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Research article

The valuation of forest ecosystem services as a tool for management planning – A choice experiment

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ABSTRACT

Forest owners and managers deal with an increasing demand for forest ecosystem services (ES). In addition, a recent change can be observed from a governmental top-down approach to bottom-up initiatives, including efforts of the local population to have a say in forest management decisions. Matching supply and demand is seen as a basic condition for the sustainable utilization of forest ES. Against this background, we address the following research questions: (i) How can the preferences on the supply and demand side of forest ES be consistently determined? (ii) In how far do these preferences vary due to regional and societal differences? (iii) How can the supply and demand of forest ES be matched by forest management alternatives?

We conducted a survey in Switzerland with foresters and the wider population to compare attitudes and preferences of the supply and demand side of forest ES. The core of the study is a choice experiment (CE) to elicit the population's willingness to pay (WTP) for specific forest management alternatives, and the respective willingness to accept (WTA) on the foresters' side. To address spatial and societal heterogeneity, we compare different geographic forest zones and settlement areas.

1. Introduction

Multifunctionality is supposed to be an integral part of sustainable forest management as it is promoted in many countries today. The aim is to simultaneously account for diverse forest functions, such as protection, recreation or habitat conservation, when taking management decisions. In practice, priority is often given to specific functions, depending for example on the topographic circumstances (protection against gravitational hazards) or the demand of potential users (recreation in the spatial proximity of agglomerations). This is partly due to the fact that the population is increasingly aware of the importance of these functions. Their impact on human wellbeing was demonstrated by the ecosystem service (ES) approach (MA, 2005), and has been further developed by the recently published IPBES report (IPBES, 2018). The report emphasizes the importance of biodiversity and nature's contributions to people (NCP), but at the same time provides evidence for their current decline in many countries. Forest management can contribute to counteract this negative development by using all relevant and available information, comprising knowledge generated by natural as well as social sciences (Olschewski et al., 2018).

Concerning decision making in forestry, a recent change has been detected from a predominantly governmental top-down approach to diverse bottom-up initiatives, including efforts of the local population to have a say in forest management decisions (Thees and Olschewski, 2017). Particularly in case of rising demand for various forest ES, trade-offs can arise, when deciding which bundles of services to provide and to what extent (Schirpke et al., 2019; Mouchet et al., 2014; Turner et al., 2014). In such conflicting situations, transparent communication and decision making is notably important. Here, the economic assessment of specific ES permits to compare different options for an efficient resource use, also taking the population's preferences into account (Weller and Elsasser, 2018). Furthermore, by making the value and scarcity of ES visible, public awareness can be raised that forest services are limited and neither necessarily permanent nor available free of charge. However, ES value estimates have often been neglected in forest and land-use management so far (but see Bateman et al., 2013 for an exception). This might partly be due to the lack of standardized quantification approaches (Kroll et al., 2012). Valuation studies are often

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conducted at the regional or local level, and based on different methods. In consequence, their results are strongly context dependent and hardly comparable or applicable to other places (Müller et al., 2019). In addition, general guidance for selecting appropriate valuation methods while addressing the requirements of the diverse stakeholders is missing (Harrison et al., 2018). A promising step towards improving decision-making is the recently developed approach of 'mapping and assessment of ecosystems and their services' (MAES) (Burkhard et al., 2018). However, coherently applying this approach is often hindered by substantial data gaps (Maes et al., 2016; Howe et al., 2014).

The Swiss Forest Policy 2020 states that *"the efficiency and performance of the Swiss forestry sector and, therefore, the structure of forestry operations and cooperation beyond ownership structures shall improve. The additional expenses incurred by managers for the provision of the desired forest services, or corresponding losses in income, shall be compensated" (*FOEN, 2013*, p. 37)*. This objective shows the importance of economic information as a basis for forest management decisions. While the calculation of operational costs and income losses might be relatively straightforward, the estimation of the 'performance', e.g., quantified as benefits generated to the population, is more demanding. This is particularly true for Switzerland, due to (i) the diverse topography with altitudes ranging from 200 m up to 4600 m, (ii) the contrast between densely populated agglomerations and remote rural areas, and (iii) the regional differences in forest utilization and growing stocks. Thus, the population's demand concerning forests and their services can be quite heterogeneous. Adapting the ES supply to these diverse preferences requires to comprehensively consider a portfolio of ES including both costs and benefits of its provision. Matching supply and demand based on 'spatial localization, indication and quantification' is seen as a basic condition for the sustainable utilization of natural resources (Burkhard et al. 2012, 2014; Castro et al., 2014). In contrast, only targeting the supply will most likely result in an inefficient ES provisioning (Cimon-Morin et al., 2014).

Against this background we address the following research questions: (i) How can the preferences on the supply and demand side of forest ES be consistently determined? (ii) In how far vary these preferences due to regional and societal differences? (iii) How can the supply and demand of forest ES be matched by forest management alternatives.

In the following, we present the results of a survey of foresters and the wider population in Switzerland. We compare the attitudes and preferences of both the supply and demand side of forest ecosystem services. The core of the study is a choice experiment to elicit the population's willingness to pay for specific forest management alternatives, and the respective willingness to accept these measures on the foresters' side. To address the above-mentioned spatial and societal heterogeneity, we compare different geographic forest zones and settlement areas across Switzerland.

2. Material & methods

2.1. Study area

We conducted our study across Switzerland with the aim to detect differences and similarities concerning forest ES supply and demand based on varying spatial and societal conditions and contexts. Therefore, we stratified our sample according to different forest zones and settlement areas.

Switzerland is divided into four different forest zones based on the respective geographical structures (Fig. 1, left part): (i) the mountainous zone in the northwest (Jura), (ii) the central lowlands (Plateau), (iii) the sub-alpine zone (Pre-Alps) and (iv) the alpine zone (Alps). Our study covers all zones, except the southern part of the Alps. We assumed that the supply of forest ES differs depending on the forest zone, with emphasis on timber production in the Plateau and a priority of protection services in the Pre-Alps and Alps. Recreational services and habitat conservation services are supposed to be equally important throughout the regions.

Concerning areas of settlement, we distinguished among cities, agglomerations and rural areas. The majority of big cities is located in the Plateau (Zurich, Geneva, Lausanne, Winterthur, St Gallen, Berne). The third biggest city, Basel belongs to the forest zone Jura, Lucerne is located between Plateau and Pre-Alps. The biggest agglomerations in the part of the Alps covered by our study are Sion and Sierre as well as Visp and Brig (Fig. 1, right part). We hypothesized that the area, where people live, has an impact on their preferences for forest ecosystems, with an emphasis on recreational services in cities and agglomeration.

The forest ownership structure is characterized by comparatively many owners with small forest parcels, only. The average size of privately-owned forests is 1.5 ha per owner, whereas forest areas in public ownership have an average extent of 240 ha per owner. The majority of forests is owned by political municipalities (30%), citizen communities[1] (29%) and private forest owners (29%). 1% belongs to the Confederation, 4% to the cantons and 7% are other owners. Differences of the forest zones concerning the extent of forest land and the share of ownership types are displayed in Fig. 2.

The managed forest areas are often too small to ensure a cost-efficient forest management. Due to the small forest size, forest owners often face relatively high fixed costs and it is usually difficult or unattractive for them to professionally market their small amounts of timber (Olschewski et al., 2015).

2.2. Survey

Müller et al. (2019) have shown that the estimates of forest ES values vary substantially. In particular, studies on recreational and habitat services provide a wide range of valuation results. This is partly due to the context dependence of the valuation, where a specific service is valued in a particular spatial context at a certain point in time. On the other hand, different valuation methods are applied, sometimes without presenting important background information, which makes it hard to trace back further reasons of diverging results.

Our study focuses on the assessment of forest ES from different points of view including forest owners, forest owner representatives (e.g., foresters in the municipalities), forest managers/foresters and the wider population. For each target group we prepared a separate questionnaire. This allows us to see, whether the preferences for recreation and habitat services on the supply and demand side differ across target groups.

In a pre-test with participants from the different target groups, we checked the questionnaire for completeness, comprehensibility, and frictionless technical application. A group of forty respondents took part in the pre-test, consisting of four foresters, two forest owners, two forest representatives, nine people from the wider population, and 23 researchers. The pre-test was carried out online, as well as by written and oral interviews. The questionnaire of the wider population consisted of four parts with questions related to:

1. Personal environment & visiting behavior
2. Preferences towards forest management alternatives (choice experiment)
3. Statements related to forests in Switzerland and their management
4. Sociodemographic characteristics

Data collection took place between June and August 2018. The

[1] Citizen communities, in Switzerland called "Burgergemeinden" or "Bürgergemeinden", are municipalities without fiscal sovereignty.

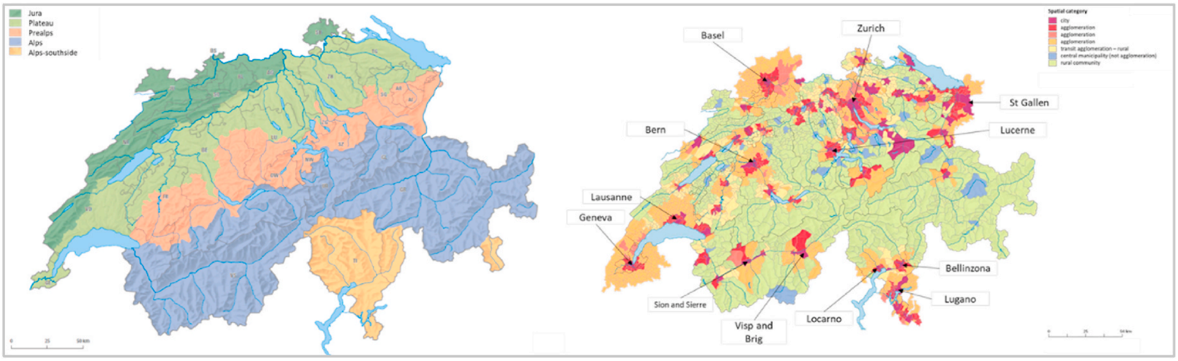

Fig. 1. The Swiss forest zones (left) and settlement areas (right) (Federal Statistical Office, 2010, adapted, and 2009–2015, mapID 17718, adapted).

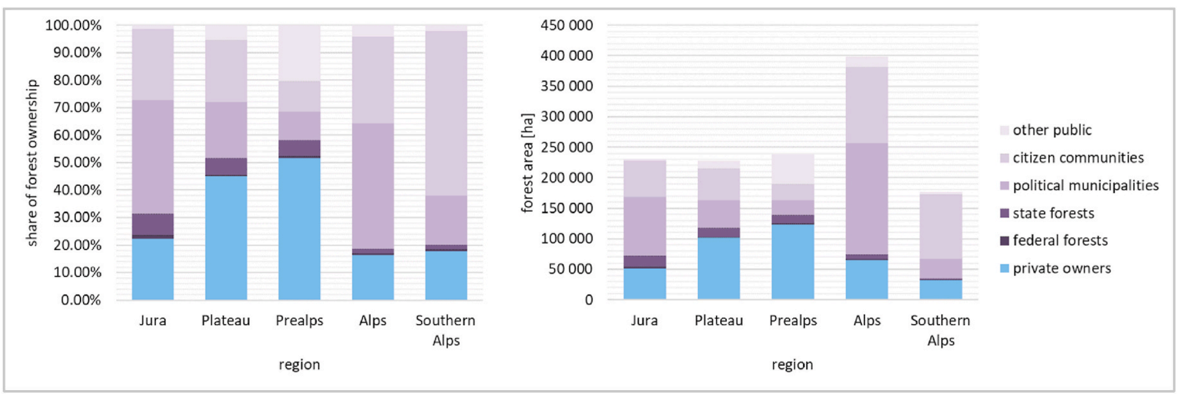

Fig. 2. Forest ownership structure in Swiss forest zones: forest areas (left) and share of owners (right).

population's survey was conducted by a professional market research institute[2] based on a household panel. The institute invited the households to participate online and was responsible to fill specific quotas based on the respective shares of the overall Swiss population (Table 1). As the chi-square statistics show, there is no significant difference between the sample and the overall population (chi-square = 110, p-value = 0,2322). The forest owners' and managers' questionnaire had a similar content, except in the first part, which dealt with questions about the forest enterprise and management strategies, and in the second part, where the utility function was specified differently (see next chapter). These groups were invited to participate through various channels: forest practitioner journals, forest associations, cantonal forest services and municipalities in order to reach as many of them as possible.

Based on a comparison of the estimated questionnaire length of about 30 min and the actual response time of the participants, we characterized respondents that needed less than 3 min for the choice experiment as 'click-throughs' and excluded them from the further analysis. This procedure resulted in a sample of 1250 (according to forest regions) or 1266 (according to settlement areas) completed questionnaires.

Unfortunately, only 48 foresters completed and returned the questionnaire, of which 3 had to be excluded as 'click-throughs'. The return rate of forest owners and their representatives was negligible. Due to the low response rate we had to exclude these two groups, and proceeded our analysis with the responses of households and foresters, only.

2.3. Choice experiments

Choice experiments (CE) offer the possibility to determine people's preferences for goods and services but also for environmental changes (Champ, 2017). In addition, CE have recently been used to elicit farmers' and foresters' preferences to participate in environmental or insurance schemes (Christensen et al., 2011; Villanueva et al., 2017; Villamayor-Tomas et al., 2019; Sauter et al., 2016). The method is based on Lancaster's consumer choice theory (Lancaster, 1966) stating that individuals take their choice decisions depending on the specific attributes of goods and services. CE aim at estimating the importance of such attributes and can detect trade-offs among them. In case a monetary attribute is included in the CE, the willingness to pay (WTP) for or willingness to accept (WTA) a change can be determined. The data collected by choice experiments is analyzed and interpreted based on random utility theory (RUT) (McFadden, 1973). Individuals are assumed to have a utility function U consisting of a deterministic observable part (V) and a random unobservable part ε (Louviere, 2001; Olschewski et al., 2012).

$$U_{ni} = V_{ni} + \varepsilon_{ni}$$

The observable component of the utility function comprises attributes of a good or service that are supposed to have major impact on the decision-making of the respondents. In our case, the focus was on forest management alternatives suitable to enhance recreational and habitat services. Given that we aimed at eliciting preferences on the supply and demand side, we had to select attributes related to forest management, which could be influenced and controlled by foresters and at the same time would be understandable by the wider population. Based on recently published findings (Elsasser and Meyerhoff, 2007b; Elsasser, 2016; Müller et al., 2019) as well as interviews with experts and practitioners, the utility function for the households (HH) and foresters (FO)

[2] More information: www.bilendi.de.
[3] Sources: https://www.bfs.admin.ch/asset/de/je-d-01.02.03.02; https://www.bfs.admin.ch/bfs/de/home/statistiken/bildung-wissenschaft/bildungsindikatoren/bildungssystem-schweiz/themen/wirkung/bildungsstand.assetdetail.7886035.html.

Table 1
Population survey: sample compared to Swiss average.[3].

	Sample	Share of Sample (in %)	Share of Total Population (CH, in %)	Deviation
Age				
18–19 years	103	3.39%	2.12%	1.27%
20–39 years	833	27.39%	26.65%	0.74%
40–64 years	1056	34.73%	35.03%	−0.31%
>65 years	1049	34.50%	18.27%	16.22%
Gender				
Male	1297	50.55%	49.58%	0.97%
Female	1269	49.45%	50.42%	−0.97%
Highest Education				
Compulsory schooling	201	7.81%	11.60%	−3.79%
Lower secondary level	984	38.26%	36.40%	1.86%
Upper secondary level	168	6.53%	8.20%	−1.67%
Higher vocational education	495	19.25%	14.90%	4.35%
University	697	27.10%	28.80%	−1.70%
Others	27	1.05%	*	*
Settlement Area				
City	768	29.87%	*	
Agglomeration	793	30.84%	*	
Rural area	1010	39.28%	*	
Region				
Jura	408	15.87%	*	
Plateau	1530	59.51%	*	
Pre-Alps	369	14.35%	*	
Alps	235	9.14%	*	
(Alps – southern part) **	29	1.13%		

(chi-square = 110, p-value = 0,2322, *no data available; **not included in the analysis; missing data not displayed).

was specified as follows:

$$U_{HH} = \beta_0 + \beta_1{*}TS + \beta_2{*}FS + \beta_3{*}WU + \beta_4{*}AM + \beta_5{*}MC + \varepsilon$$

$$U_{FO} = \beta_0 + \beta_1{*}TS + \beta_2{*}FS + \beta_3{*}WU + \beta_4{*}AM + \beta_5{*}MC + \varepsilon$$

where the deterministic part consists of five attributes: (i) 'tree species' (TS), (ii) 'forest structure' (FS), (iii) 'wood utilization' (WU), (iv) 'area with additional measures for recreational and habitat services' (AM), and the 'monetary contribution' (MC). Note that in case of households, MC means their cost contribution to a program, whereas for foresters it reflects an additional revenue, when realizing a program. β_0 represents the alternative-specific constant (ASC) of the label 'program orientation'. It reflects the systematic impact of otherwise unobservable variables that are not covered by our attributes. In the following, we present each attribute with its respective levels (Table 2), together with our hypotheses (*in italics*) about their potential impact on habitat and recreational services.

"Program orientation" refers to the label of the options provided in the choice sets (Fig. 3). The participants were asked to assume that the federal government will launch a support program to compensate foresters and forest owners for efforts to improve the recreational and habitat services of their forests. To qualify for this financial support, they have to fulfill clearly stated requirements with regard to (i) the mixture of tree species, (ii) the structure of the forest, (iii) the utilization of wood, and (iv) the area with specific measures to enhance habitat or recreational services (number of biotope trees and dead wood, recreational sites and facilities). The scenario envisaged that the population and the foresters can participate in the design of the funding programs. Therefore, the respondents could decide between two alignments: a more recreation-oriented and a more habitat-oriented program as well as the none-option. Our hypothesis is:

- *The orientation or name of the program has an impact on the respondent's choices, although the listed attributes are equal for both options, except the additional measures to be taken for enhancing recreation and habitat services, respectively.*

"Tree species" expresses the share of coniferous and deciduous trees. The respondents could choose between the dominance of either coniferous or deciduous trees as well as an approximately equal distribution. The proportions were chosen in a way to make clear which species dominates, while maintaining a realistic representation of actual forest management practices. We hypothesize the following:

Table 2
Description of CE attributes and levels.

Attributes/Labels	Levels
Program orientation (ASC)	Habitat
	Recreation
	Status quo
Tree species (TS)	Deciduous trees dominate
	Coniferous trees dominate
	About the same number of coniferous and deciduous trees
Forest structures (FS)	No pattern visible (permanent forest)
	Patterns partially visible (mixture of permanent and cutting forests)
	Patterns clearly visible (cutting forest)
Wood utilization (WU)	Interventions not visible
	Interventions occasionally visible
	Interventions largely visible
Area with additional measures (AM)	Area extended by 5%
	Area extended by 10%
	Area extended by 20%
Monetary contribution (MC) Households: Amount to be paid annually per household Foresters: Amount to be received annually per ha	10; 25; 50; 75; 100 or 125 USD[4]

Table 3
MNL estimates of foresters' preferences.

Attribute	Level	Foresters
Program orientation	Habitat	−0.85*** (0.23)
	Recreation	−0.77*** (0.24)
	Status quo	–
Tree species	Deciduous trees	−0.46*** (0.15)
	Coniferous trees	–
	Mixture of both	−0.14 (0.15)
Forest structures	No pattern visible	0.27* (0.15)
	Partially visible	0.32** (0.15)
	Clearly visible	–
Wood utilization	Not visible	0.02 (0.16)
	Occasionally visible	0.58*** (0.15)
	Largely visible	–
Area with additional measures	Extended by 5%	–
	Extended by 10%	−0.15 (0.15)
	Extended by 20%	−0.43*** (0.01)
Annual payment per ha		0.01*** (0.002)
Number of respondents		48
Rho-square		0.065
Percentage chosen	*Habitat*	34.38
	Recreation	31.24
	Status quo	34.38

(Standard errors shown in brackets. *, **, *** indicate 10, 5, 1% significance level).

[4] As the CE was conducted in Switzerland, the monetary contribution was originally presented in Swiss Francs. For publication purposes, we converted these values to USD using a 1:1 conversion rate, which approximately reflects the current exchange rate.

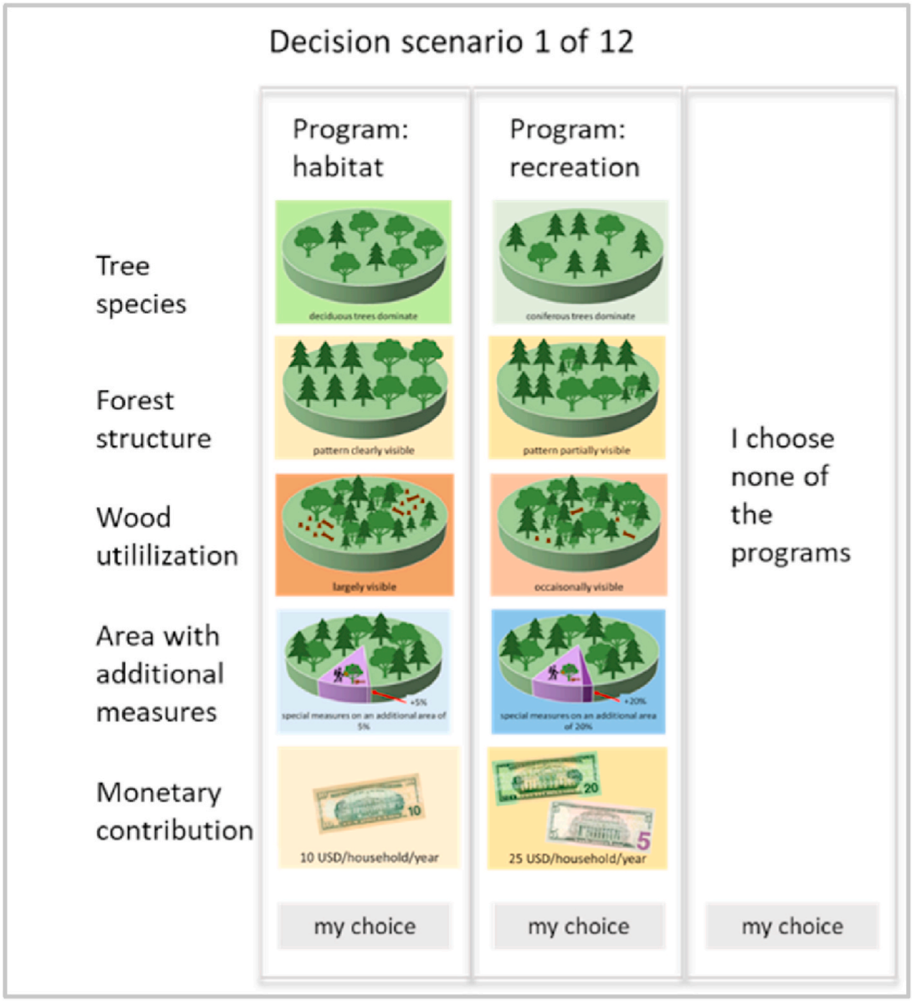

Fig. 3. Example of a choice set used in the questionnaire.

- *The choice of tree species has a major influence of the forest appearance.*
- *A mixture of coniferous and deciduous trees increases the attractiveness of the forest for recreationists and enhances biodiversity.*

"Forest structures" reflects the visibility of patterns concerning different stages of the forest's development (age, height, diameter). The alternatives provided were 'no pattern visible' (permanent forest), 'patterns partially visible', and 'patterns clearly visible' (cutting forest).

- *Multi-layered forests are denser. The access and attractiveness for recreationists might be restricted due to undergrowth and shorter viewing distances.*
- *There might be a positive impact on some people (*e.g. *those who prefer 'naturalness') and a negative impact on others (*e.g. *those who like to move around freely in the forest)*
- *Forests rich in structures are regarded as biodiversity promoting.*

"Wood utilization" concerns the visibility of harvesting activities, which in our study comprise interventions that are 'largely', 'occasionally' or 'not at all visible'.

- *The more visible wood utilization is, the more negative they are perceived by the population.*

"Area with additional measures" describes the additional space (from 5% to 20%) to be dedicated and prepared for habitat or recreational measures (biotope trees and dead wood, recreational sites and facilities).

- *Additional recreation sites and facilities are welcomed by recreationists, but might also have negative effects by attracting many additional visitors.*
- *The creation of additional habitats and small structures has a positive impact on biodiversity.*
- *Additional habitat trees and deadwood provide spots of interest for recreationists and increase the forest's attractiveness, but might also be regarded as negative ("untidy forest").*

"Monetary contribution" is the annual amount to be paid by the households or received per hectare by the forest enterprises participating in the programs (between 10 and 125 USD annually).

- *The payment has a negative impact on the household's utility because it reduces its budget and cannot be spent on other goods and services.*
- *The payment increases the forest enterprises' revenues and, thus, has a positive impact on its economic situation.*

For a better understanding, the attribute levels were visualized by pictograms. To familiarize the respondents with the attributes, we asked them in the first part of the questionnaire to describe the forest they usually visit based on the pictograms for the respective attributes. Fig. 3 shows and example of a choice set.

The design of the labeled choice experiment is a 'Full profile CBC Design' generated by the Sawtooth Software (Lighthouse Studio 9.5.3). It is based on the balanced overlap specification comprising 300 versions with twelve choice sets each. Each respondent was randomly assigned to a version. Each choice set consisted of three options: program orientation 'habitat', program orientation 'recreation', and a none-option. The latter could be chosen as an opt-out alternative in case the respondent did prefer neither of the proposed programs. For all answers, the respondents were asked to think of and refer to the forest they usually visit. Consequently, the none-option means to keep the status quo of that particular forest.

To test our hypotheses we applied a multinomial logit model (MNL), which is commonly used for analyzing discrete choice experiments and implemented in several statistical packages (Street and Burgess, 2012; Matejka and McKay, 2015). We estimated the MNL model both in the preference and the WTP/WTA space to determine the preferences as well as the households' willingness to pay and the foresters' willingness to accept for different forest management programs. We used the Apollo package in R for all our estimations (Hess and Palma, 2019b, 2019a).

3. Results

3.1. Descriptive statistics

3.1.1. Foresters

Most of the 48 foresters who completed the questionnaire are responsible for forests in the mountainous zones (Pre-Alps: 28% and Alps: 49%), while approx. 10% are from the Jura and Plateau, respectively. About 50% of the participants manage public forests with an area between 200 and 1000 ha, another 25% an area of more than 1000 to 2000 ha. About 60% of the foresters exclusively manage the forests of their own enterprise, while the rest additionally takes care of private forests in the area. The average size of private forests is smaller than the size of public ones with one-third below 250 ha and about one-quarter between 250 ha and 500 ha. About one-third of the forest enterprises is profit-oriented, while more than half aim at covering their costs, and about 10% do not have a specific economic goal.

With respect to tree species, coniferous forests clearly dominate, which reflects the dominance of responses from the mountainous zones. Concerning forest structure, a mixture of cutting and permanent forest prevails. The predominant characteristic of wood utilization is partial visibility through harvesting in groups, carried out by the forest enterprise itself or with the help of entrepreneurs.

About half of the foresters indicated that their forests are frequently visited by people looking for recreation all year round. Several foresters reported that they markedly (10%) or slightly (30%) increased the rotation period to enhance recreational and habitat services, while 60% did not change the harvesting cycle for this purpose. With respect to the costs of providing recreational services, financing through timber revenues and by the owners themselves (often municipalities) prevail.

In contrast, habitat services and protection against natural hazards are largely financed by subsidies, compensations and grants. Many enterprises implement measures to enhance ecosystem services beyond legal requirements - largely voluntarily, but partly also by request of the forest owners.

3.1.2. Population

To get information on the usually visited forests, the participants were asked several questions about the composition, structure, etc. of these forests. According to the perceptions of the participants, these forests are often mixed (with an equal share of coniferous and deciduous trees) and have structures similar to permanent forests. Timber harvesting is often clearly or partially visible.

About half of the participants visit the forest at least once a week, and getting there does not take them more than 20 min on average. Concerning the time people stay in the forest, there is a big difference between summer and winter time. In summer, the majority spends between 30 min and 2 h, whereas in winter a maximum of 1 h. The most favored activities are 'walking', 'just being' and 'observing nature'.

The respondents use a variety of sources to inform themselves about the forest, with the most frequently mentioned being the internet (27%), television (17%) and colleagues, family and friends (19%). About 40% of the participants feel to be 'well' or 'rather well' informed. Overall, the respondents agree that the Swiss forest area is 'just right' or 'should expand further' (together about 90%). In addition, only a minority of about 20% thinks that timber harvesting is 'too high' (3%) or 'rather too high' (17%).

3.1.3. Foresters' and populations' opinion on forest ecosystem services

We asked foresters and the population to give their opinion about different statements related to forest management and ecosystem services (Fig. 4). The comparison shows that there is a number of statements, on which foresters and the wider population have a similar opinion. This holds particularly for the broad agreement of both groups that the tasks of forest management should include preserving habitats, promoting biodiversity, providing drinking water, enabling recreation, and storing carbon. At the same time, it is jointly recognized that forestry also implies using wood.

However, when asked to rank specific ES according to their importance, foresters and the population show partially dissenting opinions (Fig. 5).

For foresters, the most important services are wood production and the protection from natural hazards, which also reflect the main forest ES according to the specification of the National Forest Inventory (NFI). For the population, habitat services are ranked first, whereas wood production is the least important service.

In addition, different opinions prevail with respect to the degree management decisions account for specific ecosystem services. While about half of the population thinks that ecological and recreational aspects receive too little attention, only about 20% of the foresters agree with this statement (Fig. 4). A further mismatch exists related to including different interest groups in forest management decisions. While a majority of about 70% of the population would 'completely' or 'rather' agree with this statement, only about 40% of the foresters support it. This reflects on the one hand that demand of forest ES is getting increasingly important and the population wants to be involved in forest management decisions. On the other hand, many foresters seemingly prefer to take decisions based on their own expertise and experience without consulting the broader population.

3.2. Choice experiment results

3.2.1. Analysis of the overall samples

3.2.1.1. Foresters. The participating foresters have a clear preference for coniferous trees, while deciduous tree species are significantly less favored compared to the other levels. Concerning the forest structure, they prefer a permanent forest, where patterns are only partially visible. Large-scale harvesting interventions should be avoided, so that wood utilization is only occasionally visible. With respect to the area with additional measures for habitat and recreational services, there is a significant preference against a 20% extension and a (non-significant) tendency against a 10% increase. Annual payments have a significant positive influence on the foresters' decision. Compared to the status quo (none-option), both program orientations have a significant negative impact on the foresters' utility.

3.2.1.2. Population. The overall population (Table 4, column (1)) has a significant preference for mixed forests combining deciduous and coniferous tree species. This is in contrast to the foresters' preferences, and might be explained by the high response rate of foresters from mountainous forests, where coniferous trees prevail due to natural conditions. In line with the foresters' preferences, the population is in favor of a permanent forest with partially visible patterns, but would

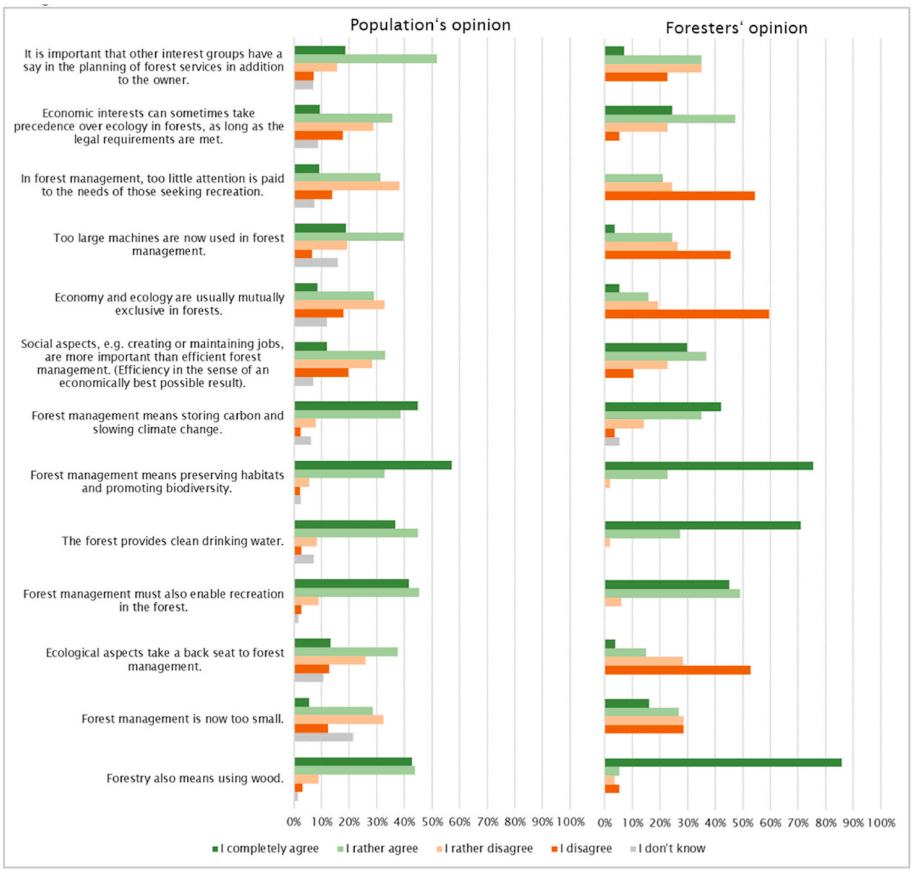

Fig. 4. Comparison of the population's and the foresters' agreement with specific statements.

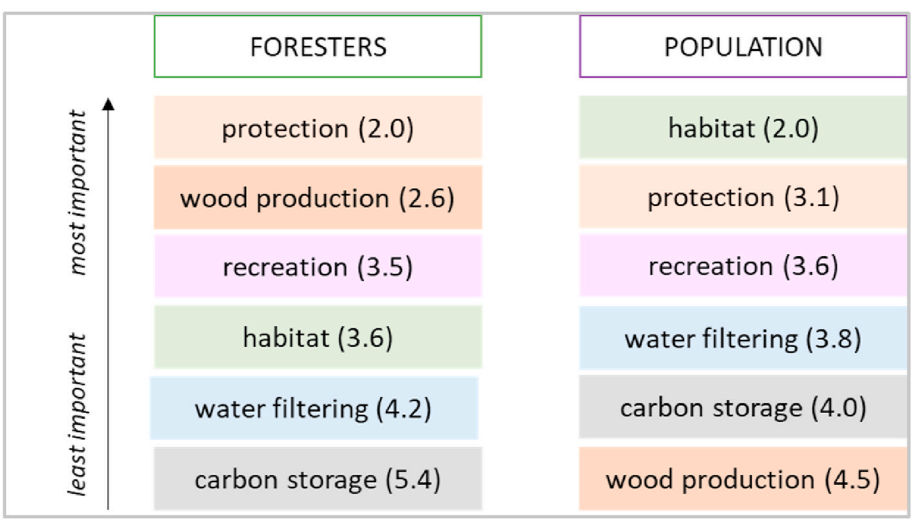

Fig. 5. Foresters' and population's ranking of forest ecosystem services (average values in brackets: ranking from 1 (most important) to 6 (least important).

even prefer non-visibility. Concerning wood utilization, the wider population significantly prefers an invisible harvest, while accepting occasionally visible interventions (preferred by the foresters) as a second-best solution. With respect to the area with additional measures for habitat and recreational services, there is no significant preference for an extension of 10%, while tending against an extension by 20%.

3.2.2. *General findings concerning forest zones and settlement areas*

3.2.2.1. Forest zones. Given the topographic differences, we expected varying preferences of the population towards forest management in the respective regions. However, we found very similar results across all zones Table 4). In all forest zones, a mixed forest of deciduous and coniferous trees is significantly preferred, except in the Alps, where this preference is not significant. Further, throughout the zones, the population significantly prefers permanent forests without visible patterns.

Table 4
MNL estimates of households' preferences.

Attribute	Level	(1) Overall population	(2) Jura	(3) Plateau	(4) Pre-Alps	(5) Alps	(6) Cities	(7) Agglo-merations	(8) Rural areas
Program orientation	Habitat	0.417*** (0.044)	0.286*** (0.109)	0.434*** (0.057)	0.501*** (0.119)	0.425*** (0.146)	0.445*** (0.081)	0.515*** (0.078)	0.333*** (0.069)
	Recreation	0.422*** (0.044)	0.274** (0.108)	0.433*** (0.573)	0.573*** (0.119)	0.394*** (0.149)	0.385*** (0.082)	0.534*** (0.079)	0.372*** (0.070)
	Status quo	–	–	–	–	–	–	–	–
Tree specie	Deciduous trees	0.112*** (0.028)	0.069 (0.072)	0.139*** (0.036)	0.116 (0.076)	−0.001 (0.097)	0.145*** (0.052)	0.084* (0.051)	0.108*** (0.045)
	Coniferous trees	–	–	–	–	–	–	–	–
	Mixture of both	0.331*** (0.028)	0.452*** (0.071)	0.345*** (0.036)	0.282*** (0.077)	0.142 (0.094)	0.315*** (0.052)	0.312*** (0.049)	0.355*** (0.045)
Forest structures	No pattern visible	0.579*** (0.028)	0.491*** (0.072)	0.589*** (0.037)	0.602*** (0.077)	0.592*** (0.095)	0.518*** (0.052)	0.585*** (0.051)	0.618*** (0.045)
	Partially visible	0.346*** (0.028)	0.278*** (0.072)	0.363*** (0.037)	0.354*** (0.076)	0.346*** (0.096)	0.313*** (0.053)	0.350*** (0.051)	0.366*** (0.045)
	Clearly visible	–	–	–	–	–	–	–	–
Wood utilization	Not visible	0.531*** (0.029)	0.615*** (0.073)	0.559*** (0.037)	0.427*** (0.077)	0.328*** (0.096)	0.546*** (0.053)	0.522*** (0.051)	0.521*** (0.045)
	Occasionally visible	0.476*** (0.028)	0.549*** (0.074)	0.489*** (0.037)	0.382*** (0.076)	0.349*** (0.096)	0.475*** (0.053)	0.490*** (0.051)	0.462*** (0.045)
	Largely visible	–	–	–	–	–	–	–	–
Area with additional measures	Extended by 5%	–	–	–	–	–	–	–	–
	Extended by 10%	0.041 (0.028)	0.085 (0.069)	0.063* (0.036)	0.008 (0.075)	−0.032 (0.094)	0.112** (0.052)	0.019 (0.050)	0.007 (0.044)
	Extended by 20%	−0.039 (0.028)	−0.114 (0.071)	−0.002 0.036	−0.125* (0.076)	0.019 (0.095)	−0.058 (0.052)	0.019 (0.050)	−0.072 (0.044)
Annual payment per household		−0.010*** (0.0003)	−0.013*** (0.0008)	−0.010*** (0.0004)	−0.009*** (0.0008)	−0.009*** (0.001)	−0.011*** (0.0006)	−0.010*** (0.0005)	−0.010*** (0.0005)
Number of respondents		*1266*	*211*	*763*	*168*	*108*	*372*	*388*	*506*
Rho-square		*0.096*	*0.095*	*0.106*	*0.092*	*0.065*	*0.094*	*0.109*	*0.091*
Percentage chosen	*Habitat*	*39.09*	*35.94*	*39.8*	*41.07*	*37.42*	*37.43*	*40.61*	*39.15*
	Recreation	*39.37*	*37.88*	*39.91*	*38.74*	*38.89*	*40.17*	*39.95*	*38.32*
	Status quo	*21.54*	*26.18*	*20.29*	*20.19*	*23.69*	*22.4*	*19.44*	*22.53*

(Standard errors shown in brackets. *, **, *** indicate 10, 5, 1% significance level).

The same holds for wood utilization, where invisible harvesting interventions are preferred. With respect to the area with additional measures to enhance habitat and recreational services, no significant preferences could be detected, except for a 10% increase in the Plateau.

3.2.2.2. Settlement areas. We assumed that people living in different settlement areas would have different preferences for specific forest management characteristics. Our results only partly support this assumption. Actually, preferences are quite similar favoring mixed forests as well as the invisibility of forest patterns and harvesting interventions. The only substantial difference we found is that people in cities would significantly prefer an extension of the area with specific measures by 10%, while in agglomerations and rural areas no significant preferences could be detected related to this attribute.

Forest management close to cities might have a different focus compared to rural areas, as more people visit the forest and the pressure on forest owners to perform a 'visitor-friendly' forest management is accordingly high. On the other side, people living in cities are sometimes supposed to be less informed about forest issues and not so familiar with related topics. Consequently, due to a lower degree of awareness, they could have different preferences, as indicated for some attributes in our CE. However, according to the respondents' self-assessment, there seems to be no major difference in the feeling of being informed among the different settlement areas (Fig. 6).

Overall, our results show quite homogenous preferences across forest zones and settlement areas. This is in contrast with the expectation that people's preferences would differ depending on the spatial and societal particularities they face. Interestingly, also preferences for the program orientation did not vary substantially: People in all settlement areas and forest zones prefer both suggested programs compared to the none-option. This however is, in contrast to the foresters who showed a significant preference for the status quo.

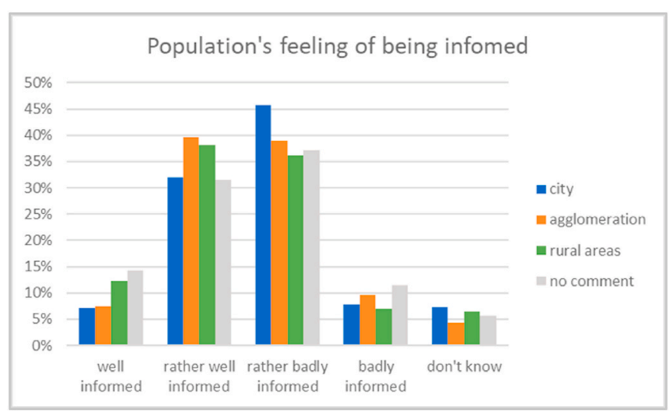

Fig. 6. The population's self-assessment of feeling informed.

3.2.3. Households' willingness to pay and foresters' willingness to accept

To obtain WTP/WTA estimates for the different forest management attributes across forest zones and settlement areas we also estimated the MNL model in the WTP/WTA space. The results in Table 5 reveal substantial differences among forest zones and settlement areas with respect to the calculated WTP measures.

3.2.3.1. Program orientation. The orientation of the program has a significant impact on the WTP compared to the status quo. Despite similar

Table 5
Willingness to pay for changes in forest management according to forest zones and settlement areas (USD per household and year. *, **, *** indicate 10, 5, 1% significance level). The models in the WTP/WTA space have the same fit as those in preference space, thus, kindly refer to the information provided in Tables 3 and 4.

Attribute	Level	Overall population	Jura	Plateau	Pre-Alps	Alps	Cities	Agglomerations	Rural areas
Program orientation	Habitat	40.17*** (3.95)	24.51*** (8.04)	41.84*** (5.14)	53.98*** (11.93)	49.87*** (16.03)	38.76*** (6.93)	51.38*** (7.32)	33.61*** (6.39)
	Recreation	40.64*** (3.98)	23.85*** (7.96)	41.80*** (5.19)	61.75*** (11.85)	46.44*** (16.34)	33.25*** (7.01)	53.33*** (7.36)	37.50*** (6.42)
	Status quo	-	-	-	-	–	-	-	-
Tree species	Deciduous trees	10.74*** (2.73)	4.94 (5.58)	13.38*** (3.53)	12.59 (8.17)	1.33 (11.44)	13.74*** (4.80)	8.39* (5.08)	10.14** (4.37)
	Coniferous trees	–	-	-	-	–	-	-	-
	Mixture of both	31.86*** (2.81)	34.51*** (5.73)	33.36*** (3.64)	30.35*** (8.52)	16.35 (11.18)	29.15*** (4.92)	31.09*** (5.17)	34.31*** (4.56)
Forest structures	No pattern visible	55.82*** (3.10)	37.54*** (5.87)	56.99*** (4.03)	64.50*** (9.57)	70.24*** (14.06)	47.53*** (5.27)	58.45*** (5.79)	60.10*** (5.09)
	Partially visible	33.29*** (2.87)	21.09*** (5.68)	35.10*** (3.74)	37.90*** (8.72)	41.19*** (12.33)	29.00*** (4.98)	34.94*** (5.36)	35.53*** (4.66)
	Clearly visible	–	-	-	-	-	-	-	-
Wood utilization	Not visible	51.13*** (3.05)	47.02*** (6.09)	54.24*** (3.99)	45.51*** (8.98)	39.16*** (12.09)	50.03*** (5.34)	52.09*** (5.73)	50.65*** (4.87)
	Occasionally visible	45.88*** (3.00)	41.82*** (6.13)	47.50*** (3.89)	40.79*** (8.77)	41.73*** (12.30)	43.66*** (5.22)	48.89*** (5.63)	44.78*** (4.82)
	Largely visible	–	-	-	-	-	-	-	-
Area with additional measres	Extended by 5%	–	-	-	-	–	-	-	–
	Extended by 10%	4.03 (2.69)	5.88 (5.43)	6.20* (3.49)	0.89 (8.09)	3.84 (11.17)	10.55** (4.71)	1.88 (5.02)	−0.54 (4.33)
	Extended by 20%	−3.74 (2.69)	−9.44* (5.50)	−0.07 (3.48)	−13.55* (8.16)	2.13 (11.24)	4.78 (4.71)	1.94 (5.01)	7.11 (4.34)

preferences indicated by the estimated attribute coefficients, there is a substantial variation of WTP among forest zones and settlement areas. While the average WTP of the overall population for both programs is about 40 USD, it ranges between about 25 USD in the Jura and approx. 62 USD in the Pre-Alps. Respondents in the Pre-Alps, agglomerations and rural areas have a significant higher WTP for recreational programs, while the opposite holds for the Alps and the cities. Jura and the Plateau have a similar WTP for both programs.

In general, the program orientation had a high impact on the population's decisions during the CE. This is in line with the statements provided in the debriefing section, where about 80% said that the program orientation was important or rather important for their decisions.

3.2.3.2. Tree species. Concerning the tree species composition of the forests people usually visit, WTP for switching from coniferous to purely deciduous forests is comparatively low and only significant in the Plateau zones. In contrast, for a switch from coniferous to mixed forests, there is a significant WTP for all forest zones with the highest annual amount of about 35 USD in the Jura. In the Pre-Alps the WTP for such a change is about 15% lower and not even significant in the Alps. Supposedly, this is due to the different vegetation conditions in the Alps, of which the population is well aware. With respect to settlement areas, WTP for switching to mixed forests is highest in rural areas (about 34 USD) and approx. 15% and 10% lower in cities and agglomerations, respectively.

3.2.3.3. Forest structures. WTP for switching from clearly visible structures to permanent forest is -with 65-70 USD per year-highest in the Pre-Alps and Alps, while being about 20%–40% lower in the Plateau and Jura, respectively. This difference might be explained by the importance of the protection function of forests in mountainous regions, which can better be fulfilled by multi-layered forests (Motta and Haudemand, 2000). For a switch from clearly to partially visible patterns, WTP is significant in all forest zones and settlement areas, too. WTP for this change reaches about 60% compared to a switch to invisible structures. The highest WTP for partial/total invisibility among settlement areas can be found in the rural areas (35/60 USD) and agglomeration (35/58 USD), whereas respondents from cities would only pay about 20% less (29/47 USD).

3.2.3.4. Wood utilization. Among the forest zones, WTP for switching from largely visible to occasionally visible harvesting interventions is highest in the Plateau (about 48 USD), while reaching slightly above 40 USD in the Jura, Pre-Alps and Alps. For a further switch to non-visible interventions the population would only be willing to pay about 5–7 USD more, which reflects the decreasing marginal utility of such an additional management effort. In the Alps, such a change would even lead to a lower WTP, reflecting a disutility for the population. Respondents from the different settlement areas have a similar WTP between 43 and 49 USD for occasional visibility and additional 5 USD on average for non-visibility.

In all zones, people tend to favor forests that have a mix of species and structures without largely visible harvesting interventions. There is no zone with an exceptionally high or low WTP. In general, a scenario of a forest with trees of different species and mixed ages, as well as invisible wood utilization generates the highest WTP. Interestingly, we were able to detect a decreasing marginal utility when stepwise increasing the attribute levels. Taking wood utilization as an example, the WTP for the step from the basic level 'largely visible' to the intermediate one 'occasionally visible' is usually larger than the further step 'invisible' wood

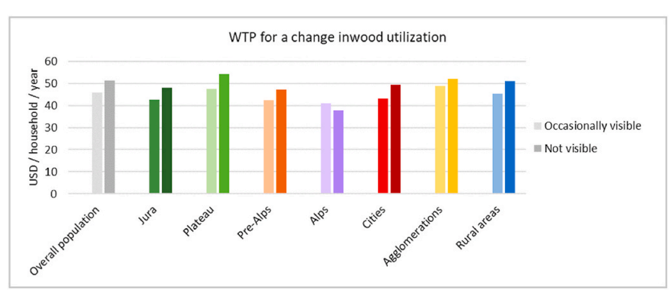

Fig. 7. Example for the WTP for a change in "wood utilization" (based on Table 5), light color refers to "occasionally visible", dark color to "not visible". (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

harvest (compare Fig. 7). An exception in this example are the Alps, where there is a smaller WTP for an invisible wood harvest compared to occasional visibility. An explanation for this finding could be that the population in this mountainous forest zone is aware of the fact that due to the topography and growing conditions an invisible wood harvest is hardly possible. In consequence, the WTP for reducing the visibility of harvesting interventions is comparatively low in the Alps, as well as in the other mountainous zones Pre-Alps and Jura.

3.2.3.5. Area with additional measures. In most cases, the WTP for dedicating more forest area to habitat or recreational services is not significant. Only respondents in the Plateau and in cities have a significant WTP of about 6 and 11 USD, respectively, for increasing this area by 10%. For an extension by 20%, WTP is even significantly negative in the Jura and Pre-Alps.

The foresters' diverse preferences are reflected by their willingness to accept management changes with respect to the different attributes (Table 6). A monetary incentive would be required for (i) participating in a specific program with a habitat or recreational orientation, (ii) switching from coniferous to deciduous trees or a mixture of both, and (iii) extending the forest area with additional measures. In contrast, switching from clearly visible to partially or not visible forest structures, as well as reducing the visibility of harvesting interventions seems to be in the self-interest of the foresters or forest owner, reflected by a negative WTA (i.e. a willingness to pay) for such measures (though not significant for the extreme case of invisibility).

Based on the estimated WTP and WTA we are able to compare specific management measures to enhance habitat or recreational services. Table 7 shows an exemplary WTP/WTA comparison for different scenarios.

Note that negative WTP values mean that households would not be willing to pay for such a change but would have to be compensated for accepting it. On the other hand, negative WTA values of foresters indicate that they would realize this change even without extra payments, for example because it would be in line with their preferences or enterprise goals, respectively. As a consequence, we can distinguish management changes resulting in (i) positive WTP and WTA (e.g., from T1 to T2), (ii) positive WTP and negative WTA (e.g., W3 to W2), (iii) negative WTP and positive WTA (e.g., S1 to S3), and (iv) negative WTP and WTA (e.g., T3 to T1). Table 8 shows and describes these combinations.

A further application of our results consists in comparing WTP and WTA for a broader management program consisting of several measures. Table 9 shows an example based on the WTP/WTA estimates shown in Table 7. Note that WTP and WTA show different units used for standardization. The population's WTP is estimated per household and year,

Table 6
Foresters' willingness to accept (WTA) changes in forest management.

Attribute	Level	Foresters' WTA
Program orientation	Habitat	78.61*** (19.28)
	Recreation	70.69*** (19.15)
	Status quo	–
Tree species	Deciduous trees	42,46*** (15.29)
	Coniferous trees	–
	Mixture of both	13.05 (13.83)
Forest structures	No pattern visible	−25.79* (14.58)
	Partially visible	−30.27** (14.71)
	Clearly visible	–
Wood utilization	Not visible	−2.94 (14.66)
	Occasionally visible	−54.90*** (15.84)
	Largely visible	–
Area with additional measures	Extended by 5%	–
	Extended by 10%	13.92 (13.83)
	Extended by 20%	40.02*** (15.08)

(USD per hectare and year. Standard errors given in brackets. *, **, *** indicate 10, 5, 1% significance level).

whereas the foresters' annual WTA is calculated per hectare and year. Consequently, both estimates have to be made comparable, e.g., based on data for a specific municipality. Taking the example in Table 9 and assuming a municipality of 900 households with a forest area of 1000 ha, our calculation would result in an annual willingness to pay of the inhabitants of about 123,000 USD, which would be sufficient to cover the foresters' WTA of changing the forest management from the status quo to the new management goal. Alternatively, considering the average size of publicly owned forests of 240 ha would result in costs of about 30,000 USD, which may be covered by the contribution of about 220 households. In case that no information on the foresters' or forest owners' preferences is available, the households' WTP estimates could also be compared with the actual costs generated by the different management options or programs.

The above calculation is based on the results of our overall Swiss household sample, including the not significant values for 'area with additional measures'. Excluding these values would slightly change the WTP estimate to about 133 USD per household and the WTA to approx. 110 USD per hectare. Provided that significant results are available for the respective subsamples, the approach could also be applied to the forest zones and settlement areas. A comparison of the respective results shows that the annual WTP for the same management program differs substantially among forest zones, varying between about 107 USD in Jura and 162 USD in the Pre-Alps (Table 10). Concerning settlement areas, respondents in agglomerations have the highest WTP (148 USD) followed by those living in rural areas (137 USD), while WTP is lowest in cities with about 127 USD. Note that in case the current state of forest management in a specific (local) area is known, the population's WTP for a deviation from this practice could be determined, too.

4. Discussion and conclusions

In light of the diverse natural conditions and heterogeneous preferences of the population, we analyzed in how far supply of and demand for forest ecosystem services can be matched. For this purpose, we determined the preferences of foresters and the wider population, and analyzed differences with respect to forest zones and settlement areas. Finally, we determined the changes in willingness to pay and willingness to accept in forest management programs. In the following, we discuss our approach and results with respect to several aspects.

4.1. Comparison with results of other studies

Comparing our results with other studies shows that our WTP estimates are within a similar range, although at the lower end of the largely scattered values of recreational and habitat services (Elsasser and Meyerhoff, 2007b; Elsasser, 2016; Müller et al., 2019). In a recently compiled data base with more than 20 studies on biodiversity conservation most WTP estimates range between 100 and 800 USD per year (Müller et al., 2019). While many of these studies applied similar stated preference techniques, such as Contingent Valuation or Choice Experiments, results vary from 6 USD/person/year (Elsasser and Meyerhoff, 2007a) to over 1700 USD/visitor/year (Ott and Baur, 2005). This spread demonstrates that results of WTP studies are highly context and method dependent, which exacerbates the comparison with and transfer to other study sites.

4.2. Labeled versus unlabeled CE

The decision to conduct a labeled or unlabeled experiment can have impact on the results. Which design to choose, strongly depends on the aim of the study. Results from other research fields (e.g. health economics) show that if a CE is aimed at investigating trade-offs between attributes, the alternatives should preferably not be labeled. If, on the other hand, real life choices should be explained, labeled CE are more suitable (Bekker-Grob et al., 2010). Blamey et al. (2000) argue that

Table 7
Households' willingness to pay and foresters' willingness to accept changes in forest management.

Attribute	From status quo		To new goal		Households' WTP	Foresters' WTA
Program orientation	P0	No program	P1	Recreation	**40.17**	**70.69**
			P2	Habitat	**40.64**	**78.61**
Tree species	T1	Coniferous trees	T2	Deciduous	**10.74**	**42.46**
			T3	Mixture	**31.86**	13.05
	T2	Deciduous trees	T1	Coniferous	**(-10.74)**	**(-42.46)**
			T3	Mixture	**21.12**	(-29.41)
	T3	Mixture	T1	Coniferous	**(-31.86)**	**(-13.05)**
			T2	Deciduous	**(-21.12)**	29.41
Forest structures	S1	No pattern visible	S2	Partially visible	**(-22.53)**	**(-4.48)**
			S3	Clearly visible	**(-55.82)**	**25.79**
	S2	Patterns partially visible	S1	Not visible	**22.53**	**4.48**
			S3	Clearly visible	**(-33.29)**	**30.27**
	S3	Patterns clearly visible	S1	Not visible	**55.82**	**(-25.79)**
			S2	Partially visible	**33.29**	**(-30.27)**
Wood utilization	W1	Not visible	W2	Occasionally	**(-5.25)**	**(-51.96)**
			W3	Largely	**(-51.13)**	**2.94**
	W2	Occasionally visible	W1	Not visible	**5.25**	51.96
			W3	Largely	**(-45.88)**	**54.90**
	W3	Largely visible	W1	Not visible	**51.13**	(-2.94)
			W2	Occasionally	**45.88**	**(-54.90)**
Area with additional measures	A1	+5%	A2	+10%	4.03	13.92
			A3	+20%	3.74	**40.02**
	A2	+10%	A1	+5%	(-4.03)	(-13.92)
			A3	+20%	(-7.77)	**(-26.10)**
	A3	+20%	A1	+5%	(-3.74)	(-40.02)
			A2	+10%	7.77	**(-26.10)**

(WTP=USD per household and year, WTA=USD per hectare and year; negative signs reflect households' WTA and foresters' WTP, respectively; significant values in bold).

Table 8
Combinations of positive and negative WTP and WTA.

Households' WTP	Foresters' WTA	Description
+	+	Households are willing to pay for a change and foresters would need a compensation
–	+	Households and foresters would need a compensation
+	–	Households are willing to pay for a change, but foresters would not need a compensation
–	–	Households would need a compensation but foresters not

labeled CE better reflect the emotional context, a fact that should not be neglected in valuing recreational and habitat services, which can be supposed to have such an emotional component. Further, labelling might reduce the cognitive burden of the respondents and enable them to better embed their decisions in the specific context (Olschewski, 2013).

4.3. *Using a MNL model to analyze CE data*

The multinomial logit model implies that the random component ε is independently and identically 'extreme value' distributed. Further, the respondents' choices are assumed to be independent from irrelevant

Table 9
Comparison of households' WTP and foresters' WTA of an exemplified forest management program (overall sample, significant values in bold).

Attribute/label	From status quo		To new goal		Households' WTP USD/year	Forester's WTA USD/ha/year
Program	P0	No program	P1	Recreation	**40.17**	**70.69**
Tree species	T1	Coniferous trees	T2	Mixture	**31.86**	**13.05**
Forest structures	S3	Clearly visible	S1	No pattern visible	**55.82**	**(-25.79)**
Wood utilization	W2	Occasionally visible	W1	Invisible	**5.29**	**51.96**
Area with additional measures	A1	+5%	A2	+10%	3.99	13.92
					137.13 per household	**123.83 per hectare**

Table 10
WTP (per household and year) for an exemplified forest program in different forest zones and settlement areas (significant values in bold).

Attribute	From status quo		To new goal		Jura	Plateau	Pre-Alps	Alps	Cities	Agglomerations	Rural areas
Program	P0	No program	P1	Recreation	**23.85**	**41.80**	**61.75**	**46.44**	**33.25**	**53.33**	**37.50**
Tree species	T1	Coniferous trees	T3	Mixture of both	**34.51**	**33.36**	**30.35**	16.35	**29.15**	**31.09**	**34.31**
Forest structures	S3	Clearly visible	S1	No pattern visible	**37.54**	**56.99**	**64.50**	**70.24**	**47.53**	**58.45**	**60.10**
Wood utilization	W2	Occasionally visible	W1	Invisible	**5.20**	**6.74**	**4.72**	**−2.57**	**6.37**	**3.20**	**5.87**
Area with additional measures	A1	+5%	A2	+10%	5.88	**6.20**	0.89	3.84	**10.55**	1.88	−0.54
					106.98	**145.09**	**162.21**	**134.30**	**126.85**	**147.95**	**137.24**

alternatives (IIA) (Hensher et al., 2005). Given that it is hardly ever possible to identify all types of correlations among the provided alternatives, it cannot be presupposed a priori that the IIA assumption is fulfilled (Olschewski et al., 2019). This, however, is particularly an issue when deriving general forecasts or predicting shifts in market shares. In our study, we focus on eliciting preferences and deriving WTP/WTP measures, while abstaining from making any forecast. Notwithstanding, to ensure that IIA does not lead to biased results we additionally estimated a nested logit model. This allows us to control for the fact that alternative 1 and alternative 2 may be close substitutes, which eventually may lead to a violation of the IIA assumption (Hess and Daly, 2014). The results show that the magnitude of the estimates is very similar to those of the MNL model presented in Table 4. The nesting parameter 'Lambda_alternatives' close to '1' indicates that there is only a weak correlation between the error terms of alternative 1 and alternative 2. Consequently, a potential violation of the IIA assumption can be discarded. The same procedure has been applied to the foresters' data. Here, the small sample size clearly affects the robustness of our estimates. While the results for the preference space differ in magnitude, they tell a similar story. The same applies for the WTP estimates. For further details please check the supplementary information.

4.4. Impact on decision-making in forest management: matching supply and demand

Our study took advantage of simultaneously collecting data from different forest zones and settlement areas to detect respective differences within the same experimental setting. Furthermore, as foresters as well as the wider population participated, we were able to compare WTP and WTA estimates, thereby eliciting options for matching supply and demand of management alternatives. Our results and the determined WTP differences between forest zones and settlement areas show that it is feasible and useful to consider the demand side, in our case the local population, when taking forest management decisions, especially in the context of emerging bottom-up approaches as for example detected by Olschewski et al. (2018). Our analysis shows that different combinations of WTP and WTA are possible (compare Table 8), leading to different management recommendations. In case that WTP and WTA are both positive, they have to be compared to check whether WTP is sufficiently high to cover the additional costs of a management change. If WTP is negative and WTA positive, a management change is economically not feasible. If WTP is positive and WTA negative, a management change is in line with population's preferences and would be realized even without extra financing. Finally, if WTP and WTA are both negative, a management change would be against population's preferences but could be realized even without extra financing. In any case, due to the fact that WTP and WTA are related to different units (USD/household and per hectare, respectively), they can only be compared in a specific context, where the number of households and the relevant forest area are known. Given these prerequisites, our approach provides the opportunity to assess the feasibility of different management scenarios at the local and regional level. In cases where an additional financing is required, flexible payment schemes can be applied (Lienhoop and Brouwer, 2015). They could be tailored to the population's preferences and silvicultural needs (Villamayor-Tomas et al., 2019) with the aim to ensure an effective and efficient forest management.

4.5. Outlook: significance of the results for future management

Summing up, it becomes clear that the population prefers forests, which are neither dominated by coniferous nor by deciduous trees but show a balanced mixture of both. Furthermore, there is significant preference for permanent forests instead of single-age-cohort management. Besides that, bigger forest clearings should be avoided, even if they would be part of a natural forest development. Notwithstanding these similarities, WTP varies substantially among forest zones and settlement areas, respectively.

Given the recently observable change from a predominantly governmental top-down approach to diverse bottom-up initiatives, including efforts of the local population to participate in forest management decisions (Thees and Olschewski, 2017), a better matching of the population's preferences with feasible forest management option is necessary. Our WTP and WTA estimates give an indication, in how far residents are disposed to finance specific management alternatives. However, given that the foresters' sample was comparatively small and biased towards mountainous regions, the results should be interpreted with care. Practice-relevant advice should be based on a broader data and response base, especially on the supply side of ES.

In a next step, these results could be integrated into optimization processes for different management options. Such optimization could build on methods demonstrated by Uhde et al. (2017) for a forest or by Knoke et al. (2020) for a land-use example Our approach provides the methodology and information required for the described matching and optimization procedures.

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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.

CRediT authorship contribution statement

Alexandra Müller: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Software, Visualization, Writing - original draft, Writing - review & editing. **Roland Olschewski:** Conceptualization, Data curation, Formal analysis, Methodology, Software, Supervision, Validation, Visualization, Writing - original draft, Writing - review & editing. **Christian Unterberger:** Formal analysis, Methodology, Software, Visualization, Writing - original draft, Writing - review & editing. **Thomas Knoke:** Conceptualization, Supervision, Writing - original draft, Writing - review & editing.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jenvman.2020.111008.

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