Repurposing the Paving: The case of surplus residential parking in Davis, CA

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ABSTRACT

The city of Davis, CA, has a rich history of high bicycling levels, and the city has ambitious transportation policies and goals. However, both the city of Davis and transportation scholars have overlooked the potential opportunities a surplus of on-street residential parking provides to cities. The existing literature on the influence of parking policy and provision has focused primarily on commercial districts and on large metropolises, neglecting parking in more purely residential areas. In this descriptive case study, we systematically observed the number of cars on a transect of residential streets in the early morning and late evening on weekdays to conservatively estimate the average peak parking demand by residents as a percentage of available parking spaces. On average, only 2 in 7 available parking spaces were occupied during peak hours. We note that the over-provision of on-street parking in residential neighborhoods could be a nexus for the city to achieve its sustainable transportation policy goals while addressing its fiscal and housing supply challenges. We discuss possible design solutions, including providing ecosystem services, implementing traffic calming measures, and creating accessory dwelling units.
INTRODUCTION
The small city of Davis, California (pop. 66,000) has a well-earned reputation as the bicycle capital of the United States (Buehler & Handy, 2008). Part of its success stems from extensive implementation of bicycle infrastructure: the city has over 50 miles of bicycle lanes and 50 miles of bicycle paths in its 10 square miles. But the city sees room for further improvement, with expansive policy goals and plans to further promote sustainable transportation, including the state-mandated Complete Streets element of its General Plan transportation element (City of Davis, 2010; Cox, 2010). We find in this paper that Davis’ residential parking situation is particularly ripe for reform.

Despite its important influences on land use patterns and mode use, parking has flown under the radar in Davis and other cities throughout the US. Residential parking in small towns in particular has been overlooked by both local planners and parking scholars (Guo & Schloeter, 2013), who have traditionally focused on residential and commercial parking in higher-density urban areas (R. Cervero, Adkins, & Sullivan, 2010; D. C. Shoup, 2016). The parking requirements that engender the oversupply of residential parking are notoriously based on thin to non-existent evidence (D. C. Shoup, 1997, 1999), suggesting that evidence-based analysis could encourage a hard reset of municipal parking policies.

In this descriptive case study, we systematically count the number of cars parked on residential streets in Davis at peak parking hours, offering refinements to existing methodologies as well as contributing to the underdeveloped literature on residential on-street parking utilization. After reviewing the parking literature, we provide background on the city, its policies and the state policies for complete streets. We then present the results of our on-street parking survey, demonstrating substantial underutilization of this resource even at peak parking demand by residents. We conclude with a discussion of how underutilized residential streets could be repurposed to simultaneously achieve transportation policy goals and address several related urban challenges that Davis and other cities in California and the US are currently facing.

BACKGROUND

Literature Review
A sizeable portion of the literature on parking policy and practices has been authored by Donald Shoup, whose work has led to a focus on parking for residential and commercial uses in urban settings in the US (Marshall, Garrick, & Hansen, 2008; D. C. Shoup, 2016; Smith, 2013; Weinberger & Karlin-Resnick, 2015) and internationally (Fan & Lam, 1997; Lau, Poon, Tong, & Wong, 2005). Parking scholars have argued that minimum parking requirements exacerbate some of the most important contemporary civic challenges, including high rates of car ownership (Guo, 2013) and use, the negative environmental and health externalities associated with car use, and even high housing costs and housing shortages (D. Shoup, 2014; D. C. Shoup, 2016). To more rationally manage parking supply, Shoup has called for cities to institute demand-responsive priced parking (D. C. Shoup, 1999), which has been answered by a handful of cities, such as San Francisco with its SFpark system (Alemi, 2015).

The inextricable link between residential on-street parking and street design (Guo, Rivasplata, Lee, Keyon, & Schloeter, 2012; Guo & Schloeter, 2013) also impacts – often negatively – how people use and move on the street itself. For example, as with the experiences of the Dutch in the 1960s, Berkeley, CA citizens in the 1970s, or Australians in the 1980s, Daisa and Peers demonstrated a strong correlation between increasing street width and faster average
car speeds in their 1997 study of San Francisco Bay Area streets (Daisa & Peers, 1997). Many local governments have responded to these street life ills with “traffic calming,” using “physical measures that reduce the negative effects of motor vehicle use, alter driver behavior, and improve conditions for non-motorized street users” (Ewing, 1999).

Still, despite its outsized impact, parking policies have not attracted much attention from concerned citizens and have proven durable despite the substantial evidence against them. In a survey of local officials from nearly 100 US cities about minimum street width standards, Guo et al. found that in almost all cases parking and minimum street width requirements were completely opaque to local citizens (Guo et al., 2012). Furthermore, they found that these requirements were not based on a consistent application of safety concerns or demand needs, instead reflecting an implicit assumption of the necessity of providing residential on-street parking space.

Much of the previously-mentioned parking literature, however, draws on data from high-density urban areas. Little ink has been spilled regarding the state of on-street parking in lower-density and more purely residential settings (Guo & Schloeter, 2013; Schlossberg & Amos, 2015; Willson & Roberts, 2011). As Guo and Schloeter (2013) put it: “When we investigate [the assumed demand for on-street residential parking], the first thing we notice is the scarcity of information. Most work concerns metered parking in urban centers, and few, if any studies examined parking demand on residential streets. The short description in the [first three editions of the] ITE [parking] standards (1967, 1984, 1997), fewer than four hundred words, represents the best knowledge of the engineering profession on residential parking demand for more than three decades.”

Indeed, the most recent edition of the ITE Parking Generation manual does not even estimate on-street residential parking demand or occupancy. It merely calculates an average of 1.83 vehicles owned per dwelling unit in single-family detached neighborhoods, based on a small sample size (6 sites) (Institute of Transportation Engineers, 2010).

Some scholars have investigated multi-family housing, both in typical suburban settings (Willson, O’Connor, & Hajjiri, 2012; Willson & Roberts, 2011) and in transit-oriented developments (R. Cervero et al., 2010; Rowe, Bae, & Shen, 2012), consistently finding that parking is over-supplied relative to demand.

In the single-family housing residential setting that we address in this study, there appears to be just two exceptions to this shortage of peer-reviewed evidence. Schlossberg and Amos analyzed on-street residential parking in Eugene, OR, and found that it is an oversupplied resource, with an average vacancy rate of 89 percent (Schlossberg & Amos, 2015). Roth, in his master’s thesis, calculated overnight on-street parking occupancy rates in 16 (primarily single-family) residential permit zones in Bellevue, WA, finding an average vacancy rate of 86 percent (Roth, 2016). Both studies only utilized one-time parking counts.

This paper adopts a modified version of Schlossberg and Amos’s methodology and applies it to the California town of Davis. We sought to improve upon both their and Roth’s approaches by collecting repeated measures of parking occupancy data for the same street segments, which allowed us to more accurately assess the average parking utilization as well as its variation. Beyond methodological refinements, this study also contributes additional evidence of on-street parking demand in single-family housing residential neighborhoods.
Parking and street design policies and characteristics in Davis

Requirements for wide residential streets with ample on-street parking are embedded in the City of Davis’ plans, ordinances and street design standards, just as they are in most cities across the country (Guo et al., 2012). The General Plan Transportation Element, for example, lists the “typical” local street width as 34 feet, increasing to 40 feet for “modified” local streets, and states that “[v]ehicular parking is permitted on most streets in Davis” (City of Davis Transportation Advisory Group, 2013, p. 5, 24). Similarly, the Public Works Department’s standard street plans for collector streets – those that connect the local roads to the City’s arterials – provide for parking on both sides of the street (City of Davis, 1991). And the City’s Zoning Code requires minimum dimensions of 9 feet by 18 feet for standard parallel parking spaces (City of Davis, 2017, section 40.25.070). Overall, the average Davis local road is 34-feet wide (Nichols Consulting Engineers, 2016).

These street design policies are in addition to off-street parking requirements for Davis dwellings. Depending on their size, single family houses are required to provide one uncovered and one covered space, and apartment complexes are required to provide one or more spaces per unit (City of Davis, 2017, section 40.25.090(f-h)).

METHODOLOGY

To study the utilization of on-street parking on residential streets, we selected a two-mile transect of low-volume local streets in Davis. This transect was chosen to include a gradient of construction dates, beginning with the oldest neighborhood built in the early 1900s near downtown Davis and the most recent built in the 1980s at Davis’ northern-most city boundary. The transect begins in the Old North Davis neighborhood at 7th St, continues through the numbered streets to 12th St, then resumes in North Davis at Baja Ave and extends to Sandpiper Drive (FIGURE 1). We selected only East-West oriented streets and restricted their length to between B and F Streets or the extension of that corridor. None of these streets currently serve transit routes. The only street with parking restrictions within this transect was the southern half of 7th St, which required parking permits from 8 AM to 5 PM on weekdays. Given our interest in peak parking occupancy, though, this workday parking restriction is unlikely to have impacted the observed parking use on this half of 7th St.

We measured maximum on-street parking utilization by running audits in May and June 2016 on weekdays, between 5:30 and 6:30 AM and from 8:30 to 9 PM, close to the times used in other studies and reports to evaluate peak parking demand in residential areas within minimal to no non-residential uses nearby (Robert Cervero, Adkins, & Sullivan, 2010; Institute of Transportation Engineers, 2010; Roth, 2016; Willson et al., 2012; Willson & Roberts, 2011). While it is possible that the size and timing of weekend demand differs from that we observe on weekdays, based on our anecdotal observations, the likelihood of a large discrepancy is unlikely (though this could be evaluated in future studies). These hours were selected to ensure that most residents would be home and that parking utilization by residents would therefore be at its peak. The choice of these hours of observation were corroborated by additional time-of-day parking analyses of residential neighborhoods within the study transect, which found that parking occupancy peaks at approximately 8 or 9 PM and does not begin declining until 6 or 7 AM. Given the sizeable portion of Davis’ population who are UC Davis students, we only collected counts during the school year to get a true peak measurement. We systematically varied our observations for the same streets to occur on different days of the week and in different directions to avoid order effects, which would occur if people were leaving or returning home as we made observations. We ignored motorcycles due to their small size and omitted dumpsters
due to their temporary nature, while we included RVs due to their size and more permanent status.

Off-street parking can play an important role in absorbing parking demand. Because of the City of Davis zoning code’s parking requirements, Davis houses are built with at least one covered and one uncovered parking space. The only exceptions to this rule within our transect are instances in which homeowners have converted their driveway and/or garage to other purposes, or in Old North Davis where the parking space requirement “may be reduced by one parking space” to provide additional landscaping (City of Davis, 2017, section 40.04A.070(b)). Within our transect, only 4 driveways and 26 garages were converted to other purposes, out of 392 parcels. Apartment complexes in Davis also provide parking free of charge (confirmed by phone calls to property managers), again due to local ordinance. Given the widespread availability of off-street parking, we focused instead on on-street parking and therefore did not count vehicles parked in driveways.

Because on-street parking spaces are not explicitly delineated, we approximated the available number of on-street parking spaces \( n_{\text{available}} \). We multiplied the street length \( l_{\text{street}} \) by two to account for available parking on both sides of the street. We then subtracted driveway space: the number of driveways on the street \( n_{\text{driveways}} \) multiplied by 18 feet, the minimum permitted residential on-street parking space length in Davis (City of Davis, 2017), and by a correction term of 1.25 to account for streetscape discrepancies that reduce the amount of useable curb space for parking, such as adjacent driveways that would cause a car parked on the street to overlap one or both driveways. We further subtracted the number of intersecting streets \( n_{\text{intersections}} \), multiplied by two to account for the available space reduced by intersections on both sides of the street and by 40 feet to account for the width of a large intersecting street. Finally, we divided the resulting number of linear feet available to on-street parking by 18 feet, yielding a quotient of the total number of available on-street parking spaces.

We note that several conservative measures were used in this equation to avoid over-estimating the total number of on-street spaces and thereby over-inflate later calculations of the percent of available spots left vacant at peak hours.

\[
 n_{\text{available}} = \frac{(2 \times l_{\text{street}}) - [(18 \text{ feet} \times n_{\text{driveways}} \times 1.25) + (2 \times 40 \text{ feet} \times n_{\text{intersections}})]}{18 \text{ feet}}
\]

To assess the external validity of our results, we gathered information on the regulatory, physical, and sociodemographic characteristics of the streets. To account for regulatory characteristics, we determined the zoning designation for each street. We included the earliest year homes were built on the street, the number of total residential parcels and apartment complexes, and the Walk, Bike, and Transit Scores (Walk Score, 2016) to report the physical characteristics of our sample streets. Finally, we relied on the American Community Survey’s 2014 5-year estimates to evaluate the sample and cross-population generalizability of our sample by examining the average household size, commute car use, vehicle ownership, annual household income, and monthly owner costs for our streets’ block group neighborhoods, the city of Davis, and 20 similarly-sized comparison cities that were either a college town or in close proximity to Davis (U.S. Census Bureau, 2016).
RESULTS

We find a wide variety in on-street parking utilization in our sample streets (TABLE 1). Within the Old North Davis neighborhood, which encompasses 7th through 12th streets, occupancy rates ranged from a low of one in seven to a high of just over half. Streets in the Covell Park neighborhood, which includes Baja Avenue through Lindo Place, were similarly varied, though with a lower maximum occupancy rate. In contrast, the four streets in the Northstar neighborhood (Tern Place through Merganser Place) had consistently low occupancy rates ranging between 12 and 28 percent. On average, only 29 percent, or two in seven, of available on-street parking spots were occupied during peak parking hours in our sample.

The rate of on-street parking occupancy does not appear to systematically vary by zoning designation or by most of the street characteristics in our sample (TABLE 2). The three streets with the highest occupancy rates include all four of the zones featured in this study, suggesting that zoning regulations are not directly influencing patterns of on-street car parking. However, on-street parking occupancy does appear to associate with an important zoning-related outcome – dwelling type. The highest occupancy rate (55%) corresponds to the block with by far the most apartment buildings (10) (TABLE 2). Using paired-sample Pearson’s tests for correlations, we found that the number of apartment complexes had a moderate correlation exceeding 89% confidence (positive correlation) (McElreath, 2015). This was the only street characteristic to exhibit such confident correlations; some of the other characteristics showed moderate associations but had wide confidence intervals. For example, the newer, less accessible developments, built farther from most city destinations, have the lowest rates of parking occupancy. We were surprised to find that the number of residential parcels, even after considering residential parcel density by accounting for street length, surprisingly have little discernable correlation with parking occupancy.

Most of the sociodemographic characteristics of the sample neighborhoods do not display strong associations with parking occupancy rates (TABLE 3). According to paired-sample Pearson’s tests for correlation, we found that only one characteristic had correlations with parking occupancy that exceeded 89% confidence: drive alone rate (negative correlation). Otherwise, both high and low occupancy rates are found in neighborhoods that are disparate in terms of vehicle ownership, number and density of residential parcels, annual household income, Walk Score, Transit Score, and Bike Score. With each of the associations we examined, though, we caution against making strong inferences due to our small sample size and the application of Census-derived neighborhood characteristics to individual streets.
FIGURE 1  Photos of Davis residential streets representative of our sample.
<table>
<thead>
<tr>
<th>Street</th>
<th>Available Parking Spots</th>
<th>Fri AM&lt;sup&gt;2&lt;/sup&gt;</th>
<th>Fri PM S-N&lt;sup&gt;3&lt;/sup&gt;</th>
<th>Mon AM S-N</th>
<th>Mon PM S-N</th>
<th>Thur AM N-S</th>
<th>Thur PM N-S</th>
<th>Tue AM N-S</th>
<th>Tue PM N-S</th>
<th>Wed AM N-S</th>
<th>Average Occupied / Vacant Spaces (rounded)</th>
<th>Average Percent Occupancy / Vacancy (rounded)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7&lt;sup&gt;th&lt;/sup&gt; St.</td>
<td>92</td>
<td>28</td>
<td>30</td>
<td>-</td>
<td>-</td>
<td>34</td>
<td>-</td>
<td>-</td>
<td>34</td>
<td>32 / 60</td>
<td>35% / 65%</td>
<td></td>
</tr>
<tr>
<td>9&lt;sup&gt;th&lt;/sup&gt; St.</td>
<td>93</td>
<td>52</td>
<td>45</td>
<td>-</td>
<td>-</td>
<td>51</td>
<td>-</td>
<td>-</td>
<td>56</td>
<td>51 / 42</td>
<td>55% / 45%</td>
<td></td>
</tr>
<tr>
<td>10&lt;sup&gt;th&lt;/sup&gt; St.</td>
<td>92</td>
<td>29</td>
<td>29</td>
<td>-</td>
<td>-</td>
<td>30</td>
<td>-</td>
<td>-</td>
<td>26</td>
<td>29 / 63</td>
<td>32% / 68%</td>
<td></td>
</tr>
<tr>
<td>11&lt;sup&gt;th&lt;/sup&gt; St.</td>
<td>98</td>
<td>23</td>
<td>20</td>
<td>-</td>
<td>-</td>
<td>19</td>
<td>-</td>
<td>-</td>
<td>20</td>
<td>21 / 77</td>
<td>21% / 79%</td>
<td></td>
</tr>
<tr>
<td>12&lt;sup&gt;th&lt;/sup&gt; St.</td>
<td>93</td>
<td>14</td>
<td>15</td>
<td>-</td>
<td>-</td>
<td>13</td>
<td>-</td>
<td>-</td>
<td>11</td>
<td>13 / 80</td>
<td>14% / 86%</td>
<td></td>
</tr>
<tr>
<td>Baja Ave.</td>
<td>28</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>12</td>
<td>14</td>
<td>-</td>
<td>-</td>
<td>13 / 15</td>
<td>46% / 54%</td>
<td></td>
</tr>
<tr>
<td>Cortez Ave.</td>
<td>37</td>
<td>-</td>
<td>-</td>
<td>12</td>
<td>12</td>
<td>-</td>
<td>13</td>
<td>13</td>
<td>-</td>
<td>13 / 24</td>
<td>35% / 65%</td>
<td></td>
</tr>
<tr>
<td>Diablo Ave.</td>
<td>36</td>
<td>-</td>
<td>-</td>
<td>10</td>
<td>7</td>
<td>-</td>
<td>9</td>
<td>10</td>
<td>-</td>
<td>9 / 27</td>
<td>25% / 75%</td>
<td></td>
</tr>
<tr>
<td>El Cajon Ave.</td>
<td>40</td>
<td>-</td>
<td>-</td>
<td>6</td>
<td>6</td>
<td>-</td>
<td>7</td>
<td>6</td>
<td>-</td>
<td>6 / 34</td>
<td>15% / 85%</td>
<td></td>
</tr>
<tr>
<td>Faro Ave.</td>
<td>43</td>
<td>-</td>
<td>-</td>
<td>6</td>
<td>8</td>
<td>-</td>
<td>11</td>
<td>11</td>
<td>-</td>
<td>9 / 34</td>
<td>21% / 79%</td>
<td></td>
</tr>
<tr>
<td>Luz Pl.</td>
<td>40</td>
<td>-</td>
<td>-</td>
<td>17</td>
<td>17</td>
<td>-</td>
<td>16</td>
<td>20</td>
<td>-</td>
<td>18 / 22</td>
<td>45% / 55%</td>
<td></td>
</tr>
<tr>
<td>Inca Pl.</td>
<td>27</td>
<td>-</td>
<td>-</td>
<td>15</td>
<td>7</td>
<td>-</td>
<td>9</td>
<td>8</td>
<td>-</td>
<td>10 / 17</td>
<td>37% / 63%</td>
<td></td>
</tr>
<tr>
<td>Leon Pl.</td>
<td>13</td>
<td>-</td>
<td>-</td>
<td>3</td>
<td>6</td>
<td>-</td>
<td>4</td>
<td>4</td>
<td>-</td>
<td>4 / 9</td>
<td>31% / 69%</td>
<td></td>
</tr>
<tr>
<td>Lindo Pl.</td>
<td>21</td>
<td>-</td>
<td>-</td>
<td>9</td>
<td>5</td>
<td>-</td>
<td>8</td>
<td>6</td>
<td>-</td>
<td>7 / 14</td>
<td>33% / 67%</td>
<td></td>
</tr>
<tr>
<td>Tern Pl.</td>
<td>29</td>
<td>-</td>
<td>-</td>
<td>7</td>
<td>8</td>
<td>-</td>
<td>9</td>
<td>8</td>
<td>-</td>
<td>8 / 21</td>
<td>28% / 72%</td>
<td></td>
</tr>
<tr>
<td>Pintail Pl.</td>
<td>26</td>
<td>-</td>
<td>-</td>
<td>3</td>
<td>4</td>
<td>-</td>
<td>3</td>
<td>3</td>
<td>-</td>
<td>3 / 23</td>
<td>12% / 88%</td>
<td></td>
</tr>
<tr>
<td>Sandpiper Dr.</td>
<td>63</td>
<td>-</td>
<td>-</td>
<td>5</td>
<td>12</td>
<td>-</td>
<td>8</td>
<td>9</td>
<td>-</td>
<td>9 / 54</td>
<td>14% / 86%</td>
<td></td>
</tr>
<tr>
<td>Merganser Pl.</td>
<td>18</td>
<td>-</td>
<td>-</td>
<td>3</td>
<td>2</td>
<td>-</td>
<td>3</td>
<td>3</td>
<td>-</td>
<td>3 / 15</td>
<td>17% / 83%</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>889</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>258 / 631</td>
<td>29% / 71%</td>
<td></td>
</tr>
</tbody>
</table>

1 Available parking spots are calculated based on street length and the position and number of driveways and the number of intersections.
2 “AM” refers to counts collected between 5:30 and 6:30 AM, and “PM” refers to counts collected between 8:30 and 9 PM.
3 “S-N” refers to counts collected starting with the southern-most street and proceeding north, and “N-S” refers to counts collected starting with the northern-most street and proceeding south.
### Table 2: Street Characteristics

<table>
<thead>
<tr>
<th>Street</th>
<th>Zoning designation</th>
<th>Earliest year built</th>
<th># Res. Parcels</th>
<th># Apt. bldgs</th>
<th>Walk Score</th>
<th>Transit Score</th>
<th>Bike Score</th>
<th>Length (ft.) x Width (ft.)</th>
<th>Area (sq. ft.)</th>
<th>Average Percent Occupancy (rounded)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7th</td>
<td>R-2 &amp; R-3</td>
<td>1916</td>
<td>22</td>
<td>4</td>
<td>81</td>
<td>49</td>
<td>100</td>
<td>1,135 x 37</td>
<td>41,995</td>
<td>35%</td>
</tr>
<tr>
<td>9th</td>
<td>R-1 &amp; R-3</td>
<td>1937</td>
<td>27</td>
<td>10</td>
<td>72</td>
<td>45</td>
<td>100</td>
<td>1,205 x 40</td>
<td>48,200</td>
<td>55%</td>
</tr>
<tr>
<td>10th</td>
<td>R-1, R-3, PD</td>
<td>1946</td>
<td>30</td>
<td>3</td>
<td>62</td>
<td>45</td>
<td>98</td>
<td>1,205 x 32</td>
<td>38,560</td>
<td>32%</td>
</tr>
<tr>
<td>11th</td>
<td>R-1, R-2</td>
<td>1936</td>
<td>34</td>
<td>0</td>
<td>57</td>
<td>43</td>
<td>95</td>
<td>1,205 x 32</td>
<td>38,560</td>
<td>21%</td>
</tr>
<tr>
<td>12th</td>
<td>R-1</td>
<td>1955</td>
<td>38</td>
<td>0</td>
<td>56</td>
<td>44</td>
<td>94</td>
<td>1,215 x 40</td>
<td>48,600</td>
<td>14%</td>
</tr>
<tr>
<td>Baja</td>
<td>PD, R-2</td>
<td>1973</td>
<td>28</td>
<td>0</td>
<td>45</td>
<td>37</td>
<td>86</td>
<td>565 x 38</td>
<td>21,470</td>
<td>46%</td>
</tr>
<tr>
<td>Cortez</td>
<td>R-1</td>
<td>1967</td>
<td>19</td>
<td>0</td>
<td>45</td>
<td>37</td>
<td>86</td>
<td>545 x 38</td>
<td>20,710</td>
<td>35%</td>
</tr>
<tr>
<td>Diablo</td>
<td>R-1</td>
<td>1967</td>
<td>19</td>
<td>0</td>
<td>39</td>
<td>36</td>
<td>84</td>
<td>540 x 38</td>
<td>20,520</td>
<td>25%</td>
</tr>
<tr>
<td>El Cajon</td>
<td>R-1, PD</td>
<td>1973</td>
<td>17</td>
<td>0</td>
<td>22</td>
<td>35</td>
<td>83</td>
<td>550 x 38</td>
<td>20,900</td>
<td>15%</td>
</tr>
<tr>
<td>Faro</td>
<td>R-1, PD</td>
<td>1973</td>
<td>15</td>
<td>0</td>
<td>14</td>
<td>34</td>
<td>80</td>
<td>555 x 38</td>
<td>21,090</td>
<td>21%</td>
</tr>
<tr>
<td>Luz</td>
<td>PD</td>
<td>1978</td>
<td>37</td>
<td>0</td>
<td>10</td>
<td>24</td>
<td>79</td>
<td>830 x 30</td>
<td>24,900</td>
<td>45%</td>
</tr>
<tr>
<td>Inca</td>
<td>PD</td>
<td>1978</td>
<td>16</td>
<td>0</td>
<td>13</td>
<td>32</td>
<td>79</td>
<td>430 x 30</td>
<td>12,900</td>
<td>37%</td>
</tr>
<tr>
<td>Leon</td>
<td>PD</td>
<td>1977</td>
<td>12</td>
<td>0</td>
<td>14</td>
<td>27</td>
<td>78</td>
<td>250 x 30</td>
<td>7,500</td>
<td>31%</td>
</tr>
<tr>
<td>Lindo</td>
<td>PD</td>
<td>1976</td>
<td>16</td>
<td>0</td>
<td>13</td>
<td>32</td>
<td>79</td>
<td>355 x 30</td>
<td>10,650</td>
<td>33%</td>
</tr>
<tr>
<td>Tern</td>
<td>PD</td>
<td>1993</td>
<td>15</td>
<td>0</td>
<td>8</td>
<td>22</td>
<td>78</td>
<td>420 x 30</td>
<td>12,600</td>
<td>28%</td>
</tr>
<tr>
<td>Pintail</td>
<td>PD</td>
<td>1992</td>
<td>15</td>
<td>0</td>
<td>8</td>
<td>22</td>
<td>78</td>
<td>410 x 30</td>
<td>12,300</td>
<td>12%</td>
</tr>
<tr>
<td>Sandpiper</td>
<td>PD</td>
<td>1993</td>
<td>22</td>
<td>0</td>
<td>2</td>
<td>21</td>
<td>77</td>
<td>810 x 36</td>
<td>29,160</td>
<td>14%</td>
</tr>
<tr>
<td>Merganser</td>
<td>PD</td>
<td>1993</td>
<td>10</td>
<td>0</td>
<td>9</td>
<td>0</td>
<td>80</td>
<td>285 x 30</td>
<td>8,550</td>
<td>17%</td>
</tr>
<tr>
<td>Total</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>439,165</td>
<td>29%</td>
</tr>
<tr>
<td>Davis, CA</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>16,700,000</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Notes: 1. The zoning designations refer to one-family (“R-1”), one- and two-family (“R-2”), “garden apartment” (“R-3”), and planned development (“PD”) districts.
2. The number of residential parcels column includes the number of apartment buildings.
3. Street width excludes the 4 foot sidewalks on either side of the street, though they are part of the public right-of-way.
<table>
<thead>
<tr>
<th>Block Group Neighborhood</th>
<th>Street</th>
<th>Mean Percent Occupancy</th>
<th>Mean Household Size</th>
<th>Mean Percent Drove Alone</th>
<th>Mean Vehicle Ownership</th>
<th>Median Annual Household Income (1,000s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>107.01 (BG 3)</td>
<td>7th</td>
<td>35%</td>
<td>2.4</td>
<td>33%</td>
<td>1.6</td>
<td>$50-60</td>
</tr>
<tr>
<td></td>
<td>9th</td>
<td>55%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10th</td>
<td>32%</td>
<td>1.8</td>
<td>39%</td>
<td>1</td>
<td>$30-35</td>
</tr>
<tr>
<td></td>
<td>11th</td>
<td>21%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>12th</td>
<td>14%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>107.01 (BG 2)</td>
<td>Baja</td>
<td>46%</td>
<td>2.5</td>
<td>56%</td>
<td>1.9</td>
<td>$75-100</td>
</tr>
<tr>
<td></td>
<td>Cortez</td>
<td>35%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Diablo</td>
<td>25%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>El Cajon</td>
<td>15%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Faro</td>
<td>21%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>105.09 (BG 2)</td>
<td>Luz</td>
<td>45%</td>
<td>2.6</td>
<td>49%</td>
<td>2.1</td>
<td>$125-150</td>
</tr>
<tr>
<td></td>
<td>Inca</td>
<td>37%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Leon</td>
<td>31%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lindo</td>
<td>33%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>105.10 (BG 4)</td>
<td>Tern</td>
<td>28%</td>
<td>2.9</td>
<td>68%</td>
<td>2.2</td>
<td>$150-200</td>
</tr>
<tr>
<td></td>
<td>Pintail</td>
<td>12%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sandpiper</td>
<td>14%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Merganser</td>
<td>17%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Block Groups Average$^1$</td>
<td>-</td>
<td>-</td>
<td>2.4</td>
<td>49%</td>
<td>1.8</td>
<td>$75-100</td>
</tr>
<tr>
<td>Davis, CA</td>
<td>-</td>
<td>-</td>
<td>2.5</td>
<td>53%</td>
<td>1.7</td>
<td>$50-60</td>
</tr>
</tbody>
</table>

Household characteristics obtained from the American Community Survey’s 2015 5-year estimates, contained in tables B11016, B25088, B25044, and B19001 (U.S. Census Bureau, 2016).

$^1$ These figures represent a simple, unweighted average, not taking block group size into account. The reported average for Median Annual Household Income is the median.
<table>
<thead>
<tr>
<th>City</th>
<th>State</th>
<th>Mean Household Size</th>
<th>Mean Percent Drove Alone</th>
<th>Mean Vehicle Ownership</th>
<th>Median Annual Household Income (1,000s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Davis</td>
<td>CA</td>
<td>2.5</td>
<td>53%</td>
<td>1.7</td>
<td>$50-60</td>
</tr>
<tr>
<td>Ann Arbor</td>
<td>MI</td>
<td>2.2</td>
<td>56%</td>
<td>1.4</td>
<td>$50-60</td>
</tr>
<tr>
<td>Asheville</td>
<td>NC</td>
<td>2</td>
<td>76%</td>
<td>1.6</td>
<td>$40-45</td>
</tr>
<tr>
<td>Boulder</td>
<td>CO</td>
<td>2.2</td>
<td>52%</td>
<td>1.6</td>
<td>$50-60</td>
</tr>
<tr>
<td>Champaign</td>
<td>IL</td>
<td>2.2</td>
<td>64%</td>
<td>1.4</td>
<td>$40-45</td>
</tr>
<tr>
<td>Chapel Hill</td>
<td>NC</td>
<td>2.3</td>
<td>55%</td>
<td>1.6</td>
<td>$60-75</td>
</tr>
<tr>
<td>Chico</td>
<td>CA</td>
<td>2.3</td>
<td>73%</td>
<td>1.6</td>
<td>$40-45</td>
</tr>
<tr>
<td>Corvallis</td>
<td>OR</td>
<td>2.2</td>
<td>59%</td>
<td>1.6</td>
<td>$40-45</td>
</tr>
<tr>
<td>Eugene</td>
<td>OR</td>
<td>2.2</td>
<td>65%</td>
<td>1.6</td>
<td>$40-45</td>
</tr>
<tr>
<td>Flagstaff</td>
<td>AZ</td>
<td>2.4</td>
<td>66%</td>
<td>1.7</td>
<td>$45-50</td>
</tr>
<tr>
<td>Greenville</td>
<td>SC</td>
<td>2</td>
<td>81%</td>
<td>1.4</td>
<td>$40-45</td>
</tr>
<tr>
<td>Iowa City</td>
<td>IA</td>
<td>2.2</td>
<td>57%</td>
<td>1.5</td>
<td>$40-45</td>
</tr>
<tr>
<td>Madison</td>
<td>WI</td>
<td>2.2</td>
<td>63%</td>
<td>1.5</td>
<td>$50-60</td>
</tr>
<tr>
<td>Palo Alto</td>
<td>CA</td>
<td>2.5</td>
<td>65%</td>
<td>1.8</td>
<td>$125-150</td>
</tr>
<tr>
<td>Rohnert Park</td>
<td>CA</td>
<td>2.5</td>
<td>81%</td>
<td>1.9</td>
<td>$50-60</td>
</tr>
<tr>
<td>San Luis Obispo</td>
<td>CA</td>
<td>2.3</td>
<td>67%</td>
<td>1.8</td>
<td>$45-50</td>
</tr>
<tr>
<td>Santa Cruz</td>
<td>CA</td>
<td>2.3</td>
<td>57%</td>
<td>1.8</td>
<td>$60-75</td>
</tr>
<tr>
<td>Fairfield</td>
<td>CA</td>
<td>2.9</td>
<td>76%</td>
<td>2</td>
<td>$60-75</td>
</tr>
<tr>
<td>Napa</td>
<td>CA</td>
<td>2.6</td>
<td>77%</td>
<td>1.9</td>
<td>$60-75</td>
</tr>
<tr>
<td>Vacaville</td>
<td>CA</td>
<td>2.6</td>
<td>83%</td>
<td>2</td>
<td>$60-75</td>
</tr>
<tr>
<td>Woodland</td>
<td>CA</td>
<td>2.7</td>
<td>75%</td>
<td>1.8</td>
<td>$50-60</td>
</tr>
</tbody>
</table>

Household characteristics obtained from the American Community Survey’s 2015 5-year estimates, contained in tables B11016, B25088, B25044, and B19001 (U.S. Census Bureau, 2016).
External validity

Sample generalizability

Our target population is Davis residential neighborhood streets. Our sample includes only a small number of streets within a small transect of Davis, which could limit the ability to generalize to this target population. But we minimize that risk and increase the generalizability of our study by sampling streets spanning the breadth of Davis’ history and with a diverse set of socio-demographic groups. Additionally, the sampled streets have similar physical characteristics (35-feet wide, with on-street parking on both sides) to the average Davis local road (34-feet wide, also generally with parking on both sides) (City of Davis Transportation Advisory Group, 2013, p. 5, 23, 25; Nichols Consulting Engineers, 2016). Furthermore, our sample is primarily composed of single family homes but also includes some multi-family housing developments, such as apartment complexes and duplexes, which is representative of the remainder of Davis residential neighborhoods. Finally, for each of the sociodemographic characteristics we measured, the block groups’ range encompasses the overall Davis average and the block groups’ average is close to Davis’ average (TABLE 3).

Cross-population generalizability

Prevailing engineering and planning standards over the past century make it unlikely that the physical dimensions of Davis streets differ dramatically from those of other cities, lending credence to cross-population generalization. Additionally, we assessed the similarity of Davis’s sociodemographic characteristics to other small cities, first by testing similarities to other college towns across the US and then to other cities in close proximity to Davis (TABLE 4). We anticipate that our results are less likely to replicate in much larger cities, and therefore did not include cities that were substantially larger than Davis (pop. 66,000).

Davis’s sociodemographic characteristics are similar to those of other small U.S. college towns (TABLE 4). The city of Davis has slightly higher household sizes but comparable vehicle ownership rates and annual household income. Davis is on the lower end of the range of percent drove alone compared to other college towns.

Despite Davis’s reputation as a bicycling city, the city’s transportation characteristics differ only to a moderate degree from other small, neighboring cities (TABLE 4). Davis households tend to be slightly smaller and make slightly less annual income than their peers in nearby cities. Residents of Davis drive alone at much lower rates than other Northern California citizens, but on average own vehicles at only a slightly lower frequency.

Most notably, average vehicle ownership in Davis, the variable theoretically most likely to be closely linked to parking occupancy, is very similar to the two other populations we examined, even though Davis residents’ car use is typically much lower. And given Davisites’ lower rate of non-automobile mode use, this even suggests that Davis residents may be more likely to leave their car parked than their peers in other cities.

Further evidencing cross-population generalizability is the similarity of our results to those of Schlossberg and Amos in Eugene, OR, a city with a much higher (65%) drive-alone rate (TABLE 4). Schlossberg and Amos found an average on-street residential parking vacancy rate of 89 percent, which is even higher than the 71 percent average vacancy rate we found in Davis despite the lower drive-alone rate (53%) (Schlossberg & Amos, 2015).
DISCUSSION
Several parking-related movements have emerged within the last decade. Probably the best
known is the PARK(ing) Day movement, which protests the extensive public space used for car
storage by converting a parking space into a park for the day. The event has its roots in San
Francisco, but as of 2011 had expanded to 850 parks in 183 cities (Coombs, 2012) and helped
usher in formal city adoption of the concept in the form of San Francisco’s parklet program
(Davidson, 2013). Other movements have pushed, for example, for converting the public right-
of-way on local streets to residential buildings and prioritizing existing roadway maintenance
over new roadway construction.

These movements, paired with our study results, beg the question: what could Davis do
with its underutilized pavement resource? Economists might ask the same question in terms of
opportunity cost: what is the cost of the status quo compared to the alternatives? And relatedly,
could those alternatives simultaneously help address other urban challenges? In the following
sub-sections, we briefly outline two main urban challenges and follow with possible design
solutions. Given preliminary and anecdotal evidence from other cities’ infill efforts, such as
Vancouver’s laneway houses (Holden & Thumm, 2016; Shepherd, 2017), we suggest that the
main challenges facing intensive redesign alternatives are political rather than technical.
Furthermore, we acknowledge that the design solutions we discuss below are sketches rather
than fully-rendered proposals. Though we paint the benefits, costs, and challenges of each
solution in broad strokes, a more thorough and detailed analysis would be necessary before
considering implementation. Finally, we conclude our discussion by briefly touching on the
intersection of parking and equity and noting the relevance of parking policy to the impacts of
innovations such as shared and autonomous vehicles.

Fiscal and Housing Challenges
Davis, like many other cities in California, faces major fiscal challenges, due in large part to the
continued influence of Proposition 13’s restrictions on property tax assessment (W. Fulton &
Shigley, 2012), the disbanding of redevelopment agencies in 2011 (W. Fulton & Shigley, 2012),
and the burden of the recent economic recession. In the realm of pavement management alone,
there is a projected funding shortfall of more than $50 billion for pavement needs on California’s
local roads through 2025 (Senate Transportation and Infrastructure Development Committee &
Staff Consultants, 2015). Across the state, most local governments simply do not have the
resources to both maintain their good-condition pavements while also rehabilitating poor
condition pavements and replacing failing pavements. Davis is no exception. If the city does not
increase its annual pavement management budget, by 2035 it will face an estimated $154.7
million in deferred maintenance (using 4 percent interest and inflation rates), along with a
reduction in its average pavement condition index (PCI) from 63 (“fair”) to 35 (“poor”)
(ABbanat, 2015; Nichols Consulting Engineers, 2016; Yapp, 2013). To attain and maintain a
“good” average PCI by 2035, Davis would need to spend an inflation-adjusted average of $8
million per year on pavement management, over $6 million more annually than its current
pavements budget (Nichols Consulting Engineers, 2016).

Just as Davis has encountered the same fiscal challenges as other California cities, Davis
also mirrors the overall state trend of severe housing shortages. Davis vacancy rates are
consistently well below the recommended 5 percent level (Belsky, 1992), and most recently
dipped to 0.2 percent (BAE Urban Economics, 2015). One major reason for this is Measure J,
which Davis residents passed in 2000, which requires a citizen vote on any development beyond
the city’s existing boundary (Pistochini, 2015). Davis voters have since voted down or otherwise
discouraged many housing development proposals, thereby constricting the city’s housing supply. Davis and Yolo County’s progressive conservation and agricultural preservation policies have further discouraged greenfield development outside the city’s boundaries (Design Community and Environment, 2006). Limited opportunities for infill development within the city have caused supply to lag even further behind the growing housing demand.

While municipal fiscal challenges and housing shortages may seem only distantly related to parking, this paper suggests that one way to achieve Davis’ progressive transportation policies and meet these twin challenges could be to repurpose excess on-street parking in residential neighborhoods.

**Design Solutions**

Excluding bicycle paths, Davis manages approximately 160 centerline miles and 340 lane miles of paved roads (Nichols Consulting Engineers, 2016; Yapp, 2013). That equates to about 33 million square feet of pavement, or about 1.2 square miles. Local/residential streets (as opposed to collector and arterial streets) consume 0.61 square miles, equivalent to more than 170 standard city blocks, within Davis’ 10 square miles of total area (Nichols Consulting Engineers, 2016).

Repurposing even a portion of this expansive, underutilized asset could yield significant neighborhood and environmental benefits, while also padding the city’s coffers. Furthermore, because our proposals would only repurpose pavement currently used (or, rather, underutilized) for parking, none of them would reduce the width or restrict the use of the existing travel lanes.

**Cost Savings to The City**

If Davis maintains its current pavement management budget, it would spend an estimated $6,995,809 (inflation adjusted) on residential/local streets through 2025, or an average of $349,790 (2.1¢/ft²) annually (Nichols Consulting Engineers, 2016). To instead attain Davis’ targeted average PCI of 60 for its local/residential streets, over the next 20 years the city would need to spend an estimated $43,920,360 (inflation adjusted), or $2,196,018 (13.2¢/ft²) annually (Nichols Consulting Engineers, 2016). Under either scenario, the city could save a substantial amount by reducing its paved residential street surface area.

On the residential streets we studied, we found average on-street parking vacancies between 45 and 88 percent at peak usage (TABLE 1). That equals an average of 631 vacant parking spaces for the entire area surveyed. Using our field estimate of the size of the spaces – 9 feet by 18 feet (162 ft²), which are also the standard minimum on-street parallel parking space dimensions under Davis’ Municipal Code – that equals 102,222 square feet of unnecessary pavement, or 23.3 percent of the entire roadway area (Nichols Consulting Engineers, 2016).

If we apply that same vacancy percentage – 23.3 percent – to the city’s entire residential/local roadway network, that equals approximately 3,887,166 square feet of excess pavement. If Davis repurposed all that unutilized pavement, it could reduce the annual cost of achieving Davis’ 60 PCI target for its local streets over the next 20 years by approximately $513,000 ($0.132/ft²*3,887,166 ft²), or about $21 per converted parking space. Even if Davis only repurposed 7 feet of the required 9-foot-wide parking spaces, to increase the average local road lane width to 10 feet (34-foot average curb-to-curb width minus 14 feet of parking, 7 feet on each side), it could still reduce that annual cost by approximately $399,000 ($513,000*7/9), or almost $17 per parking space. Davis might also achieve additional costs savings through reduced street sweeping and other non-pavement-related road maintenance. And while the city might incur different additional maintenance costs depending on how the pavement was repurposed, green infrastructure maintenance can be cheaper than maintaining conventional roadway and...
associated stormwater facilities (Environmental Protection Agency, 2007; HR Green Inc., 2016; Wise, 2008), especially when adjacent property owners help maintain the system (Seattle Public Utilities, 2016).

If the unutilized segments of local roads were repurposed for private ownership and use, they could net the city substantial additional revenue from both selling the land (net of transaction costs) and the resulting property tax increases, as discussed in the next section. And even if Davis retained ownership of the road segments, it could repurpose them in a way that would increase adjacent property values and indirectly increase property tax revenues.

We review some of these no-sell redesign options after discussing the sale options. We discuss the constraints on and obstacles to achieving these outcomes in the final Design Solutions subsection.

**Accessory Dwelling Units and Other Benefits of Selling Excess Parking Land**

What could Davis do with its excess on-street residential parking spaces? One option is to parcel the land out in chunks corresponding to the width of the adjacent privately owned parcels (often 30 to 40 feet), and sell the plots to the adjacent property owners. The adjacent landowners could then add it to their current parcels through lot line adjustments, and indeed would have to combine their parcels to construct any type of accessory structure (City of Davis, 2017, section 40.26.010(c)(3)). By unifying their parcels, landowners would reduce the cost of extending any necessary utilities to the added land, e.g. for an accessory dwelling unit, since new utility connections (as opposed to extensions from existing laterals, etc.) are generally only required for separate parcels (Matthew Wolf, personal communication).

The city could incentivize landowners to purchase the converted parking parcels by promising to approve the lot line adjustments without imposing any conditions or exactions and pay for any needed public infrastructure relocation. One obvious relocation requirement would be moving the sidewalk and curb out 7 to 10 feet and tearing out the existing parking space pavement. To both reduce the per-parcel infrastructure relocation cost and maximize the utility of the repurposed parcels, the city would be wise to convert multiple adjacent parking spaces at once. For example, the city could convert all parking spaces on one side of the street on selected residential blocks, limiting parking to the other side of the street and nearby streets.

What could the landowners do with the additional parcels? One option would be to use them as additional garden or lawn space (Schlossberg & Amos, 2015). This would benefit landowners by giving them more space to, e.g., grow their own fruits and vegetables, while also increasing their property values, including the per-square-foot value for the entire properties (Adair, Berry, & McGreal, 1996; Coley, Florkowski, & Bowker, 2006; Lin & Evans, 2000). It would also net the city additional revenue from both selling the land and the resulting property tax increases. While Proposition 13 limits annual assessed property value increases to 2 percent, the property is fully reassessed for tax purposes when it changes ownership. Thus, if and when the enlarged properties are sold, the property appraisals would capture that greater value and increase the city’s property tax base and revenue, which constitutes a large portion of its total revenue. In 2015, approximately 22.5 percent of Davis’ total $53,910,547 in general fund revenues came from property taxes (City of Davis, 2016).

Another option for landowners would be to build accessory dwelling units (ADUs). An ADU is commonly defined as “a small self-contained dwelling,” usually “less than 800 square feet” and “typically with its own entrance, cooking and bathing facilities, that shares the site of a larger, single-unit dwelling” (Brown & Watkins, 2012; City of Davis, 2017, section 40.01.010;
Wegmann & Nemirow, 2011). With an additional 210 to 360 square feet of land for lots 30 to 40 feet wide (assuming a repurposed parking space width of between 7 and 9 feet), landowners would have additional lot space in which to build an ADU. One option would be to build a small ADU in their backyard (see “Sited in the Setback” for an example (Williamson, 2013)), and use the expanded front yard to replace or augment any open space and recreational uses previously concentrated in the backyard. Landowners could also locate a small ADU between their primary residence and the street, or expand and convert their garages, as at least one family did with their front yard garage in Portland, Oregon – and in not so subtle fashion (FIGURE 2) (Menard, 2014). Even at a relatively small size, say 200 to 400 square feet, the ADUs could accommodate sleeping quarters, a bathroom and a kitchen (Mitchell, 2014). But even without a bathroom or kitchen, ADUs can still be used as extra bedrooms for renters or guests, called “guest houses” in Davis’ Zoning Code (City of Davis, 2017, sections 40.01.010, 40.03.045(b), 40.26.450).

Depending on the lot configuration, ADU construction might necessitate rezoning in some areas to modify setback and other requirements (Chapple, Wegmann, Nemirow, & Dentel-Post, 2012; City of Davis, 2017), but that would be more easily accomplished if the city created blocks of adjacent repurposed parking space parcels rather than converting individual spaces here and there. Following the lead of jurisdictions like Santa Cruz, California, Davis could further incentivize ADU construction by adopting pre-approved ADU designs, a how-to manual for landowners, and a low-interest loan program (Wegmann & Nemirow, 2011).

ADUs would provide a trifecta of key benefits to the city and its residents. First, ADUs would increase property values and also provide the landowners a potential additional source of rental income. Not many studies have attempted to quantify how much an ADU adds to the value of the property as a whole (Brown & Watkins, 2012; Lang, 2005; Sirmans, MacDonald, Macpherson, & Zietz, 2005; Wegmann & Nemirow, 2011). But what evidence there is indicates that while ADUs in low-density suburbs may actually reduce property values (Sirmans et al., 2005), they can substantially increase property values in denser suburbs and urban areas (Brown & Watkins, 2012; Lang, 2005).

![FIGURE 2 Garage Conversion to ADU, Before and After (Menard, 2014)](image)

One study found that people would pay a 15 percent premium to live in a New Urbanist community, with amenities like ADUs, instead of a comparable conventional suburb (Eppli & Tu, 1999; Lang, 2005). More recently, Brown and Watkins recently tested two income-based
formulas to value 14 properties with legal, permitted ADUs in Portland (Brown & Watkins, 2012). The authors found that, despite comprising only a small proportion of the combined residential floor area, the ADUs contributed an average of 25 percent of the total property value using one valuation method, and 34 percent using the other method, though the increased value took time to accrue (Brown & Watkins, 2012). The authors thus concluded that “[a]dding an ADU to a single-unit property could reasonably add 51%” (0.34/(1-0.34)) “to longer-term measures of value or return” (Brown & Watkins, 2012).

While the ADUs made feasible by repurposing on-street parking spaces in Davis would likely be smaller on average than those that Brown and Watkins studied, their findings indicate that landowners could still expect ADUs to significantly increase their property values. Using the $586,200 median Davis home value estimated by Zillow (Zillow, n.d.), if the ADUs increased total property values by even the lower 15 percent figure Eppli and Tu (Eppli & Tu, 1999) found, that would be a median value bump of $87,930.

Second, ADUs would create even more additional revenue for the city than if the converted parking spaces were used just for gardens or lawns. Allowing ADUs on the larger residential plots created by adding the former street parking spaces would likely increase the sale price of the parking space parcels. And if the landowners actually built ADUs on their enlarged lots, it would eventually increase property tax revenues for Davis if and when the properties were sold. As a rough estimate, we can assume that adding an ADU increases the average property value by between 15 and 51 percent, using the lower and upper figures from Eppli and Tu (Eppli & Tu, 1999) and Brown and Watkins (Brown & Watkins, 2012), respectively. That translates to an $87,930 to $298,962 increase in the median home value (Zillow, n.d.).

Once those properties are sold and reassessed for property tax purposes under Proposition 13, which limits the property tax rate to 1 percent, that increased value would create an additional $879.3 to $2,989.62 in annual property tax, of which the city gets 5 percent (Douglas Olander, personal communication). Thus, for every 100 properties that added ADUs, the city would increase its annual property tax revenues by between $4,396.50 and $14,948.10 (tax*100*0.05). It would be an even bigger boon for the Davis Joint Unified School District, which receives about 50 percent of the total property tax collected on Davis properties (Douglas Olander, personal communication), and would thus increase its annual revenues by between $43,965 and $149,810 (tax*100*0.5) under the same scenario.

Third, ADUs would provide additional affordable housing to help reduce the city’s housing shortage. Even at 200 to 400 square feet in size, each ADU rented to Davis residents (as opposed to serving as a guest house or short-term rental via an Airbnb-like service) could house 1-2 people. Coincidentally, college towns like Davis have just the sort of population – young, less likely to have children and often more environmentally conscious – that desires “relatively small-lot, high-density housing types” (Chapple et al., 2012; Wegmann & Nemirow, 2011). In addition, as a generally ministerially approved infill use, ADUs circumvent Davis’ Measure J as well as onerous review under, for example, the California Environmental Quality Act (City of Davis, 2017, section 40.26.450). As a result, and because of their small size and informal management, ADUs can provide “relatively low-cost rental housing,” making them even more desirable in a city lacking adequate affordable housing (Wegmann & Nemirow, 2011).

**No-Sell Design Options**

Even if Davis retained ownership of the road segments, it could repurpose them in a way that would increase adjacent property values and indirectly increase property tax revenues. According
to Jacobs (Jacobs, 1993), “[g]iven a limited budget, the most effective expenditure of funds to improve a street would probably be on trees.” Replacing the pavement with trees, especially in areas with few existing trees, would provide additional oxygen, shade and evaporative cooling, creating more comfortable conditions for pedestrians (Jacobs, 1993). In addition, it could improve driver visibility and safety, while reducing auto speeds (Daisa & Peers, 1997; Macdonald, 2007). For these same reasons, replacing parked cars with trees would also likely increase adjacent residential property values (Anderson & Cordell, 1985; Des Rosiers, Thériault, Kestens, & Villeneuve, 2002). It could also be done without moving the existing sidewalk, reducing the city’s costs. However, many of Davis’ residential streets already have ample trees (FIGURE 1).

Another option is to replace the parking spaces with bioswales or landscaped parklets. One of the primary functions of bioswales is to capture rainwater and runoff and let it infiltrate into the ground slowly, rather than rush into the storm drain, thereby reducing pressure on the stormwater management system (Church, 2015; Lucas, Clar, & Gracie, 2011; Wise, 2008). This infiltration process also filters and cleans the water (Lucas et al., 2011; Wise, 2008). Additionally, like trees, bioswales improve street aesthetics and can have traffic calming benefits (Church, 2015). Parklets can provide many of the same benefits as trees and bioswales. Portland has implemented a number parking-for-bioswale replacement projects, to good success and at a relatively modest cost of between $4,000 and $8,200 per parking space replaced (in 2002-2004 dollars) (Schlossberg & Amos, 2015; Wise, 2008).

Obstacles and Limitations

Repurposing Davis’ excess parking spaces is not without its challenges. One of the primary challenges from a logistical and cost perspective is the potential need to relocate utilities, utility access points or other infrastructure. For example, some of the pavement conversion options discussed, particularly the privatization options, would require moving the sidewalk and curb out 7 to 10 feet and tearing out the existing parking space pavement. Additionally, water mains and other utilities are commonly located beneath city streets.

Fortunately, though, utility access points are often located closer to the street centerline, including in Davis (Van Dam et al., 2015; Matthew Wolf, personal communication). And Davis does not require new utility hookups for ADUs on the same parcel as the main residence, allowing extensions from the main structure’s existing hookups (Matthew Wolf, personal communication). Nor, under recent state legislation, may ADUs “be considered new residential uses for the purposes of calculating local agency connection fees or capacity charges for utilities” (State of California, 2017, section (f)(2)). Furthermore, for ADUs within “one-half mile of public transit,” as many parcels in Davis are, the landowners would not have to provide any off-street parking for the ADU, saving them even more costs (State of California, 2017, section (d)(1)).

Costs could also be a major obstacle for some of the no-sell repurposing options. Planting additional trees is generally cheap, but it would have to be done so as to minimize the risk of root damage to the adjacent pavement. Parklets and bioswales would all likely be more expensive than tree planting, as discussed above, though bioswales especially could reduce some stormwater-related public works costs. And though these options would require some ongoing maintenance, the costs of green infrastructure maintenance can be less than conventional roadway and stormwater facilities (Environmental Protection Agency, 2007; HR Green Inc., 2016; Wise, 2008). Those costs are even lower when adjacent property owners help maintain the system, as Seattle Public Utilities encourages with its green streets infrastructure (Seattle Public
Utilities, 2016). Furthermore, in the long term, the green infrastructure could also increase property tax revenues by increasing the value of adjacent properties. Green streets infrastructure projects also often have substantial environmental benefits that are difficult to monetize (Environmental Protection Agency, 2007).

A major – and probably the greatest – challenge for any privatization plan would be obtaining political buy-in from politicians and affected neighbors, as Vancouver’s experience has shown (Holden & Thumm, 2016; Shepherd, 2017). For one, the adjacent landowners would need to be willing buyers at near-market prices, which would be less likely if they thought the city would repurpose the excess parking spaces to their benefit whether or not they purchased the plots. Creating an adequate private market could require an extensive outreach effort by the city and potentially also creative incentives.

Some of the landowners whose properties were not targeted for enlargement would also likely oppose repurposing due to equity (they would not benefit as much as their neighbors), parking (more vehicles would park on their side of the street) and other reasons. Again, this would likely require an aggressive outreach effort to explain how the projects would benefit everyone in the neighborhood through, e.g., traffic calming.

Some vexatious nearby neighbors or unscrupulous developers might even try to purchase the newly created parcels next to other people’s houses to either prevent them from developing there or force them to move by creating an incongruous use there. But Davis’ Zoning Code and common law nuisance remedies should prevent that. Given the narrow width of the parcels (9 feet or less), the codified setback restrictions in Davis’ residential districts would prohibit almost any use of the parcels, including any structure construction (City of Davis, 2017, articles 40.03, 40.04, 40.08).

Another limitation for the ADU-development option is that it could increase the local demand for parking, thus reducing the total amount of pavement available for conversion. Recent state legislation prohibiting local governments from requiring any off-site parking for ADUs within one-half mile of public transit could exacerbate any increased parking demand (State of California, 2017, section (d)(1)). However, there is no guarantee on-street parking demand would increase. The same kind of people who are more likely to move into “relatively small-lot, high-density housing types” – those who are young, less likely to have children and often more environmentally conscious, like college and graduate students – are least likely to commute via car (Chapple et al., 2012; Wegmann & Nemirow, 2011). According to the 2015-2016 UC Davis Campus Travel Survey, only 14.9 percent of students drove alone to campus versus 54.1 percent of employees (staff and faculty) (Gudz, Heckathorn, & Thigpen, 2016).

Note, however, that this paper is not meant to be a thorough evaluation of the technical, fiscal, and political feasibility of the proposed redesign options, but rather a starting point for future research in those areas.

Parking and Equity

Examining options to repurpose currently underutilized parking spaces raises a related consideration. Without pointing fingers or making undue insinuations, the combination of Davis citizens’ historical anti-development stance and the overprovision of residential parking could be seen as implicit support for the storage of cars over the desire of others to live and work in Davis. Put another way, should the city be subsidizing excessive car ownership and storage when so many want to live in Davis?
Parking and Shared and Autonomous Vehicles

Recent advances in communications technology have helped spur the development of innovations in transportation. Shared-use vehicle systems are one example, where a fleet of vehicles is used by many different people within a single day (e.g., Zipcar). These systems have been around for nearly two decades. In contrast, autonomous vehicle technology is still in its infancy, with a variety of car-makers and technology companies seeking to bring advances to the market. Scholars have noted that both shared-use vehicle systems (Barth & Shaheen, 2002) and autonomous vehicle technology (Fagnant & Kockelman, 2015) have the potential to reduce the demand for parking, and a combination of shared use and autonomous vehicles (L. Fulton, Mason, & Meroux, 2017) could reduce parking demand still further. Should these innovations truly take hold, parking demand would consequently decline over time. This likelihood may give cities further confidence in their decisions to retrofit underutilized pavement.

CONCLUSION

We find that the city of Davis has provided a vast oversupply of on-street parking in its residential neighborhoods. On average, and using a conservative estimate of available on-street parking, only two in seven on-street parking spots were occupied during peak parking hours, across 18 Davis streets and over 8 days of data collection. Newer, less accessible developments and larger households surprisingly were associated with lower rates of on-street parking, while the presence of apartment complexes appeared to increase on-street parking.

If we apply the same roadway underutilization percentage we found in our study area – 23.3 percent – to the city’s entire residential/local roadway network, that equals 3,887,166 square feet of unnecessary pavement. We find that if Davis repurposed all that excess pavement, it could reduce its annual pavement management costs for the next 20 years by $513,000 if Davis increased its budget to attain its desired average PCI of 60 for its local/residential streets. Additionally, we find that repurposing even a portion of this expansive yet underutilized asset could also yield significant neighborhood and environmental benefits. Privatizing the parking spaces could allow substantial additional ADU construction, which would both help reduce the city’s housing shortage and provide supplemental income to landowners. Alternatively, the city could maintain ownership of the land and replace it with bioswales, landscaped parklets, additional trees or other landscaping, all of which have multiple societal and environmental benefits. The suggested design solutions offer potential win-win scenarios for the city, citizens and homeowners, and developers.

Few cities have narrowed existing residential streets, and to our knowledge none have done so with the intent to make room for housing. Yet a scarcity of real-world examples does not necessarily make these proposals pie-in-the-sky, but rather indicates the possibility for a pioneering city to set a powerful precedent. Such a city would be likely to find support from players at many levels. In California, for example, residents report high levels of interest in building ADUs (Chapple et al., 2012), and the State Legislature recently passed laws requiring ADU permit streamlining, limiting new utility connection requirements and capping – and in some cases prohibiting – ADU parking requirements (Bloom, 2016; Wieckowski, 2016). And across the United States, developers report an unmet demand for denser residential development constrained by zoning rather than citizen’s preferences (Levine & Inam, 2004). This confluence of factors suggests that these proposals are more realistic than they may appear at first blush.

Future studies could enhance and complement this study’s findings. A thorough evaluation of the technical, fiscal, and political feasibility of the proposed redesign options, either as a technical report written in conjunction with a city or as a case study, would help...
determine which redesigns are most realistic and which face significant barriers to implementation. And given the interests of local homeowners, a set of interviews with residents regarding their preferences for the proposed alternatives could also help local planners and elected officials recommend acceptable redesigns. Finally, our counting methodology, which is more likely to yield accurate results than previous efforts with little additional effort (Schlossberg & Amos, 2015), could be applied across a wider variety of settings to better assess on-street parking utilization in the residential neighborhoods of small cities.

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