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Identifying environmental and natural resource management conflict potential using participatory mapping

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Methods have been proposed for identifying land use conflict potential using participatory mapping data and models. In a case study from Finland, we extend conflict mapping research by evaluating the capacity for participatory mapping to identify conflict for land uses that include mining, tourism development, commercial forestry, recreation, and nature protection. We evaluated two conflict models using reference sites where conflict was expected, and assessed whether conflict potential was influenced by participant social group (resident, visitor, holiday home owner). The conflict models correctly identified the locations of current and proposed mining projects and major tourism locations (ski areas) in the region, while conflict for commercial forestry and reindeer herding was spatially distributed. Preferences for land use by social group were more similar than different across the study region. Identification of conflict potential using participatory mapping can provide a useful planning diagnostic but would benefit from additional research for validation.

Keywords: land use; public participation; PPGIS; conflict analysis

Introduction

Methods and models to identify land-use conflict *potential* using participatory mapped data from public participation GIS (PPGIS) or participatory GIS (PGIS) have been described in recent studies (Brown and Donovan 2013; Brown and Raymond 2014; Hausner et al. 2014; Moore et al., 2017). The term "land-use conflict" is a situation involving land-use stakeholders with incompatible interests in a geographic location that can result in negative effects (von der Dunk et al. 2011). The key elements of conflict are stakeholders (individuals or groups with incompatible interests), a geographic location, and the perceived consequences, often negative, of alternative land uses. Despite conflict having an implicit spatial dimension, relatively few studies have identified the conflict potential spatially, with even fewer studies validating conflict mapping methods. This study addresses this knowledge gap by evaluating spatial models that identify conflict potential for natural resource management uses that include mining and tourism development, commercial forestry, reindeer herding, recreation, and nature protection. The setting and data for evaluating conflict derive from a large PPGIS study conducted in Finnish Lapland.

Two types of conflict involving natural resources are described in the literature: social values and interpersonal (goal interference). Social values conflict occurs between groups who do not share similar values or norms about an activity and can occur even when there is no direct physical contact between groups (Ruddell and Gramann 1994; Vaske et al. 1995; Vaske et al. 2007). For example, individuals may hold different opinions about the social value of mining without actually encountering the mining activity directly. The social value conflict would likely focus the relative benefits of employment and income generation versus potential environmental externalities associated with mining. Interpersonal conflict occurs when the physical presence or behaviour of an individual or group interferes with goals, expectations or behaviour of another individual or group (Jacob and Schreyer 1980). An example of interpersonal conflict in outdoor recreation is the clash between snowmobilers and skiers who have different expectations for the experience; an important finding is that interpersonal conflict can be asymmetrical, i.e., one group experiences significantly more conflict than the other group (Vaske et al. 2007).

Natural resource management conflict can include differences in social values and goal interference from incompatible activities in the same location. Common triggers for conflict include new infrastructure development (e.g., siting of power lines, energy generation, and landfills), changes in the built environment (e.g., new residential, and tourism development), and resource extraction (e.g., logging, mining, oil/gas development). Land-use conflicts are often presented in the literature as case studies that describe not-in-my backyard (NIMBY) reactions to prospective changes in land use. Some specific examples include conflict over new residential development (Pendall 1999; Young et al. 2005), commercial development (Freestone 2009), and energy development (van der Horst 2007; van der Horst and Toke 2010; Devine-Wright 2005, 2013; Pocewicz and Nielsen-Pincus 2013). NIMBYism is a type of conflict that involves spatial geographic discounting where people express preferences for positive environmental conditions closer to home and negative conditions further from home (Hannon 1994; Norton and Hannon 1997). Not all changes in land use will trigger conflict and some types of conflict may be beneficial as a means to prioritize social values. Thus, the key issue is not conflict avoidance per se, but conflict management. Methods that can identify antecedent conditions for conflict can assist land-use planning and management efforts to keep the conflict bounded and to identify prospective areas where there is general agreement on future land use.

Within the environmental social sciences, there is increasing focus on research methods that provide spatially-explicit social data. For example, Brown (2004) and Nielsen-Pincus (2011) described research methods for including spatially-explicit variables in conventional mail survey research, Donovan et al., (2009) described methods for mapping places using qualitative interviews, and Hawthorne et al. (2008) described methods for geo-referencing social data collected using the Q method. Thus, qualitative, quantitative, and mixed methods research can provide valid, spatially-explict social data (Brown et al., 2017), with an increasing trend in the use of participatory mapping methods variously described as public participation GIS (PPGIS), participatory GIS (PGIS), and volunteered geographic information (VGI) for collecting spatial information (see Brown and Kyttä 2014).

PPGIS methods are particularly well-suited to identifying the potential for conflict because they incorporate the essential components of conflict—multiple stakeholders, spatial location, and a means to identify spatially-explicit social values and land use preferences. Brown and Raymond (2014) proposed that land-use conflict potential derives from differences in mapped place values and land use preferences (i.e., stakeholder interests) that can be formulated into different conflict indices and presented on maps. Their conflict models and indices were grounded in social values and interpersonal conflict theory described above. They applied a conflict mapping model to residential and industrial development and evaluated multiple conflict indices based on values compatibility scoring (see Brown and Reed 2012), mapped preferences only, and an index that combined both mapped values and preferences. They concluded the preferred method for assessing conflict potential was one that integrates both land use preferences (supporting/opposing) and place values, although the preference-only conflict indices performed slightly better in identifying residential and industrial development reference sites selected for benchmarking. A limitation of this study was it only evaluated conflict mapping for two non-natural resource related land uses, residential and industrial development.

Brown and Donovan (2013) identified conflict potential for natural resource management using data from PPGIS study conducted for national forest planning in the U.S. They calculated and mapped conflict potential using an index that combined mapped preferences (acceptable/unacceptable) and place values to reveal areas of conflict potential for nine forest uses: commercial timber, vegetation management, forest gathering, recreation facilities, motorized recreation, commercial tourism, subsistence hunting/fishing, mining, and wilderness designation. The study demonstrated the potential for conflict mapping across a large region in a natural resource context, but the results were limited by the sample size relative to the large study area and the absence of benchmarking the results against known conflict areas.

Moore et al. (2017) extended conflict potential mapping to marine and coastal areas using participatory mapping data from a study in Western Australia. Place value data was collected using qualitative interviews with participants drawing polygons in the region representing different values such scenery, biodiversity, recreation, and commercial fishing. Conflict potential was assessed by assigning compatibility scores to each pairing of place values which were categorized as either consumptive or non-consumptive. The supporting rationale was that conflict potential is more likely in places where consumptive and non-consumptive values clash based on goal interference or social norm violation because the uses associated with the values are competitive rather than complementary. A limitation to this study was the conflict potential maps were not systematically benchmarked against known conflict areas in the study region.

Hausner et al. (2014) identified conflict potential in Norway using multiple conflict indices derived from mapped preferences to either increase or decrease an activity, optionally weighted by preference or place value counts. The research examined whether conflict potential for various resource uses was related to land tenure (e.g., private land versus different categories of public land). The study found conflict potential was related to land tenure with private land having the highest potential for conflict. Because the focus of this study was on land tenure, there was no systematic benchmarking of the conflict results by known conflict areas.

The influence of participant location and distance to land uses with conflict potential has been examined in several participatory mapping studies. Pocewicz and Nielsen-Pincus (2013) examined participatory mapped data for evidence of geographic discounting (a type of NIMBYism) associated with residential and energy development and found that where people live influenced their mapping patterns. Specifically, they observed NIMBYism for wind energy and residential development based on mapped preferences. Participants also mapped preferences for oil/gas development further from home but this outcome likely reflected preferences for concentrated development rather than NIMBYism per se. Similarly, Brown, Kelly, and Whitall (2014) found evidence for NIMBYism in national forests in California where individuals living closer to the forests expressed fewer preferences for resource utilization than those living more distant to the forests. More generally, both visitors and residents in a region can express preferences for increased tourism development, a land use often associated with NIMBYism, but the preferences appear place-specific and conditional within a region (Raymond and Brown 2007).

The preceding review of conflict mapping research indicate that participatory mapping methods can identify conflict potential for a range of prospective land uses and that participant location and stakeholder (social groups) are key variables. This prior research, however, consists of case studies that differ in geographic location, study population and sample size, spatial attributes, and research objectives. One objective of this study is to enhance external research validity by applying similar conflict research protocols to other resource issues, conditions, and geographic settings. A second objective is to address current internal research validity gaps that include assessing the predictive validity of conflict models for different natural resource issues such as mining and tourism development, evaluating the performance of conflict models for land uses that are site-specific versus spatially distributed, and determining the effects of social groups in identifying spatial conflict potential.

Social groups have been identified as a key variable in conflict research. Empirical evidence suggests that place attachment, one of the variables assumed to underlie the potential for land use conflict, differs between social groups, such as between second home owners and permanent residents (Stedman, 2006), between natives and non-natives (Hernández et al. 2007), and between occupational groups living in the same region (e.g., farmers vs. professionals) and urban vs. rural residents (Brown, Raymond, and Corcoran 2015). In the stakeholder literature, there is evidence that social groups identified by stakeholder categories can influence place values and land use preferences. For example, Brown et al. (2016) found moderate levels of association between stakeholder classifications (based on stakeholder identity vs. interests) that were logically related to general and place-specific participatory mapping behavior in the study region. Despite the putative importance of social groups (e.g., holiday home owners vs. permanent residents and tourists vs. residents), there are few studies that have examined conflict potential spatially by social group.

This study differs from previous conflict research in its geographic and research context with more robust sample sizes for conflict analyses, as well as assessment of a broad range of natural resource uses that are spatially variable. Importantly, this study examines the influence of a key independent variable (social group) in identifying conflict potential in a natural resource dependent region. Specifically, we explore: (1) How effective is participatory mapping in identifying conflict potential using pre-selected reference sites, i.e., natural resource areas reported as experiencing conflict over land use? (2) Does the type of conflict potential model (i.e., mapped values and preferences model versus preferences-only model) influence the spatial results and are the results more or less effective depending on the type of land use? and (3) To what extent is conflict potential influenced by participant social group (i.e., resident, holiday home owner, visitor)? We answer these questions by analysing participtory mapping data collected in northern Finland as part of a regional natural resource planning application. Following presentation of the results, we discuss the implications for future research on assessing land use conflict that use participatory mapping methods.

Methods

Study area

The study area (14380 km^2) is located in northern Finland, 50 to 200 km north of the Arctic Circle (See Figure 1a). The main municipalities covered by the rural study area are Kolari, Kittilä and Sodankylä with an estimated population of 19,000. The landscape is characterized by forests, large mires, fast-flowing rivers and some distinctive fells (highest 719 m) rising from an otherwise flat terrain. The study area contains two national parks and multiple nature conservation areas, either established by law or allocated for nature conservation but not yet legally formalized. Outside of these protected areas, forests within the study area are subject to commercial timber production.

In addition to forestry, the main livelihoods/land uses in the area include tourism, mining and mineral exploration, forestry, and reindeer herding. The main tourist destinations are three ski resorts Levi, Ylläs and Luosto and two national parks (NP) Pallas-Yllästunturi NP and Pyhä-Luosto NP (Figure 1a). Levi ski resort in the Kittilä municipality is the most popular ski resort in Finland and Ylläs in Kolari is the third most popular ski resort. Pallas-Yllästunturi NP, located near Ylläs ski resort, is the most popular National Park in Finland with 525,600 visits in 2015 while Pyhä-Luosto NP, located near Luosto ski resort, received 115,000 visits in 2015 (Metsähallitus 2016). During the 2000s, there were active mining exploration activities in the study area. As of 2016, there are four operating mines: Kevitsa Nickel-Copper mine in Sodankylä, Suurikuusikko gold mine in Kittilä, and two small-scale amethyst mines in Sodankylä. In addition, a few mines were on hold such as the Hannukainen mining project which is in the feasibility analysis stage. There is also a Nickel-Copper discovery site (Sakatti) that lies almost entirely inside a Natura 2000 area.

Data collection and sampling

We implemented an internet-based PPGIS mapping website in Finnish language for data collection. The website contained a Google® maps application programming interface (API) where participants could drag and drop digital markers onto a map of the study area. The mapping interface consisted of three "tab" panels containing digital markers with 10 place values (panel 1) and seven parallel preferences to either increase/allow a land use (panel 2), or decrease/restrict (panel 3) the same land use (SOM Table 1).

Participants were instructed to drag and drop the markers onto study area locations that are important for the place values and to identify preferences for seven types of land use (mining, commercial forestry, tourism development, recreation facilities, reindeer herding, snowmobile/ATV use, and nature conservation). To facilitate mapping, the website contained a base map of Finland with overlays of protected area boundaries and mining sites, both operating and proposed. The survey also included text-based questions to collect participant characteristics: participant post code, home municipality, age, gender, education, family structure, how they learned about the study, and occupation.

The PPGIS website survey was pre-tested before opening of the autumn tourist season in 2015. Data was collected until March 2016 to cover the winter tourism season. The survey was open for anyone to participate and we used several methods to recruit participants: (1) we prepared a press release containing a link to the study URL and distributed it through social (Facebook®, Twitter®) and traditional media (local newspaper, radio); (2) we sent email invitations to local organizations, societies, and entrepreneurs related to mining, tourism and recreation, forestry, nature protection, reindeer herding, and hunting and fishing; (3)

municipalities and ski resorts shared the information with the study URL on their webpages and/or Facebook; (4) we distributed leaflets about the study in local villages and ski resorts; and (5) we sent 3,000 invitation cards to a random sample of local households (1000 households per each of the three municipalities). The random sample of addresses was drawn from the Finnish Population Information System provided by Population Register Centre. In total, 563 individuals participated in the study and mapped 11,679 locations in the study region.

Data analysis—generating and comparing conflict indices by land use

Consistent with previous conflict potential modelling studies, a sampling grid approach was chosen for spatial analysis. Spatial analysis with point data requires a judgment be made regarding the appropriate scale (i.e., size of the sampling grid for points relative to the size of the study area) to model conflict potential. If the sampling grid cell size is too small, there are too few points in each cell for modelling. If the grid cell size is too large, the conflict maps provide insufficient spatial resolution to provide place-specific guidance for land use decision support. We examined the number and spatial distribution of mapped values and preferences and determined the optimum size for analysis would be a 2 km grid cell size. This generated n=3,794 grid cells for the study region. This cell size is consistent with previous conflict mapping studies given the study area size and number of points mapped (see Brown and Raymond, 2014). At this scale, a sufficient number of points were mapped per cell to generate conflict indices for comparison. At a larger scale (e.g., 1 km sampling grid), there were too few points (empty cells) to generate sufficient variability in conflict indices.

There are multiple options for calculating conflict indices. We selected two conflict indices described by Brown and Raymond (2014) that posit conflict potential derives from opposing preferences for a given land use in the same geographic location. The weighted preference index (WPS) calculates conflict potential as a ratio between the number of mapped preferences for increasing and decreasing a particular land use, weighted by the total number of mapped preferences in the cell. The magnitude of the preference difference is an indicator of conflict potential with larger ratios suggesting greater conflict potential. For example, if a grid cell has five preferences to increase the land use and five preferences to decrease the land use, the ratio would be one (the maximum index value). Weighting the preference score differential by the number of mapped preferences accounts for different land use saliencies across the landscape. Without weighting, a grid cell with one supporting and one opposing land use preference would generate same conflict index as a cell with five supporting and five opposing preferences. Although the preference ratio score would be the same in both cases, logic suggests the potential for conflict is significantly higher in the cell where more preferences were expressed because the land use in that location appears more salient to study participants. The equation for weighting the preference ratios by the the

$$WPS = \frac{MAX(MIN(P_S, P_O), 0.1)}{MAX(P_{S,} P_O)} * (P_S + P_O)$$

where *WPS* is the weighted preference score per cell, P_S is the number of preferences supporting the land use, and P_O is the number of preferences opposing the land use. The (0.1) constant in the numerator is intended to handle grid cells containing only markers of a single preference type—either supporting or opposing—and to differentiate these cases from true "no data" grid cells that do not contain any preference markers. Without a small, positive constant to keep the numerator non-zero, the ratio would evaluate to 0/n (where n is the number of supporting or opposing markers) indicating no potential for conflict, an inaccurate conclusion. Any expression of preference, even small, suggests some potential for conflict. Further, any expressed preference in a grid cell, including a single marker, should be distinguished from "no data" cells without any preference markers. For example, according to the above equation, a cell that contained one supporting preference and no opposing preferences for the same land use would evaluate to .1 x 1 = .1. A cell containing 5 supporting preferences and no opposing preferences would evaluate to .1/5 x 5 = .01 suggesting lower conflict potential. This result appears logical because greater expression of similar preferences should generate smaller conflict indices.

The second conflict index, the preference and value index (*PVS*), is the same as the *WPS* except preference ratios are weighted by the number of mapped values. To operationalize, the preference ratios are multiplied by the number of mapped values located in the grid cell. The preference and value score (*PVS*) represents conflict potential on a continuous scale with higher scores associated with higher conflict potential. The equation is as follows:

$$PVS = \frac{MAX(MIN(P_S, P_O), 0.1)}{MAX(P_S, P_O)} * V_c$$

where *PVS* is the preference and value score per cell, P_S is the number of preferences supporting the land use, and P_O is the number of preferences opposing the land use, and V_c is the count of all mapped values in the cell.

We compared the similarity/difference in conflict distribution maps using the *WPS* and *PVS* indices for each of seven land use preferences in the study (tourism development, recreation facilities, commercial forestry, mining, nature protection, reindeer herding, and snowmobile use). For visual comparison, we plotted each conflict map side-by-side to examine the spatial location of areas of high conflict potential. We then calculated Pearson's product moment correlation between the *WPS* and *PVS* indices for the same grid cells that contained one or more mapped preferences. This statistic provides an overall measure of similarity between conflict indices across the entire study region.

Selecting and comparing land use reference sites

We selected n=11 reference sites within the study area for in-depth examination of conflict potential (Figure 1b). These sites were either (1) pre-selected by the research team based on the known location of current or prospective land uses that we anticipated would be controversial in the region (i.e., n=5 mining projects and n=2 tourism areas associated with ski areas), or (2) inductively emergent reference sites (i.e. sites with clustered preferences) for spatially distributed land uses (snowmobiling, nature protection, and recreation facilities) that could occur throughout the region. These latter reference sites (n=4) were not selected to validate the predictive quality of the conflict indices, but to identify how mapped values and preferences for these land uses were related to the social grouping variable described below. Some of the mining projects were the subject of media reports reflecting their controversial nature.[5] The final selected reference sites consisted of locations for mining (n=5), tourism development (n=2), snowmobiling activity (n=1), recreation facilities (n=1), and nature protection (n=2). The mapped preferences for commercial forestry and reindeer herding were spatially disbursed within the study area without sufficient clustering to provide reference sites.

For the seven pre-selected reference sites, we assessed whether each conflict index (*WPS* and *PVS*) identified the location as having conflict potential to validate participatory

[5] Media stories for **Hannukainen** mine: *Maaseudun tulevaisuus* 14 September 2014 , *Luoteis-Lappi* 13 May 2015. **Sakatti** mine: *Taloussanomat* 18 September 2013, Helsingin sanomat 13 July 2014.

mapping as a means to predict controversial sites associated with mining and tourism development. Next, for all reference sites, we examined the distribution of preferences based on the characteristics of the mapping participant to assess the potential influence of participant social group. Specifically, we used the chi-square test of independence to determine whether the distribution of mapped preferences across the study region and in each reference site was related to three social groups—(1) those who live in or near the study area, (2) those who have a holiday home in or near the study area, and (3) those who were visitors to the study area. We compared the proportions of each classification using a z test with Bonferroni adjustment for multiple comparisons using SPSS software (version 23). Because participants were not limited in the number of markers placed, an individual could disproportionately influence the outcome at a given reference site with his/her mapping behavior. To account for this potential bias, we also tabulated the number of unique participants who mapped preferences in each reference site to compare with the proportion of markers.

Results

Participation rates and sampling group response

A total of 563 individuals mapped one or more locations and 467 individuals completed the post-mapping survey. The response rate from the random household sample was about two percent (n=54), representing 10 percent of total participants in the study as a whole. Probable reasons for the low household response rate include the mailing of a single recruitment letter without follow-up reminders, the study region being located in a rural area of Finland with poorer internet connectivity compared to urban areas, and a higher proportion of elderly people without internet skills. There were 11,679 mapped locations, with the mean number of markers per participant equal to 20.7 and a median value of 12. Participants mapped disproportionately more place values ($\bar{x}$=14.2) than preferences ($\bar{x}$=6.5) Participants had a mean age of 50 years and there were more male participants (56%) than female participants (44%). Participants were distributed between those with a home in or near the study area (n=170), those with a holiday home in or near the study area (n=137), and visitors to the study area (n=126).

Given the potential bias associated with random household sampling versus convenience/volunteer sampling (Brown, 2016), we analysed general mapping behaviour by sampling group. There were no statistically significant differences (t-tests, $p > 0.05$) between the random household and convenience sampling groups on the mean number of markers placed (household=22.6, convenience=20.5) or the type of markers placed (values, household=17.6, convenience=13.8; preferences, household=5.0, convenience=6.7). Because the mean number of markers can be influenced by greater mapping effort by a few participants, we also examined the general propensity of participants in the two sampling groups to map values or preferences based on the proportion of individuals within each group that placed one or more markers. We found no statistically significant differences in mapping propensity for general marker categories (values or preferences) by sampling group (chi-square tests, $p > 0.05$). When we examined specific marker categories, the household sample placed more markers and had a greater propensity to map hunting/fishing, gathering, snowmobile use, and economic values than the convenience sampling group. With preferences, the household sample had greater propensity to map preferences to increase mining activity and to decrease reindeer herding. In summary, there were more similarities than differences in the mapping behaviour of the two sampling groups, with the differences in mapping behaviour being small. Where differences in mapping behaviour were present, they reflected priorities of households in the region for recreational activities and preferences to increase economic opportunities, e.g., from mining activity.

Mapping of conflict potential by land use

Conflict potential was calculated for the *WPS* and *PVS* indices for each land use type. The two indices were most similar in results for recreation facilities (r=0.85), nature protection (r=0.75), and tourism development (r=0.72), and least similar for commercial forestry/logging (r=0.34) and reindeer herding (r=0.30). Mining (r=0.46) and snowmobile use (r=0.47) were in the mid-range of index similarity. The spatial results are presented as maps (SOM Figure 1) and show tourism development conflict potential proximate to the two ski areas of Ylläs and Levi, respectively, while nature protection conflict extended to areas associated with tourism development and mining land uses. In the case of mining, the *PVS* index expanded the spatial area of conflict potential relative to the *WPS* index by accounting for the intensity of mapped values that were spatially proximate to mapped mining preferences. The opposite effect occurred with snowmobile use, forestry, and reindeer herding where mapped preferences were more spatially distributed in the study area. For these land uses, the PVS index had the effect of spatially contracting the areas of conflict potential to smaller areas because of higher mapped value intensity. Thus, the two conflict indices exhibited different spatial effects based on the type of land use preference mapped.

Analysis of conflict potential by reference site

The pre-selected mining and tourism references sites (A – G) were spatially identified by both conflict indices, *WPS* and *PVS* (Table 1), affirming that participatory mapping does identify conflict potential locations that are logically consistent with mapped preferences. In the case of mining, four out of five mining reference sites (A – D) were visible to participants on the website base map. The number of unique mapping participants for each mining reference site ranged from 95 participants for reference site A, to eight participants for mining reference sites B and D. The Sakatti reference site (E) provides a useful indicator of conflict potential mapping because participants identified the location of this exploratory mining project without the mining project being visible (labelled) on the base map. A total of 15 participants mapped mining preferences in this location which lies within a Natura 2000 reserve.

The inductive and emergent reference sites for recreation facilities, snowmobile use, and nature protection (H – J) were located proximate to the Ylläs ski area (Figure 1b) indicating these land use preferences are related to tourism development, broadly defined. The overall intensity of mapped values and preferences was greatest in the vicinity of the Ylläs ski area. A second nature protection reference site (K) was located at the proposed Hannukainen mine site, not far from the Ylläs ski area.

For commercial forestry and reindeer herding land uses, the mapped preference data were not spatially clustered to provide reference sites for in-depth analysis (SOM Figure 1). Mapped preferences were spatially disbursed with many areas located outside of national parks and reserves, suggesting more localized conflict relative to specific locations where participants live, have holiday homes, or visit.

[Insert Table 1]

Analysis of conflict potential by social group

An analysis of mapped preferences by social group (resident, holiday home, visitor) reveals that conflict potential is related to social group, however, group preferences appear more similar than different. For mining, there were more mapped preferences in opposition to mining from all three social groups across the study region, however, residents and those with holiday homes in the study area showed stronger opposition to mining (Table 2, z test, $p < 0.05$). Data were sparse for mining reference sites with the exception of site A (Hannukainen), with most references sites represented by 5 or fewer participants. The

Hannukainen proposed mine (A) showed a similar pattern of response to whole region results except that residents were somewhat more conflicted about this proposed mine, with nearly an even split of residents favouring and opposing the mine.

[Insert Table 2]

Increased tourism development was preferred by residents and visitors, whereas similar to the mining results, holiday home owners were less enthusiastic (F – G). With respect to snowmobile use, both residents and visitors were supportive of increased activity across the region while holiday home owners preferred a decrease in snowmobile use. Within the snowmobile reference site (H), the majority of visitors opposed increased snowmobile use along with holiday home owners. However, the number of visitors who mapped preferences in the reference site was small (n=4). There were no significant differences in preferences for recreation facilities by social group in the whole study region or by reference site (I), with all groups supportive of increasing facilities. Nature protection was also preferred by all social groups in general, and there were no statistical differences concerning the whole study area and reference site (K). At the reference site (J) proximate to the Ylläs ski area, visitors were unanimous in mapping preferences to increase nature protection compared to other groups.

All social groups expressed strong preferences (about 90%) to decrease commercial forestry in the study region while residents and holiday home owners expressed strong preferences (between 80 - 90%) to increase reindeer herding (Table 2). Visitors differed from residents and holiday home owners with only a narrow majority of visitors (52 – 48%) supporting increased reindeer herding. Overall, holiday home owners expressed the fewest preferences for increasing mining, tourism development, snowmobile use, and commercial forestry.

Discussion

We evaluated the use of mapped place values and preferences to identify conflict potential for seven types of land use with two conflict indices. Both indices were effective in identifying expected locations for conflict associated with mining and tourism development and for identifying emergent conflict potential locations. Is there a preferred index based on the type of land use being evaluated? Given these results, we suggest using the weighted preferences index (*WPS*) to evaluate land uses that are project or site-based such as mining and tourism development and the value and preference index (*PVS*) to evaluate more spatially distributed land uses such as forestry and herding/grazing. The supporting rationale is that interpretation of spatial results is less ambiguous with less area being identified as having conflict potential. For site-specific land uses such as mining, the *WPS* index is not affected by proximate values that may or may not be compatible with the proposed land use. For distributed land uses such as forestry where conflict potential covers large spatial areas, weighting the preferences by mapped values has the effect of narrowing conflict potential to those areas where place values could be incompatible with the land use. As a practical matter, the conflict indices are relatively easy to calculate and it would be prudent to generate and evaluate multiple conflict indices in the study region.

Brown and Raymond (2014) suggest that higher social values conflict occurs in areas where there is development preference ambivalence while higher interpersonal conflict is likely to occur in areas of high place importance (high intensity of mapped place values). The conflict potential over mining activity in region, especially for the proposed Hannukainen mine, appears to have elements of both social value and interpersonal conflict. Social value conflict is manifest in the inherent trade-offs between economic development (jobs and income) and environmental protection and amenities in the region (residents were most ambivalent in mapped preferences). Interpersonal conflict is manifest in the potential for the mining activity to be visible from the Ylläs ski area and potentially disruptive to the recreation experience (visitors and holiday home owners were more opposed to the mine).

There were relatively small differences in mapped preferences by social group, with most preferences being directionally the same to increase or decrease the particular use across the study region. An exception was snowmobile use where holiday home owners favoured a decrease in the region while residents and visitors favored an increase. There were some differences in the intensity of preferences by social group even though there was general agreement to increase or decrease the activity. We speculate that these intensity differences reflect perceived impacts with the land use based on geographic proximity of the social group (i.e., NIMBYism) and stronger place attachment in the case of residents and also holiday home owners.

The effects of geographic proximity could not be systematically evaluated without knowing the specific physical domicile of the participant relative to the prospective land use, data that were not collected in this study. Analysis by social group aggregates geographic proximity information, thus increasing spatial variability in the data that can mask important place-based results. For example, in the case of the proposed Hannukainen mine, the number of residents supporting or opposing the mining activity was nearly evenly divided, but opponents placed proportionally more markers suggesting greater intensity of opposition and perhaps closer proximity, a finding consistent with the NIMBYism phenomenon. Analysis of spatial results by social group may be further confounded by other non-spatial factors. In rural areas that are experiencing a declining population, the mining industry can be seen as having the potential to bring positive socio-economic development like job opportunities, and thus favoured by some residents. However, uncertainties about how mining may affect other important nature-based livelihoods, like tourism and reindeer herding, can raise concerns (Heikkinen et al. 2013, Suopajärvi et al. 2016). In Kolari municipality, where the Hannukainen mine is planned, almost half of the population gets income from tourism (Satokangas 2013), and the natural landscape is an important attraction. As the planned Hannukainen mine would be only approximately 10 km from Ylläs ski resort and Pallas-Ylläs national park, the possible negative impact of the mine on the environment and scenery could affect the image of area, and partly explain the opposition among all social groups. The Hannukainen mine project was a timely issue in the study region during the survey, which explains the high intensity of mapped values and preferences in the Hannukainen area. In addition, holiday home owners are a special case for NIMBYism, as they may feel strong place attachment, but aren't directly affected by possible changes in job opportunities at given site.

The mapping of conflict potential, as described in this study, is intended to be a regional planning diagnostic tool. The number of participants and amount of spatial data available for analysis was reasonably high compared to other participatory mapping studies (see Brown and Kyttä, 2014), and yet when the data were analyzed at specific locations in the study region, the quantities of data were quite limited. For example, the number of individuals expressing preferences for the mining reference sites was as low as eight individuals, thus increasing the level of uncertainty in place-specific results. A more definitive characterization of the acceptability of land use in specific locations would require that participants be asked to identify preferences in pre-determined place locations (a deductive approach) rather than rely on an inductive mapping where spatial results are emergent.

Conclusion

This case study provided supporting evidence to complement previous research, finding that participatory mapping can be an effective method for identifying potential conflict with resource management activities in a regional planning context. We evaluated two conflict models (*WPS* and *PVS*); both were effective in identifying conflict reference sites. However, the conflict model weighted by mapped preferences appears more suitable for identifying site-specific projects (e.g., mining, tourism development), while the conflict model weighted by place values may be more suitable for identifying conflict potential in spatially dispersed resource uses (e.g., commercial forestry and reindeer herding).

The systematic evaluation of conflict potential based on participatory mapping is a nascent area of social research. As such, there is little guidance and no data standards for linking mapped conflict potential levels (e.g., low, medium, high) with real-world locations, or constructing confidence intervals based on the quantity of mapped data to inform such judgements. Our approach in this study was to determine whether mapped data actually identified (hit/miss) a presumed conflict site (reference site), and to generate interval-level conflict indices that showed the relative potential for conflict within the study region. We are confident that participatory mapped data, when generated from relatively large samples, will identify the majority of conflict potential locations within a given study region. However, in the absence of ground-truthing, we are less confident about whether the conflict indices accurately reflect the magnitude of real-world conflict conditions.

Future reseach should provide more guidance on how to use participatory mapped data to generate conflict measures that reflect actual social conditions in the study region (i.e., internal validity). For example, in this study and the previous study by Brown and Raymond (2014), unweighted conflict potential indices, as operationalized, were generated to range from 0 to 1 with one representing the highest conflict potential. As a heuristic, one could classify geographic areas by the unweighted conflict index, for example, into low conflict areas (0 - 0.3), medium conflict areas (0.3 – 0.7), and high conflict areas (0.7 to 1). Weighted conflict indices could be classified by their distribution (bottom third—low potential, middle third—medium potential, and top third—high potential) or into quartiles as shown in Figure 2. These levels of conflict potential would benefit from social research that triangulates these indices.

Another future research possibility would be to weight the mapped preferences based on the social influence or power of the participants. The conflict models described herein assume each participant and mapped preference is equally relevant to the spatial conflict diagnostic and the models do not account for the potential social influence of different participants over land use decisions. A non-spatial variable could ask participants to self-identify their relative social power or influence over land use decisions, or alternatively, their stakeholder group if social power can be inferred from stakeholder classifications. The unweighted and weighted spatial data based on social power could be compared to determine if social power influences the mapped conflict results.

To date, mapping conflict potential has been a secondary purpose of participatory mapping activity and as such, has not received the research attention necessary to establish conflict mapping standards and guidelines, or the data requirements necessary to establish confidence intervals. If participatory mapping is to effectively guide allocation of planning resources, there must be greater confidence that participatory mapping diagnostics, such as the conflict potential indices described herein, provide accurate assessments of the potential for land use conflict. Having established a stronger basis for the internal validity of conflict mapping, future research should progress to include systematic comparative studies across different populations and settings to enhance external validity and overcome the inherent limitations of case study research.

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Table 1. Reference sites analyzed within the study region. Reference sites (A-G) were pre-selected based on known locations of projects or development, or on basis of spatially clustered preferences to either increase or decrease the activity (H-K). All reference sites were identified by the two conflict potential mapping indices, weighted preferences (WPS) and values + preferences (PVS). No reference sites for forestry or reindeer herding where selected for analysis because preferences were too spatially disbursed to identify specific reference areas.

Land Use	Site/Project Name	Description	Map Reference (see Figure 1b)	Site was identifiable to participant by name on website base map	Weighted Prefs *WPS*	Prefs + Values *PVS*	r value (# cells)[b]
Mining	Hannukainen	Closed mine (1978-1992), now at planning stage for new mine, OP+UG[a]	A	•	•	•	0.46 (n=468)
	Kevitsa	Operating since 2011 and planning to expand, OP	B	•	•	•	
	Suurikuusikko	Operating since 2008, UG (started OP)	C	•	•	•	
	Kuotko	Planning stage, OP and may extend to UG	D	•	•	•	
	Sakatti	Exploration site near Natura 2000 site. Permission for exploration on hold.	E		•	•	
Tourism Development	Ylläs Ski Area	Number of beds: 23,000; ski slopes= 63	F	•	•	•	0.72 (n=130)
	Levi Ski Area	Number of beds: 24,000; ski slopes= 43	G	•	•	•	
Snowmobiling	Ylläs area	Area south and proximate to Ylläs ski area	H	•	•	•	0.47 (n=127)
Recreation facilities	Ylläs area	Area adjacent to Ylläs ski area	I	•	•	•	0.85 (n=224)
Nature Protection	Ylläs area	Area west and proximate to Ylläs ski area	J	•	•	•	0.75 (n=282)
	Hannukainen	Closed mine (1978-1992), now at planning stage for new mine, OP+UGa	K	•	•	•	
Forestry/logging	Not assessed (spatially disbursed)	N/A	N/A	N/A	No reference sites given spatially disbursed mapped data		0.34 (n=347)[c]
Reindeer herding	Not assessed (spatially disbursed)	N/A	N/A	N/A	No reference sites given spatially disbursed mapped data		0.30 (n=314)[c]

[a] OP= open pit, UG= underground

[b] Pearson's product moment correlation between *WPS* and *PVS* indices for all cells in region containing one or more markers. All correlations statistically significant ($p < 0.01$).

[c] Correlations between *WPS* and *PVS* were calculated region-wide as indicators of spatial concurrence and are not affected by the presence/absence of reference sites.

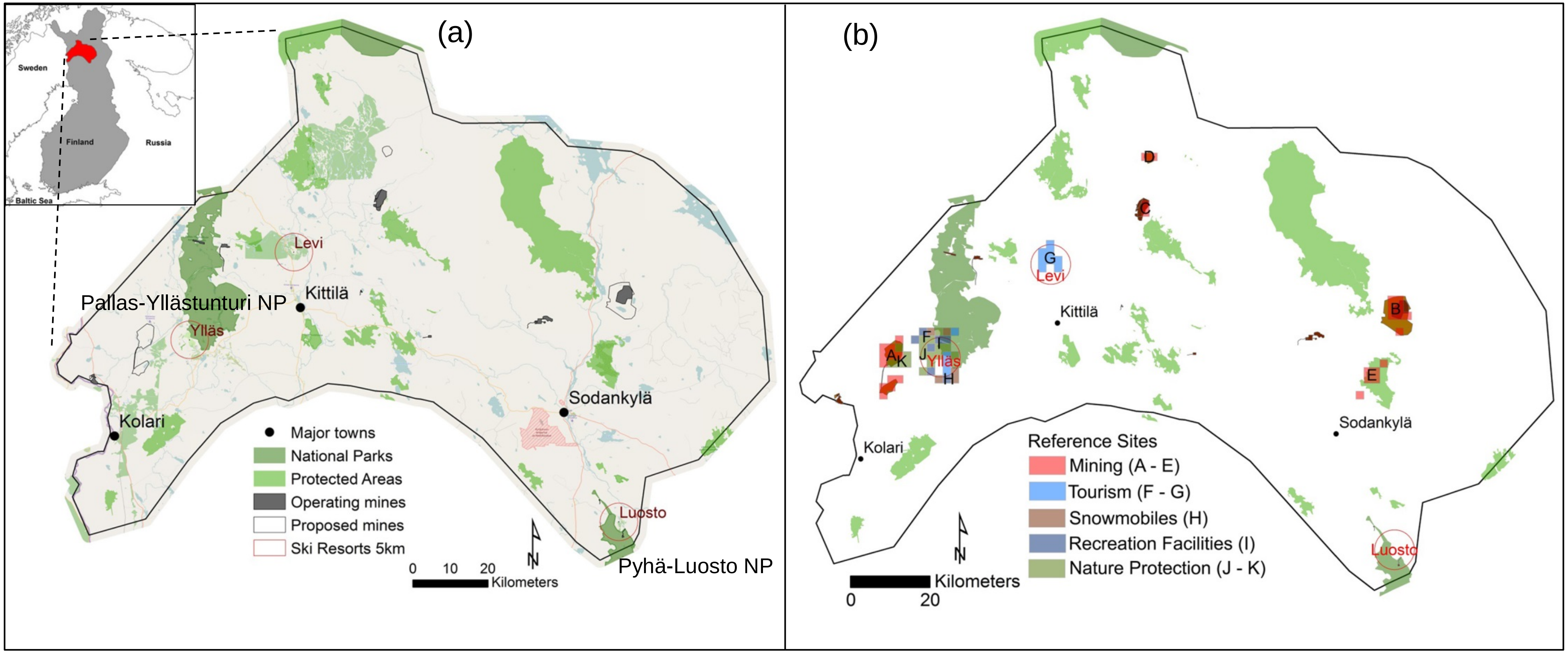
Table 2. Distribution of mapped preferences to increase/decrease resource management activity by participant group (resident, holiday home, visitor) and reference site based on proportion of markers. Each superscript letter (a,b) denotes categories whose marker proportions do not differ significantly from each other at the 0.05 level. Significant chi-square results are indicated in bold. A dash (-) indicates there was insufficient mapped preference data by participant group at the reference sites.

Land Use	Site/Project Name	Map Reference	Live in/near study area (% of markers)		Holiday home in/near study area (% of markers)		Visitor (% of markers)		X^2 (p value)
			Increase	Decrease	Increase	Decrease	Increase	Decrease	
Mining	Whole study area		23	77[a]	18	82[a]	44	56[b]	**46.7, p < 0.001**
	Hannukainen	A	39	61[a]	7	93[b]	21	79[a]	**26.7, p < 0.001**
	Kevitsa	B	7	93[a]	-	-	83	17[b]	**15.4, p < 0.001**
	Suurikuusikko	C	60	40[a]	-	-	80	20[a]	0.5, p > 0.05
	Kuotko	D	25	75[a]	-	-	80	20[a]	2.7, p > 0.05
	Sakatti	E	40	60[a]	64	36[a]	60	40[a]	1.3, p > 0.05
Tourism Development	Whole Study area		70	30[a]	50	50[b]	82	18[a]	**34.1, p < 0.001**
	Ylläs Ski Area	F	72	28[a,b]	58	42[b]	81	19[a]	**8.3, p < 0.05**
	Levi Ski Area	G	71	29[a]	36	64[a]	80	20[a]	5.3, p > 0.05
Snowmobiling	Whole Study area		65	35[a]	30	70[b]	56	44[a]	**27.9 p < 0.001**
	Ylläs area	H	83	17[a]	19	81[b]	33	67[b]	**27.7, p < 0.001**
Recreation facilities	Whole Study area		80	20[a]	84	16[a]	90	10[a]	4.6, p > 0.05
	Ylläs area	I	60	40[a]	72	28[a]	78	22[a]	1.7, p > 0.05
Nature Protection	Whole Study area		83	17[a]	82	18[a]	89	11[a]	4.8, p > 0.05
	Ylläs Area	J	64	36[a]	52	48[a]	100	0[b]	**12.8, p < 0.05**
	Hannukainen Mine Area	K	100	0[a]	59	41[a]	92	8[a]	5.5, p > 0.05
Forestry/logging	While Study area		10	90[a]	10	90[a]	10	90[a]	0.0, p > 0.05
Reindeer herding	Whole Study area		81	19[a]	89	11[a]	52	48[b]	**42.5, p < 0.001**

SOM Table 1. Spatial variables with operational definitions and number of markers placed in the study.

Values	
Recreation (n=2,514)	Areas are important for outdoor recreation activities (e.g., camping, walking, skiing, alpine, cycling, horse riding, etc.)
Hunting/fishing (n=927)	Areas are important because of hunting and/or fishing.
Gathering (n=596)	Areas are important for berries, mushroom or collecting herbs/plants here.
Snowmobiling/ATVs (n=179)	Areas are important for snowmobiling or ATV use.
Biological diversity (n=986)	Areas are important because they provide a variety of plants, wildlife, and habitat.
Undisturbed nature (n=845)	Areas are relatively untouched, providing for peace and quiet without too many disturbances.
Beautiful areas (n=1,329)	Areas are important because they include beautiful nature and/or landscapes.
Cultural history (n=278)	Areas are important because of their historical value, or for passing down stories, myths, knowledge and traditions, and/ or to increase understanding of the way of life of our ancestors
Income (n=211)	Areas are important because they provide tourism opportunities, forestry, mining, or other potential sources of income.
Special places (n=133)	Identify other areas that are important and indicate why
Preferences (allow/increase)	
Tourism development (n=285)	Increase or allow commercial tourism development (lodging, food, services, ski slopes, attractions)
Recreation facilities (n=317)	Increase or allow recreation facilities (trails, ski tracks, campsites)
Logging (n=44)	Increase or allow logging
Mining (n=220)	Increase or allow mining
Nature protection (n=439)	Increase or allow nature protection
Reindeer herding (n=300)	Increase or allow reindeer herding
Snowmobiles/ATVs (n=142)	Increase or allow the use of snowmobiles or ATVs (including snowmobile trails and/or extended seasons)
Increase other uses (n=137)	Describe other changes in use or activities to increase or be allowed
Preferences (restrict/decrease)	
Tourism development (n=155)	Decrease or restrict tourism development (lodging, food, services, ski slopes, attractions)
Recreation facilities (n=58)	Decrease or restrict recreation facilities (trails, ski tracks, campsites)
Logging (n=561)	Decrease or restrict logging
Mining (n=767)	Decrease or restrict mining
Nature protection (n=75)	Decrease or restrict nature protection
Reindeer herding (n=112)	Decrease or restrict reindeer herding
Snowmobiles/ATVs (n=152)	Decrease or restrict the use of snowmobiles or ATVs
Decrease other uses (n=21)	Describe other changes in use or activities to decrease or restrict

Figure 1. (a) Map of study area and (b) map of conflict reference sites in the study area.



SOM Figure 1. Mapped conflict potential for (a) mining using weighted preference (*WPS*) index, (b) mining using preferences and value (*PVS*), (c) nature protection using weighted preference index, (d) nature protection using preferences and values, (e) tourism development using weighted preference (*WPS*) index, (f) tourism development using preferences and value (*PVS*) index, (g) snowmobile activity using weighted preference index, (h) snowmobile activity using preferences and value index, (i) forestry/logging using weighted preference (*WPS*) index, (j) forestry/logging using preference and value (*PVS*) index, (k) reindeer herding using weighted preference index, and (l) reindeer herding using preferences and value index. R values show correlation between conflict indices.