Landscape and Urban Planning xxx (2011) xxx–xxx

Contents lists available at ScienceDirect

Landscape and Urban Planning

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

Public Participation GIS: A new method for national park planning

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ARTICLE INFO

Article history:
Received 21 September 2010
Received in revised form 1 March 2011
Accepted 12 March 2011
Available online xxx

Keywords:
Park experiences
Environmental impacts
PPGIS
Indicators
Standards
Public participation GIS

ABSTRACT

This paper describes research to evaluate the use of a public participation geographic information system (PPGIS) methodology for national park planning. Visitor perceptions of park experiences, environmental impacts, and facility needs were collected via an internet-based mapping method for input into a national park planning decision support system. The PPGIS method presupposes that consistent with the dominant statutory framework, national parks should be managed for both visitor enjoyment and natural and cultural resource protection. This paper: (1) describes the PPGIS method used in a 2009 park planning study conducted for national parks in the Greater Alpine region of Victoria, Australia; (2) presents and evaluates selected results of the Greater Alpine study and provides examples of how PPGIS data can be used for decision support in park planning; (3) provides a summary of lessons learned including a discussion of future implementation constraints. The results demonstrate that an internet, participatory mapping method, though not without limitations, can be effective in measuring visitor experiences, environmental impacts, and facility needs for a variety of park planning processes. PPGIS expands a park agency's repertoire of methods to engage the public in planning and can help build and sustain trust in a park agency's planning process and decisions.

1. Introduction

Most national park systems have a dual and potentially conflicting statutory mandate to provide for both visitor enjoyment and natural and cultural landscape protection. For example, the purpose of U.S. National Park system is "to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations" (National Park Service Organic Act of 1916, 16 U.S.C. 1). In the U.K., the purposes of national parks are to conserve and enhance the natural beauty, wildlife and cultural heritage while promoting opportunities for the understanding and enjoyment by the public, with an added duty to foster the social and economic well-being of the local communities (National Parks and Access to the Countryside Act of 1949, Part II § 5 and 11a). In Victoria, Australia, the location of this study, the purpose of Parks Victoria is to conserve, protect, and enhance natural and cultural values, provide quality experiences, services and information to customers, provide excellence and innovation in park management, and contribute to the environmental, social and economic wellbeing of Victorians (Parks Victoria, 2009).

To be effective, national park management authorities require park planning and management methods that provide useful information for decision support including information about visitor experience and resource protection. Resources available for park planning and decision-making include statements of park purposes, observations of park staff, indicators and standards of quality, and public input (Anderson, Lime, & Wang, 1998). Common to national park planning is the development of plans that recognize the diversity of national park resources and visitor opportunities both within individual national park units, and at different parks on a regional or national scale. Differential national park qualities may be reflected in a regional or national park system plan (e.g., Ecosystem Management Plan), a park comprehensive plan (e.g., a Master or General Management Plan), or a park sub-area plan (e.g., a Backcountry Management Plan).

Two planning concepts that are central to national park planning are park management zones and indicators of quality. Large parks comprise multiple management zones that address management priorities within a park (e.g., conservation, recreation or educa-

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doi:10.1016/j.landurbplan.2011.03.003

tion) and typically reflect the spatial heterogeneity of biophysical conditions and visitor opportunities. Management zones provide a means to spatially separate potentially conflicting park activities, or alternatively, to collocate complementary activities. The potential for diverse visitor experiences is recognized in various public lands planning frameworks such as the Recreation Opportunity Spectrum (Driver & Brown, 1978); Limits of Acceptable Change (Stankey et al., 1985), Visitor Impact Management (Graefe, Kuss, & Vaske, 1990), Visitor Activities Management Process (Parks Canada, 1991); Visitor Experience and Resource Protection (Hof & Lime, 1997; Manning, Graefe, & McCool, 1996; Wilkinson, 1995), and Quality Upgrading and Learning (Chilman, Foster, & Everson, 1990). Future park management frameworks will likely move towards a systems approach focused on linkages between the physical environment and visitor opportunities (Brown, Koth, Kreag, & Weber, 2006) and the application of geographic information systems (GIS) technology can facilitate these linkages.

Indicators and standards of quality are often attached to management zones to provide criteria to assess the effectiveness of management activities. Indicators may be established for both physical resources and experiential outcomes. For example, on Kangaroo Island in South Australia, environmental indicators include the number of hooded plover pairs and the percentage of waste diverted from landfill on the island, whereas the experiential indicators include the proportion of visitors who believe they had an intimate experience with wildlife in a natural setting, and the proportion of visitors who believed their experience was similar to that suggested in marketing documents (TOMM, 2006). Other common indicators used in park management include encounters with particular visitor groups (Hall, Shelby, & Rolloff, 1996; Martinson & Shelby, 1992; Stankey, 1980; Vaske, Graefe, Shelby, & Heberlein, 1986; Young, Williams, & Roggenbuck, 1991); number of groups camped within sight or sound of each other (Roggenbuck, Williams, & Watson, 1993; Williams, Roggenbuck, Patterson, & Watson, 1992; Young et al., 1991); number of pieces of litter visible from campsite (Roggenbuck et al., 1993); and depth of erosion on a trail (Parks and Wildlife Service Tasmania, 2003).

Standards are threshold points associated with an indicator (e.g., depth of erosion should not exceed 3 cm or “no more than six encounters with other groups per day during peak season”). Establishing useful and cost effective indicators remains a major challenge to park managers. Research as early as Clark, Hendee, and Campbell (1971) demonstrated differences between recreationists and managers in defining what constitutes an environmental experience, highlighting the need to seek public input when establishing indicators and standards.

Public participation is important to protected area planning and management because decisions about management zones and indicators of quality involve a series of subjective value judgments and a diversity of interests (McCool & Cole, 1997). Experiential knowledge gained through a public involvement process can add different perspectives and augment scientific knowledge and expert judgment. The scope of public participation in park planning can vary widely from inviting individual comments on a park plan, to working with national park stakeholder groups in a planning process, to broad-scale surveys of park visitors. It is important in public participation GIS (PPGIS) projects (described below) to articulate clear goals and understand the limitations of the project. For example, acknowledging that visitors perceptions of management will be based on a range of socioeconomic and individual factors including past experience, may lead us to expect that an assessment of current management effectiveness conducted by a visitor is likely to be different to that conducted by a manager who is likely to have a different set of experiences.

Gathering high quality public input is however, a difficult task for park managers. It is difficult to engage many visitors in park planning when they are intent on enjoying limited leisure time. Further, parks are often large and dispersed with low number of staff which makes intercepting park visitors difficult. Research by Weber (2007) in other Parks Victoria sites highlighted demand by visitors for convenient participation methods with the internet being cited frequently as an example of a convenient method. The internet PPGIS platform developed for this study provides a useful mechanism to gather public input from a wide spectrum of Australians. In 2009, 80.1% of the Australian population used the internet (Nielsen, 2009). In 2005 it was estimated that these users have a median age of 36.56 years (www.internetworldstats.com). Importantly, the Australian Bureau of Statistics (2010) showed 71% of users had broadband connections of speeds of 1.5 Mbps or greater which makes using the internet-based PPGIS, particularly accessing the demonstration, a quicker exercise.

As well as being a convenient method that is accessible to the general public, respondents seem to readily understand internet-based PPGIS systems. People’s spatial awareness and use of mapping is likely to have improved with usage of programs such as Google Maps and Near Maps. This does not suggest that more traditional methods such as public meetings, focus groups or surveying should not take place. In fact, the PPGIS reported in this study was only one method of a variety used to elicit public input for a management plan. What makes a PPGIS system particularly valuable to land managers is the functionality it provides, for example the ability to overlay visitor data on existing GIS layers such as trails, vegetation and soil. This paper uses data from a project in the Alpine area of Victoria to demonstrate the application of PPGIS in park planning.

1.1. Review of PPGIS applications

In this paper, we present public participation using geographic information systems (PPGIS) as a method for assisting national park planning. The term “public participation geographic information systems” (PPGIS) was conceived in 1996 at the meeting of the National Center for Geographic Information and Analysis (NCGIA). PPGIS combines the practice of GIS and mapping at local levels to produce knowledge of place. The formal definition of the PPGIS remains nebulous (Tulloch, 2007) with use of the term “PPGIS” emerging in the United States and developed-country contexts while the term participatory GIS or “PGIS” is often used to describe participatory planning approaches in rural areas of developing countries, the result of a spontaneous merger of Participatory Learning and Action (PLA) methods with geographic information technologies (Rambaldi, Kwaku Kyem, Mbile, McCall, & Weiner, 2006). Since the 1990s, the range of PPGIS applications has been extensive, ranging from community and neighborhood planning to mapping traditional ecological knowledge of indigenous people (see Sieber, 2006 and Sawicki & Peterman, 2002 for a review of PPGIS applications). Although PPGIS activity often involves community mapping and database development outside of formal government processes, the focus of this paper is on the genre of PPGIS that seeks to expand and enhance public participation and community collaboration in governmental processes for environmental planning and management.

In an early PPGIS public lands application, Brown and Reed (2000) asked individuals to identify the location of landscape values for the Chugach National Forest (U.S.) planning process. Reed and Brown (2003) subsequently developed a quantitative modeling approach using the PPGIS mapped attributes to determine whether management alternatives were generally consistent, and more important, place-consistent, with publicly held forest values. Research using PPGIS has also been conducted to identify the location of highway corridor values (Brown, 2003); to identify "coupled social–ecological" hotspots (SES) where human and biophysical systems are closely linked (Alessa, Kliskey, & Brown, 2008); to identify preferences for tourism and residential development (Brown, 2006); to identify priority areas for conservation (Pfueller, Xuan, Whitelaw, & Winter, 2009; Raymond & Brown, 2007); to manage recreation resources on public lands (McIntyre, Moore, & Yuan, 2008); to identify place attachment (Brown & Raymond, 2007); and to measure urban park and open space values for park planning (Brown, 2008). 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 hectare study area in the province of Alberta, Canada (Beverly, Uto, Wilkes, & Bothwell, 2008). Additional internet-based studies for national forest management in the U.S. followed (Brown & Reed, 2009; Clement & Cheng, 2010).

In their assessment of the strengths and weaknesses of internet-based PPGIS, Brown and Reed (2009) report that the spatial results from the methodology are sensitive to the subpopulations being sampled and that general public data collection using the internet may need to be augmented by traditional mail-based PPGIS methods to increase participation rates, a finding supported by a recent internet-based PPGIS study in Wyoming (Pocewicz, Schnitzer, & Nielsen-Pincus, 2010). However, the internet-based PPGIS methodology appears complementary to workshop or public meeting-based mapping of landscape values that may be included in national park planning participatory processes. A key strength of the PPGIS methodology is that it can build and strengthen trust by increasing opportunities for collaboration in public lands management (Brown & Reed, 2009).

1.2. Research objectives

To better understand the strengths and limitations of PPGIS spatial mapping methods for national park planning, we developed a PPGIS process for national parks in the Greater Alpine region of Victoria, Australia, in 2009. PPGIS systems have the flexibility to be tailored to the national park planning application through choices about sampling, the attributes to be mapped, and the analyses to be performed. As one of the first PPGIS studies for national park planning, we were guided by a series of research questions related to both the method and the usefulness of the resulting data and analysis for park planning: (1) can the concepts of visitor experiences, perceived environmental impacts, and park facilities/service needs be effectively mapped using an internet-based PPGIS? (2) will park visitors participate in the study following contact during their park visit? (3) what are the similarities and differences in the mix of visitor experiences and environmental impacts in different national park units? (i.e., the park "profile") and (4) are mapped visitor experiences, perceived environmental impacts, and facilities/services needs consistent with existing management zones for the national park units?

To describe the use of PPGIS for national park planning, we provide a framework for organizing and presenting the results in Fig. 1. This paper will focus on the data collection methods used, descriptive analysis of the results, and one planning application—the exploration of management indicators for determining the consistency of visitor experience and environmental impact data in park management zones in the region. Although not presented in this paper, other park planning applications are possible using PPGIS data. For example, Fig. 1 shows three such applications: determining whether level of service (LOS) criteria are being met; establishing or validating Recreation Opportunity Spectrum classifications; and examining visitor perceptions of facilities/services needs against asset management plans.

2. Methods

2.1. Study area and planning process

Parks Victoria, the national park management agency for Victoria, Australia, is preparing a new Greater Alpine National Parks Management Plan that will include the Alpine, Baw Baw, Mount Buffalo, Errinundra and Snowy River National Parks as well as the Avon Wilderness Park, Walhalla and adjacent historic areas. The planning area covers over 860,000 ha and is located in central and eastern Victoria. National parks and historic areas extend in an arc from Baw Baw National Park in the southwest to Errinundra National Park in the east (see Fig. 2). Specifically, the management plan will cover the 9 park units comprising 5 national parks; 1 wilderness area; and 3 historic areas. All units were included in the study. Under government legislation, all national parks and other protected areas need to have a management plan and most plans are reviewed every 10–15 years. The Greater Alpine National Park management plan will consolidate the existing, individual national park plans to provide a broad strategic plan for managing the mix of Alpine parks. Substantial changes have occurred since the last management plan was published, including climate change, fire frequency, cessation of cattle grazing, and an increase in nature-based tourism. A PPGIS was initiated to gather data from the general public about their use and experience in the study area, as well as their perceptions of environmental impacts. This data informed a wiki draft plan, which was available for public input. More traditional methods such as public forums and focus groups were also used to gather data, as well as approaches targeted at younger audiences, such as blogging via a purpose built website (www.weplan.parks.vic.gov.au). The draft plan was then open for public input for a period of three months before the final plan was developed.

2.2. Survey procedure

After consultation with Parks Victoria staff and based on current literature, park experience and environmental impact variables for investigation were identified. The variables were pre-tested and modified based on comments from Parks Victoria staff (see Table 1). In January 2009, an interactive web-based public participation GIS survey was launched (http://www.landscapemap2.org/pvppgis/). Participants were recruited on-site at various national parks and also by advertising the web-site. Parks Victoria staff members that worked for national parks in the Greater Alpine region were sent email invitations with specific access codes by the Parks Victoria planning team. When participants accessed the website they were welcomed by a page explaining the study and the time needed to complete the survey. Participants then entered their access code to begin the survey. An option to request an access code was provided for those who had not received an access code via field surveying or staff invitation. The survey consisted of two components: (a) a spatial component where participants mapped experience, impact, and facilities variables and (b) 10 questions measuring respondent characteristics such as their self-assessed knowledge of the Victorian Alps, their self-assessed knowledge of the natural environment, the number of times they had visited the national parks in the Victorian Alps, and basic demographic questions including age, gender, income, and level of formal education.

After reading background information and consenting to participate, respondents were offered an optional demonstration of how the PPGIS system worked. To enter data, they would click on a map tile representing a park section they had visited and then select and drag different park experience and environmental impact markers to the relevant location on the map (see Fig. 3). Each person was provided a total of six markers for each of the 18 variables shown in

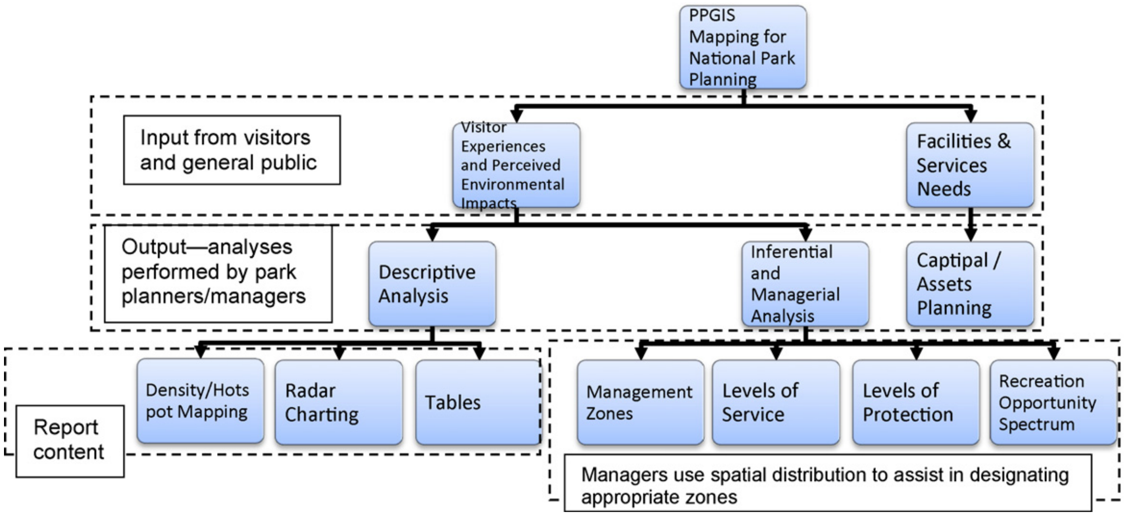

Fig. 1. A framework for using PPGIS in national park planning.

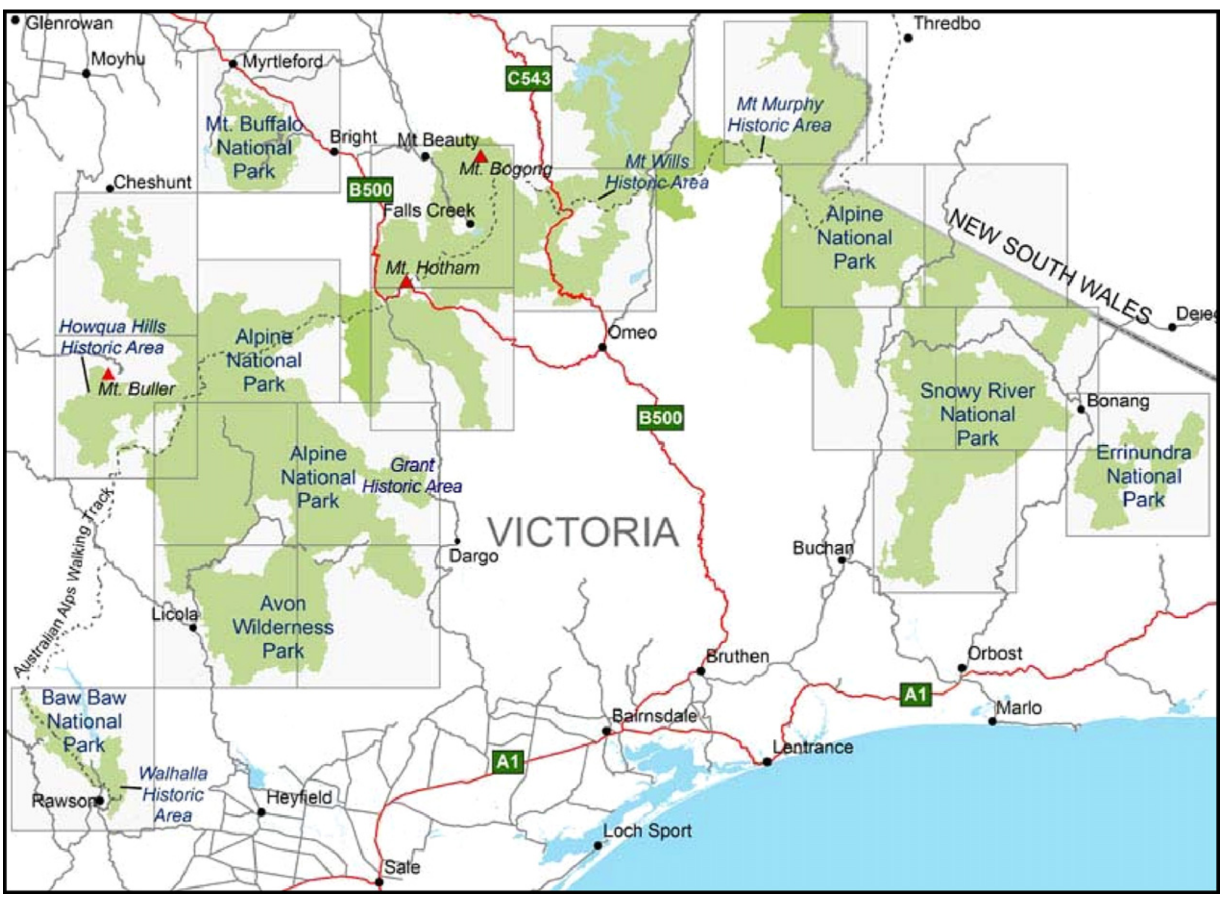

Fig. 2. Map of Greater Alpine study area, Victoria, Australia.

Table 1
Variables (markers) that park visitors could map on the PPGIS website.

Experience variables	Impact variables	Other variables
Aesthetic/scenic	Track condition (degraded)	Special places
Crowding/congestion	Campsite condition (degraded)	Facilities/services changes
Solitude/escape	Rubbish/litter	
Social interaction	Wildlife (dead or sick)	
Trail-based activity	Vegetation (dead/unhealthy)	
Other physical activity/adventure	Water quality (degraded)	
Overnight stay/camping	Noise	
Learning/discovery		
Wildlife viewing		

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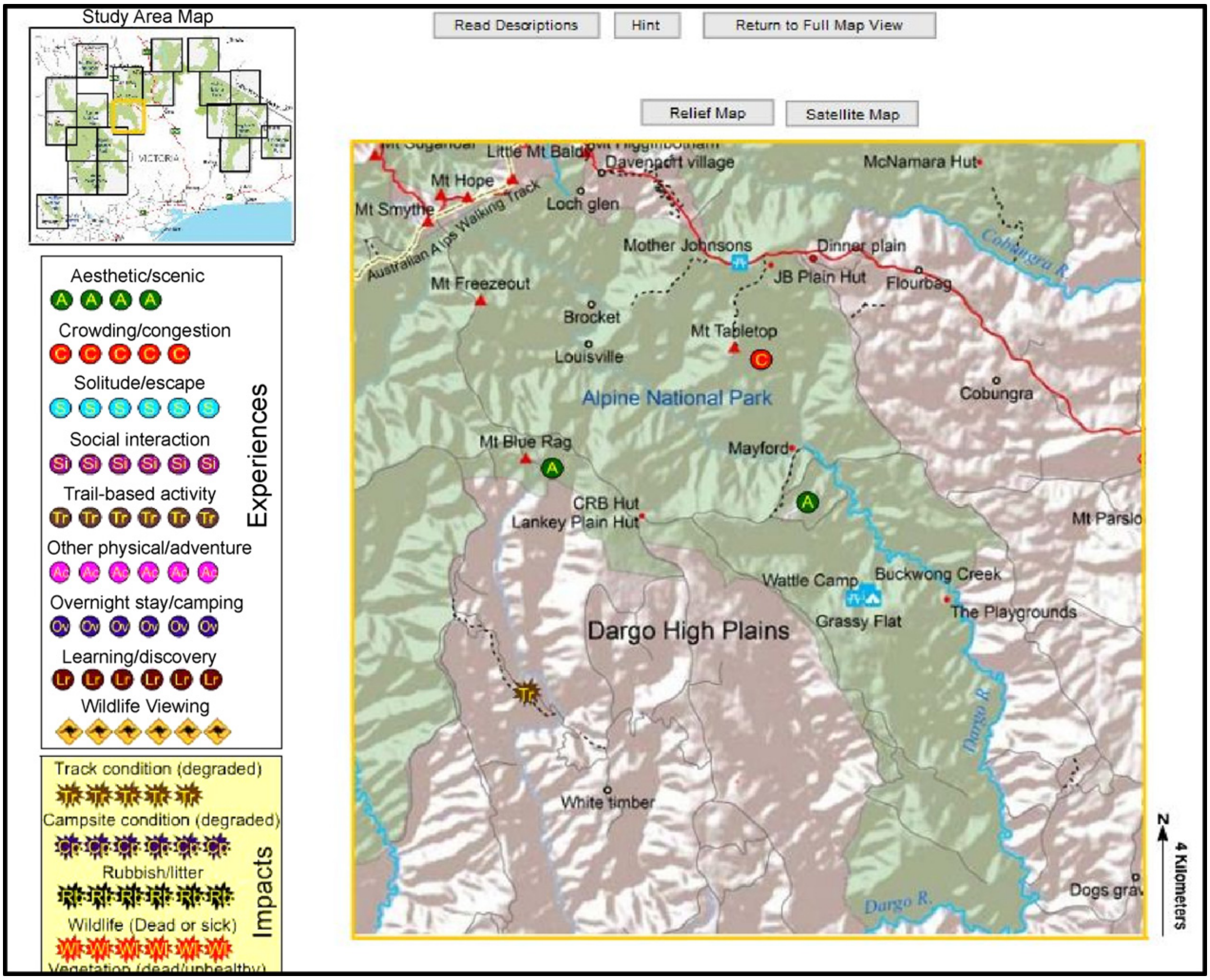

Fig. 3. Screenshot of PPGIS user interface after entering access code. Participants drag and drop markers (left) onto the map image (right).

Table 1. Respondents were able to optionally annotate each marker location with text. Respondents could see all the markers they had placed but not the overall mapping pattern created by other users. Respondents were asked if they would like copies of the results and in the spirit of PPGIS these were made available to all interested users via a web link that was emailed to them.

The survey procedure was consistent with recommendations from the tailored design method described by Dillman (2000). For those email addresses collected on-site, if no response had been registered after one week, a personal reminder of the importance of completing the survey was emailed. If another two weeks elapsed without response, another reminder was emailed. This reminder emphasized the ease of the PPGIS system and offered potential rewards (e.g., shopping vouchers for the first five to complete the survey). The Parks Victoria (PV) staff sample was invited to participate via email from a member of the Parks Victoria Alpine Planning team. PV staff were sent at least three reminders of the importance of participation.

2.3. Sampling

Park visitors were contacted face-to-face at multiple locations in the study area. Surveying was conducted over eleven days, including the Australia Day long weekend and the Easter school holidays. A convenience sample was collected where interviewers intercepted potential participants at key visitor nodes, for example trail heads of popular hikes, high use camping areas, picnic spots and along high use nature trails in each of the nine park units in the study location. The nature of the PPGIS study was briefly described and the visitors were asked if they would voluntarily participate in the study. If they agreed, they were provided with a one-page information sheet that described the study and were provided an access code to the PPGIS website. To increase ability to intercept people and also to provide greater consistency, all participants completed the internet-based PPGIS activity at a later date, rather than in the field. A total of 579 visitor contacts were made using this method.

To increase the sample size, an option was provided that allowed individuals to visit the PPGIS website and request an access code without having been explicitly contacted for participation. The PPGIS web-site was advertised via radio spots, through flyers in visitor information centres and on the Parks Victoria Alpine Planning Team's wePlan website (www.weplan.parks.vic.gov.au). Media releases were also sent to all local newspapers in the study region and outdoor magazines. Additionally, Parks Victoria staff were requested to participate via a series of emails from the Parks Victoria Planning team. The aim of this sample was to allow for a comparison between "expert" and "amateur" assessment of impacts.

2.4. Analysis methods

The most meaningful analyses of PPGIS data for park planning are those that generate information for decision support. More specifically, PPGIS systems that collect visitor and staff data about

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park experiences and perceived environmental impacts, facilities/services needs, and special places can be analyzed to: (1) prioritize park areas and facilities to allocate scarce managerial resources, (2) determine standards of quality for different park areas, (3) identify visitor experiences and impacts with existing management zones, levels of service (LOS), or other management standards for the park, and (4) suggest new options for the planning and management of national parks or sub-areas within a park. The scope of the planning activity (e.g., regional/multiple national parks vs. single national park) should guide the type and nature of the analyses performed. Quantitative analyses consist of both descriptive and inferential methods designed to inform park planning decisions.

Descriptive analysis. The most useful starting point for analysis is to generate descriptive tables, maps, and charts of the visitor and staff survey data. These descriptive inventories provide the foundation for more sophisticated analysis and modeling for park planning.

Tables show the frequency and rank of mapped attributes by study region, park unit, or other planning sub-area. For illustration, tables were generated by region and national park unit. GIS maps can be generated for each mapped attribute or a combination of attributes. Descriptive maps of park experiences, environmental impacts, facility needs, and special place locations were generated using ArcGIS® software to show the spatial distribution of visitor and staff mapped attributes. Density maps of the attribute point data were created using a kernel density function to show experience and impact "hotspots", for example, areas of perceived park crowding, or alternatively, solitude. Specialized charts or graphs can provide better visualization of attributes by area than tabular results. In this study, radar charts were generated to show the mix of experience and perceived impacts of different national park study units in the Greater Alpine region.

Inferential and managerial analysis. The types of inferential and management analysis should be guided by the management framework used by the national park management agency. Management of national parks in Victoria is guided by a number of management concepts including park management zones, levels of service (LOS), levels of protection (LOP), and asset planning.

Data collected through a PPGIS system provide for the creation of a variety of management indicators that can augment traditional indicators used in carrying capacity approaches such as encounters per day or number of pieces of litter seen from a campsite. Generating indicator data using PPGIS systems provides flexibility for the creation of a variety of management indicators and has the potential to be more cost effective because data pertaining to multiple indicators can be collected from a large number of people at one time (e.g., via the internet). Multiple management indicators can be easily generated from single mapped attributes (e.g., crowding, track conditions) or a composite of mapped attributes (e.g., the ratio of positive park experiences to environmental impacts). Table 2 provides some examples of potential management indicators that can be generated from PPGIS data.

In this paper, we provide an example of the use of PPGIS data in a managerial analysis that examines the consistency of existing park management zones with mapped experiences and impacts. Management zones provide a geographic framework for: (1) indicating which management directions have priority in different parts of the park, (2) minimizing existing conflicts between uses and activities or between activities and the park's values, and (3) assessing the suitability of future activities and development proposals. Parks Victoria has six primary management zones (conservation, conservation and recreation, recreation development, education, wilderness, reference) and a number of overlay zones including special protection areas. Historical zones/areas also exist within and external to national parks and are managed to protect historical and cultural resources and to provide opportunities for people to learn about and understand the heritage values of the reserve. Each zone is accompanied by an aim and scope. For example, the aim of the conservation zone is to "protect sensitive natural environments and to provide for minimal impact recreation activities and simple visitor facilities subject to ensuring minimal interference to natural processes" while the scope covers "broad areas containing sensitive natural environments or ecosystems which are unable to sustain the impact of significant levels of dispersed recreation activity and other uses." A series of managerial presuppositions regarding the relationship between management zones and experiences and impacts were examined: (1) there should be proportionately fewer environmental impacts observed in the *conservation* and *reference* zones relative to the *recreation and conservation* and *recreation development* zones, (2) there should be more recreation experiences (e.g., trail activity, physical activity) in the *recreation* zones than in the other zones, and (3) there should be more opportunities for solitude experience in the *remote* and *wilderness* zones than in other zones.

To examine the relationship between park management zones and visitor experiences and perceived environmental impacts, respondent mapped attributes were intersected with the spatial boundaries for management zones using ArcGIS®. Cross-tabulations were generated in SPSS® based on the spatial distribution of attributes that fell within the management zones. Analysis was limited to management zones for which there were a minimum of 30 attributes. Chi-square statistics and analysis of standardized residuals (difference between observed and expected cell counts) were completed to indicate which map attributes were disproportionately represented within a given management zone thus contributing to the overall association between map attributes and management zones. Standardized residuals greater than 1.96 indicate that a given map attribute/zone association contributes significantly to the overall relationship between attributes and management zones.

Following analysis of experiences and impacts by management zone, we explored the use of several composite metrics as a means of determining normative standards by management zone. Is there an acceptable range of experiences and impacts per management zone? The first alternative is based on the ratio of positive or neutral park experiences to negative environmental impacts by management zone. Ideally, one would want this ratio to be high in all park management zones, but given that some zones emphasize environmental protection over visitor access, there may be differentiation in those management zones where resource protection receives priority. For example, *conservation* zones should have a higher ratio of positive or neutral park experiences to environmental impacts compared to the *conservation and recreation* or *recreation development* zones because of the potential for more environmental impacts associated with visitation. The second potential indicator explored in this paper is based on the number of observed environmental impacts per zone divided by the area of the zone, or the density of impacts. A reasonable starting point for establishing a zone standard would be metrics that fall within one standard deviation of the empirical average for the management zone.

3. Results

3.1. Survey response rates and respondent characteristics

A total of 351 responses were received on the PPGIS website. This comprised 248 responses from visitors intercepted on site; 83 responses from the general public; and 20 responses from Parks Victoria staff. The overall response rate from on-site surveying was 51% while the response rate from Parks Victoria Alpine-based staff

Table 2
Potentially useful management indicators using park experience and impacts.

Indicators	Calculation	Usefulness	Limitations
Single attribute			
Crowding—measures perceived crowding within management zone.	Sum of all points within zone. To standardize across management zones, divide by the area of the zone or the number of visitors per zone.	Indicates the most crowded management zones.	Unless standardized by number of visitors or area, may have higher count simply by virtue of higher visitation rates or larger management zones.
Track condition—measures perceived track condition problems within management zone	Sum all points within zone. To standardize across management zones, divide by the area of the zone or kilometers of track within the zone.	Indicates areas in need of track maintenance or upgrade.	Unless standardized, will likely reflect areas with high track use.
Composite attributes			
Experience/impact ratio—the ratio of positive or neutral park experiences to perceived environmental impacts	Sum all positive or neutral park experiences within zone and divide by number of environmental impacts in the zone.	Indirect measure of sustainable park management. High ratios indicate high visitor benefit relative to environmental impact.	Assumes equality among park experiences and impacts. A zone with 10 positive experiences and 5 impacts would be evaluated the same as 2 positive experiences and 1 impact.
Impact density—the number of perceived environmental impacts by area	Sum all perceived environmental impacts within zone and divide by the area of the zone.	Indirect measure of sustainable park management. High values indicate park degradation and need for management attention.	Assumes equality among park environmental impacts. Not all impacts are anthropogenic.
Experience diversity—indicates the diversity of park experiences by management zone (Shannon diversity index)	$D = \sum_{i=1}^{v} p_i \ln p_i$, where p_i = the proportional abundance of the ith park experience = (n_i/N); n_i = the number of mapped park experiences in the ith experience category; N = the total number of all mapped park experiences; ln = natural logarithm; v = the number of park experience categories.	Indicates how visitors are using a management zone. The diversity of park experiences may or may not be consistent with zone management objectives.	Diversity of park experiences may or may not be a useful proxy for potential visitor conflict, or alternatively, visitor satisfaction.

members was 25%. The response rate for on-site surveying was significantly higher than other web-based PPGIS studies, e.g., Brown and Reed (2009) reported 10–12%, Beverly et al. (2008) reported 22%, and Brown (2005) reported 25%. It is unclear why response rate from Parks Victoria staff was so low. It could be speculated that staff were too busy, did not see value in the process, or there was some discord between the central office planning staff making the request and the regional staff being asked to respond. While disappointing, the sample was still sufficient to make some general observations.

Participants were asked 10 sociodemographic questions to help understand the characteristics of the study participants and to examine whether some of these characteristics might be related to the type of experiences and impacts identified in the study. Approximately 80 percent of visitors report average or better knowledge (self-identified) of places in the Victorian Alps and about 86 percent had average or better knowledge (self-identified) of the natural environment. This "knowledge" was not assessed in anyway. The majority of visitors (55%) participating had visited the Victorian Alps more than 10 times in their lifetime. About 60 percent of respondents were male and 40 percent female with an average age in the mid-forties. Respondents were divided between those with children (about 54 percent) and those without (about 46 percent). The respondents' level of formal education and income were consistent with the general population that visits national parks in Victoria.

The number of mapped park experiences and impacts was significantly related to one's knowledge of places in the region which was also related to the number of times visiting national parks in the region. In general, the greater the self-reported knowledge of places in the region, the larger the number of mapped attributes. A one-way ANOVA statistical test confirmed that individuals identifying "good" or "excellent" knowledge of places mapped significantly more experiences and impacts than individuals reporting "low" or "average" knowledge of places. Park experiences also differed somewhat by household income (Chi-square = 37.8, $p \leq .05$). Lower income individuals/families experienced more overnight stays and more solitude while experiencing less social interaction. Higher income individuals/families engaged in more trail-based activities (bushwalking) in particular. Individuals/families in the middle income category had the highest level of learning/discovery experiences.

The park experiences of visitors differed somewhat from Parks Victoria staff. Park visitors identified proportionately more social interaction and less solitude experiences than PV staff. PV staff identified fewer wildlife viewing and social experiences than visitors but more solitude experiences. The types of perceived impacts also differed by sampling groups. PV staff identified proportionately more than double the number of campsite impacts and significantly more track condition impacts while visitors identified proportionately more noise, rubbish, water, and wildlife impacts.

3.2. *Distribution of visitor experiences and environmental impacts in the study region*

A total of 5776 attributes were mapped in the study region, and specific comments were annotated for 372 markers. The frequency of attributes mapped appears in Table 3. Mapped park experiences account for 79.2% of total mapped attributes while perceived environmental impacts account for 12.9% of mapped attributes. Special places (6.7%) and facilities/services (1.5%) account for the remainder of mapped attributes. The number of mapped, positive park experience attributes (aesthetic, overnight, solitude, physical activity, trail activity, social interaction, learning, and wildlife viewing) represent about 75 percent of total attributes mapped while the number of negative attributes (crowding, track condition, campsite condition, rubbish, vegetation, noise, water quality, and wildlife) represent about 18 percent of total attributes mapped.

The relationship between mapped attributes (experiences and impacts) was explored using bivariate correlations between the number of mapped experiences and perceived environmental impacts. A number of significant relationships were found: aes-

Table 3
Frequency of mapped attributes in the study region. "E" indicates experience attribute and "I" indicates impact attribute. "F" indicates facilities or services need.

Map attribute	Frequency	Percent of mapped attributes
Aesthetic/scenic (E)	942	16.3
Overnight (E)	812	14.1
Solitude/escape (E)	558	9.7
Other physical activity (E)	546	9.5
Trail activity (E)	496	8.6
Special Places	385	6.7
Social interaction (E)	366	6.3
Learning/discovery (E)	312	5.4
Crowding/congestion (E)	269	4.7
Wildlife viewing (E)	265	4.6
Track condition (I)	166	2.9
Rubbish/litter (I)	119	2.1
Vegetation (dead/unhealthy) (I)	113	2.0
Campsite condition (I)	109	1.9
Noise (I)	109	1.9
Facilities/services (F)	87	1.5
Water quality (I)	80	1.4
Wildlife (dead or sick) (I)	42	.7
Total	5776	100.0

thetic and solitude experiences ($r = .64$), trail and overnight ($r = .51$), other (non-walking) physical activities and overnight ($r = .56$), crowding and noise ($r = .61$), solitude and overnight ($r = .62$), track and campsite conditions ($r = .65$), campsite and rubbish conditions ($r = .58$), rubbish and wildlife (.50), and noise and rubbish ($r = .64$).

3.3. Distribution of visitor experiences by park

A total of nine visitor experience variables were investigated. The point distributions can be presented in map, tabular, or chart format. The mapped, spatial distribution of park experiences in the greater Alpine Region appears in Fig. 4. Table 4 presents the distribution of these experiences by park unit and highlights the park unit where people associate most strongly with each experience. Park experiences in the Greater Alpine Region are unevenly distributed among the different national park units. About 63 percent of all mapped experiences were in Alpine National Park ($n = 2195$) followed by Mt. Buffalo National Park (15%, $n = 510$) and Howqua Hills Historic Area (7%, $n = 260$). The results show that aesthetics and overnight experiences are an important part of the visitor experience at all parks. Errinundra N.P. had the highest percentage of aesthetic/scenic experiences (33%). Howqua Hills H.A. had the highest percentage of crowding/congestion experiences (19%) but this may be a function of the time of surveying (Australia Day long weekend). Errinundra N.P. had the highest percentage of solitude/escape experiences (19%), Howqua Hills H.A. the highest percentage of social interaction experiences (13%), Grant H.A. the highest percentage of trail (track) experiences (17%), Mt. Buffalo N.P. the highest percentage of (non-hiking) physical activity experiences (18%), Mt. Wills H.A. the highest percentage of overnight experiences (26%), Grant H.A. the highest percentage of learning/discovery experiences (31%), and Avon Wilderness Park the highest percentage of wildlife viewing experiences (10%).

Interestingly, solitude/escape was not an experience confined to only remote or wilderness parks but was important to visitors at most parks. The three historic areas and Mt. Buffalo were the only sites where less than 15% of the mapped experiences related to the solitude/escape variable. Over 10% of variables mapped for the Howqua Hills and Mount Wills Historic Areas related to social interaction. Trail-related activity was an important part of the visitor experience at most parks with 6 of the 10 units recording more than 10% of the experiences mapped as trail related. Other physical activities were very important at Mt. Buffalo, Snowy River, Baw

Table 4
Percentage of mapped visitor experiences for national parks and historic areas in the Greater Alpine region. Bold/underline indicates the largest percentage for the experience category.

Park unit	Aesthetic/scenic	Crowding/congestion	Solitude/escape	Social interaction	Trail activity	Other physical activity	Over-night	Learning/discovery	Wildlife viewing
Alpine National Park	21.3	4.9	14.8	5.4	13.1	10.2	19.5	6.0	5.0
Avon Wilderness Park	16.7	0.0	16.7	3.3	13.3	6.7	23.3	10.0	**10.0**
Baw Baw National Park	17.4	3.0	15.2	7.6	13.6	15.9	18.9	4.5	3.8
Errinundra National Park	**33.3**	0.0	**19.0**	1.6	9.5	1.6	9.5	15.9	9.5
Grant H.A.	8.6	8.6	2.9	8.6	**17.1**	2.9	17.1	**31.4**	2.9
Howqua Hills H.A.	12.7	**18.8**	5.0	**12.7**	7.7	6.5	22.3	7.7	6.5
Mount Buffalo National Park	22.5	3.1	9.2	9.0	11.8	**17.8**	13.5	5.5	7.5
Mount Wills H.A.	13.2	2.6	7.9	10.5	7.9	10.5	**26.3**	18.4	2.6
Snowy River National Park	21.4	3.6	15.2	6.3	5.4	17.0	15.2	6.3	9.8
Walhalla H.A.	22.8	5.7	7.3	8.9	10.6	8.1	13.0	17.9	5.7

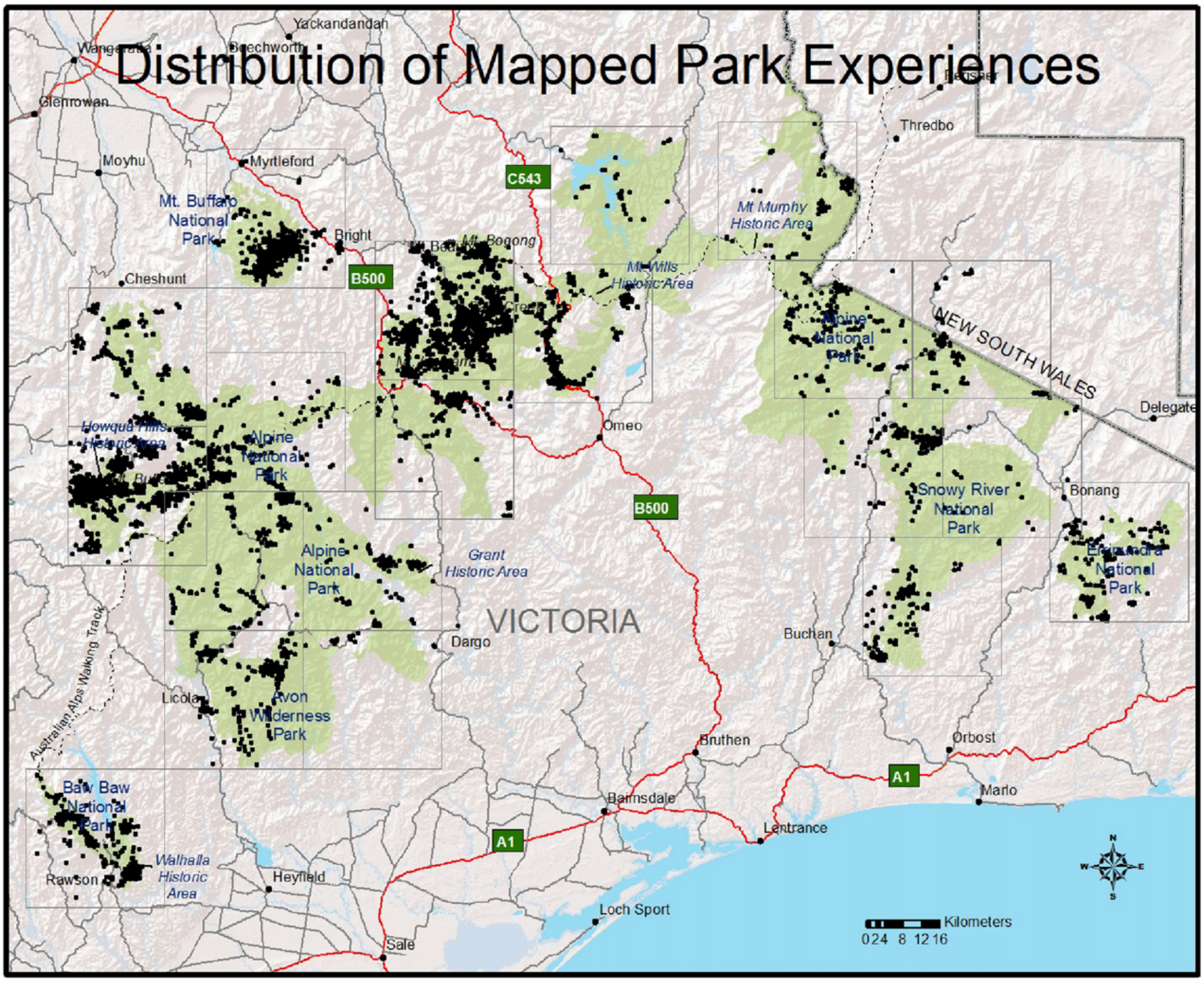

Fig. 4. Distribution of all experience points in Greater Alpine planning area.

Baw, and Alpine National Parks. Learning/discovery was an important experience at several parks, most notably at the Grant Historic Area. Wildlife viewing was not mapped as extensively as other variables.

3.4. Assessing similarity/differences in experiences by park unit

To better understand the overall similarity (dissimilarity) in park experiences, bivariate rank correlations were calculated for the park units (see Table 5). A rank correlation quantifies the relationship between the park experiences (using the ranks of frequencies) on a scale from −1 to +1. A high, positive correlation would indicate that individuals have similar experiences in the two parks while a value of 0 would indicate no relationship between experiences in the two parks. A negative rank correlation would indicate that park experiences tend to have opposite frequency ranks.

The strongest correlations in park experiences occurred between Baw Baw and Mt. Buffalo National Parks ($r = .92$), Avon Wilderness Park and Alpine N.P. ($r = .85$), and Mt. Buffalo and Alpine N.P. ($r = .83$). The weakest rank correlations in park experiences were between Mt. Buffalo and Grant H.A. ($r = .00$) and Mt. Buffalo and Howqua Hills H.A. ($r = .03$). The park experiences tend towards opposite ranks between Snowy River N.P. and Grant H.A. ($r = -.21$) and between Snowy River and Howqua Hills H.A. ($r = -.18$).

The distribution of experiences in park units can be presented in graphical format using radar charts that display multiple quantitative variables allowing visual comparison of park experience profiles (see Fig. 5). For example, the radar charts of Mt. Buffalo N.P. and Snowy River N.P. are similar in shape, but both differ significantly from Grant Historic Area.

3.5. Distribution of perceived environmental impacts

A total of seven perceived environmental impacts were examined in this study. It is important to note that these were perceptions of the respondents and not measured according to any standard or indicator. Observed environmental impacts in the Greater Alpine Region, similar to park experiences, are also unevenly distributed among the different national park units. About 67 percent of all mapped impacts were in Alpine N.P. ($n = 381$) followed by Howqua Hills H.A. (11%, $n = 64$) and Mt. Buffalo N.P. (7%, $n = 39$). Mt. Buffalo N.P. had the highest percentage of track impacts (51%), Grant H.A. the highest percentage of campsite impacts (37%), Avon Wilderness Park the highest percentage of rubbish/litter impacts (22%) and wildlife impacts (26%), Mt. Wills H.A. the highest percentage of vegetation impacts (60%), Walhalla H.A. the highest percentage of water quality impacts (40%), and Howqua Hills the highest percentage of noise impacts (36%).

Track condition appears to be the recognizable impact at most parks. This impact represented about 25% of the all impact markers. Campsite condition and rubbish were also mapped extensively at many parks. At least a third of impact markers at Grant, Errinundra and Snowy River are related to degraded campsite conditions. Dead

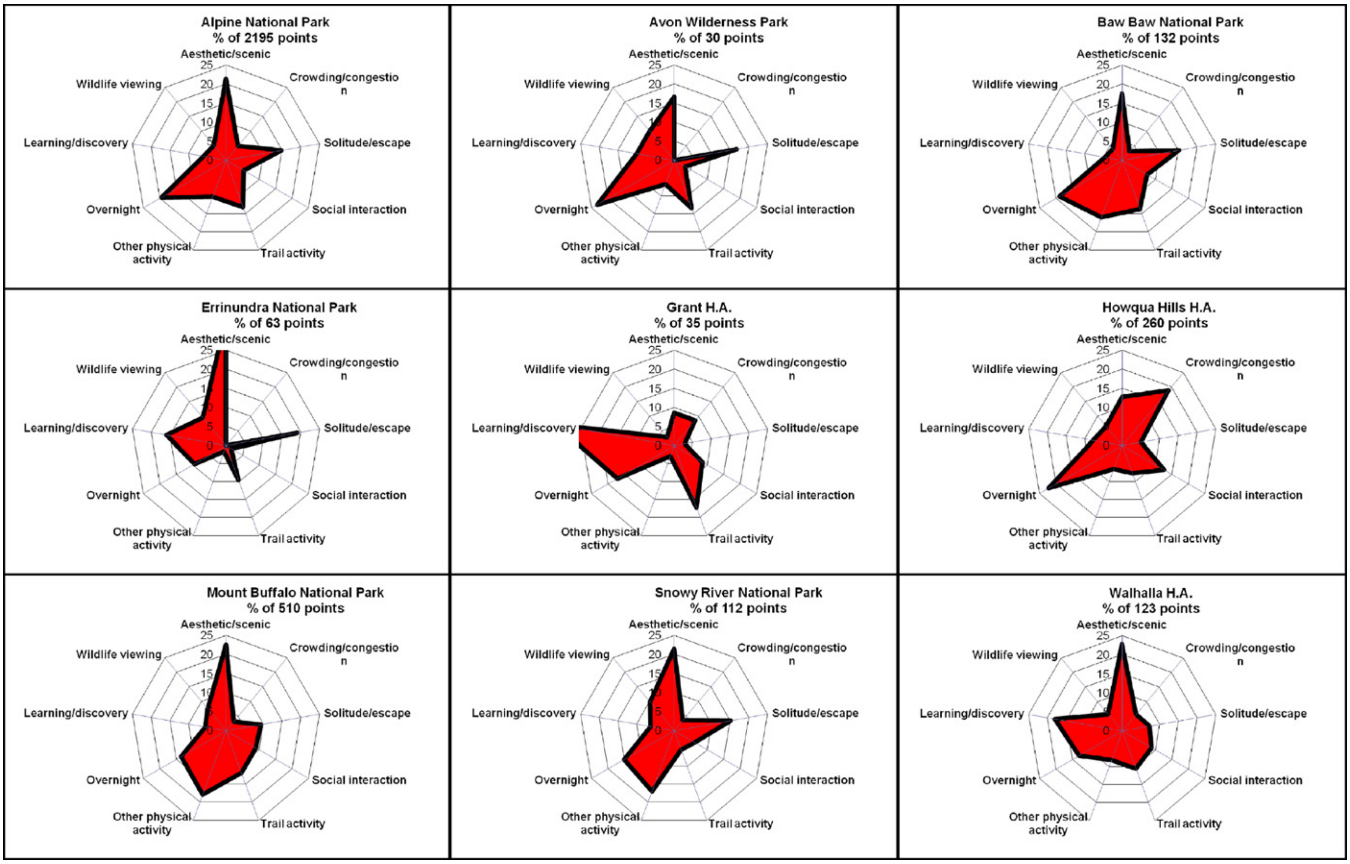

Fig. 5. Radar charts showing the distribution of park experiences by park in the Greater Alpine Region.

or sick wildlife was not mapped extensively at most parks, although this impact was noted in the Avon Wilderness Park. Degraded vegetation was observed in many locations, notably Mount Wills, Avon and Mt. Buffalo N.P. Noise impacts were most pronounced at the Howqua Hills Historic Area.

A combined impact "hotspot" map was generated for the region and appears in Fig. 6. Hotspot maps are raster images containing grid cells representing a density of points that are often color-coded to show increasing density of points as increasing color intensity. Hotspot maps were generated for the impact observations using a point density function (kernel method) with a grid cell size of 500 m and a 2000 m search radius. An impact hotspot map visually indicates priority areas for managerial attention and potential remediation.

3.6. Relationship between experiences and impacts and management zones

A total of 2707 experience and impact attributes were analyzed in 25 management zones that had at least 30 attributes per management zone in the Greater Alpine Region. As one would expect from the large sample size, there is a statistically significant association between management zones and visitor experiences ($\chi^2 = 177.0$, df = 40, $p \leq .001$) and perceived environmental impacts ($\chi^2 = 78.8$, df = 30, $p \leq .001$). The results are presented in Tables 6 and 7.

The presupposition that there should be more recreation experiences in the recreation zones is supported for both physical trail activity experiences in the *recreation development* zone and for physical activity experiences in the *conservation and recreation* zone. These relationships are major contributors (standardized residuals > 1.96) to the overall chi-square value. The presupposition that there should be more opportunities for solitude experiences in the *remote* and *wilderness* zones is also supported by the empirical findings. The opposite experience, crowding, appears highest in the *historic* and *recreation development* zones. Other significant experience/zone associations include *conservation* and *wilderness* zones having the highest proportion of aesthetic experiences and historic areas having the highest proportion of learning and social experiences.

The presupposition that there should be proportionately fewer environmental impacts observed in the *conservation* zones relative to the *recreation and conservation* zones is empirically supported (standardized residual > 1.96). There were insufficient markers mapped inside of *reference* areas to infer any conclusion about this management zone. Other significant experience/zone associations include: *conservation* and *remote* zones had the highest proportion of track impact conditions; *historic* areas had the highest proportion of noise; *conservation and recreation* zones had the highest proportion of rubblish/litter impacts; and *remote* zones had proportionately fewer campsite impacts.

3.7. Management zone indicators by experiences and impacts

Table 8 presents the empirical results of experiences and environmental impacts by type of management zone for 2 possible indicators: ratio of experiences to impacts, and the density of impacts. The ratio can be considered an overall standard for a zone. The ratio of experiences to impacts ranged from a low of 5.5:1 in *wilderness* zones to a high of 12.7:1 in the *recreation development* zone. The mean of impact densities per zone ranged from a low of .0468 per sq. kilometer in *wilderness* zones to 1.6 in *historic* zones. The standard deviation and range statistics for the ratios indicate a high degree of variability within a given type of zoning classification. With a normative standard of the ratio falling

Please cite this article in press as: Brown, G., & Weber, D. Public Participation GIS: A new method for national park planning. *Landscape Urban Plan.* (2011), doi:10.1016/j.landurbplan.2011.03.003

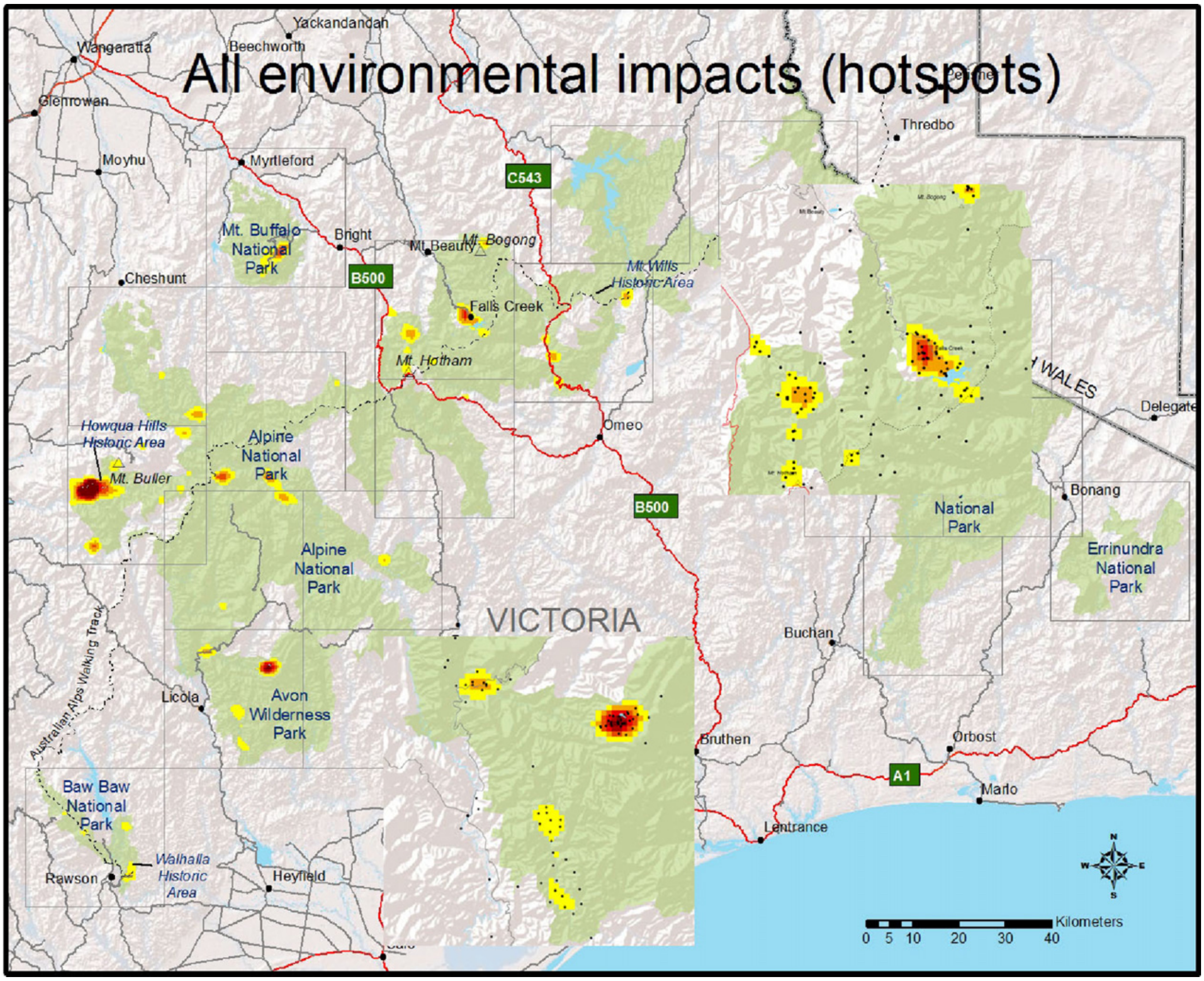

Fig. 6. Density "hotspot" map of all perceived environmental impacts in the Greater Alpine Region with insets showing enlarged areas to assist interpretation.

within one standard deviation of the mean ratio on the low end (i.e., higher impacts relative to experiences) only one management zone, a *wilderness* zone, would be flagged for potential management attention.

4. Discussion

This study was the first to evaluate the effectiveness of a public participation geographic information system (PPGIS) for identifying national park visitor experiences and perceived environmental impacts. As a pilot effort, the project had mixed results. The positive aspects of the research project included: (1) an acceptable response rate from park visitors contacted to participate (50%), (2) a PPGIS website that was robust and continuously available for mapping, (3) general respondent agreement that the PPGIS website was easy to use, and (4) results that provided basic descriptive information about the distribution of visitor experiences and perceived environmental impacts in the Greater Alpine region, which park planners felt would provide a useful platform for developing an integrated management plan for the region.

There are multiple areas where future implementation of a PPGIS project with similar goals could be improved.

Sampling. The response rates from Parks Victoria staff were disappointing. One of the project objectives was to compare the perceptions of impacts from professional and management staff with visitors. The research literature indicates that park managers often observe impacts that visitors do not. With the low participation rate of PV staff (about 25%), comparative results are only suggestive of potential differences between the sampling groups. PV staff identified proportionately more track and campsite impacts than visitors while visitors identified more noise, rubbish, wildlife, and water impacts. It is likely that higher usage by some visitor segments in more remote sections of parks would result in visitors noticing some impacts not identified by parks managers. Likewise, visitors engaging in specialized activities such as bird-watching might be more likely to notice impacts associated with their interest. One potential application of this data could be the development of an ongoing, public park monitoring program that focuses on impacts such as noise, rubbish, wildlife and water. Such a program would need clear and objective indicators that could easily be measured by visitors and compared to standards established by managers.

The visitor sampling effort was concentrated during two periods – Australia Day long weekend and Easter School Holidays – and while attempts were made to spatially stratify the data collection, weather conditions and fire events contributed to greater populations using parks in the January period compared to April. As a result, the sample is geographically focused on the western reach of the Alpine region. Ideally, the sampling effort would be more spatially and temporally stratified and would include more residents that live in the region, not just those that visit the parks (in this study 15.6% of the sample resided in the region). In addition it is likely that weekday visitors had different experiences than weekend visitors who comprise the majority of this sample, and hence a

Table 5
Rank correlation coefficients of park experiences between park units. Bold/underlined values are statistically significant.

Park Unit	Alpine National Park	Avon Wilderness	Baw Baw N.P.	Errinundra N.P.	Grant H.A.	Howqua Hills H.A.	Mount Buffalo N.P.	Mount Wills H.A.	Snowy River N.P.	Walhalla H.A.
Alpine National Park	–	**0.850**	**0.917**	**0.717**	0.225	0.058	**0.833**	0.625	**0.700**	0.675
Avon Wilderness Park	**0.850**	–	0.683	**0.867**	0.208	−0.075	0.533	0.458	0.567	0.508
Baw Baw National Park	**0.917**	0.683	–	0.467	0.125	0.125	**0.917**	0.692	**0.783**	0.575
Errinundra National Park	**0.717**	**0.867**	0.467	–	0.258	−0.175	0.417	0.425	0.550	0.592
Grant H.A.	0.225	0.208	0.125	0.258	–	**0.700**	−0.008	0.617	−0.208	**0.717**
Howqua Hills H.A.	0.058	−0.075	0.125	−0.175	**0.700**	–	0.025	0.450	−0.175	0.467
Mount Buffalo National Park	**0.833**	0.533	**0.917**	0.417	−0.008	0.025	–	0.508	**0.767**	0.508
Mount Wills H.A.	0.625	0.458	0.692	0.425	0.617	0.450	0.508	–	0.542	**0.850**
Snowy River National Park	**0.700**	0.567	**0.783**	0.550	−0.208	−0.175	**0.767**	0.542	–	0.375
Walhalla H.A.	0.675	0.508	0.575	0.592	**0.717**	0.467	0.508	**0.850**	0.375	–

Table 6
Visitor experiences by management zone classification. Cells with bold fonts indicate significantly larger and cells with parentheses significantly smaller than expected contributions to overall chi-square (standardized residuals > 1.96).

Management zone			Conservation ($n = 5$)	Conservation and recreation ($n = 8$)	Historic ($n = 3$)	Recreation development ($n = 1$)	Remote ($n = 5$)	Wilderness ($n = 3$)	Total
Experience category	Scenic/aesthetic	Count	**134**	137	(36)	20	78	41	451
		%	**24.68%**	16.69%	(12.37%)	21.51%	20.69%	25.47%	19.47%
	Crowding/congestion		(11)	**64**	**36**	4	(7)	14	136
			(2.03%)	**7.80%**	**12.37%**	4.30%	(1.86%)	8.70%	5.87%
	Learning/discovery		34	52	**37**	7	19	10	162
			6.26%	6.33%	**12.71%**	7.53%	5.04%	6.21%	6.99%
	Overnight stay		96	163	66	18	81	30	461
			17.68%	19.85%	22.68%	19.35%	21.49%	18.63%	19.91%
	Physical activity		52	**101**	19	13	34	(7)	228
			9.58%	**12.30%**	6.53%	13.98%	9.02%	(4.35%)	9.84%
	Social interaction		35	49	**36**	7	15	5	148
			6.45%	5.97%	**12.37%**	7.53%	3.98%	3.11%	6.39%
	Solitude		78	116	(16)	(5)	**66**	**32**	318
			14.36%	14.13%	(5.50%)	(5.38%)	**17.51%**	**19.88%**	13.73%
	Trail activity		81	91	25	16	58	14	289
			14.92%	11.08%	8.59%	17.20%	15.38%	8.70%	12.48%
	Wildlife Viewing		22	48	20	3	19	8	123
			4.05%	5.85%	6.87%	3.23%	5.04%	4.97%	5.31%
	Total		543	821	291	93	377	161	2316
			100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Table 7
Perceived environmental impacts by management zone classification. Cells with bold fonts indicate significantly larger and cells with parentheses significantly smaller than expected contributions to overall chi-square (standardized residuals > 1.96).

Management zone			Conservation (n = 5)	Conservation and recreation (n = 8)	Historic (n = 3)	Recreation development (n = 1)	Remote (n = 5)	Wilderness (n = 3)	Total
Impact category	Campsite conditions	Count	9	40	12	3	(2)	5	71
		%	15.52%	22.47%	18.18%	37.50%	(3.92%)	16.67%	17.15%
	Noise		7	20	**21**	1	8	6	63
			12.07%	11.24%	**31.82%**	12.50%	15.69%	20.00%	15.22%
	Rubbish/litter		6	**40**	10	1	(1)	3	66
			10.34%	**22.47%**	15.15%	12.50%	(1.96%)	10.00%	15.94%
	Track (trail) conditions		**23**	31	(6)	0	**24**	9	93
			39.66%	17.42%	(9.09%)	0.00%	**47.06%**	30.00%	22.46%
	Vegetation		9	26	5	1	9	3	60
			15.52%	14.61%	7.58%	12.50%	17.65%	10.00%	14.49%
	Water quality		2	18	8	1	3	3	40
			3.45%	10.11%	12.12%	12.50%	5.88%	10.00%	9.66%
	Wildlife (sick/dead)		2	(3)	4	1	4	1	21
			3.45%	(1.69%)	6.06%	12.50%	7.84%	3.33%	5.07%
	Total		58	178	66	8	51	30	414
			100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

larger sample comprising more weekday users may yield different results.

The sampling for this particular study provides a snapshot of park experiences in peak periods. However, that also means results should be viewed in that context. For example, while Howqua Hills Historic Area may appear to have a noise and crowding problem on Australia Day weekend, one should not conclude the problem exists throughout the rest of the year.

Sampling was the major expense associated with this study. This study used professional interviewers based in Melbourne and the large geographic area meant this approach was not cost effective. It is suggested that future PPGIS studies consider the use of trained park staff or local residents to make the visitor contacts. The growth in professional online research panels is also worth consideration. Such groups can provide access to a comprehensive cross section of demographic, psychographic, and socioeconomic groups and can screen members for particular characteristics (e.g., recreation experience in the Victorian Alpine parks). The costs of engaging such panels may prove less expensive when considering travel and interviewer expenses.

Research questions. The list of spatial attributes and survey questions appear reasonable and respondents were able to map all attributes. However, in the future, the spatial attributes would benefit from refinement. For example, the vegetation impact could have been divided into two categories, one for dead or trampled vegetation and one for invasive species (i.e., weeds). Review of the additional comments provided by respondents suggests invasive weeds was an issue some respondents were very concerned about but the impact was defined as "I observed dead or unhealthy vegetation" meaning observation of pest plants were unlikely to be mapped. Also, the web interface should more strongly encourage annotation of mapped attributes, especially for variables such as facility or service changes. This was an example of a variable where not having specific information as to whether the marker indicated the facility or service needed to be better maintained, changed or added, limited the usefulness of such information; only half of the facilities/services markers were annotated by respondents. Comments from a number of study participants indicated they would have liked more map markers (the application provided 6 markers per attribute). In the future, an option can be included to increase the number of available markers. Similarly, other methodologies that allow "on the spot" mapping and assessment could be employed, for example using GPS-equipped data loggers or remote device/smartphones (e.g., iPhone) applications. While this would appear unnecessary for mapping experiences that seem to have greater retention with visitors, it would add an improved dimension to mapping impacts. Not only would it be more accurate, but it would provide a prompt for people to be actively looking for impacts, rather than trying to remember them after the fact.

This study can inform similar future park studies and this process should begin with a discussion of the application potential with both planners and managers. The mapping of some PPGIS attributes is likely to be more useful than others. For example, wildlife viewing appears to be a ubiquitous visitor activity but other than its marketing potential, the value of such information, given the results, may be of limited use. Another issue that should be discussed in terms of methodology is the ground-truthing of results. Our intention was to compare visitor data with PV staff data but it was not possible due to the low PV sample. An additional complication was people mapping attributes from previous experiences. Although surveyors requested respondents to map experiences from that trip, it was obvious from the response patterns that some people mapped areas from previous trips. This raises the question about the accuracy of some data, as an impact that existed two years ago, may not currently exist.

Table 8
Descriptive statistics for 2 potential management zone indicators.

Management zone	Ratio of experiences to impacts					Density of impacts (sq. km)				
	Mean	Std. dev.	Min.	Max.	Median	Mean	Std. dev.	Min.	Max.	Median
Conservation and recreation ($n = 8$)	7.2	6.6	1.4	18.8	4.8	.07	.05	.01	.12	.06
Conservation ($n = 5$)	10.9	4.9	5.5	17.0	9.1	.14	.02	.11	.17	.14
Historic ($n = 3$)	6.1	2.1	4.3	8.4	5.6	1.04	1.66	.06	2.96	.11
Recreation development ($n = 1$)	12.7	N/A	12.7	12.7	12.7	.44	N/A	.44	.44	.44
Remote ($n = 5$)	8.3	8.0	2.3	21.4	4.8	.06	.03	.03	.11	.06
Wilderness ($n = 4$)	5.6	3.8	1.3	10.3	5.3	.05	.02	.02	.06	.05
Total	8.0	5.7	1.3	21.4	6.1	.20	.57	.01	2.96	.07

In this study, respondents were interested in expressing preferences for resource management options in the region: cattle grazing, fire management, and logging. Although this particular study was focused on park experiences, impacts, and facilities, it is possible to include resource management markers where participants could indicate preferences for resource management outcomes in the region. Anchoring the survey with some questions that respondents really want to provide feedback is a proven strategy to increase response rate.

Survey questions that followed the mapping activity provided basic demographic information to determine the representativeness of the sample but lacked questions that would be useful for providing context for understanding the experience and impact variables. In particular, survey questions should be included that provide greater opportunity for visitor segmentation including motivations for visiting and measures of satisfaction or benefits associated with the visit. For example, many park visitors identified overnight and trail activity experiences—were these positive or negative experiences?

Analysis. This article provided descriptive information about the spatial location of different park experiences and perceived impacts and examined the relationship with existing management zones for the region. Additional analysis could relate the mapped attributes to levels of protection (LOP) and levels of service (LOS) to provide additional insight about the choice of particular park management strategies. Where Recreation Opportunity Spectrum (ROS) maps exist, analysis can determine whether the mapped experiences are consistent with the ROS classifications.

We explored the development of several experience and impact metrics for establishing indicators and standards for different management zones. The results indicate a wide range of mapped attributes within management zone types and are suggestive of potential differences between management zones, but more PPGIS data is needed to provide greater confidence that the results are representative. A potential weakness with these indicators is that they are not necessarily correlated with the level of visitation within the management zones. We suggest that scores for the experience/impact ratio be adjusted by actual visitation data for a given management zone if that data were available.

An important research question is whether the potential management indicators derived from PPGIS data meet the nine criteria for good indicators as suggested by Manning (2007). Are the indicators significant, specific, objective, reliable and repeatable, related to visitor use, sensitive to visitor use in a relatively short period of time, manageable, efficient and effective to measure, and integrative? We believe that they are. For example, the criteria of significance relates to user concerns. In the Howqua Hills area, the most significant impact appears to be noise so the indicator for that zone would focus on noise. This indicator could be improved by making it more specific and time bounded (Lime, Anderson, & Thompson, 2004; Manning, 2007) for example, by focusing on noise above conversation level after 9 p.m. Is the indicator objective? Noise is a subjective experience and subject to individual variability, but when the experience is observed among multiple visitors, the criteria of objectiveness may be approached through a sort of collective validity. The PPGIS indicators are reliable and repeatable, manageable, related to visitor use, efficient to measure, and sensitive to visitor use in relative short period of time. We would recommend monitoring (data collection) in peak and non-peak periods each year. On the final criteria, integrative, we would argue that composite indicators derived from PPGIS attributes have the potential to be highly holistic and integrative because the PPGIS attributes collected are related to the physical setting, the social environment, and the managerial setting.

5. Conclusions

In a time of increasing demands on national parks, park planning would benefit from a set of information tools that provide information about what visitors experience, what environmental impacts they observe, the facility/service needs they perceive, and importantly, where these attributes are spatially located. The traditional, often ad hoc processes for soliciting public participation in national park planning processes can leave park managers, interests groups, and the general public wanting better information to assist park management decisions.

The PPGIS mapping method described in this paper provides a systemic tool for collecting and analyzing spatial data that can display the consistency of visitor experiences and perceived impacts with park management zones at the regional, national park unit, or subunit level. The technical merits 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 internationally. A less obvious, but equally important benefit is the importance of the PPGIS protocol for engaging the public in park planning and decision processes. Because the PPGIS protocol is based on both sound science and social inclusiveness, it has the potential to build trust in national park management agencies.

Acknowledgements

This research was funded by Parks Victoria. The authors would like to acknowledge the valuable support and advice of Dino Zanon and Louise Rose.

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Please cite this article in press as: Brown, G., & Weber, D. Public Participation GIS: A new method for national park planning. *Landscape Urban Plan.* (2011), doi:10.1016/j.landurbplan.2011.03.003