Public Participation GIS: A New Method for Use in National Forest Planning

Gregory G. Brown and Pat Reed

Abstract: In this article we describe and evaluate a public participation geographic information systems (PPGIS) methodology for use in national forest planning in the United States. The Internet-based mapping method collects public landscape values and special places data for input into a national forest planning decision support system. The PPGIS method presupposes that, within their existing statutory framework, national forests should be managed for compatibility with the range of values the public holds for those lands and that inadequate understanding, modeling, and documentation of place-specific forest values can negatively affect public acceptance, viability, and the usefulness of national forest plans. In this article we 1) review previous applications of landscape value mapping methods across a variety of planning applications, 2) describe the participatory, Internet mapping method used in three studies of national forests in Arizona and Oregon in 2006 and 2007, 3) present and evaluate the results to show likely future implementation constraints, and 4) based on lessons learned, describe a recommended PPGIS protocol for national forest planning. The results from the three studies demonstrate that an Internet, participatory mapping method, although not without limitations, can be effective in measuring landscape value and special place data for use in a variety of forest planning processes. Because the protocol expands and in a sense democratizes the agency's public participation process, implementation of the PPGIS protocol across the national forest system can help restore public trust in the agency's forest planning processes and forest management decisions. FOR. SCI. 55(2):166–182.

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NATIONAL FOREST PLANNING in the United States is a process often marked by conflicting values and ambiguous or contested goals at multiple scales of analysis. The traditional rational-comprehensive forest planning model does not often perform well under these "messy" conditions (Lachapelle et al. 2003), particularly when such values have no ready means of quantification. The US Forest Service, the agency responsible for developing and implementing forest plans (formally called "Land and Resource Management Plans"), currently lacks formal protocols to cope with these "wicked" value-related problems and often place-based planning issues. 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 (NF) system.

Since inception of the requirement to develop forest management plans under the National Forest Management Act of 1976 and codified in 36 CFR 219, there has been little, if any, practical advancement in systematic inventory and mapping of place-specific values the public attaches to NFs or rigorous and replicated quantitative analysis of place-specific value data in spatial modeling to assess forest plan decisions for consistency with public values—much less in a manner that is helpful to most forest planners and capable of withstanding legal challenges in the NEPA process.

In a time of rapid social and economic changes, the Forest Service would benefit from tools and methods that provide reliable information about what the public values from NF lands and where these forest values are located. In this article we describe a public participation method that uses geographic information systems (PPGIS) for collecting and analyzing spatial data to provide decision support in forest planning. Although the method is designed to assist with the development of forest plans under the National Forest Management Act of 1976 (NFMA), the data collected can be used for a variety of forest planning processes including travel management planning and recreation facilities planning on NFs.

In this article we first briefly review previous applications of landscape value mapping methods across a variety of land use planning applications followed by a description of the PPGIS mapping method used in three studies of NFs in Arizona and Oregon completed in 2006 and 2007. Data collected from the three NF PPGIS studies are analyzed and evaluated to show the range of results, analytical possibilities, and future implementation constraints. Based on the lessons learned from the studies, we conclude with a recommended PPGIS protocol for implementation in NF planning.

Background

The term "public participation geographic information systems" was conceived in 1996 at the meeting of the National Center for Geographic Information and Analysis (Sieber 2006). The concept describes the process of using GIS technologies to produce local knowledge with the goal

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of including and empowering marginalized populations. Since the 1990s, the use of PPGIS applications has been extensive, ranging from community and neighborhood planning to mapping traditional ecological knowledge of indigenous people (for a review of PPGIS applications, see Craig et al. 2002, Sawicki and Peterman 2002, Sieber 2006). A concept related to PPGIS, volunteered geographic information, is the harnessing of tools to create, assemble, and disseminate geographic data provided voluntarily by individuals (Goodchild 2007). The PPGIS methods described in this article are distinguished from volunteered geographic information in that the spatial data collection process is purposive and agency-driven rather than citizen-initiated and voluntary. Further, the PPGIS method described herein contains a probability sampling component.

In an early PPGIS application, Brown and Reed (2000) asked individuals to identify the location of landscape values such as aesthetic, recreation, economic, and ecological values, in addition to more indirect and symbolic landscape values such as spiritual and intrinsic values as part of the Chugach NF planning process. Intrinsic value is the concept that landscapes can have value independent of human use. The set of spatial attributes measured was based on a forest values typology adapted from Rolston and Coufal (1991). Reed and Brown (2003) subsequently developed a quantitative modeling approach to using the PPGIS mapped landscape values data to determine whether forest plan management alternatives were generally consistent and, more important, place consistent with publicly held forest values (for a summary of the Chugach NF case study, see Farnum and Reed 2008). This decision support method was initially called "values suitability analysis" in deference to its conceptual similarity to traditional physical land suitability analysis but was later called "values compatibility analysis" (VCA) when applied to NF planning. In VCA, forest management allocations and prescriptions (proposed management activities) are determined on the basis of the consistency of the activities with the range of publicly held landscape values collected using PPGIS.

Based on the initial success of the landscape values data collection and the promise of VCA for decision support, additional PPGIS research was conducted in a number of studies in Alaska and Australia (Brown 2005). For example, PPGIS methods were applied to marine and coastal areas to compare "expert" with "lay" conservation priorities (Brown et al. 2004), to assist in the designation, planning, and management of national scenic byways (Brown 2003), to identify "coupled social-ecological" hot spots where human and biophysical systems are closely linked (Alessa et al. 2008), to measure preferences for tourism and residential development (Brown 2006), to identify priority areas for conservation (Pfueller et al. 2006, Raymond and Brown 2007), and to identify park and open space values for urban park planning (Brown 2008). Additional PPGIS studies that mapped landscape values on national forestland were completed by doctoral students at the University of Idaho (Nielsen-Pincus 2006) and Colorado State University (Clement 2006). Using the Brown (2005) landscape value PPGIS method as a model, researchers with the Canadian Forest Service designed and developed the first Internet-based participatory mapping application to collect data on the locations of forest landscape values across a 2.4-million ha study area in the province of Alberta, Canada (Beverly et al. 2008).

Although the PPGIS methods that map landscape values and special places are best characterized as applied research for land use and forest planning, the method has also contributed to theory development and validation. For example, the method has been used to validate the presence of spatial discounting of environmental resources (Brown et al. 2002), the development of a theory of urban park geography (Brown 2008), and the development of proxy measures and indices for scale-based place attachment (see Williams and Vaske 2003) that provide place-based information to assess the risk associated with landscape modification (Brown and Raymond 2007).

In some PPGIS applications, greater emphasis is placed on the GIS technology, whereas in other applications, the social learning and community development aspects of PPGIS are emphasized. The Forest Service has long had access to GIS technology for forest management, but has not effectively integrated GIS technology with landscape values from public participation in NF planning. The working assumptions of a PPGIS tool for forest planning are that NFs should be managed for compatibility with the values the public holds for NF lands, subject to legal constraints on forest management imposed by statute and that inadequate understanding, improper modeling, and incomplete documentation of place-specific forest values can negatively affect public acceptance, viability, and usefulness of NF plans. In implementation of a PPGIS tool for NF planning, one must be mindful of the larger question regarding how public participation data will be used in forest plan decisionmaking. With VCA, this becomes more of a social or political question then a technical question.

Considerable legal discretion, in theory, exists for the Forest Service to develop forest plans that are consistent with publicly held values. The Multiple Use Sustained Yield Act of 1960 and the NFMA provide broad discretionary powers, if not contradictions and ambiguities (Schallau 1989), to manage for multiple resources on a sustained yield basis provided the land and resource management plans are rationally developed and conform to other relevant environmental laws such as the Endangered Species Act of 1973. In practice, Congress has historically established more prescriptive outcomes (e.g., timber "targets") for NF management through the Congressional budget appropriation process. In the forest planning process, the agency must carefully navigate between the broad goals of NF management expressed in the legislation and political pressures manifested in the planning process, both from Congress and special interest groups.

The NF planning process currently lacks a standardized method to collect and interpret beliefs about the values the general public holds toward various NFs in a way that can equalize the individual and organized group interests, which are ever present in the planning process. PPGIS is a tool with the potential to enhance the NF planning process by both increasing public participation and by providing place-specific information to guide forest plans.

Methods Used in Three National Forest PPGIS Projects

To better understand the strengths and limitations of PPGIS spatial mapping methods for NF system planning, results from three NFs are reported to assess the Internet-based, participatory mapping method: the Coconino NF in Arizona, the Deschutes and Ochoco NFs in Oregon (together administered as a single unit), and the Mount Hood NF in Oregon. These forests are pertinent based on their potential use of the PPGIS data for the forest plan revision process (Coconino NF), for potential use in travel management planning (Deschutes and Ochoco NFs), and for potential use in recreation facilities planning (Mount Hood NF). In each case, the purpose of the study was to learn about the feasibility of the Internet-based PPGIS method and not the provision of spatial data to help the three forests in their planning processes per se.

Selecting the PPGIS Data Collection Approach

The mapping of landscape values and other spatial attributes can be achieved using a number of different data collection methods: paper maps through mail surveys, electronic maps through the Internet, and structured interviews or facilitated group processes such as workshops. Each approach has its inherent strengths and weaknesses. The paper GIS method is the simplest method for collecting landscape value information from the general public as it requires no computer or Internet technology. Following the instructions provided with a paper map, participants place sticker dots (or use other markers) on a study area. The respondent data on the maps is then digitized into a GIS. The two primary disadvantages to the paper GIS approach are cost and turnaround time. Maps and markers can be expensive per mail contact and digitizing is an additional step not required if spatial data are entered on electronic maps and one that adds one more opportunity for spatial error. Structured interviews or facilitated group meetings can be done with either paper or electronic maps, but considerable human effort is required to set up the interviews or meetings. Electronic mapping via the Internet can have the shortest turnaround time but has the disadvantage of requiring prospective participants to have access to both a computer and the Internet. The lack of Internet access among a general public population will negatively influence the response rate and potentially introduce bias by limiting participation to those with competency in or access to computers and the Internet.

The three web-based studies were conducted between August 2006 and May 2007. Within this timeline, the studies were designed, implemented, and completed using an Adobe Flash Web-based interface with a MySQL backend database. The Internet-based PPGIS method provided for rapid development and implementation of the studies at significantly reduced cost compared with a mail or workshop-based approach. The three studies were completed as university-sponsored research projects without formal Forest Service sponsorship that would have required federal Office of Management and Budget (OMB) review and approval under the Paperwork Reduction Act (44 U.S.C. 3501 et seq.). Social research conducted or sponsored by the Forest Service, including survey research in which the same questions are asked of multiple people, requires OMB review and approval before implementation.

Selecting the PPGIS Attributes to Be Mapped

The landscape value and special place typology used in the three NFs was based on a number of goals and constraints. An overarching goal was that the selected values typology needed to be grounded in previous peer-reviewed research that demonstrated the validity of multiple landscape value measures.

The human valuing process is complex with multiple meanings of the "value" concept. For example, Brown (1984) classified the realm of values into three categories: held values, relationship values, and assigned values with preference relationships providing a linkage between held and assigned values. Content analysis research by Bengston and Xu (1995) resulted in a four-part classification system for forest values: economic/utilitarian, life support, aesthetic, and moral/spiritual.

In the operationalization of landscape values and special places in PPGIS, individuals express preference relationships that link their held values with values assigned to the study landscape such as a NF. Brown's (1984) conception of the human valuing process appears consistent with the transactional concept of human-landscape relationships (Zube 1987), in which 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. In the PPGIS process, we did not attempt to parse the influence of held values (based on life experiences) from assigned values (based on object attributes) as the process of mapping landscape values and special places through PPGIS is best viewed as holistic. The landscape value and special place maps that result from aggregated public or interest group responses represent a mix of preferential values that exhibit some degree of collective, spatial consistency, despite a high degree of spatial variation on an individual basis. The analogy of Surowiecki's (2004) "wisdom of crowds" may be appropriate here in observing that that a diverse collection of independently deciding individuals in the PPGIS process can produce collective spatial information that is better than that of individuals or even experts.

In previous PPGIS projects, the number of values/attributes mapped ranged from 10 to 13 landscape values plus the mapping of special places. The opportunity to modify an existing Internet-based mapping application developed by the Canadian Forest Service (Beverly et al. 2008) required that the number of landscape values measured be similar (but not necessarily equal) to the number used in the Canadian application. The Canadian research team chose 10 landscape values (with no mapping of special places), in part to avoid having Web application screen scrolling with the inclusion of more landscape values.

The 23 landscape values included in the three studies was chosen on the basis of the most common landscape values mapped in other landscape value mapping studies (see Table 1 for the list of landscape values included in the three studies). The Coconino NF study was the first to be completed (Fall 2006). For the NFs in Oregon (Spring 2007), a decision was made after talking with forest planners to modify the value typology to split recreation value into "developed" and "primitive" recreation value. The forest planning teams wanted this distinction to assist in travel management planning (selecting and managing all-terrain vehicle/off-road vehicle areas). To maintain 12 landscape values in the Internet application, "Future" value was not mapped in the Oregon studies.

Although there is no technical limit on the number of attributes to map with an Internet-based application, one potential threat to the quality of information collected is participant fatigue in the mapping exercise. Thus, there is an implicit researcher-imposed constraint on the number of spatial attributes for a participant to map. In addition to the 12 potential landscape values and special places, participants in the three studies could optionally "double-click" on any landscape value or special place marker to annotate the marker to explain why the particular value or special place marker was placed on the map.

The number and type of landscape values included in the three studies was not intended to constitute a definitive list of values for all NFs. A national PPGIS protocol for collecting landscape value data should include a core set of landscape values common to all NFs with options for forest planning staff to include additional landscape values that are specific to the forest.

Selecting the PPGIS Sampling Plan

The sampling plan for a NF mapping study is as important as determining the set of landscape attributes to be mapped. What stakeholder landscape values and special places are to be mapped? Residents? Visitors? Interest group members? How far should the geographic scope of the sampling plan be extended? The choice of sampling plan depends on the population(s) of interest as well as pragmatic limitations associated with various sampling goals.

Somewhat different sampling strategies were used in the three studies, but the core element of each sampling plan was to sample residents of households living in communities inside or proximate to the NF. The goal was to measure the landscape attributes of individuals who probably would

Table 1. Landscape value typologies used in the three national forest (NF) public participation geographic information systems studies

Coconino NF	Deschutes and Ochoco NFs and Mount Hood NF
Aesthetic—I value these areas for their scenic qualities.	Aesthetic—I value these areas for their scenic qualities.
Economic—I value these areas because they provide income and employment opportunities through industries like tourism, forest products, mining or other commercial activity.	Economic—I value these areas because they provide income and employment opportunities through industries like tourism, forest products, mining, or other commercial activity.
Recreation—I value these areas because they provide outdoor recreation activities such as hiking, camping, fishing, skiing, or wildlife viewing.	Developed Recreation—I value these areas because they provide for recreation activities such as hiking, camping, fishing, skiing, or wildlife viewing with motorized access and some facilities.
Future—I value these areas because they provide opportunities for future generations to know and experience them.	Primitive Recreation—I value these areas because they provide for primitive recreation activities such as backpacking and horsepacking without motorized access and facilities.
Life Sustaining—I value these areas because they help produce, preserve, and renew air, soil, and water.	Life Sustaining—I value these areas because they help produce, preserve, and renew air, soil, and water.
Learning/Scientific—I value these areas because they provide opportunities to learn about the natural environment through activities like nature interpretation and scientific study.	Learning/Scientific—I value these areas because they provide opportunities to learn about the natural environment through activities like nature interpretation and scientific study.
Biological Diversity—I value these areas because they provide places that support a variety of plants, wildlife, or other living organisms.	Biological Diversity—I value these areas because they provide places that support a variety of plants, wildlife, or other living organisms.
Spiritual—I value these areas because they are sacred, religious, or spiritually special places.	Spiritual—I value these areas because they are sacred, religious, or spiritually special places.
Intrinsic—These areas are valuable for their own sake, even if I or others don't use or benefit from them.	Intrinsic/Existence—These areas are valuable for their own sake, even if I or others don't use or benefit from them.
Historic or Cultural—I value these areas because they have features that represent history, or provide places where people can continue to pass down wisdom, traditions, and a way of life.	Historic or Cultural—I value these areas because they have features that represent history, or provide places where people can continue to pass down wisdom, traditions, and a way of life.
Therapeutic—I value these areas because they make me or others feel better, physically and/or mentally.	Therapeutic/Health—I value these areas because they make me or others feel better, physically and/or mentally.
Wilderness—I value these areas because they are wild, uninhabited, or relatively untouched by human activity.	Wilderness—I value these areas because they are wild, uninhabited, or relatively untouched by human activity.
Special Places—I value these places because they are special to me. Please double click on the Special Place marker to indicate the reason why the place is special to you.	Special Places—I value these places because they are special to me. Please double click on the Special Place marker to indicate the reason why the place is special to you.

Table 2. **Sample sizes and response rates for three national forest (NF) public participation geographic information systems studies**

	Coconino NF	Deschutes and Ochoco NFs	Mount Hood NF
Invitations mailed	3,009	3,056	1,825
Nondeliverable	467	137	263
Presumed delivered to invitee	2,542	2,919	1,562
Full or partial responses	257	344	179
Response rate (%)	10.1	11.8	11.4
General public sample	(see above)		
Mailed		1,916	1,350
Nondeliverable		92	68
Responses		159	112
Response rate (%)		8.7	8.7
Forest Service list	Not applicable		
Mailed		1,140	475
Nondeliverable		45	195
Responses		185	67
Response rate (%)		16.9	23.9

have a strong interest in NF planning outcomes. These individuals are presumed to live in households inside and proximate to the NF boundary.

The Coconino NF study randomly sampled households living in communities inside the administrative forest boundary and communities proximate to the forest but outside the administrative boundary. A similar process was used to select communities for the Oregon NFs. The sampling frame for households in communities near the three NFs consisted of names and addresses of households provided by commercial vendors.

The Deschutes and Ochoco NFs study and the Mount Hood NF study also sampled individuals from Forest Service-maintained lists of individuals who had previously expressed interest in NF planning or had attended some previous Forest Service meeting. The Forest Service mailing lists were generally ad hoc and not maintained or updated on a regular basis. For example, the Forest Service list of interested parties on the Mount Hood NF was decentralized by ranger district, with each district mailing list having differing levels of comprehensiveness and accuracy. The list of individuals from the Deschutes and Ochoco NFs study was composed primarily of individuals who had expressed interest in the travel management planning process of the forests. Both lists contained the names of individuals as well as of organizations. Only list entries with individual names were included in the samples.

The sample sizes for the three studies were based primarily on administrative feasibility and budgetary constraints. Totals of 3,009, 3,056, and 1,825 invitations were mailed to individuals in the Coconino NF, Deschutes and Ochoco NFs, and Mount Hood NF studies, respectively. About 37% of the Deschutes and Ochoco NFs sample and 26% of the Mount Hood NF sample contained the names of individuals provided by the forest planning staff (Table 2). An analysis of the response rates for the three studies is presented in the Results section.

Selecting the Methods to Analyze PPGIS Data

Once the spatial data are collected, the data can be analyzed using a variety of methods. The most useful starting point for analysis is to generate descriptive maps of the landscape value and special place locations. The landscape value data will reveal spatial patterns of distribution on the NF. Maps can be generated for each landscape value or in aggregate to reveal the location and density of landscape values relative to various NF features. These descriptive inventories are the starting point for more sophisticated analysis and modeling for forest planning. For example, Figure 1 shows a simple descriptive map of all landscape value and special place locations mapped on the Deschutes and Ochcoco NFs.

The analysis of landscape values can be schematically mapped into five domains: 1) the relationship among landscape values, 2) the relationship between landscape values and forest management activities and/or policies, 3) the modeling of compatibility with existing or prospective forest plans, 4) the relationship between landscape values and biophysical forest conditions, and 5) the relationship between landscape values and prevailing public uses. Although a comprehensive decision support system for NF planning should ultimately use information from each of the

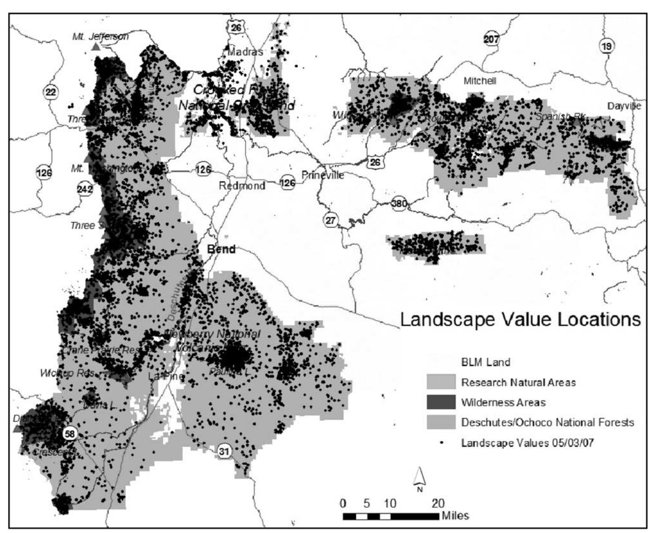

Figure 1. Descriptive map of all landscape value and special place locations on the Deschutes and Ochoco NFs using PPGIS.

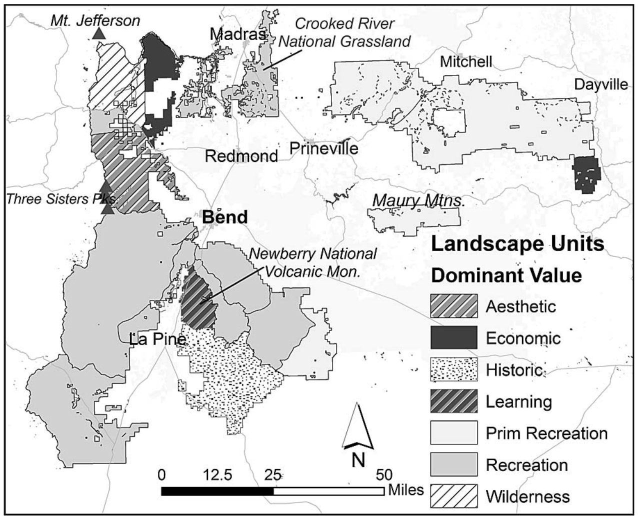

Figure 2. Map of Deschutes and Ochoco NFs showing the dominant landscape value mapped per management unit using PPGIS.

analytical domains, the relationship between landscape values and prospective forest management activities (e.g., all-terrain vehicle/off-road vehicle management) appears most salient to forest planners.

Suitability analysis is a set of analytical techniques designed to identify and narrow the range of potential land/water areas that are suitable for a specified land use based on a predefined set of decision criteria (see Steiner 2000). Suitability maps based on single decision criteria are generated to provide a set of individual data layers that can be overlaid to identify areas of intersection. Mapped areas that satisfy multiple decision criteria are thought to be most suitable for the specified land use. Various weights and ranks can be applied to the decision criteria to derive a single suitability classification score for the proposed land use under consideration.

In the Chugach NF planning process, a suitability analysis method called values compatibility analysis was developed to map landscape values to determine the consistency of potential forest management activities and management unit allocations with publicly held landscape values (Reed and Brown 2003). Rather than the biophysical characteristics of the forest driving the planning allocation process, the VCA framework places landscape values for the forest on equal operational (if not theoretical) footing with biophysical features. The simplified VCA process for modeling compatibility of landscape values with forest management activities consists of 1) identifying the typology of landscape values and attributes relevant to the planning purpose, 2) sampling and querying the general public and optional groups about the distributions (i.e., location and relative importance) of the identified landscape values through a participatory process, 3) compiling and preparing the landscape value data for VCA analysis and interpreted mapping, 4) modeling the compatibility of proposed management activities with the values, and 5) using the results to enhance collaborative learning opportunities through dialogue with the public.

In VCA analysis, the spatial data from the GIS are used as input into a spreadsheet model that calculates various landscape metrics and indices by forest area or management unit. VCA analysis also has the potential to determine the consistency of various forest activities with perceived landscape values based on judgments regarding the compatibility of value/activity relationships. The fullest potential of VCA modeling is realized when the NF planning team has previously identified management units relevant to the forest planning purpose. Although VCA has the potential to generate "prescriptive" results in a qualitative sense, it is important to note that it is not capable of, nor intended for use in, generating quantitative analyses for land and resource allocation purposes. Figure 2 graphically displays the dominant (or most common) landscape values for different management units in the Deschutes and Ochoco NFs study. All of the indices generated by the spreadsheet can be displayed in a GIS system.

Results from Three NF Studies

Response Rates

The three Internet-based participatory mapping studies for NFs in Arizona and Oregon yielded response rates of slightly more than 10% (Table 3). This participation is lower than the average response rate of 25% reported by Brown (2005) in paper-based GIS mapping methods and 22% reported by Beverly et al. (2008) in the first Internet-based mapping study. What accounts for the lower participation rate than that in previous studies? An analysis of nonresponse was performed for each of the three studies. Letters accompanied by postage-paid return postcards were mailed to nonrespondents as follows: Coconino NF (500 mailed, 102 responses), Deschutes and Ochoco NFs (300 mailed, 88 responses), and Mount Hood NF (250 mailed, 55

Table 3. Results of nonresponse bias check in three national forest studies

	Coconino NF	Deschutes and Ochoco NFs	Mount Hood NF
Nonresponse cards returned (*n*)	102	88	55
Respondent indicated he or she participated in survey (presumed error in tracking response) (*n*)	24	7	1
No convenient Internet access (%)	31	29	22
Internet survey too difficult (%)	6	9	12
Didn't feel like could contribute much information (%)	21	24	25
Just too busy (%)	17	8	17
Survey is biased (%)	1	3	0
Other reason (%)	24	26	27

NF, national forest.

responses). The postcards contained a list of potential reasons for not participating in the study including an open-ended reason. Responses indicate the greatest factors contributing to nonparticipation were the lack of convenient Internet access or reasons related to using the Internet-based application such as accessing the survey website, web browser problems, or impatience with the application at dial-up Internet speed (Table 3). About 25% indicated they did not feel like they could contribute much to the study, and between 7 and 16% indicated that they were just too busy to participate. Perceived bias with the study did not appear to be a major factor reported for not participating in the study.

The nonresponse data suggest that about 30% of the invitees did not have convenient access to the Internet. This estimate may be somewhat low, given the rural character of the communities surveyed in Arizona and Oregon. Data regarding regional and national Internet usage provided by the Pew Internet & American Life Project indicate that Internet penetration in the United States reached 73% of adults and that the share of Americans with broadband coverage is 42% (Madden 2006).

Survey data collected by the Pew Internet & American Life Project in February–March of 2006 were queried to determine statewide Internet adoption rates in Oregon and Arizona. About 75% of Oregonians indicated they use the Internet "at least occasionally" (including work), but this figure drops to about 65% for rural areas. About 66% of Oregonians report having a home computer with 43% of these households having "dial-up" rather than broadband Internet connectivity. In Arizona, about 71% of those surveyed indicated that they use the Internet "at least occasionally" with the same level of usage reported in rural areas. Of those in Arizona with a computer at home (approximately 68%), approximately 22% of these households connect to the Internet through dial-up service. Thus, the national survey data are consistent with the nonresponse survey data suggesting that the lack of convenient access to the Internet is a major factor contributing to nonparticipation.

The two Oregon studies yielded slightly higher response rates than the Arizona study because those samples included individuals from lists provided by the Forest Service who had expressed interest in some aspect of NF management. For the Deschutes and Ochoco NFs, the list included individuals who had participated or commented on the future travel management plan for the forest. The origin of the Forest Service list for the Mount Hood NF is more ambiguous. Presumably, these were individuals who had participated in or commented on some aspect of forest planning or proposed action in the past. The mailing list supplied by the Mount Hood NF was not very current, as approximately 41% of the requests for participation were returned as nondeliverable.

Respondent Characteristics

The characteristics of individuals who participated in the three studies deviate from those of the population as a whole considering national census statistics. Participants were somewhat older, were disproportionately male, were more highly educated, and had higher household incomes levels (Table 4) than might be expected given the population characteristics. The participants' higher age is probably due to the sampling frame containing higher average ages than the general public as younger populations often may not

Table 4. Participant sociodemographic characteristics compared with national census statistics

Characteristic	Coconino NF	Deschutes and Ochoco NFs	Mound Hood NF	US Census data*
Length lived in community (years)				
Mean	19	28	29	NA
Median	14	25	28	
Mode	10	30	15	
Age (years)				
Mean	53	55	51	
Median	55	54	52	36.3 (34.2)
Mode	55	54	49	
Household size				
Mean	2.3	2.5	2.6	2.5 (2.6)
Median	2.0	2.0	2.0	
Mode	2.0	2.0	2.0	
Level of formal education (%)				
Bachelor's degree or higher	57	50	50	25.1 (23.6)
High school diploma or less	3.5	11	6.5	41 (43.3)
Occupation (%)				
Employed	63	66	75	65.2 (61.1)
Retired	33	29	17	NA
Gender (%)				
Male	70	75	68	49.6 (49.9)
Female	30	25	32	50.4 (50.1)
Household income (%)				
≥\$100,000 or more	19	23	30	10 (11)
≤\$20,000 or less	5	2.5	4.7	21 (21)

NF, national forest; NA, not applicable.
* 2000 Census data for Oregon; Arizona census data appear in parentheses.

give particular attention to NF planning. The higher percentage of male respondents is probably the result of the sampling frame containing a higher number of males as well as the propensity for males to have significantly higher rates of Internet usage than females (Pew national survey data, χ^2, $P < 0.05$). The higher participation rate among individuals with higher levels of formal education and higher income levels is consistent with national level data about Internet participation. The Pew national survey data indicate that Internet usage is higher in younger age groups, among households with higher income levels, and among individuals with higher levels of formal education (Madden 2006).

Sensitivity of PPGIS Mapping Process to Respondent Characteristics

The extent to which responses from the sampled study participants deviate from those for the general population (sampling error) affects the generalizability of the findings. Because the mapping of landscape values and special places is not a traditional type of survey, sampling error can be further compounded if certain respondent characteristics influence the mapping of landscape values and special places. To assess the sensitivity of the PPGIS mapping activity to respondent characteristics, a series of statistical tests were conducted to examine the relationship between respondent characteristics and the number and type of attributes mapped. The results of the analyses appear in Tables 5and 6.

Gender

Two of the three study results indicate that women map more of certain types of landscape values than men, such as biological, life sustaining, and learning values. These results are consistent with a number of studies that indicate the propensity of women to express stronger environmental concern than men. To the extent that women are underrepresented as a respondent group as is the case with the three studies, the proportion of various landscape values will deviate from what would be expected in the general population.

Age of Respondent

There are small, but statistically significant negative correlations between the age of the respondent and the number of mapped therapeutic and spiritual values and the number of mapped special places. These results indicate that older respondents map fewer of these types of values and special places. To the extent that older respondents are overrepresented as a respondent group, the proportion of these two landscape values and mapped special places will deviate from what would be expected in the general population.

Level of Formal Education

Respondents with a higher level of formal education mapped more aesthetic landscape values than those with a lower level of formal education. Because the level of reported formal education among respondents is significantly higher than that of the general population, the proportion of aesthetic values would also be overrepresented in the respondent group compared with that in the general population.

Self-Reported Knowledge of the Forest

Respondents who reported greater familiarity with the forest quantitatively mapped more landscape values and special place locations than individuals reporting less familiarity with the forest. The differences in number and type of mapped values were larger in the two Oregon studies than the Coconino NF study.

Self-Reported Recreational Use of the Forest

Respondents who reported greater recreational use of the forest mapped more recreation (developed and primitive) and recreation-related values (e.g., wilderness) than those respondents reporting less recreational use. In the Mount Hood NF study, greater reported recreational use of the forest also resulted in a higher number of mapped aesthetic and biological diversity values.

Livelihood

The only significant finding was that individuals associated with the forest products industry mapped more economic landscape values than other occupational groupings such as the tourism industry in the Deschutes and Ochoco NFs study.

Income

The only significant finding was that individuals in a lower income category for one of the three forests mapped fewer recreation landscape values than those in a higher income category.

Self-Reported Environmental Advocacy

Respondents who self-identified as environmental advocates (the majority of respondents in all studies) mapped a higher number of biological diversity values in two of the three studies. Environmental advocates also mapped more aesthetic, intrinsic, life-sustaining, spiritual, and primitive recreation landscape values in at least one of the studies. The Mount Hood NF study contained too few nonenvironmental advocates to meaningfully assess the relationship of this variable.

Sensitivity of Landscape Value Mapping to Sampling Groups

Two of the three studies (Deschutes and Ochoco NFs and Mount Hood NF) sampled individuals from Forest Service-maintained lists of individuals who had previously expressed interest in NF planning or had attended some previous Forest Service meeting. Do these individuals differ from a general public sample with regard to sociodemographic characteristics and to the number and type of

Table 5. Statistically significant relationships ($P < 0.05$) between selected respondent variables and the number and type of mapped landscape values from three national forest (NF) studies

Variable (statistical test)	Coconino NF	Deschutes and Ochoco NFs	Mount Hood NF
Gender (*t* tests)	Aesthetic (female > male) Biological (female > male) Historic (female > male) Life Sustaining (female > male) Spiritual (female > male) Learning (female > male) Total number of mapped values (female > male)	No difference	Biological (female > male) Life Sustaining (female > male) Learning (female > male) Intrinsic (female > male) No difference in total number of values mapped
Age (bivariate correlation)	Therapeutic ($r = -0.21$, $P < 0.05$) No relationship with total number of values mapped	Spiritual ($r = -0.13$, $P < 0.05$) Therapeutic ($r = -0.14$, $P < 0.05$) Special Places ($r = -0.14$, $P < 0.05$) No relationship with total number of values mapped	Spiritual ($r = -0.16$, $P < 0.05$) Special Places ($r = -0.25$, $P < 0.05$) No relationship with total number of values mapped
Formal Education (ANOVA* with Tukey)	Aesthetic (Some college courses < a graduate degree) Biological (Some college courses < a graduate degree) No difference in total number of values mapped	Aesthetic (High school certification < university degree) No difference in total number of values mapped	Aesthetic (High school certification < university degree) No difference in total number of values mapped
Group—Public versus Forest Service list (*t* test)	Not applicable	Learning (Public > Forest Service List) ($P < 0.05$) No difference in total number of values mapped	Primitive Recreation (Forest Service list > public ($P < 0.05$) Recreation (Forest Service list > public ($P < 0.05$) Special Places (Forest Service list > public ($P < 0.05$) No difference in total number of values mapped
Self-reported knowledge of forest (ANOVA* with Tukey)	Aesthetic (Poor < Fair, Good, Excellent) Special Places (Poor < Excellent; Fair < Excellent) No difference in total number of values mapped	Aesthetic (Poor < Fair, Good, Excellent) Biological (Poor < Fair, Good, Excellent) Historic (Poor < Excellent) Learning (Poor < Excellent) Primitive Recreation (Poor < Fair, Good, Excellent) Recreation (Poor < Excellent) Intrinsic (Poor < Excellent) Wilderness (Poor < Fair, Excellent) Spiritual (Poor < Excellent) Therapeutic (Poor < Excellent) Life Sustaining (Poor < Good, Excellent) Special Places (Poor < Good, Excellent; Fair < Excellent) Total number of mapped values (Poor < Good, Fair, Excellent)	Aesthetic (Poor < Excellent, Fair < Excellent) Biological (Poor < Excellent) Primitive Recreation (Poor < Good, Excellent); (Fair < Excellent) Recreation (Poor, Fair < Excellent) Spiritual (Fair < Excellent Wilderness (Poor < Excellent; Fair < Good, Excellent); Special Places (Poor < Good, Excellent; Fair < Excellent) Total number of mapped values (Poor < Good, Excellent; Fair < Excellent)

* One-way analysis of variance (ANOVA) with Tukey's honestly significant difference post hoc test.

mapped responses? One would hypothesize that these individuals, by virtue of their volitional expression of interest in forest planning issues, would map a greater number of landscape values and special places because of greater familiarity with the forests than the general public.

Respondents from the Forest Service lists did not differ markedly from the general public sample on sociodemographic characteristics with one exception—the list provided by the Mount Hood NF contained a higher proportion of male respondents than the general public sample (Table 7). As might be hypothesized, the Forest Service lists contained proportionately more individuals who were more familiar with the NFs and who more frequently use the NFs for recreation. These differences in levels of familiarity and

Table 6. Statistically significant relationships ($P < 0.05$) between selected respondent variables and the number and type of mapped landscape values from three national forest (NF) studies

Variable (statistical test)	Coconino NF	Deschutes and Ochoco NFs	Mount Hood NF
Self-reported recreational use of forest (ANOVA* with Tukey)	Recreation (Frequent use > Don't use, Rarely use, Occasional use) No difference in total number of values mapped	Primitive Recreation (Rarely use < Frequent use; Occasional use < Frequent use) Recreation (Rarely use < Frequent use) Wilderness (Rarely use < Frequent use) Special Places (Do not use < Frequent use; Rarely use < Frequent use; Occasionally use < Frequent use) Total number of mapped values (Rarely use < Frequent use)	Aesthetic (Rarely use < Frequent use) Biological (Rarely use < Frequent use) Primitive Recreation (Rarely use, Occasional use < Frequent use) Recreation (Rarely use, Occasional use < Frequent use) Wilderness (Rarely use < Frequent use) Special Places (Rarely use < Frequent use) Total number of mapped values (Rarely use < Frequent use)
Livelihood (Forest Products, Tourism, state or federal agencies, other) (ANOVA* with Tukey)	No difference	Economic (Forest Products Industry > Tourism industry, Other professions) No difference in total number of values mapped	No difference
Income (6 categories ranging from ≤$20,000 to ≥$100,001) (ANOVA* with Tukey)	No difference	Recreation ($20,000 and less < $40,000-$60,000) No difference in total number of values mapped	No difference
Environmental advocacy (Yes, No, Somewhat) (ANOVA* with Tukey)	Aesthetic (Yes > No, Somewhat > No) Biological Diversity (Yes > No, Somewhat > No) Historic (Yes > No) Life Sustaining (Yes > No, Somewhat > No) Spiritual (Yes > No) Total number of mapped values (Yes > No)	Biological Diversity (Yes > Somewhat) Primitive Recreation (Yes > Somewhat) Intrinsic Value (Yes > Somewhat) No difference in total number of values mapped	No differences (but only 7 "no" responses)
Self-reported recreational use of forest (ANOVA* with Tukey)	Recreation (Frequent use > Don't use, Rarely use, Occasional use) No difference in total number of values mapped	Primitive Recreation (Rarely use < Frequent use; Occasional use < Frequent use) Recreation (Rarely use < Frequent use) Wilderness (Rarely use < Frequent use) Special Places (Do not use < Frequent use; Rarely use < Frequent use; Occasionally use < Frequent use) Total number of mapped values (Rarely use < Frequent use)	Aesthetic (Rarely use < Frequent use) Biological (Rarely use < Frequent use) Primitive Recreation (Rarely use, Occasional use < Frequent use) Recreation (Rarely use, Occasional use < Frequent use) Wilderness (Rarely use < Frequent use) Special Places (Rarely use < Frequent use) Total number of mapped values (Rarely use < Frequent use)

* One-way analysis of variance (ANOVA) with Tukey's honestly significant difference post hoc test for group differences.

recreational use did translate into two significant differences between the two sampling groups. For the Mount Hood NF study, respondents from the Forest Service list mapped more recreation values (both developed and primitive) and more special place locations on average than the general public sample. The differences in landscape familiarity do not appear to introduce significant bias toward the mapping of particular landscape values, with the exception of recreation values, which tend to track familiarity with the forest. Familiarity with the forest also results in the mapping of more special place locations.

Frequency and Spatial Distribution of Landscape Values

The frequency of landscape values and a calculated measure of point distribution for the three studies appear in Table 8. Frequency measures the number of landscape values mapped by participants whereas distribution is measured by the R statistic, a global measure of the point distribution that tests the hypothesis that each point distribution is completely spatially random within the study area. The R scale ranges from $r = 0$ (completely clustered) to $r =$

Table 7. Differences/similarities in respondent variables between general public sample and Forest Service mailing list

Variable	Deschutes and Ochoco NFs	Mount Hood NF
Gender (χ^2)	No difference	Forest Service list contained higher proportion of males (78%) than females (61%) ($P < 0.05$)
Age (*t* test)	No difference	No difference
Formal education (χ^2)	No difference	No difference
Self-reported knowledge of forest (χ^2)	Forest Service list had significantly higher percentage of "Excellent" knowledge (37%) than general public sample (15%) ($P < 0.05$)	Forest Service list had significantly higher percentage of "Excellent" knowledge (35%) than general public sample (12%) ($P < 0.05$)
Self-reported recreational use of forest (χ^2)	Forest Service list had much higher percentage of "Frequent use" (69%) than general public sample (40%) ($P < 0.05$)	Forest Service list had much higher percentage of "Frequent use" (84%) than general public sample (30%) ($P < 0.05$)
Livelihood (Forest Products, Tourism, state or federal agencies, other) (χ^2)	No difference	No difference
Income (6 categories ranging from ≤$20,000 to ≥$100,001) (χ^2)	No difference	No difference
Environmental advocacy (Yes, No, Somewhat) (χ^2)	Forest Service list had higher percentage of self-defined environmental advocates (71%) than general public sample (62%) ($P < 0.05$)	No difference

NF, national forest.

1 (random) to $r = 2.149$ (completely dispersed). For comparison, results from the Chugach NF study also appear in Table 8.

To date, there is general consistency across NFs in the frequency of mapped landscape values: recreation and aesthetic values are the most frequently mapped forest values whereas spiritual value is the least mapped landscape value. The frequency of mapped landscape values appears to provide a reasonable proxy for the perceived importance of the landscape values in general. In the three studies, respondents were asked to rank up to the five most important landscape values after the mapping activity. The similarity in results between the frequency of mapped landscape values and the separate landscape value ranking exercise was assessed using Spearman's rank correlation coefficient. The correlation coefficients range from 0.82 to 0.88 ($P < 0.01$), indicating a strong correlation between frequency of mapped values and general perceptions of landscape value importance.

The general spatial distribution of landscape values across the three studies shows much greater variability in the clustering/dispersion of landscape values. The *R* statistic can be influenced by the shape of the forest as well as by the number of mapped landscape values. At least one general conclusion can be inferred from the results: More *tangible* landscape values associated with forest use or visitation (e.g., recreation, aesthetic, and learning) tend to be more clustered, whereas more *intangible* landscape values tend to be dispersed (e.g., intrinsic and therapeutic). However, there are exceptions. The usefulness of generalizing spatial results is limited because the spatial features of the forest landscape are also highly variable.

Discussion

Lessons Learned from the Three Studies

The three studies reinforce the important conclusion that the spatial location and to a lesser extent the type and number of landscape values and special places are sensitive to the subpopulations being sampled. A NF unit mapping study is a regional study that may involve multiple communities. Community residents develop relationships with surrounding landscapes based on their identity with the landscape, their dependence on the landscape, and the meanings they associate with the landscape. Empirically, the community relationships with the NF will manifest in different landscape value and special place maps. For example, in the Coconino NF study, landscape value density maps were generated for the two communities of Flagstaff and Sedona. Although these communities are relatively close to each other, the community landscape value maps are significantly different (for landscape value maps of Flagstaff and Sedona residents, see Figure 3). Residents of Flagstaff tended to have a broader, forestwide distribution of values compared with that of Sedona residents, whose landscape values tended to cluster closer to the community. The potential impact of community sampling methods on the mapping results should be carefully considered in planning of future PPGIS projects for NFs.

A second important lesson from the three studies is that the PPGIS project should be complementary to workshop- or public meeting-based mapping of forest values. The Deschutes and Ochoco NFs study offered the opportunity to compare dominant values from a series of travel management workshops conducted by forest planning staff with the mapped results from the study. Although the value typologies (categories) differed somewhat in the two methods, there were significant areas of agreement regarding the dominant values for the management areas. For example, in the management unit in which mapped aesthetic values were dominant, workshop participants indicated that the same area should be managed for "scenic beauty." In the management unit in which mapped wilderness values were dominant, workshop participants indicated the management area should be managed for nonmotorized recreation.

Table 8. **Summary of landscape values—nearest neighbor statistic (*R*) and value frequency counts—for three national forest (NF) studies and the Chugach NF planning study (1998)**

Landscape value	Deschutes and Ochoco NFs study (2007)	Mount Hood NF study (2007)	Coconino NF study (2006)	Chugach NF study (1998)*
Aesthetic				
R value (rank)	0.433 (3)	0.556 (3)	0.638 (3)	0.664 (1)
No. observations (rank)	1,032 (3)	537 (3)	908 (2)	1,710 (4)
Economic				
R value (rank)	0.481 (8)	0.589 (7)	0.595 (1)	0.741 (5)
No. observations (rank)	651 (7)	322 (6)	439 (10)	1,089 (8)
Recreation				
R value (rank)	0.390 (1)	0.470 (1)	0.677 (7)	0.675 (2)
No. observations (rank)	1,129 (1)	550 (1)	1,044 (1)	2,095 (1)
Life Sustaining				
R value (rank)	0.482 (9)	0.611 (9)	0.655 (5)	0.775 (10)
No. observations (rank)	513 (11)	279 (7)	514 (7)	1,759 (2)
Knowledge/Learning				
R value (rank)	0.427 (2)	0.538 (2)	0.659 (6)	0.743 (6)
No. observations (rank)	668 (6)	248 (10)	470 (8)	982 (10)
Biological Diversity				
R value (rank)	0.458 (5)	0.601 (8)	0.705 (9)	0.763 (9)
No. observations (rank)	706 (5)	334 (5)	608 (4)	1,751 (3)
Spiritual				
R value (rank)	0.484 (10)	0.578 (4)	0.645 (4)	0.765 (11)
No. observations (rank)	478 (12)	239 (12)	420 (11)	834 (12)
Intrinsic				
R value (rank)	0.476 (7)	0.656 (12)	0.701 (8)	0.828 (13)
No. observations (rank)	601 (8)	278 (8)	524 (6)	1,030 (9)
Historic*				
R value (rank)	0.481 (8)	0.585 (5)	0.633 (2)	0.670 (3)
No. observations (rank)	519 (10)	247 (11)	546 (5)	860 (11)
Future				
R value (rank)	NA	NA	0.727 (10)	0.745 (7)
No. observations (rank)			413 (12)	1,577 (5)
Subsistence				
R value (rank)	NA	NA	NA	0.745 (7)
No. observations (rank)				1,189 (7)
Therapeutic				
R value (rank)	0.504 (11)	0.618 (11)	0.754 (11)	0.720 (4)
No. observations (rank)	535 (9)	249 (9)	463 (9)	1,191(6)
Cultural*				
R value (rank)	0.481 (8)	0.585 (5)	0.633 (2)	0.813 (12)
No. observations (rank)	519 (10)	247 (11)	546 (5)	502 (13)
Wilderness				
R value (rank)	0.438 (4)	0.612 (10)	0.773 (12)	NA
No. observations (rank)	946 (4)	425 (4)	680 (3)	
Primitive Recreation				
R value (rank)	0.460 (6)	0.586 (6)	NA	NA
No. observations (rank)	1,085(2)	549 (2)		

NA, data for this landscape value not collected in the study. Ranks of frequency counts and *R* values appear in parentheses.
* Year of data collection. Source: Brown et al. (2002).
† Historic and cultural values combined in 2006 Coconino NF study.

Where appropriate, future PPGIS projects for NF planning should be complementary rather than competitive replacements for community workshop/public meeting approaches. The Internet-based PPGIS mapping approach offers the important advantage of scientific sampling of residents to achieve greater regional population representativeness, but it does not obviate the need for face-to-face forest planning interactions at the community level.

A third lesson is that Internet-based participatory mapping methods are currently insufficient to capture the broadest cross-section of the public and will need to be augmented by traditional mail-based PPGIS methods and/or increased numbers of contacts to significantly increase participation rates. Survey coverage error (i.e., the potential population that can be reached via the Internet relative to the target population) appears to be a significant contributor to the lower response rate in the three studies. Internet access and speed are currently limiting factors, especially in rural communities surrounding many MFs. The potential for bias from coverage error (in other words, the "digital divide") is generally known and includes underrepresentation of lower-income, black, and Hispanic households and overrepresentation of individuals with college degrees, with this disparity being even greater in rural areas (Crouper 2000). Future PPGIS projects for NF planning should provide for multiple modes of survey participation, including some

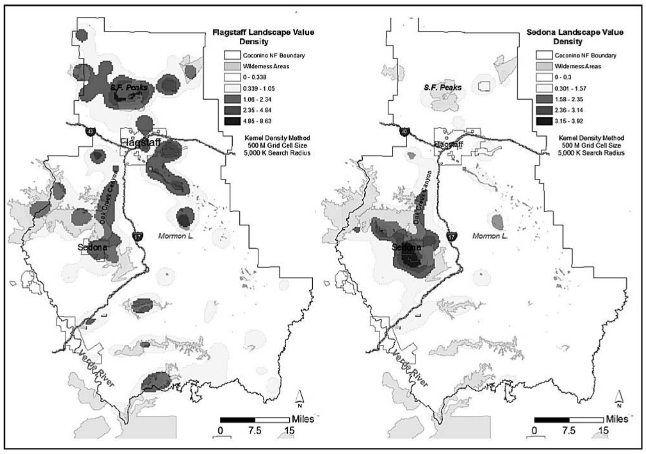

Figure 3. Density of mapped landscape values (darker color represents higher density) for Flagstaff residents (left image) and Sedona residents (right image) in the Coconino NF. Flagstaff residents' values are more widely distributed across the forest whereas Sedona residents' values are concentrated near the community.

combination of Internet, mail-based, and workshop/public meeting participation. Not only can multiple modes of participation increase response rates (Dillman 2000), but they also can reduce some of the inherent bias associated with each data collection method. Survey contacts should also be increased because the number of contacts, especially the prenotice contact, seems to have the strongest impact on survey response rate (Dillman 2000).

Another important lesson learned from the studies is that the Forest Service sanctioning of the PPGIS project will probably increase public participation rates. The studies were conducted independent of the Forest Service without formal approval or sanctioning by the agency. A number of individuals questioned why the request for participation came from a research team located in the East and not the Forest Service itself. These comments suggest that a number of individuals may not have accepted the legitimacy of the study and therefore chose not to participate. The inability to promote the studies as backed by the Forest Service probably reduced the perceived importance of the study to some individuals. Future PPGIS projects for NF planning should have the full support of the Forest Service, and this support should be communicated to prospective participants. In addition, the actual data collection should be done in partnership with a perceived neutral research organization such as a university or research institute.

The final lesson is that distrust of Forest Service by interest groups can carry over into distrust of the PPGIS mapping method, particularly if they were not able to understand or be guaranteed how the study results would influence decisions. Some interest groups were fearful that the PPGIS method would result in Forest Service decisions that are not in their group's best interest. In this case, distrust in the agency can result in reduced participation. One pathway to building trust in the agency is to provide opportunities for collaboration through public-private partnerships (Wondelleck and Yaffee 2000). The Forest Service would be prudent to consider making PPGIS data collection at least partially collaborative by approaching forest interest groups to encourage participation from their members. An effective collaborative process would create mutual responsibilities among all parties to collect valid data for the planning process. Given the political and often contentious nature of forest planning, building and sustaining trust will always be an important component in PPGIS success.

Constraints for PPGIS in NF Planning

The development and implementation of the NF systemwide PPGIS protocol for mapping landscape values, special places, or other spatial attributes faces some formidable constraints. The list of constraints includes, but is not limited to, the lack of specific agency directives, the cost of developing and implementing the protocol, the OMB review and approval process, the lack of agency experience in working with this type of data, the public acceptability of this type of data for forest planning, and the uncertain legal implications of planning decisions that reference landscape value data. Each of these constraints will be briefly explained below.

Lack of Specific Directives

The Forest Service is required by law to develop land management plans (forest plans) under the NFMA for each of its NF or grassland units. The agency is guided by planning rules that describe forest planning procedures and requirements. In recent years, the agency revised its planning rules only to have those revised planning rules nullified by a federal circuit court decision based on inadequate NEPA analysis. The agency readopted the forest planning rules (36 CFR 219) in 2008 after NEPA review. Both the older forest planning rules and revised rules provide agency discretion to engage with the public and stakeholder groups in the forest planning process. However, the collection of landscape value and special place data through PPGIS for the purposes of forest planning is not specifically identified as a requirement in the forest planning process. If the PPGIS protocol remains discretionary in the forest planning process, NFs could choose not to implement the protocol.

Cost of Developing and Implementing the Protocol

The PPGIS protocol for collecting and analyzing landscape value and special place information as part of the forest plan development process would not be disproportionately expensive relative to other components of forest plan development, but in an agency with static or shrinking operating budgets, any alternative or additional expense will need to be justified. PPGIS would require an initial capital investment for software development for a customizable Internet version of the mapping protocol plus a per unit cost of implementing the PPGIS protocol for each NF or grassland. A reasonable estimate for the collection and analysis of landscape value and special place data for each NF unit would be about $25,000 per forest. This planning cost is considerably less than the costs associated with conducting many basic biological surveys and inventories of forest resources for NF units.

OMB Approval

Under the Paperwork Reduction Act (44 U.S.C. 3501 et seq.), the Forest Service is required to have certain public information collection activities approved by the director of the OMB. The collection of PPGIS data as part of the forest planning process would come under the authority of the Act and thus require the Forest Service to seek approval through the OMB. Although the Act may limit the paperwork burden on the public, the opposite is true for federal agencies seeking to collect information from the public to help them plan and allocate federally managed public resources. The set of administrative procedures to be followed to obtain OMB approval for data collection is often onerous at best and labyrinthian at worst. Further, the turnaround time for OMB review and approval is highly variable. OMB reviews can take from several months to years to complete. Such processing times are not satisfactory for individual forest plan timelines, often meaning that survey results become “water under the bridge” for decisionmaking in an agency that is attempting to reduce the total amount of time to complete revisions of forest plans. The administrative burden to obtain OMB approval is significant to the point that the only reasonable strategy for the Forest Service is to request “blanket” approval for a general PPGIS protocol that could be implemented for each NF planning unit (or to be able to identify issues for a survey far in advance of both traditional public involvement processes and to have the survey reviewed and approved).

Lack of Forest Service Experience

Although the Forest Service has historical experience working with quantitative decision support systems (e.g., FORPLAN and Spectrum) and GISs, the agency has little experience working with PPGIS data and the VCA decision support system that is used to analyze the data. The initial study of collecting PPGIS data for the 1998 Chugach NF planning process was received with caution, if not a degree of skepticism, by the interdisciplinary forest planning team (Reed and Brown 2003). Similarly, the forest planning team at one of the three NFs reported herein that was actively engaged in their forest plan revision process has done little with the PPGIS data to inform its forest planning process. The mapping of landscape values and special places through PPGIS and the VCA decision support system that uses the data represent new technology for assessing forest plan options. Personnel in federal agencies such as the Forest Service are not rewarded for taking risks; few individuals want to be without support on the leading edge of technology. Positive agency experience using a PPGIS protocol in forest planning will eventually overcome distrust and skepticism, but this will only happen if the agency can accumulate “stories of success” with the protocol.

Public Acceptance

If we assume that the agency can obtain approval for the PPGIS protocol and gains the experience and confidence to use the protocol for forest planning, there is an open question about the public acceptability of using PPGIS data to inform forest plan development or revision. The initial studies of the protocol suggest that the public appreciates the opportunity to provide their personal values and perspectives for forest planning. However, the Deschutes and Ochoco NFs study, in particular, suggested that established interest groups (both “environmental” and resource-use based nongovernmental organizations) can have some concerns about the agency collecting PPGIS data because these organizations did not know how the information would be used by the Forest Service. Interest groups have become familiar with methods to lever their interests in the forest planning process and the new protocol represents “uncharted waters.” They are not familiar enough with the protocol to endorse its use, and in lieu of this familiarity, some interest groups would prefer to maintain their status quo in representing deeper public meaning in forest planning processes. This reaction is not unexpected. Research indicates that significant differences in opinion may exist between leaders of interest groups and nonmembers (Lord and Elmendorf 2008). Any protocol that measures the “silent majority” represented by the general public (especially probability-based surveys that tend to be viewed as surrogates for voting) is likely to be viewed as a “wildcard” to the forest planning process, one that cannot be easily manipulated by interest groups to present a particular perspective. Once a history of using the PPGIS protocol is established, interest group skepticism may diminish.

Uncertain Legal Implications

The forest planning process has become a politically charged environment with interest groups perceiving final forest plans as a zero-sum game; that is, one group’s influence necessarily diminishes another’s. Interest groups do not hesitate to use the federal court system to challenge the legality of forest plans under the NFMA or the adequacy of the NEPA process used to develop the forest plans. A reasonable assumption for the agency is that a forest plan’s process will be reviewed by a court of law. However, history suggests that the court system has provided imperfect guidance at best for the agency to develop plans that will pass legal muster under the wide range of issues and regulations. Expanding the public participation process in forest planning through a PPGIS protocol would presumably be viewed favorably by the courts, but the legal implications are unknown.

A Recommended PPGIS Protocol for NF Planning

The recommended PPGIS protocol for NF planning is intended to provide information about public values for NFs to inform forest plan decisions. The PPGIS process can be considered one component of a NF’s public participation plan to supplement traditional social and biophysical inventories collected and used in the forest planning process. The protocol should be implemented as early as feasible in the forest planning process so the data are available to the forest planning team and forest stakeholders. Whereas the protocol is intended for use in developing and revising NF plans and plan implementation, the landscape value and special place data collected can be used for a variety of related NF planning processes such as travel management planning and recreation facilities planning.

Data Measures

A typology of landscape values that individuals can identify as points on a NF map, with the option to identify multiple special places, provides the minimal set of basic data that should be collected. Demographic information about the respondents would facilitate understanding of how subpopulations vary in their perceptions, a useful capability considering the amount of time spent identifying and resolving issues. The number and type of landscape values can vary by NF unit, but the protocol should provide a minimum of 10 and a maximum of 15 landscape values to be mapped. Providing too few options risks not capturing the full range of values; providing too many options risks essentially double counting values if they are too similar. The number of points available for mapping each landscape value should be between a minimum of three and a maximum of six. Each point mapped should provide the participant with the opportunity to annotate the point to describe the rationale for mapping the landscape value or special place. Providing too few points for mapping risks not allowing the respondent to identify a meaningful set of locations; providing too many points risks "littering" the map to cover every possible location at the expense of being unable to differentiate the truly important from the common.

The use of points rather than polygons simplifies the mapping process for participants, but there are data tradeoffs with any map-marking method. The use of polygons results in a high degree of variability in responses that can limit the usability of the data (e.g., how does one interpret and use a polygon drawn over the entire study area?). With the point mapping method, the landscape area associated with a given respondent value is indeterminate. Each point is assumed to represent a polygonal area, but the shape and size of the polygons are unknown. One respondent could be referencing a spatial area as small as a camp site, whereas another might be referencing a spatial area as large as the entire study region. To handle this problem, data analysis relies on the spatial aggregation of multiple points to delineate areas of value concentration. Polygonal areas are inductively generated from point distributions. Our experimentation with the use of both point and polygon map markers among general public populations indicates fewer data integrity and integration problems with the use of points, but we see no inherent limitation in using polygons or a combination of both if participant mapping instructions can be clearly communicated and understood by participants.

The landscape value typologies used in the three studies provide a reasonable starting point for each NF unit to customize the typology based on specific forest needs and geographic contexts. For example, "subsistence" value was an important landscape value to map for the Chugach NF in Alaska, but this value appears much less important for the Arizona and Oregon NFs, which are nearer larger metropolitan areas. The inclusion of two types of recreation values in the Oregon NF studies (developed and primitive recreation) reflected the desire to obtain more specific information about recreation values in these forests that have very high recreational use.

The PPGIS protocol should allow participants to map special places and to identify their rationale for mapping the special place location. Although the protocol described in this article provides a full range of landscape values that includes use and nonuse values, some participants may nonetheless believe the mapping options to be too limiting or the value definitions expressed in terms not familiar to the participants. The mapping of special places provides participants the ability to fully express their landscape values and supporting rationale in their own words.

Data Collection Methods

At least two data collection methods that allow individuals to participate in forest planning should be provided: one based on a representative, scientific sample and the other based on a voluntary desire to participate if not selected as a part of the scientific sample. The responses should be tracked and analyzed separately. If the Internet-based PPGIS method is used for primary data collection, a second method should be made available to those who desire to participate but lack a computer and/or Internet access. Traditional mail-back surveys fill this role well. The ideal process for implementing the PPGIS protocol would combine multiple data collection methods and multiple sampling strategies as shown in Figure 4.

Sampling

An important part of the PPGIS protocol is the inclusion of both random and purposive sampling. The regional public sample is designed to measure the values of a representative sample of the "general public" living proximate to the NF unit. These are individuals who are presumed to have the greatest direct interest in the NF unit's management options. Further, probability-based random sampling offers the advantage of estimating the true proportions of the value distributions within the larger population. The general public should be randomly sampled from a comprehensive

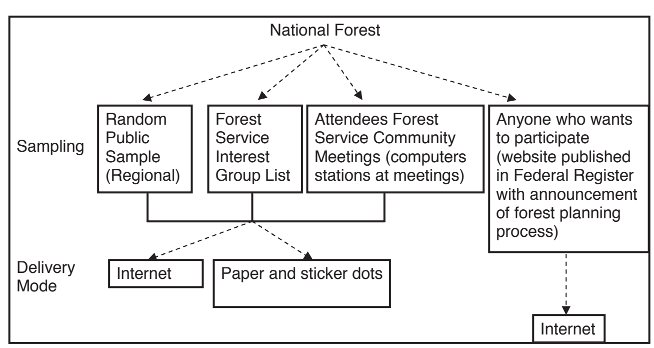

Figure 4. A proposed method for collecting PPGIS data for NF planning.

sampling frame of households in the region. Lists of household names and addresses in the region are available from a variety of commercial vendors.

In contrast to the general public sample, individuals who express interest in the forest planning process for the NF should be allowed the opportunity to participate in the PPGIS process. The ideal protocol would provide participation options for individuals on a NF-maintained "list" of interested parties, for individuals who attend any Forest Service-sponsored public meetings, and for any person who follows NF planning processes through the Federal Register announcement.

The importance of both random and purposive sampling cannot be overstated. The traditional participatory methods the Forest Service has used in public participation for forest planning (requests for scoping comments and public meetings of various types) are not representative of the general public. Interest groups are frequently overrepresented in the public participation process, whereas the silent majority of citizens living proximate to the NF are, in fact, "silent." Although the results of the three studies reported herein show that respondent demographic characteristics may deviate from those of the regional population, if the deviations are known, weighted adjustments can be made in the data collected.

The purposive sample data collected from individuals who volunteer to map landscape values from lists, public meetings, and the Federal Register should be tracked independently of the public sample data so the responses of the various groups can be compared. There is the real possibility that NF interest groups could "mobilize" and orchestrate responses to the PPGIS process in an attempt to influence the outcome. If a careful and systematic comparison of the random and purposive samples reveal few differences, the results can be combined to provide a more comprehensive picture of landscape values and special places for the NF unit. However, there is generally greater benefit in keeping the sampling group responses separate to compare the landscape value profiles of the different groups.

The target number of responses for the random sample should be a minimum of 300 completed responses. This number will generate enough spatial locations to conduct a reasonable VCA analysis for a typical NF unit. The number of contacts necessary to achieve 300 responses will obviously vary by the response rate. Based on the response rates reported herein, 3,000 households would have to be contacted, assuming a 10% response rate. With Forest Service sponsorship, it seems reasonable to obtain response rates that approach 20%, thus reducing the number of contacts by one-half or to approximately 1,500.

The number of responses from other sources (Forest Service list, public meetings, and Federal Register) will vary significantly, depending on the NF unit. The study results indicate that somewhat higher response rates can be expected from lists of interested parties maintained by the Forest Service compared with the general public sample. To compare voluntary responses with the random public sample, there should be a minimum of 100 responses.

Data Analysis

The type of data analysis that is possible with the landscape value and special place data is virtually unlimited. The following analyses are the suggested minimum for the landscape value data. Descriptive analysis would determine the frequency and type of landscape values mapped within the NF unit. The general spatial distribution of landscape values using nearest neighbor analysis should also be measured with the *R* statistic. Density maps should be generated for each of the landscape values in aggregate and by subgroup (e.g., community) to identify hot spots. Modeling compatibility analysis for various forest management options is useful and may be the heart of the traditional forest planning analysis. The forest planning team should develop subforest landscape units of interest for which the type of landscape values can be tabulated and various landscape value and special place indices calculated. This analysis provides forest planners with information about the distribution and intensity of forest values and the potential for management conflict in the landscape units.

Conclusion

The technical merits and constraints of the PPGIS data collection and analysis protocol are relatively easy to describe because the protocol has been successfully implemented in a variety of land use planning contexts, both within the United States and internationally. Implementation of the protocol across the National Forest System will provide the agency with information it has never had before for forest planning, information that will assist in place-specific forest management decisions. A less obvious but equally important benefit is the importance of the PPGIS protocol for restoring public trust in the agency's forest planning and decision processes. This gradual erosion of public trust had made it more challenging for the agency to manage NFs in the public interest. Because the PPGIS protocol is based on both sound citizen science and social inclusiveness, it has the potential to rebuild trust in agency forest management.

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