Recreation benefits of Lake Puruvesi under various development alternatives

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Summary

This study is a part of Freshabit LIFE IP (LIFE14/IPE/FI/023) -project, where several measures will be implemented to improve the water quality of Lake Puruvesi. The purpose of this study is to examine the association between water quality changes and recreation use and estimate the recreation benefits before the management actions. An internet based survey was conducted to gather information from people visiting Lake Puruvesi. In particular, the focus was on respondents' perception on the current water quality and how the number of visits to Lake Puruvesi would change, if the water quality improved or decreased from the current state. The results indicate a clear connection between the water quality and the recreation benefits. The consumer surplus for a recreation trip under different water quality scenarios ranged between 153 euros for the best water quality and 82 euros for the worst water quality, while the consumer surplus for current water quality was 114 euros per trip.

Introduction

Recreation is one of the key ecosystem services that can be enhanced by management of lake ecosystems. Developing the quality of environment and the services for recreation affects also wellbeing effects from recreation. Measuring the changes in recreation behavior and benefits due to development projects provides information for justifying the management actions and for prioritizing various management alternatives. In this report, we are interested in the association between recreation behavior and water quality on a local scale i.e. on Lake Puruvesi in Eastern Finland.

In Finland, there are almost 190 000 lakes larger than 500 square meters, and nearly ten percent of the country is covered by water. Thus, it is evident that water recreation is an important leisure time activity in Finland. For example, about two-thirds of the Finnish population annually swims in natural water systems, 44% go fishing and almost half uses water bodies for boating (Sievänen & Neuvonen 2011). The water recreation of Finns is further strengthened by the leisure home culture (Sievänen, Pouta & Neuvonen 2007). Finland has a population of 5 million and there are approximately 500 000 leisure homes, often situated by a lake. Since water recreation is a significant leisure activity in Finland, it undoubtedly has effects on people's wellbeing. Thus, it is important to know how the benefits from recreation would be affected by potential changes in water quality (on national level Vesterinen et al. 2010; Lankia, Neuvonen & Pouta 2017).

Previous studies have shown the importance of different water quality attributes such as water clarity, absence of blue green algal blooms and low tendency for sliming (for review Ahtiainen, Pouta & Artell 2015). However, importance of these water quality attributes is always case specific. In this report, we are interested in Lake Puruvesi, which is one of the Freshabit LIFE IP project target areas. Case of Lake Puruvesi is special, as it is currently on excellent state, but facing a threat of eutrophication. Hence, people's perception on the water quality and its changes may differ from the objectively measured quality. This implies special challenges for the study. Regardless of the special conditions of Lake Puruvesi, this study enables the development of an approach that is applicable to other sites of lake restoration in Freshabit LIFE IP and other projects.

In this report, we evaluate the benefits of recreation and water conservation on Lake Puruvesi before management actions. We use the approach of combined contingent behavior and travel cost method to take into account the wide range of possible water qualities. The estimated demand functions based on this approach reveal the effect of water quality on water recreation, and allow us to calculate the welfare effects of water quality changes at the lake scale. Here, we present results of recreation benefits, but the full statistical models are estimated in future for welfare analysis (upcoming Deliverable Report of an approach for valuing recreation wellbeing effects). The final results would facilitate the comparison of recreation benefits with the cost of management. As the data collection and the analysis reported here takes place before the management actions, it is important to repeat the data collection and analysis after the implementation of measures to verify the ex-ante approach.

This report describes the survey based method and data and then provides results of recreation behavior, water quality perceptions, and the benefit estimates of recreation under different water quality conditions.

Case area

Lake Puruvesi is part of the Vuoksi water system and of the Lake Saimaa. Lake Puruvesi is located in Eastern Finland between South-Savo and North-Karelian regions and surrounded by Savonlinna and Kitee municipalities. The morphology of the lake is very complex with several large basins and over 850 islands. In total, 77 % of the lake area belongs to the N2000 site representing an oligotrophic lake. The catchment area in relation to the lake surface area (416 km^2) and volume (mean depth ~9m) is small.

The lake is known for its pure water and has unique, excellent underwater visibility that reaches up to 12 meters. Part of the water originates from groundwater entering the lake from below. The oxygen situation of the lake is good and water does not contain humus either. According to the general usability classification the water quality is on average excellent.

Unfortunately, recent observations have shown that eutrophication and spread of vegetation has increased around the shallow basins. Rocks can be slimy, and in some locations there exists thick eutrophic bottom sediment. Also blue green algal blooming has occurred few years. The main reason for eutrophication is forestry including forest cuttings and drainage of peatlands. Fields cover less than 10% of the catchment land area, but partly affect the eutrophication. Only noteworthy point source of nutrients is Kerimäki population centre.

The use of Lake Puruvesi for recreation is abundant, as it is popular location for summer cottages and also due to Punkaharju's status as a major tourism destination. The lake is actively used for fishing and other outdoor activities by local people, although there have been signs of declining water quality. In addition, many private enterprises in the region are dependent on outdoor water recreation activities.

In the Freshabit LIFE IP project, several measures will be implemented to improve the water quality of Puruvesi. The controlling of loading targets both agricultural and forestry loads. The measures include 12 hectares new floodplains and 55 action locations with e.g. sedimentation pits, peak runoff control and wetland bay management. Also removal of fish is carried out by removing dense fish stocks in selected target areas. Recreation facilities will be developed by providing new trails, information boards, tables and benches. This report provides information on the visitors' perceptions of the water quality and recreation benefits before these measures are implemented.

Methods and data

Travel cost and contingent behavior methods

Traditional way to estimate the benefits of water-related and other outdoor recreation is to use travel cost (TC) method (Ward & Beal 2000, Haab & McConnell 2002). In this method, a demand

curve for recreation is derived from the travel cost that varies between individuals. The benefits of the recreation can then be estimated as a consumer surplus. Nevertheless, the travel cost method does not take differences in the site quality in to account and, hence, their effect on recreational value is not provided.

In order to provide information on the effect of water quality on recreational value, travel cost method can be supplemented with contingent behavior approach (e.g. Bhat 2003, Hanley, Bell & Alvarez-Farizo 2003, Alberini, Zanatta & Rosato 2007). In this method, the respondents respond to hypothetical questions concerning their future behavior under different environmental quality scenarios (Whitehead, Haab & Huang 2000). This makes possible to examine the effect of water quality that is not currently observed (Englin & Cameron 1996, Eiswerth et al. 2000). Supplementing travel cost method with contingent behavior method improves validity of the results as the stated behavior is grounded in real behavior. Also, combining these two approaches provides more than one observation per respondent, therefore improving statistical efficiency (Hanley et al. 2003).

Survey

To explore the perceptions on the water quality and the recreation use of Lake Puruvesi, we implemented a survey that targeted people who had visited Puruvesi and used area for recreation during the last 12 months. The survey began with questions concerning respondents' relationship with Puruvesi, recreation activities, evaluation of overall water quality and the importance of different water quality attributes.

The survey then focused on trips to Puruvesi. It elicited the information needed for a travel cost model and a contingent behavior model, i.e. both revealed- and stated-preference questions concerning the trip frequency were asked. The respondents identified the location of their last visitation site and reported the number of trips taken to this site during the previous twelve months. The distance from the home or leisure home together with the travel time to the site were used as the basis for the travel cost variable.

The survey then proceeded to questions concerning site characteristics of the last visited site on Puruvesi. These questions included the respondents' perceptions of the water quality. To obtain water quality variables as usable as possible, it was important to select water quality attributes that are understandable and easily observed by individuals. The selected water quality indicators, which are also affected by eutrophication, included water clarity, blue-green algal blooms, the amount of slime on piers and rocks, vegetation (reed) on the beach and the muddiness of the beach. These indicators can be measured objectively and are therefore applicable in management design. Especially water clarity is an important determinant of water recreation (Egan et al. 2009). As it has been shown to correlate with nutrient levels, water clarity can be improved by using management activities that decrease nutrient loads (Sandström 1996, Soutukorva 2005).

Respondents evaluated their perception of five different water quality attributes on a scale from one to four. They were also able to select Don't know option. For water clarity, a score of one indicated that the bottom could be seen from the surface at a water depth of over eight meters, and a score four that the bottom was visible from the surface at a depth of under two meters. For blue-green

algae, score of one indicated that there were no blue-green algal blooms noticeable during the summer, and a score four that there was blooming during more than 10 days in a summer. For sliming, a score of one indicated that there was no slime on piers and rocks, and score of four that there was abundant sliming. Attribute indicating the amount of reed on the beach ranged from none to abundant, and the muddiness of the beach ranged from no mud to over 10 cm of mud.

Water quality scenarios

After the revealed preferences questions concerning the actual past behavior, the respondents were presented with four contingent behavior questions asking how their visits to Lake Puruvesi would change under different water quality scenarios. The respondents were given the following information before presenting alternative scenarios. *Many things affect the water quality of Lake Puruvesi. The water quality is maintained/improved in the Puruvesi area by many measures, for example by building wetlands to prevent nutrient flow to waterbodies. Despite these measures, the water quality may deteriorate locally, if the conditions change in the area, for example due to the changes in forestry and agriculture.*

The respondents were then asked to state how many times they would visit the site they had last visited under different water quality scenarios. Table 1 presents these four different water quality scenarios. The first contingent behavior question asked how many times respondents would visit the site in the next twelve months if the water quality of the water system was the best possible (Scenario A). The following contingent behavior questions presented rest of the scenarios ending in the worst water quality in Scenario D. The current measured water quality of Lake Puruvesi is on average between Scenarios A and B. Overall, the water quality of Lake Puruvesi is excellent, especially in the middle of the lake, but the quality is inferior near the shoreline.

Table 1. Different water quality scenarios.

	Scenario A
Water clarity	Over 8 meters
Blugreen algae blooms	None
Sliming	None
Amount of reed on the beach	None
Muddiness of the beach	No mud

	Scenario B
Water clarity	6 meters
Blugreen algae blooms	1-4 days
Sliming	Slight
Amount of reed on the beach	Individual canes
Muddiness of the beach	Under 2 cm

	Scenario C
Water clarity	4 meters
Blugreen algae blooms	5-10 days
Sliming	Some
Amount of reed on the beach	Patchy
Muddiness of the beach	3-10 cm

	Scenario D
Water clarity	2 meters
Blugreen algae blooms	More than 10 days
Sliming	Abundant
Amount of reed on the beach	Abundant
Muddiness of the beach	Over 10 cm

Data

The data were collected during the end of the year 2016 using an Internet based survey that allowed incorporation of spatial information. The respondents consisted of those who had responded to visitor survey in Puruvesi implemented by Metsähallitus (State Forest Enterprise) in the summer 2016. In addition, the survey was sent to the members of Pro Puruvesi association. The purpose of these data collecting methods was to reach as many respondents who had visited Puruvesi during the last 12 months as possible.

The questionnaire was tested with a pilot study and then finalized based on the answers obtained from the pilot. Overall, the survey was sent to 868 recipients and 327 respondents replied to the survey. Out of these respondents, 251 completed the whole questionnaire, with the response rate being 29%. Table 2 presents the descriptive statistics of the respondents.

Table 2. Descriptive statistics.

	Mean	Std.dev.	Min	Max
Living in Puruvesi	0.22	0.414	0	1
Leisure home	0.69	0.462	0	1
Boat owner (user)	0.83	0.377	0	1
Distance to Puruvesi (km)	158.6	175.62	0.01	1000
Number of recreation activities	5.01	1.78	0	8
Overall water quality	2.56	0.662	0	5
Importance of water quality	1.57	0.438	0	5
Gender (1=male)	0.64	0.481	0	1
Age (years)	57.5	12.3	18	81
High education	0.51	0.50	0	1
Household size (persons)	2.40	1.04	1	6
Individual gross income (€/month)	3197	1264	500	5500

The respondents had a strong connection to Lake Puruvesi as 22% of the respondents lived at the waterfront and almost 70% had a leisure home in Puruvesi. The majority of the respondents (83%) had an access to boat. The mean one-way distance travelled to Lake Puruvesi was approximately 158

kilometers, varying from 10 meters to 1000 kilometers. For half of the sample, however, the distance was only 45 kilometers or less. The respondents were on average engaged in five different recreation activities during the last twelve months. The perception on the water quality of Lake Puruvesi in general was 2.65 (scale from 1 – excellent to 4 – poor), and the mean importance of water quality attributes was 1.57 on a scale ranging from 1 to 4 (very important – not at all important). The sample consisted of slightly more men than women and the respondents' average age was 57 years. The mean monthly gross income was a bit over 3000 euros per respondent.

Results

This section of the report presents the results obtained from the survey implemented in Puruvesi. It considers the trips made to Lake Puruvesi, the recreational activities, locations for recreation and the perceived water quality. The benefits of recreation are also estimated.

Use of Lake Puruvesi for recreation

The average number of trips taken to Lake Puruvesi in the previous 12 months was 58, while the largest reported number was 365, as some of the respondents lived at the waterfront. The median number of trips was 12, meaning that half of the respondents have taken trips 12 times in a year or more seldom. The most popular recreation activities were spending time on the beach, swimming and boating. Different recreation activities and their frequencies are summarized in Table 3.

Table 3. Recreation activities in Lake Puruvesi.

	% of the respondents	Standard deviation
Spending time at the beach	98	0.148
Swimming	95	0.220
Boating	81	0.393
Canoeing or rowing	73	0.446
Fishing in summer	68	0.466
Skiing	44	0.496
Fishing in winter	31	0.462
Skating	20	0.401

As a part of the survey, the respondents were asked to place their last visited site in Lake Puruvesi to the map. Figure 1 shows these visitation sites. As can be seen, there are observations all around Lake Puruvesi and they are not concentrated only to couple specific locations.

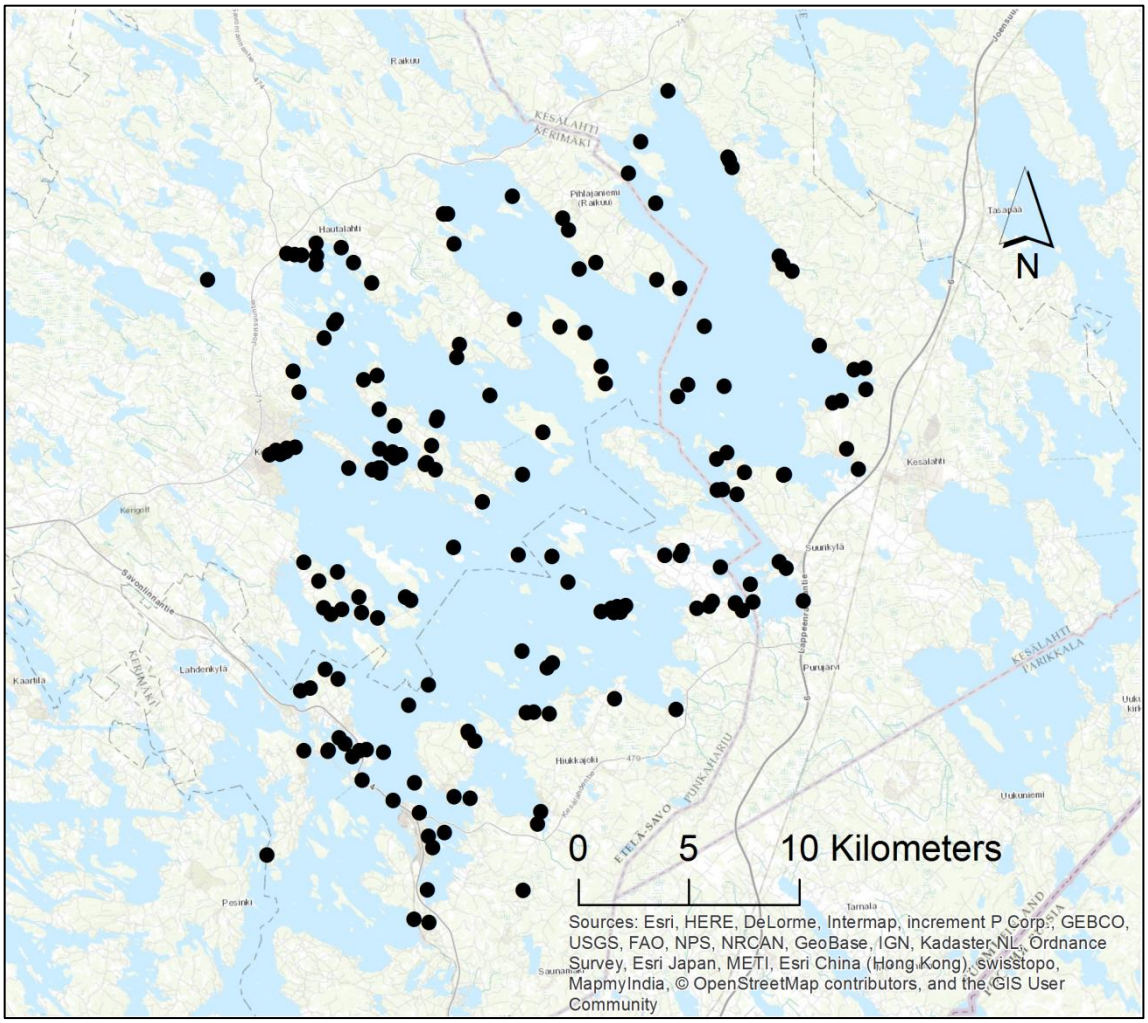

Figure 1. Map of the respondents' latest visitation sites in Lake Puruvesi (map by Janne Artell).

Water quality perceptions

The respondents were asked to evaluate the water quality of Lake Puruvesi in general as well as in the location they had last visited. The respondents also assessed how the water quality has changed during the last 10 years. The answers indicated that the direction in which the water quality in Lake Puruvesi is currently developing is somewhat concerning, as 71.2% of the respondents felt that water quality had deteriorated during the last 10 years. Meanwhile, 16.6% of the respondents thought that it had stayed the same and only 0.6% considered that the water quality had improved. A bit over one-tenth (11.5%) of the respondents did not have an opinion on the matter.

Figure 2 presents the perceptions of general water quality of Lake Puruvesi perceived by respondents. The majority of the respondents considered swimmability, fishability and water clarity to be in either excellent or good condition. In turn, water level stability, sliming and amount of reed in beach areas were seen as more problematic.

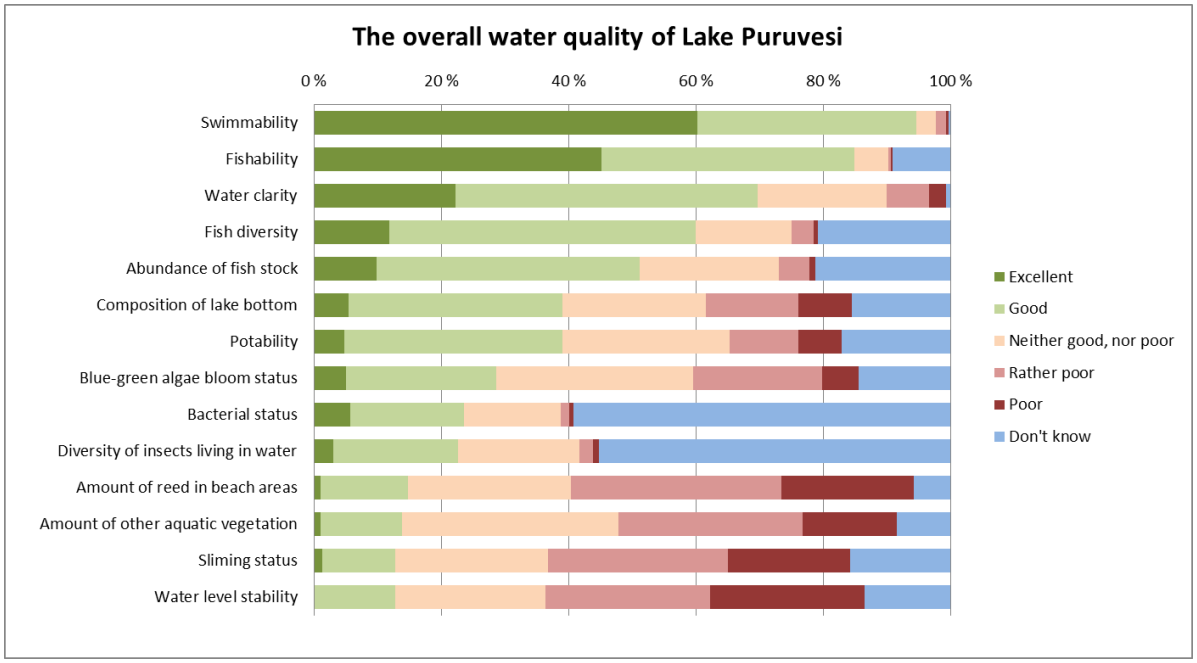

Figure 2. The overall water quality of Lake Puruvesi perceived by the recreationists.

In addition to their assessment of the current state of water quality attributes, the respondents also rated how important these quality attributes are to them (Figure 3). Most important attributes were swimmability, water clarity and the low number of blue-green algal blooms. These attributes were very important to over 90% of the respondents. Potability (i.e. suitability for drinking) was the least important among these water quality attributes, but still, it was very important or important to 68% of the respondents. Overall, all the attributes presented to the respondents were rated highly.

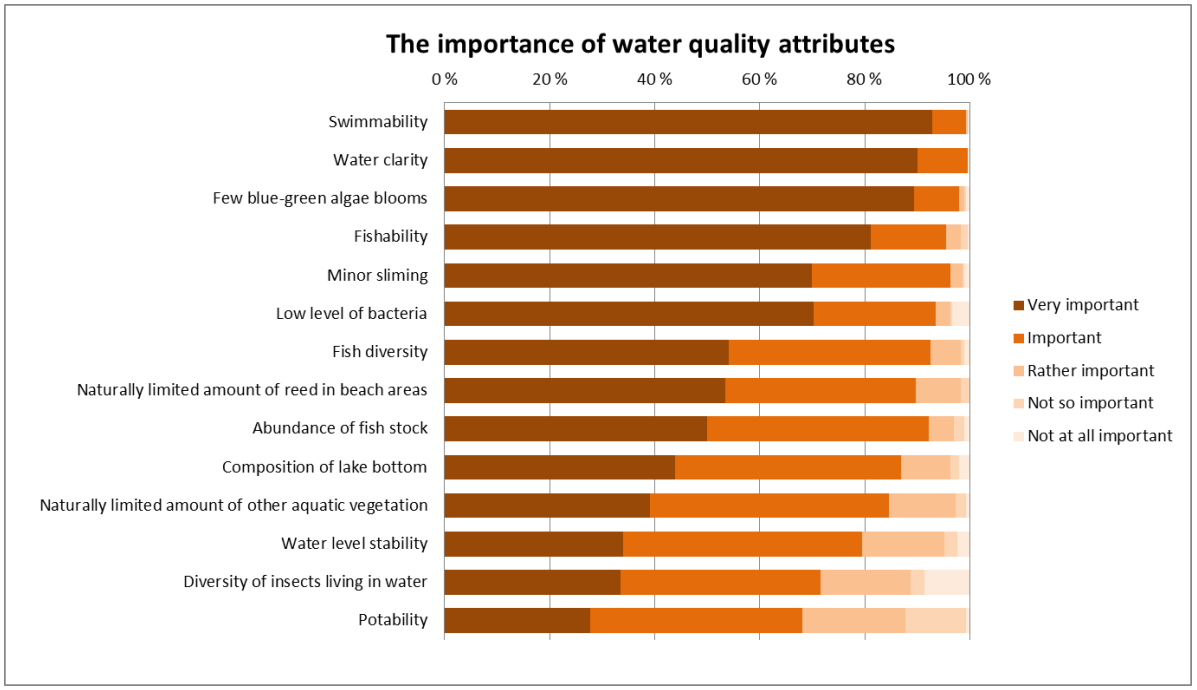

Figure 3. The importance of water quality attributes perceived by recreationists at Lake Puruvesi.

The respondents also assessed the water quality of the last site they had visited in Lake Puruvesi. Table 4 and figure 4 present respondents' perceptions on the site-specific water quality. As the scale was set in such a way that best quality had score of one and worst quality score of four, the lower the mean value is, the better the perceived state of the water quality attribute. Concerning the water clarity of the last site visited, the majority (43%) of the sample reported that the bottom of the water system could be seen from a depth of four meters. As Puruvesi is exceptionally clear watered lake, respondents also reported the bottom to be visible up to a depth of six meters (25%) and eight meters or more (6%). Approximately one-fifth of the respondents stated that the water clarity was two meters or less. A bit under 40% of the respondents reported that there were no blue-green algal blooms during the summer, and 27% stated that there were algal blooms only during 1-4 days. Only 4% of the respondents reported blue-green algae blooms to be present more often than 10 days in a summer.

The situation with sliming on piers and rocks was not as good, as only 12% of the respondents experienced no sliming. Instead, the majority (39%) reported some sliming. Also the amount of reed in beach areas was not optimal as many respondents reported reed to be either abundant (33%) or patchy (43%). The muddiness of the beaches appeared to be in better state. There was no mud in one third of the sites and approximately 30% of the respondents told that the depth of the mud was under 2 cm, whereas 14% of the sites had mud layer deeper than 10 cm.

Table 4. Site-specific water quality perceptions (1 excellent – 4 poor).

	Mean	Std.dev.
Water clarity: depth from which the bottom is still visible	2.83	0.83
Bluegreen algae blooms noticeable during summer	1.78	0.87
Sliming: slime on piers and rocks	2.58	0.89
Amount of reed on the beach	3.09	0.82
Muddiness of the beach	2.15	1.06

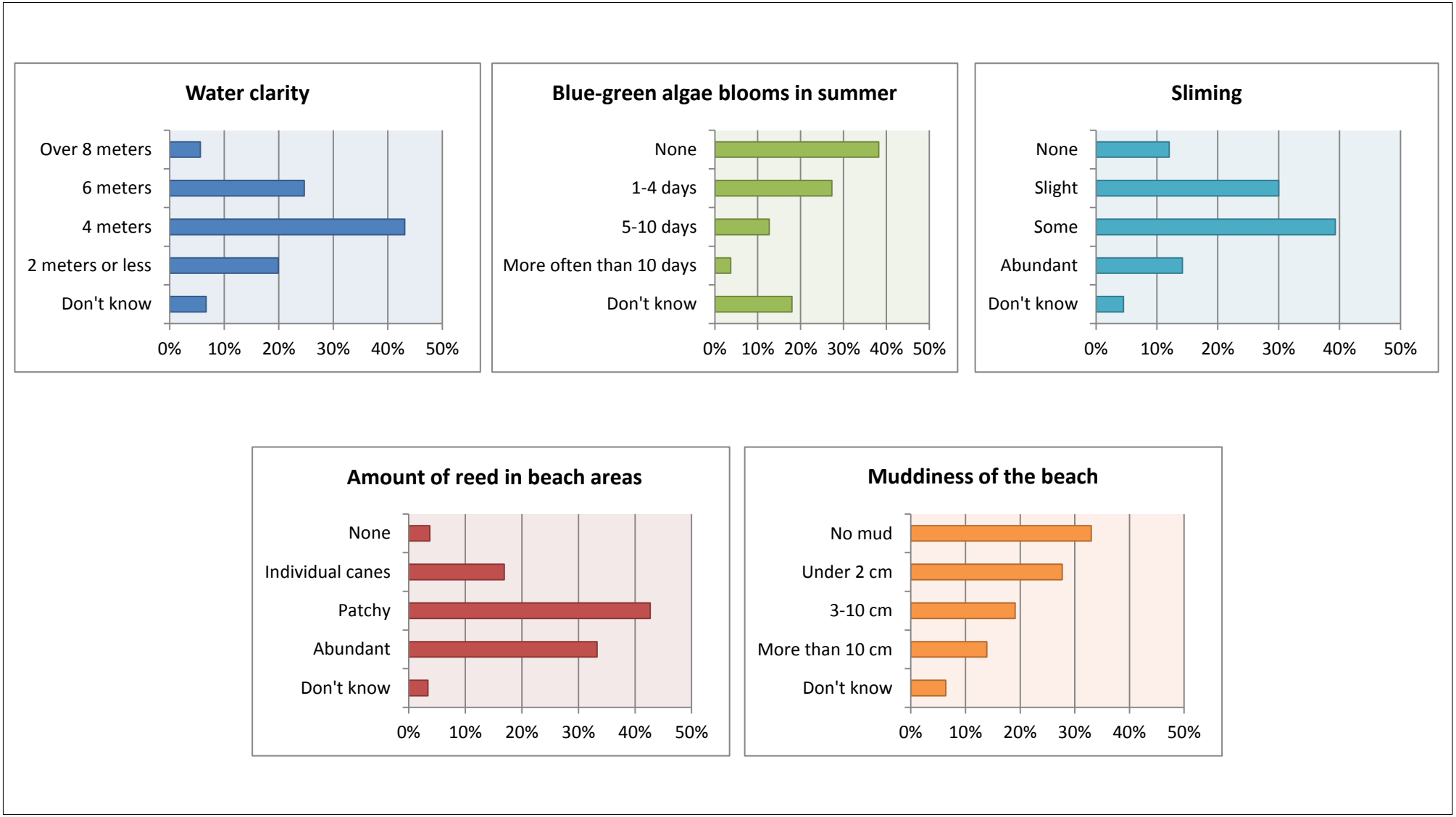

Figure 4. The respondents' perceptions on the water quality of the last site they have visited.

The ratings of these five different water quality attributes were used to calculate the mean water quality for each visitation site. Figure 5 presents a map showing the respondents' perceived water quality on these sites.

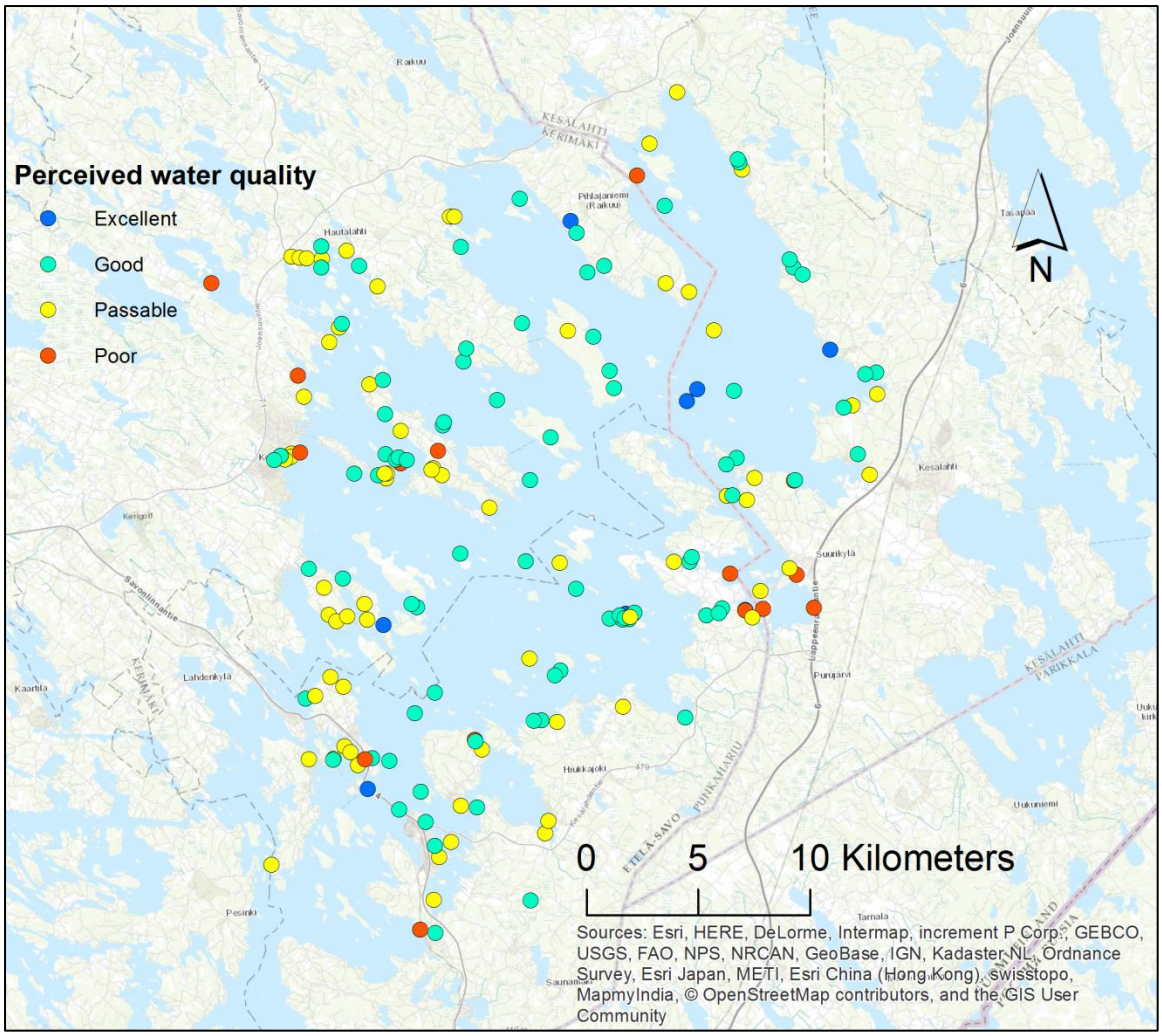

Figure 5. Respondents' perceptions on the water quality in the visitation site (map by Janne Artell).

Two maps showing the phosphorus and hummus loads in Lake Puruvesi are provided in Appendix. Comparison of the perceived water quality (figure 5) with these maps shows that the respondents' perceptions correspond well with the actual observed water quality.

Recreation use under water quality changes

In addition to asking the respondents about their actual trips made to Puruvesi during the last year, we also examined how their trips would change, if the water quality of Lake Puruvesi changed. We used contingent behavior questions to present each respondent four different water quality scenarios with varying water quality. The results showed a clear drop in the amount of trips as the

water quality decreases. Table 5 presents the number of trips (mean and median) under each water quality scenario.

Table 5. Number of trips under different water quality scenarios.

Water quality	Trips	
	Mean	Median
Current state	58	12
Scenario A (best water quality)	61*	20
Scenario B	55*	12
Scenario C	47*	10
Scenario D (worst water quality)	30*	5

*hypothetical trips

If the water quality declined according to Scenario D, so that the water clarity was less than two meters, blue-green algal blooms were present more than 10 days a year, abundant slime was present, there was abundant reed and mud layer on the beach was over 10 cm, the respondents would make on average 30 trips in a year. Conversely, after a hypothetical improvement in water quality from the current state to Scenario A, the mean number of trips would increase to 61. It should be noted that the median values for the number of trips are noticeably lower than the mean values. This is because 22% of the respondents are living in Puruvesi, thus visiting the lake daily and raising the mean.

Benefits of recreation

To examine the value of recreation, we utilized travel cost model. Travel cost model was estimated with panel version of Poisson regression. The results of this model are reported in Table 6. Number of respondents in the travel cost model is 221, since all of the respondents who did not report their travel costs were excluded from the model.

As expected, travel cost is negative and significant. Interaction variables between travel cost and different scenarios were included to measure the welfare effect of water quality changes, as they allow the slope of the travel cost to vary. All other interaction variables were significant except for scenario C. The coefficients for interactions with travel cost and scenario A and scenario B were positive indicating that better water quality affects travel cost positively, i.e. improvements in water quality would make people less responsive to changes in travel costs. In turn, interaction with travel cost and scenario D was negative, implying an increase in the price elasticity, i.e. people would be more sensitive to changes in travel costs in case of decreased water quality. As the interaction between travel cost and scenario C was not significant, travel costs for current state and scenario C do not differ.

Table 6. Travel cost model.

Independent variables	Coefficient (standard error)
Constant	4.192 (0.110)***
Travel cost	-0.009 (0.001)***
Travel cost – Scenario A interaction	0.002 (0.000)***
Travel cost – Scenario B interaction	0.001 (0.000)***
Travel cost – Scenario C interaction	0.000 (0.00)$^{ns.}$
Travel cost – Scenario D interaction	-0.004 (0.000)***
Number of observations	1101
Number of respondents	221
Log-likelihood	-9074.49
Restricted log-likelihood	-9023.12

*** p <0.01 , ns. =non-significant, p >0.10

The coefficients from the travel cost model were used to estimate the consumer surplus for trips to Lake Puruvesi. First, we calculated the recreation value for the current water quality level. The consumer surplus estimate for an average trip was 114 euros. Interaction variables were used to estimate consumer surplus for different water quality scenarios. Consumer surplus estimates for scenario A and B were 153 and 134 euros, both being higher than the estimate for the current state. In the case of worst water quality (scenario D), the consumer surplus was lower, 82 euros.

Table 7. Recreation benefits estimates.

Water quality	**Consumer surplus per trip, €**
Current state	114
Scenario A	153
Scenario B	134
Scenario C	114
Scenario D	82

Conclusions

The survey yielded responses all around Lake Puruvesi. The majority of the respondents felt that the water quality has been deteriorating during the last ten years. The swimmability, fishability and water clarity were seen to be in excellent or in good condition. These were also considered to be in top four of the most important water quality attributes. In addition, low number of blue-green algal blooms was very important to the respondents. While considering the last site they had visited in Lake Puruvesi, the respondents perceived the current state of water clarity and blue-green algal blooms as well as muddiness of the beach to be in relatively good level. However, the current state of sliming and the amount of reed were not as good. Respondents' perceptions on the water quality were in line with measured water quality.

The results of this study suggest that Lake Puruvesi produces apparent recreation benefits and these benefits are clearly linked to the water quality. The number of hypothetical trips made to Lake Puruvesi changed between different water quality scenarios decreasing as the water quality decreased. The consumer surplus for a recreation trip ranged between 153 and 82 euros under different water quality scenarios, while the consumer surplus for current water quality was 114 euros per trip.

The analysis of the data will continue. The next step will be conducting a more comprehensive welfare analysis to compare the recreation benefits of different water quality scenarios with the cost of management needed to achieve the corresponding water quality.

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Appendix

The phosphorus consentration and the amount of humus in Lake Puruvesi. Maps from Puruveden taustaselvitysraportti (Etelä-Savon ELY-keskus 2013).

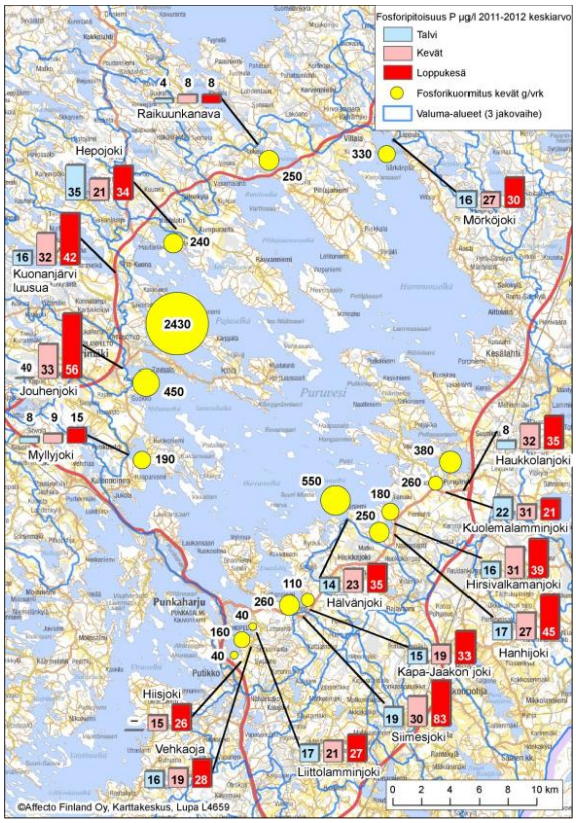

Figure 1. Phosphorus consentration in Lake Puruvesi.

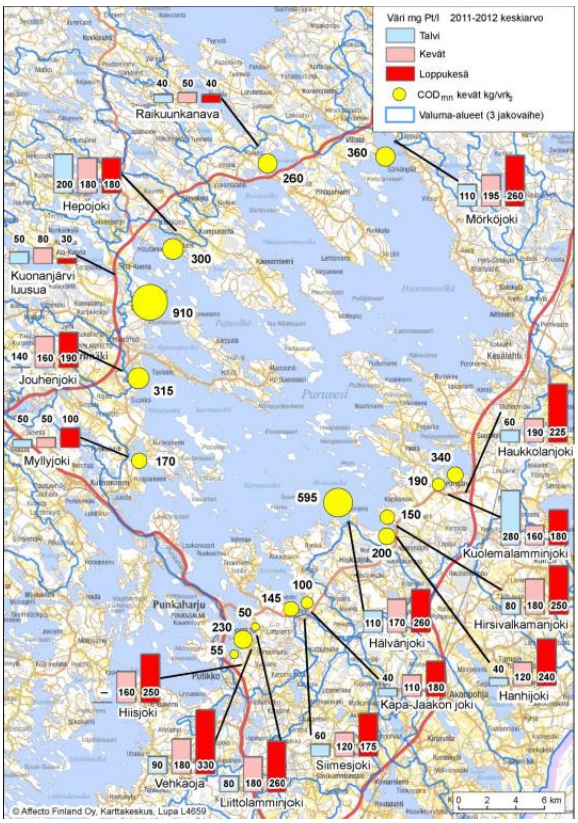

Figure 2. The amount of humus in Lake Puruvesi.