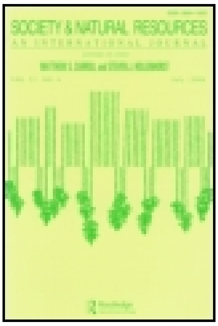

Society & Natural Resources: An International Journal
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/usnr20

Measuring Change in Place Values for Environmental and Natural Resource Planning Using Public Participation GIS (PPGIS): Results and Challenges for Longitudinal Research

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Published online: 01 Nov 2013.

Society and Natural Resources, 0:1–19

ISSN: 0894-1920 print/1521-0723 online
DOI: 10.1080/08941920.2013.840023

Measuring Change in Place Values for Environmental and Natural Resource Planning Using Public Participation GIS (PPGIS): Results and Challenges for Longitudinal Research

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Landscape values are a type of place value and are identified and mapped using public participation GIS (PPGIS). PPGIS engages nonexperts to identify important spatial information for environmental or natural resource planning. In 1998, we used PPGIS to identify landscape values for the Chugach National Forest (Alaska) plan revision process. In 2012, we conducted a longitudinal study of the same national forest using Internet PPGIS to identify changes in landscape values. The empirical results indicate stability in landscape values both in importance and spatial distribution. However, the use of different PPGIS methods (paper map vs. Internet) in the longitudinal study also introduced challenges in interpreting and explaining the spatial results. We discuss trade-offs in conducting longitudinal PPGIS research using mixed methods. PPGIS appears well suited for public lands planning, and national forest planning in particular, but barriers to use, such as regulatory approval, remain formidable.

Keywords forest planning, landscape values, public participation GIS (PPGIS), spatial analysis

In 2005, *Society & Natural Resources* published the first article describing methods for including spatial measures in survey research (Brown 2005). These new methods were based on an emerging area of public and stakeholder engagement called public participation geographic information systems (PPGIS) or participatory GIS (PGIS). The term PPGIS was conceived in 1996 at the meeting of the National Center for

Received 23 May 2012; accepted 17 September 2012.

The authors acknowledge the Institute of Social and Economic Research (ISER) at the University of Alaska Anchorage for providing funding to support the data collection for this project.

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Geographic Information and Analysis (NCGIA). Although the formal definition of PPGIS remains "nebulous" (Tulloch 2007) and "inconsistent across applications" (Schlossberg and Shuford 2005), PPGIS generally describes the practice of having nonexperts, or the lay public, identify spatial attributes for integration with GIS. The use of the term "PPGIS" has generally been applied to developed-country contexts while the term participatory GIS or "PGIS" is often used to describe participatory planning approaches in rural areas of developing countries (Rambaldi et al. 2006). In developed countries, the primary goal of PPGIS is to enhance public participation processes within existing regulatory planning frameworks.

As a new method in survey research, there has been a steady accumulation of knowledge and experience in applying PPGIS to environmental and natural resource applications. PPGIS applications have included identifying and mapping landscape values in support of forest planning (Beverly et al. 2008; Clement-Potter 2006), parks and protected areas planning (Pfueller et al. 2009; Raymond and Brown 2006), rural development (Nielsen-Pincus 2007), tourism and residential development (Raymond and Brown 2007), climate change risk (Raymond and Brown 2011), and identifying ecosystem services (Brown, Montag, and Lyon 2012).

To advance PPGIS methodology within the social sciences, researchers have examined the benefit of weighting mapped PPGIS attributes (Nielsen-Pincus 2011), using points versus polygons in participant mapping (Brown and Pullar 2012), using Internet panels for PPGIS sampling (Brown et al. 2012), evaluating Internet versus paper GIS technology (Pocewicz et al. 2012), identifying when clusters of points become significant "hot spots" (Zhu, Pfueller, Whitelaw 2010), mapping coupled or high-importance social–ecological areas (Alessa, Kliskey, and Brown 2008), extrapolating mapped values to nonmapped areas (Brown and Brabyn 2012; Sherrouse, Clement, and Semmens 2011), mapping place attachment or meaning (Gunderson and Watson 2007), and developing metrics to quantify mapped attributes (Brown and Reed 2012a).

PPGIS for natural resource planning was first used in the United States in the Chugach National Forest (Alaska) planning process in 1998. Brown and Reed (2000) developed a typology of landscape values and surveyed a broad cross section of randomly sampled households to identify and determine the spatial location of national forest areas with significant public value. Subsequently, different terminology has been applied to the same or similar typology of values; they have been variously called forest values, ecosystem values, environmental values, landscape values, wilderness values, and social values. The shifting terminology reflects, in part, the particular study context. For consistency, we refer to these predefined values as *landscape values* to connote their applicability to a variety of place settings. The focus of this article is on measuring change in landscape values and the implications for PPGIS used in support national forest planning in the United States. We present and interpret the results of a longitudinal study of Alaska residents that measured landscape values using PPGIS methods at two points in time, 1998 and 2012.

Landscape Values

The initial development of the landscape values typology for PPGIS was inspired by the integration of the philosophical work of Rolston and Coufal (1991) and the study of place embodied by the work of humanistic geographer Yi-Fu Tuan (see e.g., Tuan 1974; 1977). People are place-makers and learn to differentiate place from space by attaching meaning and values to space. Places become "centers of felt values" (Tuan 1977) that emerge through experience and are influenced by culture. The values that humans associate with place are central to individual and collective decisions about appropriate and desirable land use at multiple scales. For a recent review of the place literature, see Lewicka (2011).

The human value formation and expression process is complex and involves both "held" and "assigned" values. Held values are ideas or principles that are important to people (Lockwood 1999) and take the form of enduring beliefs about a specific mode of conduct or an end state of existence (Rokeach 1973). Some held values appear universal across cultures (Schwartz 1994). Assigned values express the importance of an object relative to one or more other objects (Brown 1984). Held values tend to be quite general, while assigned values are more specific (McIntyre, Moore, and Yuan 2008). Held values are believed to influence assigned values through the subjective evaluation of objects (Brown 1984; Lockwood 1999). For example, family trips to national parks and forests as a child may help create held values for scenic beauty, outdoor recreation, and solitude/spirituality. These held values, at a future point in time, may influence the assignment or transference of these values to different natural areas the person experiences.

Landscape values are an operationalized form of place value used for natural resource and environmental planning applications (Brown, 2005). A landscape value is best described as a type of "relationship" value that bridges held and assigned values. In the process of associating meanings with place, what is personally important to an individual (held value) merges with conceptions of what appears important to the individual in the physical landscape (assigned value). When mapping in PPGIS, individuals call upon their tacit, held values in the process of assigning values to a landscape such as the Chugach National Forest. This landscape value mapping process attempts to have the participant recall both experiences and symbolic meanings created through transactional human–landscape relationships (Zube 1987) where humans are active participants in the landscape—thinking, feeling, and acting—leading to the attribution of meaning and the valuing of specific landscapes and places.

The typology of values developed by Rolston and Coufal (1991) was implemented as general survey questions about national forests in Vermont by Manning et al. (1999) and operationalized as place-based values by Brown and Reed (2000) in Alaska. The place-based values typology was later used in other national forest studies in Colorado (Clement-Potter 2006), Arizona and Oregon (Brown and Reed 2009), and Canadian forest lands (Beverly et al. 2008).

How Stable Are Landscape Values over Time?

General human values have been described as relatively stable (Rokeach 1973, 11), but the literature on value change offers somewhat conflicting results, with some researchers reporting minimal change in values (e.g., Feather 1975; Lubinski, Schmidt, and Benbow 1996; Schwartz 2005) while others report substantive change in values (Kohn and Schooler 1982; Sheldon 2005). Hitlin and Piliavin (2004) define value change as a change in the importance of a value as in the rating or ranking of a value on a questionnaire.

Brown and Weber (2012) measured changes in the quantity and location of landscape values of residents on Kangaroo Island (KI), South Australia. The empirical results, with values remeasured after 6 years, indicated general stability in values in both importance and spatial distribution. The results also suggested that land-use changes from human development may significantly influence the distribution of landscape values. Importantly, however, that study had methodological limitations that merit further inquiry. First, the method of identifying landscape values changed from a paper-map GIS method in 2004 to an Internet-based mapping method in 2010. Different mapping methods are also present in this study. Second, there were small changes in the landscape values typology used in the longitudinal study on KI. These changes, in isolation, were probably not material but could be significant when combined with the change in mapping method. Third, there were sampling issues in the research design that increased uncertainty about the results. The longitudinal study did not include an explicit cross-section sampling design, and the number of participants in the longitudinal study panel was marginal for making strong inferences. Finally, while natural resource management is important on KI, the focus in that study was tourism and residential development, not natural resource management. To date, there has been no longitudinal study focused on changes in landscape values on public lands such as national forests in the United States that are managed for multiple resources. Hence, there is a need for a more robust PPGIS study to examine how landscape values might change over time on public lands to support public land planning and management efforts.

National Forest Planning and Longitudinal Study Context

This article examines the stability and change of landscape values collected using PPGIS in support of national forest planning. National forest planning in the United States is a process marked by conflicting values and ambiguous or contested goals. The U.S. Forest Service, the agency responsible for developing and implementing forest plans (called "Land and Resource Management Plans"), has historically lacked formal protocols to cope with these "wicked" and "messy" planning contexts that are characterized by multiple and competing goals, little scientific agreement on cause–effect relationships, limited time and resources, lack of information, and structural inequities in access to information and political power (Lachapelle, McCool, and Patterson 2003). The public participation process for forest planning required under the National Environmental Policy Act of 1969 (NEPA) that accompanies the development of forest plans has not been sufficient to mediate the conflict over the multiple values intrinsic to the national forest system (NFS). For example, every one of the 96 national forest plans completed through 1996 had been appealed (Kaiser 2006).

The requirements to develop forest management plans under the National Forest Management Act (NFMA) of 1976 and codified in 36 CFR 219 have not resulted in any practical advancement in the systematic inventory and mapping of place-specific values the public attaches to national forests. In response to these perceived deficiencies, university researchers and the Chugach National Forest (CNF) planning staff cooperated in 1998 to develop a new public participation method that included a spatially explicit survey component to assist forest planners make informed decisions about forest allocation and management. The result was a method that appeared to significantly advance the potential usefulness of public participation for decision support.

After a decade, the CNF is preparing to revise its national forest plan once again as required by the NFMA. The CNF was identified as one of eight national forests that will be the first to revise their land management plans using a new National Forest System Planning Rule after the rule is finalized (Forest Service Press Release, January 30, 2012). The proposed planning rule (http://www.fs.usda.gov/planningrule) does not specifically indicate that PPGIS methods be used in public involvement and collaboration but does encourage the agency to be "proactive and use contemporary tools, such as the Internet, to engage the public" (§ 219.4) while continuing to require that the agency identify the presence and consider the importance of various physical, biological, social, cultural, and historic resources on the plan area (§ 219.7) in the plan revision. The identification of social, cultural, and historic resources in the plan area appears ideally suited for use of PPGIS. Thus, the 2012 PPGIS study for the CNF reported herein serves two broad purposes: to identify how landscape values have changed since the last study in 1998, and to provide new data for the forthcoming CNF plan revision process.

In 2012, we developed and implemented an Internet-based PPGIS to identify changes in landscape values for the CNF. Our purpose here is to describe the methods used while seeking answers to the following research questions: (1) Has the importance (nonspatial) of landscape values changed over time? (2) Has the spatial distribution of landscape values changed? (3) What effects did changing the method of PPGIS data collection (from paper PPGIS to Internet PPGIS) have on the results? (4) What are the implications of these empirical findings for national forest planning processes that seek to identify place values?

Methods

Study Location

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 United States. 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 (population 3976) and Cordova (population 2239) in the east, and the Kenai Peninsula communities of Soldotna (population 4163) and Seward (population 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 (population 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).

Data Collection Process

To conduct the 2012 PPGIS study, we sampled two groups of participants. The first group was made up of individuals who participated in the 1998 CNF paper-map PPGIS study. The 1998 PPGIS study was a self-administered survey that requested individuals to place mnemonically coded sticker dots on a color map of the CNF (scale 1:500,000) provided in a mail packet with a covering letter and separate questionnaire. The sticker dots were attached to a paper legend providing definitions for each landscape value, 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 analysis (see Brown and Reed [2000] for a detailed description of the paper-PPGIS method). By consulting Internet address databases, we were able to identify $n = 512$ individuals still living in Alaska who participated in the 1998 CNF study. This group was the longitudinal panel of our study. In social research, a panel study collects longitudinal information on a group of people termed "the panel" over a period of months, years, or decades (Marshall 1998).

The second group of participants was made up of randomly selected individuals living in communities proximate to the CNF. The names and addresses were provided by a commercial vendor based on zip codes matching desired communities. In the 1998 study, we had randomly sampled individuals from 12 communities in close proximity to the CNF (Anchorage, Cooper Landing, Cordova, Girdwood, Hope, Kenai, Moose Pass, Seward, Soldotna, Sterling, Valdez, and Whittier). In 2012, we sampled the same communities from the 1998 study and invited $n = 2{,}335$ individuals to participate. This sampling group represented the 2012 cross-section study component.

We mailed letters of invitations to both the panel and cross-section groups inviting them to the PPGIS study website. Each letter of invitation contained a unique access code to be entered by the participant on the website that would allow us to track responses by sampling group. The study website consisted of an opening screen for the participant to enter the access code, followed by an informed consent screen for participation, and then a Google Maps interface that allowed the participant to drag and drop different digital markers representing 13 landscape values onto a web map of the CNF. The PPGIS application interface can be viewed at (http://www.landscapemap2.org/chugach). The instructions requested the participant to "use the map markers to identify the places you value . . . with your mouse, click on a marker and drag it onto the relevant map location." The different types of markers placed and their spatial locations were recorded for each participant on the Web server in a database, along with other information including a timestamp of when the marker was placed, the Google map view at time of placement, and the Google map zoom level (scale) at which the marker was placed. The first panel of markers in the Web interface replicated landscape values and their definitions from the1998 study. Participants could place as few or as many value markers as they deemed necessary to identify their values. The landscape value typology and definitions appear in Table 1.

Following completion of the mapping activity (placing markers), participants were directed to a new screen and were provided with a set of text-based survey questions to assess general, nonspatial forest management preferences and to measure respondent sociodemographic characteristics. PPGIS data collection ended with completion of the survey questions. Study participants had the option to return to the PPGIS website later to use their access code to add new markers or adjust previously placed markers.

To increase participation, two additional mail reminders were sent to nonrespondents following the initial mail invitation. On the second reminder, an incentive of a $10 electronic gift card was offered to participants who completed the study.

Table 1. Landscape value definitions and distribution of values in 1998 and 2012 by all respondents

		1998				2012			
Landscape value	Operational definition	Frequency	Percent	Rank[a]	R[b]	Frequency	Percent	Rank	R[b]
Aesthetic	These areas are valuable because they contain attractive scenery including sights, smells, and sounds.	1,980	11.8	2	.52	1,221	20.3	2	.43
Economic	These areas are valuable because they provide timber, fisheries, minerals, or tourism opportunities such as outfitting and guiding.	1,189	7.1	7	.61	332	5.5	5	.54
Recreation	These areas are valuable because they provide a place for my favorite outdoor recreation activities.	2,095	12.4	1	.53	2,072	34.5	1	.38
Life-sustaining	These areas are valuable because they help produce, preserve, clean, and renew air, soil, and water.	1,030	6.1	9	.62	240	4.0	8	.55
Learning/scientific	These areas are valuable because they provide places where we can learn about the environment through observation or study.	982	5.8	10	.61	218	3.6	9	.52
Biological	These areas are valuable because they provide a variety of fish, wildlife, plants, or other living organisms.	1,759	10.4	3	.59	356	5.9	4	.58
Spiritual	These areas are valuable because they are sacred, religious, or spiritually special places or because I feel reverence and respect for nature here.	1,191	7.1	6	.59	190	3.2	10	.59

(*Continued*)

Table 1. Continued

		1998				2012			
Landscape value	Operational definition	Frequency	Percent	Rank[a]	R[b]	Frequency	Percent	Rank	R[b]
Intrinsic	These areas are valuable in their own right, no matter what I or others think about them.	834	5.0	12	.66	154	2.6	12	.67
Historic	These areas are valuable because they represent natural and human history that matters to me, others, or the nation.	1,751	10.4	4	.58	311	5.2	6	.39
Future	These areas are valuable because they allow future generations to know and experience the area as it is now.	860	5.1	11	.59	182	3.0	11	.66
Subsistence	These areas are valuable because they provide necessary food and supplies to sustain my life.	1,577	9.4	5	.62	377	6.3	3	.58
Therapeutic	These places are valuable because they make me feel better, physically and/or mentally.	1,089	6.5	8	.59	259	4.3	7	.57
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.	502	3.0	13	.70	92	1.5	13	.46
		16839	100.0			6004	100.0		

[a]Spearman's rank correlation between 1998 and 2012 value rankings based on frequency distribution = .91 ($p < .001$).

[b]R is a ratio of observed distances between points to the expected distances between points if the points were randomly distributed. R ranges from R = 0 (completely clustered) to R = 1 (random) to R = 2.149 (completely dispersed). From the R statistic, a standardized z score is computed to test the hypothesis that the point distribution deviates from randomness, either toward clustering or uniformity. The hypothesis of complete spatially random (CSR) distribution of points is rejected for all four PPGIS attributes.

Analyses

Respondent Characteristics. To assess the similarity of 2012 respondents with the 1998 respondents, we compared variables common to both studies: age, gender, level of formal education, and number of visits to the CNF. The 2012 study also included 18 variables replicated from the 1998 study that measured attitudes toward various forest management uses, such as "commercial logging" and "motorized recreation." These items were measured on a 5-point Likert scale ranging from *strongly favor* to *strongly oppose*. We compared mean scores for the panel and cross-section groups.

Changes in the Relative Importance of Landscape Values over Time. In total, 16,839 landscape value points were identified in the 1998 study, while the 2012 study yielded 6004 value points for analysis. The large difference in the number of points available for analysis was the result of both a smaller sample size and a lower response rate in 2012. To assess potential changes in the importance of landscape values over time, we tallied the marker counts for each landscape value in 1998 and 2012. Previous research indicated the frequency of mapped landscape values was strongly correlated with separate, nonspatial survey questions measuring the ranked importance of the same landscape values (Beverly et al. 2008; Brown and Reed 2009). Thus, the frequency of mapped landscape values is a proxy measure of the perceived importance of landscape values appearing in the typology. The 13 mapped landscape values common to both studies in 1998 and 2012 were rank ordered from most to least frequent, and Spearman's rank correlation coefficient (Spearman 1904) was calculated to determine the similarity in the relative importance of landscape values over time.

Changes in Landscape Value Spatial Distribution. There are multiple approaches to assessing change in the spatial distribution of landscape values over time. A visual examination of two spatial distributions placed side-by-side to determine spatial accordance (agreement) is an important, but subjective, first step. To describe the general dispersion and clustering of value distributions on the CNF, we calculated the nearest-neighbor R index (Clark and Evans, 1954), which is a ratio of the observed distances between points to expected distances. R values less than 1 indicate clustering, values greater than 1 indicate dispersion, and values near 1 indicate random distribution. The R index is useful to describe the overall distribution of values but can miss specific locational changes in values.

To measure changes in landscape values by location between 1998 and 2012, we compared the spatial distributions of markers placed by respondents using standardized kernel density "hot-spot" analysis and the phi-coefficient statistic, which measures the strength of relationship between two binary distributions, thus quantifying the degree of spatial accordance (spatial overlap) between the distributions.

Kernel density mapping is a technique that fits a smoothly curved surface (grid) over each point, producing a circular area (kernel) of a certain bandwidth (or search radius). A density calculation is made for each grid cell in the study area. The resulting highest densities of grid cells are commonly referred to as "hot spots." Because the number of points influences the kernel density calculations, we standardized kernel densities by subtracting the mean grid density and dividing by the grid standard deviation. The two key parameters for density-based hot-spot analysis are the size of the grid cell and the search radius around each point. The standardized kernel density maps were generated using 1,000-m grid cell size and 5,000-m search radius for each landscape value point distribution. These parameters are a heuristic judgment based on the perceived accuracy of marker placement and expected area intended by the marker. Empirical research suggests that landscape values tend to cluster between 3 and 6 km (Nielsen-Pincus 2011). By heuristic convention (see Alessa, Kliskey, and Brown 2008; Brown and Pullar 2012), we classified standardized kernel densities in the top third of the distribution as hotspots.

To measure the degree of association between the spatial distributions in 1998 and 2012, we first clipped each density grid to the boundary of the CNF. We then calculated the phi correlation coefficient (φ) for each pair of landscape value distributions using data from a 2×2 contingency table where cell values represent the presence or absence of a standardized grid hot spot in the same map location. The phi coefficient is a variation of the Pearson correlation coefficient that is used for binary data and is related to the chi-squared statistic (χ^2), where $\chi^2 = n\varphi^2$ (Chedzoy 2006; Zhu, Pfueller, and Whitelaw 2010). The phi coefficient measures the strength of the relationship on a scale from 0 to 1 and the statistical significance of the relationship can be evaluated with the chi-square statistic. In total, we examined the 13 pairs of landscape value spatial distributions using this method from all respondents in 1998 and 2012. We also calculated the phi coefficient for the four most abundant landscape values identified by panel respondents ($n = 80$), as well as the phi coefficients for landscape values in the cross-section-only group in 2012.

To visualize locational changes in landscape values reflected in the phi-coefficient results, we spatially overlayed the standardized hotspot maps for the pairs of landscape value distributions in GIS.

Results

Response Rate and Respondent Characteristics

Of the 2,335 letters of invitation mailed to the cross-section sample, there were 215 full or partial responses. A full response is an individual who maps one or more point locations and completes the survey questions at the end; a partial response is an individual who maps one or more locations but does not answer the survey questions following the mapping activity. After accounting for known nondeliverable letters, the 2012 Internet-based PPGIS cross-sectional response rate was 10.1%. By way of comparison, the 1998 paper-based PPGIS response rate was 30.8%. For the panel group, of the 512 invitations mailed to the panel group, there were 80 responses, yielding a response rate of 19.1% after accounting for known nondeliverable letters. The combined response rate for the cross-section and panel groups was 11.6%.

Respondent characteristics in 1998 and 2012 were analyzed for similarities and differences. Respondents were similar in average age (approximately 45 years) and gender proportion (about 60% male) after accounting for the higher expected age of the panel group, but appeared to differ on the level of formal education reported (67% of 2012 respondents completed a bachelor's degree, compared to 40% of 1998 respondents) and familiarity with the CNF, as indicated by the proportion of respondents with more than 5 visits (84% for 2012 respondents compared to 69% for 1998 respondents). Anchorage residents also represented a higher proportion of participants in 2012 (32%) than in 1998 (10%).

Changes in the Attitudes toward Potential National Forest Uses

The mean responses to 18 replicated survey items measuring attitudes toward potential CNF use are presented in Table 2. The results indicate little change in attitudes over a 14-year time interval. Alaska residents continue to oppose resource development activities in the CNF, including timber, mining, and energy, but favor a variety of uses, especially sightseeing, wildlife viewing, gathering forest products, and nonmotorized recreation. Responses were very similar between the cross-section and panel groups.

Changes in the Importance of Landscape Values

The number of mapped landscape values and their relative ranks based on frequency for the 13 landscape values common to both studies appear in Table 1. Recreation and aesthetic values were the most important values in both studies. Although the relative percentage of landscape values mapped changed significantly between 1998 and 2012, the rank order of mapped landscape values changed relatively little, with Spearman's rank correlation equal to 0.91 ($p < .001$).

Changes in the General Spatial Distribution of Landscape Values over Time

All landscape values would be considered spatially clustered within the CNF boundary as seen in Table 1, where all R values are less than 1. Lower R values indicate more clustering and R values that approach 1.0 indicate more random distribution. In 1998, there is less numeric contrast among the computed R values for the distributions due to the larger number of points mapped and greater uniformity in frequency distribution compared to 2012. However, the relative order of the landscape value clustering is generally preserved between 1998 and 2012 with a few exceptions. Aesthetic and recreation values are among the most spatially clustered values, while intrinsic, future, and biological values tend to be more dispersed within the CNF. The significant change in R values for most mapped values between 1998 and 2012, especially cultural and historic values, is likely the result of differences in the number of values mapped between 1998 and 2012 and greater mapping precision available in the 2012 Internet PPGIS method with dynamic zoom.

Changes in Landscape Value Locations

Standardized density maps for 12 of the 13 landscape values measured in 1998 and 2012 are overlayed and appear in Figure 1. The degree of spatial accordance as measured by the phi coefficient is visually apparent in the figure, with aesthetic ($\phi = .43$, $p < .001$) and recreation ($\phi = .47$, $p < .001$) values showing the highest degree of spatial accordance. These findings represent a relatively high degree of spatial similarity between 1998 and 2012. Historic ($\phi = .32$, $p < .001$) and subsistence ($\phi = .28$, $p < .001$) values occupy the mid-range of spatial accordance, with the remaining landscape values showing greater variation in distribution within the CNF. Intrinsic value ($\phi = .13$, $p < .001$) shows the least amount of spatial accordance between the 1998 and 2012 results.

The potential changes in value locations were further assessed by examining the spatial distribution of the four most frequently mapped values (aesthetic, recreation,

Table 2. Mean attitudinal responses to forest management preference survey items asked in 1998 and 2012, with scale 1 = *strongly favor*, 2 = *favor*, 3 = *neither favor or oppose*, 4 = *oppose*, and 5 = *strongly oppose*

				Panel ($n = 69$)		
Survey item	1998 ($n = 834$)	2012 ($n = 244$)	Result[a]	1998	2012	Result[a]
Fish and wildlife habitat	1.44	1.43	NC	1.32	1.41	NC
Camping and picnicking	1.62	1.55	NC	1.46	1.46	NC
Wildlife viewing/observing	1.69	1.57	More favorable	1.39	1.48	NC
Nonmotorized recreation	1.69	1.60	NC	1.36	1.46	NC
Gathering forest products	1.74	1.68	NC	1.47	1.57	NC
Providing fresh water	1.81	1.72	NC	1.59	1.63	NC
Sport fishing	1.88	1.90	NC	1.95	1.84	NC
Sightseeing	1.93	1.79	More favorable	1.84	1.62	NC
Wilderness areas	2.10	1.84	More favorable	1.84	1.87	NC
Sport hunting	2.15	2.29	NC	2.21	2.19	NC
Subsistence hunting/fishing	2.16	2.14	NC	2.07	2.03	NC
Helicopter skiing/hiking	2.78	2.62	More favorable	2.63	2.48	NC
Communication sites and utility easements	2.82	2.66	More favorable	2.83	2.51	More favorable
Commercial outfitting/guiding	2.84	2.70	NC	2.72	2.74	NC
Motorized recreation	2.84	2.79	NC	2.87	2.85	NC
Commercial logging	3.26	3.54	Less favorable	3.46	3.54	NC
Oil/gas drilling	3.40	3.62	Less favorable	3.59	3.67	NC
Commercial mining	3.46	3.78	Less favorable	3.67	3.83	NC

[a]Differences measured using t test with $\alpha \leq .05$. NC, no statistically significant change.

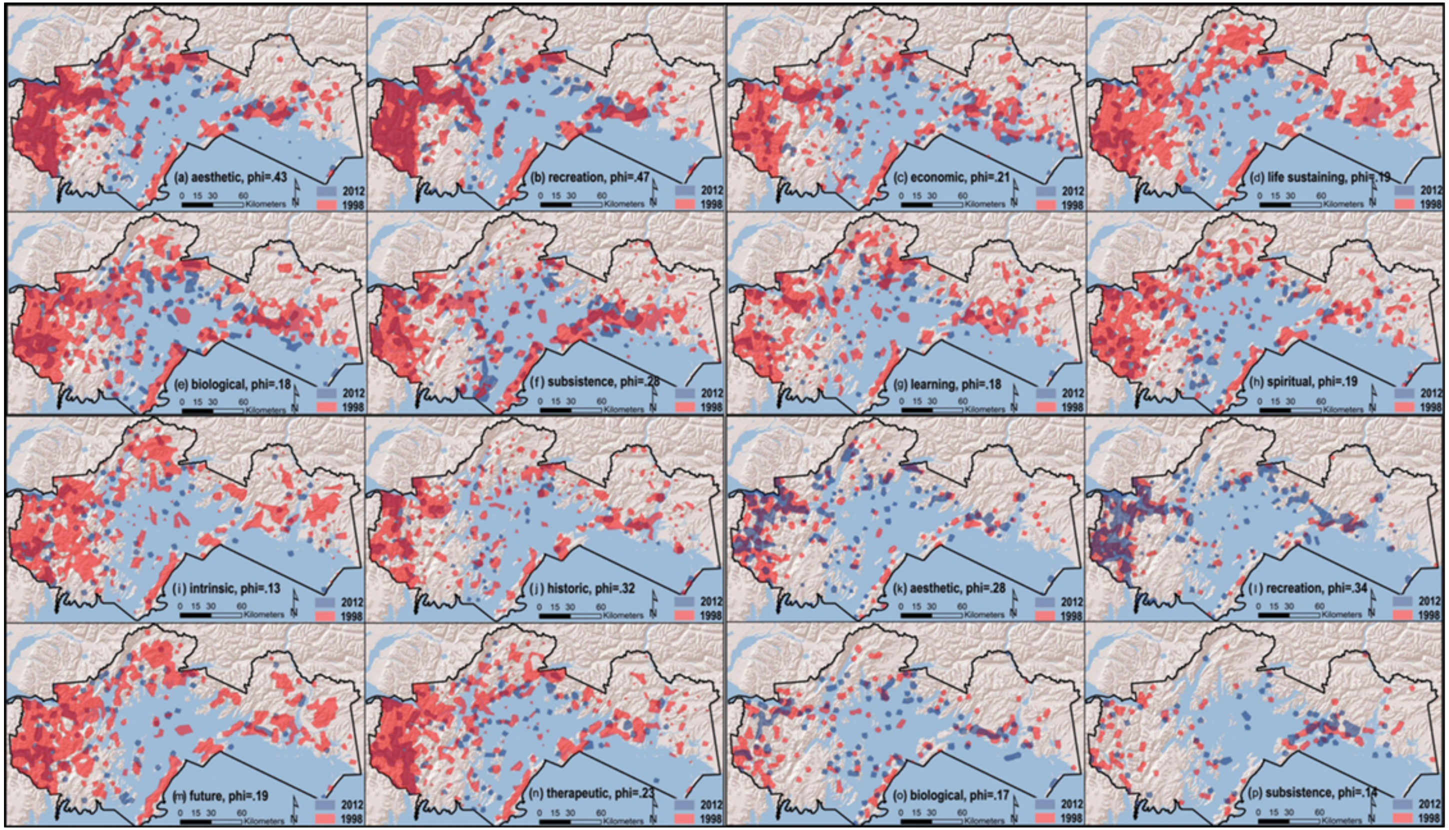

Figure 1. Overlap of value hot spots from study participants in 1998 ($n = 768$, red) and 2012 ($n = 295$, blue) in panels: (a) aesthetic, (b) recreation, (c) economic, (d) life-sustaining, (e) biological, (f) subsistence, (g) learning, (h) spiritual, (i) intrinsic, (j) historic, (m) future, and (n) therapeutic. The phi coefficient measures the degree of spatial accordance. Overlap of value hot spots from study panel ($n = 80$) in 1998 (red) and 2012 (blue) with values in panels: (k) aesthetic, (l) recreation, (o) biological, and (p) subsistence. All hot spots rendered from standardized raster values calculated from kernel densities (1,000-m cell, 5,000-m bandwidth). (Color figure available online.)

biological, and subsistence) with the panel group only—the same individuals who mapped values in 1998 and 2012 (see Figures 1k, 1l, 1o, and 1p). Spatial accordance, as measured with the phi coefficients, was less with the panel group than with the cross-section group for all values. For example, the phi coefficient for recreation value was .47 ($p < .001$) in the cross-section analysis, but only .34 ($p < .001$) in the panel analysis. These results reflect fewer points from the panel group from which to generate hot spots. Although using standardizing hot-spot densities attempts to limit the influence of unequal-sized point distributions, hot-spot densities and the calculated phi coefficients are still sensitive to the number of observations.

We also measured spatial accordance between landscape values measured at a single point in time (2012) as a general measure of the extent to which the same landscape values colocate within the same physical setting. Phi coefficients were generated for each pair of 2012 landscape value distributions. Aesthetic and recreation values tend to physically colocate ($\phi = .67$, $p < .001$) as do the value pairs of spiritual/aesthetic ($\phi = .41$, p < .001), historic/cultural ($\phi = .42$, $p < .001$), and intrinsic/future ($\phi = .43$, $p < .001$). With the higher colocation of therapeutic value with recreation ($\phi = .47$, $p < .001$) and aesthetic ($\phi = .48$, $p < .001$) value, one could logically infer that the combination of scenery and outdoor recreation combine to have a therapeutic effect on individuals in multiple CNF locations.

While it is useful to generate summary measures of spatial accordance, the phi coefficient masks important locational changes in landscape values that are far more useful in actual forest planning. For example, Montague Island in the south of Prince William Sound had consistently higher densities of all landscape values in 1998 compared to 2012. The Copper River delta east of Cordova was a subsistence hot spot in 1998 but appears less so in 2012. The locations of recreation hot spots appear to have shifted in the Port Nellie Juan region from 1998 to 2012. A Forest Service planning team could study these spatial results to generate a relatively long list of inferences about apparent changes in landscape values at specific CNF locations.

Discussion

Measuring change in place-based values for public lands is challenging under the best of social research conditions. The quality of longitudinal research can be negatively impacted by participant attrition, change in measurement methods, or changed social conditions that influence participation. Social researchers cannot control attrition or changed social conditions, but can control the methods used to measure change over time. When the methods substantively change, in this case from paper PPGIS to Internet PPGIS, how can one know whether the apparent change in place values is "real" or simply reflects change in the methods used? The truthful answer is that one can't, but in our judgment, the lower levels of spatial accordance observed in the mapped results are more indicative of the methods used than of actual changes in landscape value locations. In this discussion, we reflect on some of the issues and challenges of applying PPGIS methods in social research for environmental and natural resource management.

The nonspatial survey results that measured attitudes toward potential CNF uses were remarkably stable over the 14-year interval. Both the panel and cross-section groups showed little, if any, change. Based on the value–attitude–behavior hierarchical model of social psychology (Homer and Kahle 1988), the stability in attitudes would suggest stability in general values over time. However, landscape values are not general values, but rather relationship values that bridge people and place. Changes in either the individual or the place can confound the measurement of landscape values. The potential effect of changes in personal values on landscape values has not been empirically examined but appears worthy of future research. Changes in land use or the physical landscape, especially increased access through roads, is suggested to influence the distribution of landscape values (Brown and Weber 2012), although this relationship was not specifically examined in this study. The CNF would appear to provide an opportunity to examine landscape value change as a result of enhanced access to Whittier, a portal community to Prince William Sound.

In 2012, we made the decision to not replicate the paper-map PPGIS method after considering the trade-offs associated with each method. Paper-PPGIS methods are known to have higher public participation rates (Pocewicz et al. 2012) and potentially less bias owing to the digital divide (Brown and Weber 2012). But these advantages must be weighed against some of the benefits of new digital technology. The 1998 paper-PPGIS method had a fixed map scale of 1:500,000. This map scale did not offer participants the opportunity for increased precision in placing the landscape value sticker dots. In contrast, the 2012 Internet PPGIS enforced a minimum mapping scale within Google Maps at zoom level 12 (approximately 1:100,000 scale). Participants could optionally zoom in to level 19 (approximately 1:2,000). About 69% of all digital markers were placed at the default minimum zoom level (12), while the remaining 31% were placed at a higher zoom level (larger map scale). For some "fuzzy" landscape values such as intrinsic or future value, mapping precision does not appear all that important. But for other values, such as recreation, biological, or historic value, mapping precision is more important. A close examination of the value density hot spots in 2012 (e.g., see aesthetic value) suggests a potential mapping precision effect. The aesthetic hot spots would appear to more closely follow the main highway routes on the Kenai Peninsula compared to the 1998 PPGIS results. The 1998 paper-PPGIS also reflects a higher density of values along the highway corridors, but the combination of mapping imprecision with the sticker dots and the inherent digitizing error result in greater diffusion of values along the corridors.

The paper-PPGIS method offers study participants a static view of the study area. Place features are defined by what can reasonably fit on the map provided at the chosen scale. In contrast, digital maps offer participants a variety of map views, features, and potential overlays. For example, Google Maps offers "Map," "Terrain," "Satellite," "Hybrid," and three-dimensional (3-D) "Earth" views of the CNF study area. In addition, a number of specific CNF features were provided as optional (toggled) overlays for PPGIS participants, such as trails, recreation sites, and publicly contributed photos. This wealth of map information and flexibility in viewing the study area, however, does not necessarily translate into participant use of these features. About 93% of the mapped markers were placed in the default Google map type of "Hybrid" (an annotated satellite view). Elsewhere, researchers reported similar results when providing participants with extended mapping features. For example, when digital markers could be placed using Google Earth 3-D mode in an Internet PPGIS application, this feature was virtually unused (Brown et al. 2012).

In 2012, we made the decision to include markers representing preferred and nonpreferred forest uses (e.g., commercial forestry), in addition to the landscape value typology. This increased the number of markers from 13 in the paper-PPGIS in 1998 to 41 in the Internet PPGIS interface. If participant time for completing the survey is assumed to be relatively fixed (i.e., participants are subject to a personal time budget regardless of the method), adding more markers may have the paradoxical effect of diluting the participant's landscape value mapping effort. In 1998, participants identified, on average, 22 landscape value locations out of a possible 52 value markers. In 2012, the average number of landscape values identified by participants remained at 22 despite having no limit on the number of value markers that could be placed. We believe that differences in the percentages of landscape values mapped from 1998 to 2012 were partially a result of this change in the number and diversity of markers available for mapping. The change in method altered the percent of value markers mapped, but not the relative importance (ranking) of the values mapped.

The significantly lower participation rate in 2012 using the Internet PPGIS method is a concern that is shared by all survey research methods, with survey response rates showing declines across all modes of delivery (Curtin, Presser, and Singer 2005; de Leeuw and de Heer 2002; Hansen 2006). The study limitation from response rate can potentially be addressed by offering sampled individuals multiple modes of participation, as suggested by Brown and Reed (2009) and implemented by Pocewicz et al. (2012). Using Internet survey panels can also achieve higher participation rates in PPGIS, but the initial findings on the quality of PPGIS data using Internet panels are not encouraging (see Brown et al. 2012). Web-based surveys do have lower response rates than other modes of survey delivery (Cook, Heath, and Thompson 2000; Couper 2000), but increased research funding could improve participation rates through the use of incentives. The incentive offered in this PPGIS study in the second round of mailing had a positive but modest effect on response rates.

Given the preceding discussion about the challenges of measuring landscape value change, why would one also change the PPGIS method of data collection? Aside from the pragmatic reason that we did not have the funding to conduct a multimode PPGIS survey that would have replicated the 1998 study, the use of new PPGIS data collection methods may be unavoidable, given the specific research context of national forest planning.

National forest plans are long-range (10–15 years) strategic plans that guide allocation of the forest to particular uses and activities. The development of these plans is the one certain opportunity for comprehensive public participation in the forest planning process. If PPGIS is only used during forest plan revision, there will be long intervals (in this case, 14 years) between PPGIS studies for a given national forest. Technological change, particularly in geospatial technology, will be difficult to resist when considering the choice of PPGIS data collection methods. Normatively, we would advocate a 5-year interval for assessing and monitoring landscape values on public lands, but this scenario is unlikely, given persistent constraints on funding for social research within federal agencies. Further, the onerous regulatory approval process for federal agencies wanting to engage in PPGIS continues to be a major barrier to implementation (Brown 2012).

The proposed national forest planning rule offers important opportunities to engage PPGIS for suitability analysis. Specifically, the proposed forest planning rule states that forest plans should identify the *suitability of areas* for the appropriate integration of resource management and uses (§ 219.7). Incorporating a social assessment for resource management uses in suitability analysis is made possible with spatially explicit landscape values collected using PPGIS. Further, methods have been developed that use landscape values in suitability mapping for decision support (Brown and Reed 2012b; Reed and Brown 2003; Sherrouse, Clement, and Semmens 2011).

The measurement and analysis of landscape values appear ideally suited to assist planning and management of public lands because in theory, public lands should be managed for public values subject to legal constraints. Public values represent the social acceptability component of the sustainability triad. But to date, the use of PPGIS systems to measure landscape values for public land planning has been largely promoted by academics who see its potential for expanding public participation processes and developing decision support systems. The next important step will be for agencies to surmount regulatory barriers and take the lead in implementing PPGIS for national forest planning. Only then can we know for sure whether the putative benefits of using PPGIS for measuring and monitoring public values are real.

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