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Multimethod valuation of peatland ecosystem services: Combining choice experiment, multicriteria decision analysis and deliberative valuation

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ABSTRACT

This paper presents a multi-method valuation study using discrete choice experiment, participatory multi-criteria decision analysis and deliberative citizens' panels to evaluate the value of peatland ecosystem services in southern Finland. All three valuation studies addressed the same scenarios and drew on the same biophysical assessment data to facilitate a comparison of the valuation processes as well as the results. The results indicate that people place high value on regulating and cultural ecosystem services, especially on biodiversity, and less value on energy peat. The experiences sustain the argument that learning is important as people rarely have ordered set of preferences for unfamiliar objects like regulating services. They also illustrate the scope of citizen and consumer preferences and support the assumptions that preferences may change as a result of well-informed group deliberation. In terms of integration, the lesson learned is that regardless of the preference elicitation method, all valuation studies would benefit from structured and participatory approach when defining the scenarios as well as attributes and their levels. Furthermore, full integration is not possible among different valuation methods, which can be conceptualized as value articulating institutions, operating under different rationalities.

1. Introduction

Human well-being is fundamentally dependent on ecosystem services, but decision-making processes often fail to acknowledge their societal and economic significance (MA 2005; TEEB 2010). Ecosystem service assessment and valuation is expected to address this shortcoming by explicitly accounting for and articulating the importance of ecosystems and their services to people (Carpenter et al. 2009; Kareiva et al. 2011; de Groot et al., 2018). However, scholars disagree on the most appropriate methods for assigning value to ecosystem services. Some argue that the best way to demonstrate the value of ecosystem services is to quantify them in economic terms (Boyd and Banzhaf 2007; ten Brink, 2011), while others maintain that monetising ecosystem services can be counterproductive, leading to the commodification of nature and the overlooking of social and ethical concerns that are not amenable to monetary transactions (Spash 2007; Farley 2012; Chan et al. 2012).

The relative merits of different valuation paradigms are addressed by several studies on environmental valuation in general (see e.g. Getzner et al. 2005) or ecosystem services in particular. For the latter, Vatn (2009) has interrogated the underlying assumptions of different valuation methods, which he terms value articulation institutions. Spangenberg and Settele (2010), Wegner and Pascual (2011) and (Hanley 2001) have discussed the pros and cons of economic and non-economic valuation. Kenter et al. (2015) have evaluated the ability of different deliberative-analytical valuation methods, including deliberative monetary valuation, to capture different types of shared and social values, and Pascual et al. (2017) and Christie et al. (2019) have outlined a pluralistic valuation approach for evaluating nature's contributions to people. Some theorists have proposed that researchers should make use of different methods, both monetary and non-monetary, to capture a

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Table 1
The characteristics of different valuation methods along the key dimensions, based on Vatn (2015).

	Stated preference methods	Multi-attribute value theory	Deliberative valuation
The agent	Autonomous individual	Varying assumptions	Social
Rationality	Instrumental	Instrumental or communicative	Communicative
Participants	Consumers, representative sample of the whole population	Stakeholders or decision-makers (citizen)	Citizens or stakeholders, usually limited to 20–50 individuals
Forms of participation	Surveys	Interactive facilitated group meetings, often accompanied with individual interviews	Interactive facilitated group meetings like citizens' juries and other mini-publics
Preferences			
- formation	Are given	May change/develop	May change/develop
- form	Prices and quantitative preference information	Weights, preferences and arguments	Arguments, preferences and/or joint recommendations, voting or consensus based)
Level of aggregation	Commensurable, aggregated	Mostly commensurable, aggregated or non-aggregated	May be incommensurable, mostly non-aggregated
Information	Relatively straightforward questions with some background information	Information can be created during the process; scope for learning	Possible to request additional information during the process
The good/ problem	Commodity	Complex, often common good	Complex, often common good
The social choice	Sum of individual preferences	Compromises/give-and-take of arguments	Give-and-take of arguments, voting or consensus
Ideal institution	Market	Participatory stakeholder process	Forum

wide spectrum of values and engage a diversity of interests and perspectives (Kenter et al. 2016; Raymond et al. 2014; Kronenberg and Andersson 2019).

However, there are only a few empirical analyses employing both monetary and non-monetary valuation methods to evaluate ecosystem services in the same planning or policy situations. Kontogianni et al. (2001) and Hattam et al. (2015) have used a mixed-method approach with focus groups and survey-based economic valuation methods to evaluate marine and wetland ecosystem services, respectively, while Kenter et al. (2016) combined monetary valuation and Kenter et al. (2016) deliberative monetary valuation with group-based non-monetary valuation methods to evaluate coastal and marine ecosystem services in the United Kingdom. A few studies have also combined multi-criteria methods with interpretive (Ranger et al. 2016) and deliberative valuation methods (Orchard-Webb et al. 2016). However, few studies have addressed the same scenarios and have drawn on the same biophysical assessment data to facilitate a comparison of the valuation process as well as the results.

This paper fills in the gap in empirical comparative research and presents a multi-method valuation study using discrete choice experiment (DCE), participatory multi-attribute value theory (MAVT) and deliberative citizens' panels (CP) to evaluate the value of peatland ecosystem services in southern Finland. The case study was linked to a topical debate on extending the network of protected peatlands in Finland and the potential of valuation to overcome some of the gridlocks in this debate (Primmer et al. 2018). DCE is a monetary valuation method that is particularly suited to evaluating bundles of ecosystem services (Hanley et al. 2001). MAVT is a non-monetary method under a general framework of multi-criteria decision analysis (MCDA), which can address trade-offs between multiple mutually exclusive criteria (Belton and Stewart 2002). Deliberative non-monetary valuation methods like citizens' juries or panels seek to form value judgements on the basis of the informed give-and-take of arguments (Smith 2003).

Each individual valuation study is documented in detail in separate papers, DCE in Grammatikopoulou et al. (2019, 2020, 2021), MAVT in Saarikoski et al. (2019) and Mustajoki et al. (2020), and CP in Saarikoski and Mustajoki (2021). In this paper, we compare the results from the three different valuation studies and analyse the ways in which they capture the various value dimensions of peatland ecosystem services, drawing on the theory of value-articulating institutions (Vatn 2009, 2015). We also explore possible ways of combining the value information from different methods effectively.

2. Theoretical framework

Environmental valuation refers to formal analytical processes where various types of values, which people assign to ecosystem services or other environmental attributes, are explicitly expressed or constructed via a range of value elicitation methods. Following Kenter et al. (2015), we distinguish between two major value categories: contextual values, which refer to the relative importance of particular objects of value, in a certain time and place, and transcendental values, which denote our overarching principles and life goals that transcend specific contexts and shape our contextual values. Transcendental values are often associated with ethics and normative beliefs, which are shared culturally, and therefore these values can also be characterised as shared, social or cultural values (Kenter et al. 2015). Value indicators, in turn, are a measure of the importance of something, expressed in monetary or non-monetary terms.

According to Vatn (2009), valuation methods can be understood as value-articulating institutions (VAIs), which are based on different assumptions regarding rationality and views of human interaction as well as the goods to be valued. Different VAIs can be characterised along four key dimensions: In what capacities people are participating (e.g. as consumers, citizens, stakeholders, decision-makers), what form participation takes (as responses to surveys or interview questions, group meetings, etc.); how values are expressed (prices, weights, arguments), and how recommendations are produced (aggregated, non-aggregated, by voting or consensus-based) (Vatn 2015). Different methods are based on different assumptions regarding these questions, as they are grounded in different theoretical foundations – e.g. neoclassical economics and classical institutionalism (Vatn 2009). A similar argument is made by Raymond et al. (2014), who maintain that valuation methods follow either instrumental or deliberative paradigms (see also Wegner and Pascual 2011). In the former, the focus is on contextual values, which can be objectively measured, quantified, traded off and aggregated arithmetically into social values, using stated preference methods and other survey-based methods. In the latter, the focus is on contextual and transcendental values, which are formed through interaction in structured processes of participation, communication and learning in deliberative designs such as citizens' juries and panels.

Stated preference methods such as DCE are rooted in neoclassical economics, which assumes that autonomous individuals are the best judges of their preferences and can make rational choices between bundles of goods that maximise their utility. Individual preferences can then be summed up to estimate aggregate individual well-being from the object of valuation. In this model, the goods involved are expected to resemble commodities with value dimensions seen as commensurate; they can be measured using a single unit of value and traded off against each other in competitive markets that are real or hypothetical (Vatn 2009). Value estimates are applicable for the cost-benefit analysis of an environmental programme or policy (Hanley 2001). The respondents in

DCE are provided with background information on the problem at hand, but the level of detail is limited as the survey instruments need to be relatively simple and concise. Measured attitudinal information provides further information on perceptions and a tool to evaluate the validity of responses. Key considerations that engage researchers in this instrumental paradigm, according to Raymond et al. (2014), are sample sizes and representativeness, and decision-makers are mainly seen as end users of the value information who are not involved in generating it.

The classical institutionalist view on rationality underlying deliberative valuation methods assumes that values are constructed via social interaction as people learn about the object of valuation and the views of others. It also holds that individuals hold different preferences when acting as consumers as opposed to when they are acting as citizens (Vatn 2009). Consumer preferences are associated with gains in individual welfare ('I want'), whereas citizen preferences express beliefs about appropriate courses of action in societal choice situations, given our shared principles, beliefs and commitments ('We ought to') (Sagoff, 1988). According to Raymond et al. (2014), deliberative approaches can consider both contextual and transcendental values that are sought through a structured process of communication in forums such as citizens' juries. This approach also recognises that some goods might be incommensurable – i.e. they cannot be traded (Vatn 2009). Interactive methods can also handle more complex environmental questions as they provide space for learning and requests for additional information. A key consideration in the deliberative approach is not statistical representativeness but whether relevant interests are represented in the process and whether the process is adequately managed (Raymond et al. 2014). Decision-makers are often involved to frame the research and they may also participate in the deliberations.

From the value articulation institution perspective, the scholarly debates over the appropriateness of valuation methods are partly misplaced, as different valuation methods are suited for different purposes, like eliciting consumer preferences for environmental goods via hypothetical markets or articulating societal preferences for common goods in deliberative forums (Vatn 2009). The characteristics of three major categories of valuation methods along the key dimensions are presented in Table 1. It should be noted that the characteristics presented here for MAVT also apply to several other MCDA methods. They also share most characteristics with deliberative methods, as most MCDA methods assume commensurability (i.e. they use the additive utility model, which is completely compensatory) like economic valuation methods. The main difference between the single units of measurements used in these methods is that monetary units have a universal interpretation while weights in MAVT are always context-dependent (Kangas et al. 2010). Furthermore, in survey-based methods with a statistically representative sample, the results can be aggregated across the population while MAVT process can also be used in a non-aggregative fashion. In a similar way, deliberative monetary valuation methods are hybrid approaches as they support learning and reflection of initial preferences, but they elicit individual preferences in monetary terms and aggregate them.

Several authors have proposed pragmatic solutions to combine the strengths of the different valuation approaches. Raymond et al. (2014) have presented two strategies to bring together instrumental and deliberative valuation approaches. In the first one, values aggregated from a statistically representative sample of individuals, elicited via instrumental methods, can inform group deliberations, and negotiations are used to establish social values. In the second one, social values are elicited and negotiated through deliberative designs with a small number of participants, and the outcomes are then cross-checked through survey instruments to consider the degree of agreement by a demographically and socio-economically representative sample. Kronenberg and Andersson (2019) also maintain that there is untapped potential for the integrated use of different valuation methods to cover social, ecological and economic value dimensions. While full integration between valuation methods based on a different understanding of rationality is problematic, a parallel use of diverse sets of methods serving different purposes can provide a more comprehensive picture than using any of those methods alone.

3. Context

Peatlands amount to one third of the land surface in Finland (Alanen and Aapala, 2015) and their economic utilisation, or protection, is a source of long-standing debate. The use of peatlands has been very extensive, especially in the southern part of the country where over 80 % of the original 3 million hectares of peatlands has been drained for forestry, agriculture and peat extraction. Currently, Finland is one of the world's largest peat extractors. The share of peat fuel in Finnish energy production has dropped from 15 % to 5 % in the last five decades but there is a high demand for horticultural peat that is extracted from the same sites as energy peat (Soimakallio et al. 2020). In recent years, energy peat burning accounts for around 10 % of CO2-ekv. emissions in Finland (Soimakallio et al. 2020).

The extensive draining of peatlands has resulted in a decline of natural peatland habitats and species dependent on them. Around half of the Finnish peatland habitats are threatened (Kontula and Raunio, 2019) and peatlands are a primary habitat for more than 200 endangered species in Finland (Hyvärinen et al. 2019). Draining and peat extraction also reduces the provision of other peatland ecosystem services such as berries, carbon storage, water purification, landscape amenities and recreational opportunities (Bonn et al., 2016). These trade-offs have caused conflicts over peat extraction at the local level (Albrecht and Ratamäki, 2016) as well as the national level. The Ministry of the Environment set off in 2012 to prepare a Supplementary Programme for Peatland Protection, with the aim of filling in the gaps in peatland protection, especially in southern Finland. However, land-owner organisations strongly resisted a statutory protection programme and consequently the initiative turned into a voluntary programme called the Proposal for Supplementing Peatland Protection (Alanen and Aapala, 2015).

The valuation process started in 2015 when the Proposal for Supplementing Peatland Protection (Alanen and Aapala, 2015) was finalised, and peatland protection and the rationale of energy peat extraction were widely discussed and hotly debated in Finland. Peat producers had launched a media campaign that claimed that 'Finns are fools' as they do not make use of their energy reserves, which according to them correspond to the oil reserves in Norway. Environmental organisations were concerned that the failure of the statutory peatland protection programme would compromise biodiversity protection, and the Finnish Climate Panel emphasised the need to give up energy peat for climate reasons. The valuation study aimed to provide a multifaceted evaluation of different peatland use options and explore the views of the public at large. The results of the different studies were presented to policymakers and stakeholders in a seminar in December 2017.

4. Methodological approach

The multi-method valuation study included the parallel application of DCE, MAVT and CP methods to evaluate the value of peatland ecosystem services in southern Finland. To ensure consistency across the application of different methods, all of them addressed at least three identical scenarios and a set of peatland ecosystem services (see section 4.1). The scenarios were formulated, and the ecosystem services identified, with the assistance of peatland experts at the Finnish Environment Institute. They also carried out the biophysical assessment process to determine the impacts of the scenarios on the provisioning of ecosystem services and socio-economic criteria. This information was used to define the units of measurement and their levels in the valuation studies.

In some studies, the biophysical assessment process itself is considered a valuation method (Gómez-Baggethun and Martín-López, 2015). This view is justified in the sense that biophysical assessment can

Table 2
The scenarios and the peat extraction targets, volumes and levels of conservation in them. The scenarios included in all studies are bolded.

Scenario	Peat extraction target	Volume of peat extraction, ha/a	Level of conservation
S1: Conservation+	Extraction will end by 2030	34 000 until year 2030, 0 from year 2030	All pristine peatlands will be protected
S2: Conservation	Extraction will decrease by 30 %	34 000	All pristine peatlands will be protected
S3: Proposal for Supplementing Peatland Protection (PSPP)	Extraction will continue at the current level	47 000	All PSPP sites will be protected
S4: Business as usual (BAU)	Extraction will continue at the current level	47 000	60 % of PSPP sites will be protected
S5: Intensified peat extraction	Extraction will increase by 30 %	64 000	47 % of PSPP sites will be protected

include explicit evaluation of ecological importance, like the estimate of biodiversity impacts in this case. However, the judgement about whether certain ecologically important changes, e.g. in the surface area of endangered peatland habitats, are important for people still requires human evaluation: the numbers, such as percentages of pristine peatlands, do not speak for themselves. Therefore, we define ecosystem service valuation here as a process in which people express, or construct, personal or societal value judgements concerning the relative importance of ecosystem services and other relevant criteria (see Kenter et al. 2015).

The process started with the DCE study, followed by the MCDA study that partly overlapped in time with the first CPs. The individual methods and their use in this study are described briefly in the following sections.

4.1. Scenarios and their impacts

The study area for this paper is southern Finland, where peatlands cover around 25 % of the land surface (Natural Resources Institute Finland, 2019). The use of peatlands in the study area has been very extensive and of the original 3 million hectares of peatlands, over 80 % has been utilised for forestry, agriculture, peat extraction or other uses. The time horizon was up to 2050, which is a relevant period from the perspective of the United Nations' Paris Climate Agreement (United Nations, 2015). The scenarios were spatially explicit, and they were constructed using CORINE Land Cover data.

The initial scenarios constructed by the research team for the DCE study included a business-as-usual (BAU) scenario with the current rate of peat extraction (S4), as well as a 30 % increase (S5) and a 30 % decrease (S2) in peat extraction compared to BAU. In S2, it was possible to preserve all pristine peatlands over 10 ha and use only those areas that are already drained. This is because large areas of peatland were drained in the earlier years for forestry and agriculture, but were never used for such purposes.

In order to connect the valuation process with the topical policy debate (see section 3) in the MAVT process, a fourth scenario (S3) was constructed that illustrated the full implementation of the Proposal for Supplementing Peatland Protection (current level of peat extraction but peat extraction not carried out in the ecologically valuable sites identified in the proposal). The difference between S3 and S4 was that in the former, all peatland protection programme sites were saved, while in the latter the extraction sites were randomly placed across the peatlands using an ArcGis sampling design tool (NOAA/Biogeography Branch). In

Table 3
The ecosystem services and their attribute levels in the different valuation studies. For the carbon stock, the corrected estimates are presented in parentheses. The dark grey cells indicate attribute levels that were the same in different studies.

	Attribute levels in scenarios S1-S5				
The criteria and their attributes	**S1**	**S2**	**S3**	**S4**	**S5**
Energy produced with peat, TWh/a					
- MAVT	8^a / 0^b	8	11	11	15
- CJ	8^a / 0^b	8		11	15
Use of peat and share of domestic energy production					
-DCE		Decreases from the current level, 7 % share		Remains at the current level, 10 % share	Increases from the current level, 13 % share
Horticultural peat, Mm³/year					
- MAVT	0.7^a / 0^b	0,7	1	1	1.3
- CJ	0.7^a / 0^b	0,7		1	1.3
Berries, constructed scale 0…-4					
- MAVT	No significant changes (0)	No significant changes (0)	Around one fifth of potential berry production area is lost (-1)	Around one fifth of potential berry production area is lost (-1)	Around one third of potential berry production area is lost (-2)
- CJ	0	0		-1	-2
Change in carbon stock of peatlands in 2017-2050, %					
- DCE		-6		-9	-12
- MAVT	-2 (-1)	-6 (-2)	-9 (-3)	-9 (-3)	-12 (-4)
- CJ	-2	-6		-9	-12
Water quality, the number of deteriorated lakes					
- DCE		10		70	100
- MAVT	0	10	70	70	110
- CJ	0	9		70	110
Biodiversity, constructed scale 0…-4					
- DCE		Remains at the current level		Deteriorates slightly	Deteriorates significantly
- MAVT	Localities of threatened mire species do not disappear. Decline of threatened species slows down (0)	Localities of threatened mire species do not disappear. Decline of threatened species slows down (0)	Some of the localities of threatened mire species may disappear due peat extraction (-1)	More localities of threatened mire species may disappear than in scenario S3 (-2)	Several localities of threatened mire species disappear. Decline of threatened species accelerates (-4)
- CJ	0 (see above)	0		-2	-4
Recreation, constructed scale 0…-4					
- MAVT	Recreational opportunities remain at the current level (0)	Recreational opportunities remain at the current level (0)	Some negative impacts because some of the pristine mires nearby people are lost (-1)	Some negative impacts because some of the pristine mires nearby people are lost (-1)	Rather big impacts, especially for those interested in berry picking and observing nature (-2)
- CJ	0 (see above)	0 (see above)		-1 (see above)	-2 (see above)
Area in a natural state suitable for berry picking, km²					
-DCE		850		370	120
Landscape, constructed scale 0…-4					
- MAVT	no landscape impacts (0)	no landscape impacts (0)	around 80 % of the landscapes remain intact (-1)	around 80 % of the landscapes remain intact (-1)	28 % of the landscapes are lost (-2)
- CJ	0	0		-1	-2
Environmental education, constructed scale 0…-4					
- MAVT	No impacts (0)	No impacts (0)	Some impacts as some schools will lose nearby mires (-1)	Some impacts as some schools will lose nearby mires (-1)	Rather big impacts as some pristine mires will be lost (-2)
- CJ	0	0		-1	-2
Increment value from peat extraction, incl. multiplicative effects, M€/year					
- MAVT	100^a /0^b	100	140	140	190
- CJ	100^a /0^b	100		140	190
Employment in peat extraction, man-years					
- MAVT	1500^a /0^b	1500	2100	2100	2900
- CJ	1500^a /0^b	1500		2100	2900
Landowners' freedom of choice, scale 0…-4					
- MAVT	Statutory protection on all over 10 ha mires (-3)	Statutory protection on all over 10 ha mires (-3)	Some limitations on the use of peatlands (-2)	No limitations on the use of peatlands (0)	No limitations on the use of peatlands (0)
- CJ	-3	-3		0	0
Tax payments, € bid range					
-DCE	0, 10, 20, 50, 100, 200, 300, 500				

a Untill year 2030
b From 2030 on

a Untill year 2030.
b From 2030 on.

the MAVT process, the participants also added a fifth scenario (S1) in which peat extraction will be phased out completely by 2030. Scenarios S3 and S1 were relevant for the stakeholders involved in the MAVT process, as they were familiar with the debates surrounding the Proposal for Supplementing Peatland Protection. However, S3 was not used in the CP study as it would have been too demanding for lay participants to grasp the difference between S3 and S4 in such a short time.

The ecosystem services included were: i) biodiversity, ii) surface water quality, iii) recreational opportunities, iv) carbon storage and v) fuel peat production. The scenarios and ecosystem services included in the different valuation studies are presented in Table 2 and Table 3. The reasons for including additional criteria, or omitting some, are elaborated in the following sections describing the individual methods used in the process.

The ecosystem service and other impact assessments are presented in Appendix 1 and summarised below. The attribute levels in Table 3 refer to the units of measurement of each criterion. For example, the attribute for the energy produced with peat is TWh/a.

The estimate of **energy peat** production in the scenarios is based on annual statistics of the volume of peat production (m^3) and the amount of peat energy (TWh) produced. In the study area, the volume of peat production is on average 47 000 ha/a (Metsätilastollinen vuosikirja 2014), which amounts to energy production of 11 TWh/a in scenarios 3 and 4 (BAU). Another important peat product is **horticultural peat**, which is usually produced at the same sites as energy peat. The current horticultural peat production in the study area is 1 million m^3/a. **Cloudberries and cranberries** are the most important wild berries that are picked from pristine peatlands for commercial and household use. They have commercial importance in northern Finland, but the yields are underused in southern Finland. The calculation of the **carbon content** of extracted peat in each scenario with different amounts of energy peat extraction is based on the estimate that CO_2 emissions from peat energy production are 106 g CO2 ekv/MJ (Kirkinen et al. 2007).[1] The total change in the **carbon stock** in 2017–2050 was estimated on the basis of carbon emissions from pristine and drained peatlands as well as the carbon content of the peat extracted in different scenarios, drawing on Kirkinen et al. (2007). The baseline is the current amount of carbon stored in peatlands in the study area (Minkkinen, 1999). The effect of peat extraction on **water quality** was estimated using specific loading coefficients per area unit (Kortelainen et al., 2006) and an estimate of the present loading, the latter being calculated with the VEMALA model (Huttunen et al., 2016). The **biodiversity** impact assessment is based on expert evaluation. The impacts on **cultural ecosystem services** were evaluated on a constructed scale from 0 (no impact) to −4 (a major negative impact). The estimate on **recreational impacts** is based on the surface area of pristine peatlands and it is conservative because most people visit peatlands in nature protection areas or nature parks with existing nature trails and other infrastructure. In the DCE study, the proxy for recreational impacts was the area in a natural state suitable for berry picking (km^2). **Landscape impacts** were assumed to be proportional to the surface area of pristine peatlands. Pristine peatlands can also serve **educational** purposes. An accessibility analysis was carried out to estimate the average travel time to nearest pristine peatland. The impacts on **regional economy and employment** were estimated by using results from an input–output analysis of socio-economic impacts of northern Finland peatlands by Piirainen et al. (2013). The criterion 'landowners' freedom of choice' refers to the restrictions posed by protection programmes and opposed by some landowners (Alanen and Aapala 2015).

4.2. Discrete choice experiment study

The DCE method is a direct survey approach to estimate individual willingness-to-pay (WTP) for a hypothetical change in the level of provision of non-market goods and benefits, such as ecosystem services. It is particularly suited to situations where changes are multi-dimensional and trade-offs between the valued environmental attributes are of interest (Hanley et al. 2001, Carson and Louviere 2011). In this study, the attributes were the initial set of ecosystem services (see section 4.1), which were complemented with a cost attribute.

The survey instrument was tested with a focus group with nine participants and modified according to the feedback. The most important change was that the attribute 'recreation' was redefined. It was originally measured in terms of travel time by car to the nearest pristine peatland site. However, the focus group participants did not consider the travel time relevant and therefore the 'recreation' attribute was defined as 'area of peatland in natural state available for berry picking' in southern Finland. The attributes and their levels are presented in Table 2 and the ways in which the DCE attributes were described to the respondents are presented in Appendix 2.

The carbon storage and water quality attributes as well as biodiversity were basically the same as in the MAVT and CJ process (see Table 2). However, the attribute energy was defined as 'share of peat within the national energy mix (%)', not in terms of TWh as in the other studies. The reason for using relative instead of absolute energy production figures was to simplify the criterion and provide the context for the survey respondents who may have little prior information about energy production.

Scenario attribute levels were transformed into choice sets where each respondent faced six choice tasks out of 36 possible combinations of attribute levels (see Grammatikopoulou et al. 2019 for specific description). A pilot DCE survey was sent out in June 2016 with 204 internet panel responses (68 % response rate). The pilot study employed a split sample, where one version used the BAU scenario (S4) and the other the Bioeconomy scenario (S5) as the status quo trendline. The status quo serves as the baseline for comparing different choices in choice tasks, anchoring the choices and thus values to changes from an absolute rather than just a relative level. The pilot study results led to the choice of the Bioeconomy scenario (S5) to serve as a status quo trendline, as the other version provided unrealistically high WTP estimates and may have been difficult to answer.

The final DCE survey (N 1997, internet panel response rate 18 %) tested in four split samples (N ~ 500 each) varying the time frame of payments: i) lump-sum payment, ii) 10-year annual payment starting from the year of the survey, iii) 10-year annual payment starting three years after the year of the survey, iv) 10-year annual payment starting six years after the year of the survey. Considering the objectives of the present paper, we have conducted a pooled sample analysis.

The analysis presented here was conducted with mixed logit model to accommodate taste and scale heterogeneity, as well as correlated parameters in WTP space (Hess and Train, 2017). All attribute parameters were assumed to be random normally distributed and correlated. Models in WTP-space reparameterize utility such that the distribution of WTP is estimated directly (Hess and Train, 2017). This is accomplished by dividing the attribute's coefficients by the payment coefficient in the model estimation phase. The model was estimated with the gmnl

[1] There was a mistake in the initial impact assessments documented in Saarikoski et al. (2019). The correct difference in carbon stock between the scenarios is 1–4% up to 2050, not 2–12%. The initial and corrected figures are presented in Table 2. The mistake does not influence the comparison of the different valuation studies as they all used the same figures, but it could have influenced the importance that the respondents assigned to carbon storage. However, it was the most difficult criterion for the citizens to grasp both in the DCE and DV studies, hence the differences in the numeric estimates were not necessarily a crucial issue. In the MAVT process, too, the respondents were mainly thinking about CO2 emissions, which was a more familiar way of approaching energy peat use than carbon storage.

Table 4
Summary of results of WTP space model.

Description of CE attributes	Description of state	WTP estimates	Stand. Error
Alternative specific constant (ASC_{SQ})	The constant represents the bioeconomy scenario (S5), which was the status quo in DEC study	−720,083***	33,718
Ecosystem services (ES)			
Regulating ES			
Carbon storage	Decrease by 12 % (*status quo*)[R]	/	/
	Decrease by 9 %	24,336*	10,305
	Decrease by 6 %	17,857	11,335
Species diversity	Deteriorates significantly from the current level (*status quo*)[R]	/	/
	Deteriorates slightly from current level	91,610***	13,693
	Remains at the current level	117,366***	18,915
Lakes with poor water quality	Increase by 100 (*status quo*)[R]	/	/
	Increase by 70	23,738*	11,284
	Increase by 10	96,569***	14,990
Cultural ES			
Area for berry picking	120 km^2 (*status quo*)[R]	/	/
	370 km^2	52,276***	7,012
	850 km^2	89,423***	7,829
Provisioning ES			
Share of peat in domestic energy production	Increases from the current level: share is 13 % (*status quo*)[R]	/	/
	Remains at the current level: share is 10 %	14,076	11,769
	Decreases from the current level: share is 7 %	12,633	12,134

***, ** and * indicate statistical significance at 1%, 5% and 10% level respectively.
[R] : reference level.

package in R software (Sarrias and Daziano, 2017) using 100 Halton draws.[2] The model specification incorporated all environmental attributes as well as an alternative specific constant for choosing the status quo choice (Bioeconomy scenario) over the two other choices in each choice task. The welfare change related to a hypothetical choice scenario was estimated using the compensating surplus measure, which corresponds to the maximum amount of money that individuals must pay (WTP) or accept, so that after the hypothetical change, they can be as well off as before the change (Hanemann 1984).

4.3. Multi-attribute value tree analysis

In this study, we applied an MCDA method called multi-attribute value tree analysis (MAVT), which can be used for eliciting the importance that people assign to ecosystem services (Saarikoski et al. 2016). In MAVT, a problem is structured in the form of a value tree that presents a hierarchical structure of the alternatives, or scenarios, and the criteria against which the alternatives are evaluated, using units that characterise the different types of impacts (e.g. TWh and percentage of protected areas). The next step is to construct value functions for each criterion that normalise individual impacts to a common scale of comparison (scoring). In the preference elicitation stage, participants are asked to assign numerical weights to reflect the relative importance of each appraisal criterion for them, considering the range of variation in the scores (weighing). An overall value for each alternative is obtained by using an additive model and multiplying normalised criteria-wise performance scores with corresponding criteria weights and then summing them up. In participatory MAVT processes, the weights are usually assigned by stakeholders and/or policy-makers, and these actors are often also engaged in constructing the value tree (Marttunen et al. 2015).

The nine participants in this MAVT process were representatives of relevant government departments and stakeholder organisations, including peat industry organisations as well as environmental and recreational non-governmental organisations. The participants introduced the no-peat extraction scenario (S1), and they also proposed supplementing the initial list of ecosystem services with horticultural peat, berries, landscape, education, flood protection and ground water quality (see Table 2). The two latter criteria were dropped at the impact evaluation stage when it turned out that there were no differences between the scenarios (see Saarikoski et al. 2019). The list was further extended after the weight elicitation stage as it transpired that the service 'energy peat' measured in terms of TWh/year did not adequately capture the socio-economic implications of peat production emphasised by some participants. A further addition was a criterion related to landowners' freedom to make decisions concerning their holdings. The argument about landowners' independence was a central one in the debate over the peatland protection programme, hence it was included to improve the policy relevance of the analysis.

Two workshops were organised with the participants to construct the value tree and discuss the assessment result. These were compiled into an assessment report that was circulated for several rounds of written comments. To elicit the criteria weights, interactive decision-analysis interviews using an Excel tool based on the WebHipre software (Mustajoki and Hämäläinen 2000) were carried out in April 2017. A second round of interviews was conducted in May, with a revised value tree, as the first round of interviews showed the need to include socio-economic criteria. The second round of interviews was organised in small groups so that the participants could also discuss the results together (for more detail, see Saarikoski et al. 2019).

4.4. Deliberative valuation study

The most frequently used deliberative design is a citizens' jury (CJ), which brings together a cross-section of a population to come to a considered judgement (a 'verdict') about an issue of public concern though a detailed exposure, and scrutiny, of the relevant evidence base (Smith 2003). The deliberative valuation design in this study adopted several elements from the CJ method, but the process was shorter than a typical CJ, which runs for two to four full days, and it was not commissioned by public authorities like CJs. Due to these differences, we used the term citizen panel (CP), which comes close to what Fish et al. (2011) have termed as in-depth discussion group and Lo (2013) as a deliberative workshop.

Three parallel citizen panels with between 9 and 11 participants in each, 31 in total, were organised sequentially in April–October 2017 to address the use of peatlands in southern Finland. Each panel met three times for two-hour meetings, totalling six hours over a month. The panel process was structured loosely according to the MCDA process: In the first meeting, the participants familiarised themselves with the scenarios and evaluation criteria. In the second one, they discussed the impacts and the relative importance of the criteria, assisted by the same Excel tool that was used in the MAVT process. In the third meeting, they discussed the panel's recommendation(s) on the preferred scenario. The panellists were asked to produce a considered value judgement, possibly a consensual one, from the perspective of society as a whole: What is the right course of action to manage peatlands as an important part of natural capital in Finland?

The meetings were assisted by a professional facilitator, but no expert witnesses were used; instead, the organisers answered the panellists' questions by drawing on the assessment work in the MAVT

[2] The number of draws may be regarded as modest, and we acknowledge that there may be a risk of instability in convergence and simulation error. Nonetheless, this is a risk we could not overcome because when we tried increasing the number of draws the rather complex model did not converge.

Table 5
Welfare estimates of scenarios (in €/respondent/year).

Scenarios	Mean estimate (lower and upper bound)
S5: Intensified peat extraction	−720,083 (-786,169 to −653,997)
S4: Business as usual	−514,047 (-686,094 to −342,000)
S1: Conservation+/ S2:Conservation	1053,930 (992,220 to 1115,64)

process, and consulting experts if additional information was needed. The panellists also received a simplified version of the background material prepared for the MAVT process.

All panel sessions used small groups with varied compositions and started and ended with a plenary session. At the end of the final meeting, the panellists filled in a feedback form and answered the same questions as they did in the recruiting stage to allow for a comparison of pre-deliberation responses with post-deliberation responses.

5. Results of the valuation studies

5.1. DCE study

In most of the environmental attributes, WTPs increased statistically significantly with improved attribute levels (Table 4). The average WTP was highest for maintaining species diversity at the current level (€117/respondent/year). The second most important attribute was water quality (WTP €97/year for the smallest negative impacts on lakes) and the third was recreational services, measured in terms of area for berry picking (WTP €90/year for the largest area). For carbon storage, the respondents were WTP around €24/year for a 9 % decrease of carbon stock instead of a 13 % decrease. However, here WTP did not increase with the improved attribute level, as the WTP for the smallest decrease of 6 % (€18/year) was less than for a 9 % decrease. In a similar way, WTP did not increase with an improved level of share of peat in domestic energy production. However, the WTP estimates were not statistically significant; hence it is not possible to draw conclusions for people's WTP for provisioning service energy peat.

Due to the respondents' positive WTP for peatland ecosystem services except for peat provisioning services, they have a high disutility towards scenarios with high levels of energy peat extraction (Table 5). The DCE baseline scenario with increased peat extraction (S5) would lead to a welfare loss of approximately €720/year. The business-as-usual scenario (S4) would lead to a welfare loss of €514/year, whereas the conservation scenario (S2) corresponds to a welfare gain of €1053/year. The welfare estimates and their heterogeneity between respondents are further elaborated in Grammatikopoulou et al. (2019, 2020, 2021).

5.2. MAVT study

The weights assigned by each participant to the different ecosystem services are presented in Fig. 1. For instance, interviewee 1 gave no weight to energy and horticultural peat, around 5 % weight to berries, around 25 % weight to carbon sequestration, water quality and biodiversity, and around 20 % of weight to cultural ecosystem services. As the figure indicates, the results were quite polarised as some stakeholder representatives placed very high value on regulating services and some value on cultural services, while others placed a very high value on provisional services and related socio-economic criteria and very little value on cultural services.

We distinguished four groups with similar preference models, which were grouped into four clusters according to the preference order of the alternatives (Fig. 2). The length of the bar indicates the overall value of each scenario. In this figure, we have presented four overall rankings of the scenarios given by four interviewees who are representative of their cluster. We did not calculate average rankings because the nine participants were not a representative sample of any population; instead, we wanted to capture the range of variation in views and value statements behind the criteria weights (see Saarikoski et al. 2019).

Group 1 were 'conservationists', who placed a lot of value on regulating services, hence preferred scenarios in which peat extraction would be completely phased out by 2035. Group 2, 'moderate conservationists', had relatively similar preferences but they considered phasing out peat production and a 30 % reduction as equally good options. Group 3 were 'productionists' who emphasised peat extraction and the related socio-economic factors, and consequently preferred scenario 5 with the highest level of peat extraction. Group 4, 'status quo', emphasised provisioning services and the related socio-economic factors but placed quite a lot of weight on regulating and cultural

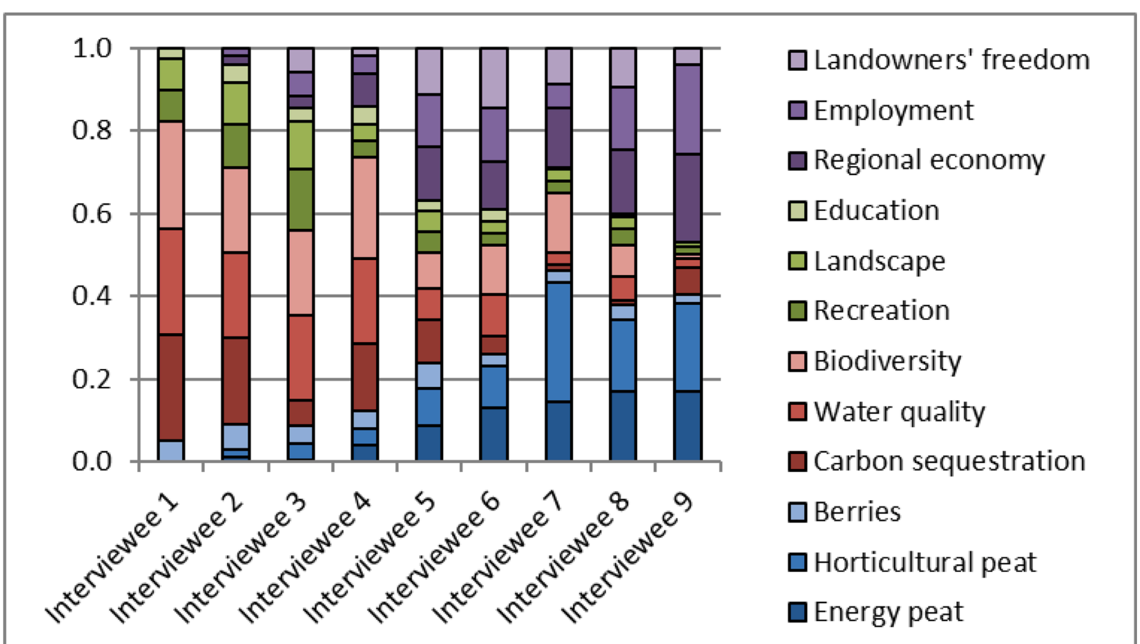

Fig. 1. The weights that each interviewee gave to different ecosystem services and other aspects relevant for decisions concerning the use of peatlands in the MAVT process.

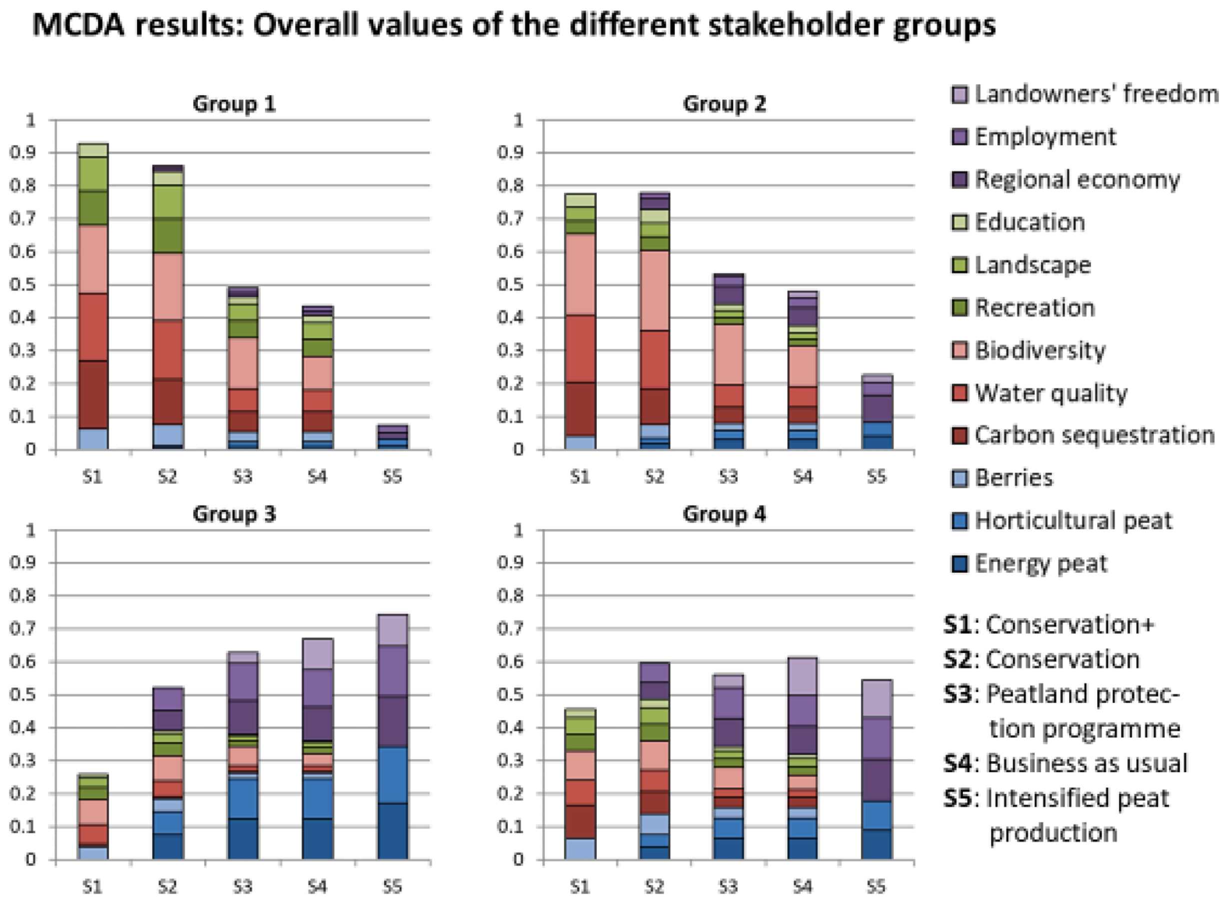

Fig. 2. Four typical rankings of the scenarios in the MAVT process.

services. Hence, they preferred the business-as-usual scenario 4 but viewed scenario 2 with 30 % reduction in peat production as nearly as good.

An additional output of the process was a set of arguments that the participants used when justifying their weights. These included the intrinsic and heritage value of biodiversity and the moral duty to prevent climate change, as well as the importance of employment and economic prosperity for human well-being (see Saarikoski et al. 2019).

5.3. Deliberative valuation study

The citizens' panels were tasked to produce recommendations on the future use of peatlands in southern Finland. The majority of the participants preferred scenarios 1 and 2 with no or a reduced amount of peat extraction, as indicated in Figs. 3 and 4. The figures depict the results of group work in the second and third panel, using the same Excel tool as in the MAVT process. Each group was given a task to jointly weigh the criteria according to MAVT procedure (see section 4.3) and the overall value of each scenario is presented in Fig. 3 (second panel) and 4 (third panel). In both panels, there were three groups of three to four people with a strong preference for scenario 1 with no peat extraction and one group with three to four people who preferred either scenario 2 with a 30 % reduction (panel two) or the status quo scenario 4 (panel three). The first panel did not use the software but discussed the order of the scenarios in general. In that panel, the majority of the participants advocated scenario 1 while a few preferred the status quo (S4) and a few the scenario with increased peat extraction (S5). However, the panellist advocating S5 wanted to increase horticultural peat extraction but reduce energy peat extraction, so they did not stick with the initial scenario description.

To facilitate the final discussion on joint recommendations, the participants were not asked to agree on a single scenario as they had become quite anchored to their preferred scenarios. Instead, they were asked to think 'outside the box', as the first panel did, and come up with innovative solutions to tackle the problem of the future use of peatlands. Consequently, all panels reached a similar proposal to give up energy peat and gradually replace it with renewable energy sources, especially forest bioenergy. They debated the pace of the process and the need for economic drivers, but they were unanimous on the need for the energy transition and the future role of peat in the Finnish energy system.

The process also generated estimates of the importance of peatland ecosystem services for the participants before and after the process. Most importantly, the participants changed their views on the importance of energy peat and adopted a much more negative view of it (Fig. 5). The difference between the views before and after the process was statistically significant. Flood control, water quality and services related to the recreational use of peatlands were regarded as slightly less important after the process than before, and carbon storage a little more important, although the differences were not statistically significant (see Saarikoski and Mustajoki 2021).

6. Analysis and discussion

6.1. Comparison of the results

All three valuation studies addressed at least three identical scenarios and five ecosystem services with the same or corresponding attribute levels; therefore, it is possible to compare the processes as well as the outputs of the different studies. The DCE and CP studies, which both engaged members of the general public, provided fairly similar results, indicating clear preferences for phasing out energy peat extraction. In the DCE study, the respondents were willing to pay around

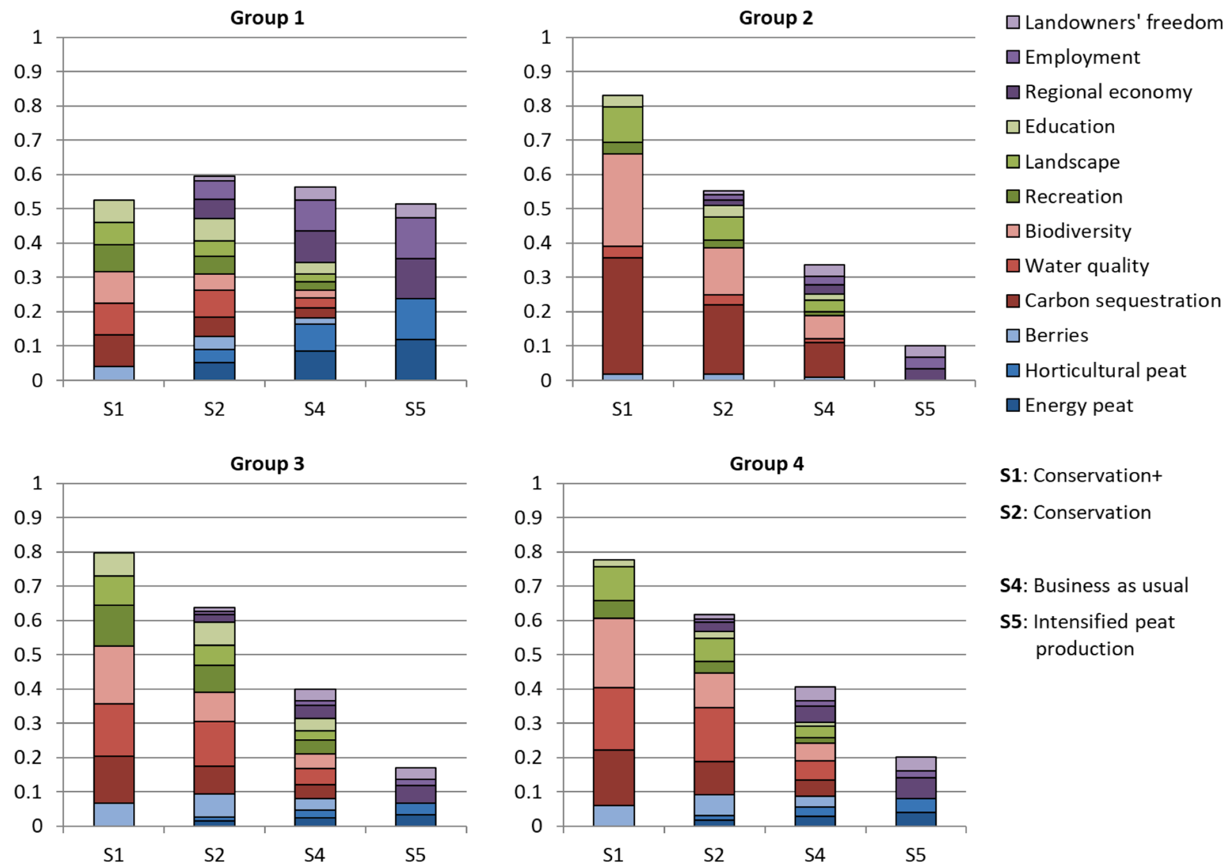

Fig. 3. The rankings of the scenarios by the second CP break-out groups in the last panel meeting.

€1000 per year for cutting peat extraction by 30 % (S2) compared to the maximum peat extraction scenario (S5). In the CP study, most respondents preferred scenarios in which energy peat production will be renounced completely (S1) or cut by 30 % (S2). The consensus recommendations by two panels were somewhere between S2 and S1 and by one panel between S3 and S1. The MAVT results were more divided, which is understandable as the participants were stakeholders who were selected on the grounds that they represent different interests and perspectives on the issue.

In terms of different ecosystem services, the DCE and CP studies indicate that people place relatively little value on energy peat, while biodiversity was regarded as the most important peatland ecosystem service. In the MAVT study, too, biodiversity was the highest-ranking non-provisioning service among the participants. The most important difference between the results is that in CP and MAVT, carbon storage ranked very highly, whereas in the DCE it received relatively low value. Furthermore, water quality was regarded as relatively important in DCE and MAVT studies but less important in the CP study. We will return to these observations in the next section, where we discuss the role of information in valuation studies.

6.2. *Capacity of the methods to capture value dimensions of peatland ecosystem services*

The relevance of different types of value information is determined by the characteristics of the decision-making situation as well as decision-makers' knowledge needs (Primmer et al. 2019). The decisions concerning peatland use is a good example of a complex public choice situation, which concerns multiple ecosystem services that are not all familiar to people. According to the literature on different valuation approaches, such problems benefit from methods that enable learning and reflection on facts and values (Vatn 2009; Raymond et al. 2014).

Learning also turned out to be a key issue in this case, especially regarding the carbon storage service provided by peatlands. The incongruous DCE results, according to which people were willing to pay more for a larger decrease of carbon storage than a smaller decrease, suggest that some people assumed that higher figures represent a better environmental state. The notion of carbon emission reductions is a familiar concept to most people while the idea of carbon storage is less well-known.

Pre-testing the survey using a focus group discussion with nine participants and a pilot survey with over 200 respondents did not reveal any problems in understanding this attribute. The focus group participants were selected from a survey panel consisting of people from the Helsinki metropolitan region, who are, on average, more environmentally aware than the rest of the population. A few panellists were also selected because of their interest in the recreational use of peatlands. Furthermore, the focus group participants benefited from the presence of a researcher who introduced the criteria. However, the pilot survey respondents received the same information as the DCE respondents, indicating that misunderstandings cannot be fully controlled in the post-pilot survey phase. In the deliberative valuation process, the panellists had an opportunity to familiarise themselves with the role of peatlands as a carbon sink, and this new knowledge was the most important reason why the participants adopted a negative view of energy peat extraction. An important piece of information for the panellists was that the carbon emissions from peat burning equal the emissions from traffic in Finland. This info helped them to grasp the scale of impacts and formulate the notion of carbon stock in more familiar terms; if the stock is used, it will turn into CO_2 emissions. In the DCE, the respondents' task to evaluate the magnitude of peat energy production was eased by providing context and using relative instead of absolute energy production figures.

MAVT and other MCDA methods are also expected to support reflective thinking (Saarikoski et al. 2016), but this potential is

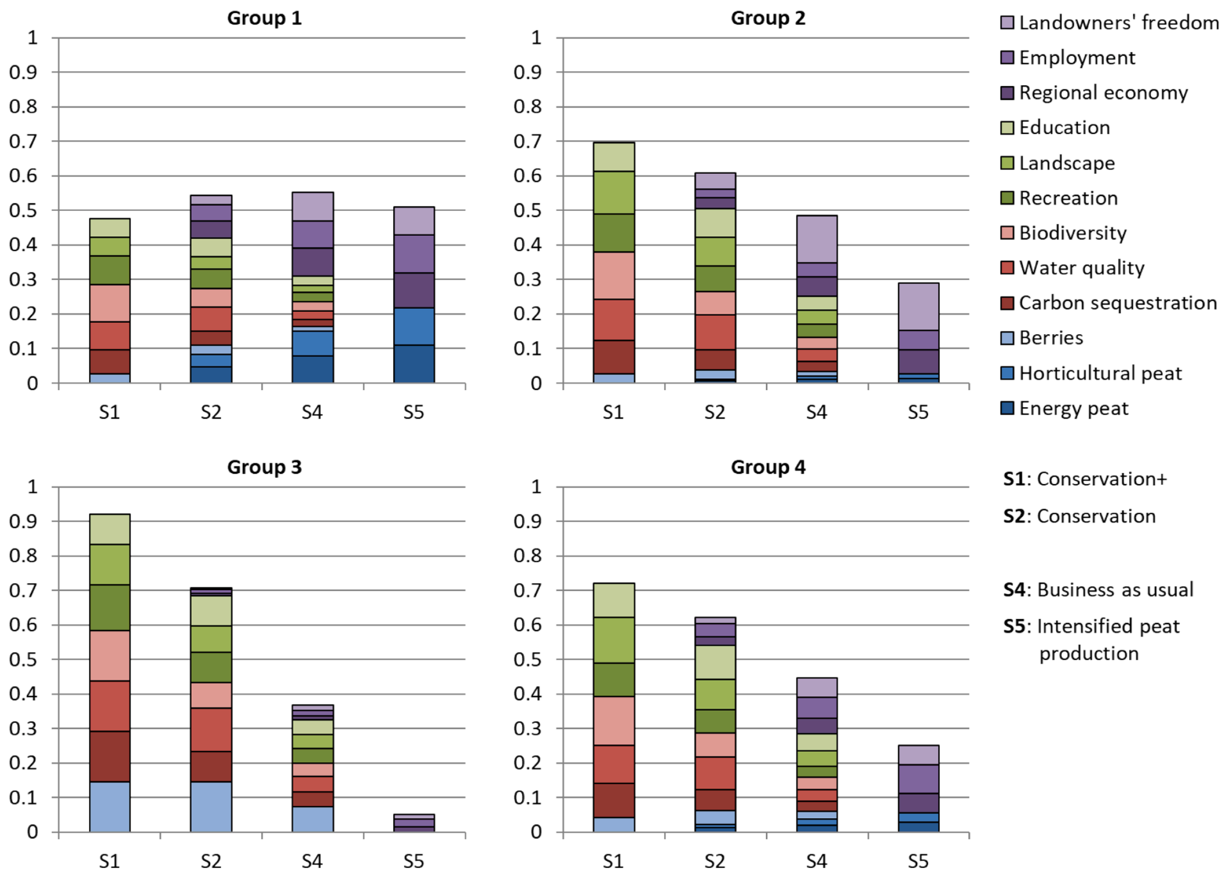

Fig. 4. The rankings of the scenarios by the third CP break-out groups in the last panel meeting.

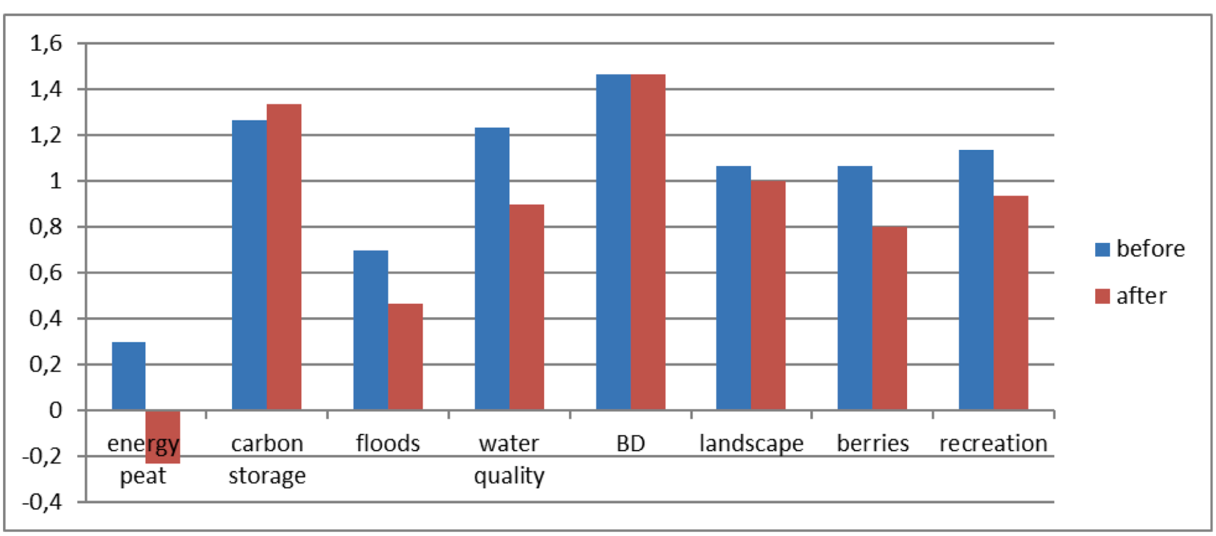

Fig. 5. The scores of different peatland ecosystem services before and after the panel process, on a scale 2 = very important, 1 = quite important, 0 = not important or unimportant, −1 = quite unimportant, −2 = very unimportant.

conditioned by the context as well as the capacity in which the participants are involved in the process. In this case, the participants were policy actors expressing organisational rather than personal preferences in a research-driven process in which there was no incentive to agree on jointly acceptable solutions. Consequently, the process did not contribute much to reflection on initial preferences, and the participants' positions were quite immovable. However, the process promoted learning about the facts as the participants co-created the evaluation framework with the research team and also provided important input into the impact evaluation stage. Furthermore, the MAVT process was helpful in articulating transcendental values because the participants were asked to provide justifications for the weights for different ecosystem services.

The capacity of MAVT to support value-focused thinking was experienced in the CP process, where the two last panels used an MAVT Excel tool to support small-group discussions on the preferability of the scenarios. According to the participants' feedback, the interface, which showed the results with a different set of weights, was helpful as it required the participants to revisit their weights if they produced unexpected results – or revisit their initial preference order of the scenarios. However, MAVT was not used to support the final discussion on the preferred solution as it could have shifted the focus to recording positions instead of developing jointly acceptable solutions (Vatn 2009). This concern was relevant in the CP as the participants reached joint recommendations by going beyond the initial scenarios: The first panel bypassed the conflict between proposals to decrease and increase the use of peat by advocating a shift from energy peat to horticultural peat, while the two latter panels agreed on the principle that energy peat needs to be substituted with renewable energy sources.

The valuation literature distinguishes between consumer and citizen preferences (Sagoff 1988; Wilson and Howarth 2002). The DCE study may indicate that monetary assessments may not evoke only a consumer rationality. At least one may ask if they are willing to pay €1,000 per year for the next ten years for cutting back on peat extraction from a consumer perspective. More detailed analysis of respondent heterogeneity in Grammatikopoulou et al. (2019) revealed the lexicographic preferences among some of the respondents for increasing the average welfare estimate. This kind of non-compensatory preferences challenges the use of welfare estimates in cost-benefit analysis.

The underlying assumption in much valuation literature is that deliberative methods, which evoke citizen preferences, are prone to place more value on life-supporting ecosystem services than monetary valuation methods evoking self-serving consumer preferences (Aldred and Jacobs 2000; Wilson and Howarth). However, in this case, the DCE study showed that people place a very high value on pristine peatland ecosystems, whereas the CP study also emphasised the economic importance of energy peat extraction. One explanation is that in the CP, the economic impacts were not framed in terms of personal economic benefits but in terms of employment opportunities and the regional economy in rural communities. The capacity of deliberative valuation to evoke other-regarding values is also suggested by the fact that the participants placed more value on global concerns related to biodiversity and carbon storage and less value on recreational opportunities after the process than before it.

One concern with quantitative valuation methods is that they reduce all value information into a single unit of measurement and disguise the plurality of values and difficult choices in complex environmental decision-making situations (Martinez-Alier et al. 1998). The welfare estimates in the scenarios (Table 5) merge the value of individual ecosystem services but the information about WTP for each ecosystem service (Table 4) allows decision-makers to examine the different dimensions of the problem. The MAVT results, which present the preference order of each scenario (Fig. 2), also sum up the importance of different criteria. However, the non-aggregative approach, which presents different preference orderings, draws attention to the fact that there is no single best solution to the use of peatlands, but the desirability of the scenarios depends on one's value system. The CP results, which reflect the panellists' practical judgement of the conflict situation, do not assume commensurability but are consistent with the notion of weak comparability (Martinez-Alier et al. 1998).

The most important shortcoming of MAVT and deliberative valuation methods is that they usually involve only a limited number of people and do not provide statistically reliable information on the views of the general public (Hanley 2001). From the perspective of deliberation, the issue is rather to cover relevant argumentative perspectives (Aldred and Jacobs 2000) or provide a legitimate representation of the societies or communities involved (O'Neill, 2001). In this case, there was a specific limitation to the CP as the participants were all from the Helsinki metropolitan region. Basically, it would also have been possible to organise CPs in other regions, but it was not feasible in the research project context – costs and time are issues in actual decision-making situations.

The DCE study and the accompanying survey had 2,000 respondents covering the whole study area, hence the results were statistically reliable. It was also possible to create latent value groups (Grammatikopoulou et al. 2019) and analyse the views of landowners and people from rural and urban areas (Grammatikopoulou et al. 2021). That kind of stratified information is important in the peatland decision-making context, as the consequences from phasing out energy peat extraction fall heavily on certain rural communities with limited employment opportunities.

One concern with deliberative valuation is that group processes are subject to group dynamics and undue influence of dominant participants (Kenyon and Nevin 2001; Kenter et al. 2014). According to the CP participants' feedback, all except one person felt that their views were heard and respected during the process (see Saarikoski and Mustajoki 2021). Professional facilitation and small-group discussions with varied composition helped to ensure constructive and balanced dialogue. However, the facilitators conveying expert knowledge to the participants probably had an unintentional distorting effect, as they might have put too much emphasis on the unexpected findings that the scenarios did not have an impact on water purification and flood control, not realising that the details of different water quality impacts might not be understood by ordinary citizens hearing about these issues for the first time. This information might have led some participants to downgrade the importance of water-related criteria in general, although the scenarios did have impacts of lake water quality.

6.3. *Potential for integrated use of different valuation methods*

Some authors have suggested that the strengths of the different valuation approaches can be combined by using integrated valuation approaches, either by using information collected via survey methods as an input to DV or MAVT processes, or using these processes to specify questions for survey instruments (Raymond et al. 2014). However, it is not theoretically sound to cross-check social values elicited via deliberative non-monetary valuation processes through DCE surveys designed to elicit estimates of personal WTP. Furthermore, values that are formed via interaction are not comparable with pre-given values that are elicited via valuation instruments (Kenter 2018). It is also unfeasible – due to it being expensive and time-consuming – to carry out parallel full-blown valuation studies for purposes other than for methodological research. However, the experiences from this exercise suggest some ways to combine the use of different methods effectively.

First, all valuation studies need a carefully designed baseline scenario and alternative(s), as well as criterion/criteria, or attribute(s), against which the baseline and alternatives are evaluated. In this case, the participatory MAVT process was instrumental for this purpose as it helped to complement the initial set of scenarios and the list of criteria developed by the research team. Furthermore, the stakeholders could provide important information on peat extraction practices and local water quality impacts that complemented the expert evaluations.

Second, the MAVT process with stakeholders and/or decision-makers can also gain from the input of valuation studies with ordinary people. In this case, the assessment framework was further extended after the input from the citizen panellists who did not limit themselves to the ecosystem service concept, but added employment and the regional economy as criteria to be considered. One way to combine MAVT and CP processes is to (i) structure the problem by using participatory MAVT, (ii) carry out CP, or just a focus group, to test the relevance of the framework from a lay perspective, (iii) adjust the framework if necessary, and (iv) carry out the weight elicitation process with stakeholders and/or decision-makers in MAVT.

In a similar way, carrying out the CP prior to the DCE study could have helped to clarify the concepts that were difficult for the DCE respondents. For reasons discussed in section 6.2, neither the DCE focus group nor the pilot survey spotted the ambiguity of the attribute decrease in carbon storage, where some respondents seemed to assume increasing percentages in a choice situation for a positive change. However, the focus group helped redefine the recreation attribute to concrete and familiar terms as an area for berry picking. In the MAVT and CP studies, which stuck with the ecosystem service framework, the respondents were asked to weigh the (quantitatively small) berry yields and recreational experiences separately. This somewhat atomistic approach, which reduced berries to a quantitative commodity, might have been one reason why cultural services ranked quite low in these studies compared to the DCE study. A better integration of the methods would have helped to revisit the criteria in the MAVT and CP processes.

Also, DCE or a standard survey could be used to inform the MAVT process. Alternatively, MAVT or CP processes might single out some ecosystem services, the importance of which could be surveyed across the whole population. In this case, data on people's preferences and actual use of peatlands would have been helpful in evaluating the societal significance of recreational services in the MAVT process. The recreational use of peatlands is also more amenable to monetary estimates than regulating ecosystem services, because it can be viewed as an environmental commodity that is enjoyed in a similar way to commercial recreational services. Also, water quality is a familiar ecosystem service that is closely linked with recreational benefits. In contrast, the importance of carbon sequestration is difficult to capture in terms of personal WTP. As Vatn (2009) points out, the choices concerning this kind of ecosystem services are fundamentally ethical in the sense that they influence the well-being of other people, in other parts of the world, across generations. In this context, the right question is not 'What do I want?' but rather 'What are we entitled to?' – a claim that becomes negotiable by public standards (Pitkin 1981).

7. Conclusions

The messages from the two valuation studies that engaged the general public are similar as they both indicate that people place high value on pristine peatlands and the ecosystem services they provide. The recommendations by the CPs are consistent with the notion of just transition, which emphasises the need to find sustainable uses for peatlands, in order to compensate the losses from the unavoidable shift from peat burning to renewable sources of energy. The DCE results indicate that even if part of the WTP for peatland protection were to become actualised, it would be possible to compensate the economic losses of those entrepreneurs.

The experiences from the DCE and CP studies sustain the argument that learning is important, as people rarely have an ordered set of preferences for unfamiliar objects like regulating services (Spash, 2007). They also support the assumptions (e.g. Aldred and Jacobs 2000; Raymond et al. 2014) that preferences may change as a result of well-informed group deliberation. The peatland case study also illustrated the scope of citizen and consumer preferences: Life-supporting ecosystem services are difficult to view as commodities, whereas recreational services are easier to evaluate and measure in monetary terms. In the MAVT process, stakeholder input was vital in structuring the analysis. However, the process would have supported transparent decision-making better if the weight elicitation stage had engaged policy-makers instead of stakeholders whose positions were quite fixed at the outset.

In terms of integration, the lesson learnt is that regardless of the preference elicitation method, all valuation studies would benefit from a structured and participatory approach when defining the scenarios as well as attributes and their levels. Relevant information obtained via survey methods can feed into deliberative processes, and deliberative processes can assist in generating suitable and well-defined survey questions to the population at large. In this case, the evaluation of societal benefits from peatland recreation in the CP and MAVT processes would have benefited from information on peoples' preferences and the actual recreational use of peatlands.

Some of the problems with the valuation approached observed in this study derive not from the applied methods but from the ecosystem service framework. First, the DCE results on climate impacts would probably have been different if the question had been framed in terms of carbon emissions instead of carbon storage. Second, the initial set of criteria following the ecosystem service categories had to be supplemented with socio-economic criteria like jobs and the rural economy, because the criterion of energy peat, measured in terms of energy units, did not quite capture the societally relevant dimensions of the problem. Third, dividing cultural ecosystem services into separate categories and listing berries under provisioning services potentially devalued holistic recreational experiences where the sounds, smells and natural beauty of peatlands are an inseparable part of berry-picking outings with family and friends.

Our research suggests that interactive methods are helpful for complex and contested policy-making situations, and they could be complemented with survey-based methods in situations where it is important to have statistically representative results of public preferences. According to Primmer et al. (2018), policy-makers expect valuation studies to address trade-offs between ecosystem services and also to serve real-life negotiations between different interests. However, this valuation project was a self-standing academic inquiry which did not feed directly into a policy process. Consequently, it was not possible to analyse decision-makers' perspectives on the relevance and usefulness of different types of value information. In the future, it would be important to study the use of valuation methods in a real-life decision-making context, and carry out follow-up studies on the uptake and use of value information by managers and policy-makers.

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.

Data availability

Data will be made available on request.

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Appendix 1

The assessment of the impacts of the different scenarios on the delivery of ecosystem services is documented in this Appendix.
Provisioning services

Energy peat

The estimate of energy peat production in the scenarios is based on annual statistics of the volume of peat production (m^3) and amount of peat energy (TWh) produced. In the years 2011–2015, 18 TWh/a energy was produced by burning peat in the whole Finland (Metsätilastollinen vuosikirja 2014). In the study area, the volume of peat production is on average 47 000 ha/a (Metsätilastollinen vuosikirja 2014), which is 64 % of the total peat production area in Finland. Consequently, it was assumed that 64 % of the total peat energy produced in Finland is produced in the study area (11 TWh/a). The scenarios S3 and S4 represent the current situation, in scenarios S1, S2 and S5 the volume of peat production and consequently the amount of energy produced varies. The results are presented in Table A1.

Table A1
Energy peat production in different scenarios.

Attribute	S1	S2	S3	S4	S5
Energy peat production (Mm^3/a)	17[a], 0[b]	12	18	18	23
Energy production (TWh/a)	8[a], 0[b]	8	11	11	15

a Until year 2030.
b From 2030 on.

Horticultural peat

Another important peat product is horticultural peat, which is usually produced at the same sites as energy peat. It is used for growing medium in gardening and landscaping as well as for desiccator and filtering material in agriculture. The current horticultural peat production in Finland is 1,5 million m^3 annually (Leinonen 2010), and in the study area, which accounts for 64 % of the total Finnish peat production area (Metsätilastollinen vuosikirja 2014), it is currently 1 million m^3 annually. The amount of horticultural peat production is proportional to the amount of peat extraction in each scenario (Table A2).

Table A2
Horticultural peat production in different scenarios.

Attribute	S1	S2	S3	S4	S5
Horticultural peat production, Mm^3/year	0,7[a], 0[b]	0,7	1	1	1,3

a Untill year 2030.
b From 2030 on.

Berries

Cloudberry (*Rubus chamaemorus*) and Cranberry (*Vaccinium oxycoccos*) are the most important wild berries that are picked from pristine peatlands for commercial and household use. In the pilot area, most of the cloudberries are picked for household use as commercial picking takes place predominantly in Northern Finland (Roininen and Mokkila 2017). Food industry in Finland uses a lot of cranberry, but it is mainly imported due to low price and availability (ibid). There are no statistics for berry picking for household use and hence we used the amount of pristine peatlands in each scenario as a basis of estimate for berry picking on a constructed scale: 0 = no changes (or very minor changes); 1 = small negative impacts; −2 = rather negative impacts; −3 = big negative impacts; −4 = very big negative impacts (Table A3). The best score is 0 because the amount of pristine peatland does not increase (within the timeframe of this study); it can stay at the current level or decrease.

In scenarios 1 and 2 there are no changes in berry picking because the amount of pristine peatland remains the same. In scenarios 3 and 4 the impact is estimated to be negative but relatively small (-1). In scenario 5 the negative impact is rather big (-2) because almost one third of the potential berry picking area will be lost. The reason for the conservative estimates is that in Southern Finland, a majority of the berries remain unused in any case, as berry picking is mostly something that people do as part of their recreational activities. Therefore, the berry yields are not directly proportional to the surface of pristine peatlands. However, it is possible that in the future the value of wild berries, also commercial value, can be bigger due to healthy lifestyle trends and therefore the negative impacts from peat extraction can be higher than estimated.

Table A3
The supply of berries in different scenarios.

Scenario	Change in area of pristine open peatlands	Effect on the supply of the berries
S1	No significant changes	0
S2		
S3	Around one fifth (18 %) of potential berry production area is lost	−1
S4		
S5	Around one third (28 %) of potential berry production area is lost	−2

Regulating services

Change in carbon stock

There was a mistake in the initial impact assessments documented in Saarikoski et al. (2019). The correct difference in carbon stock between the scenario is between 1 and 4 % until 2050, not 2 – 12 %. The initial results concerning the changes of carbon storage in different scenarios is presented in Table A4 and the corrected results are presented in Table A5. The calculation of carbon content of extracted peat (column A) in each scenario with different amount of energy peat extraction is based on the estimate that CO2 emissions from peat energy production are 106 g CO2 ekv/MJ (Kirkinen et al. 2007). However, this is the mass of the whole CO2 atom while the mass of C is only 29 g C/MJ, hence the mistake in Table 4.

Table A4
Changes of carbon storage in different scenarios.

Scenario	A: Carbon content of extracted peat (1000 t/a)	B. Carbon emissions from pristine peatlands (1000 t/a)	C: Carbon emissions from drained peatlands (1000 t)	D: Change in carbon storage (1000 t/a)	E: Change in carbon storage 2017–2050 (1000 t)	F: Change in carbon storage 2017–2050 (%)
S1	3381	–22	52	−3411	−47 755	− 2 %
S2	3381	–22	120	−3479	−118 288	−6 %
S3	4897	174	132	−5203	−176 910	−9 %
S4	4897	174	132	−5203	−176 910	−9 %
S5	6413	272	132	−6817	−231 761	−12 %

Table A5
Corrected changes of carbon storage in different scenarios.

Scenario	A: Carbon content of extracted peat (1000 t/a)	B. Carbon emissions from pristine peatlands (1000 t/a)	C: Carbon emissions from drained peatlands (1000 t)	D: Change in carbon storage (1000 t/a)	E: Change in carbon storage 2017–2050 (1000 t)	F: Change in carbon storage 2017–2050 (%)
S1	922	–22	52	−952	−13 326	−0,7 %
S2	922	–22	120	−1020	−34 675	−1,7 %
S3	1336	174	132	−1642	−55 824	−2,8 %
S4	1336	174	132	−1642	−55 817	−2,8 %
S5	1749	272	132	−2153	−73 186	−3,7 %

The carbon emission from pristine peatlands (columns B and C) are based on the estimates in Table A6. The carbon emissions (*E*) from pristine (p) and drained (d) peatlands are calculated taking into account the area of pristine and drained fens (f) and bogs (b) to be turned into peat extraction fields (P) in different scenarios (*s*). The selection of peatlands to be taken into peat extraction in each scenario was conducted using a Sampling design tool for ArcGis (NOAA/Biogeography Branch).

The following formulas were used for the emission calculation.

$$E_s^p = \left(e_p^f\right) \bullet A_s^{pf} + \left(e_p^b\right) \bullet A_s^{pb} + \left(e^P\right) \bullet A_s^{pP} \quad (1)$$

$$E_s^d = \left(e_d^f\right) \bullet A_s^{df} + \left(e_d^b\right) \bullet A_s^{db} + \left(e^P\right) \bullet A_s^{dP} \quad (2)$$

where e_p^f is carbon emission from pristine fens (see Table A6), e_p^f is carbon emission from pristine bogs, e_d^f carbon emission from drained fens, e_d^b carbon emission from pristine bogs, e^P carbon emission from peat extraction field, A^{pf} is the area pristine fens in the scenario, A^{pb} is the area pristine bogs in the scenario, A^{df} is the area of drained fens in the scenario, A^{db} is the area of drained bogs in the scenario, A^{pP} is the area of pristine peatland that will be taken into peat mining, and A^{pP} is the area of drained peatland that will be taken into peat mining in each scenario.

The total change in carbon storage (D) within the next 34 years (column E) is compared with the current amount of carbon stored into the peatlands of the pilot area to get the change in percentage (column F).

The total C store of Finnish peatlands was calculated to be 5,6 billion tons in 2000 (Minkkinen 1999). Based on Forest statistical yearbook (2014) we estimated that 36 % of the C store is located in the study area. That is around 2 billion tons.

Table A6
Carbon net emissions of pristine and drained peatlands, and peat production fields (g C/m^{-2}(–|–)a^{-1}) (based on Pohjala 2014). Net emissions refer to emissions (+) and sinks (-).

Pristine peatlands	CO_2	CH_4	Sum
Minerotrophic (Fen)	−40,1	10,4	−29,7 (=e_p^f)
Ombrotrophic (Bog)	−28,4	4,1	−24,3 (=e_p^b)
Drained peatlands	CO_2	CH_4	Sum
Minerotrophic (Fen)	68,2	0,2	68,4 (=e_d^f)
Ombrotrophic (Bog)	41,5	0,3	41,8 (=e_d^b)
Peat extraction field	CO_2	CH_4	Sum
Emissions of peat extraction field	379,1	2,0	381,1 (=e^P)

Water quality

Peatlands, especially fens can function as filters as the runoff from above catchment is infiltrated through them (Sallantaus et al. 2014, Karjalainen et al. 2015). However, there are no quantitative estimates of the filtering impact in Finland. Furthermore, most fens in the study area have lost their natural filtration capacity because they have been cut off from the larger water basin by ditches (Tahvanainen 2011; Sallantaus et al. 2014). Therefore, the water quality impact estimate focuses on the emissions form peat extraction, which, in any case, are more significant than natural water purification impacts.

Drainage of peatlands causes leaching of nutrients as well as dissolved and particulate organic matter (see e.g. Klöve 1997; Karjalainen et al. 2015). Phosphorus was selected as the water quality indicator as phosphorus is a more common growth-limiting nutrient than nitrogen in fresh waters in Finland (Pietiläinen 1997, Räike et al. 2003). In addition, phosphorus loading has been estimated nationally with operational water quality model (Huttunen et al. 2016).

The effect of peat production on water quality was estimated using specific loading coefficients per area unit. Phosphorus leaching from undrained peatlands is estimated to be 0.053 kg ha^{-1} a^{-1} (Mattsson et al. 2003; Kortelainen et al. 2006) and around 0.1 kg ha^{-1} a^{-1} for the peatlands drained for the forestry (Kortelainen et al. 2006). The average loading from peat mining with different types of water protection measures is 0.26 kg ha^{-1} a^{-1} (Pöyry 2013) (Table A7).

Table A7
Specific loading of peat mining per hectare per year with different types of water protection measures. COD_{Mn} = Chemical oxygen demand (Pöyry 2013).

Water protection measure	Total phosphorus (kg ha^{-1} a^{-1})	Total nitrogen (kg ha^{-1} a^{-1})	Suspended solids (kg ha^{-1} a^{-1})	COD_{Mn} (kg ha^{-1} a^{-1})
Sedimentation pond	0.26	9.5	38	203
Sedimentation pond in winter, overland flow in summer	0.26	9.2	32	219
Overland flow	0.26	8.1	29	202
Wetland	0.32	7.0	40	168

The assessment was limited to small headwater lakes (area smaller than 5 km^2 or mean depth less than 3 m) because small water bodies are more sensitive to additional loading. The water quality effects were estimated in the lowest sub catchment level of Finnish national river basin system. The mainland of Finland is divided into 5637 sub catchments in a hierarchical river basin system (Ekholm 1993). If the phosphorus loading of a sub catchment would increase more than 5 % as a result of peat extraction, then the status of headwater lakes was estimated to be in a risk to deteriorate. The present loading was estimated with VEMALA-model (Huttunen et al. 2016) and the change in loading (δL) with following formula for each scenario (s):

$$\delta L_s = (l_p - l_n) \cdot A_{us} + (l_p - l_f) \cdot A_{ds} \quad (3)$$

where l_p is specific loading from peat mining, l_n specific loading from undrained peat lands, l_f specific loading from drained peat lands, A_u is the undrained peatland that will be taken into peat mining in the scenario, and A_d is the area of already drained peat land that will be taken into peat mining.

The total number of headwater lakes within the study area is 1013, with an area of 2040 km^2. The total area of all lakes (incl. bigger lakes than 5 km^2) is around 21 000 km^2. The number of lakes being at a risk of deteriorating varies between 9 and 105, being largest in the scenario S5 (Table A8).

Table A8
Number and surface area of lakes in a risk of deteriorating status in different scenarios.

Scenario	Number of lakes in a risk of deteriorating status	Surface area of lakes in a risk of deteriorating status	Share of the surface area form the headwater lakes
S5	105	349 km^2	17 %
S4	70	282 km^2	14 %
S3	73	287 km^2	14 %
S2	9	86 km^2	4 %
S1	0	0 km^2	0 %

Biodiversity

Undrained peatlands provide habitats for hundreds of species that are adapted to wetland conditions. Around 4 % of species in Finland live predominantly in peatlands, and they have become increasingly endangered since the beginning of 2000. Peatlands are a primary habitat for 223 and secondary habitat for 197 threatened or near threatened species in Finland, following the categories of International Union for Conservation of Nature (Alanen and Aapala 2015). There are also 24 threatened or near threatened peatland habitat types in Southern Finland that are endangered by peat extraction (ibid).

The biodiversity impacts of the scenarios were based on a biodiversity expert evaluation, using a constructed scale: 0 = no changes (or very minor changes); 1 = small negative impacts; −2 = rather big negative impacts; −3 = big negative impacts; −4 = very big negative impacts (Table A9).

In scenarios 1 and 2, there are no changes in the surface area of pristine peatlands and hence no impacts on biodiversity dependent on them (0). In scenario 3, the most important peatlands from biodiversity perspective will be saved due to full implementation of the Proposal for Supplementing Peatland Protection. However, other pristine peatlands (excluding existing protected areas) will decrease by 42 % which will have negative impacts on biodiversity (-1). In scenario 4, peat extraction can take place also in the peatlands that are designated in the Proposal for Supplementing Peatland Protection, and hence the negative impacts are rather big (-2). In scenario, more than half of the currently undrained peatlands will be used for peat production, including some sites that are designated to the Proposal for Supplementing Peatland Protection, and hence the negative impacts are very big (-4).

Table A9
Biodiversity impacts in different scenarios.

Scenario	Mire habitat and mire complex types	Mire species	Value
S1 and S2	The Proposal for Supplementing Peatland Protection (SPCP) improves the representativeness of the current protected area (PA) network for habitats and species of raised bogs and southern aapamires. Decline of threatened mire habitat- and complex types slows down. The area of undrained raised bogs and aapamires does not decrease due to peat extraction. Mire habitat types typical for the central parts of raised bogs (*Sphagnum fuscum* bogs and ridge-hollow pine bogs) do not decline. No significant effect on habitat types typical for the margin parts of raised bogs and aapamires.	Localities of threatened mire species in undrained raised bogs and aapamires do not disappear due peat extraction. Decline of threatened species typical to these mire complex types slows down.	0
S3	SPCP improves the representativeness of the current protected area (PA) network for habitats and species of raised bogs and southern aapamires. The area of undrained raised bogs and aapamires outside the SPCP and PA network decrease by 42 % due peat extraction. Decline of threatened mire habitat- and complex types continues. Mire habitat types typical for the central parts of raised bogs (*Sphagnum fuscum* bogs and ridge-hollow pine bogs) may become threatened. Decline of already threatened habitat types on both raised bogs and aapamires may increase.	Some of the localities of threatened mire species on undrained raised bogs and aapamires may disappear due peat extraction.	−1
S4	The area of raised bogs in SPCP decreases appr. 40 % and that of aapamires appr. 50 %. In addition the area of other undrained peatlands outside PA network decreases appr. 43 % due to peat extraction. In total the area of all undrained peatlands outside the PA network decreases 42 %. Decline of raised bogs and aapamires continues. Mire habitat types typical of the central parts of raised bogs (*Sphagnum fuscum* bogs and ridge-hollow pine bogs) may become threatened. Decline of already threatened habitat types of both raised bogs and aapamires may increase.	Clearly more localities of threatened mire species on undrained raised bogs and aapamires may disappear due peat extraction than in scenario S3.	−2
S5	64 % of the area of undrained raised bogs and aapamires disappear, including 53 % of the area of the SPCP sites. Decline of raised bogs and aapamires accelerates. Decline of habitat types typical of the central parts of raised bogs and aapamires accelerates. Decline of habitat types typical of the margin parts of raised bogs and aapamires may continue.	Several localities of threatened mire species on undrained raised bogs and aapamires disappear due peat extraction. Decline of threatened species typical to these mire complex types accelerates.	−4

Cultural services

Recreation

Recreational use of peatland includes hiking, berry picking, hunting, bird watching, skiing, and orienteering. Peatlands suitable for recreation are peaceful, pristine, and accessible. Most important peatlands for recreational use are located near the users' homes (Ojala et al. 2013). The analysis of the impacts of the scenarios on recreational opportunities was based on the amount of pristine peatlands as well as their accessibility, measured by the amount of people living within 5 km (walking or biking distance) radius from the nearest peatland (Table A10).

Table A10
Impacts on recreation in different scenarios.

Attributes	S1	S2	S3	S4	S5
Reduction of pristine peatlands, %	0	0	18	18	24
Number of people living within 5 km radius from pristine peatlands	1 100 000	1 100 000	800 000	900 000	700 000
Number of recreational homes within 5 km radius from pristine peatlands	110 000	110 000	87 000	87 000	69 000
Recreational opportunities, scale 0…-4	0	0	−1	−1	−2

In scenarios 1 and 2, there are no changes to the surface area of pristine peatlands and hence no impacts on outdoor recreation. In scenario 3, there are some negative impacts (-1) because some of the pristine peatlands nearby people are lost. However, most people visit peatlands in nature protection areas or nature parks with existing nature trails and other infrastructure so on average outdoor recreation opportunities do not diminish considerably. In scenario 4, some of the most ecologically valuable peatlands will be lost, which has negative impacts on amateur naturalists interested in plants and animal species. On the other hand, there are more pristine peatlands within 5 km radius from people than in scenario 3. This is because pristine peatlands tend to be located far away from population centers. Due to these factors that pull to different directions, the impact is estimated to be the same as in scenario 3 (-1). In scenario 5, the impacts are rather big (-2), especially for people who are interested in berry picking and observing nature.

Landscape

Peatlands are an important part of Finnish national landscape. Large open peatlands with mosaic of ponds and islets of trees are usually found most aesthetically pleasing peatland landscapes (Ojala et al. 2013). The landscape impacts (Table A11) are directly related to the surface area of pristine peatlands but not linked to their ecological values (i.e. whether the peatlands are designated to the Proposal for Supplementing Peatland Protection).

A constructed scale was used for the landscape impact estimates: 0 = no changes (or very minor changes); 1 = small negative impacts; −2 = rather big negative impacts; −3 = big negative impacts; −4 = very big negative impacts.

Table A11
Landscape impacts in different scenarios.

Attribute	S1	S2	S3	S4	S5
Landscape impacts, scale 0 …-4	0	0	−1	−1	−2

In scenarios 1 and 2, there are no changes in the amount of pristine peatlands and hence no landscape impacts related to them (0). In scenarios 3 and 4, around 80 % of the landscapes remain intact and the impact is estimated to be small (-1). In scenario 5, 28 % of the landscapes are lost and the negative impacts are estimated to rather big (-2).

Environmental education

Pristine peatland can also serve educational purposes. For instance, school classes can make field trips to nearby peatlands if the travel time is reasonable. An accessibility analysis (see e.g. Ala-Hulkko et al. 2016) was carried out to estimate an average travel time to nearest pristine peatland. The analysis was based on a 250 m grid, including the number of population within each cell. The accessibility (travel time by car) was calculated from each cell based on the national road network. The average travel times for each scenario are weighted with the number of population in each sell. The average travel time to nearest pristine peatland varied from 16 to 19 min between the scenarios (Table A12) However, most school classes do not use car transportation during school time. Therefore, the accessibility analysis was used to support an evaluation on a constructed scale: 0 = no changes (or very minor changes); 1 = small negative impacts; −2 = rather big negative impacts; −3 = big negative impacts; −4 = very big negative impacts.

It was estimated that there are no impacts (0) in scenarios 1 and 2 on environmental education opportunities, small impacts (-1) in scenarios 3 and 4. The impacts is scenario 5 are rather big (-2) because some schools as well as hobby groups like scouts will lose access to nearby peatlands that they can visit during schooldays, or in the evenings.

Table A12
Impact on environmental education opportunities in different scenarios.

Attribute	S1	S2	S3	S4	S5
Travel distance to the nearest pristine peatland by car, (min)	16 min	16 min	18 min	18 min	19 min
Impact on environmental education, scale 0 …-4	0	0	−1	−1	−2

Socio-economic impacts

Regional economy and employment

The impacts of the scenarios on regional economy and employment were estimated by using results from an input–output analysis of socio-economic impacts of Norther Finland peatlands by Piirainen et al. (2013). According to this study, a peat production area of 16 800 ha/a generated an increment value of 51 M€/a and the employment effect was 750 person years. These figures were used as a starting point to extrapolate the impacts in the scenarios (Table A13). These estimates are only indicative but nevertheless suggest the magnitude of the impacts.

Table A13
Increment value and employment effects in different scenarios.

Attribute	S1	S2	S3	S4	S5
Production, ha/a	34 000[a] 0[b]	34 000	47 000	47 000	64 000
Increment value from peat production, incl. multiplicative effects from intermediate products, M€/year	100[a] 0[b]	100	140	140	190
Employment in peat production, man-years, incl. multiplicative effects from intermediate products	1500[a] 0[b]	1500	2100	2100	2900

a Untill year 2030.
b From 2030 on.

Landowners' freedom of choice

The original aim of the peatland protection programme process in 2012–2015 was to prepare a statutory protection programme. However, landowners, including The Central Union of Agricultural Producers and Forest Owners, argued that a state enforced protection would violate landowners' rights for self-determination and insisted that the programme has to be implemented on a voluntary basis. Consequently, the protection programme was replaced with the Proposal for Supplementing Peatland Protection with voluntary measures. During the programme process, a survey was administered to owners of ecologically valuable peatland in Southern Finland (response rate 42 %). 47 % of the respondents had a positive attitude and 41 % negative attitude towards peatland protection in their lands (Alanen and Aapala 2015). Around 42 % were interested in negotiating with authorities about establishing a private protection area in their property (ibid).

The survey results were used in evaluating the impact of the scenarios on landowners' autonomy and rights for self-determination (Table A14) on a constructed scale: 0 = no changes (or very minor changes); 1 = small negative impacts; −2 = rather negative impacts; −3 = big negative impacts; −4 = very big negative impacts.

Table A14
Impact on landowners' freedom of choice in different scenarios.

Attribute	S1	S2	S3	S4	S5
Impact on landowners' freedom of choice, scale 0 …-4	−3	−3	−2	0	0

In scenarios 1–3, it is expected that all ecologically valuable sites identified the Proposal for Supplementing Peatland Protection will be protected. As around half of the landowners have a negative attitude towards peatland protection, it is likely that voluntary measures would not be sufficient to implement the programme but statutory measures would be needed. These are estimated to have a rather big negative impact (-2) on land owners' freedom of choice. In scenario 2 and 1, all pristine over 10 ha peatlands will be protected, which would have a big negative impact (-3) on landowners' freedom of choice. On the other hand, scenarios 1 and 2 improve the freedom of choice of those landowners, who would like to protect their peatlands, but cannot do that because the peatlands bordering their land holdings would be drained. Due to the impacts that pull to different directions, the estimate in scenarios 1 and 2 is −3, not −4 (a big negative impact).

References

Ala-Hulkko, T., Kotavaara, O., Alahuhta, J., Helle, P. & Hjort, J. 2016. Introducing accessibility analysis in mapping cultural ecosystem services. Ecological indicators 66: 416–427.

Alanen, A., & Aapala, K. (eds). 2015. Soidensuojelutyöryhmän ehdotus soidensuojelun täydentämiseksi [A proposal by peatland protection committee for supplementing peatland protection in Finland]. Ministry of the Environment Report Series no 26/2015. Helsinki, Finland.

Ympäristöministeriön raportteja 26 | 2015.

Ekholm, M. 1993. Drainage Basins in Finland. Publications of the Water and Environment Administration – series A 126. Helsinki 166 p. (In Finnish, English abstract).

Huttunen I., Huttunen M., Piirainen V., Korppoo M., Lepistö A., Räike A., Tattari S. & Vehviläinen B. (2016). A national scale nutrient loading model for Finnish watersheds — VEMALA. *Environmental Modeling and Assessment* 21: 83–109.

Karjalainen, S.-M., Heikkinen, K. & Ihme, R. (2016). Long-term purification efficiency of a wetland constructed to treat runoff from peat extraction. *Journal of Environmental Science and Health, Part A: Toxic/Hazardous Substances and Environmental Engineering* 51(5): 393–402.

Kirkinen, J., Minkkinen, K., Penttilä B, T., Kojola, S., Sievänen, R., Alm, J., Saario, S., Silvan, N., Laine, J. & Savolainen, J. (2007). Greenhouse impact due to different peat fuel utilisation chains in Finland: a life-cycle approach. Boreal Environment Research 12(2): 211–223.

Kløve, B. 1997. Environmental impact of peat mining; development on storm water treatment methods. Doctoral thesis, Lund Univ., Lund.

Kortelainen P., Mattsson T., Finér L., Ahtiainen M., Saukkonen S. & Sallantaus T. 2006. Controls on the export of C, N, P and Fe from undisturbed boreal catchments, Finland. *Aquatic Sciences* 68(4): 453–468.

Leinonen, A. (ed), 2010. Turpeen tuotanto ja käyttö - Yhteenveto selvityksistä. VTT tiedotteita 2550, 104s. [Peat production and use – A summary of studies. VTT Technical Research Centre of Finland, Research Notes 2550].

Mattsson T., Finér L., Kortelainen P. & Sallantaus T. 2003. Brook water quality and background leaching from unmanaged forested catchments in Finland. *Water Air and Soil Pollution* 147(1–4): 275–297.

Metsätilastollinen vuosikirja 2014. Metsäntutkimuslaitos, Vantaa. [Finnish Statistical Yearbook of Forestry, Finnish Forest Research Institute, Vantaa].

Minkkinen, K. 1999. Effect of forestry drainage on the carbon balance and radiative forcing of peatlands in Finland. PhD thesis. Department of Forest Ecology, University of Helsinki. 42 p. ISBN 951-45-8757-X (PDF version).

Ojala, L., Hannu I. Heikkinen, Tolvanen, A. 2013. Soiden merkitys virkistyskäytölle. Haastattelututkimus Oulussa, Haukiputaalla, Muhoksella ja Pudasjärvellä. [The recreational import of peatlands. An interview study in Oulu, haukiputaa, Muhos and Pudasjärvi]. Metlan työraportteja 258: 213–229. [Finnish Forest Research Institute, Research Notes 258: 213–229].

Pohjala, M. (2014). What are the climate impacts of different life cycles of energy and horticultural peat? Master's thesis. Department of Forest Sciences, University of Helsinki. 70 p. (In Finnish, English abstract).

Pietiläinen, O.-P. 1997. Agricultural phosphorus load and phosphorus as a limiting factor for algal growth in Finnish lakes and rivers. In Tunney, H., Carton, O.T., Brookes, P.C. and Johnston A.E. (Eds.), *Phosphorus loss from soil to water.* Cab International, Wallingford, pp. 354–356.

Piirainen, A., Juutinen, A., & Tolvanen, A., 2013. Soiden käytön aluetaloudelliset vaikutukset Pohjois-Pohjanmaalla—esimerkkinä Siikalatvan ja Pudasjärven kunnat. [Regional Economic Impacts of Peatland Use in the Municipalities of Siikalatva and Pudasjärvi]. Metlan työraportteja 258: 230–253. [Finnish Forest Research Institute, Research Notes 258:230–253].

Pöyry 2013. The assessment of pollution from peat mining areas - Water quality and loading assessment based on the monitoring date 2003–2011. Pöyry Finland Oy. (In Finnish).

Roininen, K. & Mokkila, M. 2017. Selvitys marjojen ja marjasivuvirtojen hyödyntämispotentiaalista Suomessa. [A study on the utilization potential of berries in Finland] Sitra ja VTT. [The Finnish Innovation Fund Sitra and VTT Technical Research Centre of Finland] [https://media.sitra.fi/2017/02/27173257/VTTn20marjaselvitys20b-2.pdf.

Räike, A., O.-P. Pietiläinen, S. Rekolainen, P. Kauppila, H. Pitkänen, J. Niemi, A. Raateland & J. Vuorenmaa 2003. Trends of phosphorus, nitrogen and chlorophyll *a* concentrations in Finnish rivers and lakes in 1975–2000. *Science of The Total Environment* 310, 47–59.

Sallantaus, T., Kondelin, H., Lahti, T. & Tuominen, S. 2014. Potential to restore hydrochemical ecosystem services of aapa mires, a case study. In Tolvanen, A. & Hekkala, A-M. (eds.). 2014. The 9th European Conference on Ecological Restoration – Abstracts. 231p. ISBN 978–951-40–2480-1.

Tahvanainen, T. 2011: Abrupt ombrotrophication of a boreal aapa mire triggered by hydrological.

disturbance in the catchment. *Journal of Ecology* 99 (2): 405–415.

Appendix 2

Description of the DEC attributes to the respondents

Carbon storage and climate effects: Peatland vegetation captures carbon from the air. Peatlands also provide a long-term carbon storage in peat. Peat production areas release the stored carbon to the atmosphere, accelerating climate change.

Peatland species diversity effects: Peatlands provide a habitat for species acclimatized to them. Peat production destroys peatland species habitats.

Water quality effects: Peatlands with drainage leak humus and nutrients to downstream surface waters. These effects can cause local harm to water recreation and aquatic species.

Berry picking effects: Berry picking is allowed in peatlands by the right of public access, regardless of their protection status. Significant edible berries growing in peatlands include the cloudberry, cranberry and bilberry.

Peat use for energy production effects: In peat production, the peatland requires drainage and the peat is extracted for fuel and seedbeds. Peat is a domestic fuel and in the short term replaces coal burning from foreign sources.

Welfare effects: Economic contribution to peatland conservation through taxation.

References

Alanen, A., Aapala, K., 2015. Soidensuojelutyöryhmän ehdotus soidensuojelun täydentämiseksi [A proposal by peatland protection committee for supplementing peatland protection in Finland]. Ympäristöministeriön raportteja 26/2015 [Ministry of the Environment Report Series no 26/2015]. Helsinki, Finland.
Albrecht, E., Ratamäki, O., 2016. Effective arguments for ecosystem services in biodiversity conservation – a case study on Finnish peatland conservation. Ecosyst. Serv. 22, 41–50.
Aldred, J., Jacobs, M., 2000. Citizens and wetlands: Evaluating the Ely citizen's jury. Ecol. Econ. 34 (2), 217–232.
Belton, V., Stewart, T.J., 2002. Multiple Criteria Decision Analysis: An Integrated Approach. Kluwer Academic Publishers, Boston.
Bonn, A., Allott, T., Evans, M., Joosten, H., Stoneman, R. 2016. (Eds), Peatland Restoration and Ecosystem Services: Science, Policy and Practice. Cambridge University Press, Cambridge, pp. 63-76.
Carson, R., Louviere, J., 2011. A Common nomenclature for stated preference elicitation approaches. Environ. Resour. Econ. 44 (4), 539–559.
Chan, K., Satterfield, T., Goldstein, J., 2012. Rethinking ecosystem services to better address and navigate cultural values. Ecol. Econ. 74, 8–18.
Christie, M., Martín-López, B., Church, A., et al., 2019. Understanding the diversity of values of "Nature's contributions to people": insights from the IPBES Assessment of Europe and Central Asia. Sustain. Sci. 14, 1267–1282.
de Groot, R., Costanza, R., Braat, L., Brander, L., Burkhard, B., Carrascosa, J.L., Crossman, N., Egoh, B., Geneletti, D., Hansjuergens, B., Hein, L., Jacobs, S.J., Kubiszewski, I., Leimona, B., Li, B., Liu, J., Luque, S., Maes, J., Marais, C., Willemen, L., 2018. Ecosystem Services are Nature's Contributions to People: Response to: Assessing nature's contributions to people. Sci. Prog. 359 (6373).
Farley, J., 2012. Ecosystem services: The economics debate. Ecosyst. Serv. 1 (1), 40–49.
Fish, R., Burgess, J., Chilvers, J., Footit, A., Haines-Young, R., Russel, D., Turner, K, Winter D. 2011. Participatory and Deliberative Technoques for Embedding an Ecosystems Approach into Decision Making. Full Technical Report. NR0124. Department for Environment, Food and Rural Affairs, London.
Getzner, M., Spash, C., Stagl, S., 2005. Alternatives to Environmental Valuation. Routledge, London.
Gómez-Baggethun, E., Martín-López, B., 2015. Ecological economics perspectives on ecosystem services valuation. In: Martinez-Alier, J., Muradian, R. (Eds.), Handbook of Ecological Economics. Edward Elgar, Cheltenham, Northampton, pp. 260–282.
Grammatikopoulou, I., Eija, P., Janne, A., 2021. Relationship between value orientations, attitudes, and behavioral intentions regarding peatland conservation in Finland: an empirical application of the cognitive hierarchy model. Society Natural Resour. 34 (7), 943–965.
Grammatikopoulou, I., E. Pouta, and J. Artell. 2019. Heterogeneity and attribute non-attendance in preferences for peatland conservation. Forest Policy and Economics 104:45–55.
Grammatikopoulou, I., J. Artell, T. Hjerppe, and E. Pouta. 2020. A mire of discount rates: Delaying conservation payment schedules in a choice experiment. Environ. Resour. Econ. 77 (3):615–39.
Hanemann, W., 1984. Welfare evaluations in contingent valuation experiment with discrete responses. Am. J. Agric. Econ. 66, 332–341.
Hanley, N., 2001. Cost-benefit analysis and environmental policy-making. Environ. Planning C 19 (1), 103–118.
Hanley, N., Mourato, S., Wright, R., 2001. Choice modeling approaches: a superior alternative for environmental valuation? J. Econ. Surveys 15 (3), 435–462.
Hattam, C., Böhnke-Henrichs, A., Börger, T., Burdon, D., Hadjimichael, M., Delaney, A., Atkins, J.P., Garrard, S., Austen, M.C., 2015. Integrating methods for ecosystem service assessment and valuation: mixed methods or mixed messages? Ecol. Econ. 120, 126–138.
Huttunen, I., Huttunen, M., Piirainen, V., Korppoo, M., Lepistö, A., Räike, A., Tattari, S., Vehviläinen, B., 2016. A national scale nutrient loading model for Finnish watersheds — VEMALA. Environ. Model. Assess. 21, 83–109.
Hyvärinen, E., Juslén, A., Kemppainen, E., Uddström, A. & Liukko, U.-M. (eds.) 2019. The 2019 Red List of Finnish Species. Ympäristöministeriö & Suomen ympäristökeskus. Helsinki. 704 p.
Kangas, A., Horne, P., Leskinen, P., 2010. Measuring the Value of Information in Multicriteria Decisionmaking. Forest Sci. 56 (6), 558–566.
Kareiva P., Tallis, H., Ricketts, T., Daily, G. & Polasky, S. 2011. Natural Capital. Theory and Practice of Mapping Ecosystem Services. Oxford University Press, Oxford.
Kenter, J., 2018. IPBES: Don't throw out the baby whilst keeping the bathwater; Put people's values central, not nature's contributions. Ecosyst. Serv. 33, 40–43.
Kenter, J., O'Brien, L., Hockley, N., Ravenscroft, N., Fazey, I., Irvine, K., Reed, M., Christie, M., Brady, E., Bryce, R., Churche, A., Cooper, N., Davies, A., Evely, A., Everard, M., Fish, R., Fisher, J., Jobstvogt, N., Molloy, C., Orchard-Webb, J., Ranger, J., Ryant, M., Watsont, V., Williams, S., 2015. What are shared and social values of ecosystems? Ecol. Econ. 111, 86–99.
Kenter, J., Reed, M., Fazey, I., 2016. The deliberative value formation model. Ecosyst. Serv. 21, 194–207.
Kenyon, W., Nevin, C., 2001. The use of economic and participatory approaches to assess forest development: a case study in the Ettrick Valley. Forest Policy Econ. 3 (1-2), 69–80.
Kirkinen, J., Minkkinen, K., Penttilä B, T., Kojola, S., Sievänen, R., Alm, J., Saario, S., Silvan, N., Laine, J., Savolainen, J., 2007. Greenhouse impact due to different peat fuel utilisation chains in Finland: a life-cycle approach. Boreal Environment Research 12(2): 211-223.
Kontogianni, A., Skourtos, M.S., Langford, I.H., Bateman, I.J., Georgiou, S., 2001. Integrating stakeholder analysis in non-market valuation of environmental assets. Ecol. Econ. 37 (1), 123–138.
Kontula, T. & Raunio, A. (eds). 2019. Threatened Habitat Types in Finland 2018. Red List of Habitats – Results and Basis for Assessment. Finnish Environment Institute and Ministry of the Environment, Helsinki. The Finnish Environment 2/2019. 254 p.
Kortelainen, P., Mattsson, T., Finér, L., Ahtiainen, M., Saukkonen, S., Sallantaus, T., 2006. Controls on the export of C, N, P and Fe from undisturbed boreal catchments, Finland. Aquatic Sci. 68 (4), 453–468.
Kronenberg, J., Andersson, E., 2019. Integrating social values with other value dimensions: parallel use vs. combination vs. full integration. Sustain Sci. 14 (5), 1283–1295.
Lo, A., 2013. Agreeing to pay under value disagreement: Reconceptualizing preference transformation in terms of pluralism with evidence from small-group deliberations of climate change. Ecol. Econ. 87, 84–94.
MA 2005. Millennium Ecosystem Assessment. Ecosystems and Human Well-being: Synthesis. World Island Press, Washington DC, 137.
Martinez-Alier, J., Munda, G., O'Neill, J., 1998. Weak comparability of values as a foundation for ecological economics. Ecol. Econ. 26 (3), 277–286.
Marttunen, M., Mustajoki, J., Dufva, M., Karjalainen, T.P., 2015. How to design and realize participation of stakeholders in MCDA processes? A framework for selecting an appropriate approach. Eur. J. Decision Processes 3 (1-2), 187–214.
Metsätilastollinen vuosikirja 2014. Metsäntutkimuslaitos, Vantaa. [Finnish Statistical Yearbook of Forestry, Finnish Forest Research Institute, Vantaa].
Minkkinen, K. 1999. Effect of forestry drainage on the carbon balance and radiative forcing of peatlands in Finland. PhD thesis. Department of Forest Ecology, University of Helsinki. 42 p.
Mustajoki, J., Hämäläinen, R.P., 2000. Web-Hipre: global decision support by value tree and AHP analysis. Information Systems Operational Res. 38 (3), 208–220.
Mustajoki, J., Saarikoski, H., Belton, V., Hjerppe, T., Marttunen, M., 2020. Utilizing ecosystem service classifications in multi-criteria decision analysis – experiences of peat extraction case in Finland. Ecosyst. Serv. 41, 101049.
O'Neill, J., 2001. Representing people, representing nature, representing the world. Environ. Planning C: Government and Policy 19 (4), 483–500.
Orchard-Webb, J., Kenter, J.O., Bryce, R., Church, A., 2016. Deliberative democratic monetary valuation to implement the ecosystems approach. Ecosystem Services 21: 308-318.
Pascual, U., Balvanera, B., Dıaz, S., Pataki, G., Roth, E., Stenseke, M., Watson, R., Basak, E., Islar, M., Kelemen, E., Maris, V., Quaas, M., Subramanian, S., Wittmer, H., Adlan, A., Ahn, S., Al-Hafedh, Y., Amankwah, E., Asah, S., Berry, P., Bilgin, A., Breslow, S., Bullock, C., Caceres, D., Daly-Hassen, H., Figueroa, E., Golden, C., Gomez-Baggethun, E., Gonzalez-Jimenez, D., Houdet, J., Keune, H., Kumar, R., Ma, K., May, P., Mead, A., O'Farrell, P., Pandit, R., Pengue, W., Pichis-Madruga, R., Popa, F., Preston, S., Pacheco-Balanza, D., Saarikoski, H., Strassburg, B., van den Belt, M., Verma, M., Wickson, F., Yagi, N., 2017. Valuing Nature's Contributions to People: The IPBES Approach. Current Opinion in Environmental Sustainability 26–27, 7–16.
Piirainen, A., Juutinen, A., & Tolvanen, A., 2013. Soiden käytön aluetaloudelliset vaikutukset Pohjois-Pohjanmaalla—esimerkkinä Siikalatvan ja Pudasjärven kunnat. [Regional Economic Impacts of Peatland Use in the Municipalities of Siikalatva and Pudasjärvi]. Metlan työraportteja 258: 230-253. [Finnish Forest Research Institute, Research Notes 258:230-253].
Primmer, E., Saarikoski, H., Vatn, A., 2018. An empirical analysis of institutional demand for Valuation Knowledge. Ecol. Econ. 152, 152–160.
Ranger, S., Kenter, J.O., Bryce, R., Cumming, G., Dapling, T., Lawes, E., Richardson, P., 2016. Forming shared values. Ecosystem Services 21, 344–357.
Raymond, C., Kenter, J., Plieninger, T., Turner, N., Alexander, K., 2014. Comparing instrumental and deliberative paradigms underpinning the assessment of social values for cultural ecosystem services. Ecol. Econ. 107, 145–156.
Saarikoski, H., Mustajoki, J., Barton, D., Geneletti, D., Langemeyer, J., Gomez-Baggethun, E., Marttunen, M., Antunes, P., Keune, H., Santos, R., 2016. Multi-Criteria Decision Analysis and Cost-Benefit Analysis: Comparing alternative frameworks for integrated valuation of ecosystem services. Ecosyst. Serv. 22, 238–249.
Saarikoski, H., Mustajoki, J., Hjerppe, T., Aapala, K., 2019. Participatory multi-criteria decision analysis in valuing peatland ecosystem services—Trade-offs related to peat extraction vs. pristine peatlands in Southern Finland. Ecol. Econ. 162, 17–28.
Saarikoski, H., Mustajoki, J., 2021. Valuation through deliberation – Citizens' panels on peatland ecosystem services in Finland. Ecol. Econ. 183, 106955.
Sagoff, M., 1988. The Economy of the Earth: Philosophy, Law and Environment. Cambridge University Press, Cambridge.

Smith, G., 2003. Deliberative democracy and the environment. Routledge, London.
Soimakallio, S., Sankelo, P., Kopsakangas-Savolainen, M., Sederholm, C., Auvinen, K., Heinonen, T., Johansson, A., Judl, J., Karhinen, S., Lehtoranta, S., Rasanen, S., Savolainen, H. 2020. Turveraportti: Turpeen rooli ja sen käytöstä luopumisen vaikutukset Suomessa (Peat report: The role of peat and the consequences of stopping its use in Finland, in Finnish). SITRA tekninen raportti. ISBN 978-952-347-186-3 (PDF).
Spangenberg, J.H., Settele, J., 2010. Precisely incorrect? Monetising the value of ecosystem services. Ecol. Complexity 7 (3), 327–337.
Spash, C. 2007. Deliberative monetary valuation (DMV): Issues in combining economic and political processes to value environmental change. Ecological Economics 63: 690–699.
TEEB, 2010. The Economics of Ecosystems and Biodiversity: Ecological and Economic Foundations. Earthscan, London.
ten Brink, P. 2011 (ed.). The Economics of Ecosystems and Biodiversity in National and International Policy Making, Earthscan, London.
Vatn, A., 2015. Environmental Governance. Institutions, Policies and Actions. Cheltenham: Edward Elgar.
Vatn, A., 2009. An institutional analysis of methods for environmental appraisal. Ecol. Econ. 68, 2207–2215.
Wegner, G., Pascual, U., 2011. Cost-benefit analysis in the context of ecosystem services for human well-being: A multidisciplinary critique. Global Environ. Change 21 (2), 492–504.
Wilson, M.A., Howarth, R.B., 2002. Discourse-based valuation of ecosystem services: establishing fair outcomes through group deliberation. Ecol. Econ. 41 (3), 431–443.