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Appreciation of Nordic landscapes and how the bioeconomy might change that: Results from a discrete choice experiment

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ABSTRACT

Surface waters and their catchments provide societal benefits through cultural ecosystem services like recreation and appreciation of nature. The supply of cultural services depends on landscape characteristics like the extent of forested area, water clarity and the intensity of land use. These attributes vary spatially and will likely be influenced by a possible transition to a bioeconomy, i.e. a shift towards more use of renewable, biological resources like forestry products. Using a discrete choice experiment, we quantified survey respondents' preferences and willingness to pay for changing landscape attributes in six Nordic catchments and explored how different characteristics of both the landscape and respondents affect these preferences. Results from a mixed logit (MXL) model analysis show preference for a more equal distribution of agriculture and forest, improved water clarity, increased area used for nature reserves, reduced flood frequency and increased employment from agriculture, forestry and fishery. Variation in preferences between study areas is significant in several of these attributes, and likely linked to respondent characteristics. Since these attributes can be affected by the transition to a bioeconomy, policy makers should take into account the effects of this transition on the supply of cultural services by considering the effects on welfare generated by cultural services when implementing land management policy.

1. Introduction

The ecosystem services framework views ecosystems from an anthropocentric perspective, in which the key variables are the quantified benefits that society derives from the existence of ecosystems. It gives insight into benefits that may not be easily recognised by policy makers and the public, but which can be substantial (MA, 2005; Fisher et al., 2009; Grizzetti et al., 2016), making the framework of increasing interest for policy makers (Belling, 2017). Cultural services are a subset of ecosystem services that are derived from experiential and intellectual activities through interaction with ecosystems (Daniel et al., 2012; Haines-Young and Potschin, 2017). Examples are the possibility to recreate in a lake or river, the enjoyment of being in a natural scene or the knowledge that a certain species exists somewhere in the world. Cultural services are widely recognised as providing a significant contribution of total ecosystem services value (Brander et al., 2006; Daniel et al., 2012). They are also possibly the services that are most widely recognised by the general public (Larson et al., 2016), making them especially important for policy making with an interest in public perception.

Surface waters and their catchments supply a variety of cultural services (Barton et al., 2012; Richnau et al., 2013), from direct use of the water like boating, swimming and fishing, to enjoying the aesthetics of the total landscape. The value of cultural services supplied by catchments depends on a number of factors (Garcia-Martin et al., 2017) which can be grouped into two kinds: attributes of the landscape supplying the potential services, and preferences of the individuals benefitting from these services (Halkos and Matsiori, 2014). In Europe, previous work on the relationship between landscape attributes and cultural services has been performed in the context of man-made landscape changes, such as vegetation removal (Boerema et al., 2014), agricultural practices (Bernues et al., 2014), water quality improvements (Czajkowski et al., 2015), effects of river restoration (Vermaat et al., 2016; Brouwer and Sheremet, 2017) and measures specifically applied for the enhancement

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of recreational value (Juutinen et al., 2017). Analysing the relationship between cultural services and these attributes is complex, and intercorrelations between the different attributes likely exist (Garcia-Martin et al., 2017). Further complicating the matter, this relationship is not one-directional: catchments are subject to pressures from both societal (Lepistö et al., 2014) and climate change (Øygarden et al., 2014), all potentially affecting the supply of cultural services.

One possible change that can affect these attributes within the coming decades is the transition from our current fossil fuel based society to a bioeconomy (Hetemäki et al., 2017). This transition may involve a range of societal, economic and land use changes, and can play a major role in addressing climate change, food security, health, industrial restructuring and energy security (Issa et al., 2019). What a bioeconomy constitutes is not strictly defined, but key aspects are increased development and use of biotechnology, more widespread and efficient use of biological materials, optimised use of energy and nutrients and promotion of biodiversity and sustainable land management (Bugge et al., 2016). Policy makers have expressed support for and interest in such a transition (Belling, 2017). The shift to a bioeconomy can have a substantial effect on land use and land management intensity, for instance due to forestry practices aimed at increasing timber production for use as biofuel or as material input in production processes (Heinonen et al., 2018). This can impact water quality negatively (Forsius et al., 2016), as well as other ecosystem traits linked to recreational value, such as habitat availability and berry yields (Eyvindson et al., 2018). If the demand for biological resources increases, areas used as nature reserves might also be converted to productive areas. Flow regimes and flood frequencies can also be impacted by changes in land management (Komatsu et al., 2011; Collentine and Futter, 2018), possibly leading to changes in recreational possibilities. With increasing demand for biological resources, local employment in agriculture and forestry can also be affected, as well as in the recreational sector by changes in demand for recreation. In Europe, the transition to a bioeconomy has been a recognised policy aim since the launch of the European Commission's Bioeconomy Strategy in 2012 (Geoghegan-Quinn, 2012). The strategy acknowledges that European landscapes provide a wide variety of ecosystem services, including cultural services like recreation, and that the green shift to a bioeconomy needs to take into account likely effects on ecosystem services supply. This also suggests that there needs to be some knowledge on how landscape change due to the green shift will affect benefits from cultural ecosystem services. The previous paragraph draws from a substantial literature on the links between landscape change and recreational value, but an important issue is transferability (Bateman et al., 2011, Brown et al., 2016): transferring estimates from previous work to new sites comes with uncertainty both due to respondent- and area-related variability. Therefore, collecting data specific to the study area is generally preferred.

The links between changes in land management and the potential supply of cultural services are the motivation for this study. It is of interest to decision makers and land use planners to consider how societal changes might affect the value of benefits derived from ecosystems. Though the links between landscape attributes and supply of cultural services have been studied before (Lankia et al., 2015; Queiroz et al., 2015; Brown et al., 2016), and comparative multi-national studies on public preference for ecosystem services have been done (Czajkowski et al., 2015; Dallimer et al., 2015), to our knowledge a valuation study with consistent attributes linked to bioeconomy development on a multi-national scale has not been performed. Doing this allows for analysis of the causes of variation and facilitates an integrative assessment of the effects of this transition on an international scale. Though one can argue that there are intrinsic and communal values to these cultural services that cannot be measured in monetary terms (du Bray et al., 2019), we argue that monetisation offers a way to elicit preferences under scarce resources, facilitates cost-benefit analysis for different scenarios, and allows for quantitative analysis of trade-offs and synergies between different ecosystem services.

The aims of this explorative study are: (1) To quantify the preference and willingness to pay for landscape changes that can arise from the transition to a bioeconomy for consumers of cultural ecosystem services; (2) To explain the observed variation in these preferences from catchment and population characteristics across the Nordic countries.

2. Methods and data

2.1. Study area selection

We chose to focus on catchments in the Nordic countries (Denmark, Finland, Norway and Sweden) because these countries have set the common goal of transitioning to a bioeconomy (Belling, 2017), and Nordic catchments are often intensively used by sectors that might be impacted by the transition to a bioeconomy, like forestry and agriculture. We selected our study areas to cover the variation in land use, population density and overall geography characterising the Nordic countries. We sought at least one catchment in each of these countries (Table 1, Fig. 1, Fig. 2). Key selection criteria were the availability of respondents, defined by a nearby city with at least 50,000 inhabitants, and the availability of data on land use, water quality and water quantity: ample data availability allows for quantification of other provisioning and regulating ecosystem services for estimation of total economic value as well (Immerzeel et al., 2021). We aimed to select a mix of catchments representing both agricultural, more densely populated areas and forested, less densely populated areas. When we selected multiple catchments per country, we did so based on maximal contrast in size, land used as forest and agriculture and population density.

2.2. Survey design

We used a discrete choice experiment (DCE) to elicit preference and willingness to pay (WTP) for changes in environmental condition. A DCE is a survey based stated preference method designed for estimating the marginal value of change in separate environmental attributes (Adamowicz et al., 1998; Rakotonarivo et al., 2016) and is therefore often used in scenario studies on environmental change. The respondents are asked to choose their preferred alternative and are assumed to select the option that produces highest personal utility. The alternatives also include a cost to respondents, allowing estimation of willingness to pay for different alternatives or attribute levels. We used the guidelines as presented by Johnston et al. (2017) for designing the experiment as well as for collecting and analysing the data. In our DCE, we presented respondents with choice cards (see Fig. 3 for an example). For each choice card, respondents were asked to make a choice between three scenarios for a situation 30 years in the future. Each scenario consisted of combinations of landscape attribute levels. The combinations were selected for efficiency of analysis and did not necessarily follow a coherent storyline of future development. Key criteria for attribute choice were their expected sensitivity to change from the implementation of a bioeconomy and their understandability to respondents, based on pre-testing. In the final design, we used the attributes as described in Table 2. We did not use the term 'bioeconomy' in the survey text because we assumed it was not commonly understood among respondents, as well as not strictly defined: it might carry different connotations in different countries and between different subgroups of respondents, possibly causing uncontrolled variation.

On each choice card, Option A was a business-as-usual scenario (BAU), where current trends in land use are extended into the future – this served as an opt-out choice without changes in land management.

Table 1
Study area descriptions showing size and land use for forest, agriculture, water bodies, urban area and nature reserves as percentage of the total area, as well as the dominant agro-ecosystem, average population density and the proximity of the closest city to the catchment. We took land use values for forest, agriculture, water bodies and urban area from 2012 CORINE land cover data, a European land cover dataset based on satellite data covering 39 countries (Buttner et al., 2000). We took the area of nature reserve from GIS-databases of the national environmental agencies. We used population data from 2019 estimates by WorldPop.[1] We defined cities as having more than 50,000 inhabitants.

	Halden-vassdraget	*Orre-vassdraget*	*Odense*	*Simojoki*	*Sävjaån*	*Vindelälven*
Country	Norway	Norway	Denmark	Finland	Sweden	Sweden
Size (km^2)	1006	102	1199	1178	733	778
Forested area (%)	67	3	6	76	60	75
Agricultural (arable and pasture) area (%)	17	70	80	2	32	6
Water area (%)	6	15	1	1	1	2
Urban area (%)	1	8	12	0	2	1
Nature reserve area (%)	3	10	0	14	2	1
Dominant agro-ecosystem	Forestry	Pasture	Cropland	Forestry	Cropland	Forestry
Population per km^2	16	167	205	1	41	5
Closest city	Oslo	Stavanger	Odense	Oulu	Uppsala	Umeå
Distance from city (km)	20	15	0	70	0	20

Options B and C were alternative future scenarios, which included an annual environmental tax per household and changed landscape attribute levels. Each attribute had three possible levels, except the tax attribute, which had six levels, based on national household purchasing power and experience from previous choice experiments (Grammatikopoulou et al., 2012; Juutinen et al., 2017; Spegel, 2017).[2] The attribute levels were based on the current situation per study area for each attribute. Before filling out the cards, respondents were informed on the current state of the various landscape attributes to familiarise them with the attributes. For the specific attribute levels per study area, see Supplement 1.

Thirty choice tasks were constructed with a D-efficient design using NGene (version 1.2.0) software. To minimise the burden on respondents, the choice tasks were divided into six blocks giving each respondent five choice tasks to respond to. The final design has a D-error of 0.001. While a Bayesian efficient design, e.g. Juutinen et al. (2014), would have been preferable, the mode of survey (personal interviews) in different countries did not allow for large scale pilot studies to attain priors. The DCE design is added in Supplement 1.

Beyond the DCE, we asked questions on the respondent's current use of the landscape for recreational purposes and their opinion on environmental issues. For this we included the New Ecological Paradigm Scale (NEP-scale), a revised version of the New Environmental Paradigm Scale, which is used to measure the ecological-mindedness of respondents' worldview (Dunlap and Vanliere, 1978). This scale has been used in a wide variety of studies to measure concern with environmental quality (Dunlap et al., 2000) and is known for its cross-cultural applicability (Hawcroft and Milfont, 2010). In it, respondents are presented a series of statements that either endorse an anthropocentric world view or an ecocentric world view. Respondents must rate their agreement from 'fully disagree' to 'fully agree'. We transformed these responses to a score per respondent on a five-point scale to measure their ecological-mindedness. Hawcroft and Milfont (2010) performed a meta-analysis of studies using NEP-scores on this five-point scale, allowing us to compare our results with a large international dataset. We also asked questions on general demographic information, such as age, gender, education level, occupation and income, to be used in statistical analysis as interaction terms and for validation of sample representativeness. One of the questionnaires is available in Supplement 2.

We performed two qualitative pre-tests of the questionnaire and DCE design, to assess whether the attributes and their levels were realistic to respondents and whether the questions were easy to understand. The first was performed on the survey population in collaboration with Lars Selbekk, manager at the Haldenvassdraget River Basin District (Vannregion). He distributed the questionnaires among colleagues at the municipal office of Marker municipality in the Haldenvassdraget study area in the period 25–31 May 2018. The second pre-test was performed with a small focus group of researchers during the annual Biowater meeting from 1 to 6 June 2018. Around ten researchers filled out the questionnaire. This group consisted of both economists familiar with designing DCEs, and researchers unfamiliar with the theory and practice of DCEs. Here we focused on applicability of the attributes to our other study areas as well. Because we aimed at consistency between study areas, we did not perform separate qualitative pre-tests for each subsequent study area. Instead for each study area we checked the accuracy of attribute levels with local experts and evaluated on the first day of data collection for each site whether respondents understood and agreed with the design. Though Johnston et al. (2017) advise the use of quantitative pre-testing within the target population, we chose not to do so because the large geographic spread of our study sites made quantitative pre-testing in all sites logistically impossible within the study's timeframe, since we were limited to summer seasons for efficient data collection. We made minor adjustments based on feedback from the pre-testing sessions.

2.3. Data collection

We performed the survey on-site. This allowed us to perform face-to-face interviews, minimising risk of misinterpretation of the questions and giving us opportunity to collect opinions on both the topic and the quality of the survey. Also, as Lindhjem and Navrud (2011) show, there appears to be no significant difference in results between internet or face-to-face interviews, but a higher response rate for face-to-face interviews, potentially limiting self-selection bias in the data. We defined the population for sampling as: all the users of cultural services supplied by the catchment landscape. This included both residents and visitors, so for each study area, we wrote a version of the questionnaire in English and made a translation in the local language. In each area, two or three surveyors visited the area and performed face-to-face interviews with respondents at local recreation hotspots, other public spaces and by going door-to-door. In addition, we set up pick-up and drop-off points for the questionnaire at recreational locations such as cafés, museums

[1] WorldPop (www.worldpop.org - School of Geography and Environmental Science, University of Southampton; Department of Geography and Geosciences, University of Louisville; Departement de Geographie, Universite de Namur) and Center for International Earth Science Information Network (CIESIN), Columbia University (2018).

[2] There is a difference in tax levels between the surveys performed in 2018 (Norway and Denmark) and those performed in 2019 (Finland and Sweden). Pre-testing was done step by step in each study area as the surveys were conducted. The original bid vector, adapted to Norway, was also suitable for Denmark, but based on pre-testing the bid levels turned out to be too high for Finland and Sweden: preliminary analysis showed that respondents considered the highest bids too high. We therefore lowered the tax levels for Finland and Sweden.

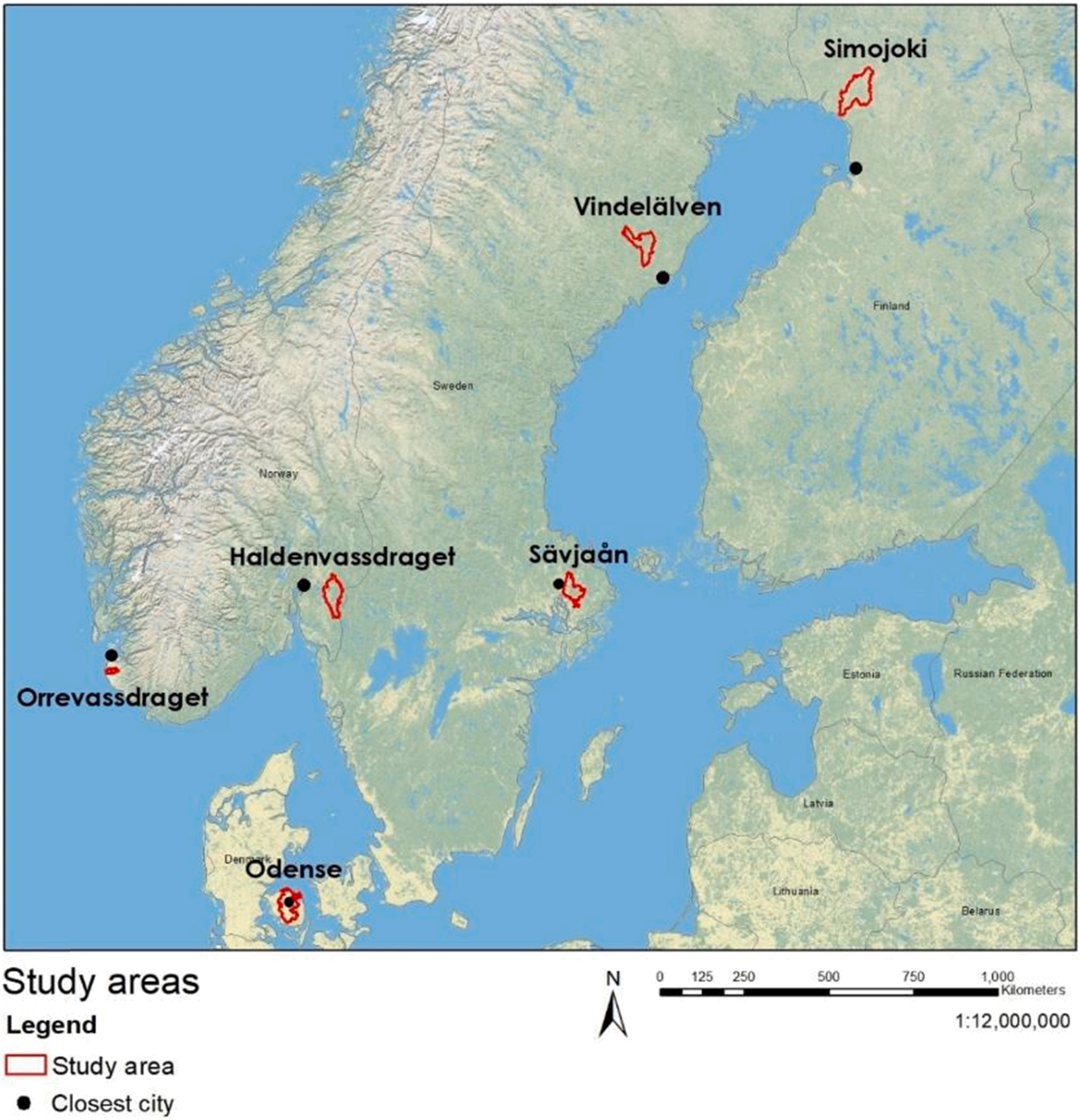

Fig. 1. A map showing the relative positions of the different study areas across the Nordic countries. Study area boundaries are shown in red. Black dots show the city closest to the catchment as described in Table 1. This map illustrates the spatial range of study areas across the Nordic countries, as well as the range of dominant land use types. Orrevassdraget, Odense and Sävjaån are close to cities and in areas with relatively large areas of agricultural land, while Haldenvassdraget, Vindelälven and Simojoki are further from densely populated areas and contain relatively little agricultural land. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

and tourist visitor centres, to increase sample size during the surveying period. Though this sampling method is not probabilistic, which might affect representativeness, it does cover a broad range of types of users, including those that would normally not be reached using sampling from population registers or other digital forms of sampling. In each of the study areas, at least one of the surveyors was fluent in the native language, and one of the surveyors was present in all study areas to ensure the interpretation of questions remained uniformly controlled. We collected the data in Norway and Denmark in the summer of 2018, and Finland and Sweden in the summer of 2019. We surveyed in each study site for a period of two to three weeks.

2.4. Data description

Sample size varied between the six study areas, as shown in Table 3. We present the sample characteristics that showed significant effects on preference as interaction terms in the DCE. Comparing the sample characteristics to national statistics gives an indication which

Fig. 2. Photographic examples of study area landscapes used for recreation. A: Haldenvassdraget. B: Orrevassdraget. C: Odense. D: Simojoki. E: Sävjaån. F: Vindelälven. Photos were taken by the first author.

differences might be caused by population differences, and which might be caused by differences in sampling. For instance, the relatively high percentage of men in the Simojoki sample is not visible in the population statistics and was likely caused by the fact that much of the recreation in the Simojoki area in summer is salmon fishing, which can be considered a male-dominated activity. When considering the most popular recreational activities per study area, walking is the only activity in the top three in all study areas. Other popular activities are swimming and just relaxing. See Supplement 3 for a figure showing the top three activities per study area.

The mean NEP-score per catchment is similar across all areas. The range between 3.47 for Haldenvassdraget and 3.70 for Sävjaån falls within the expected range when compared to Hawcroft and Milfont (2010). In that meta-analysis, 69 studies using the NEP-scale in 36 countries were compared, in which they found a mean NEP-score of 3.75, with a standard deviation of 0.32. This indicates that respondents recreating in our study areas are likely not outliers. They generally place a high value on nature and are concerned about the negative environmental impacts of human activity.

The percentage of respondents choosing only the business-as-usual scenario is relatively low in all six study areas except in Simojoki, suggesting that in general respondents did not judge the future scenarios and accompanying tax levels as unrealistic or unacceptable.

2.5. Econometric model and analysis

We used a mixed logit (MXL) model in preference space to analyse the choice experiment data (Train, 2009). The MXL model allows the coefficients to be random according to any distribution, which makes it possible for the model to take into account preference heterogeneity (Hensher et al., 2015). This model is also computationally efficient, making it possible to experiment with different set-ups without excessive time investment (McFadden and Train, 2000).

The MXL model assumes that a sampled individual n ($n = 1, \ldots, N$) maximizes their utility through making a choice from C ($c=1, \ldots, C$) alternatives in every choice situation S ($s = 1, \ldots, S$) described by observed attributes $\boldsymbol{x}_{csn} = \{x^1_{csn}, \ldots, x^K_{csn}\}$. The utility that individual n derives from choosing c in situation s is specified in Eq. (1).

$$U_{csn} = \alpha_{cn} + \boldsymbol{\beta}'_{nk}\boldsymbol{x}_{csn} + \varepsilon_{csn} \tag{1}$$

In this specification, α_{cn} is an alternative-specific constant, $\boldsymbol{x}_{csn}$ is a vector of the observed variables capturing the attributes of the alternatives, $\boldsymbol{\beta}'_{nk}$ represents the individual's preference vector for the attributes and ε_{csn} is the i.i.d. idiosyncratic error. The probability of a respondent making a choice, based on this utility function, then is:

$$\Pr(y_{ns} = c) = \frac{\exp(\alpha_{cn} + \boldsymbol{\beta}'_{nk}\boldsymbol{x}_{csn})}{\sum_{q=1}^{C}\exp(\alpha_{qn} + \boldsymbol{\beta}'_{nk}\boldsymbol{x}_{qsn})} \tag{2}$$

In the MXL model the individual-specific preference parameters $\boldsymbol{\beta}'_{nk}$ and alternative-specific constants α_{cn} are not fixed for all respondents, but vary around means and are modelled as follows:

$$\beta_{nk} = \beta_k + \boldsymbol{\delta}'_k z_n + \vartheta_{nk}, \tag{3}$$

$$\alpha_{cn} = \alpha_c + \boldsymbol{\delta}'_c z_n + \vartheta_{nc}, \tag{4}$$

where α_c is an alternative-specific constant, and ϑ_{nc} is normally distributed (with zero mean) heterogeneity of the choice-specific constants; β_k is the population mean of the k-attribute coefficient and ϑ_{nk} is the individual specific heterogeneity of a taste parameter. The means of

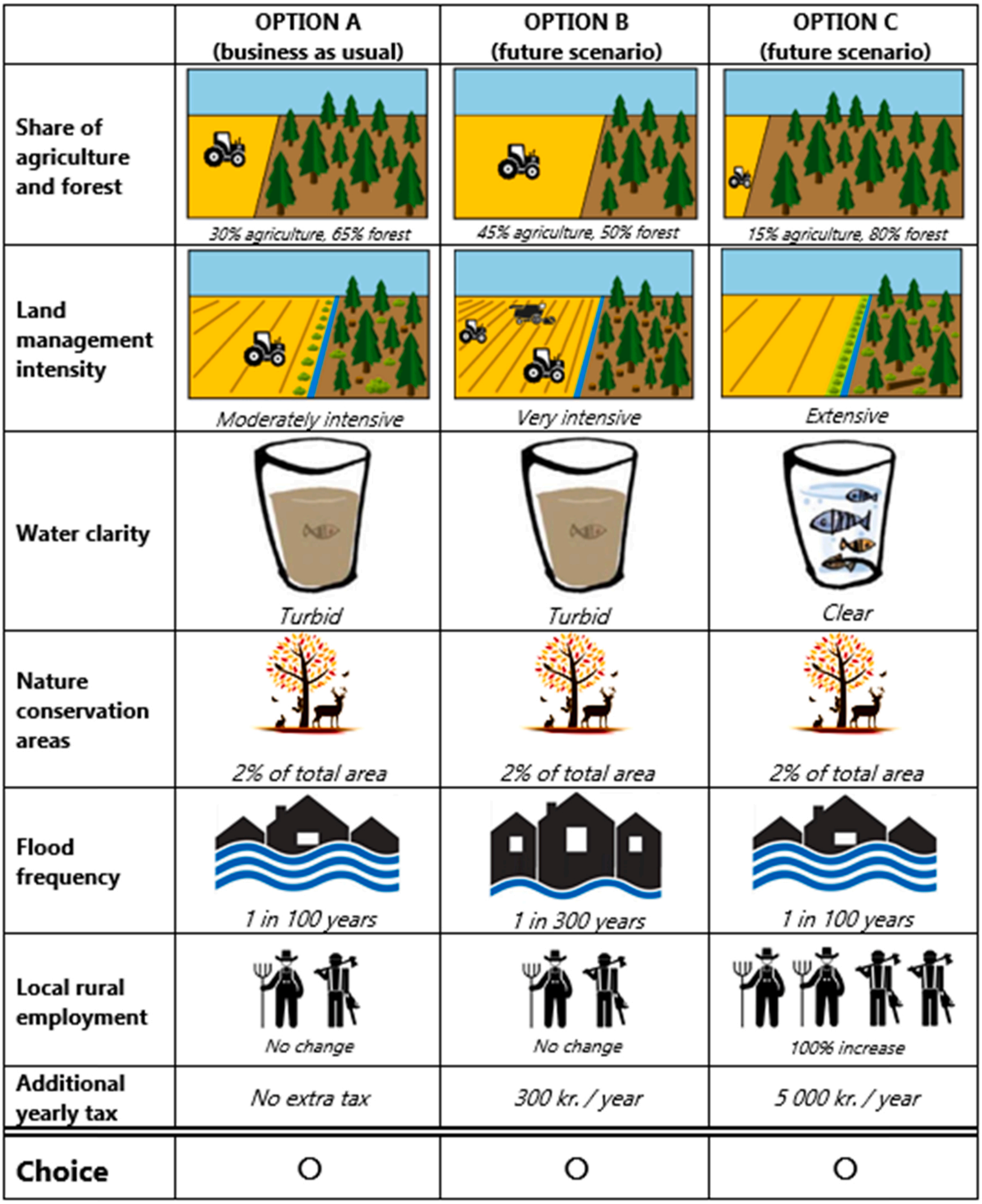

Fig. 3. Example of a choice card from the Sävjaån survey. This shows three scenarios the respondents were presented with, each with a unique combination of landscape attribute levels and an increase in annual household tax. Each respondent was faced with five different choice cards, each with the same business as usual scenario and two unique future scenarios.

the parameter distributions of β_{nk} and α_{cn} are also allowed to be heterogeneous with respondents' individual characteristics z_n, which enter the formulas for taste parameters and alternative-specific constants with vectors of weights $\boldsymbol{\delta}_k$ and $\boldsymbol{\delta}_c$ respectively. We examined individual characteristics that explain heterogeneous preferences of the alternative-specific constant, a dummy variable which was equal to the business-as-usual alternative.

Notice the observed attributes include a price attribute and non-price attributes. In this study the former was a tax that respondents were willing to pay for improving the quality of landscape. We set the parameters to follow a random distribution across respondents, where the tax attribute varies along a lognormal distribution and the non-price attributes along a normal distribution. Since there is a large number of attribute variables in the model, we chose not to analyse for correlated variables, since this complicates the model significantly and increases the risk of the model not converging. Given the selected form, the parameters can be calculated using a simulated maximum likelihood estimation. We chose to use Halton draws with 500 draws, because using this method, the simulation error is lower than with random draws and the estimation procedure is much faster (Hensher and Greene, 2003).

Table 2
Landscape attributes. This describes what the different landscape attributes mean, how they were explained to the respondents and what the different levels are.

Attribute	Description	Levels
Share of agriculture and forest	The percentage share of agricultural land and forested land in total land use in the study area. In Orrevassdraget, this was replaced by the shares of cultivated and uncultivated land due to the absence of forested area.	Dependent on current CORINE land use in the study areas (Buttner et al., 2000), with BAU as intermediate level.
Agricultural and forest management intensity	The intensity of land use management, qualitatively described as the labour and machinery used, as well as the rate of biomass production and harvesting.	• Extensive • Moderately intensive - BAU • Very intensive
Water clarity	Qualitative levels of the clarity of water in rivers and lakes in the study area. In Simojoki the clarity was changed to water colour, since total organic carbon concentrations and related effects on colour have increased significantly due to changing climate and land use here (Lepistö et al., 2014).	• Clear • (Simojoki: Clear) • Moderate • (Simojoki: Slightly brown) • Turbid - BAU • (Simojoki: Dark brown)
Nature conservation	The percentage share of land used as natural conservation area in total land use in the study area.	Dependent on current CORINE land use in the study areas (Buttner et al., 2000), with BAU as intermediate level.
Flood frequency	The frequency of floods that cause damage to land, infrastructure and property in the study area, described as one flood per a certain amount of years.	Dependent on the current frequency of flooding in the study area, with BAU as worst-case level.
Local rural employment	The percentual change in employment in agriculture, forestry and fishery.	• No change - BAU • 50% increase • 100% increase

We used the software package NLOGIT 6 for the econometric analysis (Greene, 2016).

Where attributes (Table 2) were quantitative, as in the fraction of land used for agriculture or the increase in flood frequency, we used a continuous variable in the model. Where attributes were qualitative, as in the clarity of the water or the intensity of land use, we used dummy variables for each attribute level.

We pooled the data from all study areas into one dataset for analysis to improve the explanatory power of the modelling. Because we used local currencies in the DCE, when pooling the data, we transformed the tax attribute to a normalised scale, where 1 is equal to the maximum tax level for each specific study area. Since the continuous variables also have different levels per catchment, we normalised these in the same manner.

After first running a basic MXL model without explanatory variables, we then ran six separate models on the same pooled dataset where for each study area we used a dummy variable as an interaction term one by one (Eq. (4)). This allowed us to see the effect of the survey being from that catchment on the attribute coefficients.

To better understand differences between the study areas, we also analysed correlations between preference for attribute levels and characteristics of the respondents. We chose these characteristics based on their variability across catchments and potential policy relevance in a bioeconomy context. For a description of these characteristics, see Supplement 4. We used these respondent characteristics as interaction terms in the MXL model (Eq. (4)), where we used six different respondent characteristics as interaction terms on the pooled dataset, to examine how characteristics of respondents are associated with preference heterogeneity.

As a final step we ran separate models for each catchment-specific dataset and quantified the marginal WTP for changes to the attribute levels in monetary value. We had to use separate models here because valuation is based on the original tax attribute, which differs per catchment. We used the same model specification as for preference, but using the original attribute values instead of normalised values, and the absolute tax value divided by 1000 as an attribute to prevent scale issues (Hensher et al., 2015). We also only varied the business-as-usual coefficient according to a normal distribution because the separate datasets for each study area were not large enough to allow a model with more complexity. Since the marginal rate of substitution between two attributes is the ratio of their respective coefficients, we then computed marginal WTP of each attribute as the negative of the coefficient of the attribute divided by the coefficient for the tax variable (Hanemann, 1982). To ease comparability, we then transformed these WTP values into euros using the exchange rate on the first day of the field work per study area (xe.com/currencyTables).[3] For the various model specifications in NLOGIT6, see Supplement 5.

3. Results

3.1. Preferences for landscape change

Preferences for changes to the landscape across all study areas were quantified as coefficients in our MXL model for each of the attribute levels, applied to the pooled dataset for all study areas (Table 4). The first variable is 'business as usual', which is a dummy variable indicating that the choice is option A, i.e. the business as usual scenario. The negative coefficient suggests a preference for a changed landscape instead of continuing current trends, after taking into account the effects of the landscape attributes. From the landscape attributes the strongest effects appear to be linked to water clarity, though comparison should be made with care since the attributes are measured on different scales. It is also worth pointing out that the coefficient for high water clarity is higher than for medium water clarity, showing a stronger preference for higher clarity as well as a decreasing marginal utility. Both extensive and very intensive land management have negative coefficients, suggesting that respondents on average prefer the current intensity over a change in any direction. An increase in area of nature reserves and an increase in local employment also appear to have a positive effect on probability of choice, while an increase in the frequency of flooding has a negative effect. The final column shows the standard deviations of the random parameters. This variable stems from the fact that a mixed logit model allows each respondent to have an individual specific preference parameter for each attribute, as opposed to the conditional logit model where all respondents have identical tastes. The estimates that show a significance at the 1% level indicate that for this variable, taste heterogeneity likely exists among respondents. This is the case for the preference for distribution of forest and agriculture, preference for extensive land management, for water clarity improvements, for increasing nature reserve areas and for the tax attribute.

3.2. Study area effects

For comparing the effects of study area on preferences, we performed mixed logit regressions on the pooled dataset, each time using a dummy

[3] Haldenvassdraget: 1 NOK = €0.11, Orrevassdraget: 1 NOK = €0.11, Odense: 1 DKK = €0.13, Simojoki: Already in €, Sävjaån: 1 SEK = €0.09, Vindelälven: 1 SEK = €0.09.

Table 3
Socio-demographic profiles per study area. This table summarizes the main characteristics of respondents per study area, with standard error in brackets where appropriate, in the left column. For comparison, the right column shows equivalent national statistics, taken from national central authorities on statistics (*) and the CIA World Factbook (#).

Study area	Characteristics	Sample	National
Haldenvassdraget	Median age	55 (1)	39#
N = 324	Men	42% (3%)	51%#
	University/college degree	48% (3%)	36%*
	Median monthly gross household income	NOK 25,000–34,999	54,000*
	Non-nationals	9% (2%)	17%#
	Works in agriculture, forestry or fishery	10% (0%)	2%*
	Mean NEP-score	3.47 (0.03)	–
	Mean travel distance to recreation area	96 km (30)	–
	Respondents only choosing BAU	5% (1%)	–
Orrevassdraget	Median age	49 (1)	39#
N = 209	Men	47% (4%)	51%#
	University/college degree	77% (3%)	36%*
	Median monthly gross household income	NOK 35,000–44,999	54,000*
	Non-nationals	21% (3%)	17%#
	Works in agriculture, forestry or fishery	6% (0%)	2%*
	Mean NEP-score	3.48 (0.04)	–
	Mean travel distance to recreation area	236 km (41)	–
	Respondents only choosing BAU	5% (2%)	–
Odense	Median age	30 (1)	42#
N = 284	Men	45% (3%)	50%#
	University/college degree	38% (3%)	33%*
	Median monthly gross household income	DKK 7500 – 19,999	43,000*
	Non-nationals	18% (2%)	16%#
	Works in agriculture, forestry or fishery	4% (0%)	2%
	Mean NEP-score	3.63 (0.03)	–
	Mean travel distance to recreation area	71 km (25)	–
	Respondents only choosing BAU	4% (1%)	–
Simojoki	Median age	49 (1)	43#
N = 197	Men	67% (3%)	49%*
	University/college degree	19% (3%)	31%*
	Median monthly gross household income	EUR 3000 – 3999	2300*
	Non-nationals	1% (1%)	5%*
	Works in agriculture, forestry or fishery	7% (1%)	4%*
	Mean NEP-score	3.50 (0.04)	–
	Mean travel distance to recreation area	170 km (18)	–
	Respondents only choosing BAU	20% (3%)	–
Sävjaån	Median age	31 (1)	41#
N = 379	Men	44% (3%)	50%*
	University/college degree	59% (3%)	42%*
	Median monthly gross household income	SEK 25,000–29,999	40,000*
	Non-nationals	17% (2%)	19.1%#
	Works in agriculture, forestry or fishery	2% (0%)	2%*
	Mean NEP-score	3.70 (0.03)	–
	Mean travel distance to recreation area	506 km (267)	–
	Respondents only choosing BAU	5% (1%)	–
Vindelälven	Median age	44 (1)	41#
N = 210	Men	41% (3%)	50%*
	University/college degree	47% (4%)	42*
	Median monthly gross household income	SEK 25,000–29,999	40,000*
	Non-nationals	8% (2%)	19.1%#
	Works in agriculture, forestry or fishery	6% (0%)	2%*
	Mean NEP-score	3.68 (0.04)	–
	Mean travel distance to recreation area	203 km (24)	–
	Respondents only choosing BAU	9% (2%)	–

variable for one of the study areas as an interaction term. We performed likelihood ratio (LR) tests as in Poe et al. (1994) for each of the study sites to see whether differences in attribute preference varied significantly across study areas, which showed all study areas except Vindelälven varied significantly from the others at the 5% level (LR > $\chi^2_{21,5}$ = 32.67).

Some significant differences in attribute preference among the areas appeared (Table 5). The major differences lie in the preference for the ratio of forest and agriculture. In general, respondents in the more agricultural study areas prefer an increase of forest over agriculture, while respondents in the more forested areas prefer increasing agricultural land at the cost of forest. It also appears that preference for improved water clarity, though high everywhere, is significantly higher in the Swedish study areas. Respondents in the Haldenvassdraget study area appear to differ from the others in having a negative preference for a shift to more extensive agriculture, as well as a less strong positive preference for increasing the percentage of land used for nature reserves. In Odense there appears to be a stronger negative preference for increasing flood frequency, while in Sävjaån this negative preference appears weaker.

3.3. *Explaining variability*

For estimating the effects of respondent characteristics on

Table 4
MXL attribute preference coefficients. This shows coefficients of preference for the different attribute levels, with standard errors and stars indicating the level at which the coefficients are statistically significant. The type of variable is also stated. The column 'RP distribution of standard deviation' shows the standard deviation of the distribution of the random parameters in the model specification.

Variable	Type	Coefficient for preference (SE)	RP distribution of standard deviation
Business as usual	Dummy	-0.88 (0.21) ***	1.93***
Increase in agriculture over forest	Continuous	0.96 (0.15) ***	1.46***
Very intensive land management	Dummy	-0.48 (0.13) ***	0.32
Extensive land management	Dummy	-0.60 (0.14) ***	1.00***
Medium water clarity	Dummy	1.96 (0.22) ***	1.28***
High water clarity	Dummy	2.77 (0.12) ***	1.41***
Increase in nature reserve area	Continuous	1.51 (0.13) ***	1.32***
Increase in flood frequency	Continuous	-0.61 (0.11) ***	0.14
Increase in local employment	Continuous	0.44 (0.09) ***	0.08
Tax increase	Continuous	-1.08 (0.29) ***	3.22***
N (observations)			6956
McFadden Pseudo R^2			0.33
Log-likelihood value			-5137.22

***, **, * ==> Significance at 1%, 5%, 10% level respectively.

Table 5
Effects of study area on attribute preference. This shows the effect of the survey being performed in a study area on preference for attribute levels in the DCE. The values represent the difference in preference between the study area subsample and the total sample; for full model output, including absolute preference estimates and standard deviation of the distribution of the random parameters, see Supplement 6.

	Halden-vassdraget	Orre-vassdraget	Odense	Simojoki	Sävjaån	Vindelälven
Variable	Coefficient for interaction effect (SE)					
Business as usual	-0.85 (0.59)	-0.46 (0.64)	0.73 (0.47)	0.95 (0.74)	-1.01 (0.53) *	0.98 (0.72)
Increase in agriculture over forest	0.59 (0.33) *	-1.24 (1.13)	0.79 (1.15)	-0.05 (0.42)	-1.06 (0.36) ***	0.61 (0.35) *
Very intensive land management	-0.44 (0.37)	-0.16 (0.39)	0.40 (0.33)	0.48 (0.41)	-0.18 (0.29)	0.33 (0.39)
Extensive land management	-0.71 (0.36) **	-0.23 (0.38)	-0.07 (0.35)	0.43 (0.43)	0.40 (0.31)	0.21 (0.38)
Medium water clarity	-0.49 (0.36)	-0.18 (0.38)	-0.20 (0.37)	-0.59 (0.42)	0.93 (0.34) ***	0.90 (0.52) *
High water clarity	-0.13 (0.23)	0.13 (0.26)	-0.03 (0.24)	-0.15 (0.32)	-0.31 (0.22)	1.05 (0.30) ***
Increase in nature reserve area	-0.74 (0.32) **	0.46 (0.37)	0.34 (0.31)	0.16 (0.46)	0.01 (0.32)	0.06 (0.38)
Increase in flood frequency	0.14 (0.29)	-0.42 (0.33)	-0.67 (0.28) **	-0.01 (0.37)	0.66 (0.29) **	-0.05 (0.33)
Increase in local employment	-0.25 (0.24)	-0.16 (0.28)	0.31 (0.21)	0.17 (0.32)	0.03 (0.22)	0.27 (0.30)
Tax increase	-0.78 (0.42) *	-1.47 (0.63) **	-18.94 (360,425)	-2.25 (0.37) ***	1.02 (0.24) ***	0.20 (0.36)
N (observations)	6956	6956	6956	6956	6956	6956
McFadden Pseudo R^2	0.33	0.33	0.33	0.33	0.33	0.33
Log-likelihood value	-5119.57	-5129.89	-5138.91	-5096.58	-5121.13	-5127.83

***, **, * ==> Significance at 1%, 5%, 10% level respectively.

Table 6
Effects of respondent characteristics on attribute preference. This shows the effect of selected respondent characteristics on preference for attribute levels in the DCE. The values represent the difference in preference between the study area subsample and the total sample; for full model output, including absolute preference estimates and standard deviation of the distribution of the random parameters, see Supplement 6.

	Travels more than 25 km	*NEP-score*	*Age*	*Higher education*	*High income*	*Employed in forestry, agriculture or fishery*
Variable	Coefficient for interaction effect (SE)					
Business as usual	-0.08 (0.57)	-0.21 (0.59)	0.04 (0.02) **	-0.58 (0.56)	-0.16 (0.59)	-2.06 (1.33)
Increase in agriculture over forest	-0.05 (0.37)	-0.05 (0.36)	0.03 (0.01) ***	-0.62 (0.36) *	0.05 (0.38)	-0.15 (0.87)
Very intensive land management	0.58 (0.33) *	0.15 (0.33)	0.01 (0.01)	-0.21 (0.34)	-0.58 (0.33) *	-0.61 (0.67)
Extensive land management	0.58 (0.34) *	0.45 (0.35)	-0.00 (0.01)	0.20 (0.34)	-0.19 (0.36)	-0.20 (0.66)
Medium water clarity	-0.76 (0.35) **	0.66 (0.36) *	-0.02 (0.01) **	0.07 (0.36)	0.55 (0.38)	-1.05 (0.76)
High water clarity	0.39 (0.22) *	0.07 (0.23)	0.00 (0.00)	0.37 (0.22) *	-0.09 (0.22)	-0.93 (0.56) *
Increase in nature reserve area	0.21 (0.31)	0.98 (0.30) ***	0.00 (0.01)	0.43 (0.29)	0.01 (0.32)	-1.05 (0.68)
Increase in flood frequency	0.00 (0.28)	-0.44 (0.30)	-0.01 (0.01)	0.24 (0.27)	0.24 (0.30)	0.97 (0.75)
Increase in local employment	0.05 (0.24)	0.28 (0.22)	0.01 (0.01)	-0.33 (0.22)	-0.09 (0.25)	-0.91 (0.61)
Tax increase	0.84 (0.28) ***	-0.94 (0.30) ***	-0.03 (0.01) ***	-0.25 (0.28)	0.39 (0.30)	0.36 (0.60)
N (observations)	4958	4958	4958	4958	4958	4958
McFadden Pseudo R^2	0.36	0.36	0.36	0.36	0.36	0.36
Log-likelihood value	-3511.29	-3511.29	-3511.29	-3511.29	-3511.29	-3511.29

***, **, * ==> Significance at 1%, 5%, 10% level respectively.

Table 7
WTP estimations for attribute levels per study area, based on area specific MXL models in preference space, in euros per household per year. WTP is measured as an increase in a new household tax for environmental improvement. The attribute preference outputs of the area-specific MXL models can be found in Supplement 6.

Variable	Haldenvassdraget	Orrevassdraget	Odense	Simojoki	Sävjaån	Vindelälven
	WTP (95% Confidence interval)					
1% of area from forest to agriculture	€ 28.58** (4.09–53.07)	-€ 59.35*** (−92.11 to −26.6)	-€ 58.01*** (−89.92 to −26.11)	-€ 2.42 (−14.78 to 9.95)	€ 1.58 (−3.85 to 7.02)	€ 21.46 (−5.47 to 48.39)
Very intensive land management	-€ 1 479.32*** (−2 562.12 to −396.53)	-€ 1 217.49*** (−2 113.17 to −321.83)	-€ 663.91 (−1 764.71–436.89)	-€ 28.73 (−134.07 to 76.61)	-€ 105.49 (−262.22 to 51.25)	-€ 131.87 (−462.34 to 198.6)
Extensive land management	-€ 1 283.17** (−2 386.71 to −179.64)	-€ 580.26 (−1 599.44–438.92)	-€ 431.25 (−1 630.2–767.7)	€ 91.93 (−21.16 to 205.02)	-€ 28.55 (−203.1 to 146.01)	-€ 201.20 (−620.22 to 217.82)
Medium water clarity	€ 1 261.59** (253.45 – 2 269.72)	€ 1 389.12** (208.19 – 2 570.06)	€ 2 021.70** (412.76 – 3 630.64)	€ 86.41 (−32.61 to 205.44)	€ 596.99*** (300.04–893.94)	€ 782.70** (104.55 – 1 460.85)
High water clarity	€ 2 859.38*** (1 844 – 3 874.76)	€ 2 373.28*** (744.06 – 4 002.49)	€ 3 048.42*** (1 101.28 – 4 995.55)	€ 245.37*** (101.03–389.71)	€ 618.50*** (310.89–926.12)	€ 1 094.82** (225.3 – 1 964.35)
1% of area to nature reserve	€ 65.25 (−29.82 to 160.32)	€ 42.62 (−24.74 to 109.98)	€ 360.12* (−39.92 to 760.16)	€ 0.54 (−5.11 to 6.18)	€ 79.70** (15.12–144.29)	€ 95.58 (−23.63 to 214.78)
1-year increase in flood frequency	-€ 13.08 (−64.6 to 38.44)	-€ 7.10 (−86.51 to 100.71)	-€ 54.59 (−56.62 to 165.8)	€ 1.06 (−3.48 to 1.36)	-€ 0.28 (−0.42 to 0.97)	-€ 2.26 (−1.83 to 6.36)
1% increase in local employment	-€ 2.50 (−6.32 to 1.32)	-€ 3.85 (−9.18 to 1.48)	€ 1.08 (−5.88 to 8.04)	-€ 0.35 (−1.36 to 0.65)	€ 1.37 (−0.29 to 3.03)	€ 2.45 (−1.26 to 6.16)
N (observations)	1274	908	1123	876	1797	1324
McFadden Pseudo R^2	0.29	0.31	0.32	0.34	0.31	0.39
Log-likelihood value	-996.51	-685.17	-840.61	-630.54	-1371.29	-651.31

***, **, * == > Significance at 1%, 5%, 10% level respectively.

preference, we once again ran mixed logit regressions on the pooled dataset, using six respondent characteristics as interaction terms in a single model, to account for possible correlations (Table 6). Those travelling more than 25 kilometres (i.e. likely non-residents) appear to have a more positive preference for an increase in tax and for a one-step improvement in water clarity, but a stronger preference for changing the intensity of land management in either direction. Respondents with a higher NEP-score appear to have a stronger preference for improving water clarity and increasing the percentage of land used as nature reserve, but also a more negative preference for an increase in tax. Age appears to have a positive effect on preference for the business-as-usual scenario as well as for having more agricultural area, but a negative effect on preference for a one-step improvement in water clarity and an increase in tax. Respondents with higher education appear to show stronger preference for increasing the area covered by forest and having high water clarity, while the effects of high income are a possible stronger negative preference for very intensive land management. Respondents working in a sector directly linked to natural resources appear to have less positive preference for high water clarity.

We found that respondents that indicated they found the scenarios unrealistic do not have significantly different preference for the different attribute levels. The only significant effect is a weaker negative preference for choosing the business-as-usual scenario.

3.4. Willingness to pay for landscape change

Looking at differences in willingness to pay for landscape change, there is a clear distinction between the first three study areas and the second three. WTP in the Finnish and two Swedish areas is substantially lower than in the Danish and the two Norwegian areas (Table 7). To some extent this can be explained by the difference in tax levels between the surveys performed in 2018 (Norway and Denmark) and in 2019 (Finland and Sweden). Since there is a relatively low percentage of voters only choosing BAU as shown in Table 4, this suggests that most respondents felt the tax levels were acceptable. Taking the difference between the two groups of study areas into account by looking at the relative differences between attributes per study area, there is still a consistently high WTP for improving water clarity across all study sites compared to the other landscape attributes. See Supplement 6 for estimation results in preference space for each study area.

4. Discussion

Our findings show that respondents in our selected Nordic catchments have statistically significant preferences for landscape changes associated with the transition to bioeconomy. Improving water clarity is a strongly preferred change in all study areas. An increase in area used for both agriculture and nature reserves is also preferred, as well as reducing the frequency of floods and the number of jobs provided by forestry, agriculture and fishery, sectors closely linked to the development of a bioeconomy. This suggests that when land management practices change due to the development of a bioeconomy, this may affect the appreciation of cultural services supplied in these areas. For instance, the transition to a bioeconomy can cause both an increase in land used for forestry, as well as an increase in management intensity for these forests, which both can impact water quality negatively (Forsius et al., 2016). Since preference among respondents for increasing water clarity is positive and for increasing the intensity of land management is negative, our findings suggest that both increasing the area used for forestry and increasing management intensity would decrease the value of these landscapes for respondents visiting the area for recreation and non-use services. Of course, land use policies are rarely implemented on catchment scale but often on national scale, so preference of the respondents found in our study areas are likely not the only targets for policy changes. For a social optimum on a national scale, other stakeholders, as well as implementation costs, need to be considered as well. The strong preference for improved water clarity fits with previous findings in Northern Europe (Ahtiainen et al., 2015). Outside the region, a global meta-analysis of WTP estimates by Brouwer and Sheremet (2017) also found that water quality was of special importance to respondents. Additionally, Doherty et al. (2014) found water clarity and smell to have the strongest effect on preference in a study on public appreciation of water bodies in Ireland, similarly to our findings. Previous work by Lankia et al. (2015) also indicates that in heavily forested

Finland, there is positive preference for other, more open natural land cover, suggesting a similar preference as our results for a mixed landscape of densely vegetated and more open areas. Similarly, Soini et al. (2012) find strong positive perceptions for edges of field and forest among residents in Southern Finland.

We also found differences between study areas that bring nuance to the results from analysing the total dataset, and that can have implications for possible future land use changes. Respondents from the Swedish study areas show a significantly stronger preference for improving water clarity and the general preference for shifting from forest to agriculture does not hold in all areas, suggesting that the change in value from cultural services depends on the location of changes in environmental and landscape attributes. Preference for increasing nature reserves also varies across catchments. Since increasing landscape productivity for the bioeconomy might reduce land available for nature reserves, this suggests location selection for land use change should take these variations in preference into account if the supply of cultural services is a consideration. The average preference for an increase in agricultural land over forested land was stronger in catchments that already have a relatively large share of forest like Haldenvassdraget and Vindelälven. In a more agricultural and densely populated catchment like Sävjaån, an increase in forest over agriculture seems in fact preferred. This suggests that where to increase the land used for forestry in a bioeconomy matters when considering the value of the landscape for the supply of cultural services. Respondents appear to favour a mixed landscape, irrespective of being resident or visitor. This corresponds with previous findings in a study on German forest landscapes by Elsasser et al. (2010), where results from a DCE show a positive preference for an increase in landscape diversity as well.

Our analyses indicate that respondent characteristics affect preference for landscape change. Respondents travelling from further away appear to have a less negative preference for changing land management intensity, as well as a lower positive preference for a medium improvement in water clarity. This suggests that respondents feel more strongly about changing the landscape when they live closer to it, an intuitively logical interpretation. Since there are significant differences in travel distance between the study areas (Table 3), this can help explain variation. This also suggests that in areas with a higher population density, the aggregate effects of changing the landscape on the value of cultural services can be higher because more people live close to the area in which they recreate. Respondents with higher NEP-scores also appear to have a stronger positive preference for improving water clarity and increasing the area used as nature reserve. Since there are indications that average NEP-scores are increasing over time (Dunlap et al., 2000; Inglehart and Baker, 2000), this effect needs to be taken into account when studying future scenarios where societal change is a factor. Age also has significant effects on preference: with higher age, respondents seem more likely to choose the business-as-usual scenario and have stronger negative preference for increased tax, as well as a stronger positive preference for increasing agriculture at the cost of forest and a weaker positive preference for increasing water clarity. This indicates that in the future, population preference might shift towards stronger preference for increasing forest area and improving water clarity, and a higher willingness to pay for that.

When analysing the preference data, we worked under several assumptions. In our MXL model, we transformed discrete attribute levels in the choice cards into continuous scales where possible, for instance in the percentage of land used as nature reserve. Estimating the marginal effect of increasing an attribute level based on discrete levels in the DCE in this way assumes constant marginal benefit. This is not necessarily true (Bateman et al., 2011). An increase from 1% to 2% might be much more preferable to respondents than an increase from 30% to 31%. Since the baseline levels varied per study area, this is an issue to keep in mind. We also did not include correlation effects between attributes in the MXL model, even though preference for these attributes might be correlated. We chose not to include these to prevent estimation issues caused by the complexity of the model (Greene, 2016). When using socio-demographic characteristics as interaction terms in the choice models, we did not take into account that these might be latently dependent on other observed or unobserved variables (Sheremet et al., 2018). This may lead to endogeneity issues in the model estimation. For further analysis on this issue, we suggest further study by performing a hybrid MXL model analysis on the data, as described by (Czajkowski et al., 2017). Another interesting avenue for future research is a latent class model analysis on the data to identify different segments of respondents similarly as in Hess and Train (2017) and Hensher et al. (2015).

The WTP estimations show statistically significant WTP values for changing the landscape in each of the study areas. This will be valuable information when analysing possible trade-offs in scenarios for land use change, especially when taking into account the monetary values of other ecosystem services, such as crop and timber production. The WTP values from our DCE can be included in an ecosystem services framework that uses monetisation as a standardisation method, as for instance in Vermaat et al. (2016). This allows for comparison of the effects of scenarios on total ecosystem services provision, including how respondents from this study value the landscape for recreation and non-use benefits. It also allows for the comparison of distributions of benefits across different societal stakeholder groups, where respondents recreating in the area are one of those groups. However, care must be taken when interpreting the WTP values. There is inherent uncertainty in the WTP values derived from DCEs because there is a risk that respondents do not think the payment vehicle is realistic, possibly causing them to overstate how much they would be willing to pay (Johnston et al., 2017). This is especially relevant for respondents visiting from abroad, who might feel that an increase in tax would not apply to them, leading to potential overstating of WTP. The data shows slightly higher mean WTP for English-language questionnaires than native language ones in all catchments except Odense (we exclude Simojoki because it only contains two English questionnaires). However, we did not find evidence that respondents (national or foreign) experienced the scenarios as unrealistic in their preference for attribute levels in any of the control quesitons. Care should also be taken in comparing the WTP estimates of the different study areas. Since we changed the tax levels in the DCE for the second year of surveying, comparing the WTP estimates from Norway and Denmark with those from Sweden and Finland should take this change into account. However, since there were relatively few respondents that only chose the business-as-usual scenario (Table 4), we assume that respondents judged the tax levels in our DCE to be realistic and acceptable.

5. Concluding remarks

This study draws on extensive data from four different countries and shows that across our Nordic study sites, respondents benefitting from cultural ecosystem services have clear preference for a more equal distribution of agriculture and forest, improved water clarity, increased area used for nature reserves, reduced flood risk and increased employment from agriculture, forestry and fishery. There is significant variation in preferences between study areas, which appear linked to characteristics of our respondents. The preferences for landscape change and the variation in these preferences carry implications for future policy decisions. If Nordic societies transition toward a bioeconomy, this can affect the landscape attributes that we studied and that contribute to the supply of cultural ecosystem services. Our results indicate that how and where land use changes can impact the total value of cultural ecosystem services delivered by Nordic catchments. As Raudsepp-Hearne et al. (2010) showed, increasing the output of provisioning services in a growing bioeconomy can lead to trade-offs with the supply of cultural services like recreational opportunities and appreciation of nature. Most tellingly, the strong preference for improved water clarity suggests that the transition to a bioeconomy, possibly including more intensive management of agricultural and forested land, should take care not to compromise on water quality. Policy aimed at minimising these trade-offs should consider local differences in preference: for instance, our results indicate increasing forested area is most beneficial to cultural services supply in agriculturally dominated areas. Of course, for a socially optimal solution, other ecosystem services and costs of implementation also have to be considered. Nonetheless, our WTP estimates can be useful for integrated assessment, to make comparison of producing different bundles of ecosystem services possible.

We suggest further study in two directions. First, we think that a further analysis of the determinants of preference and WTP is needed to explain how much different societal groups benefit from the cultural services supplied by Nordic catchments. Subgroups of beneficiaries can be determined, and larger study sites can be added, including more detailed spatial analysis, to better understand how characteristics of the catchment affect the value of the cultural services they provide. Secondly, we suggest quantifying the impact of the transition to a bioeconomy on total ecosystem services provision from Nordic catchments. This can be done by integrating the results from this work into a quantification of the total economic value of ecosystem services provision. Our WTP estimates make their inclusion in an integrative ecosystem services framework possible. Doing so elucidates the relative importance of cultural services and the trade-offs between different ecosystem services and their beneficiaries caused by land use change.

Supplementary materials

1. Attribute levels per study area and DCE design
2. Sävjaån questionnaire (English, DCE version 1)
3. Top three recreational activities per study area
4. Characteristics of respondents and the landscape used to explain variation of preference between study areas
5. Model set up for the pooled mixed logit estimation and the WTP estimation
6. Full model outputs

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.landusepol.2021.105909.

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