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Validation of a visual landscape quality indicator for agrarian landscapes using public participatory GIS data

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HIGHLIGHTS

- PPGIS data are fit for validating an indicator (CLI) for visual landscape quality.
- The validity of CLI differ depending on the region and its land use / land cover.
- A mix of water, wetland and forest may be preferred over agricultural landscapes.

1. Introduction

European agrarian landscapes are highly valued for their livestock, historic buildings, and mosaic-like land covers (van Zanten, Verburg, Koetse, & van Beukering, 2014). The European Landscape Convention (Council of Europe, 2016; Déjeant-Pons, 2006) and the Millennium Ecosystem Assessment (2005) have highlighted the value of landscapes for human well-being. Both the European Landscape Convention and Millennium Ecosystem Assessment require measuring and monitoring either the landscape composition or its services; they consider landscape aesthetics, such as visual landscape quality, to be cultural services (Hermes, Albert, & von Haaren, 2018).

Visual landscape quality consists of several aspects, including stewardship, naturalness, or complexity/diversity (Tveit, Ode, & Fry, 2006). A number of methods and approaches exist for assessing visual landscape quality (e.g., Frank, Fürst, Koschke, Witt, & Makeschin, 2013; Schirpke, Timmermann, Tappeiner, & Tasser, 2016; Tveit, 2009; Tveit et al., 2006). Based on this conceptual work mentioned before, indicators were developed for monitoring landscape quality either for a specific region as, the Tyrolian mountains (Schirpke et al., 2013), or for the whole country, such as Poland (Sowińska-Świerkosz & Michalik-Śniezek, 2020), Sweden (Hedblom et al., 2020), Germany (Hermes et al., 2018), or Switzerland (Kienast et al., 2015). Most of these indicators aim to evaluate the whole landscape, including a broad range of land-use and land-cover (lu/lc) categories from forest to agriculture or from settlement and infrastructure to water. As a result, the differentiation of values within agricultural land-use (e.g., crops) is limited or particularly adapted to specific case studies or landscapes (e.g., Schirpke et al., 2013).

However, the monitoring program, "Landschaftsbeobachtung Schweiz," which evaluates the quality of Swiss landscapes (Wartmann, Stride, Kienast, & Hunziker, 2021), revealed that agricultural land had a major impact on landscape quality. Furthermore, many inhabitants have direct access to the agriculturally used landscape within a 15-minute walk (BAFU/WSL, 2022). This means that agricultural land, especially its quality, plays an important role in recreation.

The composite landscape indicator (CLI) (Schüpbach et al., 2020), which focuses on agricultural landscapes, was initially developed to include visual landscape quality as a social aspect in a sustainability assessment of agriculture (Roesch et al., 2017). The basis of this sustainability assessment was the Swiss Agriculture Life Cycle Assessment (Nemecek, Freiermuth Knuchel, Alig, & Gaillard, 2010). As a part of a life cycle assessment, the CLI indicator is an aggregation of two subindicators—the aggregated diversity index (ADI) and area-weighted preference value (AwPv)—and is based on the Swiss national farm database for agricultural direct payments; it explicitly evaluates the impact of agriculture on aspects of visual landscape quality, such as naturalness and diversity (Schüpbach et al., 2020). Herein, the preference values of ecological focus areas (EFAs) and most frequent grassland and crop types are integrated. The CLI has been particularly adapted to Swiss agriculture, differentiating between the seasonal stages of crops and EFAs. Therefore, not only element diversity, but also seasonal diversity can be measured (see section 2.6). The visibility of the seasons is important for the visual quality of agrarian landscapes, as shown by Stobbelaar et al. (2004). Nevertheless, seasons are rarely implemented in the assessment of visual landscapes (e.g., Wang, Li, Zhang, & Song, 2020).

Initially, the calculated indicator values referred only to farm

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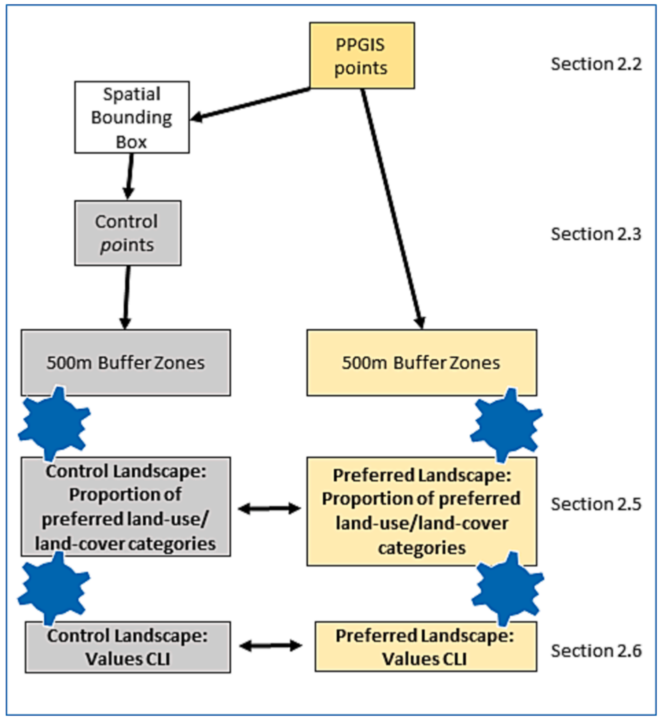


Fig. 1. Workflow of the involved datasets to validate CLI and its subindicators with two existing PPGIS surveys.

locations and, therefore, were not spatially explicit. Farmland in Switzerland is not necessarily located directly around the farmhouse it belongs to, but the fields of the respective farm are mixed with fields belonging to other farms. This makes validation with real-life perceptions difficult. Hence, the CLI value of a farm cannot be allocated to a defined section of the landscape. A second problem for validation is the focus on the agrarian landscape because nonagrarian land-cover types, such as forest or water, are excluded. Landscape perception, however, is not restricted to the agrarian part of the landscape. Recently, land-use maps have become available for all of Switzerland. These maps enable spatially explicit evaluations of the visual landscape quality of the agrarian part of the landscape by means of the CLI and its subindicators. This development considerably simplifies the validation of the indicator because indicator values can now be allocated to a spatially explicit region.

The aim of the present paper is to validate the CLI and its subindicators. In general, landscape indicators can be validated by observed or inferred human behavior or direct surveys of people, such as photo surveys (e.g., Frank et al., 2013; Weitkamp, Lammeren, & Bregt, 2014), interviews, or participatory mapping (e.g., Brown, Hausner, & Lægreid, 2015). Because we had neither data on observed human behavior nor representative photographs of any kind of the Swiss landscape, we opted to use the Public Participatory Geographical Information System (PPGIS) dataset. PPGIS surveys are direct spatial surveys of people and can be used to evaluate participants' preferences regarding recreation, routines, and so forth. For example, Brown et al. (2020) provided an overview of key lessons from participatory mapping projects. They found a correlation between mapped places for landscape preferences and those for land-use categories.

Based on these findings, we tested i) whether the areas surrounding PPGIS points have greater numbers of preferred land-use and land-cover categories (lu/lc categories) so that ii) higher visual landscape quality can be expressed as higher CLI values. We used an existing PPGIS survey mapped in two case study regions of Switzerland (Fagerholm et al., 2019) and compared the surrounding (=buffer zones) of the PPGIS points to the buffer zones of an equal number of randomly distributed points. The two datasets were compared i) according to their proportions of preferred lu/lc categories and ii) according to the values of the CLI and its subindicators. With these comparisons, we intended to validate the CLI indicator.

2. Conceptual background, materials, and methods

2.1. Conceptual background

For the validation of CLI and its subindicators, we used an existing PPGIS survey based on the hypothesis of Brown et al. (2020), which claims a correlation between mapped places for landscape preferences and those for land-use categories. Therefore, we assume that PPGIS points show landscapes that are particularly beautiful, and as a result, they contain a higher proportion of preferred lu/lc categories, yielding a higher CLI value. To compare the PPGIS points with a control, we adopted the setting of Ridding et al. (2018), who compared a 500 m buffer around PPGIS points to randomly set points regarding the lu/lc categories contained in the buffer zone. Fig. 1 illustrates our approach.

In the following sections (2.2 to 2.7), the two study regions, the involved datasets, and the analysis are described.

2.2. Description of the two study regions

The study was conducted in two case study regions in Switzerland. The first region—the Freiberge region—includes four municipalities: La Chaux-des-Breuleux, Le Noirmont, Les Breuleux, and Muriaux. This region is located in western Switzerland and comprises parts of the cantons of Jura, Neuchâtel, and Berne. Grassland and wooded pastures with conifer and broadleaf trees dominate the region. The trees are scattered on pastures grazed by traditional horse breeds and cattle. Besides agricultural production, the region attracts outdoor tourists, especially for hiking, horse riding, and cross-country skiing. The gorge of the Doubs River and a protected mire (Etang de Guère) are the touristic parts of the region.

The second region—the Schwarzbubenland region—is located in northwestern Switzerland in the cantons of Solothurn and Basel-Landschaft. It includes the seven municipalities of Büren, Gempen, Hochwald, Nuglar-St. Pantaleon, Seewen, and Seltisberg. The region lies in the larger area of the city of Basel and is known for its traditional fruit orchards. Its orchard grasslands are either grazed by cattle or mown. Although fruit production has declined because of pest damage and high management costs, tourism has recently started to valorize the flowering season.

Both regions are considered parts of the federal inventory "Landscapes and Natural Monuments of National Importance" (SR 451.11, 2010). For the location of the two regions, see the maps and photographs in Appendix A1.

2.3. PPGIS points and control points

In both regions, a web-based PPGIS survey took place using the online Maptionnaire platform, as described in detail by Fagerholm et al. (2019). For the survey, a purposive stratified random sample was drawn from residents, balanced by place of residence, age, and gender according to the local census. The participants were asked to map spatially explicit where and what services (provisioning, social culture, etc.) they perceived the rural landscape offered them. Among these services was also "aesthetics"; therefore, the participants were asked to mark the places where they enjoyed the landscape or landmark to determine the aesthetic value of a landscape (Fagerholm et al., 2019). The participants were free to map as many points as they saw fit.

In the Freiberge region, the participants were recruited in public places as market places or cafés. The participants jointly answered an online questionnaire with an interviewer. Altogether, 167 participants mapped 2,574 points. About 10 % (257) of them mapped aesthetically appreciated points (Fagerholm et al., 2019).

In the Schwarzbubenland region, the participants were recruited in public places such as marketplaces or cafés, but half of the participants were recruited in a crowdsource process and were asked to take part in the online study by In the Scharzbunenland region, 221 participants mapped 2,877 points. About 13 % (274) of them referred to aesthetically appreciated points (Fagerholm et al., 2019). Tables S1.1 and S1.2 in the supplementary material S1 report the details about the sample in the two regions.

For our analysis, we selected PPGIS points representing only places where the participants enjoyed the landscape or landmark to determine the aesthetical landscape value. From the Freiberge region, we included 253 PPGIS points in our analysis; from the Schwarzbubenland region, 372 PPGIS points were included.

The control points were generated using the setting of Ridding et al. (2018), who compared the landscapes inside 500 m buffer zones around selected PPGIS points with those inside 500 m buffer zones around an equal number of randomly placed control points. Following this method, for each region, a bounding box was generated that surrounded the PPGIS points. Because the Freiberge region shares a border with France, the bounding box was clipped by the Swiss border and, therefore, is not a regular rectangle (see map A1 in Appendix A). For this reason, 2 points were removed from the Freiberge sample because they were located in France. An additional 2 points were removed in both regions because they were more than 10 km away from the next PPGIS point. Once established, two bounding boxes—253 and 273 random points—were generated to have a minimum distance of 20 m. This was the minimum distance between the PPGIS points and should ensure a comparable distribution of random points.

A buffer zone of 500 m was generated around each PPGIS and random control point. Hereafter, the buffer around the PPGIS points will be referred to as the "preferred landscape," and the buffer around the control points will be called the "control landscape." Fig. 1 shows a map for each study region and location of the PPGIS points and the control points, respectively.

2.4. Land-Use and land-cover datasets

We combined maps containing agrarian land-use and nonagrarian land cover to produce an inclusive map and include all possibly preferred land-use and land-cover categories. Therefore, four different datasets from different origins were used, as follows:

1. An agricultural land-use dataset provided by the Federal Office for Agriculture (FOAG): This dataset is available for Swiss farmland and provides spatially explicit reports on agricultural land-use in 2021. It reports on different EFAs, arable crops, grassland types (according to management), special crops, or traditional orchards.
2. The Swiss digital landscape model (TLM3D, swisstopo): This dataset contains the most important land-cover types. Forests, open forests, water, wetlands, and buildings were extracted. The buildings were buffered by 20 m to represent the settlement areas.
3. The inventory of fens, mires, and raised bogs in Switzerland, as provided by the Federal Office of Environment (FOEN), was used.
4. A dataset comprising all wooded pastures in the Freiberge region, as provided by the canton of Jura, was used.

Data processing was carried out in several steps using ArcGIS 10.8 (ESRI Redlands, 2020). In the first step, each lu/lc category received a unique code that was rasterized with a resolution of 2 × 2 m. Thereafter, all four datasets were combined. The final table was ordered by a global code that integrated all lu/lc categories from the four different datasets. For the different codes, see Supplementary Material S2, Table S2.1.

Table 1
Summary table of land-use and land-cover types into categories, their origins and visual preferences.

Land-use/land-cover type	Land-use/land-cover category	Origin	Visual Preference	Reference
Wheat, rape-seed, potatoes, etc.	Arable crops	Agriculture	Low to Medium	Junge et al., 2015
Grass-clover ley, intensively managed meadows and pastures	Grassland	Agriculture	Medium	Junge et al., 2015
Extensively managed meadows, pastures, wild flower strips, etc.	Ecological Focus Areas (EFAs)	Agriculture	High (Preferred)	Junge et al., 2015
Traditional Orchards / Wooded Pastures	Traditional Orchards / Wooded Pastures	Agriculture	High (Preferred)	Junge et al., 2015
Intensive Fruit Production	Intensive Fruit Production	Agriculture	Medium	Expert (analogy to traditional orchards)
Forest	Forest	Nonagriculture	High (Preferred)	Foltête et al., 2020 Tieskens et al., 2018
Open Forest	Forest	Nonagriculture	High (Preferred)	Foltête et al., 2020
Water And Wetland	Water and Wetland	Nonagriculture	High (Preferred)	Foltête et al., 2020 Tieskens et al., 2018
Other (Special Crops, Buildings, Rocks etc.)	Other		Low/Unknown	

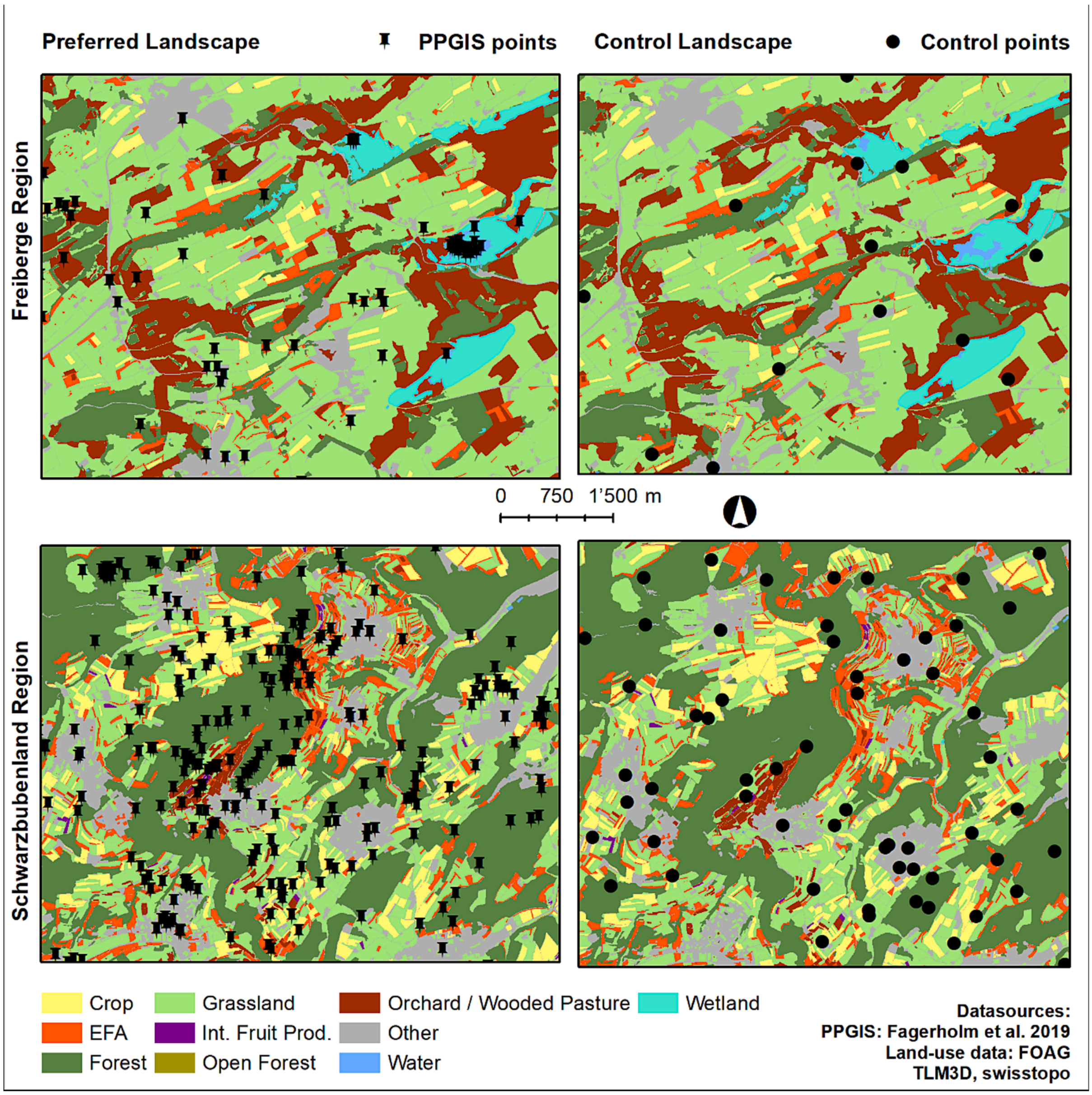


Fig. 2. A section from both study regions: Freiberge above and Schwarzbubenland below. On the left is the landscape with the PPGIS points; on the right is the landscape with the random control points.

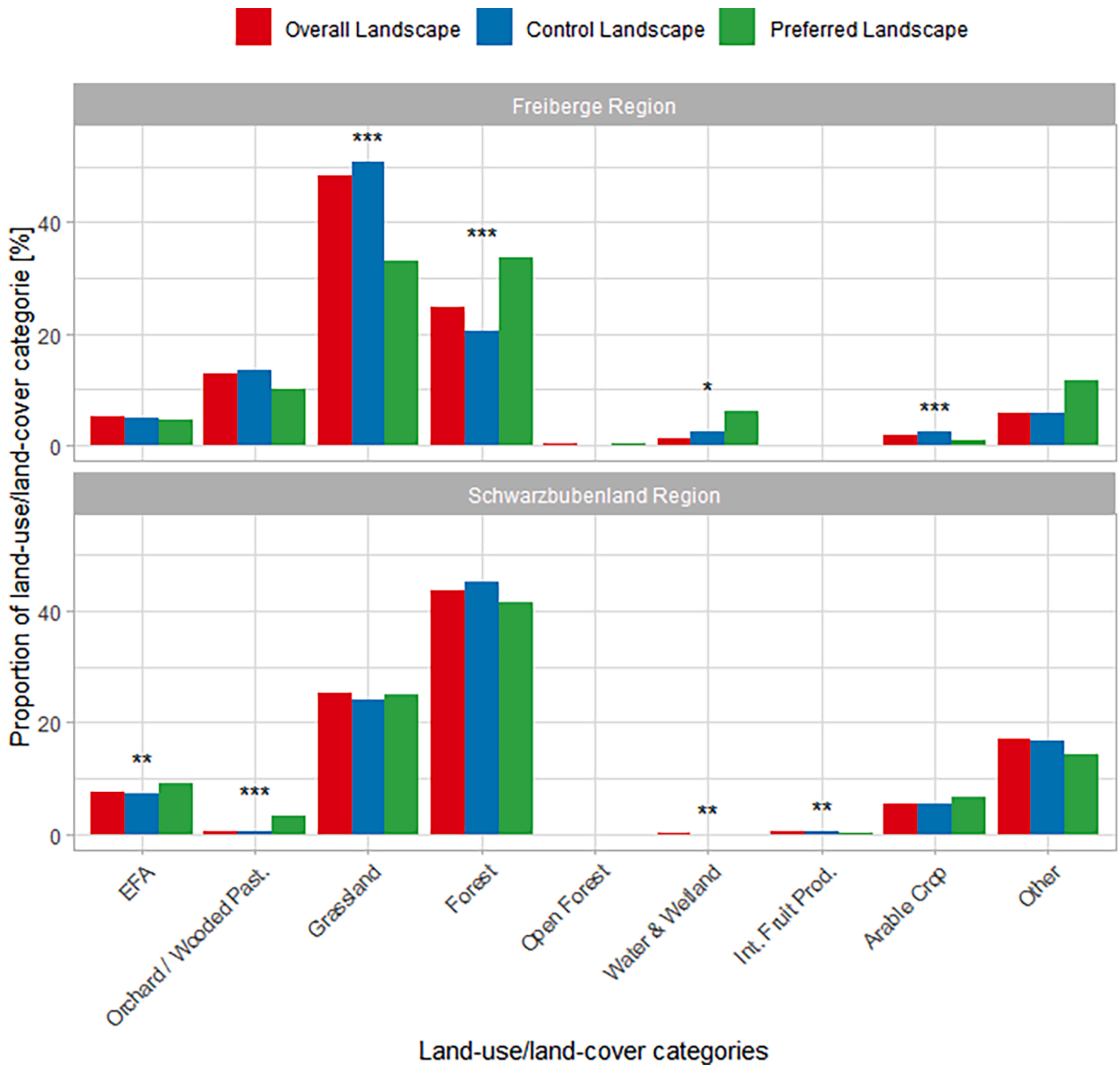


Fig. 3. Percentage of lu/lc categories in the preferred landscape and in the control landscape of the Freiberge region (top) and Schwarzbubenland region (bottom). Significances: $p < 0.05$ *, $p < 0.01$ **, $p < 0.001$ *** (MANOVA).

2.5. Analysis of lu/lc categories and their proportions

To facilitate the analysis of the proportions of preferred land-use and land cover in the preferred and control landscapes, the original land-use and land-cover types from the datasets described in section 2.4 were aggregated into categories of similar visual preference. In this process, land-use and land-cover data were kept in separate categories. Table 1 gives an overview of the different lu/lc categories, their origins, their preferences, and the references they are based on. The most important land-cover types—forest and water—were treated as separate categories. Their preferences have been previously reported by Foltête, Ingesand, and Blanc (2020) and Tieskens, Van Zanten, Schulp, and Verburg (2018). Wetlands, which are mostly protected areas, were assigned to the water category because both land-cover types were rather rare and occurred only in the Freiberge region. The agricultural land-use types (different arable crops, grassland, etc.) were categorized based on Junge et al. (2015). Herein, five different categories were defined. The remaining land-use categories (e.g., special crops, settlement areas, streets, and rocks) were summarized as "other" because they were rare and not much knowledge exists about their preference values. Fig. 2 shows the lu/lc categories, the PPGIS, and the control points in the two regions.

The categorized data were collected in two tables: one for the preferred landscape and one for the control landscape. Each contained the lu/lc information from the 500 m buffer zones of each PPGIS and each control point. This table allowed us to calculate the proportions of each lu/lc category for each PPGIS and control point. The representativeness of the control points for each respective landscape was assessed by the proportion of each lu/lc category in relation to the landscape in the bounding box. All analyses were performed using R.

2.6. Calculation of the composite landscape indicator (CLI)

The CLI is an aggregation of two subindicators: the aggregated diversity index (ADI) and the area-weighted preference value (AwPv). Both are based on the preference values for the most frequent land-use types in Switzerland (Junge et al., 2015). These preference values describe the most characteristic stages for each land-use type. To enlarge the applicability of the CLI and its subindicators, additional land-use types, such as different cereal crops, vegetable crops, and vineyards, were added. To achieve this, we used land-use types with a similar visual character (e.g., an existing cereal for an additional cereal) and adapted them to the different phenological evolutions of the respective land-use types. For instance, wooded pastures in the Freiberge region were assigned an adapted preference value based on orchard values because both land-use categories had park-like aspects (e.g., Kaplan, 1992). For

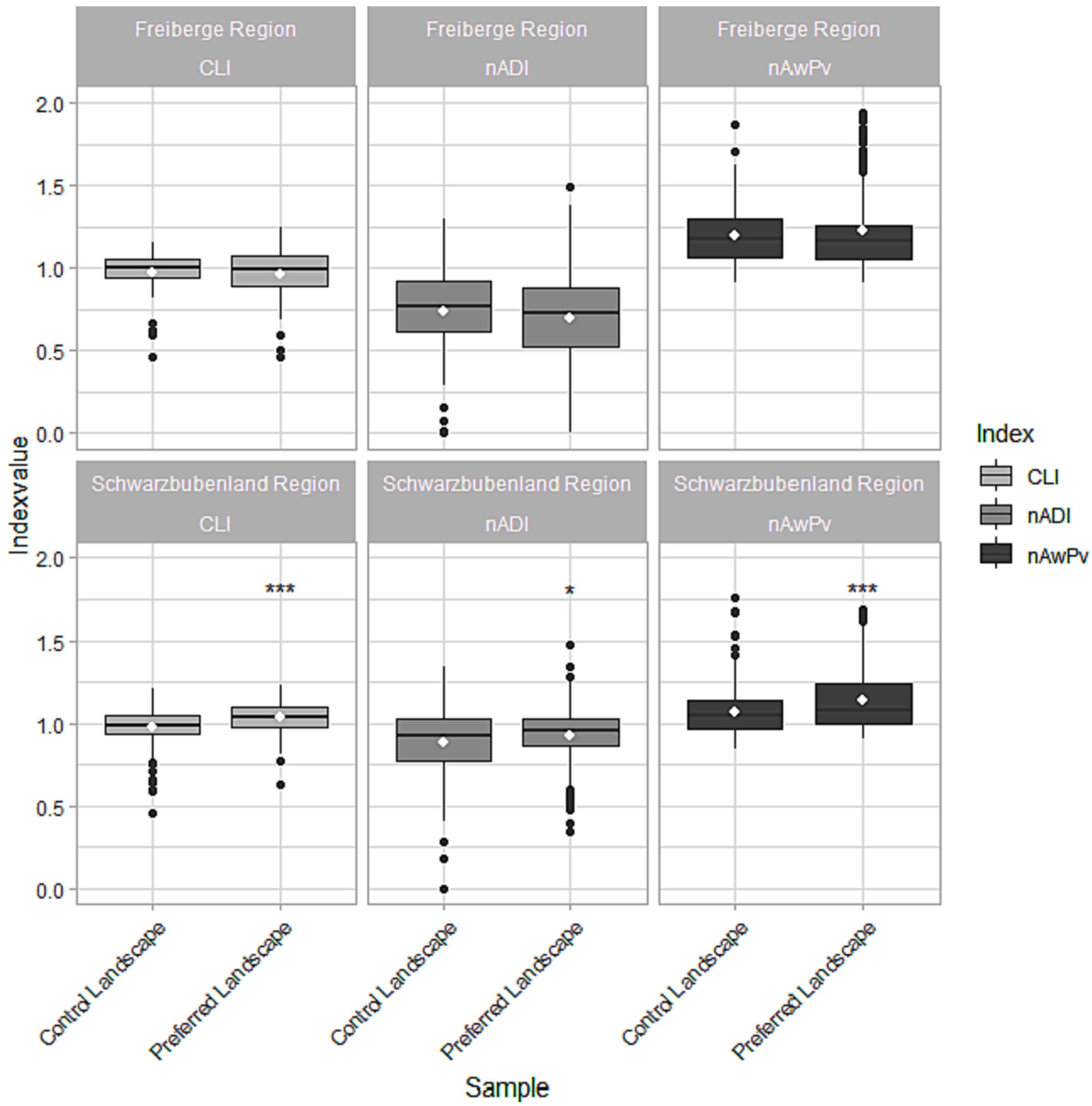


Fig. 4. Values of the composite landscape indicator (CLI), normalized aggregated diversity index (nADI), and normalized area-weighted preference value (nAwPv) for the preferred landscape and control landscape of the Freiberge region (on top) and Schwarzbubenland region (below). Significances: $p < 0.05$ *, $p < 0.01$ **, $p < 0.001$ *** (Wilcoxon test).

the values, see Supplementary Material S2, Table S2.2.

The subindicator ADI is an aggregation of element diversity and seasonal diversity. For element diversity, a Shannon indicator was calculated based on the area of each land-use type, as weighted by its mean preference value. For seasonal diversity, a biweekly time series of Shannon indices was calculated based on the area of each land-use type, as weighted by a time series between March and October of its preference value. Next, the absolute differences of two timely adjacent Shannon values were summed up, representing seasonal diversity. The two diversity indices were then aggregated by Euclidian distance (Schüpbach et al., 2020).

The subindicator, nAwPV, measures naturalness and beauty; it was calculated by summing the surface of each land-use type, which was weighted by its preference value, and dividing the result by the sum of all evaluated land-use types in each assessment unit. Both the ADI and AwPv were normalized by the regional average of the respective indicators. The CLI was then calculated from the arithmetic mean of the two normalized subindicators (Schüpbach et al., 2020).

For the analysis, the original land-use data of each region were selected and assigned their respective preference values (see Supplementary Material S2, Tables S2.1 and S2.2). Thereafter, a table was established for the preferred landscape (the 500 m buffer of PPGIS points) and for the control landscape (the 500 m buffer of control points). Based on this table, the CLI and its subindicators were calculated for the buffer zone of each PPGIS and control point, respectively, using R.

2.7. Statistical analysis

To test the difference between the preferred landscape and control landscape when it comes to the proportions of lu/lc categories, we applied a multivariate analysis of variance (MANOVA) in R. To answer the question of whether the preferred landscape provided higher CLI, nADI, and nAwPv index values, we used R to perform a Wilcoxon test for each (sub)indicator. We applied several packages (Harrell, 2018; R Software, 2016; Wickham, 2016a; Wickham, 2016b).

3. Results

3.1. Proportion of preferred lu/lc categories in the preferred landscape and in the control landscape

In the Freiberge region, the preferred landscape contained about 54 % of the preferred lu/lc categories compared with about 41 % in the control landscape. However, the proportion of EFAs and wooded pastures did not differ significantly between the control landscape and preferred landscape. In contrast, the proportions of water, wetland, grassland, and forest were significantly higher in the preferred landscape than in the control landscape (Fig. 3). The lu/lc categories preferred by participants in the Freiberge region were water, wetlands, and forests, all of which originated from the nonagrarian landscape.

In the Schwarzbubenland region, about 53 % of the lu/lc categories were categorized as preferred in the preferred landscape and in the control landscape. The proportions of EFAs and traditional orchards were significantly higher in the preferred landscape than in the control landscape, while the proportions of intensive fruit production, as well as water and wetland, were significantly higher in the control landscape than in the preferred landscape. However, both categories were negligible in the Schwarzbubenland region (see Fig. 3). In this region, the lu/lc categories that the participants preferred were agrarian land-use categories.

Analyzing a buffer zone of 500 m around PPGIS points and randomly set control points confirms that PPGIS points show locations in the landscape where local residents believe the landscape is particularly beautiful. The comparison of the overall landscape in the bounding box and control points' buffer zones showed similar proportions in both landscapes in both regions. For more details, see Appendix B and Table B1.

3.2. The values for CLI and its subindicators in the preferred landscape and control landscape

The CLI and its subindicators—nADI and nAwPv—showed contrasting outcomes in the two regions. In the Freiberge region, neither the CLI nor the two subindicators significantly differed between the preferred landscape and control landscape (Fig. 4 and Appendix B, Table B2). In the Schwarzbubenland region, the CLI and both subindicators were significantly higher in the preferred landscape compared with the control landscape.

4. Discussion

4.1. Methodological approach

Our methodological approach has been based on a comparison between PPGIS points and randomly generated control points to assess landscape visual quality. PPGIS studies have been successfully used to find the relationships between the physical landscape and its values (aesthetics, etc.) or ecosystem services (Brown et al., 2015; Solecka et al., 2022), but we could not find any study validating landscape indicators using PPGIS data. Nevertheless, the major advantage of the PPGIS approach is that participants can specify their preferred locations spatially explicit and quite individually (Garcia et al., 2017). However, they always deal with people and their perceptions, which differ depending on the individuals and their social backgrounds (Fagerholm et al., 2019; Plieninger, Dijks, Oteros-Rozas, & Bieling, 2013). Therefore, a preferred method for analyzing PPGIS points (preferred locations) is to analyze clusters and point densities to summarize these different opinions and draw holistic conclusions (Cusens, Barraclough, & Måren, 2022; Solecka et al., 2022). We took a different approach; in our case, an independent sample of the individual points was important for calculating the CLI and its subindicators. This qualitative approach based on individual PPGIS points instead of a quantitative approach via density analysis was also used, for example, in health-related studies, such as on walking behavior in older people (Laatikainen, Haybatollahi, & Kyttä, 2019) or recreation studies (Lowery & Morse, 2013).

In addition to the question of whether to use a quantitative or qualitative approach, the question of the "truth" of the data is crucial. The participants in our PPGIS survey were asked to mark places "where they enjoy the landscape or landmark." Using this dataset, we calculated a buffer distance of 500 m to model the landscape that the participants enjoyed. This has led to two limitations. First, it is not clear whether the participants enjoyed the landmark, the landscape around the indicated location, or the view from the indicated location. This problem was also faced in a previous study (Wilczyńska, Niin, Vassiljev, Myszka, & Bell, 2023) that mapped and analyzed blue spaces in cities; the study concluded that, although the survey targeted the preferred "blue elements," there was often a preference for "blue spaces" that included different land uses and land covers, on the one hand, and were associated with activities, on the other hand. The second limitation is the focus on analyzing areas (buffers) instead of point data. This was also supported by Ramírez Aranda et al. (2021). In a study on the mapping of cultural services in the city of Ghent, they found that point data reproduced spatial truth the worst, while polygon and marker data generated better results.

Building on these findings, applying a buffer zone was an appropriate solution. However, the radius of the buffer zone has been a much discussed issue in the literature, ranging from fixed buffers (Fagerholm et al., 2019) to several distance zones (Liu, Kang, Wu, Yang, & Meng, 2022; Paracchini et al., 2014) up to 50 km for, for example, mountain regions (Schirpke et al., 2013, 2016). For our purpose of testing CLI (evaluating the impact of individual farms on landscape diversity and perceived naturalness), we kept a 500 m buffer as the initial intention of CLI, and its subindicators were used to measure the impact of agricultural management on visual quality. Therefore, an approach with distance zones is neither applicable nor useful.

4.2. Perception of lu/lc categories

The perception of different land-use and land-cover types is an essential element in the assessment of landscape visual quality. Therefore, we first checked and confirmed that the overall landscape and control landscape were similar. Consequently, we can suppose that our outcomes are reliable. Second, in both regions, the proportion of preferred lu/lc categories was higher in the preferred landscape than in the control landscape. This confirmed Brown et al.'s (2020:4) hypothesis that "mapped place values are related to attitudes toward land-use."

However, our assumption concerning the relative preference for traditional elements and land uses (Freiberge: wooded pasture; Schwarzbubenland: orchards and EFAs) was not generally confirmed. The traditional land-use category in the Freiberge region is wooded pastures consisting of a mixture of grassland, patches of forest, and scattered trees. Traditionally, they are grazed by horses and cows. Because of this mixture, they are of high value for ecology, the landscape, and tourism (Douchet, 1999). Land-use intensification is a threat to this system. Therefore, measures to preserve wooded pastures have been defined in landscape quality projects (Beinder, 2018; Perret, 2016; Scherrer, 2014). However, a local survey of wooded pastures in the canton of Neuchâtel showed that people living in the La Sagne municipality appreciated wooded pastures mainly for identification, relaxation, and natural experience, while participants from Le Locle and La Chaux-de-Fonds (more urban municipalities) appreciated the visual quality of the nice landscape (Miéville-Ott & Barbezat, 2005). These survey results show differences in the perceptions of people from outside the region and of local inhabitants, which was also reported by Hunziker et al. (2008) for landscapes with different amounts of wooded areas. However, the values reported in Miéville-Ott and Barbezat (2005) refer to an attachment to the local landscape and experience of nature, both of which are important values of landscape quality (e.g., Kianicka et al., 2006; Tveit et al., 2006).

Although the literature has suggested a preference for this traditional system, forest, water, and wetland were preferred over traditional wooded pastures in the Freiberge region. Svobodova, Sklenicka, and Vojar (2015) also found high preferences for water and forest in a restored mining landscape, and similar results were reported in Germany when assessing the aesthetic qualities of landscapes. Hermes et al. (2018) attributed a high value to water because of its high perceived naturalness (based on the results presented by Jackson et al., 2008). However, we observed that forest plays a divergent role in terms of landscape preference in the two regions, highlighting the regional dependences of perception values. These regional preferences are also reflected in the literature. Brown (2013), for example, found a high frequency in assigning forest when asked about landscape values in Australia, while Plieninger et al. (2013) could not find any preferences for forest in Germany. We conclude that there are generally valid preference values, but they differ in scope and level depending on the region.

A clear preference was found for traditional orchards and EFAs in the Schwarzbubenland region. These findings are in line with the literature, such as Junge et al. (2011, 2015) and Strumse (1994a,b). Both traditional orchards and EFAs are preferred for their perceived naturalness and flowers. This effect was also reported by Arriaza, Cañas-Ortega, Cañas-Madueño, and Ruiz-Aviles (2004), who, based on a photo-survey for southern Spain, found preferences for wilderness in agrarian landscapes. In addition, we found that the participants avoided intensive fruit production because their share was significantly lower in the preferred landscape than in the control landscape. These findings—high preferences for traditional orchards and low preferences for intensive fruit plantations—imply that these intensive systems cannot serve as modern visual substitutes, despite their intensive blossom.

This unexpected low preference for wooded pastures in the Freiberge region and for intensive fruit production in the Schwarzbubenland region shows either a methodological issue or might be because of the missing "perceived naturalness" (Arriaza et al., 2004; Kianicka et al., 2006). Both preference values were not collected in the original survey, but were derived from the value of traditional high-stem orchards because of their similar habitus. Based on our results, we assume that these preference values were overestimated. Therefore, caution is needed when transferring preference values from one land-use category to another that is presumed to be similar. Moreover, further research is recommended to untangle the interlinkages between traditional and modern land-use categories in terms of how they are perceived.

4.3. Impact on CLI and its subindicators

Based on the datasets and analyses discussed above, the CLI and its subindicators were tested and validated. This validation revealed a clear restriction of CLI and its subindicators to agricultural land-use. Forest, water, and wetlands were not included in its assessment. However, these land-cover categories have, depending on the landscape, a high impact on landscape preference. This interrelation between the agrarian and nonagrarian lu/lc categories and its impact on the indicator was confirmed by our results. To find and understand these interrelations, it was important to base the analysis on an inclusive map that included all possibly preferred lu/lc categories.

The results of the validation of the CLI and its subindicators were satisfactory because the indicators worked as assumed. However, although, on the one hand, the focus on agricultural land limits the area of application of the CLI because only 36 % of Switzerland's surface is covered by agricultural land (Bundesamt für Statistik, 2021), it is, on the other hand, the part of the landscape characterized by the highest rate of changes. These changes originate from different sources. A simple example is the obligation of crop rotation (Bundesrat, 1998, DVZ, Art. 16), which leads to changes in the landscape more or less every year. In addition, the farmers' "management decisions" can lead to land-use changes, such as cutting down trees or converting grassland to cropland.

Assessing landscape changes is important when evaluating the impacts of agricultural policy and maintaining landscape quality for recreation. The CLI and its subindicators provide a toolkit to quantitatively compare different scenarios (policy and land-use) in terms of their impact on visual landscape quality, allowing for the selection of the "best possible" option.

5. Conclusion

Our study has confirmed that PPGIS points mapping aesthetically valuable places indeed showed places where landscape is aesthetically preferred. Therefore, PPGIS points are suitable for validating the indicators that measure visual landscape quality. As a result, we were able to validate the CLI and its subindicators—the ADI and AwPw—by focusing on the assessment of agricultural landscapes. The validation revealed that, in one of the two study regions, the nonagricultural landscape was more preferred than the agricultural landscape. In this case, (protected) wetland, water, and forest were preferred over wooded pastures and EFA and grassland. In both cases, however, the indicator worked as expected. Hence, we consider the validation as being successful.

From this result, we can draw two conclusions. First, it is important to consider the whole landscape when evaluating landscape quality, as in some cases, both the nonagricultural and agricultural parts are important for landscape quality. Second, the CLI and its subindicators are not suitable for a general landscape assessment because they are specialized only for the agricultural landscape. Consequently, the validation highlighted that its application should be restricted to the agricultural landscape. However, the agricultural landscape is important for local recreation. Furthermore, it is characterized by high dynamics induced by seasons, farm management, and policy. Both factors—the high local value and high dynamics—underline the importance of the agricultural part of the landscape and demand regular assessment for monitoring. To meet both, considering the whole landscape and applying a specific indicator specific for the agrarian landscape, we would recommend striving for a combination of a method measuring the overall landscape quality with a method specifically measuring the quality of the agricultural landscape, such as CLI.

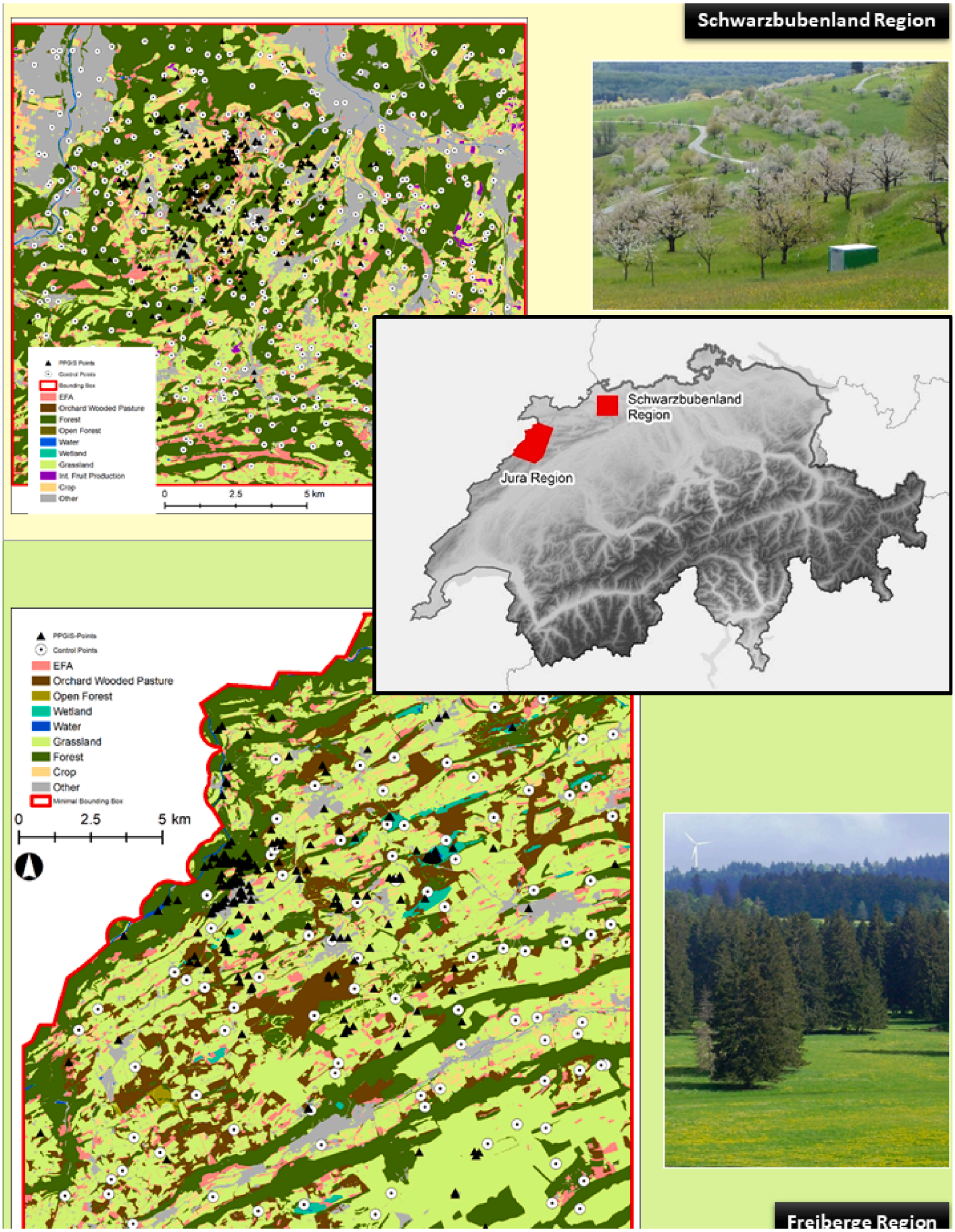
Declaration of Competing Interest

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

Data availability

Data will be made available on request.

Appendix A



Appendix B. Significances

Table B1:
Table B2

Table B1
Proportions of element categories in the control landscape compared with the preferred landscape and statistical significances of the differences (MANOVA).

Region	Land-use type	Overall landscape in bounding box [%]	Control landscape [%]	Preferred landscape [%]	p-value*
Freiberge Region	EFA	5.1	4.82	4.57	ns
	Orchard / Wooded Past.	12.8	13.51	10.17	ns
	Grassland	48.4	**50.79**	**32.99**	**< 0.001**
	Forest	24.9	**20.52**	**33.61**	**< 0.001**
	Open Forest	0.16	0.02	0.12	ns
	Water and Wetland	1.2	**2.37**	**6.03**	**< 0.05**
	Arable Crop	1.7	**2.31**	**0.88**	**< 0.001**
	Other	5.8	5.65	11. 62	Not tested
	Total preferred agriculture	17.8	18.33	14.74	Not tested
	Total preferred Forest, Water, wetland	26.3	25.16	39.74	Not tested
Schwarzbubenland Region	**EFA**	7.4	**7.3**	**9.05**	**< 0.01**
	Orchard / Wooded Past.	0.6	**0.6**	**3.2**	**<0.001**
	Grassland	25.2	24.1	24.94	ns
	Forest	43.7	45.1	41.6	ns
	Open Forest	0.01	0.02	0.004	ns
	Water and Wetland	0.2	**0.2**	**0.02**	**<0.001**
	Int. Fruit production	0.5	**0.47**	**0.27**	**< 0.01**
	Arable Crop	5.5	5.5	6.5	ns
	Other	16.9	16.7	14.4	Not tested
	Total preferred agriculture	8	7.9	12.25	No tested
	Total preferred nonagriculture	44.3	45.32	41.624	Not tested

*The significance refers to the statistical difference between the control and preferred landscape. The statistical difference between the overall and control landscapes was not tested.

Table B2
Values of the composite landscape indicator, the normalized aggregated diversity index, and the normalized area-weighted preference value in the overall and in the visible landscape and statistical significances of the differences (MANOVA and two-sample *t*-test).

Region	Subindicator	Mean value for the Control landscape	Mean value for the Preferred landscape	p-value
Freiberge Region	CLI	0.967	0.959	0.7495
	nADI	0.74	0.692	0.937
	nAwPv	1.199	1.227	0.6233
Schwarzbubenland Region	CLI	**0.98**	**1.03**	**< 0.001**
	nADI	**0.89**	**0.93**	**< 0.05**
	nAwPv	**1.07**	**1.14**	**< 0.001**

Appendix C. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.landurbplan.2023.104906.

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