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Biodiversity in boreal Sweden: what aspects are appreciated, and how will the biodiversity change in the coming decades?

Sophie Valeur Ottmann

Master of Environmental and natural resources

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Supervisors:

Jan E. Vermaat, Head of Department

Bart Immerzeel, PhD Candidate

- Faculty of Environmental Sciences and Natural Resource Management

PREFACE

The completion of this thesis marks the end of my master's degree in Environment and natural resources at the Norwegian University of Life Science. It has been an exciting project from the beginning, and I am grateful for been allowed to work with and assisting a larger project, BIOWATER. This thesis has also been a great possibility for me to research and write something on my own and get a peek into the science world.

I would like to show my gratitude to my two supervisors, Jan Vermaat and Bart Immerzeel. They have been patient, given great feedback and engaged in my thesis from the beginning. Jan Vermaat helped me with the formation the thesis questions and my writing, whilst infected me with his contagious excitement for his work. Bart Immerzeel has tried to assist me with the statistics and spent one month of his summer with me during the survey fieldwork. Bart Immerzeel also typed in all the data from the physical questionnaires and later gave the worksheet to me. This was a huge time saver and I am grateful. I would also like to thank the BIOWATER project for making it possible to carry out the fieldwork in the summer of 2019 in Sweden. This includes lodgings, flights, and vehicles, and could economically not been doable without them.

Finally, I would like to express gratitude to family and boyfriend for letting me be distant and moody through a whole year and still supporting me and providing me love I so desperately needed. They also read my thesis and aided with feedback on my writing, which was of great help.

Sophie V.Ottmann

Sophie Valeur Ottmann

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ABSTRACT

Humans affect the environment at both local and global scales and the manifold of these influences are considered major threats to global biodiversity. Both climate change and land-use change have been two major drivers of the transformation in biodiversity. The observed and projected changes in biodiversity by experts may not correspond with the general appreciation among inhabitants or visitors of a region. This is why the study goals were to (I) find the importance of biodiversity in two boreal landscapes in Sweden for both inhabitants and visitors; (II) discover if plausible future changes to land use with considering global change will affect biodiversity in these catchments; and (III) whether such projected biodiversity change would affect people's appreciation. The survey fieldwork was set in the summer of 2019 in the Vindeln and Sävjaån area of Sweden and the biodiversity scenarios assessments were conducted with the use of BioScore. In both catchments, survey participants found that the most essential element of nature was a variety of wildlife and large areas of 'untouched' nature. Respondents answers could be connected to either how aesthetically pleasing nature is, tourism, the possibility of physical outdoor activities or from a conservational viewpoint. The BioScore results showed that the present state Sweden had the most stable number of species whilst the SSP1-scenario has more potentially increasing species than SSP3 for both catchments. Such projected biodiversity change would affect the people's appreciation as less variety in forest composition would occur and a substantial loss in biodiversity is possible under these scenarios. The environmental variables quantified in BioScore had a stronger negative effect than land cover change for the SSP3-scenario, while the opposite occurred in SSP1. Both land cover change and environmental change affect future biodiversity but are likely to affect different species groups differently.

Keywords:

Biodiversity, survey, BioScore, climate change, scenarios, SSPs.

ABSTRAKT

Mennesker påvirker miljøet på både lokal og global skala, og mengden av disse påvirkningene anses som store trusler mot det globale biologiske mangfoldet. Både klimaendringer og endring av arealbruk har vært to store pådrivere for denne biologiske forandringen i mangfoldet. De observerte og anslåtte endringene i biologisk mangfold av eksperter trenger ikke samsvare med den generelle forståelsen blant innbyggere eller besøkende i en region. Dette var grunnen til at studiemålene var å (I) finne hvilken betydning biologisk mangfold i to boreale nedbørsfelt i Sverige har for både innbyggere og besøkende; (II) oppdage om sannsynlige fremtidige endringer i arealbruk med hensyn til global endring vil påvirke biologisk mangfold i disse to nedbørsfeltene; og (III) om slik prosjektert biologisk mangfoldsendring vil påvirke folks forståelse. Feltarbeidet med spørreundersøkelse ble utarbeidet sommeren 2019 i Vindeln og Sävjaån-området i Sverige, og vurderingene av biologisk mangfold gjennom scenarioer var gjennomført med bruk av BioScore. I begge nedbørsfeltene fant undersøkelsens deltakere at det viktigste elementet i naturen var variert natur og store områder av 'uberørt' skog. Respondentenes svar kan knyttes til enten hvor estetisk vakker natur er, turisme, muligheten for fysiske friluftslivsaktiviteter eller fra et bevaringssynspunkt. BioScore-resultatene viste at Sveriges nåværende tilstand hadde det mest stabile antallet arter, mens SSP1-scenariet har en høyere mengde potensielt økende arter enn SSP3 for begge fangstområder. En slik prosjektert biologisk mangfoldsendring vil påvirke folks forståelse da mindre variasjon i skogens sammensetning ville forekomme og et betydelig tap i biologisk mangfold er trolig under disse scenariene. Miljøvariablene kvantifisert i BioScore hadde en sterkere negativ effekt enn endring av arealbruk for SSP3-scenariet, mens det motsatte skjedde i SSP1. Både arealbruk og miljøendringer påvirker fremtidig biologisk mangfold, men vil sannsynligvis påvirke forskjellige artsgrupper på en annen måte.

Nøkkelord:

Biologisk mangfold, spørreundersøkelse, BioScore, klimaendringer, scenario, SSPs.

Table of Contents

1. INTRODUCTION

Humans affect the environment at both local and global scales and the manifold of these influences are considered major threats to global biodiversity (Cahill et al., 2013; Hooper et al., 2005; Kalnay & Cai, 2003; Loreau et al., 2001). Biodiversity is defined as the diversity within and among species, but also diversity in ecosystems and genotypes (Hooper et al., 2005). Anthropogenic impacts on biodiversity have been discovered all over the world: in every ocean and on land, and in nearly all major taxonomical groups (Parmesan, 2006). Environmental change can lead to loss of species and this again can transform how ecosystems function (Hooper et al., 2005). The loss of biological diversity or species extinction is not reversible and therefore is considered one of the most serious consequences of environmental change (Pimm et al., 2001; Wilson, 1989). Climate change, land-use change, overexploitation and increased nutrient availability are likely the strongest drivers of biodiversity change and species loss (Hooper et al., 2005).

Climate change is undoubtedly an important driver of the changing biodiversity ((Oliver & Morecroft, 2014)). Each species has a tolerance level that can be exceeded due to global warming, like increased temperature and changed precipitation patterns (Armsworth et al., 2004; Loreau et al., 2001). This sensitivity is decided by intrinsic factors and their genetic diversity, which makes some species more sensitive than others (Williams et al., 2008). Climate change alters species distribution, affects trophic networks, and in some cases can lead to extinction since species are not adapted to the new conditions of the environment that now might be outside their climatic niche (Bellard et al., 2012). This means that species have to be able to adapt or acclimatize as fast as the climate to survive. One example of this is the increase in temperature that is caused by global warming, which is a threat to species close to their upper thermal tolerances (Somero, 2010). This temperature increase can also enhance the possibility of heat stress in vulnerable species (Kearney et al., 2009) and without shade can exceed the lethal thermal limit (Broadmeadow et al., 2011).

Land-use change has possibly been the main driver of environmental change in the past centuries and is still on-going (Klein-Goldewijk et al., 2011). Land-use changes directly cause habitat loss (Martinuzzi et al., 2015), and lead to changes in evapotranspiration and the albedo effect (Popp et al., 2017). Land-use change can also cause indirect biological effects, e.g. on population sizes, through its interaction on and with a contribution to climate change (Rosenzweig et al., 2008). Land-use change may cause increases in anthropogenic CO_2

emissions and daily evaporation which affects the land surface energy and water balance (Foley et al., 2005; Kalnay & Cai, 2003). Also without apparent change in land-use cover, increased land-use intensity may involve a loss of biodiversity (Hendrickx et al., 2007; Kleijn et al., 2009). One example of this is the loss of plant species with increasing nitrogen inputs with land-use intensification (Kleijn et al., 2009). With a continued increase in the global human population, a strong pressure exists to realise an increase in agricultural production (Godfray et al., 2010).

One important form of land-use change is the on-going urbanisation across the world, with an estimated 70% of Europeans already living in cities and a further increase of 10% projected for 2050 (Müller et al., 2018). Urban development causes habitat loss for native species and is considered a major cause of local extinction (McKinney, 2002). Both forested and agricultural land is converted to accommodate expanding peri-urban agglomerations (Chapin et al., 2000).

Thus, both climate change and land-use change may have profound effects on biodiversity, and their interaction may lead to unforeseen second-order effects (de Chazal & Rounsevell, 2009; Oliver & Morecroft, 2014). Studies made on only climate change or land-use changes can over-estimate or under-estimate the potential loss of biodiversity as the interactions are missing (de Chazal & Rounsevell, 2009; Jetz et al., 2007). Both Vermaat et al. (2017) and Sala et al. (2000) predicted future changes by involving both land use and climate change as driving factors of biodiversity loss and found terrestrial biomes like boreal, wetlands and grasslands were highly affected.

In Scandinavia, land-use change and climate change are affecting biodiversity as well (Lindborg et al., 2005; Linderholm, 2002). Examples are the near disappearance of untouched old-growth forest (Östlund et al., 1997) and the slow upward move of the treeline on Scandinavian high mountains reducing the open habitat available for typical high mountain species (Klanderud & Birks, 2003), or the disappearance of palsa mires in Finnmark (Farbrot et al., 2013). However, it is not very clear whether such changes also occur in the more widespread, 'common' Scandinavian habitats, such as the boreal forest and its associated mire complexes.

Observed and projected changes in biodiversity by experts may however not correspond with the general appreciation of biodiversity, or nature, among inhabitants or visitors of a region. Kaltenborn et al. (2016) analysed the perception of biodiversity among a Gallup panel sample of Norwegian citizens and found that 75% of the respondents consider biodiversity loss as ‘real’, and 50% see it as a ‘considerable environmental problem’ but ranked it lower than other recognised environmental issues. The authors’ interpretation is that the issue is not perceived as sufficiently severe to trigger massive concern and policy action and they support the claim by Martín-López et al. (2007) for a focus on affection rather than a ‘cognitive fix’. Christie et al. (2006) observed a generally positive attitude towards the protection of ‘rare’ species, but an indifference to how this is implemented. Major differences in perception and actual use of the landscape in question may be a source of conflict and affect the credibility of nature conservation policy measures (Götmark, 2009). Hence, future changes in land use and climate may affect boreal forest biodiversity, but this may well have little effect on the appreciation of the landscape by residents or visitors. Assessing the importance of biodiversity as an element in the appreciation of a changing landscape would help designing policy instruments that will meet support and understanding among the public. This thesis uses biodiversity as defined above, but is aware that the concepts of biodiversity, nature and landscape are often strongly overlapping for the general public.

The goal of this study was to (I) find the importance of biodiversity in two boreal landscapes in Sweden for both inhabitants and visitors; (II) discover if plausible future changes to land use with considering global change will affect biodiversity in these catchments; and (III) whether such projected biodiversity change would affect the people’s appreciation.

2. MATERIALS AND METHODS

2.1 Study areas

This study was conducted in two catchments in Sweden. The first is the Sävjaån river basin area in Uppsala county, situated in central Sweden (fig. 1a). The second is the southern Vindelälven river basin area based in Västerbotten county, situated in northern Sweden (fig. 1b). The Sävjaån catchment has a population of 35,347 people, a population density of 48 inhabitants / km^2 and a size of about 730 km^2 (Immerzeel et al., in review). Uppsala county includes 60% woodland, of which most (91%) classifies as productive woodland (Table 1, Forslund, 2015). The river in the Sävjaån area is of natural origin and moderate ecological status[1]. The Vindeln catchment has a lower population with 4,713 inhabitants, a size of about

[1] https://viss.lansstyrelsen.se/Waters.aspx?waterMSCD=WA82797609

780 km² and a population density of 3 inhabitants/km² (Immerzeel et al., in review). The Vindelälven river reportedly has a good ecological and chemical surface water status[2].

The two catchments were selected as they are part of a broader study of possible changes in ecosystem services provided by Nordic catchments due to the implementation of 'bioeconomy' (Immerzeel et al., in review), making combined data collection practical. The Sävjaån catchment has more towns and particularly more agricultural land than Vindeln, whereas the latter has more forest and terrestrial nature (Table 1).

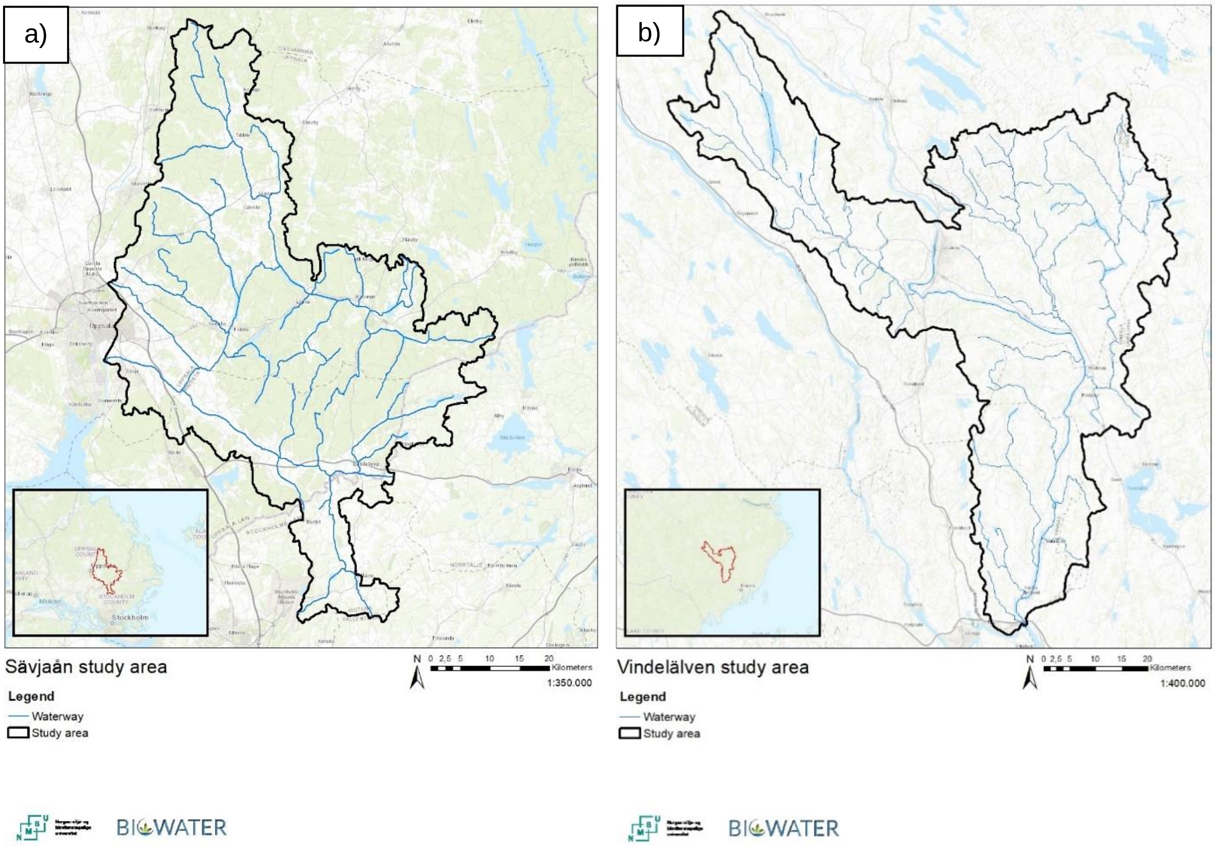

Figure 1. Maps over the study areas retrived from the survey (Appendix B). a) Sävjaån catchment and b) Vindeln catchment.

[2] https://viss.lansstyrelsen.se/Waters.aspx?waterMSCD=WA56092023

Table 1. Percentage of CORINE land cover distribution with CORINE coding in the two study catchments, Sävjaån and Vindeln. The total areal percentage for each catchment is 100%. Data from Bossard et al. (2000).

CORINE class	CORINE_ID	Sävjaån	Vindeln
Urban	1.1-1.4	2	1
Agricultural	2.1.1, 2.3, 2.4.2, 2.4.3	32	6
Forest	3.1	60	75
Terrestrial Nature	3.2.1, 4.1	5	15
Water	5.1	1	3

2.2 Modelling with BioScore 1

BioScore is a software tool intended to inform policymakers on possible impacts on habitat suitability and sensitivity of European biodiversity concerning a selection of environmental pressures. It is developed by the European Centre for Nature Conservation (ECNC) (Delbaere et al., 2014; Vermaat et al., 2017). BioScore is a large, compiled relational database that includes aggregated niche information on a large number of European species from the following higher-order taxonomic groups: mammals, birds, freshwater fish, benthic macrofauna, reptiles, amphibians, butterflies, dragonflies and vascular plants (Delbaere et al., 2014). Data availability determined the richness and cover of the tool in different parts of Europe. The tool has been used in several large-scale assessments (Eggers et al., 2009; Vermaat et al., 2017).

The freely available version 1 of the BioScore tool was used to evaluate the effects of changes in land use towards 2050 on biodiversity in both catchments. The comparatively coarse spatial resolution of this tool allows to model individual countries or biogeographic regions. The two catchments fall within the national boundaries of Sweden, and in those of the much larger boreal biogeographic region. We chose to use Sweden and assume that this has only quantitative effects on the abundance of most species included in the tool, rather than a considerable shift in total species pool, as can be expected between biogeographic regions.

Changes in land use, which may affect biodiversity, were modelled with the help of scenarios. In addition to a ‘current’ state, we chose to align our scenarios to those used in the BIOWATER project[3], to which the PhD project of Immerzeel is a contribution. BIOWATER has translated the well-established shared socio-economic pathways (SSPs), which capture global socio-economic development and boundary conditions (Kriegler et al., 2012), for

[3] www.biowater.info

Nordic, boreal catchments (Rakovic et al., in revision). In the present study we only used two of the 5 SSPs in addition to ‘current state’: SSP1 and SSP3, and we used 2050 as time horizon. Scenarios are often used by scientists to project outer envelopes of climatic but also socio-economic change towards a near or further-away future (Kriegler et al., 2012; Riahi et al., 2017; Sala et al., 2000; van Vuuren & Carter, 2014). The SSPs provide plausible descriptions and quantifications of possible developments of socio-economic variables, but should not be understood as predictions (van Vuuren et al., 2014). These socio-economic variables can for example be population growth, economic development and rate of technological change (van Vuuren & Carter, 2014). SSP1 has been labelled “Sustainability” and is considered to have little socio-economic challenges to climate mitigation and adaptation (O’Neill et al., 2015). This scenario is thought to have a focus on sustainable development, rapid technological change and a trajectory dominated by environmentally friendly processes (O’Neill et al., 2014). As a result, SSP1 portrays a world that focuses on sustainability and has a higher respect for environmental boundaries (O’Neill et al., 2015). SSP3 is called “Regional Rivalry” and has greater challenges to both mitigation and adaptation. CO_2 emissions are high due to moderate economic growth, population growth and slow-moving change in technological processes (O’Neill et al., 2014). This world will have concerns about competitiveness and security and will, therefore, have policies more oriented towards these issues instead of environmental policies (O’Neill et al., 2015).

*Table 2. BioScore inputs for environmental variables for SSP1 and SSP3 scenarios. The 7 categories are on the left side the environmental variables within each category, both terrestrial and limnological are included. * = highest or lowest magnitude of change when only three degrees of magnitude are possible, not seven.*

BioScore categories			Scenarios SSP1	Scenarios SSP3
Pollution				
		Eutrophication	- -	+ + +
		Acidification	0	0
		Salinification	0	0
		Pollution (aquatic)	0	0
		Pollution (terrestrial)	- -	+ + +
	Water			
		Water quality sensitivity	0	0
		Water acidification	0	0
		Water eutrophication & organic pollution	- -	+ + +
		Water pollution	- -	+ +
		Water siltation	- -	0
Water-related changes				
	Land			
		Soil moisture	0	+ +
		Permanent water surface	+	+
		Temporary water availability	+	+
		Water quantity/flow (reduced)	0	0
		Water transparency	0	+ +
Climate change				
	Land			
		Climate change	+*	+*
		Continentality	+	+
		Temperature	+	+ + +
	Water			
		Water temperature	+	+ +
Disturbance				
	Land			
		Disturbance	0	+*
		Powerlines	+*	0
		Trampling	0	0
Direct pressures				
		Harvesting crop	0	+*
		Hunting	0	0
		Persecution	0	0
Species interaction				
	Water			
		Introduction of non-native species or genotypes	+ +	+ +
		Disease organisms or parasites	0	0
Management				
	Land			
		Amount of dead wood	-*	+*
		Even aged forest	-*	+*
		Young felling age of forest	-*	+*

The environmental variables that can be changed in BioScore are divided into 7 categories: pollution, water-related changes, habitat changes, climate change, disturbance, species interaction and management (Table 2; Delbaere et al., 2014). No changes to the environmental variables were made for the present-state scenario since BioScore has incorporated the present-day influences, but these variables were changed in the SSP1 and SSP3-scenarios. The changes follow those made in Vermaat et al. (2017) and as they use SRES scenarios, A2 corresponds to SSP3 and B1 to SSP1. The magnitude of change can be adjusted for each of the environmental variables in BioScore using a stepwise, ordinal scale with either 3 or 7 steps (Fig. 2). The figure visualises how a 7-step varies around zero. Delbaere et al. (2014) explain that these two different scales are used because they have variable confidence in the expert knowledge for the different modelled factors. SSPs consider future climate change and other environmental variables which is not standard for SSPs that focus on the economy and society. In that sense, the scenarios are likely to be similar to A2 and B1 from SRES scenarios that combine society and climate change.

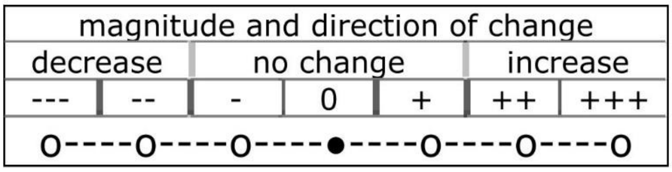

Figure 2. BioScore 1 degrees of magnitude of change to environmental variables. (Delbaere et al., 2014)

The next step was to match land cover typology of BioScore with CORINE. The 9 different BioScore land cover types are artificial surfaces, agricultural areas, forests, scrub and/or herbaceous vegetation associations, open spaces with little or no vegetation, inland wetlands, maritime wetlands, inland waters and marine waters (Appendix Table A1; Delbaere et al., 2014). The now-scenario is not detailed or specified for each of the catchments but instead used land cover data from the whole of Sweden. This was because BioScore gave negative numbers when changing the land cover for each of the catchments to match the present state and was there for discarded. This means that the data for 'present state' on species numbers is the current state of Sweden and not the areas chosen for this study. The negative numbers came from the fact that BioScore is designed to model whole countries and biogeographic regions and not areas within a country. Land-use change projections to SSP1 and SSP3 were adopted from those in Vermaat et al. (2020) for Haldenvassdraget, a large forest-covered catchment in Eastern Norway which is assumed to be comparable to the two Swedish catchments (Appendix Table A1). This was done as accurately as possible, but some complications in BioScore occurred, and therefore an evaluation had to be done to get these changes to fit into the program. A different amount of square meters of the land cover of a category is attached to each percentage, which means that changing the percentage under a category like coniferous forest will change a different amount of square meter than if it were moors and heathland. In this way, there will be discrepancies between the percentages desired for each catchment and what is possible through BioScore.

2.3 Survey

This survey was performed in collaboration with Immerzeel et al. (in review). The survey aimed to discover the public opinion on the importance of nature and biodiversity, by using a discrete choice experiment (Appendix B). A discrete choice experiment is a commonly used tool in social sciences to assess preferences among the public (Rakotonarivo et al., 2016). In a choice experiment, a participant can choose from two or more multi-attribute options (Johnston et al., 2017). This approach assumes that an environmental good can be expressed as a set of individual attributes (Latinopoulos, 2014), and allows an estimate of the value of these attributes needed for the participant to make their choices (Johnston et al., 2017).

The survey questions in this study included the participants' relation to the area, typical activities, an opinion on the current state of the landscape, and several respondent characteristics. In the discrete choice experiment part, respondents reveal their preference for future landscape changes by choosing card options, and their associated willingness to pay (WTP) through an environmental tax. The cards presented have a "Business as usual"-option and two possible future scenario options. The respondent then expresses a preference by selecting an option. Each participant was presented a series of 5 cards so that the combined responses from all respondents forms a replicated set of answers across all factorial combinations. One question specific for this thesis focused on what a respondent considers to be the most important element of 'nature' in the catchment and the choice stands between the variety of forest, wetland, streams and lakes, pristine nature, big predators, birds or other (Box 1). The survey was confidential but included questions on gender, age, and income.

Box 1. Question 16 from the survey breaking down specific components of biodiversity in this landscape (Appendix B).

Question 16: What is the most important element of nature in this landscape, in your opinion?

a)	The variety of forests, wetlands, streams and lakes	○
b)	The large area of untouched nature	○
c)	The presence of large predators (bear, wolf, lynx)	○
d)	The presence of characteristic birds (crane, eagle, Lapland owl, capercaille)	○
e)	Other:___________________________________	○

The survey was done on-site by in-person interviews in the field, using the self-administration mode where the participant fills out a physical paper questionnaire by ticking the preferred box. The questionnaire was made in English and translated into Swedish by BIOWATER. We started handing out surveys in the Sävjaån river basin area on July 13th 2019 and used 14 days to conduct the survey, and then continued in the Vindelälven river basin area and stayed for 16 days. We chose to conduct the survey by lakesides and recreational locations, libraries, museums, camping spots and cafés to achieve variability in participants in terms of age, gender, profession, use of the landscape and home area. This was done because selecting a random sampling of the population is important for a reliable result (Johnston et al., 2017). The city library in Uppsala and different museums were chosen for the Sävjaån catchment as pick-up and drop-off points, a campsite and a fishing spot and Café Mjölnaren for the Vindeln catchment.

2.4 Statistical analyses

A Chi-Square test was used to assess possible differences in responses between the two catchments. This was calculated with Excel for three of the survey questions. The first question I analysed was on what is considered the most important element in the landscape, and the options to choose from were different in their specificity (question 16, Box 1). The second question is about ‘nature’ in the catchment and how the respondent’s well-being is related to this. The benefits mentioned are the source of drinking water, source of forestry products, CO_2 storage to prevent climate change, water storage to prevent floods, clean water for nature, habitats for plants and animals, availability of game species, growth of berries, mushrooms and nuts, recreational possibilities, educational possibilities, food from agriculture, the fact that there is nature, the beauty of the landscape and cultural heritage sites and areas. These benefits can be interpreted as ecosystem services. The participants would here choose if they found a benefit (I) very unimportant, (II) somewhat unimportant, (III) neither important nor unimportant, (IV) somewhat important, (V) very important or (VI) if they did not know. The third question was which aspects the participant considered during answering the choice cards. The aspects respondents were offered to choose from are the share of agriculture and forest in total land use, the intensity of land management, water clarity, the area with nature protection status, the probability and magnitude of flood risk, local employment in agriculture, forestry and recreation, and household tax burden.

The observed frequencies of the Sävjaån and the Vindeln catchment, subtotals, and totals of both for all the possible answers were calculated. Calculating the expected frequency within one catchment by multiplying with the total observed frequencies from both catchments within one answer with the total amount of participants choosing any of the possible answers. This again was divided by the total sum of frequencies including both catchments. This was done for all the possible answers and both the Sävjaån and the Vindeln river basin area. Next step was to square and normalize the differences by using equation 1. Further calculations needed to find the p-value and were done by using the Chi-Square function in Microsoft Excel.

Equation 1.: Chi-Square equation used to square and normalize the differences. O = Observed frequency and E = Expected frequency.

$$\chi 2 = \sum \frac{(O - E)^2}{E}$$

3. RESULTS

3.1 Surveys

For a majority of the participants in both the Sävjaån and the Vindeln catchment, the most important element in the landscape was the variety of forests, wetlands, streams, and lakes (Table 3). The second most important element for both catchments was the large area of 'untouched' nature. The distribution in these answers did not differ between the two catchments (P-value = 0.648).

Table 3. Chi-Square results on what the most important element in the landscape is. Df = degrees of freedom.

	Observed Frequencies		
Category:	Sävjaån	Vindeln	Subtotal
The variety of forests, wetlands, streams and lakes	217	122	339
The large area of untouched nature	123	68	191
The presence of large predators (bear, wolf, lynx)	12	6	18
The presence of characteristic birds (crane, eagle, Lapland owl, capercaillie)	9	8	17
Other	9	2	11
Subtotals	370	206	576
Chi-Square outcome	2.4800		
Df	4		
P-value	0.6482		

The two catchments were significantly different for 10 out of the 14 benefits addressed in the second question on the importance of these benefits for a respondent's well-being (Table 4, Fig. 3). Often, the pattern was similar but the weight of the ranking 'very important' or 'important' differed (Fig. 3). The main exception was the importance attributed to the presence of the game species (Fig. 3c). Here the two respondent samples differed greatly in the pattern of distribution, with the majority of the Sävjaån respondents ranking this as 'very unimportant', whereas in Vindeln this was opposite.

*Table 4.: Chi-Square results on which degree of importance the participant finds a benefit generated by nature for their wellbeing. χ^2 = Chi-squared distribution, V = Vindeln catchment, S = Sävjaån catchment. *, ** and *** symbolise a p-value below 10%, 5% and 1% respectfully.*

	χ^2	P-value	Where more important?
Source of drinking water	19,6875	0,0014***	V
Source of forestry products	28,7319	2,6172E-05***	V
CO2 storage to prevent climate change	4,7096	0,4523	-
Water storage to prevent floods	14,4137	0,0131**	S
Clean water for nature	12,3057	0,0308**	V
Habitats for plants and animals	5,5275	0,3549	-
Availability of game species	47,7150	4,06E-09***	V
Growth of berries, mushrooms, and nuts	24,1673	0,0002***	V
Recreational possibilities	7,7928	0,1680	-
Educational possibilities	12,1835	0,0323**	V
Food from agriculture	17,0231	0,0044***	V
The fact that there is nature	8,4607	0,1326	-
The beauty of the landscape	11,7992	0,0376**	V
Cultural heritage sites and areas	10,4047	0,0645*	V

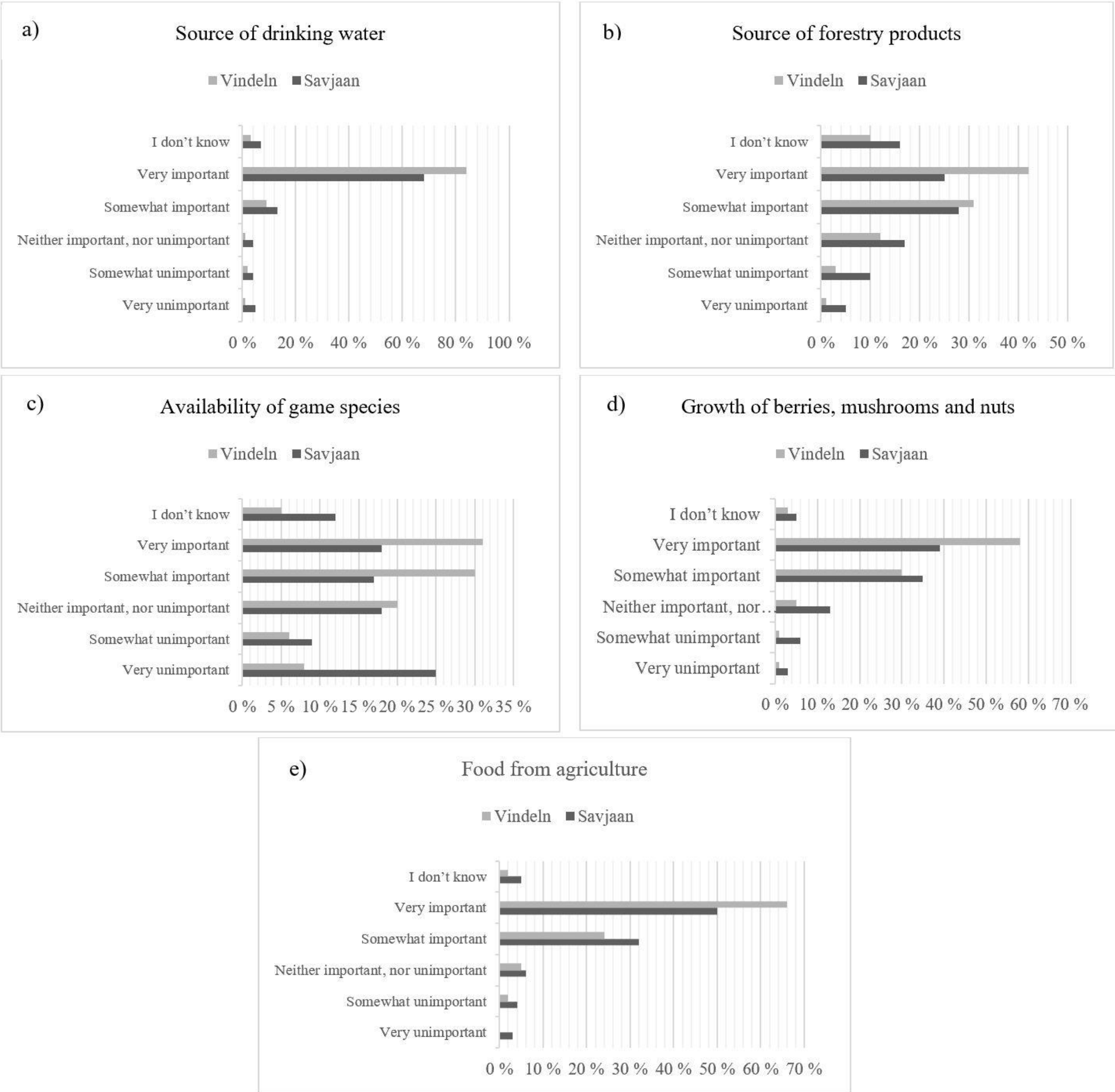

Figure 3.: Frequency distribution of the importance attached to a benefit by respondents in the Vindeln and Sävjaån catchments, for their wellbeing. Data presented as percentage of the total number of respondents.

When it comes to the third question, that is the aspect considered when answering the choice card in the survey, the respondents from the two catchments showed a similar and a rather flat pattern with no significant difference (Table 5). Share of agriculture and forest in total land use, water clarity and amount of nature conservation had the highest frequencies. Flood risk was mentioned as the least considered aspect.

*Table 5.: Chi-Square results on what aspect that the participant considered during answering the choice cards. *, ** and *** symbolise a p-value below 10%, 5% and 1% respectfully. The respondents could answer more than ones, so the total frequencies are > n respondents. S = Sävjaån catchment, V = Vindeln Catchment, Df = degrees of freedom.*

	Observed frequencies		
Category:	Sävjaån	Vindeln	Subtotals
The share of agriculture and forest in total land use.	142	122	264
The intensity of land management.	94	93	187
Water clarity.	165	174	339
Nature conservation.	130	111	241
Flood risk.	73	64	137
Local employment from agriculture, forestry and recreation.	116	121	237
Tax for my household.	115	92	207
Subtotals	835	777	1612
Chi-Square outcome	4.4285		
Df	6		
P-value	0.6189		

3.2 BioScore output

From the BioScore output, it appears that for every taxonomical group the present state is more favourable than any future scenario modelled, and this is the case for both catchments (Table 6 & 7). The potential decrease and increase, as well as the stable number, of dragonfly and freshwater fish species, did not differ between both the future scenarios for the Sävjaån catchment (Table 6). Secondly, there is almost no difference for the mammal species between the scenarios, as SSP1 has two stable and one potentially increase and SSP3 has only two species that potentially increase||. Birds have a higher potential decrease in the SSP3 scenario and here SSP1 appears the better option with a higher number of stable species and more potentially increasing species. In contrast, butterflies appear to show a lower potential decline in SSP3. The vascular plant species do however have a higher potential decline of 289 species in SSP3-scenario and for this well-represented species group the better option would be SSP1.

The potential increase in bird species for the SSP1-scenario implies that it is more secure than SSP3 with a possible loss of 75 species in the Vindeln catchment (Table 7). There are no large differences for butterflies within the two future scenarios, and both SSP1 and SSP3 give the same result for freshwater fish. Contrary to the other species groups mammals are favoured in the SSP3-scenario over the SSP1-scenario, with less potential decrease and more stable species. Both future scenarios do have an extreme loss of vascular plant species in the area, but with a greater amount of stable and potentially increasing species for SSP1 than SSP3. Like the Sävjaån catchment, there are no changes between SSP1 and SSP3-scenario in regards of dragonflies for Vindeln.

Table 6.: BioScore results for Sävjaån catchment including all three scenarios and potential change in the number of species, including environmental factors and land cover change.

	Now-scenario			SSP1-scenario			SSP3-scenario		
	Potential decrease	Stable	Potential increase	Potential decrease	Stable	Potential increase	Potential decrease	Stable	Potential increase
Birds (water- and breeding birds)	0	134	0	-47	45	42	-61	44	29
Butterflies	0	44	0	-41	1	2	-39	1	4
Freshwater fish	0	44	0	-43	1	0	-43	1	0
Mammals	0	29	0	-26	2	1	-27	0	2
Vascular plants	0	435	0	-192	192	51	-289	136	10
Dragonflies	0	58	0	-40	18	0	-40	18	0
All taxonomical groups (%)	0	100	0	79	15	6	83	12	5
All taxonomical groups Red Lists (%)	-	-	-	52	52	2	52	54	5
All taxonomical groups Birds and Habitat Directive (%)	-	-	-	40	42	17	38	42	13

Table 7.: BioScore total results for Vindeln catchment with all three scenarios and potential change in the number of species, including environmental factors and land cover change.

	Now-scenario			SSP1-scenario			SSP3-scenario		
	Potential decrease	Stable	Potential increase	Potential decrease	Stable	Potential increase	Potential decrease	Stable	Potential increase
Birds (water- and breeding birds)	0	134	0	-64	38	32	-75	39	20
Butterflies	0	44	0	-39	2	3	-39	1	4
Freshwater fish	0	44	0	-43	1	0	-43	1	0
Mammals	0	29	0	-27	0	2	-21	3	5
Vascular plants	0	435	0	-239	189	7	-297	134	4
Dragonflies	0	58	0	-40	12	6	-40	12	6
All taxonomical groups (%)	0	100	0	81	12	6	81	12	7
All taxonomical groups Red Lists (%)	-	-	-	53	54	4	49	52	7
All taxonomical groups Birds and Habitat Directive (%)	-	-	-	39	43	10	39	43	8

A higher number of bird species will remain stable or possibly increase in the Sävjaån catchment than in the Vindeln catchment for all the future scenarios (Fig. 4ac). SSP1-scenario has only slight differences between the total (all environmental factors and land cover change) and when only including land cover change for both the Sävjaån and the Vindeln catchments. The SSP3-scenario does vary, as land cover change has a lesser amount of potential decreasing species than the total result. There is also a less potential increase in the number of bird species for the total than when only regarding the land cover change. This trend is also present for the vascular plant species in figure 4b and d. There are more stable species when solely looking on land cover change for SSP3 than the total, but a higher number of stable vascular plant species for the total in SSP1 than for only land cover change. The difference between land cover change and when including environmental variables was only seemingly distinct when looking at birds and vascular plants, and not for the other species groups and, therefore, not included.

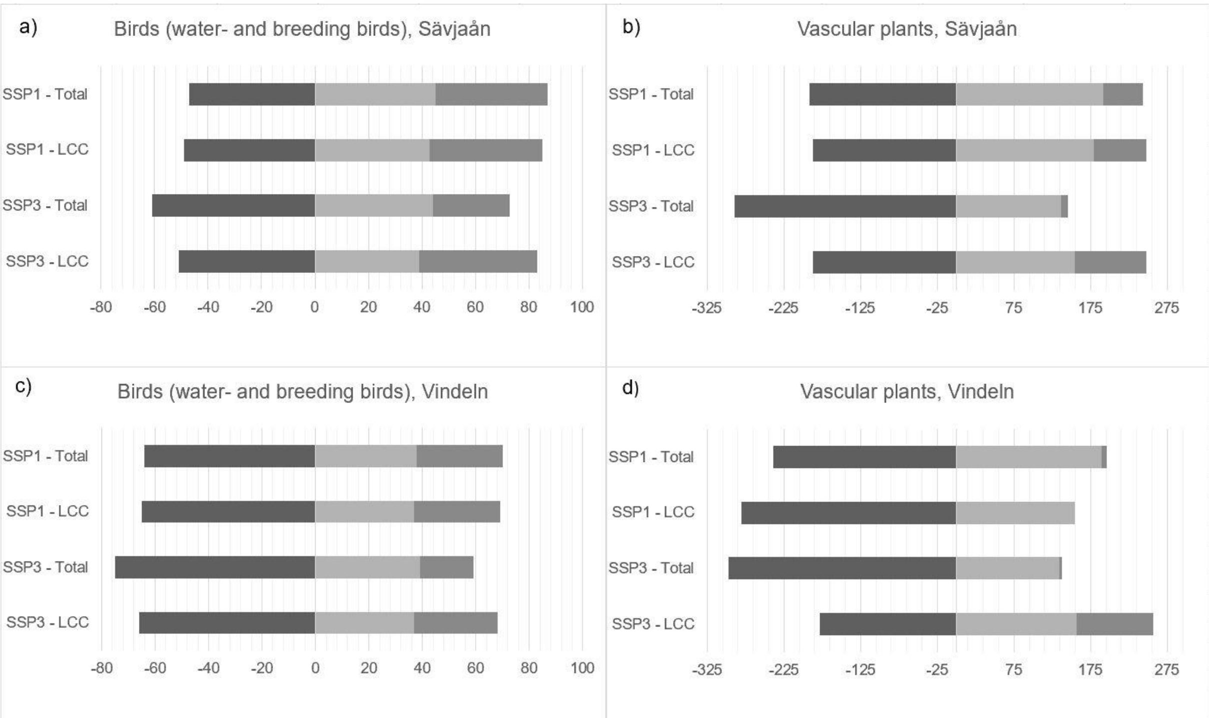

Figure 4. Difference in bird vascular plant species between now-scenario, SSP1 and SSP3. The black parts are the possible decreasing number of species, light grey are the stable number of species and dark grey is the possible increase of species. (a) Bird species in Sävjaån, b) vascular plant species in Sävjaån, c) bird species in Vindeln and d) vascular plant species in Vindeln. LCC stands for Land Cover Change. The now-scenario does not have any LCC because it is identical to the total.

4. DISCUSSION

4.1 Survey

Biodiversity is important for ecosystem functions, although not necessarily in a simple and straightforward way (Cardinale et al., 2012). Still, this makes changes in biodiversity have both ecological and social consequences (Chapin et al., 2000). The first research question was what the importance of biodiversity for inhabitants and visitors of the two catchments is and there is an agreement between respondents from both catchments that the variety of forests, wetlands, streams, and lakes was the most essential element of nature. This suggests that overall, the diverse landscape is more important than the presence of a particular species or species group (Table 3). Kaltenborn et al. (2016) found a similar preference, but these authors included species-specific proxies because of the emotions connected to them. The least chosen elements were the ones including predators and birds, which contradicts Kaltenborn et al. (2016) assumption as their prediction was that "Using specific species as proxies for biodiversity can prove quite effective since people attach various meanings to species they can recognize, such as rarity, nativeness, endangerment, and economic meanings, as well as aesthetic values" (Kaltenborn et al., 2016, p. 7). In the current study, the emotional experiences connected to natural environments and human well-being are highly affecting the participant's viewpoint rather than specific groups of plant or animal species (Johansson & Henningsson, 2011). The second important element chosen was that there are large areas of 'untouched' nature (Gillson & Willis, 2004; Tscharntke et al., 2012), but actually most forests are not untouched even though it may appear that way. Nearly all forests have been modified by humans for centuries, also in Scandinavia. Even though it might not be truly 'untouched' nature, the participants' answers could be connected to how aesthetically pleasing experienced nature is, the possibility of physical outdoor activities or it may come from a conservational viewpoint.

Human well-being is connected to the 'goods and services' that are provided by ecosystems (Pecl et al., 2017). Respondents in the Vindeln catchment found the provision of drinking water more important than those in the Sävjaån catchment (Table 4). River water quality is just a bit higher in the Vindeln catchment than in Sävjaån and groundwater quality is higher for Vindeln as Sävjaån is subject to saline intrusion and chemical pollution according to Water Information System Sweden (WISS)[4]. On first sight this appears contradictory since the water quality in

[4] Vindelälven: https://viss.lansstyrelsen.se/Waters.aspx?waterMSCD=WA56092023 and https://viss.lansstyrelsen.se/Waters.aspx?waterMSCD=WA54290822, and Sävjaån: https://viss.lansstyrelsen.se/Waters.aspx?waterMSCD=WA93715408 and https://viss.lansstyrelsen.se/Waters.aspx?waterMSCD=WA23980703

Sävjaån reportedly is less than in Vindeln, hence the respondents of the catchment should be more concerned about the source of their drinking water. A study done by Bendz and Boholm (2019) in Sweden found that local policy-makers believed that inhabitants showed no interest and took the supply of drinking water for granted. This appreciation may differ among catchments, as our data suggest. Water clarity was also considered as an important element in the choice card experiment (Table 5, also see Immerzeel et al., in review).

The Vindelälven area has a higher percentage of forest-covered area, terrestrial nature (Table 1) and has more forest owners (Christiansen, 2018) than the Sävjaån catchment. The higher importance of forestry products for the respondents in the Vindeln catchment could be caused by the coniferous forest-landscape where work opportunities in forestry business appear obvious. This percentage can also explain why the respondents of the Vindeln catchment found the availability of game species and growth of berries, mushrooms, and nuts more important than Sävjaån. There are 206 fishery conservation areas in Västerbotten county and only 24 in Uppsala county according to the Swedish County Administrative Boards registered for fishing areas[5], therefore, higher fishing accessibility. Immerzeel et al. (in review) went further with the survey questions and found that 6 % of the participants are working in forest, fishing, or agriculture in the Vindeln catchment, while only 2% of the respondents in the Sävjaån catchments. People with a background in farming or other occupations within the primary industry could be more aware and interested in nature conservation. If a high percentage of the participants has this background, then it could shift the results into a higher degree of importance in their catchment.

The only part that respondents from the Sävjaån catchments found significantly more important than those from the Vindeln catchment was food from agriculture. The Sävjaån catchment also has a larger area covered with agriculture than Vindeln, which can be a plausible explanation (Table 1;(SCB, 2018)). Another plausible explanation could be that there were more young and academic people interviewed, as they could have been sensitive to the on-going re-appreciation of local food production (Table 3 in Immerzeel et al., in review)

4.2 BioScore

Biodiversity loss has accelerated after the Industrial Revolution and human activity has to be the true main cause of this change (Rockstrom et al., 2009). The importance of biodiversity

[5] https://fiskekartan.se/

for the respondents in the two boreal catchments varied but overall they agreed on the diversity of forest and other components of nature. The SSPs in BioScore changed the land cover and environmental variables for the year 2050. A higher percentage of arable land, coniferous and mixed forest, and less traditional woodland-shrub was projected for the SSP3 scenario (Appendix Table A1), and this will affect the aspect of biodiversity that the survey participants found most important, a diverse landscape.

The fact that BioScore is designed to model whole countries and biogeographic regions and not areas within a country, makes it somewhat impossible to understand the true species number that are present in each area and if these species would increase or decrease when altering their living conditions. There are species specified to different ecosystems within Sweden that are not present in the chosen catchments but could not be removed from the analysis beforehand, so we had to assume that all species current in the whole of Sweden also potentially are present in both study catchments.

Rith-Najarian (1998) found that disturbance from timber-management harmed the number of dragonfly species present in Minnesota, and Sahlén and Ekestubbe (2001) found that there might be an association between species richness of vascular plants and dragonflies, as there were a higher number of dragonflies in locations with more vascular plants. This contradicts the results in this study as there was no change in dragonflies for both Vindeln and Sävjaån river basin area for the future scenarios, but vascular plants did illustrate a higher number of stable species in SSP1-scenario. BioScore does not include indirect effects like species interactions (Delbaere et al., 2014), therefore, the positive association between vascular plants and dragonflies is not present in the current study. Also, adult dragonflies are quite mobile and may rather respond to landscape features than to the vascular plant species richness that is available in different landscapes.

The temperature increase that comes with global warming has made and will make vascular plants to colonize new areas, which will cause shifts northwards and upwards in elevation (Bertin, 2008). This corresponds to the BioScore results for both the Sävjaån and the Vindeln catchment, as the present state is favoured and SSP1 is a better option than the SSP3-scenario (table 6 & 7). Warming can increase seed production and enhance the seed germination, but also cause heat stress and habitat loss (Bertin, 2008). Global warming might trigger increased competition since more nutrients may come available, and it is likely that competitive growth forms may increasingly outcompete resource-conserving forms (Klanderud, 2005).

The environmental variables changed for the SSP3-scenarios had a higher negative effect on species number than land cover change (Fig. 4a-d). There is a higher percentage of agricultural land for the SSP3-scenario, but also additional coniferous and mixed forest that could explain the results (Appendix Table A1). The degree of environmental variables added to SSP3, like elevated temperatures, the introduction of non-native species, crop harvesting, and terrestrial pollution must have a higher effect on both bird and vascular plant species than land cover changes alone. The SSP1-scenario has less extreme environmental variables, less forest but more transitional woodland-shrub that can explain the lack of differences between the total and simply land cover change. Birds and plants usually show the same phenological change to climatic warming, and birds that migrate shorter distances have shown a tendency of earlier spring arrival and breeding than previously (Walther et al., 2002). This can cause stronger competition rates for nest sites and lack of fully optimal habitat conditions as these birds might arrive and breed outside of the peak of insect abundance (Both & Visser, 2001).

Thomas and Lennon (1999) found for birds in England a northward range shift of 18.9km in 20 years, which they postulate to be caused by global warming. My BioScore analyses only showed a minor difference between SSP1 and SSP3-scenarios, and the highest numbers of bird species are estimated for the present state for both catchments (Table 6&7). This could mean that environmental and land cover changes would drive most boreal bird species to build nests further north and at higher elevation. The same scenario pattern is found for butterfly species, where the present state has the highest number of species. Non-migratory butterflies have indeed been shown to migrate further north, and this is all between 35-240 km (Parmesan et al., 1999). The land cover change and environmental variables shaping SSP3 should, therefore, make butterflies move further north if we projected a consistent pattern from Parmesan et al. (1999). Vermaat et al. (2017) found that a fraction of birds and dragonflies could decline in European wetlands caused by climate change. Their study included BioScore where they increased temperature and degree of climate change. Their findings support our results.

Brown bear (*Ursus arctos*) live and breed in the Vindeln river basin area (McLellan et al., 2017), and Eurasian lynx (*Lynx lynx*) exist in both catchments (Ågren & Cedervind, 2017). Barnosky et al. (2003) found that global warming will lead to change in mammal populations and their geographic range, which to some extent is supported by the BioScore results. For almost all the mammal species BioScore projected a potential decrease with the highest numbers in the present state. This could mean that the adjusted land cover and environmental variables in both scenarios have a strong effect on mammal species.

Fish are sensitive to temperature change and must acclimatize to the changing environment to survive (Souchon & Tissot, 2012). If the water temperature increases to a level higher than tolerance, which is called incipient lethal temperature, it will cause mortality. Since BioScore runs for both future scenarios led to a decrease in the number of fish species, and the setting for water temperature was increased for both scenarios, this could indeed mean that the temperature increase might be a key factor. Another factor could be the increase in non-native species in both scenarios that increases the competition rates. If the non-native species can integrate successfully into the ecosystem and thrive with the benefits found there, this could cause competition, predation, disease transmissions (Gozlan et al., 2010) or increases the generic competitive pressure.

Finally, I found that the most important feature of biodiversity for both inhabitants and visitors in the two boreal landscapes in Sweden was diversity in the (apparently) natural landscape, but also different benefits and aspects of nature. Future scenarios do show a change in boreal forest and wetlands as the land cover changed for both SSP1 and SSP3. Biodiversity will appear different in both catchments when including both land-use changes and global change in the future. There are clear losses of all species groups from the current situation to the predicted future scenarios, with more losses for the SSP3 scenario than for SSP1. SSP1, on the other hand, is not far behind and does not appear to be a clear hope for the future either (Table 6&7). The participants favoured the variety of forests, wetlands, streams, and lakes, but there is an increased area covered by coniferous forest projected for SSP3 and also a higher potential decrease in vascular plants. It is the opposite of the SSP1-scenario: less coniferous forest, a lower potential decrease of vascular plants. What the participant's found to be most substantial will be affected if the scenarios developed in this study do occur as a major biodiversity depletion happens to appear in both SSP1 and SSP3 for both catchments.

5. Conclusion

The most important aspect of biodiversity in the two boreal landscapes in Sweden for the survey participants was a diverse landscape with a variety of forests, wetlands, streams and lakes, high water quality and large areas of 'untouched' nature. These important aspects of biodiversity will change as the future scenarios, which included changes to land use and global change, effected biodiversity in both catchments. A potential decrease in almost all species groups was found. Both scenarios had a low number of stable species, but SSP3 was less stable than SSP1. Such projected biodiversity change would affect the people's appreciation as less variety in forest composition is projected to occur with a correspond loss in biodiversity. The environmental variables had a higher negative effect on biodiversity than land cover change for the SSP3-scenario, while land cover change was most important for SSP1. Both land cover change and environmental variables affect future biodiversity and hit different species groups differently.

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Appendix A

CORINE was used to find the actual land use for each catchment in percentages. In order to obtain the area in square meters needed for each land cover subject, the total area for the whole of Sweden was used to be able to make the scenarios in BioScore. This was because BioScore do not work with catchments but needed to operate with countries or geographic regions. BioScore start with zero change and by knowing what zero is in square meters made it possible to change the land cover for each of the scenarios.

*Table A1. Land cover change in BioScore for both future scenarios within each catchment in percentages, and the NOW scenario is the present state of the whole of Sweden. * = rounding error*

Land cover	Present state	Sävjaån SSP1	Sävjaån SSP3	Vindeln SSP1	Vindeln SSP3
Urban fabric	1 %	2 %	2 %	1 %	1 %
Green urban areas	>1 %	>1 %	>1 %	0 %	0 %
Arable land	7 %	18 %	32 %	2 %	5 %
Permanent crops	0 %	1 %	1 %	>1 %	>1 %
Pastures	1 %	1 %	1 %	>1 %	>1 %
Heterogeneous agricultural areas	2 %	2 %	1 %	1 %	1 %
Broad-leaved forest	5 %	>1 %	>1 %	>1 %	>1 %
Coniferous forest	49 %	44 %	56 %	57 %	78 %
Mixed forest	4 %	5 %	6 %	4 %	6 %
Moors and heathland	6 %	3 %	0 %	0 %	0 %
Transitional woodland-shrub	10 %	22 %	>1 %	29 %	5 %
Sparsely vegetated areas	2 %	2 %	0 %	0 %	0 %
Inland marshes	>1 %	>1 %	>1 %	>1 %	>1 %
Peat bogs	6 %	>1 %	>1 %	2 %	>1 %
Water courses	>1 %	0 %	0 %	1 %	1 %
Water bodies	7 %	1 %	1 %	2 %	2 %
Total	100 %	101* %	100 %	99 %	99 %

Appendix B

This is the survey used in fieldwork for the Sävjaån catchment in English. The fieldwork started on July 13th and was conducted for 14 days. It was made by Bart Immerzeel for his PhD and the BIOWATER project.

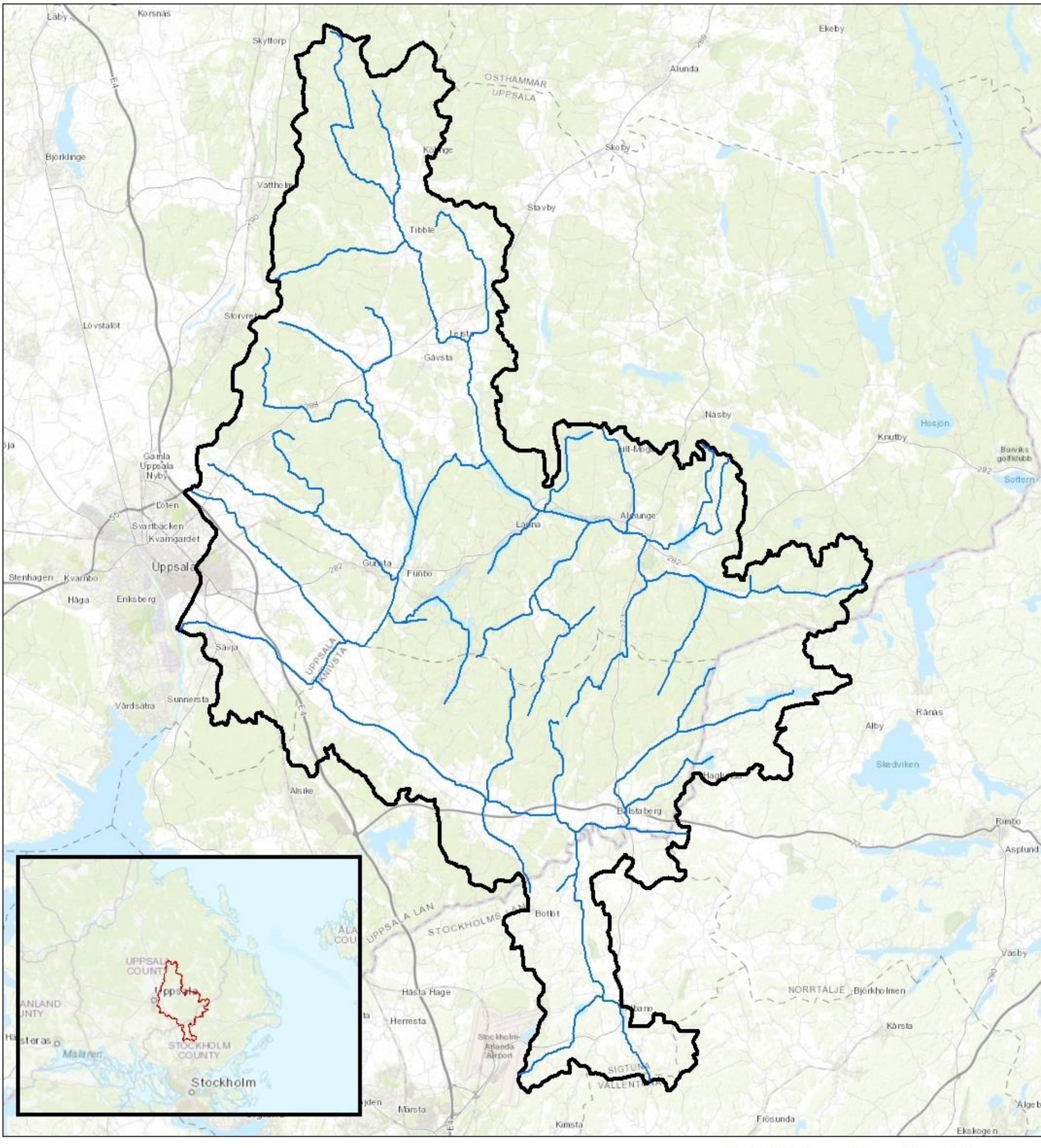
Dear survey participant,

Thank you for your willingness to participate in this survey. The survey is part of BIOWATER, a publicly funded research project in the Nordic countries. For more information on BIOWATER, please see the final page of this questionnaire.

Your answers will help us in estimating the effects of expected future developments on the benefits you gain from recreating and enjoying the local landscape. All your answers are important – it is not necessary at all that you have specific knowledge on nature, agriculture or the environment.

We will ask questions about your opinion of the local landscape in the Sävjaån river basin area. The map on the following page shows the study area. It lies directly east of Uppsala and has a size of about 730 km^2. The area contains several lakes and nature reserves including Tjäderleksmoissen and Storskogen, as well as several rivers, the biggest of which is the Sävjaån river.

Completing the survey takes about 20 minutes. Your responses will be kept confidential and individual responses cannot be identified from the data or traced back to you. If you have any questions regarding the study, please contact the interviewers or send an email to bart.immerzeel@nmbu.no.



Sävjaån study area

N 0 2,5 5 10 15 20 Kilometers

1:350.000

Legend

Waterway

Study area

Your relationship to the area

The map on the previous page shows the Sävjaån river basin area, which is our study area.

1. During the past 12 months, what have you used the area for? Multiple answers are possible. Also state the estimated number of visits for recreation.

a)	Short recreational visits (less than a day).	○	Number of visits: _______
b)	Long recreational visits (more than a day).	○	Number of visits: _______
c)	I live in the area.	○	
d)	I work in the area.	○	
e)	I am only travelling through the area.	○	
f)	Other: ________________________________	○	

If you did not recreate in the area during the last 12 months, please jump to question 9. Otherwise, continue to question 2.

2. Please mark on the map on page 2 with an X which location you visit most often for recreation. <u>Please mark only one location.</u>

3. If the above location would not be accessible, would you have an alternative location for recreation? <u>Please choose only one answer.</u>

Yes, in the Sävjaån area	Yes, in another area	No
○	○	○

4. **Please check the activities you typically do when visiting the area. Multiple answers are possible.**

		I do this in the local area
a)	Walking	○
b)	Running	○
c)	Cycling	○
d)	Orienteering	○
e)	Observing or photographing nature	○
f)	Berry/mushroom gathering	○
g)	Collecting firewood	○
h)	Hunting	○
i)	Managing my property	○
j)	Skiing	○
k)	Motorized boating	○
l)	Rowing, sailing, canoeing	○
n)	Fishing	○
o)	Swimming	○
p)	Visiting cultural heritage site	○
q)	Just relaxing	○
r)	Other:________________________________	○

5. Do you own property in the area? Multiple answers are possible.

I own a house	I own a holiday home	I own farmland	I own forest	Other: ______	I do not own property in the area
○	○	○	○	○	○

6. How far do you travel to the area where you recreate most often?

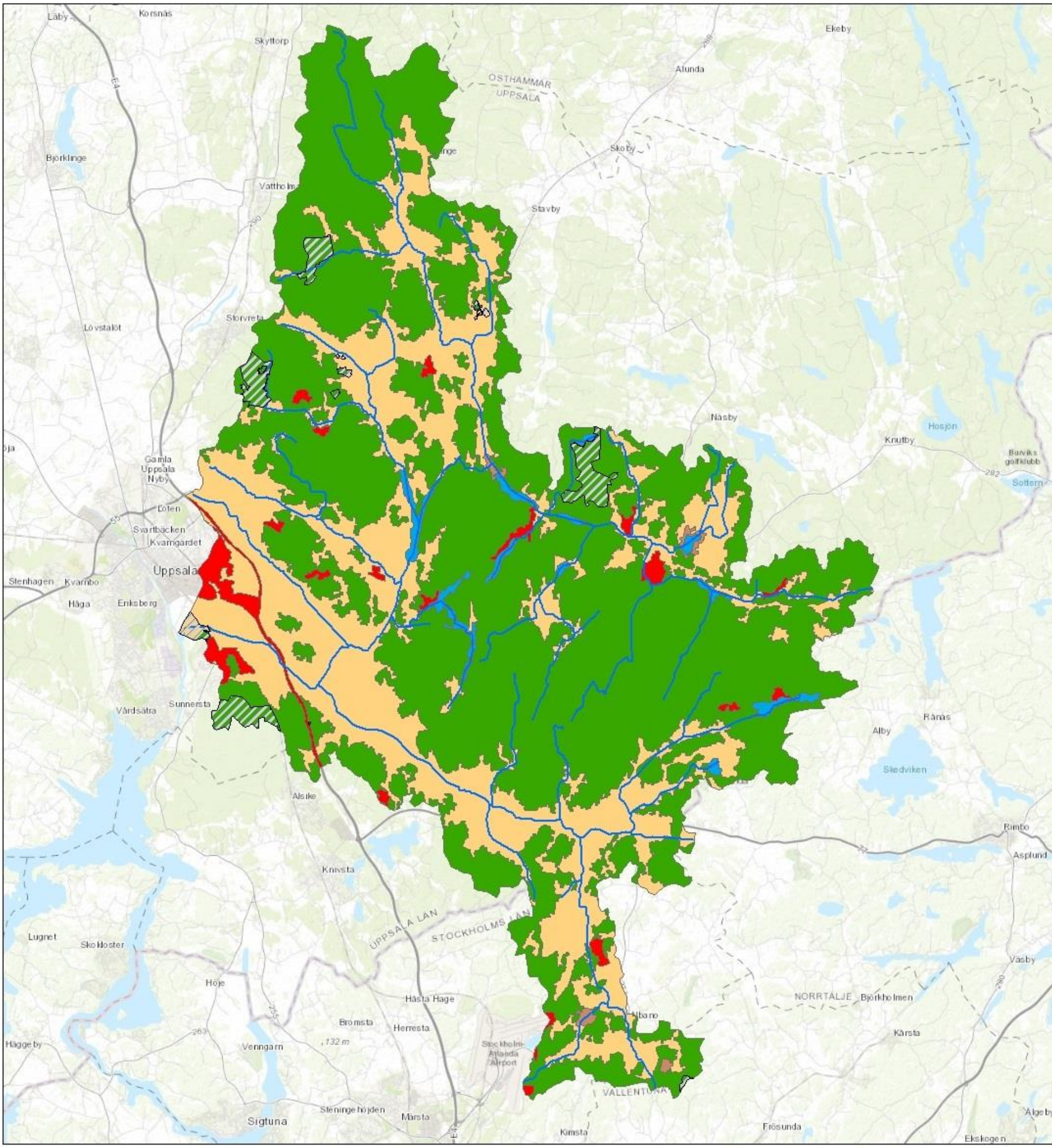
__________ km

7. How do you usually travel when recreating there? <u>Please mark only one option.</u>

a)	Car	○
b)	Bus	○
c)	Train	○
d)	Bicycle	○
e)	Motorcycle	○
f)	Public boat	○
g)	Private boat	○
h)	Walking	○
i)	Motorhome	○
j)	Other: ________________	○

8. **How would you describe the general quality of the local landscape in the Sävjaån river basin area for recreation?**

Very bad	Bad	Decent	Good	Very good	I don’t know
○	○	○	○	○	○



Sävjaån land use

Legend

- Nature reserve
- Waterway
- Built area
- Agriculture
- Forest
- Wetland
- Lake

N

0 2,5 5 10 15 20 Kilometers

1:350.000

Current state of the landscape

We will now go into more detail on the current state of the Sävjaån area, and possible future developments in land use and environmental quality. On the previous page, a map showing current land use and nature reserves in the area is shown.

9. Currently, about 30% of the Sävjaån river basin area is used for agriculture, which is mostly crop production. Around 65% of the area consists of forests, which are mainly coniferous forests. Please consider the local area and think about the enjoyment you receive from the current combination of landscapes.

How would you describe the balance between agriculture, forest and peat bogs in the local area, compared to your preferences?

Bad	Moderate	Good	I don't know
○	○	○	○

10. Agricultural land can be managed in different ways. For instance, intensive agriculture, where modern drainage, mechanical work and fertilization increase crop production, can be contrasted with organic farming, where crop production is lower and more expensive, but there is more room for nature and biodiversity. Forestry can also be more intensive, with soil preparation, tree planting, thinning, fertilization and high cutting frequencies, compared to less intensive management with natural tree growth, low cutting frequencies or no clear-cutting and more diverse tree species composition, which enhances biodiversity.

How would you describe the intensity of land use management in the local area, compared to your preferences?

Bad	Moderate	Good	I don't know
○	○	○	○

11. Water clarity is an important part of the environment also linked to recreation. If large amounts of nutrients drain into the water from adjacent fields, algal blooms can occur. When organic matter from dead plants dissolves in the water, it can turn brown. When there is much erosion upstream, the water can contain a large amount of sediment and turn turbid.

How would you describe the water clarity of lakes and rivers in the local area, compared to your preferences?

Bad	Moderate	Good	I don't know
○	○	○	○

12. Nature conservation areas are important for some species of plants and animals, because they cannot survive in intensively managed forests or agricultural areas. These areas conserve biodiversity and may increase the possibility to spot otherwise rarely seen species of plants and animals. There are several nature conservation areas in the Sävjaån river basin, covering about 2% of the total area, mostly in forested areas.

How would you assess the amount of nature conservation areas in the Sävjaån area, compared to your preferences?

Bad	Moderate	Good	I don't know
○	○	○	○

13. Periods of heavy rainfall or snowmelt can lead to a large amount of water flowing through the rivers and lakes in the area. This can cause flooding, with potential damage to land, infrastructure and property.

How would you describe the frequency of flooding in the local area?

High	Moderate	Low	I don't know
○	○	○	○

14. Agriculture and forestry generate local employment, as do recreational possibilities in the countryside. In the Sävjaån area, around 450 people (3% of all local workplaces) work in agriculture, forestry and fishery.

How would you describe the number of jobs generated by the local area from agriculture, forestry, fishery and recreation?

Bad	Moderate	Good	I don't know
○	○	○	○

15. Nature in the Sävjaån area generates benefits to society. How important are the following benefits to your own wellbeing?

		Very unimportant	Somewhat unimportant	Neither important, nor unimportant	Somewhat important	Very important	I don't know
a)	Source of drinking water	○	○	○	○	○	○
b)	Source of forestry products	○	○	○	○	○	○
c)	CO_2 storage to prevent climate change	○	○	○	○	○	○
d)	Water storage to prevent floods	○	○	○	○	○	○
e)	Clean water for nature	○	○	○	○	○	○
f)	Habitats for plants and animals	○	○	○	○	○	○
g)	Availability of game species	○	○	○	○	○	○
h)	Growth of berries, mushrooms and nuts	○	○	○	○	○	○
i)	Recreational possibilities	○	○	○	○	○	○
j)	Educational possibilities	○	○	○	○	○	○
k)	Food from agriculture	○	○	○	○	○	○
l)	The fact that there is nature	○	○	○	○	○	○
m)	The beauty of the landscape	○	○	○	○	○	○
n)	Cultural heritage sites and areas	○	○	○	○	○	○

16. What is the most important element of nature in this landscape, in your opinion?

a)	The variety of forests, wetlands, streams and lakes	○
b)	The large area of untouched nature	○
c)	The presence of large predators (bear, wolf, lynx)	○
d)	The presence of characteristic birds (crane, eagle, Lapland owl, capercaille)	○
e)	Other:________________________________	○

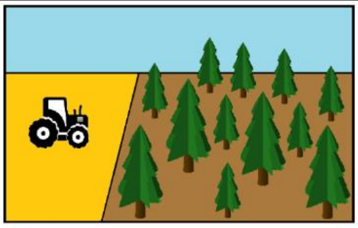
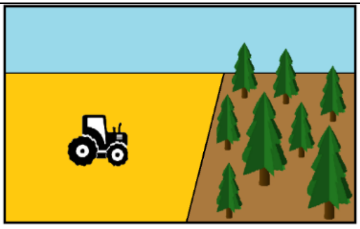
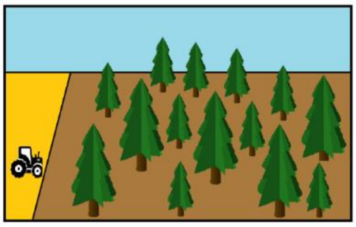
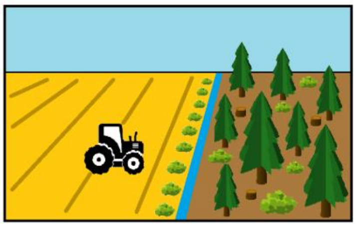
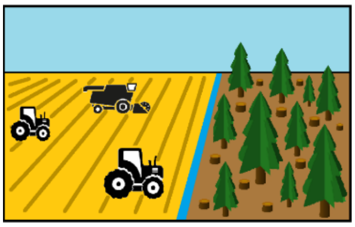
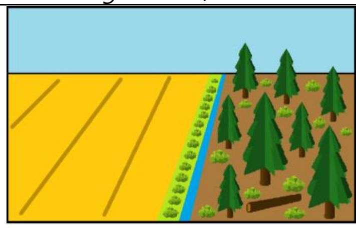
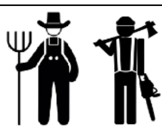
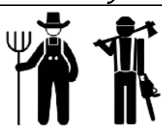
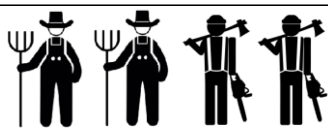
Future landscape changes: your preference

Societal developments and climate change can have local effects on land use, land management intensity, water quality, nature conservation, flood risk and employment in the Sävjaån area. To learn how you appreciate these aspects for recreation and enjoyment of the landscape, we will give you a set of choices, which represent different possible futures. Each possible future also comes with an environmental tax. The environmental tax is not yet in place, but it could be collected in the future and the revenues from it can be used to change land management practices, take measures against flood risk and manage nature conservation areas.

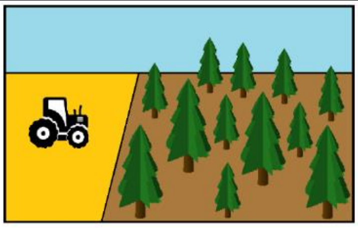
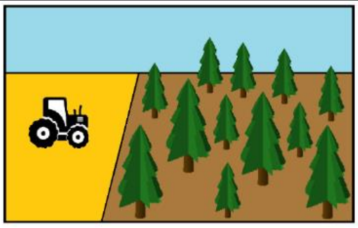
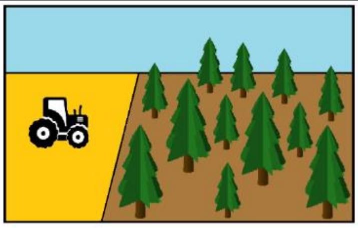
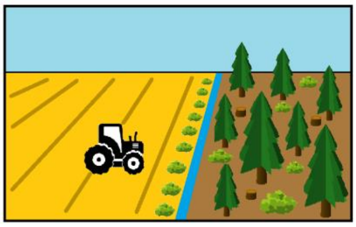
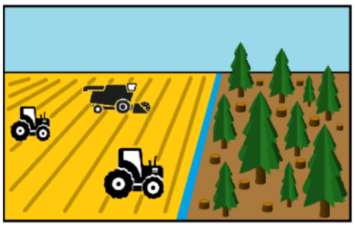
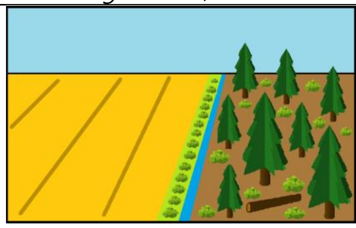
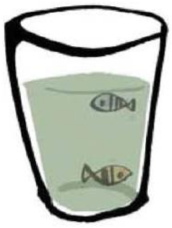
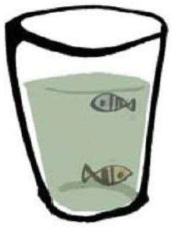
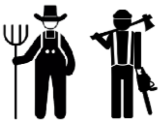
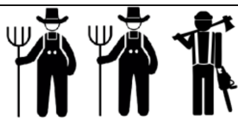
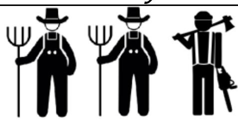
17. We will now show you five choice cards, each with three options. The options describe a situation 30 years from now. Option A is the same in all choice cards, describing a situation where the current trends in land use continue. For the two other options, each of the aspects described above varies in level, and comes with an increased level of municipal tax. Each choice card shows a different set of combinations, but all of the choice cards are equally important. Bear in mind that the environmental tax would reduce your income and consumption possibilities.

Please state for each card which option you prefer.

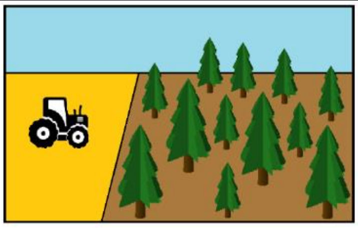
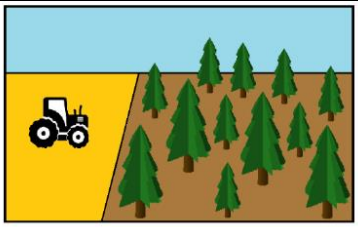
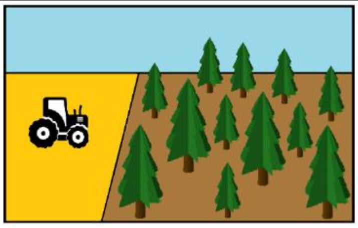
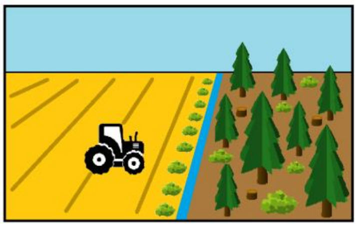
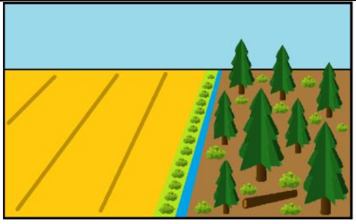
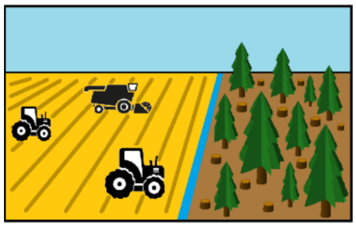
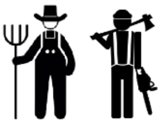
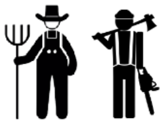
Card 1

	OPTION A (business as usual)	OPTION B (future scenario)	OPTION C (future scenario)
Land use	 *30% agriculture, 65% forest*	 *45% agriculture, 50% forest*	 *15% agriculture, 80% forest*
Land management intensity	 *Moderately intensive*	 *Very intensive*	 *Extensive*
Water clarity	 *Turbid*	 *Turbid*	 *Clear*
Nature conservation areas	 *2% of total area*	 *2% of total area*	 *2% of total area*
Flood frequency	 *1 in 100 years*	 *1 in 300 years*	 *1 in 100 years*
Local rural employment	 *No change*	 *No change*	 *100% increase*
Additional yearly tax	*No extra tax*	*300 kr. / year*	*5 000 kr. / year*
Choice	○	○	○

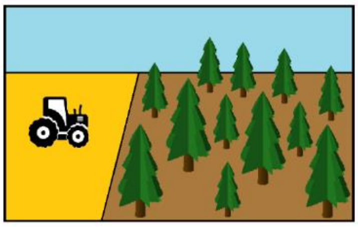
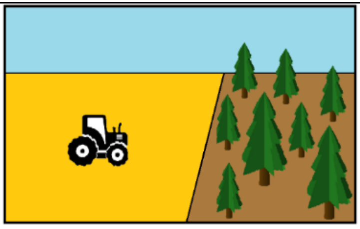
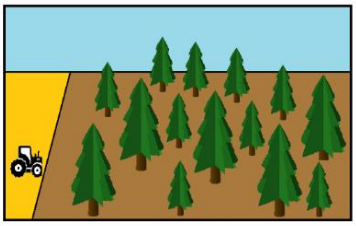
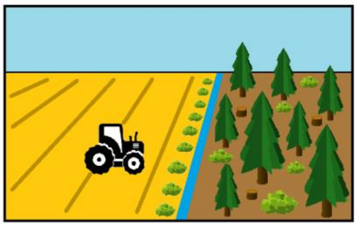
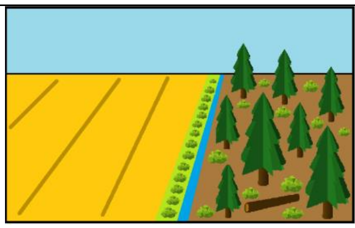
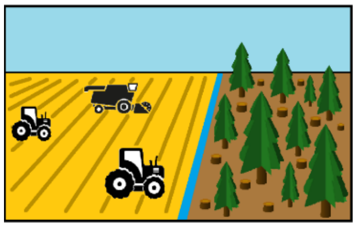
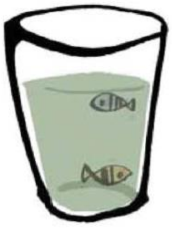
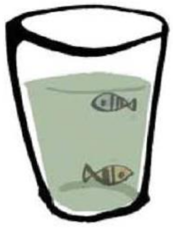
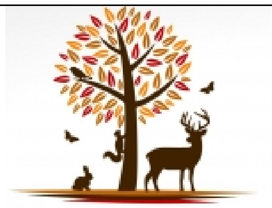
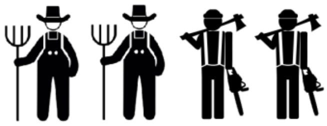
Card 2

	OPTION A (business as usual)	OPTION B (future scenario)	OPTION C (future scenario)
Share of agriculture and forest	 *30% agriculture, 65% forest*	 *30% agriculture, 65% forest*	 *30% agriculture, 65% forest*
Land management intensity	 *Moderately intensive*	 *Very intensive*	 *Extensive*
Water clarity	 *Turbid*	 *Moderate*	 *Moderate*
Nature conservation areas	 *2% of total area*	 *2% of total area*	 *2% of total area*
Flood frequency	 *1 in 100 years*	 *1 in 100 years*	 *1 in 300 years*
Local rural employment	 *No change*	 *50% increase*	 *50% increase*
Additional yearly tax	*No extra tax*	*1 500 kr. / year*	*1 500 kr. / year*
Choice	○	○	○

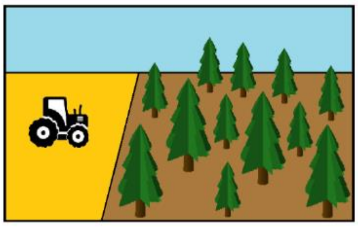
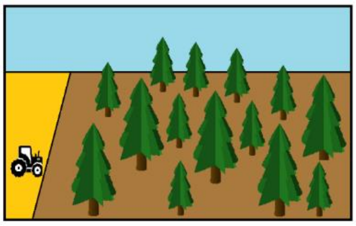
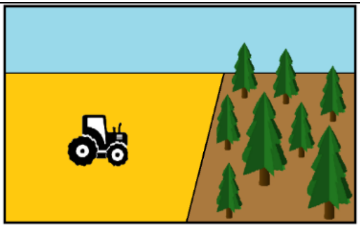
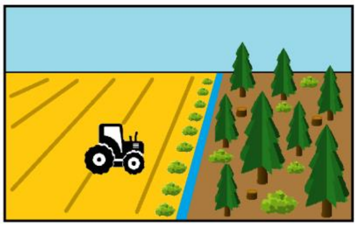
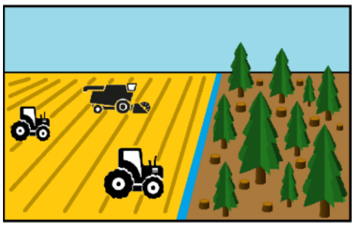
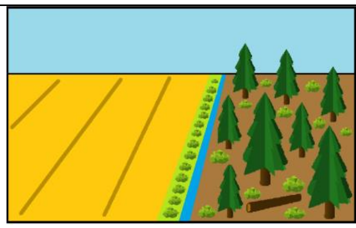
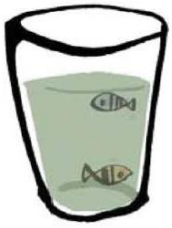
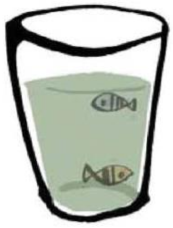
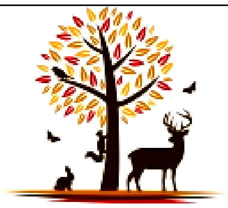
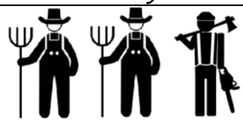
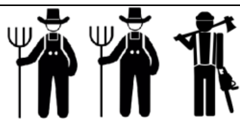
Card 3

	OPTION A (business as usual)	OPTION B (future scenario)	OPTION C (future scenario)
Share of agriculture and forest	 *30% agriculture, 65% forest*	 *30% agriculture, 65% forest*	 *30% agriculture, 65% forest*
Land management intensity	 *Moderately intensive*	 *Extensive*	 *Very intensive*
Water clarity	 *Turbid*	 *Clear*	 *Turbid*
Nature conservation areas	 *2% of total area*	 *2% of total area*	 *2% of total area*
Flood frequency	 *1 in 100 years*	 *1 in 300 years*	 *1 in 100 years*
Local rural employment	 *No change*	 *100% increase*	 *No change*
Additional yearly tax	*No extra tax*	*300 kr. / year*	*5 000 kr. / year*
Choice	○	○	○

Card 4

	OPTION A (business as usual)	OPTION B (future scenario)	OPTION C (future scenario)
Share of agriculture and forest	 *30% agriculture, 65% forest*	 *45% agriculture, 50% forest*	 *15% agriculture, 80% forest*
Land management intensity	 *Moderately intensive*	 *Extensive*	 *Very intensive*
Water clarity	 *Turbid*	 *Moderate*	 *Moderate*
Nature conservation areas	 *2% of total area*	 *5% of total area*	 *1% of total area*
Flood frequency	 *1 in 100 years*	 *1 in 100 years*	 *1 in 300 years*
Local rural employment	 *No change*	 *No change*	 *100% increase*
Additional yearly tax	*No extra tax*	*1 500 kr. / year*	*1 500 kr. / year*
Choice	○	○	○

Card 5

	OPTION A (business as usual)	OPTION B (future scenario)	OPTION C (future scenario)
Share of agriculture and forest	 *30% agriculture, 65% forest*	 *15% agriculture, 80% forest*	 *45% agriculture, 50% forest*
Land management intensity	 *Moderately intensive*	 *Very intensive*	 *Extensive*
Water clarity	 *Turbid*	 *Moderate*	 *Moderate*
Nature conservation areas	 *2% of total area*	 *1% of total area*	 *5% of total area*
Flood frequency	 *1 in 100 years*	 *1 in 300 years*	 *1 in 100 years*
Local rural employment	 *No change*	 *50% increase*	 *50% increase*
Additional yearly tax	*No extra tax*	*3 000 kr. / year*	*800 kr. / year*
Choice	○	○	○

18. How certain were you about your choices in the choice cards?

Very uncertain	Slightly uncertain	Slightly certain	Very certain
○	○	○	○

19. Which of the following aspects did you take into account when making your choices on the five choice cards?

		I took this into account	I did not take this into account
a)	The share of agriculture and forest in total land use.	○	○
b)	The intensity of land management.	○	○
c)	Water clarity.	○	○
d)	The amount of nature conservation.	○	○
e)	The amount of flood risk.	○	○
f)	The amount of local employment from agriculture, forestry and recreation.	○	○
g)	The amount of tax for my household.	○	○

20. Are there any aspects of the landscape you took into account that were not part of the choice sets? If so, write them down here:

____

_____

21. In filling in the choice cards, did you think specifically of the Sävjaån area, or of Swedish landscapes in general?

The local Sävjaån area	Swedish landscapes in general	I don't know
○	○	○

22. How realistic did you find the alternative options for future developments?

Very unrealistic	Slightly unrealistic	Slightly realistic	Very realistic	I don't know

○	○	○	○	○

23. If you chose the business as usual option (option A) on all five choice cards, please indicate why you did so. <u>If not, you can skip this question.</u>

a)	This happened to be my preferred option each time.	○
b)	I did not find the alternative future options realistic.	○
c)	I do not want to pay an extra tax on principle.	○
d)	I do not have enough money to pay an extra tax.	○
e)	Other: ___________________________________	○

24. If you chose one of the future scenarios (option B or C) on all five choice cards, please indicate why you did so. <u>If not, you can skip this question.</u>

a)	This happened to be my preferred option each time.	○
b)	I did not find the business as usual option realistic.	○
c)	I believe current land use policies are moving us in the wrong direction.	○
d)	Other: ___________________________________	○

25. To what extent do you agree or disagree with the following statements in general?

		Strongly disagree	Disagree	Agree	Strongly agree	I don' t know
a)	We are approaching the limit of the number of people the earth can support.	○	○	○	○	○
b)	Humans have the right to modify the natural environment to suit their needs.	○	○	○	○	○
c)	When humans interfere with nature it often produces disastrous consequences.	○	○	○	○	○
d)	Human ingenuity will insure that we do NOT make the earth unlivable.	○	○	○	○	○
e)	Humans are severely abusing the environment.	○	○	○	○	○
f)	The earth has plenty of natural resources if we just learn how to develop them.	○	○	○	○	○
g)	Plants and animals have as much right as humans to exist.	○	○	○	○	○
h)	The balance of nature is strong enough to cope with the impacts of modern industrial nations.	○	○	○	○	○
i)	Despite our special abilities humans are still subject to the laws of nature.	○	○	○	○	○
j)	The so–called "ecological crisis" facing humankind has been greatly exaggerated.	○	○	○	○	○
k)	The earth is like a spaceship with very limited room and resources.	○	○	○	○	○

		Strongly disagree	Disagree	Agree	Strongly agree	I don’t know
l)	Humans were meant to rule over the rest of nature.	○	○	○	○	○
m)	The balance of nature is very delicate and easily upset.	○	○	○	○	○
n)	Humans will eventually learn enough about how nature works to be able to control it.	○	○	○	○	○
o)	If things continue on their present course, we will soon experience a major ecological catastrophe.	○	○	○	○	○

Background information

26. What is your age?

____

27. What is your gender?

a)	Male	○
b)	Female	○

28. What is your nationality?

a)	Swedish	○
b)	Other: ____________________	○

29. In what kind of neighbourhood did you grow up?

a)	Rural area or village	○
b)	City, town or urban agglomeration	○

30. In what kind of neighbourhood do you currently live?

a)	Rural area or village	○
b)	City, town or urban agglomeration	○

31. What is the highest level of education you have received? <u>Please choose only one answer.</u>

a)	Primary school	○
b)	Secondary school	○
c)	Vocationary education	○
d)	University degree	○
e)	Other education: ____________________________	○

32. Are you currently employed? <u>Please choose only one answer.</u>

a)	Yes	○
b)	I am unemployed	○
c)	I am retired	○
d)	I am a student	○
e)	I manage the household	○
f)	No, other reason	○

33. In which sector do you work (pensioners and unemployed: past work, students: future work)?

a)	Agriculture	○
b)	Forestry	○
c)	Building and construction	○
d)	Manufacturing industry	○
e)	Energy and mining	○
f)	Fishery	○
g)	Services	○
h)	Healthcare	○
i)	Education	○
j)	Public sector	○
k)	Other:____________________	○

34. What is your monthly gross income level?

a)	No income	○
b)	Less than 15 000 kr.	○
c)	15 000 – 19 999 kr.	○
d)	20 000 – 24 999 kr.	○
e)	25 000 – 29 999 kr.	○
f)	30 000 – 39 999 kr.	○
g)	40 000 – 59 999 kr.	○
h)	60 000 – 79 999 kr.	○
i)	80 000 – 99 999 kr.	○
j)	over 100 000 kr.	○

35. What type of household do you live in?

a)	Single	○
b)	Couple	○
c)	Couple with underaged children	○
d)	Other adult household (all over 18 yrs.)	○
e)	Other	○

Thank you very much for taking the time to fill in this questionnaire. Below there is some room for additional comments. The final page gives some additional information on our research project.

On BIOWATER

BIOWATER is a Nordic Centre of Excellence funded by Nordforsk, a funding organization under the Nordic Council of Ministers. It is a collaboration between the following research institutes and universities:

Swedish University of Agricultural Sciences (SE)
Norwegian University of Life Sciences (NO)
NIBIO – Norwegian Institute of Bioeconomy Research (NO)
Norwegian Institute of Water Research (NO)
Aarhus University (DK)Natural Resources Institute Finland (FI)
Finnish Environment Institute (FI)
University of Oulu (FI)

The objective of BIOWATER is to quantify the future effects of land use change, climate change and industrial innovation due to the development of a 'bioeconomy' on the environmental quality of Nordic river catchments and the benefits society derives from them.

This survey is part of a Master's thesis and PhD research project under BIOWATER, performed by Sophie Ottmann and Bart Immerzeel at the Norwegian University of Life Sciences. Our aim is to quantify the value of the benefits society derives from catchments from biodiversity, recreation and other cultural activities, and to find how possible future changes would affect this value.

For more information on BIOWATER, please see:
https://biowater.info/

For more information on the study this survey is part of, please contact:
bart.immerzeel@nmbu.no

Norges miljø- og biovitenskapelige universitet
Noregs miljø- og biovitskapelege universitet
Norwegian University of Life Sciences

Postboks 5003
NO-1432 Ås
Norway