



THE EFFECTS OF RESIDENTIAL OFF-STREET PARKING AVAILABILITY ON TRAVEL BEHAVIOR IN SAN FRANCISCO

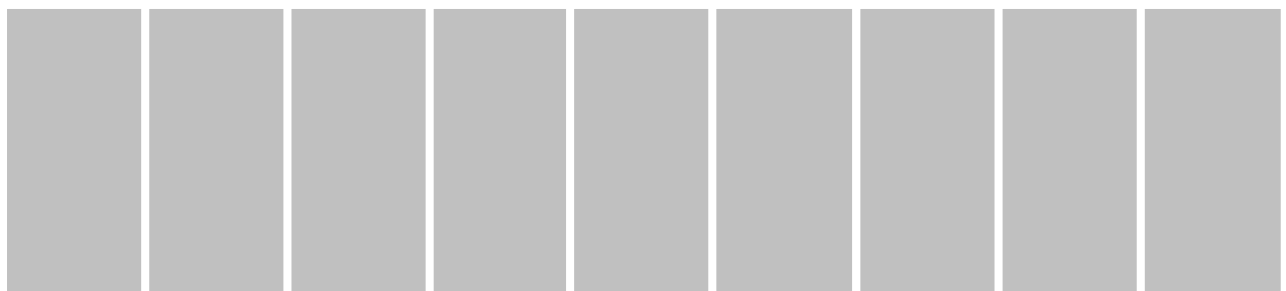
**A Planning Report
Presented to
The Faculty of the Department of
Urban and Regional Planning
San José State University**

**In Partial Fulfillment
Of the Requirements for the Degree
Master of Urban Planning**

By

Alyssa B. Sherman

May 2010



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Introduction

For years, it has been standard practice for cities across the country to require developers to provide a minimum number of parking spaces when building new residential developments. Although these policies were intended to prevent spillover parking on the street and to respond to market demand for residential parking, in recent years it has become apparent that minimum parking policies subsidize the cost of using single occupant vehicles and encourage people to use vehicles. The widespread use of single occupant vehicles in the United States has been tied to increases in pollution, sprawl, housing prices, and unpleasant urban aesthetics.

To encourage people to drive less and to take transit or walk to their destinations more often, dense urban areas that are well-served by transit, such as San Francisco, are beginning to reduce the amount of residential parking that developers are required to provide out of a belief that density and the availability of transit in such areas reduces residents' need for a vehicle. San Francisco recently implemented parking maximums, which replace minimum parking requirements with a limit on the number of parking spaces that developers can build in certain dense neighborhoods.

At this point, there is little information available to describe the effects of reduced parking requirements on peoples' travel behavior. Thus, urban planners who are considering instituting parking maximums, reducing parking minimums, eliminating parking minimums, or implementing any other program to reduce the number of off-street residential parking spaces provided with new development in San Francisco or elsewhere are likely to be interested in how such policies will effect travel behavior.

To determine the effects of reduced parking requirements on travel behavior, a survey was prepared and data was collected and analyzed to answer the following questions:

1. In San Francisco, to what extent does the availability of an off-street residential parking space influence residents' travel behavior?
2. Will reducing residential off-street parking requirements encourage people to drive less?

The study also analyzes differences in the travel behavior of people who live in areas with parking minimums and areas where the city has recently introduced parking maximums and eliminated parking minimums. It also provides an overview of current parking policies intended to reduce motor vehicle trips. This study produces data that helps predict whether policies aimed at reducing residential off-street parking requirements will be effective in encouraging people to drive less.

The City of San Francisco in Context

San Francisco is a city of 808,976¹ residents located in Northern California. Located at the tip of a peninsula, San Francisco is bordered by the Pacific Ocean to the west and the San Francisco Bay to the north and east. It is located at the center of the nine-county Bay Area region, with Silicon Valley approximately 35 miles to the south, the cities of Berkeley

¹ U.S. Census Bureau, "Population Finder," <http://factfinder.census.gov/servlet/SAFFPopulation> (accessed August 30, 2009).

and Oakland to the east, and the scenic and agricultural lands of Marin, Napa, and Sonoma counties to the north.

In addition to its geographic position at the center of the Bay Area, San Francisco is also the region's hub of employment, shopping, entertainment and transportation. In 2008, 573,124 people were employed in San Francisco,² and in 2005 the city had \$13.03 billion in taxable sales.³ There are more than 150 venues and events spaces in the city, including theatres, music clubs, galleries, and meeting spaces.⁴

San Francisco also enjoys the distinction of being one of the most expensive housing markets in the United States.⁵ In January of 2010, the median sale price for single-family homes in San Francisco was \$720,000, and \$599,000 for condos.⁶ In 2007, the average household size was 2.3, and the median annual household income was \$65,519.⁷

The city is historically well-served by transit. Cable cars have been operational since 1873,⁸ and today the country's seventh largest transit system - Municipal Transportation Agency (MUNI) - operates electric streetcars, light rail lines, and diesel and electric buses in addition to the city's iconic cable cars.⁹ Bay Area Rapid Transit (BART) is a regional rapid rail system that maintains eight stations in San Francisco and connects the city to Berkeley, Oakland, Fremont, San Francisco Airport, and suburban areas outside the city. Caltrain is a heavy rail system that connects San Francisco with San Jose and Silicon Valley. In addition, ferry lines connect San Francisco's downtown Embarcadero to Marin, Solano, and Alameda counties.

Although a variety of transit resources are available in San Francisco, most of the city was developed after the advent of the automobile in an auto-oriented pattern. Parking requirements for residential developments were introduced in 1955. Despite the wide availability of transit in San Francisco, the majority of city residents own cars. Today in San Francisco, 70.3% of households have at least one car available¹⁰, and among workers, 39.6% drive alone to work, 32.2% use public transportation, and 9.5% walk to work.¹¹ However, there are no existing statistics to measure the travel behavior of people with a residential parking space as opposed to those without a parking space at home. 63.5% of

² U.S. Bureau of Labor Statistics, "Quarterly Census of Employment and Wages," <http://data.bls.gov/cgi-bin/survey/most> (accessed August 30, 2009).

³ California Department of Finance, "Financial & Economic Data," under "San Francisco County Profile," http://www.dof.ca.gov/HTML/FS_DATA/profiles/pf_home.php (accessed August 30, 2009).

⁴ Yelp, "Venues and Event Spaces," www.yelp.com (accessed August 30, 2009).

⁵ Sustain Lane, "2008 US City Rankings: Housing Affordability," <http://www.sustainlane.com/us-city-rankings/categories/housing-affordability> (accessed August 30, 2009).

⁶ Rosen Consulting Group, "Market Focus: A Monthly Analysis of the San Francisco Real Estate Market," February 2010.

⁷ U.S. Census Bureau, 2005-2007 American Community Survey, "Fact Sheet: San Francisco County, California," <http://factfinder.census.gov> (accessed September 20, 2009).

⁸ San Francisco Cable Car Museum, "Cable Car Heritage," <http://www.cablecarmuseum.org/heritage.html> (accessed August 30, 2009).

⁹ San Francisco Municipal Transportation Agency, "About Us," <http://www.sfmta.com/cms/ahome/indxabmu.htm> (accessed August 30, 2009).

¹⁰ U.S. Census Bureau, "San Francisco County, California: Selected Housing Characteristics 2005-2007," <http://factfinder.census.gov> (accessed August 30, 2009).

¹¹ U.S. Census Bureau, "San Francisco County, California: Selected Economic Characteristics 2005-2007," <http://factfinder.census.gov> (accessed August 30, 2009).

the city's housing stock was built prior to 1949,¹² which means there are a number of units in the city that were built without the amount of parking that is required under San Francisco's parking policies today. In other words, there are plenty of residences in San Francisco without one parking space per unit. Thus, the city's development pattern provides an opportunity to study the differences in travel behavior among those residents that have a parking space and those that do not.

The Practical Relevance of This Study

This study presents newly collected survey data comparing the travel behavior of people with or without an off-street parking space in areas with and without parking minimums within the same city. This data provides insight into whether policies that discourage vehicle ownership such as implementing parking maximums, reducing parking minimums, or eliminating parking minimums may be effective means of decreasing motor vehicle trips for work, errands, and entertainment. This study can help advise city planners and developers in San Francisco and elsewhere as to whether policies to eliminate parking minimums and introduce parking maximums will effectively realize the intended goals of reducing congestion, encouraging denser development, making housing more affordable, and supporting improved urban form.

San Francisco is an ideal laboratory in which to study the influence of residential off-street parking space availability on travel behavior. In several dense San Francisco neighborhoods with good transit access, the city recently introduced policies to eliminate parking requirements. Although planners and analysts believe San Francisco's parking policies will influence the eventual residents of units without off-street parking spaces to be less auto-dependent than their counterparts with off-street parking spaces,¹³ there is little evidence to suggest differences in the travel preferences of residents of these two types of neighborhood.¹⁴ In fact, parking policy is generally a little-studied topic, and one that is typically omitted from textbooks.¹⁵ Although those who do study parking policy generally agree that minimum parking requirements are unnecessary, there is very little evidence to actually suggest that parking policy can change behavior.¹⁶ Residential parking is the area of parking policy with the least empirical evidence available, yet this is possibly the most important area for study because of the variety of social and economic effects that residential parking policy can bring about.¹⁷

¹² U.S. Census Bureau, "San Francisco, California: Selected Housing Characteristics: 2005-2007," <http://factfinder.census.gov> (accessed August 30, 2009).

¹³ Tom Radulovich, Interviewed by author in person, San Francisco, California, July 2, 2009 and Joshua Switzky, Interviewed by author in person. San Francisco, California, July 9, 2009.

¹⁴ Rocco Pendola, Stephanie Ruddy, and Elmer Tosta, "Residential Parking Requirements in San Francisco: Do They Affect Travel Behavior?" Unpublished report presented to Livable City by San Francisco State University Urban Studies Program, May 2005.

¹⁵ Jason Henderson, "The Spaces of Parking: Mapping the Politics of Mobility in San Francisco," *Antipode* 41, no. 1 (2009): 73.

¹⁶ Greg Marsden, "The Evidence Base for Parking Policies – A Review," *Transport Policy*, no. 13 (2006): 455.

¹⁷ *Ibid.*

About the Survey Methods

The desired respondent group for this survey was San Francisco residents who live in areas that have eliminated parking requirements, and a control group of people who live in parts of the city where residential parking requirements are still in place. As such, all residents of San Francisco over age 18 were within the desired group of respondents for this survey. A survey containing 23 questions covering travel, parking, housing, and demographics was prepared, and was administered to more than 200 people in San Francisco, both online through neighborhood associations and social networks and through intercept survey administration at supermarkets and in parks. This random sample yielded 182 unique and usable surveys. The variables were described with descriptive statistics and relationships between the variables were described with statistical tests including Chi-Square and T-Tests of Independent Means. A full analysis of the survey data follows.

Description of Report Organization

The report of this study begins with an overview of current parking policy practice, which provides an in-depth discussion of the development and current applications of minimum and maximum parking requirements for all land uses, with particular focus on residential parking policies. Then, the discussion narrows to a brief history of parking policy in San Francisco, and an overview of the city's more recent introduction of parking maximums and retraction of parking minimums. This section includes a chart outlining all of the San Francisco neighborhoods where the city eliminated parking minimums and adopted parking maximums for residential development.

A literature review details the effects of parking requirements and describes the limited existing research regarding the ways in which residential parking availability shapes travel behavior. It then discusses the body of related studies, which describe the relationships between off-street parking requirements at destinations and travel behavior; land use and travel behavior; parking requirements and urban design; and parking requirements and housing affordability. The literature review finishes with descriptions of developers' and the public's perceptions of parking requirements, and suggestions for alternatives to parking requirements.

Next, the report describes the survey administered to answer the research questions. This section focuses on the survey results and analysis process, and discusses the survey methodology, including the survey instrument, sample selection, survey administration, and limitations. Finally, a set of recommendations and conclusions drawn from the data and research is presented.

An Overview of Current Parking Policy Practice

Introduction

Although cities have required developers to provide a minimum number of off-street parking spaces for both residential and commercial uses since shortly after the advent of the motor vehicle, in the 1980s innovative planners started to introduce a new wave of parking requirements such as commercial parking maximums and limits on the amount of parking that developers are permitted to build in certain downtown areas. Today, cities are considering implementing a wider range of alternative parking standards, such as elimination of parking minimums for both residential and commercial development and residential parking maximums. Such policies are designed to limit the influence of the vehicle and to create walkable and vibrant neighborhoods and commercial destinations by reducing the amount of land taken up by parking. This section will explore the historical development of parking requirements and will provide an overview of the state of the practice regarding current parking policy.

Minimum Parking Requirements

Today, free parking is available just about everywhere such as on the street, in strip malls, or at the condominium complexes of our friends. The widespread availability of free parking developed from a tradition of providing curbside tethers for horses and carriages.¹⁸ As more people bought cars and the demand for curbside parking increased, cities began to include in zoning ordinances requirements that developers provide the minimum number of off-street parking spaces necessary to accommodate the demand for parking created by development on a particular site. This practice is now known as a minimum parking requirement. By 1946, a survey of 76 cities found that 17% had implemented minimum parking requirements. A follow-up study of the same 76 cities five years later found that 71% of cities had adopted parking requirements,¹⁹ making for a 54% jump in the number of cities with minimum parking requirements. Today, most cities establish minimum off-street parking requirements in zoning ordinances for all land uses, including commercial, office, and residential developments.

Beyond the traditional custom of providing free parking in the United States, there are several reasons why cities today require developers to provide off-street parking spaces. Two primary motivations are commercial viability and market demand. Developers and cities want to maximize the market demand for a particular type of housing or business, and thus the conventional belief is that a land use should provide off-street parking in a quantity that is sufficient to accommodate all of the vehicles that might want to access that particular land use.²⁰ Neither developers nor funders want to discourage people from purchasing, renting, or shopping at a property because it is inaccessible. Also, city

¹⁸ Donald Shoup, *The High Cost of Free Parking* (Chicago: Planners Press, 2004), 1.

¹⁹ Mogren, Edward and Wilbur Smith, *Zoning and Traffic* (Saugatuck, Connecticut: Eno Foundation for Highway Traffic Control, 1952) as quoted in Donald Shoup, *The High Cost of Free Parking* (Chicago: Planners Press, 2004), 22.

²⁰ Richard Willson, "Suburban Parking Requirements: A Tacit Policy for Automobile Use and Sprawl," *Journal of the American Planning Association* 61, no. 1 (1995): 30.

governments like to minimize the number of vehicles that “spill over” into on-street parking spaces in neighboring residential areas or illegal spaces.²¹

Cities typically establish minimum parking requirements in one of two ways: by following examples set by neighboring cities or by using a manual developed by the Institute of Transportation Engineers, called *Parking Generation*. However, according to parking policy researcher Donald Shoup, both of these methods are flawed. By copying the parking plans enacted by other local agencies, cities run the risk of repeating the mistakes of others, and may inadvertently replicate arbitrary calculations.²² The parking rates outlined in *Parking Generation* are not generally applicable, as they are based on a few parking surveys that are conducted during peak hours in suburban locations.²³ Although most cities lack the financial resources to conduct individual parking demand surveys for each land use, it is difficult to rationalize applying the ITE rates to all circumstances.

Since most cities follow the same rules of thumb to calculate parking requirements, many cities implement requirements that are similar. Typical minimum parking rates in California cities are as follows:²⁴

- Residential: one to two spaces per unit. (1:1 or 2:1)
- Office Space: three spaces per 1,000 square feet of office space.
- Retail: one to four spaces per 1,000 square feet of retail space.
- Restaurant: varies greatly by restaurant type and jurisdiction; but one space per 200 square feet is fairly typical.

Many developers choose to build more parking than the minimum amount required because funders favor projects with abundant parking.

Although drivers do not pay a direct fee to use most parking spaces, the spaces are not free: developers must pay to build the spaces and they add the fee to rental and purchase prices. Commercial tenants, in turn, pass the fee on to consumers by adding it to the prices for goods and services. The perception that parking is free and plentiful and the reality that free parking is nearly always available makes driving to a destination seem more cost effective than taking transit, which entails payment of a fare for each ride. Studies have found that minimum parking requirements can lower density, encourage sprawl, increase congestion, and reduce demand for transit services.²⁵ These factors, in combination, create auto-centered communities and downtown areas with little streetscape vitality.

Planners are beginning to recognize the influence of plentiful parking on community vitality and are starting to scrutinize the practice of minimum parking requirements. As a result, some communities, such as Berkeley, California, allow exceptions to parking minimums for developers who opt to build fewer than the required number of spaces.²⁶ Other cities, such as Seattle, Washington, have eliminated minimum parking requirements

²¹ Ibid.

²² Donald Shoup, “The Trouble with Minimum Parking Requirements,” *Transportation Research Part A: Policy and Practice*, no. 33 (1999): 550.

²³ Ibid., 551.

²⁴ Metropolitan Transportation Commission, “Developing Parking Policies to Support Smart Growth in Local Jurisdictions: Best Practices,” (Metropolitan Transportation Commission, Report, May 2007), 24-25.

²⁵ Richard Willson, “Suburban Parking Requirements: A Tacit Policy for Automobile Use and Sprawl,” *Journal of the American Planning Association* 61, no. 1 (1995): 38-40.

²⁶ Adam Millard-Ball, “Putting on Their Parking Caps,” *Planning*, April 2002.

altogether in certain areas. In Seattle, developers are not required to provide a minimum number of parking spaces for vehicles in the downtown core, though they are required to provide parking spaces for bicycles.²⁷ Parking is also not required in commercial zones near light rail stations in Seattle.²⁸ Meanwhile, Portland, Oregon has eliminated minimum parking requirements in the central residential and commercial core, neighborhood commercial zones, and certain other areas zoned for commercial and office land uses.²⁹ Portland also excludes “sites located less than 500 feet from a transit street with 20-minute peak hour service” from minimum parking requirements³⁰ and allows developers to provide bicycle parking in place of 25% of required parking.³¹ As the discussion below will explore in more detail, San Francisco has also eliminated off-street parking minimums altogether in certain parts of the city in and around downtown.

The cities discussed in this section have adopted progressive parking policies that serve as alternatives to minimum off-street parking requirements. In the next section, I will discuss another group of innovative parking policies from cities that have decided to change the status quo of parking policy by establishing thresholds limiting the amount of parking that developers may build in certain areas.

Maximum Parking Requirements

Planners looking to prevent sprawl and auto-dependency in favor of creating more walkable and vibrant places are more frequently considering parking maximums in place of traditional parking minimums. As opposed to parking minimums, which require developers to provide a certain minimum number of parking spaces, which they can exceed, maximum parking requirements establish a limit on the amount of parking spaces that a developer can provide. Cities may establish parking maximums instead of parking minimums, or in concert with a parking minimum. Like parking minimums, maximum parking designations are included in zoning ordinances or neighborhood plans.

Parking maximums are a relatively new alternative parking policy strategy. The limit on the number of spaces allowed is typically determined in one of two ways. Some cities base parking maximums on the availability of alternative modes of transportation (as in Portland, Oregon; San Francisco, California; and Cambridge, Massachusetts, which all tie parking maximums to transit policies).³² Other cities conduct parking utilization studies locally to derive parking maximum allowances for their municipality, rather than relying on *Parking Generation* rates. The cities that have conducted utilization studies include Portland, Bend, and Hood River in Oregon.³³

Cambridge, Massachusetts is credited with being one of the first cities to set parking maximums, which it did in the 1980s. Cambridge’s parking maximum today allows, for

²⁷ City of Seattle Municipal Code, Title 23, Subtitle III, Subdivision 2, Chapter 23.49, Subchapter I. “Downtown Zoning: General Provisions.”

²⁸ City of Seattle Municipal Code, Title 23, Subtitle III, Subdivision 2, Chapter 23.54. “Quantity and Design Standards for Access and Off-Street Parking.”

²⁹ City of Portland City Code, Chapter 33.266.110: Parking and Loading, Minimum Required Parking Spaces.

³⁰ Ibid.

³¹ Ibid.

³² Metropolitan Transportation Commission, “Developing Parking Policies to Support Smart Growth in Local Jurisdictions: Best Practices,” (Metropolitan Transportation Commission, Report, May 2007), 35.

³³ Ibid.

example, for a maximum of two parking spaces per 800 square feet of general office space, or for two spaces per five seats at a bar.³⁴ In addition to removing parking minimums, Portland has also set parking maximums in parts of the downtown business district. The maximum allows, for example, .7 off-street parking spaces per 1,000 square feet of office space, and 1.35 spaces per residential unit.³⁵ San Francisco has also set parking maximums in several neighborhoods. A detailed discussion of San Francisco's parking policies and requirements will follow.

Although realized benefits of residential parking maximums are not well-documented, there is some evidence that parking maximums lead to marginal increases in transit ridership and decreases in vehicle congestion.³⁶ Cities may choose to impose parking maximums to encourage transit ridership, maximize limited land resources, and improve urban aesthetics.³⁷ Units without parking spaces are more affordable,³⁸ so removing the cost of a parking space from the price of a house (also known as "unbundling" parking) can make housing affordable for more people.

Despite the benefits, parking maximums as an alternative parking policy are often controversial. Developers are often opposed to parking maximums because, over the many years that minimum parking requirements have been the status quo in development, developers have created a rule of thumb for what will sell: residential units such as single family homes, condominiums, or apartments with a ratio of at least one parking space per unit (1:1).³⁹ It is often difficult for developers to convince funders to invest in projects that provide less than one parking space per unit because it is a deeply rooted industry standard. Developers also fear that units without parking will not be able to compete with similar developments.⁴⁰

However, two studies have produced evidence contradicting developers' and funders' fears about the marketability of units without parking. A study of the effects of parking requirements on the cost of homes in San Francisco found that condominiums sold with a parking space actually have a slower absorption rate than those without a parking space. That study found that condominium units with parking took 41 days longer to sell than those without.⁴¹ Another study found that housing without parking provides developers with a higher rate of return. The author of that study calculated that parking

³⁴ City of Cambridge Zoning Ordinance, Section 6.36: Schedule of Parking and Loading Requirements.

³⁵ Metropolitan Transportation Commission, "Developing Parking Policies to Support Smart Growth in Local Jurisdictions: Best Practices," (Metropolitan Transportation Commission, Report, May 2007), 36-37.

³⁶ San Francisco Planning and Urban Research Association, "Parking and Livability in Downtown San Francisco: Policies to Reduce Congestion."

www.spur.org/publications/library/report/parkingandlivabilityindowntownsf_010105 (accessed September 27, 2009)

³⁷ Joshua Switzky, Interviewed by author in person. San Francisco, California, July 9, 2009.

³⁸ Jia and Wachs, 158.

³⁹ Luke H. Klipp, "The Real Costs of San Francisco's Off-Street Residential Parking Requirements: An Analysis of Parking's Impact on Housing Finance Ability and Affordability," Master's Thesis, University of California, Berkeley, 2004, 6.

⁴⁰ Richard Willson, "Parking Policy for Transit-Oriented Development: Lessons for Cities, Transit Agencies, and Developers." *Journal of Public Transportation* 8, no. 5 (2005): 87.

⁴¹ Wenyu Jia and Martin Wachs, "Parking Requirements and Housing Affordability: Case Study of San Francisco," *Transportation Research Record*, no. 1685 (1999): 159.

sells for less than it costs to build, and that a unit without parking yields a significantly greater profit per square foot than a unit with parking.⁴²

I will now turn to a discussion of the development of parking policy in the City of San Francisco, from the introduction of parking minimums to the current rise of parking maximums.

⁴² Klipp, 26.

A History of Parking Policy in San Francisco

1906-1955: San Francisco Before Minimum Parking Requirements

Much of today's San Francisco was built in the aftermath of the 1906 earthquake, during the years when motor vehicle use was initially growing. North Beach and Chinatown are two dense, mixed commercial and residential districts near Downtown San Francisco that were rebuilt immediately following the earthquake. The buildings are set at the edge of the sidewalk with retail on the ground floor and housing above. Buildings in North Beach and Chinatown do not have garages, driveways, or parking lots. Today, finding street parking there can be competitive, but it does not keep people from visiting, shopping, or dining, as evidenced by the crowds found eating outside or browsing shop windows on weekend nights.

Although San Francisco's downtown core remained dense, like many other cities that developed during the early 20th Century, San Francisco began to develop in an auto-centric pattern as vehicles became ubiquitous during the 1920s and 1930s. During those years, developers constructed many buildings with ground-floor parking garages and residential units on top, although they were not yet required to provide parking. Many of the city's outer neighborhoods, such as the Sunset District and the Richmond District, developed during this period. Single-family homes with garages, neighborhood commercial districts, and supermarkets with large parking lots define these neighborhoods today.

1955-1997: The Era of Parking Minimums

In 1955, San Francisco instituted its first minimum parking requirement of one residential off-street parking space for each dwelling unit. This requirement remains in effect in most neighborhoods in the city today. In 1960, the city added commercial and industrial parking requirements to the zoning code.⁴³ In 1968, the city adopted what is known as a "soft maximum" wherein developers can provide no more than 150% of the minimum number of required parking spaces as accessory.⁴⁴ However, there are provisions whereby the city grants conditional use permits to developers who wish to provide more parking.

In 1973, shortly after Bay Area Rapid Transit (BART) commuter rail service started to operate, San Francisco introduced its "Transit First" policy, which continues to comprise the theoretical foundation of the city's General Plan.⁴⁵ The policy prioritizes investment in transit and encourages street design and parking policies that minimize vehicle traffic. The policy guides the path of development in San Francisco by encouraging investments in infrastructure that benefits highly-connected, multi-modal transportation systems that adequately accommodate pedestrians, bicyclists, and transit riders as well as drivers of motor vehicles.⁴⁶

⁴³ Livable City, "A Brief History of Parking Requirements in San Francisco," <http://www.livablecity.org/campaigns/parkinghistory.html> (accessed December 7, 2009).

⁴⁴ Ibid.

⁴⁵ City of San Francisco General Plan, Transportation Element: The Freeway Revolt and "Transit First" (1960-1989).

⁴⁶ Ibid.

The city does not require construction of off-street parking facilities in conjunction with the development of commercial buildings downtown, and it maintains a commercial parking maximum that allows developers to construct parking for up to 7% of the gross floor area of a development.⁴⁷ This totals about one parking space per 4,000 square feet of developed space. Developers may exceed that limit with a conditional use permit from the Planning Commission, which is only granted if there is a determination that trips the parking would serve cannot be accommodated by transit, carpooling, or use of existing parking, and if the parking will not contribute to congestion or disrupt transit.⁴⁸ In more recent years, the city has begun to extend parking maximums to residential development downtown and in areas that are well-served by transit.

1997 and Beyond: Discarding Residential Parking Minimums and Introducing Maximums

Today, the city's population density is 17,259 people per square mile,⁴⁹ making it one of the densest cities in the country. San Francisco's density is greater than that of Chicago, Boston, or Philadelphia, three cities with extensive and well-utilized transit systems. However, many San Francisco residents own vehicles and use them. In 2008, the population of San Francisco was 798,176⁵⁰ and there were 470,333 vehicles registered in the city.⁵¹ If a different individual owned each one of those vehicles, this would mean that 59.8% of San Francisco residents own their own vehicle. Additionally, 39.2% of the city's population reports commuting to work by car or truck.⁵²

Although, initially, the majority of regional office jobs were located in San Francisco's downtown core, the Bay Area region is experiencing a sprawling growth in technology-related jobs in Silicon Valley, which is located approximately 40 miles south of San Francisco. Most of the office space in Silicon Valley is located in low-rise car-oriented business parks, and many of the people who work in these offices commute from San Francisco districts such as the trendy South of Market, Mission, and Noe Valley neighborhoods.

In 1997, San Francisco introduced its first parking maximum in Mission Bay and it has implemented several additional neighborhood-based parking maximums since then. Table 1 contains a chart describing the city's residential parking maximums. In addition to

⁴⁷ City and County of San Francisco Public Works and Planning Departments, "Parking in San Francisco: Conditions and Trends," December 1975.

⁴⁸ San Francisco Planning and Urban Research Association, "Ballot Analysis, November 2007, Proposition H: Parking Initiative," <http://spur.org/goodgovernment/ballotanalysis/Nov2007/proph> (accessed December 7, 2009).

⁴⁹ United States Census Bureau, "Persons per Square Mile: 2008," <http://factfinder.census.gov/> (accessed December 7, 2009).

⁵⁰ United States Census Bureau, "Fact Sheet: San Francisco City: 2006-2008 American Community Survey 3-Year Estimates," <http://factfinder.census.gov/> (accessed December 7, 2009).

⁵¹ State of California Department of Motor Vehicles, "Estimated Vehicles Registered by County For the Period of January 1 Through December 31, 2008," http://www.dmv.ca.gov/about/profile/est_fees_pd_by_county.pdf (accessed December 7, 2009).

⁵² United States Census Bureau, "Fact Sheet: San Francisco City: 2006-2008 American Community Survey 3-Year Estimates," <http://factfinder.census.gov/> (accessed December 7, 2009).

implementing parking maximums, the city has also eliminated parking minimums in the neighborhoods with parking maximums.

The propagation of parking maximums included in Neighborhood Plans in San Francisco indicates that the city is dedicated to reaching the goals set forth in its Transit-First policy. According to the city’s Planning Department, residential parking maximums are good for the city for several reasons. First, they decrease the overall number of cars in the city and encourage people who live near transit to use it.⁵³ It also maximizes the efficiency of limited land in a dense area.⁵⁴ Finally, from an urban design point of view, building fewer parking entrances will create more attractive and walkable places.⁵⁵

Table 1. Maximum Parking Allowances in San Francisco

Year	Neighborhood	Description	Parking Maximum	Exceptions Allowed?
1998	Mission Bay	Redevelopment Area	1 space per unit	None specified
2005	Rincon Hill (RH DTR)	High-Rise Residential, adjacent to downtown	.5 spaces per unit	Up to 1 parking space per unit through Planning Commission review if spaces are operated with mechanical stackers or valet. Requires unbundling of parking
2006	Downtown (C-3)	Dense Commercial/Office/High-Rise Residential	.75 space per unit	Allows maximum of 1 parking space per unit for units with 2 or more bedrooms
2008	Eastern Neighborhoods: -Mission -East SOMA -Central Waterfront -Showcase Square/Potrero	Residential, East of downtown	.5 to .75 spaces per unit	Up to .75 - 1 parking space per unit through Planning Commission review if spaces are operated with mechanical stackers or valet.
2008	Market and Octavia	Residential/Commercial, adjacent to downtown	.75 space per unit	Allows maximum of 1 parking space per unit for units with 2 or more bedrooms

Sources: City and County of San Francisco Municipal Code, Section 151.1: Schedule of Permitted Off-Street Parking Spaces in Specified Districts; City and County of San Francisco Planning Department. Market and Octavia Area Plan. May 30, 2008; City and County of San Francisco Redevelopment Agency. Design for Development for the Mission Bay North and South Project Areas. Approved March 16, 2004; City and County of San Francisco Planning Department. Eastern Neighborhoods Zoning Guide. January 19, 2009.

⁵³ Joshua Switzky, Interviewed by author in person. San Francisco, California, July 9, 2009.

⁵⁴ Ibid.

⁵⁵ Ibid.

In Downtown San Francisco, the minimum off-street residential parking requirement was one space for every four units (1:4) for as long as anyone could remember until the city implemented a parking maximum in the C-3 Zoning District in 2006.⁵⁶ However, developers would often build more or less parking than required with approval from the city.⁵⁷ So, although the current weak economy has prevented developers from constructing many new buildings since the parking maximums were established, there is a precedent in the city for constructing buildings with limited off-street parking spaces. With the implementation of the parking maximums in downtown San Francisco, there is no longer any provision for exceeding the amount of parking specified as allowable exceptions in Table 1.

⁵⁶ Ibid.

⁵⁷ Ibid.

Literature Review

Introduction

There is currently a debate swirling around the issue of minimum parking requirements for residential developments. While it has been common practice for cities to require developers to provide a minimum amount of parking for more than 70 years, recently researchers have begun to discuss the effects of such practices on urban form and travel behavior. This literature review points out some of the key arguments against the continued use of minimum parking requirements as the status quo in residential development and discusses the wide array of solutions that have been proposed as alternatives to minimum parking requirements.

This paper is specifically interested in the influence of the availability of a residential off-street parking space on individuals' travel behavior. Despite the many arguments against minimum parking requirements, there has been virtually no research conducted to specifically describe my research question. Several researchers have noted that this topic is one that warrants further investigation.⁵⁸ There are, however, many studies that examine closely related topics that have direct influence on travel behavior.

In this literature review, I will start with a discussion of the widely recorded negative effects of minimum parking requirements. I will then turn to a discussion of the few studies that directly address how availability of an off-street parking space influences travel behavior. Next, I will provide an overview of the related studies that discuss how the availability of parking at a destination may influence travel behavior, and a more general discussion of how urban form and land use influence travel behavior. I will then discuss the handful of studies that consider the impacts of parking requirements on urban design before turning to a discussion of how parking requirements influence housing prices, which is the dominant focus of research into the impacts of parking requirements. Before turning to policy considerations, I will provide an analysis of the studies that describe developers' and residents' perceptions of residential parking. Finally, I will discuss the variety of alternatives to minimum parking requirements that have been proposed recently and I will identify gaps in the literature.

Main Themes and Debates

The negative effects of minimum parking requirements

Traditionally, most cities have followed a system of minimum parking requirements to ensure that new development provides enough parking to accommodate all uses, without creating spillover parking and excess through traffic on residential streets. These requirements aim to help foster efficient transportation systems, strong economies,

⁵⁸ Luke H. Klipp, "The Real Costs of San Francisco's Off-Street Residential Parking Requirements: An Analysis of Parking's Impact on Housing Finance Ability and Affordability," Master's Thesis, University of California, Berkeley, 2004: 17; Greg Marsden, "The Evidence Base for Parking Policies – A Review," *Transport Policy*, no. 13 (2006): 455; John Noble and Mike Jenks, *Parking: Demand and Provision in Private Sector Housing Developments*, Eynsham, England: Information Press, 1996: 11.

accessibility, clean urban environments, and safety.⁵⁹ Essentially, most cities determine the demand for parking that various land uses will create at peak times and write a required minimum number of parking spaces for each use into their zoning codes. To determine the necessary quantity of parking, they typically consult the Institute of Transportation Engineers *Parking Generation* manual or survey neighboring cities.⁶⁰

Today, nearly every researcher studying parking policy has pointed out fault with this system. Although most researchers studying the topic would agree that parking requirements should be calculated differently, they have many different arguments to support their contentions that changes are needed. The main arguments that researchers cite against minimum parking requirements are as follows:

- ITE *Parking Generation* methodology is flawed⁶¹
- Required parking raises the price of goods and housing⁶²
- Required parking subsidizes the cost of operating a vehicle⁶³
- Required parking leads to increased use of motor vehicles⁶⁴
- Required parking makes transit less viable⁶⁵
- Required parking reduces the amount of land available for development⁶⁶
- Required parking leads to increased sprawl⁶⁷
- Required parking harms the environment⁶⁸
- Required parking leads to unpleasant urban design⁶⁹

In the subsequent pages, I will provide an overview of the body of literature that has emerged to describe the effects of parking requirements and the alternative policies that have been proposed to address these issues.

⁵⁹ Marsden, 448.

⁶⁰ Ryan. Russo, "Parking & Housing: Best Practices for Increasing Housing Affordability and Achieving Smart Growth," Master's Thesis, University of California, Berkeley, 2001: 12.

⁶¹ Christopher Cherry, Elizabeth Deakin, Nathan Higgins, and S. Brian Huey, "Systems-Level Approach to Sustainable Urban Arterial Revitalization," *Transportation Research Record*, no. 1977 (2006): 208; Donald Shoup, "The High Cost of Free Parking," *Journal of Planning Education and Research*, no. 17 (1997): 4; Donald Shoup, "The Trouble with Minimum Parking Requirements," *Transportation Research Part A: Policy and Practice*, no. 33 (1999): 551.

⁶² Jason Henderson, "The Spaces of Parking: Mapping the Politics of Mobility in San Francisco," *Antipode* 41, no. 1 (2009): 77; Todd Litman, "Parking Requirement Impacts on Housing Affordability," *Victoria Transport Policy Institute* (January 2009): 11; Russo, 11; Shoup (1999), 556; Donald Shoup, *The High Cost of Free Parking*, Chicago: American Planning Association Press, 2005: 141-143.

⁶³ Shoup (1997), 11-12; Donald Shoup, *The High Cost of Free Parking*, Chicago: American Planning Association Press, 2005: 217; Rachel Weinberger, Mark Seaman and Carolyn Johnson, "Residential Off-Street Parking: Car Ownership, Vehicle Miles Traveled, and Related Carbon Emissions (New York City Case Study)," *Transportation Research Record*, no. 2118 (2009): 25.

⁶⁴ Litman (January 2009), 11; Russo, 1,11; Weinberger, Seaman, and Johnson, 25; Richard Willson, "Suburban Parking Requirements: A Tacit Policy for Automobile Use and Sprawl," *Journal of the American Planning Association* 61, no. 1 (1995): 34.

⁶⁵ Henderson, 77; Russo, 10.

⁶⁶ Litman (January 2009), 9-10; Russo, 1; Shoup (1997), 11.

⁶⁷ Litman (January 2009), 10-11; Noble and Jenks, 5-6; Russo, 1,10; Willson (1995), 36-37.

⁶⁸ Henderson, 77; Noble and Jenks, 5-6; Russo, 11; Shoup (2005), 291; Willson (1995), 34.

⁶⁹ Litman (January 2009), 11; Noble and Jenks, 5-6; Shoup (2005), 129-135.

How availability of an off-street residential parking space influences travel behavior

The few articles that specifically discuss how residential parking availability influences mode choice suggest that people without an available residential off-street parking space tend to drive less than those who have access to a parking space at home. However, only a handful of prior studies have specifically studied this question.

A study conducted in New York compared the travel behavior of residents of two neighborhoods that are equally served by transit and about the same distance from Manhattan's central business district: Jackson Heights, Queens and Park Slope, Brooklyn.⁷⁰ Using city parking lot data, tax records, and visual recording, the researchers found that residents of Jackson Heights, which has 156% more parking than Park Slope⁷¹, were 45% more likely to drive to work in Manhattan than residents of Park Slope.⁷² Although the results suggest that people will drive more when a residential parking space is available, the authors mention additional factors that could account for the higher rate of Manhattan-bound auto trips originating in Jackson Heights, such as higher rates of shift work or more parking at the workplaces of Jackson Heights residents.⁷³

A group researching whether availability of a residential off-street parking space in San Francisco influences travel behavior found conflicting results as to whether the travel behavior of people with parking varies from those without.⁷⁴ The authors first administered a survey with a sample size of 42 and found that in developments with parking ratios of one parking space per unit (1:1), 81.5% of residents owned a car, 50% drove to work, and 70.4% drove for non-work purposes.⁷⁵ In developments with parking ratios of less than 1:1, they found that 46.7% owned a car, 26.7% drove to work, and 42.9% drove for non-work purposes.⁷⁶ They also conducted a small Trip Generation study, in which they found that a development in a neighborhood with a good transit system and a parking ratio of .14:1 had the highest Trip Generation rate (1.67 auto trips per parking space during peak hours), although the other buildings examined had high trip generation rates as well (.79, .42, and .55).⁷⁷ The results, which are inconclusive, focused on a handful of specific developments, and use a very small sample size, suggest that people without parking at home drive less than those with a parking space, but those who have a parking space drive frequently.

Finally, a review of 26 residential transit oriented developments (TODs) across California found that residents of developments with more parking used transit less for work trips, but this finding was not statistically significant.⁷⁸ The study also found that TODs with higher rates of transit use had about the same amount of parking space,

⁷⁰ Weinberger, Seaman, and Johnson, 27.

⁷¹ Ibid.

⁷² Ibid., 26.

⁷³ Ibid., 26.

⁷⁴ Rocco Pendola, Stephanie Ruddy, and Elmer Tosta, "Residential Parking Requirements in San Francisco: Do They Affect Travel Behavior?" Unpublished report presented to Livable City by San Francisco State University Urban Studies Program, May 2005: 16-17.

⁷⁵ Ibid.

⁷⁶ Ibid.

⁷⁷ Ibid., 18.

⁷⁸ Richard Willson, "Parking Policy for Transit-Oriented Development: Lessons for Cities, Transit Agencies, and Developers." *Journal of Public Transportation* 8, no. 5 (2005): 81.

suggesting that too much parking was provided considering the transit-accessibility of the development.⁷⁹

How availability of a parking space at the destination influences travel behavior

Since there are not many studies that examine the influence of residential parking availability on peoples' travel behavior, it is instructive to look at the body of literature that looks at whether parking availability at work or shopping locations influences travel behavior. The literature on this topic suggests that people drive more when there is a parking space available at the destination.

One study of 10 office parks in Southern California that met minimum parking requirements found that peak utilization was only 56%,⁸⁰ which suggests that the parking minimums are too high. This study also revealed that people who work at offices with free parking travel with 10% fewer people than those who work at offices without free parking, because less people are riding transit or carpooling.⁸¹ In Curitiba, Brazil, a city that is well known in transportation planning circles for its extensive Bus Rapid Transit (BRT) system, parking minimums were imposed evenly in the downtown and outskirt areas. A recent study of the areas around five BRT stations in Curitiba found that parking minimums led to free or cheap parking in the city, promoting single occupant vehicle use and running against the stated goals of the city's adopted land use policies.⁸²

Meanwhile, a small, informal study of three work sites in Scotland (a hospital, a corporate headquarters, and a business park) built in compliance with Great Britain's parking maximum recommendation found that rates of transit use, walking, and bicycling were 14% to 20% higher at the sites with limited parking than that expected at locations with similar land uses.⁸³ More research is certainly necessary to confirm the results of this unpublished, limited study.

How land use influences travel behavior

Another useful group of studies looks at how land use influences travel behavior. A variety of land use factors other than parking can influence travel behavior, including residential density, land use mix, employment density, roadway design, bicycle facilities, site design, and retail.⁸⁴ Travel behavior indicators that can be studied include mode choice, vehicle miles traveled and vehicle ownership. Some studies in this category find that density can influence mode choice, and in recent years this proves particularly true for residents of TODs. However, another body of literature in this area has reached inconclusive results, and some argue that it's impossible to isolate the factors that influence travel behavior.

⁷⁹ Ibid., 82

⁸⁰ Willson (1995), 32.

⁸¹ Willson (1995), 36.

⁸² Christopher Ziemann, "Is Curitiba, Brazil the Model City for Parking Management?" Submitted for presentation and publication, 88th Annual Meeting of the Transportation Research Board, Washington, DC, 2009: 14.

⁸³ Tom Rye and Stephen Ison, "The Use and Impact of Maximum Parking Standards in Scotland, UK," Submitted for presentation and publication, 86th Annual Meeting of the Transportation Research Board, Washington, DC, 2007: 12-13.

⁸⁴ Todd Litman, "Land Use Impacts on Transport," *Victoria Transport Policy Institute* (August 2009): 2.

A landmark study conducted in 1995 found that residential density and mixed uses generally influence people to use single occupant vehicles less frequently and to use transit or walk more.⁸⁵ In professional practice, it is commonly accepted that people will use cars less often when there are other means of travel such as transit available, walkable destinations nearby, and local employment opportunities.⁸⁶ Similarly, studies of TODs, which are similar to most dense urban areas in their proximity to transit and mixed land uses, have revealed that TOD residents typically own fewer cars due to smaller household size and proximity to transit⁸⁷ and use transit two to five times more often.⁸⁸ There could be a self-selection factor at play when it comes to TOD residents, which, as other studies point out, must always be taken into consideration when linking land use to travel behavior.⁸⁹

A 1998 study did not find that any of the land uses analyzed influenced travel behavior with great statistical significance, and concluded that we cannot sufficiently use land use to predict peoples' travel behavior.⁹⁰ Using a regression model that accounted for peoples' housing location preferences, this study found a weak correlation that suggests residents of zip codes with higher service employment density made a greater number of non-work trips in single occupant vehicles, and those who lived in zip codes with higher retail employment density made fewer non-work single occupant vehicle trips.⁹¹

The author of a highly critical review of the body of literature that attempts to explain linkages between land use and travel behavior argued that there is little evidence to support the argument that urban form can predict or influence travel⁹² and that it's difficult to isolate whether a specific variable under consideration actually has a causal relationship with the independent variable.⁹³ The article goes on to suggest that studies in this category can be more effective if researchers use appropriate geographic scales and account for peoples' decisions about where to live.⁹⁴

The impact of parking requirements on urban design

There is also a small group of work that studies the impact of parking on urban design. Since parking requirements create lower densities, they essentially control growth.

⁸⁵ Lawrence D. Frank and Gary Pivo, "Impacts of Mixed Use and Density on Utilization of Three Modes of Travel: Single-Occupant Vehicle, Transit, and Walking," *Transportation Research Record*, no. 1466 (1995): 51-52.

⁸⁶ San Francisco Planning and Urban Research Association, "Rethinking Parking," http://www.spur.org/publications/library/report/reducinghousingcostsbyrethinkingparking_110198 (accessed September 20, 2009).

⁸⁷ G.B. Arrington and Robert Cervero, "TCRP Report 128 Effects of TOD on Housing, Parking, and Travel," Transportation Research Board, Washington, DC: 2008, 25.

⁸⁸ *Ibid.*, 2.

⁸⁹ Marlon Boarnet and Sharon Sarmiento, "Can Land Use Policy Really Affect Travel Behavior?" *Urban Studies* 35, no. 7 (1998): 1166; Randall Crane, "The Influence of Urban Form on Travel: An Interpretive Review," *Journal of Planning Literature* 15, no. 1 (August 2000): 18.

⁹⁰ Boarnet and Sarmiento, 1166.

⁹¹ Boarnet and Sarmiento, 1166.

⁹² Randall Crane, "The Influence of Urban Form on Travel: An Interpretive Review," *Journal of Planning Literature* 15, no. 1 (August 2000): 3.

⁹³ Crane, 8.

⁹⁴ Crane, 19.

However, some believe that growth control measures should be implemented more directly in zoning policies, such as floor area ratios limits.⁹⁵ One study looks at the small, narrow lots on San Pablo Avenue in Berkeley and finds that, with minimum parking requirements in place, the amount of land that would have to be devoted to parking would make development unfeasible, or feasible only by placing parking in the front of the lot and moving the building toward the back.⁹⁶ This makes for poor urban design, and if landowners decide they don't want to develop because of the parking requirements, the land will lay vacant.⁹⁷

Another study looks at the impact that parking minimums have on downtown land use and resolves that the requirements lead to congestion because, as each new development is approved with a minimum number of off-street parking spaces, the supply of parking spaces and the number of cars using them increases but the capacity of surrounding streets remains the same.⁹⁸ This creates neighborhoods that are congested and unpleasant for walking. Also, parking lot entrances and driveways require additional sidewalk curb cuts and reduce space for street trees, leading to a less pleasant pedestrian experience.⁹⁹

The impact of parking requirements on housing affordability

The impact of parking requirements on housing affordability is one of the most studied aspects of minimum parking requirements. The body of literature describes the ways in which minimum parking requirements make housing less affordable, contributes to sprawl, and amounts to inequitable treatment of people who do not own cars.

There are a multitude of studies that estimate the cost of a parking space.¹⁰⁰ Although many of these studies are several years old and the numbers would have to be adjusted for inflation, they are still instructive indicators of how parking increases the price of housing. A 2005 study of TODs found that each unit had 1.41 spaces, equaling roughly \$16,920, a cost that is factored into rents or purchase prices.¹⁰¹ Two recent studies of parking costs in San Francisco estimate that a parking space adds about 20% to the cost of a housing unit and can cost anywhere from \$20,000 for an aboveground space to \$100,000 for an underground space.¹⁰²

The high cost of parking is passed on to the consumer through an increased sales price. As early as 1964, a study of apartment construction in Oakland, California found that once the city established minimum parking requirement, developers began building larger units and charging higher rents to pass the cost of parking construction on to renters.¹⁰³ A

⁹⁵ Willson (1995), 39.

⁹⁶ Cherry et al., 208.

⁹⁷ Ibid.

⁹⁸ Michael Manville and Donald Shoup, "Parking, People, and Cities," *Journal of Urban Planning and Development* 131, no. 4 (December 2005): 244-5.

⁹⁹ Henderson, 77.

¹⁰⁰ Henderson, 78; Wenyu Jia and Martin Wachs, "Parking Requirements and Housing Affordability: Case Study of San Francisco," *Transportation Research Record*, no. 1685 (1999): 158; Klipp, 25; Litman (January 1999), 9; Russo, 7-8; Shoup (1997), 6; Willson (2005), 83.

¹⁰¹ Willson (2005), 83.

¹⁰² Henderson, 78; Klipp, 25.

¹⁰³ Wallace F. Smith, *The Low-Rise Speculative Apartment*, Berkeley: University of California, Berkeley Center for Real Estate and Urban Economics, Institute of Urban and Regional Development, 1964.

more recent study of the cost of housing in San Francisco with and without parking spaces found that single-family homes with parking cost 11.8% more than those without parking, and condominiums with parking cost 13% more than those without parking.¹⁰⁴ The authors determined that the mortgage needed to purchase a home without parking would be \$9,000 less than what a buyer would need to purchase a home with parking, meaning 24% more people could afford to purchase a home if it didn't include a parking space.¹⁰⁵ A 2004 study estimates that a parking space costs \$68,000 in San Francisco.¹⁰⁶

Parking requirements also generally decrease the amount of affordable housing that can be built. Developers' profits decrease with high minimum parking requirements, because costs increase and unit capacity on the land decreases. Developers typically respond by building more expensive units, which can more easily absorb the cost of parking, and decrease the number of affordable units built.¹⁰⁷ Also, parking requirements increase the amount of the government subsidy that is needed for each unit of subsidized housing.¹⁰⁸

Parking requirements also encourage sprawl and decreased density. When parking requirements increase from zero spaces to one space, urban development becomes more expensive by 22% while suburban development only goes up by 6%,¹⁰⁹ making suburban development cheaper and more attractive. Also, the need to build parking on the lot limits the amount of housing that a site can accommodate.¹¹⁰ Typically, developers choose to build less housing when there is a parking requirement, which decreases density and creates fewer units that can absorb the cost of parking.¹¹¹

Finally, parking requirements are inequitable for people who do not own cars. A greater percentage of lower income people do not own vehicles. In 1990, the average number of household vehicles in the Bay Area was 1.76.¹¹² For households earning between 48% and 60% of the median income, it was 1.3.¹¹³ Households earning between 24% and 26% of the median owned .98 vehicles on average.¹¹⁴ Minimum parking requirements cause people who do not own cars, and who cannot afford them in some cases, to subsidize the cost of parking for those who do own cars because the cost of parking is built into rental rates and product prices.

Developers' perceptions of parking requirements

Developers follow a strict set of guidelines to ensure that projects will be financially successful and they will be able to secure the funding they need. They tend toward caution in their investments and avoid taking unnecessary risks because potential funders consider

¹⁰⁴ Jia and Wachs, 158.

¹⁰⁵ Ibid.

¹⁰⁶ Klipp, 22.

¹⁰⁷ Todd Litman, "Parking Requirement Impacts on Housing Affordability," *Victoria Transport Policy Institute* (January 2009), 13.

¹⁰⁸ Todd Litman, *Parking Management Best Practices*. Chicago: American Planning Association Press, 2006: 262; Henderson, 78.

¹⁰⁹ Russo, 7-8.

¹¹⁰ Ibid.

¹¹¹ Henderson, 78.

¹¹² Russo, 14.

¹¹³ Ibid.

¹¹⁴ Ibid.

a project's expected rate of return, which can be affected by units in the mix, location, local amenities, and the number of parking spaces.¹¹⁵ Commercial success is usually based on whether a developer complies with city regulations, the location of the development, 1:1 parking, and building a unit mix that has already proven to sell in the neighborhood.¹¹⁶ Overcoming industry standards governing the amount of parking financiers are confident will enable a unit to sell can be challenging for planners.

Development industry standards are why, even if developers expect that proximity to rail will influence travel behavior, they are cautious to provide less parking near transit.¹¹⁷ Developers insist that housing without parking sells at a slower rate than housing with parking,¹¹⁸ but the Jia and Wachs study finds that people are willing to purchase a residential unit even if it does not include a parking space.¹¹⁹ Specifically, that study finds that condos with parking took 41 days longer to sell than condos without.¹²⁰

Willson (2005) found that the tides are beginning to change. As downtown areas in cities are beginning to eliminate minimum parking requirements, developers are showing a greater willingness to reduce the number of spaces they build.¹²¹ He is confident that as developers see more examples of successful developments built with less parking, they will be more willing to approach projects with less parking.¹²² Another study examined whether reducing parking minimums in Toronto would encourage developers to build less commercial parking.¹²³ They find that many commercial spaces, such as office, general retail, and medical land uses, were more likely to provide less parking than necessary. Although limited to Toronto, this finding suggests that developers might be willing to provide lower levels of parking for some uses if lower minimums are instituted.¹²⁴

The public's perceptions of residential parking

As the government in Great Britain began to consider replacing residential off-street parking minimums with maximums of 1.5 spaces per unit, several studies of public opinion were conducted to determine optimal levels of parking and how the populace would respond to reductions in parking availability. Respondents in one auto-oriented suburb cited safety and proximity of parking spaces to their home as main concerns, and the authors concluded that high parking ratios should be instituted to meet car ownership rates and high rates of visitors – such as 1.25 parking spaces per 1-bedroom apartment, and 2.25 for semi-detached homes.¹²⁵

¹¹⁵ Klipp, 6.

¹¹⁶ Ibid.

¹¹⁷ Willson (2005), 86.

¹¹⁸ Klipp, 27.

¹¹⁹ Jia and Wachs, 159.

¹²⁰ Ibid.

¹²¹ Willson (2005), 86.

¹²² Ibid., 87.

¹²³ Joshua Engel-Yan, Brian Hollingworth, and Stuart Anderson, "Will Reducing Parking Standards Lead to Reductions in Parking Supply?: Results of Extensive Commercial Parking Survey in Toronto, Canada," *Transportation Research Record*, no. 2010 (2007): 102.

¹²⁴ Engel-Yan, Hollingworth, and Anderson, 109.

¹²⁵ Noble and Jenks, 62.

Another study was conducted in 2002 to assess the attitudes of Southeast London residents and residents of nearby suburbs toward off-street residential parking.¹²⁶ 99% of respondents said they had a dedicated off-street parking space and 94% of respondents said they would not consider purchasing property without an off-street parking space.¹²⁷ Even those without a car reported that they would not be interested in housing without parking.¹²⁸ When asked what factors would encourage people to live in a unit without a parking space, they responded that proximity to transit, shops, and facilities and location could sway their opinions.¹²⁹ Stubbs concluded that residents did not support policies to eliminate 1:1 parking because they were worried that housing without parking would be worth less and because of the potential inconvenience associated with not having a personal parking space.¹³⁰ Although these results are very interesting, they are limited in geographic scope and sample size, as only 47 people in and around London responded.¹³¹

Alternatives to minimum parking requirements

Many studies have put forth suggestions for alternative policies and practices that can help address some of the problems that the current parking minimum paradigm creates. A brief discussion of each alternative policy follows.

Some studies suggest that cities should adopt parking maximums, which would replace the required minimum number of spaces with a maximum number of spaces, over which a developer could not provide additional parking.¹³² A small survey of governments in Scotland revealed support for the potential of parking maximums to reduce car use and stimulate denser development, and even some support from developers.¹³³

A large group of studies advocates for the unbundling of parking from the cost of purchasing or renting a home.¹³⁴ “Unbundling” means that parking spaces are available at a residential building for purchase or rent, but are not automatically included in the sale price of the home. These studies argue that parking requirements hide the true cost of driving,¹³⁵ which subsidizes driving and encourages people to drive more since it appears to be a rather inexpensive form of travel. Also, when parking is bundled with the price of housing, developers can’t measure the market demand for it.¹³⁶ Unbundling parking could decrease the cost of housing and ensure that those who use the parking spaces are the ones

¹²⁶ Michael Stubbs, “Car Parking and Residential Development: Sustainability, Design and Planning Policy, and Public Perceptions of Parking Provision,” *Journal of Urban Design* 7, no. 2 (2002): 213.

¹²⁷ Ibid, 232.

¹²⁸ Ibid, 228.

¹²⁹ Ibid, 232.

¹³⁰ Ibid, 234.

¹³¹ Ibid., 213.

¹³² Cherry et al., 209.

¹³³ Rye and Ison, 11-12.

¹³⁴ Litman (January 2009), 2; Klipp, 30; Russo, 11; SPUR (2004); San Francisco Planning and Urban Research Association, “Parking and Livability in Downtown San Francisco: Policies to Reduce Congestion.” www.spur.org/publications/library/report/parkingandlivabilityindowntownsf_010105 (accessed September 27, 2009); Willson (2005), 83.

¹³⁵ Russo, 11; SPUR (2004)

¹³⁶ Willson (2005), 83.

who pay for it.¹³⁷ There is some evidence that, although initially resistant, developers are becoming more supportive of unbundling parking.¹³⁸

Many papers advocate for reducing parking requirements, either in conjunction with a parking management program,¹³⁹ or by creating reduced, context-specific parking requirements for TODs¹⁴⁰ and affordable housing.¹⁴¹ Russo describes a parking management system for providing off-street residential parking wherein projects would be approved with lower parking minimums, but developers would be required to provide landscaped areas that could later be converted to parking.¹⁴² In conjunction, the city would require the developer to fund transit pass programs for residents and it would restrict street parking permits for residents to reduce spillover impacts.¹⁴³ Engel-Yan advocates for reduced parking minimums in conjunction with a parking management program that considers environmental, economic, and transportation system concerns.¹⁴⁴

Several studies lay out frameworks for reducing parking requirements for TOD and affordable housing units, which tend to attract people who either prefer to live near transit and without a car, or who are constrained to live as such due to their financial situation.¹⁴⁵ Arrington suggests that the *ITE Parking Generation* handbook adopt alternate requirements specifically for TOD, which should be more flexible than the standard parking requirements and allow for reduced parking at TODs.¹⁴⁶ Another study suggests that the demographic characteristics of a proposed development's likely inhabitants, such as age, income, disability status,¹⁴⁷ and car ownership rates¹⁴⁸ be taken into consideration when assigning parking requirements.

Shared parking facilities are frequently mentioned in conjunction with commercial parking facilities, but they can also be used to address issues with residential parking.¹⁴⁹ TODs can partner with transit agencies to share parking near transit stations, since the two land uses require parking at different times of day.¹⁵⁰ Shared parking is perceived as safer than dedicated parking and it makes the best use of driveway space, requires that less overall parking be provided, and can help increase housing densities.¹⁵¹ Shared parking provides the added benefit of enabling underutilized parking lots to later be converted to communal space if parking demand is later reduced.¹⁵²

Design solutions can help alleviate some of the negative aesthetic impacts of parking lots. Innovative design solutions like tandem parking and car elevators can reduce the

¹³⁷ SPUR (2004).

¹³⁸ Klipp, 30.

¹³⁹ Engel-Yan, Hollingworth, and Anderson, 110; Russo, 24.

¹⁴⁰ Arrington and Cervero, 54; SPUR (2006), 3; Willson (2005), 90.

¹⁴¹ Russo, 20; SPUR (2006), 4-5.

¹⁴² Russo, 21.

¹⁴³ Russo, 21-24.

¹⁴⁴ Engel-Yan, Hollingworth, and Anderson, 110.

¹⁴⁵ SPUR (2006), 3. Willson (2005), 90.

¹⁴⁶ Arrington and Cervero, 54.

¹⁴⁷ Russo, 20.

¹⁴⁸ SPUR (2006), 4-5.

¹⁴⁹ Cherry et al., 209; Russo, 25.

¹⁵⁰ Willson (2005), 90.

¹⁵¹ Noble and Jenks, 65-66.

¹⁵² Ibid.

amount of space dedicated to parking,¹⁵³ though this class of solution does not address the prevalence of single occupant vehicles in cities. Improving the physical design of parking lots by dropping them a few feet below pedestrian level and adding solar panels or landscaping can help create more pleasant urban experiences.¹⁵⁴ For parking garages, design solutions include wrapping the garage with retail shops, making the garage look like a building, and placing parking only on upper levels.¹⁵⁵ For single-family units, cities can restrict the size of garage doors that face the street to only the width of a single car, require that a garage door take up less than 50% of a building's façade, or require that developers place parking at the rear of the house.¹⁵⁶

Finally, a group of innovative alternatives to parking minimums has developed. These solutions shouldn't necessarily be used in isolation, but in combination with one of the policies listed above could be quite effective at reducing some of the impacts of required parking. These solutions include car-sharing programs that make vehicles available for short-term rental right at developments,¹⁵⁷ development-wide transit passes,¹⁵⁸ and in-lieu fees that can be used to build communal parking.¹⁵⁹

In the minority of research regarding parking policy is one article arguing that minimum parking requirements are not responsible for increases in Vehicle Miles Traveled (VMT) and, in fact, haven't kept pace with increases in car ownership. This paper states that car ownership in the United States increased by about 200% between 1946 and 1990, but VMT only increased by 18% and minimum parking requirements haven't even doubled.¹⁶⁰ Although the author doesn't offer evidence to support this claim, he suggests that only one-third of the increase in VMT can be attributed to parking requirements, and suggests that VMT has increased in recent years because of sprawl and longer periods of peak travel.¹⁶¹

Conclusions From the Literature

The body of research regarding the influence of residential parking space availability on travel behavior is rather thin, and even studies in related areas such as the effects of parking on mode choice for work and shopping trips are somewhat limited. The literature describing how urban form influences travel behavior is inconclusive, and some researchers say that urban form factors cannot be used to predict or measure travel behavior. The literature regarding the influence of parking requirements on housing prices is a little bit bulkier, with a general agreement that parking requirements are expensive, and they raise the cost of housing and can negatively influence density.

¹⁵³ Klipp, 32-33; Russo, 26.

¹⁵⁴ Vinit Mukhija and Donald Shoup, "Quantity versus Quality in Off-Street Parking Requirements," *Journal of the American Planning Association* 72, no 3 (Summer 2006): 302.

¹⁵⁵ *Ibid.*, 303.

¹⁵⁶ *Ibid.*, 305.

¹⁵⁷ Klipp, 35; Russo, 24.

¹⁵⁸ Russo, 25.

¹⁵⁹ Cherry et al., 209; Russo, 25; Mukhija and Shoup, 299.

¹⁶⁰ Erik Ferguson, "Zoning for Parking as Policy Process: A Historical Review," *Transport Reviews* 24, no. 2 (March 2004): 188.

¹⁶¹ *Ibid.*, 189.

Many researchers in this area have noted the need for additional research on topics related to parking and travel behavior. Researchers are starting to take note that parking is by and large understudied and omitted from most planning curricula.¹⁶² Future research is suggested to understand how people will react to the introduction of parking maximums that could lead to reductions in the availability of off-street residential parking spaces.¹⁶³ Also, more must be learned about how parking, particularly residential parking,¹⁶⁴ influences mode choice on a smaller geographic level, possibly the block group level.¹⁶⁵ Finally, any research about residential travel behavior must include consideration of whether peoples' housing preferences allow them to self-select to travel and live in certain locations, which is another area of research about which little is known.¹⁶⁶

This study fits well into the research void concerning the influence of residential parking space availability on travel behavior. Since very little comprehensive research has been done in this area, I think that the results of my survey should help inform the body of research that describes the impact of both parking and land use on travel behavior. I also intend to address whether people self-select to live near transit or in a certain location, so I expect this study to expand the literature in that area of focus as well. It is my hope and expectation that my analysis will help to shed light on this understudied, yet important, aspect of parking policy.

¹⁶² Henderson, 73.

¹⁶³ Stubbs, 235.

¹⁶⁴ Jia and Wachs, 159; Marsden, 455.

¹⁶⁵ Frank and Pivo, 52.

¹⁶⁶ Boarnet and Sarmiento, 1162; Marsden, 455.

A Survey of the Influence of Residential Parking Availability on Travel Behavior

Survey Methodology

Although the elimination of minimum off-street parking requirements and the implementation of parking maximums in residential areas are seen as two methods for limiting use of motor vehicles and for reducing congestion on city streets, very little research has been conducted to determine whether the residents of these two types of neighborhoods may be pre-inclined toward less frequent use of automobiles or whether these policies may potentially be successful in encouraging people to change their travel preferences. As such, a survey was conducted as part of this study to determine:

1. The extent to which the availability of an off-street residential parking space influences residents' travel behavior in San Francisco.
2. Whether reducing residential off-street parking requirements encourages people to drive less.

Prior to this study, there was little to no information available to describe the extent to which the travel behavior of San Francisco residents with access to an off-street parking space at home varied from that of San Francisco residents without access to an off street parking space at home. Neither the United States Census nor the American Community Survey includes questions about residential parking. Although two recent surveys conducted in San Francisco included questions about parking availability at home, both covered limited geographic areas that would not provide useful data comparisons.¹⁶⁷

Thus, primary data was needed to answer the research question posed in this study. A survey is an appropriate method for gathering data on questions of travel behavior and attitudes because it can yield qualitative data that other methods of data collection do not consider. Many previous studies of the influence of parking on travel behavior have used surveys to gather data.¹⁶⁸

Although the survey method is an extremely accurate, inexpensive, and fast method for collecting data about travel behavior, it is not without its challenges. At times, survey samples may be too small or unrepresentative, or memory, recency, or consistency biases

¹⁶⁷ Rocco Pendola, Stephanie Ruddy, and Elmer Tosta, "Residential Parking Requirements in San Francisco: Do

They Affect Travel Behavior?" Unpublished report presented to Livable City by San Francisco State University Urban Studies Program, May 2005; San Francisco Planning Department, "Resident Travel Behavior Survey: SOMA/Transbay Area," Research conducted by Godbe Research, December 2008.

¹⁶⁸ Engel-Yan, Joshua, Brian Hollingworth, and Stuart Anderson. "Will Reducing Parking Standards Lead to Reductions in Parking Supply?: Results of Extensive Commercial Parking Survey in Toronto, Canada." *Transportation Research Record*, no. 2010 (2007): 102-110; Pendola, Rocco, Stephanie Ruddy, and Elmer Tosta. "Residential Parking Requirements in San Francisco: Do They Affect Travel Behavior?" Unpublished report presented to Livable City by San Francisco State University Urban Studies Program, May 2005; Stubbs, 213.

may exist.¹⁶⁹ The survey method also makes it difficult to quantify how peoples' tendency toward self-selection of residential characteristics based on pre-held attitudes may influence their travel behavior.¹⁷⁰ One study states that experiments conducted to measure the influence of a change to the built environment on travel behavior are among the more reliable methods of establishing a relationship between travel behavior and the built environment.¹⁷¹ Although the experimental method may achieve more valid results than the survey method, a before and after experiment would be outside the purview of this study because of funding and time limitations, and the difficulty of identifying appropriate experiment locations in San Francisco during the current construction slowdown.

Survey Instrument

I based the survey instrument (Appendix 1) on questions that other researchers studying travel behavior included in their surveys and on questions that are included in the National Household Travel Survey.¹⁷² I then tailored the questions to more specifically collect the qualitative data that my research questions require. I included a question probing the reasoning informing peoples' decisions to live in specific locations, to address and limit the possibility that people may self-select where they live because of deep-held ideologies, attitudes, and preferences. The survey asked subjects to note the cross streets that are closest to their home to determine whether they live in an area with or without a parking maximum. Finally, I asked peers, colleagues, and my faculty advisor to review the survey and provide feedback and suggestions for improvements.

Sample Selection and Survey Administration

The sample population for the survey includes San Francisco residents who live in neighborhoods where parking maximums have been enacted and a control group of those who live in neighborhoods where parking maximums have not been enacted. The focus is on the dense inner urban areas where parking maximums have recently been enacted because parking space availability is more likely to have an influence on the travel behavior of residents in these neighborhoods than those who live in the more sprawling, less transit-accessible outer edges of the city where parking minimums still apply. I collected data from neighborhoods that do not have parking maximums in place to compare differences within the two groups. Figure 1 indicates the cross-streets closest to the residences of survey respondents who live near downtown San Francisco and the boundaries of the various neighborhoods where residential parking maximums have been enacted.

The survey was administered to 203 subjects who are San Francisco residents aged 18 or older. 19 responses were eliminated because they provided incomplete information and two responses were deleted because they were duplicates. Thus, the study sample yielded 182 complete, unique surveys that could be analyzed. The survey was administered

¹⁶⁹ Patricia L. Mokhtarian and Xinyu Cao, "Examining the impacts of residential self-selection on travel behavior: A focus on methodologies," *Transportation Research Part B: Methodological* 42, no. 3. (2008): 207-208.

¹⁷⁰ *Ibid.*, 205, 211.

¹⁷¹ *Ibid.*, 225-226.

¹⁷² United States Department of Transportation, "National Household Travel Survey," Bureau of Transportation Statistics, Research and Innovative Technology Administration, United States Department of Transportation, www.bts.gov/programs/national_household_travel_survey (accessed February 23, 2010).

as both an in-person intercept survey and as an online survey to a random sample between February 28, 2010 and March 21, 2010. The intercept survey was administered at the locations and on the dates indicated in

Table 2.

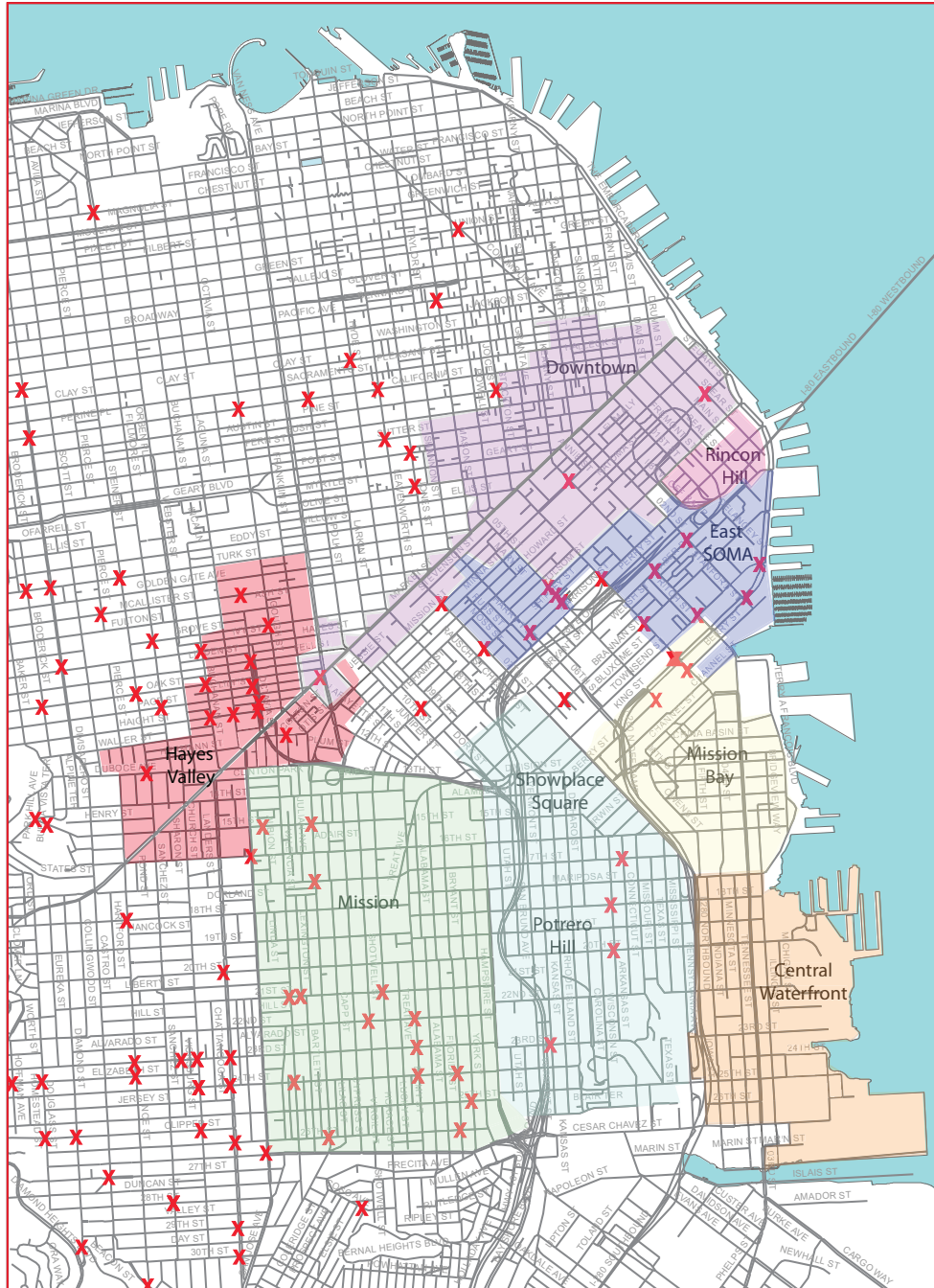
Table 2. Locations, Dates, Times, and Sample Size of Intercept Survey Administrations

Location	Date	Time	Sample Size
SOMA Whole Foods Grocery Store, 4 th St. and Harrison St.	Sat. 2/29	9:00 am - 10:30 am	13
Rainbow Grocery, 13 th St. and Folsom St.	Sat. 2/29	11:00 am – 2:00 pm	37
Mission Creek Park, 4 th St. and Channel St.	Sat. 3/6	11:30 am - 2:00 pm	14
Dolores Park, 18 th St. and Dolores St.	Sat. 3/6	3:00 pm – 5:00 pm	17
Noe Valley Whole Foods Grocery Store, 24 th St. and Noe St.	Sun. 3/7	9:00 am- 10:00 am	25
TOTAL =			106

All locations are transit-accessible. The SOMA Whole Foods, Rainbow Grocery Store, and Mission Creek Park are within parking maximum areas; the Noe Valley Whole Foods and Dolores Park are not within parking maximum areas. At the store locations, subjects were recruited as they entered or exited the store, or as they walked by on the street. The surveys were self-administered and filled in on clipboards. Several volunteers trained in proper survey administration protocol and provided with an overview of the project’s objectives assisted the principal investigator with data collection. Volunteers also wore buttons that identified them as “Graduate Student Researchers” affiliated with San Jose State University.

The sample also included San Francisco residents from other parts of the city, who completed the survey online. The Glen Park Association and Hayes Valley Neighborhood Association distributed the survey link to their members via email, and several volunteers posted the survey link to the social networking site Facebook or sent emailed invitations to colleagues. The Hayes Valley group is located minutes from the San Francisco Civic Center in an area without residential parking minimums and with parking maximums; the Glen Park group is located near the southern edge of the city in a neighborhood with a BART station. Glen Park still has residential parking minimums and no parking maximums. Contacts in each of these organizations circulated a link to members with a request identifying the study as student research and requesting that they complete the survey online at <http://www.surveygizmo.com/s/251929/jnarg>.

Figure 1. Map of Survey Respondents and Areas with Parking Maximums in San Francisco.

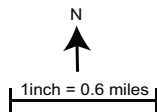


Key
 Areas Zoned with Parking Maximums
 Eastern Neighborhoods Planning Areas
 Central Waterfront
 East SOMA
 Mission
 Potrero Hill/Showplace Square
 Downtown C-3 Residential Zones

Market Octavia Neighborhood Plan Area
 Mission Bay Redevelopment Plan Area
 Rincon Hill Plan Area

X = Location of survey respondent's residence

Base Map Source: San Francisco Enterprise GIS Program (SFGIS), www.sfgov.org/gis.



Issues with Survey Administration

Although the sample was random to avoid sampling bias, there were some issues with self-selection, affinity, and accessibility bias. I originally planned to deliver the survey outside of a busy Safeway store at the intersection of 4th Street and King Street in SOMA, and was ignored by every person who walked by for 10 minutes, despite my clean appearance and an introductory line and a button identifying me as a student conducting research for a school project. There are a number of panhandlers who typically operate in this area, so this response is understandable. As a result, I moved to nearby Mission Creek Park, where I had a higher response rate. I originally wanted to include Safeway stores in my analysis because the supermarket's prices are lower than those at Whole Foods, which might have provided a more balanced survey sample.

As with all intercept surveys, a touch of affinity bias also entered the picture because we tended not to approach people who were involved in conversation, talking on a cell phone, listening to headphones, or who displayed obvious disinterest by walking quickly past us or averting their gaze. We also did not approach people who were walking dogs if another person with a dog was already completing the survey in the area, to avoid conflicts between the animals. Finally, due to the time and resource constraints, we could not access all areas of the city, which could have introduced some accessibility bias as we were unable to represent all possible situations. As such, I reached out to the most accessible subjects, which are those who were present at public areas that I could readily access and who self-selected to complete the survey, or those who subscribe to neighborhood listservs and are thus already pre-disposed to civic mindedness.

Survey Results

The final sample size was 182, with 65 respondents from areas where parking maximums have been implemented and 114 who live in areas of the city where residential parking minimums are still in place. Three respondents did not indicate where they live. Table 3 displays survey respondent demographics.

Table 3. Demographics of Survey Respondents

<u>Year of Birth</u>			
1971 to 1992 61.5%	1945 to 1970 31.3%	1944 and earlier 2.7%	No Answer 4.4%
<u>Income</u>			
\$36,000 or less 19.2%	\$36,001 to \$75,000 18.7%	\$75,001 to \$150,000 24.2%	\$150,000 and greater 26.9%
<u>Gender</u>			
Male 49.5%	Female 47.3%	Self-Identified .6%	
<u>Number of adults in household</u>			
1 28%	2 47.3%	3 11.5%	4 or more 8.2%
<u>Number of children in household</u>			
0 82.4%	1 6%	2 6%	3 or more 2.2%
<u>Home Ownership</u>			
Rent 58.8%	Own 37.9%		

Analysis of the survey responses yielded the following statistically significant results: People who live in areas where parking maximums have been introduced make fewer work trips in single-occupant motor vehicles than those who live in areas without parking maximums. There is also a relationship between availability of an off-street residential parking space and the choice of single-occupant vehicle as the primary mode for work commutes. Also, there is a relationship between availability of an off-street parking space at home and mode choice for entertainment trips.

In terms of overall trips, people without an off-street residential parking space available at their home reported making, on average, 1.4 trips by bicycle each day. This is compared to the .5 trips per day that people who have motor vehicle parking at home report. Availability of a parking space was not correlated with mode choice for other modes with statistical significance, but people who have a parking space at home took an average of 2.2 trips by vehicle per day, as compared to the 1.5 trips per day made by people without a parking space available at home.

Finally, people who live in areas with parking maximums also make more trips by bicycle each day. Those who live in areas with parking maximums reported making 1.8 trips by bicycle each day, as opposed to the .6 trips per day that people who live outside of parking maximum areas reported. Also, people who live in areas with maximums make an average of 2.2 trips by single occupant motor vehicle each day, compared to the .86 trips by motor vehicle that people who live in parking maximum areas make. In the next section, I will describe in greater detail the methods utilized in this study to determine these results.

Statistical Analysis

In San Francisco, to what extent does the availability of an off-street residential parking space influence residents' travel behavior?

The primary focus of this paper considers the relationship between access to an off-street residential parking space and travel behavior. To address this issue, several research questions were developed to analyze the survey data using PASWStatistics18.0. The survey respondents were coded based on whether or not they had access to an off-street parking space at their residence, regardless of whether they own a motor vehicle. The sample was relatively evenly split, with 86 respondents who do not have access to an off-street residential parking space and 79 respondents who do have access to an off-street residential parking space.

The first research question was:

“Whether people who have an off-street residential parking space make more work trips by single occupant vehicle than those who do not have an off-street residential parking space.”

This question was analyzed using a T-test for independent samples, which found that people with access to an off-street parking space at home make an average of .89 trips to work by single occupant vehicle, while people without access to an off-street parking space make an average of .64 trips by motor vehicle per day. This result had a p value of .172,

which is greater than the critical value of .05, which means the result is not statistically significant.

Next, Two-Factor-Chi-Square tests were utilized to analyze “whether there is a relationship between availability of an off-street residential parking space and primary commute, errand, and entertainment modes” For the purposes of this study, “primary mode” was defined as “the mode used for the longest part of the trip.”

Respondents were asked to identify the mode they considered their primary mode for travel to work or school, for errands such as shopping, and entertainment such as a trip to the movies, from a list that included bicycle, car share, single occupant motor vehicle, carpool, public transit, walking, or other.

As for commute mode, the majority of respondents reported commuting by single occupant vehicle (55), public transit (46) or bicycle (26). Table 4 below displays the breakdowns produced by this test.

Table 4. Off-Street Residential Parking and Primary Commute Mode Cross-Tabulation

		Primary Commute Mode							Total
		Bicycle	Motor Vehicle (SOV)	Motor Vehicle (Carpool)	Public Transit	Walking	Work at Home	Other	
Off-Street Residential Parking	No	20	23	3	21	8	8	0	83
	Yes	6	32	3	25	3	4	2	75
Total		26	55	6	46	11	12	2	158

For entertainment trips, people primarily reported driving single occupant motor vehicles (46), riding public transit (38) or walking (33). Table 5 below displays the breakdowns for entertainment trips.

Table 5. Off-Street Residential Parking and Primary Entertainment Mode Cross-Tabulation

		Primary Entertainment Mode							Total
		Bicycle	Motor Vehicle (SOV)	Motor Vehicle (Carpool)	Public Transit	Walk	Other	8	
Off-Street Residential Parking	No	16	20	4	21	18	3	0	82
	Yes	3	26	10	17	15	1	1	73
Total		19	46	14	38	33	4	1	155

Although a Chi-Square Test can reveal correlation and a relationship, it cannot determine causality. Thus, we learn from this test that there is a relationship between availability of an off-street parking space at home and primary commute mode choice, and

between availability of an off-street parking space at home and primary entertainment choice. However, we do not know the precise nature of these relationships.

The finding for commute mode is statistically significant with a p value of .024 (see Table 6 below).

The finding for entertainment mode is statistically significant with a p value of .025 (see Table 7 below).

Table 6. Off-Street Residential Parking and Primary Commute Mode Statistical Significance

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	14.597 ^a	6	.024
Likelihood Ratio	15.865	6	.014
N of Valid Cases	158		

a. 4 cells (28.6%) have expected count less than 5. The minimum expected count is .95.

Table 7. Off-Street Residential Parking and Primary Entertainment Mode Statistical Significance

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	14.469 ^a	6	.025
Likelihood Ratio	15.812	6	.015
N of Valid Cases	155		

a. 4 cells (28.6%) have expected count less than 5. The minimum expected count is .47.

A Cross-Tabulation was also prepared to investigate the existence of a relationship between off-street residential parking availability and primary errand mode. Although the results indicate that more people who do not have a parking space at home consider bicycling their primary mode of transportation for errands, and fewer consider a motor vehicle as their primary mode, these results are not statistically significant. The result of this test is included in Table 8 and Table 9 below.

Table 8. Off-Street Residential Parking and Primary Errand Mode Cross-Tabulation

		Primary Errand Mode						Total
		Bicycle	City Car Share	Motor Vehicle (SOV)	Motor Vehicle (Carpool)	Public Transit	Walk	
Off-Street Residential Parking	No	16	1	29	3	4	30	83
	Yes	7	0	40	3	2	22	74
Total		23	1	69	6	6	52	157

Table 9. Off-Street Residential Parking and Primary Errand Mode Statistical Significance

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	7.682 ^a	5	.175
Likelihood Ratio	8.164	5	.147
N of Valid Cases	157		

a. 6 cells (50.0%) have expected count less than 5. The minimum expected count is .47.

Finally, a T-Test was performed to analyze the question, “Whether people who have an off-street residential parking space available {bicycle, use city car share, drive single occupant motor vehicle, carpool, ride public transit, walk, or use another mode} more than those who do not have a residential off-street parking space available for all trips combined.”

This question analyzed data combined from several of the survey questions. The survey instrument (See Appendix 1) asked respondents how many trips they took on each of the modes listed above. It also asked respondents to indicate their primary mode for errand and entertainment trips, and how many trips per day they took for each of these purposes on average. By combining average number of trips per day using each mode, a “total trips per day on each mode” value was calculated. Table 10 displays the descriptive statistics for each mode. Although many interesting relationships are revealed, the only correlation that is statistically significant is that between bicycle commute trips and availability of a parking space. People with a parking space at home make .5 trips for work on bicycle on average, while people without a parking space at home make an average of 1.4 trips for work via bicycle each day. This finding is statistically significant with a p value of .042.

Table 10. Descriptive Statistics for Work Mode Share and Availability of a Parking Space at Home

Group Statistics					
	Off-Street Residential Parking	N	Mean	Std. Deviation	Std. Error Mean
Bicycle Work Trips/day	No	81	1.3563	3.13616	.34846
	Yes	69	.5138	1.42967	.17211
Car Share Work Trips/day	No	81	.0062	.05556	.00617
	Yes	69	.0290	.24077	.02899
Motor Vehicle Work (SOV)/day	No	81	1.5037	2.39551	.26617
	Yes	69	2.2004	2.99002	.35996
Motor Vehicle Work (Carpool)	No	81	.2148	.96707	.10745
	Yes	69	.3199	1.09823	.13221
Public Transit Work Trips/day	No	81	1.1191	1.95768	.21752
	Yes	69	1.2325	1.87598	.22584

Walk Work Trips/day	No	81	1.7743	2.48222	.27580
	Yes	69	1.7029	2.36950	.28525
Other mode (see #4)	No	81	.0370	.19003	.02111
	Yes	69	.0688	.34269	.04125

Thus, it seems that in San Francisco, availability of an off-street residential parking space is related to the mode of travel that people choose for commute and entertainment trips. Although the exact nature of that relationship is not entirely clear, it is clear that people who do not have an off-street parking space at home commute via bicycle more frequently than those who have an off-street parking space available at home.

Will reducing residential off-street parking requirements encourage people to drive less?

The second issue this paper addresses looks for the existence of a relationship between residential parking requirements and travel behavior. Specifically, the survey prepared in conjunction with this paper asked questions about the ways in which people travel in areas where residential parking maximums have been implemented and those where maximums have not been introduced. These questions seek to reveal whether reducing parking maximums may achieve the intended result of encouraging people to drive less in areas where maximums are introduced.

The survey respondents were broken into two groups: one composed of people who live in neighborhoods in San Francisco where parking maximums have been introduced, and one composed of people who live in San Francisco neighborhoods that still maintain more traditional parking minimum requirements in the zoning code. The former group lives in areas closer to downtown that are well-served by transit; the latter group is primarily located toward the edges of the city and further from downtown.

First, a T-Test for Independent Means was conducted to determine whether causality can be determined between living in an area with a parking maximum and number of work trips taken by single-occupant motor vehicle, public transit, bicycle, and walking modes. This test found with statistical significance that single occupant motor vehicle trips are influenced by a person's residence in an area with a parking maximum. People who live in areas with parking maximums make .87 trips for work by single occupant motor vehicle each day; those who do not live in areas with parking maximums make .46 trips for work by single occupant vehicle. The p value was .022, which is less than the critical value of .05, meaning this result is statistically significant, and, thus, residence within an area with parking maximums seems to cause people to make fewer work trips by single occupant vehicle. Although the results for work trips by bicycle, transit, or on foot were interesting, none of these findings were statistically significant.

Next, a T-Test for Independent Means was conducted to determine if there is a relationship between parking maximums and the total number of trips respondents made each day via each mode. As described above, the total number of trips that respondents made each day was calculated by combining the reported number of trips that respondents made using their primary work, errand, and entertainment modes.

This test found that people who live in areas with parking maximums made 1.8 trips on bicycle per day, while people who live in areas without parking maximums made .6 trips per day via bicycle. In other words, people who live in areas with parking maximums make

3 times as many trips by bicycle each day as those who do not. This finding is statistically significant at the .006 level.

The test also found that people who live in areas with parking maximums made .9 trips by single occupant motor vehicles each day, while people who live in areas without parking maximums made 2.2 trips per day via single occupant motor vehicle. In other words, people who live in areas with parking maximums make fewer than half as many trips via single occupant motor vehicle each day as those who do not. This finding is statistically significant at the .002 level.

Table 11 below displays the findings of this test.

Table 11. Relationship Between Parking Maximums and Number of Trips Per Day by Mode

		Group Statistics			
Lives in Maximum area?		N	Mean	Std. Deviation	Std. Error Mean
Bicycle Work Trips/day	Not Maximum Area	101	.6095	1.42377	.14167
	In Maximum Area	54	1.7694	3.71784	.50593
Car Share Work Trips/day	Not Maximum Area	101	.0050	.04975	.00495
	In Maximum Area	54	.0370	.27217	.03704
Motor Vehicle Work (SOV)/day	Not Maximum Area	101	2.2206	3.02002	.30050
	In Maximum Area	54	.8620	1.42933	.19451
Motor Vehicle Work (Carpool)	Not Maximum Area	101	.3059	1.19102	.11851
	In Maximum Area	54	.1587	.53137	.07231
Public Transit Work Trips/day	Not Maximum Area	101	1.0592	1.76650	.17577
	In Maximum Area	54	1.3557	2.13153	.29006
Walk Work Trips/day	Not Maximum Area	101	1.7755	2.53047	.25179
	In Maximum Area	54	1.6276	2.27377	.30942
Other mode	Not Maximum Area	101	.0396	.24169	.02405
	In Maximum Area	54	.0694	.30874	.04201

Thus, it seems that people who live in areas where residential parking maximums have been implemented prefer to drive less and to ride bicycles more. Although these residents may have self-selected their housing location, as the next section will describe, people who live in these areas tend to drive single occupant vehicles less frequently than their counterparts in other parts of the city. Thus, it is likely that policies aimed at reducing parking requirements in dense areas such as those that have already adopted parking maximums in San Francisco, will make some progress toward reaching their intended goals of reducing the number of trips made by single occupant vehicle and reducing congestion.

Do people self-select to live in places that allow them to travel in a certain preferred way?

A third, related question arises. As mentioned above, there is some concern that surveys are not the most precise method for researching travel behavior because of

peoples' tendencies to choose housing locations that allow them to travel a certain way. For example, there is a theory that people who live in TODs may self-select to do so because they are pre-disposed to living without a car or near transit, and TODs meet these goals. Thus, studies contending that TODs encourage people to alter their travel behavior and give up their cars are sometimes criticized for failing to account for the fact that people choose to live in the TODs because they enable them to live their chosen travel lifestyle – and are not actually the cause of the behavior itself.

Thus, a question was included in the survey that asked respondents why they chose to live in a specific location. The reasons varied a great deal, but the majority of respondents indicated that they chose to live where they live because it is close to work or school (47), or for reasons not included in the survey. Respondents were given the option to indicate another reason why they chose their residence, and the open-ended responses included: price, neighborhood, size, ability to bike, and attributes of the house. Table 12 indicates the choices listed in the survey and peoples' responses to the closed-ended portion of the question. Although these results are not statistically significant (Chi-Square p value = .106), they are still telling because they indicate that availability of transit, bicycling, or parking, were not the predominant reason why most of the survey respondents chose their homes.

Table 12. Why People Chose Their Housing Location

		Why people chose their housing location						
		Close to work or school	Close to retail and entertainment	Close to friends and family	Close to public transit	Availability of parking	Close to scenic locations/recreation	None of the above/other
Lives in	Not Max	25	10	9	12	5	14	25
Maximum area?	In Max Area	22	10	3	9	0	3	10
Total		47	20	12	21	5	17	35

Conclusion

Study Findings

In summary, this study found that, overall, people who live in areas where parking maximums have been introduced make fewer trips in single-occupant motor vehicles than those who live in areas without parking maximums and more trips by bicycle each day. People who live in areas with maximums make an average of 2.2 trips by single occupant motor vehicle each day, compared to the .86 trips by motor vehicle that people who live in parking maximum areas make. Those who live in areas with parking maximums reported making 1.8 trips by bicycle each day, as opposed to the .6 trips per day that people who live outside of parking maximum areas reported.

The study also found a relationship between availability of an off-street residential parking space and the choice of mode for work commutes and entertainment trips. Also, people without an off-street residential parking space available at their home reported making, on average, 1.4 trips by bicycle each day. This is compared to the .5 trips per day that people who have motor vehicle parking at home report.

These findings suggest that availability of a parking space at home is linked with mode choice and that people who live in areas where parking maximums have been implemented do, indeed, exhibit travel behavior that is different than that of people who live in areas without parking maximums. Thus, it is very likely that policies like implementing residential parking maximums or eliminating residential parking minimums in the dense areas closer to downtown are likely to encourage people to make fewer trips by motor vehicle because people who live in these areas are already using other modes more often than single occupant motor vehicles.

Limitations of the Study

This study was conducted in a rather limited geographic area within San Francisco. Thus, the results might not be generalized to the population of the city as a whole or to the populations of other cities. Also, the sample size was constrained to those who were willing to complete the survey, to the areas the surveyors were able to access, and to those who were able to access the survey online and fill it in accurately. The sample size of 182 is also relatively small, considering the population of San Francisco as a whole is more than 800,000. A larger and more stratified sample selection might be necessary to produce more robust results.

Policy Implications of the Research

The findings of this research supplement and augment the limited literature regarding the effects of reduced parking requirements on peoples' travel behavior. This research yielded results that indicate that people who live in areas of San Francisco that have adopted parking maximums drive less and ride bicycles more than residents of other parts of the city. This result suggests that progressive parking policies that limit the amount of parking that can be built with new development are likely to meet their goals of encouraging people to drive less and to take transit or walk to their destinations more

often. These results also suggest that density and the availability of transit in such areas do, indeed, reduce residents' need for a vehicle.

Also, the results do suggest a relationship between availability of a parking space at home and mode choice for work and entertainment trips. Thus, by limiting the number of parking spaces that developers can build in future residential projects in San Francisco, the city can influence the ways in which people travel. It is possible that availability of a parking space at home influences peoples' decisions to drive for work and entertainment trips, and, thus, by not making as many of those parking spaces available with new developments, people can be encouraged to drive less often.

Opportunities for Future Research

This paper pinpoints several opportunities for future research into the influence of parking maximums and residential off-street parking on travel behavior. First, detailed studies with travel diaries should be administered in neighborhoods where parking maximums have been adopted and those where parking minimums are still on the books. The data collected from such a thorough study would help expand the limited data presented in this study regarding the differences in travel behavior between people who live in areas with and without parking maximums. Second, a before-and-after study should be undertaken to measure, for example, neighborhood transit boarding rates before and after the development of a new residential building with limited parking availability in an area of San Francisco with parking maximums. This study would serve the purpose of determining whether limited parking availability really does drive people to seek out alternative modes of transportation. Finally, a random study like this one should be conducted over a longer period with a larger sample size to generate more easily generalized data about peoples' travel preferences.

Appendices

Appendix 1. Survey Instrument

Travel	
<p>1. Which of the following is your primary mode of travel for commuting? For the purposes of this survey, please consider "primary" to mean "the mode you use for the longest part of your trip."</p> <p><input type="checkbox"/> Bicycle</p> <p><input type="checkbox"/> City Car Share, Zipcar, or other car share service</p> <p><input type="checkbox"/> Motor vehicle (single occupant) (car, truck, van, scooter, motorcycle)</p> <p><input type="checkbox"/> Motor vehicle (carpool)</p> <p><input type="checkbox"/> Public Transit (Muni, BART, Caltrain, AC Transit, etc...)</p> <p><input type="checkbox"/> Walk</p> <p><input type="checkbox"/> Work at Home/Unemployed</p> <p><input type="checkbox"/> Other _____</p>	<p>5. How many trips for errands do you typically take each day? Answer can be a fraction; Please consider each stop made on the way to or from another destination as a separate trip.</p> <p>_____</p>
<p>2. Please indicate the number of times you used each of the following modes to get to and from work on the day of your last commute. For example: if you walked 1/2 mile to MUNI, rode MUNI, then walked to your office, and did the reverse for your trip home, these would count as 4 walking trips and 2 Public Transit trips.</p> <p>_____ Bicycle</p> <p>_____ City Car Share, Zipcar, or other car share service</p> <p>_____ Motor Vehicle (single occupant)</p> <p>_____ Motor Vehicle (carpool)</p> <p>_____ Public Transit</p> <p>_____ Walk</p> <p>_____ Work at Home/Unemployed</p> <p>_____ Other</p>	<p>6. Which of the following is your primary mode of travel for entertainment, such as going out to a restaurant or a movie?</p> <p><input type="checkbox"/> Bicycle</p> <p><input type="checkbox"/> City Car Share, Zipcar, or other car share service</p> <p><input type="checkbox"/> Motor vehicle (single occupant)</p> <p><input type="checkbox"/> Motor vehicle (carpool)</p> <p><input type="checkbox"/> Public Transit</p> <p><input type="checkbox"/> Walk</p> <p><input type="checkbox"/> Other _____</p>
<p>3. How many minutes is your typical one-way commute to work?</p> <p>_____</p>	<p>7. How many trips for entertainment do you typically take each day? Answer can be a fraction; Please consider each stop made on the way to or from another destination as a separate trip.</p> <p>_____</p>
<p>4. Which of the following is your primary mode of travel for errands, such as grocery shopping or dropping off dry cleaning?</p> <p><input type="checkbox"/> Bicycle</p> <p><input type="checkbox"/> City Car Share, Zipcar, or other car share service</p> <p><input type="checkbox"/> Motor vehicle (single occupant)</p> <p><input type="checkbox"/> Motor vehicle (carpool)</p> <p><input type="checkbox"/> Public Transit</p> <p><input type="checkbox"/> Walk</p> <p><input type="checkbox"/> Other _____</p>	<p>8. What percentage of your overall travel time for all trips do you spend on each mode?</p> <p>_____ Bicycle</p> <p>_____ City Car Share, Zipcar, or other car share service</p> <p>_____ Motor Vehicle (single occupant)</p> <p>_____ Motor Vehicle (carpool)</p> <p>_____ Public Transit</p> <p>_____ Walk</p> <p>_____ Other</p> <p>_____ 100% Total</p>
	<p>9. Travel patterns are affected by where people choose to live. It is important that we get at least a general location of your household. What street do you live on and what is the closest cross street?</p> <p>_____ and _____</p> <p>City: _____</p>

(Survey continues on the reverse)

10. How many vehicles are owned, leased, or available for regular use by the people who currently live in your household?
Household members include people who consider your home their primary residence, with whom you share resources such as income and vehicles.
 0 1 2 3 4 5 6 or more

18. In which era do you estimate your residence was built?
 1954 or earlier
 1955 to 1997
 1998 to Present
 Don't know

Parking

11. How many off-street parking spaces, if any, do you have access to at your residence?
An off-street parking space is in a garage or lot on the same property as your residence, and not on a city street or rented off-site.
 0 (Skip to #13) 1 2 3 4 5 6 or more
12. How do you pay for your off-street residential parking space?
 It was included in the residence purchase price or monthly rent
 Rent it for \$_____/month
 Purchased it for \$_____/month
 Other _____
 (Skip to #15)

13. If you do not have an off-street residential parking space available at your residence, where do you park your motor vehicle(s) if you own any?
 Rent a space elsewhere for \$_____/month
 Park on the street with permit
 Park on the street without permit
 Other _____

14. From where you typically park, how many minutes is the walk to your residence?
 _____ minutes

Housing

15. What is the main reason you chose to live in the location of your current residence?
 Close to work or school
 Close to retail and entertainment
 Close to friends and family
 Close to public transportation
 Availability of parking
 Close to scenic locations and/or recreation
 None of the above/Other _____
16. Do you rent or own the residence you are living in?
 Rent Own Other
17. Which best categorizes your residence?
 Small Multi-unit condo or apartment building (9 units or less)
 Large Multi-unit condo or apartment building (10 units or more)
 Single-family home
 Other

About You

19. How many adults age 18 or greater, including yourself, are in your household?
 1 2 3 4 5 6 or more
20. How many children under age 18 are in your household?
 0 1 2 3 4 5 6 or more
21. What is your gender?
 Male Female Self-Identified
22. In what year were you born?

23. What is your annual household income?
 \$36,000 or less
 \$36,001 to \$75,000
 \$75,001 to \$150,000
 \$150,001 or greater
 No Answer

Thank you for your help!

Survey #	_____
Date	_____
Location	_____

Glossary

Parking Maximums: An upper limit placed on supply of parking allowed, either at individual sites or throughout an area, such as a commercial district.

Todd Litman, *Parking Management Best Practices*. Chicago: American Planning Association Press, 2006: 271.

Parking Requirement: Number of parking spaces that must be supplied at a particular location, which is often mandated in zoning codes or development requirements based on published standards.

Todd Litman, *Parking Management Best Practices*. Chicago: American Planning Association Press, 2006: 272.

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