Can Crowdsourcing Support Co-productive Transportation Planning in Megaregion? Evidence from Local Practice

Greg P. Griffin & Dr. Junfeng Jiao

June 2018

A publication of the US DOT Tier 1 Center:
Cooperative Mobility for Competitive Megaregions
at The University of Texas at Austin

PRELIMINARY REVIEW COPY

Technical Report Documentation Page

1. Report No. USDOT/69A3551747135	2. Government Accession No.	3. Recipient's Catalog No. ORCID: 0000-0002-7272-8805
4. Title and Subtitle Can Crowdsourcing Support Co-productive Transportation Planning in Megaregion? Evidence from Local Practice		5. Report Date July 2018 6. Performing Organization Code
7. Author(s) Greg P. Griffin Junfeng Jiao		8. Performing Organization Report No. CM2-2017-2
9. Performing Organization Name and Address Urban Information Lab, School of Architecture The University of Texas at Austin 3925 West Braker Lane Austin, TX 78759		10. Work Unit No. (TRAIS) 11. Contract or Grant No. USDOT/69A3551747135
12. Sponsoring Agency Name and Address Center for Cooperative Mobility for Competitive Megaregions The University of Texas at Austin 310 Inner Campus Drive, Goldsmith Hall, 2.308 Austin, TX 78712		13. Type of Report and Period Covered Technical Report conducted August 2017-July 2018 14. Sponsoring Agency Code
15. Supplementary Notes Project performed in cooperation with the United States Department of Transportation		
16. Abstract This project explores how different technologies (smart phone, social media, web scrapping) can facilitate co-productive transportation planning process in Megaregion. As case studies, GRAs explored bike-sharing planning in NYC, Chicago, Austin, San Antonio and Houston.		
17. Key Words Megaregions, transportation planning, bike-sharing, bike-share		18. Distribution Statement No restrictions. This document is available to the public through https://trid.trb.org/ and http://sites.utexas.edu/cm2/research/projects/ .

19. Security Classif. (of report)	20. Security Classif. (of this page)	21. No. of pages	22. Price
Unclassified	Unclassified	33	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

Table of Contents

This project supported two related studies. The first study on Austin, Texas is chapter one of this report, and the second study on bike share planning in New York and Chicago is the second chapter. Both explore public-generated knowledge through a crowdsourced geographic information system, and have implications for megaregion planning.

1. Scaling Co-productive Transportation Planning to the Megaregion: In-person and Online Approaches in Austin, Texas

Megaregion planning is an emerging concept in planning, reflecting the geographical convergence of regions in the United States, and the relationship of digital information as the primary commodity in a knowledge-based economy. Megaregional scale presents three challenges for planners: larger areas are more likely to have information gaps across the geography, they are more likely to be formatted and quality-controlled differently in different jurisdictions, and traditional face-to-face meetings are difficult to apply evenly across such a large area. Despite recent studies on potential structures of governance and other impacts related to planning, very little empirical work has been done to consider how public participation could function in a megaregional context. This study evaluates crowdsourcing as one potential perspective to support transportation planning at widely varying scales. Bicycle transportation planning in Austin, Texas, serves as case study material, focusing on the geographic breadth of public participation received at the local level using three categories of involvement: face-to-face meetings, online text-based methods, and an online crowdsourcing platform used by the city called Ride Report. Generally, crowdsourcing is on online, participatory approach that distributes a problem to communities for bottom-up input. Ride Report is a crowdsourcing platform that addresses similar challenge in bicycle planning as traditional methods—seeking to understand where the community is currently able to safely and comfortably bicycle, and where roadways present problems and barriers. This study evaluates evidence from a local bicycle transportation context to determine the challenges and opportunities for crowdsourcing in megaregional planning.

The objective of this chapter is to evaluate crowdsourcing as a method for public participation in transportation planning to scale from local and regional to megaregional contexts, through local planning evidence in Austin, Texas. This chapter includes sections on the background of online participation, description of the data and methods used, before discussion and conclusions drawn from this case.

1.1. Background

Public participation is a well-acknowledged requirement of transportation planning in most democratic societies, and is generally required at all levels: local, regional, state, and national (McAndrews and Marcus 2015). No evidence suggests that megaregional planning should be different—in fact, we can expect citizens to demand involvement in any public planning process that involves significant resources or impacts (Alexander 2001). Structures of governance and involvement are only beginning at the scale of a megaregion (Innes, Booher, and Di Vittorio 2011; Dewar and Epstein 2007; Ross, Woo, and Wang 2016; Schafran 2013; Evers and de Vries 2013). One study does report that metropolitan planning organizations may offer the flexibility to help address megaregion problems, but "without formal funding or structures, MPOs have limited time and staff to apply to megaregion planning and tend to limit participation to projects or studies with direct and immediate benefits such as interregional rail plans or data access" (Peckett and Lyons 2012). Megaregions, then, could be a particularly challenging context for participatory planning.

Traditional public participation focuses on the use of language to support and direct planning to serve the needs of the community. This approach comes from a background that focuses on the conditions of discourse as meeting communicative ideals (Innes 1995; Hoch 2007), or supports public re-framing of planning challenges and approaches of working together through collaborative processes (Healey 1997; Margerum 2002a). However, co-production between the state and public offers an alternative perspective. In co-productive planning, emphasis is shifted from words to actions—the public can be responsible for generating the data necessary for planning decisions, in addition to performing other tasks alongside, or in place of state sponsorship (Watson 2014; Albrechts 2012). However, when digital technology is involved in co-productive processes such as crowdsourcing, the digital divide implies an opportunity for bias that could further disparities by race, education, and income (Clark et al. 2013). Co-productive planning processes may support additional ways for people to guide their future communities, but integration of technologies must consider the role of distributional biases.

Genuine public involvement involves pulling people into the planning process—typically involving existing conditions, analysis of challenges, and review of draft concepts, at the very least (Federal Highway Administration n.d.). Therefore, a participatory transportation planning process for megaregions would have to solve challenges of data availability, quality, and communication across an area that currently has no governance structure to support such an effort (Innes, Booher, and Di Vittorio 2011; Curtin 2010). Participatory geographic information systems (PGIS) may offer a way to combine all three of these issues by citizen-produced data, but traditional approaches to PGIS leave open questions of accuracy and coverage (Brown 2012). Timothy Nyerges identified the need for democratic process combined with objective information about places, presenting "scaling up as a grand challenge" that community-based GIS faces (Timothy Nyerges 2005). Crowdsourcing is an online approach to solving problems with a "deliberate blend of bottom-up, open, creative process with top-down organizational goals" (Brabham 2013). PGIS that includes a specific top-down task that is guided by a platform to consolidate data formatting and accuracy, with bottom-up contributions by people knowledgeable about local conditions, amounts to what could be called a crowdsourced geographic information system (CGIS). This approach may be a match to what Peckett and Lyons identified as a future research problem specific to transportation planning for megaregions: "Uncertainty remains as to how megaregions can best encompass top-down leadership and bottom-up activities and how to transition between informal and formal megaregion activities" (Peckett and Lyons 2012).

The challenges of megaregion transportation planning are documented (Dewar and Epstein 2007), but little or no empirical research exists that suggest how public participation could scale to the megaregion, suggesting two research questions:

RQ1: What are the geographic differences of spatial representation between face-to-face meetings, an online public participation GIS, and the Ride Report crowdsourcing platform for bicycle transportation planning in Austin, Texas?

RQ2: Were the distributional biases different between the three categories of involvement?

A previous synthetic review of literature suggests that future research on participatory spatial technologies must include the actual engagement process, rather than simply examining the technologies themselves (Brown and Kyttä 2014). Therefore, this study contextualizes the analysis of crowdsourcing with an empirical case, using evidence from Austin, Texas. To address these questions requires a mixed-methods approach, including quantitative data to answer the first question, and qualitative insights for the second.

1.2. Participation Data

The data for participation come from three different public participation processes in Austin, and represent three different participation purposes. The participation methods represent professional-quality engagement efforts in a single region, but each are tailored for the separate processes. Therefore, comparison of geographies in this study must be considered in the context of each separate planning process—the comparison of different planning processes might be likened to a fruit basket, rather than ‘apples-to-apples’. This limitation is a tradeoff that enables analysis of real, *ex post* participation within one region, rather than simulated or modeled results that may show little about the way actual participation methods work. Data show actual results in the context of its own planning case within the Austin region.

1.2.1. In-person Meetings

In-person meetings were held for development of the 2014 Austin Bicycle Master Plan Update, and were one part of a broad engagement process that included a telephone survey, an urban trail intercept survey, an online survey, a virtual open house, and discussion at multiple City of Austin boards and commissions meetings (Austin Transportation Department 2014). Though few in number, the meetings connected interested persons with city staff directly—a rich engagement approach not afforded by online methods. Table 1 shows that 144 people participated in the in-person meetings, contributing input on the draft plan concepts before further review by the city’s boards and commissions.

1.2.2. Public Participation Geographic Information System (PPGIS)

The Capital Area Metropolitan Planning Organization (CAMPO)—the regional transportation planning agency for the Austin area—used a public participation geographic information system (PPGIS) called “WikiMaps” in development of the 2045 Regional Active Transportation Plan (Capital Area Metropolitan Planning Organization 2017). This method supported public contribution of knowledge to the planning process through an online tool that allowed people to click a location on a computer-based map, and identify barriers and other issues for bicycling and walking. Since this organization’s focus is region-wide—a seven county area surrounding the capital city—the geography of participation is expectedly broad, in comparison with methods focused only on the city. Table 1 shows more than twice the number of people involved, compared to the city’s in-person meetings, which is comparable with the overall population of the region as nearly double that of the core city.

1.2.3. Ride Report in Austin

Ride Report is a smartphone application used by the Austin Transportation Department that records contributors’ bicycle trips, detected automatically using the phone’s accelerometer and GPS (City of Austin 2018; Ride Report 2016). The app detects the conclusion of a bicycle trip, and prompts users to rate a ride as positive or negative. The platform aggregates multiple overlaid trips by all participants to compute an average rating, in addition to recording the total count of users for each roadway and trail segment. In this way, Ride Report provides planners with information about bicycling in a city as reported by its users. Table 1 shows use by 1,234 people in the Austin region, but note the time period involved is longer than three years to date.

Table 1. Sources of Participation Data

	Dates Used	Agency	Count of Features	Persons Involved	Purpose of Participation
In-person Meetings	11/12/13-4/2/14	City of Austin	7	144[a]	Receive public input "before the plans were taken to boards and commissions for review"(Austin Transportation Department 2014)
PPGIS	11/28/2016-2/17/17	CAMPO	143	358[b]	"allowed residents to identify barriers and difficult routes for walking and biking" (Toole Design Group 2017)
Ride Report	4/4/15-5/31/18	City of Austin	23,693	1,234	"help to inform how the City prioritizes investments in the bicycle network" (City of Austin 2018)

Notes: [a]City staff report notes "86 participants completed a paper questionnaire and 58 completed the same questions offered in an online survey" at meetings. This. [b]PPGIS consultant summary notes 358 participated in the broader survey, and an exact count of people noting bicycle barriers is not available.

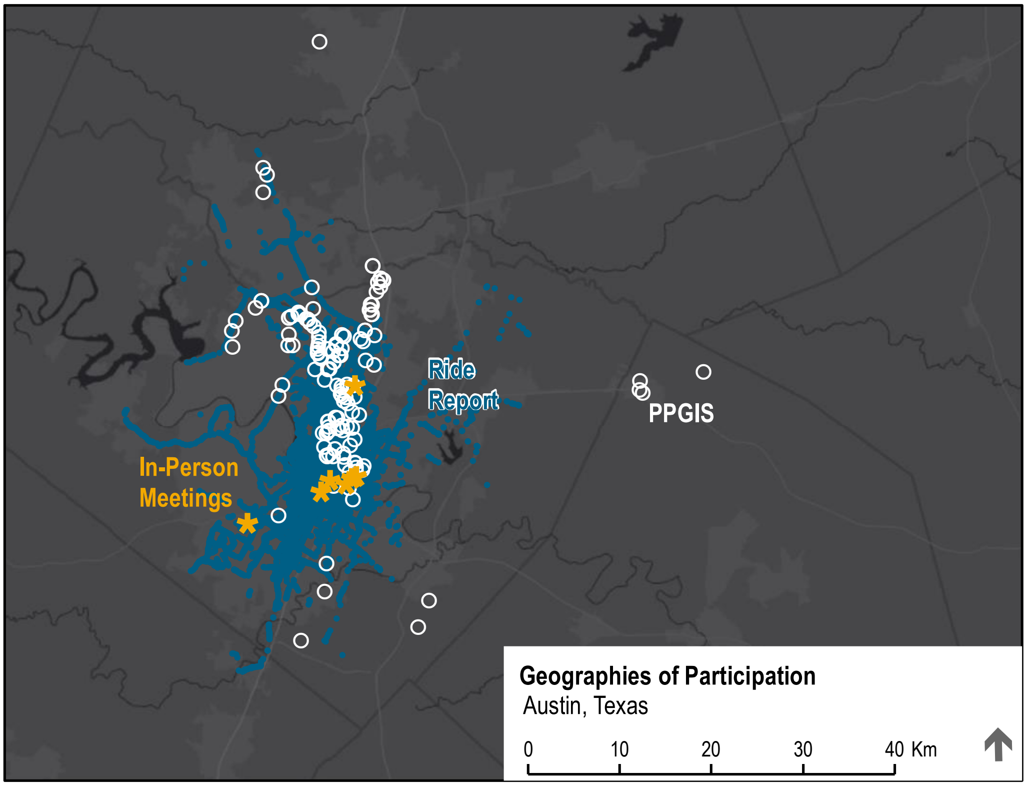

Figure 1. Participation Geographies of In-Person Meetings, PPGIS, and Street Segments Rated on Ride Report

1.3. Spatial Analysis Methods

The first research question is addressed using case study and crowdsourcing materials gathered from Austin-area bicycle planning staff and from Ride Report. City meeting records for recent planning efforts were obtained, identifying geographic locations for the location of participation. Each of the participation methods was geostatistically analyzed in terms of spatial extent. Finally, individual interviews with at least two bicycle planning staff at the City of Austin was used for two purposes. First, the city planners' insights helped evaluate initial quantitative findings of RQ1, providing member checking as a form of external validation (O'Cathain 2010; Finlay and Bowman 2016). Second, interviews help describe how planners actually used the three types of participation, and worked through issues of geographic scale.

The second research question builds from analysis of RQ1, comparing the spatial location of the three involvement methods with educational attainment and income levels associated with the locations of each. Descriptive statistics and analysis of variance will indicate differences between the methods, in terms of the level of distributional bias observed from the case materials. Planner interviews were used as a check against the initial findings, and offer insights as to potential methods to mitigate biases present.

1.4. Geography of Participation Results

Calculation of the directional distribution of participation through a standard deviational ellipse of each participation technique simplifies the geographic range of participation. Figure 2 shows the second standard deviation, including 95% of the participation points for each method. By excluding the same percent of spatial outliers, this approach provides a comparable analysis, recognizing that each method was part of a unique planning case for different purposes.

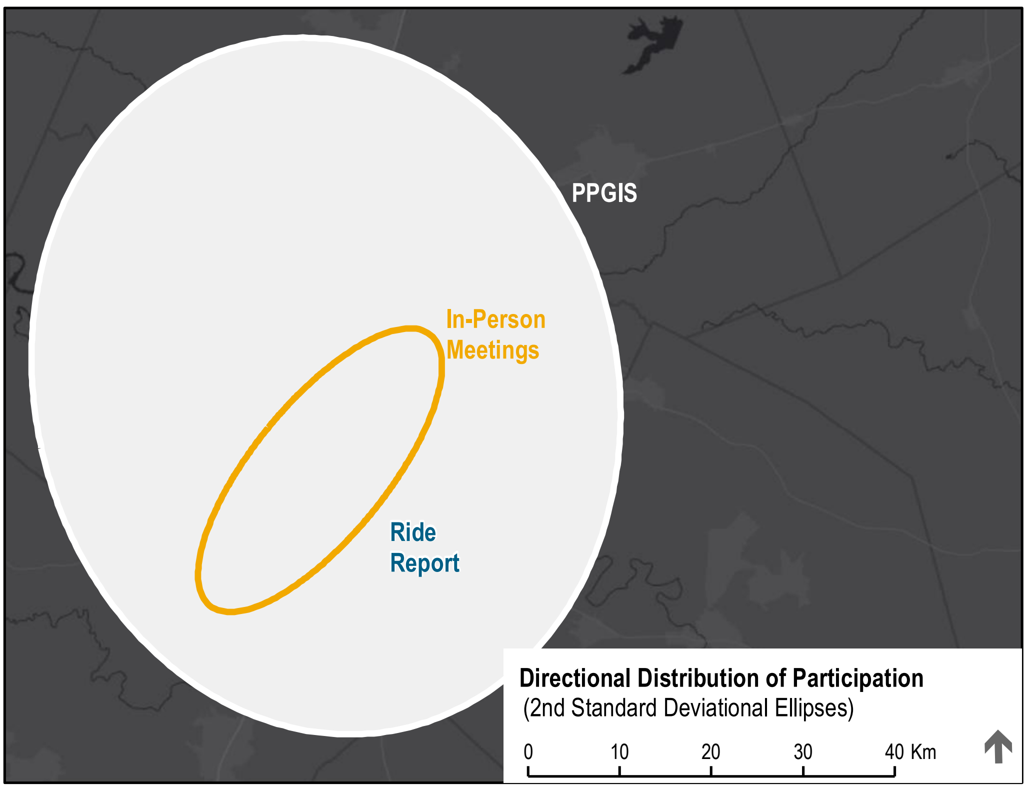

Figure 2. Directional Distribution of Participation

Table 2 shows the participation geography of the PPGIS used by CAMPO to be largest by far, which is appropriate considering the larger geography of the agency's representation. This online tool shows the potential for use across a large area, without participants having to meet at a given location at a certain place and time. The directional distribution in Table 1 shows the northeasterly skew of in-person meetings, with a more north-south orientation of Ride Report, likely reflecting the distribution of bicycling in the core area of the region.

Table 2. Geography of Participation through the Standard Deviational Ellipse

	Sq. Kilometers	Rotation (degrees from North)
In-person Meetings	435.2	39.9
PPGIS	3,802.0	167.9
Ride Report	244.0	8.8

1.5. Potential for Distributional Bias Results

The geographies of participation also relate to a potential income bias, as well. Figure 2 shows the percent of low-wage worker by census block group in 2010, through longitudinal employer-household dynamics (LEHD) data from the Smart Location Database (Ramsey and Bell 2014). Figure 2 shows the highest levels of low-income households in the east-southeast area of the central city, in addition to the rural edges of the region.

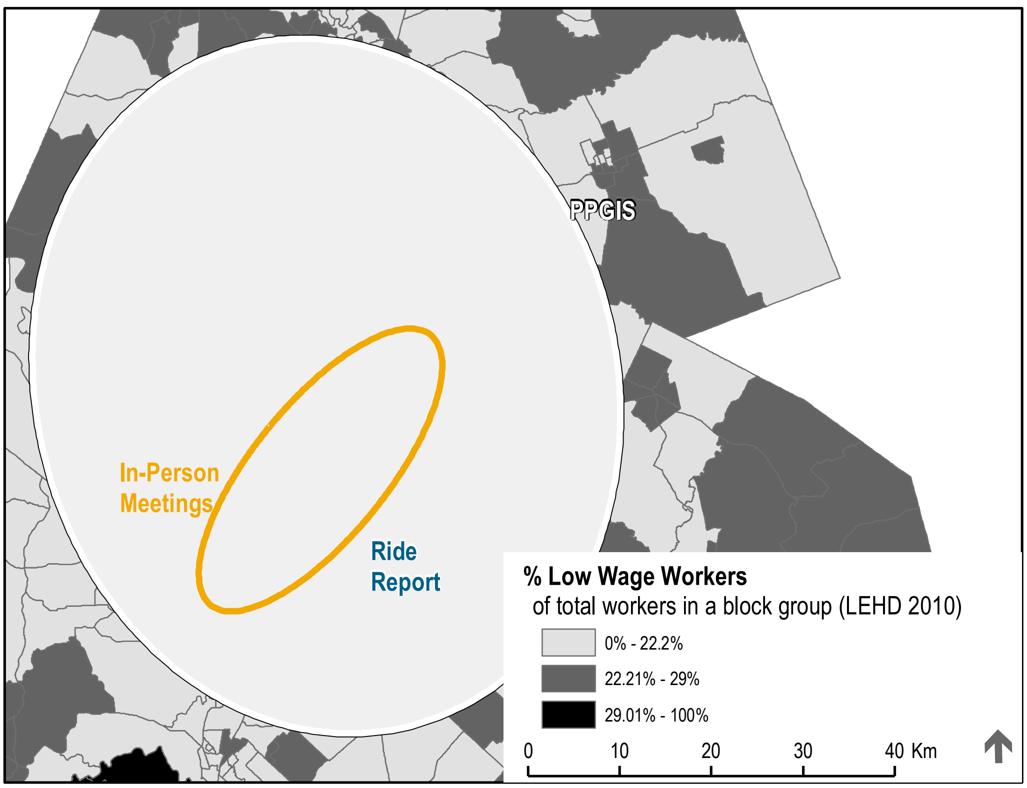

Figure 2. Directional Distribution of Participation

When simplified through averages among block groups with their centers in each participation geography, Table 3 shows Ride Report use covers areas with the largest percentage of low wage workers, as compared with other engagement approaches and the region as a whole. This does not mean that the users of Ride Report necessarily represent low-wage workers, however. More research is needed to determine whether there are significant differences in the routes chosen by Ride Report users as compared with the broader population, or low wage workers in specific. However, the geography of participation reviewed in this study does suggest that online crowdsourcing approaches for public participation are not necessarily representing higher-income areas.

Table 3. Geography of Participation through the Standard Deviational Ellipse

	% Low Wage Workers of total workers in a block group (home location), 2010	
	Mean	**Standard Deviation**
In-person Meetings	23.75	5.64
PPGIS	21.72	6.23
Ride Report	24.91	5.88
Austin-Round Rock-San Marcos MSA	22.96	6.13

Interviews with two planners in Austin show concern for bias in participation via crowdsourcing centers around access to technology, rather than location of the resident or in-person participation. One planner suggested that crowdsourcing does not represent the entire population, simply describing that “bias should be assumed until proven otherwise”. The planner continued, noting that ideal crowdsourcing tols would include “feedback systems to reach new desired users

Another planner suggested a difference between not being able to control whether participants had smart phones that would give them access to “tools like Ride Report, Strava, or others [that rely] on cooperation from the community,” and whether people “hear about the tool and are willing to use it”. Therefore, the planners provided both in-person and online methods of participation, and found interesting ways to connect the two. Interviews showed that more recent planning work by the Austin Transportation Department (following the 2014 Bicycle Master Plan) includes staff present at public meetings with tablet computers to facilitate digital input from in-person participants. In this way, planners provide a variety of methods for public input, yet consolidate the information using tools that are efficient for the planners.

When questioned about the overall impact of crowdsourcing on transportation planning, one planner described it as “generally positive”. However, they suggested it “requires transportation professional[s to] have a strong understanding of the limitations as to the crowd they are sourcing to make sure that those populations that lack access to tools that crowdsourcing relies on are not underrepresented in the decisions”.

1.6. Implications for Megaregional Planning

This study shows three main implications for transportation planning in megaregions. Crowdsourcing tools scale geographically, providing a practical method for engaging populations across large areas. The PPGIS showed use across the largest area, but this could be related to CAMPO's broad regional outreach; whereas the City of Austin's efforts were logically related to the core area. Crowdsourcing is co-productive in the sense that people can contribute knowledge about specific planning topics in a structured manner for use by planners. Crowdsourcing tools facilitate gathering this information with GIS attributes such as latitude, longitude, and time, in addition to related variables, in a way that planners can easily incorporate into a planning process. Optimally, this facilitates incorporation of public input that actually lead to planning results. Interviews with planners suggest the methods are practical, even if they raise important questions about bias that require careful approaches. Finally, multiple methods reach the broadest population meaningfully. Planners explained that they find crowdsourcing tools useful in their work, and practical for participants, but that some bias must be expected when digital tools are used. Planners in the City of Austin and CAMPO use a range of tools to broaden public engagement, while structuring input that can be useful.

1.7. Conclusions

Crowdsourcing methods may be useful for gathering structured public input over large areas, which are likely to be particularly helpful for megaregion-scale planning. These examples of planning from local and regional transportation planning suggest potential along these lines, but more research is needed to evaluate real impacts over the medium and long term.

None of these seeming advantages and problems should suggest that crowdsourcing tools provide a useful alternative to in-person participation in traditional public meetings. Rather, interviews with planners show increasing need to find ways to combine a variety of methods in a way that is practical for both broad publics and planners. As the city and region's long-range plans are put into practice, the programming of funding and completion of projects will provide additional data to evaluate the ex post impacts of crowdsourcing as a public engagement method.

2. Crowdsourcing Bike Share Station Locations: Empty voices or powerful participation?

Please cite the following version of record of this paper, available from the link below or gregpgriffin@utexas.edu.

Griffin, Greg P., and Junfeng Jiao. 2018. "Crowdsourcing Bike Share Station Locations: Evaluating Participation and Placement." *Journal of the American Planning Association* 84 (3). https://doi.org/10.1080/01944363.2018.1476174.

The section that follows is an earlier version of this paper.

Public participation is a key element in most formal US planning processes. Ensuring public participation is at the core of the American Planning Association's ethical principles, addressing a planner's responsibility to "recognize the rights of citizens to participate in planning decisions" (APA 1992). The American Institute of Certified Planners' Code of Ethics and Professional Conduct further specifies the need to "give people the opportunity to have a meaningful impact on the development of plans and programs that may affect them" (AICP 2016). Planners now widely include digital participation methods in their practice, intensifying questions about the efficacy and legitimacy of citizen input. We assess evidence on how planners use crowdsourcing as a form of participation through cases of bike share system planning in New York (NY) and Chicago (IL).
We question whether the use of a specific participatory technology—a map-based crowdsourcing platform—is merely a new medium for empty participation or if it genuinely supports new ways for planners to work with the public. We evaluate whether a specific type of participatory technology, public participation geographic information systems (PPGIS) designed to crowdsource information and knowledge to inform planning decisions—in fact influences planning decisions about where to locate bike sharing stations in two US cities.

New York and Chicago each used a PPGIS in conjunction with more traditional neighborhood meetings and community workshops to solicit the views of stakeholders on where to locate bike share stations. Participants could specify the precise location of a suggested bike share station and offer a written defense of their suggestions. We asked two research questions: First, how well do publicly suggested stations predict where the stations will be built? Second, how do the written comments vary across the bike share system? We found over 80% of suggested stations were within a quarter-mile of a built bike share station, but fewer than ten percent were within 100 feet of a built station. In both cities, participants suggested significantly more stations in downtown than the other areas. They were likely to defend their site selections through perspectives of demand, convenience, safety, and sustainability.

We believe our findings have three lessons for planners. First, PPGIS provides a practical approach to collect geographically-specific information for urban planning. Second, PPGIS platforms should include fundamental planning constraints, such as setting spatial boundaries for the planning decisions being made. Finally, planners and researchers should continue to evaluate PPGIS efforts to analyze large data sets created from online public involvement processes.

We first discuss the foundations of participatory planning and the role of new technologies in these processes; we then provide background on the use of PPGIS in New York City and Chicago, our methods, and results. We conclude with broader findings and implications for planning.

2.1. Planning with the crowd

2.1.1. Co-productive Planning

Urban planning in democratic countries has supported participatory processes since the late 20th Century, valuing input from citizens and using their ideas explicitly in decision-making, albeit at varying levels (Alexander 2001; Healey 1997; Margerum 2002b). Participatory planning opens a decision-making process to the people likely to be impacted by the ultimate decisions. Planning without a meaningful participatory element runs contrary to traditional tenets of representative democracy, including leadership that respects and understands public views, or at least those of voters (Campbell and Marshall 2000). Public participation is at the core of current planning practice and is often mandated in formal planning processes by various levels of government (Brody, Godschalk, and Burby 2003; Sciara 2017). Empirical studies demonstrate that the breadth and depth of public involvement contributes to plan strength and implementation (Burby 2003).

Co-production involves participants by emphasizing *doing* planning versus *talking* about planning, spotlighting actions those stakeholders may undertake in concert with government organizations, rather than emphasizing the role of communication. Co-productive actions are those in which the public performs needed planning roles otherwise conducted by planners within an agency (Watson 2014). Co-production in bike share planning allows and encourages the public to share perceptions and opinions and submit ideas for station locations based on their own experience of the environment. Those community insights could then result in a valuable GIS dataset that planners could integrate with other sources needed to choose the best locations for bike stations.

A public process requires broad representation, which may be facilitated by, or even require the use of multiple involvement methods including on-line based technologies including social media (Evans-Cowley and Griffin 2012; Schweitzer 2014). Many scholars and participants, however, question the validity and legitimacy of a range of participatory processes (Forester 2001; Trapenberg Frick 2013). Technology-supported public involvement, while useful, may be insufficient to open the planning process to all relevant stakeholders (Desouza and Bhagwatwar 2014).

Afzalan and Muller (2018) reviewed the literature on the strengths and weakness of a variety of online participatory techniques, noting that any online participatory tool inherently excludes those without technology access, knowledge, or interest. Participants, moreover, may be limited in the kind of information they can provide on various platforms, while planners may be limited in their ability to evaluate and analyze the data produced. They find that planning agencies are often poorly equipped to make the best decisions about which technology to acquire and the staffing and training needed to operate these platforms successfully, protect user privacy, and appropriately use the data.

Planners are expanding their use of online participatory technologies to incorporate crowdsourcing approaches. In crowdsourcing, an organization like a planning agency requests information and ideas from a large and relatively open group of Internet users. In each instance, participants use an online portal, through a computer or smartphone, to provide needed information, ideas, or value judgements in response to a direct request by planners. Planners have used crowdsourcing techniques to identify and assess historic structures (Minner et al. 2015); collect travel data (Griffin and Jiao 2015), and to assess property conditions in New Orleans (Thompson 2016). Some scholars suggest that crowdsourcing might support planning in a manner that is convenient to participants and geographically specific, providing data useful to planners (Evans-Cowley and Hollander 2010; Griffin 2011; Kahila-Tani et al. 2016). Afzalan and Muller (2018), however, note concerns about how well planners can use some or all data provided online.

The majority of studies evaluating participation in planning focus on assessing the plan before actual implementation takes place (*ex-ante* or *a priori*), or during implementation, termed *ongoing* by Guyadeen and Seasons (2018). Time lag and complexity are two issues that prevent many planning evaluation studies from connecting process with completed real-world outcomes through *ex-post* evaluations—a significant gap in knowledge about the effectiveness of planning

(Guyadeen and Seasons 2018). Bike sharing is implemented quickly, relative to other transportation improvements, which supports *ex-post* evaluation with a minimum of intervening complexities.

2.1.2. Evaluating the role of PPGIS in Planning for Bike Sharing

Online public technologies create new opportunities for reaching audiences and stakeholders for participatory planning but create new challenges for planners and publics as well (Afzalan and Muller 2018). Civic-oriented software developers have launched replicable PPGIS platforms for collecting geographically-based public input on a variety of topics. PPGIS and bike sharing technologies are stabilizing, yet the evaluation of PPGIS in planning is not yet settled.

Most studies of PPGIS tend to evaluate the tools and methods (*ex ante* or ongoing assessments), rather than the outcomes of the participatory process (Brown and Kyttä 2014). Planning agencies using PPGIS seldom have the time and resources to perform systematic evaluations of the relationship between public inputs and results of planning (Guyadeen and Seasons 2018; Afzalan and Muller 2018); academics have avoided evaluating the outcomes of PPGIS processes because of the time delay involved in seeing projects come to fruition. A 2015 study analyzed the relationship of suggested bike share locations with bike share checkouts and returns in Washington, D.C., and New York, finding a "moderate correlation between crowdsourced suggestions and station usage" (Owen, Neita, and Froehlich 2015, 1), but did not evaluate the planning process. A 2016 case study of four United States bike share PPGIS platforms analyzed the potential for representative bias among platform users (Piatkowski, Marshall, and Afzalan 2017). The researchers found that the residential locations of PPGIS contributors were not representative of the community at large—they concluded that using only the online platform could exacerbate problems in equity of access to the bike share system (Piatkowski, Marshall, and Afzalan 2017). Another study of PPGIS use in planning for Muncie (IN) corroborates the previous bike share study, showing bias in geographic representation (Radil and Jiao 2016). A case study of bike share planning in Cincinnati (OH) provided an example of a city that relied on the PPGIS for public input, while holding in-person meetings only with business owners and similar stakeholders (Afzalan and Sanchez 2017). They found planners' available time, skills, and funding restricted use of public comments, suggesting qualitative content analysis skills may "help planners analyze the comments more quickly and easily" (p. 42). The two planners interviewed for the study found the ability to combine suggested bike share locations with other GIS data useful but did not use the written comments offered by participants in the PPGIS. A review of fifteen years of PPGIS research argues that "rigorous evaluation of PPGIS outcomes, in contrast with PPGIS tools, is arguably one of the most critically important research needs" (Brown and Kyttä 2014, 134). Applied to bike share planning, Brown & Kyttä's finding suggests a key outcome would include the location of constructed bike share stations—the focus of the present study.

2.1.3. Bike Sharing in New York and Chicago

Bike sharing systems provide access to bicycles in cities, either for rent or at no cost to users. The number of public bike sharing systems has increased quickly in recent years, from only 13 cities across the globe in 2004, to 855 city systems by 2014 (Fishman 2016). New York and Chicago's bike sharing systems in 2016 and 2017 use permanent docking stations, where users can check in and out bikes using credit cards. Figure 4 shows a bike station in the Citi Bike system in New York City.

Figure 4. Bike share station in upper Manhattan, New York City. Photo by New York City Department of Transportation (CC BY-NC-ND 2.0).

Bike share systems offer benefits to individuals and communities, subject to local conditions impacted by planning. Short trips taken via bike share are comparable in speed to taxis in New York during rush hour (Faghih-Imani et al. 2017). Bike share ridership is linked to residential and employment density and proximity to rail stations in New York (Noland, Smart, and Guo 2016) as well as to how extensive the service area is (Ahillen, Mateo-Babiano, and Corcoran 2016). New York and Chicago both have robust systems by these measures, supporting options for urban transport.

Development and expansion of the systems in New York and Chicago provided us with critical cases to evaluate the impact of the use of PPGIS on planning outcomes. New York's Citi Bike and Chicago's Divvy bike share program are the first and third largest systems in the United States based on the number of bikes available (second is the Capital Bikeshare in Washington, D.C.) (O'Brien 2018). Citi Bike launched in late May 2013 with 6,000 bikes and 332 stations in Manhattan south of 59th street and in Brooklyn north of Atlantic Avenue and west of Nostrand Avenue (Citi Bike 2016a). Divvy launched in June 2013 with 750 bicycles and 75 stations in an area from the Loop north to Berwyn Ave, west to Kedzie Ave, and south to 59th street, rapidly growing to 4,000 bicycles by 2014 (Citi Bike 2016a; Faghih-Imani and Eluru 2015). By the end of 2015, Citi Bike served nearly 45 square miles of New York and into New Jersey, and Divvy covered 145 square miles of the Chicago region. Primary startup funds for Citi Bike came from private sponsorship—including its namesake bank. Conversely, government grants supported Divvy's initial rollout, including "$18 million in federal Congestion Mitigation and Air Quality Improvement Program funds and $3 million in municipal funds" (Cohen and Shaheen 2016).

Both systems expanded significantly in 2016; Divvy into the communities of Oak Park and Evanston north and west of Chicago, and Citi Bike into Jersey City, the Upper East Side & Upper West Side in Manhattan, and added new stations in Brooklyn (Citi Bike 2016b; Motivate International and Divvy Bikes 2016). By September 2017, Divvy had 5,800 bikes in its system with 580 stations in Chicago, Oak Park, and Evanston. Citi Bike had 10,000 bikes and 706 stations in New York and Jersey City. Citi Bike stations are 976 feet apart, on average, and Divvy stations are only slightly wider-spaced, at 1,020 feet average between stations by our calculations, similar to systems in Montreal and Paris (García-Palomares, Gutiérrez, and Latorre 2012).

Both cities have dense populations, mixed land uses, and an extensive system of highly connected streets—factors considered supportive of bike share use and bicycling in general (O'Brien, Cheshire, and Batty 2014; J. R. Pucher and Buehler 2012). Chicago is a city of over 2.7 million residents, less than a third that of New York City which had 8.6 million people in 2015 (U.S. Census Bureau Population Division 2016). Chicago leads the nation in the extent of its protected bike lanes, however, with 161 linear miles, as compared with New York City's 51 miles of protected bike lanes (Alliance for Bicycling and Walking 2016). Bike lanes protected by buffer space, flexible posts, parked cars, or other traffic devices, may increase both real and perceived safety for bicycling (Lusk et al. 2013; Thomas and DeRobertis 2013) making cycling attractive to a broader spectrum of the population, including women (Dill et al. 2015). In 2016, both New York and Chicago had over two linear miles of protected and unprotected bike lanes and paved paths per square mile of area—ten times that of the average large city in the United States (Alliance for Bicycling and Walking 2016). Roughly 1.4% of Chicago commuters bicycle to work, versus 1.0% in New York; although the data on which these estimates are based only count cycling as a commute mode when it is the primary mode to work (and not, for example bicycling to and from transit stops) (Alliance for Bicycling and Walking 2016; Whitfield, Paul, and Wendel 2015).

Participants in both systems followed a similar process to use the PPGIS. The platforms in both New York and Chicago were based on an open-access software platform that provided a map of the city with existing bike share station locations, a map of the station locations suggested previously by other participants, and a large "Suggest a Location" button that allows participants to identify a new station site (OpenPlans 2013). After suggesting a location, participants are prompted to respond in a two-line text box: "this would be a great location because…" for Citi Bike, and Divvy has a similar prompt for a simple "description." These two contributions—the location suggestion and a written description—are the PPGIS data source for this study. The platforms also incorporated 'liking' and commenting on others' suggestions, and included social media links to allow participants to spur interest from others online. Both cities also organized neighborhood meetings, community workshops with paper-based mapping sessions, although the PPGIS was a central form of participation (New York City DOT 2013; Vickers 2013).

2.2. Connecting Suggestions and Stations

We developed a method to assess how well bike share station locations suggested through PPGIS platforms in these two cities predicted where the bike share stations were later placed, in addition to finding what the written descriptions tell us about suggested station locations. To do this, we compared the suggested locations against the built stations in New York and Chicago using three data sources: online records of the planning process, spatial locations of suggested stations and built stations, and the participants' written descriptions of the locations. We analyzed these data using three approaches.

First, we reviewed the planning process and use descriptive statistics to compare how close suggested stations were to built stations in each city. Descriptive statistics provide answers to our fundamental question relating to the proximity of suggestions and built stations.

Second, we used a spatial analysis method (local Moran's *I*) to identify spatial clustering of built stations in relation to suggested stations (Esri 2016; Anselin 1995)(Esri 2016; Anselin 1995). This approach reveals whether the proximity between built stations and suggested stations is due to random chances. Spatial clustering matters here because if many bike stations clustered far from suggested locations, we might conclude that planners in siting stations may have ignored these areas.

Finally, we interpret written descriptions of site suggestions in sampled areas of each city, showing variation from the center of each system to its outer edge. Our sampling approach supports analysis of participant descriptions in specific locations, providing ground truth for three areas covering a square mile (259 hectares) each in these two cities.

2.3. Evaluating where Bike Stations were Located

Both Citi Bike and Divvy used the Shareabouts platform created and shared by Open Plans (OpenPlans 2013) to gather data on where participants suggested locating bike share stations in New York and Chicago and how they viewed bike share programs. We accessed the PPGIS databases through the Shareabouts application programming interface (Hebbert 2016). We downloaded the location suggestions to represent all submissions from the date each platform was set up for planning of each city's significant expansions following initial rollout—Citi Bike starting October 28, 2014, and Divvy starting February 11, 2015—ending when we web-scraped the PPGIS sites on March 26, 2016. We excluded suggestions after December 31, 2015, to focus on PPGIS suggestions contributed in late 2014 through 2015, which could have influenced the planning of subsequent stations. This approach yielded 4,744 locations from New York's Citi Bike system, and 5,318 comments from Chicago's Divvy system.

Each system has had multiple waves of expansions and minor relocations over our data collection period. The location of bike share stations are relatively permanent, but cities may relocate stations to alternative locations on a temporary or permanent basis, because of financial constraints, construction projects near a station (NYCDOT 2015; Divvy Bikes 2015), and even legal threats (Briquelet 2013). We collected bike share station locations from each system's ridership data as they existed as of August 3, 2016.

We had to undertake several steps to ensure we analyzed suggested locations in a way that relates to how planners use the data for system planning. First, we excluded suggested locations outside the service area of the system. PPGIS did not automatically require suggestions within a realistic boundary—neither bike share program imposed any locational requirements on public input. We defined two distance thresholds for whether a built station served a suggestion either directly (100 feet or 33 meters) or indirectly (1/4 mile or 402 meters). The 100-foot threshold is set to approximate a reasonable distance for a station location to meet the direct intent of a PPGIS contributor. The field of view from a specific point, called an *isovist* (Benedikt 1979), is a useful concept for relating the visual experience of a streetscape (Batty 2001). We propose 100 feet as a reasonable distance, considering a person is likely to have a clear sight for 100 feet in most streetscapes. Previous research also shows that people are more likely to use bike share stations when they are located closely together, with a minimum station spacing of approximately ¼ mile, but relative benefits decrease as station proximity approaches 400 feet (122 meters) apart (García-Palomares, Gutiérrez, and Latorre 2012; Noland, Smart, and Guo 2016).

Second, we used a local Moran's *I* geostatistic to detect any spatial clusters of built stations (Anselin 1995). This approach helps identify whether there are spatial clusters where built stations were relatively near or far from suggested stations and whether these clusters were due to random chances.

Third, we devised a sampling approach to enable interpretation of specific suggestions. We adapted a transect-based method and centered sampling boxes in GIS, covering one square mile (259 hectares) at three locations in each system: the bike share station closest to the geographic center of the system, the station furthest from the center, and the station closest to the midpoint between these extremes (Figure 5).

Figure 5. Map of Square Mile Transect Samples of Divvy and Citi Bike Suggestions

2.4. Results of Crowdsourcing PPGIS and Planning Bike Share in New York and Chicago

Participants on both the Citi Bike and Divvy PPGIS platforms suggested a total of 10,062 individual bike share locations within the study period. There were 4,744 and 5,318 suggested stations for the New York City and Chicago areas, respectively. Eighty-five percent of Divvy Bike suggestions and 43% of Citi bike suggestions were within the boundary of the systems as of 2016. Due to the lack of clear spatial boundary and guidance, most of the suggested stations in New York were outside of the system boundary and thus excluded from the analysis. In total, 6,529 (NY: 2,022 and Chicago: 4,507) suggested bike share locations were included in this analysis.

2.4.1. Planning Process Evidence

Our review of the planning process descriptions available online in both cities show that planners used the suggestions on the PPGIS platform in decision-making—but only as one method of public participation along with more traditional methods such as public meetings and hearings. In New York, planners used an iterative process to choose many potentially viable sites including responses from the PPGIS. They started with geographic information for bike share planning, including "proximity to transit and other destinations, distance from other stations, access and proximity to bike lanes" in their bike sharing system planning process (New York City DOT 2013, 18). Planners evaluated the viability of sites suggested on the PPGIS; they then brought a reduced list of potential and viable sites back to the public at in-person meetings. Planners mounted large maps at those meetings and invited participants to manually annotate potential sites on the map with red "No" arrows and green "Yes" arrows. Citi Bike planners reported conducting 159 public meetings, presentations, and demonstrations of the system, between September 2011 when the concept was unveiled and late 2013 (New York City DOT 2013). New York City DOT staff reported synthesizing and reviewing all of the input received from all sources of public participation, conducting studies of the technical feasibility of Citi Bike station suggestion portal (New York City DOT 2013). They then ranked suggested stations by priority, reporting that, "stations that received votes via the [PPGIS] website were prioritized over stations that had not" (New York City DOT 2013, 18).

In Chicago, Mayor Emanuel announced the expansion of Divvy from the original boundaries near downtown, which would involve significant community engagement and review new stations suggestions collected from the PPGIS website (Claffey 2015). Neither Divvy, nor the Chicago DOT provides a comprehensive report on the planning process as in New York, but they do provide detailed information about planning at focused expansion sites. For instance, Divvy described the expansion process into Evanston on the north side of Chicago (Divvy Bikes 2015). Planners used "data from a survey during the City's Bike Plan Update, a Northwestern University Industrial Engineering capstone project, a community meeting, an online survey [the PPGIS], and paper surveys provided at the Levy Senior Center and Evanston Public Library's Main Library" (Divvy Bikes 2015).

2.4.2. Public Suggestions as a Predictor for Bike Share Station Location

We first assessed the relationship between the locations of the suggested station within system boundaries and the locations of built stations in each city. Many of the differences in the average distances between suggested and constructed stations in both cities are likely associated with their geographic characteristics—New

York's service area is spatially smaller, yet is more densely populated and constrained by waterways. Moreover, logical locations for bike share stations are limited by spatial constraints of streetscapes, including utilities, transit stops, accessibility requirements, vehicle parking, and other issues. Regarding evaluating planning, this creates problems of *multicausality* (Talen, 1996; Guyadeen and Seasons, 2018)—where there may be intervening issues that complicate connecting factors with final outputs, like PPGIS contributions and construction of bike share stations. We can therefore only draw limited conclusions by comparing the spatial distances between suggested and constructed bike share stations.

Table 4 shows that the average Citi Bike station was placed 625 feet (190 meters) from its suggested location. The average distance between suggested and constructed stations was 909 feet (277 meters) in Chicago's Divvy bike share program, which is less than the "1,000 feet or five minutes walking" recommended by a practice guide (NACTO 2015), or 1/4 mile (402 meters) researchers estimate people will walk to a bike share station (Noland, Smart, and Guo 2016). Table 5 shows that over 80% of the stations were placed within a ¼ mile of a suggested location in both cities. However, fewer than 10% of the stations were less than 100 feet from sites suggested on the PPGIS platform. There may be intervening site conditions that could prevent feasibility of a given location, but this finding suggests that the PPGIS contributions might not be the key information for locating bike share stations. New York City DOT presentations by staff to community boards consistently described the process as "DOT and Citi Bike…working with communities to find best locations for Citi Bike stations in their neighborhoods" (NYCDOT 2015). The presentations further describe the "public web portal" as only one form of input among "meetings with elected officials, community boards, local institutions and stakeholders" and "community planning workshops" (NYCDOT 2015).

Table 4. Distance from suggested location within service area to built location (feet)

	Minimum	Mean	Maximum	Standard Deviation
Citi Bike	7	625	3,513	463
Divvy	0	909	9,899	994

Bike share systems tended to build more stations near suggested stations in Downtown Chicago, Upper Manhattan and the Williamsburg neighborhood in Brooklyn, New York. The inverse is also true—suggested stations were further from constructed stations in the suburban fringes of Chicago and the outer reaches of the Citi Bike system in New York. There were four times as many locations suggested for Citi Bike than were eventually built and almost eight times as many locations for Divvy.

Table 5. Suggested bike share locations

	Suggested Locations	Stations Built	Suggestions per Station Built	Suggestions with stations built within 100 feet (30.5 meters)	Suggestions with stations built within ¼ mile (402.3 meters)
Citi Bike	2,022	523	3.9	105 (5.2%)	1,875 (92.7%)
Divvy	4,507	577	7.8	436 (9.7%)	3,645 (80.9%)

We performed additional spatial analysis to explore the role of suggested locations in determining future station locations. In the local Moran's *I* calculation, clustering includes whether neighboring features have similar characteristics (Esri 2016; Anselin 1995)—in this example, the distance from a built station to the nearest suggested station. Models showed 17% of Citi Bike stations were in spatial clusters close to PPGIS suggestions, and 7% of them were in clusters significantly far from suggestions. Remaining stations were not clustered regarding their proximity to PPGIS suggestions. Results in Chicago were similar, with 16% of stations in clusters near suggestions, and 11% of stations in clusters far from suggestions. This shows that despite the differences in geography and planning process in the cities, the overall spatial relationship between suggested stations and built stations were similar.

2.4.3. PPGIS Site Descriptions from Sampled Downtown, Middle, and Outer-edge Bike Share Station Locations

A sampling of three square mile areas along a transect in each system supported interpretation of participants' written station site descriptions and reasonings. Figure 2 shows the sites in both cities, with a square mile downtown centered on the central bike share station, an outer-edge site at the bike share station furthest from the center, and a third site positioned over the bike share station halfway between each site. Table 6 shows a much higher density of PPGIS suggestions in downtown areas, fewer in areas further out, and even fewer in suburban areas, with no suggestions in the sampled area of Greenville in New Jersey. Conversely, there were more than fifteen suggestions for Divvy stations in North Park for every station constructed in the sampling area, suggesting higher public participation than was ultimately supported. The content of the descriptions varied about both the geographical position of the sampling site in the cities and by distance to built stations.

Table 6. PPGIS sampling square mile areas (259 hectares each)

	Suggested locations with descriptions	Suggested locations without descriptions	Built stations	Suggestions per built station
Citi Bike				
Manhattan	70	4	34	2.2
Jersey City	20	0	10	2.0
Greenville	0	0	2	0.0
Divvy				
Downtown Chicago	78	9	9	9.7
North Park	59	2	4	15.3
Wilmette	4	0	1	4.0

In Manhattan, participants suggested seventy-four sites, and eighty-seven in Downtown Chicago. Descriptions furthest away from built stations tended to include site-specific rationalization, such as "*Add a stop here, our whole company has Divvy memberships and the new restaurant and event space would also benefit from bikes*." A suggestion from Manhattan highlights the challenges of balancing bike share trips in an employment-heavy area: "*This is in a citibike station deadzone... and the few around are empty in the mornings and full in the evenings...I have to walk 5-10 minutes to find a bike…*".

Comments close to built stations often focused on station balancing problems: "*Add another station here right next to the one that NEVER WORKS OR IS ALWAYS FILLED….*" Few commenters addressed site-specific location issues, such as this mention of adequate space for new stations: "*Montrose & Cicero.... Plenty of room for Divvy station. Currently there are no stations on Montrose west of Lincoln Ave. Many bike commuters using Montrose*".

The middle sites in Figure 5 are typical urban areas, which are not as dense as the downtown sites. Many of the twenty suggested locations in the Jersey City square mile include comments describing proximity to transit stations, or wide sidewalks. However, one comment referred to perceived personal security bicycling, over walking in the area. *"Anyone living or often visiting the marina will not have to walk .... Thank you*." Suggestions for sites were more sparse near the outermost stations. No one suggested a station within the entire square mile area surrounding the Citibike station near the Greenville community in New Jersey. The bike share station that was built there is on the edge of Columbia Park, which could be used by both park users and the local community.

The outermost Divvy site near the village of Wilmette is just north of Chicago, and near Northwestern University in Evanston, Illinois. The four suggested stations in this area all included written comments, and one defended his/her comments from the better network connection and sustainability perspectives "*The Ecology Center would be a natural Divvy Bike location. It would fill in a gap in the Divvy Bike locations in Evanston serving people both North and South of the Channel. Divvy Bikes are a sustainable mode of transportation and thus are consistent…*"

As we expected, there were significant more comments in the downtown than in the middle and outer-edge areas. When people added descriptions, they tended to present evidence and defend their site choices from demand (high Divvy membership and low bike supply), convenience (better connections to transit), safety (compared to walking) and sustainability perspectives. These topics generally aligned with discussion about transit on social media in Los Angeles (Schweitzer, 2014).

2.4.3.1. How Scalable are Our Findings?

The expansion of the New York and Chicago bike share programs gave us the opportunity to observe and understand the impact of crowdsourcing suggested bike share station sites offered via a PPGIS portal on the ultimate siting decisions that planners made. New York and Chicago are hardly typical; their large populations, extensive transit services, and financial resources make them very different from most other cities considering bike share programs. Neither PPGIS solicited information on participant demographics, however, so it is not possible to tell whether participants offering suggestions were representative of the income, racial or ethnic, gender or other composition of specific neighborhoods or the city as a whole.

We also could not tell how influential PPGIS results were in the staff's final decisions because a) there are only so many reasonable bike share station sites in the core of each city, and, b) staff reports gave no in-depth indication of how they weighted the PPGIS results against the input at the more traditional participatory exercises in which they also engaged. Finally, siting bike share stations, while doing so may create conflict in some cases, is a relatively simple and straightforward planning problem. Our analysis does not indicate how useful a platform like PPGIS would be in handling far more complex and controversial issues, such as siting public housing or a major transit station, for example.

We agree with Afzalan and Sanchez (2017) that future studies of crowdsourcing in planning should consider the reliability of contributions, particularly in terms of geographical accuracy (Brown 2012) consistency of subjective ratings (Nguyen et al. 2016), sample effects and response bias (Brown 2017) to provide guidance for improving practice and research in the reliability of crowdsourced contributions.

2.5. Implications of these Crowdsourcing Cases for Planning

We assessed two large datasets each of which showed the locations of bike share stations suggested by stakeholders in New York and Chicago using a crowdsourcing PPGIS platform. The platform allows participants to specify the precise location of the bike share stations that they suggest and to offer a written defense of their suggestions. We analyzed the spatial relationship between the suggested stations and actual stations. On average, built stations were 625 and 909 feet away from suggested stations in New York and Chicago. Most stations (81% and 93%) were placed within a ¼ mile of a suggested location in New York and Chicago. However, most stations were not built precisely at the suggested locations. Only 5.2% and 9.7% stations were within 100 feet of a suggested location. Participants suggested between four and eight times more stations than were constructed at the city scale, with more variation in our sampling areas. Downtown areas have significantly more suggested stations than middle and outer-edge areas in both cities. Participants tended to defend their site choices from demand, convenience, safety, and sustainability perspectives.

Planning documents showed that planners mixed the input they received through the PPGIS platform with input from public hearings and meetings. The online portal offered an opportunity for any participant to quickly suggest a location, but evidence from planning process descriptions, spatial analysis, and sampled text descriptions do not suggest the PPGIS was a genuinely empowering participatory technology. Attendees of public meetings in New York were given much more contextual information about the process than was available on the website. Online participants in the Chicago area have even less material about the planning process, suggesting continued importance for planners to connect online and in-person participation experiences.

Planners can improve implementation of PPGIS as a participatory technology. Planners or PPGIS designers could provide a feasible planning boundary or guidance to avoid unrealistic suggestions. For example, 57% of suggested stations in New York were outside of the system boundary and had to be excluded from the analysis, wasting participant's time and energy. Online platforms could also highlight additional opportunities to stay engaged in the planning process, including upcoming ways to provide guidance or co-productive support, such as assessing preliminary choices.

Other cities can learn the opportunities and limits of PPGIS for planning by examining what New York City and Chicago did to expand their bike share systems. Previous studies show that online participation is unlikely to represent the entire population, suggesting that PPGIS should be part of a broader strategy including traditional involvement techniques. Planners should work with decision-makers in a given context to carefully define the parameters of how they can and should use public suggestions, and be transparent with the public about how their suggestions will be used.

This article provides context-dependent knowledge about an emerging practice in public engagement, using bike sharing as a growing transportation technology. The crowdsourcing process does reflect a *co-productive* method in the sense that ways of working together are opened up for people to contribute planning actions beyond the traditional communicate approach. The notion of involving people to do some portion of the 'work' of planning to use online mapping information and identify potential locations may be valuable.

Our findings have implications for practice, including evidence for expanding involvement by offering PPGIS as an action-oriented option for participation, case detail to support performance measurement of future planning efforts, and a method for evaluating the impact of PPGIS contributions regarding the outcomes of plans. Doing so may "give people the opportunity to have a meaningful impact on the development of plans and programs that may affect them" (AICP 2016). However, we find that even in the largest United States cities with significant support for bike share planning, that planners need to engage with the design of PPGIS systems to support trust and legitimacy. Though evidence of participants' voices in completed projects from these cases are mixed, improving the co-production of plans with tailored online and in-person approaches can support more powerful participation.

The United States has seen a long period of migration, urbanization, and modernization that has fundamentally changed the distribution of people and development in the country. However, the political subdivisions have remained largely unchanged since the beginning of the 20th century; they represent a dispersed and rural country divided roughly into states. As the country progresses further into the 21st century, this model has become increasingly unrepresentative when most of the U.S. population lives and works in metropolitan areas and multi-city regions bonded by economic, cultural, and geographic connections that may not map to state or local borders at all.

3. References

Afzalan, Nader, and Brian Muller. 2018. "Online Participatory Technologies:

Opportunities and Challenges for Enriching Participatory Planning." *Journal of the American Planning Association* 84 (2):162–77. https://doi.org/10.1080/01944363.2018.1434010.

Afzalan, Nader, and Thomas Sanchez. 2017. "Testing the Use of Crowdsourced Information: Case Study of Bike-Share Infrastructure Planning in Cincinnati, Ohio." *Urban Planning* 2 (3):33. https://doi.org/10.17645/up.v2i3.1013.

Ahillen, Michael, Derlie Mateo-Babiano, and Jonathan Corcoran. 2016. "Dynamics of Bike Sharing in Washington, DC and Brisbane, Australia: Implications for Policy and Planning." *International Journal of Sustainable Transportation* 10 (5):441–54. https://doi.org/10.1080/15568318.2014.966933.

AICP. 2016. "Code of Ethics and Professional Conduct." 2016. https://www.planning.org/ethics/ethicscode/.

Albrechts, Louis. 2012. "Reframing Strategic Spatial Planning by Using a Coproduction Perspective." *Planning Theory* 12 (1):46–63. https://doi.org/10.1177/1473095212452722.

Alexander, E. R. 2001. "The Planner-Prince: Interdependence, Rationalities and Post-Communicative Practice." *Planning Theory & Practice* 2 (3):311–24. https://doi.org/10.1080/14649350120096848.

Alliance for Bicycling and Walking. 2016. "Bicycling and Walking in the United States 2016 Benchmarking Report." *Bicycling and Walking in the United States 2016 Benchmarking Report*. Washington, D.C.

Anselin, Luc. 1995. "Local Indicators of Spatial Association-LISA." *Geographical Analysis* 27 (2):93–115. https://doi.org/10.1111/j.1538-4632.1995.tb00338.x.

APA. 1992. "Ethical Principals in Planning." 1992. https://www.planning.org/ethics/ethicalprinciples.htm.

Austin Transportation Department. 2014. "2014 Austin Bicycle Plan Appendices." Austin, TX.

Batty, M. 2001. "Exploring Isovist Fields: Space and Shape in Architectural and Urban Morphology." *Environment and Planning B: Planning and Design* 28 (1):123–50. https://doi.org/10.1068/b2725.

Benedikt, Michael L. 1979. "To Take Hold of Space: Isovists and Isovist Fields." *Environment and Planning B: Planning and Design* 6 (1):47–65. https://doi.org/10.1068/b060047.

Brabham, Daren C. 2013. *Crowdsourcing*. Cambridge, MA: MIT Press.

Briquelet, Kate. 2013. "City Moves Citi Bike Stations from Richest Areas While Letting Other Contested Racks Stay." New York Post. 2013. http://nypost.com/2013/06/23/city-moves-citi-bike-stations-from-richest-areas-while-letting-other-contested-racks-stay/.

Brody, Samuel D, David R Godschalk, and Raymond J Burby. 2003. "Mandating Citizen Participation in Plan Making: Six Strategic Planning Choices." *Journal of the American Planning Association* 69 (3). Routledge:245–64. https://doi.org/10.1080/01944360308978018.

Brown, Greg. 2012. "An Empirical Evaluation of the Spatial Accuracy of Public Participation GIS (PPGIS) Data." *Applied Geography* 34 (May). Elsevier

Ltd:289–94. https://doi.org/10.1016/j.apgeog.2011.12.004.
———. 2017. "A Review of Sampling Effects and Response Bias in Internet Participatory Mapping (PPGIS / PGIS / VGI)." *Transactions in GIS* 21 (1):39–56. https://doi.org/10.1111/tgis.12207.
Brown, Greg, and Marketta Kyttä. 2014. "Key Issues and Research Priorities for Public Participation GIS (PPGIS): A Synthesis Based on Empirical Research." *Applied Geography* 46 (JANUARY 2014):122–36. https://doi.org/10.1016/j.apgeog.2013.11.004.
Burby, Raymond J. 2003. "Making Plans That Matter: Citizen Involvement and Government Action." *Journal of the American Planning Association* 69 (1):33–49. https://doi.org/10.1080/01944360308976292.
Campbell, Heather, and Robert Marshall. 2000. "Public Involvement and Planning: Looking beyond the One to the Many." *International Planning Studies* 5 (3):321–44. https://doi.org/10.1080/713672862.
Capital Area Metropolitan Planning Organization. 2017. "2045 Regional Active Transportation Plan." Austin.
Citi Bike. 2016a. "About Citi Bike: Company, History." 2016. https://www.citibikenyc.com/about.
———. 2016b. "Expansion 2016." 2016. https://www.citibikenyc.com/expansion.
City of Austin. 2018. "Ride Report App and Bicycle Comfort Map." 2018. http://www.austintexas.gov/department/ride-report.
Clark, Benjamin Y, Jeffrey L Brudney, Morten Jakobsen, and Simon Calmar Andersen. 2013. "Coproduction of Government Services and the New Information Technology: Investigating the Distributional Biases." *Public Administration Review* 73 (5):704–13. https://doi.org/10.1111/puar.12092.Coproduction.
Cohen, Adam, and Susan Shaheen. 2016. *PAS Report 583 Planning for Shared Mobility*. Chicago: IL: American Planning Association.
Curtin, G. G. 2010. "Free the Data!: E-Governance for Megaregions." *Public Works Management and Policy* 14 (3):307–26. https://doi.org/10.1177/1087724X09359352.
Desouza, Kevin C., and Akshay Bhagwatwar. 2014. "Technology-Enabled Participatory Platforms for Civic Engagement: The Case of U.S. Cities." *Journal of Urban Technology* 21 (4):25–50. https://doi.org/10.1080/10630732.2014.954898.
Dewar, M., and D. Epstein. 2007. "Planning for 'Megaregions' in the United States." *Journal of Planning Literature* 22 (2):108–24. https://doi.org/10.1177/0885412207306615.
Dill, Jennifer, Tara Goddard, Christopher M. Monsere, and Nathan Mcneil. 2015. "Can Protected Bike Lanes Help Close the Gender Gap in Cycling ? Lessons from Five Cities." In *Compendium of Transportation Research Board 94th Annual Meeting*. Vol. 8581. Washington, D.C.: Transportation Research Board of the National Academies.
Divvy Bikes. 2015. "About Divvy." 2015. http://www.divvybikes.com/about.
Esri. 2016. "How Cluster and Outlier Analysis (Anselin Local Moran's I)

Works." 2016. http://desktop.arcgis.com/en/arcmap/10.3/tools/spatial-statistics-toolbox/cluster-and-outlier-analysis-anselin-local-moran-s.htm.

Evans-Cowley, Jennifer, and Greg Griffin. 2012. "Microparticipation with Social Media for Community Engagement in Transportation Planning." *Transportation Research Record: Journal of the Transportation Research Board* 2307 (December):90–98. https://doi.org/10.3141/2307-10.

Evans-Cowley, Jennifer, and Justin Hollander. 2010. "The New Generation of Public Participation: Internet-Based Participation Tools." *Planning Practice and Research* 25 (3). Routledge:397–408. https://doi.org/10.1080/02697459.2010.503432.

Evers, David, and Jochem de Vries. 2013. "Explaining Governance in Five Mega-City Regions: Rethinking the Role of Hierarchy and Government." *European Planning Studies* 21 (4):536–55. https://doi.org/10.1080/09654313.2012.722944.

Faghih-Imani, Ahmadreza, Sabreena Anowar, Eric J. Miller, and Naveen Eluru. 2017. "Hail a Cab or Ride a Bike? A Travel Time Comparison of Taxi and Bicycle-Sharing Systems in New York City." *Transportation Research Part A: Policy and Practice* 101 (July). Elsevier Ltd:11–21. https://doi.org/10.1016/j.tra.2017.05.006.

Faghih-Imani, Ahmadreza, and Naveen Eluru. 2015. "Analysing Destination Choice Preferences in Bicycle Sharing Systems: An Investigation of Chicago's Divvy System." In *Compendium of Transportation Research Board 94th Annual Meeting*. Vol. 6270. Washington, D.C.: Transportation Research Board of the National Academies.

Federal Highway Administration. n.d. "Reference Tool - Public Involvement - Planning." Accessed April 20, 2015. http://www.fhwa.dot.gov/planning/public_involvement/reference_tool/.

Finlay, Jessica M., and Jay A. Bowman. 2016. "Geographies on the Move: A Practical and Theoretical Approach to the Mobile Interview." *The Professional Geographer* 0124 (October):1–12. https://doi.org/10.1080/00330124.2016.1229623.

Fishman, Elliot. 2016. "Bikeshare: A Review of Recent Literature." *Transport Reviews* 36 (1):92–113. https://doi.org/10.1080/01441647.2015.1033036.

Forester, John. 2001. "An Instructive Case-Study Hampered by Theoretical Puzzles: Critical Comments on Flyvbjerg's Rationality and Power." *International Planning Studies* 6 (3):263–70. https://doi.org/10.1080/713672905.

García-Palomares, Juan Carlos, Javier Gutiérrez, and Marta Latorre. 2012. "Optimizing the Location of Stations in Bike-Sharing Programs: A GIS Approach." *Applied Geography* 35 (November). Elsevier Ltd:235–46. https://doi.org/10.1016/j.apgeog.2012.07.002.

Griffin, Greg P., and Junfeng Jiao. 2015. "Crowdsourcing Bicycle Volumes: Exploring the Role of Volunteered Geographic Information and Established Monitoring Methods." *URISA Journal* 27 (1):57–66.

Griffin, Greg P. 2011. "Evolving Innovations in Bicycle Transportation." *Practicing Planner* 9 (3).

Guyadeen, Dave, and Mark Seasons. 2018. "Evaluation Theory and Practice: Comparing Program Evaluation and Evaluation in Planning." *Journal of Planning Education and Research* 38 (1):98–110. https://doi.org/10.1177/0739456X16675930.

Healey, Patsy. 1997. *Collaborative Planning: Shaping Places in Fragmented Societies*. London: Macmillan.

Hebbert, Frank. 2016. "Viewing Data via the Django Admin Interface." 2016. https://github.com/openplans/shareabouts-api/blob/master/doc/GETTING_YOUR_DATA.md.

Hoch, Charles J. 2007. "Pragmatic Communicative Action Theory." *Journal of Planning Education and Research* 26 (3):272–83. https://doi.org/10.1177/0739456X06295029.

Innes, Judith E. 1995. "Planning Theory's Emerging Paradigm: Communicative Action and Interactive Practice." *Journal of Planning Education and Research* 14 (3):183–89. https://doi.org/10.1177/0739456X9501400307.

Innes, Judith E., David E. Booher, and Sarah Di Vittorio. 2011. "Strategies for Megaregion Governance -- Collaborative Dialogue, Networks, and Self-Organization." *Journal of the American Planning Association* 77 (1). Routledge:55–67. https://doi.org/10.1080/01944363.2011.533640.

Kahila-Tani, Maarit, Anna Broberg, Marketta Kyttä, and Taylor Tyger. 2016. "Let the Citizens Map—Public Participation GIS as a Planning Support System in the Helsinki Master Plan Process." *Planning Practice & Research* 31 (2):195–214. https://doi.org/10.1080/02697459.2015.1104203.

Lusk, Anne C, Patrick Morency, Luis F Miranda-Moreno, Walter C Willett, and Jack T Dennerlein. 2013. "Bicycle Guidelines and Crash Rates on Cycle Tracks in the United States." *American Journal of Public Health* 103 (7). https://doi.org/10.2105/AJPH.2012.301043.

Margerum, Richard D. 2002a. "Collaborative Planning: Building Consensus and Building a Distinct Model for Practice." *Journal of Planning Education and Research* 21 (3):237–53. https://doi.org/10.1177/0739456X0202100302.

———. 2002b. "Collaborative Planning." *Journal of Planning Education and Research* 21 (3):237–53. https://doi.org/10.1177/0739456X0202100302.

McAndrews, Carolyn, and Justine Marcus. 2015. "The Politics of Collective Public Participation in Transportation Decision-Making." *Transportation Research Part A: Policy and Practice* 78. Elsevier Ltd:537–50. https://doi.org/10.1016/j.tra.2015.06.014.

Mike Claffey. 2015. "Mayor Emanuel Announces Divvy Expanding To New Neighborhoods." 2015. https://www.cityofchicago.org/city/en/depts/cdot/provdrs/bike/news/2015/april/mayor-emanuel-announces-divvy-expanding-to-new-neighborhoods.html.

Minner, Jennifer, Michael Holleran, Andrea Roberts, and Joshua Conrad. 2015. "Capturing Volunteered Historical Information: Lessons from Development of a Local Government Crowdsourcing Tool." *International Journal of E-Planning Research* 4 (1):19–41. https://doi.org/10.4018/ijepr.2015010102.

Motivate International, and Divvy Bikes. 2016. "About Divvy." 2016. https://www.divvybikes.com/about.

NACTO. 2015. “Walkable Station Spacing Is Key to Successful, Equitable Bike Share.” NACTO Bike Share Equity Practitioners’ Paper #1. 2015. https://www.bicyclenetwork.com.au/media/vanilla_content/files/NACTO_Walkable-Station-Spacing-Is-Key-For-Bike-Share.pdf.

New York City DOT. 2013. “NYC Bike Share Designed by New Yorkers.” 2013. www.nyc.gov/html/dot/downloads/pdf/bike-share-outreach-report.pdf.

Nguyen, An T., Matthew Halpern, Byron C. Wallace, and Matthew Lease. 2016. “Probabilistic Modeling for Crowdsourcing Partially-Subjective Ratings.” In *Proceedings of the Fourth AAAI Conference on Human Computation and Crowdsourcing*. Austin, TX: AAAI.

Noland, Robert B., Michael J. Smart, and Ziye Guo. 2016. “Bikeshare Trip Generation in New York City.” *Transportation Research Part A: Policy and Practice* 94. Elsevier Ltd:164–81. https://doi.org/10.1016/j.tra.2016.08.030.

NYCDOT. 2015. “Citi Bike Expansion : Draft Plan Manhattan Community Board 7.” 2015. http://nycdotbikeshare.info/maps_plans.

O’Brien, Oliver. 2018. “Bike Share Map.” 2018. http://bikes.oobrien.com/.

O’Brien, Oliver, James Cheshire, and Michael Batty. 2014. “Mining Bicycle Sharing Data for Generating Insights into Sustainable Transport Systems.” *Journal of Transport Geography* 34 (January). Elsevier Ltd:262–73. https://doi.org/10.1016/j.jtrangeo.2013.06.007.

O’Cathain, Alicia. 2010. “Assessing the Quality of Mixed Methods Research: Toward a Comprehensive Framework.” In *SAGE Handbook of Mixed Methods in Social & Behavioral Research*, 2nd:531–56. Thousand Oaks, CA: SAGE Publications, Inc. https://doi.org/10.4135/9781506335193.n21.

OpenPlans. 2013. “Shareabouts.” 2013. https://github.com/openplans/shareabouts.

Owen, Joseph, Cy Neita, and Jon Froehlich. 2015. “Crowdsourcing Bikeshare Transit Planning: An Empirical Investigation of Washington D.C. and New York City.” University of Maryland.

Peckett, Haley, and William M Lyons. 2012. “Evolving Role of Metropolitan Planning Organizations in Transportation Planning for Megaregions.” *Transportation Research Record*, no. 2307:43–51. https://doi.org/10.3141/2307-05.

Piatkowski, Daniel, Wesley Marshall, and Nader Afzalan. 2017. “Can Web-Based Community Engagement Inform Equitable Planning Outcomes? A Case Study of Bikesharing.” *Journal of Urbanism: International Research on Placemaking and Urban Sustainability* 10 (3). Routledge:296–309. https://doi.org/10.1080/17549175.2016.1254672.

Pucher, John R, and Ralph Buehler. 2012. *City Cycling*. Edited by John Pucher and Ralph Buehler. Cambridge, MA: MIT Press.

Radil, Steven M., and Junfeng Jiao. 2016. “Public Participatory GIS and the Geography of Inclusion.” *The Professional Geographer* 68 (2):202–10. https://doi.org/10.1080/00330124.2015.1054750.

Ramsey, Kevin, and Alexander Bell. 2014. *Smart Location Database*. Washington, D.C.: U.S. EPA Office of Sustainable Communities.

Ride Report. 2016. “Ride Report Whitepaper.” 2016. https://static.ride.report/static/promosite/assets/whitepaper.ef1622d2516d.pdf

.
Ross, Catherine, Myungje Woo, and Fangru Wang. 2016. “Megaregions and Regional Sustainability.” *International Journal of Urban Sciences* 20 (3):299–317. https://doi.org/10.1080/12265934.2016.1189846.
Schafran, Alex. 2013. “Rethinking Mega-Regions: Sub-Regional Politics in a Fragmented Metropolis.” *Regional Studies* 48 (4). Taylor & Francis:1–16. https://doi.org/10.1080/00343404.2013.834043.
Schweitzer, Lisa. 2014. “Planning and Social Media: A Case Study of Public Transit and Stigma on Twitter.” *Journal of the American Planning Association* 80 (3):218–38. https://doi.org/10.1080/01944363.2014.980439.
Sciara, Gian-Claudia. 2017. “Metropolitan Transportation Planning: Lessons From the Past, Institutions for the Future.” *Journal of the American Planning Association* 83 (3):262–76. https://doi.org/10.1080/01944363.2017.1322526.
Thomas, Beth, and Michelle DeRobertis. 2013. “The Safety of Urban Cycle Tracks: A Review of the Literature.” *Accident Analysis & Prevention* 52 (March). Elsevier Ltd:219–27. https://doi.org/10.1016/j.aap.2012.12.017.
Thompson, Michelle M. 2016. “Upside-Down GIS: The Future of Citizen Science and Community Participation.” *The Cartographic Journal* 53 (4). Taylor & Francis:1–9. https://doi.org/10.1080/00087041.2016.1243863.
Timothy Nyerges. 2005. “Scaling-Up as a Grand Challenge for Public Participation GIS.” Directions Magazine. 2005. http://www.directionsmag.com/entry/scaling-up-as-a-grand-challenge-for-public-participation-gis/123341.
Toole Design Group. 2017. “WikiMap Summary Respondent Overview.”
Trapenberg Frick, Karen. 2013. “The Actions of Discontent: Tea Party and Property Rights Activists Pushing Back Against Regional Planning.” *Journal of the American Planning Association* 79 (3):190–200. https://doi.org/10.1080/01944363.2013.885312.
U.S. Census Bureau Population Division. 2016. “Annual Estimates of the Resident Population: April 1, 2010 to July 1, 2015.” 2016. http://factfinder.census.gov/.
Vickers, Alex. 2013. “Bike Share: Not Just a Solution for the First and Last Mile.” Bikeshare. 2013. http://bikeshare.com/2013/09/bike-share-not-just-a-solution-for-the-first-and-last-mile/.
Watson, Vanessa. 2014. “Co-Production and Collaboration in Planning – The Difference.” *Planning Theory & Practice* 15 (1):62–76. https://doi.org/10.1080/14649357.2013.866266.
Whitfield, Geoffrey P., Prabasaj Paul, and Arthur M. Wendel. 2015. “Active Transportation Surveillance — United States , 1999 – 2012.” *MMWR Surveillance Summaries* 64 (7):1–17.