

Chapter 21

Developing Computer-Based Participatory Approaches to Mapping Landscape Values for Landscape and Resource Management

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21.1 Introduction

The last 50 years or so have seen a steady increase in the rate of destructive wildfires across the world, partly as a result of climate change and partly as a result of encroachment of human settlement on fire-based ecosystems (Russell *et al.* 2004; Westerling *et al.* 2006). Years of active fire suppression in such areas has inevitably led to the build-up of hazardous fuel loads, creating ideal conditions for destructive wildfires (Johnson *et al.* 2001). Recently, serious wildfires have occurred in Australia, southeast Asia and the Mediterranean, as well as those occurring in the USA in California, Montana, Idaho and Alaska. Current thinking on fire management is very much focused on re-instating natural fire regimes and allowing fire, as nearly as possible, to function in its natural ecological role (Miller 2006), thereby reducing the occurrence of destructive fires. Mechanical fuel treatments (e.g. thinning) and prescribed burning are being used to reduce fuel loads to near natural conditions, after which natural fire regimes can be allowed to operate. There are two main types of thinning that either remove selected trees to create a more widely spaced forest consisting of trees of different sizes/ages or remove all smaller trees and brush within the understory to leave a more uniform forest of more widely spaced older trees. Prescribed burning uses small managed fires, rather than mechanical means, to achieve the latter. This is a long and involved process and often has the potential to create conflict between the different management regimes associated with adjacent lands and between the different inhabitants and stakeholders affected in the short to medium term. This requires a high degree of collaboration and participatory planning if acceptable fuel reduction strategies and management plans are to be developed.

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Throughout the western USA and in Alaska, rural communities and federal, state and local agencies are working cooperatively to initiate plans for reducing risks associated with the build-up of hazardous fuel on forest and grass lands. Most of the emphasis of this collaborative planning is on reducing these risks in the wildland/urban interface, where public lands and private, developed lands meet (Gunderson 2006). Another interface that is critically important in accomplishing fuel treatment and fire management objectives is the interface between wilderness and non-wilderness lands. In designated wilderness, the use of wildland fire, including prescribed burns, can help restore the natural role of fire as well as create a buffer along the wilderness boundary to protect non-wilderness values associated with adjacent lands.

This chapter describes a participatory process and methodology that has been developed to help capture personal and community meanings (or values at risk) associated with different landscapes and uses that are otherwise difficult to document. The case study is described in detail together with initial results from a participatory planning process. This is a project conducted collaboratively between the Confederated Salish and Kootenai Tribes (CSKT), the Aldo Leopold Wilderness Research Institute (ALWRI), the University of Montana (UM) and the University of Leeds (UoL). It represents Phase 2 of a three part study to incorporate personal and community meanings associated with a buffer zone for the planning and potential application of fuel treatment and fire management.

The aims of the project are to:

- contrast the meanings that tribal and non-tribal residents place on the protected landscapes of the Tribal Wilderness and the Tribal Buffer Zone within the Flathead Indian Reservation with the ultimate goal of using this local knowledge to better inform forest fuel reduction strategies implemented by the Tribal Forestry Department; and
- map these meanings for the Tribal Buffer Zone to understand the intensity and spatial distribution of individuals and communities associated with this controversial landscape and to describe how the potential application of fuel treatments in this wilderness/non-wilderness interface may affect them.

The objectives of this chapter are to review the development and use of GIS-based participatory mapping tools within this case study and use the results to better understand these values and meanings associated with Tribal lands within the Mission Mountains Tribal Buffer Zone. From the Phase 1 qualitative research, five layers of meanings were mapped: wildlife and water values; access and functional benefits; wilderness protection; personal and cultural values; and recreational and scenic values. This chapter discusses the efficacy and utility of such an approach in obtaining a range of views from diverse cultural backgrounds and in capturing local knowledge with a view to evaluating its wider applicability to similar problems in other locations.

21.2 Background

On the Flathead Indian Reservation in Montana, an interface area exists between the Mission Mountains Tribal Wilderness and the non-wilderness valley floor. The area, formally protected as a ‘buffer zone’ (referred to as the Mission Mountains Tribal Buffer Zone), was established in 1987 in the foothills of the Mission Mountains with the intention of protecting the wilderness from outside influences; primarily human civilization and development on the valley floor. The interface area provides opportunities for multiple uses corresponding to both wilderness and non-wilderness, including cultural uses, home sites, recreation, and other consumptive and non-consumptive resource uses. Figure 21.1 shows a map of the Mission Mountains Tribal Wilderness and the Buffer Zone. Figure 21.2 provides a glimpse of this Rocky Mountain landscape.

One of the primary concerns within the study area is the effect that fire suppression has had on the structure and general health of the forest within significant portions of the buffer zone. The widespread policy of fire suppression throughout much of the twentieth century in the U.S., as popularized by the U.S. Forest Service mascot ‘Smokey Bear’, has led to a forest ecosystem in both the Tribal Wilderness and the Tribal Buffer Zone that exhibit heavy and hazardous accumulations

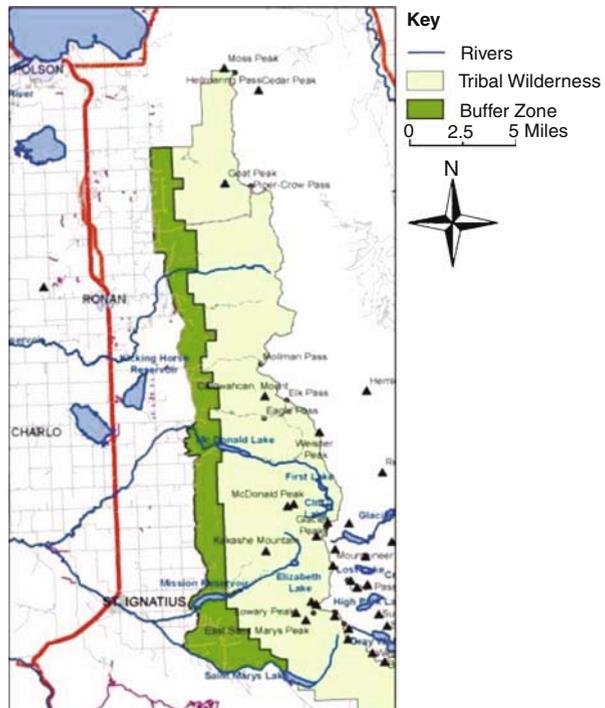


Fig. 21.1 Map of the Mission Mountains Tribal Wilderness and the Buffer Zone

Fig. 21.2 View of the Mission Mountains



of dead wood and down timber on the forest floor, a dense understory of brush and young trees, and closely spaced trees and closed forest canopy (Fig. 21.3a) (CSKT 2005c).

Such forests are increasingly regarded as ‘unhealthy’ and highly susceptible to destructive wildfires, as well as diseases such as mountain pine beetle *Dendroctonus ponderosa*. In contrast, the traditional culture of local tribes included the use of fire as a tool to nurture and sustain the natural resources of the land. Tribal people used fire on a vast scale, applying it to the land at different times of the year for various reasons. This included the thinning of dense brush in forested areas to keep them ‘clean’ for wildlife and hunting, clearing of trails for travel-



Fig. 21.3 (a) ‘Unhealthy forest’ and (b) ‘clean forest’ maintained by mechanical thinning

ling, and nurturing of food and medicinal plants for subsistence use (Fig. 21.3b). In the nineteenth century, native use of fire began to be altered as European settlement expanded into the West, and by the early twentieth century, following some devastating fires in 1910, the traditional use of fire by tribal people was largely eliminated. This greatly impacted tribal knowledge of traditional use of fire with the result that tribal resource managers now employ modern fire management, though under the guidance and direction of the cultural values ascribed



Fig. 21.4 Smokey Bear with tribal elder (U.S. Forest Service)

to the land that have been passed down through the generations (CSKT 2005a) (Fig 21.4).

The current focus of resource managers is on how to reduce potentially hazardous fuel loads in the Tribal Buffer Zone in order to address “*emerging issues of public and firefighter safety, reduce the risk of large high intensity fires, and restore the forests to a more biologically balanced condition*” (CSKT 2005b, p. 1). However, past proposals to reduce hazardous fuel loads in the Buffer Zone have failed due to lack of support among tribal members, especially for commercial thinning operations. The current process, therefore, uses participatory methods adapted from a previous project in the adjacent Bitterroot National Forest (Gunderson *et al.* 2004) and expanded to use web-based mapping methods developed in the UK (Carver *et al.* 2001; Evans and Waters 2007) to better capture how tribal and non-tribal Reservation residents view the Tribal Buffer Zone and how they might respond to new fuel treatment proposals in this area.

21.3 Participatory Approaches to Mapping Landscape Values

One of the key problems in developing a better understanding of different responses to resource management proposals, such as the fuel treatments dealt with here, is being able to faithfully record and accurately spatially delineate the meanings that stakeholders ascribe to the landscape in question. This needs to be done in a consistent and repeatable manner if cross-comparisons are to be made between different stakeholder groups and/or different areas.

Previous work on mapping landscape values and meanings relative to landscape-level fuels treatment has been carried out in cooperation with the Bitterroot National Forest. The Bitterroot Ecosystem Management Research Project (BEMRP) conducted a baseline assessment of individual and community meanings attached to the Bitterroot landscape using a rapid appraisal methodology (Gunderson 2006; Gunderson and Watson 2007). Semi-structured interviews, key informant interviews and focus group interviews were conducted to encourage people to talk about their local landscape, to differentiate between the meanings associated with places they commonly went to and those they have seldom or never visited, and to discuss how these meanings interact with alternative fuel treatments. Critically, as part of these interviews, respondents were asked to spatially define these areas and the meanings attached to them by drawing on paper base maps. These were then digitised and imported into GIS for analysis and integration in decision making along with existing ecological modelling efforts used to evaluate alternative fuel treatments on the Bitterroot landscape. Example output maps from the Bitterroot project are shown in Fig 21.5. This has allowed managers to better understand the juxtaposition of both social and ecological/resource data in the development of better and more acceptable fuel treatments.

Being able to actually map and compare the different meanings people place on the landscape in this fashion has a number of advantages over more basic place-based techniques of rapid appraisal. These include the ability to link meanings to specific locations or landscape units, and perform advanced analyses on responses by looking

at spatial relationships based on proximity, adjacency, containment, connectivity and visibility. An area index describing the overall importance of a particular landscape unit is defined by the BEMRP methodology as a summative combination of scores based on specificity of area (broad, medium or specific), site replication (the number of times different respondents select the same site), frequency of visit, and level of importance as specified by the respondents themselves (Fig. 21.6). This has been used to identify areas with high levels of significant meanings attached by local community members.

Despite the success of the BEMRP work, a number of shortcomings were identified in the mapped-based aspects of the methodology adopted. These include the varying degrees of detail used by respondents when delineating areas on the paper map and the labour intensive nature of the digitising process (Carver *et al.* 2005). While the latter is just a matter of access to sufficient time and resources (i.e. labour), the former issue is more fundamental in nature and concerns how people actually conceptualise their environment. An individual's relationship with their local landscape is essentially fuzzy and cannot be easily captured using traditional map-based features or entities such as points, lines and polygons. Rather, people usually talk about places they know, use or have visited either by name (i.e. place-based nomenclature) in more vague terms such as 'the head of valley beyond the lake' or 'the woods out the back of my acreage' (Waters and Evans 2007). Where these places begin and end is hard to define in definitive terms and therefore is not easily captured and incorporated within the strictures of Cartesian-based GIS data models. Inevitably, when given a map and a pencil and asked to define areas which have value or meaning, respondents will adopt a variety of approaches ranging in scale and detail from broad sweeping circles that indicate an approximate area to small, crisply outlined regions that attempt to follow the landscape as closely as possible.

In order to address these issues, the current project adopts more fuzzy methods of capturing the landscape areas that people value or for which they hold a particular meaning. This is based around the application of a Java-based mapping Applet called 'Tagger' that uses a spray can tool, similar to that found in most desktop image processing/manipulation packages, to allow users to define areas over a base map in a manner that allows them to easily vary the density, extent and shape of the sprayed area (Evans and Waters 2007). This is used to capture information about fuzzy spatial concepts such as vagueness and approximation in defining spatial pattern and extent, as well as (un)certainly and importance in the relative values and meanings attached to these. The system can be used both online over the internet and offline on a stand-alone laptop facilitated by a member of the research team. Individual spray patterns are logged by the system together with their associated text describing relative values and meanings and converted to raster GIS maps for subsequent combination and analysis.

21.4 Methodology

An expanded rapid appraisal technique (Beebe 1995) is used to direct three phases of data collection. Each phase is guided by a specific objective as follows: In Phase 1 key knowledgeable informant interviews were used to develop an understanding of

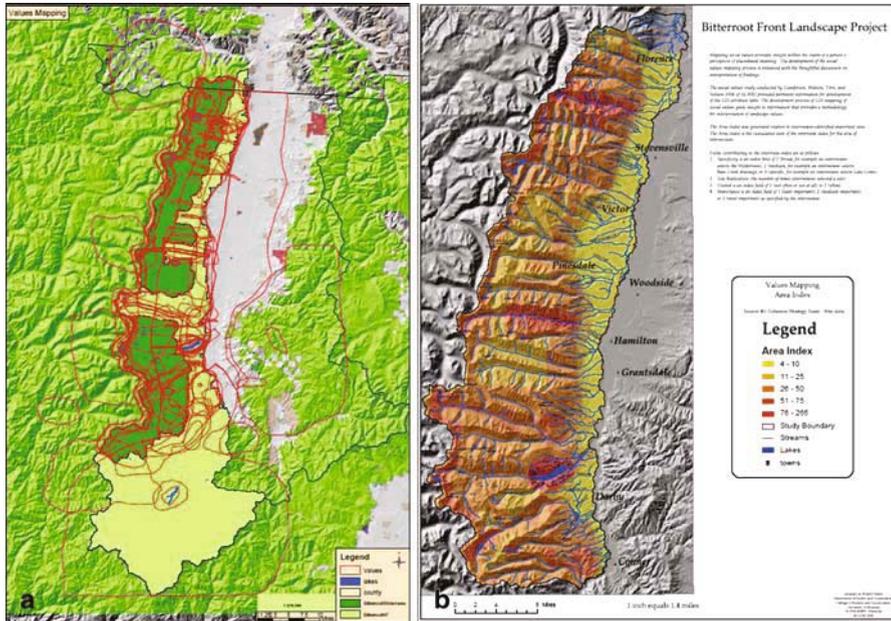


Fig. 21.5 Example of (a) a digitised polygon net and (b) a composite map from the BEMRP work (See also Plate 56 in the Colour Plate Section)

the range and types of values attached to the Mission Mountains landscape (focussing both on the Tribal Wilderness and the Tribal Buffer Zone for contrast) by tribal members and non-tribal residents on the Flathead Indian Reservation (Watson *et al.* in press). In Phase 2, participatory GIS methods were used to visually illustrate the range, intensity and spatial distribution of the meanings differentiated in Phase 1 within only the Buffer Zone. In Phase 3, focus group interviews will be used to

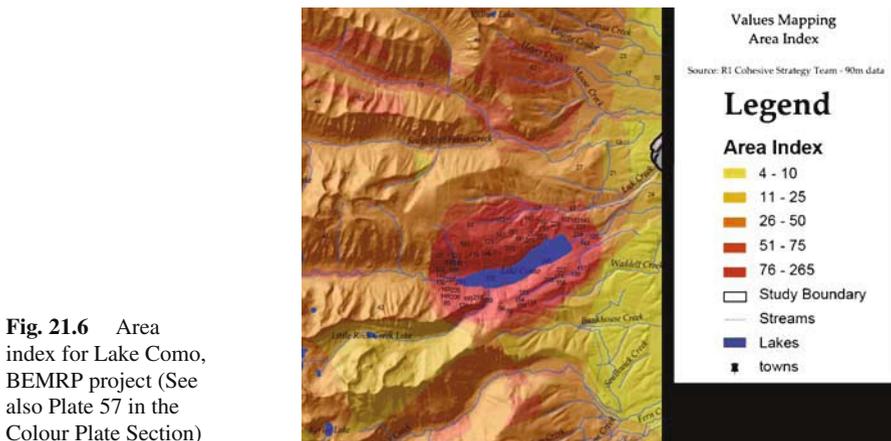


Fig. 21.6 Area index for Lake Como, BEMRP project (See also Plate 57 in the Colour Plate Section)

better understand the interaction between mapped landscape meanings from Phase 2 and potential fuel treatment options at the wilderness/non-wilderness interface.

21.4.1 Phase 1: Key Informant Interviews

Semi-structured interviews were conducted with tribal members and non-tribal Reservation residents to solicit information on the range and types of meanings associated with this landscape with varying levels of protection (Wilderness and Buffer Zone). Following the work of Lewis and Sheppard (2005), key informants were selected to meet the following criteria:

- knowledge, understanding and appreciation of traditional tribal and non-tribal meanings associated with the landscape;
- roles in the community that require a wide exposure to a range of tribal and non-tribal perspectives and perceptions of the landscape; and
- ability to communicate with outsiders and ability to discuss relevant research issues in detail.

Twenty-two interviewees were asked to provide information about the range and type of meanings attached to the landscape in interviews scheduled and conducted at the convenience of the interviewee. These analyses and results are described in detail by Watson *et al.* (2007; in press).

21.4.2 Phase 2: Landscape Mapping

In this phase, the objective is to understand where local meanings associated with the landscape are actually located or the regions/places they are attached to, together with the intensity of attachments. This phase is guided by the findings from the Phase 1 interviews, with the emphasis on capturing the spatial patterns in the meanings using fuzzy rather than traditional discrete mapping methods. The actual methods used here to capture spatially fuzzy regions and their ascribed attributes draw strongly on previous work on mapping place meanings (Gunderson and Watson 2007) and on participatory GIS (Carver *et al.* 2001; Waters and Evans 2007). These methods are brought together in developing a fuzzy GIS-based tool for collecting qualitative, but spatially referenced, local knowledge and meanings from a range of key informants and local people representing both tribal and non-tribal residents and stakeholder groups. These are analysed by creating composite maps of the fuzzy attribute-tagged maps generated by survey respondents and linking these to more in-depth interview transcripts from the Phase 1 key informant interviews. The result of this phase of the project is a GIS dataset (and hard copy maps) that provides a visual representation of the range, types, intensity and spatial distribution of the meanings associated with the Buffer Zone. Where possible, the same interviewees from Phase 1 of the project are used, with additional input from

other residents within the region via an online version of the system. Whereas it is believed possible to reach saturation in regard to the range and types of landscape meanings through 15–20 key informant interviews, research by Gunderson (2006) would suggest that greater numbers of Phase 2 respondents are required to capture the richness and variation in the spatial distribution of these meanings across the whole of the study area. Initially, 34 respondents were solicited to test the system for possible errors and software problems, with some of them using the online method and some completing the exercise offline on a stand-alone laptop computer. In both cases, everything appeared exactly the same to the subject, rather it was just the method of recording and storing their results that differed. All offline exercises were assisted by one of the research team, sometimes to make it easier for high priority participants to engage and sometimes due to deficiency in computer skills or internet access.

Data were collected in a way that generated five map layers of themed meanings. These were driven by the Phase 1 findings, and collected to represent the meanings of the Buffer Zone for themed topics covering ‘wilderness protection’, ‘wildlife and water values’, ‘recreation’, ‘access’, and ‘personal and cultural meanings’. For demonstrative purposes, this paper focuses on 154 images developed by these 34 respondents across the five themed layers. For the overall map and categorization process, these 154 images are averaged and images produced using classes based on natural groupings inherent in the data with break points identified by picking the class breaks that group similar responses and maximize the differences between classes using the ArcGIS software (Jenks 1967). For further insight, the five individual meaning layer images are also presented, based on the same classification scheme used to develop the ‘overall mean’ image. Whilst conflicts between respondents are handled at this stage by simple averaging, future research will look at areas where conflicting opinions exist with particular reference to any potential tribal and non-tribal differences.

21.4.3 Phase 3: Focus Group Interviews

The objectives of the third phase of the project are to present the GIS representations outlined above and collaboratively evaluate these with tribal members and non-tribal residents in regard to the potential effects of different fuel treatment methods in the Tribal Buffer Zone. At the time of writing, this work is still ongoing. At least two focus group interviews will be conducted facilitated by the research team members and the Tribal liaison. The information gathered from these focus groups will be used to understand how the meanings associated with the landscape will likely interact with potential application of fuel treatments in the Buffer Zone. Phase 3 also serves the very positive purpose of informing the public that their views are valued and are being incorporated into the planning process thereby helping to break down one of the main barriers in accomplishing resource management objectives.

21.4.4 Development of the Landscape Mapping Tool and User Interface

The main user interface is based around the ‘Tagger’ fuzzy area definition software developed by Evans and Waters (2007) as a Java applet running within a standard web browser environment. This uses a spray can tool that will be familiar to many users from popular desktop image editing packages, and with which a user can define fuzzy areas of varying density on a map. Variations in intensity or importance can be easily made by spraying more or less over an area, making it correspondingly darker or lighter. Attribute information can be attached to the fuzzy area through the use of free-format text input boxes. The basic interface is shown in Fig. 21.7 and consists broadly of:

- a spray can tool that enables the user to spray fuzzy areas on a map;
- Radio buttons to select small or large spray sizes;
- an Erase button to remove any spraying from the current map;
- a New Area button to save the current sprayings and allow the user to spray another area;
- a Paint All button that opens up a dialog window asking for a number from 0-100 per cent to uniformly spray over the whole area;
- a Send Everything button that sends all the saved sprayings and attached attributes to the server; and
- text areas where the user is asked to type about ‘Why the areas are important’, and ‘What are the threats to these areas?’

Users progress through the application in a linear fashion as follows:

1. Welcome and outlining of the tasks and any technical requirements needed.
2. Background information about the project, fire and fuel treatments and the area of the Buffer Zone.
3. Introduction to the mapping system, showing the graphical user interface, explaining concepts such as ‘The longer you hold down the mouse button the darker it gets. The darker it gets means it has more importance’ showing examples, and how users can use the mapping tool to indicate intensity (Fig. 21.8).
4. Practice page, which helps people become familiar with the spray can mapping tool using a map of the USA and asking participants to ‘Spray the areas that are the warmest’—and in the text areas type ‘Where is the hottest area you’ve been to?’ and ‘How hot was it?’
5. Questionnaire, with questions about age group, gender, residency of the Flat-head Indian Reservation, tribal membership, zip code, and a question asking if they were doing the exercise individually, or in a group.
6. After the questionnaire, a short explanation of the task is given i.e. ‘Please show on the next map those areas that are most important to you for either personal or cultural reasons, for example, childhood memories, family outings, memorable experiences, ancestral ties, and/or spiritual and symbolic activities’. An option is given to skip a map, if desired.

7. Maps were given for each category:
 - Wildlife habitat and water quality
 - Access and functional benefits
 - Protection of the wilderness
 - Personal and cultural
 - Recreation and scenic values
8. Each user is given these maps in random order, to help reduce any bias.
9. Participants are asked to spray on each map showing where the most important areas to them were and write in the text areas ‘Why these areas are important?’ and ‘What are the threats to these areas?’

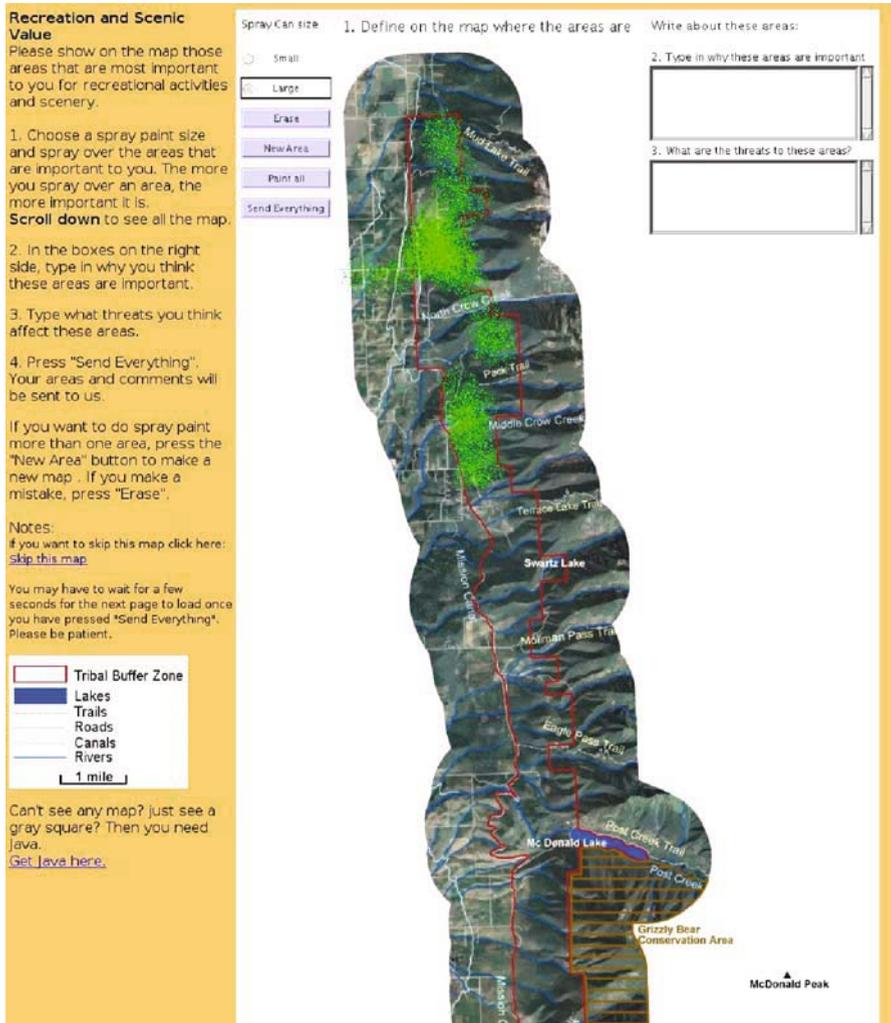


Fig. 21.7 Landscape mapping tool interface (See also Plate 58 in Colour Plate Section)

10. After completing all the maps, a thank you page is shown together with further details about the project.

Each sprayed area entered by the user is processed by the Tagger software into a standard image format (gif and GeoTIFF) and compressed. The image and associated attribute information are stored, and can be viewed either as an individual entity or combined into an aggregate ‘average’ map based on all the users’ responses. The Tagger system also includes a query functionality, where researchers can click on the composite image of everyone’s responses and query this area for the text associated with that area, weighted by intensity. Additional administrative tools include the ability to examine, delete or edit individual maps and textual responses. The Tagger code is open source and may be freely used by academic and non-profit, non-governmental organisations, as well as private individuals (see <http://www.ccg.leeds.ac.uk/software/tagger/>).

21.5 Results

The results from the Phase 2 mapping exercise are shown in Fig. 21.9 grouped into the five themed topics and including the composite of all meanings for all users. These data are preliminary, representing the initial effort at obtaining public participation in this process. A mixture of online (web-based) and offline (laptop-based) participants were included and results monitored to assure quality of presentation, data capture and to plan more complex analyses that make the distinction between tribal and non-tribal groups as well as standard geo-demographic differences of age and gender. After this preliminary data collection with the 34 participants, the wider public was invited to participate in this process via the local media including announcements in the local weekly newspaper and on the tribal government intranet web site appearing on every employee’s start-up login page.

It can be seen from the averaged maps in Fig. 21.9 that there are marked differences in the spatial pattern and intensity of meanings associated with the five themes. It should be noted that in order to aid comparison, the same classification and colour scheme is used for all five theme maps and the composite map. It should also be noted that whilst the focus of the mapping exercise is the Buffer Zone, users were not limited to this area by the Tagger software and can spray extensively outside of the Buffer Zone boundary. Marked edge effects can

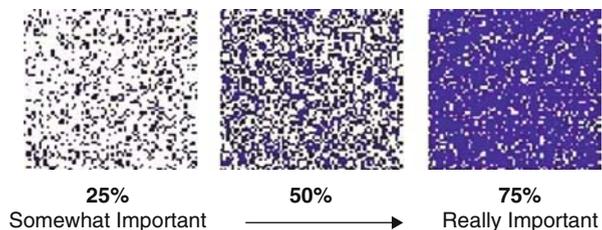


Fig. 21.8 Spray pattern examples

therefore be seen in some maps such as for the wildlife and water theme shown in Fig. 21.9b. Although the system records all spray patterns, those falling outside the Buffer Zone are largely ignored in the following analysis as they are outside the area of interest.

Of the five themes, wilderness protection (Fig. 21.9a) shows the greatest uniformity, perhaps as a result of the general view among respondents of the Buffer Zone as a policy zone with equal protection along its length. A significant proportion of users used the 'Paint All' button to apply a uniform spray density over the whole area for this theme to indicate value and meaning that is both broad in scale (covering the whole Buffer Zone) and not specific to any one area. The access theme (Fig. 21.9d) exhibits the greatest localized differences which is most likely due to the limited number of maintained trails within the Buffer Zone, with most people associating higher levels of importance to those areas along and adjacent to these trails. Hot spots within the recreation (Fig. 21.9c) and personal/cultural (Fig. 21.9e) theme maps reflect the nature of the access corridors shown in Fig. 21.9d and are likely to be driven by frequency of visits to popular sites such as McDonald Lake, Mission Reservoir, Saint Mary's Lake, Swartz Lake and North Crow Creek trail (Fig. 21.1). This said, it is clear that other more remote and inaccessible areas are also highly valued and have meaning for both recreational and personal/cultural use. The map for wildlife and water (Fig. 21.9b) shows perhaps the greatest spatial variation of all the five themes with users identifying areas not on their ease of access and frequency of use, but on their environmental credentials for wildlife and water protection. Many of the hotspots on this map relate to watersheds, rivers and lakes.

21.6 Conclusions and Further Research

This chapter describes work in progress on a new planning support system aimed at collecting spatial and contextual information about public perceptions of landscapes with an emphasis on developing better understandings of place-based values and associated meanings. The three phase approach based around key informant interviews, landscape mapping and focus group interviews demonstrates a rigorous approach to participation and data collection in developing publicly acceptable management strategies and actions in the face of multiple, spatially variable and sometimes conflicting viewpoints. The process described involves a mix of both face-to-face and automated methods of data collection using key informant interviews (Phase 1) to inform the development and application of automated methods of spatial and attribute data capture using map-based computer interfaces (Phase 2). Both initial phases are now complete and the project is currently in the final stage of focus group interviews to evaluate the resulting maps and suggest appropriate fuel treatments for the Buffer Zone area.

Experience from Phase 2 and the results gained suggest that this combined approach has been successful in capturing the rich picture of meanings attached

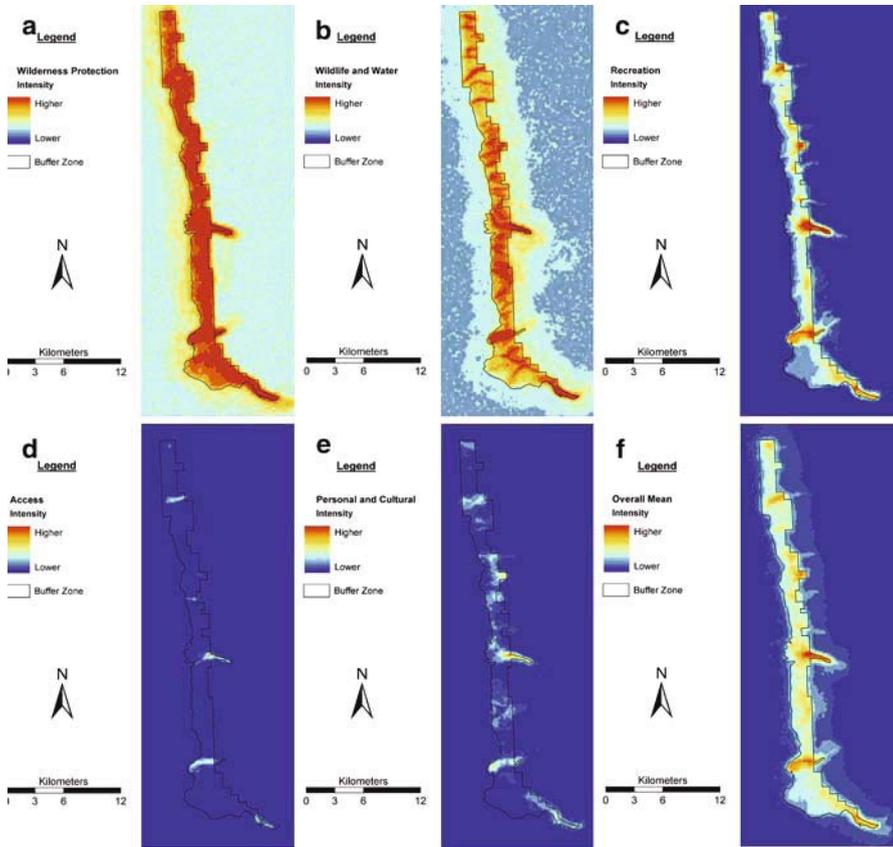


Fig. 21.9 Results for (a) wilderness protection theme, (b) wildlife and water theme, (c) recreation theme, (d) access theme, (e) personal and cultural theme, and (f) composite map for overall averaged results

to the complex landscape mosaic represented in the Buffer Zone. In particular, the combination of user defined fuzzy areas and qualitative data collection methods has enabled a wide range of personal and community meanings to be spatially delimited across a broad area in a manner and detail that would be impossible by verbal and/or manual means. Automated data collection and 24/7 availability of the online version of the system also means that the work can span a far greater audience than would be possible via traditional face-to-face or paper-based social survey methods, making detailed and disaggregated analyses (e.g. comparisons of tribal and non-tribal responses) possible with the higher numbers of respondents realised, even though it is understood that data collected online might not be as reliable as that collected face-to-face (Carver *et al.* 2001). In addition, the linkage of themed spray patterns and tagged attributes with user profiles makes detailed analysis of differences between different demographic and/or stakeholder groups possible. For example, in the final analysis, focus will likely be on tribal member responses, though understanding of

non-tribal responses is also of interest to land managers and the Tribal Council. The resulting dataset and possibilities for further analysis represents an extremely rich resource for policy development in regard to landscape resource management that takes both public perceptions and the realities of the physical world into account.

The approach adopted is not without its problems however. The initial setting up of the mapping software requires customization for each application and a relatively high level of competence with web/Java programming. From the point of view of usability, experience suggests that there is a wide range in the levels of familiarity with IT among members of the public. Although independent use of the system only requires knowledge of how to use a web browser (i.e. simple mouse and keyboard skills), there is still a significant proportion of the population who have had little or no previous exposure to computers and the internet. Previous research in the field of web-based participatory approaches suggests that lower levels of computer literacy and internet access/usage are strongly associated with rural and/or older demographics (Carver *et al.* 2001). Work by Hoffman *et al.* (2001) suggests that noticeable differences exist between racial groups in urban areas that may extend to rural communities, but note that this is mainly a function of access to a computer and the internet within the home environment. While some barriers to internet access appear to persist in rural areas and on tribal lands, particularly in respect to culturally sensitive issues, Tribal Councils and Reservations are actively embracing digital technologies with relative enthusiasm (Gordon *et al.* 2003; Monroe 2002) and use of IT is increasing. Nonetheless, it is clear from the current research that many older members of the community, including tribal elders who are the holders of much important traditional knowledge, benefit from the use of facilitated offline systems where problems arising from unfamiliarity with IT or reluctance to use it can be avoided.

The case study described here has demonstrated that the approach is well suited to developing a better understanding of indigenous peoples' relationships with the land, and is particularly useful for contrasting meanings attached to different classifications of land, articulating what is worth protection and what it should be protected from (i.e., threats from development and alternative uses or values) and how it is viewed by people from different cultures and/or stakeholder groupings. In dealing with complex human/landscape relationships, we need in the twenty-first century to fully understand and appreciate the different orientations toward landscapes and wilderness in particular as the original or primary landscape type. One area of significant future research will be in how global climate change will impact on both forest ecosystems and the communities that rely on them. Methods such as those described here could usefully be adapted and expanded on to provide inputs to further our understanding of transition periods and allow society to proactively increase the resilience of society to wider changes in global climate and shifting ecosystems.

As a general conclusion, the positive experiences and results from the work described here would indicate that the approach adopted will find wider application across a range of spatial problems requiring an element of public participation involving vague or spatially fuzzy concepts. Examples might include studies of

NIMBYism, landscape, urban and regional planning and mental mapping, in fact, almost anything where there is a need to better understand the spatial and contextual elements of human relationships with the social, cultural, built and natural environment that do not fit neatly into the sharp, crisp world of traditional mapping methods. The Tagger software has already been successfully tested in projects aimed at mapping perceptions of crime and wilderness qualities (Evans and Waters 2007; Carver *et al.* 2005) and some aspects of the work described here are already being considered for use by other U.S. Forest Service projects and similar organisations elsewhere in the world. On a technical level, the Tagger software could be developed to work with commonly used web mapping interfaces such as *Google Earth* or NASA's WorldWind. This would make the tool more readily available to a larger audience and make it easier to incorporate into a wider range of applications.

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