

Utilizing Shared Parking to Mitigate Imbalanced Supply in a Dense Urban Neighborhood

Case Study in Vancouver, British Columbia, Canada

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Excess off-street parking can have a range of impacts, including undesirable effects on housing costs, urban form, mode choice, and overall density. In urban residential areas, excess off-street parking can coexist with on-street parking congestion because of restrictions in parking access, nonmarket pricing, and other factors. This paper examines the potential for shared parking to address such an imbalance in parking supply by using a case study of the West End, a high-density residential neighborhood in Vancouver, British Columbia, Canada. The West End's residential parking permit (RPP) program has faced parking shortages and congestion, with on-street parking consistently reaching 90% occupancy. At the same time, off-street residential parking facilities in the neighborhood have occupancy rates consistently less than 50%. This analysis uses the inventory and occupancy data for off- and on-street parking stalls to investigate the impacts of making off-street stalls available to RPP users in a shared-parking program. Results showed that on-street parking congestion could be greatly reduced by introducing a relatively small number of off-street stalls from select residential buildings to the RPP program. Methods to unlock currently underutilized off-street parking supply are also discussed.

Land dedicated exclusively for moving and housing automobiles is the largest allocation of city space in most North American cities (1, 2). Parking provision can dictate building design, with impacts on residential and commercial density; the convenience of walking, cycling, or transit; and a city's overall urban form and character. Greater parking supply and lower parking price are both associated with higher auto mode share (3, 4). In Vancouver, British Columbia, Canada, parking vacancy rates in strata properties (similar to condos) are roughly 20% to 40% (5). Excess parking can encourage driving by increasing opportunities to find parking at the ends of trips and discourage other travel modes by making the built environment primarily hospitable to private motor vehicles (3).

Overabundant parking supply also creates financial burdens through direct construction costs and indirect opportunity costs of

other land uses (6). In Metro Vancouver, construction of on-site parking can range from \$20,000 to \$45,000 per stall, in addition to maintenance and operation costs (5). Structured parking in the United States costs around \$15,500 per stall (7). Construction costs are higher in dense areas of a city, where parking is often built underground. A study in King County, Washington, found that excess parking development (0.4 stall of unused parking per unit) added \$400,000 to project costs on average (8). Parking made up 10% to 20% of construction costs, but only 6% was recovered through parking fees, which likely are added to tenant rent.

Parking research and policy recommendations across two decades have focused on assessing and reducing the oversupply of off-street parking (9–11). During that time, cities have experimented with various strategies to reduce parking requirements for new construction and to utilize the unused existing supply (12, 13). North American cities such as Denver, Colorado; Portland, Oregon; and Seattle, Washington; along with international examples like Stockholm, Sweden; Zurich, Switzerland; and Tokyo have ambitious policies and strategies to reduce or eliminate new parking construction, mitigate parking demand, and use parking restrictions to encourage alternative travel modes (14–17).

CITY OF VANCOUVER PARKING POLICY

In the *Greenest City 2020 Action Plan*, Vancouver prioritized reaching a combined mode share of at least 50% for walking, cycling, and transit and reducing residential driving distances by 20% by 2020 (18). In *Transportation 2040*, the City of Vancouver's long-range transportation plan, parking management was identified as "one of the biggest opportunities to support a smart and efficient transportation system" (19, p. 40). Furthermore, the City of Vancouver anticipates nearly 150,000 new residents between 2011 and 2041, almost a 25% increase in population (20); addressing parking demand with appropriate strategies and policies is an important step for accommodating new residents while moving forward with transportation and sustainability goals. Three proposed motor vehicle policies are particularly relevant to utilizing parking as a shared resource: (a) M2.1 (use off-street parking requirements to support reduced auto ownership and use), (b) M2.4 (approach parking as a shared district resource), and (c) M2.7 (manage parking in neighborhoods).

The West End neighborhood has some of the highest residential density in the city of Vancouver. With nearly 217 persons per hectare, the West End is the fourth-densest neighborhood in the city, preceded

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Transportation Research Record: Journal of the Transportation Research Board, No. 2651, 2017, pp. 92–100.
<http://dx.doi.org/10.3141/2651-10>

TABLE 1 Required Parking in West End Residential Buildings by City of Vancouver Parking Bylaws

Multifamily Housing Type	Buildings	Units	Residential ft ² × 1,000	Total Stalls Required by Bylaw Year						
				1959	1964	1974	1986	1987	2000	2015
Market co-op	17	640	626	447	550	712	737	727	768	768
Nonmarket rental	18	1,625	1,031	736	905	812.5	812.5	812.5	812.5	812.5
Strata	157	6,229	6,033	4,309	5,294	6,856	7,098	7,006	6,757	4,004
Stratified market rental	12	324	300	214	263	341	353	348	336	199
Unstratified market rental	411	19,293	12,618	9,013	11,072	14,340	14,845	14,653	14,132	8,373
Nonprofit rental	3	137	69	49	60	69	69	69	69	46
Other rental	15	1,264	836	597	733	949	983	970	970	554
Total	633	29,512	21,513	15,366	18,877	24,079	24,897	24,587	23,844	14,756
Average stalls per unit				0.52	0.64	0.82	0.84	0.83	0.81	0.50
Additional stalls (%) compared with current bylaw				4	28	64	68	66	62	na

NOTE: na = not applicable.

only by Downtown South (304.9 persons per hectare), City Gate (335 persons per hectare), and Triangle West (352.2 persons per hectare) (21). By using the current residential building stock in the West End as an example, Table 1 illustrates how changing parking bylaws over time can affect parking supply. The City of Vancouver first required residential parking in 1959. Parking requirements were increased in 1964, and specific parking regulations were introduced for the downtown region in 1975. Parking became its own bylaw (no. 6059) in 1987, and parking requirements began to decrease in the 2000s. After nearly 60 years, parking requirements have returned to about where they began. For the current building stock, 60% to 70% more stalls would be needed to comply with the high-parking bylaws of the 1970s to the 2000s than with the current bylaws or those of 1959. In addition, the City of Vancouver now offers several options for developers to reduce the amount of parking required for a given project in exchange for amenities (e.g., shared vehicles, shared parking stalls, proximity to rapid transit network) or cash payment.

SHARED AND DISTRICT PARKING

Existing parking infrastructure in many cities is oversupplied and inconsistently utilized. In 2011, Metro Seattle surveyed 240 residential developments and found that parking was, on average, oversupplied by 40%: stalls were supplied at 1.4 stalls per unit but utilized at only one stall per unit (22). Suburban developments had 1.6 stalls per unit supply and a 1.2 stalls per unit utilization, while the central business district had 0.8 and 0.6 stall per unit supply and utilization rates, respectively. Residential utilization rates were even lower during work hours. Similar results were found around Metro Vancouver, where parking was seen to be consistently oversupplied by between 18% and 35% (5).

Shared parking is the practice through which two or more entities use the same parking stalls to meet their parking requirements (10). Facilities with additional parking sell their excess to neighbor-

ing entities or partner with a building that has a different parking schedule. Ad hoc parking relationships have long existed, as shared parking strategies involving churches and movie theatres or other venues with irregular hours have shown. Growing costs of parking construction, and improved technologies to aid in the renting and leasing of spaces, are allowing more creative partnerships and making shared parking more feasible. Proximate business and residential properties can now partner to maximize the utilization of existing parking stalls and to alleviate the need for new construction. Approaching parking as a systemwide utility allows stalls to be more consistently utilized and can provide greater returns on parking infrastructure investments.

Five approaches to shared parking currently used include these:

- Alternate-schedule partnerships,
- Mixed-use development,
- Leased-parking strategies,
- District parking, and
- Capped parking.

Alternate-schedule partnerships commonly involve one property allowing another nearby business to utilize its parking when the first property is closed or its parking lot is not fully needed. This approach is being used to meet parking requirements without new construction (23).

Mixed-use development strategies allow parking minimums to be reduced for land uses with differing parking needs, if the total projected parking demand can be shown to be less than the combined minimums. The Cook Street Apartments in Portland used this strategy to reduce required parking construction from 250 to 146 stalls for its development that includes 206 residential units and 15,000 ft² of retail space (24).

Leased-parking strategies allow building owners to make currently unused parking supply available to other users. Building owners generate revenue from unused stalls, and cities satisfy some unmet parking demand without additional infrastructure.

District parking allows new projects to partner with surrounding properties to satisfy parking needs, dependent on distance and excess parking availability, through a formal-use agreement. This parking management strategy is now being recommended to help to preserve the walkable characteristics of Seattle's Capitol Hill neighborhood (25).

In capped-parking strategies, a city identifies a certain quantity of parking for an area, and new projects must remove existing stalls so as to place parking within the development. Capped parking was established in Zurich in 1996, and new projects with off-street parking now must remove on-street parking (16).

Various hurdles, particularly legal and political, commonly impede implementation of shared parking strategies. The Vancouver parking bylaw does not permit parking stalls to fulfill parking requirements for multiple uses; parking can be combined in multiuse developments, but individual minimums must be met without specific authorization by the director of planning and the city engineer (26). Provincially, under the British Columbia Strata Property Act, parking stalls cannot be sold independently from their paired property (27). If nonresident vehicles are parked on private property, insurance and liability for parked vehicles are concerns that would need to be addressed through contractual agreements between building owners and users or between building owners and city programs.

The objective of this paper was to investigate the potential for shared parking to improve existing parking infrastructure utilization and to relieve parking congestion by using a case study of Vancouver's West End neighborhood. Vancouver's residential parking permit (RPP) program aims to provide priority parking for neighborhood residents within a designated zone. For a small annual fee (\$76.37 in the West End), residents in the neighborhood can purchase a permit allowing them to park their registered vehicle in dedicated areas of the surrounding residential blocks. Although this program reduces the number of nonresident West End customers and visitors parking on residential streets, the comparatively low permit price has led to consistent congestion and on-street parking shortages, as residents choose the streets instead of more expensive off-street

parking. As a result, despite on-street parking congestion, off-street residential parking facilities in the neighborhood have consistently low occupancy.

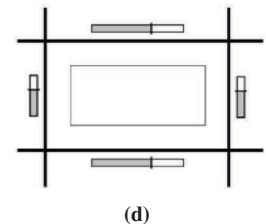
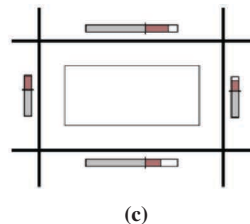
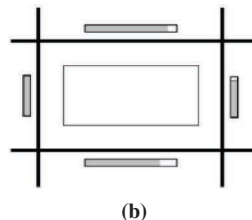
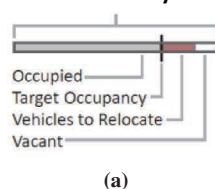
METHOD

First, data from the City of Vancouver and the Insurance Corporation of British Columbia were used to estimate off-street parking utilization for multifamily residential buildings in the West End RPP zone and to identify potential buildings for a shared parking program. The off-street utilization results were then combined with data from an on-street utilization study to investigate how opening off-street stalls to the RPP would affect on-street and off-street parking utilization. The analysis method is illustrated in Figure 1.

Property information (name, address, tenure, construction date, number of rooms, number of parking stalls, residential parking permit registrations, and tax coordinates) was obtained from the City of Vancouver by referencing each property's tax attribute report and the corresponding building permits. This process involved manual review of all original building permits and any listed renovations to calculate all existing off-site parking stalls. Only multifamily residential properties within in the RPP zone with at least four units were included in the analysis (630 buildings). Off-street parking includes all structured or surface parking listed in a building's construction documents. Each property's unique tax coordinates were then used to link to existing geographic information system data sets for spatial analysis.

Vehicle registrations were obtained from the Insurance Corporation of British Columbia's database of registration of vehicle ownership. Vehicle ownership for each building was assumed to be the number of vehicles registered at the property address through the Insurance Corporation of British Columbia. "Parking surplus" for each building was defined as the difference between off-street parking stalls and vehicle ownership, and the "adjusted surplus" was 95% of the parking surplus rounded down (a conservative adjustment down to account for vehicles potentially owned but not yet

On-Street Analysis



Off-Street Analysis

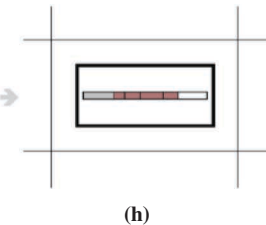
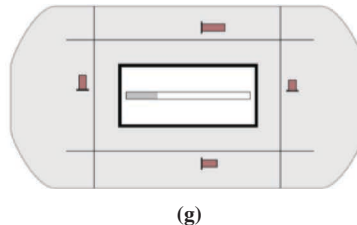
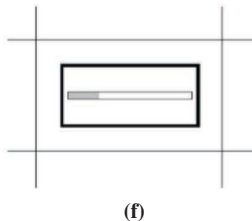
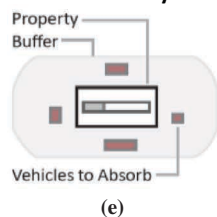


FIGURE 1 Analysis method for on-street parking consists of (a) total parking supply, (b) existing condition, (c) establishment of target occupancy, and (d) resulting occupancy and for off-street parking consists of (e) three components (property, buffer, and vehicles to absorb), (f) existing condition, (g) selection of buffer distance, and (h) resulting occupancy.

registered at the address or for unusable stalls). Building parking occupancy was calculated as

$$\frac{\text{stalls} - \text{adjusted surplus}}{\text{stalls}}$$

Buildings with adjusted surplus of at least 50 stalls were selected for inclusion in the hypothetical shared parking program.

To examine the potential impact of shared off-street residential parking with the RPP program, the authors assessed the number of parked vehicles that needed to be relocated from each block to achieve a target occupancy and then the number of those vehicles that could be absorbed by the parking surplus in nearby residential buildings. On-street parking data (number of RPP parking stalls per block and parking occupancy) were gathered from a weekday (7:30 a.m. to 9:00 p.m.) parking survey conducted for the West End Community Plan in August 2012. The two target occupancies of 85% and 65% were selected to represent desired parking availability to avoid parking congestion, slightly higher than target occupancy rates for retail streets (28, 29).

Building catchment areas were based on buffers representing straight-line walking distances of 50, 100, and 200 m. The longest blocks in the West End are 200 m, which is within the level-of-service-by-walking rating for residential uses developed by Smith and Butcher (30). For a 200-m block length, 100 and 50 m represent half- and quarter-block distances. Vehicles to relocate from a block were assigned to buildings with surplus parking and buffers intersecting the block midpoint, proportionally if the area had multiple buffers. Then new occupancy rates were computed for the off- and on-street stalls. Six scenarios were evaluated, each combination of two target occupancies and three buffer sizes.

After relocation, distances from blocks with remaining occupancy above 90% to the nearest blocks with occupancy below 70% were measured to assess the potential for redistribution of on-street parking in response to the relocated vehicles. The analysis method was not a behavioral model of the decision to use off- or on-street stalls; in a shared parking program, utilization of each will depend on pricing, ease of access, and other factors. Assumptions and limitations of the method are discussed in the final section of the paper.

RESULTS

Figure 2 shows the RPP zone and multifamily residential buildings by decade constructed. The RPP zone covers all residential blocks in the West End neighborhood but excludes a commercial strip along Robson Street. Most of the buildings were constructed between the 1950s and 1980s, which coincided with a period of increasing parking requirements (Table 1).

Figure 3 shows average number of off-street parking stalls per unit for West End multifamily buildings by tenure and decade. Rental properties represent the largest portion of tenures and have the fewest stalls per unit, while strata have the most. As could be expected from Table 1, properties built between the 1970s and 2000s had the most parking per unit. The effects of parking bylaws from the past century were reflected in the neighborhood's off-street parking stock.

Of the 630 properties, 46 had parking vacancies of at least 50 stalls and were included in the shared parking analysis. These selected 46 buildings had, on average, 140 units, were built between 1960

and 2010, and were predominantly market rentals (26 of 46). These buildings had a combined 7,394 off-street parking stalls, more than half of them (3,771) believed to be vacant. The parking surplus ranged from 51 to 143 unoccupied stalls per building. In contrast, the RPP zone had 2,747 on-street stalls, 316 of them believed to be vacant. With average off- and on-street occupancies of 47% and 88%, respectively, the potential was clear for shared parking strategies to help balance existing parking infrastructure utilization.

Figure 4 shows the shared parking results for the scenario with a 100-m buffer and 85% occupancy. Most of the RPP zone was covered by a 100-m buffer from the 46 buildings with substantial surplus parking stalls, which were fairly well distributed. Even after the relocated vehicles were absorbed, parking occupancy in all 46 buildings remained below 80%, and most were below 60%. Most streets in the RPP zone reached the target occupancy of 85%, although 33 of the 216 blocks outside the 100-m buffers were still more than 90% occupied.

Shared parking results for all six scenarios is given in Table 2 (off-street stalls) and Table 3 (on-street stalls). The range in the number of vehicles relocated was wide across scenarios: 122 to 757. However, even in the high-relocation scenario, final building occupancy remained quite low (average below 60%, with occupancy increases of up to 11%) (Table 2). In contrast, the on-street parking condition had the potential to improve substantially (Table 3). Average on-street occupancy in the RPP zone fell from 88% to as low as 60%. With small buffer sizes (walking distances), many blocks remained at high-occupancy of more than 90%, but the potential for redistribution of on-street parking was fairly high, as indicated by the moderate average distances from remaining high- to low-occupancy blocks. The redistribution distance was shorter in scenarios with lower overall average occupancy, as expected.

The distribution of buildings and blocks by final occupancy for each scenario is shown in Figures 5 and 6, respectively. Figure 5 shows that only in the highest-relocation scenario (65% occupancy, 200-m buffer) did any building become high occupancy (more than 90%). Figure 6 shows that high-occupancy blocks were greatly reduced in all the scenarios, particularly with buffers—walking distances of 100 m or more. Overall, Figures 5 and 6 support the previous results that shared parking could potentially greatly reduce on-street parking congestion with relatively small impacts on off-street parking facilities.

CONCLUSIONS

The West End neighborhood had 16,000 registered vehicles, 15,000 of which had access to at least one of the 22,000 off-street parking stalls in the neighborhood's residential buildings. Despite this access to off-street parking, 6,000 RPP permits had been issued for the neighborhood's 2,747 on-street RPP parking stalls. This imbalance of supply and demand resulted in frequent on-street parking shortages throughout the West End, with average parking occupancy rates consistently reaching 90%. If the RPP program were limited to those without access to off-street parking, only 1,000 West End vehicles would need the on-street RPP stalls, and much of the existing stock could be repurposed as short-term parking supply. Alternatively, increasing the RPP price would likely shift some of the demand to the off-street facilities. While limiting the number of RPP permits or increasing the permit price are potential solutions, political pressure and concerns about equal access to public resources make both of these options challenging. With this in mind, incorporating some of

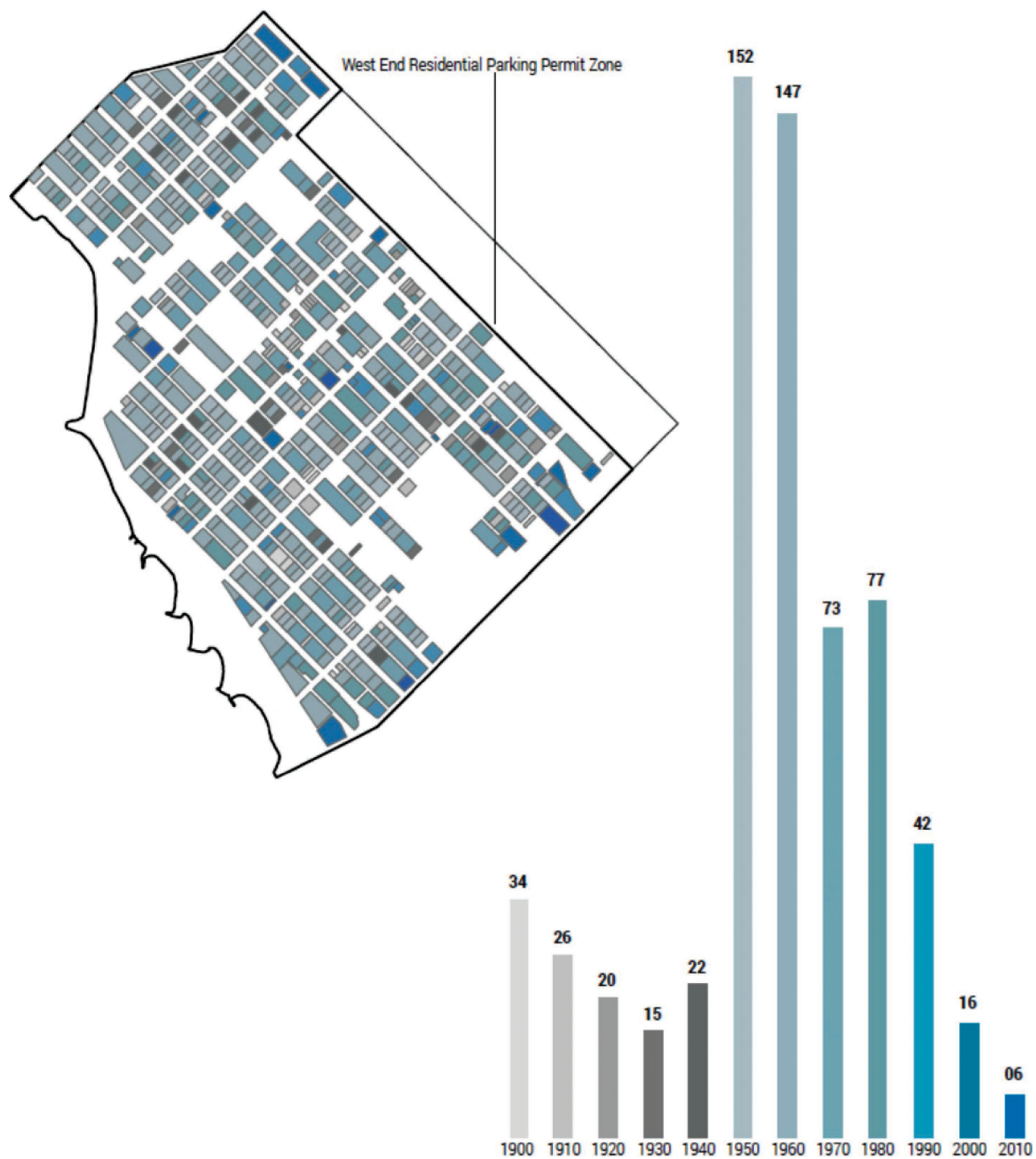


FIGURE 2 West End multifamily residential buildings by decade constructed.

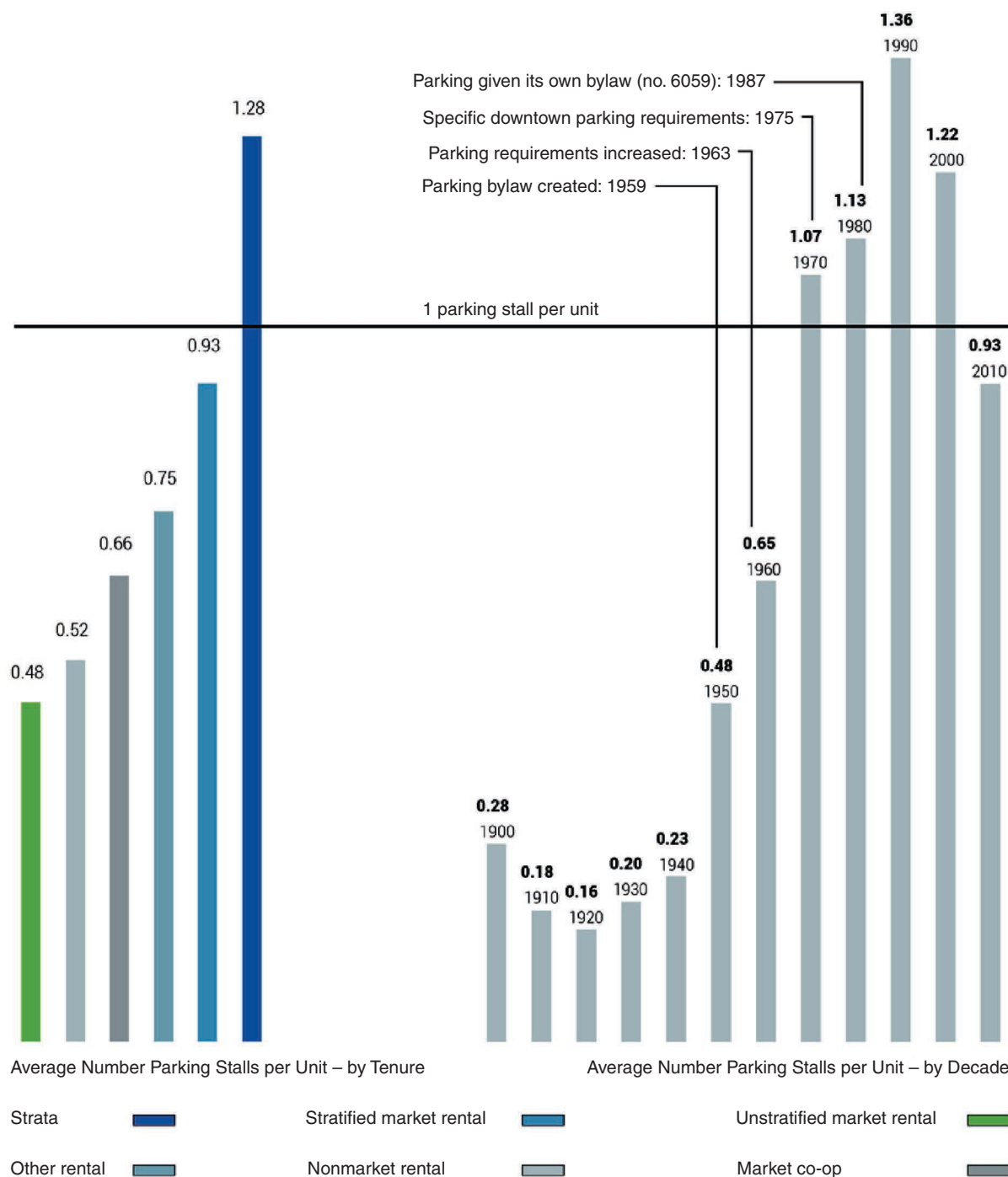


FIGURE 3 Parking stalls per unit by tenure and decade for West End multifamily buildings.

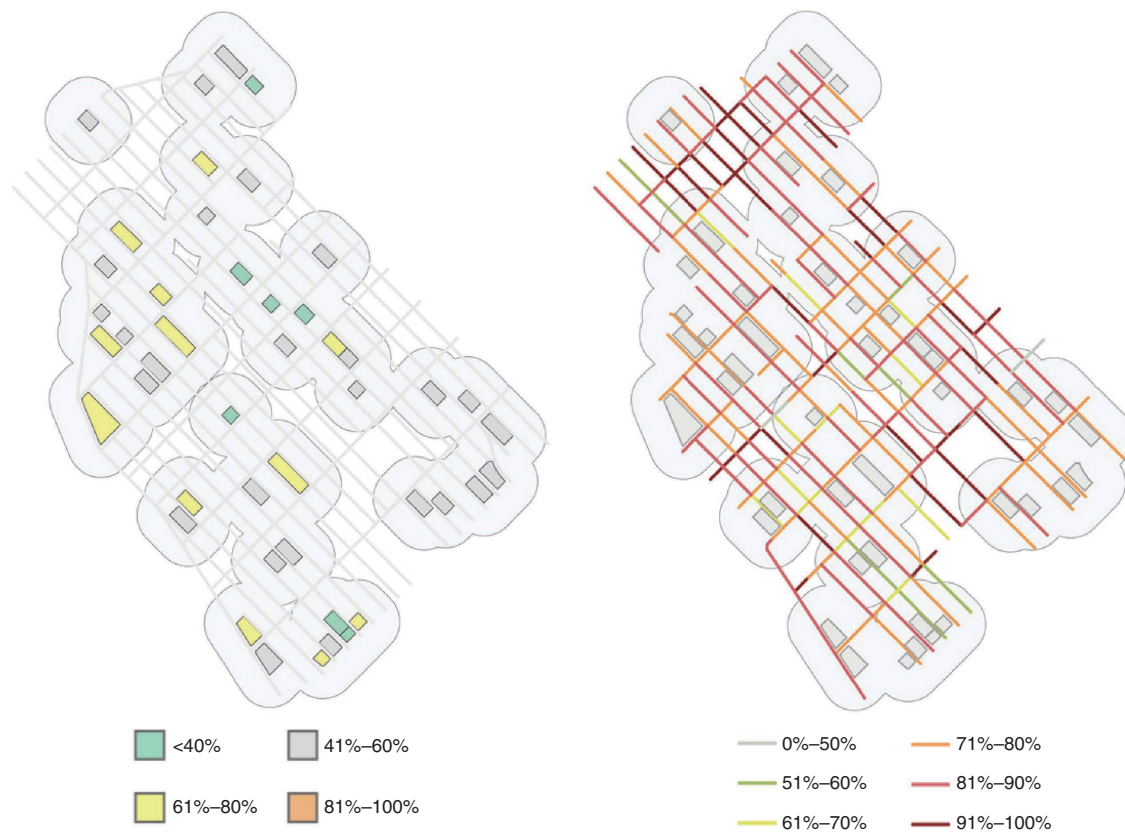


FIGURE 4 Shared parking analysis results for 100-m buffer and 85% on-street occupancy: (a) building parking occupancy and (b) on-street parking occupancy.

TABLE 2 Summary of Off-Street Results for Each Scenario

Target Occupancy	Buffer (m)	Vehicles Relocated	Remaining Vacancies	Average Final Building Occupancy (%)	Average Change in Occupancy (%)
0.85	50	122	3,649	49	2
0.65	50	317	3,454	52	5
0.85	100	205	3,566	50	3
0.65	100	554	3,217	56	8
0.85	200	279	3,492	51	4
0.65	200	757	3,014	58	11

NOTE: Base condition: 3,771 vacant of 7,394 total stalls—47% average building occupancy.

TABLE 3 Summary of On-Street Results for Each Scenario

Target Occupancy	Buffer (m)	Vehicles Relocated	Average Final Occupancy (%)	Average Change in Occupancy (%)	Remaining High-Occupancy Blocks	Average Distance to Low-Occupancy Block (m)
0.85	50	122	85	3	76	200
0.65	50	317	78	10	76	89
0.85	100	205	81	7	33	175
0.65	100	558	67	21	33	71
0.85	200	279	78	10	0	na
0.65	200	757	60	28	0	na

NOTE: Base condition: 316 vacant of 2,747 total stalls—88% average occupancy. High-occupancy blocks are >90% occupied; low-occupancy blocks are <70% occupied.

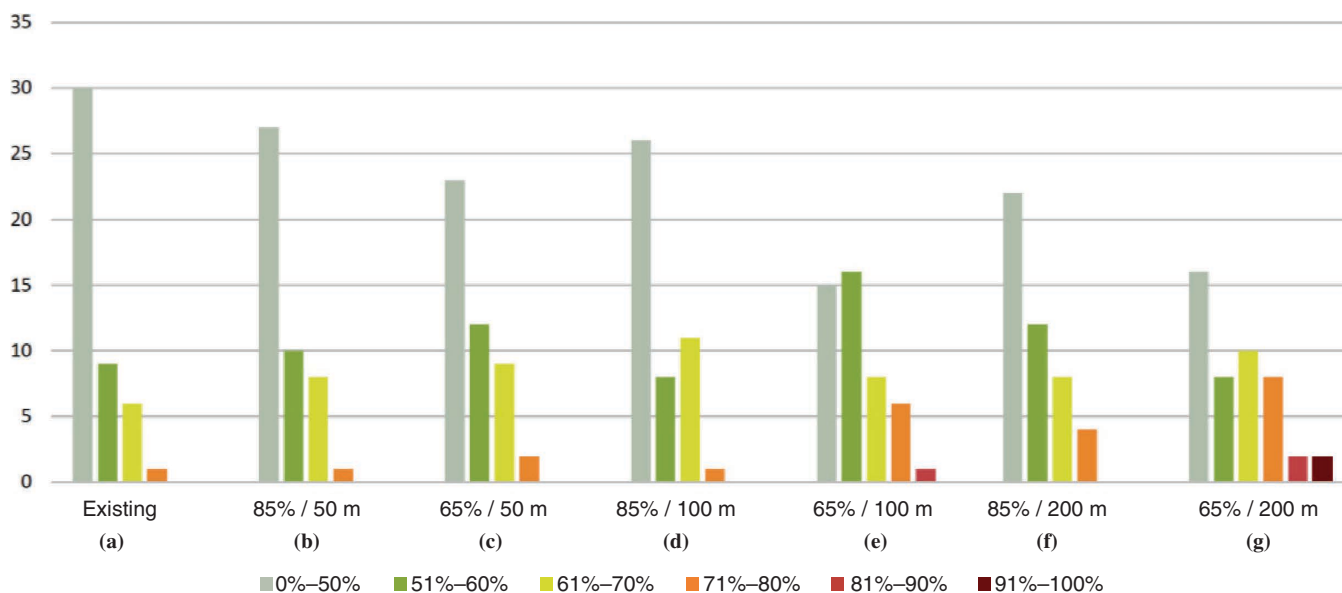


FIGURE 5 Number of buildings by final occupancy for each scenario: (a) existing condition, (b) 85% occupancy and 50-m buffer, (c) 65% occupancy and 50-m buffer, (d) 85% occupancy and 100-m buffer, (e) 65% occupancy and 100-m buffer, (f) 85% occupancy and 200-m buffer, and (g) 65% occupancy and 200-m buffer.

the neighborhood's off-street parking into the RPP may offer a less contentious solution.

The results presented in this paper show that a shared parking program has the potential to reduce dramatically the West End's on-street parking congestion with minimal increases in parking occupancy of select large multifamily buildings in the neighborhood. In addition to easing on-street parking congestion, this potential partnership between the RPP program and private buildings could better utilize existing infrastructure, generate revenue for building owners, and increase availability of short-term parking for caretakers and visitors, an issue commonly voiced by West End residents.

The analysis in this paper used a number of simplifying assumptions, and the estimated occupancy on individual streets and in individual buildings should be interpreted with caution. The number of vehicles registered to a building is an imperfect measure of parking occupancy; future analysis would benefit from a multiday utilization study at each building. Multifamily parking utilization data can be generated by first counting the number of parked vehicles in a building and then using video cameras to monitor vehicle entrances and exits over weekdays and weekends. Utilization data collected in this way would show utilization rates throughout the day, as well as the number of residents who use on-street parking instead of on-site parking.

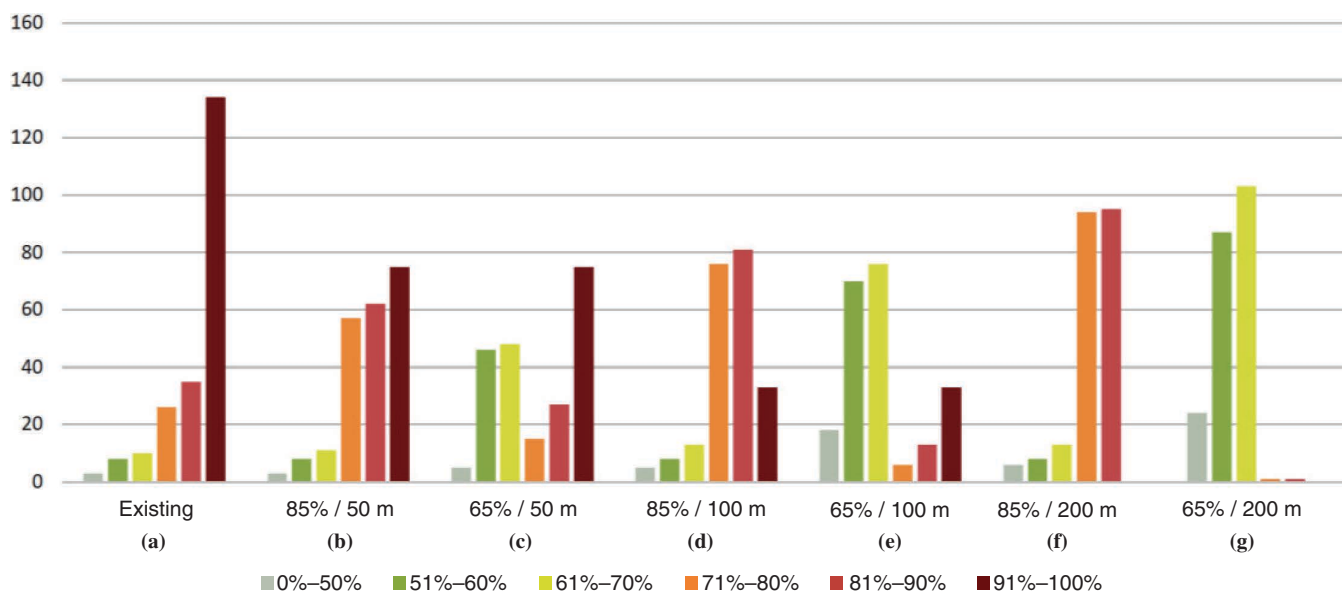


FIGURE 6 Number of blocks by final occupancy for each scenario: (a) existing condition, (b) 85% occupancy and 50-m buffer, (c) 65% occupancy and 50-m buffer, (d) 85% occupancy and 100-m buffer, (e) 65% occupancy and 100-m buffer, (f) 85% occupancy and 200-m buffer, and (g) 65% occupancy and 200-m buffer.

Although the number of RPP permits registered to each building was known, use of the permits for on-street parking was not. Some RPP holders likely park on street rather than in their building, so actual off-street parking occupancy is likely lower than assumed in this analysis. For the 46 selected buildings, subtracting the RPP permits would increase parking surplus by on average of 20 stalls per building; thus, neglecting RPP permit holders is conservative with respect to the findings presented here. In contrast, increasing the supply of RPP stalls through a shared parking program could induce additional demand for RPP stalls and would lead to higher final on-street occupancy than modeled here. As noted earlier, the analysis did not account for possible redistribution of on-street parking as occupancy on some blocks would fall with relocation. Equilibrium on-street occupancy could be more evenly dispersed than modeled here, but a more detailed model would need destination information as well as parking utilization.

On-street and off-street parking do not always serve the same purpose. Commonly, off-street stalls are used for long-term storage, while on-street stalls have high turnover uses in commercial areas and lower turnover uses in residential areas with dedicated on-street residential parking (such as an RPP). In this analysis, off-street stalls were considered a direct substitute for on-street stalls in the RPP. This assumption would not apply to all parking demand, and its accuracy depends on the off-street surface parking that offers a similar level of convenience to on-street parking.

Key next steps in creating a shared parking program in the West End include identifying site and building design characteristics that are conducive to shared private–public parking, designing pricing schemes, analyzing business cases for the city and the building owners, and examining the relevant legal requirements. Preliminary analysis suggests that a large number of off-street stalls could be made available relatively easily, with little to no site modification, by using surface parking. In doing so, building owners could lease stalls to either the city's existing RPP program or directly to users. Analysis of the business case for building owners must also consider the challenges of shared parking, such as insurance, liability, and the pricing of on-street and off-street stalls. Once the preliminary shared parking program designs have been developed, further work should undertake more detailed modeling of parking demand under different program designs, including neighborhood access, site design, circulation, and elastic demand. In dense urban neighborhoods with markedly imbalanced parking supply, such as Vancouver's West End, shared parking is a potentially powerful strategy to ease parking congestion without losing valuable land.

ACKNOWLEDGMENTS

The authors acknowledge the City of Vancouver's Greenest City Scholar program, the Transportation 2040 team, and the Neighborhood Parking team, in particular Daddi Ottosson, Eric Mital, Christopher Darwent, Paul Krueger, and Paul Storer.

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The Standing Committee on Transportation Demand Management peer-reviewed this paper.