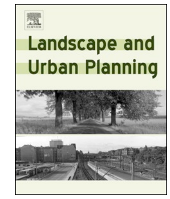
Landscape and Urban Planning 206 (2021) 103954

Contents lists available at ScienceDirect

Landscape and Urban Planning

journal homepage: www.elsevier.com/locate/landurbplan



What determines preferences for semi-natural habitats in agrarian landscapes? A choice-modelling approach across two countries using attributes characterising vegetation

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1. Introduction

The second pillar of the EU-Common Agricultural Policy (CAP) introduced agri-environmental schemes to support the development of rural areas and to protect biodiversity and ecosystem functions (EU, 2013; 2014). Since 2015, greening measures, including the implementation of ecological focus areas (EFAs), have been introduced as a precondition for farmers to obtain direct payments as part of the cross-compliance system. EFAs encompass a series of specifically defined types of green infrastructures and semi-natural habitats (SNH). According to Holland et al. (2017), within CAP SNH are defined as “any habitat within or outside of the crop containing a community of non-crop plant species” (Holland et al., 2017). Grassy and woody SNH in our study comprise hedgerows and low-input grassland.

Studies in Europe including Switzerland showed the different agri-environmental measures have a positive influence on biodiversity though considerable variation in the botanical quality of semi-natural grassland is recorded (Batáry et al., 2010; Ó hUallacháin, Finn, Keogh, Fritch, & Sheridan, 2016). While there is some knowledge about the impact of SNH on biodiversity, less is known about the effectiveness of such measures in promoting multiple ecosystem services. Indeed, existing studies focus on the importance of SNH, predominantly grassy and woody elements, for providing regulating ecosystem services such as pollination and pest control (Gurr, Wratten, Landis, & You, 2017; Holland et al., 2016, 2017). Yet there is growing interest in investigating, mapping and quantifying other services in agrarian landscapes (Felipe-Lucia & Comín, 2015; van Zanten, Verburg, Koetse, & van Beukering, 2014). Cultural services like recreational, aesthetic and spiritual benefits were already highlighted in the Millennium Ecosystem Assessment in 2005 (MEA, 2005).

Regarding the aesthetic preferences for typical SNH elements in the landscape only a few studies exist. In the United States, research based on a photo survey showed that landscape scenarios with grassy and woody buffer strips are preferred to landscape scenarios without such elements (Klein et al., 2015; Sullivan, Anderson, & Lovell, 2004). Two experimental studies in Germany and Switzerland, similarly, reveal respondents’ preferences for species rich, flowering and colourful meadows (Lindemann-Matthies & Bose, 2007; Lindemann-Matthies, Junge, & Matthies, 2010).

The existing studies about the public’s preferences for SNH suggest people show a preference for characteristics like a tidy, dense and green vegetation and landscapes with flowers and various colours (Junge, Schüpbach, Walter, Schmid, & Lindemann-Matthies, 2015). However, the definition of these characteristics remains unclear. Besides local conditions and management, seasons turned out to have an important impact on the visual aspect of the agrarian landscape (Stobbelaar, Hendriks, & Stortelder, 2004).

In this paper, we analysed the complex relationship between characteristics of vegetation as e.g. flowers, type and structure on the one hand and preferences of people for the visual quality of these characteristics on the other hand. Using choice experiments, we pursued the overarching aim to better understand the reasons for people’s preferences for landscapes containing elements like certain typical crops as well as grassy and woody SNH. We do this by taking into account, in addition to the landscape elements like crops as well as grassy and woody SNH, their underlying characteristics that might even vary in the course of the seasons. We think that this study is an important contribution to better understand why respondents like the visual aspect of combinations of crops with grassy and woody SNH. Knowledge about this may help policy makers or practitioners to increase the aesthetic value of the agricultural landscape for the population in the future.

Compared to studies based on multivariate models using preference rating of landscape pictures, choice experiment models have three advantages: first, they force the evaluators (i.e. respondents of a survey) to

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https://doi.org/10.1016/j.landurbplan.2020.103954
Received 14 November 2019; Received in revised form 7 September 2020; Accepted 9 September 2020

make trade-offs, by requiring them to choose the preferred landscape from a given set of pictures. Second, they provide a framework for a rigorous quantitative analysis of the factors determining the observed choices. Third, they allow considering preference heterogeneity between people evaluating the aesthetic aspects of the landscape pictures. Choice experiments are often used for an assessment of the economic value of ecosystem services (Bernues, Rodriguez-Ortega, Ripoll-Bosch, & Alfnes, 2014; Campbell, 2006; Graves, Pearson, & Turner, 2017; Rewitzer, Huber, Grêt-Regamey, & Barkmann, 2017; van Berkel & Verburg, 2014). In these studies, money is typically used as a measuring rod for preferences.

In our study, however, we aim at finding out which characteristics of pictures best explain why a picture is considered aesthetic. Respondents should make trade-offs between landscape elements only whereas we opted deliberately for not including cost as an element for trade-off. Including cost would require constructing a credible payment scheme for SNH which is typically problematic and adds considerable sources of bias in respondent behaviour. We therefore applied a similar approach as Graves et al. (2017), in that we presented respondents pictures to choose from and used visual attributes as explanatory variables for the observed choices. Respondents were not given verbal explanations of attributes, i.e. they made their choices based only on the visual aspects of the pictures and, ideally, implicitly on the attributes. With this approach, we aimed for an unbiased evaluation by participants while also being able to include the attributes qualifying the vegetation in a choice model.

Applying these models, we aim at answering the following questions:

1. Are respondents' choices based on the SNH themselves or rather on their underlying characteristics?
2. How do seasons influence the vegetation's characteristics of a restricted number of crop and grassy or woody SNH combinations and how does this impact preference statements in choice experiments?

Our research was part of the EU FP7 QuESSA project. The QuESSA project evaluated ecosystem services, i.e. pollination, biological pest control and soil conservation provided by semi-natural habitats in eight European countries (Holland et al., 2014). Covering the United Kingdom, France, Germany, Italy, Hungary, Estonia, the Netherlands and Switzerland, the project comprises a big range of climatic, geological and pedological settings as well as different social conditions. However, embedding our study in the research project QuESSA meant that our choice experiment was restricted to the combinations of a limited number of crops as well as grassy and woody SNH. For this study, we focus on the two countries Hungary and Switzerland.

2. Material and methods

2.1. Choice modelling and landscape aesthetics

Choice experiments (CE) are used widely in marketing (James, Rickard, & Rossman, 2009; Vecchiato & Tempesta, 2015), transport (Masiero & Hensher, 2010; Willigers & van Wee, 2011) and environmental economics (Bernues et al., 2014; Campbell, Scarpa, & Hutchinson, 2008) to analyse preferences for alternatives, based on estimated monetary values of the different characteristics of a good or service. There are also numerous studies using CE to assess different options of landscape management or landscape preference in a broad sense (Arnberger & Eder, 2011; Graves et al., 2017; Rewitzer et al., 2017; van Berkel & Verburg, 2014).

Choice experiments are firmly rooted in consumer theory (Lancaster, 1966) and make use of the random utility model (McFadden, 1974) as analytical framework. The basic idea behind CE is that from a set of various alternatives, rational individuals choose the alternative whose specific combination of characteristic attributes provide them with the greatest utility. By varying the set of attributes of the available alternatives across a series of choice occasions and recording responses, the relative strength of preferences for the different attributes can be assessed. The random utility model assumes that from the perspective of a researcher utility is composed of a systematic part, which is observable, and a random part, which is not observable. This can be described as follows:

$$U_{ni} = V_{ni} + \varepsilon_{ni} \tag{1}$$

where U_{ni} represents the utility of alternative i for the individual n, V_{ni} the observable component of utility that the individual n associates with alternative i and ε_{ni} denotes the error term of the model and, therefore, the unobservable or random part. The observable part V_{ni} can further be specified by

$$V_{ni} = x_{ni}^{'}\beta \tag{2}$$

where x_{ni} is the vector of the specific attribute levels of the alternative i and β is the respective parameter vector. Assuming that the error term follows a Type I Extreme Value distribution and that the individual indicates their most preferred alternative, the probability of this alternative being selected is

$$P_{ni} = \frac{\exp(x_{ni}^{'}\beta)}{\sum_{j=1}^{J}\exp(x_{nj}^{'}\beta)} \tag{3}$$

The main shortcoming of this multinomial logit (MNL) model is the assumption of a representative utility function for all individuals as expressed in the fact that only a sample average of the preference weights vector, beta, can be estimated. However, in reality one can expect preference heterogeneity, i.e. the β-vector differs among individuals. The mixed logit model (MLM) assumes the elements of β to follow a continuous distribution. Different distributional forms for the elements of the β-vector are possible, with the normal and lognormal distribution most commonly used (Train, 2009). Parameters to the MLM can be estimated using simulated maximum likelihood. As an alternative, the latent class model (LCM), a special variant of mixed logit, assumes a discrete distribution of the preference weights. As a result, the LCM produces a limited number of systematic clustering of individuals into classes with sufficiently similar β-vectors. In this case, the probability that individual n belonging to class q chooses alternative i in a given choice set t is specified by:

$$P_{ni}|(class = q) = \frac{\exp(x_{nit}^{'}\beta_q)}{\sum_{j=1}^{J} exp(x_{njt}^{'}\beta_q)} \tag{4}$$

Note that this probability is conditional on membership in class q. Class membership of individuals is probabilistic and determined within the model based on the choice observations. Using a standard Maximum Likelihood procedure, the parameters of both the class selection model as well as the choice probability model can be estimated (Pacifico & Yoo, 2013; Sarrias & Daziano, 2017).

The probability of class membership of an individual n is modelled similarly based on an individual's characteristics z_n and the class-conditional parameter vector γ_q.

$$H_{nq} = \frac{\exp(z_n'\gamma_q)}{\sum_{q=1}^{Q}\exp(z_n'\gamma_q)} \tag{5}$$

Joining the class membership probabilities with the choice model probabilities yields the aggregate log-likelihood function for individual n

$$S_n = \sum_{n=1}^{N}\ln\left\{\sum_{q=1}^{Q} H_{nq}\prod_{t=1}^{T}\prod_{j=1}^{J}\left[\frac{\exp(x'_{njt}\beta_q)}{\sum_{j=1}^{J}\exp(x'_{njt}\beta_q)}\right]^{\gamma_{njt}}\right\} \tag{6}$$

where Q is the number of classes, T is the number of choice sets an individual is presented and J is the number of choices within each choice set. γ_{njt} equals 1 if individual n chose the j-th alternative in the t-th choice set and 0 otherwise.

In this study, we chose to model our choice data using the latent class model for a number of reasons. While the MNL model rests on rather strict assumptions like the Independence of Irrelevant Alternatives (IIA) property and the inability to account for unobserved preference heterogeneity, this is not the case for the MLM and LCM. Further, the analysis showed that LCM had a better model fit as assessed by the criteria Bayesian Information Criterion (BIC) than any of the other model types (see appendix C1 for a comparison of model performance). In addition, among the two methods MLM and LCM, which both consider preference heterogeneity among individuals, the LCM appears to be more suitable for policy makers since such models deliver, as output, more or less homogeneous classes with similar preferences. This makes it easy for policy makers to assess which groups in society are in favour of a particular alternative.

In our analysis, we estimate the model shown in equation (6), which yields as results the respective classes q, the estimates of choice parameter vectors β_q for each class as well as the class sorting vectors γ_q.

2.2. The QuESSA project as the experimental framework

The QuESSA project evaluates pollination and predation services provided by hedgerows or woodlots (woody SNH) and grassy elements, such as low input meadows or pastures (grassy SNH) (Holland et al., 2014). In order to analyse the respective services, QuESSA experiments applied the following design:

(1) A core crop was combined with three different adjacent elements: (a) an adjacent crop, (b) a grassy or (c) a woody SNH. (2) The core crop in each country was fixed; in Hungary the core crop was sunflower, in Switzerland it was rapeseed. As an additional service, our study evaluated the effect of woody and grassy SNH on the visual landscape quality in order to include aesthetic values in overarching analyses about ecosystem services of SNHs. The need for visual preference values for experimental fields requires a picture-based survey among the QuESSA partner countries that visualise the examined combinations.

2.3. Data collection

2.3.1. Definition of attributes characterising the pictures

In order to better explain the preferences behind the *superordinate attributes* crop, grassy and woody, we used the existing literature (Junge et al., 2015; Lindemann-Matthies & Bose, 2007; Lindemann-Matthies et al., 2010) to determine *additional attributes* that describe these aspects. The attributes are related to vegetation density, vegetation structure and neatness, but also colour quality. These attributes were defined in parallel to the creation of the pictures, but they were not mentioned in the choice set. Respondents made their choices only on the basis of the pictures. To ensure that the assignment of additional attributes was as precise and as free from subjective assessment as possible, objective criteria were defined for all attributes, which were used to classify the attribute levels (see Table 1 and Supplementary material S3).

Thereafter, three of the authors and a student assistant applied the criteria to the pictures. The assessments of the four persons were compared and discussed until there was consensus on the classification for each attribute and each picture. Initially, a large number of attributes were considered (for an overview of all attributes and the respective criteria, see Supplementary material S1- S3.). In a next step, based only on the Swiss dataset, we analysed the correlation among the SNH as well as the full set of attributes to select the relevant attributes and reduce multicollinearity. To this end, a factor analysis using the varimax rotation procedure was conducted to determine those attributes that obtain the highest loadings on independent factors. This resulted in four central and uncorrelated attributes to be used in our analysis: (1) ordered structure in the depicted combination ('Ordered'); (2) the amount of bare soil, gravel or rocks in the depicted combination ('NoVeg'); (3) the amount of green vegetation in the picture ('Green'); (4) the availability of yellow, white, or purple features in the landscape, which usually originate from flowers ('ColAvail)', For all attributes except 'ColAvail' three levels (including 0) were defined (this was implemented by separating the respective attribute into two dummy variables). Together with the two superordinate attributes 'Grassy' and 'Woody' indicating the two SNH, these additional attributes were included in our models (see Section 2.4). In Table 1, all attributes with their respective levels are listed. The additional attributes together with the superordinate attributes formed the basis of the choice experiment.

2.3.2. Study material and photo editing

Following the design of QuESSA, all sites where pollination and predication experiments were conducted were photographed. In Hungary, the sites were located in eastern Hungary in the Jászság region. The landscape in this region is monotonously flat and dominated by crop production. The annual precipitation amounts to 570 mm (www.met.hu/eghajlat/magyarorszag_eghajlata/varosok_jellemzoi/Szolnok). The sites in Switzerland are located in the north-eastern part of Switzerland, in the Canton of Aargau (see maps (a), (b) and (c) in Appendix A). The landscape is characterised by rolling hills, a mixture of grassland and crops (Sutter, Albrecht, Jeanneret, & Diekötter, 2018). The annual precipitation amounts to 1000 mm (MeteoSchweiz, 2014).

Photos were taken on three (Switzerland), respectively four (Hungary) different occasions in 2014 in order to depict the relevant stages in the vegetation period of the included crops (see Tables 2 and 3). Photos were taken as to always show the same section of the landscape, with the same focal length and from the same side of the field in a defined angle. The position of the focal crop field in the picture was also determined. The pictures were provided by the project partner of the respective country.

In order to maximize variation, we selected two pictures for each combination and season. The attributes characterising the combination as defined in Section 3.2.1 (i.e. ordered structure, bare soil, green vegetation and colour) were used as criteria to select two samples of each combination in each season and country. Photo editing was used to standardise the pictures by transferring the same neutral but seasonally adapted background to all pictures. As a result, we created the following four pictures for both countries and for each available season:

Crop – crop (cc, control): A combination of the focal crop field (Hungary sunflower, Switzerland rapeseed) and an adjacent other crop field.

Crop – grassy (cg): A combination of the focal crop field and an adjacent grassy SNH.

Crop-woody (cw): A combination of the focal crop field and an adjacent woody SNH.

Crop-grassy-woody (cgw): This combination was not provided by the original QuESSA design. We therefore used the crop-grassy pictures described above and copied for each country a woody element which was identic for both replicats of each country but varied with season into the background of the already existing crop-grassy combinations. We created this combination to achieve an orthogonal factorial design (Montgomery, 2001) with respect to the two SNH types grassy and woody (an overview of all pictures is provided in Tables S1 and S2 in the supplementary material).

2.3.3. Questionnaire

The survey was developed by a group of scientists involved in the QuESSA project. The questionnaire was designed in English and compiled as an online questionnaire in UniPark (QuestBack, –1999, 2012) in order to enable pilot testing in a preliminary design by different researchers of the University of Landau (Germany) as well as by further researchers involved in the QuESSA project in other European countries. The aim of the pilot test was to receive feedback on the quality of

Table 1
Definition of the attributes characterising the combination.

Variable	Level	Description
Ordered	0	No clearly defined borders. Surfaces not homogeneous and no clear pattern like rows visible; Patchy, scrubby vegetation.
	1	One more or less clearly defined border, one surface either with a homogeneous structure or with a clear pattern like rows, or several homogeneous patches.
	2	Only clearly defined borders and all surfaces have a homogeneous structure or a clear pattern like rows.
NoVeg	0	All surfaces in the picture are covered with dense vegetation. Bare soil is not visible.
	1	Several spots of bare soil or one land-use type with sparse (dry) vegetation, or one field with bare soil in the background
	2	One land-use type is dominated by bare soil; only a few small plants.
Green	0	No green vegetation
	1	Some green vegetation; the occurrence of green vegetation does not stand out.
	2	Green surfaces clearly visible
ColAvail	0	No or only isolated colours like yellow, white or purple in the picture.
	1	Yellow, white or purple patches (e.g. sunflowers or flowering SNH) clearly visible. At least one colour
Woody SNH	0	Combination without woody element
	1	Combination with woody element
Grassy SNH	0	Combination without grassy element
	1	Combination with grassy element

Table 2
Seasonal stages of sunflower and grassy SNH represented in the different choice tasks in the questionnaire for Hungary.

	Season 1	Season 2	Season 3	Season 4
Date	April	May	July	September
Crop status	Freshly sown	Young plants	Flowering	Dry, brown Flowers and plants
SNH grassy status	Green, a few tufts of dry grass	Green, a few tufts of dry grass	One dominated by dry grass, the other green, with tufts of dry grass	One green, a few tufts of dry grass the other with a grass species of brown colour

the pictures, the length of the questionnaire, the clarity of the questions and the tasks. Once a satisfying version of the questionnaire was achieved, it was translated into Hungarian, German and French. The German and French versions were used in Switzerland. These versions were pilot tested again using a convenience sample of about 10 persons in the respective country to verify the quality of the translation.

A next version of the questionnaire was then pre-tested using 50 participants of a panel provided by Respondi ® (www.respondi.com). In Switzerland, this was done between June 1 and June 6, in Hungary between June 30 and July 13. The main aim of the pre-test was to see, if all quota were correctly set and if they were functioning as expected. Furthermore, some descriptive statistical analyses were performed to see whether the answers were plausible.

In accordance with the choice experiment approach described in Section 2.1, we presented choice cards with four pictures each, depicting a crop – crop, crop – grassy, crop – woody and a crop – grassy – woody combination from the same season (see an example for Hungary and Switzerland in Appendix B). As described in Section 2.3.2, each combination in each season (and country) was represented by two different pictures to reduce a potential bias due to picture selection. This resulted in two choice cards for each season and country. Participants from Hungary therefore evaluated eight choice cards, participants from Switzerland 6 choice cards.

From each choice card participants had to select the picture they liked best. Furthermore, we collected information on gender, age and education, and participants were asked how familiar they were with pictures of landscapes similar to the pictures in the choice cards.

Table 3
Seasonal stages of rapeseed and grassy SNH represented in the different choice tasks in the questionnaire for Switzerland.

	Season 1	Season 2	Season 3	Season4
Date	Mid-April	June	End of July	NA
Crop status	Flowering	Ripe	Harvested	NA
SNH grassy status	Brown, patchy with bare soil	Green with a few flowers	Green with flowers	NA

2.3.4. Data collection and respondents

Respondents for both countries were recruited from a panel of Respondi ® (www.respondi.com). In both countries the sample is representative of the population with regard to gender and education and in Hungary also for age. In Switzerland, it was additionally representative with regard to the two dominating languages German and French. The survey was conducted between June 12 and June 22, 2015 in Switzerland and between July 22 and August 8, 2015 in Hungary. In both countries we sought for a sample of 350 participants.

In Switzerland altogether 380 respondents completed the questionnaire; in Hungary there were 408 participants. The answers of the respondents of both countries were subjected to a quality check on the base of which the final selection of the participants used was determined. This check was based on the quality index. It calculates a rate from the time a participant needs to fill in one page compared with the time needed to fill in all pages available in the questionnaire. Furthermore, several questions that were answered with “I don't know”, while no particular knowledge was necessary to answer this question, were used as an additional information about the validity of the answers. In Hungary, additionally participants who used less than 5 min to fill in the questionnaire were excluded. Furthermore, the balance of the different quota (gender age and education) was considered. After quality control, the sample size for each country was 352 respondents. In Switzerland, we had to exclude 11 participants while performing the choice models, as they did not answer all the choice cards. The final number of respondents for each social group in each country can be found in Table 4.

2.4. Data analysis

In order to answer the two research questions, we estimated a model based on the structure described in Section 2.1 with the superordinate

Table 4
Proportions of gender, age and education in the different classes for Hungary and Switzerland.

	Hungary				Switzerland		
Variables	All [352][1]	Class 1 [65%][2]	Class 2 [20%][2]	Class 3 [15%][2]	All [341][1]	Class 1 [35%][2]	Class 2 [65%][2]
Gender							
Male	49 [49][3]	49.1	38.2	60	49.5 [50][3]	51.1	46.6
Female	51 [51][3]	50.9	61.8	40	50.5 [50][3]	48.9	53.4
Education							
Primary education	10 [10][3]	12.8	4.2	8.7	12 [12][3]	12.6	11.8
Secondary education	59 [59][3]	60.8	59.4	51.4	40 [39][3]	41.6	36.7
Higher education	31 [31][3]	26.4	36.4	39.9	48 [49][3]	45.8	51.5
Age							
19–39	46 [47][3]	47.1	47.	44.5	47 [34][3]	48.9	45.8
40–59[4]	43 [43][3]	38.6	60.8	44.2	38 [45][3]	38.3	38.7
60–64[4]	11 [10][3]	14.2	2.2	11.3	13 [21][3]	12.8	15.5

[1] Number of participants included in the analysis
[2] Proportion of participants belonging to the respective class calculated on the basis of posterior membership probability (Sarrias & Daziano, 2017)
[3] Proportion of social group in the whole society in Hungary and Switzerland respectively
[4] In Switzerland 19–39, 40–65 and > 65.

attributes ‘Grassy’ and ‘Woody’ as well as the additional attributes. The socio-demographic variables enter via the classes indirectly into the estimation. The model was estimated separately for the two countries. To determine the number of classes in latent class models, the information criterion was used. We have considered the Bayesian Information Criterion (BIC) since this is the most common for latent class models (Heckman & Singer, 1984). Another decision criterion was the requirement that all classes must differ significantly from each other. In our analyses we found that above a certain number of classes, one or more classes no longer differed significantly from class 1. Such models were not considered but are reported in Appendix C. Other decision criteria, such as the size of the estimates of class probabilities or the stability of the structural parameters did not play a role in our case. All models were performed in R (R Core Team, 2008).

3. Results

3.1. Description of the classes

Considering BIC and the fact that all classes must differ significantly from class 1, the calculations of the Latent Class Models showed that for our model containing the superordinate as well as the additional attributes in Hungary a three-class model and in Switzerland a two-class model explained the data best. The largest group (class 1) in Hungary included 65% of respondents and the second largest 20% (class 2). In Switzerland, 65% of respondents belonged to class 1 (Table 4).

In Hungary, older participants and participants with a primary or secondary education tended to belong to class 1 while younger and higher educated participants tended to belong to class 2 or class 3. Women belonged more often to class 2 than to class 1 or class 3 (Table 4). Overall, participants of classes 2 and 3 selected substantially more combinations containing SNH. The choices of participants of class 3 were dominated by crop – woody combinations (Fig. 1).

In Switzerland, men and participants with primary or secondary education more often belonged to class 1 (Table 4), while women and more educated participants more often belonged to class 2. Furthermore, participants of class 2 tended to be older than those of class 1. Similar to Hungary, participants of class 2 overall selected more frequently combinations containing SNH (Fig. 2).

3.2. Vegetation characteristics

The results of the model (Table 5) showed that ‘Woody’ had a significant positive influence on the selection probability of the pictures both in Hungary and in Switzerland. However, in Switzerland this was true only for class 2. ‘Grassy’, on the other hand, had a significant negative influence on preferences in class 1 and 3, yet only in Hungary. Also, the first level of ‘Ordered’ (Ordered_1) had an influence on the selection probability only in Hungary (class 2 and 3), but in this case a positive one. In contrast, a higher degree of ordered structures (Ordered_2) had a positive influence on selection in both countries, in Hungary in class 2 and in Switzerland in class 1. A low percentage of green vegetation (Green_1) only had a positive effect on class 1 in Hungary, whereas a high proportion (Green_2) had a positive effect on classes 1 and 3 in Hungary and class 1 in Switzerland. The availability of colour had a positive effect in Hungary in classes 1 and 3 and in both classes in Switzerland. The proportion of surface area without vegetation (only considered for Switzerland) had a negative influence on the selection probability for both classes in the first level and in the higher level for class 1. Non-significant coefficient estimates are not relevant for participants in the respective class and the associated attributes do therefore not influence their choices.

3.3. Seasons

Fig. 1 shows the choices for the three Hungarian classes by season. The comparison of the classes shows that the respondents of classes 1 and 2 chose a mixture of all combinations, while the respondents of class 3 mainly chose crop-woody combinations. In terms of the season, it is apparent that in all classes the proportion of selected crop-crop combinations is by far highest in the first season (spring), while the proportion of crop-grassy-woody combinations is highest in season 4 (autumn, see also Table 2). In addition, the combination crop-woody is on the whole most prominent in all three classes in season 2 and 3. Further, it is also apparent that the combination crop-grassy was hardly ever chosen in class 3.

Fig. 2 shows the choices for the two classes in Switzerland by season. The comparison of the classes indicates that the proportion of crop-grassy-woody combinations was much higher in class 2 than in class 1. This is especially true in early and late summer where crop-grassy-woody combinations dominated the selections in class 2. In class 1, however, the proportion of crop-crop combinations was much higher. Furthermore, it can be seen that in class 2 the combination crop-crop and crop-grassy were hardly ever chosen. Moreover, both in classes 1 and 2, in season 1 the proportion of crop-woody is considerably higher than in the other seasons. Furthermore, in class 1 the proportions of crop-grassy and crop-grassy-woody also increased in early and late summer (season 2 and 3) compared to spring.

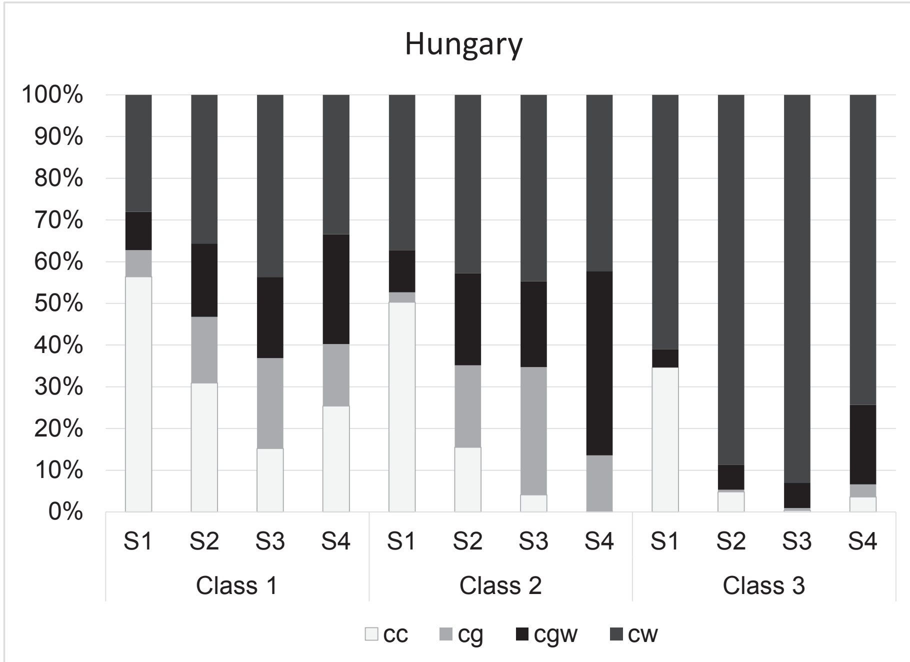


Fig. 1. Preference for combinations by class and season in Hungary Cw: crop – woody; cgw: crop – grassy – woody; cc: crop – crop; cg: crop – grassy.

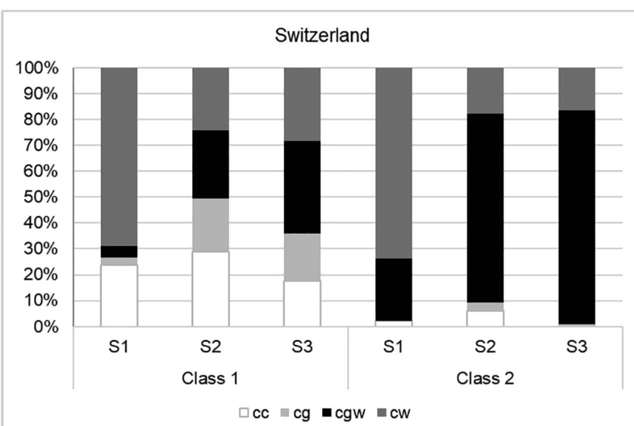


Fig. 2. Preference for combinations by class and season in Switzerland Cw: crop – woody; cgw: crop – grassy – woody; cc: crop – crop; cg: crop – grassy.

4. Discussion

4.1. Which characteristics explain preferences?

The clear preference of respondents for landscape pictures containing SNH (see Figs. 1 and 2) is in line with the existing literature (Hasund, Kataria, & Lagerkvist, 2011; Junge et al., 2015; Klein et al., 2015; Schaak & Musshoff, 2020; Sullivan et al., 2004).

The results of our models containing both the superordinate as well as the additional attributes reveal that 1) the additional attributes contain explanatory power in addition to the superordinate attributes grassy and woody SNH. This follows from the results that the additional attributes are significant and that the model fit as measured by BIC of the model with additional attributes is significantly better than the fit of the model containing only the superordinate attributes (BIC changes from 7272 to 6204 in Hungary and from 5035 to 4328 in Switzerland, see Appendix C2–C4). 2) The superordinate attributes still contain explanatory power in the case of 'Woody' in both countries and 'Grassy' in

Table 5
Coefficients of the latent class models for Hungary and Switzerland.

	Hungary			Switzerland	
Attributes	Class 1 [1][65%]	Class 2 [1][20%]	Class 3 [1][15%]	Class 1[1][65.2%]	Class 2 [1][34.8%]]
Woody	0.179*	0.459**	2.932***	0.173	3.362***
Grassy	−0.358***	0.664	−1.969***	−0.433	1.088
Ordered_1	0.146	2.168***	0.677**	0.335	0.301
Ordered_2	0.514***	1.097**	0.47	1.683***	4.508
Green_1	0.357**	10.463	0.935	−0.068	−0.531
Green_2	1.006***	10.895	1.924*	0.549**	1.636
ColAvail	2.663***	12.494	4.625***	1.928***	3.576**
NoVeg_1	Excluded	Excluded	Excluded	−1.809***	−1.919***
NoVeg_2	Excluded	Excluded	Excluded	−0.770**	2.061
Class 2		2.588***			−0.334*
Class 3			0.761***		NA

* < 0.05, ** < 0.01, *** < 0.001
[1] Proportion of participants belonging to the respective class, calculated on the base of posterior membership probability (Sarrias & Daziano, 2017).

Hungary, however, not in the case of 'Grassy' in Switzerland. From this, it follows that in the case of grassy SNH in Switzerland we were able to comprehensively capture the aesthetic characteristics people associate with those SNH, so that 'Grassy' loses its significance as an explanatory attribute in itself. In the other cases the superordinate attributes may be explanatory in themselves or still contain some characteristics that we failed to capture by our chosen additional attributes. For example, respondents may like woody SNH simply because they are woody or because they break the horizon and represent a structural element in the foreground. This is subject to further research.

Considering the different attributes (Table 5), 'ColAvail' turned out to be the attribute preferred by most respondents in both countries. 'ColAvail' denotes the presence of colourful flowers as yellow, white or purple patches. The importance of colourful flowers for landscape preference is already known (Akbar, Hale, & Headley, 2003; Graves et al., 2017; Junge et al., 2015). While in Hungary blooming rapeseed and sunflower fields were the source of colour, it was rapeseed fields and blooming meadows in Switzerland. Pictures of crops and meadows were consequently preferred because they contained colours from flowers.

The attribute 'Green' applied to all areas of the picture containing green vegetation (level 1) or that were uniformly green (level 2). The results showed that green vegetation was highly valued in Hungary, whereas it was less important in Switzerland. The considerably dryer climate in Hungary may explain the higher appreciation for the green colour there, since during the dry summer months, green vegetation is rare. Indeed, the Jászság region receives about half the precipitation of Switzerland (MeteoSchweiz, 2014, www.met.hu/eghajlat/magyarorszag_eghajlata/varosok_jellemzoi/Szolnok). With respect to the research question, we conclude that one of the main reasons for respondents' preference for meadows as well as hedgerows is that they are green for a large part of the year.

The attribute 'Ordered' was defined by the proportion of clearly delineated homogeneous areas or areas with clearly visible seed rows. Our results showed that, overall, a high degree of ordered structure was appreciated in both countries. Previous studies (Junge et al., 2015; Stilma et al., 2009) have already demonstrated that a lack of ordered structure leads to a lower appreciation. According to Nassauer (2011) 'stewardship' and 'care' are important aspects in landscape preference; "Care means protecting or maintaining what we pay attention to…". Furthermore, Sevenant and Antrop (2010), have shown that care and naturalness have the largest positive effects on landscape aesthetic preference. An ordered structure, however, is not the main quality of woody and grassy SNH. Especially low input meadows, as shown in Switzerland, can have a rather messy character. Woody plants may also appear rather patchy due to their composition; this can be aggravated in certain vegetation periods. However, woody plants in straight lines can also add clear patterns and homogeneous areas to the landscape. The acceptance of grassy and woody SNH in terms of the preference for an ordered structure thus clearly depends on their composition, but also on the respective season.

In our study, the attribute 'NoVeg' described the proportion of bare soil or sparse (dry) vegetation. While this attribute could not be tested in Hungary, it was found to be very important in Switzerland. Respondents significantly rejected pictures with 'NoVeg1′ and 'NoVeg2′ attributes more often than pictures without such elements. Junge et al. (2015) showed that dry or sparse vegetation is valued low. However, our study finds that 'NoVeg' has a more diverse dimension: In Hungary, it was associated either with freshly sown plants in straight lines in spring or harvested fields with dry organic remain in autumn. While the first situation was related with an ordered structure, the second reflected a messy aspect. In Switzerland, 'NoVeg' also occurred in patchy meadows in spring.

We can summarise, that all additional attributes were relevant to the population in our study. Attributes were crucial to explain SNH choices, as the elements crop, grassy and woody SNH that define our combinations changed their visual appearance over time. Depending on their visual appearance characterized by the mentioned additional attributes, combinations were or were not selected. However, the superordinate attributes may still contain explanatory power, depending on the specific case.

4.2. The role of seasons for explaining preferences

The results presented above largely depend on the seasonal differences of the combinations shown in the questionnaire. This is true for all of the attributes studied. The influence of the season on the attribute colour is certainly the most obvious, since plants naturally bloom during a limited time of the year and, therefore, this attribute may or may not be present. The same applies to the attribute 'Green'. On the one hand, intensity and shade vary throughout the year, on the other hand some plants wilt during the year and thus lose their colour altogether. In addition, the area covered by green vegetation increases during the year due to plant growth. The degree of ordered structure of the landscape is also subject to seasonal changes. While in spring plants sown in rows provide such ordered structure, this can be lost over the course of the year as plants grow; this is even more the case once crops are harvested. For meadows and woody plants, the effect is somewhat different, but here too, a seasonal effect on an ordered structure of the landscape can be expected: both types of vegetation experience an increase in biomass over the course of the year while parts of the vegetation die off, thus creating a change in structure. The fact that surfaces are not covered with vegetation is, of course, also related to seasonal effects and, in particular, the agricultural cycle of sowing and harvesting.

These findings can also be illustrated by studying the pictures that were selected by participants. In Hungary for example, spring pictures of pure agricultural combinations (crop-crop) were chosen more often. Crop-woody and crop-grassy combinations, on the other hand, are increasingly preferred in early and late summer pictures, while crop-grassy-woody combinations were more likely to be preferred in autumn pictures.

The decisions were based on the characteristics available at the respective time of year. If, for example, colour was only available in the crop-crop combination (spring), this picture was preferred. If colour was not available in any combination (early summer) or in every combination (late summer), then the choices were based on the other characteristics, green vegetation, ordered structure and bare soil, depending on their availablility in the pictures.

Our results clearly show that preferences for a landscape element cannot really be determined without taking seasonal effects into account. Until now, the literature has mostly examined mere snapshots (Brassley, 1998) and has left out the seasonal variability in vegetation. Our results demonstrate the need to include all relevant stages (seasons) during the vegetation period in order to obtain an accurate picture of preferences for agrarian landscape elements or agrarian landscapes in general in survey studies based on landscape pictures.

4.3. Implications for the management of grassy and woody SNH

In this section we discuss how to optimise the management of grassy and woody SNH with regard to the visual landscape and to what extent visual landscape quality and biodiversity may be in conflict with each other. Measures for the management of grassy and woody SNH are particularly effective when they foster the most important characteristics. Our results show that all the attributes studied had a significant impact on the choice of pictures in both countries for at least one of the classes (Table 5). However, the size of the coefficients of the attributes allows no clear statement about the most important attribute since the units of the attributes are not comparable (see Table 1).

Nevertheless, we know the proportion of participants for which a certain attribute is relevant, and we know that the coefficient estimates of all relevant attributes never had conflicting signs within one country (Table 5). We therefore consider those attributes to be robust in representing people's preferences within each country.

In Hungary all additional attributes turned out to be relevant for at least 80% of participants, while the attribute for bare soil could not be included in the Hungarian model (see also Sections 3.2 and 4.2). In Switzerland the additional attributes 'NoVeg' (bare soil) and 'ColAvail' (colours) were relevant for all participants, 'Order' (ordered structure) and 'Green' (green vegetation) were still relevant for 65% of Swiss participants.

In the following we discuss how the evaluated characteristics could be enhanced in woody or grassy SNH in order to increase the quality of the visual landscape for people. The original reason to introduce SNH in the agrarian landscape in Europe and EFAs in Switzerland was to enhance biodiversity. Our results show that in general the characteristics of SNH are also appreciated by respondents from an aesthetic perspective, but also some conflicts between aesthetic aspects and biodiversity become apparent and need to be taken into account by decision makers.

Regarding woody SNH it was found that people in both countries appreciate woody elements like hedgerows simply because they are woody. In addition, woody SNH can contribute to the fulfilment of people's aesthetic preferences for green vegetation (throughout the year, except in winter), colourful flowers (in spring) as well as providing an ordered structure in an agricultural landscape. A potential conflict with biodiversity targets may arise because respondents preferred those pictures that contained relatively ordered and homogeneous elements, but patchy hedges are typically more valuable for biodiversity (Graham, Gaulton, Gerard, & Staley, 2018).

While the effects of measures regarding hedgerows are similar in Hungary and Switzerland, they clearly differ regarding grassy SNH as their visual aspects are fundamentally different between the two countries. The depicted grassy SNH of Hungary have a predominantly green aspect in most seasons and have a rather ordered character. These characteristics meet the aesthetic preferences of respondents in this respect. What is missing, however, in grassy SNH in Hungary are colourful flowers. In Switzerland, in contrast, the shown grassy SNH have a messy aspect with open soil in spring but flowers in addition to the green colour later in the year. While these meadows do not always satisfy the need for ordered structure and only little open soil, they serve respondents' needs for colour in a later period. In Switzerland, existing agri-environmental programs foster the presence of colourful flowers. For example, the program for 'botanical quality' rewards farmers if their EFA-meadows harbour a certain number and composition of (flowering) plant species. EFA meadows not fulfilling these criteria receive lower payments (SR 910.13, 2013). Improvements to the existing regulations could be to make the 'botanical quality' program mandatory to fulfil cross compliance. Furthermore, species composition of these meadows should be developed towards mixtures providing flowering plants and therefore colours throughout the whole vegetation period. This would also be favourable for pollinators. Nevertheless, we identify a potential conflict between aesthetic preferences and biodiversity regarding the aspect of open soil as well as ordered structure. Open soil as well as structural diversity are further positive aspects for (insect) biodiversity (Holland et al., 2016; Jeanneret et al., 2016).

On the EU level, however, no such rules for species richness and composition exist. As Hungary has no country-specific regulation for this aspect there is currently no incentive to promote flowering plant species in grassy SNH. Moreover, in Hungary and also in the Jászság region, low-input grassland in general is subject to be converted to cropland (Bozsik & Koncz, 2018). In this situation the EU regulation to not convert permanent grassland into cropland (EU Comission 2013, 2014) may be helpful to preserve unmanaged grassy SNH and preserve at least in late summer and autumn green colour in a rather dry landscape. In addition, programs to foster flowering plant species providing colourful flowers during the whole vegetation period are recommended.

4.4. Limitations of the approach

The discussion until now showed that including seasons in our study was indispensable to understand participants' choices. This, however, required showing pictures of real combinations of crops and SNH following a seasonal sequence and caused several limitations of our study. Firstly, the number of possible combinations of vegetation elements was restricted, consequently, precluding a full orthogonal or factorial design with regard to the vegetation characteristics. As a result, variations within the pictures regarding our attributes may necessarily have been low, in some cases. This, secondly, also limited the number of additional attributes used. Future studies should consider additional attributes, such as the presence of dry vegetation, to determine what other characteristics are hidden behind the preferences for SNH. Thirdly, our study is based only on two countries. It will be necessary to test the performance of our empirical model in other contexts like the remaining QuESSA countries.

Finally, the sample sizes were rather small. The number of ca. 350 participants in each country was a trade-off between financial resources and recommendations for a minimum sample size we found in the literature (Graves et al., 2017; Rewitzer et al., 2017; van Berkel & Verburg, 2014). A higher sample would probably have resulted in a further differentiation of classes in the models. However, we expect that even with a larger sample size the core result that all attributes are relevant for most respondents does not change.

5. Conclusions

In this study, we used choice experiments with standardised landscape pictures to investigate how to best explain the aesthetic preferences of the general population for woody and grassy SNH in combination with typical crops. The results of the study show that the superordinate attributes for SNH are not sufficient to explain the aesthetic preferences of the population adequately, while the used attributes for colour, green vegetation, ordered structure and bare soil contribute significantly to the explanation of these preferences. Colours and ordered structure were particularly important for most participants. The preference for colourful flowers is in line with the needs of biodiversity. The preference for ordered structure and homogeneity, however, conflicts with these needs. Furthermore, our approach allows for a better consideration of the seasonal effects on visual landscape quality. By differentiating the relevant seasons in the choice experiment and thus relating the seasons to our additional attributes, we can identify the different characteristics that are preferred.

One of the limitations of our study results from the inclusion of seasons, which forced us to show seasonally realistic combinations of landscape elements and led to a reduced variation and a suboptimal choice design. Further, the sample sizes of 350 respondents in each country was still rather small due to limited financial resources. Future studies should use larger sample sizes and increase variation of the characteristics in the pictures in order to be able to test more potential aesthetic attributes.

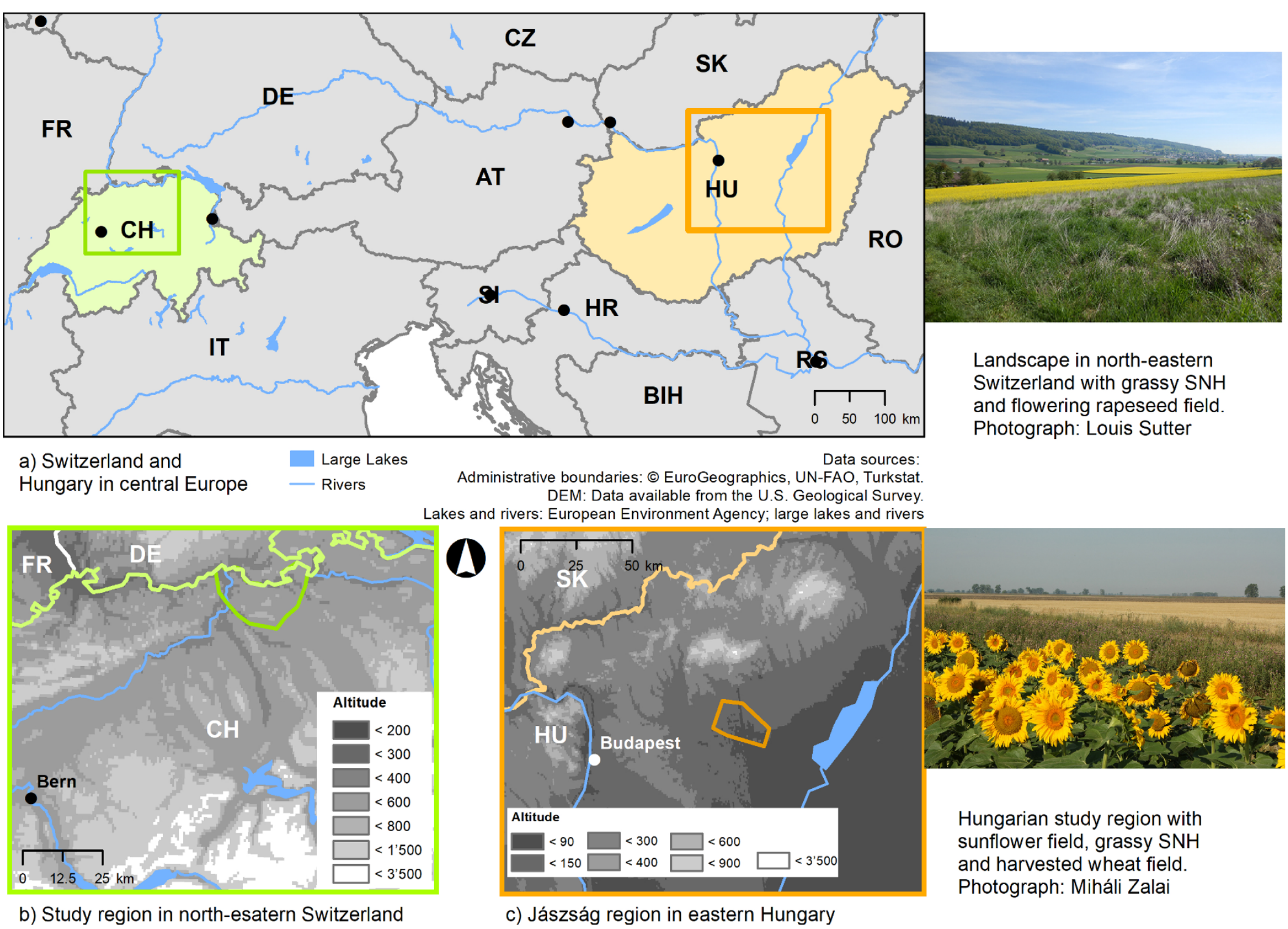
In order to increase the aesthetic value of SNH for the population, various measures could be taken and recommendations made following our results. Firstly, more hedges, ideally with visible flowering species should be included in the agricultural landscape since they provide structure, a fresh green aspect and, at least in some seasons, colour through flowering. Second, measures should be taken to increase colourful flowering ideally throughout the year. For this purpose the existing 'botanic quality program' in Switzerland, could be made mandatory to fulfil cross-compliance. In Hungary, it is recommended to establish a similar program at all. In a first step, we recommend protecting the existing meadows and prevent the on-going land conversion.

However, we identified also potential conflicts with biodiversity targets regarding SNH. In general, people preferred an ordered and well-structured landscape with rather homogeneous elements. Also, patches of open soil in spring are not appreciated. But a more patchy, unstructured landscape with heterogeneous elements is typically beneficial to sustain biodiversity in agricultural landscapes. Decision makers should be aware of these potential conflicts and carefully take into account society's preferences both regarding biodiversity as well as landscape aesthetics.

Acknowledgements

Beatrice Schüpbach acknowledges the receipt of a fellowship from the OECD Co-operative Research Programme: Biological Resource Management for Sustainable Agricultural Systems in 2015. This fellowship was the base for this publication. The project the publication is based on has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no. 311879 (QuESSA). The authors furthermore thank Louis Sutter (Agroscope / Federal Office for Agriculture) for providing the base for the photographs for Switzerland, Erlend Dancke Sandorf (CERE, Umea, SE / University of Stirling, UK) for his support when starting with latent class models, Eva Knop (Agroscope) for her valuable advices in statistics. We also thank to Julian Helfenstein (Agroscope) for reading a previous draft of this manuscript, and Melanie Ströbel for reading a previous manuscript before resubmission. Last but not least we thank our thee anonymous reviewers for their valuable comments and advices, which substantially improved the publication.

Appendix A



Appendix A. Map of the study regions

Appendix B

Appendix B1. Example of a choice card of Hungary

Appendix B2. Example of a choice card of Switzerland

Appendix C

Table C1
Model fit for multinomial-logit, mixed-logit and latent class models for Hungary and Switzerland.

Model Input	BIC / AIC	Multinom. Logit model		Mixed logit model		Latent class model,	
		Hungary	Switzerland	Hungary	Switzerland	Hungary	Switzerland (2 classes)
Grassy + woody + gender + age + education	BIC	7192.072	5206.453	7120.689	5087.629	[2]7072.703	5035.349
	AIC	7120.755	5139.023	7037.486	5008.96	[2]7013.272	4979.156
Grassy + woody + green_1 +green_2 + Ordered_1 + Ordered_2 + [1]Noveg_1- + [1]Noveg_2 + ColAvail + gender + age + education	BIC	6546.159	4669.773	6396.712	4515.968	[3]6204.735	4286.632
	AIC	6249.005	4388.811	6069.843	4138.452	[3]6008.613	4151.77

[1] Not included in the Hungarian model
[2] Model with 2 classes
[3] Model with 3 classes

Table C2
BIC and AIC of latent class models for Hungary.

Model input	Number of classes	BIC	AIC
Grassy + woody + gender + age + education	*2*	*7072.703*	*7013.272*
Grassy + woody + gender + age + education	3[1]	7107.428	7000.453
Grassy + woody + Ordered_1 + Ordered_2 + NoVeg_1 +NoVeg_2 + Green_1 + Green_2 + ColAvail + gender + age + education	2[1]	6197.2	6054.566
Grassy + woody + Ordered_1 + Ordered_2 + NoVeg_1 +NoVeg_2 + Green_1 + Green_2 + ColAvail + gender + age + education	3[1]	6177.607	5945.827
Grassy + woody + NoVeg_1 +NoVeg_2 + Green_1 + Green_2 + ColAvail + gender + age + education	2[1]	6254.367	6135.506
Grassy + woody + NoVeg_1 +NoVeg_2 + Green_1 + Green_2 + ColAvail + gender + age + education	3[1]	6293.749	6097.628
Grassy + woody + Ordered_1 + Ordered_2 + + Green_1 + Green_2 + ColAvail + gender + age + education	2	6204.054	6085.193
Grassy + woody + Ordered_1 + Ordered_2 + + Green_1 + Green_2 + ColAvail + gender + age + education	**3**	**6204.735**	**6008.613**

The model in italic letters was used to compare with the full model in bold letters; the model in bold letters is reported in Tables 4 and 5.
[1] One of the tow classes does not significantly differ from class 1

Table C3
BIC and AIC of latent class models for Switzerland

Model input	Number of classes	BIC	AIC
Grassy + woody + gender + age + education	*2*	*5035.349*	*4979.156*
Grassy + woody + gender + age + education	3[1]	5055.012	4953.865
Grassy + woody + Ordered_1 + Ordered_2 + NoVeg_1 +NoVeg_2 + Green_1 + Green_2 + ColAvail + gender + age + education	**2**	**4286.632**	**4151.77**
Grassy + woody + Ordered_1 + Ordered_2 + NoVeg_1 +NoVeg_2 + Green_1 + Green_2 + ColAvail + gender + age + education	3[1]	4328.887	4109.737

The model in italic letters was used to compare with the full model in bold letters; the model in bold letters is reported in Tables 4 and 5.
[1] One of the tow classes does not significantly differ from class 1

Table C4
Coefficients of the base model (latent class) for Hungary and Switzerland.

Attribute	Hungary		Switzerland	
	Class 1 [75%]	Class 2 [25%]	Class 1 [65%]	Class 2 [35%]
Grassy	-0.605***	-1.841***	-0.4878***	0.2977*
Woody	0.249**	1.773***	0.478***	3.619***
Class 2		-0.648**		0.3252*

* < 0.05, ** < 0.01, *** < 0.001

Appendix D. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.landurbplan.2020.103954.

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