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Peer Review
This work has undergone a double-blind review by a minimum of two faculty members from institutions of higher learning from around the world. The faculty reviewers have expertise in disciplines closely related to those represented by this work. If possible, the work was also reviewed by undergraduates in collaboration with the faculty reviewers.

Abstract
Urban community gardens have been shown to have positive affects social capital, yet like many public spaces, are open to negative activities like crime. Contrary to this idea, most of the literature has indicated that urban green spaces are associated with a reduction in crime. This study utilized a mixed-methods research design to explore the hypothesis that areas around Seattle’s “P-Patch” community gardens are associated with a reduction in crime. We employed spatio-temporal GIS (Geographic Information Systems) analyses, statistical analyses, and qualitative interviews with gardeners. Yearly violent and property crime rates for 132 census tracts in Seattle, locations of 84 P-Patches were mapped, and changes in crime and garden establishment from 1996 to 2006 were observed. Correlations were conducted on socio-demographic, crime, and P-Patch variables. Interviews with four gardeners were conducted and qualitatively analyzed for common themes. Geographic visualization showed interesting patterns in crime and P-Patch establishment in South Seattle in particular, but outcomes of the correlation between P-Patch and crime variables were inconclusive. Qualitative interviews with gardeners provided a fuller account of the overall changes in Seattle crime, gardeners’ perceptions of neighborhood safety, and its relation to the development of urban community spaces such as P-Patches.

Keywords
Community Gardens, Crime, Mixed-Methods Research, Urban Studies, Geographic Information System, Exploratory Data Analysis

Acknowledgements
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INTRODUCTION

Seattle’s first urban community garden was Picardo Farm, established in 1973 and located in Northeast Seattle. The “P” in Picardo was used to name Seattle’s future community gardens “P-Patches.” Over the past 42 years, the P-Patch program has grown in number of gardens, volunteers, and overall support, to now managing 88 active gardens within the city.

Seattle’s P-Patches vary in number of gardeners, number of garden plots, size of the garden, and land ownership. The city’s P-Patch program staff has established rules for all of the gardens, which state that gardeners must organically tend their garden (e.g., plant, weed, water, and harvest), volunteer eight hours of time to the P-Patch apart from their individual plot, maintain shared pathways and equipment, and “be a good neighbor.” Each P-Patch has at least one volunteer coordinator who works as a liaison with the P-Patch program staff, organizes garden work parties, and facilitates communication among gardeners about issues or events within their garden. The P-Patch staff is responsible for monitoring plot activities (e.g., controlling invasive species), assisting garden coordinators with problems that arise, holding monthly meetings with coordinators, and managing the application process for new gardeners.

Community gardening, by nature, is a social activity. Gardens have often been established out of neighborhood initiative and many studies have examined the relationship between garden participation and social capital at the city level. For example, Glover (2004) defined social capital in the context of community gardens as “a collective asset that grants members social ‘credits’ that can be used as capital to facilitate purposive actions (p. 145).” These purposive actions include decreased social barriers, an increased connection with the larger community and neighbors, feelings of safety, and opportunities for social activism (Glover et al., 2004; Poulsen et al., 2014; Teig et al., 2009). Community gardening at the individual and household level is also associated with feelings of trust for neighbors and social support (e.g., getting assistance from neighbors and how often neighbors attend social events), responsibility for the neighborhood, and collective efficacy (Alaimo et al., 2010). Additionally, community gardening has been shown to facilitate increased political citizenship (Glover et al., 2005).

Despite the numerous social benefits, community gardens are public spaces, which can be susceptible to negative activities like theft and vandalism. We are particularly interested in examining urban community gardens and their relationship to crime. Our initial hypothesis was that there would be a negative correlation between the two. Existing studies have shown mixed outcomes. One study in Houston, Texas, showed no statistical relationship between the community gardens and property crime (Gorham et al., 2009). However, after conducting interviews, Gorham (2009) later found that gardeners perceived greater neighborhood safety in areas that had gardens. Results from a survey completed by 445 community garden organizations in the US and Canada reported that 18% of gardeners addressed theft and vandalism frequently, 27% occasionally, 31% infrequently, and 19% did not address it at all (Drake & Lawson, 2014). In addition, in qualitative interviews of community gardeners in Denver, Colorado, some gardeners noted that theft and vandalism in the garden affected their trust of people

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1 All rules and tips for establishing and maintaining P-Patches can be found at http://www.seattle.gov/neighborhoods/p-patch-community-gardening/toolkit-for-gardeners
outside the garden (Teig et al., 2009). More broadly speaking, multiple studies have shown that urban greenery, such as trees, bushes, and general vegetation, is associated with lower crime rates in those areas (Donovan & Prestemon, 2012; Kuo & Sullivan, 2001; Wolfe & Mennis, 2012).

In this regard, urban community gardening has been identified as a tool for individuals and neighborhoods to turn land that attracts negative activities into positive community spaces (Poulsen et al., 2014; Sokolovsky, 2011). Building on these previous studies, we will explore whether there is any meaningful relationship between crime and Seattle’s P-Patch community gardens, particularly by applying a mixed-methods approach.

METHODS

This study used a mixed-methods approach to tell a more complete story of the relationship between crime and P-Patches inductively, rather than deductively. A mixed-methods approach allows researchers to integrate both quantitative and qualitative approaches, and prevents the research from being confined to any particular type of method (Brewer & Hunter, 2006; Creswell, 2003). In supporting both quantitative and spatial data with well-grounded contextual qualitative information, we attempted to include them in the research process from data collection to data analysis. We particularly combined Exploratory Data Analysis (EDA) with a Geographic Information System (GIS), statistical analyses, and qualitative interviews, to examine any statistical or perceived relationships between P-Patch locations and crime.

Data Collection

The City of Seattle public data website\(^2\) provides a dataset with the total yearly violent and property crimes from 1996 to 2006, based on 1990 census tract boundaries (hereon called “census crime data”). In this dataset, property crimes include theft, vehicle theft, residential burglary, and non-residential burglary. Violent crime includes aggravated assault, robbery, rape, and homicide. We collected total number of crimes for the years 1996, 2001, and 2006, and calculated differences for each crime type between the two 5-year periods, and the 10-year period. Although using census tract-level crime data is a relatively large geographic unit, it allowed us to systematically compare various socio-economic data aggregated at the census tract level. Using this data allowed us to consider temporal factors that may reveal interesting spatial characteristics and variations about crime and P-Patch changes over the decade observed.

No existing dataset was found that included current active P-Patches and their locations in Seattle. We created our own dataset of descriptive information (e.g., P-Patch name, size, address, year established, ownership) that was available on the P-Patch program website.\(^3\) We used Google Earth to visually locate and pinpoint the P-Patch’s geographic location. The geographic coordinates were added to the P-Patch dataset to create a point shapefile in GIS. A field for census tract was created, as well as fields for whether the P-Patch was established before 1996, between 1996 and 2006, or after 2006, to allow for analysis of the specific P-Patches established between the years crime data were available.

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\(^2\) The Seattle public data website can be found at http://data.seattle.gov

\(^3\) Descriptive information about each P-Patch can be found at http://www.seattle.gov/neighborhoods/p-patch-community-gardening
Various socio-demographic data from the 2010 census for King County were collected from the United States Census Bureau’s American FactFinder 2 database. Data collected included population, race, employment status, household income, marital status, education level, poverty status, and food stamp usage. These variables were chosen because socio-economic and demographic factors have often shown to have an influence on urban crime rates (Messner & Tardiff, 1986).

A shapefile of the 2010 King County census tract boundaries was obtained from the Washington State Geographic Data Analysis (WAGDA) database. Since the census crime data were based on 1990 census tract boundaries and the socio-demographic data were based on 2010 census tract boundaries, we decided to use the most recent 2010 census boundaries for the analysis due to the size and complexity of the socio-demographic data compared to the census crime data. This is a geographic normalization process that is often required in geographic analysis to minimize the Modifiable Areal Unit Problem (MAUP) in order to improve spatial accuracy (Vogel, 2016). Census boundary changes from 1990 to 2010 were identified and put into two categories: divided tracts or merged tracts. Area percentages of tracts that had been divided were calculated. Each crime type was divided or combined using the new area percentages in the changed census tracts.

**GIS and Statistical Analysis**

GIS visual analysis helps researchers to interactively detect and reveal any distinctive spatial patterns and characteristics of data (Dykes, MacEachren, & Kraak, 2005; MacEachren et al., 2005). Knigge & Cope (2006) discuss how Exploratory Data Analysis (EDA) can be used in geographic visualization in that it “employs statistical techniques to reveal hidden characteristics and facilitate seeing what the data ‘tell’ us in order to develop new questions or hypotheses (p. 2027).” We utilized this method to manipulate geographic data, and then exported it to a statistical package for correlation analysis. Spendley and Brehme (2014) used a similar method to understand the relationship between altitude and particulate matter. We explored spatial patterns of crime, P-Patch, and socio-demographic data in GIS. The socio-demographic dataset was joined to the census boundary and census crime data attribute table using census tract as the geographic unit of analysis to create a dataset that could be exported for statistical analysis.

Maps of total crime and crime changes were created to visually analyze any spatial characteristics or pattern in the data. Only P-Patches that were established before the year of crime data displayed were included in the maps in order to observe any distinctive pattern between P-Patch locations and crime. Quantile classification was chosen, considering the fact that only 11% of census tracts in Seattle had over 600 yearly crimes, although the range of yearly crime per census tracts varied from 29 to 4,819 crimes. Quantile classification breaks up the number of census tracts evenly by class, rather than the number of crimes, which lessens the skew of the census tracts with very high crime rates when observing the maps.

We also applied a statistical analysis using SPSS (IBM). Descriptive statistics were conducted to observe the mean, median, and standard deviations of socio-demographic, crime, and garden variables. A Pearson’s correlation was also conducted on scale-level variables, to show the linear dependence between socio-demographic variables and crime, socio-demographic variables and garden variables, and crime and garden variables.
**Qualitative Analysis**

Semi-structured interviews were conducted with four active gardeners from different geographic areas of Seattle. This was a convenience sample as we contacted gardeners to participate based on information given to us by the P-Patch staff. Two interviews were conducted at the respective P-Patches, and two were conducted by phone. Interviews took place from April, 2015 to May, 2015, and lasted thirty minutes to one hour. Structured questions included descriptive information about the garden such as the age range of gardeners and length of participation in the garden. In addition, open-ended questions about crime within the garden as well as within the surrounding neighborhood were asked. Community gardeners also shared the changed perception of neighborhood safety. Field notes were taken during the interviews, and were qualitatively analyzed to understand the contextual and experiential meanings of the data. Two coders reviewed the data and codes were crosschecked for inter-rater reliability. We particularly used the methods of grounded theory (Glaser & Strauss, 1967) in the way of evaluating and organizing data in an effort to understand meanings in the interview data. It helped us to find any common categories and frequently mentioned themes from gardeners’ response.

**RESULTS**

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4 This research was reviewed in accordance with University of Washington Institutional Review Board (IRB) interpretations of federal guidelines, and determined that it required no IRB review.

5 One coder is a qualitative researcher who teaches and uses qualitative methods at the University of Washington. The other coder was trained and supervised by the first coder.

**Descriptive Statistics**

There are 132 census tracts in the city of Seattle (n = 132) and 84 P-Patches were included in this study. Fifty-seven census tracts (43.2%) have at least one P-Patch within their boundary. Table 1 shows some characteristics of these tracts, such as poverty, crime, and racial distribution. Forty-five (34.1%) have one P-Patch, seven (5.3%) have two P-Patches, three (2.3%) have three P-Patches, and two (1.5%) have four P-Patches within their boundaries.

**GIS Mapping Outcomes**

After exploratory visual analysis of the crime and P-Patch maps, we observed the changes in crime for census tracts that contain P-Patches during each of the three years. P-Patches that were located within a census tract that showed a decrease or increase in crime by one classification (as stated in the map legends in Figures 1 through 3) are reported in Table 2. Twenty-two P-Patches had an observed decrease in crime from 1996 to 2001, compared to only two that showed large increases in crime. However, from 2001 to 2006, the number of P-Patches with large, observable increases and decreases in crime was the same, with 12 increasing, and 12 decreasing. These changes are observed through differential color classifications and locations of P-Patches displayed in Figures 1 through 3.

The total change in crime from 1996 to 2006 is displayed in Figure 4. This map reveals that the greatest decreases in crime, as indicated by the light green areas, happened generally in South Seattle, while the majority of crime increases (blue areas) occurred in North Seattle. Twelve P-Patches were established on the north side of Seattle during that decade, compared to 17 that were established on the south side of Seattle.
Table 1. Descriptive statistics for Seattle by population per census tract (2010 census) (n = 132)

<table>
<thead>
<tr>
<th>Race</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caucasian</td>
<td>3331.59</td>
<td>1477.31</td>
</tr>
<tr>
<td>African-American</td>
<td>352.76</td>
<td>479.81</td>
</tr>
<tr>
<td>Asian</td>
<td>669.55</td>
<td>625.06</td>
</tr>
<tr>
<td>Pacific Islander</td>
<td>19.19</td>
<td>44.16</td>
</tr>
<tr>
<td>American Indian</td>
<td>33.84</td>
<td>39.55</td>
</tr>
<tr>
<td>Total Population</td>
<td>4609.89</td>
<td>1512.01983</td>
</tr>
</tbody>
</table>

**Poverty Characteristics**
- Percentage of households living below the poverty level*: 7.82%
- Household Food Stamp Usage: 209.64, 181.25

**Crime Characteristics**
- Total Crime 1996: 420.85, 476.14
- Total Crime 2006: 328.02, 262.87
- Total Property Crime 1996: 386.76, 434.34
- Total Property Crime 2006: 296.95, 230.78
- Total Violent Crime 1996: 34.09, 46.86
- Total Violent Crime 2006: 31.06, 38.72

*The poverty threshold for a family of four in 2010 was $22,315 (source: https://www.census.gov/hhes/www/poverty/data/threshld/)

Table 2. Number of P-Patches in locations with crime changes as observed in crime rate maps (Figures 1 – 4)

<table>
<thead>
<tr>
<th>Number of P-Patches in census tracts with crime changes by one crime classification</th>
<th>Percentage of total P-Patches established at that time</th>
<th>Average increase or decrease in crime</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Increase in crime from 1996 – 2001</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>5%</td>
<td>121.5</td>
</tr>
<tr>
<td><strong>Decrease in crime from 1996 – 2001</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>52%</td>
<td>-91.6</td>
</tr>
<tr>
<td><strong>Increase in crime from 2001 – 2006</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>21%</td>
<td>83.6</td>
</tr>
<tr>
<td><strong>Decrease in crime from 2001 – 2006</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>21%</td>
<td>-88.7</td>
</tr>
</tbody>
</table>
**Statistical Analysis Outcomes**

We conducted a Pearson’s correlation on P-Patch and various socio-demographic variables. The population of African-American residents per census tract had a positive, moderately strong correlation to the number of P-Patches per census tract (p < .01). Average family size had a weak, positive correlation to P-Patch number (p < .01), along with number of families receiving food stamps (p < .01). Percentage of families living below the poverty level was also positively correlated with P-Patch number, but only significant at the .05 level.

Crime rates and socio-demographic variables had multiple significant correlations, with violent crime consistently having the strongest correlation (Table 3). Total violent crime in 1996 (“TVC 1996”) had a positive correlation with food stamp usage, percentage of families living below the poverty level, and African-American population (p < .01), and was negatively correlated with median income (p < .01). Violent crime in 2001 and 2006 were similarly correlated to the same socio-demographic variables.

We found no significant correlations between P-Patch number and crime variables after conducting a Pearson’s correlation. However, we also conducted Spearman’s rank correlation analysis. Unlike a Pearson’s correlation, a Spearman’s rank correlation does not assume a linear relationship between two variables. We used this test in order to focus on identifying any relationship between our two variables without assuming their relationship is linear and also not assuming the frequency of distribution of the variables (Hauke & Kossowski, 2011). We recoded crime variables from scale to ordinal (e.g., 1-50 crimes, 51-100 crimes), in order to “rank” them by lower crime areas versus higher crime areas. The results of the Spearman’s rank correlation analysis

| Table 3. Pearson’s correlation of violent crime and socio-demographic variables |
|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
|                          | TVC 1996 n = 131         | TVC 2001 n = 131         | TVC 2006 n = 131         | Food Stamps n = 131      | Percent Poverty n = 131 | African-American n = 131 | Median Income n = 131    |
| TVC 1996                 |                          |                          |                          |                          |                          |                          |                          |
| TVC 2001                 | .968**                  | --                       |                          |                          |                          |                          |                          |
| TVC 2006                 | .931**                  | .938**                   | --                       |                          |                          |                          |                          |
| Food Stamps              | .523**                  | .527**                   | .591**                   | --                       |                          |                          |                          |
| Percent Poverty          | .415*                   | .393*                    | .449*                    | .741**                   | --                       |                          |                          |
| African-American         | .320**                  | .328**                   | .402**                   | .673**                   | .565**                   | --                       |                          |
| Median Income            | -.410**                 | -.418**                  | -.469**                  | -.642**                  | -.588**                  | -.327**                  | --                       |

** Correlation is significant at the .01 level (two-tailed)
* Correlation is significant at the .05 level (two-tailed)
showed weak, but significant, correlations between P-Patch number and violent crime for all three years, suggesting that an increase in number of P-Patches per census tract is correlated with an increase in violent crime per census tract (Table 4).

DISCUSSION

Although the results do not clearly explain a spatial or statistical relationship between P-Patch locations and crime rates, several questions about the story of Seattle’s P-Patches and crime from 1996 to 2006 have been revealed. The Pearson’s correlation did not show any significant correlations between P-Patch numbers and crime, but the Spearman’s correlation, although based on broader crime levels (e.g., low crime and high crime), suggested a weak, positive correlation between violent crime and P-Patch number. This poses questions about how neighborhood changes and characteristics are influencing crime, as well as why there have been more P-Patches established in those areas. It seems that this weak correlation may be better explained by socio-demographic variables, which were more strongly correlated with both crime rates and P-Patch numbers, and indicated that areas with higher populations of African-American residents, families with a lower median income, families relying on food stamps, and families living below the poverty level were correlated with greater numbers of violent crimes and P-Patches.

The qualitative interviews can tell us a fuller account of this issue as well. One theme brought up by the gardeners was gentrification. Seattle as a whole has gone through a gentrifying period in the last twenty to thirty years that has influenced crime rates and, possibly, garden establishment. Seattle’s gentrification has been studied in the literature. Kreager and colleagues (2011) discuss how census tracts that underwent gentrification from 1982 to 2000 showed greater decreases in total crime than those that remained predominately low-income, and that the greatest decreases in crime could be explained by targeted revitalization of areas with the highest crime rates. The exploratory visual analysis of the crime and P-Patch maps showed more P-Patches in census tracts with decreased crime from 1996 to 2001 than from 2001 to 2006, potentially during the same time that Seattle was undergoing greater gentrification. Gentrification, rather than establishment of more P-Patches, may better explain crime changes. The larger, shifting economic and demographic picture of Seattle should be taken into greater account in future research on P-Patch establishment and overall neighborhood crime changes.

Multiple gardeners also stated that their P-Patch was established out of the desire to take a crime-ridden area and turn it into a community space. Future research could examine case studies of P-Patches and the reasons they were established, and whether those established for crime deterrence were successful.

One major limitation to this study was analyzing the crime rates based on a large-scale geographic unit such as census tracts. Future research should examine crime changes around or within P-Patches on a finer level, such as census block groups or census blocks to see if the correlation between the two is strengthened as the geographic unit of analysis is reduced. Future research could also employ more sophisticated statistical analyses such as linear regression to explore whether P-Patch number effects crime rates when controlling for socio-demographic variables statistically. In addition, we also acknowledge that our use of GIS was limited to the visual representation of data and a more advanced GIS analysis, such as spatial statistics, could be used in future research to analyze a
CONCLUSION

This study employed a mixed-methods approach to explore the spatial and temporal relationship between crime and Seattle’s P-Patch community gardens. Through exploratory data analysis using a GIS and qualitative data gathered from interviews with gardeners, we discovered an interesting story about Seattle’s P-Patches and crime. Violent crime was the only crime type that was significantly, and positively correlated with P-Patch number, but the correlation was weak. Geographic visualization revealed general decreases in crime in South Seattle during the years 1996 to 2006 along with increased development of P-Patches in the same area. This could be explained by the socio-demographic characteristics of this area, or gentrification that was occurring during that time period. Interesting questions about crime and P-Patches were raised in interviews with gardeners such as whether crime is a common motivator for developing a garden. We hope this research will provide greater insight into the growing story of the Seattle P-Patch program and its effects on the urban community. The integrated and mixed research methods provide various ways to answer the main question. More importantly, it also provides a new insight into the research topic throughout the iterative and interactive engagement with visual, quantitative, and qualitative research methods.

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