Landscape and Urban Planning 139 (2015) 1–15

Contents lists available at ScienceDirect

Landscape and Urban Planning

journal homepage: www.elsevier.com/locate/landurbplan

Research Paper

Identifying public land stakeholder perspectives for implementing place-based land management

Greg Brown[a,*], Kelly de Bie[b,c], Delene Weber[d]

[a] School of Geography, Planning, and Environmental Management, University of Queensland, Brisbane, QLD 4072, Australia
[b] School of BioSciences, The University of Melbourne, Parkville, VIC 3010, Australia
[c] Parks Victoria, 535 Bourke St, Melbourne, VIC 3000, Australia
[d] Barbara Hardy Institute, School of NBE, University of South Australia, Mawson Lakes, SA 5085, Australia

HIGHLIGHTS

- Identifies and classifies stakeholder perspectives for public land management.
- Measures spatial stakeholder preferences for access, conservation, and development.
- Implements a model to identify level of spatial stakeholder agreement.
- Spatial results were sensitive to method of aggregation and stakeholder weighting.
- Need for more research that integrates stakeholder analysis methods with spatial data.

ARTICLE INFO

Article history:
Received 5 January 2015
Received in revised form 4 March 2015
Accepted 5 March 2015

Keywords:
PPGIS
VGI
Participatory mapping
Public lands
Stakeholder analysis

ABSTRACT

Public lands provide significant environmental, economic, and social values to society across a range of classifications and tenures. Stakeholders representing multiple interests are presumed to hold different management preferences for these lands. The purpose of this study was to demonstrate how stakeholder perspectives can influence place-based management preferences for public lands. We developed a multi-dimensional public land preference scale and used cluster analysis of responses to classify individuals ($n = 1507$) into stakeholder groups using data collected from a large public participation GIS (PPGIS) survey in Victoria, Australia. We analyzed the results of the two largest stakeholder groups (identified as "Preservation" and "Recreation") to assess their spatial preferences for public land conservation, access, and development. We developed a method to assess the level of spatial stakeholder agreement, with the results identifying geographic areas of both agreement and disagreement between stakeholder groups. To determine the effects of unequal stakeholder participation in mapping, we performed sensitivity analysis by weighting the responses of the Recreation stakeholder group to approximate the mapping effort of the Preservation stakeholder group. The place-based management preferences changed significantly for conservation/development and improving/limiting public land access, while preferences for increasing/limiting facility development were less sensitive to stakeholder weighting. The spatial mapping of stakeholder preferences appears effective for identifying locations with high potential for conflict as well as areas of agreement, but would benefit from further research in a range of land management applications to provide further guidance on the analysis of stakeholder group responses that result from diverse stakeholder group participation.

1. Introduction

Public lands provide a diversity of environmental, economic, and social values to society across a range of public land categories (Brown, Weber, & de Bie, 2014a). The laws that govern public lands often identify their purpose, but rarely provide specific guidance on how to balance the multiple and sometimes conflicting

* Corresponding author. Tel.: +61 7 33656654.
E-mail addresses: greg.brown@uq.edu.au (G. Brown), khun@unimelb.edu.au (K. de Bie), delene.weber@unisa.edu.au (D. Weber).

http://dx.doi.org/10.1016/j.landurbplan.2015.03.003
0169-2046/

uses. Management of "multiple-use" public lands can generate controversy as they provide for recreation opportunities as well as resource use and extraction. Even national park agencies throughout the world, an important sector of public lands managers, are challenged to find a balance between conservation and development (see e.g., Budowski, 1976; Newsome, Moore, & Dowling, 2012; Western & Henry, 1979).

Public land management is inextricably linked with the elusive concept of public interest that seeks to advance the welfare of a social collective over private interests. In the absence of specific legislative guidance, the determination of what constitutes the public interest falls on the agencies responsible for management of public lands. The resolution as to what constitutes public interest manifests in small and large-scale decisions related to resource use versus protection, the level of public access, the types of recreation opportunities provided, the development of visitor facilities, and regulatory control. In this study, we developed an exploratory scale that measures public land management preferences across these multiple dimensions of public land management.

Individuals and organizations that share common interests in public land decisions are commonly called "stakeholders". The term *stakeholder* has numerous formal definitions. For example, in the corporate world, Freeman (1984) defined stakeholders as groups or individuals that can effect, or are affected by the organizational purpose (p. 25). Another definition applied to natural resource management considers stakeholders to be "any group of people, organised or unorganised, who share a common interest or stake in a particular issue or system. . .who can be at any level or position in society, from global, national and regional concerns down to the level of household or intra-household, and be groups of any size or aggregation" (Grimble & Wellard, 1997, p. 176). Especially relevant to public lands, stakeholders can include the nebulous categories of 'future generations', the 'national interest' and 'wider society' (Grimble & Wellard, 1997). A key distinction between general stakeholders is those who *affect* decisions and those who are *affected by* decisions. In this study, we do not identify public land stakeholder groups a priori but provide for the emergence of stakeholder groups through an inductive analysis of individual preferences for public land management.

Reed et al. (2009) provide a typology of stakeholder analysis approaches for participatory natural resource management research. The typology consists of methods for identifying stakeholders, differentiating between and categorizing stakeholders, and investigating relationships between stakeholders. Our approach for identifying stakeholders differs from the reviewed approaches (e.g., using focus groups, interviews, or snowball sampling) in that we first identify stakeholders based on preferences for public land management collected through a survey, and then use cluster analysis to group individuals based on these preferences. This alternative approach is pragmatic given there are many individuals and organized stakeholder groups whose interests span the diversity of public land types found within our study area, the state of Victoria, Australia.

A common stakeholder analysis technique identifies and maps stakeholders in two-dimensional space consisting of power/influence by level of interest (Bryson, 2004). Our analyses do not assess stakeholder power/influence and only indirectly assess level of interest as indicated by participatory mapping effort. Rather, we focus on how stakeholder values translate into specific place-based preferences for three key public land management issues—access, development, and conservation. We use data collected from public participation GIS (PPGIS) methods that identify spatial preferences to determine location-specific agreement or disagreement between stakeholder groups.

1.1. Public participation GIS (PPGIS) and stakeholder analysis

Public participation GIS (PPGIS), participatory GIS (PGIS), and volunteered geographic information (VGI) refer to methods and processes that generate spatial information for a variety of urban, regional, and environmental planning applications (see Brown, 2005; Brown & Kyttä, 2014; Sieber, 2006 for a review of applications). PPGIS has typically been implemented by government planning agencies or academics to enhance public involvement in developed countries for urban and regional planning using random sampling methods and digital mapping technology. PGIS has typically been sponsored by NGOs in rural areas of developing countries to build social capital using purposive sampling and non-digital mapping technology (Brown & Kyttä, 2014). These two methods have different origins and applications, but many common characteristics. The key difference is around the definition of participation, specifically who participates and why. A related concept, volunteered geographic information (VGI) refers to systems that create, assemble, and disseminate geographic data provided voluntarily by individuals (Goodchild, 2007). The general term "participatory mapping" describes any process where individuals share in the creation of a map and would include PPGIS, PGIS, or VGI. In practice, multiple sampling methods may be used for participant recruitment. The language used to describe participants frames the PPGIS/PGIS/VGI process and explains why some PPGIS studies have used the term "stakeholder" to characterize participants while other studies have continued to use the term "public".

Most PPGIS/PGIS/VGI processes that inform planning may be said to involve stakeholders, given the broad definition of stakeholder that includes those affected by planning decisions. Schlossberg and Shuford (2005) describe how the term "public" in PPGIS may include decision makers, implementers, affected individuals, interested observers, or the general public—in other words, stakeholders. However, stakeholder research and analysis, as traditionally practiced, involves methods that identify key individuals and groups with interests within a specific policy domain and do not usually include broad-based social surveys (Reed et al., 2009). Thus, stakeholder analysis is considered narrower in scope than survey research and involves purposive rather than scientific sampling.

The challenge for analyzing PPGIS/PGIS/VGI data from a stakeholder perspective is the ability to differentiate mapping behavior associated with stakeholder group affiliation, from the high degree of individual variation found in general mapping behavior. Several studies have found that participants translate their personal, non-spatial attitudes and values into behavioral choices when mapping place-specific attributes. For example, in a PPGIS study of park visitors ($n = 323$) to the Channel Islands National Park in the U.S., Van Riper and Kyle (2014) found differences in the mapped locations of ecosystem values perceived by visitors holding neutral versus strong environmental worldviews. In a study of mapping behavior, Brown (2013) analyzed non-spatial values and preferences with place-based values and preferred resource uses across three PPGIS studies of national forests and found that positive, non-spatial attitudes toward extractive uses of national forests were correlated with participant mapping of economic values and extractive uses while nonmaterial forest attitudes were correlated with participant mapping of amenity values and conservation-related uses.

There have been several PPGIS studies using the more narrow conception of stakeholder that targeted specific stakeholders for participation in the mapping activity for natural resource management decisions. When analysis disaggregates for stakeholder group (e.g. Darvill & Lindo, 2014; García-Nieto et al., 2014, results show differences in stakeholder perceptions of the spatial distribution of ecosystem services. These studies highlight the importance

of including different stakeholder groups to capture the diversity of knowledge sources, human–environment relations, and value systems (García-Nieto et al., 2014) and that the differences in stakeholder mapping are likely a complex combination of individual factors such as household income, individual needs, rural versus urban living, and time spent living in the study region rather than stakeholder affiliation per se (Darvill & Lindo, 2014). In a study most thematically similar to ours, Eadens et al. (2009) conducted participatory mapping workshops with 35 individuals representing six stakeholder groups for recreation planning in a Bahamian National Park. They modeled spatial agreement by examining the spatial overlap in future activity zones mapped by the six groups. "Strong" agreement was defined as areas mapped by five to six groups and "some" agreement was defined as areas mapped by three to four groups. This method resulted in a park map showing areas of spatial agreement for protection, ecotourism, and hunting activities.

Other PPGIS studies have used stakeholder terminology without disaggregating results by stakeholder group (Fagerholm, Käyhkö, Ndumbaro, & Khamis, 2012; Palomo, Martín-López, Potschin, Haines-Young, & Montes, 2013; Ruiz-Frau, Edwards-Jones, & Kaiser, 2011) or have examined the spatial results of different groups without using stakeholder terminology. The studies that have analyzed mapped data by groups highlight the potential influence of stakeholder sampling and participation to spatial outcomes for public land planning and management. For example, Brown, Smith, Alessa, and Kliskey (2004) compared the results of general public perceptions of biological value ($n = 542$) with results from an expert mapping workshop consisting of individuals holding science and non-science positions with government, educational, and non-profit organizations ($n = 31$). The study found a moderate degree of spatial coincidence between the two groups but also distinct geographic areas of agreement and disagreement. Brown, Kelly, and Whitall (2014) compared responses from a random household sampling group ($n = 144$) with volunteer participants ($n = 84$) in a national forest planning application in the U.S. The volunteer group expressed stronger utilitarian values and consumptive forest use preferences, both spatially and non-spatially. Importantly, the study concluded that if forest planning decisions were based on one group or the other, there would be very different outcomes. In another forest planning application, Brown et al. (2014) found that spatial information generated from community-based PPGIS workshops ($n = 71$) differed from spatial data collected through random household sampling ($n = 244$).

1.2. The study context—public land values and preferences

In many countries the public land estate is significant. In Australia, 23% of terrestrial land area is public land (Geoscience Australia, 2014) and in the United States the combined total of federal and state-owned public land encompasses 35% of total land area (NRCM, 2014). Parks and protected areas on public land comprise 15% of the world's land area (WDPA, 2014). Typical categories of public lands include forests, national parks, wilderness areas, historic areas, and nature reserves. The quantity, structure, regulations, and management of public lands vary by country, and often include a state or region-specific governance framework. In countries such as Australia and the U.S., participatory processes are legally embedded in the planning and management of public lands thus providing a formal arena where values and preferences may be expressed and contested by stakeholders.

The primary purpose of this study was to advance understanding of how stakeholders can influence participatory mapping information for public land planning and management. To achieve this purpose, we seek to answer the following research questions, identified as research aims in Section 2:

(1) What are the core dimensions of public land management and can these be operationalized and measured in a multi-dimensional preference scale?
(2) Can public land management preferences be used to identify and classify multiple stakeholder groups?
(3) What type and quantity of public land values and preferences do stakeholder groups identify in a PPGIS process and how are these distributed by public land type and location?
(4) How do different stakeholder preferences for public land conservation, access, and development influence place-specific results in a participatory mapping process?
(5) Given differences in public land mapped preferences among stakeholders, how does spatial aggregation and weighting of stakeholder preferences influence the results?

We seek answers to these questions using data collected as part of a statewide PPGIS study of public lands in Victoria (Brown et al., 2014a). We apply a novel approach that combines an exploratory, multi-item public land preference scale with cluster analysis to classify participants into stakeholder groups. The resulting stakeholder groups are profiled and compared on their socio-demographic characteristics, public land use and familiarity, and self-identified reasons for using public lands. We analyze the mapping behavior of the two largest stakeholder groups by developing and applying a spatial model that assesses the level of stakeholder agreement for place-specific preferences for conservation, access, and development. Sensitivity analysis is performed to determine the potential effects of unequal stakeholder mapping effort by weighting the mapped responses of one stakeholder group to match the mapping behavior of the other stakeholder group. In Section 4, we reflect on the findings that have strong implications for the use of participatory mapping methods in public land planning and management. We provide some guidance for future participatory mapping processes that seek to integrate multiple stakeholder groups for decision support.

2. Methods

2.1. Study location and context

The setting for this study was the state of Victoria, the sixth largest state in Australia with an area of 237,629 km^2 and an estimated population of 5,768,600 (ABS, 2013). Most of the state's population is located near the capital city of Melbourne, Australia's second most populous city. Public lands in Victoria comprise about 35% of the terrestrial land area (DEPI, 2013) with the largest contiguous areas located in the mountainous eastern third of the state, and the northwest sector. Public lands in Victoria, known as "Crown" lands, have a wide variety of classifications including state managed national parks, state forests, federally managed commonwealth lands, metropolitan and regional parks, and specialized reserves for the protection of historic and cultural resources. Parks and conservation reserves make up 3.98 million hectares (approximately 50% of all Crown land), state forests comprise 3.14 million hectares (approximately 40%), and other Crown lands cover 796,000 hectares (10%) including Commonwealth Government land, metropolitan parks, and land held under lease from the Crown (DEPI, 2013).

2.2. Data collection process

The research team designed, pre-tested, and implemented an internet-based PPGIS application for data collection. The application used a Google® maps interface or "mashup" where participants could drag and drop digital markers onto a map of Victoria. The web

Table 1
Landscape values and preferences used in this study with their operational definitions.

	Operational definition
Values	
Scenic/esthetic	These areas are valuable because they contain attractive scenery including sights, smells, and sounds.
Recreation	These areas are valuable because they are where I enjoy spending my leisure time—with family, friends or by myself, participating in outdoor recreation activities (e.g., camping, walking, or fishing).
Economic	These areas are valuable because they provide natural resources or tourism opportunities.
Life sustaining	These areas are valuable because they help produce, preserve, clean, and renew air, soil, and water.
Learning/education/research	These areas are valuable because they provide places where we can learn about the environment through observation or study.
Biological/conservation	These areas are valuable because they provide a variety of plants, wildlife, and habitat.
Heritage/cultural	These areas are valuable because they represent natural and human history or because they allow me or others to continue and pass down the wisdom and knowledge, traditions, and way of life of ancestors.
Therapeutic/health	These places are valuable because they make me feel better, physically and/or mentally.
Spiritual	These areas are valuable because they are sacred, religious, or spiritually special places or because I feel reverence and respect for nature here.
Intrinsic/existence	These areas are valuable in their own right, no matter what I or others think about them.
Wilderness/pristine	These areas are valuable because they are wild, uninhabited, or relatively untouched by European activity.
Preferences	
Increase conservation/protection	Increase conservation and protection here (e.g., due to encroaching development, feral animals/weeds, illegal use).
Add recreation facilities	Add more recreation facilities (e.g., walking trails, playgrounds, picnic ground) here.
Add tourism services/development	Add new tourism services (e.g., guided tours, signs, brochures, apps) or development (e.g., trail head, toilet block, visitor center) here (Please specify).
Improve access	Improve vehicular access (i.e., from no access to 4WD access or from 4WD road to 2WD road). Note: please map increased walking trail access under the recreation facilities icon.
Improve bushfire protection	Improve bushfire protection here.
Resource extraction	Engage in resource extraction such as logging or mining here.
Resource use	Engage in resource use such as grazing, hyroelectric energy, or wind energy here.
Decrease or limit access	Decrease or limit access here (e.g., close to vehicles or 4WD).
No development or change	No development or change to land use here.

interface is described in greater detail in a technical report associated with the project (see Weber & Brown, 2014). Two different panels contained markers representing 11 landscape values and nine management preferences (see definitions in Table 1). The value categories were derived from a landscape values typology (Brown & Reed, 2000), also called social values for ecosystem services (Brown & Fagerholm, 2014; Sherrouse, Clement, & Semmens, 2011). The typology includes cultural values such as recreation, esthetics, history/culture, and spiritual values, values for provisioning ecosystem services (economic/subsistence value), and supporting/regulating ecosystem services (biological and life sustaining values), and has been used in more than 15 published PPGIS studies (Brown & Kyttä, 2014). The public land estate in Victoria collectively contains the full range of values found in the values typology (Brown, Weber, & de Bie, 2014a, 2014b). The public land preference items were identified and selected in consultation with the protected area management agency, Parks Victoria, and included items for increased conservation/protection, resource use and extraction, increased or limited access, increased facilities, bushfire protection, and an option for no development or change.

Before the mapping activity, participants were asked to identify the postcode of their home location and how they learned about the study. The application instructions requested the participant to "drag small icons onto a map of Victoria to identify places you value and your public land preferences. . .although you can place markers anywhere, the focus of this study is on public lands". Participants were instructed to place as few or as many markers as they deemed necessary to express their values and management preferences. Following completion of the mapping activity (placing markers), participants were directed to text-based survey questions to assess non-spatial public land management preferences (16 items), sociodemographic characteristics, self-identified familiarity with public lands, frequency of use, and motivation for visiting national parks.

From December 2013 to February 15, 2014, study participants were recruited using both purposive and convenience sampling methods as follows: (1) visitors to 16 national parks, 5 state parks and 9 metropolitan parks were contacted on site as part of Parks Victoria's biennial visitor satisfaction survey; (2) Parks Victoria prepared and distributed a press release about the study, placed a link to the study URL on the agency's website, and an agency spokesperson promoted the study in an Australian Broadcasting Corporation radio interview; and (3) a recruitment letter was distributed to members of the Victoria National Parks Association (VNPA), a non-governmental organization (NGO) that promotes nature conservation in Victoria. Participants in the study were also encouraged to refer friends, relatives, and acquaintances to the study website. Any member of the public could request an instant access code to participate in the study. To encourage participation, the choice of a modest non-cash incentive equivalent to about $10 was provided the to the first 1500 study participants. This sampling approach resulted in a geographically representative statewide sample. A full evaluation and discussion of the representativeness of the sample can be found in Brown et al. (2014a).

2.3. Public land management preference scale

We developed an exploratory scale to measure general preferences for public land management that would accommodate the diversity of public land types ranging from national parks/reserves to multiple-use lands such as state forests to local/regional parks. We hypothesized and pilot-tested five preference dimensions consisting of multiple items related to recreation experience (7 items), resource extraction (2 items), renewable resource use (3), access/control of public lands (2 items), and facilities development (2 items). Each survey item was measured on a seven point semantic-differential scale with contrasting preferences located at either end of the scale. See Fig. 1 for the specific wording of the items. The instructions provided to participants were as follows:

> *Public lands (not just parks) can be managed many different ways. Below are some contrasting views about public land management. Thinking about your own preferences for public lands, where would you place yourself on the scales below? There is no right or wrong answer. A position in the middle (number = 4) indicates you don't have a preference leaning either direction on the scale, whereas the positions 1 and 7 suggest you have a very strong preference.*

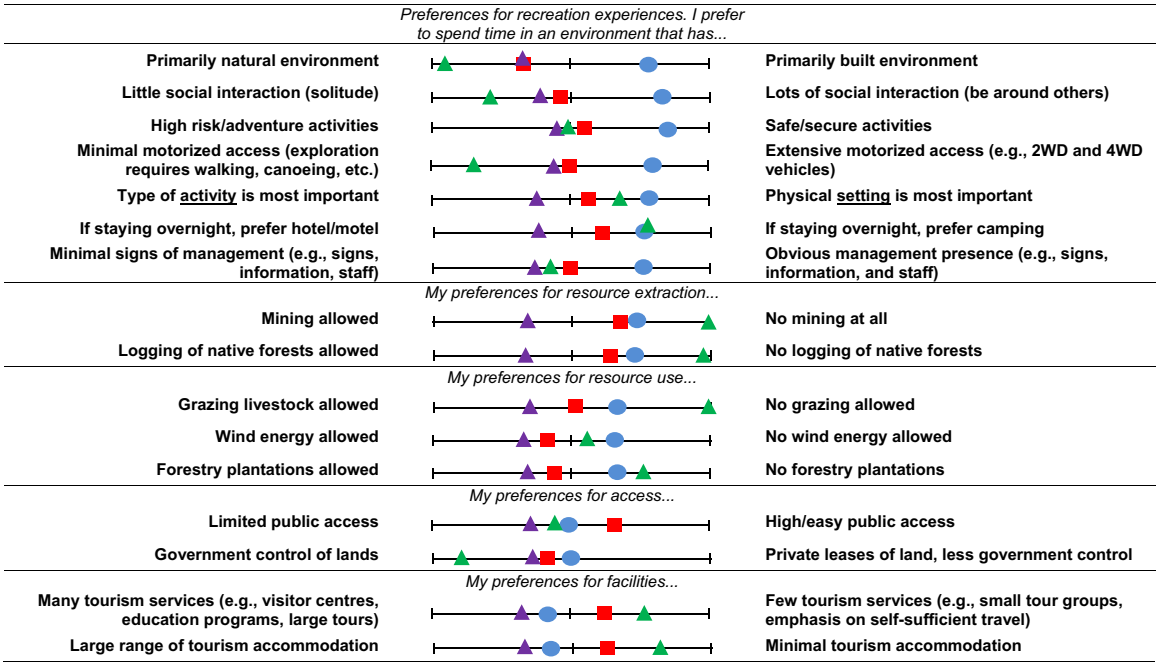

Fig. 1. Groups means of four groups (Preservation, Recreation, Socialization, Utilization) derived from cluster analysis plotted on 16 public land preference items that were scaled on a semantic-differential scale.

The recreation experience items were based on research suggesting that the quality of the recreation experience is influenced by the physical, social, and managerial setting that comprise a recreation opportunity spectrum (Clark & Stankey, 1979; Driver & Brown, 1978). The resource extraction and use items were based on historical and contemporary use of public lands in Victoria and included preferences for logging of native forests, mining, grazing, wind energy development, and plantation forestry. The two access/control survey items assessed preferences for ease of access to public lands and a question about who should control public lands. The two facilities items assessed preferences for tourism services and accommodation associated with public lands.

2.4. Analyses

2.4.1. Public land management components (aim 1)

In the absence of theory about the structure of public land preference dimensions, we ran exploratory factor analysis (SPSS v.22) on the 16 preference items (1) to determine whether our initial grouping of the items held in the results, and (2) to identify potential latent variables. We used principal components extraction method which forms uncorrelated linear combinations of the observed variables where the first component has maximum variance. The number of factors extracted was determined by eigenvalues greater than one (Kaiser, 1960) and the resulting factors were rotated using direct oblimin (non-orthogonal) for interpretation under the assumption that the components could be related.

2.4.2. Cluster analysis and interpretation (aim 2)

Cluster analysis is a method for grouping individuals based on the similarity in responses to survey questions. To identify potential groups of study participants based on public land preferences, we used a model-based clustering program developed and implemented in R (Mclust v.4.4) by Fraley and Raftery (1998). The program does not assume prior knowledge about the number of clusters and evaluates a number of different cluster models with different geometric properties and parameters. The different models are compared using the Bayesian Information Criterion (BIC) which allows comparison of more than two models at the same time. Thus, the problem of identifying the number of clusters and the clustering method are solved simultaneously by identifying the best cluster model according to the BIC. In our cluster analysis, the responses to the 16 public land preference questions from $n = 1507$ participants were used as input to the cluster procedure.

Interpretation and validation of the four cluster (stakeholder groups) solution was determined by examining the characteristics of the individuals classified into the groups using a number of statistical methods: (1) the means of the 16 public land preference items for each of the stakeholder groups were analyzed and plotted on the semantic differential scale to visually show the relative position of the groups on each of the preference items, (2) the means of the factor scores derived from principal components analysis (PCA) were analyzed to determine whether the stakeholder groups formed homogenous subsets on the public land components, (3) the demographic characteristics of the four groups were analyzed and compared to available census data, (4) participant responses to survey questions about their level of familiarity, frequency of public land use, and motivation for using public lands were analyzed by stakeholder group, and (5) the different sources of how participants learned about the study were compared across the stakeholder groups.

2.4.3. Analysis of mapping behavior by stakeholder group (aim 3)

We analyzed the number of value and preference markers placed by participants in each stakeholder group. We used analysis of variance (ANOVA) to determine whether the mean number of markers mapped differed by stakeholder group and we generated chi-squared statistics with standardized residuals to determine whether the proportion of markers by value or preference category differed significantly from what would be expected across the stakeholder groups.

To examine the potential association between public land type and stakeholder group, we selected 11 major categories of public lands (coastal reserves, community/metro/regional parks, state forests, marine parks and sanctuaries, national parks, natural

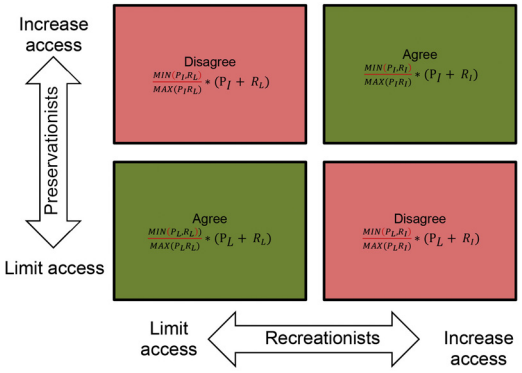

Fig. 2. Possible outcomes related to preferences for public land access for two stakeholder groups, with the formula for calculating the agreement/disagreement indices. *P* = preservation group marker density, *R* = recreation group marker density, *I* = increase, and *L* = limit. (For interpretation of the references to color in the text, the reader is referred to the web version of the article.)

features reserves, nature conservation reserves, wilderness parks, state parks, and water production and reservoir areas) that account for over 90% of Victorian public lands, and cross tabulated marker counts with the stakeholder groups. Chi-squared statistics and standardized residuals were used to determine whether the number of markers differed significantly from what would be expected in each public land category.

2.4.4. Modeling group preferences by location (aim 4)

We examined the spatial distribution of public land preferences for the Preservation and Recreation groups, the only two groups with sufficient data for this particular analysis. This allowed for identification of similarities and differences in the spatial location of preferences, not just the number and type of markers. Preferences were examined for three public land management issues: access to public lands, facility development, and conservation/resource use. In simple terms, two groups can agree or disagree on the spatial location for the three preference issues, resulting in four possible outcomes as illustrated in Fig. 2 which uses public access as an example. The two groups can both agree to increase or decrease access in the same location or the two groups can disagree on access, but for different reasons.

To illustrate preferences spatially, we generated agreement and disagreement indices for each of the four possible outcomes using a GIS grid-based modeling approach. For access and facilities development preferences, we generated point densities (kernel) using a 1 km cell size with a 3 km search radius. This assumes that access and facilities development are reasonably place specific. Conservation versus resource use preferences were modeled using kernel densities with 2 km grid cell with a 5 km search neighborhood under the assumption that preferences for conservation versus resource use cover larger areas on public lands. Spatial agreement (concurrence) was determined by aggregating the densities of the two groups in each 1 km or 2 km cell. For example, to identify similarity in limiting public land access, the cell densities of Preservation group markers for increasing access (P_I) were added to the cell densities of Recreation group markers for increasing access (R_I). However, this aggregation accounts for the intensity or level of spatial agreement but does not account for the evenness of distribution between the two groups. It is possible that all the markers to increase access in a given location were mapped by just one group, which by definition, would not constitute agreement. Therefore, the intensity of agreement (combined densities) was multiplied by the ratio of mapping evenness between the two groups at the location. As the ratio of evenness approaches one (completely even), the index tabulates the actual combined densities. When the evenness ratio becomes small (i.e., only one group mapped preferences at the location), the agreement index tabulates a smaller proportion of the combined density. Thus, the formula for agreement on increasing access would be as follows:

$$\text{Agreement to increase access} = \frac{\text{MIN}(P_I, R_I)}{\text{MAX}(P_I R_I)} \times (P_I + R_I)$$

where P_I = density of Preservation group markers for increasing access; R_I = density of Recreation group markers for increasing access.

Total spatial agreement was found by adding the two agreement boxes in Fig. 2 (shown in green). Total spatial disagreement was found by adding the two disagreement boxes (shown in red). This aggregation approach identifies areas of spatial agreement and disagreement for the three preferences across the study area. The final step was to combine the agreement and disagreement indices to identify where spatial agreement or disagreement preferences dominate in a given location. This was done by subtracting the total disagreement index from the total agreement index. Where the difference score is positive, there is spatial agreement between the two groups and where the score is negative, there is spatial disagreement. The magnitude of the difference provides an indicator of the intensity of the agreement or disagreement in preferences at the location. The preference outcomes were plotted on a map to show the locations where agreement and disagreement occur for the three preference issues. This procedure was repeated to generate preference maps for facility development and conservation/resource use on public lands. Markers for increasing conservation/protection were assumed to be incompatible with markers for "resource extraction" and "resource use". Markers for "no development/change" were assumed incompatible with markers to "add recreation facilities" and "add tourism services/development".

The final analysis performed was to determine how sensitive the results are to group size and/or mapping behavior (aim 5). In participatory mapping, the quantity of preference markers will be determined by the participant group size and the mapping intensity of individuals comprising the group. The Recreation group contained more participants, but these participants mapped only half as many markers. Given the quantity of markers placed by the Preservation group were about twice that placed by the Recreation group, we modeled potential changes to location preferences by increasing the weight of markers placed by the Recreation group. We multiplied the point densities of the Recreation group by two, a hypothetical scenario that assumes the Recreation group engaged in similar preference mapping behavior to the Preservation group. Using the same agreement/disagreement spatial analysis described above, we examined how this weighting of markers changed locational preferences for the three public land issues.

3. Results

3.1. Participation

A total of 1905 participants accessed the study website and placed one or more markers. Of these participants, 1624 (85%) fully or partially completed the survey questions that followed the mapping activity. A total of 35,347 markers were mapped during data collection, with 30,194 (85%) of these attributable to public lands in Victoria. Approximately 85% of the markers placed were *value* markers with the remaining 15% being *preference* markers. For this study, we only included respondents that engaged in participatory mapping and answered the survey questions following the mapping activity (n = 1507).

Table 2
Descriptive statistics and factor analysis results for public land preference survey items. The number of responses per item ranged from $n = 1620$ to $n = 1636$. Factors were extracted using principle components and were rotated using direct oblimin (non-orthogonal). The highest loadings on each factor are shown (highlighted, underlined) with Cronbach's alpha calculated for these items. Cronbach's alpha is also shown when asterisk * item is not included in factor scale.

Item	Mean	Std. Dev.	Resource extraction preferences (λ=4.2, 26%)	Recreation type preferences (λ=3.2, 20%)	Regulatory preferences (λ=1.7, 10%)	Renewable resource preferences (λ=1.4, 9%)	Activity vs. setting preferences (λ=1.0, 6%)
Natural vs. built environment (recreation)	3.0	2.1	−.280	.637	.138	−.352	.163
Low social interaction vs. high social interaction (recreation)	3.7	1.9	−.122	.752	.142	−.184	.115
Adventure/risk activities vs. safe/secure activities (recreation)	4.3	1.7	.254	.746	.083	−.094	−.047
Non-motorized use vs. motorized use (recreation)	3.6	2.0	−.459*	.427	.263	−.120	−.363
Activity vs. setting importance (recreation)	4.6	1.7	.114	.246	-.079	−.087	−.669
Lodging vs. camping (recreation)	4.9	1.8	-.058	-.218	-.043	−.060	−.854
Minimal management vs. obvious signs of management (recreation)	4.0	1.8	.197	.649	.060	.234	−.350
Mining allowed vs. no mining	5.4	1.8	.823	.064	.076	−.018	−.143
Logging native forests allowed vs. no logging	5.2	1.8	.886	.097	.025	−.010	−.046
Grazing livestock allowed vs. no grazing	4.8	1.9	.710	.000	−.055	−.392	.068
Wind energy allowed vs. no wind energy	3.9	1.9	−.013	.069	−.047	−.829	−.094
Forestry plantations allowed vs. no plantations	4.3	1.9	.266	−.030	−.083	−.772	−.066
Limited public access vs. easy public access	4.3	1.7	.085	.014	.850	.228	.034
Government control of lands vs. privatization/less control	3.0	1.8	−.253	.227	.639	−.162	.196
Many tourism services vs. fewer tourism services	4.6	1.8	.188	−.604*	.478	−.239	−.197
Extensive tourism accommodation vs. minimal tourism accommodation	4.7	1.8	.271	−.591*	.402	-.195	-.253
Cronbach's Alpha			.52	.51	.52	.72	.52
If item deleted*			.84	.78			

3.2. Public land management components

The exploratory factor analysis of the 16 public land preference items resulted in the extraction of five factors with eigenvalues ranging from 0.98 (rounded to 1.0) to 4.2, explaining 71% of the cumulative variance. The Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy for factor analysis was 0.80 indicating the sample quality falls in the "meritorious" range of values as described by Hutcheson and Sofroniou (1999). The loadings for each factor appear in Table 2. Structurally, the factors measured preferences for resource extraction (4 items), recreation experience (6 items), access and regulatory control (2 items), renewable resource use (2 items), and activity versus setting preferences (2 items). Factor loadings measure the correlation between the survey item and the latent variable represented by the factor. With the exception of the motorized versus non-motorized item, which had moderate correlation with multiple factors, loadings were 0.6 or greater indicating moderate to high correlation with the factor. Cronbach's alpha for all survey items was 0.72 with individual factor reliability scores ranging from 0.52 to 0.72. Reliability scores are dependent on the number of items and usually increase with more items.

The loading of the 16 items on the five extracted factors deviated somewhat from our initial grouping in the survey. The tourism services and accommodation items loaded with the recreation experience factor but decreased the reliability of the recreation subscale. Grazing is generally regarded as a renewable resource but was more highly correlated with the resource extraction factor than the renewable resource use factor. The last factor extracted (activity versus setting preference) was weakest in capturing overall variability with the least intuitive interpretation as it loaded two seemingly unrelated items on the importance of activity versus setting when using public lands, and preferences for camping over lodging when visits involve overnight stays.

3.3. Cluster analysis results

The R cluster analysis (Mclust v.4.4) identified a four cluster model (ellipsoidal, equal shape) using the 16-item public land preference scale. This model was selected over other potential models with fewer or more clusters based on the Bayesian Information Criterion. A general description of each stakeholder group was determined by examining the distribution of responses to the 16-item public land scale and other survey variables. Fig. 1 shows the mean position of each of the four stakeholder groups on the public land semantic-differential preference scale.

The first group ($n = 394$, 26%) was labeled "Preservation" and consists of individuals that prefer public lands for their natural environment, non-motorized recreation opportunities, and potential for solitude. They are strongly opposed to all forms of resource extraction and use (native forest logging, grazing, mining, plantation forestry, wind energy) and they prefer minimal tourism facilities and services. They prefer to see decreased or limited access to public lands with government maintaining regulatory control. The public land setting is more important than the activities they actually do and if they are to stay on public lands overnight, they would prefer camping over lodging. In summary, public lands are important for their natural values, with activity and use preferences focused on appreciating and preserving these natural values.

The second and largest stakeholder group ($n = 656$, 44%) was labeled "Recreation" and are individuals that appear more focused on public lands for recreation. While preferring a natural environment, they want more opportunities for social interaction with greater motorized access than the Preservation stakeholder group. They moderately oppose resource extraction (mining, logging of native forests), are ambivalent about grazing on public lands, and show slight support for wind energy and plantation forestry. Of all groups, they prefer to see easier access to public lands but are less concerned about government control compared to the Preservation group. Similar to the Preservation group, they slightly prefer camping over lodging when visiting public lands and prefer places with fewer tourism services and facilities.

The third stakeholder group ($n = 263$, 17%) was labeled "Socialization" and comprise individuals that prefer a primarily built environment, social interaction, safe activities, extensive motorized access, and obvious management presence. Similar to the Preservation group, they oppose all forms of resource extraction and use, but with less conviction. They are ambivalent about limiting or increasing general access and government control and prefer more tourism services and facilities associated with public lands.

The fourth and smallest stakeholder group ($n = 194$, 13%) was labeled "Utilization" and are individuals that show similar recreation preferences to the Recreation group, but place more emphasis on the activity rather than setting, and have a moderate preference

for lodging over camping. Similar to the socialization group, they prefer more tourism services and facilities. A distinguishing attribute of this stakeholder group is their preference toward all forms of resource extraction and uses of public lands.

3.4. Interpretation and validation of the stakeholder groups

Factor scores for the five public components for the four stakeholder groups were analyzed using ANOVA with Tukey's HSD post hoc tests to confirm the results for individual public land survey items. All mean factor scores for the four groups were significantly different (ANOVA, Tukey HSD, $p < 0.05$) and formed unique homogenous subsets for all public land factors with one exception—the Recreation group was not significantly different from the Socialization group on the resource extraction factor. As might be expected, the Preservation and Utilization groups had the greatest difference in factor scores on the resource extraction and tourism development factors. The Socialization and Utilization groups were most different on the renewable resource factor with the Utilization group more inclined toward resource use. On the Recreation factor, the Preservation and Utilization groups were most different from the Socialization group, favoring recreation experiences in less managed natural environments. Overall, the analyses of factor scores for the five public land factors appear logically consistent with results from the individual preference items.

There were some significant differences in the demographic composition of the four groups. See descriptive statistics in Table 3. The Preservation group was the oldest of the four groups with a high level of formal education but with the least amount of household income and the greatest diversity of family structure. The Utilization group tended to be younger males with families from the Melbourne area who had attained a high level of both formal education and income. The Socialization group tended to be families with children (95%) in households with higher income and lower levels of formal education. The Recreation group was typically male with income and education levels in the mid-range of the other groups. A distinguishing characteristic of the Recreation group was the high proportion of individuals from regional Victoria rather than the capital city of Melbourne.

The Preservation group was most active in the use of national/state parks and reported a high frequency of general public land use. The Socialization group was least likely to visit national parks but reported the highest frequency of use of other types of public lands. The Recreation and Utilization groups were the least frequent users of public lands of the four groups. The reported frequency of public land use was not necessarily related to self-identified familiarity with the lands. The Utilization group reported the least frequent use, but the highest level of self-identified familiarity (95% = good or excellent). The Recreation group reported the lowest levels of public land familiarity.

The survey included a question that asked participants to identify their primary reason for visiting national parks in Victoria. The choices were based on cluster analysis of extensive national park visitor research conducted by Parks Victoria ($n = 11{,}700$) (see Zanon, Hall, Lockstone-Binney, & Weber, 2014). The most frequent response for the Preservation and Recreation groups was to engage in a trail-based activity while the most frequent response for the Socialization and Utilization groups was to sightsee. A relatively high percentage (31%) of the Socialization group identified socialization as their primary reason for visiting national parks while a relatively high percentage of the Utilization group (23%) selected rest/relax as their primary reason.

The final survey items providing insight into group characteristics was a question asking how participants learned about the study. The Preservation group identified the Victorian National Parks Association (an organized stakeholder group) as their source of information (25%) with another 14% identifying bushwalking clubs. The Socialization group primarily learned of the study from the Parks Victoria website and the Utilization group learned of the study through friend referral (55%). The Recreation group had the greatest diversity of sources and notably included 4 wheel-drive clubs.

3.5. Stakeholder group mapping behavior

The mapping behavior of the groups was assessed by analyzing the categories of values and preferences mapped by each group in the study. The Preservation group mapped significantly more values than the other groups, about 36 markers on average per respondent compared to about 14 and 5 markers for the Recreation and Socialization groups, respectively. See Table 4. Further, a higher proportion of respondents in the Preservation group placed one or more markers in all value categories with the exception of economic value. The largest proportional differences in value categories were associated with wilderness (residual = 16.7), biological (residual = 11.9), and intrinsic (residual = 9.9) values mapped by respondents in the Preservation group. Respondents in the Recreation group mapped proportionately more economic values (residual = 7.2) than the other two groups.

The number of mapped preferences was significantly less than the number of values markers for all study participants. Individuals in the Preservation group also placed more preference markers, on average, than the other groups, in particular those markers associated with increasing conservation/protection, decreasing or limiting access, and preventing further development on public lands. Proportionately fewer individuals in the Preservation group mapped resource extraction, use, and improved access preferences. The Recreation group had a higher proportion of individuals express preferences to increase bushfire protection and to extract resources. The largest group differences in mapping behavior were associated with preferences for "increased conservation/protection", "no development/change", and "decreasing/limited access".

The mapping behavior of the groups was further analyzed by examining where the four groups mapped their values and preferences using 11 major categories of public lands. See Table 5. The Preservation group placed disproportionately more markers in national parks, nature conservation areas, and marine parks/sanctuaries and proportionately fewer markers in community/regional parks, state forests, historic/cultural areas, and reservoirs. In contrast, the

Recreation group placed more markers in community/regional parks, state forests, reservoirs, and wilderness parks and fewer markers in national parks, nature conservation areas, and marine parks. The Socialization and Utilization groups placed relatively few markers in all public land categories, and are distinguished by the fact that they placed disproportionately more markers in community/regional parks than any other public land category.

3.6. Spatial distribution of stakeholder preferences

The spatial distribution of all markers placed by the four groups appears in Fig. 3. The Preservation group placed significantly more markers ($n = 16{,}251$) than the Recreation group ($n = 8562$), the Socialization group ($n = 608$), and the Utilization group ($n = 208$). The Utilization and Socialization markers were highly clustered ($R = 0.07$ and $R = 0.12$) with the majority of markers mapped in the greater Melbourne area in community/regional parks. The Preservation and Recreation group markers were more spatially dispersed throughout Victoria ($R = 0.21$ and $R = 0.23$) reflecting the general spatial distribution of public lands in the state.

Table 3
Study participant and cluster group demographics with comparison to Victoria census data (ABS, 2011). Participant familiarity, use, and motivations for using public lands.

Variable	All Study Participants	ABS Census 2011	Cluster 1 Preservation ($n = 394$)	Cluster 2 Recreation ($n = 656$)	Cluster 3 Socialization ($n = 263$)	Cluster 4 Utilization ($n = 194$)
Age (median)**	36	37	55	37	35	30
Gender*						
Male	57%	49%	50%	63%	43%	72%
Female	43%	51%	50%	37%	57%	28%
Education (highest level completed)*						
Bachelor's degree	39%	16%	37%	34%	38%	75%
Postgraduate education	16%	11%	38%	13%	0%	4%
Household income (annual)*						
Median	$110,000	$63,200	$70,000	$110,000	$130,000	$150,000
Less than $20,000	2.6%	3.1%	6%	2%	0%	2%
$140,000–$160,000	15.1%	7.3%	6%	10%	18%	44%
$160,000–$180,000	9.4%	4.2%	3%	10%	13%	13%
$180,000–$200,000	5.0%	1.9%	2%	6%	7%	3%
$200,000+	2.9%	3.1%	4%	4%	0%	0%
Household structure*						
Families with children	41%	46%	30%	58%	95%	77%
Mature couple/no children at home			35%	17%	0%	18%
Mature single			17%	7%	0%	0%
Young couple/no children			11%	13%	3%	0%
Young single			7%	6%	2%	4%
Live in Greater Melbourne area***	46%	75%	53%	34%	51%	65%
Visits to national/state parks last 12 months (mean/median)**			28/12	20/10	7/6	14/12
Self-rated knowledge of public lands*						
Excellent			20%	22%	46%	25%
Good			58%	46%	50%	70%
Average			21%	29%	4%	5%
Below average/poor			2%	3%	0%	1%
Frequency of public land use*						
Daily			21%	9%	23%	3%
At least once week			39%	26%	36%	17%
At least once month			31%	47%	35%	71%
Less than once month			9%	18%	6%	10%
Most common reason(s) for visiting public lands*			Trail activity (44%)	Trail activity (33%)	Sightsee (35%)	Sightsee (47%)
			Sightsee (32%)	Sightsee (19%)	Socialize (31%)	Rest/relax (23%)
			Stay/camp (9%)	Rest/relax (15%)	Trail activity (20%)	Trail activity (14%)
			Other activity (6%)	Stay/camp (14%)	Rest/relax (10%)	Socialize (10%)
Most frequent recruitment sources			VNPA (25%)	Friend (27%)	PV Website (71%)	Friend (55%)
			Friend (23%)	PV website (17%)	VNPA (10%)	PV website (30%)
			Bushwalking clubs (14%)	VNPA (15%)	Park contact (6%)	Park contact (8%)
				4WD Club (8%)		

Note: ABS income percentages are estimates to match survey income categories.
* Proportional differences are statistically significant (chi-square, $p \leq 0.05$).
** Mean differences are statistically significant (ANOVA, $p \leq 0.05$).
*** Percentages are estimates based on postcodes provided by study participants.

Table 4
The total and average number of landscape value and management preference markers placed by four stakeholder groups and the percent of individuals within each cluster group placing one or more markers for the given value or preference category. Chi-square analysis and residuals analysis was performed on the proportion of participants with cell color indicating whether the value or preference category was significantly over-represented (green) or under-represented (pink) based on standardized residuals being greater than +2.0 or less than −2.0.

Marker category by Group[a]	Preservation (n=394)				Recreation (n=656)				Socialization (n=263)				Utilization (n=194)			
	Number (rank)	Mean	Pct	Std. Res.[a]	Number (rank)	Mean	Pct	Std. Res.	Number (rank)	Mean	Pct	Std. Res.	Number (rank)	Mean	Pct	Std. Res.
Scenic value	2488(2)	6.3	15.5%	–4.1	1441(2)	2.2	17.1%	2.8	129(1)	0.5	21.3%	3.4	56(1)	0.3	19.3%	1.4
Recreation value	2536(1)	6.4	15.8%	–17.6	2194(1)	3.3	26.1%	20.0	81(2)	0.3	13.3%	–3.6	32(2)	0.2	11.0%	–3.5
Economic value	208(11)	.5	1.3%	–13.7	283(9)	0.4	3.4%	8.2	56(4)	0.2	9.2%	11.6	29(5)	0.1	10.0%	8.9
Life sustaining value	1207(5)	3.1	7.5%	3.1	532(5)	0.8	6.3%	–3.5	39(3)	0.1	6.4%	–.7	31(3)	0.2	10.7%	2.4
Learning value	845(8)	2.1	5.3%	.0	424(7)	0.6	5.0%	–1.1	35(5)	0.1	5.8%	.6	30(4)	0.2	10.3%	3.9
Biological value	2345(3)	6.0	14.6%	19.3	555(3)	0.8	6.6%	–17.6	33(6)	0.1	5.4%	–4.8	20(7)	0.1	6.9%	–2.5
Heritage value	863(7)	2.2	5.4%	.6	442(6)	0.7	5.3%	–.3	29(7)	0.1	4.8%	–.6	13(9)	0.1	4.5%	–.6
Therapeutic value	615(9)	1.6	3.8%	–.7	328(8)	0.5	3.9%	.0	25(8)	0.1	4.1%	.3	21(6)	0.1	7.2%	3.0
Spiritual value	485(10)	1.2	3.0%	3.4	171(11)	0.3	2.0%	–4.9	25(8)	0.1	4.1%	2.1	17(8)	0.1	5.9%	3.3
Intrinsic value	964(6)	2.4	6.0%	11.2	234(10)	0.4	2.8%	–10.8	22(10)	0.1	3.6%	–1.4	12(10)	0.1	4.1%	–.6
Wilderness value	1211(4)	3.1	7.5%	4.8	537(4)	0.8	6.4%	–2.5	5(11)	0.0	0.8%	–6.0	11(11)	0.1	3.8%	–2.1
Total values	13767	36.4	85.7%		7141	14.1	84.9%		479	4.8	78.8%		272	<1	93.8%	
Increase conservation (pref)	947(1)	2.4	5.9%	15.7	128(5)	0.2	1.5%	–15.6	25(3)	0.1	4.1%	–.3	7(1)	0.7	2.4%	–1.6
Add recreation facilities (pref)	88(6)	0.2	0.5%	–10.5	165(4)	0.3	2.0%	9.9	14(4)	0.1	2.3%	3.0	2(4)	0.1	0.7%	–.6
Add tourism services/development	41(7)	0.1	0.3%	–4.3	49(7)	0.1	0.6%	3.6	7(6)	0.0	1.2%	3.1	0(6)	0.0	0.0%	–1.1
Improve access (pref)	82(5)	0.2	0.5%	–16.6	260(2)	0.4	3.1%	15.2	26(2)	0.1	4.3%	5.9	3(3)	0.2	1.0%	–.6
Improve bushfire protection (pref)	115(4)	0.3	0.7%	–11.2	189(3)	0.3	2.2%	9.0	29(1)	0.1	4.8%	7.5	4(2)	0.2	1.4%	.1
Resource extraction (pref)	2(9)	0.0	0.0%	–8.6	40(8)	0.1	0.5%	7.2	7(6)	0.0	1.2%	5.5	0(6)	0.0	0.0%	–.8
Resource use (pref)	7(8)	0.0	0.0%	–11.3	79(6)	0.1	0.9%	10.4	8(5)	0.0	1.3%	3.9	1(5)	0.0	0.3%	–.1
Decrease/limit access (pref)	189(3)	0.5	1.2%	7.3	22(9)	0.0	0.3%	–7.2	5(9)	0.0	0.8%	–.1	1(5)	0.0	0.3%	–.9
No development/change (pref)	824(2)	2.1	5.1%	5.1	340(1)	0.5	4.0%	–3.1	7(6)	0.0	1.2%	–4.1	0(6)	0.0	0.0%	–3.8
Total preferences	2295	5.8	14.2%		1272	2.2	15.1%		128	1.0	21.2%		18		6.2%	

[a] The overall association between cluster group and marker category is significant ($X^2 = 2779.5$, $df = 57$, $p < 0.001$).

The spatial preferences for public land access, development, and conservation were modeled for agreement/disagreement between the Preservation and Recreation groups because there was sufficient data for this type of analysis. The model for public land access preferences indicated inter-group agreement in all locations mapped statewide (see Fig. 4c). However, when the preferences of the Recreation group were weighted to match the mapping behavior of the Preservation group, there were significant changes in agreement location in multiple, statewide public lands including Alpine National Park, Wilsons Promontory National Park, and Grampians National Park, among other locations (see Fig. 4d). The significant change in modeled agreement with weighting indicates that preferences for public land access are sensitive to the sample size of the stakeholder group, the group mapping behavior, or a combination of the two factors.

The model for public land conservation versus resource use/extraction resulted in a patchwork of agreement/disagreement locations across the state (see Fig. 5c). The most significant areas of disagreement were located in Alpine National Park, the greater Melbourne area, state forest lands northeast of Melbourne, and to a lesser extent, Wilsons Promontory National Park. The result for Alpine National Park is not surprising given that grazing has been a controversial issue in this park (Fraser & Chisholm, 2000). When the Recreation group preferences were weighted (see Fig. 5d), there were few changes in agreement or disagreement. The effect of density weighting was to amplify existing levels of agreement or

Table 5
The number of landscape value and preference markers placed in public land categories by the four stakeholder groups. Chi-square analysis and standardized residuals analysis was performed with the cell color indicating whether the public land category was significantly over-represented (green) or under-represented (pink) based on standardized residuals being greater than +2.0 or less than −2.0.

Public Land Category by Group[a]	Preservation (n=394)			Recreation (n=656)			Socialization (n=263)			Utilization (n=194)		
	Number	Pct.	Std. Res.	Number	Pct.	Std. Res.	Number	Pct.	Std. Res.	Number	Pct.	Std. Res.
National park	10024	66.5%	17.0	4222	55.5%	–15.8	88	51.8%	–2.9	4	8.5%	–7.7
Community/regional park	1055	7.0%	–12.2	851	11.2%	9.7	38	22.4%	6.4	32	68.1%	14.5
State forest	779	5.2%	–13.3	756	9.9%	13.5	13	7.6%	.5	0	0.0%	–1.8
State park	1009	6.7%	–0.6	539	7.1%	1.3	0	0.0%	–3.5	1	2.1%	–1.3
Natural features	579	3.8%	–1.5	309	4.1%	0.4	16	9.4%	3.6	7	14.9%	3.8
Coastal reserve	522	3.5%	–0.8	286	3.8%	1.3	0	0.0%	–2.5	2	4.3%	0.3
Nature conservation	528	3.5%	6.1	150	2.0%	–6.5	10	5.9%	2.2	1	2.1%	–0.4
Historic/cultural areas	153	1.0%	–10.5	222	2.9%	10.6	4	2.4%	0.7	0	0.0%	–0.9
Water reservoir	163	1.1%	–6.8	173	2.3%	7.1	1	0.6%	–1.0	0	0.0%	–0.8
Marine park/sanctuary	187	1.2%	5.4	39	0.5%	–5.1	0	0.0%	–1.3	0	0.0%	–0.7
Wilderness park	67	0.4%	–3.9	67	0.9%	4.1	0	0.0%	–1.0	0	0.0%	–0.5
Total markers/pct.	15066 (65.8%)			7614 (33.2%)			170 (0.7%)			47 (0.2%)		

[a] The overall association between group and public land category is significant ($X^2 = 932.8$, $df = 30$, $p < 0.001$). However, the results must be interpreted cautiously as 14 cells (32%) have an expected count less than 5.

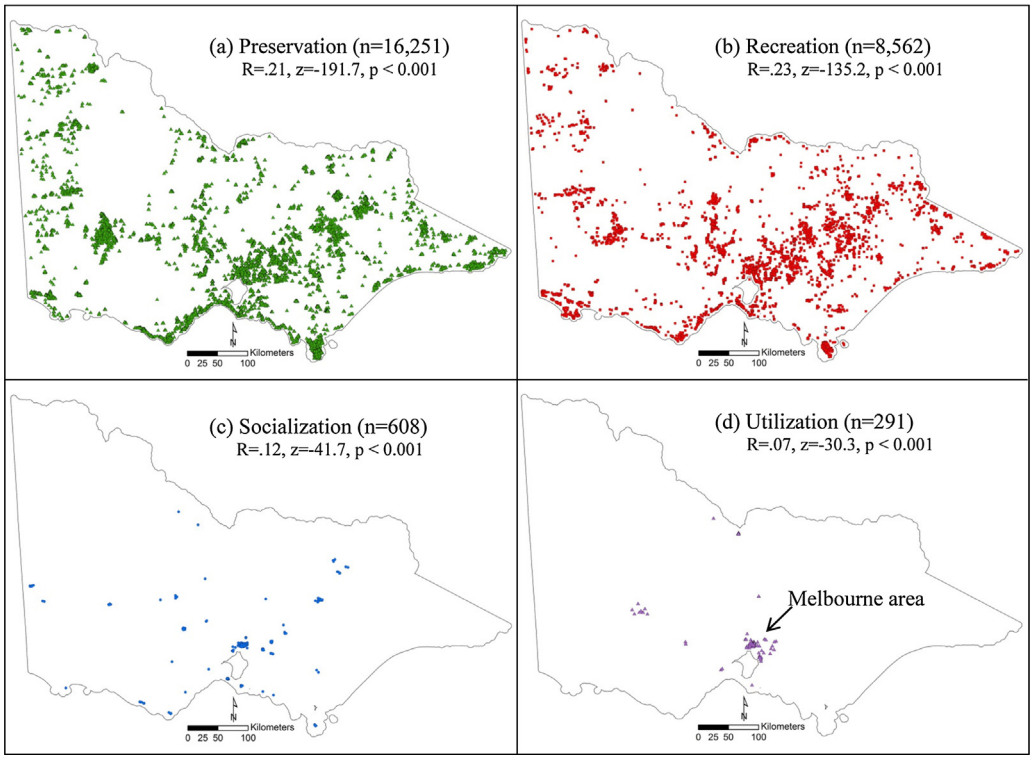

Fig. 3. Spatial distribution of mapped values and preferences by cluster group with nearest neighbor ratio for (a) preservation; (b) recreation; (c) socialization; and (d) utilization groups. Smaller *R* ratios indicate greater clustering within the study region while larger *R* ratios indicate greater dispersion.

disagreement, for example, in places like the Great Otway and Alpine National Parks. Thus, conservation and resource preferences were less influenced by sampling and mapping behavior compared to public land access preferences.

The final model examined preferences for new facility development versus preferences for no development or change. Compared to preferences for conservation, there were significantly more locations and greater variability in agreement (see Fig. 6c). One location

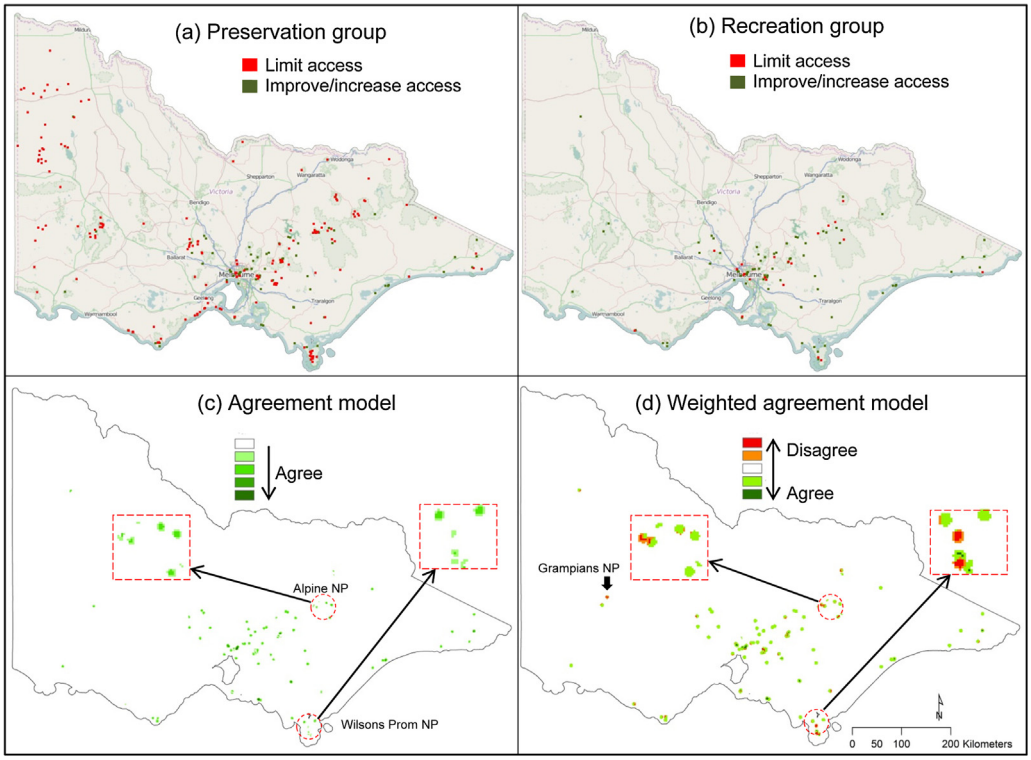

Fig. 4. Mapped locations of public land access preferences by group: (a) Preservation and (b) Recreation. Map (c) shows the location and intensity of agreement/disagreement for limiting or improving public access while map (d) is a weighted model with Recreation group densities doubled.

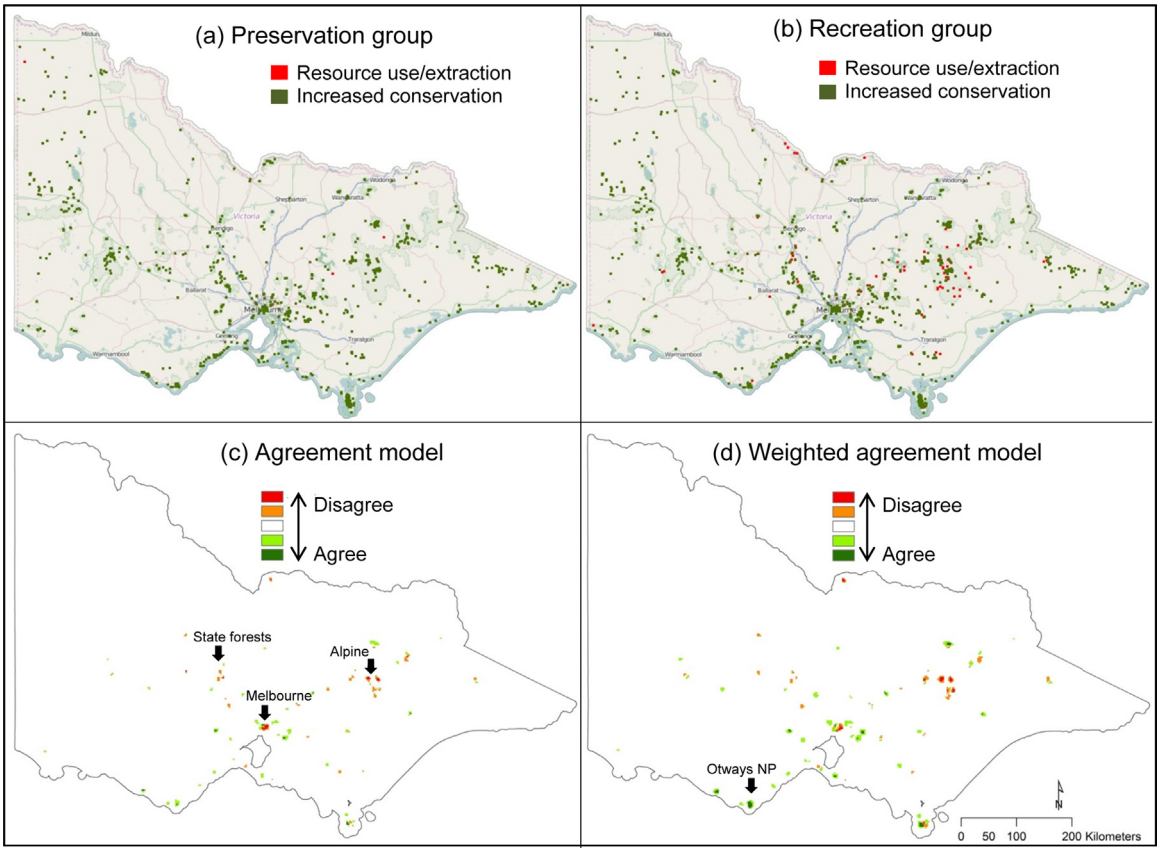

Fig. 5. Mapped locations of public land conservation versus resource use preferences by group: (a) Preservation and (b) Recreation. Map (c) shows the location and intensity of agreement/disagreement for increasing conservation versus resource use while map (d) is a weighted model with Recreation group densities doubled.

with significant agreement was Wilsons Promontory National Park where both Preservation and Recreation groups favor no further development. In contrast, there was significant disagreement about further development at Mt. Buffalo National Park, but in this case, the preferences were divided as much *within* each group as *between* the two groups. Another interesting result was preferences for development of facilities along the Great Ocean Road. This road is an iconic scenic highway that follows the rugged southern coast of Victoria around Cape Otway peninsula to the Twelve Apostles, a highly photographed coastal feature of eroded limestone rocks at Port Campbell. Overall, there is general agreement not to develop new facilities along the scenic route with the exception of the stretch between the two communities of Lorne and Apollo Bay where some individuals in the Recreation group favor new facilities. The weighting of Recreation preferences for facilities development had little observable effect on the results compared to the other two preference issues.

4. Discussion

The purpose of this research was to identify key public land management preference components, use this information to identify and classify public land stakeholder groups, and examine how stakeholder groups could influence spatially explicit information collected in a PPGIS process. Given the historical conflict over public land management, we anticipated that preferences for conservation and development of public lands would be important to identify stakeholder perspectives. While these factors were important in classifying stakeholder groups for public lands in Victoria, preferences for the type of recreation experience on public lands were equally or more important in identifying stakeholder groups. We identified four stakeholder groups using cluster analysis of preferences and found differences in their socio-demographic structure, familiarity, and use of public lands.

The Preservation stakeholder group showed strong preferences for maintaining natural values on public lands and engaging in nature-based recreation activities, mapping twice as many value and preference locations as the largest group, Recreation. The dominant focus of the Preservation group is protecting national parks and reserves with many Victoria National Park Association (VNPA) members being part of this group. The Recreation stakeholder group represents a broad spectrum of public land values and preferences, unified mostly by the belief that public lands provide important recreation opportunities. This group contains individuals that span multiple organized stakeholder groups such as the VNPA and four wheel-drive clubs, with primary interests in state forest lands and community/regional parks. The Socialization and Utilization groups were smaller groups with dominant interests in community/regional parks. Although the Utilization group had the strongest preferences for resource use and development of public lands, these preferences did not manifest in actual mapping behavior. The Socialization group held strong preferences for public land protection similar to the Preservation group, but these preferences also did not manifest in actual mapping behavior.

The public land preferences of the Preservation and Recreation groups were reflected in the quantity, type, and location of map markers placed, resulting in identifiable geographic areas of agreement and disagreement in preferences for public land conservation, access, and development. That differences in preferences exist for how public lands should be managed is certainly not new, but rendering these differences spatially is potentially useful for considering future management options. The capacity

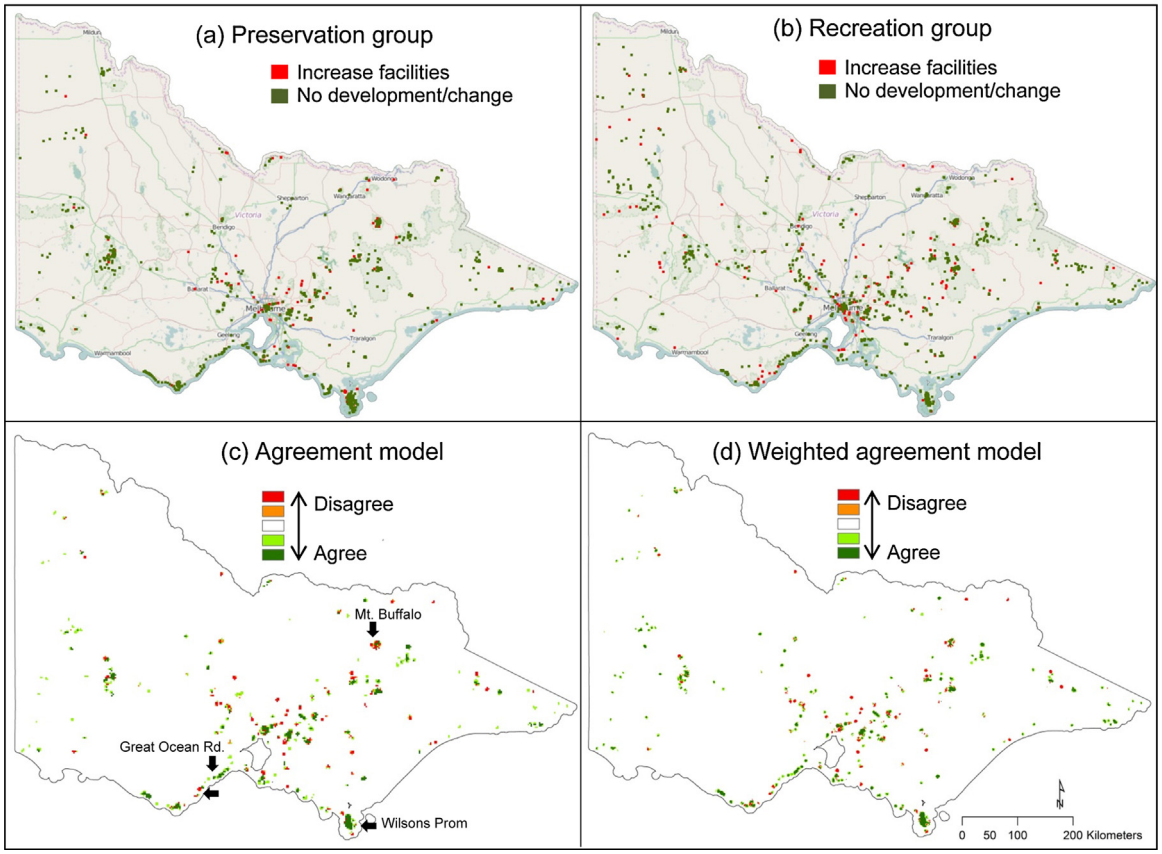

Fig. 6. Mapped locations of public land facility development versus no development preferences by group: (a) Preservation and (b) Recreation. Map (c) shows the location and intensity of agreement/disagreement for facility development while map (d) is a weighted model with Recreation group densities doubled.

for participatory mapping to generate spatially explicit preference maps raises an important question for its prospective use in public land planning and management. How should one aggregate stakeholder values and preferences to identify outcomes that reflect the "public interest"? In this study, we showed that weighting one stakeholder group over another changes some of the location-specific outcomes regarding level of agreement. Specifically, preferences for public land access appear sensitive to the sample size of the stakeholder group, the group mapping behavior, or a combination of the two factors. To address the important issue of aggregation, it is necessary to briefly discuss the role of stakeholders and politics in the domain of public land management.

Public land management generally fits a punctuated—equilibrium policy model (Baumgartner & Jones, 1993), where in a normal state of equilibrium, public land decisions (many of which are largely administrative or technical in nature) are made in policy subsystems dominated by public land management agencies, interested parties, and stakeholder groups. Rare, major events such as catastrophic wildfire or the discovery of major energy resources can sometimes provide the "punctuation", "window of opportunity" (Kingdon, 1995), or the formation of "advocacy coalitions" (Sabatier & Jenkins-Smith, 1993) needed for major shifts in public land management. Generally, public land management is characterized by relatively low public salience on the wider political agenda, resulting in relatively stable policy subsystems dominated by a limited number of stakeholder groups. The high participation rate and diversity among respondents of this study showed PPGIS processes are capable of having the potential to disrupt the subsystem by systematically seeking and including alternative voices in the form of unorganized stakeholder interests into the planning and decision process. But elsewhere, Brown (2012) has identified the reluctance of public land agencies to use PPGIS methods for a range of institutional reasons including lack of incentives to engage non-traditional stakeholders, lack of experience in participatory process, and distrust of non-expert knowledge. To this list, one could also add the potential for destabilization of the public land policy subsystem.

If public land management decisions are expanded to include larger-scale public participation as described in this study, the fundamental problem of aggregation and potential weighting of the spatial results must be addressed. For example, an agency decision to increase public access to Wilson's Promontory National Park would be controversial as evidenced in our spatial model when Recreation group preferences were given greater weight. In traditional stakeholder analysis, the relative influence or power of stakeholder groups suggests a strategy for managing stakeholder interests. Spatial weighting of mapped results could, in principle, be assigned based on an assessment of stakeholder power. But stakeholder power is a subjective judgment and is not indicated in the participatory mapping results per se. Mapping effort is a reasonable proxy for the salience of public land management to participants, but salience is not equal to influence. Perceived threats to public lands require mobilization where salience is a necessary, but insufficient condition for influencing public land outcomes. We posit that the Socialization group which is sympathetic toward public land protection, though not highly engaged in the mapping component of the study, could be mobilized by the Preservation stakeholder group for a significant public land management plan or decision. The two groups would be natural allies on many public land development issues. The same preference affinities are not present between the Recreation and Utilization groups because some types of resource use would be considered a threat to

public land recreation. Without weighting, the preferences of the Preservation group dominate the aggregated mapping results. This may, in fact, represent the actual Victorian political landscape where public land preservation interests secured expansion of national parks in the Otways region at the expense of former, multiple-use state forest lands (OREN, 2014; Parks Victoria, 2009). In Barmah too, there is a movement to create the "Great Forest National Park" in the central highlands of Victoria (Rees, 2014).

4.1. Study limitations and future research

The exploratory public land preference scale was designed to measure public land preferences across a full range of public land classifications and tenures. The semantic-differential scale was reasonably effective in segmenting stakeholder groups, but the scale would benefit from further development and refinement. The scale was most effective in segmenting recreation and conservation/development preferences and least effective in identifying more nuanced preferences about public land tenure and access that were simplistically presented in the scale.

The quantity of spatial data collected was the largest of any PPGIS process to date (over 35,000 mapped locations) but this study covered a large area with a high diversity of public land types. When specific public land units are examined in detail, the spatial data becomes quite sparse, along with confidence that the spatial data adequately captures stakeholder values and preferences at the smaller scale. Assessment of the spatial data quality of the study data showed that the statewide mapping process missed smaller public land units and less densely populated areas (Brown et al., 2014b). For several of the larger and more popular national park units, such as Alpine and Wilson's Promontory, the quantity of spatial data appears adequate to model stakeholder preferences.

The spatial model presented for assessing stakeholder agreement is but one of many alternative approaches. Our focus on spatial stakeholder agreement/disagreement was selected because stakeholder agreement has been the subject of stakeholder research in other policy domains including park and resource management (see Eadens et al., 2009). Stakeholder agreement may be viewed as an indicator of conflict potential and we could have alternatively modeled spatial conflict using methods described by Brown and Raymond (2014) which combine both values and preferences to generate a conflict index. This conflict mapping method has been applied to public land units, but not stakeholder groups (Brown et al., 2014a).

Developing defensible guidelines for spatial aggregation and the rationale for potentially weighting stakeholder responses are an important future research need. Simulation methods such as Monte Carlo can be used to identify the range of possible spatial outcomes based on input probabilities, but the more pressing need is critical insight into stakeholder dynamics, power relations, and the perceptions of stakeholders held by public land decision makers. The default position for spatial analysis is that stakeholder participants are similar in importance and influence, and accordingly, their mapped values and preferences should be treated equally. This may sound appealing to those holding the position that public land should be managed by the principle of participatory democracy. However, such a position would require that existing sampling problems and non-response bias be overcome given that participatory GIS processes result in low response rates and participants that are not representative of larger populations (Brown & Kyttä, 2014). Based on our experience in multiple PPGIS studies, it is unlikely that such sampling deficiencies can be overcome, at least in the short run, without a significant investment in sampling effort. Therefore, we suggest more research with public land managers, as well as organized stakeholder groups, to glean their knowledge and experience with stakeholder subsystems as a potential path forward to develop defensible spatial aggregation rules and supporting rationale for the weighting of stakeholder responses.

References

Australian Bureau of Statistics. (2013). *QuickStats*. Available from http://www.censusdata.abs.gov.au/census_services/getproduct/census/2011/quickstat/2?opendocument&navpos=220 Accessed 27.04.14

Baumgartner, F., & Jones, B. (1993). *Agendas and instability in American politics*. Chicago: University of Chicago Press.

Brown, G. (2005). Mapping Spatial Attributes in Survey Research for Natural Resource Management: Methods and Applications. *Society & Natural Resources*, *18*(1), 1–23.

Brown, G. (2012). Public Participation GIS (PPGIS) for regional and environmental planning: Reflections on a decade of empirical research. *URISA Journal*, *25*(2), 5–16.

Brown, G. (2013). Relationships between spatial and non-spatial preferences and place-based values in national forests. *Applied Geography*, *44*, 1–11.

Brown, G., & Fagerholm, N. (2014). Empirical PPGIS/PGIS mapping of ecosystem services: A review and evaluation. *Ecosystem Services*, http://dx.doi.org/10.1016/j.ecoser.2014.10.007

Brown, G., & Kyttä, M. (2014). Key issues and research priorities for public participation GIS (PPGIS): A synthesis based on empirical research. *Applied Geography*, *46*, 122–136.

Brown, G., & Raymond, C. (2014). Methods for identifying land use conflict potential using participatory mapping. *Landscape and Urban Planning*, *122*, 196–208.

Brown, G., & Reed, P. (2000). Validation of a forest values typology for use in national forest planning. *Forest Science*, *46*(2), 240–247.

Brown, G., Smith, C., Alessa, L., & Kliskey, A. (2004). A comparison of perceptions of biological value with scientific assessment of biological importance. *Applied Geography*, *24*(2), 161–180.

Brown, G., Kelly, M., & Whitall, D. (2014). Which "public"? Sampling effects in public participation GIS (PPGIS) and Volunteered Geographic Information (VGI) systems for public lands management. *Journal of Environmental Planning and Management*, *57*(2), 190–214.

Brown, G., Weber, D., & de Bie, K. (2014a). Assessing the value of public lands using public participation GIS (PPGIS) and social landscape metrics. *Applied Geography*, *53*, 77–89.

Brown, G., Weber, D., & de Bie, K. (2014b). Is PPGIS good enough? An empirical evaluation of the quality of PPGIScrowd-sourced spatial data for conservation planning. *Land Use Policy*, *43*, 228–238.

Bryson, J. M. (2004). What to do when stakeholders matter: Stakeholder identification and analysis techniques. *Public Management Review*, *6*(1), 21–53.

Budowski, G. (1976). Tourism and environmental conservation: Conflict, coexistence, or symbiosis? *Environmental Conservation*, *3*(1), 27–31.

Clark, R. N., & Stankey, G. H. (1979). *The recreation opportunity spectrum: A framework for planning, management, and research*. USDA Forest Service, General Technical Report (PNW-98).

Darvill, R., & Lindo, Z. (2014). Quantifying and mapping ecosystem service use across stakeholder groups: Implications for conservation with priorities for cultural values. *Ecosystem Services*, http://dx.doi.org/10.1016/j.ecoser.2014.10.007

DEPI—Department of Environmental and Primary Industries. (2013). *Victorian crown land area statement*. Available from http://www.depi.vic.gov.au/_data/assets/pdf_file/0006/199068/FactSheet_CrownLandVictoria_20130821FINAL.pdf Accessed 22.04.14

Driver, B. L., & Brown, P. J. (1978). The opportunity spectrum concept in outdoor recreation supply inventories: A rational. In *Proceedings of the integrated renewable resources inventories workshop* (pp. 24–31). Ft. Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station (Gen. Tech. Rep. RM-GTR-55).

Eadens, L. M., Jacobson, S. K., Stein, T. V., Confer, J. J., Gape, L., & Sweeting, M. (2009). Stakeholder mapping for recreation planning of a Bahamian National Park. *Society and Natural Resources*, *22*(2), 111–127.

Fagerholm, N., Käyhkö, N., Ndumbaro, F., & Khamis, M. (2012). Community stakeholders' knowledge in landscape assessments—Mapping indicators for landscape services. *Ecological Indicators*, *18*, 421–433.

Fraley, C., & Raftery, A. E. (1998). How many clusters? Which clustering method? Answers via model-based cluster analysis. *The Computer Journal*, *41*(8), 578–588.

Fraser, I., & Chisholm, T. (2000). Conservation or cultural heritage? Cattle grazing in the Victoria Alpine National Park. *Ecological Economics*, *33*(1), 63–75.

Freeman, R. E. (1984). *Strategic management: A stakeholder approach*. Boston: Pitman.

García-Nieto, A. P., Quintas-Soriano, C., García-Llorente, M., Palomo, I., Montes, C., & Martín-López, B. (2014). Collaborative mapping of ecosystem services: The role of stakeholders' profiles. *Ecosystem Services*, http://dx.doi.org/10.1016/j.ecoser.2014.11.006

Geoscience Australia. (2014). *Land tenure*. Available from http://www.ga.gov.au/education/geoscience-basics/land-tenure.html Accessed 28.04.14

Goodchild, M. F. (2007). Citizens as sensors: The world of volunteered geography. *GeoJournal*, *69*(4), 211–221.

Grimble, R., & Wellard, K. (1997). Stakeholder methodologies in natural resource management: A review of principles, contexts, experiences and opportunities. *Agricultural Systems*, *55*(2), 173–193.

Hutcheson, G., & Sofroniou, N. (1999). *The multivariate social scientist*. London: Sage Publications Ltd.

Kaiser, H. F. (1960). The application of electronic computers to factor analysis. *Educational and Psychological Measurement*, *20*(1), 141–151.
Kingdon, J. (1995). *Agendas, alternatives, and public policies*. Boston: Little, Brown.
Newsome, D., Moore, S. A., & Dowling, R. K. (2012). *Natural area tourism: Ecology, impacts and management* (2nd ed.). Clevedon, UK: Channel View Publications.
NRCM—Natural Resource Council of Maine. (2014). *Public land ownership by state*. Available from http://www.nrcm.org/documents/publiclandownership.pdf Accessed 28.04.14
OREN. (2014). *Overview OREN/Otway forest campaign (1995–2008)*. Available from http://www.oren.org.au/campaign/intro.htm Accessed 22.12.14
Palomo, I., Martín-López, B., Potschin, M., Haines-Young, R., & Montes, C. (2013). National parks, buffer zones and surrounding lands: Mapping ecosystem service flows. *Ecosystem Services*, *4*, 104–116.
Parks Victoria. (2009, December). *Great Otway National Park Management Plan*. Government of Victoria., ISBN 9-7807-3118-384-5. Available from http://parkweb.vic.gov.au/__data/assets/pdf_file/0019/313282/great-otway-np-mp.pdf Accessed 22.12.14
Reed, M. S., Graves, A., Dandy, N., Posthumus, H., Hubacek, K., Morris, J., et al. (2009). Who's in and why? A typology of stakeholder analysis methods for natural resource management. *Journal of Environmental Management*, *90*(5), 1933–1949.
Rees, S. (2014). A new national park. *Interaction*, *42*(4), 8–12. Available from http://search.informit.com.au/documentSummary;dn=776222132814300;res=IELHSS Accessed 22.12.14
Ruiz-Frau, A., Edwards-Jones, G., & Kaiser, M. J. (2011). Mapping stakeholder values for coastal zone management. *Marine Ecology Progress Series*, *434*, 239–249.
Sabatier, P., & Jenkins-Smith, H. (1993). *Policy change and learning: An advocacy coalition approach*. Boulder, CO: Westview.
Schlossberg, M., & Shuford, E. (2005). Delineating 'public' and 'participation' in PPGIS. *URISA Journal*, *16*(1), 15–26.
Sherrouse, B. C., Clement, J. M., & Semmens, D. J. (2011). A GIS application for assessing, mapping, and quantifying the social values of ecosystem services. *Applied Geography*, *31*(2), 748–760.
Sieber, R. (2006). Public participation geographic information systems: A literature review and framework. *Annals of the Association of American Geographers*, *96*, 491–507.
Van Riper, C. J., & Kyle, G. T. (2014). Capturing multiple values of ecosystem services shaped by environmental worldviews: A spatial analysis. *Journal of Environmental Management*, *145*, 374–384.
Weber, D., & Brown, G. (2014). *Identifying & mapping the values of Victorian public lands*. University of South Australia and University of Queensland. Available from http://www.landscapemap2.org/publications/StatewidePVreport2014.pdf Accessed 03.03.15
Western, D., & Henry, W. (1979). Economics and conservation in third world national parks. *BioScience*, *29*(7), 414–418.
WDPA. (2014). *World database on protected areas*. Available from http://www.wdpa.org/resources/statistics/2013_MDG_Regional_and_global_stats_Indicator_7_6.xlsx Accessed 19.04.14
Zanon, D., Hall, J., Lockstone-Binney, L., & Weber, D. (2014). Development of a whole agency approach to market segmentation in parks. *Journal of Leisure Research*, *46*(5), 563–592.