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Integrating recreation into National Forest Inventories – Results from a forest visitor survey in winter and summer

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ABSTRACT

Forest policy and management traditionally rely on physical forest data from National Forest Inventories (NFIs). Nationwide questionnaire surveys on the other hand provide information on the relationship between the human population and the forest, but data on the link to the physical forest is missing. In order to monitor outdoor recreation, both are needed. The aim of the present study is to bridge this gap by conducting a forest visitor survey in the vicinity of NFI sample plots and linking questionnaire data and NFI data in a multilevel model to determine the visual attractiveness of the forest plots in both winter and summer. In addition to traditional NFI measurements, visibility range was determined by terrestrial laser scanning (TLS). The results show that visual attractiveness was mainly determined by the individual characteristics of forest visitors. Although forest plots were generally liked better in summer, major seasonal differences between forest characteristics were limited to a few parameters, and differences in the characteristics of winter and summer visitors were small. Non-seasonal plot-specific variables played a greater role in explaining visual attractiveness than seasonal differences within the forest plots. TLS proved to be a sophisticated and reliable, but time-consuming, method for determining visibility range. We conclude that the resource-intensive on-site survey yielded interesting results, but that intangible factors and confounding effects made it difficult to pinpoint exactly which features determine forest attractiveness. Future monitoring of forest recreation should aim to strengthen the link between physical forest monitoring, as conducted in NFIs, and socio-cultural forest monitoring.

Management implications: To address the question which methods are suitable to link socio-cultural forest monitoring with an National Forest Inventories (NFI), we recomment to use photos from NFI plots in an online questionnaire survey instead of an on-site study. Although many variables were used in both studies, their explanatory value was considerably lower in the on-site survey than in the online survey. Future on-site studies should aim to capture intangible factors and confounding effects by including more qualitative research, for example by employing Go-Along interviews or visitor-employed photography, in order to provide in-depth information on which social factors should be included in future monitoring approaches. Including standardised visualisations of NFI plots in each round of socio-cultural forest monitoring together with a set of NFI variables relevant for recreation and visual attractiveness could form the missing link between NFIs and socio-cultural forest monitoring.

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1. Introduction

In today's widely urbanised society, forests in the vicinity of settlements are important natural areas for recreation and tourism (Bell, Simpson, Tyrväinen, Sievänen, & Pröbstl, 2009; Pearlmutter et al., 2017; Pröbstl, Wirth, Elands, & Bell, 2010). Recreational areas around urban agglomerations are frequented all year round (Schirpke, Meisch, Marsoner, & Tappeiner, 2018). The increasing importance of forests for recreational purposes also poses questions about how to integrate forest visitor needs and preferences into forest management.

1.1. Forest use in winter and summer

Numerous studies exist on forest use and visitor preferences during the summer season, e.g. extensive reviews by Ciesielski and Sterenczak (2018), Gundersen and Frivold (2008) and Ribe (1989). Studies focusing on winter use or on a comparison of summer and winter recreation, on the other hand, barely exist (Meyer, Rathmann, & Schulz, 2019). In the few existing studies, seasonal differences have been found concerning tree beauty (Zhao, Xu, & Li, 2017), the suitability of forest environments for recreational use (Tyrväinen, Silvennoinen, & Hallikainen, 2017), forest attractiveness (Koivula, Silvennoinen, Koivula, Tikkanen, & Tyrväinen, 2020), perceived restorativeness of forest vegetation (Vassiljev, Kuldkepp, Külvik, Kull, & Mander, 2007) and forest recreational value (Bartczak, Englin, & Pang, 2012).

With the exception of Bartczak et al. (2012), the above-mentioned studies were not conducted as on-site surveys, but used summer and winter photos in off-site surveys. Palmer and Hoffman (2001) caution the use of photographic representations, as physical and visual qualities of the landscape are not always adequately represented in photos, yet this is common practice in landscape preference studies. Furthermore, in the above-mentioned Scandinavian and Polish studies, snow is present in winter and influences the assessments. In large parts of Western and Central Europe, however, snow only covers the ground for a few days a year, if at all, especially in the highly urbanised lowland areas. As the deciduous trees native to these areas shed their leaves in autumn, an impact on forest attractiveness is to be expected. In a rare field study conducted in Southern Germany in summer and winter, Meyer et al. (2019) found that forest benefits were mostly rated lower in winter than in summer. Little is known about the factors determining forest attractiveness in winter compared with in summer, yet this knowledge is needed for forests frequented all year round.

1.2. Visual attractiveness of the forest

Several studies have shown that the perceived visual attractiveness of the forest depends on forest characteristics and on social factors such as values and attitudes concerning forests. Regarding forest characteristics, varying preferences have been found with respect to forest cover, tree spacing and stand structure (Carvalho-Ribeiro & Lovett, 2011; Giergiczny, Czajkowski, Zylicz, & Angelstam, 2015). Understorey height and the presence of flowers and footpaths influence aesthetic and recreational preferences (Wang, Zhao, & Meitner, 2017), while the presence of dead wood remains highly controversial (Pastorella et al., 2016; Rathmann, Sacher, Volkmann, & Mayer, 2020). Agimass, Lundhede, Panduro, and Jacobsen (2018) observed that visually dense forests are less likely to be chosen for recreational trips. Logging, thinning and timber harvesting have also been found to affect visual attractiveness (e.g. Jensen & Skovsgaard, 2009; Petucco, Skovsgaard, & Jensen, 2013; Ribe, 2009).

Concerning the influence of social factors on the assessment of forests, values and attitudes play an important role (Eriksson, Nordlund, Olsson, & Westin, 2012), as do the importance of forest during childhood (Oppliger, Lieberherr, & Hegetschweiler, 2019), socio-demographic variables (Frick, Bauer, von Lindern, & Hunziker, 2018; Tyrväinen, Silvennoinen, & Kolehmainen, 2003) and the level of education and background information (van der Wal et al., 2014).

Insight on linkages between landscape and forest features and recreational use may help in predicting the uses of forest areas for which visitor data are not available (Gerstenberg, Baumeister, Schraml, & Plieninger, 2020). For example, results from predictive models could encourage forest managers to promote recreational activities at specific sites, to manage less attractive areas with a higher priority given to timber production, or to adapt visitor management in ecologically valuable forests that also have a high potential for recreational use (Gerstenberg et al., 2020).

1.3. Natural and social scientific forest monitoring

The assessment of forest features, resource availability and evaluation of the state of the forest has traditionally been carried out though National Forest Inventories (NFIs) in many countries (Tomppo, Gschwantner, Lawrence, & McRoberts, 2010; Vidal, Alberi, Hernández, & Redmond, 2016). NFIs monitor a wide range of forest characteristics, such as stand structure, ground vegetation cover and dead wood, and document changes over time, thereby providing relevant information as a basis for policy, planning and management (Brändli & Hägeli, 2019; Tomppo et al., 2010). Modern NFIs use statistical sampling designs, mostly with plots within systematic grids covering whole countries (Lawrence, McRoberts, Tomppo, Gschwantner, & Gabler, 2010).

Social indicators, however, are only marginally considered in NFIs, in spite of the increasing recreational use of forests (Atkinson et al., 2020). In the Swiss NFI, only infrastructure for and damage caused by recreational use are assessed during the field survey. However, the Swiss NFI uses interviews with all local forest services to enquire about recreation, e.g. intensity, type and seasonality (Fischer, Brändli, Leuch Allgaier, & Cioldi, 2020; Fischer & Fraefel, 2019; Fischer & Traub, 2019). Direct measures of people's attitudes, preferences and behaviour have been lacking.

On the other hand, social indicators including forest preferences and recreational behaviour are often assessed in national surveys (Sievänen et al., 2008). In Switzerland, socio-cultural forest monitoring (WaMos) has been conducted approximately every 10 years, i.e. in 1997 (BUWAL, 1999), 2010 (BAFU, 2013; Hunziker, von Lindern, Bauer, & Frick, 2012) and 2020 (ongoing). The survey provides information on people's perception and knowledge of the forest, their preferences for certain forest types and features, and their assessment of the forest they visit most often (Frick et al., 2018; Hunziker et al., 2012). However, an objective description of the forest characteristics according to the NFI is lacking in this context.

1.4. Linking forest characteristics with social factors

One possible model describing the bridge between forest characteristics, i.e. the physical forest and social factors, was developed by Hegetschweiler, de Vries, et al. (2017). In this so-called confluence model, an ecosystem, e.g. a forest, characterised by factors such as size, type, vegetation and facilities, supplies cultural ecosystem services (CES) as defined by the Millennium Ecosystem Assessment (MEA, 2005). Concerning social factors, the population comprising individuals with varying e.g. age, preferences and values demands the CES offered. The match between the physical and social factors results in the use of CES and subsequent benefits, such as enjoyment of an attractive forest and good health (Hegetschweiler, de Vries, et al., 2017).

When applying this model to forest characteristics, such as those assessed in NFIs, and the population's relationship to the forest, as examined in socio-cultural forest monitoring, we are aware of two approaches. One is to take visualisations of NFI sample plots with underlying forest data and use them in a questionnaire survey, as in Hegetschweiler, Fischer, Moretti, and Hunziker (2020). The other approach is to conduct an on-site forest visitor survey in NFI sample plots and relate recreational use and forest perceptions to on-site forest data. This approach was successfully tested in a pilot study (Hegetschweiler, Plum, et al., 2017).

1.5. Aim and research questions

In the present study, we extended the approach used in the pilot study to the whole of Switzerland in winter and summer. Our first aim was to evaluate the method developed in the pilot study of Hegetschweiler, Plum, et al. (2017) of carrying out forest visitor surveys at NFI sample plots as a way of integrating socio-cultural forest monitoring into NFIs. We aimed to provide a link between these two forest monitoring instruments by using data on forest characteristics assessed in the NFI and questionnaire data obtained from population surveys to determine the perceived visual attractiveness of the forest. Given the lack of on-site studies concerning visual attractiveness of forests in winter compared with summer, especially in conditions without snow, our second aim was to assess socio-demographics and activities of forest visitors, their motives for forest visits, and their perceived visual attractiveness of the forest in winter compared with summer.

Our specific research questions were:

- Are forest visitor surveys conducted at NFI sample plots a suitable method to integrate socio-cultural forest monitoring into NFIs?
- Are there seasonal differences in forest visitor characteristics, activities and motives?
- Which forest characteristics and social factors determine the visual attractiveness of the forest in winter and summer as perceived by forest visitors?

2. Material and methods

2.1. Determination of forest plots and data collection

The NFI database was searched for sample plots with a high or very high recreational demand according to the local recreation potential model (Brändli & Ulmer, 2001). After field inspection, 26 forest plots were chosen. We took care to ensure that the plots were more or less well distributed across Switzerland. After this first plot selection, several regions remained underrepresented, so an additional 15 plots were chosen based on recommendations of forest authorities, resulting in a total of 41 plots (Fig. 1).

The interview location near each NFI sample plot was determined by searching for the highly frequented footpath nearest to the plot. The area to be surveyed was defined by looking in the direction of the unmarked NFI plot from the centre of the footpath as far as one could see. A red and white pole was inserted into the ground on each side at an angle of 85 gon and a distance of 8 m (Fig. 2).

This setup was developed and tested in four different forests in spring 2017. Subsequently, the same setup was applied to all 41 plots. The interview locations were marked with blue paint and documented on maps with coordinates and a hand-drawn sketch.

The winter forest visitor survey was carried out between December 2017 and March 2018, and the summer survey between May and September 2018. Forest visitors were interviewed face-to-face using tablets with the offline function of the online survey tool Sawtooth Software Lighthouse Studio, version 9.3.0 (Sawtooth, 1998), with paper versions of the same questionnaire on hand as backup.

We aimed to capture data from 20 or more visitors per plot in both winter and summer, following the recommendations for sample size required for multilevel modelling by Baltes-Götz (2013). This target was achieved with seven exceptions in winter and one exception in summer due to low frequentation of those areas. However, in each of these instances at least 15 visitors were interviewed. In total, the questionnaire was completed by 1745 forest visitors, with 850 participants in winter and 895 in summer. It was assumed that the participants from each season were independent, i.e. all different people.

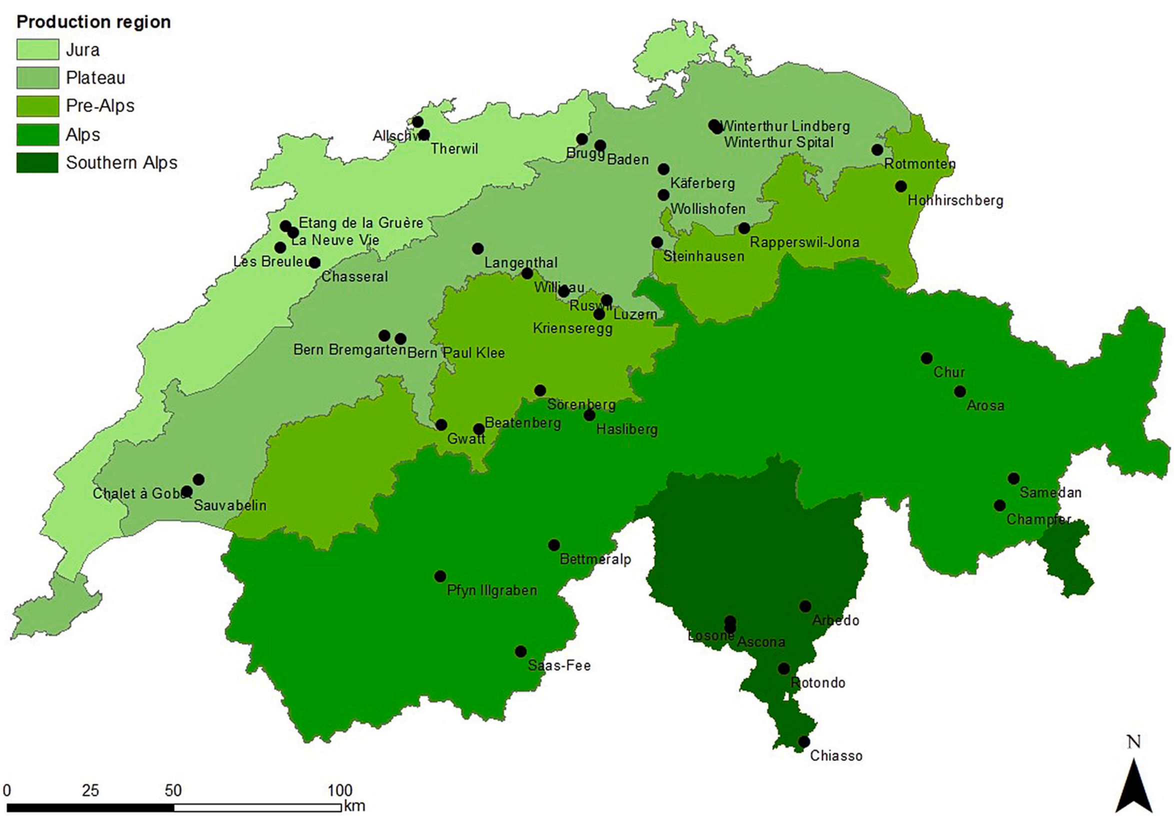

Fig. 1. Distribution across Switzerland of the 41 NFI sample plots where interviews were conducted.

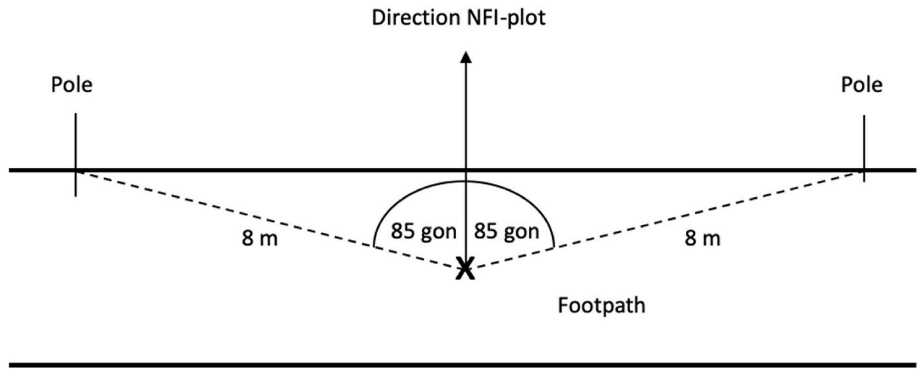

Fig. 2. The setup at each interview location determining the forest area to be rated for perceived visual attractiveness by forest visitors.

2.2. Questionnaire survey

The questionnaire (Appendix A; Hegetschweiler, Fischer, Ginzler, & Hunziker, 2021) was an adapted version of the questionnaire used in our pilot study (Hegetschweiler, Plum, et al., 2017) and mainly consisted of a subset of questions that had been asked during the 2010 household survey (Swiss socio-cultural forest monitoring WaMos2; Hunziker et al., 2012). The questionnaire was pretested during 4 days at two plots, one highly frequented and one moderately frequented, on one weekday and one weekend day each. This ensured the clarity of the questions and the optimal length of the questionnaire. The questionnaire consisted of general questions concerning activities the respondents were undertaking in the forest at the time of the interview, the frequency of their visits, travel time to the forest and socio-demographics. The core part was the question asking respondents to look in direction of the NFI plot and rate the perceived visual attractiveness of the forest on a scale from 1 to 10. Respondents were also asked about their own inherent forest preferences, irrespective of the forest they were rating, their motives for visiting the forest, and what they disliked about the forest.

2.3. Collection of objective physical forest data (“NFI data”)

Objective physical forest data were collected from the defined interview location (“**X**” in Fig. 2), to match the visitors’ perspective. In this respect, data collection differed from the standard NFI procedure, where data are collected on fixed-area plots with field crews moving freely within the plot to estimate the various parameters. Data were collected on a tablet, using the open-source software Open Foris, version 3.13.9 (FAO). Because many forest characteristics differ in appearance and prevalence between the seasons, data were collected twice, once in winter (February/March 2018) and once in summer (May/June 2018) – contrasting the standard NFI procedure, where data on a given sample plot are collected only once per NFI cycle (field season April to November).

The objective physical data largely consisted of a subset of parameters normally examined on NFI sample plots (Düggelin et al., 2020). First, we recorded the forest type, e.g. beech forest or larch–pine forest. Fourteen parameters followed the NFI definition. These were: the structure, size, height and age of the stand, the stage of stand development, the cover of ground vegetation, shrub layer and berry bushes (*Rubus* sp. and *Vaccinium* sp.), the degree of mixture of coniferous and broadleaved trees, and the presence of root plates, snags (standing dead trees), natural and artificial regeneration, geomorphological objects, dry stonewalls and stone piles.

Three NFI parameters were adapted for use in this study: stumps, lying dead trees and lying dead wood. Stumps were recorded separately from lying dead trees when visible and dead wood was recorded at an estimated diameter of >3 cm instead of >7 cm. Seven parameters considered possibly relevant for recreation were additionally defined, following recommendations in the literature. The presence of moss, ivy, ferns, flowers and fallen leaves or needles could be important for visual attractiveness (Nielsen, Gundersen, & Jensen, 2018; Nielsen, Heyman, & Richnau, 2012; Vega-Garcia, Burriel, & Alcazar, 2011; Wang et al., 2017). Likewise, we estimated the number of stems per ha, as stem density has been found to affect visual attractiveness (Jensen & Skovsgaard, 2009). Because Switzerland was affected by windstorms in December 2017 and January 2018, we also recorded recent windthrow in the plots.

2.4. Visibility/openness of the forest measured with a terrestrial laser scanner

In order to quantify the depth of view into the forests at the points of the interviews, 3D data were taken using terrestrial laser scanning (TLS). With TLS, laser pulses are emitted in a 360° sphere. When a laser pulse hits an obstacle, it is reflected. The distance to the scanner is determined from the phase shift and the coordinates of the obstacle are calculated from the scan angle. Within a short time (ca. 7 min) 170 million distances are measured and a 3D point cloud is calculated. If most of the emitted laser pulses are reflected close to the observer’s point of view, a low visibility depth into the forest is inferred. The distribution of the reflection points was subsequently analysed.

2.5. Data analysis

Data analysis consisted of three distinct parts. First, we wished to identify the underlying constructs or factors that preference and motive-items were measuring – using exploratory factor analysis (EFA), and then we aimed to determine how well these constructs were being measured – using confirmatory factor analysis (CFA). The EFA employed Principal Axis Factoring to extract factors and oblique rotation to aid interpretation (Conway & Huffcutt, 2003). The EFA and CFA were run on distinct randomly selected halves of the data (a construction half and a validation half), so as to avoid any upward bias in the CFA model fit caused by testing a model on the same responses that it was built on (Fokkema & Greiff, 2017). Following these analyses, we computed mean scale scores for the forest preference and motive factors, by computing the average scores across the respective sets of items loading on each factor.

The second stage of the analysis involved a descriptive approach to examining differences between winter and summer in the forest characteristics and visitor characteristics. For assessing seasonal differences in the forest characteristics, we calculated the percentage of the plots where each NFI variable differed between summer and winter. To assess any seasonal variations in visitor characteristics, we compared the summer and winter questionnaire results, using mean scores or percentages as appropriate.

Finally, we addressed the questions of whether perceived visual attractiveness of the forest differed between the seasons; which forest characteristics and social factors were most strongly related to perceptions of visual attractiveness; and whether the relative importance of these forest characteristics and social factors varied by season. We fitted a multilevel regression model in which visual attractiveness of the forest was predicted by season of visit, forest characteristics and social factors; and the effects of forest characteristics and social factors were moderated by (i.e. allowed to vary by) season. A three-level multilevel approach was necessary. Respondents (person-level) were nested within the plot-season level. This level consisted of season-dependent plot-level variables. Respondents were also nested in the plots themselves, for which we had a limited number of non-season-specific estimates of variables such as stand age and stand height (Fig. 3).

For each season nested within a plot, a mean value was calculated for each person-level variable and subtracted from the original value to obtain a centred value for each respondent. The same procedure was applied to plot-season level variables. By doing this, we took into account that ratings within a group are related to each other and used values relative to other group members for further modelling rather than the absolute value of each group member (Enders & Tofighi, 2007).

The dataset was again randomly split into two equal halves, with the model built on one (construction) half. The unconditional model showed how much variance in perceived visual attractiveness could be attributed to each level. We then added the person-level predictor variables measuring demographic background, variables related to the subject's visit (e.g. weather, activity, travel details) and the mean scale scores from the factor analysis for forest visit motives and forest preferences. We retained variables that explained at least 1% of the variability on the person level.

Using the same criteria for retention, we then explored the best plot-season level model, adding as predictors the NFI measures of plot characteristics that varied by season. We applied the same process at the plot level, adding as predictors the NFI measures of plot characteristics that were season invariant. Finally, we explored whether any further variance was explained by allowing the person-level effects to vary by season by adding the interaction terms of person-level effects by season. The resulting model was then tested on the other (validation) half of the data.

For the estimation of visibility range, TLS data were analysed as follows:

The field of view of the two eyes of the observer overlap (binocular vision). The visual field of binocular vision and thus of depth perception is 120°. Therefore, for further analysis, the 3D point cloud was restricted to a horizontal range of 120° (60° to the left of the observer's centre point and 60° to the right) and 130° in the vertical range (60° up and 70° down). The viewing space was divided into spheres of 1 m width and the distribution of reflected points was calculated for each sphere. For each sphere, the fraction of all points was calculated. When a cumulative fraction of 90% was reached, this distance was used as a proxy for the openness of the forest. The longer the distance, the more open the forest.

The building and testing of our factor model (EFA and CFA) were conducted using path analysis software Mplus version 8.2 (Muthén & Muthén, 2018). All other analyses were performed using SPSS statistical software version 25 (SPSS, 2015). When testing our model, a $p < 0.05$ level of statistical significance was employed.

3. Results

3.1. Factor structure of forest preference and motive items

A series of exploratory factor analyses (EFA) examined the factor structure of the 14 forest preference items and the 9 motives for visiting the forest items (listed in Appendix A). The items, each of which was plot-season centred, were analysed together, with the analysis run on one random half of the data. The results suggested that a seven-factor solution provided the best fit, based on both a scree plot of the eigenvalues and Kaiser's Criterion (Conway & Huffcutt, 2003). Appendix B shows the item-factor loadings from this seven-factor solution. Three items were dropped due to not achieving adequate loadings on any factor, unless a further factor was extracted that would be specific to that item. Furthermore, for each of these items, responses were clustered at one end of the scale resulting in minimal variance between respondents.

The four factors retained for forest preference were interpreted as:

- preference for micro vegetation (moss, lichens, ferns, ivy, ground vegetation)
- preference for certain tree types (predominantly coniferous or predominantly deciduous forests)
- preference for dead wood (many branches/piles of branches on the ground, lying dead trees, a lot of dead leaves/needles on the ground)
- preference for mixed, more open forest structure (coniferous and deciduous trees mixed, many bushes/shrubs and young trees)

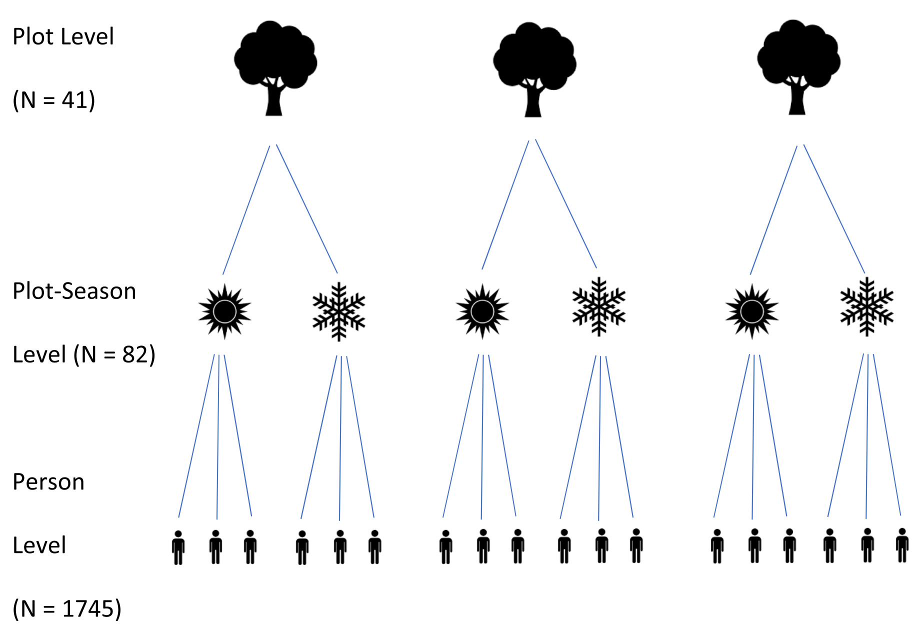

Fig. 3. Diagram of the multilevel structure of forest data.

A preference for being able to see far into the forest was dropped due to failure to achieve adequate loading on any factor.

The three factors retained for motives for forest visits were interpreted as:

- motive of experiencing peace and nature (enjoying nature, enjoying peace and quiet)
- motive of physical health/fitness (to do sports, for health reasons)
- motive of social reasons (to have fun, to meet friends, to spend time with family)

The two motives "to be unobserved" and "to walk the dog" were dropped due to failure to achieve adequate loading on any factor.

When performing a confirmatory factor analysis (CFA) of this seven-factor structure on the other random half of the data, a satisfactory fit was achieved (Chi-sq = 663.757 on 149 df, CFI = 0.938, RMSEA = 0.053, SRMR = 0.050; Hu & Bentler, 1999). This seven-factor model also out-performed plausible competing models in which various combinations of the forest preference and/or the motive factors were combined (see Appendix C for model comparisons).

The internal consistency reliability of the items loading on each factor varied between low and satisfactory (specifically, preference for micro vegetation: Cronbach's alpha = 0.72; preference for certain tree types: alpha = 0.63; preference for dead wood: alpha = 0.74; preference for mixed open forest structure: alpha = 0.45; experiencing peace and nature: alpha = 0.48; physical health/fitness: alpha = 0.55; 'for social reasons': alpha = 0.44). The weak internal consistency of the motive scales and the forest preference for mixed open forest scale was influenced by the small numbers of items (two) within these scales.

Table 1
Number (percentage) of plots where forest characteristics differed between the winter and the summer assessment.

Variable	No difference	Differences between winter and summer assessment
Seasonal characteristics		
Ground vegetation cover* (6 classes)	9 (22%)	32 (78%)
Shrub layer cover* (6 classes)	21 (51%)	20 (49%)
Cover of berry bushes* (6 classes)	16 (39%)	25 (61%)
Geomorphological objects, microrelief* (11 classes)	34 (83%)	7 (17%)
Stone walls and stone piles** (visible/non-visible)	38 (93%)	3 (7%)
Stumps >30 cm diameter** (visible/non-visible)	34 (83%)	7 (17%)
Lying dead trees >30 cm DBH** (visible/non-visible)	35 (85%)	6 (15%)
Standing dead trees** (visible/non-visible)	36 (88%)	5 (12%)
Woody debris >3 cm diameter** (visible/non-visible)	32 (78%)	9 (22%)
Root plates >30 cm height** (visible/non-visible)	35 (85%)	6 (15%)
Cover of leaves or needles on the ground (6 classes) ***	17 (46%)	20 (54%)
Windthrow by recent storms*** (visible/non-visible)	35 (85%)	6 (15%)
Presence of moss*** (visible/non-visible)	31 (76%)	10 (24%)
Presence of ferns*** (visible/non-visible)	33 (80%)	8 (20%)
Presence of flowers*** (visible/non-visible)	12 (29%)	29 (71%)

* NFI parameters;
** Adapted NFI parameters;
*** Additional parameters.

3.2. Seasonal differences in forest characteristics

Table 1 shows the forest characteristics that differed between the winter and the summer assessment. Seasonal differences in vegetation, e.g. the cover of the shrub layer, ground vegetation and berry bushes, and the presence of flowers were found in the majority of the plots. Several differences reflect the reduced visibility in summer due to screening by vegetation. Certain geomorphological objects, stone piles, dead wood, etc. sometimes could not be seen from the path in summer because they were hidden by vegetation. Similarly, certain objects and leaves and needles on the ground were covered by snow in some plots in winter.

In contrast to the seasonally differing characteristics, the following characteristics did not differ between the seasons and were hence treated as plot-level variables, as opposed to season-dependent variables (plot-season-level variables) in the subsequent model building and testing:

- Stand structure (4 classes)
- Stage of stand development (5 classes)
- Stand age (years)
- Stand size (3 classes)
- Stand height (m)
- Degree of mixture (% deciduous trees, 4 classes)
- Number of stems per ha
- Type of regeneration (2 classes)
- Presence of ivy (yes/no)

Non-seasonal plot characteristics were typically stand characteristics and the presence of ivy on trees, which could easily be seen irrespective of snow cover or dense vegetation.

3.3. Seasonal differences in forest visitor characteristics, activities and motives

The socio-demographic profile of winter visitors to the forest barely differed from that of the summer visitors (Table 2). In winter, visitors were usually interviewed in the forest they visited most often, whereas in summer this was less often the case. A greater proportion of winter visitors came from urban areas compared with summer visitors. Together, these patterns suggest that the winter respondents regularly visited the same forest, most likely as a local recreation destination, whilst in summer at least some of the respondents were visiting a forest they did not go to regularly, which might be interpreted as a touristic activity. There were no differences between summer and winter respondents in age, gender, level of education, number of children in household, disabilities, parents' country of origin, forest ownership, membership in environmental organisations, membership in youth organisations such as scouts, and free play in the forest as children (Table 2).

Table 2
Summary of the characteristics of 850 forest visitors in winter and 895 visitors in summer.

	Winter	Summer
Mean age (years) ± SD	54 ± 17	52 ± 17
Number of children in household ± SD	0.58 ± 1	0.62 ± 1
% females	54	54
% members environ. organisations	29	28
% forest owners	34	37
% respondents with disabilities	7	8
% respondents with Swiss origins	78	80
% from urban place of residence	68	62
% members of youth groups	39	37
% with free play in forest	81	82
% respondents interviewed in the forest they visit most often	61	49

Regarding research question 2, Fig. 4 shows the activities that respondents were doing immediately prior to their interview. The most frequent activities were walking with or without a dog and hiking. The graph shows that the proportion of people going for a walk was higher in winter than in summer. In contrast, in summer the proportion of people hiking, mountain biking or cycling was higher, while the proportion of forest visitors jogging, horse riding and Nordic walking was similar in both seasons. It seems that the range of activities conducted in winter is smaller and strongly dominated by walking, no doubt due to the winter conditions (i.e. snow and ice) being less conducive to the other activities seen more frequently in summer. Winter sports could be conducted at only 7 of the 41 plots in winter and played a minor role.

The most important motive for visiting the forest was experiencing peace and nature, both in winter and in summer (mean score winter: 4.72, 95% CI = 4.68–4.75; mean score summer: 4.68, 95% CI = 4.64–4.72), followed by the motive to do something for physical health and fitness (winter: 4.37, CI = 4.32–4.43; summer: 4.26, CI = 4.20–4.32). The least important motive in both seasons was visiting the forest for social reasons (winter: 3.29, CI = 3.22–3.36; summer: 3.32, CI = 3.25–3.39).

Of the potential factors that visitors disliked about forests, mosquitoes, ticks and other creepy-crawlies were rated as most relevant by forest visitors on a scale of 1–5, but were perceived as less of a threat in winter (mean score winter: 3.73, 95% CI = 3.63–3.84) than in summer (4.00, CI = 3.90–4.09). This is likely because insects are less prevalent or at least less active in winter, and possibly because those people visiting forests in the harsher conditions of winter are more tolerant regarding the unpleasant sides of nature. This was followed by a dislike of logging (winter: 2.38, CI = 2.28–2.48; summer: 2.29, CI = 2.20–2.39) and logging residues (winter: 2.27, CI = 2.18–2.37; summer: 2.35, CI = 2.26–2.45), feeling disturbed by other forest visitors such as bikers (winter: 2.20, CI = 2.11–2.29; summer: 2.21, CI = 2.12–2.30), and a fear of unleashed dogs (winter: 2.04, CI = 1.95–2.14, summer: 2.04, CI = 1.95–2.13). Of least concern was poisonous plants (winter: 1.20, CI = 1.15–1.24; summer: 1.29, CI = 1.24–1.34).

3.4. Model for predicting perceived visual attractiveness from season, forest characteristics and social factors

When building the model for predicting perceived visual attractiveness of the forest on one random half of the data, the variance in visual attractiveness was concentrated at the person level (84%), with the remainder split almost equally between the plot-season and plot levels. Of the person-level predictors, age and having a Swiss (as opposed to foreign) background were the only demographic variables that explained 1% or more of the person-level variance. Visiting the forest to walk a dog (single item), visiting the forest for social reasons (scale mean score), and a preference for micro-vegetation such as ferns, moss and

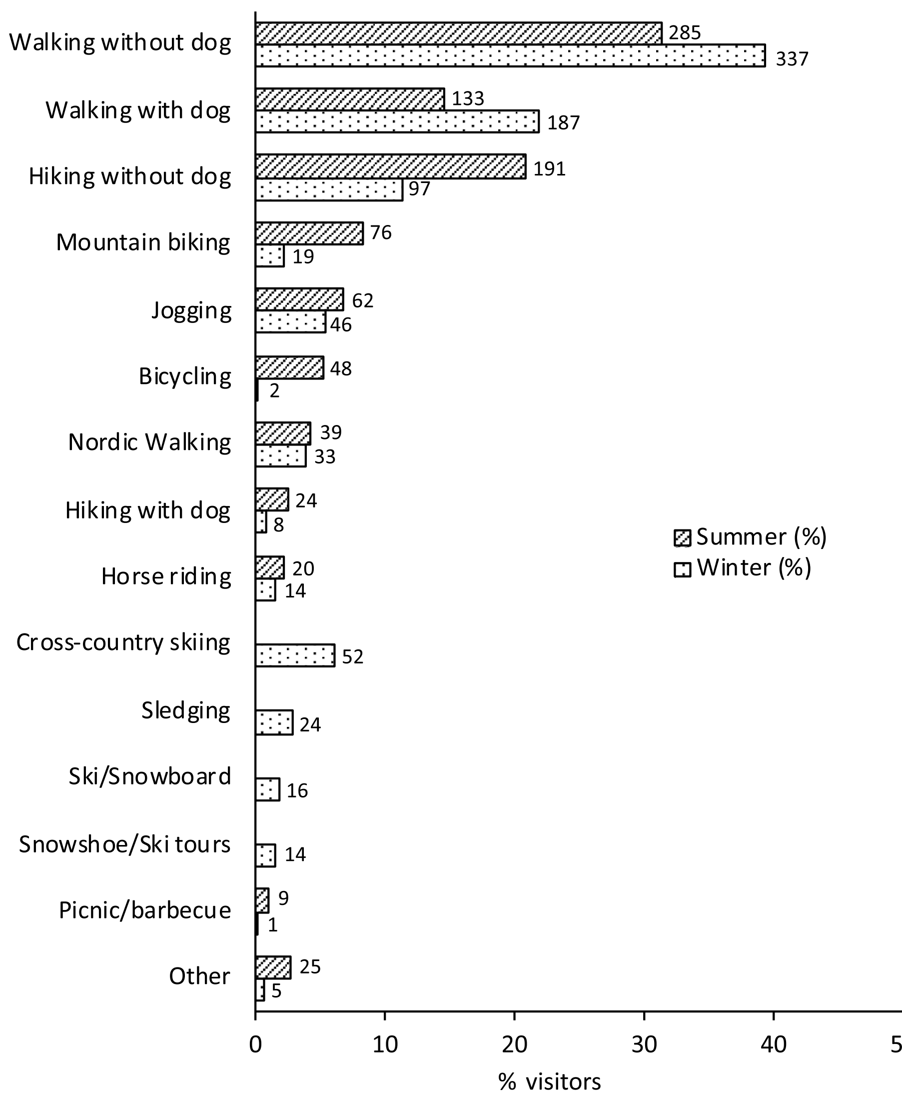

Fig. 4. Activities of forest visitors in summer and winter at 41 forest plots in the whole of Switzerland. Numbers next to bars indicate sample sizes.

lichens (scale mean score) were likewise the only person-level forest-appreciation or visit-motivation variables that were retained. At the plot-season level, the strongest explanatory variables for between-plot-season variance were the presence of stone piles (negative effect), the presence of large dead lying trees (negative effect), and the presence of berries/berry bushes, the effect of which was moderated by season such that it was positive in summer. Finally, at the plot level, the predictors that explained the most variance between plots were the presence of windthrow, the presence of ivy, and the openness of the forest, each of which had a negative effect.

Testing this proposed model on the validation half of the data resulted in the majority of effects achieving statistical significance at the $p < 0.05$ level, though none of the effects at the plot-season level were supported in this way. Collectively these predictors explained 3% of person-level variance, 3% of plot-season-level variance, and 40% of plot-level variance (Table 3).

4. Discussion

4.1. Integrating social aspects into the NFI

Our first goal was to develop and test forest visitor surveys as a method to integrate socio-cultural forest monitoring into the Swiss NFI. In order to discuss this question, we first need to investigate links between the physical forest and forest visitors' preferences. The first very general finding was that 16% of the variance in visual attractiveness of forest plots can be attributed to seasonal (plot-season level) and non-seasonal (plot-level) forest characteristics. This is consistent with the results of our pilot study, in which forest characteristics accounted for 15% of the variance in visual attractiveness (Hegetschweiler, Plum, et al., 2017). To conclude, what the forest looks like and therefore how it is managed do play a role in use for recreation. The survey revealed several relevant NFI variables, e.g. visibility range, lying dead trees, cover of berry bushes, and the presence of ivy on trees. Visibility range and ivy are not routinely assessed by the NFI yet, thus these findings provide an added value to the NFI. Both forest characteristics and social factors explained perceived visual attractiveness, showing that conducting questionnaire surveys and linking them to the assessment of physical forest data is a possible method of integrating recreation and other social aspects into NFIs.

Table 3
Coefficients from the model testing stage, for predicting perceived visual attractiveness.

Predictor	Estimate	SE	p
Intercept	8.832*	0.581	<0.001
Person-level predictors †			
Age (years)	0.011*	0.004	0.003
Swiss nationality (1 = Yes, 0 = No)	0.297*	0.158	0.030
Mean Scale Score – Motive for visiting forest is Social/fun	0.136*	0.063	0.015
Mean Scale Score – Motive for visiting forest is walking dog	0.070*	0.038	0.033
Mean Scale Score – Preference of micro-vegetation (e.g. mosses, lichens, ferns)	0.312*	0.095	0.001
Plot-season-level predictors (NFI data) ‡			
Season (1 = Summer, 0 = Winter)	0.100	0.176	0.286
Cover of berry bushes	−0.076	0.179	0.336
Presence of stone walls and stone piles	−0.260	0.654	0.346
Presence of large dead trees lying on ground	0.063	0.479	0.448
Cover of berry bushes * Season	0.254	0.292	0.195
Plot-level predictors (NFI data)			
Plot mean (average of season scores): windthrow	−0.867*	0.512	0.049
Distribution scan points (higher value = more open forest)	−0.170*	0.093	0.037
Presence of ivy on trees	−0.511*	0.261	0.028

N = 863 (validation half of the data, listwise deletion of missing data across items).
* $p < 0.05$, 1-tailed test.
† Plot-season-mean centred.
‡ Plot-mean centred.

4.2. Seasonal differences

Our second and third goals were to investigate seasonal differences in visual attractiveness and forest use. In the multilevel model, about 8% of the variance in perceived visual attractiveness could be attributed to seasonal differences within forest plots (plot-season level), of which we were able to explain 3% with the parameters we assessed. Overall, forests were better liked in summer than in winter. This is consistent with other studies in which summer images appeared more attractive than winter images, except when picturing intensively harvested forests, in which the visible impact of logging was reduced by snow cover (Gramann & Rudis, 1994; Koivula et al., 2020; Tyrväinen et al., 2017).

When looking at which forest characteristics influenced visual attractiveness, we must first consider which characteristics exhibited large seasonal differences (Table 1). The largest differences were found in ground vegetation cover, cover of berry bushes, presence of flowers and, to a lesser extent, cover of leaves and needles and shrub layer cover (seasonal differences found in about 50% or more of the plots). For all other parameters, seasonal differences were only found on a minority of the plots. This shows that the NFI parameters and their assessment are mostly independent of the season. Likewise, repeated measurements on NFI plots in spring and late autumn showed no effects of seasonality (Hegetschweiler, Plum, et al., 2017; U.-B. Brändli, personal communication, August 24, 2015).

The only parameter that exhibited an interaction effect with season was the cover of berry bushes, which had a negative effect in winter and a positive one in summer. Berry bushes are typically *Rubus* sp. in the lowlands and *Vaccinium* sp. in the Alps. *Vaccinium myrtillus* produces edible fruits and is popular both for its berries and as part of the alpine landscape in summer. In winter, the bushes are mostly covered with snow and often not visible. Similarly, forests in Poland were found to be most valuable for recreation in autumn, partly due to the possibilities of mushroom picking (Bartczak et al., 2012). Although the fruits of *Rubus* can be eaten, is unpopular because of its thorns. It covers the ground in large areas in the lowland forests and is visible all year round, especially as the ground in the lowlands is normally covered with snow for only a few days each winter, if at all.

Regarding individual characteristics of forest visitors, we found hardly any differences between the seasons, indicating that essentially the same type of people visit the forest in winter as in summer. Because we did not survey the same individuals in winter and summer, we cannot test for differences in seasonal perceptions within participants. In more touristic areas, visitor profiles to National Parks do differ between summer and winter (Bravo-Vargas, Garcia, Pizarro, & Pauchard, 2019; Gorner & Cihar, 2011). However, half of the forests in our study were typically used for nearby recreation and are probably frequented by more or less the same residents all year round.

4.3. Plot-specific characteristics

To address research question 3, we examined which forest characteristics play a role in visual attractiveness. Eight percent of the variance in visual attractiveness was due to differences in characteristics between the plots, of which we could explain 40%.

Visibility range had a negative effect on perceived visual attractiveness, suggesting that visitors preferred forests with a shrub layer and a certain amount of screening through vegetation to very open forests without any understorey. This partly contrasts studies showing that a rise in visible distance increases scenic beauty in forest stands (Chen, Sun, Liao, Chen, & Luo, 2016; Rudis, Gramann, Rudell, & Westphal, 1988). However, in a Delphi survey, experts proposed a bell-shaped relationship between visual penetration and recreational value, indicating that most people prefer a medium visibility range and that recreational value decreases for very open as well as for very dense forests (Edwards et al., 2012).

Ivy on trees showed a negative effect, as already observed in a previous online study (Hegetschweiler et al., 2020). Experience from the interviews in the field showed that a lot of people think that ivy harms the trees and rate ivy negatively for this reason. Knowledge and interpretation of scenes has been found to influence attractiveness ratings of landscapes (Kearney & Bradley, 2010).

Leaf colour is another factor that has been found to influence visual attractiveness, with scenic beauty being rated higher for colourful forest landscapes in late autumn compared with green forest landscapes in early autumn (Dhami & Deng, 2009). As deciduous trees are not foliated in winter and therefore might be considered less attractive, we expected that the degree of mixture (proportion of coniferous trees) would have an influence on visual attractiveness. This, however, was not the case.

4.4. Individual characteristics of forest visitors

Research question 3 also deals with the influence of social factors on perceived visual attractiveness. The results showed that visual attractiveness was mainly determined by individual characteristics (84% of the variance). This finding is remarkable considering that much of the forest preference research has focused on how environmental characteristics affect perceived scenic beauty or attractiveness, rather than on relationships between viewer attributes and attractiveness ratings (Kearney & Bradley, 2010). Similarly, in their review of European studies examining the effects of physical and social factors on cultural ecosystem services such as aesthetics, Hegetschweiler, de Vries, et al. (2017) noted that only few significant effects of social factors had been reported.

The person-level predictors within our model explained only 3% of the above-mentioned 84% of variance. Individual characteristics were comprised of socio-demographics, childhood experiences with forests, motives to visit the forest, and general forest preferences. In general, attitudes and values have been found to have a greater influence on perceived attractiveness than socio-demographic factors, knowledge and stakeholder group membership (Kearney & Bradley, 2010). Unfortunately, environmental attitudes and attitudes (positive or negative views) toward forest management were not assessed in our study, which may be a reason for the low explanatory power of our model.

As in our previous online study (Hegetschweiler et al., 2020), the older the respondents were, the higher they were likely to rate the attractiveness of the plot. We also found that people of Swiss origin on average rated the forests higher than foreigners. This could be due to cultural differences in the perception of nature and its management, or to familiarity with the type of forest respondents grew up with (Lindemann-Matthies, 2017). In addition, walking with a dog positively affected the rating of visual attractiveness. Dog walkers often frequent the forest nearest to their home and, again, user experience and familiarity with this particular forest might influence attractiveness ratings (Kaplan & Herbert, 1987; van der Jagt, Craig, Anable, Brewer, & Pearson, 2014).

In contrast to findings from our previous studies (Hegetschweiler et al., 2017b, 2020; Hunziker et al., 2012), the importance of forest during childhood, contemplative motives and general forest preferences hardly explained any variance in visual attractiveness.

4.5. Limitations and recommendations for future research

Although perceived visual attractiveness is mainly attributed to individual characteristics, it is still unclear which factors really determine forest perception. Van der Jagt et al. (2014) attribute this to unreliable measures, confounding variables and non-linear relationships. In the WaMos2 survey in 2010, perceived forest qualities had large effect on forest preference (Hunziker et al., 2012). We postulated that replacing perceived characteristics with real NFI data would provide a clearer picture of which characteristics determine forest attractiveness. However, the low explanatory value of our chosen variables show that it would have been necessary to include perceived forest structures as well, as it is not clear what people really saw and perceived while assessing forest plots. Furthermore, subtle details such as sunbeams, bright colours and branches in ornate patterns are often captured as favourable attributes in visitor-employed photography (Nielsen et al., 2012). Further factors that could influence the perception of forest attractiveness are the societal and symbolic meanings respondents attribute to forests (Jenal, 2019; van Marwijk, Elands, & Lengkeek, 2007), and perceptual experiences such as sounds (both positively perceived nature sounds and negatively perceived external noise) and scents (Jenal, 2019; O`Brien, Morris, & Stewart, 2012; Weber & John, 2019). Therefore, future on-site studies should aim to capture these factors by including more qualitative research, for example by employing Go-Along interviews (Kusenbach, 2003) or visitor-employed photography (Nielsen et al., 2012).

5. Conclusions and recommendations for monitoring

To address our first question regarding the search for a method to link socio-cultural forest monitoring with an NFI, we conducted a forest visitor survey at NFI sample plots. A previous online study (Hegetschweiler et al., 2020) enables us to compare these on-site findings with an online approach. Although many variables were used in both studies, their explanatory value was much lower in the on-site survey than in the online survey. Reasons for this might be intangible factors and confounding effects in the field, and factors on the individual level not captured in this study. The online survey proved to be a comparatively fast and less resource-intensive method for linking the two monitoring instruments, provided that photos are taken in a standardised way so that they can be used for surveys.

Concerning seasonal differences, the study confirmed that the assessment of most NFI parameters and especially of stand characteristics is independent of the season. Further, although parameters such as vegetation cover did exhibit seasonal differences, they mostly did not have an influence on the perception of visual attractiveness, implying that the current assessment of NFI parameters adequately reflects the characterisation of the forest throughout the year. Estimating visibility range by TLS proved to be a valuable addition to the standard NFI assessments and relevant for evaluating visual attractiveness.

Overall, the characterisation of forest visitors hardly differed between summer and winter, implying that, at least for nearby recreation, summer surveys provide a good approximation concerning visitor profiles, motives, dislikes and attractiveness assessments.

In short, adding measurements of visibility range to NFI assessments, taking photos fulfilling survey requirements, and including visualisations of NFI sample plots in each round of socio-cultural forest monitoring together with a set of NFI variables relevant for recreation and visual attractiveness could provide the missing link between NFIs and socio-cultural forest monitoring.

CRediT authorship contribution statement

K. Tessa Hegetschweiler: Conceptualization, Funding acquisition, Data curation, Writing – original draft, Writing – review & editing. **Christopher B. Stride:** Formal analysis, Writing – original draft. **Christoph Fischer:** Conceptualization, Data curation, Writing – review & editing. **Christian Ginzler:** Conceptualization, Data curation, Writing – original draft. **Marcel Hunziker:** Conceptualization, Funding acquisition, Supervision, Writing – review & editing.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jort.2022.100489.

Appendix B. 7-factor solution (pattern matrix) from an exploratory factor analysis run on first random half of data, extraction via Principal Axes Factoring, with an oblique rotation (oblimin)

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7
Items:	Preference for micro vegetation	Preference for trees	Preference for dead wood	Preference for mixed, more open forest structure	Go to the forest for: Experience peace and nature	Go to the forest for: Physical health/ fitness	Go to the forest for: Social reasons
Preferences: Do you like forests that have …							
Moss on trees and stones	**0.612**	−0.008	−0.151	0.119	0.074	0.034	−0.050
Ivy on trees	**0.587**	−0.056	0.052	−0.076	−0.040	0.052	0.059
Lichens	**0.583**	−0.004	−0.137	0.014	−0.043	0.003	−0.092
Ferns	**0.562**	−0.067	0.015	−0.148	0.045	−0.060	−0.141
Ground covered with vegatation	**0.392**	0.004	−0.144	−0.101	0.029	−0.016	0.025
Predominantly conifers	−0.093	**0.763**	0.011	0.075	0.029	−0.002	0.032
Predominantly deciduous trees	−0.009	**0.654**	−0.014	−0.118	−0.027	0.008	−0.023
Many branches/piles of branches on the ground	0.022	−0.022	**−0.820**	−0.080	−0.034	−0.015	0.008
Lying dead trees	0.052	−0.022	**−0.749**	−0.004	−0.074	−0.045	−0.033
A lot of dead leaves on the ground	0.188	0.082	**−0.346**	−0.124	0.152	0.022	−0.088
A lot of dead needles on the ground	0.243	0.115	**−0.330**	0.062	0.128	−0.012	−0.048
Many bushes/shrubs and young trees	0.032	−0.007	−0.228	**−0.527**	0.054	0.002	0.145
Conifers and deciduous trees mixed	0.087	0.062	−0.067	**−0.455**	0.225	−0.033	−0.024
Motives: I go to the forest because …							
When you can see far into the forest	0.209	0.055	0.054	0.059	0.002	−0.046	0.100
I want to enjoy peace and quiet	−0.047	0.020	−0.011	0.043	**0.635**	−0.016	0.066
I want to enjoy nature	0.091	0.023	0.022	−0.076	**0.451**	−0.125	−0.076
To do sports	0.038	0.081	0.010	0.061	−0.123	**−0.790**	0.102
Health reasons	0.030	0.003	0.123	0.029	0.222	**−0.540**	0.009
To have fun	−0.031	0.044	0.033	0.016	−0.046	−0.059	**0.567**
To meet friends	0.017	0.020	−0.014	−0.006	0.004	−0.005	**0.482**
I want to spend time with my family	0.000	−0.036	0.049	−0.085	0.230	0.029	**0.353**
I don't want to be observed	−0.019	−0.003	−0.092	0.256	0.157	0.001	0.130
I have to walk the dog	0.029	0.032	0.068	0.037	−0.009	0.144	0.021

N = 957 (first random half of the data). Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy: 0.767. Bartlett's test of sphericity: $\chi2(253) = 3756.706$, $p < 0.001$.

Appendix C. Confirmatory factor analyses comparing potential measurement models for forest preferences and motives for visiting the forest items, run on second random half of the data

	Model	Chi-sq, df	Δ Chi-sq, Δ df ‡	p	CFI	RMSEA[a]	SRMR[a]
1	7 factors	663.757, 149	–	–	0.938	0.053	0.050
2	6 factors (merging preference for trees and preference for open forest factors into general tree factor)	1162.424, 155	vs model 1: 498.667, 6*	p < 0.001	0.879	0.086	0.060
3	5 factors (merging preference for trees, preference for open forest, preference for micro vegetation into general vegetation factor)	1206.861, 160	vs model 2: 44.437, 5*	p < 0.001	0.874	0.086	0.062
4	5 factors (merging preference for trees, preference for open forest, preference for dead wood factors into general wood factor)		vs model 2:	p < 0.001			

N = 875 (second random half of the data). * p < 0.001. ‡ All items treated as ordinal and all models estimated using WLSMV estimation. Comparisons between models therefore tested using - and p values derived from - a corrected chi-square difference test rather than by the regular chi-squared difference test (see Muthén & Muthén, 2018).

[a]*RMSEA (Root Mean Square Error of Approximation) and SRMR (Standardised Root Mean Squared Residual) are 'Absolute' fit indices that assesses how far the covariance*

matrix for the observed variables (i.e. in this case, our items) in our model differs from that expected if our hypothesized model was true. RMSEA ≤ 0.06 is considered an adequate fit; similarly SRMR ≤ 0.08 is considered an adequate fit (Hu & Bentler, 1999).

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