Reassessing On-Street Parking

Wesley E. Marshall, P.E.
University of Connecticut
Civil & Environmental Engineering
U-37, Storrs, CT 06269-2037
TEL: (203) 715-4548 FAX: (860) 486-2298
wesley.marshall@uconn.edu

Norman W. Garrick, Ph.D.
University of Connecticut
Center for Transportation and Urban Planning
Civil & Environmental Engineering
U-37, Storrs, CT 06269-2037
TEL: (860) 486-2990 FAX: (860) 486-2298
norman.garrick@uconn.edu

Gilbert Hansen
University of Connecticut
Civil & Environmental Engineering
U-37, Storrs, CT 06269-2037
TEL: (860) 486-2990 FAX: (860) 486-2298
gilbert.hansen@uconn.edu

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ABSTRACT

The ongoing debate about the merits and drawbacks of on-street parking has few definitive answers because comprehensive research in this area has been lacking. Our goal is to develop a better understanding of the gamut of issues related to on-street parking, ranging from parking demand and the pedestrian environment to less researched topics such as the efficiency of land use. Additionally, we address the basic question of safety in a more precise way than previously done by taking into account actual vehicle speeds and crash severity levels.

Our investigation points to on-street parking playing a crucial role in benefiting activity centers on numerous levels. Users of the downtowns consistently valued these land-efficient on-street parking spaces over and above off-street surface lots and garages. Low speed streets with on-street parking also had the lowest fatal and severe crash rates of any road category in our study of 250 Connecticut roadway segments. Part of the reason for this is that the presence of parking had a measurable effect on vehicle speeds.

On-street parking is not purely a device to be used in the right environment; rather, it is a tool to help create that right environment. On-street parking should be more commonly used but especially in situations where the road is part of the destination and where the intent is to get drivers to slow down. Our results suggest that these places are safer, more walkable, require less parking, and have more vitality.

KEY WORDS

Parking, on-street, curbside, land use, safety, speed, sustainability, mixed-use, pedestrian, zoning, walkable, walkability, town centers, new urbanism, smart growth, urban planning.

INTRODUCTION

The ongoing debate about the merits and drawbacks of on-street parking has few definitive answers because research in this subject has been lacking over the last two or three decades. Some downtowns simply provide on-street parking wherever possible, while others prohibit it as being unsafe and a nuisance to moving traffic. Part of the problem is that prevailing thought on the subject has shifted over the years. Consequently, finding real answers is difficult because even the best studies seem to focus on one or two qualities of on-street parking, failing to account for the broad range of potential outcomes.

Even though many planners, engineers, and particularly New Urbanists now consider on-street parking an integral part of any downtown, questions linger. Proponents cite places where on-street parking works incredibly well, whereas detractors cite places with contrary results. One issue is that these examples are informal and rarely based on more than word of mouth regarding the true outcomes. The bigger issue begs the question as to why some places have been successful when it comes to incorporating on-street parking in their downtowns. With this research, we intend to develop a better understanding of the gamut of issues related to on-street parking, ranging from parking demand and the pedestrian environment to less researched topics such as land use and the impact on vehicle speed. In addition, we address the basic question of safety in a more precise way than previously done with on-street parking studies by taking into account vehicle speeds and crash severity.

The findings in this paper are an outcome of two separate studies. We assessed these questions in a first study by developing case studies for six major commercial activity centers in small New England cities and towns and in a second study by investigating vehicle speeds and safety reports from over 250 Connecticut roads. The case study sites were selected to be either traditional town centers with dense, walkable, mixed-use downtowns with on-street parking or contemporary sites with more conventional single-use zoning and little or no on-street parking. Brattleboro (VT), Northampton (MA), and West Hartford (CT) represent the older more traditional downtowns. The second group of more contemporary sites includes Avon (CT) and Somerset Square in Glastonbury (CT), two newer commercial centers, along with Glastonbury Center (CT), which was a traditional downtown that has been expanded along more conventional lines.

The speed and safety study was based on collecting over 100 free flowing vehicle speeds for each site in addition to safety information and road segment characteristics. We purposefully selected streets both with and without on-street parking as well as those with different speed limits and adjacent land uses so that the 250 sites represented a wide array of road characteristics.

By relying on multiple lines of research, we intend to forge a more complete analysis of on-street parking. We will assess the benefits and shortcomings of on-street parking vis-à-vis the other common methods of supplying parking (off-street surface parking and structured garage parking) as well as looking at the context in which on-street parking can be successfully employed.

LITERATURE REVIEW

On-street parking has a varied and inconsistent history. Once prevalent almost everywhere in the United States, restrictions against on-street parking began as early as 1920 (1). When the rapid rise of the automobile in downtown Los Angeles started to impinge upon the flow of streetcars, the quick and easy solution was to ban on-street parking. A mere 19 days later the ordinance was repealed for a variety of reasons, including claims that the parking restrictions were discriminatory against motorists. Seven years later, Chicago instituted some of the earlier successful on-street parking restrictions (1). The difference in this case was that Chicago continued to allow priced on-street parking in some areas. Los Angeles on the other hand flip-flopped back and forth on the issue for decades. What Chicago seemed to find was that on-street parking not only provided revenue, but it was also convenient and buffered pedestrians from the moving traffic. Although it is difficult to argue with the convenience factor and the idea of a pedestrian buffer, the debate continues as to the real benefits of on-street parking versus other types of parking in terms of issues such as land use, user demand, vehicle speeds, and safety concerns. This literature review examines the evolution of our approach to on-street parking in the United States as well as the existing research regarding its implications.

Even though places like Los Angeles initiated on-street parking bans in the early part of the twentieth century, the concept did not start becoming commonplace until the mid 1960s and early 1970s. By 1971, a comprehensive guide to the principles of parking by the Highway Research Board commenced their description of on-street parking by saying:

> "*Curb parking can seriously impede traffic movement along major routes. It typically contributes to or is directly involved with some 20 percent of urban street accidents. One of the best and most economical methods of increasing capacity and safety is the removal of curb parking*" (*2*).

This line of thinking took hold during this period when vehicle movement was the main focus of authorities charged with maintaining roads. By the time this 1971 book by the Highway Research Board was written, there was already abundant support from a variety of organizations for policies that advanced the ideas it contained. A 1955 policy statement from the U.S. Chamber of Commerce called for giving the first priority of any street to the "movement of people and goods with such restrictions on curb usage as this principle may dictate" (*2*). An influential 1959 report by the National Parking Association highlighted this issue further by suggesting the eventual banning of on-street parking in downtown areas based on this idea that priority in the street realm should first and foremost be for through traffic (*2*). A 1965 study deduced that limiting on-street parking not only increases road capacity, but also that off-street parking in city centers enhances retail activity (3). On this basis, the authors concluded that on-street parking should be reduced wherever possible and that off-street parking will be vital in determining the economic prospects of activity centers.

All these opinions against on-street parking started to force the hands of cities. People seemed to believe that providing off-street parking, even in the form of structured garages, was less costly than supporting the economic losses due to traffic congestion, crashes, and maintaining parking meters. Even cities that are today well-known for their on-street parking listened. A 1970 San Francisco policy eliminated on-street parking in their downtown on weekdays from 7 am to 6 pm on one side of most streets. Although the other side of the street could have been still used for parking, the city set it aside as a truck loading zone (*2*). According

to the Highway Research Board at the time, on-street parking would only be acceptable in situations where the street is not required to function as part of the street network, where the through movement of traffic can be prohibited, and where the need for parking is so great that it trumps vehicular movements (*2*). This list of warrants in essence promoted the idea that first and foremost streets are for the through movement of traffic. This widespread approach to allocating the street realm away from parking toward increased vehicular movement has been a significant factor toward the current state of affairs in many American cities.

Today, there is much more thought toward accommodating multiple types of road users as well as shifting the balance towards non-motorized modes in many urban situations. Carmel, California has gone to the other extreme by banning *off*-street parking in the downtown (*1*). Many cities however have been and are still being influenced by the long standing idea that the focus in street allocation should be on automobile movement. The research history regarding the effects of on-street parking is not extensive, but there have been some studies that describe certain components of the potentially multifaceted outcomes.

Theories about the benefits of on-street parking are as plentiful as the theories against. Aside from the convenience, on-street parking is said to be one of the best ways to provide shared parking (4). It is thought to be in higher demand than alternative off-street spaces and considered more efficient due to higher occupancy rates. For this reason, pricing proponents like Shoup suggest setting the highest fees for the on-street spaces (5). During one of Los Angeles' on-street parking bans, the city started to find a noticeable decline in retail business (6). Without the on-street parking spaces, the convenience factor seemed to diminish and people shopped elsewhere.

On-street parking is also considered to be more efficient in terms of land use since on-street spaces do not require access lanes or driveways (4). Comparing the amount of land required for an off-street surface lot to that needed for an on-street parking space, Litman and Shoup both estimate that these access lanes and driveways more than double the amount of land devoted to parking (1, 4). In addition, landscaping requirements generally account for adding another 10 to 15% of total land area to a parking lot (4). Providing parking solutions on the street is generally less expensive. When compared to off-street surface lots, the financial savings is achieved with land use efficiency (4). Versus parking garages, the expense of the structure needs to be considered carefully compared to the cumulative land costs; in many instances, providing additional on-street parking rather than structured parking allows for a more prudent use of resources (*1*). On-street parking is also widely regarded to significantly impact the pedestrian environment. Four of the most prominent pedestrian level of service methodologies all give better scores to streets with a higher degree of on-street parking (*7*). The buffer between pedestrians and through traffic imparted by on-street parking increases segment level of service scores, but these numbers do not begin to take into account the potentially increased walkability afforded to a denser place that devotes less land to parking.

In terms of the issue of on-street parking and safety, much of the research work was carried out from the 1940s to early 1970s. Almost nothing has been published since the 1980s. It would seem that to most traffic engineers the safety issues relating to on-street parking have already been decisively researched. The general conclusions drawn from these studies are that on-street parking is unsafe, prone to crashes, and subject to increased congestion. In light of the fact that a major focus of traffic engineers at the time was to speed up and discharge traffic quickly, concerned engineers were worried that on-street parking reduced road capacity,

sometimes by as much as 45% (6). Additionally, crash data from 1965 and 1966 revealed that 16% of crashes in American cities directly involved cars parking along the road (2).

Many studies on curbside parking prohibitions have generally suggested a decrease in traffic collisions with the removal of parking. One study found that non-intersection crash rates reduced by an average 37% for six road segments after on-street parking has been eliminated in a before-and-after study of curbside parking prohibition on arterial streets in the city of Hamilton, Ontario (8).

However, there have also been some contrary results. For example, an extensive Copenhagen study on the provision of bicycle lanes found an increase in crashes and injuries as a result of the prohibition of on-street parking to make way for bicycle lanes (9). The study indicated that the prohibition of curbside parking shifted parking onto side streets, which increased turning traffic. The issue of providing, maintaining, or prohibiting curbside parking should be considered not only in terms of total crashes but also in the context of the land use and traffic priority of the roadway section. If the purpose is to calm traffic and reduce the operating speeds of traversing vehicles so that pedestrians and other road users may feel confident to share the road with moving traffic, then allowing for on-street parking may be favorable. To date, few studies have been conducted that examine these issues of context and operating speed on the safety of on-street parking.

TOWN CENTER PARKING STUDY

The groundwork for this investigation of on-street parking was derived from a combination of two separate research efforts. This first study focused on parking in six New England town centers. The second study explored the effect of roadside design features on driver speeds and safety from over 250 roadway segments located in Connecticut.

Town Center Parking Study Methodology

The following three case study sites were chosen because they can be characterized by having traditional mixed land uses supported by a fee-based, organized system of parking featuring on-street parking along most streets:

Traditional Sites

1. Brattleboro, VT
2. Northampton, MA
3. West Hartford, CT

We then selected the following three more contemporary sites supported by free, privately-owned surface parking lots with similar land areas and land uses. Both sets of sites are in towns with similar income levels and demographics:

Contemporary Sites

1. Avon, CT
2. Glastonbury, CT
3. Somerset Square in Glastonbury, CT

Two of the three contemporary sites had no on-street parking and the third possessed on-street parking along less than half of one side of one street. This instance of on-street parking constituted approximately 3.6% of the parking in that single activity center. Overall, on-street parking accounted for 1.1% of the total parking at the contemporary sites and over 11.0% at the traditional sites.

Following site selection, we established a boundary around each town center to designate the area of interest. The boundary lines incorporated each activity center's commercial district and any nearby parking lots meant to serve the downtown. We then gathered data detailing the provision of parking within each town center. Each lot was mapped and categorized by the parking type. Parking lot types were initially broken into two main categories: public and private. The public municipal parking lots consisted of on-street parking spaces and off-street parking spaces, including both surface lots and structured garages. The private parking lots were open to the public and normally outdoor surface lots.

We collected land use data in terms of retail space, office space, and residential units for comparison with each town's parking regulations and with the Institute of Transportation Engineers manual on parking generation. The majority of on-site work consisted of parking lot occupancy counts carried out a minimum of five times at each site. This was done in an effort to collect what could be considered a typical peak usage as well as an average non-peak occupancy. Peak demand counts were principally collected during the busy holiday shopping season. We also counted the total number of pedestrians per site in conjunction with one parking occupancy count at each site in order to gauge the level of on-site activity.

The initial research paper detailed the amount of parking provided by each town in contrast with the amount required by zoning regulations and actual demand. Overall, the traditional sites provided less parking, used less parking, and used what parking they did have more efficiently in terms of occupancy as compared to the more contemporary sites (10). Every site provided less parking than required by the zoning regulations. The traditional sites provided approximately 45% of the parking required in the base regulations while the contemporary sites provided 79%. And even though all the sites provided less parking than required, we found a peak demand of just below 80% of the parking provided at the traditional sites while the contemporary sites were less than half full at peak. In addition to occupancy efficiency, the traditional sites were also less wasteful in terms of land dedicated to parking. For additional background information regarding the town center parking study, including topics such as land use, parking lot location, and pricing, please refer to the earlier paper (10).

Town Center Parking Study Results

Parking Demand

Based on a study of six town centers, the on-street parking spaces represented the most valuable parking spaces to the patrons of those activity centers. Table 1 displays these results.

The on-street parking spaces were consistently in highest demand. This was true even though the on-street parking spaces charged higher fees than the off-street parking and had the shortest maximum time allotments. This combination of higher fees and the shortest maximum time allotment seemed to maintain high turnover in these most convenient spaces without negatively impacting usage. The goal of the parking fees in general, especially for the off-street surface parking lots, seemed to be focused more on parking management and less on maximizing revenue. Nevertheless, parking demand for the on-street parking was consistently higher than the off-street and garage parking lots.

Land Use

One often overlooked fact in assessing parking is its efficiency in terms of both land use and cost. Our data for the six centers shows that on-street parking is by far the most cost efficient way to provide parking. In comparison to parking in a surface lot, on-street parking typically uses less than 176 SF (maximum space size is approximately 8 feet by 22 feet) per space compared to 513 SF for each space in a surface lot. These values confirm the parking space land requirements estimated by Litman and Shoup that were discussed in the literature review. The difference is caused by the need to provide single purpose driveways, access lanes, and often, landscaped islands for off-street surface lots. Although these features are necessities for off-street surface lots, they do result in significant land consumption. Figure 1 shows elements of this land consumption for an off-street surface parking lot compared to the much more efficient land use associated with on-street parking. Taking this difference in land utilization into account highlights the important role that on-street parking plays in ensuring that enough land is available in the center for more productive uses. To illustrate the point, if a town center with approximately 2,000 parking spaces, similar to our town centers, were able to provide 15% of their parking curbside instead of with off-street surface lots, they would save over 2.3 acres of land.

One outcome of being able to minimize unnecessary land used for parking is being able to devote more land to development. In fact, the traditional sites ended up having:

- 58% greater building density,

- 176% greater floor to area ratio, and
- 90% more leasable building space in each of those town centers.

The third approach to providing parking is through the use of parking garages. Parking garages use much less land area than either on-street parking or surface lots. Given that each of our traditional town centers also had one parking garage, this played a role in the increased development numbers. The trade-off in this case was in the high cost of constructing and maintaining the parking garage. For example, in looking at Brattleboro's 305-space parking garage, the cost of each parking space was approximately $29,508 in 2004 dollars (11). However, the true number of cars added by a parking structure should subtract the number of off-street surface lot spaces the same parcel of land could accommodate (1). As a result, the actual cost per parking space added to a town center by a parking garage is even higher.

Added congestion is often considered to be one of the costs associated with on-street parking. In reality, this is not a big price for most cities to pay. Various researchers, primarily studying road diet conversions, have shown that under most traffic conditions, actual road capacity is largely controlled by the capacity of the signalized intersections (12-14). Left-turn lanes and cross street traffic volumes have more to do with the throughput of a road than the number of lanes devoted to moving traffic or the reduction in speeds caused by the parking of vehicles. Additionally, most urban settings embrace the vitality of the pedestrian environment created by slower moving vehicles along the street segments. This vitality means that more people are choosing to walk (i.e. treating the area as a park once center), which works to reduce the amount of vehicle traffic that needs to be accommodated in the town center.

Assessment of the Pedestrian Environment

On-street parking is just one of many mechanisms that helps create a specific atmosphere in an activity center. Other factors that have been discussed in the literature include: street design, pedestrian connections, dense (and hence, compact) development, land use mixture, building orientation with respect to the street, setback requirements, and vehicle speeds; the combination of which, incorporated with on-street parking, can help create the desired town center atmosphere. In fact, the concept of on-street parking can easily be misapplied without taking into account the contribution of these supporting features.

Ideally in a study of this nature, it would be nice to find centers with various combinations of some features and not others, in order to separate out the contribution of each individual feature to the performance of the street and center. Unfortunately in our study design phase, we found this very difficult to achieve, especially given the resources available for carrying out the project. But even with unlimited resources, our experience suggests that it would be a challenge to find centers with certain combinations of these features and not others. In general, on-street parking came as part of a package with these other features including compact development and mixed land use. Therefore, in assessing the pedestrian environment we need to be cognizant of the fact that the differences in the pedestrian environments seen are attributable to a larger number of complementary factors, of which on-street parking is just one.

In assessing the pedestrian environments, the first thing we looked at was how the centers were being used. What we found was that the centers with on-street parking and other compatible features, including compact development, pedestrian connections, and street-oriented buildings, were much more vibrant in terms of pedestrian activities. Our data showed that the traditional sites with on-street and other supporting conditions had more than six times the

number of pedestrians walking around the site at similar times on similar days. The contemporary sites averaged fewer than 50 pedestrians while the traditional sites averaged well over 300 pedestrians. These counts represent a snapshot of the number of pedestrians per site.

A part (but not all) of the explanation for this discrepancy is the difference in modes used for accessing the sites. We questioned site users about the mode by which they traveled to the town centers and compared this information with mode choice worker data from the 2000 Census Transportation Planning Package (CTPP) for each location (15). The user survey data at the contemporary sites matched up remarkably well with the census data for a moderately sized survey. Table 2 highlights this information. Although the automobile was the prevailing mode choice for all the sites, almost 25% of those traveling to the traditional sites did not use a car compared to just 9% at the contemporary sites.

Public transportation was used almost five times more at the traditional sites; this difference was noteworthy because all the sites had similar levels of bus transit available. Non-motorized walking and bicycling trips comprised the remaining mode choices. Bike use reached 2.5% at the traditional sites compared to almost none at the contemporary sites. Other than driving, walking was the next most popular mode. The user survey found that almost 15% of trips to the traditional sites were walking trips while people at the sites without on-street parking walked less than half that rate at 7.4%.

Most trips to the sites were for shopping purposes, based upon our user surveys. For this reason, we compared the mode choice results to the U.S. average for shopping trips found in the 2001 National Household Travel Survey (NHTS) (16). This comparison showed not only how closely the user survey for the contemporary sites mirrored the national averages, but also how extraordinary the traditional sites turned out to be. Overall, the users of the traditional sites walked more than twice the national average, used public transit more than four times the national average, and biked more than eight times the national average. Furthermore, the survey found that users of the traditional sites tended to always park once and walk to multiple errands, as opposed to those at the contemporary sites who only did so sporadically. Again, these trends are not directly attributable to on-street parking; however, the presence and use of on-street parking seemed to help contribute to differences in how the places functioned and how these places were used.

The considerable difference in terms of pedestrian activities in the centers is one way of assessing the comparative pedestrian environments. However, we also used established measures of pedestrian levels of service to quantify this difference. Based upon the pedestrian level of service model developed by Landis and the Florida Department of Transportation, the level of service for the major streets in all three sites with on-street parking and other compatible factors was LOS B. Alternatively, the major streets in the three sites without on-street parking were LOS C, C and D, respectively. This quantitative measure of the pedestrian environment correlated well with the level of pedestrian activity observed. However, this LOS measure does not seem to fully capture the qualitative difference in the pedestrian environment across the six centers.

SPEED AND SAFETY STUDY

The second portion of this paper investigated the impact of on-street parking on vehicle speed and traffic safety based upon over 250 roadway segments located in Connecticut.

Speed and Safety Study Methodology

This study focused on identifying elements of the roadway and the driving environment that significantly influenced drivers' choice of speed. The predictor parameters of interest in this study were roadway type, land use type, posted speed limit, lane width, roadway width and shoulder width where present, on-street parking, planting strips, road edge delineation, side curbs, and medians. Other variables of interest in the study included the presence of sidewalks. For each site, a minimum of 100 free flowing vehicles speeds were measured to represent the speed profile of the site. The estimated mean free flow speed was measured as the dependent variable. The study suggested a strong correlation between free flow speed and on-street parking.

On-street parking was measured at three levels of occupancy of the roadside with parking: 50 - 100%, 30 - 50% and less than 30%. We determined that the 50 - 100% and the 30 - 50% levels did not show any statistical difference in the mean free flow speeds and were therefore merged into a single level recorded as significant on-street parking. The third level of less than 30% on-street parking was found not to be significant in affecting the free flow speeds of the sites. The segment lengths of the roadways were determined by the consistency of the variables we were interested in for the study. Segments began and ended with the presence and/or termination of any or all of the variables mentioned. One of the observations noted during field data collection was that on-street parking was typically present or permitted at sites with a reasonably high level of pedestrian activity. For more background information regarding the speed study, please refer to the original paper (17).

Free flow speed was used to ensure that the presence of other vehicles did not influence the drivers' choice of speed. The assumption we made was that a driver's chosen speed is influenced only by the road and roadside conditions. For streets with significant on-street parking, the parking environment is the most prominent feature in the drivers' perception. In extracting the severity levels from the crash records, the severest injury for each crash was assigned as the severity level of that crash. Due to the naturally rare occurrence of crashes, we aggregated the crashes for each road segment over a six-year period (1998-2003) so as to attain a reasonable count for statistical analysis.

Speed and Safety Study Results

Operating Speed and On-Street Parking

Our study was conducted to determine the factors affecting the speed selected by drivers given the design of the road cross-section and the roadway environment. Preliminary analysis of the data showed that it was useful to characterize the roadway into two types based upon a package of cross-section design features. The two roadways types were designated 'streets' and 'highways'. The street type was typical of roadways found in an urban environment while highway types were more characteristic of rural areas. With our definition, the primary distinction between streets and highways was that streets have no edge striping delineating shoulders while highways had shoulders. In addition, streets typically had raised, continuous,

and non-mountable curbs while highways mostly had mountable and intermittent curbs for drainage purposes. Streets also often had on-street parking while highways often did not. These patterns however were not consistent for Connecticut since highway type facilities were often found in an urban context where on-street parking might be appropriate.

Our study using analysis of variance (ANOVA) indicated that the design of the roadway and the road environment characteristics affected mean free flow speed on roadway segments (17). Overall, the model explained about 80% of the variability in the mean free speeds chosen by drivers. One of the most important predictors of speed was road type – in other words, whether the road was a street or a highway. Parameter estimates indicated that streets compared to highways resulted in speed reductions of about 1.5 mph. However, other factors were also significant in affecting the chosen speed. These factors included land use type, posted speed limit, building setback, the presence of a vegetated strip, and the presence of on-street parking. Table 3 displays these results.

For building setbacks, small setbacks registered a reduction in mean free flow speed of 1.48 and 1.50 mph as compared to speeds on roadway segments with large setbacks. Similarly, the free flow speed on streets with on-street parking found a reduction in speed of about 2.3 mph as compared to streets without on-street parking. The study showed that the largest decrease in speed occurred on those roadways with a combination of factors complementary to a 'street' type facility with smaller building setbacks and on-street parking. It was interesting to note that the three traditional centers in the town center parking study all exhibited these basic characteristics.

Road Safety and On-Street Parking

In our study of speed and road design, we also collected data on the traffic safety of the road segments. In order to examine the relative safety of roads with on-street parking, we focused just on the roads that we defined as 'streets' and not those that we defined as 'highways'. The reason for this was that a third of the streets had a significant level of parking compared to only about 3% of the sites classified as highways. As such, we did not possess a large enough sample of highways with parking to conduct a statistically rigorous analysis.

Previous studies of safety and on-street parking did not distinguish between high speed and low speed environments and did not separate crashes by severity. In our study, we did both. We separated the streets into low-speed and high-speed facilities, analyzing them separately. We used 35 mph as this delineation point since we found a very different outcome for facilities with speeds less than 35 mph versus those with speeds greater than 35 mph. For example, we found that all the recorded vehicular fatalities occurred on facilities with speeds greater than 35 mph.

Table 4 summarizes the results of the road safety analysis. The results are given in terms of crash rate per mile per site for i) low speed streets with parking, ii) high speed streets with parking, iii) low speed streets with no parking, and iv) high speed streets with no parking, respectively. The numbers represent crash data aggregated for a six-year study period. We found that low speed streets with parking had by far the lowest rate per mile of fatal and severe crashes but not the lowest rate for all types of crashes. In other words, over 96% of crashes that occurred on low speed streets with parking resulted in either a minor injury or property damage only crash while only 4% of the crashes on these low speed streets resulted in severe injuries. On low speed streets without parking, 10% of the crashes resulted in fatality or severe injuries. It is equally important to note that high speed streets with parking generally had higher crash rates at all severity levels than all other street categories (it should however be pointed out that only five street segments in our study fell into this category). However, this large discrepancy in

safety outcomes between low speed and high speed streets with parking might be one of the reasons why our results differ from previous research where no distinction was made on the basis of roadway speed.

These results point to the importance of considering context in assessing the potential for on-street parking because a low speed environment for on-street parking appears to be critical in ensuring safe use. Current thinking in street design supports this distinction. For example, the new ITE/CNU manual also recommends speeds of less than 35 mph for streets with on-street parking (18). In Europe, speeds on urban streets are often kept at less than 20 mph (19). Our results suggest than under these low speed conditions, on-street parking helps improve safety, and in particular, these roads with on-street parking show a significantly reduced crash rate for the most severe types of crashes.

Our results show that streets can be actively designed to limit speed. The provision of on-street parking is one factor that helps to reduce speeds, but on-street parking by itself is not enough. In fact, on-street parking without the other supportive conditions may be counter-productive and result in extremely unsafe conditions. This suggests that for the best results in terms of creating safe low-speed conditions, on-street parking should be part of a package that includes a 'street' type design (i.e. no shoulders, raised curbs, small building setbacks, sidewalks, and vegetated buffer strips).

CONCLUSION

Our investigation points to on-street parking as playing a crucial role in benefiting activity centers on numerous levels. Users of the downtowns consistently selected on-street parking spaces over and above less expensive off-street surface lots and garage parking. These shared on-street spaces served a wide variety of uses while experiencing the most use and the most turnover. On-street parking also resulted in a more efficient use of land. Using the curbside for parking saves considerable amounts of land from life as an off-street surface parking lot; with land being a limited resource, this issue is particularly important in areas where density and high activity are desired. Therefore, the benefit of being able to conserve over two acres of land in small to medium town centers by providing parking on the street rather than with an off-street surface lot is immense. This efficiency in land use can allow for a much higher density commercial development than is possible if the center is to rely solely on off-street surface lots to meet all its parking needs.

Based on the observed variation in activity patterns in the centers we studied, on-street parking offers pedestrians a safer and more comfortable environment. The strip of parked vehicles along the curbside serves as a buffer to pedestrian activities immediately beyond the curbside. Our study results showed that centers with on-street parking and other compatible characteristics, such as mixed land use and higher density, recorded more than six times the number of pedestrians walking around compared to the more contemporary sites, which in general lacked these traits. All other things being equal, higher density developments with fewer large, half-empty off-street surface lots to traverse are intrinsically more walkable. These types of advantages are factors in creating vibrant places where more people walk and bike both to, and within, the town centers.

Our results suggest that on-street parking can also help to create a safer environment. While this statement seems to contradict some existing research, the reality is that lower speed roads (less than 35 mph) with on-street parking have far less severe and fatal crashes. In fact, lower speed streets without parking had a severe and fatal crash rate more than two times higher than the streets with parking. We also showed conclusively that drivers tended to travel slower in the presence of features such as on-street parking and small building setbacks. Slower vehicle speeds provide pedestrians, cyclists, and drivers more time to react, and when a crash does occur, the chance of it being life-threatening is greatly reduced.

Considering the current trend towards harmonizing the conflicting demands of transportation facilities, the results of this study could inform our efforts in creating pedestrian friendly streetscapes that support vibrant centers. On-street parking is not purely a device to be used in the right environment; rather, it is also a tool to help create that right environment. On-street parking should be used more commonly but especially in situations where the street is part of the destination and where the intent is to get drivers to slow down and recognize that they have reached a place. Our results showed that these places with on-street parking tended to be safer, more walkable, require less parking, and have much more vitality.

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LIST OF TABLES AND FIGURES

TABLE 1 Parking Occupancy

	Peak Occupancy	Avg. Non-Peak Occupancy
On-Street Parking	94.5%	81.6%
Off-Street Surface Parking	59.2%	48.8%
Structured Garage Parking	75.5%	49.4%

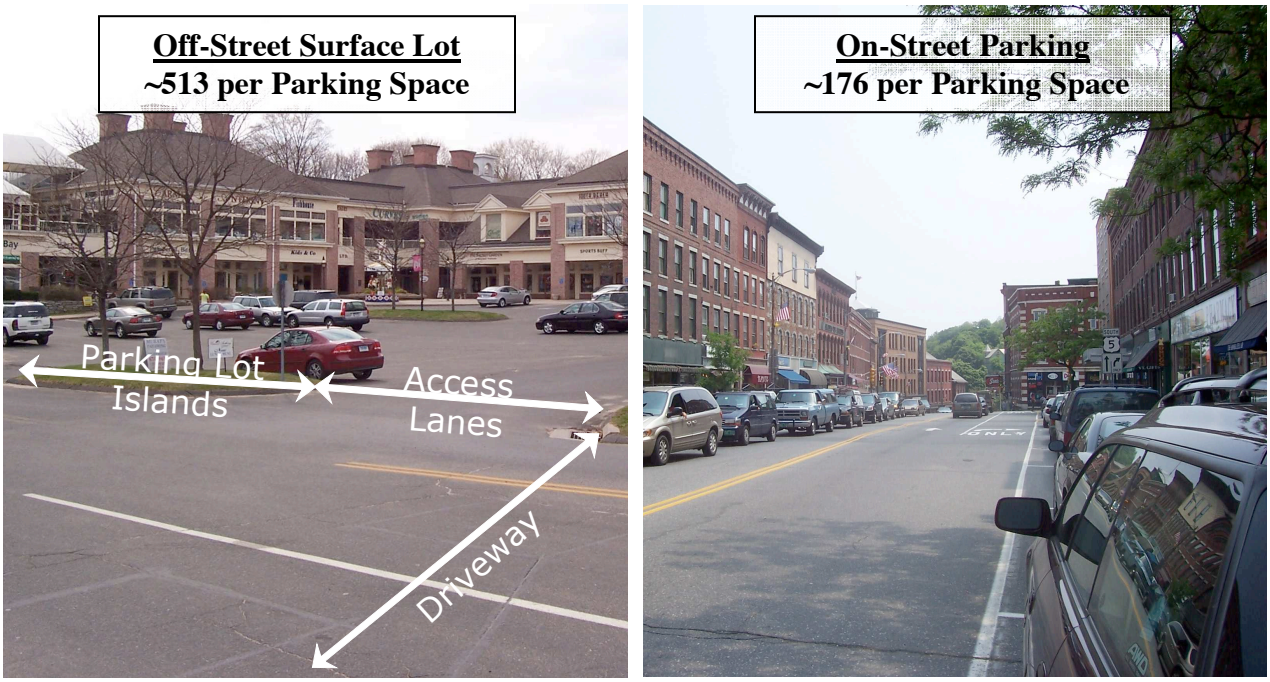

FIGURE 1 Land use of off-street vs. on-street parking

TABLE 2 Mode Choice

	User Survey		2000 Census by Town for Work Trips		U.S. Average (2001 NHTS)
MODE	Contemporary Sites	Traditional Sites	Contemporary Sites	Traditional Sites	Shopping Trips
% Driving	91.0%	75.2%	92.1%	83.4%	91.5%
% Public Transit	1.4%	6.9%	1.1%	2.3%	1.4%
% Bicycling	0.2%	2.5%	0.4%	1.6%	0.3%
% Walking	7.4%	14.8%	0.7%	8.3%	6.5%

TABLE 3 Vehicle Speed Full ANOVA Table

Source	Type III SS	Degrees of Freedom	Mean Square	F	Significance
Corrected Model	5483.890 (a)	14	391.706	66.027	0.000
Intercept	51858.064	1	51858.064	8741.336	0.000
Posted Speed Limit	860.154	4	215.039	36.247	0.000
Roadway Type	55.683	1	55.683	9.386	0.002
Land Use	351.174	5	70.235	11.839	0.000
Presence of On-Street Parking	42.292	2	21.146	3.564	0.030
Building Setback	87.053	2	43.527	7.337	0.001
Error	1477.195	249	5.933		
Total	426492.639	264			
Corrected Total	6961.085	263			

$R^2 = 0.796$ (Adjusted $R^2 = 0.781$)

TABLE 4 Crash Rates for Street Types

	Actual Speed	No. of Sites	Total Miles	Crash Rate / Mile / Site (1998 - 2003) Fatal	Severe	Minor	PDO	All
Parking	Low Speed (<35 mph)	13	3.06	0 (0%)	11.1 (3.8%)	47.7 (16.5%)	231.1 (79.7%)	289.9 (100%)
	High Speed (35-40 mph)	5	1.45	0.7 (0.2%)	29.0 (8.5%)	89.7 (26.2%)	222.8 (65.1%)	342.1 (100%)
No Parking	Low Speed (<35 mph)	13	2.36	0 (0%)	28.0 (10.4%)	48.3 (18.0%)	192.0 (71.6%)	268.2 (100%)
	High Speed (35-40 mph)	24	5.12	0.2 (0.1%)	17.2 (9.7%)	44.7 (25.3%)	114.8 (64.9%)	177.0 (100%)