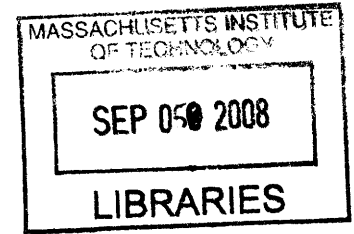


Local travel habits of baby boomers in suburban
age-restricted communities

by

Francis Hebbert

B.A. Architecture
The University of Westminster, 2003



Submitted to the Department of Urban Studies and Planning
in partial fulfillment of the requirements for the degree of

Master in City Planning

at the

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Abstract

The baby boomer generation is an unprecedented demographic of 78 million Americans, now entering retirement. Living mostly in suburbs and dependent on private vehicles for nearly all travel needs, boomers face increasing mobility challenges as they age. Evidence suggests that walkable and social neighborhoods are important in sustaining independence and good health during later life. Age-restricted communities may offer a social and physical environment that supports an active lifestyle.

I use a travel survey to investigate local activity and sociability in age-restricted communities and unrestricted typical neighborhoods in suburban Boston. I explore three techniques to account for residential self-selection, attempting to isolate the true effect of neighborhood location from personal preferences. Controlling for income, retirement and other factors, residents of restricted communities are more active than residents of typical suburbs, with more people making trips on foot and to visit neighbors. Boomers appear to select age-restricted locations to fulfill latent desires to make trips to neighbors, whereas increased walking in the same communities does not appear to be a result of self-selection.

The association between age-restricted communities and increased activity suggest that these developments have lessons for better suburban environments. How the communities influence activity is not understood: in models, measures of urban form are not significant, though these developments appear to have different layouts from typical neighborhoods. More detailed analysis and additional data collection may provide a clearer assessment of the role of different neighborhood features in influencing boomer travel habits.

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List of acronyms and initialisms

2SLS Two Stage Least Squares model with instrumented variables.

AARP American Association of Retired Persons.

AHS American Housing Survey.

ARAAC Age Restricted Active Adult Community.

BE Built Environment.

CBD Central Business District.

CCRC Continuing Care Retirement Community.

CHAPA Citizens' Housing and Planning Association.

CTPS Central Transport Planning Staff.

GHG Greenhouse Gases.

GIS Geographic Information System.

HUD US Department of Housing and Urban Development.

IMR Inverse Mills Ratio.

IV Instrumental Variables.

NAHB National Association of Home Builders.

NBM Negative Binomial regression Model.

NL Nested Logit model.

NHTS National Household Travel Survey.

NPTS National Personal Travel Survey.

MAUP Modifiable Areal Unit Problem.

MBTA Massachusetts Bay Transportation Authority.

OLS Ordinary Least Squares regression.

PMSA Primary Metro Statistical Area.

RC (age) Restricted (active adult) Community.

TAZ Traffic Analysis Zone.

TB Travel Behavior.

TN Typical Neighborhood, no age restrictions.

VMT Vehicle Miles Travelled.

1 Summary

Objectives

I investigate the effects of age-restricted communities on local travel habits for suburban boomers. Controls for residential self-selection are used, so the full influence of residential location can be assessed separately from individual preferences for certain travel outcomes.

Context

Age-restricted communities are a popular choice for boomers and a growing development type in Massachusetts, but little is known about the effects these communities have on aging or travel outcomes. Aging baby boomers are largely suburban and very auto-dependent. Many factors associated with active older people are missing from suburban locations, such as density, local attractions, regular transit and sidewalks. Residential locations offering more social and walkable settings may make it possible to stay active for longer, with benefits for aging healthily in suburban settings.

Design

A quasi-experimental design, using age-restricted and typical neighborhoods with similar regional and demographic characteristics.

Setting and participants

Suburban Boston, matching 20 age-restricted communities with nearby typical neighborhoods. The sample is households with one or two inhabitants aged 55-65 years, targeted with a commercial mailing list. Neighborhoods have limited local services but good regional accessibility.

Measurements

I use an incentivized mail-back travel diary instrument to record trip making habits with a single day of travel, and retrospective trip counts. Attitudinal questions provide controls for self-selection, and household demographic questions provide controls to minimize differences between sample locations. GIS analysis provides measures of accessibility to employment and attractions, density and neighborhood characteristics including street networks.

Two travel outcomes are modeled: trip making on foot or by cycle with the local neighborhood, and visits to neighbors. For both, the outcome of interest is making or not making any trips.

Results

Residents in both neighborhoods are similar in income, age and other demographics. Both neighborhoods have similar travel patterns. Age-restricted communities are associated with more walking and more visits to neighbors. Boomers in these communities seem to be more active than those in typical neighborhoods, making more trips per week and more local trips, and having a higher rate of travel as a passenger rather than driver.

After controlling for other factors including self-selection, residents in restricted communities are more likely to walk from home or visit neighbors. Self-selection appears to influence residential location for people who are neighborly, but not for local walkers. Living in a restricted community had a greater effect on the likelihood of making neighbor visits than local activity.

Implications

The role of the age-restricted community in fostering increased activity is not understood. Further investigation is needed to identify causal factors, beyond 'something in the air' that seems to support more activity and sociability. If these factors can be generalized to other types of suburban neighborhoods, there are opportunities to support healthier living and aging for more people. Age-restricted locations also present other opportunities for innovation in service provision, for example by providing paratransit than avoids the stigma attached to regular transit services.

2 Introduction

Introduces boomers, and explores reasons to study age-restricted communities. The research questions are summarized.

The US population is aging: as the post-war ‘baby boomer’ generation age, they skew the national demographic and raise the median age. Born between 1946 and 1964, and numbering 78.2 million adults in 2005, the boomers are now entering late middle age and retirement. A demographic shift on this scale is unprecedented, both in total numbers and proportion of the overall population (Census 2006). Whereas 1 in 8 are over 65 now, in the next 20 years the proportion will rise to 1 in 5 (Blechman 2008). As a result, the US population pyramid shown in Figure 2-1 on the following page now increasingly resembles a population rectangle (Heudorfer 2005).

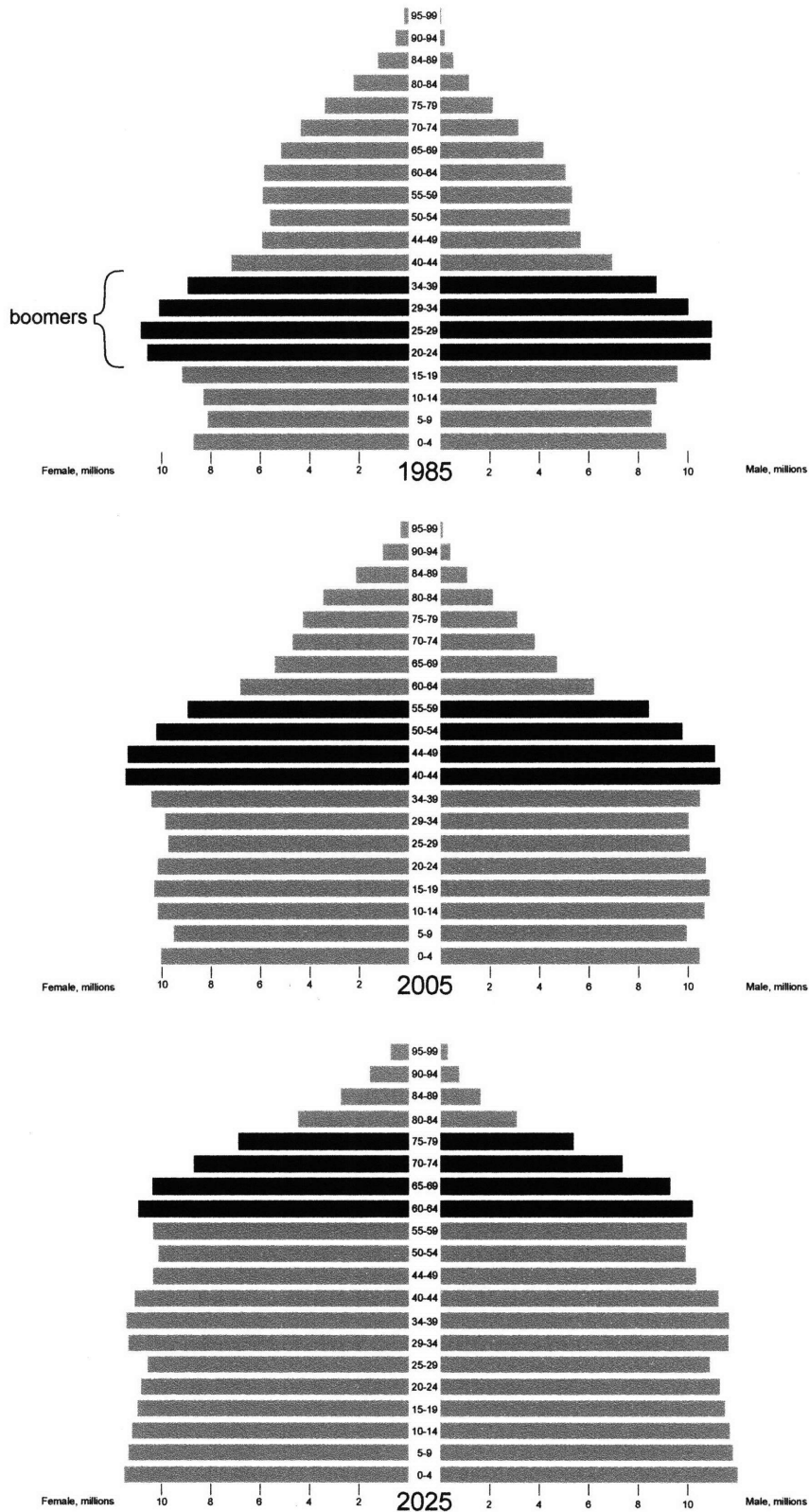
Having lived through the decentralization of urban areas and the growth of suburbia, boomers live mainly in the suburbs: in the 2000 census, only 35% of boomers lived in central cities (Frey 2007). Any ‘re-urbanizing’ of downtowns by older adults is still outnumbered 2:1 by outwardly migrating boomers, against the national backdrop of slight net migration to non-metropolitan areas¹ (Schachter et al. 2003).

Within Massachusetts, 1.87 million boomers will turn 55 years old this decade. The shift towards an older population is compounded by longer life expectancy, and younger people moving to other states (Heudorfer 2005). The 2000 census reported the state population below 35 years old decreasing by 4.5%, while those older than 35 increased by 18.9%, compared to the previous decade (Frey 2003), against a 1% decrease in the urban area’s population² (Schachter et al. 2003). As well as being suburban and a major population group, boomers are a high income household bracket with high rates of home ownership: 78% of over-55s are homeowners in Massachusetts (McCarthy and Kim 2005).

¹Frey identifies 430,000 55-65 year olds moving from city to suburb compared to 266,000 moving the other way. Schachter calculates a net national urban to suburban migration of 510,000 with 5,656,000 inbound and 6,166,000 outwards.

²44,973 people left the Boston metro area, leaving 5,819,100 behind.

Figure 2-1. The US population rectangle: 1985, 2005, 2025



Data source: US Census Bureau, Population Division

As a major demographic group, boomers have stimulated research and innovation in many areas and are responsible a shift in marketing, attitudes and innovation towards an older society (Coughlin 2007). The aging population has made some policy concerns more urgent, such as health care and active aging. Two areas of interest are closely linked: travel behavior, and residential location. Against the backdrop of an aging and suburban population, a number of relevant research questions arise, including those related to travel behavior, residential location and the interaction between the two. In particular, private vehicle use in later life may become more difficult, and vehicle use in general has negative consequences, including road safety risks and climate change. Residential locations that support alternative travel outcomes and reduce auto-dependency can help aging boomers maintain active lifestyles, with wider social benefits.

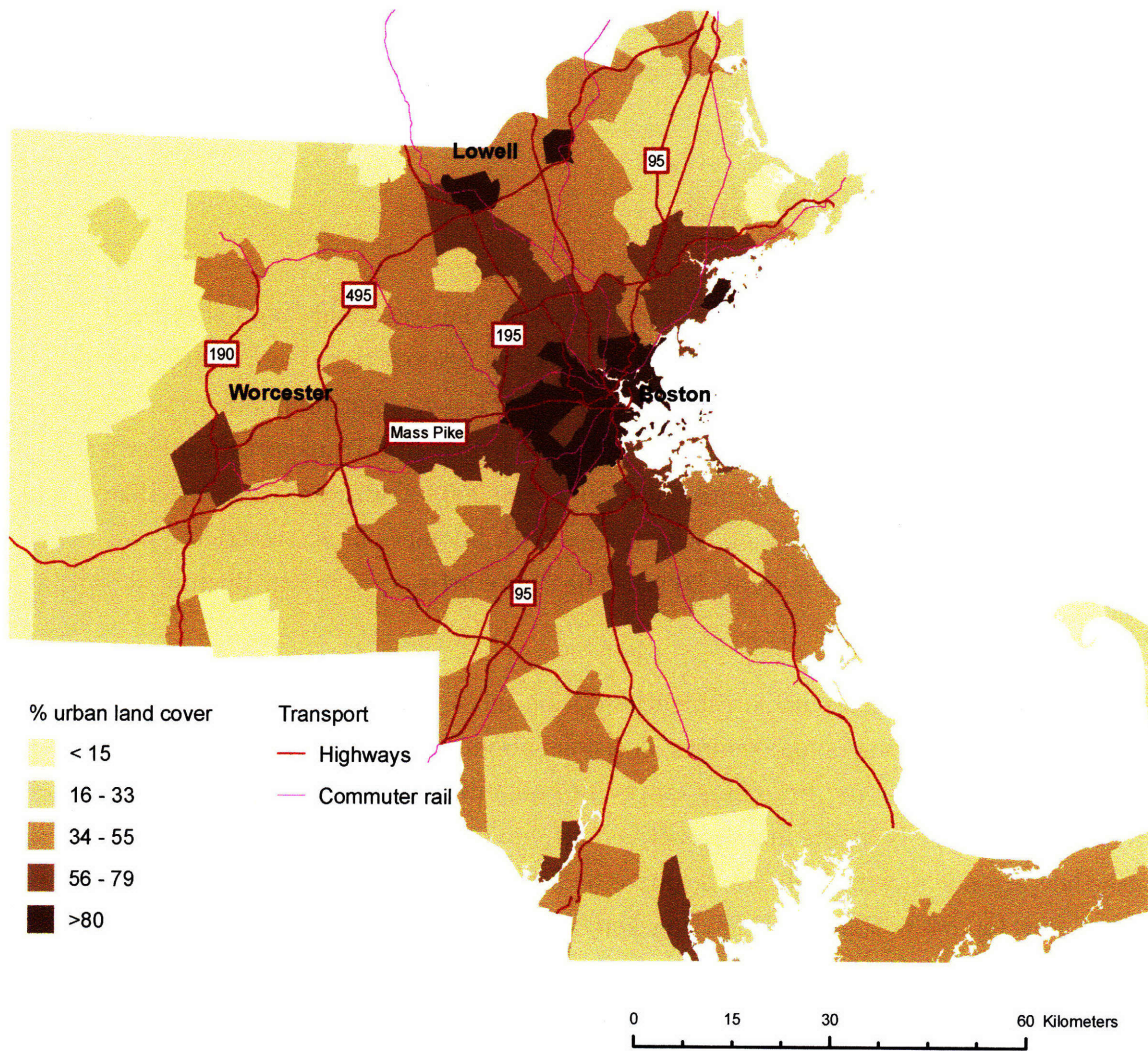
2.1 Focus of this research

This study focuses on age-restricted communities and the travel outcomes that they produce, through an examination of travel behavior in age-restricted and unrestricted neighborhoods. It is part of an ongoing project at MIT investigating boomer travel and residential location, sponsored by the New England University Transportation Center. Previous outputs include a poster presentation at the 2008 Transport Research Board Annual Meeting and a summary of focus groups with boomers in age-restricted and typical neighborhoods (Zegras et al. 2008). The study area is suburban Boston, shown in Figure 2-2 on the next page.

Age-restricted communities are a residential option mostly limited to people aged over 55 years. For healthy boomers and seniors, decisions about moving are motivated by a variety of factors, including becoming empty nesters and wanting a home more suited to current needs. Most boomers are still active and many are not retired, so when moving house they are not moving only for negative health- and aging-associated reasons. Some move to developments that are solely marketed at the older adult demographic with targeted design, community and lifestyle features, including age-restrictions that limit residential rights to households mainly aged over-55. These restricted communities are the focus of this thesis.

For people in less good health, residential options with medical care and nursing become an option. Continuing Care Retirement Communities (CCRC) offer residential neighborhoods and housing with a variety of on-site nursing and care facilities, with around 4,000 nationwide (Census 2006). Remaining in one's existing home is termed *aging in place*. For these older adults, Naturally Occurring Retirement Communities (NORC) are service organizations offering various levels of assistance and care through a

Figure 2-2. The Boston metro area. Darker colors show intensity of urban development, from land use data. Major urban centers are indicated.
Sources: Land cover MassGIS, 1999. Road network EOT highway data, 2007.



membership framework within existing urban neighborhoods. NORCs represent the opposite aging outcome to the focus of this thesis.

Existing travel behavior research does not say how people living in age-restricted suburban neighborhoods are likely to travel differently to conventional suburbs. But the age-restricted neighborhoods are clearly different in many ways to the standard suburban locations, with a different demographic and deliberate design features intended to support a certain lifestyle. Although one might be tempted to generalize travel outcomes in these neighborhoods with all suburban dwellers, this overlooks specific differences in physical design, community structure and organization that may lead to different travel outcomes.

Although the specific focus of this study is on travel behavior, age-restricted communities introduce a host of other effects for residents, towns, service providers and policy makers that warrant further analysis.

For the **residents**, we don't know if the design of the community leads to more active aging, with positive health implications. Do built environment features like walking trails and sidewalks actually increase the rates of walking and biking in beneficial ways? Do faux New England villages create more social neighborhoods, and does this sociability extend to support in times of ill-health and infirmity with increasing age? All other things being equal, is an age-restricted community a better place to grow old?

For **towns** permitting these communities, what are the implications for tax burdens on a municipality, and do these additional units merely free up other housing stock for occupancy by families? What are the social implications for town governance and community participation? Looking ahead 30 years, what happens after the boomer bulge has passed?

For **providers of transit services** and para-transit, how do these residents view and interact with non-auto services? Are the neighborhoods an untapped market for senior shuttles or an unreachable demographic? What opportunities exist for innovative profit or non-profit services to provide these concentrations of older adults with alternatives to private vehicle use?

For **planners and designers**, are positive effects - if demonstrated - from community cohesion or additional local activity replicable in typical neighborhoods, or is the age-restriction essential? What features can be used to create suburbs with better travel outcomes for all age groups? How do residents of age-restricted neighborhoods travel compared to their unrestricted neighbors? Do the developments generate as many or greater numbers of vehicle trips, or are local walk trips environmentally beneficial by reducing auto-use?

Research questions

Within the broad range of unknowns about age-restricted neighborhoods, this study focuses on travel outcomes.

What differences occur in local activities and trips between restricted and typical suburban neighborhoods? Do residents make more local trips, or are trip behaviors the same between community types?

What are the influences of neighborhood characteristics on local trips? Are certain neighborhood designs or social structures associated with particular travel outcomes?

I investigate local trip making through a travel diary. Respondents indicate the frequency of trips during a typical week, including walking and cycling, and visits to neighbors. I estimate regression models to investigate the factors associated with making zero trips in either category, compared to making at least one trip (a binary trip/no trip outcome).

Chapter 3 on page 27 reviews evidence about age-restricted communities. Chapter 4 on page 41 reviews previous travel behavior research about older adults. Chapter 5 on page 53 explores the study methodology, including modeling techniques, controls for endogeneity and the survey design. Chapter 6 on page 75 characterizes the built environment of the study area. Survey results are presented in Chapter 7 on page 105. Models are estimated in Chapter 8 on page 143. I summarize findings and discuss implications in Chapter 9 on page 161.

2.2 Terminology

The broadest definition of the *baby boomer generation* includes anyone born between 1945 and 1964. *Leading-edge boomers* are the cohort now reaching their late 50s and the group of interest in this study, aged between 55 and 65. In these pages, *boomers* refers solely to this latter group unless otherwise indicated, *seniors* are aged over 65 and *older adults* are all adults aged 55 and older (or in marketing terms, *55 or better*).

When describing age-restricted communities, the most precise term is *age-restricted active adult community* (Heudorfer 2005). HUD prefers *senior housing*, or *a 55 and older community*. Residential developer Del Webb chooses to overlook the restrictive aspect and refers to *Active Adult Communities* (Harris Interactive 2005), while the National Association of Homebuilders suggests that *Age-Qualified* is preferred by the industry for being less negative-sounding (Emrath and Liu 2007). For readability, in this study these areas are referred to as ‘age-restricted communities’ or ‘restricted communities’: *restricted*

because the ‘active adult’ modifier is unnecessary since no other type of community is discussed. In tables and charts, the initialism *RC* will be used for restricted neighborhoods. Unrestricted, ‘typical’ subdivisions will be referred to as typical neighborhoods, initialed *TN* since these locations are generally larger and more similar to a neighborhood than a master planned community.

A *low income* household is defined by the US census as a home earning less than \$25,000 per annum. *Medium income* spans \$25-75,000, and *high income* households earn over \$75,000.

Significant is only used to indicated a statistically significant effect at $p < 0.05$. *Highly significant* means $p < 0.01$ and *very highly significant* means $p < 0.001$.

Histograms are scaled so that the sum of all bar areas is equal to 1. The y-axis displays density, which can be multiplied by bar width to give relative frequency.

3 Age-restricted communities

This chapter explains the legal basis for age-restricted neighborhoods and trends in construction nationwide and in Massachusetts. I identify 35 developments in the Boston area and review feature of two representative communities. I discuss the possible role of these communities in producing different aging outcomes.

3.1 Background to age-restricted communities

The first purpose-built age-restricted community in the US was Youngtown, Arizona, built in 1954 on a 320 acre cattle ranch outside Phoenix. The founder Benjamin Schleifer wanted to build a town that would give seniors somewhere to live later years in a socially active, affordable and child-free setting, rather than simply waiting for the end. According to Andrew Blechman's (2008) acidic critique of age-restricted communities, he succeeded: Youngtown grew, the AARP's first chapter was founded, businesses came and the town incorporated in 1960. This success caught the attention of Del Webb, who instructed his staff to investigate the potential in senior-only housing. Sun City opened in 1960, a town designed around retirement as 'golden years', putting the childless mogul on the front cover of Time magazine and creating a market that went from a niche in the Del Webb empire to its primary business. Age-restricted living was established, though it took a while for the restriction to be given a solid legal basis (as Youngtown discovered when its restrictions on younger residents were thrown out by the Arizona Attorney General in 1996¹).

¹In the early days of Youngtown, no restrictions were placed on who could live there, presumably because it was inconceivable that families could be attracted to a cattle ranch in the desert filled with retired people playing bridge. As Phoenix grew, the city wrote age-restrictions into law in 1974, but these were thrown out after an extended legal battle in the 1990s. Blechman details how the city evicted over 300 families in the immediate years before the restrictions were finally ruled meaningless in 1996.

3.1.1 Legal basis

Any age-restricted housing built today can legally restrict residence to people over a certain age, one of the only permissible types of housing discrimination in the US. The Fair Housing Act of 1968 prohibited discrimination in housing on almost any basis, but lobbying by family groups and seniors resulted in modifications in 1988 allowing exemptions at both ends of the age spectrum: to seniors and to families with young children. New developments were permitted to discriminate on age, provided 'significant facilities and services specifically designed to meet the physical or social needs of older persons'; and the development should either be only available to people 62 years and older, or 80% occupied by unit containing at least one 55 year old (text from the Act, quoted in Heudorfer (2005)). The legislation did not explicitly define the requirements necessary for meeting the 'significant facilities' threshold. The Housing for Older Persons Act (HOPA) in 1995 added two provisions to the 80% clause: the community must publish and adhere to policies that demonstrate intent to comply with the age restriction; and comply with HUD's rules for verifying occupancy. If fewer than 80% of homes meet the older occupancy rule, the development becomes open to all age groups and the legal basis for restriction is lost (Blechman 2008).

Several social and community development criticisms have targeted the age-restriction for older adult neighborhoods. Some criticize RCs filled with disengaged citizens who are breaking the social contract by withdrawing their skills and knowledge from mixed communities (Blechman 2008). According to one poll, 70% of residents in RCs are 'not very' or 'not at all' involved with community affairs, compared to 52% of longer term residents (Harris Interactive 2005). Another criticism is that the current interest in RCs is short-sighted, motivated by municipalities preferring housing that avoids any additional strain on the school system, while the same support is not given to housing for key workers (Heudorfer 2005). These issues suggest the need for further study of age-restricted neighborhoods beyond travel impacts.

3.1.2 Demand for age-restricted housing

Nationwide, 42.9 million households have one or both residents aged over 55 years. Six percent of these households (2,843,000) live in a RC, with the great majority in suburban locations (Emrath and Liu 2007). Of the homes in restricted neighborhoods, 9% were built between 2000 and 2004 (calculations from AHS 2005²). The total value of

²The American Housing Survey began tracking restricted communities in recent surveys. In the 2005 data, 42,934,000 households are occupied by at least one adults aged over 55 years. 2,834,000 homes are in restricted communities, 267,000 were built in the 4 years prior to the survey publication, 411,000 contained residents who moved in the previous year, and 443,000 were mobile homes.

age-restricted housing sold nationwide in 2007 was \$7.3 billion, compared to the \$74.1 billion of housing bought by boomers in communities that are not age restricted or predominantly occupied by other older adults, according to NAHB estimates.

As boomers age, the frequency of moving home decreases and the reasons for moving change. Boomers remain mobile, though less likely to move than younger adults. Analysis of the 2003 AHS by Blake and Simic (2005) indicates that 32% of 55-61 year olds moved in the last five years, compared to 59% of 35-44 year olds. According to questions in the AHS about motivations for changing location, moving closer to family becomes more important as people age, rising from 5% for 55-61 year olds to 14% for people in their 70s. The nationwide AHS data do not show any other changes in preferences as people get older. Morrow-Jones and Kim (forthcoming) find the elderly are more likely to want public transport facilities nearby, compared to boomers and younger adults. Surveying 500 recent movers in Columbus, Ohio about reasons for choosing their neighborhood, the authors find significantly varying demand for home-related characteristics between young, boomers and the elderly, for example in home size and yard space. Neighborhood and regional accessibility motivations remain constant, with no age group identifying local stores and services within walking distance as more important. Availability of public transportation is more important for the elderly, though in general it is not considered a priority by any age group. The authors did not control for actual public transport services, so we do not know if older people with no preference for a transit lifestyle moved away from transit services.

Limited and contradictory evidence exists on the specific features that attract homebuyers to move to age-restricted communities rather than a typical neighborhood. The available data come from small surveys of buyers or potential buyers, and focuses on amenities in the neighborhood rather than regional factors. Nationwide, an AARP study of people aged over 60 identifies the weather and proximity to family as important reasons to relocate into a restricted neighborhood (Prisuta et al. 2006), while NAHB identifies proximity to medical facilities and design of the community as important factors (Emrath and Liu 2007). A survey of boomers conducted for home builder Pulte/Del Webb suggests lawn care as the biggest amenity attracting prospective residents to a restricted community (Harris Interactive 2005), which suggests the importance of 'care free' living that RCs can provide. Some evidence suggests that moves to gated communities are motivated by a fear of crime (Low 2001), though many RCs in the north east are not gated.

3.1.3 Age-restricted housing in Massachusetts

Age restricted housing is common in Massachusetts, with 12% of boomers buying their new home in a RC (Heudorfer 2005). In a review of many aspects of RC development, the

Citizens' Housing and Planning Association (CHAPA) identifies five factors driving demand: the growing senior market in the state; younger boomers being better off; boomers having equity from previous long term ownership; changing needs/preferences for housing among boomers; limited choice in the existing housing stock, in location and quality.

In the same study, CHAPA surveyed cities and towns in eastern MA to gather information on RC construction trends. In 2005, 150 developments in 93 towns were entirely built and occupied or under construction. A further 14,000 units in 172 developments were in pre-construction or seeking permits in 109 towns, including 66 where no previous age-restricted developments had taken place. 60% of communities have authorized age-restricted housing in locations or at densities where other housing could not be built. 70 communities have zoning provisions that are supportive of senior housing, which may include RCs. Assuming successful completion of all developments, nearly every town in the greater Boston region will have at least one RC.

Evidence suggests that Massachusetts is a growth area for restricted housing. Recent trends in RC building have diversified from large communities in the south of the US, with the north-east a growth region in the last decade for RCs. Whereas 80% of new RCs in 1995 were in the sunbelt states, by 2005 60% were in the north (Blechman 2008). Within Massachusetts, age-restricted developments have a five-acre minimum size requirement unless the development is subsidized housing in some way. This has led to some use of the Fair Housing statute (40B) to build restricted neighborhoods. Five towns recently successfully petitioned to exempt proposed developments from the five acre rule, but apart from these exceptions the developments are large, with only 20% containing fewer than 25 units. A survey of home builders by NAHB (quoted in Heudorfer 2005) identifies some trends in recent construction: a new restricted neighborhood in the north east is more likely to be suburban and somewhat connected to existing towns than self-contained sites elsewhere in the country. It is as likely to include walking paths as elsewhere, and more likely to include a meeting room and be located closer to existing municipal services like a library. Developers are less likely to build an on-site dedicated grocery, bike trails, golf facilities, sidewalks on both sides of street, or to be gated. Most RCs have a clubhouse, a few have a fitness center and walking trails and a minority offer tennis, golf, and swimming. Given the high homeownership rate among the target demographic, few offer any rental units.

3.2 An inventory of age-restricted communities around the Boston metro area

For this study, I attempted to inventory RCs in the Boston area, via searches of real-estate listing on websites, information from developers and other resources targeted at the 55+ home buyer. This approach biases the list towards more recent developments or ones with some units still on the market or recently changed hands.

In total I identified 35 developments, shown in Figure 3-1 on the next page, representing around a third of the 139 communities identified by the CHAPA study (Heudorfer 2005). The size (where known) and location of each development are listed in Table 3.1 on page 33. Numbers on the map refer to the table. The 35 RCs vary in size from 40 to 1,150 units, with a median of 66 units. The size of seven developments is unknown. All are suburban.

3.2.1 Features of two age-restricted communities

Two communities identified in the survey have characteristics common to RCs, I review them here to point out the common features. The Pinehills is a large restricted neighborhood, while Village at Meadwood is a smaller and more urban development. Details of the communities are summarized in Table 3.2, see Figure 3-2 on page 34 for their location in the Boston metro area.

Village at Meadwood is typical of RCs in the Boston area: it has less than 100 units, arranged on a single access road with detached housing units and no extensive amenities. Figure 3-3 on page 36 identifies typical RC features seen in this development. Located 40 km north of Boston near to the city of Lowell, the completed development has 71 units over 40 hectares. Permitted in 1998, the development is entirely age-restricted. The road network within the development is a private road connecting all homes, with no through traffic. With Lowell nearby, retail and other attractions are within a short drive.

The Pinehills is different to most RCs in the study, because it is much larger and has design innovations that differentiate it from most other large suburban developments, age-restricted and not. It is located around 70 km south of Boston, in the town of Plymouth but in an undeveloped area with no local services. Started in 1997, the development covers 1,214 hectares and consists of multiple neighborhoods, most of which are age-restricted. Most of the land cover is open space, including woodland and golf courses. Figure 3-4 on page 37 shows a map from the development's marketing brochure - dark green areas are golf fairways and light green are residential areas. Each neighborhood is built separately in staged development, with around 900 homes at present. The

Figure 3-1. Age-restricted neighborhoods in the Boston area.

I identified 35 completed age-restricted developments near Boston. Their locations are shown with numbered dots, refer to Table 3.1 on the next page for details of each site. The shading of the map indicates towns with one or more RCs, as listed in the CHAPA study (Heudorfer 2005), which tabulated the number of developments in each town.

Source: Towns with RC locations from Heudorfer (2005), town boundaries from MassGIS.

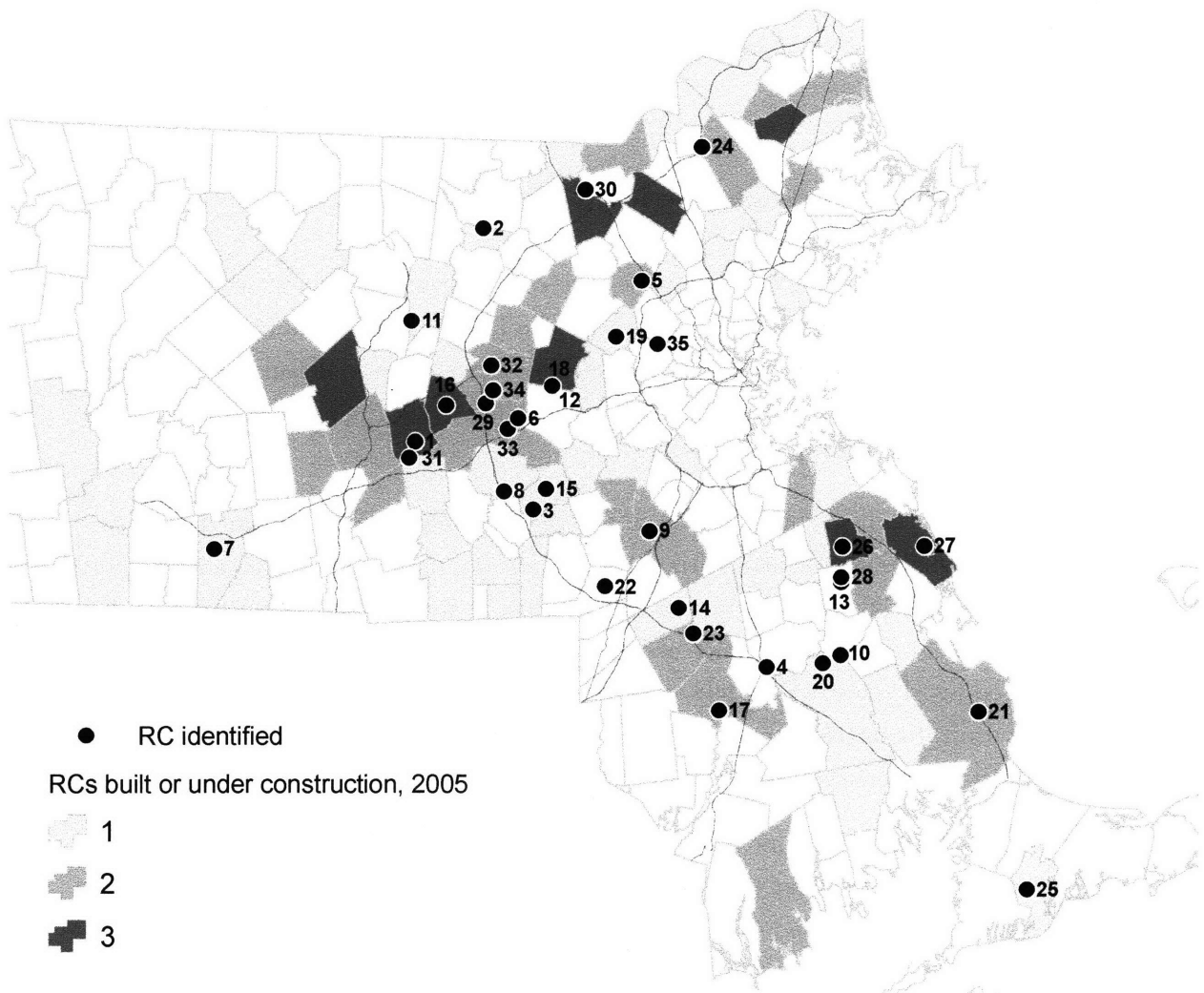


Table 3.1. Age-restricted communities identified for this study.
Refer to Figure 3-1 on the facing page.

Map reference	Age-restricted neighborhood	Number of units	Town
1	Adams Farm	90	Shrewsbury
2	Autumn Ridge Farm	-	Ayer
3	Balancing Rock	49	Holliston
4	Berry Hill	65	Bridgewater
5	Caldwell Farm	66	Bedford
6	Carriage Hill	-	Southborough
7	Crescent Gate	69	Sturbridge
8	Deerfield Estates	47	Hopkington
9	Delapond Village	40	Walpole
10	Dunham Farm	-	Hanson
11	Eagle Ridge	44	Lancaster
12	Grouse Hill	55	Sudbury
13	Heritage at St Charles	-	Hanson
14	Herons Crest	82	Mansfield
15	Juniper Hill	-	Holliston
16	Lawrence Place	30	Northborough
17	Leisurewoods	222	Rockland
18	Mahoney Farms	33	Sudbury
19	Minuteman Commons	32	Lincoln
20	Oak Point	1,150	Middleborough
21	Pinehills	900	Plymouth
22	Pond Meadow	66	Marshfield
23	Red Mill	156	Norton
24	Riverbend Crossing	43	North Andover
25	Southport	480	Mashpee
26	Spring Meadow	-	Hanover
27	Spyglass Landing	40	Marshfield
28	Stonebridge Commons	121	Hanson
29	The Village at Crane Meadow	91	Marlborough
30	The Village at Meadwood	71	Chelmsford
31	The Village at Orchard Meadow	70	Shrewsbury
32	The Village at Quail Run	150	Hudson
33	Vickery Hills	40	Southborough
34	Villages at Marlboro East	-	Marlborough
35	Wellington Crossing	118	Waltham
Total		4,420	

Figure 3-2. Location of Village at Meadwood and The Pinehills.
Source: Base map data from MassGIS.

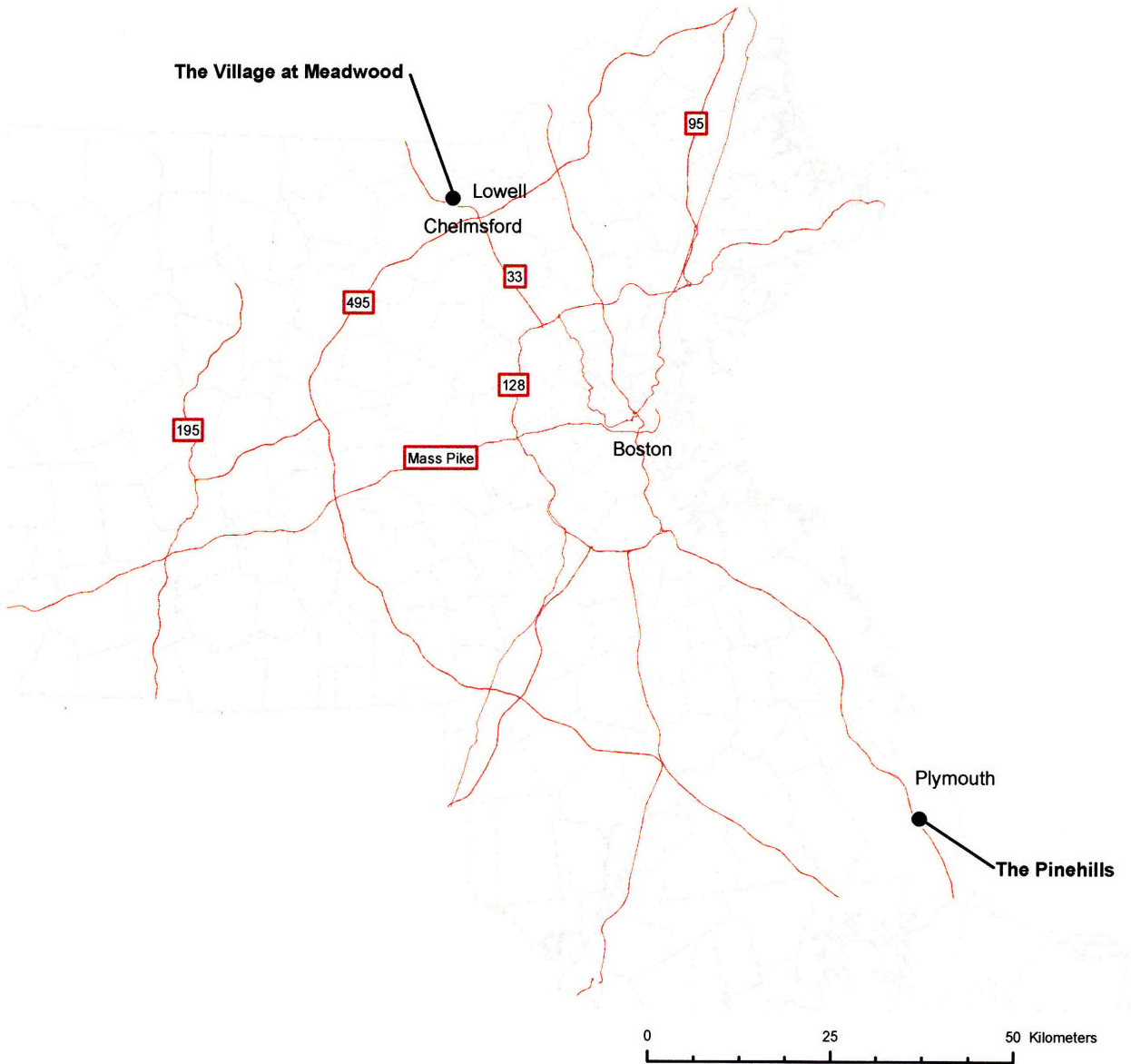


Table 3.2. Characteristics of two age-restricted communities.
Source: calculated from aerial images and Census 2000 data.

	The Pinehills	The Village at Meadowood
RC characteristics		
Housing type	Mixed	Detached single family
Units	900	71
Area (ha)	1,200	40
Household density (hh/sq km)	220	400
Local area		
Town	Plymouth	Chelmsford
Median household income (\$)	56,600	63,500
Median home value (\$)	303,000	353,000
% boomers	6	7
% SOV commute	88	88

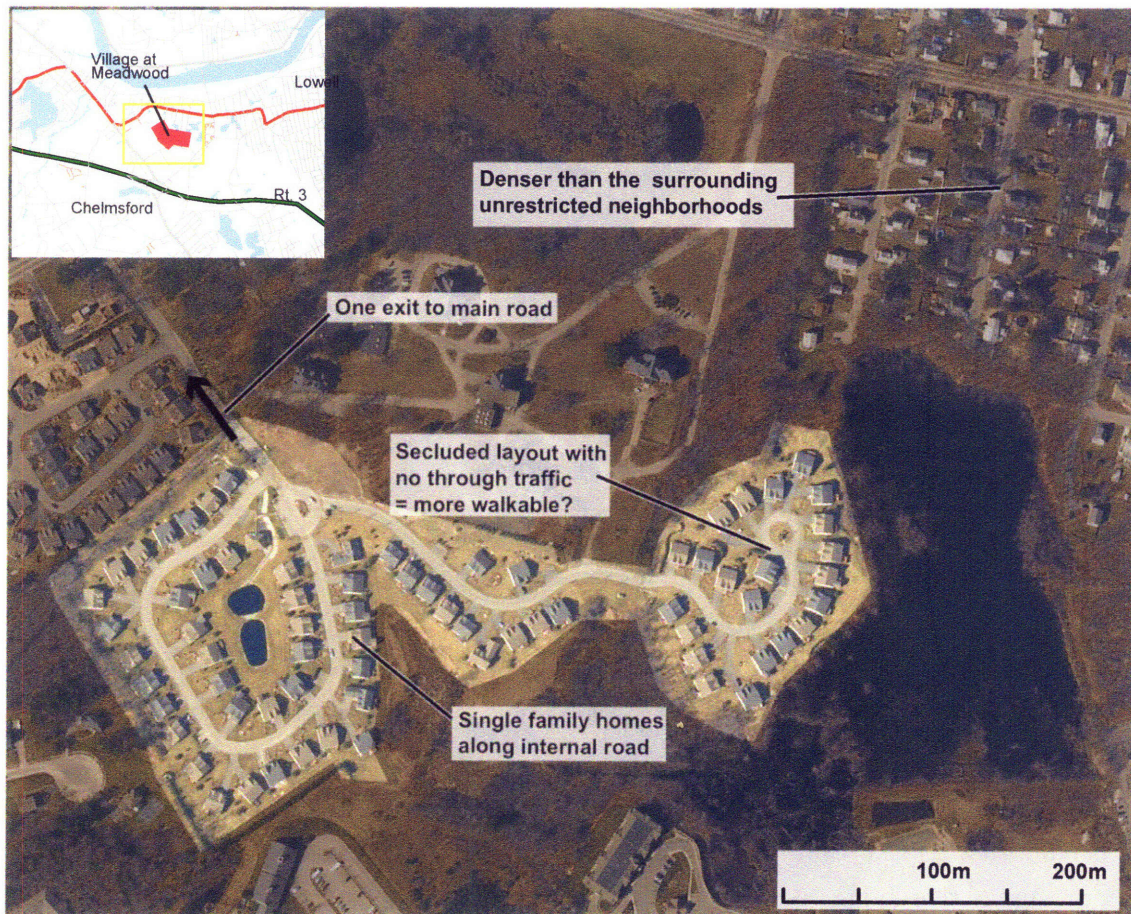
extensive size of the site means that new development does not disturb existing residents. At completion, the development will have 2,983 homes in a mixture of single family, duplex and apartments (Singh 2006).

The neighborhood form of Pinehills exemplifies the ways in which RCs can be thought to support more active living. Walking trails link neighborhoods, some shared with golf carts. A ‘village green’ offers retail and services including a cafe and central post office, with satellite mail pickups in larger neighborhoods. Streets are generally 18-22 feet wide rather than 60 feet as elsewhere in Plymouth. Built with attention to contours, existing trees and views, homes are located with more sensitivity to the landscape than a typical subdivision (Figure 3-5 on page 38). These factors combine to create an environment that is marketed as encouraging walking and local social interaction while maintaining privacy.

In addition to the physical features of the development, the range of activities within the Pinehills offer a dynamic and active community to join. In a typical October week, residents can attend 15 different social events and 17 fitness classes³.

³The Pinehills events calendar for October 2006 listed: Singles on the go potluck dinner, Weight Watchers orientation, New Bridge club, Floor cloth class, Advanced bridge, Ping pong club, Windfall investment club, Cooking up a storm, Discussion group, Beginners bridge, Brown Bag book club, Bridge club, 2nd annual holiday card stamp class, Plymouth History tour, Behind the Pines tour. The fitness classes were multiple sessions of: Interval training, Interval pilates, Total conditioning, Sculpt and Tone, Tai Chi, Chair aerobics, ‘Cheryl’s 3 C’s’.

Figure 3-3. Village at Meadwood, Chelmsford shows features typical of other suburban RCs.
Source: Base aerial photograph from MassGIS.



3.2.2 Generalizing features of age-restricted communities

Both these communities have features that set them apart from conventional neighborhoods, and could have an influence on travel and local activities. Because the age-restriction is a deliberate choice for residents when selecting their location, these factors are likely to be considered by residents at some level before moving, and prospective residents who do not consider them beneficial might choose to live somewhere else. As a result, the effect of these characteristic on residents is probably stronger than the lack of effect felt in typical neighborhoods. The following characteristics are not exclusive.

Similarity. Residents living in the neighborhoods have chosen to move in with other people who share similar characteristics, not just in age but in other ways too - income, race, ethnicity, and possibly social interests such as golf. These shared characteristics may make it more likely that residents will engage with each other. Knowing that everyone else

Figure 3-4. Brochure map of The Pinehills.

Dark green areas are golf courses, light green are neighborhoods. The central post office and retail area are near to the area marked 'Main Entry'. For comparison, Winslowe's View is similar in area to the Village at Meadwood.

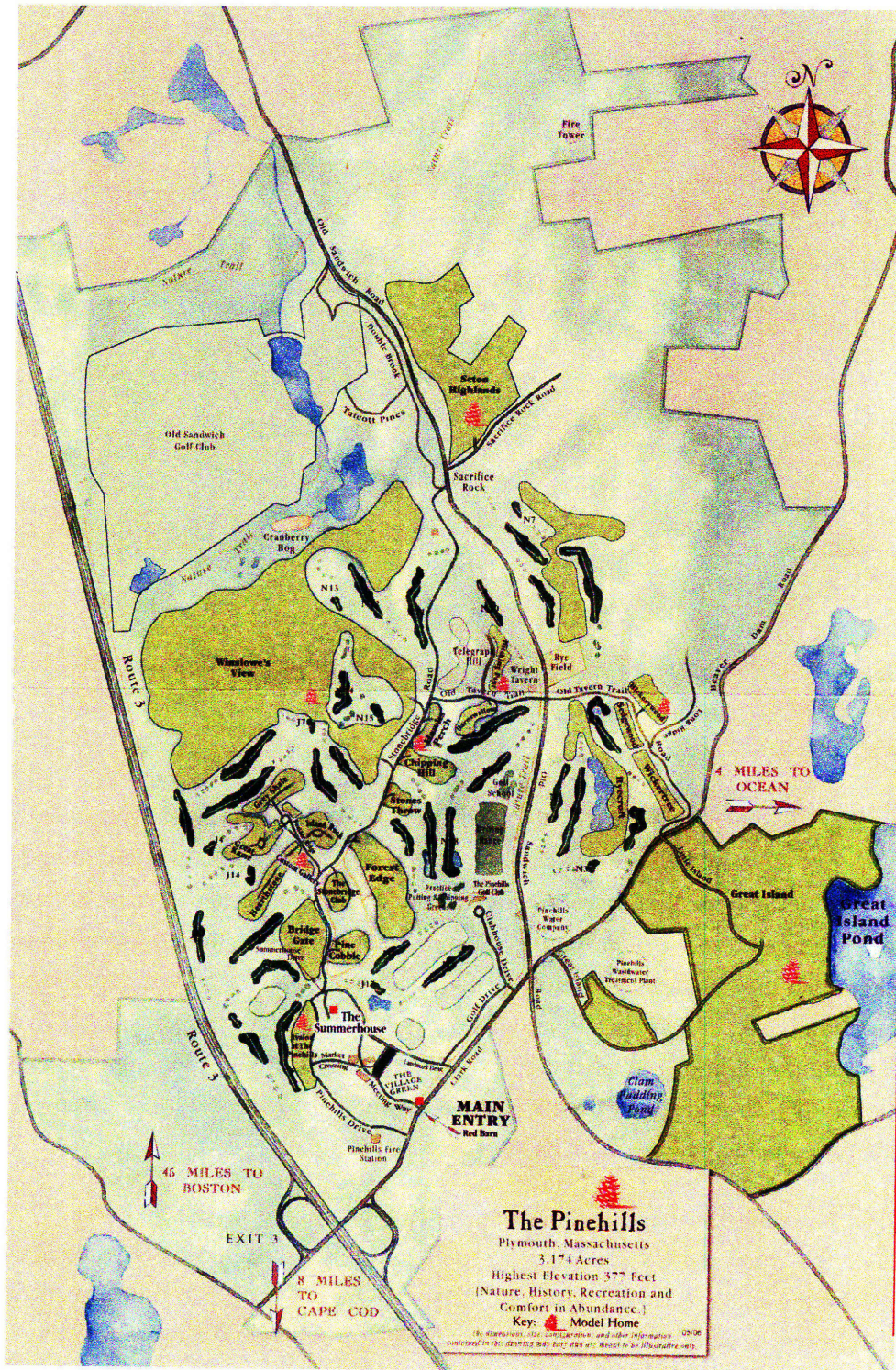


Figure 3-5. A residential street in The Pinehills.
Seclusion from the trees and contours almost conceals the two houses on the left and right side of the road. Photo by Connie Chung.



fits within a certain group may lead to easier socializing. In day to day activities in the neighborhood, age segregation and physical disconnection makes it unlikely that a stranger will be encountered.

Communality. The neighborhoods have formal and informal communality, generated by the programs of events and the presence of clubhouses. At a basic level these influence travel and local activity-making because they provide a reason to leave one's home which would otherwise not be so easily available. The immediacy of events and group meetings within a short distance makes them more likely to influence activity than a program further afield, and the similarity element ensures that everyone participating in the event will be, at minimum, a known quality and possibly already a friend. This might encourage participation in health and social events (conversely, if this cosiness does not appeal, one would probably not have moved to a RC in the first place).

Suitability. As home and neighborhoods specifically marketed at the boomer demographic, the communities are designed to be suitable for the needs of residents, and provide a lifestyle choice to aspire towards. This makes features like golf or a scenic pool appealing to boomers who imagine that they will walk frequently for exercise and pleasure, though it does not necessarily mean that more walking will take place. Either due to a genuine 'fit' between the neighborhood and the desires of the residents, or as a

result of induced behavior, the features may support a more active lifestyle both within the home and outside it.

Walkability. Through deliberate design features, and as a result of other elements of the neighborhood such as social cohesion, the neighborhoods may be more supportive of walking than a typical subdivision. Walking is easier not just because trails and sidewalks are provided, but also because the community layout is often compact and has no through traffic.

Despite these differences from traditional suburbs, these developments still share many similarities with their suburban kin: lack of connectivity to other neighborhood; limited or no retail within the development; dispersed employment and services in the vicinities, well beyond walking distance; and limited or entirely absent public transportation. In terms of possible effects on activity and travel behavior, we would expect to see any variations at the local level, because it is at the local level that physical and community differences are found.

4 Aging, travel and the built environment

This chapter summarizes previous studies of the built environment and travel behavior, self-selection, older adult travel, and the role of neighborhoods on trip making and local activity.

Our individual travel behavior is influenced by the built environment around us through the opportunities and infrastructure it presents for travel, though identifying causality is complicated. For boomers in RCs, there may be factors in their residential location that are primary determinants of daily travel, but there may be stronger or counteracting factors, such as employment, income or personal preferences. To understand the context for studying the effect of residential location on travel for this age cohort, we need to understand: the overall theoretical framework for understanding the potential influence of the physical environment on travel behavior; examples of similar investigations; the patterns of older adult travel and the role of neighborhood design.

I discuss previous examples of travel behavior research. They identify: a highly auto-dependent aging population with few travel alternatives; difficulties in measuring the contributing factors in the built environment; positive associations between walkable neighborhoods and activity levels; positive associations between activity and health; and complex and not fully understood travel patterns for older adults that change with age. Previous studies identify the empirical difficulty in identifying influences of the physical environment on travel behavior, in part due to self selection: because residents with preferences for certain travel outcomes choose neighborhoods that support their desires, identifying causality is difficult. Controlling for endogeneity in the survey design and model estimation is essential to provide valid analysis of the role of neighborhoods on travel outcomes.

4.1 Travel behavior and the built environment

Much interest in the last few decades of travel research has focused on the purported beneficial effects of New Urbanist developments on travel behavior. Through ideas of ‘neo-traditional development’, New Urbanist designers posit that more walking and local activity can be supported by building dense neighborhoods with a mix of land uses, as a positive alternative to sprawl or other models of urban development. According to proponents, living and working in a walkable and transit-oriented neighborhood will support more positive travel outcomes, and further benefits including renewed vitality of urban areas, countryside preservation, and reduced impact on the environment at local and global scales (for example, see Calthorpe and Fulton (2001)). Personal experience tends to suggest that denser areas are more walkable and require less driving, and transit is more often found in denser cities. And in fact, some studies support personal experience, such as Newman and Kenworthy’s (1989) well known study which apparently find an inverse association between gasoline consumption and city density. The increased complexity of physical, social and economic factors influencing travel in urban areas makes it hard to clearly isolate the effect of density and other built environment aspects, and harder still to establish empirical findings that can be used to inform policy towards better cities. Even simple questions do not have clear answers, for example - do more walkable neighborhoods actually result in fewer auto trips? Boarnet and Crane (2001), in an analysis of the effects of new urban designs on travel behavior, summarize a number of studies (see Table 4.1). Their conclusions provide an indication of the theoretical uncertainty with respect to the influence of the built environment and travel behavior. The challenge of understanding boomer travel behavior is typical of the type of research undertaken in this area.

Table 4.1. Travel and the built environment: uncertain outcomes.
Source: Derived from Boarnet and Crane 2001.

	Design element	
	Grid/street density	Land use mixing/intensity
Car trips	Increase	Increase or decrease†
Vehicle Miles Travelled	Increase or decrease‡	Increase or decrease
Mode share by car	Increase or Decrease	Increase or decrease

† depends on trip purpose, length and induced congestion.

‡ depends on sensitivity to trip length by trips of each mode.

A key part of the uncertainty identified by Boarnet and Crane (2001) comes from the role of personal preferences in residential selection. In a process termed self-selection, people tend to live in locations that support their travel preferences, such as choosing a dense

urban neighborhood if one prefers to walk and ride transit. Drawing conclusions without controlling for preferences risks giving undue weight to the role of neighborhood characteristics, for example overstating the effect of density on reducing auto trips. In doing so, the effectiveness of a policy response such as increasing density to reduce auto trips might be over-estimated. Self-selection is present in estimations of travel models as endogeneity, meaning that an explanatory variable is correlated with uncaptured information in the error term (Handy et al. 2006). The endogenous explanatory variable is often neighborhood choice, which is correlated with unobserved attitudes about travel. Finding effective strategies to account for self-selection through survey design and endogeneity in model estimation is a common feature in many of the studies described in this section, and a key concern for assessments of the role of residential location on boomers' travel behavior.

A simple, tractable approach for investigating the built environment and travel behavior is to consider the three components that make up the built environment: urban design is the physical layout of the city, land uses are the various activities that take place within the city, and transportation infrastructure is what people use to move between the activities. Studying the interaction of these three elements provides indications about factors in generating travel activity (Handy et al. 2002). Studies can be *aggregate*, taking relevant behavioral measures at the zonal level, for example using census geographic units such as the tract; or *disaggregate*, comparing individuals or households. *Cross sectional* studies compare data at either level from multiple locations to identify the factors associated with certain travel outcomes, through an evaluation of differences in travel behavior and key factors while holding other relevant factors constant. In most cases, the element of interest is the trip - travel from one location to another for some purpose.

Generalizing from a range of studies, Ewing and Cervero (2001) calculated elasticities for key travel behavior outcomes with respect to built environment factors. Reviewing the list of studies provides a summary of identified factors and their likely effect on several travel indicators: trip frequency, trip length, mode choice, VMT or some similar vehicle-person-distance measure. The authors note that comparing 50 independently designed and authored studies has some limitations, but they provide some general indications in four categories. I summarize their findings in each category below: neighborhood type, land use, street networks and urban design.

Looking at studies comparing **neighborhood type** between two locations, typically a conventional suburban neighborhood with a newer neo-traditional layout, or an older region with a more recent activity center, Ewing and Cervero suggest:

- Trips are shorter in areas with traditional urban form.

- Walking is more likely in traditional neighborhoods.
- The rate of trip making is not affected by neighborhood type. An increase in local trips may be a substitute for regional activity, but not the result of more frequent travel.

In neighborhood comparisons, differences in neighborhood age and household composition (e.g. household size) cause problems if not controlled for, and findings are often statistically insignificant.

From studies comparing different **land use** densities and diversity, Ewing and Cervero find:

- Mode choice is most affected by land use. Density of attractions indicates greater transit use, while walking is more affected by the mix of available destinations.
- Social and demographic factors have a bigger influence on the frequency of travel than land use.
- Total household travel is affected more by regional than local accessibility.
- Trips are shorter in locations with more accessible uses.

Ewing and Cervero find inconclusive results from studies comparing different **street networks**, possibly because benefits to pedestrians are also experienced by vehicles - for example, a grid with short streets and lots of intersections is good for drivers as well as pedestrians.

Finally, Ewing and Cervero also find inconclusive results with respect to **urban design**. Compound measures and compound effects make it difficult to isolate individual factors. Difficulties in measuring design elements also create weak indicators with limited power of interpretation, for example the authors highlight ‘ease of crossing street’ as a problematic indicator. Measuring ‘walkability’ tend to be self-fulfilling – areas with high levels of walking are generally ‘walkable’ – but the resulting indices are low on explanatory power or applicable lessons.

4.1.1 Four examples of comparable studies

From the diversity of previous investigations in this area, I present here four which provide examples of investigations into neighborhood design, walking and local activity, with implications for the opportunities for investigating boomer neighborhood travel. The

focus here is on the approach and outcome of the studies, Chapter 5 provides more information about my methodology.

Rodriguez et al. (2005) investigate the role of New Urbanist neighborhoods on walking - given that they are increasingly widespread as a neighborhood type, do the supposed benefits of these communities lead to health-inducing local activity? The authors studied two neighborhoods in North Carolina, with many characteristics common to both: regional location, freeway access, property values and age. Differences include: walking trails, sidewalks, local attractions, lot sizes and household density. Drawing from an activity survey they implemented, the authors find that the New Urbanist community has much more walking - 2.4 times higher trip rates, mostly for utilitarian trips, and much more time spent walking - 40-55 minutes more. Overall, they find no difference in activity between residents in the two communities, and no differences in moderate or intense exercise.

The study did not control for self-selection. Preferring to walk, residents might deliberately choose to live in the community that supports walking and local trips on foot, and so walking trips may not result from the influence of the built environment. For age-restricted neighborhoods, this is likely to be a key issue: as neighborhoods with specific requirements of its residents and features designed to entice a particular demographic, it is likely that the people who relocate there have a set of attitudes and preferences that may lead to certain travel outcomes. Despite not controlling for self-selection, the study indicates some other interesting and relevant outcomes: substitution appears to be occurring for walk trips, since overall levels of activity are the same between both types of community. The lack of difference in more intense exercise levels suggest that a walkable location may not lead to being healthier or more active beyond walking. Finally, the authors note that walking networks and street network characteristics are often not found to be effective indicators of walking activity in other studies.

Assessing the travel-related benefits of New Urbanism motivates a similar investigation by Cervero and Radisch (1996). The authors compare a compact, mixed use traditional early C20 neighborhood fitting the New Urbanist model in the San Francisco/Oakland region with a more suburban location nearby. Comparable characteristics between neighborhoods include: distance to the CBD, local transit accessibility to the rail transit system BART, comparable incomes. Two travel diaries were distributed to 4,000 household each, one for work trips and one for non-work. Overall trip rates are the same between neighborhoods, with around 10% more walking and biking in the compact neighborhood substituting for some drive trips. Discretionary travel seems to be more influenced than commuting.

The study reveals two issues with direct relevance to the study of boomers travel and efforts to capture neighborhood effect differences. Firstly, single day travel diaries mean that weekly or occasional trips (e.g. to the regional mall) are probably under-represented, whereas commuting is well captured. The authors suggest longer diary periods. Secondly, accounting for differences in built environment factors is also problematic: density is highly correlated with all other variables (block length, 4-way intersections, tree density, etc) and so the built environment is represented by a single variable in the model that is the same for all residents in the same areal unit, whereas personal and household characteristics are represented by multiple non-correlated measures. The study uses a single dummy to differentiate the two neighborhoods rather than try to capture the effects of individual measures of the built environment. The authors suggest that collecting a large number of diaries from many different locations could avoid some of these problems - 30 diaries from each of 50 tracts, along with innovation in ways to measure the physical configuration of neighborhoods. Despite these issues and once more the same problem of self-selection, the finding relating to discretionary travel is relevant for boomers, particularly if large cohorts of retired people reside in RCs. Travel substitution again seems to occur between local and regional travel.

Khattak and Rodriguez (2005) tackle the issues of self-selection and trip substitution in a comparative study of a neo-traditional development and typical suburb in North Carolina. The authors explore the question of how much substitution of regional and motorized travel by local walking is taking place, and whether it results from self-selection sorting residents into neighborhoods that support their existing travel expectations? Three hundred and ten households with similar regional characteristics completed travel diaries, and after attempting to control for self-selection using a model with Instrumental Variables¹, the authors find that the residents of the neo-traditional neighborhood make 22% fewer vehicle trips and 23% fewer trips outside the neighborhood, compared to the other neighborhood. Walking is more common and overall trip length is 11 miles shorter.

For RCs, Khattak and Rodriguez indicate that a more walkable neighborhood can capture travel that would otherwise take place at the regional scale. However, unlike boomers in suburban Boston, the neo-traditional neighborhood residents were able to walk to local stores and services, so there is something locally to attract trips, as well as a physical environment that is supportive of travel by foot. Evidence that walk trips are substituting for driving is also a positive indication for older adult travel beyond the boomer demographic, because it would allow sustained activity with increasing age, as walking takes over when driving becomes less desirable.

¹Instrumental Variables are discussed further on page 61

Handy et al. (2006) attempt to differentiate between utilitarian walking and strolling, in a study using surveys of walking behavior in six neighborhoods in Austin, Texas, in order to investigate how neighborhood and destination characteristics influence different travel outcomes, with controls for self-selection. All the neighborhoods had retail within walking distance, but differed in sidewalk availability and the urban design of the activity center. The results suggest that full time workers are less likely to walk, older people slightly more likely to walk and likely to stroll. Characteristics of the neighborhood influence strolling, while the retail and commercial areas influence shopping trips on foot and other functional walking.

The difference between types of walking is relevant to local activity of boomers, especially the role of the neighborhood in determining strolling and leisure walking. The authors point out that in some cases walking does not fit into the typical derived demand model for transport because people may walk for pleasure and without reaching a destination.

4.2 Aging and travel behavior

I now review research into the travel behavior of older adults. Baby boomers are generally not yet considered 'aged' in their travel behavior, and literature on this topic makes a distinction between the older old, aged over 75 years, who may have increasingly complicated health-associated issues with travel, compared to the younger old, who are post-retirement but still highly active (Alsnih and Hensher 2003). Although the ultimate focus of this thesis is the younger old, placing them in the context of the full spectrum of aging will be informative. Three areas are summarized: older adults and driving, trip making and local activity such as walking in neighborhoods, and studies that specifically investigate the role of the built environment on older adult travel.

4.2.1 Older adults and driving

Auto use by older adults is very high: 92% of trips made by American adults aged 65-84 are in a private vehicle (Rosenbloom 2001). Trip rates for older adults are increasing compared to previous generations, and younger adults entering their senior years have expectations to sustain current rates of automobility. And with good reason: 56% of older Americans live in suburbs, with only 21% in center cities, and suburban travel is almost entirely made in private vehicles (Rosenbloom 2003), as Table 4.2 on the following page shows. Nonetheless, driving patterns change with increasing years. Immediately post-retirement, trip purposes change, and the distribution of trips over the day changes,

with the work commute no longer dominant. Later in life, older drivers increasingly avoid driving at night or during the rush hour (Straight 1997).

Table 4.2. Mode share of older adults in the US, indicating a very small non-auto mode share in suburban areas.

Source: NHTS 1995, summarized in Cobb and Coughlin (1999).

Mode	Urban %	Suburban %	Rural %
Auto	77.3	93.7	94.8
– driver	54.9	71.7	68.1
– passenger	22.4	22.0	26.7
Public transportation	8.5	0.9	0.3
Walking or cycling	13.3	4.6	4.6
Other	0.9	0.9	0.3

Older people view driving as integral to maintaining quality of life, and consider negatively the prospects of driving cessation (D'Ambrosio et al. 2007). Less driving leads to fewer social interactions and withdrawal from clubs and other out of home engagements (Harrison and Ragland 2003), which has implications for community development that might offer these features without requiring a vehicle trip. Few older adults see public transport or any other options as viable alternatives to driving, and once driving stops there is an association with increased depression (Neal et al. 2008) and a reduction in all forms of mobility and activity (Whelan et al. 2006). Neal et al. (2006) suggest that older people do not use transit except in denser urban areas (presumably where it is available), but even in these locations use it much less than younger age groups. Focus groups with the older elderly indicate that strong preferences for private vehicle use and reservations about alternatives continue into later life (Coughlin 2001). With increasing years, the social aspects of travel become more important in decision making, which is relevant for neighborhoods with clusters of older people, and suggests again that discretionary non-work trip making may not be fully explained by traditional demand models.

Although driving cessation is associated with a downturn in quality of life, large numbers of older adults do not drive and are dependent on others for rides. These older adults would otherwise be unable to travel by private auto, and possibly be unable to travel at all in areas with poor transit service. From analysis of the NHTS, Bailey (2004) finds 21% of older adults do not drive. Half of non-drivers stay at home on any given day because of a self-identified lack of transport options (this could also be due to ill-health or low income, though the author does not suggest this). For driving and non-driving suburban older adults alike, the attractiveness and availability of public transportation are limited. Focus group participants were clear in their dislike for senior shuttle services, and

regardless of image problems the limited service offered by public transport does not make it a direct substitute for auto travel.

An alternative to public transportation or private vehicle use is a paratransit service. Bittner et al. (2000) review alternative transport options such as community-run shuttles and public-private partnerships. These combine innovations in service provision and less stigmatized transport offerings such as a car fleet. For the suburban boomer context, such alternatives could be effective at bridging the gap between private autos and public transport.

4.2.2 Older adults and walking

Compared to other developed countries, older Americans walk very little: only 6% of those over 65 years make regular trips on foot. In comparison, 39% of Germans aged 65-75 walk frequently and the proportion increases with age, with 48% of those older than 75 years still active on foot (Pucher and Dijkstra 2003). This lack of walking is unfortunate because walking helps to reduce obesity and is easy to incorporate into daily routines, whether for exercise or just strolling (Cavill 2001). On the basis of obesity reduction alone, finding an association between increased walking with RCs would be worthwhile: nearly a quarter of leading edge boomers are obese ² (Mokdad et al. 2000).

Older adults' local activity and short trip making follows the same pattern as most adult travel: denser areas and diversity of land use are associated with more walking. Saelens et al. (2003) study 107 adults, using accelerometers, and find more activity in locations with more density and attractions. Clarke and George (2005) in a large study of 4,100 seniors found that independence in activities and local mobility were both higher in areas with density and concentrations of employment. In a cohort study from Washington of 936 seniors, Berke et al. (2007) found more walking in denser neighborhoods and those with grocery stores nearby. Bailey (2004) analyzes senior travel in the 2001 NHTS, finding non-driving seniors in low-density areas are more likely to stay at home, with only 1 in 14 walking in rural areas compared to 1 in 3 in cities. However, self selection is again important – in the Berke study, obesity was not decreased by walkable neighborhoods, which suggests that those who walked and were healthy were predisposed towards walking and selected walkable neighborhoods to fulfill this interest, while their obese neighbors moved for other reasons, and were not motivated to walk by the density or nearby stores. Among a small sample of older elderly in their 70s ($n=174$) in several urban and suburban locations in Pennsylvania, pedometer readings were higher in areas with a nearby park or walking trails, or with nearby department stores, perhaps serving as a proxy for density

²In 1999, 24.2% of 50-59 year olds were obese, up from 23.8% one year earlier. For ages 60-69, the rate was 22.3%, up from 22.1%. All indications suggest that the rate will have risen further since.

(King et al. 2003). Many other types of land use were not associated with longer walk distance, including grocery stores and post offices, but the study allowed respondents to define what they considered 'within walking distance', which may introduce some methodological issues. A study within the same age range found that 74% of residents in large CCRCs walk for recreation, with some association between walk path quality and likelihood of walking (Joseph and Zimring 2007). Thorpe et al. (2006) study dog owners as part of a cross-sectional and longitudinal cohort study, to explore links between dog ownership and maintained mobility. They find dog owners more likely to walk at least 150 meters in a week, but with mobility declining at the same rate as people without dogs. Regular walkers had similar health status as dog owners, who tended to walk their dogs surprisingly infrequently - only 36% exercised their pet more than 3 times per week.

Some evidence suggests that walkable neighborhoods have positive social outcomes for older adults. Using the same Washington cohort, Berke et al. (2007) find depression in older men³ is negatively associated with a more walkable suburban neighborhood, possibly as proxy for a variety of sociability benefits that accompany a walkable suburb. Positive neighborhood effects like meeting neighbors and chatting with passers-by are more likely if there are sidewalks and homes are close together, and these social benefits in turn reduce depression. Looking more generally at sociability across age groups, Leyden (2003) in a study of 279 households in Galway, Ireland, finds people in traditional neighborhoods know more neighbors. Social capital seems to be higher too, with walkable locations associated with being more socially-minded and politically-engaged. Within gated communities, social interaction may be no higher than elsewhere: Blandy et al. (2003) find broad agreement from eight studies that use a wide range of methods - interaction is low within gated communities and lower in some cases than in adjacent neighborhoods. However, RCs in this thesis are not typical of those reviewed by Blandy et al., which are restricted by walls but open to all ages, are more urban and home to younger, more transient residents.

These studies focus on explaining influences on existing behavior. In terms of changes to increase local activity, some simple features might be enough to increase walking by older adults. An AARP survey of 87 seniors suggests that 32% would walk more frequently if benches were available along the route, 24% if a sidewalk was provided (Straight 1997). In the focus groups with Boston metro boomers, participants mentioned that design features such as walking trails make an area better for local strolling (Zegras et al. 2008), though we do not know if people using the trails became more likely to walk with these facilities nearby. Focus group participants living nearby in TNs indicated that they traveled to the RC in order to walk the trails.

³The sample of 740 seniors did not exhibit the same benefit for women, which the authors attribute to a variety of medical treatment and self-reporting reasons.

4.2.3 Older adults and neighborhood travel

Few studies focus specifically on boomers and the interaction between residential location and travel outcomes. Goulias (2007) use the longitudinal Puget Sound panel data to highlight the complex travel behavior of the empty-nester demographic as it enters retirement, suggesting that moving house and family composition are responsible for increases and decreases in trip making.

At the metro area scale, studies focus on auto and transit use rather than walking, and tend to look at all older adults. Schmöcker et al. (2005) find that increasing age is associated with lower trip rates for older adults in London, though the period after retirement sees an increase in recreational trips. Trip chaining is more common in locations further out from the center, presumably in response to lower densities and a greater spread of destinations, though an inner/outer binary variable is the only measure of spatial characteristics considered in the analysis. Paez et al. (2007) studies older adults in the Toronto region using a travel survey of 16,190 adults, and finds decreasing trip rates when compared to younger adults, but in a non-homogenous way and with complicated spatial effects. Dividing the same region into four density classes (high/low retail, high/low residential), Mercado and Páez (2007) found an association between shorter vehicle trips and higher densities for private vehicle drivers but not bus users. Looking at the suburban travel of 105 seniors in Manitoba, Canada, Smith and Sylvestre (2001) suggest that availability of transport options is associated with trip frequency for older adults. Using population density and income data at the census block level, Kim and Ulfarsson (2004) find that density is associated with reduced propensity to drive, as is the availability of public transportation. They also found that an area's longer-term residents are more likely to ride-share with neighbors. In this instance, duration of residence could be acting as a proxy for sociability and friendship with neighbors, so there are interesting implications for the ability of RCs to generate a rapid communality between residents.

Very few studies examine restricted residential communities and travel behavior. In a wide-ranging review of all aspects of all types of gated communities more generally (i.e. not just age-restricted), Blandy et al. (2003) only identify one travel study, which looks at a gated and open neighborhood in Brisbane (Burke and Sebaly 2001). That study found more street activity outside the gated area, but no wider implications for RCs can be drawn since the communities were not age-specific nor suburban. An estimate of traffic production for a RC in Virginia was calculated through an observational study of vehicles exiting from a 400-household neighborhood. The trip rate was estimated at 0.18 vehicles per household during the AM peak and 0.33 during the PM, which is similar to the ITE standard for a senior housing complex with nursing facilities (Flynn and Boenau 2007). These figures tell us little about the detailed travel behavior of residents, or internal travel

within the development or not by vehicle. Although qualitative, the focus groups with Boston boomers asked a range of questions about trip making and the role of community. Despite their limitations, the focus groups revealed that RC residents do seem to be more social, more inclined to ride-share and more locally active, though in general participants from both neighborhood types reported high levels of local walking and neighborliness and a high level of auto-dependence (Zegras et al. 2008).

4.3 Comments

Suburban older adults are highly auto-dependent and unwilling to use public transport, if it is available. Walking and local activity are associated with good health and aging, but mostly take place in denser areas with destinations to reach on foot.

For RCs, this presents a challenge: the setting for these developments is extremely suburban, with few local attractions, if any, within walking distance. This suggests that reasons for walking will have to come from the development itself, rather than the context. No previous studies into RCs or suburban walking outcomes away from local centers can provide precedents. If these locations are associated with higher levels of local activity, the reasons are less likely to be the ones found in previous studies, such as retail, density, street network characteristics. Instead, factors like the social network, walking paths, and a local clubhouse may be important.

5 Methodology

This chapter sets out the study methodology. I identify local trip making as the outcome of interest, through a quasi-experimental cross-sectional comparison between RCs and TNs. I discuss the problems of sample selection and endogeneity biases and some possible approaches to minimize them. The survey methodology and built environment characteristics are also described.

5.1 Experimental design

To recap the objective of this thesis: the characteristics of age-restricted neighborhoods are hypothesized to affect the local travel behavior of residents. Through comparison of a restricted neighborhood with adjacent typical neighborhoods, it should be possible to measure any difference in local travel, and if there is a difference, demonstrate some causal basis for the physical or organization structure of the neighborhood to affect travel outcomes.

A defensible analysis of causal effects requires a strong finding of association, so that we can be certain in identifying features of the age-restricted community as associated with travel outcomes rather than some other unmeasured aspect of the sampled population. Some form of multi-variate analysis can estimate the influence of different factors, including any effect of neighborhood type on travel outcomes with control for other factors. The most suitable model specification is determined by the outcome of interest. In order to attribute behavioral outcomes to the correct cause, model estimation needs to minimize two forms of bias: sample selection and endogeneity. Sample selection bias occurs when a non-random sample is truncated to exclude samples with certain characteristics, with negative consequences for any estimation based on it. Endogeneity bias is the consequence of undetected associations between the model outcome, included and omitted variables. In this context, it occurs as self-selection into a neighborhood based on desired travel outcomes. Both forms of bias are examined in detail below. But first, I will specify the outcome of interest, sampling methodology and model selection.

5.1.1 Local activity as the outcome of interest

The review of evidence about travel behavior and the built environment suggests that features within the restricted neighborhoods such as walking trails are positively associated with more local activity. Qualitative data from focus groups suggests that residents in RCs appear to have similar travel patterns as TNs in the same region, but may differ in local activity with residents strolling in the neighborhood and being more socially connected to neighbors. A clubhouse within the neighborhood or central mail pickups may also be destinations for local trips. Some of these trips are discretionary, and so are not constrained by other factors that increases the complexity required to model them (Zegras 2005). Local effects for discretionary travel were also more apparent in the study by Cervero and Radisch (1996). If these local trips can substitute for external trips made for other purposes, we would expect lower trip rates outside the neighborhood, and the overall distance travelled each week might also be lower. Alternatively, if some of the additional local trips generated by the RC are made by vehicle rather than on foot, the overall rate of driving could be higher. These effects and the likely direction of outcome are summarized in Table 5.1, with the two research questions in bold.

Table 5.1. Hypothesized effects of restricted neighborhoods on travel

Factor	Influence of RN features	Possible metrics	Possible outcome
Walk trips	Neighborhood design conducive to walking	Distance or number of trips made	RNs have more walking?
Neighborliness	Community organization, physical characteristics bring neighbors together	Social contact with neighbors	RN more neighborly?
Regional vehicle trips	Regional attractions beyond walking distance	Distance or number of trips made	No difference between neighborhood types?
Local vehicle trips	Increased driving to neighborhood attractions, mailbox, etc.	Distance or number of trips made	Higher in RN?
VMT	Less regional driving, more local	Miles traveled by vehicle	Increased in RN?
GHG emissions	Depends on VMT, greater on short trips	Tailpipe emissions, fuel consumption	Increased in RN?
Active aging	Health outcomes better for mobile, social older adults	Health; happiness; mobility	RN better for active aging?

Since RCs are hypothesized to influence local trip making, the travel outcomes of interest in this thesis are trips on foot within the immediate neighborhood of respondents, and trips to visit neighbors. Both are measured using retrospective travel diary questions about travel in the last week. For both outcomes, a simple binary measure is used where the outcome is making or not making any trips. For local walking, this means making one or more trips on foot or bicycle within the neighborhood (outcome 1), or not making any trips (outcome 0). For visiting neighbors, the dichotomy is one or more visits (outcome 1) or no visits (outcome 0). These simple measures were chosen as manageable initial explorations of the data. More complex travel patterns such as total trips made and distances traveled are reviewed in analysis of the survey results (Chapter 7 on page 105), but modeling with these data is left to future research.

5.1.2 Quasi-experimental sampling approach

Using the examples of previous travel behavior studies as a guide, the ideal experimental design would be a disaggregate longitudinal study. A theoretically ideal approach would take a random selection of boomers living in a variety of generally suburban locations, and randomly assign them to either live in a RC or an TN, with both neighborhoods completely identical in regional features such as retail accessibility, distance to the nearest highway exit, etc. Demographic elements would also be held constant, including household income, retirement status, neighborhood age, etc. After a period of settling in, measurements of travel behavior would be obtained through a reliable and transparent process that allows the researcher to be confident that all data on the experimental subjects reflects their actual behavior. Randomly assigning residents to locations would address the self-selection issue so any differences in attitudes or preferences between different groups would be cancelled out. Any quantifiable differences in travel outcomes would be defensibly attributable to residential location, and it would be reasonable to suggest that the implications from the study can be applied to any demographically similar group of boomers in a comparable regional setting. The questions about built environment influences on local activity can be answered with confidence.

Such a hypothetical experimental design may not be possible in practice but it indicates some of the important factors that must be considered when investigating the research questions. Since a random sample cannot be taken, the design is considered quasi-experimental, and since factors such as regional accessibility cannot be held constant, the selection of neighborhoods and sample locations can only attempt to minimize these differences. Some factors such as income can be included in the modeling process as controls. Instead of putting people into neighborhoods and measuring their response, the study design can account for the influence of neighborhood choice as part of

the analysis of travel outcomes by considering attitudes towards location and travel. A partial compromise (not attempted here) would be to only target recent movers, so that information on previous and current neighborhoods can be compared and inferences drawn about travel behavior.

Absent the possibility to carry out a truly randomized experiment, the most appropriate methodology for this study is a disaggregate cross-sectional comparison, using household and travel diaries to gather information on travel outcomes, and measurements of the built environment and demographic characteristics to control for regional aspects and to measure local conditions within neighborhoods. Other disaggregate sources on travel behavior for the study area such as the NHTS and the 1991 Boston metro area travel survey do not provide sufficient information about attitudes or residential location. For example, most available data sources do not examine local trip making activity, which is hypothesized to be the most detectable difference between neighborhood types. In addition, the available data do not provide enough geographic specificity about household locations to allow development of adequate measures of the built environment, such that the local differences in built form can be measured.

5.1.3 Model specification

A variety of models are used in travel behavior analysis - a small selection is shown in Table 5.2 on the next page. There are two parts to model selection: 1. **specification** – which variables are chosen, how they are measured and model choice; 2. **estimation** – how the model is calculated with the actual model type chosen (Boarnet and Crane 2001). The correct regression model to use is determined by what characteristics the dependent variable takes: dichotomous, discrete, count, or continuous.

For dichotomous variable (binary choice, such as making or not making a trip), a number of different models are available, the most common being *logit* and *probit*. The specific model depends, in rigor, on the assumption regarding the distribution of the error term. The model predicts the outcome of a binary variable by calculating the probability of a ‘success’. I use this model to estimate the take trip/don’t take trip models for local activity and neighbor visits.

Multinomial logits and probits are models that produce more than two discrete outcomes from a limited range of choices (Train 1986). In this context, either would be suitable for modeling mode choice although multinomial logit dominates current practice. *Ordered probits* are suitable for discrete data where there is an ordering, for example, trip making where the counts of trips is converted into an ordered group of categories (for example, never walk, walk infrequently, walk regularly).

Table 5.2. Some models used in travel studies

Study	Dependent type	Dependent details	Model
Noland et al. (2007)	Trip chaining	Stops on the chain, complex vs non-complex trips	Ordered probit
Giuliano (2008)	Trip distance	Total daily distance travelled	Ordinary Least Squares
Khattak and Rodriguez (2005)	Trip distance	Miles driven	Ordinary Least Squares
Schmöcker et al. (2005)	Trip distance	Distance traveled	Log linear
Zegras (2005)	Trip distance	Distance travelled by specific mode	Ordinary Least Squares
Giuliano (2008)	Trip making	Any trips vs no trips	Logit
Khattak and Rodriguez (2005)	Trip making	By auto, walk, external	Negative binomial
Giuliano (2008)	Mode choice	Transit user or not	Logit
Kim and Ulfarsson (2004)	Mode choice	Mode	Multi-Nominal logit
Zegras (2005)	Mode choice	Trip mode	Multi-nominal logit, nested logit
Paez et al. (2007)	Total trips	Trip rates for work; non-work; all trips	Ordered probit
Schmöcker et al. (2005)	Total trips	Total trips; shopping/work trips	Ordered probit
Smith and Sylvestre (2001)	Total trips	Trips per month	Ordinary Least Squares

Nested logits and probits are an extension of multinomial logit models, developed to model discrete choice in several dimensions, for example mode choice and frequency of travel (Ben-Akiva and Lerman 1985). The nested structure is also effective at dealing with endogeneity - I use a nested logit to explore whether self-selection is taking place.

Trip frequency is a categorical variable than can be modeled as a count. Count data can be modeled with a *Poisson* or *Negative Binomial Model* (NBM), as used by Khattak and Rodriguez (2005), with the correct model depending on the distribution of the error term. The Poisson model is considered more suitable when data are not over-dispersed, tested by checking for the variance to be close to the mean. With over-dispersed samples, the NBM is more suitable (Washington et al. 2004). Another count estimation is a *Zero Inflated Poisson* model, suitable for data where the zero state can come from two different situations: for the boomers study, this would qualify as choosing to not make any trips on the day of travel (for example, because the weather is poor) versus being someone who never walks locally (because they always drive or for some other reason). *Ordinary Least Squares* (OLS) regression is used on continuous data, and is unsuitable for counts because the distribution is not normal, and the values cannot go below zero or be non-integers. OLS intuitively also would not make sense because the distance in taking two trips instead of zero trips is not conceptually the same as the difference between four and six trips. I do not use any of models covered in this paragraph.

5.1.4 Bias in model estimation from sample selection and endogeneity

This study seeks to understand the causal effects of neighborhood type on travel outcomes. Demonstrating causality for travel behavior is non-trivial, as previous studies indicate. This study does not ultimately provide causal indications for travel behavior in the context of RCs, but though a methodology that supports causal inferences we can be more confident in the findings that emerge. In the following pages, I discuss two closely-related issues and some possible remedies.

Demonstrating causality has four requirements: association; time order; non-spuriousness and a causal mechanism (Cao et al. 2006). For example: do walking paths in a neighborhood increase distance walked by residents (association)? Do trips increase after the walking paths are built (time order)? Is another unobserved factor - maybe dog ownership - actually responsible change in walking (non-spuriousness)? Under what process does building more walking paths bring about a change in walking (causal mechanism)? Cao et al. note that many travel behavior studies only find association, yet even a weak association does not rule out causal effects, because strong forces could be acting in opposite directions, leaving a weak association. To find causation, we require a model estimation that controls for all four causal requirements.

Within the context of understanding how people in RCs travel and what motivates their activities, it doesn't matter if residents choose to live there for the features they offer. Knowing that residents of this type of neighborhood are more likely to be locally active or are able to live a healthy lifestyle with regular exercise would be a useful finding. Similarly, knowing that RCs produce a certain rate of vehicle trips would help towns be better informed when making decisions about building new restricted communities. To draw conclusions about RCs and travel outcomes, we need a model estimation methodology that provides strong support for causal statements through the construction of the model, controls for self-selection and other confounding factors. Without such controls, an observed travel outcome might be due to an unobserved attitude about travel, or some other factor, and the model specification might incorrectly assign the effect to an innocent or less-important factor. In the specific case of this thesis, without due care it will be invalid to suggest that travel behavior is associated with physical aspect of the RCs. The issue of self-selection may be even more relevant in this study than in examples outlined in the literature review, because the RCs are specifically marketed as a lifestyle choice. It is likely that residents do in some part display attitudinal preferences by locating there for features and the lifestyle on offer. Consequently, the experimental design needs to control for this influence.

Endogeneity bias

Previous studies indicate the importance of self-selection on travel outcomes, because study subjects may choose a neighborhood in order to fulfill certain latent travel desires, such as a preference for a walkable neighborhood, for example Handy et al. (2005). When measuring travel, the researcher can only measure walking and neighborhood type, but is unaware of individual attitudes towards travel and residential location. Certain neighborhoods might attract residents who want to fulfill desired travel outcomes, such as picking a neighborhood that supports walking. This relationship is not observed in a simple study, so the effect goes unmeasured. In formal terms, the connections between a subject's travel, location and attitudes are all examples of structure in data, both causal and direct, or otherwise confounded by other relationships Washington et al. (2004). One structural form is *endogeneity*, where variables within the model are correlated with other unobserved variables, leading to a model estimation that is incorrect, because explanatory variables have biased and inconsistent coefficients.

The hypothesized role of the built environment on travel behavior in this research can be expressed as: *Travel behavior = some function of regional accessibility, household demographics, and the effect of the restricted community, plus the influence of all other unobserved characteristics.*

Following the notation used by Cao et al. (2006), (Zegras 2005) and others,

$$TB = f(RA, HD, RC) + e$$

Endogeneity occurs when an explanatory variable, e.g. RC is correlated with e . In this state, the model violates one of the basic assumptions for regression modeling, that the regressors and error be uncorrelated. The resulting model estimations are biased (incorrect) and inconsistent (increasing sample sizes do not produce a more accurate estimate) (Upton and Cook 2002). Cao et al. (2006) identify two types of endogeneity bias that are specifically relevant to travel behavior: simultaneity bias and omitted variable bias.

Simultaneity bias occurs where an explanatory variable is also a function of the dependent. In seeking a simple explanation of travel behavior, we hope that residential location in a neighborhood type leads in one direction to some travel outcome. If simultaneity is occurring, residential location and travel behavior could be explanatory variables of each other. For example, Cao et al. (2006) suggest that income might influence travel outcomes, if lower income residents do not own a car, leading to a neighborhood choice determined by the need to use public transport. In this case, travel behavior and residential location are entwined and difficult to separate.

Omitted variable bias occurs where unobserved explanatory variables are correlated with the variables included in the model. In the context of boomer travel, personal attitudes might influence residential location and travel outcomes - the effect described as self-selection. Constructing a model without accounting for attitudes leaves the effect of attitudes in the error term (the unexplained influence of other unobserved characteristics), which produces a model with less explanatory power and incorrect assessments of the role of the built environment variables (Cao et al. 2006). Any conclusions drawn about the role of neighborhood in the model will be incorrect. Examples of this kind of self-selection are considered by Handy et al. (2006), who hypothesize that people with a propensity to walk choose a walkable neighborhood to live in, and Khattak and Rodriguez (2005), where preference for the benefits of a neo-traditional neighborhood might increase one's walking within it. In both these examples, considering the influence of individual attitudes separately in estimation of the model produces a better overall explanation of travel outcomes, either because it moves the influence of attitudes out of the error term and into a quantified model coefficient (statistical control), or because it leaves the attitudes within the error but removes endogeneity with the built environment variable (instrumental variables).

Sample selection bias

The second bias we wish to minimize comes from sample selection. Crown (1998) identifies the problem in its original formation, analysis of labor supply in the 1960s and 1970s. Using hours and wage data from samples drawn from the employed population, economists attempted to model labor supply. This sample omitted people who were not working for some reason, for example because the wages on offer were not high enough. By using only workers to estimate coefficients for the whole population, the sample was truncated and the observed effects biased by the omission of the unobserved non-workers.

Sample selection bias can occur whenever data are sampled, taking a similar form to omitted variable bias. Vella (1998) writes “The possibility of sample selection bias occurs whenever one examines a subsample and the unobservable factors determining inclusion in the subsample are correlated with the unobservables influencing the variable of primary interest” (p 129). Sample bias does not apply if all effects on the outcome of interest are accounted for through observed variables: the model estimation can simply include these explanatory variables alongside all others. But this requires the model specification to consider all possible influences, which is difficult in the context of quasi-experimental design. The risk of bias seems especially likely in this study given the various subsamples that can be hypothesized for boomers with preferences for activity, travel outcomes and different residential location types - residents of age-restricted neighborhoods form a subsample, and factors influencing the residential location choice could easily have an effect on travel behavior.

Facing the problem of sample selection bias, one might be tempted to evade the issues by qualifying the explanatory extent of the model. For example, in the context of boomer travel and neighborhood choice, any sample bias in the age-restricted neighborhoods could be described as non-generalizable beyond similar communities with similar age groups, due to limitations of the sample. Berk (1983) explains why this reasoning is incorrect: sample selection bias leads to reduced external validity for both the included and omitted samples. Even for the internal validity of the estimation with omitted samples, the estimates of coefficients will be incorrect and the effect of the explanatory variable under- or over-stated. Any systematic exclusion of omitted samples inadvertently introduces a bias in estimates that acts like an uncorrelated independent variable, in effect introducing an endogeneity bias into the model estimation.

Approaches to controlling for bias

In the context of this study and the chosen model estimation, both forms of bias are likely to be present and need to be controlled. Endogeneity bias will occur if unobserved

characteristics of the sample such as attitudes to travel have an influence on neighborhood choice and travel outcomes. Cao et al. (2006) identify 28 travel behavior studies where controls were used for endogenous attitudinal variables relating to travel or residential choice. The most obvious form of sample bias in this study has the same effect: by selecting into a particular neighborhood type, residents are forming a non-random subsample determined by attitudes. Other sample selection biases might occur, for example income or family structure, but these are observed through the survey instrument design and can be included as explanatory variables in the models. The influence of additional unanticipated unobserved effects is also possible, but probably less important than the clearly-understood problem of self-selection.

Controlling for attitudes towards residential location and travel outcomes should limit bias in the model and enable valid indications of causality. I describe five approaches identified by Cao et al. (2006): asking participants to assess the factors influencing their residential location; making attitudes an observed part of the model estimation, thus subject to statistical control; constructing instrumental variables; modeling selection independently from travel behavior; and joint estimation with a nested logit model. Other methods not reviewed here attempt to account for the inter-connected nature of attitudes, travel and residential location through longitudinal models and structural equation models. More complex models give better control for the four causal requirements, as shown in Table 5.4.

Table 5.4. Causal control in different models, based on summary table in Cao et al. (2006). In this study, I use statistical control, instrumental variables and nested logit models.

Approach	Association	Nonspuriousness	Time Precedence	Causal Mechanism
Statistical control	strong	strong	weak	yes
Instrumental variables models	strong	moderate	weak	yes
Sample selection models	strong	moderate	weak	yes
Joint simultaneous discrete choice models	strong	moderate	weak	yes
Nested logit models	strong	weak	weak	yes
Cross-sectional structural equation models	strong	strong	moderate	yes
Longitudinal models - single equation	strong	moderate	moderate	yes
Longitudinal models - structural equations	strong	very strong	very strong	yes

A qualitative approach to compensate for self-selection bias is to ask people why they chose to locate in their current neighborhood, for example in a focus group. Cao et al. (2006) suggest that this can be effective if the questioning is done right, and residents are

able to recall their motivations correctly. However, the results cannot easily be used in quantitative model estimations, so this technique cannot tell us how much the built environment affects travel behavior even when self-selection is better understood.

Statistical control counters the effect of endogeneity by using attitudes as variables in the estimation of travel outcomes. This assumes that the chosen attitudes are associated with travel behavior, and by not using them we have caused an omitted variable bias that their inclusion compensates for. In self-selection terms, the inclusion of attitudes as explanatory variables in the model estimation — $TB = f(RA, HD, RC, AT) + e$ — removes the effect of attitudes from the unexplained e and quantifies their influence. Cao et al. (2006) suggest that the change in the RC variable (representing the neighborhood type) after including attitudes will suggest how they are related: if RC becomes less significant (both through a reduction in its coefficient and actual significance), we could infer that it was previously representing some part of the attitudes now directly measured by the AT variable. The attitudes are acting in the model in a similar way to household size, income and other control variables. This approach also counters sample bias: Vella (1998) indicates that bias no longer occurs when the sample selection criteria are now included as observed explanatory variables. Cao et al. (2006) also describe a more complex method of control, using measures of dissonance between attitudes and location as an explanatory variable, rather than including attitudes directly. Both approaches to statistical control are limited by the effectiveness of measurements of attitudes: bad measures of attitudes cannot account for selection if they do not measure the attitudes leading residents to make their neighborhood choice.

The **instrumental variables** approach deals with an endogenous explanatory variable by replacing it with an exogenous variable, replacing something that correlates with the error term e by something that is uncorrelated. Winship and Morgan (1999) explain that for an endogenous explanatory variable, an instrument that explains assignment to the ‘problem’ variable and is also not correlated with e can be substituted. The instruments are one or more variables that are exogenous and thus not associated with error in the estimation, but are relevant in explaining the endogenous variable being replaced. The authors distinguish this method from statistical control: the instrumental variables should not be correlated with the error term, whereas in statistical control, the aim is to find control variables that will condition a variable to remove correlation with the error term.

Applications of instrumental variables model the built environment either as a continuous variable or a binary predictor of neighborhood choice. Greenwald and Boarnet (2001) instrument a variety of measures of the built environment including street grid density, in a study of non-work pedestrian trips in Portland, Oregon. They use non-travel related instruments from Census data, such as per capita income, percent of residents with college education levels, percent of residents identified as African American. The instruments are

directly used in the model, and are significant at the neighborhood scale in explaining walking trip rates. A more complex method is used by Khattak and Rodriguez (2005), to control for self selection into a neo-traditional neighborhood, where attitudes to travel are expected to correlate with residential choice. First, the built environment choice is modeled using exogenous instruments about residential location, with no travel outcome association. Then, the predicted built environment choice is used in a model estimating travel outcomes. Any influence of the modeled built environment variable on travel outcomes is uncorrelated to residential attitudes, which are entirely accounted for in the error term. To implement this, questions about attitudes to residential location and travel preferences were included in the survey instrument. Using a Likert scale, respondents scored 20 questions such as 'I enjoy a house close to the sidewalk so I can see and interact with my neighbors'. From the full array of responses, eight questions were selected that the authors considered expressions of attitudes unrelated to travel behavior but relevant for residential location, indicates a preference for or against traditional neighborhood development features, but not travel outcomes. For the question above, responding affirmatively (e.g. 'strongly agree') indicates a preference towards the neo-traditional development. The eight selected instruments are used to model location, using a binary logit model. The instrumented residential location was then used in models of trip making, where its effect is independent of attitudes relating to travel behavior, because it was entirely constructed with residential preference attitudes. Any measurable effect of household location on trip making can be attributed to some characteristic of the built environment rather than self-selection.

The use of attitudes as instrumental variables depends on the accuracy with which the study measured the attitudes, and how closely aligned responses are to the expectation of the researchers. If the questions asked have an element of travel implicit in the attitude, the instruments may not be exogenous. Some attitudes chosen by Khattak and Rodriguez (2005) are questioned by Cao et al. (2006), because the attitudes chosen are not inseparable from travel outcomes - for example, the preference to live near shops is probably connected to travel. This violates the requirement for exogeneity. The authors caution that the capture of built environment effects by the instrument may be imprecise, so subsequent insignificance of the built environment instrument cannot be attributed to a lack of influence. Bound et al. (1995) suggest that a weak instrument will produce estimates with large standard errors. Additionally, an instrument weakly only correlated with the endogenous variable and correlated with the original error term may produce more inconsistent estimates than the original non-instrumented biased model. Winship and Morgan (1999) suggest that a perfect instrument is difficult, because meeting the demands of exogeneity while also faithfully representing the original endogenous variable seems contradictory, even though it is possible.

The fourth approach to endogeneity is **sample selection**, also a simple control for sample bias, so potentially provides controls for both problems. Crown (1998) sets out the basic process: a sample is thought to be biased, with observed sample all members of one subset. A model estimating selection into the subset is estimated. From this model, a measure of the influence of unobserved variables is calculated, the non-selection hazard or Inverse Mill's Ratio (IMR) ¹. For each member of the sample, as the probability of being in the sample decreases, the value of the IMR increases. The calculated IMR is used in a second model, where it captures the effect of unobserved variables on the outcome, leaving the model with no bias from sample selection, assuming all error and other sources of bias are controlled for. The estimate of IMR serves a dual role, because its level of significance in the second stage model shows whether the construction was justified. This is more informative than controls for endogeneity, where influence has to be detected from change in the whole model. For example, Crown (1998) suggests the following approach to the labor supply example described on page 61: selection into the workforce is modeled with a probit model, and the IMR is calculated from this model. In the second stage, hours worked for workers only are modeled with the IMR included as an explanatory variable, where it represents unobserved factors in the decision to participate in the labor force. In the context of travel research, Cao et al. (2006) note that the sample selection approach seeks to explain all travel outcomes by initial selection into a residential location group, whereas instrumental variables consider the effect of the built environment alongside all other influences of travel behavior.

Although sample selection control with the IMR is more easily understood for situations where the unobserved group is absent and needs to be corrected for, the same method can be used when both groups are observed. In the case of residential location choice, both states of selection are observed. Cao et al. (2006) suggest that a different form of selection model is needed, called a regression model with endogenous switching. Selection for residential choice is modeled, then two separate models are estimated for travel outcomes. The authors do not identify any examples of successful use of this technique for travel behavior. Crown (1998) describes a switching model for analysis of moving in response to wage differences between states, but application of the specified model in the context of residential choice selection is unclear.

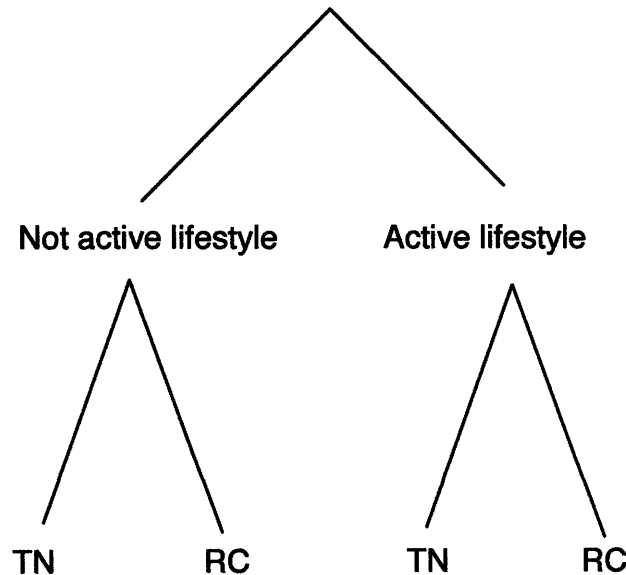
Joint discrete choice models control for self-selection by estimating the discrete outcomes of residential choice and travel behavior as a 'bundle', where the model evaluates the probability of a location and travel outcome jointly, or with one outcome conditional on the other (Cao et al. 2006). Nested logit models can be used to estimate this type of model. For example, the nesting of the lower choice (residential location) in

¹IMR is defined as the probability density function over the cumulative distribution function, see Wiggins (2005)

the model is conditional on the upper choice (travel behavior) as shown in Figure 5-1. Within a nest, the alternatives are closer than others in other nests, and may share some unobserved factors (Salon 2006). Different parts of the structure can share common observed and unobserved attributes, making the nesting structure more powerful than single models evaluated with MNL approaches (Ben-Akiva and Lerman 1985). In this context, the activity decision shares unobserved factors that are likely not relevant in the residential choice decision.

The model can either be estimated as two separate models, where conditionality is implied in the model structure, or in a single estimation where the utility is jointly assessed. I use the first approach. This type of model is effective at assessing endogeneity, because the relationship of one nest to the other indicates conditionality: by checking the logsum (also known as the inclusivity parameter), we can verify the validity of the model structure. The lower level logsum should have a parameter between 0 and 1 when included in the upper level estimation, to hold true to utility maximization theory (Zegras 2005). If the model is assessed and the coefficient of the logsum is greater than 1, the decision structure should be reversed. Applying this test will indicate if residents have observed travel behavior that is conditional on residential choice, or if the reverse is true.

Figure 5-1. Nests in a nested logit, showing travel/activity preferences, and residential choice as the lower nests. In this model, residential choice is conditional on activity preferences.



Cervero and Duncan (2002) use nested logits to examine self-selection of rail commuters living around San Francisco, to understand how development near stations could influence

mode choice for commuting. The self-selection issue in this study is the likelihood that rail users will choose to live closer to the station, so the effect of development near to stations may be overstated. In their model, the upper level predicts living close to a station, and the lower level predicts a rail commute. The model indicates the effect of self-selection: there seems to be an interdependence between living near commuter rail and rail commuting. Salon (2006) uses nested and non-nested models to model residential location, car ownership and mode choice in New York City, making the assumption that the first two are endogenous on the commute decision.

Methodology implications

There are some challenges with regard to methods of endogeneity control and the type of model estimations selected. Assumptions supporting the instrumental and sample selection approaches limit their use to certain model estimations. The outcomes of interest in this study are binary, making linear approaches unsuitable. This places restrictions on the types of model I can use. Three types of model are attempted: statistical control, instrumental variables, and a joint outcome approach with nested logits.

Statistical control can be used with any type of model estimation. I estimate a simple logistic model, using attitudes as statistical controls. This provides a base estimation to compare other models against. Before modeling any travel outcomes, I attempt to model residential choice solely with attitudes relating to transport. This is a simple attempt to assess the level of self-selection taking place.

Secondly, I use a two stage instrumented logistic model to estimate residential location and walking outcomes. The use of instrumental variables is generally limited to linear regression, for example in the explanations given by Winship and Morgan (1999). Foster (1997) suggests that typical 2SLS IV estimation cannot use a logistic model for the second stage, because the estimates will be inconsistent. Instead he uses Generalized Method of Moments, a more complex technique described in Greene (1997), to carry out instrumented variable estimation for the binary outcome of school drop out rates. Khattak and Rodriguez (2005) use instrumental variables with a logit model for the selection stage (neighborhood type) and a linear model (distance traveled) for the second stage. Compensating for simultaneity bias in a study of arrests and employment status, Borland and Hunter (2000) use a two-stage probit model. The first model estimates arrest in the previous five years, and the second model estimates employment status, using explanatory variables from the arrest estimation. Differences in assumptions about error term distribution prevent this approach from being extended from probits to logits.

I do not attempt a sample selection control model. Dubin and Rivers (1989) warn that sample selection methods using the IMR are not applicable to non-linear model estimation. The authors demonstrate the potential for logistic sample selection models in voting turnout, but for the unobserved bias form of selection rather than a model where both outcomes are considered. Stolzenberg and Relles (1997) caution that sample selection control methods can reduce the accuracy of estimation if incorrectly specified. I cannot identify relevant examples of selection control using endogenous switching regression, as proposed by Cao et al. (2006). Miranda and Rabe-Hesketh (2006) suggest that maximum likelihood estimation with advanced software is required to consider endogenous switching for non-linear outcomes, and demonstrate software to implement it, but the estimation process is beyond the scope of this research.

Joint estimation techniques such as nested logits are ideal for estimating binary outcomes, so the use of this approach has extensive precedence in travel research. Using a nested logit approach allows estimation of residential choice and mode choice to be made jointly.

5.1.5 Summary of study methodology

To summarize the study methodology:

1. Identify age-restricted neighborhoods in the Boston metro area, and nearby matching communities. Attempting to minimize regional differences between RC and TN in order to best measure the restricted/non-restricted difference.
2. Gather data on attitudes and travel behavior through a travel survey, including attitudinal questions about residential location.
3. Measure built environment characteristics for the sample locations, including built environment characteristics and demographics.
4. Estimate trip making, controlling for endogeneity with three model specifications: statistical control, an instrumental variable model with instrumented neighborhood choice, and nested logit.

The following two sections explain the methodology used for the building blocks of the model: survey data, including attitudes, personal and household demographics and trip making; and built environment measures, including census demographic data, street network measures, density, regional and local measures of accessibility.

5.2 Survey design and implementation

The survey instrument gathered information from leading edge boomers, with questions covering residential attitudes, regular travel habits and a trip diary for all travel on a specific day. Explorations of survey methods with commercial providers indicated that a mail survey could obtain a larger sample than telephone interviewing or doorstep interviews, and that in-house design and processing of the survey mailing within MIT would be most cost effective.

5.2.1 Targeting boomers for the survey

The survey population for the survey is households containing leading edge baby boomers in the Boston area. The sampling frame was a proprietary mailing list for direct marketing mailing, from which households were selected using multistage sampling: cluster sampling was undertaken to obtain the sample of boomers in RCs and TNs, then a census was conducted for all available addresses in restricted communities, and random sampling carried out for households in the non-restricted matching neighborhoods.

The age-restricted neighborhoods were identified first, using the following criteria: built out and occupied (i.e. not still under construction); entirely or mainly age-restricted; not a CCRC or offering any other nursing or medical treatments onsite. 20 locations meeting these criteria were selected from the longlist of 36 age-restricted communities gathered during the initial overview of 55+ housing (see page 31 for the methodology of this list). For each restricted community, a matching area was specified at the zip code level, as a crude approximation of similar regional accessibility and demographics. To obtain mailing addresses within the communities, the street level address and a radius (for RCs) and zip codes (for TNs) were provided to USAData, a commercial data vendor. Addresses were requested only for residents aged between 55 and 65 years. No other restrictions were specified. A total of 34,108 names and addresses were obtained.

Within the sampling frame of purchased addresses, 1,237 households of age-restricted communities were identified by matching street names of restricted streets against the purchased list. Street names in each community were obtained from online map websites and the matching process carried out in a custom Microsoft Access database. A further 5,763 households were randomly sampled from the database in areas that were not known to be age-restricted to give a total sample size of 7,000 households. Totals for each community are shown in Table 5.5. Geocoding tools within Arcmap GIS were used to locate each address at its approximate location on the street network, using year 2000 Census TIGER street network data. For locations where the street network data are not up to date, manual corrections were made.

Table 5.5. Age-restricted communities in the survey sample.
 Numbers in the first column refer to map locations, shown in Figure 3-1 on page 32.

Map	Community	Town	Units	Responses
1	Adams Farm	Shrewsbury	90	14
7	Crescent Gate	Sturbridge	69	3
8	Deerfield Estates	Hopkington	47	8
9	Dela Pond Village	Hingham	40	2
11	Eagle Ridge	Lancaster	44	12
14	Harmony Crossing	East Bridgewater	80	6
17	Leisurewoods	Taunton	222	29
20	Oak Point	Middleborough	1,150	96
21	Pinehills	Plymouth	900	92
22	Pond Meadow	Marshfield	66	6
23	Red Mill Village	Norton	156	7
25	Southport	Mashpee	480	37
29	The Village at Crane Meadow	Marlborough	91	8
30	The Village at Meadwood	Chelmsford	71	17
31	The Village at Orchard Meadow	Shrewsbury	70	17
32	The Village at Quail Run	Hudson	150	15
33	Vickery Hills	Southborough	40	11
34	Wellington Crossing	Waltham	118	4
	Total		4,277	1,216
	Response rate			28%

To provide anonymity for survey respondents, each household was assigned a random 4 digit identification code. The household location was attributed to the nearest centre point (centroid) of a statewide 250 x 250 meter grid cell. The code was printed on the outgoing envelope and matching reply envelope for each survey. Following creation of the mailing envelopes, the version of address list with identifying codes was purged from the database. This prevents any future connection of survey responses to the respondent's street address. The anonymized list of address codes and grid cells was retained to enable geographic analysis without allowing identification of any survey respondents.

The sampling methodology was the best possible option, given the dispersion of age-restricted neighborhoods and the limited availability of data on ARAAC locations. The sampling frame is likely to be biased towards more recently completed or higher profile developments, because a long-established neighborhood will be less likely to show up in realtor listing. Selecting households from a commercial list means that residents who chose to opt out of commercial listing (e.g. via the Mail Preference Service) will be outside the sample frame. Recent movers may also be less likely to be listed (though the information providers specifically offer recent mover data as a product). Some non-respondent bias from households who choose to ignore unsolicited mail is also likely. A summary of the response rate for all sample locations is given on page 107.

5.2.2 The survey instrument and incentive

The survey instrument was a mailback travel diary, with a separate sheet containing household demographic questions. I based the questions on previous instruments used in other studies, including Rodriguez et al. (2005) and Handy et al. (2005). Elements of the Physical Activity Scale for the Elderly were also incorporated, for the health-related questions (Washburn et al. 1993). Findings from the summer 2007 focus groups (Zegras et al. 2008) were used to phrase and refine the questions. A small pilot was carried out with volunteers around DUSP, with feedback on the layout, phrasing, etc provided by faculty reviewers. Because of time constraints, no pilot with the target sample was carried out.

The survey instrument had two parts (see page 169 for images of each page of the survey instrument):

- A single household page, to be completed by a resident adult. This gathered household demographic information on the type of current and previous home, age-restricted status, ownership, number of residents, number of vehicles and bicycles, and household income.
- A diary booklet, containing questions on respondent demographics, attitudes to travel, attitudes to residential location, and previous neighborhood characteristics. The second half contained a travel diary, to be completed on a single Tuesday, Wednesday or Thursday. For each trip, respondents were asked to record start time, end time, destination, mode, cost, duration and weather conditions.

All households in the sample received the same mailing: an envelope contained an introductory letter, a single page household survey, two personal booklets, a pre-paid business reply mail envelope and a cash incentive. The introductory letter requested participation and explained the project aims without specifically mentioning older adults as the focus.

A \$5 cash noncontingent incentive² was included in each envelope. Previous travel surveys have used a variety of incentives, for example Handy et al. (2005) offered the chance to win \$100. Cash was chosen for its immediacy as an incentive, and because it was logistically easier than producing individual checks, and also avoids problems where the householder opening the envelope might not be the named recipient. There is some evidence that the amount of cash provided will also affect the response rate in a non-linear

²The incentive is yours whether or not you choose to return the survey, so it is *noncontingent* on your response.

way: if the incentive is too large, recipients view the money as attempted remuneration for lost work time but decide that the amount is insufficient (Trussell and Lavrakas 2004). Contingent incentives or a lottery option for larger amount were rejected due to the likely complexity of administration. Using a grocery store or coffee voucher was rejected because it would be less immediate than cash and so less effective as an incentive. The decision to include \$5 per household determined the final sample size of 7,000.

5.2.3 Survey timescale

The survey materials were printed and stuffed into envelopes at MIT. Completed envelopes were mailed over three days starting April 18, 2008, with the first surveys arriving to recipients a few days later. First responses were received starting April 25 and continued to arrive for two weeks with around 70 per day, before tailing off to a few per day. Three weeks after the original mailing, a follow up postcard was sent to all RC addresses, thanking them for participation and encouraging anyone who had not yet returned their survey to do so. Although this could create a response bias from the restricted addresses, there were fewer addresses from RCs so it was judged worth risking any bias to increase the sample size. The wording and tone of the postcard followed Dillman (1978), who suggests a letter of thanks is more likely to stimulate additional responses than an additional request to participate.

In total, 1,752 envelopes were returned. Of these, 102 were returned with a note or some indication that the recipient did not want to complete the survey. Most declined surveys also returned the \$5. The remaining 1,650 envelopes contained partial or fully complete instruments. 102 original envelopes were returned as undeliverable, mostly because the respondent was no longer at the address (e.g. moved, deceased), with some declined unopened. 5,146 households did not respond.

5.2.4 Data entry and quality control

Data entry was carried out using an Access database with a data entry form (shown in Figure 5-2). Logic embedded in the form prevented entry of invalid values (e.g. out of range responses). Quality control was carried out using a printed view of each database record (Figure 5-3), with changes later made to the original. Most records were entered and checked by two different people. The data entry process took approximately 400 hours.

Figure 5-2. Data entry interface

<h3>Household</h3> <p>Survey ID <input type="text" value="1052"/></p> <p><input type="checkbox"/> No household returned</p> <hr/> <p>Cur home <input type="text" value="1"/></p> <p>Prev home <input type="text" value="1"/></p> <p>Own/rent <input type="text" value="1"/></p> <hr/> <p># vehicles <input type="text" value="2"/></p> <p># bikes <input type="text" value="0"/></p> <p>ARAAC? <input type="text" value="1"/></p> <p># residents <input type="text" value="2"/></p> <p># 55-65 <input type="text" value="0"/></p> <p>HH inc <input type="text" value="5"/></p> <p>Notes</p> <div style="border: 1px solid black; height: 70px; width: 100%;"></div> <div style="border: 1px solid orange; padding: 5px; margin-top: 5px;"> <p>QC by: <input type="text"/> QC changes <input checked="" type="checkbox"/></p> <p>QC Notes:</p> <div style="border: 1px solid black; height: 40px; width: 100%;"></div> </div>	<h3>Personal</h3> <p>A/B <input type="text" value="A"/></p> <hr/> <p>Age <input type="text" value="66"/></p> <p>Gender <input type="text" value="2"/></p> <p>WE rel <input type="text" value="-1"/></p> <p>WE rel <input type="text" value="Spouse/partner"/></p> <p>Work <input type="text" value="3"/></p> <hr/> <h4>2 Health</h4> <p><input checked="" type="checkbox"/> f None apply to me</p> <p><input type="checkbox"/> a keep me from working</p> <p><input type="checkbox"/> b restrict the amount i can do</p> <p><input type="checkbox"/> c limited in some way</p> <p><input type="checkbox"/> d help with care</p> <p><input type="checkbox"/> e help with routines</p> <hr/> <h4>3 Travel attitudes</h4> <p>a I enjoy driving <input type="text" value="4"/></p> <p>b I make efforts to minimize <input type="text" value="2"/></p> <p>v I like riding the bus <input type="text" value="3"/></p> <p>d I enjoy bicycling <input type="text" value="3"/></p> <p>e Taking PT is convenient <input type="text" value="2"/></p> <p>f Highways deserve more <input type="text" value="3"/></p> <p>g I prefer to combine <input type="text" value="5"/></p> <p>h Having sidewalks <input type="text" value="4"/></p> <p>i I dislike sitting in traffic <input type="text" value="5"/></p> <p>j The price of gasoline <input type="text" value="1"/></p>	<h4>4 Regular journeys</h4> <p>a Drive to work <input type="text" value="-1"/></p> <p>b PT to work <input type="text" value="-1"/></p> <p>c Walk cycle <input type="text" value="3"/></p> <p>d other for ex <input type="text" value="0"/></p> <p>e trans. someone <input type="text" value="1"/></p> <p>f shopping <input type="text" value="2"/></p> <p>g visit a neigh <input type="text" value="0"/></p> <p>h visit friend <input type="text" value="0"/></p> <p>i go for rec <input type="text" value="1"/></p> <hr/> <p>Dur commute <input type="text" value="-1"/></p> <p>Miles/week <input type="text" value="70"/></p> <p>Rail pass <input type="text" value="2"/></p> <p>MBTA <input type="text" value="3"/></p> <hr/> <h4>5 Neighborhoods</h4> <p>Year <input type="text" value="3"/> Months <input type="text" value="1"/></p> <p>b Sidewalks <input type="text" value="2"/></p> <p>c PT <input type="text" value="3"/></p> <p>d Highways <input type="text" value="2"/></p> <p>e Distance to stop <input type="text" value="2"/></p> <p>f Distance houses <input type="text" value="1"/></p> <p>f Local serv. <input type="text" value="3"/></p>	<p>g Moving? <input type="text" value="3"/></p> <p>i Downsizing <input type="text" value="-1"/></p> <p>j Current <input type="text" value="-1"/></p> <p>k health <input type="text" value="-1"/></p> <p>m closer fam <input type="text" value="-1"/></p> <p>n shops <input type="text" value="-1"/></p> <p>p closer work <input type="text" value="-1"/></p> <p>q closer schools <input type="text" value="-1"/></p> <hr/> <h4>6 Resi prefs</h4> <p>a with children <input type="text" value="2"/></p> <p>b close to s/walk <input type="text" value="1"/></p> <p>c shops in w/d <input type="text" value="3"/></p> <p>d space btwn houses <input type="text" value="5"/></p> <p>e similar people <input type="text" value="3"/></p> <p>f strangers <input type="text" value="2"/></p> <p>g housing shop <input type="text" value="3"/></p> <p>h same stage of life <input type="text" value="4"/></p> <p>i value space <input type="text" value="5"/></p> <hr/> <p>Trip date <input type="text" value="4/24/2008"/></p> <p># trips <input type="text" value="3"/></p> <p><input type="checkbox"/> bad personal</p> <p><input type="checkbox"/> bad trips</p> <p><input type="checkbox"/> Trip chain doesn't return home</p>	<h3>Trips</h3> <p>Trip # <input type="text" value="1"/></p> <p>Departed <input type="text" value="940"/></p> <p>Arrived <input type="text" value="1023"/></p> <p>Where <input type="text" value="7"/> Where other: <input type="text"/></p> <p>How <input type="text" value="7"/></p> <p>Far <input type="text" value="2"/></p> <p>Cost <input type="text" value="0"/></p> <p>Weather <input type="text" value="1"/></p> <hr/> <p>Record: <input type="text" value="1"/> of 3</p> <hr/> <p>Bad trip notes</p> <div style="border: 1px solid black; height: 60px; width: 100%;"></div>
--	---	---	--	--

Figure 5-3. Data checking interface

1050

Missing

A

65 years

Male

Wage earner: 1

R/ship -1

Retired

no work

restrict

limited

help care

help routine

none

Current home: Detached single house

Previous home: Detached single house

Own/rent: Own

I enjoy driving - 3 - -

Efforts to min x x x x x

Like bus - 2 - - -

Enjoy bike - - - 4 -

PT convenient - - - 4 -

Hywys deserve - - 3 - -

Combine act - - - 5 -

Sidewalks - - - 4 -

Dislike traffic x x x x x

Price of gas - 2 - - -

2 vehicles

1 bicycles

status: Some restricte

0 drive to work

0 PT to work

4 walk or bike

0 travel to anoth

4 Transport som

6 go shopping

-1 Visit

0 Visit friend

4 Go rec

2 residents

1 over 55-65

HH inc: Missing

-1 minutes

20 miles

Rail: 2

CharlieCard: 3

10 years, 0 months

Sidewalks 1 - - -

PT options 1 - - -

Hwys access 1 - - -

Distance to stop - 2 - - -

Distance houses - - 3 - -

Local shops 1 - - -

Moving1

Downsizing - - - 4 -

Current home - - - 4 -

Health/aging - - - 4 -

Closer family - - - 6 -

Closer shops - - - 3 - -

Closer work 1 - - -

Closer schools 1 - - -

Nhood with childre 1 - - -

Close to sidewalk - 2 - - -

Prefer shops in wal - - - 4 -

Prefer space - - - 4 -

Similar people - - 3 - -

Strangers - - - 4 -

Housing and shops - 2 - - -

Stage of life - - 3 - -

Value space - - 3 - -

4/24/2008

trp 4

more than one destinations.

1	1015	1025	Errands	Car drive	2	0	1	Take spouse to haircut	Bad trips
2	1145	1159	Home	Car drive	2	0	1		Bad trips
3	1445	1500	Errands	Car drive	3	0	1	Take spouse to pedicure	Bad trips
4	1830	1845	Home	Car drive	3	0	1		Bad trips

1050

B

72 years

Female

Wage earner: 2

R/ship Spouse/part

Retired

no work

restrict

limited

help care

help routine

none

I enjoy driving - 2 - - -

Efforts to min - - - 5 -

Like bus 1 - - - -

Enjoy bike 1 - - - -

PT convenient 1 - - - -

Hywys deserve - 2 - - -

Combine act - - - 4 -

Sidewalks - 2 - - -

Dislike traffic - - - 4 -

Price of gas 1 - - - -

0 minutes

5 miles

Rail: 2

CharlieCard: 3

10 years, 0 months

Sidewalks 1 - - -

PT options 1 - - -

Hwys access 1 - - -

Distance to stop - 2 - - -

Distance houses - - 3 - -

Local shops 1 - - -

Moving1

Downsizing - - - 4 -

Current home - - - 4 -

Health/aging - - - 4 -

Closer family - - - 5 -

Closer shops - - - 4 -

Closer work 1 - - -

Closer schools 1 - - -

Nhood with childre 1 - - -

Close to sidewalk - - 3 - -

Prefer shops in wal - - - 3 - -

Prefer space - - - 4 -

Similar people - - - 4 -

Strangers - - - 5 -

Housing and shops - - - 4 -

Stage of life - - 3 - -

Value space - - 3 - -

4/24/2008

trp 4

1	1015	1025	Errands	Passeng	2	0	1	Haircut
2	1145	1159	Home	Passeng	2	0	1	
3	1445	1500	Ent	Passeng	3	0	1	Pedicure
4	1830	1845	Home	Passeng	3	0	1	

6 Characteristics of boomer neighborhoods

To understand the role of the built environment on travel behavior, we need to be able to quantify the complexities of urban form and demographics into comprehensible, valid and reliable metrics. These can be mapped, to help interpret the study area, and used as model variables. In this section I explain the approach taken towards the built environment, then use a variety of measures and scales to explore the regional and local characteristics of sample locations in the study. I discuss specific details of characteristics and measurement difficulties for RCs.

6.1 Summary characteristics of the study area

All samples in the study are suburban, with low population density and limited land use diversity. For most locations, there are few non-residential land uses within walking distance. At the regional scale, the samples have good accessibility to retail and employment.

There are some differences between neighborhood types. RCs tend to be located in areas with lower street network density and less land use diversity. RCs are also in less dense areas, but overall they are fairly homogenous and much more similar to each other than the more urbanized areas. Samples in typical neighborhoods are more widely spread than the small number of RCs, so greater variation is not unexpected.

Measurements of density and street network characteristics are limited by the available data. Since some RCs are more recent, there may be locations where the available data pre-date the development and so underestimates occur.

6.2 Methodology for characterizing the built environment

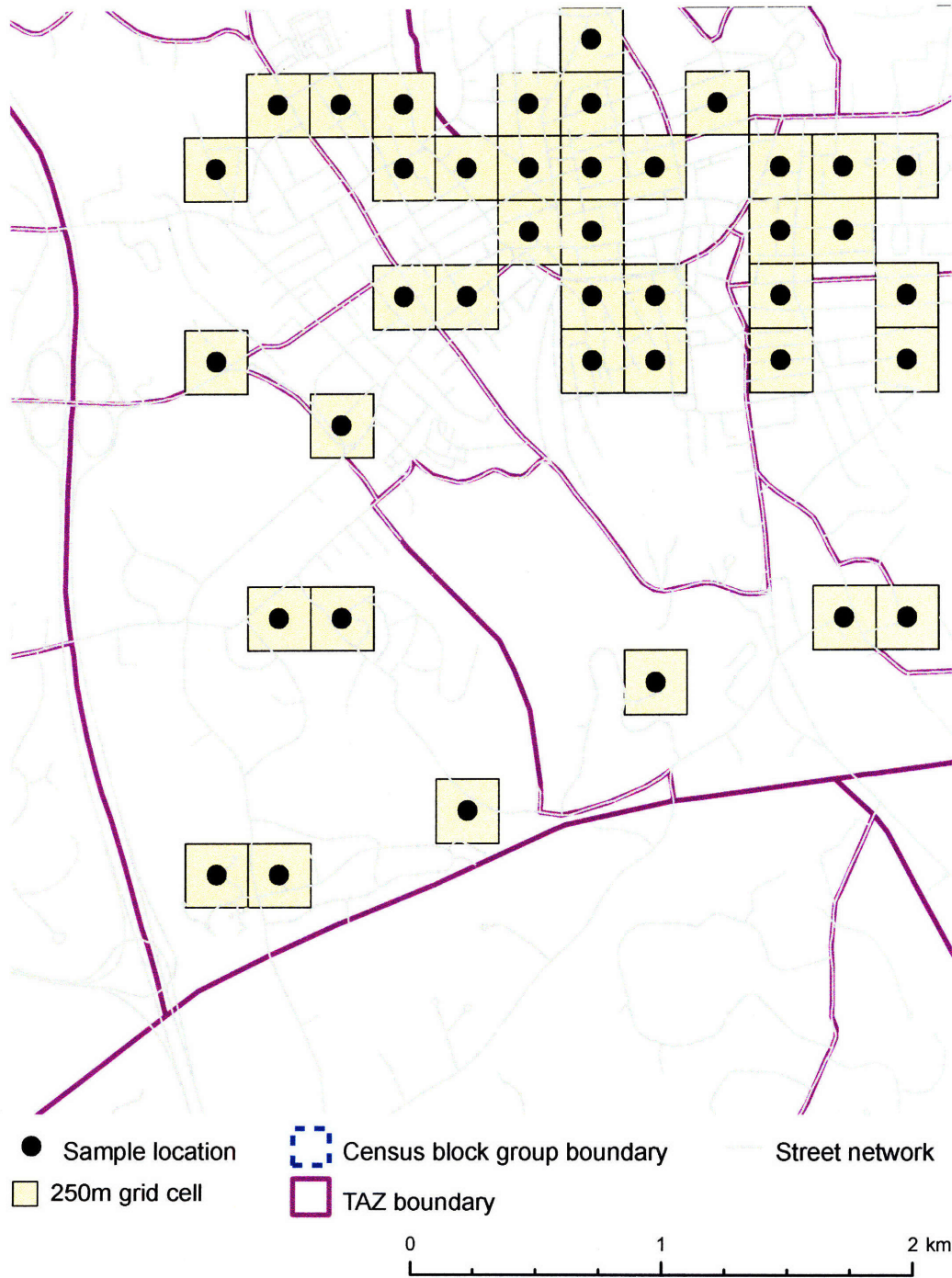
The ‘built environment’ encompasses everything about urban form, the transport infrastructure and the attractions and destinations that are the context, motivation and mechanism for trip making. Cervero and Kockelman (1997) use ‘the three Ds’ of the built environment to examine factors relating to travel behavior: density, diversity and design, with specific criteria used to measure each element. In summary,

- **density** is the concentration of people, households and employment, measured as number of attractions per unit of city form (the developed hectare), or using an accessibility index where destinations closer by score more highly than ones further away;
- **diversity** is the mixing and variation in land uses, both in absolute terms (the quantity of attractions) and relatively (how much land uses vary within a certain area), including distances from clusters, cluster types and cluster intensity, measured both in counts (shops per area) and in accessibility to uses; and
- **design** measures the street network, how buildings connect with and address the street, and provision for pedestrians.

6.2.1 Levels of aggregation

For each of these measures, choosing the correct spatial aggregation unit will ensure that the measurement is meaningful. For example, measuring density of households at the county level will provide a very different figure compared to measurements at the census block scale. For this study, more specific and smaller measurement areas are better since they will capture local variation in spatial variability to enable better model estimation (see the discussion on page 45 regarding Cervero and Radisch (1996), where the limited variation in spatial measures restricted their usefulness). Simultaneously, the division of space using areal units can unintentionally affect the measure, for example by dividing a retail zone in half between two spatial units, the density of retail in each will be lower than if all retail was allocated to a single unit only. This is the *Modifiable Areal Unit Problem* (Horner and Murray 2002), which requires mindful selection of the areal units for any given metric in order to produce the least geographically-distorted outcome. Three levels of aggregation are used for classifying the built environment in this study, listed in increasing size and shown in Figure 6-1 on the next page.

Figure 6-1. Different levels of spatial aggregation.
TAZs and block groups have similar boundaries and are similarly sized. Occasionally their boundaries differ, as seen in the lower left of this map.



Grid cells, 250m x 250m. Generated for the whole of Massachusetts by MassGIS¹. As a uniform grid laid over the state, the divisions between the grid cells have no relationship to other boundaries or geographies, and so are arbitrary for any specific location. As non-standard units, there is no relationship between the grid cells and measurements of population provided by the census, so some measures cannot be presented at this disaggregate level. The center point of each grid cell was used to provide locational anonymity for survey sample locations, so all survey information is specific to this relatively fine measure of location. For data that are available in completely disaggregate form, such as the road network, aggregation onto the grid cells preserves a high level of detail from the base layer. To provide a larger areal unit for measuring dispersed data such as retail locations, all data at the cell level are also calculated for the eight cells immediately adjacent to each grid cell - this can be considered a measure of what lies within a short walk from each sample location.

Block groups. Generated by the Census Bureau based on local boundaries and divisions between areas. The disaggregate level below the block group is the block, which is the smallest unit of measurement used by the census. The placement of block divisions tries to maximize similarity between the residents within the block while also respecting natural barriers such as local roads, waterways and other features. Each Block Group contains around 39 blocks, and can be considered representative of neighborhood characteristics, though only for neighborhoods that are defined in strictly geometric forms. For this study, block groups provide a better unit for most data than the individual block, because most demographic census data are only available at the higher level of aggregation. Additionally, the tendency of blocks to follow local roads means that the spatially averaged sample locations will commonly fall into the wrong block if the blocks are small. This effect occurs less frequently for block groups, because they are larger, but at the cost of some accuracy in local demographic data.

The highest level of spatial aggregation are **Traffic Analysis Zones (TAZ)**. Generated by the Central Transportation Planning Staff (CTPS), the Boston metropolitan planning office's transportation staff for traffic and transport modeling. The metro region is divided into 2,727 TAZs, based on the census tract geography, which is formed from block groups. This means that some boundaries of block groups and TAZs align in some locations, and TAZs will always be within a single town. The TAZ covers a larger area than a block group. When aggregating sample locations onto the TAZ geography, the same issue of misallocation of characteristics occurs for locations on the edge of a TAZ, as with block groups. For each TAZ, CTPS provided estimates of population and employment data for basic, service and retail jobs, and travel times between every TAZ. Because TAZs only

¹With the exception of this data layer, which was kindly provided by Prof. Joe Ferreira from another research project, all MassGIS data were directly obtained from <http://www.mass.gov/mgis/>

cover the metro model area, sample locations in the south and west of the study area do not have any attributes at the TAZ level, and will be dropped from model estimation by pairwise deletion.

In addition to the spatial level issues, the age of data is also relevant, though there is little that can be done about it. All census data are from 2000, so population, density and demographics are all at least 8 years out of date. The road network information dates from December 2007, and land use data from 2005. Travel times estimates from the metro model are from 2005, with the accompanying employment data from 2000. The timeliness of data is most critical when measuring characteristics for the RCs, which in some cases were not built at the time of the last census. As a partial solution, a dummy measure is assigned to each RC location: 1 to indicate if the road network does not describe the site roads adequately, otherwise 0. The total number of units in each RC was counted and attributed to the RC sample locations. These additional measures can be used in the model to provide a proxy for the local built environment data that is missing.

A full tabulation of income, demographics, accessibility and density measurements of RCs is given in Table B.1 on page 182.

6.3 Measuring density

Following Cervero and Kockelman (1997), I calculate two forms of density: density of people and households, and density of employment available in the vicinity through accessibility measures, as a proxy for land use opportunities.

Density of people and households is calculated from the census. Accessibility measures are calculated from the CTPS travel time and employment data, at the TAZ level². Density metrics are shown in Table 6.1.

²CTPS provided auto and public transit travel time skims from the metro area model, giving the OD travel time by to move from the center of each TAZ to any other TAZ. In conjunction with employment data or information on land uses, travel times between the center points of every zone can be used to calculate available totals based on the actual travel time distance between zones. Using employment within zones as a proxy for destinations, two measures of accessibility can be calculated: the cumulative accessibility and a gravity model, using the methodology identified by Makri and Folkesson (1999). For the measure of cumulative accessibility to retail within 10 minutes, for each TAZ the total number of retail jobs are summed from all TAZs within a 10 minute travel time. For the gravity measure, the number of jobs in each TAZ are weighted by an exponentially decaying function, e^{-1d} , where d is the travel time to a TAZ. These accessibility measures are calculated for total employment, and the basic, retail and service sectors. TransCAD was used to convert the CTPS EMME\2 files into TAZ-to-TAZ travel times for all 2,727 zones. Calculations were carried out in an Access database

Table 6.1. Density measures

Measure	Source	Aggregation
Population density	Census†	Block group
Household density	Census†	Block group
Employment density	CTPS†	TAZ
Cumulative and gravitational accessibility to employment, total and by sector (ret, bas, ser)	CTPS	TAZ

†: Calculated, denominator is block or TAZ area, depending on aggregation unit.

6.3.1 Density characteristics of the study area

Despite being suburban, locations in the study area are not particularly low density compared to the wider Boston area. The mean density of sample locations is 600 people per square kilometer, compared to 650 people/km² in the Boston PMSA (Census 2000, using SF1). However, the comparison is slightly misleading because the PMSA region extends out beyond Worcester and into New Hampshire, so it includes very sparsely populated areas. In comparison to the most built up parts of the metro area, the samples are in extremely low density areas: density in the City of Cambridge tops 7,000 people/km². The relative position of the samples in the density gradient for the whole metro area is shown in Figure 6-2.

Within the sample, the distribution of densities is skewed, with only a few households in higher density locations (Figure 6-3 on page 82). RCs are much lower density, with 300 people/km² compared to 750 in TNs³. This disparity in density is likely due to residents in matching neighborhoods outside RCs drawn from more urbanized areas. The lack of current data on density may also lead to under-estimates for recently-developed areas. The relative density of RCs is shown in Figure 6-4.

Households in typical neighborhoods have much higher levels of accessibility, by all measures (all employment, retail, service and basic jobs). Within a 5 minute drive, the average TN household can reach 1,075 retail jobs, compared to 667 within the same distance from RCs⁴. Retail jobs are a proxy for retail services, so all things being equal the TN households have nearly twice the retail within a short drive compared to RCs⁵. The difference in accessibility measures between sample locations is small compared to the variation across the region and the exceptionally high accessibility towards the center of densely built up areas. Cumulative accessibility to retail for the entire region is shown in

³ $t(1,281)=10.1, p < 0.001$

⁴ $t(6.93)=1,052, p < 0.001$

⁵Accessibility is measured at the TAZ level, so households outside the CTPS area are excluded. The TAZ-level aggregation means that a 5 minute drive time should be interpreted as a ‘short drive’, rather than an accurate 5 minute drive-shed from each sample location.

Figure 6-2. Population density in the Boston area.
 Shown at the block group level. Highest densities are indicated with the darkest colors. Highest density is found in the urban cores of Boston and other centers. The sample are located in sparsely populated areas.
 Source: MassGIS map data, Census 2000 demographic information.

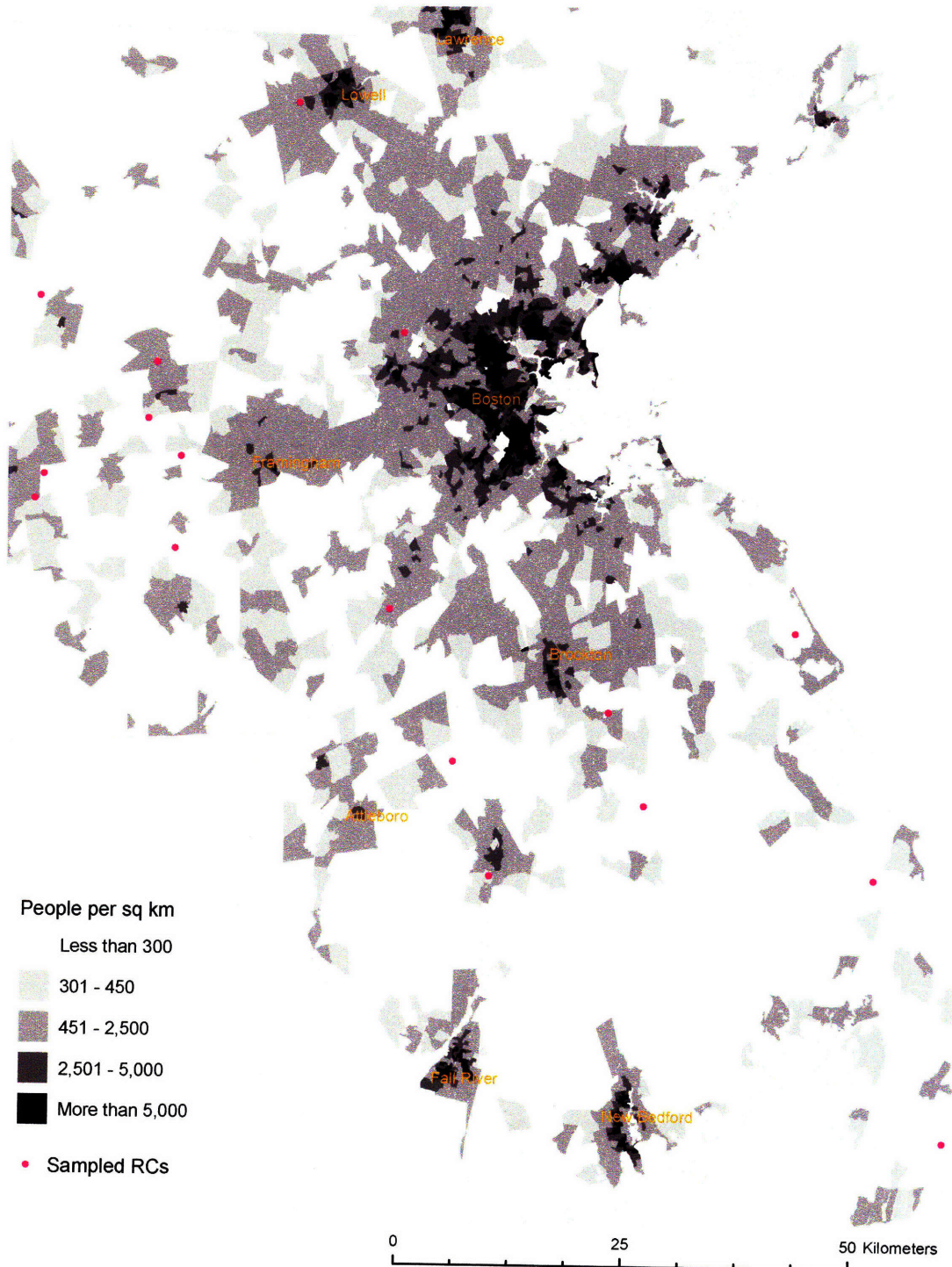


Figure 6-3. Comparison of density between neighborhoods.
 Median density is lower in RCs. The spread of densities for TNs is in part because they are so spread out, in comparison to the clustered RC sites. In each RC, several households are in the sample block group with the same density, whereas TN samples are spread across many block group with few samples in each.

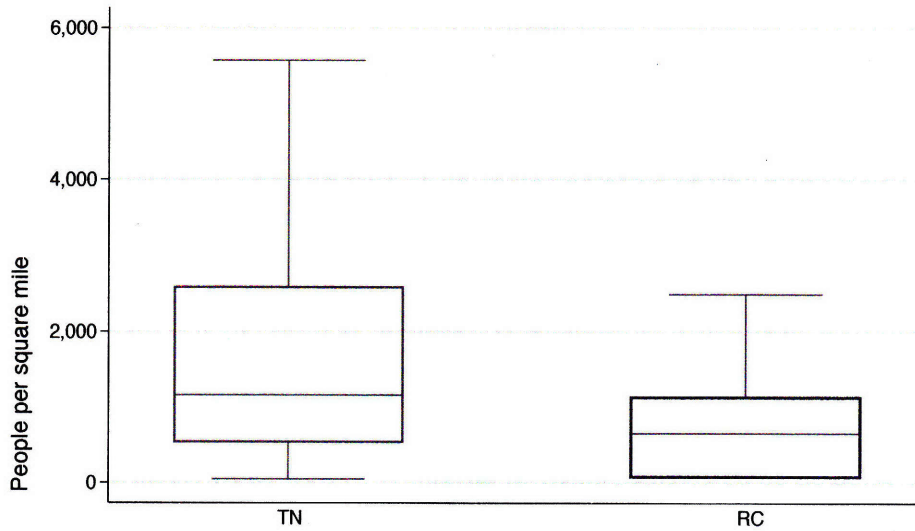


Figure 6-4. Density variation between areas.
 Density differences between the larger RCs are highlighted, showing the effect of spatial clustering. The density axis uses a log scale to show spacing differences between groups. Each point has some random scatter to make RC clusters with the same density more apparent.

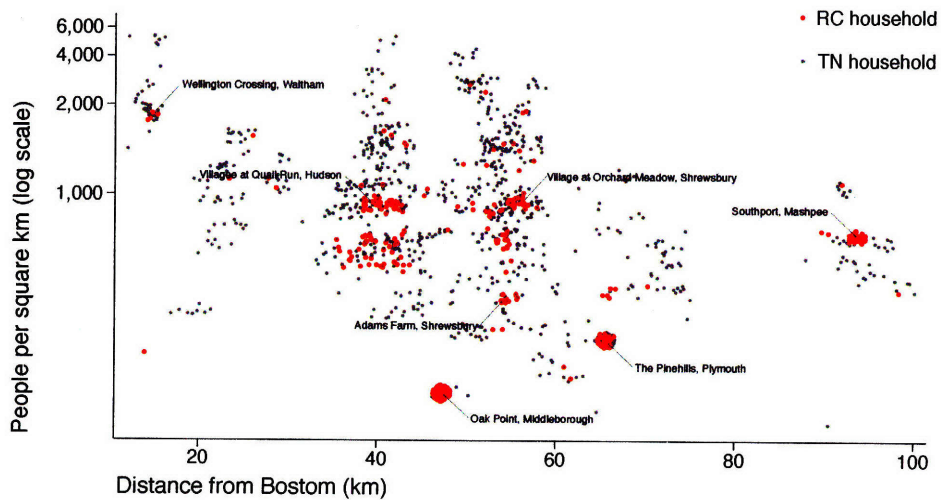


Figure 6-5 on the following page, where the sample locations can be seen in predominantly low accessibility areas. A slightly different pattern of accessibility is shown by the overall employment distribution (Figure 6-5 on the next page), but the situation for sampled households is the same - they are in the lowest accessibility areas of the metro region.

Figure 6-5. Cumulative accessibility to retail.

Accessibility to retail units within a five minute drive, calculated for each TAZ using the Boston metro traffic model (see methodology on page 79). Some RCs have high retail accessibility within a short drive, but none are regionally isolated. With a slightly longer drive time, all RCs can easily reach a wide range of attractions
Source: Base data and retail locations from MassGIS, travel times from CTPS.

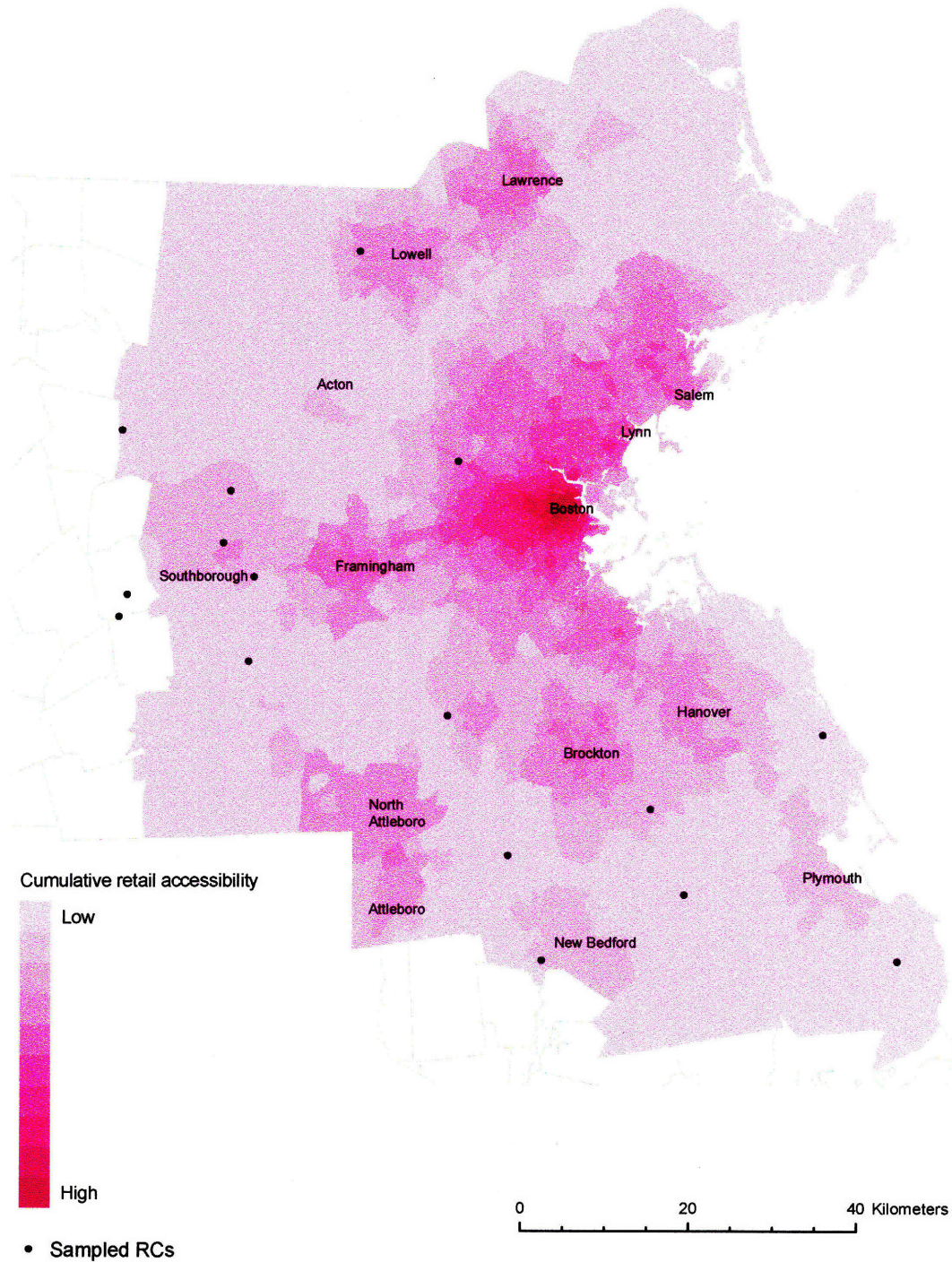
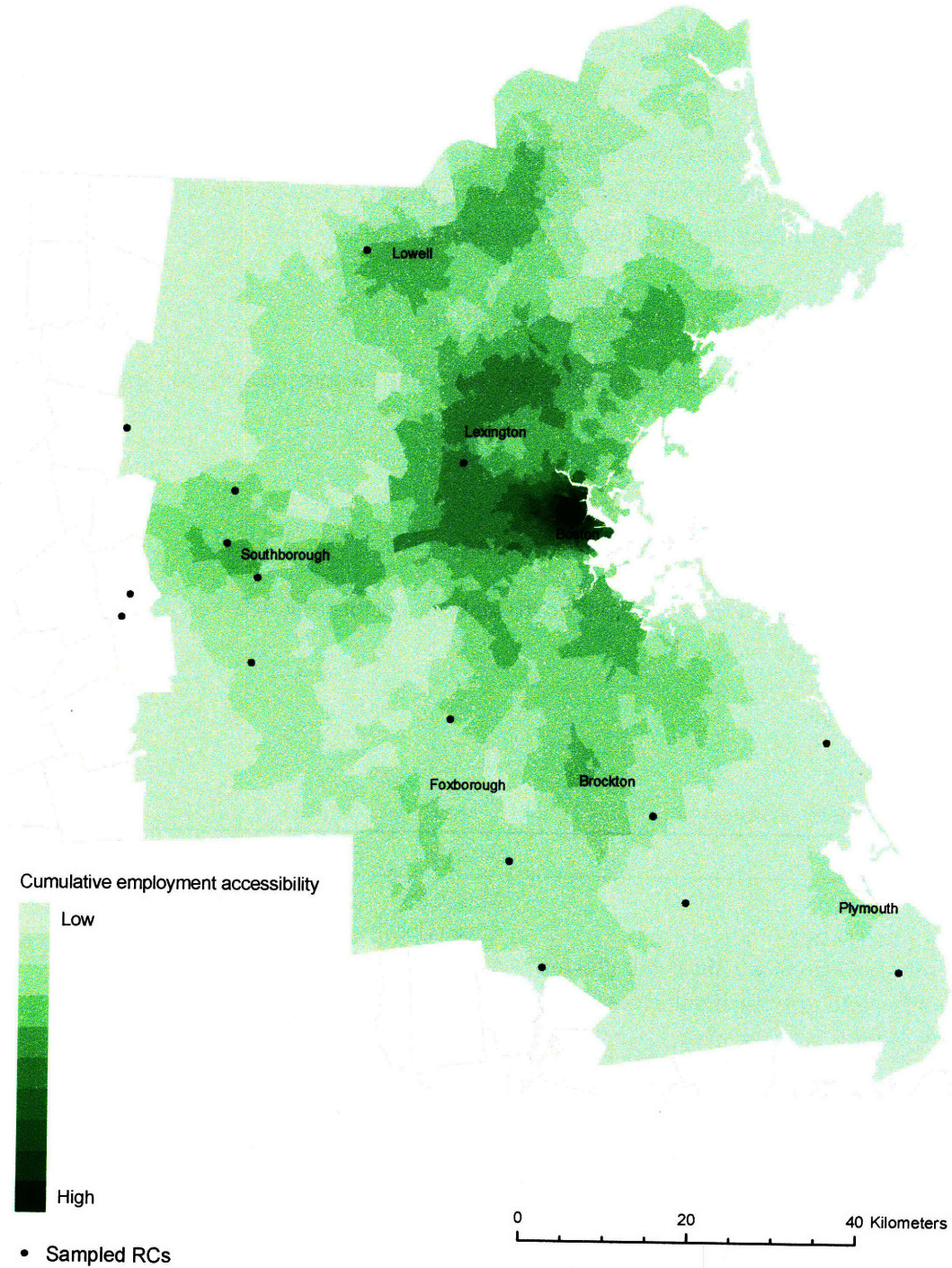


Figure 6-6. Cumulative accessibility to all employment
The distribution of employment is different from retail accessibility, but for RCs the picture is the same, with few located outside the lower accessibility areas.
Source: Base data and retail locations from MassGIS, travel times from CTPS.



6.4 Measuring land use diversity

Land use diversity measures how much land uses vary, and what the total availability of different uses is. More diversity of uses is likely to be associated with more activity, though for the suburban sample locations there are unlikely to be large variations between areas. Land use diversity is captured in two ways: through actual measures of diversity, calculated with an index of mixing between types, and basic counts of different land uses. The calculated diversity measures are shown in Table 6.2.

The grid cell data from MassGIS contains Dun and Bradstreet data on retail and service locations, aggregated to each cell. Extremely disaggregate categories were provided, for ease of analysis I consolidated them into six major groups –

- Eating: bars, restaurant, limited service eating
- Errands: auto repair, banks, beauty, day care, dry cleaner, gas station, post office, vet
- Exercise: fitness/gym,
- Medical: dentists, physicians, other doctors,
- Recreation: cinema, museum/public attraction, performing arts venue, religious, spectator sport.
- Retail: shops

Table 6.2. Diversity measures

Measure	Source	Aggregation
Diversity index	MassGIS	Grid cell, TAZ
Count of attractions	MassGIS	Grid cell, TAZ
Count of attractions within 9-cell cluster	MassGIS	Grid cell
Cumulative and gravitational accessibility to attractions	MassGIS	

The land use mixing index provides a way to represent the diversity of land use, rather than intensity of use, similar to the measures of dissimilar land uses calculated by Cervero and Kockelman (1997). I use a formula used by Rajamani et al. (2003). Taking the assumption that local activity is encouraged by a mixture of uses more than a concentration of one single use, the index is a ratio of different uses types, normalized so that the range 0 to 1 represents all levels of mixing. Independent of the intensity of use, the index shows how mixed different land use types are, by assessing how much each type

contributes to the total within each unit of aggregation. The index should consider all uses including residential units, to give a true assessment of mixing between all uses. With the available data, an index of non-residential use mixing is calculated, and assigned to each TAZ, using the formula:

$$1 - \frac{\left(\left| \frac{\text{shop}}{\text{total}} - 0.25 \right| + \left| \frac{\text{eat}}{\text{total}} - 0.25 \right| + \left| \frac{\text{errands}}{\text{total}} - 0.25 \right| + \left| \frac{\text{other}}{\text{total}} - 0.25 \right| \right)}{2.5}$$

where *other* counts all land uses not included in shops, eating or errands. A perfect score of 1 would indicate equal mixing between each use type. Although crude, this measure gives some assessment of land use clusters and activity centers, though at the TAZ level, the level of aggregation is too crude to differentiate small clusters within TAZs, as Figure 6-9 shows. Smaller TAZs in areas with denser populations are disadvantaged, while a large suburban TAZ with only one of each land use type will get a ‘perfect’ score (an example of MAUP distortion)⁶.

Land use totals are also calculated and stored at the grid cell scale, and attributed from the abutting eight cells to provide a measure of possible destinations within a short walk. Totals were aggregated from cells onto TAZs and used to calculate accessibility measures and total availability at the TAZ level, following the same methodology as the accessibility calculations for density.

Using ground cover data from MassGIS⁷, the proportion of urban land uses in each grid cell was calculated. The ground cover data represents 21 use types captured at high resolution (for example, footprints of transport infrastructure are differentiated from adjacent uses), including a range of urban uses such as residential and recreation as well as pasture, crop, forest, etc. I consolidate these into a simple built/non-built measure to identify how developed sample locations were.

6.4.1 Land use characteristics of the study area

Most sample locations are entirely residential in their immediate vicinity, with few different land uses nearby. Half have none or one non-residential land use within a 5 minute walk, and only a very small number have more than ten non-residential uses in that distance. Unlike density, there is little difference between the RCs and TNs, with a

⁶Calculating these scores at the grid level could produce more useful output, though the cells might be too small. Including residential uses would be an improvement as well, though this information is not easily available. One approach I did not attempt would be to use aggregated population information from the grid cells to estimate the number of residential units per cell, and calculate a true diversity index with that information

⁷Land use dataset, 1999

common median and similar variation. Most households have no local services such as a gas station or bank within this distance, as Figure 6-7 shows. Almost no locations have a cluster of uses within reach that could serve as suitable for a local shopping expedition.

A typical location is shown in Figure 6-8, where there is effectively nothing to walk to despite a street network covering most of the map. At the regional level, most sample are generally not located in or near the locations with high retail intensity shown in Figure 6-10 on page 91. These findings are not unexpected, given the suburban nature of the sample. Considering this map alongside the measurement of accessibility shows that households have limited local services but good regional accessibility, a land use pattern that makes local trips on foot unlikely for utilitarian activities.

Figure 6-7. Neighborhoods have similar land uses within a short walk. The chart compares the availability of non-residential uses and local errand services between neighborhood types, measuring land uses in the same grid cell as each sample location and the eight adjacent cells.
Source: Retail locations from MassGIS.

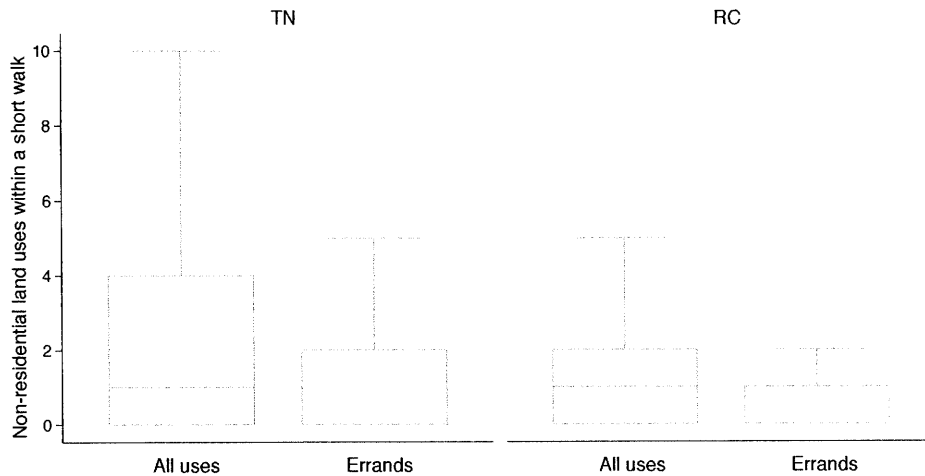


Figure 6-8. Although regional maps show good access to dense areas with mixtures of land uses, little is available locally. The map shows a fully developed area near Framingham, highlighting locations with any use other than residential. White space is residential or undeveloped. Orange cells have at least one non-residential land use, cells with a pink border have one or more retail use. Near-continuous residential neighborhoods cover the area shown, but there is little to walk to. Source: Base data and retail locations from MassGIS

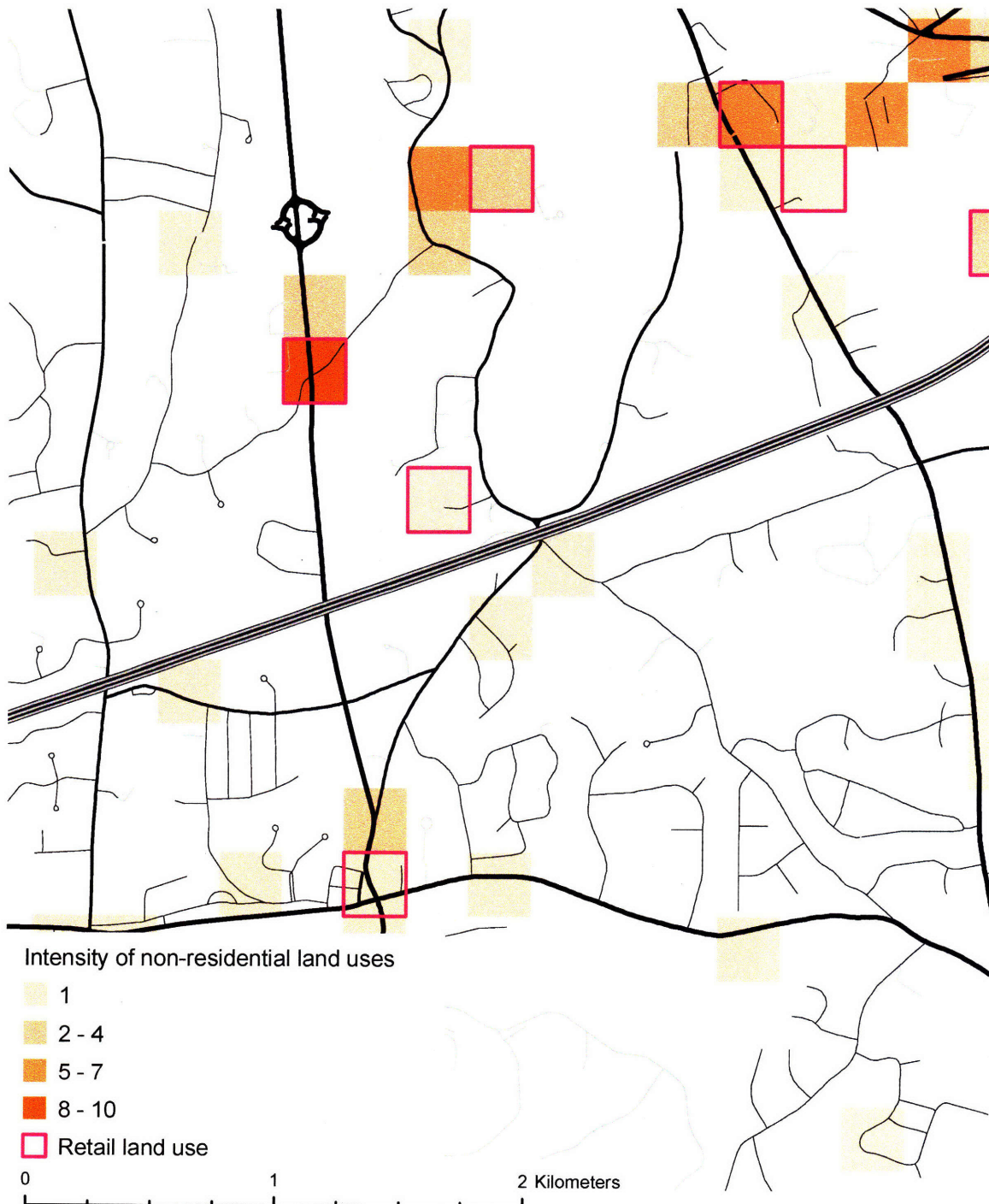


Figure 6-9. Land use diversity across the metro region.

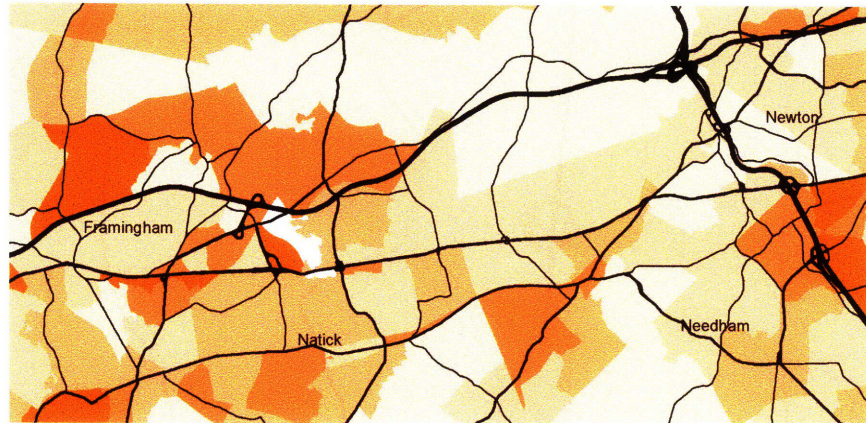
These maps show the limits of the diversity or dissimilarity index measures, which in the top panel does not appear to capture the density (middle) or land use mixing (bottom). Including residential information would create a true diversity index, which might be more accurate.

Source: Base data and retail locations from MassGIS.

Dissimilarity Index

Land use mixing index

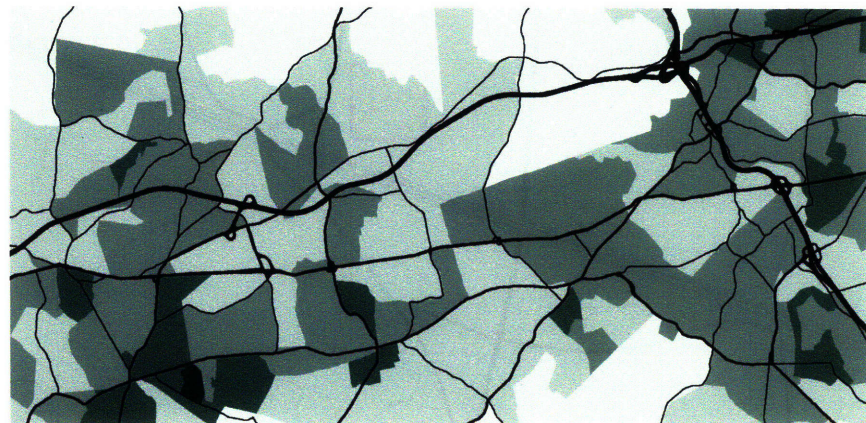
- 0.4 - 0.6
- 0.7
- 0.8
- 0.9
- 1.0



Population density

Pop/sq mile

- <800
- 800 - 2,400
- 2,400 - 5,400
- 5,400 - 13,000
- >13,000



Predominant land use

- Mixed use
- Business
- Conservation
- Highway business
- Limited business
- Institutional
- General industry
- Light industry
- Multi-family LD
- Multi-family HD
- Single family 1
- Single family 2
- Single family 3
- Single family 4
- Single family 5

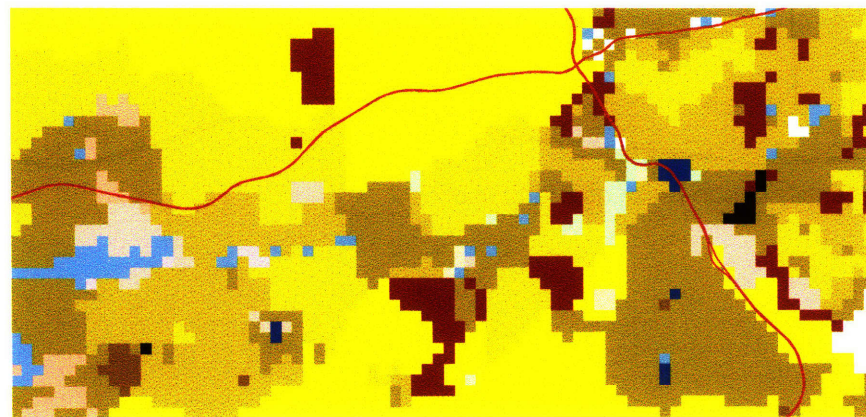
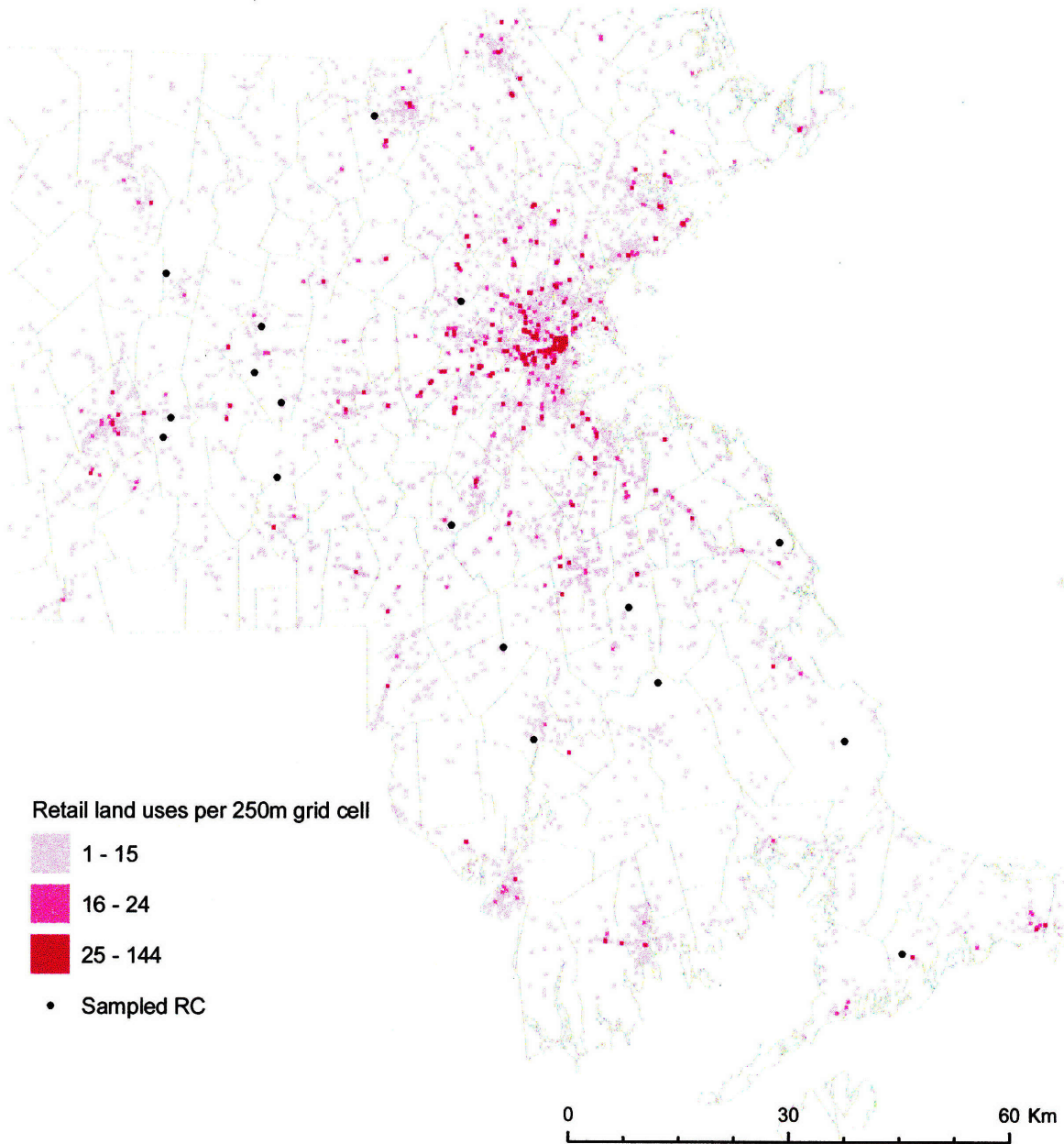
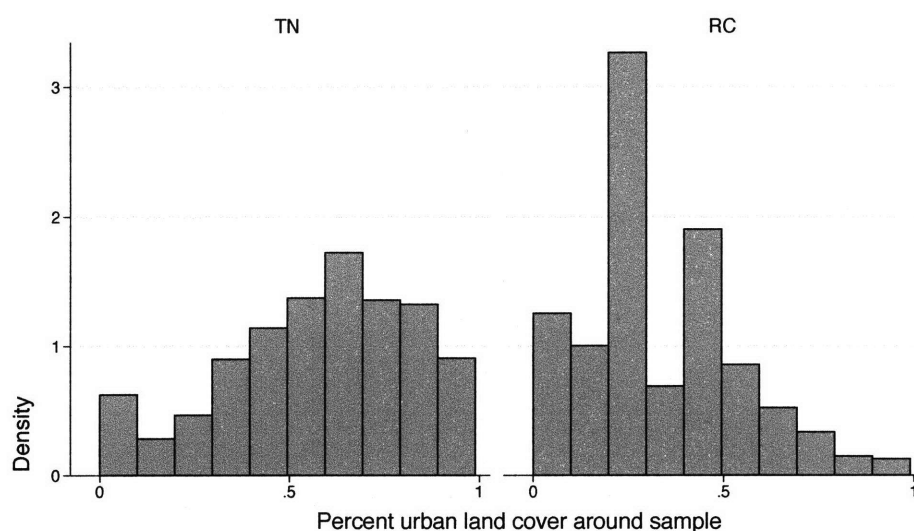


Figure 6-10. Non-residential land use intensity across the metro region.
Sample locations shown in black. Most RCs are away from retail and other non-residential areas.
Source: Base data and retail locations from MassGIS.



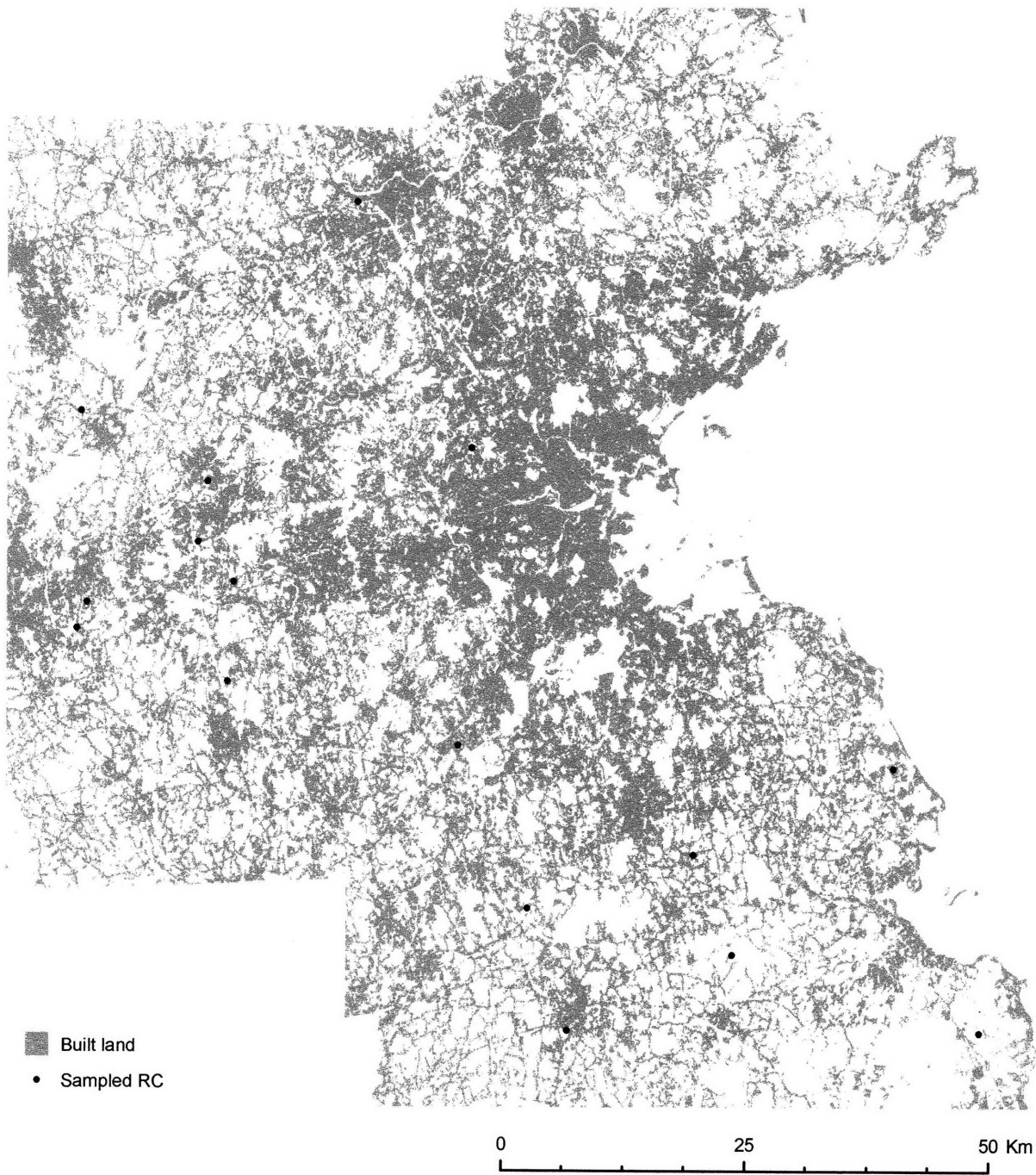
RCs are located in less densely developed locations than TNs, averaging 35% urban land cover compared to 58%⁸. The amount of land cover is measured using each sample's grid cell and the adjacent 8 cells. Since the coverage data are from 1999, some sample locations are likely to be under-represented if built since then. The concentration of sample locations within certain locations also produces a very biased distribution, as Figure 6-11 shows. The measure indicates that RCs have more natural land within reach and so potentially offer more opportunities for leisure walking. The land cover map for the entire metro region shows some open space near all RCs, in Figure 6-12 on the facing page.

Figure 6-11. Urban land comparison between sample locations.



⁸ $t(1,694)=18.0, p < 0.001$

Figure 6-12. Urban and non-urban land in the metro area. Sample locations shown in black.
Source: MassGIS



6.5 Measuring design

The street network and most physical neighborhood characteristics are measured in the final ‘D’, design. At the regional scale of this study, detailed measures of the design of the built environment and road network can only be used if they are easily generated. Using the available road network layer, the measures of design focus solely on street network measures. Unlike all other measurements described in this section, the measures are not simply aggregations, so the methodology for creating them is described at length here. The resulting maps and charts start on page 96. All design measures were calculated from the street network, shown in Table 6.3 and described below.

Table 6.3. Design measures

Measure	Source	Aggregation
Density of street network	MassGIS	Grid cell, TAZ
Density of private streets	MassGIS	Grid cell
Density of connected streets	MassGIS	Grid cell
Density of major streets	MassGIS	Grid cell
Density by street end type (dead end, cross street, cul-de-sac)	MassGIS	Grid cell
Dead-end street ratio	MassGIS	Grid cell

The level of connectivity in the street network is relevant when considering ‘walkability’: a network with many interconnected streets within a short distance offers a variety of routes and access to many destinations, whereas streets with few intersections and many dead end links are less useful as a network and less interesting to traverse. A downtown city grid is an example of a highly connected network, compared to a suburban neighborhood with many cul-de-sacs. The connectivity can also be considered a proxy for a range of other built environment characteristics, since a neighborhood with a dense street network indicates that homes are likely to be closer together and on smaller lots than a neighborhood with low street connectivity.

Unlike census data, measures of street network characteristics are not available and so must be calculated from street maps with GIS (e.g. number of streets) and manual processes (e.g. classification of four-way intersections). The choice of ‘best’ measurement requires a trade-off between the effectiveness of the measure and the complexity of gathering the information, given what is available in the base network files. Dill (2004) identifies a range of commonly-used measures of street network characteristics in recent planning literature, ranging from simple density of streets to ratio measures comparing on-the-ground walk distances to line of sight distance. Each approach measures something different about neighborhood design, but are broadly assessing the same factors of

interest, which can be loosely termed ‘walkability’. From ten measures used, she identifies three that can be easily computed in GIS for a metro area⁹:

- **Street network density** measures the length of roadway within the areal unit (e.g. miles of road per sq. mile).
- **Connected Node Ratio** is a ratio of street intersections to street intersections and cul-de-sacs, with higher values indicating a more connected street network. A value of 1.0 means that there are no cul-de-sacs.
- **Link-Node Ratio** is a ratio of links and nodes, where nodes are either intersections or all end points (intersections and cul-de-sacs). A square grid scores 2.5.

Node-based measures of connectivity are not feasible for the study area, because neither of the two sources depicting the street network contains them (Census Tiger data, from 2000, and the GIS Highways layer created by the Massachusetts EOT in 2007). However, the EOT layer offers attributed data depicting a variety of other useful measures including start and end type of intersecting roads, functional classification, jurisdiction, geometry including street and sidewalk width¹⁰. Not all road segments are attributed with all data - by length, 21% are missing some information¹¹.

To generate the design metrics, the road network file was divided using the 250m grid cells as a ‘cookie cutter’ layer, using the Intersect tool in ArcMap. Each partial road segment retained all original attribute data, and was assigned an updated length and the id of the cell it is found in. This file was aggregated using Access to calculate cell-level measures of the road length in meters and count of segments for the following subsets:

- All streets
- Major routes (any segment classified as Interstate, Arterial, Collector)
- Private streets (any segment classified as Private, Unaccepted by city or town, or status unknown)

⁹A fourth measure, intersection density, is highly positively correlated with street network density so is not discussed here.

¹⁰see (EOT 2007) for a complete listing of the fields available in the data file

¹¹Attributes based on geographic location are not missing, for example the road’s county. The missing information is specific to the road segment, e.g. sidewalk information, presumably because this requires additional surveying to gather it. Incomplete network segments are not indicated in the data table provided by EOT, so a street segment with LeftSidewalkWidth equal to 0 meters could be an incomplete record or could be a street with no sidewalk. To identify incomplete segments, the SurfaceWidth field (described as ‘Surface width in feet; measurement of traveled way, excluding shoulders/auxiliary lanes’) was queried for all streets with zero width, which seems a reasonable indicator of missing information. For the entire state, 341,004 segments make up 32,635 miles of the road network. 81,443 have no geometry characteristics, totaling 6,820 miles. It seems that incomplete streets are mostly side streets and other non-major routes.

- Streets with one sidewalk
- Streets with two sidewalks
- Dead ends (any segment where the start or finish is classified as a Dead end, Cul-de-sac, Private)
- Incomplete segments

Using these data fields, the following metrics are derived. Examples are shown in Figure 6-13 on the next page:

- Density of street network (street length per cell)
- % private streets
- % connected streets, by length (length of dead end streets divided by length of all streets)
- % major streets, by length (length of major streets divided by all length of all streets)
- Dead-end street ratio, based on the connected node ratio measure described by Dill. For all non-major streets, the total count of streets that are not cul-de-sacs divided by the total count of all streets. The street segments are substituting for nodes since we have no information on them. For each grid cell, the calculation is:

$$\frac{(\text{All segments}) - (\text{Main road segments}) - (\text{Dead end segments})}{(\text{All segments}) - (\text{Main road segments})}$$

6.5.1 Design characteristics of the study area

The road network metrics for the sample locations provide limited additional information about the locations. When measuring overall density, RC sample locations are in areas with a lower density of road networks that samples in TNs. RC locations also score lower on all other measures, including non-major roads and sidewalks, shown in Figure 6-20.

There are two explanations for the lower level of road density in RCs: firstly, these locations may not yet be mapped, so the measurement of road density is incorrect; secondly, the self-contained design of RCs means that the street network does not extend in all directions beyond a sample household. In comparison, a sampled TN household near a main road will have streets extending in several directions, even if they are also ultimately cul-de-sacs.

Figure 6-13. Street network measurements: Base street network



Figure 6-14. Street network measurements: Total density of all roads



Figure 6-15. Street network measurements: Major routes

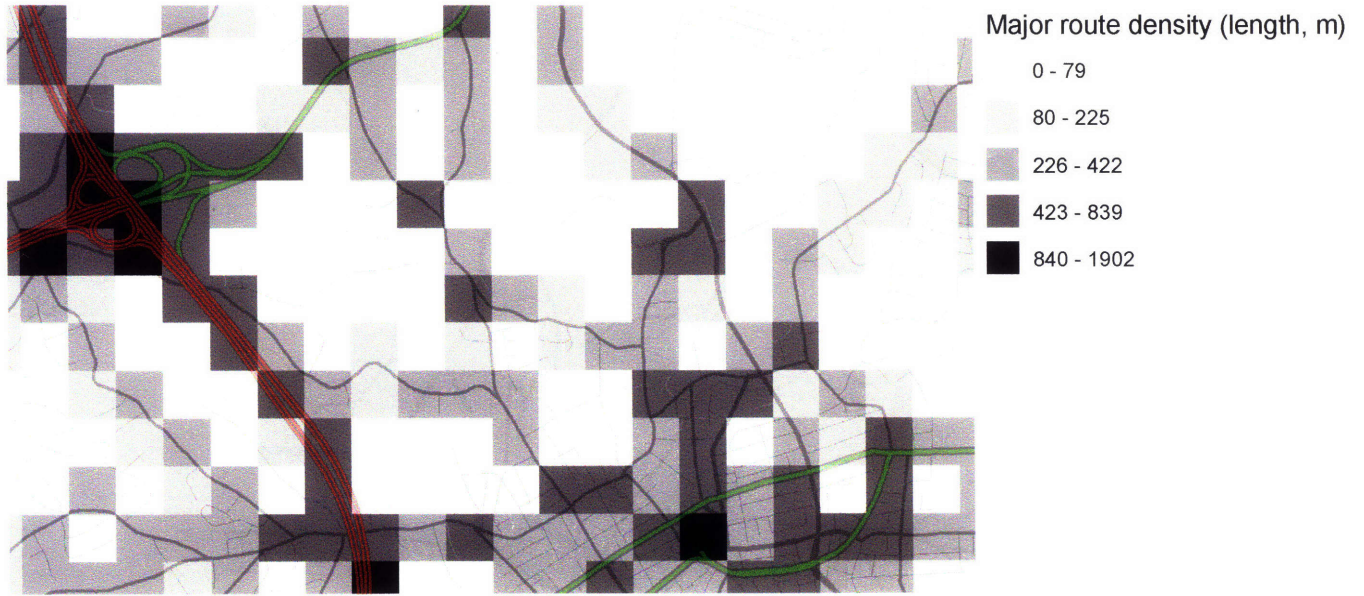


Figure 6-16. Street network measurements: Local streets

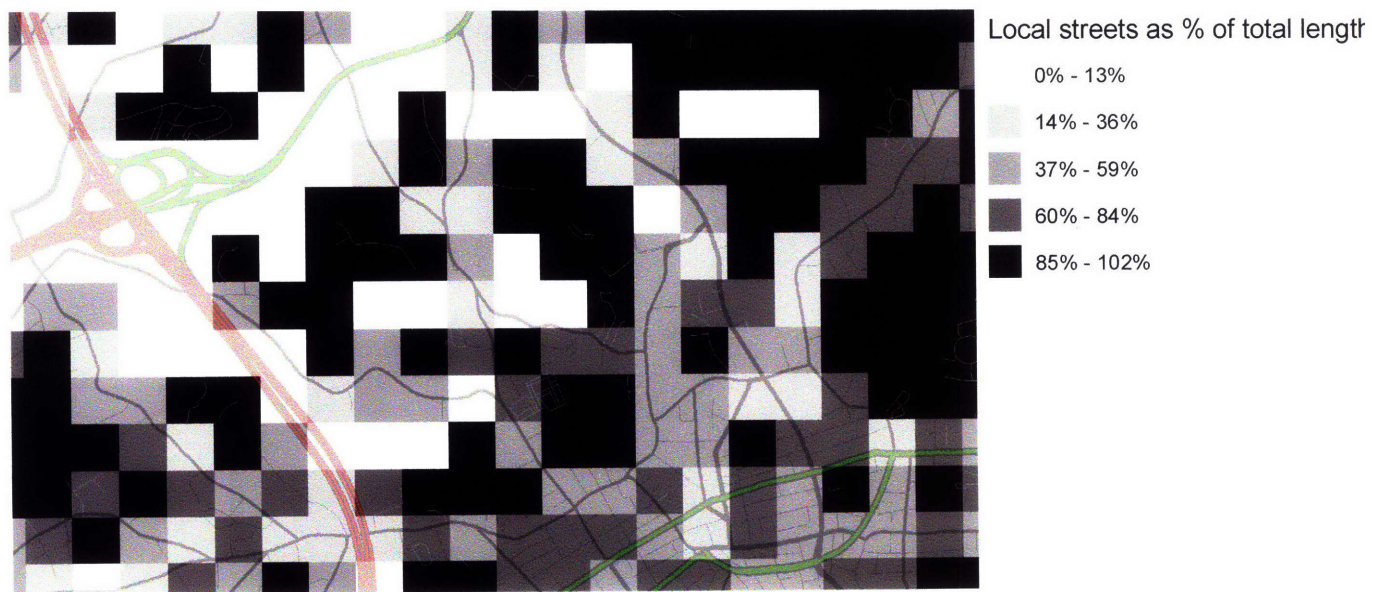


Figure 6-17. Street network measurements: Dead-end streets

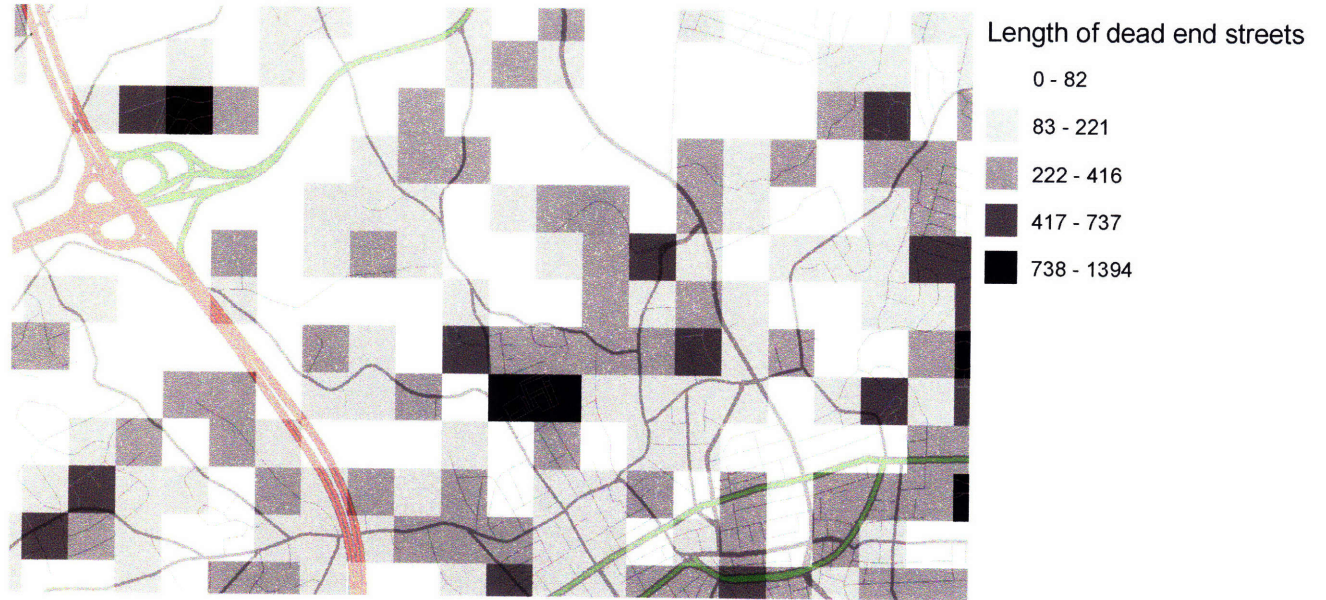


Figure 6-18. Street network measurements: Intersection density

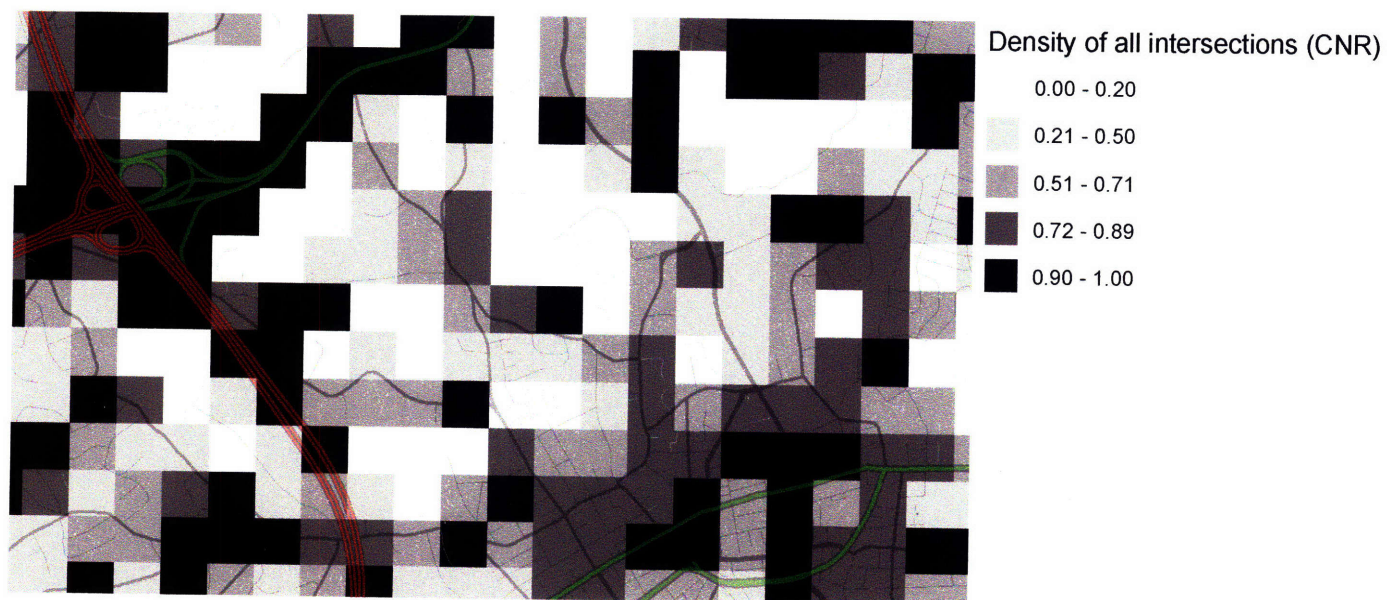
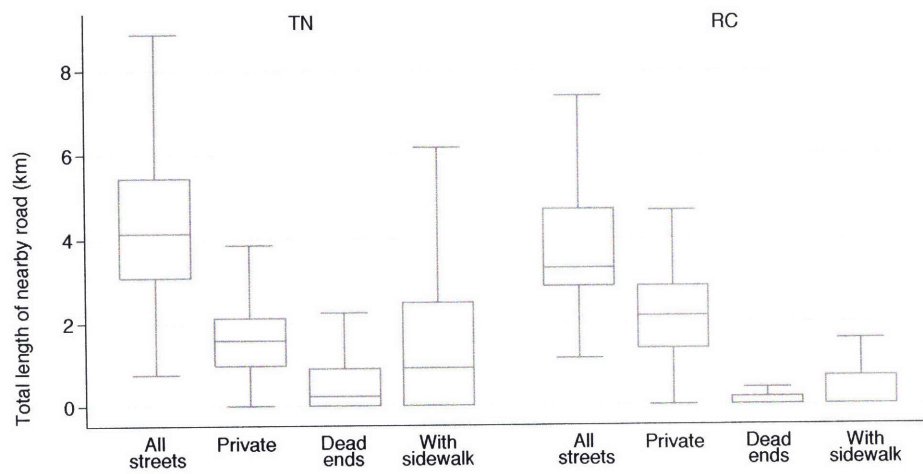


Figure 6-19. Street network measurements: Sidewalks



Figure 6-20. Greater road density in TNs



6.6 Control measures

Local demographics, regional characteristics of the built environment and the transportation system also affect travel behavior. Here I characterize these in four groups:

- **socio-demographics** describe characteristics of the individual trip-maker;
- **household demographics** describe the number of residents, vehicle ownership, etc;
- **transportation supply** measures highway access and public transport services; and
- **distance** measures how far downtown and local centers are.

Individual and household demographics are gathered by the survey instrument. Demographics at the neighborhood level of each sample are gathered from the census to provide comparisons between the survey sample and the context that samples were drawn from.

6.6.1 Household

Table 6.4. Measurements of household demographics
Census field names used are listed.

Measure	Source	Aggregation
% boomers	Census	Block group
% elderly	Census	Block group
Median household income \$ (INC_MED_HS)	Census	Block group
% households with low income (INC_LOW)	Census	Block group
Median year structures built (BUILT_MED)	Census	Block group
Median value of owner occupied units \$ (VL_MED_OWNER)	Census	Block group
% owner occupied housing units (OCC_OWNER / TOT_OCC_HS)	Census	Block group
% occupied housing units with solo inhabitant (OCC_1PER / TOT_OCC_HS)	Census	Block group

All household control measures were calculated from census data at the block group, shown in Table 6.3. All data are directly queried from the census block group data files for the block groups within the study area. No aggregation is carried out. Some simple calculations are done to turn raw household counts into percentages, e.g. % renter

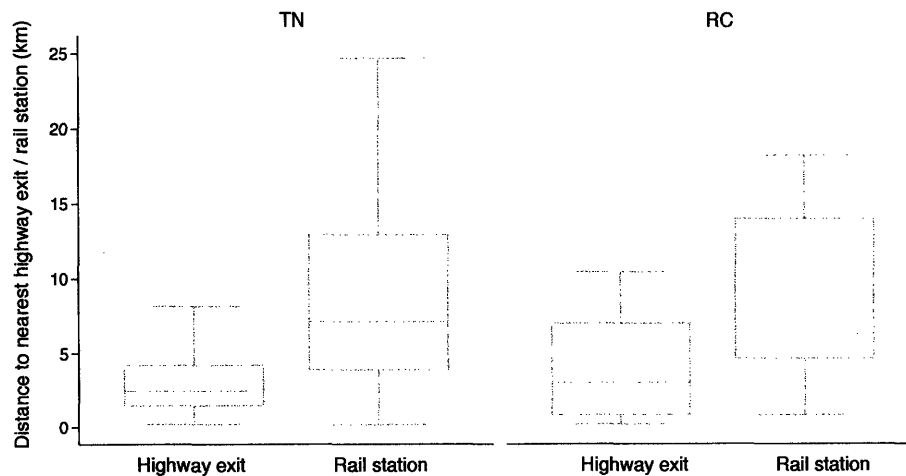
occupied housing = Number of renter occupied units / total occupied units, using the listed census field names.

6.6.2 Transportation and distance

Given the suburban nature of all locations in the study, no measures of public transport are taken, other than the straight-line distance from each sample grid square to the nearest commuter rail station. Access to highways was calculated by computing the straight-line distance to the nearest highway on-ramp. For each sample location, the straight-line distance to downtown Boston was calculated.

Access to rail and highways varies between neighborhood types. This is likely due to the centralized location of RCs, compared to the relative spread of TNs. Residents of a TN in the sample can reach a highway exit within 3.1 km, compared to 3.9 km for RCs¹². TNs are more spread when considering rail stations, as the comparison of distributions in Figure 6-21 shows.

Figure 6-21. Distance to transport facilities



¹² $t(1,282)=5.12, p < 0.0001$

6.7 Comments on built environment characteristics

The measures discussed in this chapter show the sample to be suburban, with very little land use diversity. This characterization is useful for the modeling process, though some measures may not show correct values for density and road networks because construction has occurred since data were recorded.

Comparisons between the neighborhood types has limited benefit. This information tells us nothing about all residents of the metro area, so the findings cannot be applied to suburban residents in general. The characteristics only apply to these geographically biased clusters of neighborhoods. When comparing between neighborhoods, the observed values for RCs are skewed by the larger RC locations, due to the concentration of samples in a small area. In contrast, the matching samples are widely spread, leading to a bigger range of values for the larger number of TN sample locations.

There is potential for innovation in the measurement of built environment characteristics: the land use diversity index I use does not capture differences between the suburban locations, and the road network measures are not fine-grained enough to record differences at the neighborhood scale without extensive manual data collection. The estimation of travel models in the next section finds none of the built environment characteristics to be significant - this suggests either a lack of built environment influence on travel, or measures that do not capture the relevant effects. I discuss some alternative measures in the final section.

7 Travel behavior of suburban boomers

This chapter details the results of the travel survey, including boomers' demographics, residential and travel attitudes and travel behavior. Comparisons are made between the study groups and with travel and demographic data for the region.

7.1 Summary of travel behavior findings

Table 7.1. Summary of differences between neighborhood types. Each finding is discussed in more detail later in this section, including comparisons with regional travel behavior from the 1995 NHTS.

Travel behavior	RC/TN differences	Refer to
Weekly miles driven	No difference	page 121
Trips per week	More in RC	page 124
Local trips	More in RC	page 125
Travel as auto passenger	More in RC	page 132
Walk from home	More in RC	page 133

The survey identifies differences in travel behavior between neighborhoods types (Table 7.1). In more detail, the survey findings are summarized below. Trips taken and household demographics are summarized in Table 7.2 on the next page.

Sample locations display expected characteristics: residents of the sample areas have high incomes, live mostly in single family homes, are mostly in good health and are auto-dependent for most travel. The two types of sample neighborhood are well matched and also match the regional demographic trends for this age group. The sample matches the wider similar travel to the region: high auto use, similar levels of walking and cycling. The lack of variation and expected characteristics indicates that the sampling process has produced a comparable group, despite the wide geographic spread of locations.

Age-restricted neighborhoods are associated with more walking and more local trip activity, including more social visits to neighbors. RC residents also report more ride sharing. These travel outcomes are all in line with the idea that RCs support a local travel pattern not found in TNs.

There is no evidence to support the hypothesis that local trips replace regional travel: trip rates are similar between neighborhood types, measured using daily and weekly rates. Resident of RCs travel slightly further, and make slightly more regional trips.

Residents in RCs seem to have chosen denser neighborhoods that satisfy requirements about a homogenous demographic, while attitudes in TNs are more varied. Both types of neighborhood have similar travel attitudes: enjoying or neutral about driving, and do not find public transport convenient.

All these results have statistical significance but are often the result of small variations between groups. Limitations of the survey scope, completeness of responses and the complexity of this topic make categorical findings difficult. Within these limits, there are still differences that appear to be an interaction between residents' preferences and their neighborhood's features, leading to certain travel outcomes.

Table 7.2. Descriptive statistics for reported travel by neighborhood, including trip rates.

	TN				RC			
	n	median	mean	SD	n	median	mean	SD
<u>In a typical week</u>								
Distance traveled by car (miles)	1,104	120	169	159	437	150	176	145
Commute duration (minutes)	983	30	46	58	336	40	49	56
<u>In the previous week</u>								
Total trips made	1,054	13	13.5	6.6	394	13	14.6	7.1
Neighborhood trips	1,116	2	2.8	2.9	438	3	3.8	3.3
Regional exercise and social trips	1,170	1	1.9	2.3	454	1	2	2.4
<u>From travel diary</u>								
Daily travel distance (miles)	736	34	46	40	284	48	55	38
Daily trip count	919	4	3.7	2.3	341	4	4.0	2.5
<u>Household information</u>								
Number of residents	918	2	2.2	1.1	326	2	1.8	0.53
Number of vehicles	920	2	2.2	1.0	326	2	1.8	0.7
Number of bicycles	907	1	1.3	1.3	324	0	0.8	1.0

7.2 Response rate

The total yield of reply envelopes was 1,650. Before quality control, the bulk totals of responses was 2,175 diaries containing a total of 7,475 trips. However, the usable totals are lower. For the following reasons, some responses were excluded from analysis.

Categories are not mutually exclusive, sample sizes refer to households:

- Some addresses could not be located in the metro area, or were mailed to a PO Box. These responses cannot be analyzed for their neighborhood characteristics and so were excluded. $n=55$.
- A neighborhood of non-restricted homes was erroneously included from the town of Danvers, where a possible RC had been targeted but was not included in the final sample. $n=58$.
- Some households did not return the household diary page, so information about age restrictions in the neighborhood, income, household size, etc. are not available. $n=164$. Based on expected RC locations, 42 locations without a returned diary page were imputed to be age-restricted, and are included in the RC totals without any other household demographic information.
- Households where no completed diary booklets were returned. $n=21$.
- Households where all diaries were completed by adult younger than 55 years (i.e. both diaries if two were returned, and one diary if only one was returned). $n=102$.
- Households where the relationship to primary income earner was indicated as 'son' or 'daughter'. Although grown-up children are not excluded from age-restricted communities, their attitudes on travel and residential preferences are likely to be different from the boomer demographic. The role of adult children on residential location choice would also not be clear. $n=13$.
- Households where one or both respondents was over 75 years, considered the threshold to being 'older elderly' and different travel, health. $n=22$

The final household sample size is 1,284, shown in Table 7.3. From these households, 1,698 personal booklets were obtained, shown in Table 7.4. The number of responses from each location is mapped in Figure 7-1. In tables, some totals will differ due to missing items in some samples.

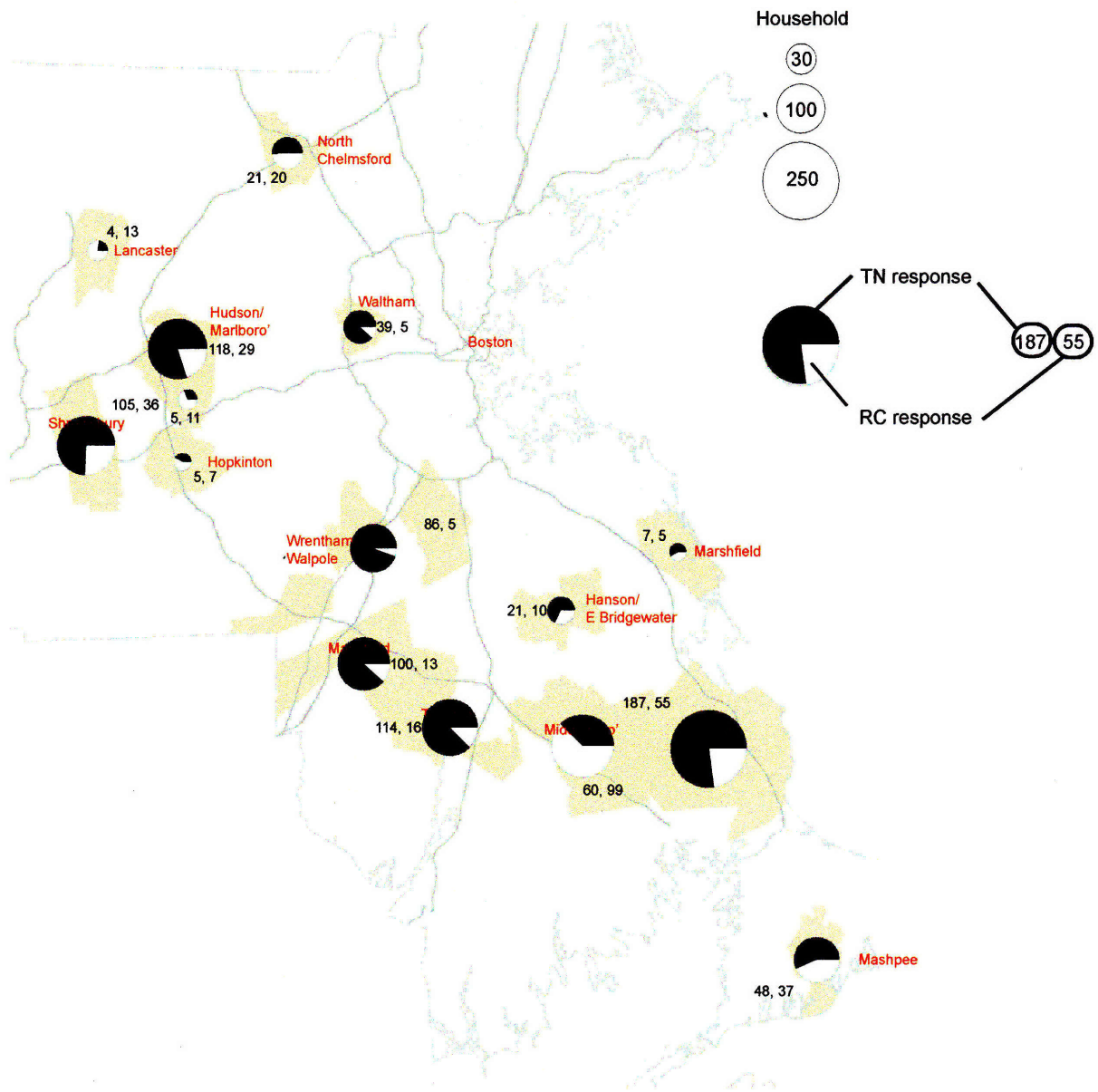
Table 7.3. Total households in the sample, after controlling for problem responses.

	Restricted Community	Typical Neighborhood	Total
All residents 55-65	260	561	821
One resident not 55-65	103	360	463
Total	363	921	1,284

Table 7.4. Totals of individual responses in the sample, after controlling for problem responses, by neighborhood.

	Restricted Community	Typical Neighborhood	Total
All residents 55-65	320	716	1,036
One resident not 55-65	165	497	662
Total	485	1,213	1,698

Figure 7-1. Geographic distribution of survey responses
 Samples are grouped into town clusters. The size of each pie is proportional to the number of responses. White pie wedges represent RC responses, black wedges show TN responses, generally the majority from each area.
 Basemap from MassGIS.



7.3 Household and home information

Samples are treated as geographically homogenous, without differentiating between different locations. This ensures a large enough sample size for both RC and TN neighborhoods.

7.3.1 Household size

Households in the sample are slightly smaller than those around them, 2.1 people compared to 2.7 according to the 2000 Census. Between neighborhood types, households in TNs have more residents on average, 2.1 compared to 1.8 people¹. Almost all homes within RCs occupied by only 1 or 2 people, as Table 7.5 shows. The larger households in TNs may have resident children or other extended family². Differences in household size may have some effect on travel behavior, but this can be controlled in the model with a series of dummy variables.

Table 7.5. Household size. Number of residents in the home, all ages, as reported in the household section of the survey instrument.

	TN	RC	Total
<i>n</i> =	918	326	1,244
Total reported residents	%	%	%
1	23	22	23
2	51	74	57
3	13	3	10
4	7	1	5
5	6	0	5

7.3.2 Income

Survey respondents are well off: more than half of households have income in the ‘high’ bracket of the census income data (earning greater than \$75,000 per year)³, and

¹ $t(1242) = 6.04, p < .001$

²At least one survey respondent must have been in the boomer age bracket for the sample item to pass initial quality control screening.

³Income was reported as total annual household income in 9 categories: less than \$15,000; \$15,000-\$24,999; \$25,000-\$34,999; \$35,000 to \$49,999; \$50,000 to \$74,999; \$75,000 to \$99,000; \$100,000 to \$150,000; \$150,000 to \$199,000; \$200,000 or more. The top four categories are equivalent to the Census high income bracket. Where mean incomes are used, the categories were recoded to represent the floor in each category, apart from the lowest category which was set to its midpoint (\$7,500).

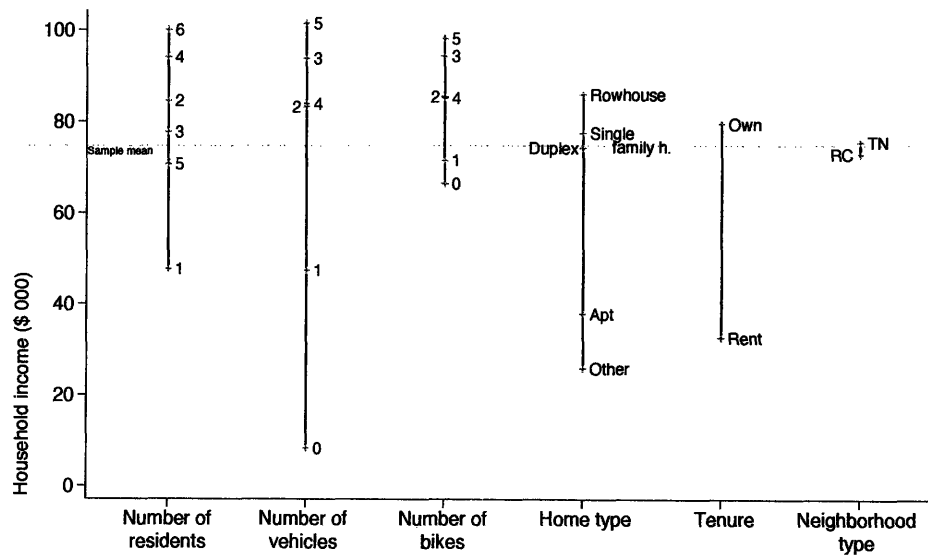
respondents are significantly more likely to be in this bracket than the average within the sampled areas⁴ (Table 7.6).

Table 7.6. Income distribution of households, by census income categories. There are no differences in households in each group between neighborhood types. The regional comparison shows income for all census block groups for the areas that samples are drawn from. Sampled residents are much more likely to be in the high income bracket than a resident in the region.

%	TN	In sample RN	All samples	<i>Regional</i>
	<i>n</i> = 836	<i>n</i> = 291	<i>n</i> = 1,127	
Low	8	9	9	18
Medium	40	41	40	47
High	52	50	51	35

Within the sample, incomes are not significantly different for households between neighborhood types, suggesting that the sample locations are well matched in income distribution.

Figure 7-2. Household income variation



Mean household income varies for different groups, though because the income was reported in categories we cannot estimate the true size of the difference. Retired people have lower incomes, as do households with female residents. Households with workers, rail and MBTA pass holders all earn more, shown in Figure 7-2.

⁴ $z=13.4, p < 0.0001$

7.3.3 Vehicle, bicycles and rail passes

Vehicle ownership is high and most households have two cars, as shown in Table 7.7. Households in RCs have fewer cars: 1.8 vehicles per household compared to 2.2 in TNs⁵. Controlling for dwelling type by only looking at households in single family homes does not account for this difference, but family size does: there is no significant difference in the number of vehicles per family member, RC = 1.00, TN = 1.05. The ownership distribution is very similar to the region, with slightly fewer households having no vehicle and more having two.

Table 7.7. Vehicle ownership, by neighborhood type with regional comparison.

	In sample			Region
	TN	RC	All	
n=	921	363	1,246	-
Number of vehicles	%	%		%
No vehicle	1	2	1	5
1	25	28	26	33
2	46	59	49	47
3	18	9	16	11
4	7	2	6	3
5 or more	3	<1	3	1

There is a higher rate of bike ownership outside age-restricted communities⁶, which is not accounted for by household size, Table 7.8 on page 114 has the detail. Overall 548 homes have no bikes at all, whereas only 12 have no vehicle. The distribution of cycle ownership for the region is similar to the sample - according to NHTS 2005, 49% of Boston metro households have no cycles, 16.8% own one, 20% two and 13.6% three or more. This survey did not specify 'full sized' cycle so there is probably some over-reporting compared to the NHTS figures. The lower rate of ownership in RCs could be due to the absence of children and households having moved recently, though there is no relationship between years of residence and number of cycles in the household (one might expect empty nesters to not bring old bicycles from a previous home).

A small number of respondents hold a commuter rail (3%) or T pass (4%), with no difference in ownership rates between neighborhood types.

Figure 7-3. Home unit type, grouped by sample area



Table 7.8. Bicycle ownership

	TN	RC	All samples
n=	907	324	1,231
	%	%	%
No cycles	41	56	45
1	21	19	21
2	23	22	23
3	9	2	7
4	4	2	4
5 or more	2	< 1	2

7.3.4 Home type

The majority of respondents live in a single family home, 72%, with only 8% in an apartment or condo. 40% of RC households live in an attached duplex or rowhouse, compared to 13% of TNs (Table 7.9). This may indicate more compact living within RCs, also reflected in residents' attitudes about space between homes (see page 134). The 2000 Census indicates that 63% of housing units in the surrounding area are single family homes, suggesting the sample neighborhoods have a higher proportion of single family homes⁷.

Table 7.9. Type of home, by neighborhood. Most households in the sample are single family homes.

	TN	RC	All samples
Home type	%	%	%
Single family	77	56	72
Duplex, townhouse	14	39	20
Apt, condo	9	5	8

There is some geographic variation in home type by sample area, though in general single family homes represent between half and three-quarters of the sample at any location. Looking at the types of units reported from each sample area (Figure 7-3 on the previous page), the most different areas are Waltham, with a higher number of apartments, and Norton.

⁵ $t(1244)=5.40, p < .0001$

⁶TN $\bar{x}=1.2$, RN $\bar{x}=0.8$, $t(1229)=5.87, p < .0001$

⁷Census 2000. The data are not directly comparable between the Census and survey, because the Census classification for detached single occupancy unit can include row houses, and the distinction between apartments and duplexes is not clear.

7.3.5 Tenure

Home ownership is high across sample, with more owners within RCs⁸ (Table 7.10). Compared to the wider area, the sampled households have a much higher proportion of ownership.

Table 7.10. Tenure status for all households in the sample. Ownership rates are much higher in the sample than the surrounding area. Regional data for block groups in sampled locations, Census 2000.

Tenure status	TN	In sample		Regional
	%	RN	All samples	%
Own	91	95	92	74
Rent	9	5	8	26

7.3.6 Years of residence

Residents of RCs have been living there for fewer years: the mean years of residence for a household in a RC is 4.6, compared to 19.0 for TNs⁹. The difference is apparent in the histogram of residential duration, Figure 7-4 on the following page. There are a few RC residents who report long durations of residence, visible around the 30 year mark. These locations are spread across multiple sites and are not similar to other responses nearby, which suggests a response error (perhaps interpreting *How long have you lived at this address?* to mean neighborhood rather than the specific home). The histograms do not show the 5% of respondent households who reported to have been resident for longer than 40 years, all residents of TNs.

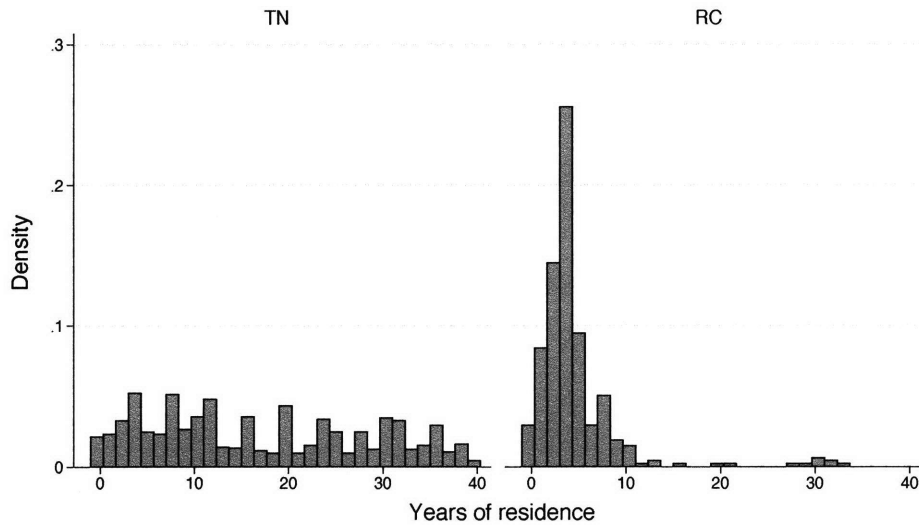
Ninety six percent of RC residents moved to their current address in the last decade, and are less likely to move again in the next few years - only 8% indicated this compared to 15% of TN residents. However, 34% of RC residents say that they will move again in the future at some point. Across both neighborhood types, 56% indicate intent to move again eventually. This contrasts with the consensus among the boomer focus group respondents that their current neighborhood is 'final', and may reflect the active nature of this sample, with most household members still working.

Years of residence and questions about moving were asked in the travel diary booklet rather than the household sheet, so for households with more than one respondent there

⁸ $z = -2.29, p < 0.05$

⁹ $t(1243) = 19.74, p < 0.001$

Figure 7-4. Years at the current address, by neighborhood type



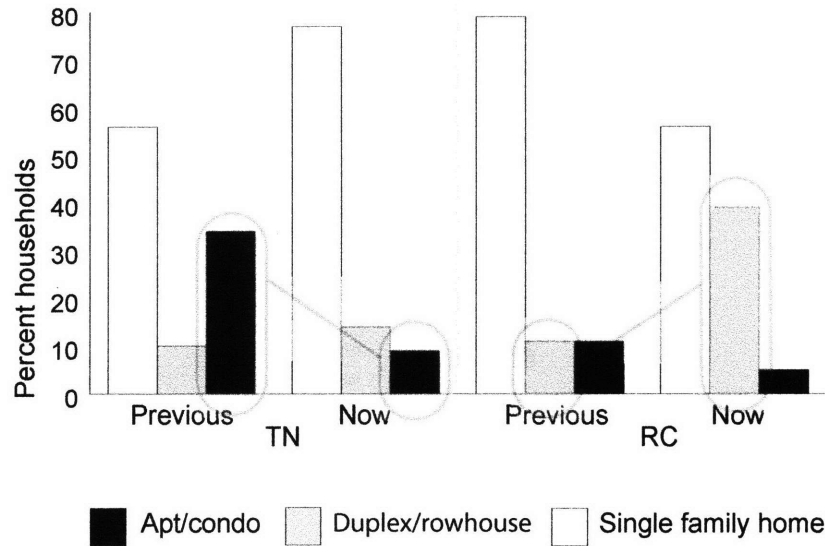
may be differences in the responses between residents, either due to error or genuine variation in duration of residence (e.g. one resident may have moved in first, then the second person joined the household). The same condition is true for responses about the previous neighborhood: reported differences in neighborhood characteristics may be erroneous recall, or the residents may have come from two different locations before living together in the current neighborhood. For analysis of years at the current address, only households where both diaries were in agreement were used.

7.3.7 Comparisons to previous home

Respondents' patterns of previous and current home type are complex, and vary between neighborhood type as well as by previous home. Two trends are noticeable in Figure 7-5. Firstly, residents of RCs are moving out of single family homes and into multi-family units, partly a result of this being a more common home type in these masterplanned neighborhoods (which itself might be a response to consumer downsizing demand from this demographic), but also an indication of downsizing in exchange for other benefits that come with the age-restriction. The second trend possibly reflects broader suburbanization trends, with residents of TNs moving from apartments and condos (third bar) to single family homes - which could have happened many years ago, since the median duration of residency in a TN is 19 years.

Figure 7-5. Previous and current home type.

The two trends discussed on page 116 are highlighted on the chart - residents in TNs moving out of apartments, and residents of RCs moving into duplex or rowhouses.



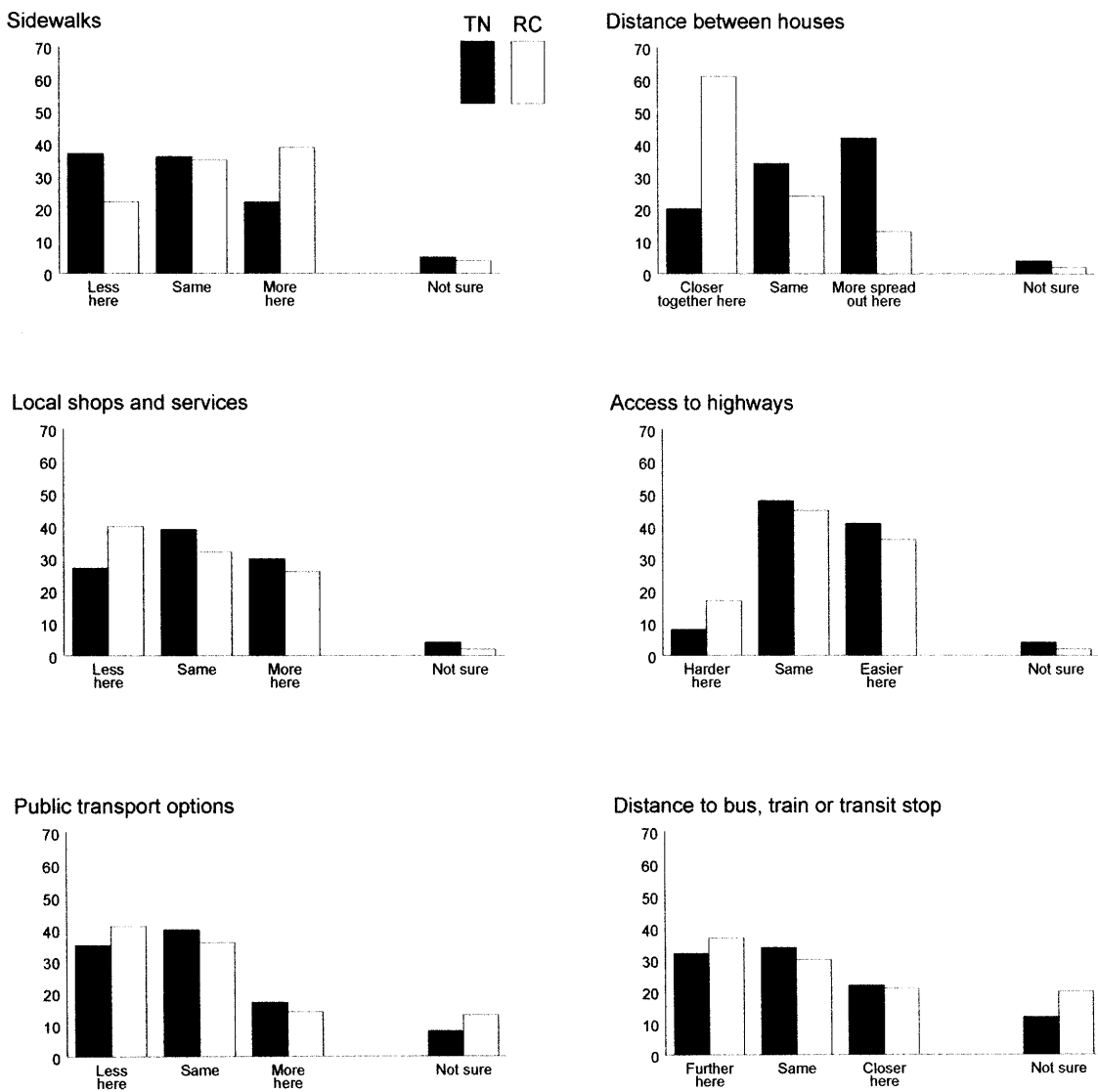
7.3.8 Comparisons to previous neighborhood

The survey asked residents to compare their current neighborhood to their previous location, focusing on sidewalks, access to public transport, distance between homes and access to local services. Residents of RC are likely to consider their neighborhood to be more urban than the previous one, based on responses to questions about sidewalks and density. When considering the presence of sidewalks, residents in a RC are much more likely to indicate more sidewalks in their current neighborhood (40%, compared to 23% of TN residents). Restricted neighborhoods are much more likely to have houses closer together than the previous neighborhood (62% indicated more, compared to 21% in TNs). Residents in unrestricted neighborhoods find their current location offers more retail and services than their previous one.

Figure 7-6 on the next page shows the responses to each question. The level of non-response and *Not sure* answers are combined in the fourth column pair. The variation is constant across questions, apart from the final two about public transport. The higher uncertainty about this topic may be a result of the lack of use and information about transit options, which seems to be greater in RCs. The chart shows the percentage split of responses across the four options (less, same, more, not sure), with TN responses in black bars and RC in white.

Figure 7-6. Perceptions of current and previous neighborhood.

The survey asked, *Consider this neighborhood and compare it to where you previously lived. How do they compare in the following categories?* For example, for the option *Sidewalks*, residents indicated that their current neighborhood has fewer sidewalks, about the same or more. Results in each category are shown in the figure, comparing the percent of responses in each neighborhood type. Black bars show typical neighborhoods, white bars show restricted communities. Each chart reads from left to right: less here, about the same, more here.



Although these indications suggest that residents in the two types of neighborhood are sorting by preference for certain features, there is no baseline to compare against. So although residents in a RC appear to be flocking to enjoy more sidewalks, their counterparts in a nearby TN may have lived with an equally good provision of sidewalks in both previous and current locations, but now be enjoying even greater local services than before. As an observation of more/same/fewer, there is also no way to assess the magnitude of the difference beyond its basic direction (i.e. there is no indication of how much less or more).

7.4 Respondent demographics

7.4.1 Age, sex and employment

1,698 responses were received from households with at least one resident boomer. More respondents are female, but there is no significant difference in gender balance for the boomer age group in the sample area, compared against Census 2000. Within RCs, the disparity is greater with 56% of diary booklets completed by a woman¹⁰.

More respondents in RCs are retired compared to TNs, 44% compared to 25%¹¹. In the overall sample, the majority of respondents are in the labor force, with 64% in full or part time employment. Table 7.11 gives a breakdown of location, gender and employment status by neighborhood type.

Table 7.11. Employment status, sex and neighborhood type

	TN %			RC %			Total %		
	Male <i>n</i> = 593	Female 607	Both 1,200	Male 210	Female 272	Both 482	Male 803	Female 879	Both 1,685
Full time	60	49	54	34	29	31	53	43	48
Part time	9	18	14	16	22	19	11	19	15
Retired	28	22	25	50	39	44	33	27	30
Homemaker	1	9	5	0	8	4	0	8	5
Seeking work	3	3	3	0	2	1	2	3	2
Total	100	100	100	100	100	100	100	100	100

7.4.2 Health

Most of the sample are in good health: 82% indicated that none of the responses associated with physical, mental or emotional problems applied to them. The detail of the physical activity scale gives a variety of measures that can be used in the modeling process, though the total number of responses to any set of questions is small (see Table 7.12 on the facing page).

¹⁰ $z=2.17, p < 0.05$

¹¹ $z=7.28, p < 0.001$

Table 7.12. Reported health for the whole sample.

Read the table vertically. For example, 83% of the sample indicated no health problems (first column), 2.4% indicated problems preventing work and limiting their activities (4th column). There are no differences in reported health between the neighborhoods. Response combinations with fewer than 0.5% response are omitted. The response ‘Need help with personal care’ is omitted for the same reason.

No health problems	●	○	○	○	○	○	○	○
Health problems keep from working	○	○	○	○	●	●	●	●
Need help with routine needs	○	○	○	○	○	○	○	●
Need help with personal care	○	○	○	○	○	○	○	○
Limited in activities	○	●	○	●	○	●	●	●
Problems restrict the work I can do	○	○	●	●	○	●	○	●
Total (%)	83.2	4.2	3.1	2.4	1.9	1.6	0.9	0.6

7.5 Total distance and commute duration

The survey instrument offers three measures of travel activity: questions about commute distance and duration, a retrospective diary of a week of travel and the daily trip diary.

7.5.1 Total distance traveled per week in a vehicle

Nearly all survey respondents travel by car every week, 171 miles on average with wide variation (sd = 155 miles). 120 miles is the median distance. Some travel much further, as the distribution in Figure 7-7 on the next page shows. The chart shows some clustering in response values around approximate distances such as 200, 300, 400, and excludes an outlying data point at 1,500 miles per week. The response was not structured or prompted (e.g. residents were not asked to document daily travel and compute a total), so estimates are likely to vary in accuracy.

There is no difference in reported weekly miles traveled between neighborhoods. Distance traveled varies across other subgroups, as shown in the chart of mean distances by group, Figure 7-8 on the following page. Workers¹², men¹³ and boomers¹⁴ travel further. Household income and car ownership are both associated with increased distance. The result of not owning a vehicle is shown in the low weekly distance travelled by households without a car. Living alone makes no difference to the total distance travelled.

No other data on miles driven per week are available for the Boston area to provide a comparison. One comparison comes from a 2001 study of drivers aged over 55 in southern

¹² $t(1,529) = 11.8, p < 0.001$

¹³ $t(1,531) = 6.49, p < 0.001$

¹⁴ $t(1,531) = 3.00, p < 0.01$

Figure 7-7. Reported distance travelled per week in a vehicle, by all respondents

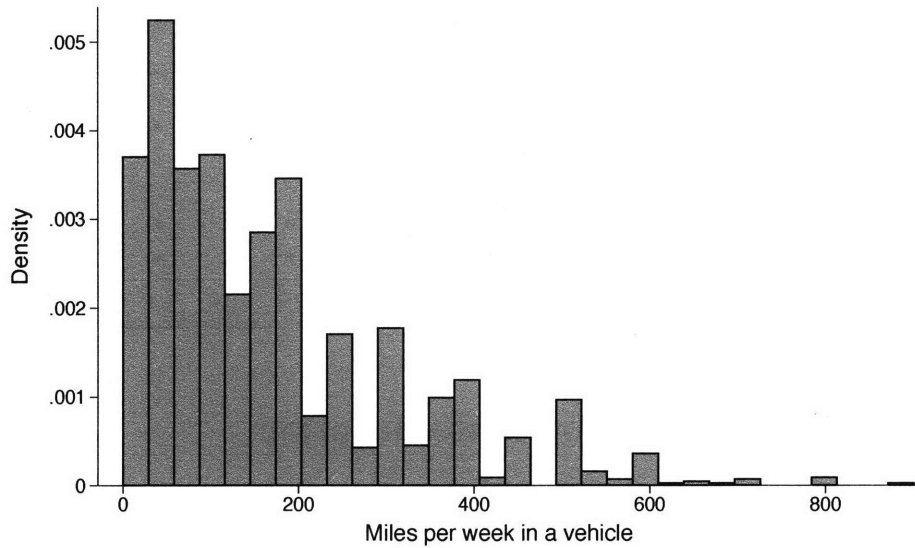
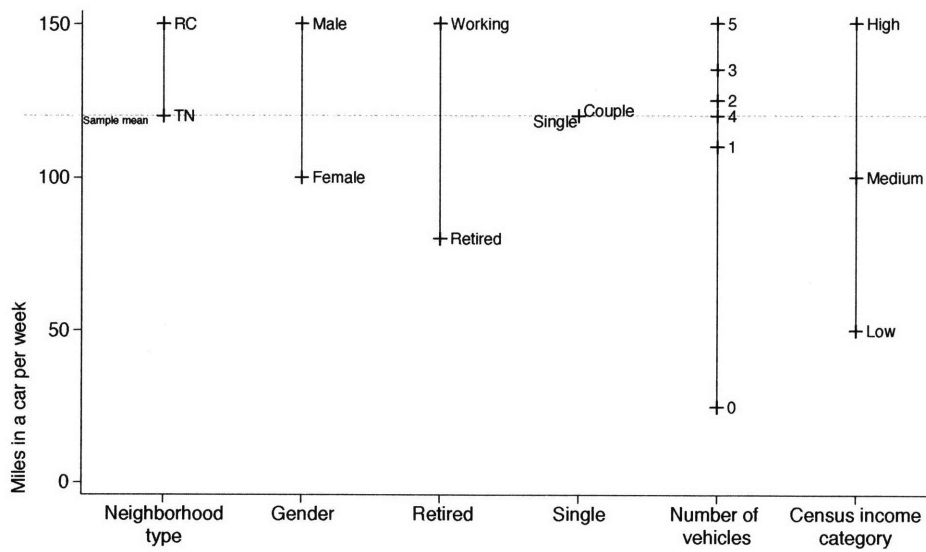


Figure 7-8. Distance travelled per week, by subgroup

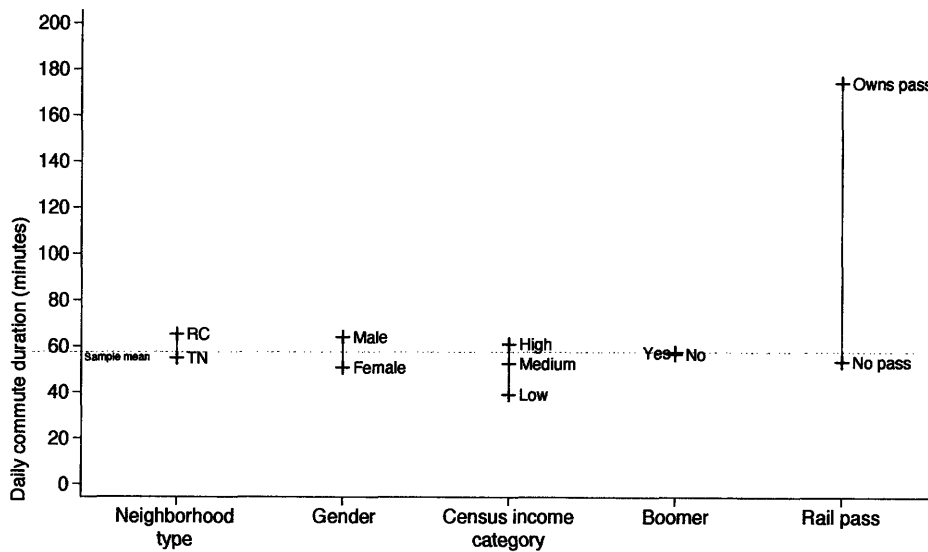


California, by Dellinger et al. (2001). Using the same tabulation brackets of <50, 50-100 and >100 miles per week, proportions of the sample in each brackets are (California-Massachussets): 31-19%, 35-27%, 34-54%. This suggests that the Boston older adults are driving further. The subjects in the California study are older (mean age=74 years), which could account for the lower rate in that study¹⁵.

For commuters, the duration of daily commute averages 60 minutes with wide variation (sd = 48 minutes), with similar group effects to miles travelled per week (see Figure 7-9). Residents of RCs spend longer commuting¹⁶, but all variation in commute is dwarfed by the very long daily commutes reported by holders of rail passes. Respondents' estimates for commute duration are probably more accurate than their estimates of miles driven per week. These averages exclude 99 residents who are employed but reported a commute of zero minutes, perhaps working from home. Four residents reported a 10 hour daily commute, also excluded as a probable response error.

Figure 7-9. Commute duration

All differences except boomer are significant. Neighborhood type: $p < 0.001$. Gender: $p < 0.001$. Income: $p < 0.01$. Boomer: $p > 0.05$. Rail pass: $p < 0.001$.



¹⁵1,686 current drivers aged over 55 years reported miles driven per week. The study used a longitudinal cohort selected in the 1970s for study of lipids and health, so there is no bias in the study focusing on cessation

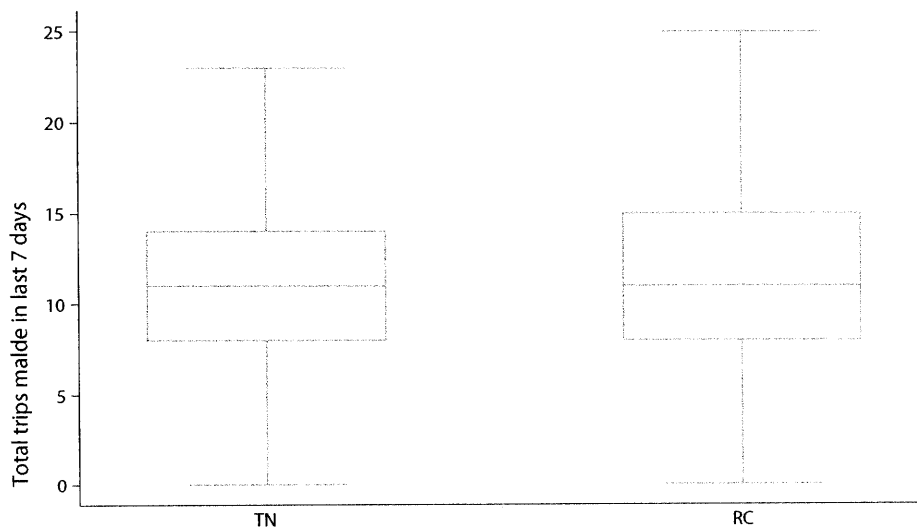
¹⁶ $t(1,014) = 3.66, p < 0.001$

7.6 Retrospective trip rates

Retrospective trip counts give an overview of all trips made during the previous week. Knowing local activity rates in different neighborhood types gives an indication of activity levels and provides evidence to help understand if RCs are associated with different travel outcomes. The measure of all trips has limitations, two assumptions are made: firstly, that respondents viewed the regular journeys categories in the survey as mutually exclusive and comprehensive. Secondly, a missing item can reasonably be imputed as zero trips if the majority of other trips types were recorded (for example, a retired person might reasonably leave the two trips to work records blank since she already indicated 'retired' earlier in the survey booklet). If more than three items were left blank, no imputation was carried out. 9% of samples have one trip count imputed, 4% have more than one.

Respondents reported a median trips per week rate of 13, from the retrospective trips record for the last 7 days of travel. There is a small difference between neighborhood types in the overall rate of trip making: a mean of 13.5 trips in TNs compared to 14.6 in RCs¹⁷, shown in Figure 7-10.

Figure 7-10. Distribution of total trips
Residents of RCs have a similar median trip rate, but higher mean.



¹⁷ $t(1,446) = 2.69, p < 0.001$

7.6.1 Trip types and frequency

Trip frequency varies by type of trip, with some differences between neighborhood type. Figure 7-11 on the following page shows two relevant measures for each trip type: the proportion of respondents who made no trips during the previous seven days; and trip frequencies, split by neighborhood type.

Common to both neighborhoods, trip rates are either heavily skewed to the right with most people making none or a few trips (e.g. exercise, neighbor visits), or approximately normally distributed (e.g. shopping). Driving to work is the only exception: making a trip 5 times a week to work, with 63% of TN residents making drive to work trips compared to 48% in RCs. Trips on public transport are extremely rare.

Differences between neighborhoods can be seen in the zero-trip pies, where no trip of that type was made. RC residents are less likely to go to work, more likely to visit a neighbor, more likely to go out for recreation and walk locally. These may all be the result of higher proportions of retired people in the RCs, but may also be the result of differences in the local environment.

7.6.2 Local social and exercise trips

Residents of restricted neighborhoods make more local trips, measured by the combined frequency of walking or cycling for exercise in the respondent's neighborhood and visits to neighbors during the last week. In RCs, the mean trip rate is 3.8 trips, compared to 2.8 in TNs¹⁸. There is also a difference in the numbers not making any trips of either type: 64% of respondents in RCs made at least one trip on foot or cycle for exercise, compared to 57% of residents in TNs¹⁹. 48% visited a neighbor at least once, compared to 33%²⁰. Overall, respondents were more likely to be locally active if any of these cases is true: living in a RC; reporting good health; being retired.

All boomers in the sample make fewer walk and cycle trips than the regional median of three trips per week, as shown in Table 7.13 on page 127. A comparison of this rate to Boston metro data for walking and cycling from the 2005 NHTS, is shown in Figure 7-12 on page 128. In the region, the histogram shows that more people are walking and are walking further, indicated by the shorter bar on the left hand side, fatter midsection and longer tail. The NHTS is gathered using a more rigorous survey method including telephone interviews with prompted recall, the higher rate of walking may be a consequence of this rigor.

¹⁸ $t(1,552) = 5.56, p < 0.001.$

¹⁹ $z = 3.04, p < 0.01$

²⁰ $z = 5.95, p < 0.001$

Figure 7-11. Regular journeys, by purpose

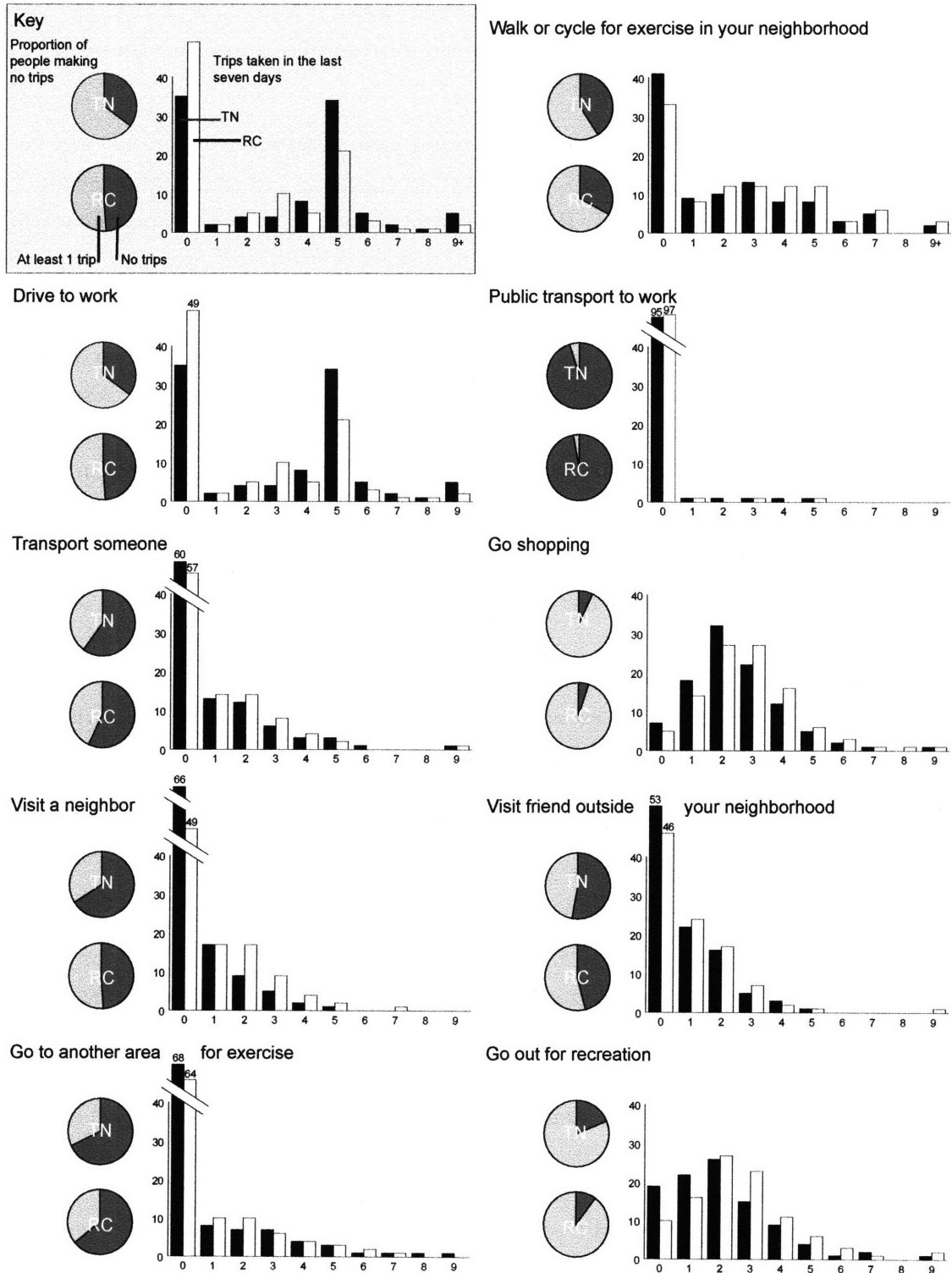


Table 7.13. Trip averages for social and leisure trips

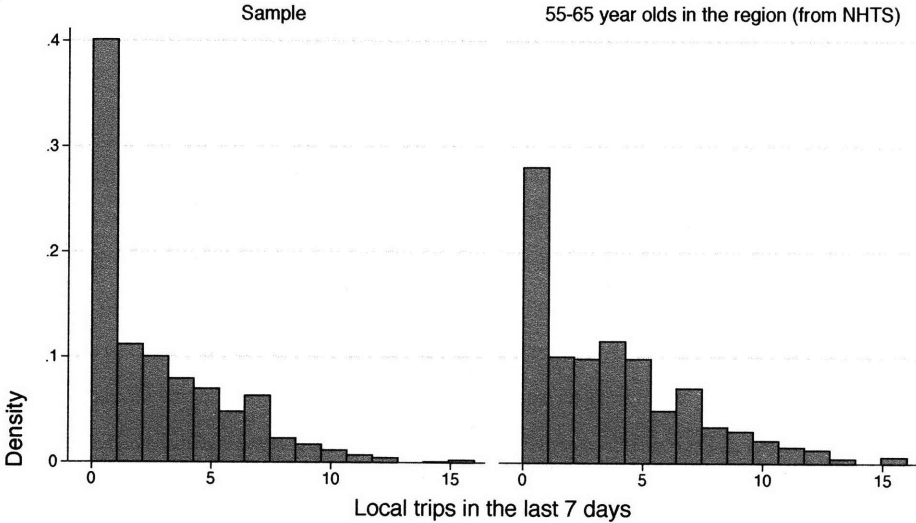
	Trip type	
	Local	Regional
Zero trip rate (%)		
RC	21.9	1.1
TN	30.1	1.4
Median trips		
RC	3	7
TN	2	6
Mean trips		
RC	3.8	7.4
TN	2.8	6.4

7.6.3 Social and exercise trips outside the neighborhood

Residents of RCs are more likely to make at least one social or exercise trip outside their neighborhood, though the mean rate of trips is not different between neighborhoods. Social and exercise trips outside the neighborhood are reported trips are to visit friends in a different neighborhood, and go for exercise in a different area. These are the complement of the local activity measures of visiting neighbors and walking or cycling locally. Although these results are all significant or highly significant and are supportive of the research hypothesis, it is worth noting that the difference in proportions observed is very small. For example, 33% of RC residents made at least one social trip outside their neighborhood, compared to 38% for TNs²¹. The difference is statistically significant due to the large sample size, $n=1,673$, but the practical implications are limited.

²¹ $z=1.87, p < .05$

Figure 7-12. Local trip distribution



7.7 Travel diaries

The trip diary provides complex and detailed information about travel patterns within the sample, with distance, mode, and duration data for a single day of travel. Given the overall hypothesis that RCs are associated with more local activity, the travel diary data should provide the following indications:

- **trip rates** – if no trip substitution occurs and all trips are recorded faithfully, including local walking trips, RCs will have more trips than TNs. If substitution of local for regional occurs, RCs will have the same number of trips.
- **trip distance** – regardless of substitution effects, distances travelled by residents in RCs should be lower, as local trips will by definition be shorter. More local travel activity could also be seen by chains that return home more frequently through the day.
- **mode choice** – more local trips and activity should be visible in a difference in walking rates between the neighborhood types.

Capturing the effect of RC on travel rates as measured by the diaries depends on the care with which recipients recorded their diary entries, and the full inclusion of non-auto and short trips. The effect of retirement could also confound the association between RCs and TN, since more retired people are in the RCs.

7.7.1 Diary sample size

A trip diary was included in each individual survey instrument. Respondents were asked to record every trip taken, including journeys on foot. To describe each trip, respondents provided: start time, end time, destination type, mode, cost, distance and weather conditions. Cost includes tolls, tickets and parking, but not gas or depreciation. Space for 10 trips legs was provided, with room to continue on the reverse of the booklet. The survey page and instructions to respondents can be seen in Appendix A. 1,698 diaries were returned in valid survey envelopes. 268 describe a trip chain that does not return home (most likely because the respondent gave up on filling in the booklet, but still returned it), and an additional 97 are incorrectly completed in some other way, or are suspected to be an incomplete record of trips made (for example, all rows in the booklet filled with a repeated pair of trips). 1,333 usable dairies remain.

158 respondents (11.9%) reported no trips taken on the survey day, by writing the date and checking the box to indicate no trips, as per the instructions. A further 73 (5.5%) did

not check the box, and did not complete the diary section. It is not possible to know if these blank diaries are because no trips were made, or are caused by the respondent giving up on the diary, forgetting to complete it, etc. When completing the survey instrument, the first half can be completed in one session immediately after opening the envelope, whereas the diary requires completion after travel. The blank diary sections indicate that people may simply have failed to complete the second half, deliberately or accidentally. Comparing blank trip diaries to reported trip rates supports this: 49 of the 73 blank trip records come from diaries where the total number of regular journeys taken in the last seven days was over 10, suggesting that these non-responders are in general fairly active. These 73 blank diaries were not imputed to be zero-trip diaries. The total diary response from different neighborhood types is shown in Table 7.14.

Respondents were asked to complete the diary on the next Tuesday, Wednesday or Thursday. Not everyone wrote the date they filled out the diary, so full information on completion is not known (16% of all diaries). Where the date was given, 74% were on the specified weekdays, with few trips occurring at the weekend (3%, n=39), as shown in Figure 7-13 on the next page. There is a significant difference in mean trip rates between weekday and weekend travel, 3.9 compared to 2.4, which could be accounted for by fewer weekend work-trips. For detailed analysis of trip rates beyond what is attempted here, weekend trips and trips without a specific travel day should be excluded.

7.7.2 Travel diary trip rates

Rates of daily travel are different between RC and TNs, mean of 3.6 trips per day taken in TNs compared to 3.8 in RC²², the median is 4 trips in both areas. Retired and workers both take around 3.6 trips (4 median). The distribution of trips between areas is similar, as shown in Figure 7-14 on the facing page. Regionally, the same median is seen for the boomer demographic, though the mean trip rate is higher, 4.6 according to NHTS.

²² $t(1,602) = 2.24, p < 0.05$

Table 7.14. Travel diary responses
Response rates are very similar between neighborhoods.

	TN	RC	Total
n=	970	363	1,333
	%	%	%
No trips	13	12	13
One or more trips	87	88	88

Figure 7-13. Day of week for trip diaries.

Respondents were asked to complete their diaries on the Tuesday, Wednesday or Thursday immediately following the arrival of the survey envelope. These days were chosen because they are least disturbed by weekend travel, though avoiding non-typical travel days may be more important when focusing on work and commuter travel.

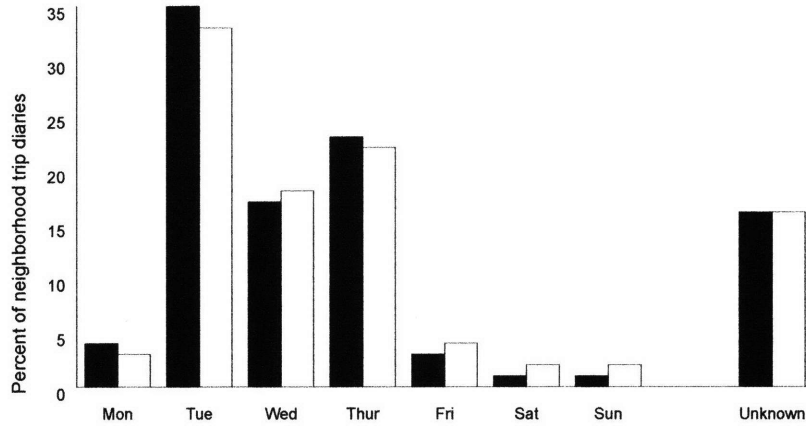
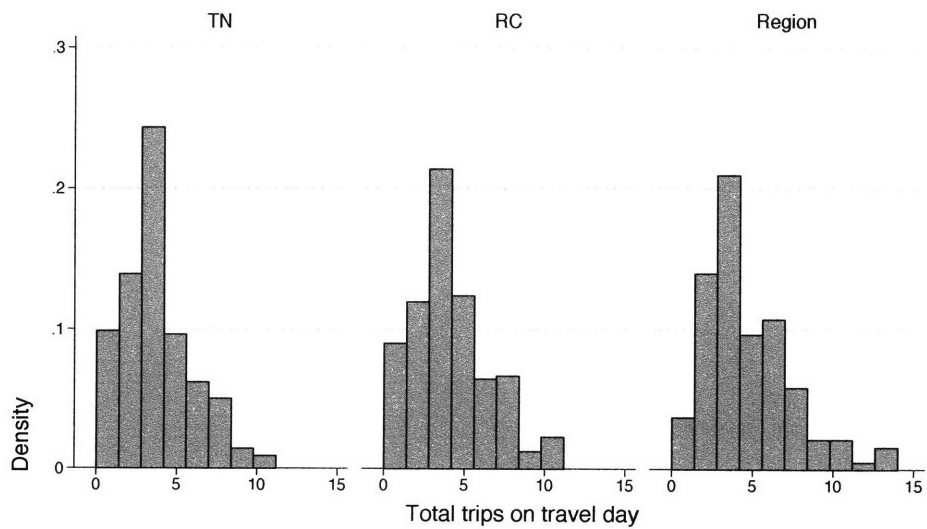


Figure 7-14. Comparison of trip rates between RC, TN and the region

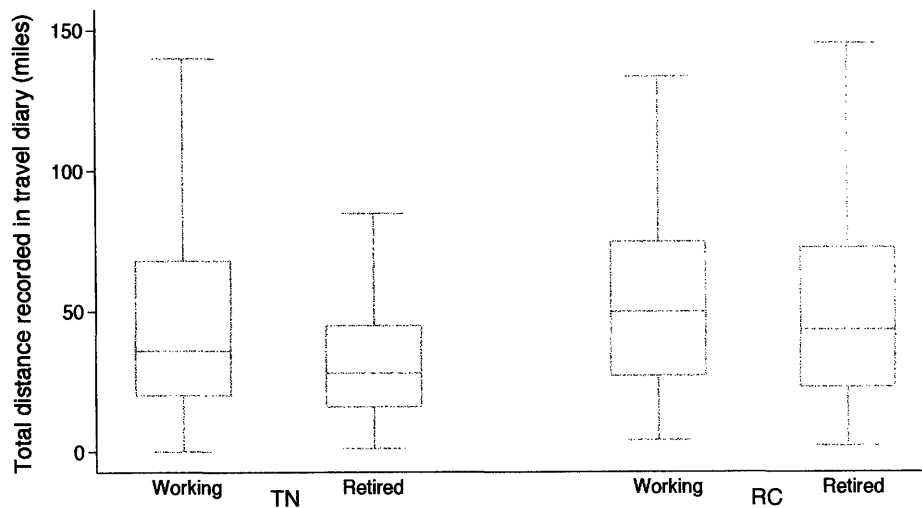


Rates of zero trip days are not different between RCs and TNs, with 9% and 10% respectively, compared to the regional proportion of 5%. This difference is again likely due to the better quality of data collection carried out by NHTS, ensuring that short local trips are still counted. However, if the difference is not due to data quality issues, it indicates that the sample in general are less active than boomers in the region.

Travel diary trip distances

The total distance reported on the diary day is 9 miles higher in RCs, 55 to 46 miles²³. Retired people travel less far, 43 miles compared to 51 for workers²⁴. The combined effect of both RC and retirement is shown in the boxplots in Figure 7-15. Workers in RCs travel further than their retired neighbors, who travel further than their respondents in TNs. Some other differences in trip rates are in line with expectations: people reporting good health travel further, women travel less far (likely due to lower levels of involvement in the workforce).

Figure 7-15. Trip distance comparison, between different neighborhoods and work status



7.7.3 Travel diary mode share

A summary of modes from all trip diaries shows that RCs seem to support more ridesharing or group travel: 13% of trips are made as a passenger, compared to TNs where

²³ $t(1,018) = 3.26, p < 0.001$

²⁴ $t(1,014) = 3.06, p < 0.05$

only 6% are and more people are drivers²⁵. This indicates that there is possibly more communal travel in RCs. Total auto share is very similar to the region, where 89% of trips by boomers are made by private vehicle, either as driver or passenger according to the 2005 NHTS. Walking occurs at twice the rate in the region, compared to the sample, but again this may be an indication of the effectiveness of the NHTS at capturing the full count of walk trips, especially in chains with multiple modes. For trips involving more than one mode, the survey used in this study may not be capturing the modes used at the start and end correctly. This evidence is not enough to suggest that people in the sample are walking less than the regional average.

Table 7.15. Mode share from trips taken on dairy day
The NHTS data are for boomers in the Boston metro region.

Mode	TN	RC	NHTS
	<i>n</i> = 3,542 %	<i>n</i> = 1,445 %	%
Private vehicle driver	87	79	89
Private vehicle passenger	6	14	-
Motorbike	< 1	< 1	< 1
Public transport	1	1	1
Cycle	< 1	< 1	< 1
Walk	5	6	9

7.7.4 Travel diary walk trips

Within the sample of good diaries, 151 days of travel included one or more walk trips, 5.2% of the total. This suggests some under reporting of walk trips because the NHTS reports 9% of all trips in the region by this age group are made on foot. I identified 95 walk trips starting or finishing at home, distinct from walk trips made at lunchtime from work, or other non-home based walk trips. Most are either at the beginning or end of the day, with several people indicating that dog walking was the reason for the trip.

Walking from home is more common in RCs: almost 10% of diaries report a walk, compared to 6% in TNs²⁶. No difference in home walking is found by gender or employment status.

People who walk locally do not make fewer trips. For the 95 trip diaries where walking from home occurred, the total number of trips reported is the same as those who did not

²⁵ $z = 7.54, p < 0.001$

²⁶ $z = 1.83, p < 0.05$

walk but the total distance traveled is shorter. Intuitively, this seems correct: making a walk trip is always going to be shorter than a vehicle trip.

An alternative measure of local activity is to measure the number of trips returning home. More returns home suggests shorter trip chains and possibly more local trips. Testing this between neighborhood types finds no difference. Retired people make more returns home, averaging 1.6 compared to 1.4 for workers, which while significant is a small actual variation. This could be an indication that retired people make shorter trip chains.

7.8 Attitudes

The survey included attitudinal questions, for later use as controls for endogeneity. There are differences in respondents' between RCs and TNs, while travel attitudes are closely matched. Residents of RCs are likely to prefer people at the same stage of life, while residents in TNs are more likely to want children in their neighborhood, and prefer a lower density neighborhood. The responses are shown in Table 7.16 on the next page.

Measures of statistically significant difference were calculated by testing the proportion of residents who *agree* or *strongly agree* in each category. For a more detailed view, comparisons of the proportions in each sample who responded to each question are shown in charts starting on page 136 (residential attitudes: Figure 7-16, Figure 7-17; travel attitudes: Figure 7-18, Figure 7-19).

7.8.1 Residential location attitudes

Responses about residential location and neighborhood type show variation between the different neighborhood types. As expected, residents in RCs are unlikely to want children in their neighborhood, and are more likely to want to live around similar residents. Variation in response to *I prefer living around people who are similar to me* compared to *...at same stage of life* suggests that residents may be demonstrating different attitudes: more TN residents agree about *people who are similar* rather than *stage of life*, perhaps indicating a preference for diversity of ages but not income or other forms of demographic variation. Only a few residents in RCs appear to be at odds with some fundamentals of their community's characteristics: agreeing about children and disagreeing about similar neighbors. Although there is no way of determining this from survey responses, there could be some desirability bias where RC residents unconsciously or consciously respond in line with common expectations about RC residents, despite any personal misgivings about the absence of children or the homogenous community. In comparison, residents in

6. Attitude differences between RC and TN residents. Residents were asked to indicate their agreement to two groups of statements about travel attitudes and residential preferences. A Likert scale was used, *strongly disagree - disagree - neutral - agree - strongly agree*. The proportion of responses either in *agree* or *strongly agree* is shown in the table. Significant differences in levels of agreement are indicated. For example, 27% of TN residents agreed that *I like to live in a neighborhood with children around me*, compared to 11% of RC residents. This difference is highly significant. There are no significant differences in travel attitudes and in general the two groups are well matched. Detail about the proportions responding to each question are shown in Figure 7-16 on the following page.

	% in agreement with the statement	
	RC	TN
Residential attitudes		
I like to live in a neighborhood with children in it	11	27 **
I prefer a house close to the sidewalk so that I can see and interact with passersby	22	17 *
I prefer to have shops and services within walking distance	41	41
I prefer a lot of space between my home and the street	39	60 **
I prefer living around people who are similar to me	61 **	40
I am concerned about strangers walking through my neighborhood	53	56
I like a neighborhood containing housing, shops and services	42	37
I prefer neighbors at the same stage of life as me	59 **	24
I value space around my home more than having shops nearby	50	63 **
Travel attitudes		
I enjoy driving	53	52
I make efforts to minimize the amount of driving I need to do	52	55
I like riding a bus	8	10
I enjoy bicycling	26	29
Taking public transit is convenient	15	18
Highways deserve more investment than public transit	31	27
I prefer to combine multiple activities into a single journey	85	85
Having sidewalks make me more likely to walk	67	65
I dislike sitting in traffic	85	83
The price of gasoline should be increased to reduce congestion	9	8

* significant, $p < 0.05$

** highly significant, $p < 0.001$

Figure 7-16. Comparison of residential location attitudes
Refer to Table 7.16 on the previous page

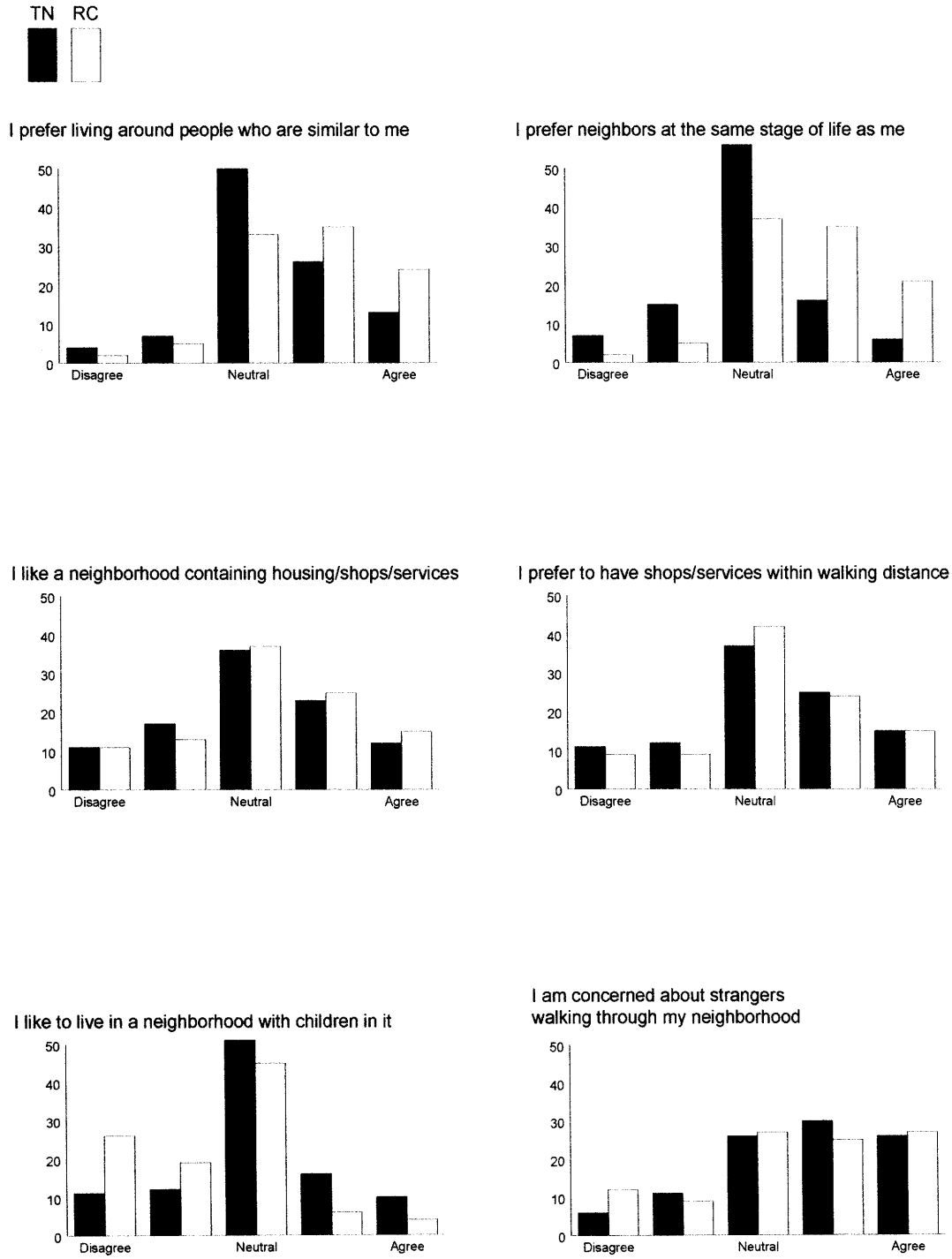
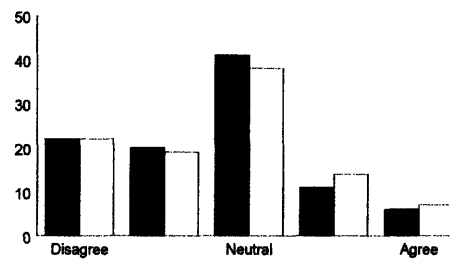


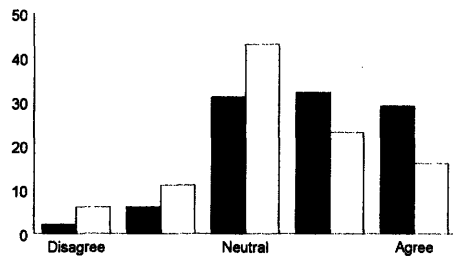
Figure 7-17. Comparison of residential location attitudes (cont.)
 Refer to Table 7.16 on page 135

TN RC

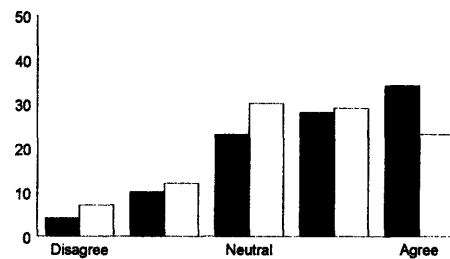

I prefer a house close to the sidewalk so that I can see and interact with passersby



I prefer a lot of space between my home and the street



I value space around my home more than having shops nearby



TN do not have an expectation about their neighborhood type, because they did not choose it on the age-restricted basis, so their responses may be less constrained.

Residents in RCs seem less concerned about density than TN residents. In both cases, this may reflect priorities in neighborhood choice as well as an attitude formed by the current neighborhood. The same pattern is visible for sidewalk attitudes.

7.8.2 Travel attitudes

The distribution of travel attitudes is very similar between the two neighborhood types. Residents display strong preference towards vehicle travel: most enjoy or are neutral about driving but dislike bus travel and bicycling.

The lack of transit in the study areas is indicated by the majority view that public transportation is inconvenient, though this could also be the result of residents' preference to driving and/or lack of information about alternatives. Although the sample could be described as pro-auto, it is not anti-transit: most residents are neutral on the question of whether transit or highway funding is more deserving of investment.

Predictably, traffic congestion is unpopular, and with gas prices passing \$4/gallon at the time of the survey, residents like to combine activities - several mentioned the motivation of gas prices as a margin comment beside this question.

7.9 Implications of the survey results

The survey identifies differences in travel behavior between different neighborhoods. This suggests that differences in RCs are associated with different travel outcomes. In simple tests between neighborhood types, RC residents appear to be more locally active, measured in several ways. The higher rates of local activity and trips to neighbors suggest that the hypothesized differences in local travel are taking place. Gathering information on residents and their travel habits provides evidence to help answer the research questions. Differences between demographic groups or neighborhood types gives guidance towards the bigger question of causality beyond the scope of this project - what is shaping travel behavior? - which in turn can lead to policy and design responses.

Most differences in measured travel are not large. Although residents are behaving differently, they are overall very similar to each other and the regional travel patterns recorded in the 1995 NHTS. Although the differences identified are extremely significant (in most cases $p < 0.001$), they do not indicate any fundamental variation in travel

Figure 7-18. Comparison of travel attitudes
Refer to Table 7.16 on page 135

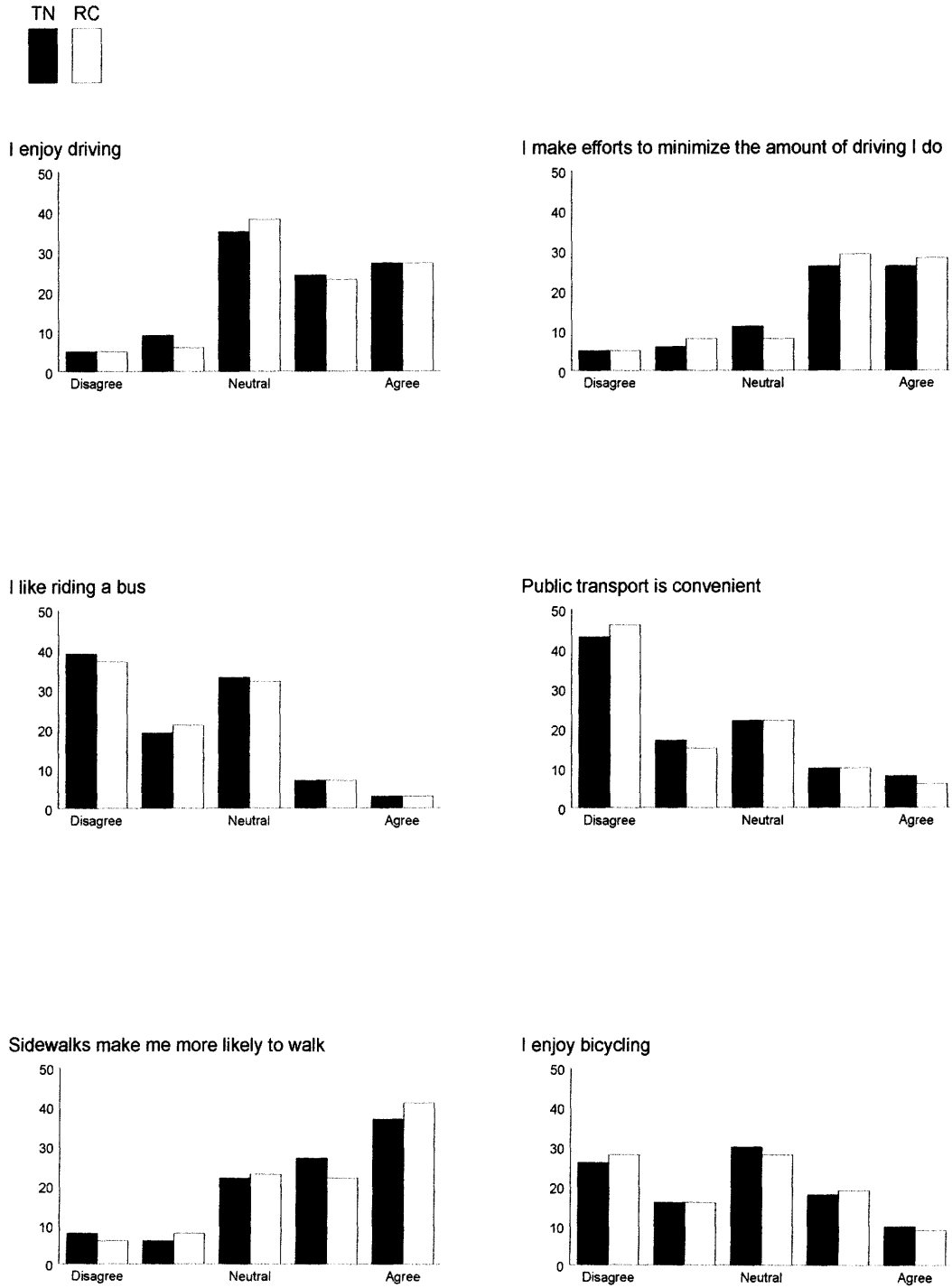
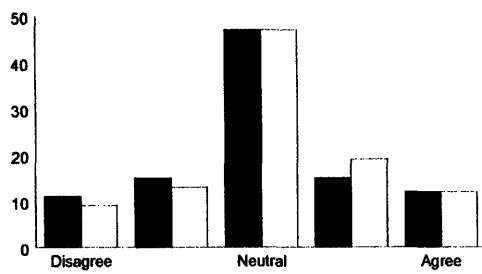
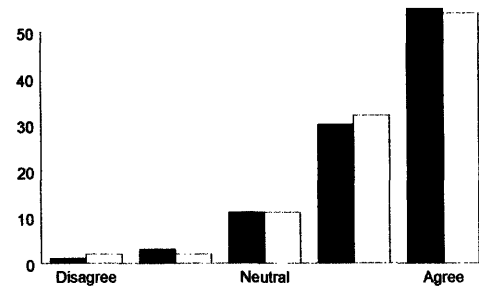


Figure 7-19. Comparison of travel attitudes (cont.)
Refer to Table 7.16 on page 135

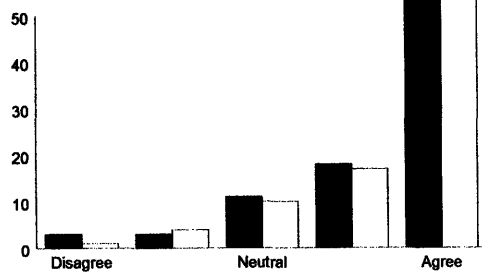
Highways deserve more investment than public transport



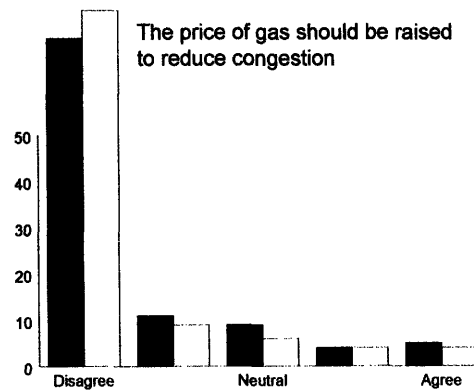
I prefer to combine multiple activities into a single journey



I dislike sitting in traffic



The price of gas should be raised to reduce congestion



outcomes: RC residents walk more, but only slightly more. This is not unexpected, because the samples are closely matched and are very suburban, requiring auto trips for basic travel needs. The next stage of analysis will provide better understanding of how much different factors influence travel rates and how substantial the observed differences are once all other factors are controlled for.

8 Trip models

This chapter presents the models used to estimate local travel activity, and discusses their findings. Estimations find age-restricted neighborhoods lead to different travel outcomes, as hypothesized. Weaknesses in the study design reduce the power of the models. Opportunities to improve the estimations are discussed.

8.1 Summary

I test three model estimations to investigate factors influencing local trips (neighborhood walk and cycle trips and visits to neighbors). The model specifications offer different approaches for endogeneity (refer to the discussion on page 58). One additional model assesses self-selection by modeling residential location with travel preferences.

RCs are associated with more trips of both kinds. After controlling for other factors including self-selection, living in a RC makes you more likely to walk locally and more likely to visit neighbors. The effect of living in a RC appears to be stronger for neighborhood trips, where the probability of making a trip is 20% higher after controlling for self-selection. Retirees and healthy people make more local trips. Household demographics are also influential, indicated by vehicle and cycle ownership variables. None of the available built environment characteristics are associated with trip making.

People with a preference for neighborliness appear to be self-selecting into RCs, with the nested logit estimation indicating residential choice conditional on activity preferences. For walking activity, the opposite is true: walking and biking are conditional on residential choice, though the indication is weaker. In general, the controls for endogeneity seem to be limited by weak models. Attitudes towards travel alone are not associated with residential choice, suggesting that neighborhood location may not be strongly influenced by travel desires, for this cohort and within measurements possible.

The models offer some indications about travel behavior, but they leave a lot unexplained: the estimations only explain a small amount of the observed variation, indicated by low ρ^2

values. The travel outcome of interest is also only a small part of people’s behavior, because it indicates whether or not a trip is made. The number of walk trips made is not known, nor anything about travel by other modes.

8.2 Model estimation

With each model estimation, two separate travel behaviors are modeled. **Local activity** is measured from the retrospective trip counts recorded by survey respondents, answering the question *Last week, how many times did you make the following trips: walk or cycle for exercise in your neighborhood?* All responses of one or more trips are considered active (local activity = 1), all zero-trip responses are not active (local activity = 0). **Neighborliness** is measured from another retrospective trips question, *visit a neighbor*. Similarly, all responses of one or more trips are considered neighborly (neighborliness = 1), all zero counts are not neighborly (neighborliness = 0). Differences in trips rates exist between neighborhood types¹, but model estimation we can provide a better indication of association and even causality once other factors are controlled for. Table 8.1 summarizes the breakdown of respondents in each category, by neighborhood.

Table 8.1. Measures of local activity and neighborliness

	RC	TN
n=	1,609	1,604
Walk/cycle locally at least once last week	67%	59%
Visit a neighbor at least once last week	51%	34%

Before beginning estimation of full models, I review association between the two dependent variables of interest and all possible model explanatory variables. Significant relationships are indicated in Table 8.2. Perhaps surprisingly, measures of accessibility, retail and road network characteristics are not associated with particular activity or neighborliness outcomes (e.g. average street network density is not significantly different between locations where people are locally active or not). The measures that are significant may be useful as explanatory variables in the modeling process, though individual significance does not mean that the same effect will be seen in conjunction with other variables. In many cases, the significant variation is a very small difference, which is a result of the large sample size.

¹Local activity: $z = 3.04, p < 0.005$. Neighborliness: $z = 5.95, p < 0.0001$

Table 8.2. Indication of associated explanatory variables.

Before starting modeling, I tested all possible explanatory variables for a significant ($p < 0.05$) association with the two dependent variables. Tests were either for difference in means or proportions, depending on the data. Weak associations and variables with no detected association are not shown. Regardless of the outcome indicated in this table, all variables were subsequently tried again in the modeling process. Italics indicate attitudes.

Associated with:	Local walk/cycle		Visits to neighbor	
	Increase	Decrease	Increase	Decrease
	Neighborhood	Dead end streets	Dead end streets	Health
	Age	Auto distance	Neighborhood	Auto distance
	Health	N'hood income	Age	N'hood income
	Retired	Family size	Retired	Household income
	<i>Like walking</i>	Vehicles owned	<i>Like sidewalks</i>	Family size
	<i>Like sidewalks</i>	Years resident		Vehicles owned
	<i>Like services nearby</i>			Years resident
	<i>Enjoy driving</i>			<i>Minimize driving</i>

8.2.1 Simple test for endogeneity: predicting residential location with travel attitudes

The first model is a simple test for endogeneity. If travel attitudes are correlated with a particular type of neighborhood, we expect some association when using the attitudes to estimate location. If travel desires are in some part determining neighborhood choice, a model of residential location with the attitudes as explanatory variables should identify both the influential attitudes and the effect they have. No other explanatory variables for residential location are considered, so their effect is contained in the error term. The outcome will not be a good estimation of residential location, but it indicates if attitudes and location are related. A logistic regression estimation is suitable for this test, because the choice of neighborhood is a binary outcome. Households are used and attitudes are measured as an average Likert scale value from both householders².

²In the survey, attitudinal variables were assessed using a Likert scale. Location decisions are made as a household unit, so the location model was estimated using households as the sample unit rather than individuals. Each response should be treated as categorical data, because the distance between *neutral* and *agree* is not necessarily the same as between *agree* and *strongly agree*.

I tried two approaches: using the Likert responses as continuous values, or converting attitudes into a simple dummy variable. In all cases the continuous variables were more significant. The dummy methodology indicated households where all occupants were in agreement = 1, neutral or disagree = 0, and a second variable for partial agreement, where only one householder agreed. This process has less detail than the original responses, because a dummy value of 1 for partial agreement could indicate a response ranging from one resident agreeing and the other being neutral, to one marking *strongly agree* and the other *strongly disagree*. Although the binary approach prevents over-interpretation of the Likert responses it is too crude to adequately capture a household's position in a way that preserves the small differences in attitudes between the neighborhood types.

Travel attitudes do not explain variation in residential location in this model estimation. This suggests that travel and residential location may not be closely correlated, and endogeneity may not be a problem in the estimation of travel outcomes. When using all 10 travel related attitudes to predict residential location, nine attitudes are insignificant, as shown in Table 8.3. The only significant attitude is the preference to minimize driving, which households in TNs are slightly more likely to agree with (the mean response is 3.6 in TN compared to 3.4 in RCs³). As expected with 9 insignificant variables and one weakly significant one, the overall model specification is poor: a link test for model specification indicates that the predicted model values have little explanatory power. A model using only attitudes directly related to local travel gives no better outcome (excluding attitudes on gas prices, highway investment and congestion).

Table 8.3. Estimation of residential location with travel attitudes

Logistic model outputs are shown with the odds ratio and standard error for each explanatory variable. Odds can be interpreted as: >1 means increased odds, <1 decreased odds with each unit change of the independent. For example, if the independent variable *Years of age* has an odds ratio 1.4, each additional year increases the odds of the outcome by 40%, all other variables held constant. An odds of close to 1 indicates no strong relationship.

	b	se
I enjoy driving	1.01	0.07
I make efforts to minimize the amount of driving I need to do	0.88 *	0.06
I like riding a bus	1.01	0.06
I enjoy bicycling	0.94	0.05
Taking public transit is convenient	0.91	0.05
Highways deserve more investment than public transit	1.01	0.07
I prefer to combine multiple activities into a single journey	0.90	0.08
Having sidewalks make me more likely to walk	1.07	0.07
I dislike sitting in traffic	1.08	0.08
The price of gas should be increased to reduce congestion	0.95	0.07
N	1129	
Log likelihood	-659	
LR χ^2	13.0	
P > χ^2	<0.001	
ρ^2	<0.01	

The lack of association between travel attitudes and living in a RC suggests that self-selection is not taking place, but we cannot rule it out: the travel attitude questions may not capture all attitudes, and residents may still have latent travel desires that their neighborhood choice is supporting. Nonetheless, the outcome is positive: if the opposite had occurred, and travel attitudes strongly predicted residential location, all subsequent findings, even with controls for endogeneity, should be considered skeptically.

³t(1,223)=2.3, p <0.05

8.2.2 Statistical control models

The statistical control model accounts for endogeneity through inclusion of attitudes towards travel as explanatory variables. Putting attitudes into the explanatory function for TB as quantified parameters removes the effect from the error term, and provides a control for endogeneity.

The estimations indicate that RCs are associated with more local walking and cycling (Table 8.4 on the following page), and more visits to neighbors, even after control for income, demographics and attitudes. If the control for attitudes made RC location insignificant in the model, we could assume that all previous effects of the RC (for example, as seen in the review of survey findings) were actually due to residents' attitudes captured by the neighborhood type variable. Since the neighborhood type variable and attitudes are both significant, neighborhood type has an effect on travel outcomes even after self-selection is controlled for. As indicated by the coefficient value, this effect is a positive association between RCs and more local activity of both types. Different attitudes appear to control better for different outcomes: for walking trips, attitudes relating to travel are important. For visits to neighbors, the significant attitudes are associated with residential features, including space around the home (negatively associated) and preferring a sidewalk nearby because it facilitates talking with neighbors (positively associated). This suggests that the relevant attitudes with this sort of activity are not travel specific like those related to driving, but are connected with residential location. The self-selection taking place for neighborliness appears to have different origins than for activity.

Looking in more detail at the model estimation, we find local activity is positively associated with living in a RC, being retired, and being in good health. The health outcome is intuitively correct. Retirement being positively associated could be an actual difference in walk rates, or a data capture issue - respondents might be more likely to report local activity if they are not commuting, where the length and duration of the commute could make other travel seem less noteworthy. Travel attitudes in the model are acting as controls for endogeneity in the BE characterization, with those who enjoy driving less likely to be locally active, and people who like walking more likely. Residents who appreciate walkability from nearby sidewalks is also more likely to walk. This attitude could be interpreted as wishful thinking - if only I had some sidewalks, I would walk - or the opposite - no sidewalks here but I'm still walking.

Living in a RC is positively associated with neighborliness. Retired people are more neighborly. Expressing a residential preference for a house that allows interaction with passers-by is also positively associated, while preferring space around one's home is negatively associated. Women are more neighborly. The association between years of

Table 8.4. Statistical control model: local activity estimation

	Odds ratio		Std. error
Neighborhood	1.37	*	0.17
Retired	1.64	***	0.21
In good health	1.65	**	0.25
Enjoy driving	0.89	*	0.05
Enjoy cycling	1.42	***	0.06
Like sidewalks	1.29	***	0.06
N	1,545		
Log likelihood	-950		
LR χ^2	155.9		
P > χ^2	<0.001		
ρ^2	0.08		

residence and neighborliness could be interpreted in several ways: people perhaps become less neighborly with increasing years of residence, or newly-moved residents are much more neighborly in general, with the large sample of RC residents all recent movers by definition. The model specification is shown in Table 8.5.

Table 8.5. Statistical control model: neighborliness

	Odds ratio		Std. error
Neighborhood	1.40	*	0.20
Retired	2.00	***	0.23
Male	0.78	**	0.08
Prefer sidewalk	1.10	**	0.05
Prefer space	0.88	**	0.04
Years residence	0.99	*	<0.01
N	1,568		
Log likelihood	-996		
LR χ^2	111		
P > χ^2	0.00		
ρ^2	0.05		

8.2.3 Instrumental variable models

The instrumental variable approach reduces endogeneity in the model by instrumenting an endogenous explanatory variable with other measures that do not correlate with the error term. For this study, the biggest source of endogeneity arises from self-selection into a particular neighborhood type in order to fulfill desired travel outcomes. The endogenous explanatory variable is residential location, which will be correlated with travel attitudes

if self-selection is occurring. Suitable instruments for residential location will be minimally correlated with any travel outcomes. I select attitudes about neighborhoods to estimate the instrument, because they provide good estimation of location preferences but are not explicitly measuring travel outcomes. Several cautions apply to this model approach. Firstly, the use of a simple logistic regression with instrumented variables is not common in previous studies, and some authors suggest that it may produce biased outcomes. Secondly, using a weak instrument may produce worse estimates than the original endogenous model. The statistical control model outcome also suggests that neighborly visits may be associated with residential attitudes, so the IV instrument may not be exogenous for this outcome. Refer to page 58 in Chapter 5 for more information on problems with the IV approach.

The IV estimation is carried out in two stages. I predict residential location with attitudes, then I use this estimated location in the second stage, to model local travel and neighborliness. Estimated location is referred to as \widehat{RC} .

Predicting residential location

Residents' attitudes are effective at predicting location in a RC. Considering attitudes that are not directly related to travel outcomes, significant associations with residing in a RC are: not preferring a neighborhood with children in it, preferring neighbors at the same stage of life, not valuing space over local services, not wanting a lot of space between one's home and the street and not being concerned about strangers in the neighborhood. All are very or highly significant, and the direction of the coefficients is in line with expectations. No other attitudinal variables were significant. Table 8.6 shows the explanatory variables.

Table 8.6. IV model: Estimating instrumented RC

	Odds ratio		Std. error
Prefer children nearby	0.64	***	0.05
Prefer similar neighbors	2.27	***	0.21
Value space over local services	0.84	*	0.06
Prefer space around home	0.66	***	0.05
Concerned about strangers	0.81	**	0.05
N	1,236		
Log likelihood	-611		
LR χ^2	251		
P > χ^2	<0.001		
ρ^2	0.17		

Some examples of classifications under this model are shown in Table 8.7. For the children variable, a one step increase along the Likert scale for reduces the odds of being in a RC by 60%, so people who disagree with that statement are more likely to be located in a RC. Desiring neighbors at the same stage of life has a large effect, each increase in agreement leads to a 220% increase in the odds of choosing the age-restricted environment. The odds for 'I prefer space around my home to local services nearby' and 'I want a lot of space between my home and the sidewalk' implies that residents are trading these characteristics for other benefits of the RC, and the absence of demand for a large setback is an artifact of the trade-off between a large lot and the local benefits of (smaller) RCs rather than a preference for density. The lack of concern about strangers may be an artifact of the secluded and private nature of RCs rather than an actual difference in worry about this topic. As a result of living in the RC, residents never see strangers and so are not concerned about them, because there aren't any. Alternatively, the lack of concern may be a result of living with older adults only, and so the negative connotations of a stranger in a family neighborhood do not apply. This can be seen in the charts of attitudes on page 136, where residents in RC are less likely to be concerned.

Table 8.7. IV model: Classification of hypothesized boomer households.
P(RC) is the probability of the household living in a RC. Household C has median values for all five attitudes.

Attitude	A	B	C	D	E
I like to live in a neighborhood with children in it	1	2	3	4	5
I prefer neighbors at the same stage of life as me	5	4	3	3	1
I prefer a lot of space between my home and the street	3	3	4	3	3
I am concerned about strangers walking through my neighborhood	3	3	4	4	3
I value space around my home more than having shops nearby	3	3	4	4	1
P(RC)	0.84	0.59	0.15	0.15	0.04

I estimated an additional model for residential location, not presented here. It uses the same attitudes, plus non-attitudinal characteristics including a dummy variable for single female householder, and years at the current address. Although this model provided a better estimation of location, the exogeneity of the non-attitude variables is less certain, especially with regard to the neighborliness indicator (for example, being the sole occupant of a house could have associations with how often you visit neighbors). Using an instrument constructed from attitudes and other variables that may not be exogenous may produce a weaker second stage model.

Modeling travel outcomes with instrumented residential location

Instrumented residential location is not significant in explaining local activity. Estimating local activity with \widehat{RC} as the only explanatory variable produces an insignificant coefficient for \widehat{RC} , and the model overall is not significant. For neighbor visits, \widehat{RC} is significant and the model is valid but explains little variation in the dependent variable. This inconsistency and the weak result overall suggests that the BE instrument is weak. The positive correlation for neighborliness perhaps shows that households who are most typical of RC attitudes are also more likely to be neighborly, whereas walking activity varies across residential characteristics.

The IV model for neighbor visits is shown in Table 8.8. Living in a RC, being retired and being female are all associated with being more neighborly. Being in a household with one vehicle and/or two bicycles are also associated with neighborliness. These variables are probably capturing the same effect as the preferences for driving and cycling seen in the statistical control model.

Table 8.8. IV estimation: Neighborliness model

	Odds ratio		Std. error
\widehat{RC}	1.45	*	0.22
Retired	2.12	***	0.24
HH income <\$15k	2.38	*	1.01
Male	0.73	**	0.08
One vehicle	1.38	*	0.18
Two bikes	1.36	*	0.17
N	1,572		
Log likelihood	-1009		
LR χ^2	85.2		
P > χ^2	0.00		
ρ^2	0.04		

8.2.4 Nested logit models

Nested logit (NL) models allow for joint estimation of residential choice and travel outcomes. For each travel outcome of interest, I estimate two model specifications: residential choice conditional on travel, and travel conditional on residential choice. The model parameters indicate if the decision structure fits with the theoretical framework of utility maximization (Ben-Akiva and Lerman 1985). The logsum from the lower nest level is included as a parameter in the upper nest. If the coefficient of the logsum is less than one, the model decision structure is correctly specified, and decisions in the lower nest are

conditional on the upper nest. If it is greater than 1, the reverse structure is a better representation of the conditionality⁴.

The NL models indicate differences in self-selection between the two types of travel. For local activity, interpretation of the model specification suggests that residents are not selecting into their neighborhood: the logsum parameter indicates that estimating activity conditional on neighborhood produces a better model. Latent demand for local walking and cycling activity is not a cause of self-selection in RCs. Instead, residential location is the conditional factor, suggestion that residents become more active after moving.

For neighborliness, the model parameters indicate that residential location is conditional on neighborly-tendencies. Residents of RCs are choosing these locations because they have a desire to live in a neighborhood that supports neighborliness, and once in the RC they fulfill this desire by being neighborly. The opposite formulation would be that residents choose a location and then decide, as a result of the neighborhood, to act in a certain way. The correct direction is indicated by the parameter of the logsum, which at 0.3 is within the expected range. Table 8.10 shows the model output. Explanatory variables are the same as the IV model and have expected effects.

8.3 Causality

Three model types were assessed to investigate alternate controls for endogeneity. Table 8.9 on the next page shows a comparison of the estimations for local activity, Table 8.10 on page 154 shows the same information for neighbor visits. Across all models, the lack of explanatory power makes the controls for endogeneity harder to evaluate, because the models in general are weak. Some points about each model approach are highlighted below.

Modeling residential location with travel outcomes suggests that endogeneity is not a problem: attitudes towards travel do not explain anything about residential location choice. One can interpret this as meaning that residents with certain travel desires do not choose one or other neighborhood type. The obvious limitation of this finding is that the travel attitude questions may not adequately capture respondents' full desires for travel. For example, there was no question asking specifically about strolling from home. If RCs offer a better strolling environment, we might expect people with a preference for local strolling to choose to live there. Since this question was not asked, it is unreasonable to rule out self-selection for people who like strolling. For attitudes that were included in the

⁴Refer to discussion on page 65.

Table 8.9. Comparison of model estimations for local activity.

This table compares the explanatory variables and overall model power for the three model types attempted. The neighborhood variable in the top row (N'hood) is different in each model: in the statistical control model, it the observed neighborhood type (RC or TN); in the IV model it is the instrumented location; in the NL it is the logsum parameter from the lower nest. In the NL, the parameter is effectively zero.

	Statistical control			IV			NL		
	<i>b</i>	<i>t</i>	<i>p</i>	<i>b</i>	<i>t</i>	<i>p</i>	<i>b</i>	<i>t</i>	<i>p</i>
N'hood	0.31	2.49	*	-0.27	-1.01		-0.04	0.34	
Retired	0.49	3.95	***	0.48	4.11	***	0.51	4.07	***
Health	0.50	3.25	**	0.72	4.96	***	0.65	4.23	***
Enjoy driving	-0.12	-2.25	*						
Enjoy walking/biking	0.35	7.89	***						
Like sidewalks	0.25	5.57	***						
Two bikes				0.40	3.13	**			
One vehicle				0.31	2.29	**			
N	1545			1578			1427		
LR $\chi^2(6)$	123.78			46.7			103.9		
$p < \chi^2$	< 0.001			< 0.001			< 0.001		
log likelihood	-986.7			-1027			-937		
ρ^2	0.08			0.02			0.05		
Hosmer-Lemeshow $\chi^2(8)$	8.95			6.92					
H-L <i>p</i>	0.35			0.54					

survey, such as enjoyment of driving or cycling, this model test indicates that there are no consistent desires for a particular outcome between neighborhood types.

Simple statistical control indicated that some part of residential location cannot simply be explained by travel attitudes. Preferences for driving and biking are present in the model, along with residential location. The coefficient of neighborhood type is not close to 1, so its presence in the model is having an effect on the odds of activity. Of all the models I estimate, this has the highest ρ^2 value and the lowest log-likelihood, suggesting that it is the 'best' model. For neighborliness, the relevant attributes appear to be related to built environment preferences.

The IV models produced mixed results. For local activity, a significant model could not be estimated. For neighborliness, the model has little explanatory power (adjusted $\rho^2 = 0.041$). Literature on IVs warns that a weak instrument can be worse than none at all, and it seems like this caution may be relevant here. For the local activity measure, the instrument provides a poor indication of residential location, and since the association between RCs and local activity is already small, the error terms overwhelm any useful information. Producing a stronger instrument for neighborhood choice could improve the explanatory effect of these models. Adjusted $\rho^2 = 0.17$ for the instrument, indicating that

Table 8.10. Comparison of model estimations for neighbor visits.

This table compares the explanatory variables and overall models for the three neighbor visit estimations. The neighborhood variable (N'hood) is different in each model: in the statistical control model, it is the observed neighborhood type (RC or TN); in the IV model it is the instrumented location; in the NL it is the logsum parameter from the lower nest. *Low income household* indicates houses with reported income below \$15,000.

	Statistical control			IV			NL		
	<i>b</i>	<i>z</i>	<i>p</i>	<i>b</i>	<i>z</i>	<i>p</i>	<i>b</i>	<i>t</i>	<i>p</i>
N'hood	0.34	2.44	*	0.37	2.45	**	0.32	2.19	**
Retired	0.66	5.8	***	0.75	6.76	***	0.83	7.01	***
Male	-0.36	-3.33	**	-0.31	-2.93	**	-0.39	-3.42	***
Two bikes	0.29	2.3	*	0.31	2.49	*			
Health rest.	0.54	8.85	**						
Prefer sidewalk	0.13	2.86	**						
Prefer space around home	-0.14	-2.85	**						
Years resident	-0.01	-2.39	*				-0.02	-3.48	***
Low income household				0.87	2.05	*			
vehicles2				0.31	2.4	*			
N	1565			1572			1427		
LR $\chi^2(6)$	124			85.2			167		
$p > \chi^2$	< 0.001			< 0.001			< 0.001		
log likelihood	-993			-1009			-905		
ρ^2	0.06			0.04			0.08		
Hosmer-Lemeshow $\chi^2(8)$	3.73			8.61					
HL <i>p</i>	0.88			0.38					

a large amount of variation is unaccounted for. However, these low values do not invalidate the findings - for comparison, in the IV models used by Khattak and Rodriguez (2005), the logit estimation for the instrument has $\rho^2 = 0.27$ with five variables not significant at 95%, and the final OLS using the instrument has $R^2 = 0.05$.

The nested logit models offer the most sophisticated understanding of the relationship between travel and location choice, though with the same warnings about weak models. For local activity, walking and biking are conditional on location. It seems that people are walking in both neighborhood types, and within the limited explanatory scope of the model estimation, residential location cannot be explained as conditional on travel desires. Neighborliness has a clear direction of causality: people select their neighborhood based on their inclination to be neighborly. This does not mean that residents make a two-stage decision before moving, but that the outcome of activity is best explained with the estimation structure of neighborhood conditional on activity.

8.3.1 What can we conclude about self-selection?

If effective, the controls for endogeneity produce better models, with independent variable that have better explanatory power and contribute to a stronger overall estimation. As the comparison in Tables 8.9 and 8.10 shows, the model controls for endogeneity are mixed in their success:

For **local activity**, indications suggest that residents are not self-selecting for this type of travel. Increased walking is conditional on neighborhood type, implying that some residents are walking more in RCs as a result of the influence of some aspect of the community, not only because of previous travel desires. This does not mean that self-selection is taking place for other types of walking, though the simple assessment of self-selection with travel attitudes indicates the same outcome, because it found travel attitudes to not be relevant in explaining location decisions.

For **neighborly visits**, self-selection is taking place. Residents are choosing their residential location conditional on preferences for neighborliness. Compared to the local activity model, all neighborly models have slightly more explanatory power, so the potential for controls for endogeneity to show a result is greater.

The simple assessment of **travel attitudes and residential location** strongly suggests that no self-selection is taking place, but only within the range of attitudes identified by the ten questions used. Only a few of those attitude questions explicitly relate to trip making and only one is about local walking activity. None of the attitudes are about neighborliness. The simple technique does not sufficiently reject any role of self-selection on neighborhood location.

8.3.2 Quantifying the effect of neighborhood type on travel outcomes

Establishing a significant causal connection between travel behavior (TB) and neighborhood location (equivalent to the built environment, BE) is only useful if the effect is meaningful. The model estimations allow us to isolate the effect of the neighborhood change and indicate what the travel outcome will be, holding all other factors constant. This makes the results more tangible and informative for interpretation. Cao et al. (2006) identify two relevant measures: the overall effect of BE on TB, as identified by the model, and the proportion of the effect on TB that is solely the result of BE once attitudes are controlled for. I refer to these as the *overall effect*, and the *controlled effect*. For the discrete outcomes studied here, the TB change is the change in probability of being active. Living in a RC is the BE measure, from TN (value of zero) to RC (one). I calculate these measures for the statistical control and IV models. Because the IV method removes the

effect of attitudes from the second model, the controlled effect cannot be calculated, so the IV models are less informative. Calculating equivalent measures from the NL estimations is beyond the scope of this thesis. Table 8.11 has the details.

Table 8.11. Isolated neighborhood effects on travel.

This table evaluates the effect on travel behavior associated with neighborhood type. I have converted the coefficients from the odds ratio, used in the previous tables, to a more typical regression coefficient.

	Statistical control		IV
	Overall effect	Controlled effect	Overall effect
Local activity	0.31	0.05	-
Neighborliness	0.34	0.21	0.37

For the statistical control models, the overall effect can be assessed by looking at the coefficient of the neighborhood type variable. The overall effect of being in a RC on being locally active is 0.31. Cao et al. (2006) define the controlled effect for a statistical model as the ‘incremental contribution to R^2 of BE (given AT and all other variables included), divided by incremental contribution to R^2 of BE and AT entered together (given all other variables included)’. In this context, the change in ρ^2 is of interest. I calculate the controlled effect for local activity to be 0.05. For neighborliness, the overall effect is 0.34 and the controlled effect is 0.20. To express these values in words, living in a RC increases the probability of making at least one neighbor visit by 20%, after self-selection is controlled for, while the chances of local activity increases by 5%. Ignoring attitudes, the neighborhood accounts for around 30% increase in making either type of trip.

For the IV models, the overall effect is the coefficient of the modeled RC value. For activity, the IV estimation is too weak to give any useful indication. For neighborliness, the value is 0.37.

The overall effect of neighborhood location is very similar between the different models and travel outcomes. The difference in the controlled effect suggests that the neighborhood type has a bigger effect on neighborliness, after controlling for self-selection. Considering this alongside the finding about self-selection, the models suggest that residents are choosing to live in RCs for neighborliness, with aspects of the RC playing an additional role in supporting more neighborly trips. This assumes that the controls for self-selection have been effective, which is not certain for the local activity models.

The values for controlled and overall effect of BE on TB would be easier to interpret if the outcome variable was not a binary measurement. For example, a 20% increase in the number of trips to neighbors is a more tangible measure than an increase in the probability of making at least one trip. For residents who already are making trips, an

increase in the probability of making one trip is less clear - do RCs encourage more activity, regardless of the initial starting point, or is the effect only seen in the few inactive people who become active? These simple outcomes cannot explore more complex effects.

8.4 Limitations

Various shortcomings of the model specifications have been highlighted in the text. This section presents a consolidated summary of these issues.

Imprecise dependent variables

The hypothesis of this study is that RCs will produce differences in travel outcomes for local trip making and activity, due to neighborhood characteristics (either physical or organizational). To investigate this, measures of local travel are needed that either include all local activity or at least a reasonable cross-section with no bias against local trips compared to all other trips. This is probably not true for the questions used to gather local activity information in the survey, which have some limitations that are likely to have produced under-reporting of local trip rates.

In the survey instrument, the section headed ‘questions about regular journeys’ gathered information on a retrospective week of trips. The use of ‘journeys’ in the title could be interpreted to not include short walks. The journey counts were intended to be exclusive and exhaustive, but this was not indicated, so respondents may vary on double-counting certain trips. How to deal with a multi-leg trip chain is also unclear, for example visiting neighbors and then going on to shop, so the effects of trip chains on the counts are unclear.

Specific problems with the frequent trip measure, *Walk or cycle for exercise in your neighborhood* include:

- Merging of two travel modes. Answers to this question cannot be used to explore walking separately from cycling.
- *for exercise* discounts all strolling and walking for other purposes, such as getting mail. One of the outcomes from a more walkable suburban neighborhood could be an increase in walking for all purposes and no specific purpose. Residents are unlikely to classify local walking for pleasure or errands as exercise, so the trip rate is under-reporting. Walking to retail is also not included.
- *neighborhood* is highly subjective. In a small RC, residents might stroll from their home beyond the boundaries of the neighborhood. In a larger community, they

might drive to the other side and walk, while remaining within the neighborhood at all times. There is no indication of how far a local walk might travel or where the resident draws the distinction. Asking specifically about walks starting from home could add precision.

- Possible non-response bias or under-scoring due to inclusion of *cycle*. Evidence from focus group participants suggests that cycling may not be common among some boomers (Zegras et al. 2008). For the suburban location of the sample, cycling to work is extremely unusual, and cycling for exercise tends to be done at a location reached by vehicle (for example, residents of The Pinehills reported driving to the nearby Cape Cod canal for recreation cycle rides). Given this, residents seeing *cycle* in the question may not consider their trips suitable for this classification.

The second neighborhood trip question, *Visit a neighbor* also has problems of precision:

- ‘Visit’ implies a formal exchange, possibly indoors. The hypothesized benefit of the RC is an increase in sociability at all levels, including informal exchanges in passing, waving to a neighbor, chatting briefly at the mailbox. Asking a non-trip related question might be a better indication of neighborliness, for example, ‘How many neighbors are you friendly with?’, or ‘How well do you know your neighbors?’.
- The same issue with neighborhood applies to *neighbor*. How far away is a *neighbor*? Does driving to reach a *neighbor* still qualify as a local trip? When does someone stop being a *neighbor* and become a *friend in another neighborhood*, as asked by the subsequent question?

The attitudinal questions did not include a walking question, which could make a stronger model for local activity: *I enjoy driving*, and *I enjoy biking*, but nothing about walking. *Having sidewalks makes me more likely to walk* could be interpreted in several ways so is slightly ambiguous.

Lack of built environment variables

Given the geographic spread and variation in neighborhood type, it is surprising that no built environment characteristics are significant in the model. For the RCs, the available measures of density and road networks may be out of date, because construction and complete occupancy postdate the 2000 census and 2007 road network, or are not mapped. I tried including various dummy values to account for uncaptured physical characteristic of the models, such as missing road networks or walking paths, but these obviously correlate with the neighborhood type variable, because most RCs are known to be missing

data, while no TNs were. Generating better local measures for the entire sample set might find significant built environment factors.

Another explanation for the absence of any physical characteristics could be a mis-match between the chosen BE variables and the TB of interest. Retail density, regional accessibility and other similar factors are all broadly the same between different neighborhoods, and maybe do not have any influence on the local activity and neighborly visits.

8.5 Comments on models

The survey analysis showed that RCs were associated with different travel outcomes, including local activity and neighborliness. Modeling these outcomes had two purposes: firstly, the model estimation assigns a quantity to the different parameters of association, secondly it illustrates the issue of self-selection.

All models indicate that neighborhood type is associated with travel outcomes, even after controlling for endogeneity and including other control variables for individual, household and neighborhood characteristics. The models do not include variables relating to the built environment, which suggests that the available measures are not effective at representing physical characteristics of the study area. Income and other demographics are not significant in any models, possibly because the areas are so closely matched.

The models suggest that residents are not self-selecting for local activity type of travel. Increased walking is conditional on neighborhood type, implying that some residents are walking more in RCs as a result of the influence of some aspect of the community, not only because of previous travel desires. For neighborly visits, self-selection is taking place. Residents are choosing their residential location conditional on preferences for neighborliness.

The effect of living in a RC seems to be greater on trips to visit neighbors than for local activity. This could be a result of the imprecise trip question for activity trips and the weak activity models, but it may also indicate the strong role of RCs in supporting neighborliness among residents. Since the outcome is a simple binary variable, the full effect may not be captured in these models. Given likely reporting errors, these measures should perhaps be interpreted more loosely as low and high levels of activity, rather than literally never making a trip.

9 Implications

This chapter reviews findings from the survey and modeling. I examine what the outcomes from the survey and models say about the research questions.

9.1 What have we learned about travel behavior in age-restricted communities?

The survey identified differences in travel behavior between different neighborhoods. The higher rates of local activity and trips to neighbors suggest that the hypothesized differences in local travel are taking place. The model estimation supports the same conclusion. RCs support neighborly lifestyles for people with existing preferences for it, and encourage walking among all residents.

9.1.1 What differences occur in local activities and trips between restricted and typical suburban neighborhoods?

The travel survey and models provide some insights into boomer travel behavior. Within the survey sample, residents of RCs and TNs are closely matched. Compared to demographic data from the Census and travel behavior information from NHTS, the survey respondents are representative of the suburban areas they were sampled from. Given this, we can draw some conclusions about travel behavior that are relevant beyond this sample, with implications for suburban boomers in the whole Boston area and other similar urban areas in the US.

Residents of RCs have different travel patterns. Specifically, they are more locally active than in typical neighborhoods, with more walking and cycle trips, and more visits to neighbors. This is demonstrated in the simple statistical analysis and also by the models, which show that the neighborhood type is important even after controlling for self-selection. Within the limits of the study design, we can say that RCs are associated

with more local travel outcomes even after controlling for attitudes that might lead residents to move to these locations in the first place. Other controls show that the effect is not due to the greater number of retired people in RCs, or income differences, home type, family composition, etc. For example, even though retired people are more likely to walk locally, RCs are still associated with more walking after controlling for this.

Controlling for endogeneity in model selection provided information about self-selection. It appears that residents are selecting RCs for neighborliness, not for walking. The small increase in walking associated with the RC is not due to self-selection. Both these findings have extremely interesting implications for the role of neighborhoods in supporting healthy aging - even after controlling for self-selection, there is a difference in travel that can reasonably be attributed to the organization or physical layout of the community. The role of RCs in supporting walking cannot be dismissed as entirely due to the desires of people who move there.

The actual differences in measured outcomes are not large. Although residents are behaving differently, they are overall very similar to each other and the regional travel patterns recorded in the 1995 NHTS. Although the differences identified are extremely significant, they do not indicate a large variation in day-to-day travel outcomes. For example, the rate of making at least one walking trip in RCs is 67%, compared to 59% in TNs. This lack of variation may be because the samples are closely matched and are very suburban, requiring auto trips for basic travel needs, but it cautions over-interpretation from the survey and model findings. When considering implications for design and policy, the relative scale of change is important, because although there may be observable outcomes associated with RCs, other changes could have a much bigger effect.

9.1.2 What are the influences of neighborhood characteristics on local trips?

Turning to the specific role of the neighborhood, I discuss how these findings can be associated with different features of the neighborhoods under scrutiny.

Although neighborhood type is an explanatory variable in all models of activity, the specific contribution of different neighborhood characteristics is not explained. So while we know that living in a RC is associated with certain travel patterns, these cannot be attributed to the neighborhood design. Although one can formulate feasible scenarios about the provision of walking paths and the effect this might have on walking rates, there is no evidence from the models to support this. The prominent social and community aspects of the age-restricted lifestyle could be equally or more important in stimulating local trips and increased engagement with neighbors. Based on the modeling process, we

can make some assumptions about what is not responsible: biases from shared characteristics of residents, and certain physical aspects of the neighborhoods.

Aspects of the respondents such as income and duration of residence give some indications about where the RC influence is not coming from. Residents do not differ between neighborhood types on income or household composition, so the observed difference is not due to a confounding factor such as higher levels of income, or differences in vehicle ownership. Factors such as retirement and duration of residence are both controlled through the modeling process, so while there are more retired people in RCs and retired people have different travel outcomes, being retired is assessed as a separate influence on travel. Controlling for duration of residence is important since people in RCs have moved recently, so the different travel outcomes could be attributed to being in any new location, rather than specifically a new age-restricted community. However, controlling for years of residence does not remove the effect of RCs from the models. This indicates that being in a location for fewer years does not account for the difference in travel. Within the limitations of the modeling process, it seems that characteristics of the residents that have relevance to the neighborhood composition are controlled for, leaving the presence of the RC in the models as an indication of some physical or organizational difference.

There are no homogenous physical features common to all RCs in this study, which could be interpreted as an indication that the social and organizational aspects are the primary travel influence. The RCs chosen covers a wide variety of communities sizes, from 40 to 1,150 units¹. Some are large enough to have extensive walking trails, like The Pinehills, and Oak Point, while others are much smaller, with fewer amenities within the community boundary. Despite the lack of similarity between the RCs in this study, they still share travel outcomes across the range of communities. If the sample was entirely from large communities with dedicated walking trails, it would be reasonable to attribute some of the RC role in travel outcomes to these features. Conversely, if the sample were only from small RCs without walking trails, it would be reasonable to discount trails as part of the RC effect on travel. Given the mixed sample in this study and the variation in sample sizes from each RC, neither approach would be valid. We can tentatively say that there are no common physical characteristics, but not that the variation in physical characteristics is enough to act as a control across different RCs.

Similar caution should be used when drawing conclusions about the social aspects of RCs. Although anecdotal evidence from several communities, the focus groups and previous studies indicate that there is an active social element to age-restricted living (e.g. Zegras et al. 2008, Singh 2006, Blechman 2008), no detailed information is available to compare the social and organizational activities taking place in the 18 communities I studied. We

¹Refer to the comparative chart, Table B.1 on page 182

know that these neighborhoods offer an environment that fosters and enables activity, and some have a clubhouse or other common building used by residents for events.

Given that the measured influence of RCs cannot be attributed to either physical or organizational difference within the sample, better data on both aspects are needed to understand where the influence is coming from.

9.2 Practical implications

The outcomes of the survey and models show that travel outcomes vary between different suburban community types, though the difference is small. In RCs, the higher levels of local activity and neighborliness are likely to support healthier aging. Replicating these positive effects in other suburban locations could benefit many older adults. Whether or not this is possible depends on a better understanding of the factors influencing both travel outcomes.

If walking activity is only stimulated by local retail and other attractions, the suburban context is difficult. There are no easy interventions that can transform suburban locations with high auto use into retail-filled walkable neighborhoods. However, the indications that RCs have slightly higher walking suggests that there are ways to increase local activity and make more social neighborhoods without major land use changes. If design features of RCs such as sidewalks are encouraging walking, these could be added to existing typical unrestricted neighborhoods for all ages to boost local walking. Alternatively, if the social aspects of RCs seem to be associated, there may be opportunities to replicate the community structure within RCs in many communities. Perhaps these effects are specific to the boomer demographic, who may hold certain common values about neighborliness that are not the same as younger generations.

For neighborliness, the RCs appear to attract people who want to be neighborly in this context with others like them (in the CHAPA review of RCs, Heudorfer (2005) suggests that this might be occurring). Finding ways to facilitate a neighborly atmosphere in existing neighborhoods might 'retain' older people in their original communities and have positive social and aging benefits. Older adults may be leaving their existing communities because they see them as insufficiently social, compared to what is on offer in an age-restricted setting.

Ultimately these questions indicate a bigger overarching question about enabling healthy aging in the suburbs. Is it better to bring the beneficial features to existing neighborhoods (assuming that the 'features' are discrete and replicable), potentially at great cost and complexity, or is it better to facilitate moves by older people into supportive locations?

For service providers, having older people clustered could be efficient, and it implies affordable outreach for aging support and health services that might typically be found in an urban center. Alternatively, clustering older adults might make it harder for community-led initiatives and informal support, both of which will rely on a diversity of ages living together.

For para-transit providers, RCs create clusters of potential passengers or customers. The survey indicated a different regional travel pattern in RCs, with auto passenger forming a larger mode share. Although this finding requires further study, it presents some interesting implications for provision of alternative transport services. What opportunities exist if residents in RCs are more amenable to ride sharing and other alternatives to private vehicle use?

9.3 Next steps

This study is a very small start in the investigation of suburban boomers and travel outcomes. There are many further directions that could be taken from here. I suggest several, grouped loosely into work that focuses mainly on the existing survey data, possibly with some additional gathering of information about BE and community characteristics. I also suggest some larger investigations that require new data collection.

9.3.1 Further analysis with existing data

The survey data from this study offers a large amount of information for further investigation. More detail about individual travel is given in the trip diary section. I focused only on the retrospective trip reports for local activity, so there is scope for a detailed investigation into trip mode, lengths, chaining and other aspects of reported travel. The distances per week also provide scope for further investigation, as well as retrospective trip records for other types of trip, including out of neighborhood travel. More could be done to differentiate travel habits within the sample, specifically at the household level where both respondents are retired, compared to those where at least one person is employed. Household-level travel effects may provide better information about the higher level of passenger auto trips in RCs. The initial indication about ridesharing deserves full investigation.

Additional resources about older adult travel could be more effectively investigated for comparison data, including the 1991 Boston region travel survey, the NHTS and NPTS before it, and other New England area resources on travel. Suburban public transport should be investigated, including any paratransit serving the sample areas to provide

better context. For those respondents using MBTA commuter rail, detailed analysis of location and rail accessibility could be carried out.

To complement any further trip analysis, more detail is needed about the built environment characteristics of these locations. For the RCs, a detailed assessment of street network and walking paths should be attempted, to capture specific design attributes such as tree cover, network characteristics, street geometry and the arrangement of homes relative to the street. Cervero and Kockelman (1997) and Dill (2004) provide examples of 'design' measures frequently used in travel research. Finding ways to gather this information from web-based mapping services and aerial imagery would provide data that is more recent than the road network GIS files I used, and could potentially be more detailed. One problem for all manual data collection is that information needs to be collected for all samples, not just those in RCs. Trying to characterize all sample locations is a huge task, but taking a subset of responses from the sample within one contiguous region could be achieved. Sample locations around Plymouth are suitable, where a large number of RC responses is matched by TN samples nearby.

Other data resources including public transport service data, land use data and the recent impervious surface layer from MassGIS could also be used to characterize the study area in a more innovative and detailed way². For example, the impervious surface data shows pervious and impervious surfaces at 50 cm pixel resolution data from 2006. For the study area, this could be used to measure development density around recent RCs that the Census and other sources cannot provide. The state-wide land use cover data from 1999 may provide measures of recreation space, which may be a better indicator for walking activity than density or retail, given the suburban location. The 2010 Census will soon provide demographic data about the samples that is nearly contemporary with the survey, and between-census demographic interpolations such as PCensus are worth investigating, though how effective these are at identifying concentrations of older adults in age-restricted areas is unknown. Developing alternative measures of BE characteristics would be beneficial to this area of research and many others.

Complementary to analysis of the built environment, better measures of the community and social effects for the sample RCs are needed. A huge amount remains unknown about these communities, including information about the governance structure, maintenance support, social events, communal facilities such as club houses, and local transport services. Understanding more about these characteristics will be informative in trying to interpret the role of organizational features and thinking about how they could be extended to other community types.

²Data layers mentioned in this section are documented on the MassGIS website: <http://www.mass.gov/mgis/database.htm>. PCensus is a proprietary software package developed by Tetrad. <http://www.tetrad.com/software/pcensus>

All improvements to the contextual data for the current survey, and advances in our understanding of the survey can be used to build more informative models. More can be understood from models with better outcomes of interest, for example trip counts, and better explanatory variables.

9.3.2 New directions for data collection

For all further investigations, the scope of the boomer age group could be expanded upwards to include people aged between 65 and 75 years. New information about the travel habits of this demographic will benefit boomers as they reach this age, and this age group has been less intensively researched, unlike the extensive study of the 'older' elderly over 74³.

Implementing a research design that provides robust findings on causality will help generate analysis with clear benefits to policy makers and transport professionals. In their extensive review of travel methods, Cao et al. (2006) identify longitudinal studies as offering the best framework for understanding causal effects. They recommend long term panel studies, with full measurement of attitudes at the start and as residential moves are made. One possible direction would be to make use of a cohort study and supplement the data with additional BE measurements, though this might not fulfill the longitudinal requirements. This approach seems to be more common in the health and activity field than among travel researchers (for example, King et al. (2003), Thorpe et al. (2006), Berke et al. (2007)), possibly because built environment characteristics are not immediately available and may be completely unobtainable due to survey anonymization.

The focus of this study is on suburban older adults. For people who choose to remain or move to denser areas, the NORC model of aging offers some similar community features to RCs but in an urban context. Comparative analysis of mobility and community support between RCs and NORCs could provide important insights for policy makers in both settings. For example, are older non-driving residents in RCs less active than NORC residents, perhaps because there are fewer destinations within reach? Alternatively, are suburban seniors mobile for longer because their residential location offers familiar faces and a supportive environment? What differences in para-transit exist between different residential locations? Data collection targeting NORCs could provide comparative data to investigate these issues.

This study also offers some lessons in survey design for future studies. Designing the instrument that captures the outcome of interest is important, because weak instruments undermine the validity of findings. Given the interest in local travel and walking, further

³Refer to discussion on page 47

data gathering could focus only on walking trips (though other travel data are still required for context). This has several advantages: the survey materials will be shorter and require less time from respondents, which may increase the response rate. Focusing attention on walking trips could avoid situations where the respondent seems to omit walking because he does not consider it a trip when considered alongside his substantial vehicle usage. More focus on walking allows the variation in types of walking to be explored. For example, Handy et al. (2006) distinguish between walking and strolling, and it would be possible to provide further distinctions that consider social aspects of walking.

Data quality issues with travel diaries suggest that innovations in data gathering could provide better travel data, especially for shorter trip making. Trip rate under-reporting is common in travel surveys (e.g. Pierce et al. (2003)) and thorough telephone surveys are expensive and increasingly problematic as households switch entirely to cell phones (Stopher and Greaves 2007). The decreasing size and increasing power of GPS units makes direct tracking of travel more feasible, but still complicated. Mackett et al. (2006) identify a range of issues encountered from implementing walking studies of children. The primary barrier to use in a study like this one is cost, both in actual instruments and also in the complexity of getting devices to survey participants, troubleshooting use and recovering the data for later analysis. Most published studies of GPS tracking focus on vehicle trips with several hundred participants (e.g. Wolf et al. 2000, Schönfelder et al. 2002), where the tracking device is powered by the vehicle, with varying degrees of additional complexity, such as a screen for drivers to record their trips. In all cases, a substantial increase in survey complexity is required, and the intensity of preparation required could bias the collected data. It would not be possible to eliminate the paper diaries from a study like this one without a large cost increase, however small-scale investigations of data capture innovations for boomer travel should be considered to further knowledge on methods and travel simultaneously. A trial study could equip a dozen residents in one RC and a matching neighborhood with tracking devices to measure activity over several weeks, with control groups using paper diaries.

A Survey instrument

Figure A-1. Survey instrument: information letter.

This letter was included with the survey instrument. Shown at 75% reduction.

**Department of Urban Studies & Planning
77 Massachusetts Avenue
Room 10-485
Cambridge, MA 02139**



To Whom It May Concern:

A survey is being undertaken as part of a research project examining the travel activities of the Boston Metropolitan Area, which we hope will bring benefit to residents in the future.

You have been randomly selected as one of 7,000 residents to participate in the survey. Your participation is voluntary but we hope you will choose to contribute to the efforts and enjoy doing so. Please keep the enclosed \$5.00 as a small thanks in advance for your participation.

Enclosed you will find a survey in two Sections. The First Section asks some general questions about your household, residential preferences, etc. This should be filled out by the head(s) of household. The Second Section includes several travel diaries, to be completed by each household member. The purpose of this diary is to record the daily travel activities on a typical weekday. Please follow the instructions on the first page of the diary.

All information obtained in this survey will be treated with absolute confidentiality and it will not be possible for the researchers to identify the respondents in any way. We would greatly appreciate complete and candid answers to all of the questions. You may, however, decline to answer any and all questions in this survey and otherwise decline to participate if you so desire and without any adverse consequences.

Enclosed please find a self-addressed, postage paid envelope to return the completed materials. We request that you complete and return the surveys within two (2) weeks.

If you have any questions about this survey instrument, contact the principal researcher: Chris Zegras at 617 452 2433. If you have any questions regarding your rights as a research subject, you may contact the Chairman of the Committee on the Use of Humans as Experimental Subjects, M.I.T., Room E25-143b, 77 Massachusetts Ave, Cambridge, MA 02139, phone 1-617-253-6787, e-mail: mede@med.mit.edu.

Thank you. Your cooperation in this survey will be valuable.

Sincerely,

P. Christopher Zegras
Asst. Professor of Transportation and Urban Planning

Figure A-2. Survey instrument: household survey
Shown at 75% reduction.

Travel Behavior Research Project Survey



Massachusetts Institute of Technology

Thank you for taking part in this survey. Your participation will help researchers at the Massachusetts Institute of Technology in a project aiming to better comprehend travel activities. All responses are voluntary, anonymous and will be kept strictly confidential. Please refer to the accompanying letter for more information about the survey and your privacy.

Instructions for an adult resident:

1. Today, please complete the questions below, on this page and on the reverse side.
2. On the first Tuesday, Wednesday or Thursday after you receive this survey, fill out one copy of the blue travel diary.
3. If no other residents are present in your home on the survey day, please place the unused additional survey in the envelope.
4. Place both parts of the survey into the pre-paid return envelope

Instructions for a second adult resident (if present)

1. On the first Tuesday, Wednesday or Thursday after you receive this survey, fill out the second blue travel diary.
2. Once complete, place the diary into the pre-paid envelope

When all parts of the survey are complete, please put the pre-paid return envelope into a mailbox as soon as possible.

Again, thank you for your participation.

The following questions should be completed by an adult resident:

Questions about your home

What type of home do you live in?

choose one answer only

<input type="checkbox"/> Detached single house	<input type="checkbox"/> Duplex	<input type="checkbox"/> Townhouse or rowhouse
<input type="checkbox"/> Apartment	<input type="checkbox"/> Don't know	

Before moving to this address, what type was your previous home?

choose one answer only

<input type="checkbox"/> Detached single house	<input type="checkbox"/> Duplex	<input type="checkbox"/> Townhouse or rowhouse
<input type="checkbox"/> Apartment	<input type="checkbox"/> Don't know	

Do you own or rent your home?

mark one answer only

<input type="checkbox"/> Own	<input type="checkbox"/> Rent	<input type="checkbox"/> Don't know
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Questions continue, please turn over.

Questions continued. Instructions on reverse side.

How many vehicles do you have at your home? Include cars, motorcycles and trucks.
mark one answer only

0 1 2 3 4 5 or more

How many bicycles do you have at your home?
mark one answer only

0 1 2 3 4 5 or more

About your neighborhood

Do you live in a community with age restrictions on who can live there (e.g. an Active Adult community)?
mark one answer only

Fully restricted (all 55+ only) Some restricted streets
 No restrictions Not sure

Questions about your household

How many people are resident at this address?
mark one answer only

0 1 2 3 4 5 or more

How many people who live here are between 55 and 65 years of age?
mark one answer only

0 1 2 3 or more

Last year, what was your total household income, from all sources before tax?
mark one answer only, or leave blank if you prefer

<input type="checkbox"/> Less than \$15,000	<input type="checkbox"/> \$15,000 to \$24,999	<input type="checkbox"/> \$25,000 to \$34,999
<input type="checkbox"/> \$35,000 to \$49,999	<input type="checkbox"/> \$50,000 to \$74,999	<input type="checkbox"/> \$75,000 to \$99,999
<input type="checkbox"/> \$100,000 to \$149,999	<input type="checkbox"/> \$150,000 to \$199,000	<input type="checkbox"/> \$200,000 or more

Thank you! Please place this document into the pre-paid return envelope.

Next, fill out the travel diary booklets on the next Tuesday, Wednesday or Thursday.
Once all documents are complete, put the envelope into a mailbox as soon as possible.

Figure A-3. Survey instrument: personal booklet and diary
The booklet was folded letter size. Shown at 75% reduction.

Travel Behavior Research Project Survey



Massachusetts Institute of Technology

Your Travel Diary Booklet

Thank you for taking part in this survey. Your participation will help researchers at the Massachusetts Institute of Technology in a project aiming to better comprehend household travel activities. All responses are voluntary, anonymous and will be kept strictly confidential. Please refer to the accompanying letter for more information about the survey and your privacy.

This booklet is a travel diary. There are two copies in this envelope. A resident adult should fill in one copy independently. If there is a second adult who lives here, he or she should fill out the second booklet.

Completing your travel diary

This booklet contains two parts:

Section 1: Background information (pages 2 - 5)

This section contains questions about your occupation, attitudes and daily trips. You can fill out this section anytime.

Section 2: Travel Diary (page 5 onwards)

The travel diary should be completed on a single day. Please fill it out on the first Tuesday, Wednesday or Thursday after receiving this survey. For example, if this survey arrives in the mail on Saturday, fill out the diary on Tuesday.

Section 1: Background Information

1 Questions about you

a How old are you? *write your age (e.g. 54)*

_____ years

b Are you male or female?

Male

Female

c What is your relationship to the principal wage earner?
mark one answer only

I am the principal wage earner

Other (write in below)

d Relationship: _____

e Which phrase best describes your current situation?
mark one answer only

Employed full time

Employed part time

Retired

Homemaker

Seeking work

2 Questions about your health

Having health problems may prevent you from making journeys or affect the types of journeys that you make. Because of a physical, mental, or emotional problem do any of the following statements apply to you?

Check all boxes that apply.

- My health problems keep me from working at a job.
- My health problems restrict the kind or amount of work I do.
- I am limited in some way in any activities because of my health problems .
- I need the help of other persons with personal care needs, such as eating, bathing, dressing, or getting around inside your home.
- I need the help of other persons in handling routine needs, such as everyday household chores, doing necessary business, shopping, or getting around for other purposes.
- None of the statements above apply to me.

3 Questions about your travel attitudes

For each statement, express your level of agreement.
1 = strongly disagree, 3 = neutral, 5 = strongly agree

a I enjoy driving

1 2 3 4 5
strongly disagree neutral strongly agree

b I make efforts to minimize the amount of driving I need to do

1 2 3 4 5
strongly disagree neutral strongly agree

v I like riding a bus

1 2 3 4 5
strongly disagree neutral strongly agree

d I enjoy bicycling

1 2 3 4 5
strongly disagree neutral strongly agree

e Taking public transit is convenient

1 2 3 4 5
strongly disagree neutral strongly agree

f Highways deserve more investment than public transit.

1 2 3 4 5
strongly disagree neutral strongly agree

g I prefer to combine multiple activities into a single journey

1 2 3 4 5
strongly disagree neutral strongly agree

h Having sidewalks make me more likely to walk

1 2 3 4 5
strongly disagree neutral strongly agree

i I dislike sitting in traffic

1 2 3 4 5
strongly disagree neutral strongly agree

j The price of gasoline should be increased to reduce congestion.

1 2 3 4 5
strongly disagree neutral strongly agree

4 Questions about regular journeys you make

Last week (Monday to Sunday), how many times did you make the following one way trips?

a Drive to work
 0 1 2 3 4 5 6 7 8 9+

b Go to work on public transportation
 0 1 2 3 4 5 6 7 8 9+

c Walk or cycle for exercise in your neighborhood
 0 1 2 3 4 5 6 7 8 9+

d Travel to another area for exercise
 0 1 2 3 4 5 6 7 8 9+

e Transport someone (pickup, drop off)
 0 1 2 3 4 5 6 7 8 9+

f Go shopping
 0 1 2 3 4 5 6 7 8 9+

g Visit a neighbor
 0 1 2 3 4 5 6 7 8 9+

h Visit a friend in a different neighborhood
 0 1 2 3 4 5 6 7 8 9+

i Go out for recreation (sports, eating out, movies)
 0 1 2 3 4 5 6 7 8 9+

j If you work, how much total time (i.e., round trip, door to door) do you spend commuting to and from work on a typical working day? *write in number of minutes (e.g. "45 minutes")*

Duration of commute: _____

k In a typical week, how many miles do you travel in a car (as driver or passenger)? *write in number of miles (e.g. 30 miles)*

Total miles: _____

m Do you have a MBTA commuter rail monthly pass?

Yes

No

n Do you have a MBTA CharlieCard pass?

Yes, monthly pass

Yes, weekly pass

No

5 Questions about previous and future neighborhoods

a How long have you lived at this address?

write in number of years and months

_____ years _____ months

Consider this neighborhood and compare it to where you previously lived. How do they compare in the following categories?

b Sidewalks:

More sidewalks here	About the same	Fewer sidewalks here	Not sure
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c Public transport options

More public transport options here	About the same	Fewer public transport options here	Not sure
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d Better access to highways

Easier to get to highway from here	About the same	Harder to reach highway from here	Not sure
------------------------------------	----------------	-----------------------------------	----------

e Distance to bus, train or transit stop

Stop/station is closer to here	About the same	Stop/station is further away from here	Not sure
--------------------------------	----------------	--	----------

f Distance between houses

Houses more spread out here	About the same	Houses closer together here	Not sure
-----------------------------	----------------	-----------------------------	----------

g Local shops and services

More shops and services close to here	About the same	Fewer shops and services close to here	Not sure
---------------------------------------	----------------	--	----------

h Are you considering moving to a new home?
choose one

In the next few years

Not now, but maybe in the future

I will not move

When thinking about moving to a new home in the future, what do you consider as important influences on the decision?
1 = not important, 3 = neutral, 5 = very important

i Downsizing to smaller home

1 2 3 4 5
not important neutral very important

j Current home becoming less practical

1 2 3 4 5
not important neutral very important

k Health/aging concerns

1 2 3 4 5
not important neutral very important

m Living closer to family

1 2 3 4 5
not important neutral very important

n Living closer to shops and services

1 2 3 4 5
not important neutral very important

p Living closer to work

1 2 3 4 5
not important neutral very important

q Living closer to schools/other education facilities

1 2 3 4 5
not important neutral very important

6 Questions about your residential preferences

For each statement, express your level of agreement.
1 = strongly disagree, 3 = neutral, 5 = strongly agree

a I like to live in a neighborhood with children in it

1 2 3 4 5
strongly disagree neutral strongly agree

b I prefer a house close to the sidewalk so that I can see and interact with passersby

1 2 3 4 5
strongly disagree neutral strongly agree

c I prefer to have shops and services within walking distance

1 2 3 4 5
strongly disagree neutral strongly agree

d I prefer a lot of space between my home and the street

1 2 3 4 5
strongly disagree neutral strongly agree

e I prefer living around people who are similar to me

1 2 3 4 5
strongly disagree neutral strongly agree

f I am concerned about strangers walking through my neighborhood

1 2 3 4 5
strongly disagree neutral strongly agree

g I like a neighborhood containing housing, shops and services

1 2 3 4 5
strongly disagree neutral strongly agree

h I prefer neighbors at the same stage of life as me

1 2 3 4 5
strongly disagree neutral strongly agree

i I value space around my home more than having shops nearby

1 2 3 4 5
strongly disagree neutral strongly agree

Section 2: Travel diary

On the next Tuesday or Wednesday or Thursday, carry this diary with you. Record all the travel that you make during the day, starting when you get up in the morning until you go to bed. We ask you to do this on one of those days because they are generally typical travel days for most people.

Fill out one Trip Record box for each trip. A trip is any journey you make during the day including journeys on foot in your neighborhood. These are all trips: jogging for exercise, walking the dog, driving to work, driving a neighbor to the mall.

Each time you reach a destination, a new trip begins. If you break a journey to do another activity, the second part of the journey is a new trip – for example, driving home with a stop at the grocery store is two trips (1. from work to the store, 2. from the store to home). However, changing between different transport options (e.g. changing from bus to train on your way to work) does not count as a separate trip.

If your job includes travel (e.g. delivery driver, police officer), do not include trips made as part of your job, but do include traveling to and from work and any other trips during the day that were not part of your job.

When writing down the cost of a trip, do not include: gas, depreciation of your vehicle, cost of monthly T or rail pass. Include all of the following costs: tolls, parking, T tickets, taxi fare.

If you need to include more trips than there is space in this booklet, please continue on a separate sheet.

The diagram below shows an example day of trips:

7 Questions about the survey day

a What date did you complete the travel diary:

Write the date MM/DD/YYYY, e.g. 10/09/2007:

b If you made no trips on the survey day, please tick this box and return the survey using the pre-paid envelope:

	What time did you set off? <i>Write in the start time</i>	What time did you arrive? <i>Write in your arrival time</i>	Where were you going? <i>Pick one only</i>	How did you get there? <i>Check all methods of transport used on this trip</i>	How far did you go? <i>Write distance in miles</i>	What was the cost? <i>Write total of tolls, parking & transit ticket/taxi</i>	What was the weather? <i>Pick one</i>
Trip	____ : ____ <input type="checkbox"/> am <input type="checkbox"/> pm	____ : ____ <input type="checkbox"/> am <input type="checkbox"/> pm	<input type="checkbox"/> To work <input type="checkbox"/> To exercise <input type="checkbox"/> Shop <input type="checkbox"/> For exercise <input type="checkbox"/> Visit friends/family <input type="checkbox"/> Errands <input type="checkbox"/> Eat/Drink <input type="checkbox"/> Entertainment <input type="checkbox"/> Medical <input type="checkbox"/> Return home <input type="checkbox"/> Other: _____	<input type="checkbox"/> Car driver <input type="checkbox"/> Train <input type="checkbox"/> Car passenger <input type="checkbox"/> Motorcycle <input type="checkbox"/> Walk <input type="checkbox"/> Bicycle <input type="checkbox"/> Taxi <input type="checkbox"/> Shuttle bus <input type="checkbox"/> Local bus <input type="checkbox"/> Other: _____	miles	\$	<input type="checkbox"/> Sunshine <input type="checkbox"/> Cloud <input type="checkbox"/> Rain <input type="checkbox"/> Snow
Trip	____ : ____ <input type="checkbox"/> am <input type="checkbox"/> pm	____ : ____ <input type="checkbox"/> am <input type="checkbox"/> pm	<input type="checkbox"/> To work <input type="checkbox"/> To exercise <input type="checkbox"/> Shop <input type="checkbox"/> For exercise <input type="checkbox"/> Visit friends/family <input type="checkbox"/> Errands <input type="checkbox"/> Eat/Drink <input type="checkbox"/> Entertainment <input type="checkbox"/> Medical <input type="checkbox"/> Return home <input type="checkbox"/> Other: _____	<input type="checkbox"/> Car driver <input type="checkbox"/> Train <input type="checkbox"/> Car passenger <input type="checkbox"/> Motorcycle <input type="checkbox"/> Walk <input type="checkbox"/> Bicycle <input type="checkbox"/> Taxi <input type="checkbox"/> Shuttle bus <input type="checkbox"/> Local bus <input type="checkbox"/> Other: _____	miles	\$	<input type="checkbox"/> Sunshine <input type="checkbox"/> Cloud <input type="checkbox"/> Rain <input type="checkbox"/> Snow
Trip	____ : ____ <input type="checkbox"/> am <input type="checkbox"/> pm	____ : ____ <input type="checkbox"/> am <input type="checkbox"/> pm	<input type="checkbox"/> To work <input type="checkbox"/> To exercise <input type="checkbox"/> Shop <input type="checkbox"/> For exercise <input type="checkbox"/> Visit friends/family <input type="checkbox"/> Errands <input type="checkbox"/> Eat/Drink <input type="checkbox"/> Entertainment <input type="checkbox"/> Medical <input type="checkbox"/> Return home <input type="checkbox"/> Other: _____	<input type="checkbox"/> Car driver <input type="checkbox"/> Train <input type="checkbox"/> Car passenger <input type="checkbox"/> Motorcycle <input type="checkbox"/> Walk <input type="checkbox"/> Bicycle <input type="checkbox"/> Taxi <input type="checkbox"/> Shuttle bus <input type="checkbox"/> Local bus <input type="checkbox"/> Other: _____	miles	\$	<input type="checkbox"/> Sunshine <input type="checkbox"/> Cloud <input type="checkbox"/> Rain <input type="checkbox"/> Snow
Trip	____ : ____ <input type="checkbox"/> am <input type="checkbox"/> pm	____ : ____ <input type="checkbox"/> am <input type="checkbox"/> pm	<input type="checkbox"/> To work <input type="checkbox"/> To exercise <input type="checkbox"/> Shop <input type="checkbox"/> For exercise <input type="checkbox"/> Visit friends/family <input type="checkbox"/> Errands <input type="checkbox"/> Eat/Drink <input type="checkbox"/> Entertainment <input type="checkbox"/> Medical <input type="checkbox"/> Return home <input type="checkbox"/> Other: _____	<input type="checkbox"/> Car driver <input type="checkbox"/> Train <input type="checkbox"/> Car passenger <input type="checkbox"/> Motorcycle <input type="checkbox"/> Walk <input type="checkbox"/> Bicycle <input type="checkbox"/> Taxi <input type="checkbox"/> Shuttle bus <input type="checkbox"/> Local bus <input type="checkbox"/> Other: _____	miles	\$	<input type="checkbox"/> Sunshine <input type="checkbox"/> Cloud <input type="checkbox"/> Rain <input type="checkbox"/> Snow
Trip	____ : ____ <input type="checkbox"/> am <input type="checkbox"/> pm	____ : ____ <input type="checkbox"/> am <input type="checkbox"/> pm	<input type="checkbox"/> To work <input type="checkbox"/> To exercise <input type="checkbox"/> Shop <input type="checkbox"/> For exercise <input type="checkbox"/> Visit friends/family <input type="checkbox"/> Errands <input type="checkbox"/> Eat/Drink <input type="checkbox"/> Entertainment <input type="checkbox"/> Medical <input type="checkbox"/> Return home <input type="checkbox"/> Other: _____	<input type="checkbox"/> Car driver <input type="checkbox"/> Train <input type="checkbox"/> Car passenger <input type="checkbox"/> Motorcycle <input type="checkbox"/> Walk <input type="checkbox"/> Bicycle <input type="checkbox"/> Taxi <input type="checkbox"/> Shuttle bus <input type="checkbox"/> Local bus <input type="checkbox"/> Other: _____	miles	\$	<input type="checkbox"/> Sunshine <input type="checkbox"/> Cloud <input type="checkbox"/> Rain <input type="checkbox"/> Snow

B Details of Sampled Age-Restricted Communities

Table B.1. Characteristics of the age-restricted neighborhoods

Town	Adams Farm	Crescent Oaks	Deerfield Estates	Delapond Village	East Ridge	Hemmy Crossing	Leicesterwood	Old Point	Pinshills	Pond Meadow	Red Mill	Southport	The Village at Cross Meadow	The Village at Meadowood	The Village at Orchard Meadow	The Village at Quail Run	Victory Hills	Wilmington Crossing	
SHIRESBURY	STURBRIDGE	HOPKINGTON	WALPOLE	LANCASTER	EAST BRIDGEWATER	ROCKLAND	MIDDLEBOROUGH	PLYMOUTH	MARSHFIELD	NORTON	MASHES	MARLBOROUGH	CHELMSFORD	SHIRESBURY	HUBBARD	SOUTHBOROUGH	WALTHAM		
Units	90	69	47	40	44	80	222	1150	900	66	156	480	91	71	70	150	40	118	
Responses	14	3	8	2	12	6	29	96	92	6	7	37	8	17	15	11	11	4	
Regional location																			
In CTPS	No	No	1	1	1	1	1	1	1	1	No	1	1	No	1	1	1	1	1
Within	Outside 495	Outside 495	Within 495	Within 495	Outside 495	Within 495	Outside 495	Within 495	Within 495	Within 495	Within 495	Outside 495	Within 495	Outside 495	Outside 495	Within 495	Within 495	Within 95	
Distance to Boston	54	90	43	28	55	37	54	47	66	40	41	94	42	39	56	41	39	14	
Distance to rail	3.0	30.2	7.7	1.4	11.0	5.2	15.8	6.3	14.0	15.0	6.8	42.9	7.2	4.4	2.8	12.1	2.3	3.8	
Nearest highway exit	2.9	1.2	3.1	0.3	0.9	1.0	1.9	0.3	8.3	5.2	1.6	2.0	6.0	1.8	0.6	4.4	0.4	7.1	
Population																			
Population (BG)	3,150	1,054	2,635	1,674	720	1,258	1,420	591	1,535	1,024	2,648	1,928	1,663	2,072	1,043	3,140	2,742	616	
Population (TAZ)	0	0	1869	2686	2905	1417	3166	824	114	2658	1384	0	1186	816	0	99	703	3149	
Pop density (BG)	725	775	514	1,698	315	548	1,105	83	178	523	656	758	1,134	1,227	1,221	1,168	734	3,899	
% boomers	4%	13%	6%	8%	11%	6%	13%	21%	8%	7%	9%	12%	8%	8%	9%	9%	9%	8%	
% elderly	5%	16%	5%	30%	11%	14%	21%	15%	11%	6%	4%	16%	5%	16%	12%	13%	6%	36%	
% single person homes	31%	30%	11%	32%	16%	16%	20%	18%	24%	12%	15%	24%	14%	24%	38%	29%	14%	43%	
% working	52%	59%	54%	48%	49%	54%	51%	52%	48%	47%	49%	51%	54%	50%	54%	53%	52%	44%	
% commute auto	95%	89%	92%	93%	92%	95%	95%	89%	85%	90%	91%	95%	95%	94%	92%	94%	95%	84%	
% commute PT	1%	0%	4%	5%	0%	4%	0%	4%	4%	5%	5%	2%	0%	3%	1%	0%	0%	8%	
Income																			
Median HH income (\$)	65,449	63,603	112,632	46,797	73,854	57,353	39,464	50,313	49,615	96,293	64,511	44,427	77,570	63,672	44,420	55,521	109,314	71,250	
% low income	11%	21%	10%	29%	11%	15%	37%	19%	21%	5%	15%	25%	13%	16%	25%	22%	7%	15%	
% medium income	49%	34%	16%	40%	41%	49%	42%	56%	52%	32%	46%	58%	36%	43%	62%	43%	20%	37%	
% high income	40%	45%	74%	30%	48%	36%	20%	25%	27%	63%	39%	18%	52%	41%	12%	35%	72%	48%	
Home ownership																			
% owner occupied	56%	76%	93%	84%	95%	86%	73%	89%	68%	94%	77%	74%	90%	78%	64%	67%	95%	70%	
Median value 00 units	229,600	147,300	338,200	214,000	185,700	169,600	131,600	196,100	208,900	278,800	180,300	159,800	234,200	205,600	128,900	178,600	286,800	146,500	
Median age built	1984	1971	1985	1961	1970	1966	1982	1966	1975	1973	1975	1982	1972	1973	1951	1965	1979	1965	
Accessibility																			
Attractions on TAZ			19	31	32	25	9	2	5	9	8		3	71		9	21	10	
Retail jobs			45	9	16	102	29	11	0	28	178		0	623		441	111	35	
All employment			257	490	824	378	121	97	9	479	294		1863	1277		2563	586	633	
All emp accessibility cumul			1,178	8,248	6,444	4,078	7,756	1,708	48	3,285	2,786		20,333	7,740		9,760	7,596	23,733	
Retail accessibility cumul			208	1,145	645	1,576	792	130	4	818	474		1,639	1,588		1,552	1,020	2,384	
All emp accessibility grav			344	662	1,051	453	400	125	9	555	394		2,968	1,662		2,808	750	1,531	
Retail accessibility grav			60	40	53	130	60	13	0	51	183		50	671		511	134	161	
All attractions accessibility cumul			60.0	208.0	156.0	173.0	268.0	53.0	14.0	121.0	43.0		235.0	230.0		275.0	135.0	215.0	
Shops accessibility cumulative			8.0	29.0	22.0	24.0	37.0	8.0	0.0	18.0	5.0		34.0	27.0		38.0	19.0	28.0	
Eat accessibility cumulative			4.0	40.0	27.0	28.0	32.0	5.0	2.0	21.0	8.0		46.0	45.0		47.0	25.0	31.0	
All attractions accessibility grav			22.9	34.8	37.0	28.1	19.1	2.8	5.1	11.4	9.2		9.3	79.1		18.4	24.3	22.2	
Shop accessibility grav			3.5	3.5	2.9	0.5	3.3	0.2	0.0	1.3	1.2		1.7	6.9		2.5	5.4	2.8	
Eat accessibility grav			2.2	3.0	3.7	4.5	2.3	0.1	1.0	0.4	2.1		2.7	15.3		3.1	3.7	2.2	
Street network																			
Road density (250m cell)	175	410	129	462	161	0	768	396	796	49	0	834	404	831	555	267	320	246	

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