs (3.5%) and RAs (1.2%).
- Bicycle use occurs in the Canterbury MUA (4.4%) and other MUAs (2.1%) with other area types showing less than 1%.
- Bus use is most highly featured in the main MUAs of Auckland (18%) followed by Wellington (15%) and then Canterbury (14%).
- RAs at 9% represent the highest bus use among the non-major MUA areas.

4.8.6 Summary findings of home to education travel

For pre-school and primary school travel, the predominant mode of travel was as a vehicle passenger for all area groups. Cycle use within the preschool and primary school age group, while representing a low proportion of trips, was most prevalent in SUAs.

For the high-school age group, the Auckland MUAs showed a higher dependence upon travel as a vehicle driver or passenger than all other areas. In the major MUAs of Wellington, a quarter of all education-related travel was undertaken by bus which was almost double that of the major MUAs of Auckland and Canterbury. In the major MUA of Canterbury the dominant mode of travel to education was undertaken as a walk trip.

For school-related education travel, it could be seen that as the age group increased and students became more travel independent, higher proportions of walk, cycle and bus use occurred.

For the tertiary education sector, travel as a vehicle driver was the dominant mode of travel for all areas. The Canterbury MUA showed higher levels of car travel both as a driver and passenger than Auckland and Wellington MUAs. The highest proportion of walk trips for this education group was undertaken by other MUAs.

5 Use of NZHTS data in a predictive context and other uses

In this section, we report on the use of NZHTS data in predictive models and give an assessment of how well three key predictor variables relate to household travel. This section also describes, through the arrangement of the NZHTS data, how it can be used for additional transport planning purposes.

The NZHTS is designed primarily with the concepts of safety and efficiency in mind, rather than as a tool specifically designed to determine trip generation characteristics of trip making. The ability of the NZHTS data to be used in a predictive model is limited, first because it is not statistically possible to expand the data to represent the entire population due to the way in which the sampling is organised, and second because travel costs are not represented or varied.

Strategic transport models are calibrated against the results of empirical data such as regional-based household and or roadside interview surveys, public transport on-board surveys, and special generator surveys which include representative samples of most meshblocks. The NZHTS, in contrast, is based on data collected on the basis of a stratified cluster sample and as such does not contain the spread of data required to enable comparisons between models based on alternative data collection techniques to be easily made.

The relative disaggregation of the input data of strategic transport models also does not allow for direct comparisons of trip rates to be undertaken with the analysis of the NZHTS which is presented at a more aggregate level.

The models that are described in the following sections of this report demonstrate the relationship between age profile, car ownership and household type, with trip generation and mode choice. Additional variables such as household income, public transport accessibility levels and the perceived cost of alternative travel modes also have an influence on travel behaviours. Noting that an element of interrelationship between variables such as income and car ownership occurs, the arrangement of the NZHTS data as presented in this report assumes all other potential variables and the relativity of travel costs by mode are equal. The information presented in the following sections therefore represents a starting point for explaining trip generation and modal choice.

5.1 Household trip generation

Strategic transport models currently have the ability to test the travel effects of changes in a range of variables. However, access to such models, which do not relate to all locations, is typically limited to the model proprietors. The models developed for this study provide additional information to practitioners for a range of area types throughout the country. They also enable various queries to be undertaken that provide a first-cut assessment of likely changes in travel behaviours based on the key variables used.

In strategic models, person trip rates for each of the categories and dimensions determined during calibration are usually assumed to be constant over time. However, changes to population demographics such as an aging population, a shift towards smaller household sizes and adjustments to travel choices following changes in the availability of carbon-based fuels are all likely to contribute towards changes in how we travel in the future.

Assuming all other potential variables and the relativity of travel costs by mode remain constant, predictive aspects of the NZHTS data can be established through the arrangement of the data, whereby users can determine potential changes in trip generation rates and modal splits that may occur as a result of future changes to demographic structures.

Using the Python programming language to extract data from the NZHTS, a series of models were established. The models were developed in Microsoft Office Excel enabling practitioners to freely access the data without the need to develop or purchase specialist modelling software.

The data was arranged to expose the differences in trip chains for each area group during the period 2003–10. The trip chains were expressed as average values with 95% confidence limits shown on the model outputs.

The data was arranged to show weekday and weekend household trip chains by mode and area types as used elsewhere in this report, dependent upon the following variables:

- population age profile
- household car ownership
- household type.

In addition to the above, a school travel model was also developed.

5.1.1 Model methodology

The number of trip chains relative to household type was calculated as the sum of trip weights for chains made by the specified household type within the area, to the destination, divided by the sum of household weights of specified type within the area, as shown in equation 5.1.

$$tripChains_{HouseholdType,Area,Destination} = \frac{\sum_{j=1}^{m}\left(\sum_{i=1}^{n} tripwgt\_ann_i\right)}{\sum_{i=1}^{n} hhweight_i} \qquad \text{(Equation 5.1)}$$

where *i…n* are the dataset rows for each combination of *household type* and *area*; and *j…m* are the dataset rows for each *destination.*

Trip chains within the selected area are calculated as a product of household type percentage and the calculated number of trip chains for each destination, as shown in equation 5.2.

$$tripChains_{Destination} = \sum_{i=1}^{n}\left(\frac{\%_{HouseholdType(i)}}{100} \cdot tripChains_{HouseholdType(i),Destination}\right) \qquad \text{(Equation 5.2)}$$

where *i…n* are the *household types.*

Overall mode split to the activity destinations is presented in the model output, and represents the mode split measured within the area to the destination.

The outputs of these equations form the data underpinning the models, samples of which are shown in tables 5.1 and 5.2. The full complement of data used in each of the models is available for viewing in the 'Data' sheet of the relevant spreadsheet model. The data values are weighted by the household type or vehicle ownership split, which is entered by the user, and then used to determine the resulting trip rate and modal split.

Table 5.1 Daily weekday person trip rates per household in relation to household composition

Household composition	Auckland MUAs	Wellington MUAs	Canterbury MUA	Other MUAs	SUAs	RAs
Person alone	2.2	2.6	2	1.9	2	2
Couple	4.6	5.4	4.1	4.4	4.6	3.9
Single parent	6.6	7.1	6.4	6.3	6.2	6.2
Adults	7.4	8.8	7.8	7.3	7.7	6.1
Couple with children	10.3	10	9.6	10.3	10.5	9.0

Table 5.2 Daily weekday person trip rates per household in relation to car ownership

Car ownership per household	Auckland MUAs	Wellington MUAs	Canterbury MUA	Other MUAs	SUAs	RAs
No vehicles	3	2	2	2.2	2	2
One vehicle	5.4	5.1	4.2	3.8	3.8	3.5
Two vehicles	7.5	7.8	7.1	7.2	6.6	5.8
More than two vehicles	10.4	10	9.3	8.5	9.9	7.2

5.1.2 Model inputs

Tables 5.3 to 5.5 summarise the default input values to the model for each of the major urban areas as they relate to age profile, household type and car ownership profiles. These values were sourced from Statistics New Zealand based on 2006 Census data. The use of the data for default values enables the model to broadly reflect existing demographics and hence determine the extent of current household trip chaining.

Table 5.3 Percentage household car ownership input values (2006)

	Percentage household car ownership (2006 Census)			
Area	**Nil**	**1**	**2**	**>2**
Auckland	7	35	40	17
Wellington	12	43	34	11
Canterbury	7	37	39	17
New Zealand	8	38	38	16

Table 5.4 Percentage age profiles input values (2006)

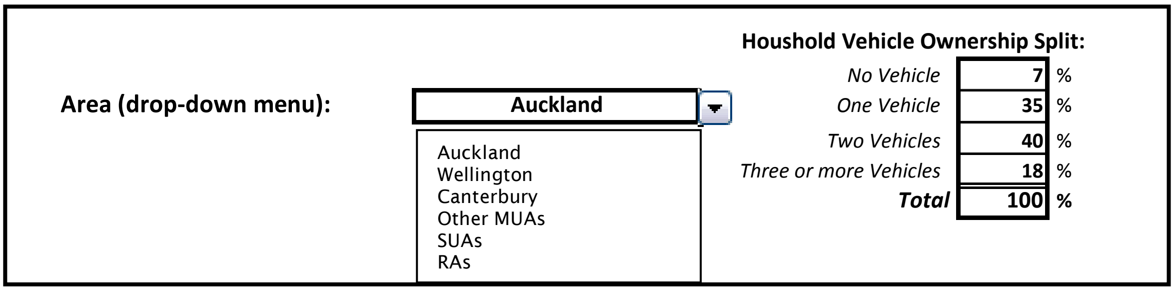
	Percentage age profile (2006 Census)						
Area	**0–14**	**15–19**	**20–29**	**30–39**	**40–49**	**50–64**	**65+**
Auckland	22	8	14	16	15	15	10
Wellington	21	7	14	15	15	16	11
Canterbury	20	7	13	14	15	17	14
New Zealand	22	7	13	14	15	16	12

Table 5.5 Percentage household types input values (2006)

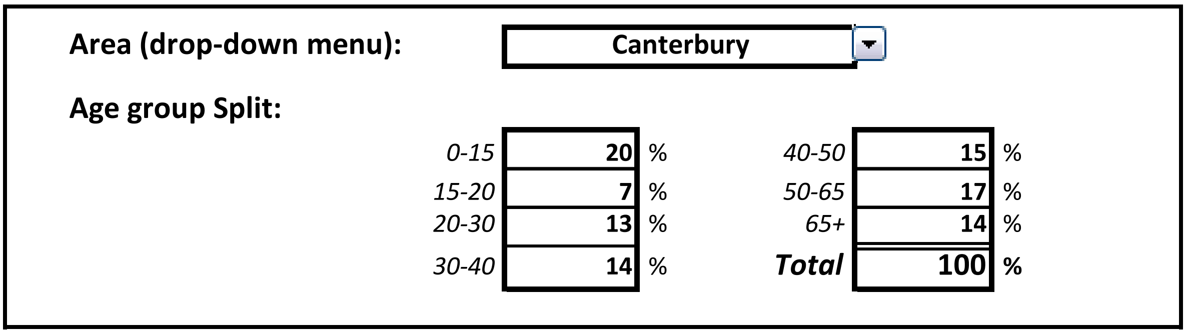
	Percentage household composition (2006 Census)				
Area	Person alone	Couple only	Adults only	Family with kids	Single parent family
Auckland	24	30	7	29	10
Wellington	19	25	10	34	12
Canterbury	25	27	8	29	11
New Zealand	23	27	9	29	12

Figure 5.1 below provides an example screen shot of the input screens for each of the models. The input screen has been arranged so that through the drop down menu, the user can select the area group of interest and input the relative variable profiles. The use of the default values as provided in tables 5.3 to 5.5 enables the user to establish the existing number of trips expressed as trip chains per household per day to various destination activities.

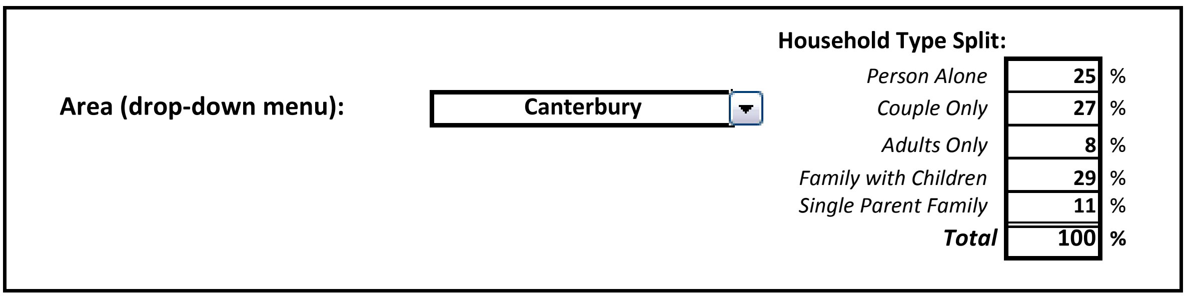
Figure 5.1 Examples of model inputs based on 2006 Census default values



Vehicle ownership



Age profile

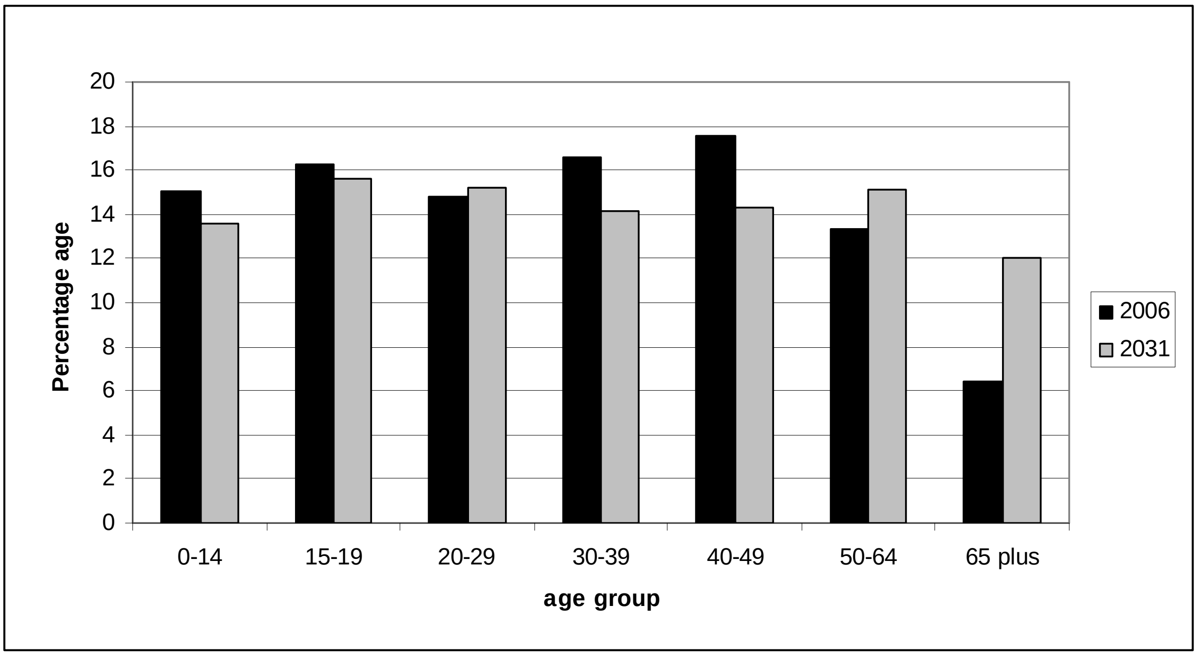


Household composition

The different area specific values for car ownership, age profile and household composition reflect some of the most obvious variables that explain the differences in the extent of travel expressed as trip changes per household and choice of travel mode within the different area groups identified.

The age variable is different in nature from the other variables tested in that the age profile relates to person travel rather than household travel. Age profile was selected as a potential variable because it was thought to have an influence on trip making and given the anticipated aging population of New Zealand, it was considered that a changing age profile would have an effect on travel patterns in the future. To test this hypothesis, the age profiles, shown in figure 5.2 and sourced from Canterbury Regional Information 2009 (Canterbury Development Corporation 2009), were used as inputs to the model.

Figure 5.2 Predicted future age profile – Canterbury, source Statistics New Zealand



Although there is predicted to be a doubling of the proportion of people within the retirement age group by 2031, the model yielded little change in the amount of travel when outputs resulting from the two age profiles were compared. While age has been shown elsewhere to influence trip making, the models established from the NZHTS data for this report did not reveal such findings. One possible explanation to this could be that a significant proportion of 65 year olds remain in work or substitute their previous work journey for some other journey purpose.

Consequently, the rest of this study focused on variables of car ownership and household composition that are most typically used as influential factors in transport models when assessing household travel.

To determine the predictive power of household composition and car ownership, an analysis of variance (Anova) of these variables was undertaken. The car ownership variable is a continuous variable while the household composition is grouped by its nature. The Anova test revealed that car ownership gave rise to the largest treatment sum of squares and was therefore the variable with the greatest explanatory power of the two variables tested.

5.1.3 Model outputs

The following example output is based on the Auckland vehicle ownership profile set out in table 5.3. Figures 5.3 and 5.4 provide example screenshots of the model outputs which represent person trips per household. Figure 5.3 sets out the overall mode split for the area selected and the number of household trip chains for the destination activities of home, employment, education and other. Figure 5.4 provides the same output presented in tabular format. The activities shown in the outputs are those that fall within the definition of a trip chain terminating when a stop of 90 minutes or more occurs.

Figure 5.3 Model output – Auckland – person trips per household in relation to vehicle ownership

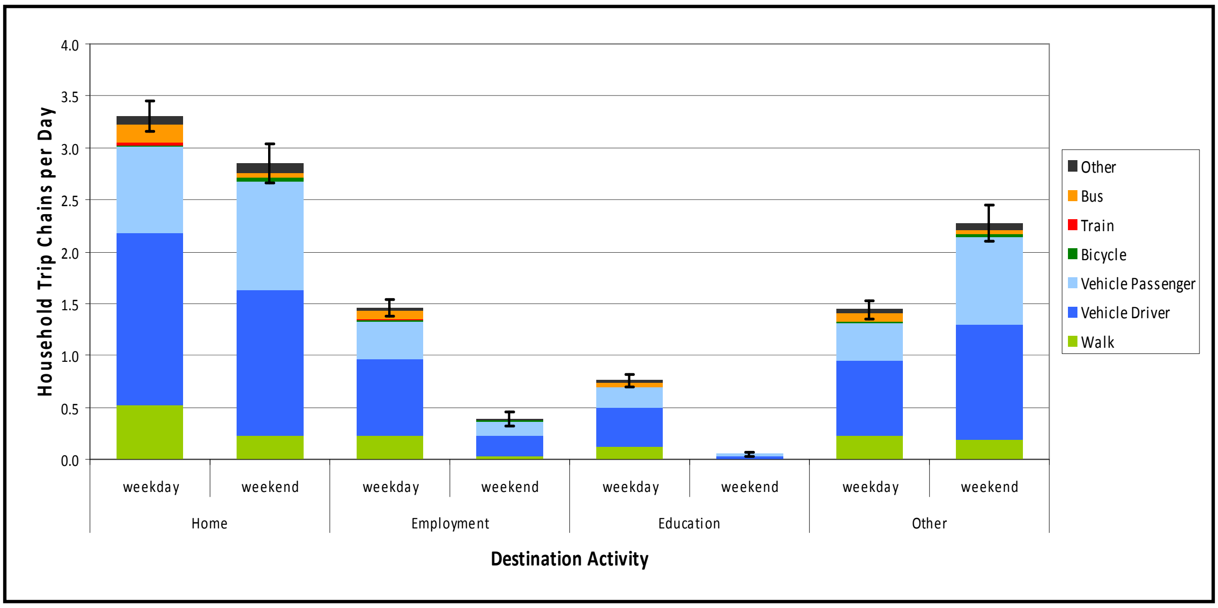


Figure 5.4 Model output – summary table – trips per household per day for Auckland MUAs

Number of Trips:		(chains/household/day)	
		weekday	**weekend**
	Home	3.3	2.8
	Employment	1.5	0.4
	Education	0.8	0.1
	Other	1.4	2.3
	Total	7.0	5.6
Overall Mode Split:		**weekday**	**weekend**
	Walk	16%	8%
	Vehicle Driver	50%	49%
	Vehicle Passenger	25%	37%
	Bicycle	1%	1%
	Train	1%	0%
	Bus	5%	2%
	Other	2%	3%

It can be seen from figures 5.3 and 5.4 that a total person trip rate per household of 7 trips per weekday and 5.6 trips per weekend is calculated on the basis of the existing car ownership profile for Auckland. The output in figure 5.4 shows that the current average mode split for person trips to all destinations is 75% as a vehicle driver or passenger.

Were the trip chain to be defined as a stop of 30 minutes or more, rather than the 90-minute definition currently used, more trip chains would be captured, such as those associated with shopping. The use of a 30-minute trip chain definition would increase the number of trip chains by around 30%.

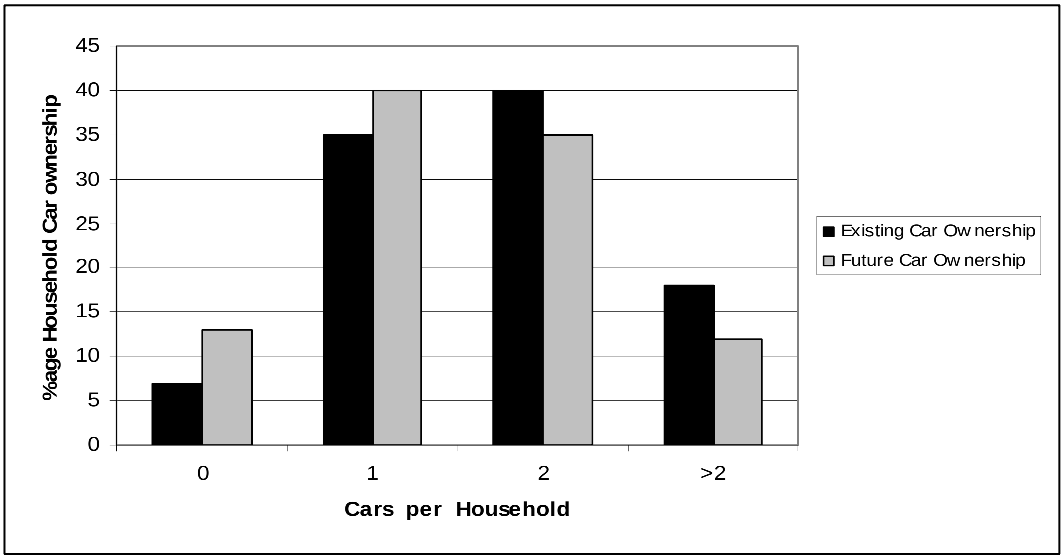
5.2 Other uses for the NZHTS models

5.2.1 Scenario testing

The model can be used to assess the outcomes of policy goals and transport strategies or external effects that result in changed travel behaviours. As an example, high car ownership and greenhouse gas emissions were seen as negative transport issues for Auckland as indicated in its previous long-term plan for a sustainable city. The plan included targets to address these issues by a variety of measures, such as the implementation of a sustainable transport programme and the encouragement of active transport modes.

Existing strategic transport models contain projected car ownership rates. Historically, the Auckland Transport Model ART2 (now ART3) projected very modest changes in car ownership profiles up to 2021 of no more than 2% change in any of the car ownership categories indicated in figure 5.1. For the purpose of illustration and assuming the policy initiatives and externalities, such as high fuel costs, have greater effects, a 5% reduction in vehicle ownership from the higher vehicle owning households and a converse increase in the number of households associated with lower or nil vehicle ownership can be tested. Such a change in future vehicle ownership levels may assume the form indicated in figure 5.5.

Figure 5.5 Current and notional future vehicle ownership levels – Auckland



The travel outcomes of changes in car ownership as indicated in figure 5.5 could be assessed using the model to reveal travel demand and mode choice changes as indicated in figures 5.6 and 5.7.

Figure 5.6 Model output - travel behaviour based on notional future vehicle ownership profile – Auckland MUAs

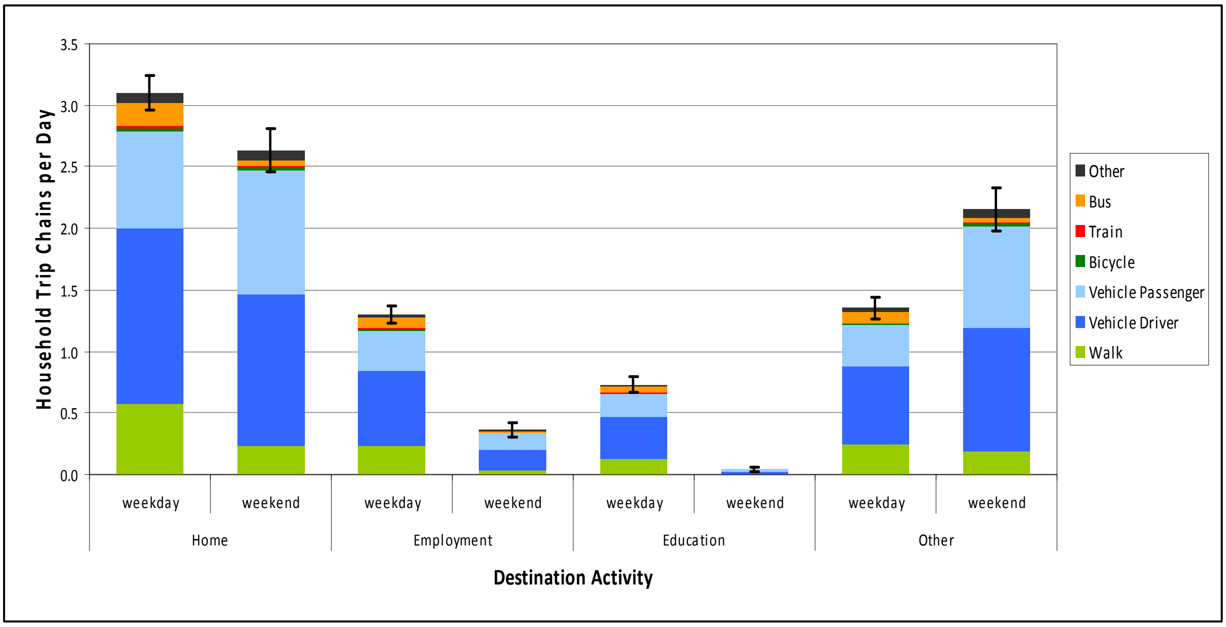


Figure 5.7 Model outputs - travel behaviour based on notional future vehicle ownership profile – Auckland MUAs

Number of Trips:		(chains/household/day)	
		weekday	**weekend**
	Home	3.1	2.6
	Employment	1.3	0.3
	Education	0.7	0.0
	Other	1.4	2.2
	Total	6.5	5.2
Overall Mode Split:		**weekday**	**weekend**
	Walk	18%	9%
	Vehicle Driver	47%	47%
	Vehicle Passenger	25%	38%
	Bicycle	1%	1%
	Train	1%	0%
	Bus	6%	2%
	Other	2%	3%

By comparing the model outputs in figure 5.3 and 5.4 against those shown in 5.6 and 5.7, it can be seen that as a result of notional future vehicle ownership profile, a measurable reduction in person trips per household and an increase in use of more sustainable forms of transport would be expected.

While the above example is based on a notional future car ownership profile, such input data could be obtained from a range of sources including those authorities that possess their own strategic land-use and transportation models.

5.2.2 Discrete analysis

The models can be used to examine the person trip per household in relation to demographic groups for each area tested. The models contain a significant amount of information, covering six area types, weekday and weekend samples over a range of household types or ownership levels as well as background information such as sample sizes and statistical measures.

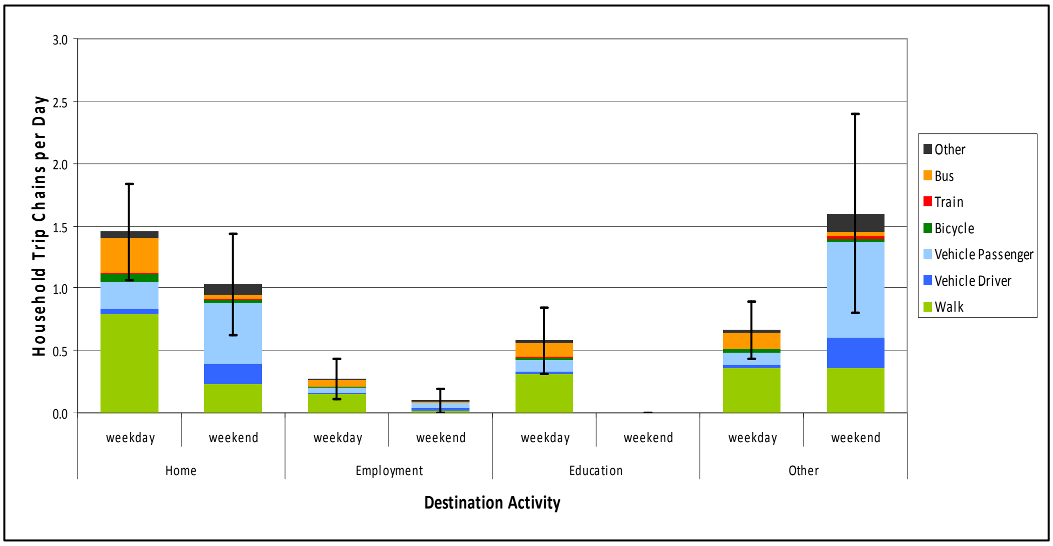
The values set out in tables 5.1 and 5.2 represent average daily person trips per household. To determine the trip rate for a specific area, the demographic structure of that area would need to be known in order to weight the values in tables 5.1 and 5.2 appropriately. However in the format presented, it can be seen that in general there are differences between each area for the same variable.

In comparing the main MUAs with the other MUAs it can be seen that the number of trip chains per household, in general, tends to be lower for the other MUAs. This finding suggests that applying main MUA trip rates to other MUA areas would generally overestimate trip rates, in the absence of some adjustment factor to reflect local conditions.

The use of a single category, such as vehicle ownership or household composition, will explain some of the variation in the number of trips generated per household. The use of multiple variables whereby trip rates are determined on the basis of ‘x’ number of people with ‘y’ number of cars available to the household can improve the predictive ability of a model. However the ability to do this with the NZHTS data is limited due to the low sample sizes available at this disaggregate level.

The model can be used to examine mode splits for a particular demographic group for each area tested. As an example, figure 5.8 shows the mode splits for Auckland households with nil vehicle ownership.

Figure 5.8 Example of model output – Auckland households with nil vehicle ownership



It can be seen in figure 5.8 that fewer trips were undertaken for this group in comparison with the model output shown in figure 5.3 which included car-owning groups. The lower trip rates for the non-car owning households indicated that car ownership influenced not only the choice of transport mode but also the amount of travel per household.

Other comparisons between the car-owning and non-car-owning groups show that for the non-car-owning households the proportion of trips as a car passenger was higher, as was the share of walking trips. The output also shows there was a more pronounced difference between travel modes for weekday and weekend in the non-car-owning households.

A summary of the effects of car ownership on the level of use of walking, cycling and bus is set out in table 5.6.

Table 5.6 Comparison of weekday percentage mode split in relation to household car ownership

Area type	O cars			1 car			2 cars			3 or more cars		
	walk	cycle	bus	walk	cycle	bus	walk	cycle	bus	walk	cycle	bus
Auckland	54%	4%	19%	17%	0%	6%	11%	0%	4%	9%	0%	3%
Wellington	33%	0%	36%	19%	1%	7%	13%	1%	4%	13%	2%	3%
Christchurch	42%	8%	29%	19%	4%	6%	15%	4%	3%	10%	2%	3%
MUAs	53%	7%	11%	15%	2%	2%	9%	2%	1%	7%	3%	2%
SUAs	45%	16%	2%	16%	2%	3%	8%	3%	2%	7%	3%	2%
RAs	53%	2%	17%	16%	2%	5%	9%	2%	5%	7%	1%	5%

It can be seen in table 5.6 that the greatest change in mode splits occurs between the non-car-owning households and those with a car. The differences in mode split among those households with access to a car are less pronounced. Of the sample tested, the standout statistics are that zero-car households in the major MUA of Wellington show no use of a bicycle while similar households in other areas such as SUAs showed as much as 16% cycle share. The data also shows that car-owning households in the major MUA of Auckland make almost no cycle trips.

5.2.3 School travel profiling

The NZHTS data can also be arranged to assess the multi-modal trip generation associated with school travel. As well as travel by students, travel associated with schools also includes trips by service people and staff. These two groups are not identified within the NZHTS, and therefore require additional consideration in the school travel model.

Service people such as plumbers or technicians may travel to school as part of their business. These types of travel would be coded as 'work-employer's business', although it is not possible to determine their association with particular education facilities. However, use of UK education trip data sourced from TRICS, shows that service vehicles represent no more than 1% of the total daily flows to education facilities. Supported by the recent *NZ Transport Agency research report 438* (O'Fallon and Sullivan 2011), indicating that trip generation characteristics in the UK and New Zealand are very similar for a range of land uses, it is reasonable to assume a similar service vehicle proportion could generally be expected with New Zealand education facilities.

Teacher or staff travel to school would be coded in the NZHTS as 'work-main job' or 'work-other job'. However, the survey does not consistently specify the type of employment, or the location type. Consequently, this proportion of trips must be assumed by applying the national teacher/pupil ratio of 1:20 to the number of students at the school and assuming that staff travel in single occupant vehicles. Following the inputs of the area group, school type and enrolment number, the model user is presented with trips by mode as indicated in figures 5.9 and 5.10.

Figure 5.9 Example model output – summary trip generation – 300 pupil high school main urban areas

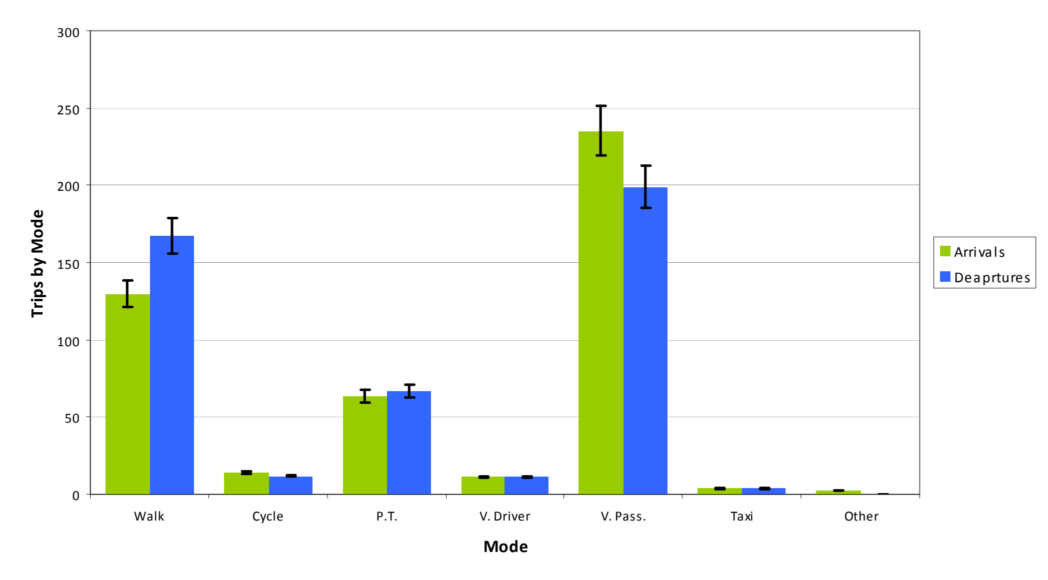


Figure 5.10 Example model output – summary trip generation – 300 pupil high school main urban areas

Total daily student trips: **918** arrivals + departures

Students by Mode of Travel - Arrivals

	Walk	Cycle	P.T.	V. Driver	V. Pass.	Taxi	Other
Mode Split (%)	30.4	5.2	16.2	14.7	29.0	0.5	4.0
No. of Students by Mode	91	16	49	44	87	1	12
Trips by Mode	139	24	74	68	133	2	18

Students by Mode of Travel - Departures

	Walk	Cycle	P.T.	V. Driver	V. Pass.	Taxi	Other
Mode Split (%)	35.0	5.5	17.2	15.1	22.4	0.8	4.1
No. of Students by Mode	105	16	52	45	67	2	12
Trips by Mode	160	25	79	69	103	4	19

School Trips undertaken by Private Motor Vehicles

	Arrivals	Departures	
Student Passenger Vehicle Trips	107	84	*Including taxi passengers.*
Student Driver Vehicle Trips	68	69	
Staff Trip Legs	15	15	*One staff member per 20 students; all drive.*
Service Vehicle Trips	1	1	*Service vehicles represent 1% of total daily flows.*

Total Daily Vehicles **359** Vehicles

Peak Hour Private Motor Vehicles

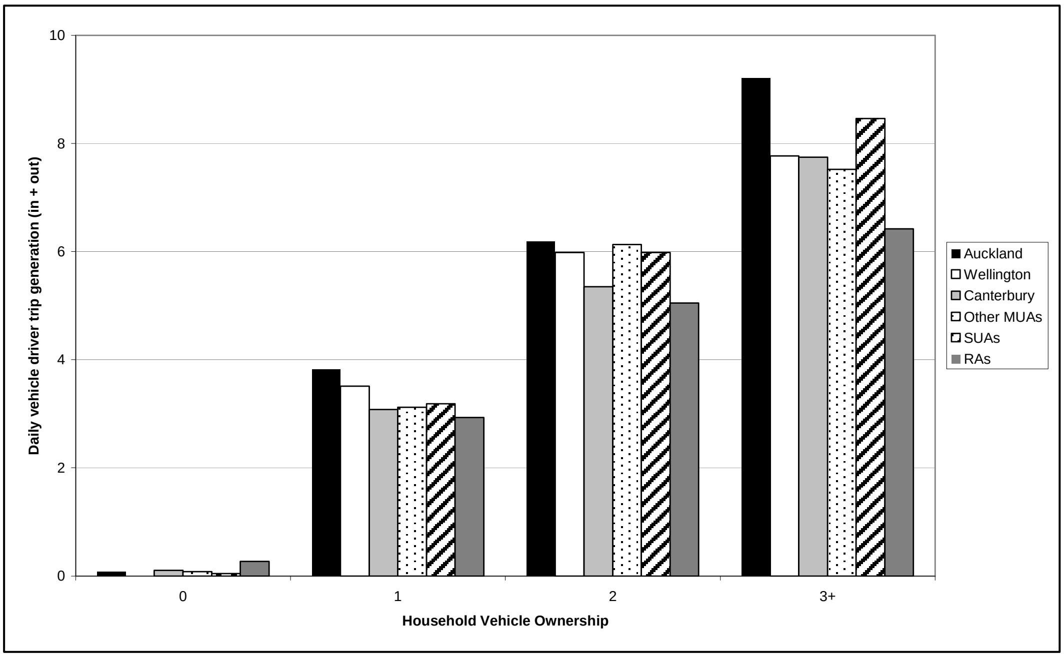
AM Peak (8AM to 9AM)	129	Vehicles
PM Peak (3PM to 4PM)	98	Vehicles

The above summary table can be used to assist school travel planners identify age groups within certain locations that could benefit the most from school travel plan initiatives. For instance, it can be seen that effort can be directed at the major urban areas to maintain and enhance travel by walking and bus between the 11 to 12 and the 13 to 17 age groups. The vehicle trip generation outputs can also be used to assess the traffic impacts of a particular school for both the morning and afternoon peak periods.

5.2.4 Daily vehicle trips and travel profiling

The NZHTS data can also be arranged to reveal daily vehicle trips per household calculated on the basis of vehicle ownership, and determining the vehicle trip generation by arranging trip legs made by vehicle drivers that originated or terminated at the home, grouped by household vehicle ownership. Figure 5.11 shows the vehicle trip rates associated with the identified area groups.

Figure 5.11 Household vehicle trip generation (vehicle driver trips to and from home) based on car ownership



As indicated in the previous sections, higher car ownership results in a greater number of vehicle trips being undertaken per household. Figure 5.11 supports this finding in terms of vehicle trip generation, showing vehicle trip rates ranging from zero trips per day per household to nine trips per day per household. These trip rates relate to all household types ranging from retirement units to large family dwellings. The values in figure 5.11 represent minimum vehicle trips and do not include vehicle trips to and from households that are associated with visitors, household members as passengers in non-household cars and service vehicles.

Table 5.7 presents an alternative way to express household trip making in terms of person trip legs and person trip chains per household, which includes travel by all modes.

Table 5.7 Average weekday person trip rates per household

Area type	Average weekday person-trip-legs/household/day	Average weekday person-trip-chains/household/day
Major MUA Auckland	15.5	7.1
Major MUA Wellington	16.8	6.7
Major MUA Canterbury	13.0	5.6
MUAs	12.8	5.6
SUAs	13.1	5.9
RAs	12.3	5.3

It can be seen in table 5.7 that the major MUA of Auckland displays the highest number of daily trip chains followed by the major MUA of Wellington. However, in Wellington a greater number of daily trip legs are undertaken, which indicates more complex trip chains and concurs with the previous findings of this report.

In addition to providing travel patterns over periods of years, the NZHTS can also be used to examine the pattern of travel throughout the day for different journey purposes and travel modes. The daily travel profiles for SUAs and the major MUA of Canterbury are shown in figures 5.12 and 5.13; profiles for all regions are contained in appendix A. To reduce the effects of rounding in the responses the output has been smoothed using a 60-minute window.

Figure 5.12 Daily travel profile – road users – secondary urban areas

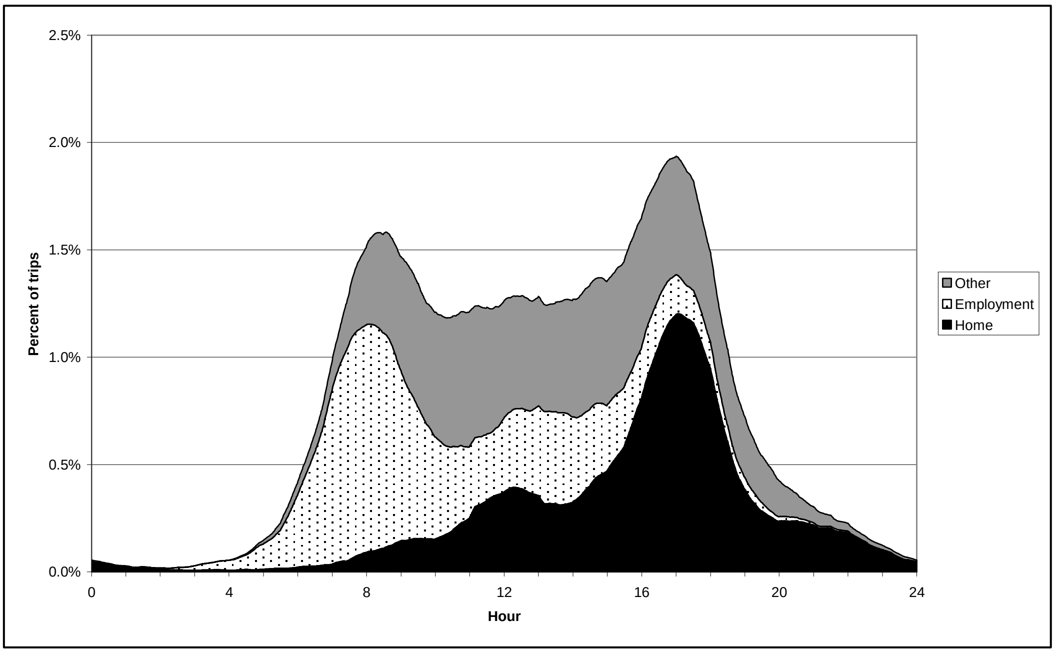
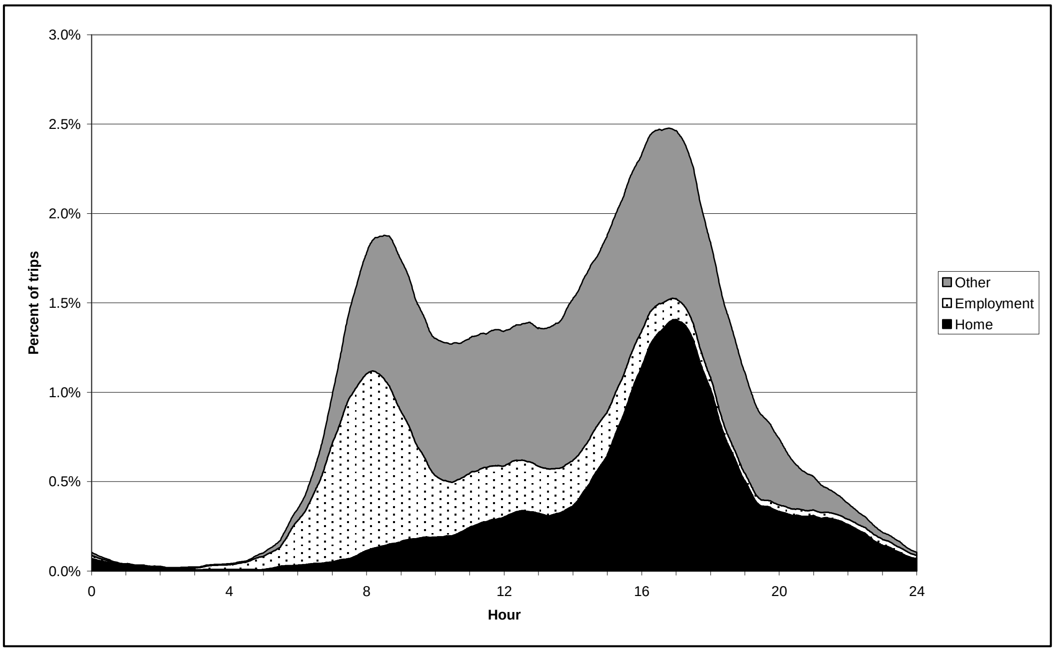


Figure 5.13 Daily travel profile – road users – Christchurch major urban area



As the examples in figures 5.11 and 5.12 show, there are basic similarities between the travel profiles for the different areas. Both figures reveal relatively similar daily travel profiles, showing the build up and decrease in travel demand throughout the day for various activities with identifiable peak periods.

However, the two profiles do contain some quite distinct differences. For instance, travel to employment constituted a higher proportion of the travel during the morning peak period (between 6am and 9am) in SUAs than in the Canterbury MUA. This would indicate the implementation of workplace travel plans in SUAs would have a greater effect on easing congestion. Other observable differences are higher peaks and a greater proportion of travel to other activities in the MUA. The outputs for the other major MUAs, and interestingly RAs, display similar characteristics to those seen in the major MUA of Canterbury.

6 Discussion

This section of the report reflects upon the findings of the analysis in the context of the project brief and the findings of the literature review. The aims of this project were to maximise the value of the travel data in the NZHTS and extend the analysis of the NZHTS reported in *NZ Transport Agency research report 353* (Abley et al 2008) by exploring recent trends in travel behaviour using a larger data set, arranged in terms of trip chains, and undertaking further analysis on a regional basis. The analysis included an examination of the changes in travel over time expressed in trip chains for a range of journey purposes and modes of travel and provided a comparison of travel behaviours between different area types including the major urban areas of Wellington, Auckland and Canterbury as well as other area types including main urban areas (MUAs), secondary urban areas (SUAs) and rural areas (RAs).

6.1 Trend analysis

6.1.1 Changes in trip rates over time

As reported in chapter three, there has been a steadily falling trend in trips per person per year in the UK. This decline is attributed to lower shopping and recreation trips and could also be caused by smaller household sizes, and from 2008 onwards, the potential effects of the global economic crisis. Additionally household vehicle trip rates have declined in the USA and Australia in recent years.

The analysis of changes in household trip rates in New Zealand during the period 2003 to 2010 was less conclusive. The trip rates associated with the 2006–08 Auckland data appeared to be uncharacteristic in comparison with the other major MUAs of Wellington and Canterbury. It is unknown whether this was due to sampling errors exacerbated by the lower sample size associated with the 2006–08 period, or simply reflected the scale of variation that could be expected between one year group and another.

In spite of the Auckland 2006–08 data, the analysis showed an overall decline in household trip rates of between 9% and 14% during the period 2003 to 2010 for all the major MUAs. Reasons for the observed decline could not be derived from the NZHTS data; however, the contributory factors might include changes to population demographics such as declining household sizes, lower car ownership levels or a reduction in the intensification of development in a particular area.

While the major MUAs showed a general decline in household trip rates there were no consistent patterns emerging from an analysis of the other area types of main urban areas, secondary urban and rural areas.

6.1.2 Changes in morning departure times

Indicators of travel are a useful way of assessing the effectiveness of policy, and can inform policy formulation. Changes in home to work departure times can be an additional indicator of travel behaviour change. The analysis of morning departure times found that the start time for vehicle drivers for the journey to work appeared to be significantly earlier for people within the Auckland MUAs compared with the other area types analysed. This could be attributed to the more dispersed nature of Auckland and the dominance that the car has historically had in shaping the land-use patterns of the region, but it could also be explained by attempts to avoid peak-hour congestion.

For the major MUAs of Wellington and Canterbury there was some indication that throughout the period 2003 to 2010, commuters were starting their morning commute earlier. There was no evidence to show commuting distances were increasing over time for these major MUAs; therefore, assuming that arrival times to work remained constant, the earlier departure times for the Wellington and Canterbury areas could be attributed to higher levels of road congestion.

Of the other area types tested, the earliest start times were associated with the SUAs and RAs, potentially reflecting the higher commuting distances, which are a feature of these areas.

6.1.3 Mode splits for different journey purposes

As reported in chapter three, there are few New Zealand-based multi-modal surveys that can be used to inform transport practitioners of New Zealand modal splits to various activities. While efforts are being made by the TDB to increase the number of multi-modal survey results, the database relies upon the good will of transport consultants to offer data they have collected. This reliance on voluntary contributions explains the slow growth of multi-modal samples within the TDB database. Practitioners are therefore compelled to turn to international data where its relevance to New Zealand may be untested, or undertake their own surveys that may not be made available for public use.

While the NZHTS does not report on the relative costs of travel, the mode split data presented in this report is implicit of such costs as the mode splits are merely reflective of the modes actually used between 2006 and 2010. Should the relative cost of travel change in the future then the mode split outputs reported in this study would not be relevant to future travel behaviours.

The analysis found that the journey from home to work was undertaken predominantly as a vehicle driver for all area types tested. The highest use of vehicle as a means of transport from home to work was associated with the SUAs and RAs, reflecting in these areas the more dispersed relationship between residential and employment land-use activities, lower levels of public transport service, lesser provision of facilities for active modes and the lack of congestion as a disincentive to driving.

The lowest vehicle driver share was found at the major MUAs reflecting the more compact urban forms and greater choice of alternative travel modes in those areas. The results were consistent with the UK HTS, which found that higher shares of public transport use were associated with larger urban areas.

The major MUA of Wellington had the highest rate of travel from home to work by public transport and walking. This is probably because of the more established commuter market in comparison with the Auckland and Canterbury MUAs, land-use patterns around rail corridors, Wellington's topography and the relatively high percentage of employment within the compact CBD. It may also be because of Wellington's committed parking restraint policy in the central area.

As indicated from the Sydney HTS, parking availability has a significant influence on people’s use of public transport. This information is gathered through a specific data field within the Sydney HTS which asks the reasons why a particular mode is used. The gathering of data that reveals ‘why’ people choose a particular mode of transport provides a solid and useful context for understanding travel behaviour. The current NZHTS provides a wealth of information, but could be enhanced by the introduction of a similar enquiry field to that used in the Sydney HTS. Such information can provide a deeper understanding of travel habits and provide policy makers with information that allows them to shape or refine policy to achieve desired transport outcomes.

In relation to major MUAs, for home to education travel, Canterbury vehicle driver mode share was more than double that of Auckland and Wellington. This is probably a consequence of the high number of trips to tertiary education sampled in Canterbury, and the location of the University of Canterbury within the suburbs, which places it further from denser residential areas and public transport routes, and the high availability of parking within and around the campus.

For shopping trips from home, RAs presented the highest share of vehicle drivers, with the major MUA of Canterbury showing the lowest proportion of vehicle drivers in comparison with the other area types tested. The lower vehicle driver share for Canterbury could be attributed to the higher share of bus use and walking in this area for shopping purposes. In the major MUA of Wellington just under 3% of home to shopping travel was undertaken by train. Travel by bicycle did not feature highly for shopping trips in any of the areas tested, with the highest bicycle mode share at 2% occurring in SUAs.

While the differences between the area types for vehicle passenger travel were statistically significant, this mode share was comparatively consistent across all area types at around 30%.

There was significant overlap in mode splits for home to recreation and home to social visit, which were dominated by travel as a vehicle driver and passenger. Of the land uses investigated, recreational and social visits attracted the highest proportion of vehicle passengers.

For home bound travel, which includes travel from all journey purposes, the vehicle driver mode share for the major MUAs was lower in comparison with other MUAs as well as the SUAs and RAs.

Trends over time showed marginal but consistent increases in vehicle driver mode share for the Auckland MUAs while the opposite trend occurred in the Wellington MUAs with no consistent trend observed for the Canterbury MUA.

6.1.4 Trip chain complexity

Research has shown that as trip chains become more complex by involving more trips and having longer distance, people are less likely to choose to walk or bicycle and more likely to use motorised forms of transport. The analysis undertaken in this study supported that finding. The analysis showed that while less complex trip chains were undertaken by active modes, public transport trip chains were the most complex. The more complex trip chains associated with the use of public transport could be attributed to the necessary additional trip segments to and from the public transport facility. The analysis showed that trips undertaken by car as a driver or passengers were more complex than those undertaken by active modes.

The relationship between trip complexity and mode choice was further confirmed by the finding that the major MUAs of Wellington, which showed the highest public transport use also had the highest amount of multi-segment trips. This may be attributed to the higher use of bus and train modes for journeys to work, which in turn may reflect the area-specific characteristics of Wellington including the compact CBD containing a high percentage of employment, topography and land-use patterns which suit rail corridors, and the effects of the CBD parking restraint policy.

In addition to showing no real distinction in trip complexity for the other areas tested, the analysis also showed no consistent patterns with regards to the direction of change in trip complexity over time.

6.1.5 Trip chain length and duration

The major MUAs showed higher vehicle driver trip durations than the other main and secondary urban areas, which potentially indicated higher levels of congestion in the major centres. Trip durations for drivers in the major MUAs of Wellington and Canterbury increased over the period tested. The major Auckland and Wellington MUAs shared a pattern of increased walk and vehicle driver trip chain durations during 2006 to 2010.

The Auckland MUAs showed marginal decreases in commute distances over time, which potentially reflected the outcome of greater investment in transport infrastructure, particularly roading. The lowest average commuting distance of about 9km was presented by the major MUA of Canterbury with rural commute distances almost double that value.

Of the major MUAs, Wellington showed the highest average commute distance of around 16km. Other MUAs and SUAs showed consistent increases in commute distances over time, which is a pattern reflected in the Sydney HTS where trip lengths were increasing as residential and employment locations moved further from the CBD. This pattern was also reflected in the UK where average journey to work lengths were also reported as steadily increasing.

6.1.6 Home to education travel

For pre-school and primary school travel, the predominant mode of travel was as a vehicle passenger for all area types. Cycle use within the pre-school and primary school age group, while representing a low proportion of trips, was most prevalent in SUAs.

For the high-school age group, the major MUAs of Auckland showed a higher dependence upon travel as a vehicle driver or passenger than all other areas, which could be a reflection of the more dispersed nature of the major MUAs of Auckland. In the major MUA of Wellington, a quarter of all school related travel was undertaken by bus which was almost double that of the major MUAs of Auckland and Canterbury.

For the major MUA of Wellington, the higher proportion of bus use for education purposes was consistent with the high proportion of journeys to work by bus and may share some of the underlying reasons for this such as a more established public transport network and potentially a greater social acceptance of the use of public transport by commuters and their spouses.

In the major MUA of Canterbury the dominant mode of travel to high schools was undertaken as a walk trip, with Canterbury also showing the lowest proportion of travel as a vehicle passenger of all area types tested.

For school travel it could be seen that as the age group increased and students became more travel independent, higher proportions of walk, cycle and bus use occurred.

For the tertiary education sector, travel as a vehicle driver was the dominant mode of travel for all areas. The major MUA of Canterbury showed higher levels of car travel, both as driver and passenger, than Auckland and Wellington MUAs which was probably a consequence of the location of the University of Canterbury within the suburbs, which placed it further from denser residential areas and public transport routes, and the high availability of parking within and around the campus.

6.2 Use of NZHTS data

The use of the NZHTS data in a predictive context was explored. While existing strategic transport models provide for the ability to test changes in variables such as new road infrastructure and changes in demographic structures, there is value in providing a readily accessible opportunity for people without access to such models to undertake their own limited analysis or scenario testing. The arrangement of the NZHTS data undertaken as part of this study allows for some scenario testing.

However the ability for the NZHTS data to be used in a predictive manner is limited as it does not contain information that responds to several issues that affect travel choice, such as improvements to public transport improvements, direct changes to fuel prices, traffic congestion, parking availability or the relative costs of other transport modes. However the arrangement of the data does provide a starting point for explaining current trip generation rates and travel behaviour in response to changes in demographic structures.

6.2.1 Limitations of use

While the NZHTS provides an excellent insight into transport behaviours, the ability of the NZHTS data to be used in a predictive context is also limited because as highlighted above, it cannot respond to changes that affect travel behaviour. In addition, strategic transport models are calibrated against the results of empirical data associated with representative samples of most meshblocks within the transport modelled area. The sample selection method of the NZHTS does not contain the spread of data required to enable easy comparisons between models based on alternative data collection techniques.

Additional variables such as household income, public transport accessibility levels, and the perceived cost of alternative travel modes have an influence on travel behaviours. There is an element of interrelationship between variables such as income and car ownership; however, the arrangement of the NZHTS data as presented in this report assumes that all other potential variables are equal and takes no account of the relativity of travel costs by mode or other key influences on travel behaviour. The use of the NZHTS data is limited therefore, to providing only a starting point for explaining historical and existing trip generation and modal choice.

The models that were produced from the NZHTS as part of this study show trip generation expressed as household trips chains per day and percentage mode split. Due to the small data samples at this disaggregate level, the mode splits were limited to the overall area and did not describe the mode split associated with the different destination activities modelled.

The conditions of use of the MoT NZHTS data require that the data must be aggregated into groups of no smaller than two survey years when reviewing regional trends. Arranging the data as per the conditions limits the maximum number of data groups to three. Although the NZHTS relates to seven years of data, information collected over a much greater period would enable a greater understanding of emerging trends and patterns in travel behaviour over time.

When analysing NZHTS data, use is made of weightings that are designed to allow expansion of the sample population to explain the travel behaviours of the larger population. These weightings are provided by MoT; however, it was unclear particularly for statistical analysis purposes, whether the weights also accounted for the regional differences.

As a stratified cluster sample, the results of the NZHTS offer a more limited explanation of the travel behaviours of the wider population. This is in contrast to a more randomly selected sample that would allow the results to be used spatially. In the US household travel survey, the samples are selected randomly by phone number from telephone exchanges, with a certain number selected from each exchange to provide a relatively even distribution. For the UK household travel survey, households are randomly selected from within randomly selected post code areas, but the selected post code areas move every year.

6.2.2 Arrangement of data

A key aim of the research was to harvest the travel behaviour information embedded within the NZHTS data and to make this more accessible to transport practitioners. This has been done through the trend analysis, providing a range of statistics, and through the arrangement of the data presented in the form of models.

The models provide the user with information on both weekday and weekend trip generation (expressed as trip chains per household and modal splits) and allow the user to test for a range of scenarios over different area types; the major urban areas within Wellington, Auckland and Canterbury regions as well as other main urban areas (MUAs), secondary urban areas (SUAs) and rural areas (RAs). The models group the data analysis by:

- age profile
- car ownership
- household type.

Using the Python programming language to extract data from the NZHTS, a set of Microsoft Office Excel models were established. These models, which can be accessed at www.abley.com/NZHTSmodels and at www.nzta.govt.nz/resources/research/reports/467/index.html, allow practitioners to freely access the data without the need to develop or purchase specialist modelling software.

The NZHTS data contains information on travel to 14 destination activities. However, based on the sample sizes available we limited the models developed in this study to show household trip chains per day to the destination activities of 'home', 'employment', 'education' and 'other', where 'other' represented all other destination activities that were not separately identified. The use of the 90-minute trip chain definition meant that many trip chains, particularly shopping trips under this 90-minute threshold could not be captured. Consequently, shopping trips were included within the other category. Were the trip chain to be defined as a stop of 30 minutes or more, rather than the 90-minute definition currently used, more trip chains would be captured.

The models were set up in accordance with the conditions of use of the data specified by the MoT. The trip chains expressed in the models are average values with 95% confidence limits shown.

6.2.3 Testing of travel predictors

Of the three variables of car ownership, age profile and household type tested in this analysis, the car ownership variable proved to have the strongest explanatory power in relation to trip generation. Due to the small sample sizes at the disaggregate level it was not possible to cross these categories to determine household trip rates at a finer level.

6.2.4 Model outputs

The data presented in chapter 4 provided comparisons of a range of statistics between each of the area types. The model set out in chapter five produces an output that is specific to the area type, based on the variables such as car ownership that are applicable to that area. For the Auckland example shown in figure 5.4, which was based on the known car ownership profile, a total weekday trip rate of seven trip chains per household was shown. The model indicated that the largest amount of travel associated with a single destination activity related to the trip home which was to be expected as this represented trips from all purposes heading home. The trip rate of 3.3 chains/household/day associated with travelling to home was within 10% of the total household trip productions.

In relation to the major MUA of Auckland, the weekend outputs showed an overall lower trip generation rate of 5.6 in comparison with the weekday rate of 7 trip chains/household/day. This can be attributed to lower employment related and education related trips being undertaken. For the Saturday scenario, trip chains associated with other activities increased but not to a level that resulted in the overall travel exceeding an equivalent weekday trip rate.

Little difference was seen in the share of vehicle driver between week day and weekends; however, the proportion of walking and bus trips decreased while vehicle passenger proportions increased, which may reflect the greater number of multi-purpose trips that occur on weekends.

For the year 2021, the ART2 (now Art3) model showed vehicle ownership changes of no more that 2% in any of the car owning categories. At the level of change predicted for Auckland, the results from our NZHTS model showed no change in mode split. The example of the effects of a more substantial change in future vehicle ownership levels are shown in figures 5.6 and 5.7, based on a 5% decrease in the two highest car-owning households and a corresponding increase of 5% in the proportion of households with no or one car. The output indicated a reduction in overall person trips per household, more trips undertaken by walking and bus and less trips occurring as a vehicle driver. The potential drivers behind lower car ownership were likely to come from improved public transport options, more integrated land-use patterns and, although fuel price volatility might have some influence on car ownership levels, effects could be countered to some extent by the uptake of alternative fuel vehicles.

A useful application of the model is that it allows users to examine the travel habits of discrete groups of people. For instance, the analysis of the major MUA of Auckland revealed that for those households without access to a private car, average household trips were three trip chains per day, indicating a lower level of travel but also revealing that the main modes of travel undertaken were walking (54%) and bus (15%). This compared with the general average Auckland household which produced seven trip chains per household per day and showed the proportion of trips undertaken by walking (16%) and bus (5%) were significantly lower than those undertaken by non-car owning households.

The effects of car availability on all area types are summarised in table 5.6. These values were taken from the model and indicate the difference between the area types in relation to mode choice for car-owning and non-car-owning households. The table reveals that the proportion of walk trips reduced as vehicle ownership increased. It also shows that the variability in mode splits between the area groups tested were greatest for non-car-owning households and that for such households the mode split profiles were unique to each area type. For households with access to a car the mode splits were not dramatically different between each area type.

As highlighted in chapter 5, the results of the discrete analysis need to be seen in the limited context that all other potential variables, and the relativity of travel costs by mode, are assumed to be constant. The results of the discreet analysis showed variations in trip rates using the same variable across all area groups. This finding suggests that, as an example, applying a major MUA trip rate to another area type would in general result in under- or over-estimating the household trip rates for the other area types, in the absence of some adjustment factor to reflect local conditions.

6.2.5 Vehicle trip rates

The NZHTS data has been arranged to reveal daily vehicle trips per household. This was done by arranging trip legs undertaken by vehicle drivers that originated or terminated at home. The analysis looked at household vehicle trip rates for all areas by car ownership. For car-owning households the trip rates ranged from three to nine vehicle trips per household per day. The method used to derive the vehicle trip rate did not allow the detection of incidental vehicle trips such as pick ups, visitors and service vehicle trips; therefore, the vehicle trip rates expressed in this study are likely to be lower than what would actually occur. Nevertheless, the trip rates derived from the NZHTS are consistent with the range of household trip rates commonly found in the existing trip generation databases used in New Zealand and elsewhere.

Schools are not featured in the New Zealand trips database and rarely featured in the other trip generation recourses. While the development of new schools does not occur as frequently as other land-use activities, their traffic effects are still required to be known and the cumulative effects of schools and other proposed land-use activities in proximity to them are commonly sought for resource consenting purposes. The ability to determine school vehicle trip generation is therefore a valuable additional resource for those tasked with assessing the traffic effects of schools or the cumulative effects of development proposals in proximity to schools.

The school travel model required the use of car occupancy rates which could not be directly taken from the NZHTS data, but were instead inferred on the basis of dividing the number of passenger vehicle trip legs by the number of passenger-carrying vehicle trip legs. The inclusion of a field that collects car occupancy information within the NZHTS questionnaire would make the model easier to use and may provide stronger results where non-household members were also driven to school.

Mode choice data from the NZHTS was also used in the model. Of the three main travel modes associated with school travel, the dominant choice of travel to school in New Zealand in most circumstances was as a passenger in a private vehicle, followed by walking then bus.

The information from the school model could be used to assist planning decisions by providing a useful benchmark of current journey to school behaviour that could progressively measure progress towards meeting transportation policy objectives. The model could also be of special assistance to land-use transportation planners in illustrating travel behaviour that occurred in different student age groups and catchment areas.

6.2.6 Household trip making

The NZHTS model presents trip making in terms of trip legs and chains per household per day by all modes. The unit of trip making in strategic transport models is typically expressed in terms of person trip rates but may be expressed as person trips per household per day. For the Waikato Regional Transport model a trip rate value of 11.06 person trips per household is used and for the Canterbury Transport Model, a trip rate value of 12.5 person trips per household is presented.

Table 5.7 sets out trip rate values taken from the NZHTS and shows trip rates ranging from 12.3 person trip legs per household per day for the major MUA of Canterbury and 16.8 person trip legs per household per day for the major MUA of Wellington. The person trip legs per household derived from the NZHTS, while higher, particularly for the major MUAs of Auckland and Wellington, are still comparable with the Canterbury and Waikato trip rates.

6.3 Daily profiling

The NZHTS has also been used to explore whether non-work trips represent a significant contributor to traffic congestion during peak times as argued in relation to the US National Household Travel Survey. The analysis found this was the case, particularly in major urban areas where a higher proportion of peak hour trips were non-work related. This finding would suggest that measures to better manage the use of the transport network through work place travel plan initiatives would be more effective in the major MUAs than in other area types tested. The daily profile information could also be used by public transport service providers in scheduling their services to meet travel demands for particular users.

7 Summary and recommendations

This research project extended the work presented in *NZ Transport Agency research report 353* 'National travel profiles part A: description of daily travel patterns' (Abley et al 2008), which assessed the trip leg patterns associated with the 2003–06 NZHTS. The earlier work has now been expanded with the inclusion of four more years of data, analysing of travel in terms of trip chains and analysis of travel behaviour on a the basis of a wider range of area types that distinguish between MUAs and the major MUAs of Auckland, Wellington and Canterbury.

The main objective of this research was to maximise the value of the travel information held within the NZHTS database. This was done by examining changes in travel behaviour between 2003 and 2010 and identifying travel behaviours such as journey times, trip complexity, mode choice and trip generation rates that were particular to the area types tested. The research also explored the extent to which the NZHTS could be used in a predictive context. This report describes a method used to extract and arrange NZHTS data into a form that allows practitioners to quickly undertake a range of enquiries based on user-specified variables such as age profiles, car ownership and household compositions to reveal area-specific travel behaviours.

7.1 Changes in travel behaviour between 2003 and 2010

- There was some evidence that person trip rates per household had declined over time.
- For the major MUAs of Wellington and Canterbury there was some indication that throughout the period between 2003 and 2010, commuters started their morning commute at an earlier time.
- There was no evidence that commuting distances were constantly increasing over time for the major MUAs in contrast with the other MUAs and SUAs, which did show consistent increases in commute distances over time.
- Trip durations for drivers in the major MUAs of Wellington and Canterbury had increased during the period tested.
- Trends showed marginal but consistent increases in vehicle driver mode share for the Auckland MUAs, while the opposite trend occurred in the Wellington MUAs with no consistent trend observed for the Canterbury MUA.
- There was no consistent pattern of change in trip complexity for any of the areas tested.
- The Auckland MUAs showed marginal decreases in commute distances over time.

7.2 Travel behaviours in relation to area type

- Higher shares of public transport use were related to larger urban areas.
- The major MUA of Wellington had the highest proportion of travel from home to work and education by public transport and walking.

- The most complex trip chains were associated with travel by motorised forms of transport particularly where public transport was used, with the least complex trip chains undertaken as walk trips.
- The major MUA of Wellington showed the highest amount of complex trip chains, which reflected high public transport use.
- There was no noticeable distinction in trip complexity for car-owning households in other areas tested.
- The major MUAs showed higher vehicle driver journey times than the other main and secondary urban areas, indicating higher levels of congestion in the major centres.
- For pre-school and primary school travel, the predominant mode of travel was as a vehicle passenger.
- Cycling to school, while representing a low proportion of trips, was most prevalent in SUAs.
- In the major MUA of Wellington, a quarter of all school-related travel was undertaken by bus, which was almost double that of the major MUAs of Auckland and Canterbury.
- The variability in mode splits between the areas tested was greatest for non-car-owning households.

7.3 Using NZHTS data in a predictive capacity

The ability of the NZHTS data to be used in a predictive capacity is limited, first because it is not statistically possible to expand the data to represent the entire population because of the way in which the sampling is organised, and second because travel costs are not represented or varied.

While strategic transport models reflect the expected level of mode change in response to a number of factors, there is value in providing a readily accessible opportunity for people without access to such models to undertake their own analysis or scenario testing through the models that have been developed as part of this research. The arrangement of the NZHTS data undertaken as part of this study allowed for some limited scenario testing that provided a starting point for explaining travel behaviour in response to changes in demographic structures. Some of the model outputs revealed:

- person trip rates per household ranged from two trip chains per person per household to 10.4 trip chains per household
- for non-car owning households, walking was the predominant mode of travel
- when non-car-owning and car-owning households were compared, walking as a mode of travel for all purposes fell by between 40% and 70%
- for households with access to a car the mode splits were not dramatically different between each area type
- different area types showed trip rates that were unique to that particular area. This suggested that a generic household trip rate could not be applied to different area types without adjustment for local circumstances.

Noting that no account can be made of several issues that affect travel choice such as improvements to public transport, fuel price changes, traffic congestion, parking availability or the relative costs of parking and all transport modes, the ability for the NZHTS data to be used in a predictive manner is limited.

However, the NZHTS model can be used to represent a first-cut estimate of trip generation and travel behaviours.

7.4 Applications

7.4.1 School trip generation estimates

The NZHTS data has been arranged in a manner that enables a first-cut estimate of likely vehicle trip generation of different schools. The information from the school model can be used to assist planning decisions by providing a useful benchmark of current journey to school behaviour which can be of use to school travel coordinators in seeking to achieve regional average or above average levels of travel to schools by active modes.

Because of the fact that schools are not featured in existing trip rate databases, there is a need to provide such information to test the transport impacts of new schools and the cumulative traffic effects of schools with other proposed land-use activities in proximity to them. The ability to determine school-related vehicle trip generation is therefore a valuable additional resource for those tasked with assessing the traffic effects of schools or the cumulative effects of development proposals in proximity to schools.

7.4.2 Household trip making

The models that have been established from the 2003–10 NZHTS data enable the user to assess person trip rates per household for a range of areas, and destination activities in relation to different demographic structures. Knowledge of person trips per household in relation to a particular area can provide an additional resource for strategic transport models and assist in the planning of appropriate transport infrastructure and services in relation to a particular area.

7.4.3 Modal split

Data on modal split and variations between inner, suburban, small town and rural situations is now deemed of great importance as this supports national and regional strategies which seek greater mode integration and an increase in sustainable transport. In most situations where new developments are proposed, there will be only limited sources of information about the particular site or activity.

The absence of the perceived cost of alternative travel modes in the models established from the NZHTS places limitations on the model outputs. However in seeking to apply the principles of sustainable transport where increased awareness of the contribution to the total transport system is required, the model outputs offer a useful first-cut estimate of modal split information.

7.4.4 Travel planning

The NZHTS data can be used to profile travel movements by mode throughout the day within a specified area. The profiling of road users allows the extent of peak demands to be established and enables different journey purposes to be identified within the overall demand profiles. This is of particular use to public transport service providers who can use the profile information to tailor passenger services to suit demands. The traffic profiles can also be of use to travel coordinators by enabling them to direct TDM measures at specific road user groups that significantly contribute to the peak demands on the road network.

7.5 Recommendations

Maintaining consistency over time is one of the greatest strengths of the NZHTS. Therefore substantial changes to the design and method of collection of data would detract from the continuity of reporting travel behaviours. While seeking to preserve the value of continuity, we have identified the following potential refinements to the NZHTS that would enhance its value to transport practitioners:

- The gathering of data that reveals 'why' people choose a particular mode of transport provides a solid and useful context for understanding travel behaviour. The current NZHTS could be enhanced by the introduction of an enquiry field similar to the one used in the Sydney household travel survey that asks for reasons why a particular mode of travel was used for journey to work purposes. Parking availability is recognised as one of the main determinants in people's choice of mode for travel for work. The current NZHTS person form contains just one question on parking availability, which is directed only at vehicle drivers. Extending this question to all mode users could provide a deeper understanding of the influences on travel choices.
- Occasionally throughout this research, we were unable to draw firm conclusions on the data analysis due to limited sample sizes. Mindful of the need to balance adequate sample sizes against the practicalities of collecting data on a national basis, there may be scope to investigate alternative, emerging data collection techniques. As an example, the introduction of smart phone applications that include accelerometers are increasingly being used in studies to measure the energy use and health implications of active travel. Such applications are capable of measuring travel for all transport modes with growing accuracy. Over time, when larger sections of the New Zealand population own smart phones there may be scope to investigate the use of such devices as a supplement to existing data gathering methods for the NZHTS.
- Shopping features as one of the 16 trip purpose classifications within the NZHTS. However, within the shopping category there are potentially different travel patterns associated with grocery shopping compared with other types of shopping in terms of frequency of trips, trip distance, shopping durations and mode share differences. It would, therefore, be of greater value to transport professionals, for the NZHTS to create an additional 'grocery shopping' category to enable the different types of shopping travel habits to be clearly seen.
- Vehicle occupancy is collected from drivers within the NZHTS person form. While this information provides the number of passengers it does not reveal the journey purposes for the passengers being carried. Such information can be gathered by modifying question 17H of the NZHTS person form to cover the number of people in the vehicle as well as the driver. This information would be of value for calculating the vehicle occupancy rate used in the calculation of school trips.

7.5.1 Future work

An area that would merit further investigation when more data has been collected is public transport transfer times between trip segments. Such work could reveal transfer penalties and assist public transport service provides in planning for services that rely upon a series of transfer points to provide service coverage over a wider area. In addition, travel behaviour associated with food and non-food shopping may be significantly different therefore further refinement of the shopping journey purpose may add additional understanding of shopping trips. When more data becomes available the models established in this research could be expanded to include more journey purposes.

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Appendix A: Daily travel profiles

Figure A.1 Daily travel profile - road users – major MUA of Auckland

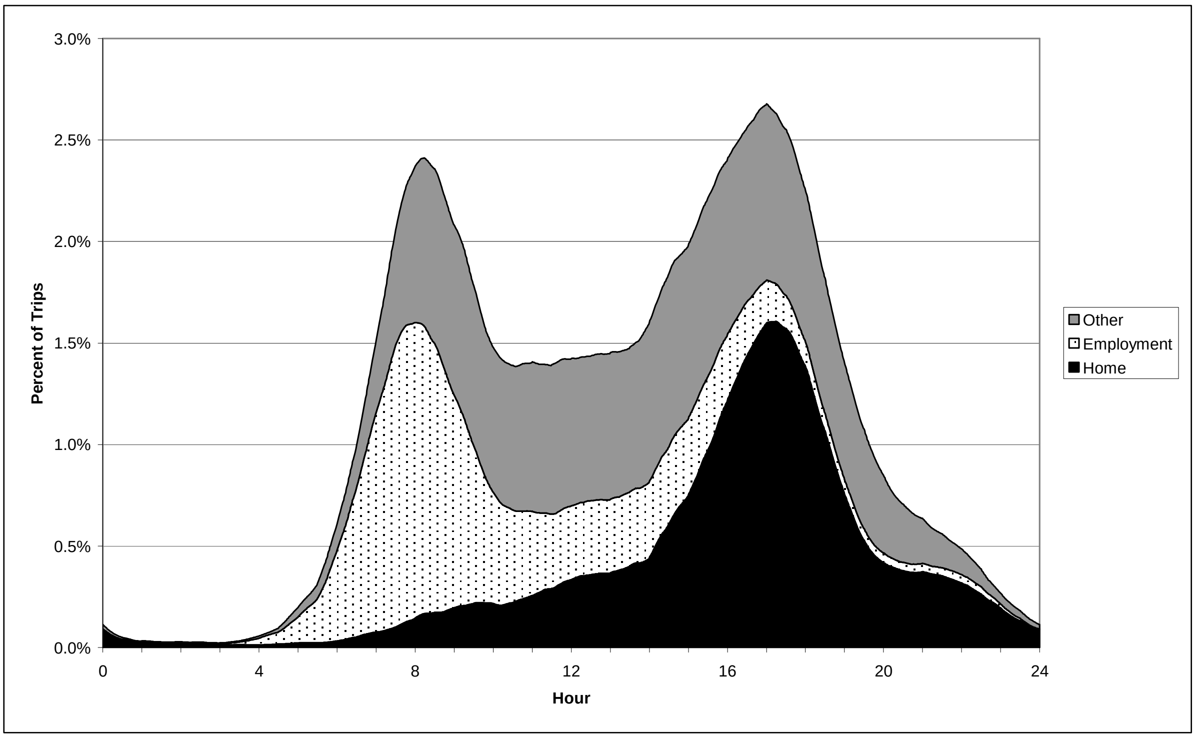

Figure A.2 Daily travel profile – road users – major MUA of Wellington

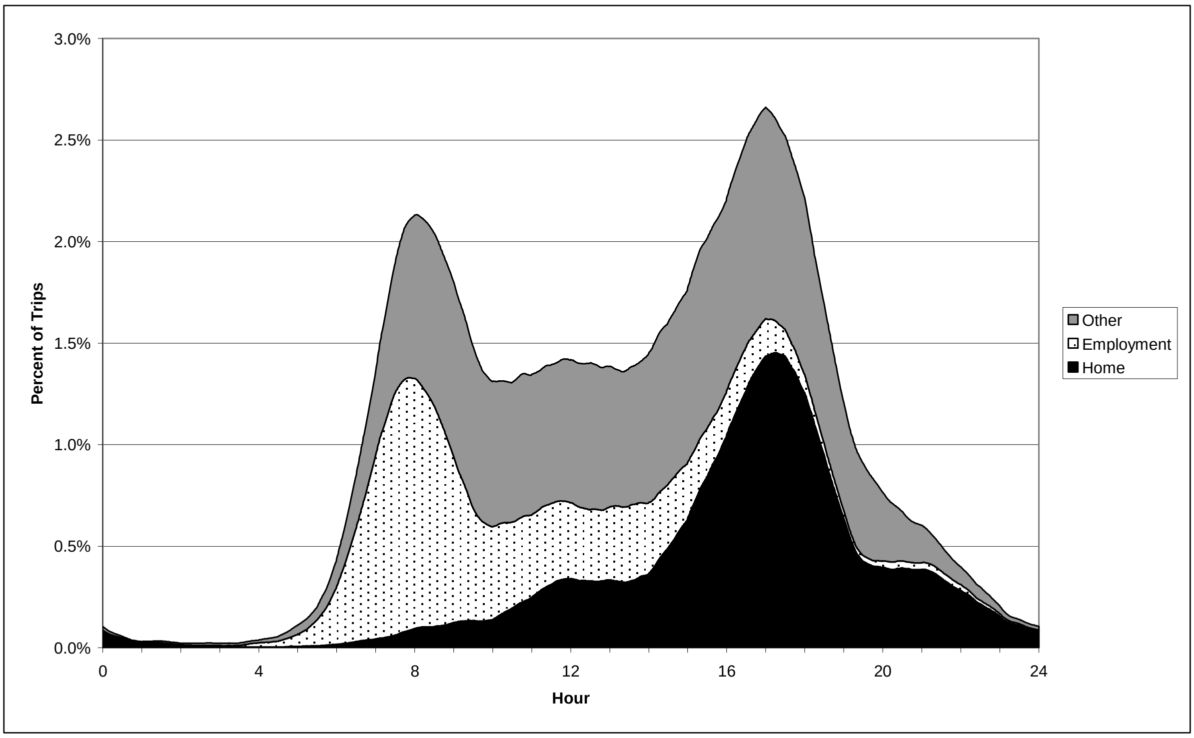

Figure A.3 Daily travel profile – road users – main urban areas

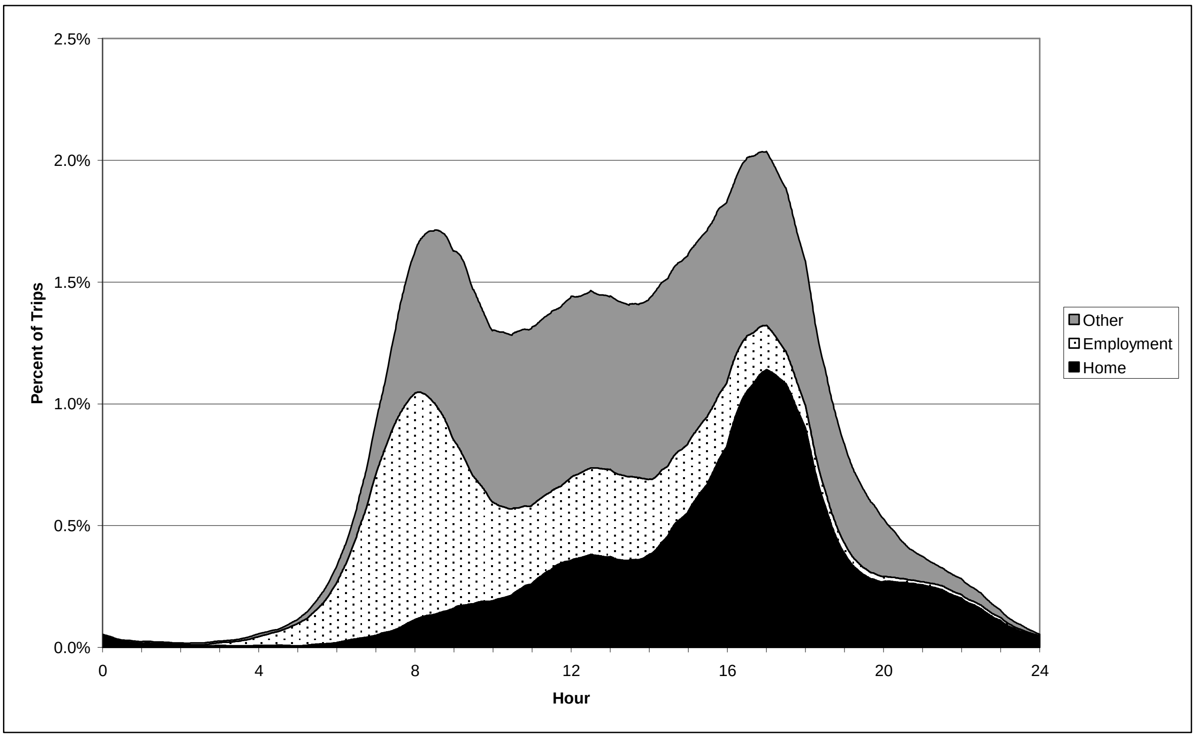

Figure A.4 Daily travel profile – road users – rural areas