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An empirical evaluation of workshop versus survey PPGIS methods

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A B S T R A C T

Two common approaches for collecting spatial information through public participation geographic information systems (PPGIS) include small-group workshops and broader-scale, household sampling. We evaluate the two approaches using empirical PPGIS data for the Chugach National Forest planning process where both approaches were implemented in spring of 2012. Results from a larger PPGIS survey completed in 1998 were also included in the study for comparison. We examined the spatial concurrence of the data generated by the two approaches (workshop versus survey) on multiple spatial attributes (landscape values) using three analytical methods—subsampling, resampling, and hotspot analysis. We found little to weak spatial association from the two participatory mapping methods on most landscape values. These results may be attributed to less spatial data for the workshops and to differences in measurement and sampling between the two approaches. The empirical results of low spatial concurrence raise important questions about the use of workshop participatory GIS for planning decision support. We discuss the implications and supporting rationale for using participatory mapping in community meetings.

Introduction

The terms public participation GIS (PPGIS) and participatory GIS (PGIS) refer to methods for collecting and using non-expert, spatial information for a variety of purposes, often related to land use planning or management. The term “public participation geographic information systems” (PPGIS) was conceived in 1996 at a meeting of the National Center for Geographic Information and Analysis (NCGIA) in the U.S. to describe how GIS technology could support public participation for a variety of applications Since then, the use of PPGIS/PGIS applications (or more generally, “participatory GIS”) has been extensive, ranging from community and neighborhood planning to environmental management, to the mapping of indigenous lands and traditional ecological knowledge (see Brown, 2005; Brown & Kyttä, 2014; Dunn, 2007; McLain et al., 2013; Sawicki & Peterman, 2002; Sieber, 2006 for reviews of applications and methods).

Two common approaches for soliciting and collecting spatial information using PPGIS/PGIS for regional and environmental planning applications include participatory workshops and household surveys. For example, household PPGIS surveys have been implemented for forest planning (Beverly, Uto, Wilkes, & Bothwell, 2008; Brown, 2005; Brown & Donovan, 2013; Brown, Kelly, & Whitall, 2014; Brown & Reed, 2009; Clement, 2006), park planning (Brown & Weber, 2011), and regional planning for tourism, conservation, or development (see e.g., Brown, 2006; Brown & Weber, 2013; Pocewicz & Nielsen-Pincus, 2013). Household surveys have the ability to reach a broad, random sample of a population while using a consistent methodology for data collection. However, securing larger, representative samples of public participants is increasingly challenging, with survey response rates declining across all modes of delivery (Curtin, Presser, & Singer, 2005; de Leeuw & de Heer, 2002). Further, one might speculate that the reported, putative declines in social capital (Costa & Kahn, 2003; Putnam, 1995; Rahn & Transue, 1998) may also contribute to lower engagement in community planning processes across many traditional participation modalities, including surveys. Although household surveys appear to be more broadly representative of regional populations than community workshops, PPGIS surveys do contain some bias from different sources such as the geographic

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location of participants, socio-demographic classes, participant beliefs, and knowledge/experience in the study area (Brown & Kyttä, 2014). Analysis of non-response bias in PPGIS surveys indicates non-participation is not systematically related to the PPGIS content or mode of implementation (Brown & Reed, 2012a,b; Pocewicz, Nielsen-Pincus, Brown, & Schnitzer, 2012).

The use of PPGIS in public meetings, workshops, or other group processes for data collection is increasingly common. Arciniegas and Janssen (2012) describe the use of maps in planning workshops as a means to communicate spatial information to stakeholders, as analysis tools for spatial evaluation of decision alternatives, and as input for interactive tools for decision support. Workshops and focus groups have been used to gather PPGIS data in support of urban planning in the US, Brazil and the Netherlands (Al-Kodmany, 1999; Bugs, Granell, Fonts, Huerta, & Painho, 2010; MAPSUP, 2010), to understand community values in Florida (Lowery & Morse, 2013), to inform public land planning in the US Pacific Northwest (Hall, Farnum, Slider, & Ludlow, 2009), and to identify contaminated water sites within the Yukon River Watershed (Wilson, Inkster, Toohey, & Donovan, 2013).

Public meetings are often legislatively required for land use planning processes in the U.S. and can take on many forms ranging from formal quasi-judicial hearings to informal workshops that engage participants in various activities. There are some important reasons why agencies responsible for land use planning, especially federal land management agencies in the U.S., would be predisposed to use workshop participatory mapping over community, regional, or national participatory mapping household surveys:

(1) National Environmental Policy Act (NEPA) regulations require that agencies "hold or sponsor public hearings or public meetings whenever appropriate or in accordance with statutory requirements applicable to the agency" (43 CFR 1506.6 (c)) where one of the criteria includes "substantial environmental controversy concerning the proposed action or substantial interest in holding the hearing." This would include most major federal land use decisions, including national forest planning as described herein. Given the requirement to hold public hearings or meetings, workshop or participatory mapping could be incorporated into the required public meetings.
(2) Federal agencies in the U.S. face significant regulatory barriers to the systematic collection of public information including surveys. Legislation prohibits federal government information collection without review and approval by the Office of Management and Budget (OMB). This regulatory requirement, which can take well over a year to obtain approval (if at all), effectively thwarts agencies from engaging in participatory mapping surveys, even if an agency is predisposed to use participatory mapping.
(3) Public meetings have multiple benefits beyond simple information collection. The potential for face-to-face, interpersonal communication with agency officials provides opportunities to explore alternative strategies, to help build consensus, to integrate traditional and local ecological knowledge, and to help build trust in the agency (Charnley, Fischer, & Jones, 2008).

Given the potential administrative advantages of workshop participatory mapping, and the likelihood that agencies at all levels of government (i.e., local, state, federal) will engage in more workshop participatory mapping in the future, there are important research questions regarding the quality and consistency of spatial data generated from a workshop approach compared to a survey approach. A workshop approach is likely to incorporate more qualitative methods than quantitative methods resulting from the need to be more flexible in a public workshop environment, and depending upon the methods used, workshop and survey approaches may also generate different amounts of spatial data. These differences between the two approaches could potentially influence planning and management decisions.

The Chugach National Forest (Alaska) planning experience provides a unique opportunity to evaluate the strengths and limitations of workshop-based participatory mapping compared to survey-based participatory mapping. Three participatory mapping spatial data sets were collected that provide a basis for evaluation: (1) a mail-based participatory mapping survey implemented in 1998 for the 2002 Chugach National Forest Plan (see Brown & Reed, 2000; Reed & Brown, 2003); (2) an internet-based participatory mapping survey implemented in 2012 for the revised Chugach National Forest Plan (see Brown & Donovan, 2013); and (3) a set of participatory mapping workshops completed in 2012 as part of the forest's "early engagement" process for plan revision (Donovan, Mock, Titre, Toohey, & Ballesteros-Lopez, 2013). All three processes asked participants to identify landscape values and their spatial location within the national forest. The surveys and workshops each collected landscape value locations as point data. Other workshop-based participatory mapping has been implemented with polygons (e.g., Hall et al., 2009; Lowery & Morse, 2013) which can achieve comparable spatial information to point data, but may be more cognitively challenging for participants (Brown & Pullar, 2012).

The spatial data sets from the two participatory mapping surveys (1998, 2012) are large samples that serve as a proxy population (baseline) for comparing the quality of the smaller sample of spatial data generated from the participatory mapping workshops (2012). The Chugach data sets allowed us to address the following research questions: 1) Can participatory workshop mapping methods achieve comparable results to household survey methods, and if so, under what conditions and for what spatial attributes? 2) Are larger, regional household samples necessary to provide the quantity and quality of spatial information to inform land use planning? We conclude the paper with a discussion of the results and their implications for future participatory mapping processes.

Methods

We compared spatial data sets collected through participatory mapping household surveys, using deductive mapping methods (predefined landscape values), completed in 1998 and 2012 with participatory mapping workshops completed in 2012 using inductive mapping methods (landscape values were coded from participant text). We included the 1998 survey data as a separate comparison because it contained significantly more spatial data than the 2012 household survey and the data was collected using paper-based mapping rather than web-based mapping. The 1998 data contained more spatial data due to a somewhat larger sample size, but more important, a significantly higher survey response rate. Longitudinal analysis of the data from the 1998 and 2012 household surveys indicated there was relative stability in landscape values over time, both in importance and spatial distribution (Brown & Donovan, 2014).

The general approach to compare two spatial data sets is to match the quantity of spatial data for each spatial attribute (landscape value), and then use a spatial metric that describes the similarity in spatial distributions across the study region. The presumptive hypothesis for this research is that workshop and survey mapping methods produce similar spatial patterns on the landscape despite differences in the quantity of spatial data mapped. We used three different analytical approaches in an attempt to find evidence that the smaller spatial data set generated from the workshop could be considered a subsample of the larger survey spatial data set. The three methods included: 1) a top–down approach that generates random sub-samples of the survey data to match the smaller quantity of workshop data, 2) a bottom–up approach that resamples the workshop data to match the larger quantity of survey data, and 3) a hotspot approach that compares significant clusters of points across two distributions. A common metric for measuring the degree of spatial concurrence (phi coefficient) was applied to the subsampling and resampling approaches while a different metric, the Getis–Ord Gi* statistic, was used to compare hotpots.

A finding of similar spatial patterns would have strong implications for the use of workshop PPGIS for decision support. More specifically, if the resampling method for workshop data produces similar spatial patterns to the larger survey data set, it may be possible for agencies to use workshop PPGIS if they are unable to conduct larger, regional surveys.

Study location

The Chugach National Forest (CNF) is located in south central Alaska and covers approximately 5.4 million acres (23,000 km^2) making it the second largest national forest in the U.S. The forest covers the mountains surrounding Prince William Sound and includes the eastern Kenai Peninsula and Copper River delta. Approximately one-third of the area of the forest is rock and ice with strips of temperate rain forest occupying the zones between the ocean and alpine regions. The largest population centers proximate to CNF include Valdez (pop. 3976) and Cordova (pop. 2239) in the east, and the Kenai Peninsula communities of Soldotna (pop. 4163) and Seward (pop. 2693) in the west. Other small communities proximate to CNF include Cooper Landing, Hope, Moose Pass, Whittier and the Alaska native villages of Tatitlek and Chenega Bay. The largest city in Alaska, Anchorage (pop. 291,826), is approximately 80 km from the national forest and includes the community of Girdwood. Although the CNF is largely wild, with only 90 miles (140 km) of Forest Service roads, none of it is currently designated as legal Wilderness. The forest is classified as IUCN category VI (protected area with sustainable use of natural resources).

PPGIS workshop process

Workshops were conducted between April and May 2012 in 10 communities: Moose Pass, Seward, Cooper Landing, Hope, Girdwood, Anchorage, Soldotna, Whittier, Cordova and Valdez. Meeting times and locations were announced in local papers, list servers, on the CNF website, on the radio, and in flyers posted in post offices, town halls and other key community locations. Community workshops were held in the evenings and lasted from 2.5 to 3 h. A total of 71 individuals participated in the workshops.

The workshops were designed to be interactive and involved multiple methods for data generation including a participatory mapping activity and an interactive focus group discussion. At each meeting, poster-sized base maps 5 ft. by 3 ft. in size (scale: 1:650,000) were placed at tables where groups of up to seven participants sat. After a Forest Service official introduced the research team, a workshop facilitator explained the three workshop activities: 1) placing stickers unique to each participant on map locations that were especially important to them, 2) brainstorming a list of services and activities, and 3) the services and/or activities participants use the most and which, if any, of these services were best suited to the CNF compared to those found on surrounding lands.

The facilitator explained that stickers stapled to the workbooks were to be used during the participatory mapping activity and were uniquely coded to each participant to help 1) maintain the confidentiality agreement, and 2) link written descriptions to the mapping activities. Mapped data generated during the workshops were digitized as points using ArcGIS v.10. The corresponding comments, demographic, and personal information were compiled into an attribute table. Comments recorded on worksheets and flip charts were then sorted and coded into themes. We used an iterative coding process (Miles & Huberman, 1994) to analyze the diversity of reasons participants gave for considering a site meaningful to create a set of themes that captured these reasons. Using peer-debriefing (Creswell, 2003), we reviewed and restructured the coding process, and developed a set of 19 themes and operative definitions that we used to categorize participants' responses. The coded themes from the workshop included all the PPGIS survey landscape values, but only seven of the themes matching the landscape values had sufficient markers for spatial analyses (see Table 1). The themes were linked to the mapped points in GIS.

PPGIS survey (1998)

The 1998 PPGIS study was a self-administered survey sent to randomly selected households in 12 communities proximate to the CNF. The sampling frame was a database produced by the State of Alaska of all individuals who had applied to receive a dividend from state oil revenues in 1997. The strength of this sampling frame is that it includes most Alaskans who consider themselves residents. A random number generator was used to select households from the database in each sampled community. The survey requested that individuals place mnemonically-coded sticker dots representing 13 landscape values onto a color map of the CNF (scale 1:500,000) provided in a mail packet with a covering letter. The sticker dots were attached to a paper legend providing definitions for each landscape value (see Table 1) and participants were instructed to place the sticker dots on the map in locations containing these values. The sticker dots from returned maps were digitized as points in GIS and prepared for spatial analysis (see Brown and Reed (2000) for a detailed description of the methods). There were 821 participants with an overall survey response rate of 30.8%.

PPGIS survey (2012)

The 2012 PPGIS survey used an internet-based, Google® Maps application programming interface (API). Two groups of prospective participants were sampled. The first group consisted of individuals that participated in the 1998 CNF paper-map PPGIS study still living in Alaska. The second group of participants were from randomly selected households ($n = 2335$) from the same communities sampled in the 1998 study. Thus, the 2012 PPGIS survey consisted of a larger cross-section survey (response rate 10.1%) and a smaller survey panel (response rate 19.1%). The mapped results of the two groups were combined, yielding spatial data from 244 participants. A more detailed accounting of the methods and results for the 2012 survey can be found in Brown and Donovan (2014).

Spatial analyses

There are multiple ways to compare two spatial distributions of points. A common approach is to measure the degree of spatial concurrence (overlap) between the two point distributions. One method involves generating "hotspots" (polygons) from each

Table 1
The list of landscape values used in the analysis, where n is the number of points mapped.

Landscape value	Workshop PPGIS (2012) (coding themes)	Survey PPGIS (2012)	Survey PPGIS (1998)
Aesthetics/scenery	*Scenic views*—areas that offer views that are especially scenic ($n = 129$).	*Esthetic value*—these areas are valuable because they contain attractive scenery including sights, smells, and sounds. ($n = 1118$)	*Esthetic value*—I value the forest because I enjoy the forest scenery, sights, smells, and sounds ($n = 1973$)
Recreation	*Extractive recreation*—areas that provide opportunities for taking resources from the land including recreational hunting, fishing and mining; *Non-extractive recreation*—areas that offer recreational opportunities that do not involve taking from the land including hiking, photography, backpacking, kayaking, etc. ($n = 293$)	*Recreation*—these areas are valuable because they provide a place for my favorite outdoor recreation activities. ($n = 1839$)	*Recreation*—I value the forest because it provides a place for my favorite outdoor recreation activities ($n = 2081$)
Biological	*Biological*—areas that offer important services and resources related to biodiversity and biological functions ($n = 36$)	*Biological*—these areas are valuable because they provide a variety of fish, wildlife, plants, or other living organisms. ($n = 325$)	*Biological*—I value the forest because it provides a variety of fish, wildlife, plants, or other living organisms. ($n = 1472$)
Economic	*Economic*—areas that provide services and support activities important to the regional economy ($n = 29$)	*Economic*—these areas are valuable because they provide timber, fisheries, minerals, or tourism opportunities such as outfitting and guiding ($n = 285$)	*Economic*—I value the forest because it provides timber, fisheries, minerals, or tourism opportunities such as outfitting and guiding ($n = 1089$)
Wilderness	*Wildness*—areas that offer wilderness like experiences that include quiet, solitude and/or serenity ($n = 83$)	*Wilderness*—these places are valuable because they are wild, uninhabited, or relatively untouched by human activity ($n = 468$)	N/A
Subsistence	*Subsistence*—areas that offer subsistence activities such as hunting, fishing, berry-picking, wood harvesting and other gathering activities ($n = 101$)	*Subsistence*—these areas these areas are valuable because they provide necessary food and supplies to sustain my life ($n = 357$)	*Subsistence*—I value the forest because it provides necessary food and supplies to sustain my life ($n = 1180$)
Historical/cultural[a]	*Historical*—areas that provide historical perspective; *Cultural*—areas that provide opportunities to learn about and/or practice cultural traditions ($n = 31$)	*Historic*—these areas are valuable because they represent natural and human history that matters to me, others, or the nation; *Cultural*—these places are valuable because they allow me or others to continue and pass down the wisdom and knowledge, traditions, and way of life of ancestors. ($n = 360$)	*Historic*—I value the forest because it has places and things of natural and human history that matter to me, others, or the nation; *Cultural*—I value the forest because it is a place for me to continue and pass down the wisdom and knowledge, traditions, and way of life of my ancestors ($n = 1348$)

[a] These two landscape values were combined for analysis because of the small sample size for each and because previous studies indicated these values were closely related.

point data set and then calculating the degree of spatial concurrence of the polygons using either the Jaccard coefficient (Van Jaarsveld et al., 1998) or the phi (φ) correlation coefficient (Chedzoy, 2006; Zhu, Pfueller, & Whitelaw, 2010). Another method uses the Getis–Ord Gi* spatial statistic or simply Gi* (Getis & Ord, 1992) that identifies "local" spatial clusters (i.e., "hotspots") in predefined sampling grid cells (Zhu et al., 2010). Of the two approaches for identifying hotspots from point data—generating density polygons or using a predefined sampling grid—we chose the latter. Although either approach is acceptable, the polygon approach requires a number of choices (kernel versus simple density, cell size, and search radius) that are sensitive to the number of points being compared, even when point densities are standardized. The sampling grid approach is also sensitive to the number of points for analysis and the cell size, but as a practical matter, the method provides for greater consistency in reporting results across the multiple analyses reported herein. We experimented with several sampling grid sizes (1 km, 5 km, and 10 km) and concluded that a 10 km sampling grid for the CNF study area provided the best scale for analyzing the point data because there were fewer empty grid cells. Thus, the CNF study area was divided into 462 grid cells (10 km × 10 km) as shown in Fig. 1.

For our analysis, we used three different methods to compare the workshop data with the survey data: (1) subsampled the larger survey data sets from 1998 to 2012 to match the sample size of the workshop data in 2012, then used the phi coefficient to calculate spatial concurrence, (2) resampled the workshop data to match the sample size of the survey data in 1998 and 2012, then used the phi coefficient to calculate spatial concurrence, and (3) generated Gi* hotspots from both workshop and survey data and then calculated spatial concurrence as the percent of workshop hotspots that were also hotspots in the survey data. Each method is described in more detail below.

Subsampling method

To measure and evaluate the spatial concurrence of workshop data with survey data using subsampling, we followed the procedure outlined in Fig. 1. For each of the seven landscape values, we randomly sampled points from the 1998 and 2012 survey data separately to match the number of the workshop points for the same landscape value.[1] We then determined the presence or absence of the workshop and survey points in each cell of the 10 km sampling grid to calculate the phi statistic as follows:

$$\varphi = \frac{ad - bc}{\sqrt{(a+b)(c+d)(a+c)(b+d)}}$$

where:

a = number of grid cells with one or more workshop points <u>and</u> one or more survey points

[1] An alternative approach would be to sample household survey participants rather than points to match the number of workshop participants ($n = 71$). However, given the variability in the number of points mapped by each participant, the number of household survey points would not match (except by chance) the number of workshop points. Given the sensitivity of spatial analysis to the number of points being compared, we choose to match the number of points over the number of participants.

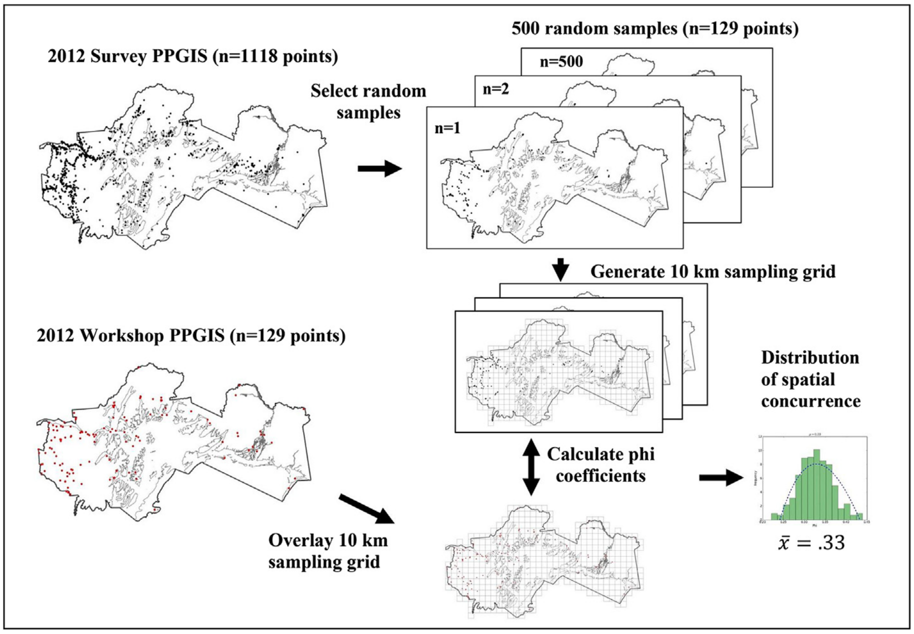

Fig. 1. Overview of method for comparing workshop and survey PPGIS using subsampling.

b = number of grid cells with one or more survey points and no workshop points
c = number of grid cells with one or more workshop points and no survey points
d = number of grid cells with no workshop points and no survey points

The phi coefficient is a variation of the Pearson correlation coefficient that is used for binary data where the statistical significance of the relationship can be evaluated with the chi-square statistic. The phi coefficient falls within the range of −1.0 and 1.0 with stronger relationships found at either extreme. Fitz-Gibbon and Morris (1987) suggest the following interpretation: $\varphi < 0.2$——little or no association, $0.2 \leq \varphi < 0.4$——weak association, $0.4 \leq \varphi < 0.6$——moderate association, and $\varphi \geq 0.6$——strong association.

The random subsampling procedure and calculation of phi was repeated 500 times[2] for each landscape value to generate a frequency distribution of phi values comparing the workshop data with both the 1998 and 2012 survey data. The mean and standard deviation were calculated for each landscape value distribution.

Resampling method

Whereas the subsampling method selects the number of survey points to match the number of workshop points, the resampling method resamples the workshop points to match the number of survey points for a given attribute. For each of the seven landscape values, we generated a kernel density surface (500 m cell size, 10 km search radius) from the workshop points. We calculated the number of new points to be generated as the difference between the number of workshop points for the landscape value and the number of survey PPGIS points for the same value. We generated new random points using the kernel density as a probability surface using a tool in the Geospatial Modelling Environment (www.spatialecology.com). The raster cell value from the kernel density is interpreted as the probability of a random point being generated within that cell by rescaling the raster values to a probability (by dividing by the maximum value). The new random points based on the probability surface were then merged with the original workshop points to equal the survey sample size. With an equal number of survey points and workshop points (from resampling), the phi coefficient was calculated as described above for the subsampling method.

Hotspot concurrence method

To determine the degree of hotspot concurrence, the Gi* statistic was calculated for each landscape value in the 2012 workshop and 2012 survey data. In this analysis, the Getis–Ord Gi* statistic identifies grid cells with larger point densities than one would expect to find by chance. A high value for the Gi* statistic indicates that greater density cells tend to be found near each other while low Gi* values indicate that lower density cells tend to be found together. The Getis–Ord tool in ArcGIS® generates z scores with an associated probability value (from 0.0 to 1.0) indicating the statistical significance of the grid cell hotspots identified in the study area.

To compare the 2012 workshop data with the 2012 survey data, we identified statistically significant hotspots (grid cells) in both distributions for each landscape value using the Gi* method. Each statistically significant ($p \leq 0.05$) grid cell in the workshop data was compared to the same locational grid cell in the survey data. Spatial concurrence was calculated as the percent for significant workshop grid cells that were also significant survey grid cells. For example, if a landscape value had 20 hotspot grid cells in the workshop data, and 10 of these same cells were also statistically significant in the survey data, the spatial concurrence would be 50 percent.

Results

Participant characteristics

There were three participant variables collected in the 1998 and 2012 PPGIS surveys as well as the 2012 workshop—community representation, gender, and age. The results in Table 2 indicate that

[2] Common practice is to run 100 iterations but we increased the number of iterations to 500 to ensure the resulting frequency distributions for all landscape values were normally distributed.

Table 2
Participant characteristics—community representation, gender, and mean age.

	Workshop PPGIS (2012) ($n = 71$)	Survey PPGIS (2012) ($n = 244$)	Survey PPGIS (1998) ($n = 821$)
Community representation (percent of total participants)	Anchorage (18%) Cooper Landing (11%) Cordova (20%) Girdwood (10%) Hope (3%) Moose Pass (3%) Seward (10%) Soldotna (3%) Valdez (11%) Whittier (11%)	Anchorage (32%) Cooper Landing (5%) Cordova (9%) Girdwood (13%) Hope (6%) Moose Pass (6%) Seward (9%) Soldotna (5%) Valdez (8%) Whittier (1%) Kenai (1%) Sterling (1%)	Anchorage (10%) Cooper Landing (8%) Cordova (9%) Girdwood (10%) Hope (3%) Moose Pass (5%) Seward (8%) Soldotna (9%) Valdez (8% Whittier (3%) Kenai (9%) Soldotna (9%) Sterling (10%)
Gender	Male 64% Female 36%	Male 58% Female 42%	Male 60% Female 40%
Mean age	55	48	45

the workshop participants were older with proportionately more males than the two PPGIS surveys. The community representation proportion also varied across the three PPGIS processes with 1998 survey participants more evenly distributed among the CNF communities compared to the 2012 survey which contained a higher proportion of Anchorage residents. The 2012 workshop process had a higher proportion of Cordova residents than either of the two PPGIS surveys.

Subsampling

The spatial association results from subsampling the survey data in 1998 and 2012 to match the workshop sample size for seven landscape values appears in Table 3. For six of the seven landscape values, the degree of spatial concurrence was greater with the 2012 survey data than with the 1998 survey data. The degree of spatial concurrence was highest for recreation (phi means = 0.40 and 0.41) and esthetic/scenic values (phi means = 0.26 and 0.33) and lowest for economic (phi means = 0.09 and 0.12) and historic/cultural values (phi means = 0.07 and 0.17). Using the Fitz-Gibbon and Morris (1987) interpretation of phi, the workshop and survey locations would be described as having *little or no* spatial association (biological, economic, historic/cultural, and wilderness values), *weak* association (esthetic/scenic, subsistence values), or *moderate* association (recreation value).

The results were plotted in Fig. 2 and fitted with a linear trend line. For both the 1998 and 2012 survey data, the degree of spatial concurrence was strongly correlated with the number of workshop observations—the larger the number of mapped locations, the higher the mean phi values.

Resampling

The spatial association results from resampling the workshop data to match the samples sizes of the 1998 and 2012 survey data appears in Table 3. In all cases, the phi coefficients for each landscape value were larger than the results using the subsampling method. The increase in spatial concurrence was lowest for those values with the largest number of workshop points (recreation, esthetic/scenic) and largest for those landscape values with the fewest workshop points (i.e., economic, biological, historic/cultural). For example, economic value had the fewest workshop points ($n = 29$) and the phi coefficient increased from 0.09 to 0.28 with the 1998 survey data. Recreation value with $n = 293$ workshop points only showed modest increases in spatial concurrence (0.40–0.44) with resampling. The larger phi coefficients appear to reflect the larger number of points used in the analysis and a higher probability that a given cell will contain both a workshop and survey point by chance. In other words, the results suggest the larger phi coefficients are largely an artifact of comparing larger point sets within the study region and not necessarily a true increase in spatial concurrence due to the resampling method over the subsampling method.

Hotspot concurrence

A graphic illustration of the method for comparing significant hotspots appears in Fig. 3 and the quantitative results of the spatial concurrence of Gi* hotspots using the 2012 workshop and survey data appear in Table 1. Recreation value had the greatest spatial concurrence in hotspots (67%) while wilderness value had the

Table 3
The results of three analyses: (a) mean phi coefficients and standard deviations from ($n = 500$) random subsamples drawn from 1998 to 2012 survey PPGIS to match # of points, 2012 workshops; (b) phi coefficients resulting from resampling 2012 workshop data using kernel density as probability surface to match size of 1998 and 2012 survey samples; (c) percent of statistically significant 2012 workshop hotspots that were also significant hotspots in 2012 survey.

Landscape value	2012 Workshop observations (n)	(a) Subsampling				(b) Resampling		(c) % Gi* hotspot workshop concurrence
		1998		2012		1998	2012	2012[a]
		Mean	Std. Dev.	Mean	Std. Dev.			
Aesthetic/scenic	129	0.26	0.04	0.33	0.04	0.33	0.39	37% (11/30)
Recreation	293	0.40	0.04	0.41	0.03	0.44	0.46	67% (14/21)
Biological	36	0.12	0.06	0.20	0.06	0.29	0.26	24% (8/33)
Economic	29	0.09	0.06	0.12	0.06	0.28	0.25	16% (4/25)
Historic/cultural	31	0.07	0.06	0.17	0.07	0.26	0.32	17% (4/23)
Subsistence	101	0.26	0.05	0.25	0.04	0.38	0.38	19% (4/21)
Wilderness	83	N/A	N/A	0.14	0.05	N/A	0.34	7% (1/14)

[a] Percent of statistically significant workshop hotspots (Gi* statistic converted to z and p values where $p \leq 0.05$) that were also significant with survey data.

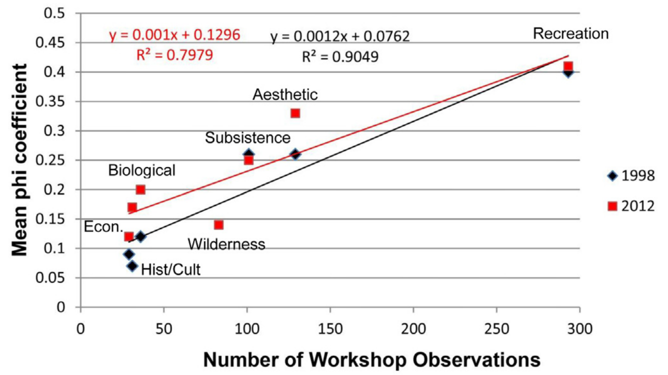

Fig. 2. Relationship between number of workshop observations and spatial concurrence measured with mean phi (φ) coefficient from $n = 500$ random subsamples.

lowest spatial concurrence (7%). With the exception of recreation value, these results indicate that the workshop participants identified different locations of landscape value intensity compared to the survey participants.

Discussion

The purpose of this research was to evaluate workshop and survey PPGIS to determine the similarity or difference in the spatial information generated. The study context was favorable for this type of evaluative research—the study area was the same (Chugach National Forest), the participatory mapping purpose was the same (assist with national forest planning), the spatial attributes mapped were similar (landscape values), and the mapping participants were sampled from the same communities proximate to the study area. Although these study conditions do not constitute research controls, they provide a stronger case for attributing similarities or differences in the results to the participatory mapping approach than would otherwise be possible.

The results from our three analytical approaches to evaluate the spatial data were consistent—the workshop method identified landscape value locations that were substantively different from the survey results. With the exception of recreation value, the degree of spatial association between the other landscape values was weak. The remainder of this discussion will focus on explaining the results and the associated implications for agencies or organizations seeking to use participatory GIS in the future.

Explaining the results

There are three plausible explanations for the empirical results observed: (1) number of participants and the quantity of spatial data collected, (2) methods of measuring the spatial attributes (landscape values), and (3) sampling methods. We attempted to account for the unequal number of points between the survey and workshop approaches using two analytical methods—subsampling and resampling. Both approaches matched the number of point observations, but still yielded weak measures of spatial concurrence with the exception of recreation value. Fewer participants and observations from the workshop may be a contributing factor, but there are other factors intrinsic to the spatial data collected.

The survey PPGIS used a deductive method for participatory mapping where participants were provided with a predefined set of landscape values with operational definitions. In contrast, the workshop landscape values were derived inductively based on the textual annotations associated with the map markers. The workshop participants were not provided with a predefined list of landscape values. We do not believe the inductive codes contain significant error from classifying the textual annotations into landscape value categories because we took a conservative approach and only included those workshop map markers that clearly had the same meaning as the predefined landscape values. Further, the assigned qualitative codes were cross-validated by other members of the research team. Nonetheless, a key need for future research would be to use the same mapping method in both the workshop and survey to ensure that the method does not have some influence on the resulting spatial patterns.

Could the multi-attribute nature of the workshop markers contribute to measurement error? Whereas the survey method identified landscape values with individual markers, the workshop method allowed participants to annotate each map marker with multiple values. Each multi-attribute workshop marker may contain an implicit, cognitive ranking of the values by the participant at a given location. The workshop method may be identifying less important landscape values with the markers that would not be possible if the participants were directed to map landscape

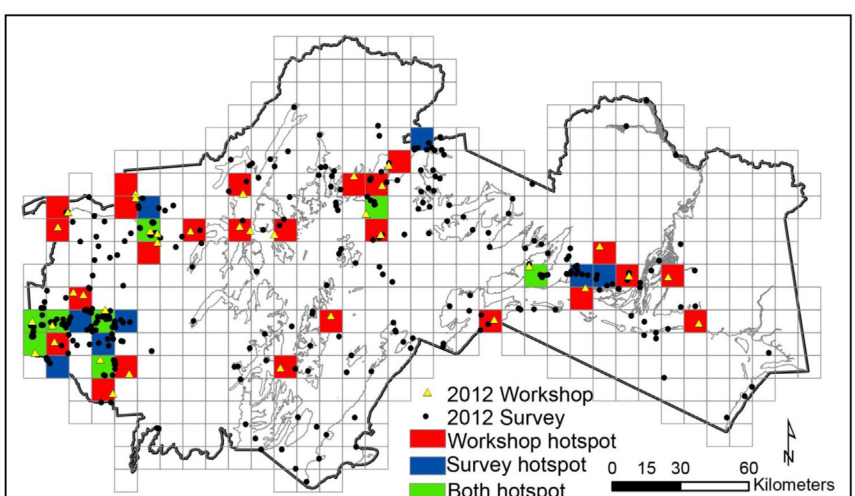

Fig. 3. Distribution of mapped biological landscape values from 2012 workshop ($n = 36$) and 2012 survey ($n = 325$) with Getis–Ord (Gi*) statistically significant ($p \leq 0.05$) grid cells for workshop data (red), survey data (blue), or both (green). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

values separately, as in the survey method. And what of the landscape value definitions themselves? Could the broad and subjective definitions of the landscape values contribute to measurement differences? Yes, in part. Brown and Pullar (2012) observed that the extent of spatial concurrence varies when mapping landscape values with polygon versus point features, with the variability related to the particular landscape value being mapped. In that study, the degree of spatial convergence was highest for esthetic and recreation values, and lowest for biological and economic values, consistent with our results. So the type of landscape value and how it is operationalized in the definition does contribute to greater spatial variability in participant mapping and thus lower spatial concurrence between workshop and survey approaches. And yet, the relatively low spatial concurrence between the workshop and survey results was consistent across all the landscape values examined, even those with greater spatial variability. Thus, there is likely some measurement error given the difference in participatory mapping processes, but measurement error is probably not definitive in explaining the results.

Another potentially important factor in the results can be attributed to sampling methods. The workshop method relied on volunteers to attend community meetings and may be characterized as volunteered geographic information (VGI) wherein geographic data is provided voluntarily (Goodchild, 2007). As Brown et al. (2014) observed in a participatory mapping study with both volunteer and randomly sampled participants, the mapped values significantly differed between the volunteer participants and the randomly sampled individuals. They concluded that "volunteered geographic information should not be presumed to represent the prevailing values and preferences of the general public proximate to national forest lands" (p. 20). The self-selected nature of volunteered mapping can introduce ideological bias that is not directly observable in traditional demographic comparisons. In this study, there were proportional differences in community representation in the two mapping processes, but all proximate communities were represented by mapping participants.

So what should be concluded regarding the three putative, explanatory factors? Does the quantity of spatial information, measurement method, and sampling approach explain the lack of spatial concurrence in the results? We cannot eliminate the possibility that the combined effects of the three factors produced the results reported herein. In the absence of a definitive explanation, it is the empirical results of low spatial concurrence that poses the greatest challenge for the choice of participatory mapping method. There were genuine differences in the mapped spatial locations that would influence planning decisions if the spatial data were used for decision support. The conditions of participatory mapping in a community meeting setting that requires flexibility in mapping spatial attributes from volunteer participants, and which also produces less spatial data, are likely to be present in future participatory mapping workshops. So what are the implications for planning agencies considering the use of participatory GIS methods in the future?

Implications for the use of participatory mapping for decision support

The purpose of workshop participatory mapping of landscape values in this study was to inform the revision of the Chugach National Forest (CNF) plan. But the results of our analysis raise important questions about what can, or should be done with the workshop spatial data. Is the spatial data sufficient and reliable enough to inform land use planning decisions on its own? Should it be combined with the survey PPGIS data to form a larger spatial data set for analysis? As academic researchers, how should we respond when an agency such as the Forest Service asks about how the workshop data should be used? More broadly, what can be said about the use of participatory mapped data from voluntary community meetings conducted for planning purposes?

The larger survey data sets (1998, 2012) from this CNF study were used to develop and evaluate a decision support system called values compatibility analysis (Reed & Brown, 2003; Brown & Reed, 2012a,b), to measure the change in landscape values over time (Brown & Donovan, 2014), and to identify areas of potential forest management conflict (Brown & Donovan, 2013). But these applications require a significant quantity of spatial data, especially when one considers the large CNF study area.

Based on the low level of spatial concurrence in our findings, we would not advocate combining the workshop data with the survey data. We are not confident that the sample of workshop participants is similar enough to the randomly selected survey participants to combine the spatial data. The available evidence suggests that participants in the workshop and surveys were drawn from different populations, i.e., there appears to be a population of individuals living proximate to the CNF willing to attend community meetings and a somewhat different population of individuals willing to complete a PPGIS household survey. These two populations produced spatial results that were substantively different.

More broadly, if workshop participatory data where the only source of data to inform a planning process, should the spatial data be used for agency decision support? Our results suggest that workshop spatial data, collected as points, may not be appropriate for primary decision support, but rather these data appear useful to identify the breadth and range of public values at stake in the planning process. This view is consistent with social research principles that suggest a progression from inductive, qualitative inquiry to more deductive, confirmatory analysis. The 2012 workshop method was comprehensive in identifying the full range of landscape values that were mapped in the earlier 1998 survey as well as the 2012 survey. The use of the workshop method for scoping and identifying the range of values and issues for further investigation appears non-controversial.

More contentious is the question of what to do when participatory workshops comprise the *only* means available for spatial data collection. For federal land management agencies in the U.S., there are significant regulatory barriers to the use of public surveys whereas a community meeting approach is more administratively achievable. There will be pressure for land management agencies to increase their use of publicly contributed spatial information because this reflects a larger trend in society, but some agencies may be administratively blocked from conducting, large representative PPGIS surveys (see Brown & Donovan, 2013). If agencies can only use the workshop approach, and the spatial data from the workshops may not appropriate for decision support, how should a convener of PPGIS workshops frame the purpose?

Public participation should adhere to ethical principles regarding the decision space for community engagement. The International Association for Public Participation (IAPP) provides a spectrum of public participation that ranges from simply informing the public to empowering the public to make decisions (IAPP, 2007). Most public agencies cannot legally delegate land management decision authority, but attempt to operate somewhere between simply informing the public and empowering the public to make decisions. According to the IAPP spectrum, this means that public participation would involve some type of "consultation", "involvement", or even "collaboration" in the decision process. Aside from the legal obligation for agencies to accept public comment about a proposed plan, what ethical obligations accrue to an agency that intentionally solicits spatial information in a community workshop? Should the agency disclose that the spatial data collected will likely not be representative and may have limited value for planning decision support? This type of disclosure is unlikely because few members of the public are likely to volunteer their time and effort under such conditions. Instead, vagueness about the actual use of the spatial data is offered to participants to keep them engaged in the process, i.e., "we will *consider* your information when formulating our planning decisions."

Even without the promise of using the spatial data from community meetings, or the ability to conduct a broader public survey as a follow-on activity, there may be non-decisional, non-planning benefits in collecting spatial data in a workshop format. Community meetings regarding future land use are known for their often contentious context. Land use change of any type is likely to spark some level of conflict. The use of participatory mapping in a community meeting can channel public passion and concern more constructively by focusing attention on the qualities of place rather than the ideology of land use (Cheng, Kruger, & Daniels, 2003). And yet, agencies must be prepared to answer the challenging questions from participants that are distrustful of the mapping process and that inquire how the spatial data will be used.

The evaluation presented herein raises as many questions about the use of participatory mapping data from workshops as it answers. If participatory mapping workshops are used to scope and identify the range of place-based values at stake in the planning process, the critical question about the use of the spatial workshop data for decision support can be deferred to the next phase of survey data collection. But if participatory mapping workshops represent an endpoint in the public participation process, engaging communities in participatory mapping knowing that workshop data is unlikely to reflect regional results, puts agencies in a difficult position. Should agencies collect spatial data if it cannot be trusted for decision support? Our findings suggest that data collected using our workshop methods are best suited to identifying the range of values and land use issues for the planning process, rather than serving as spatial data directly used for decision support. The sponsoring organization(s) should clearly communicate the limited scope and use of the PPGIS workshop data so as not to create unrealistic expectations from participants about how their mapped information will be used.

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