Ambio 2023, 52:647–664
https://doi.org/10.1007/s13280-022-01816-x

KUNGL. VETENSKAPS-AKADEMIEN
THE ROYAL SWEDISH ACADEMY OF SCIENCES

RESEARCH ARTICLE

Increased appreciation of forests and their restorative effects during the COVID-19 pandemic

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Received: 20 April 2022 / Revised: 17 August 2022 / Accepted: 18 November 2022 / Published online: 7 January 2023

Abstract Public expectations of forests as high-quality restorative environments that facilitate subjective well-being and stress relief along with numerous health benefits have been rising sharply during recent decades. In addition, the COVID-19 pandemic and its accompanying restrictive measures also transformed forests into some of the few places to spend time away from home. The presented study drew on the assumption that the pandemic situation and a rise in the number of forest visits would affect the experience, recognition, and appreciation of the well-being aspects related to spending time in forests. The study goal was to elucidate the potential effects of the COVID-19 pandemic on the relationships between forest visits, well-being and stress relief, emotions, perception of nature and forest value and importance, pro-environmental behavior, and societal expectations of the role of forests and forest ecosystem services. A survey using a digital questionnaire was conducted several months after the pandemic outbreak on a representative sample of the Slovak population. The Wilcoxon test and ordinal regression analysis were used to identify significant relationships, e.g., between the recency of anger episodes and the number of forest visits. The results showed that the pandemic strengthened the perception of forests as a high-quality restorative environment and that emotions associated with forest visits played an important role in the perceived importance of forests and their possible overexploitation. The results underscore the urgent need to put demands for forest recreation on par with the forest bioeconomy and to sensitize forest visitors to management and conservation requirements.

Keywords Forest exploitation · Forests · Ordinal regression · Restorative environment · Stress relief · Subjective well-being

INTRODUCTION

Forests benefit human well-being by providing multiple ecosystem services. They include provisioning services such as primary productivity, wood production, and habitat formation; regulating services, e.g., nutrient fluxes, carbon sequestration, water infiltration, cooling and purification, flood control, and climate regulation; and cultural and experiential services, including recreation, aesthetic enjoyment, and scientific benefits (Millennium Ecosystem Assessment 2005; Felipe-Lucia et al. 2018; Temperli et al. 2020). Safeguarding the biophysical base of forest ecosystem services (FES) and their flows is vital for various reasons. For instance, the basic needs of people, including employment, are expected to depend even more on provisions from the primary sectors of the economy based on ecosystem services, such as forestry (Day et al. 2014). Similarly, the regulatory services of forests are gaining additional importance under conditions of global climate change (Fleischer et al. 2017). Last but not least, the demand for noninstrumental forest values such as aesthetic, cultural, spiritual, and recreational appreciation has been rising in recent decades (Patel et al. 1999; Tarrant and Cordell 2002; Blazevska et al. 2012; Pichlerová et al. 2021).

The provision of recreation services has been increasingly integrated into the rural economy and it can be expected to become and explicit part of the forestry portfolio (Simpson et al. 2008; Mann et al. 2022). The trend is marked by trade-offs among competing functions due to their distinct spatial–temporal scale characteristics and different stakeholders (Wang and Fu 2013). As a result, forest owners might encounter challenges when visitors develop psychological ownership toward certain forest areas (Avey et al. 2009; Weinbrenner et al. 2021). This

tension has also been captured by some recent international surveys. For example, the Innventia International Consumer Survey (2016) aimed to assess consumer perceptions, current trends, and the role of materials in a biobased economy revealed a split between respondents who expressed positive attitudes toward the use of wood and wood-based products and those who had apprehensive views about possible forest overuse. Besides, a large portion of the cited survey participants linked forests with relaxing and recreation. This association is supported by a growing body of evidence that nature and forest recreation facilitate physical and mental health, reduce stress, anxiety and depression, and reinforce overall well-being (Hartig et al. 1996; Geisler et al. 2010; Karjalainen et al. 2010).

Although people have assigned a high value to various benefits of forest visits in the past (Schama 1995; Bell et al. 2008; Paletto et al. 2013, 2017), these have gained additional importance during the COVID-19 pandemic. The anti-pandemic measures included school and workplace closures, cancelation of public events, restrictions on mass gatherings, public transport closures, stay-at-home orders, constraints on internal movements, and international travel controls (Koh et al. 2020). Research shows that pandemic-induced measures such as social distancing may affect people's mental well-being and induce a shift toward negative emotions (Cerbara et al. 2020). As a result, people feel deprived of social contact, work, cultural and sports activities and life as we know it (Esterwood and Saeed 2020; Xiang et al. 2020). In similar situations, places that allow people to restore their mental capacities play an important role. For instance, individuals suffering from exhaustion disorder reported that they experienced peace of mind and a sense of freedom during their time spent in forests and that they were able to start making plans for the future (Sonntag-Öström et al. 2011, 2014). The perception of forests as a valuable restorative environment is supported by the results of numerous studies showing that people in different regions and countries spent more time in forests during the COVID-19 pandemic than they did before (da Schio et al. 2021; Pichlerová et al. 2021). Recently, attention has also been paid to the reconceptualization of human–environment relations using the ideas of gift, reciprocity, affect, and gratitude in the framework of ecosystem services (Singh 2015). Gratitude may be broadly defined as a state of thankfulness and/or appreciation (Sansone and Sansone 2010). As an experience of appreciating the positive aspects in one's life, gratitude has been associated with increased subjective well-being (SWB), and causal cognitive and psycho-social frameworks were proposed to explore possible mechanisms by which gratitude influences SWB (Alkozei et al. 2018).

The analysis of people's perceptions lies at the core of participatory forest planning and related decision-making (Vining and Tyler 1999; Jensen 2000; Lewis and Sheppard 2005; Hickey et al. 2007), as well as for designing and implementing management policies (Schmithüsen and Wild-Eck 2000; Edwards et al. 2012). The present study, therefore, aimed to explore interrelationships between COVID-19 pandemic-induced changes in the number of forest visits (NFVs) reported by Pichlerová et al. (2021), perceived stress reduction, SWB, positive emotions, appreciation of nature, environment, and forests, as well as forest exploitation and FES. Our first working hypothesis was that the pandemic strengthened the perception of forests as a restorative environment and a place-to-be rather than viewing forests as a source of wood. Because gratitude compels people toward prosocial or reciprocal action often involving moral acts (Armenta et al. 2017), our second hypothesis was that emotions including gratitude sensitized people against harming nature and toward the need for more environmentally friendly behavior. In both regards, COVID-19 has provided an unprecedented backdrop against which changes in perceived well-being, emotions, and ratings of forest functions can be observed and studied.

MATERIALS AND METHODS

To investigate the anticipated change in the perception of forests and the broader natural environment during the early phase of the COVID-19 pandemic in Slovakia, we conducted a nationwide survey during summer 2020 following the first pandemic wave, when pandemic measures and restrictions were moderately eased. The survey was administered on a representative sample of respondents. The stratum was divided into primary (with a known population size) and secondary categories (with an unknown population size). For the strata in which the population size was known, the required sample size was determined using the Krejcie and Morgan formula (1970). The required and actual sample sizes are shown in Table 1.

The survey questionnaire was developed on the understanding of forests as a quality restorative environment in terms of stress reduction theory (SRT; Ulrich 1983) and attention restoration theory (ART; Kaplan and Kaplan 1989). The choice of the amount of data to be collected, survey timing and methodology aimed to account for the pandemic-produced pressure on the population, possible distraction, and fatigue. It was also considered important that the participants made their assessments of the questionnaire statements after they made their (potentially multiple) forest visits and had time to reflect on these visits.

Since forests cover approximately 42% of the Slovak territory, it was assumed that they would become one of the few environments available to people to spend time outdoors during the COVID-19 pandemic. Figure 1 shows the

Table 1 Determination of the respondent sample sizes. The required sample sizes were calculated for a 5% margin and 90% confidence level (CL). The realized sample sizes corresponded to the numbers of completed and returned questionnaires. ΔNFV = NFV2 − NFV1 as a difference between the number of forest visits during (NFV2) and before (NFV1) the COVID-19 pandemic. Only 5.8% of the respondents did not make at least one forest visit per month, compared to 17.6% during the pandemic

Variable	Stratum	Population size	Required sample size	Actual sample size	Margin of error (CL 90%)
Primary					
Sex (SX)					
1	Male (≥ 16 years)	2 194 165	271	470	3.79
2	Female (≥ 16 years)	2 344 497	271	530	3.57
–	Total (≥ 16 years)	4 538 663	271	1000	2.6
Age category (AC)					
1	16–24	485 616	271	107	7.95
2	25–39	1 167 420	271	280	4.91
3	40–54	1 220 655	271	276	4.95
4	> 55	1 644 788	271	337	4.48
Region (REG)					
1	Bratislava (capital)	669 592	271	114	7.7
2	Eastern Slovakia	1 627 704	271	338	4.47
3	Central Slovakia	1 336 785	271	249	5.21
4	Western Slovakia	1 823 792	271	299	4.76
Secondary					
Settlement size (SS)					
1	< 1000	No data	No data	168	No data
2	1000–4999			218	
3	5000–19 999			148	
4	20 000–49 999			177	
5	50 000–99 999			130	
6	> 99 999			159	
0				58	
NFV1					
1–5				675	
6–10				153	
11–20				90	
21–31				24	
NFV2					
0				176	
1–5				490	
6–10				185	
11–20				114	
21–31				35	
ΔNFV					
ΔNFV1 > 0				295	
ΔNFV2 = 0				386	
ΔNFV3 < 0				319	

distribution of the forest cover and typical forest interiors in the Western Carpathians.

The survey was carried out in collaboration with the market research agency Go4Insight, commanding expertise in qualitative and quantitative research and data collection methods. It comprised 15 Likert scale questions aimed to assess the extent to which respondents agree or disagree with the proposed statements regarding (i) SWB and stress relief, (ii) perception of the value and importance of forests, nature, and the environment, (iii) pro-environmental behavior, and (iv) societal expectations on the role and ecosystem services of forests (Table 2). The respective

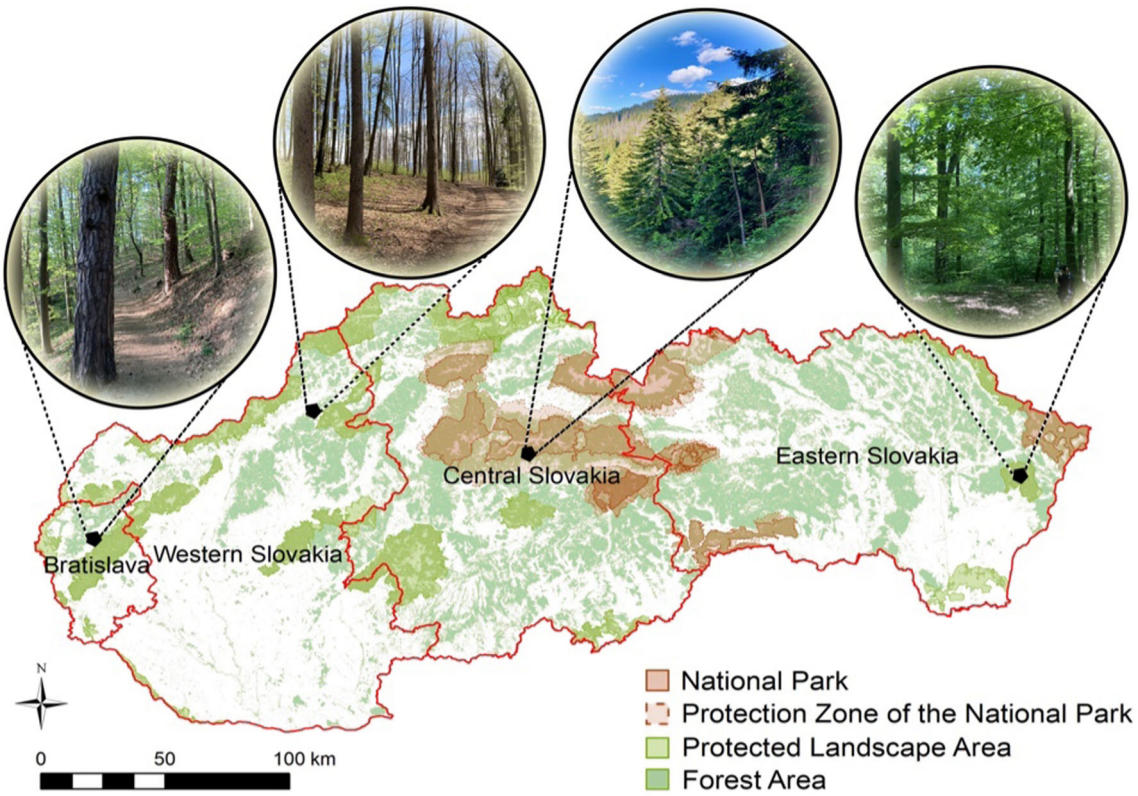

Fig. 1 Forest cover, nature conservation areas, and forest interiors characteristic of the geographical regions of Slovakia

questionnaire was distributed digitally to a panel consisting of individuals living in Slovakia and complete answers were obtained from one thousand respondents. After reaching the saturation point for the respective demographic segments, the sample ensured approximately proportional representation of the sex, age, and region categories.

Statistical analyses were performed in the IBM SPSS environment (v. 28.0.1.0) on the data obtained from 1000 respondents. The one-sample Wilcoxon signed-rank test was used to assess the deviation of the observed median from the hypothetical value of the respondents' opinions on the Likert scale. Subsequently, the dependence of a polytomous ordinal response on a set of predictors, which can be factors or covariates, was modeled by ordinal regression using the logit link function. The majority of the predictor variables were selected for the analysis because their observed median values deviated from the hypothetical, neutral median threshold. Significant deviations indicated that the COVID-19 pandemic had an effect on the shift in the respondents' opinions. The main results of the ordinal regression analysis comprised estimates that are the ordered log-odds (logit) regression coefficients. Their interpretation is that for a one-unit difference in the predictor, taken from its reference level, the dependent variable is expected to change by the respective regression coefficient, in the ordered log-odds scale, while the other variables in the model are held constant (Mertens et al. 2017). The Wald statistics and their corresponding p values were used to test the null hypothesis that the coefficient of the independent variable is equal to zero versus the alternative hypothesis that the coefficient is nonzero (Forthofer et al. 2007). The ordinal model predictive capacity was expressed by Nagelkerke's pseudo-R^2 (1991). The number of forest visits (NVF) per person/month before (NFV1) and during the COVID-19 pandemic (NFV2) averaged 5.39 and 5.87, respectively ($p < 0.01$) and were taken from our earlier work (Pichlerová et al. 2021). The change in NFV (ΔNFV) was either positive (ΔNFV1 = NFV2 − NFV1 > 0), equal to zero (ΔNFV2 = NFV2 − NFV1 = 0), or negative (ΔNFV3 = NFV2 − NFV1 < 0).

RESULTS AND DISCUSSION

Study limitations

Our study was conducted within the first 6 months of the COVID-19 pandemic, during which both the global increase in nature experience and the consistent positive associations between nature exposure and improved mental health were observed (Labib et al. 2022). While reflecting

Table 2 Questionnaire statements regarding the impact of the COVID-19 pandemic on various aspects of forest-related well-being and changes in the perception of nature, environment, and forests. A forest visit was not specified in terms of its purpose or duration

Area of perception	Item	Suggested statement	Possible response
Well-being and stress relief	Q1	After visiting the forest, I feel better than before visiting the forest	To what extent do you agree with the following statements about forest visit?
	Q2	After visiting the forest, I am less stressed, calmer	1. Fully agree
	Q3	After visiting the forest, I feel free	2. Rather agree
Emotions	Q4	Since the outbreak of the COVID-19 pandemic, I've started to associate my stay in the forest with my feelings of gratitude more than before	3. Rather don't agree
	Q5	Since the outbreak of the COVID-19 pandemic, I've started to associate my stay in the forest with my feeling of freedom more than before	4. Don't agree
	Q6	When was the last time you felt stressed or angry?	1. Today
			2. Yesterday
			3. More than 2 days ago
			4. More than 1 month
			5. I don't remember
			6. Never
Perception of value and importance of nature and forests	Since the outbreak of the COVID-19 pandemic		To what extent do you agree with the following statements about forest visit?
	Q7	I've begun to value nature more than before	1. Fully agree
	Q8	I've become more interested in the environment than before	2. Rather agree
	Q9	I've become even more aware of the importance of forests	3. Rather don't agree
Pro-environmental behavior	Q10	I 've started recycling more than before	4. Don't agree
Societal expectations of the role of forests and forest ecosystems services	Q11	I've become more interested in the state of forests in Slovakia than before	
	Q12	I've started to think more than before that forests in Slovakia are being overexploited	
	Q13	I've started to think more than before that forests should play mainly a recreational function	
	Q14	I've started to think more than before that forests should fulfill mainly a production function (e.g., wood source)	
	Q15	I've started to think more than before that forests should fulfill a ecological function	

these worldwide trends, the study has several limitations that imply uncertainties in the results and their interpretation. First, it was based on a questionnaire survey and thus relied on people's recollection of forest visits instead of diary data or on-site monitoring and surveying. The survey method, research questions, and interpretation of results assume that people's decisions and acts are memory-based (Khader et al. 2011). To avoid excessive length and response burden, the survey questions also omitted some important aspects, e.g., changes in well-being derived from the generation of positive emotions through the exchange of instrumental and emotional support in closer interpersonal relationships (Hartig 2021). It was assumed that people visited forests as individuals or as families because the pandemic-related restrictions in Slovakia did not allow nature and forest visits by mixed groups at that time. Other limitations include possible ambiguities in the understanding of certain terms used in the questionnaire. For example, gratitude can be understood as a feeling, an overall tendency, or a mood (Rosenberg 1998). Although the questionnaire contained a question specifically referring to gratitude as a feeling associated with forest visits, not as mood or attitude, it did not inquire about its object (life, fate, God, an accompanying person, nature, forests, etc.) or its possible overlap with the personal appreciation of time spent in forests.

Perceived benefits of time spent in forests

Study respondents strongly agreed that they felt better (avg. Q1 = 1.52, Fig. 2A), less stressed (avg. Q2 = 1.57, Fig. 2B), and more free (avg. Q3 = 1.71, Fig. 2C) after spending time in forests. The average opinion scores comply with the restorative capacity of forests, as

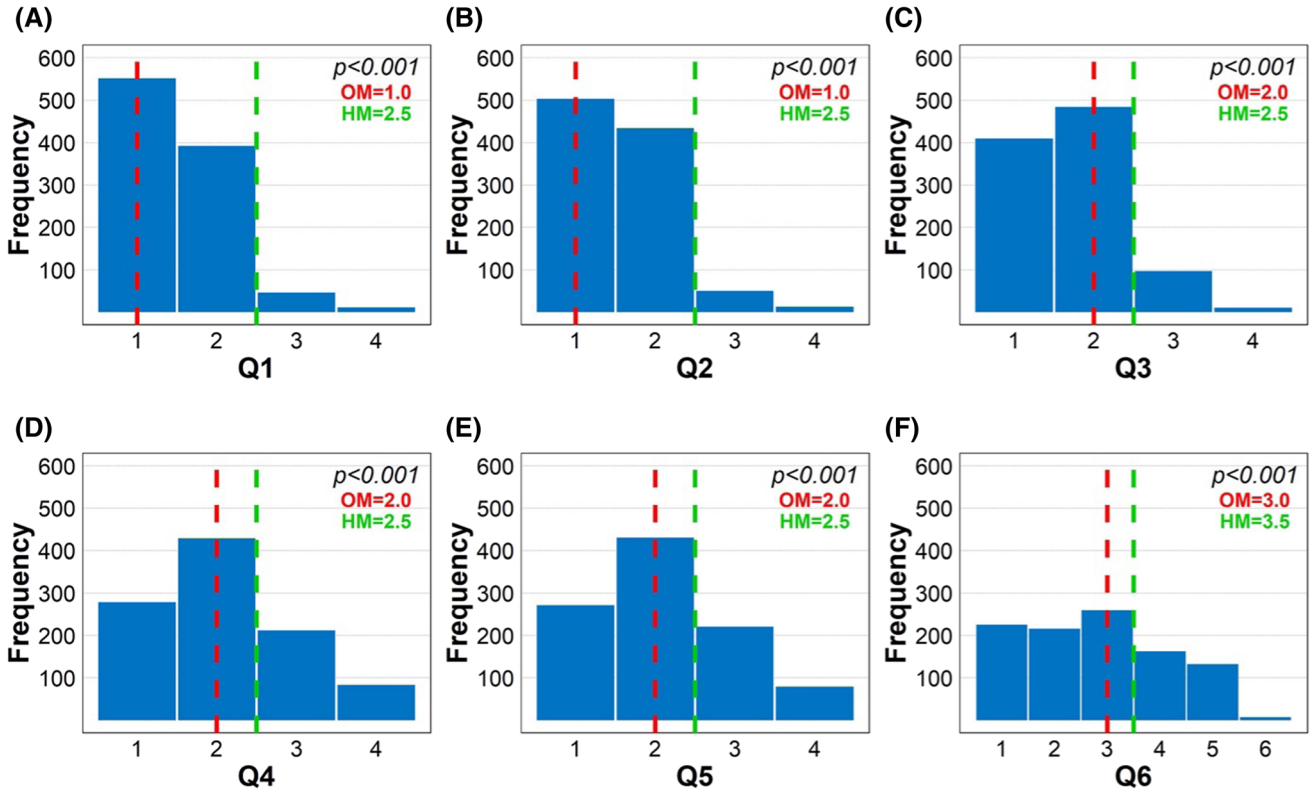

Fig. 2 One-sample Wilcoxon signed-rank test of the differences between observed median (OM) values of the respondents' agreement (1, 2) or disagreement (3, 4) with statements Q1–5 regarding perceived benefits of time spent in forests and the hypothetical median (HM = 2.5). The HM for Q6 regarding the recency of feelings of anger (1–3 vs. 4–6) was 3.5. The dashed vertical lines indicate the hypothetical median (green) and observed median (red) of the collected responses on the Likert scales. Q1–6 are given in Table 2. The results are based on data from 1000 respondents

explained by stress recovery and ARTs that link natural contents, moderate levels of complexity, gross structure and other visual stimulus attributes, fascination, extent, and compatibility, and the ability to direct attention and mobilize for action (Hartig 2021). Studies from numerous countries (Beckmann-Wübbelt et al. 2021; Jarský et al. 2022) provide evidence that the NFVs increased during the COVID-19 pandemic. Although a part of the restoration acknowledged by this study respondents almost certainly derived from social interaction during forest visits, our survey did not discern between individual and group visits. Leaning on the results from the State of Vermont, US, showing a strong decrease in the share of visitors seeking relaxation in forests with others during the pandemic (Morse et al. 2020), we deduce that the potential for relational restoration in Europe was also limited.

The respondents agreed not only on increased feelings of freedom after visiting a forest but also on a general association between spending time in forests and feelings of gratitude (avg. Q4 = 2.10, Fig. 2D) and freedom (avg. Q5 = 2.11, Fig. 2E). Lambert et al. (2009a, b) and Fagley (2012) suggest that appreciation and gratitude play a causal role in fostering well-being, possibly by reducing hedonic adaptation, which would lead to greater life satisfaction. The stated association between spending time in forests and gratitude appears to be one of the benefits of forest-stimulated emotions, along with fascination and others, that can prevent boredom and attention fatigue. Although the generation of positive emotions is primarily expected from the exchange of instrumental and emotional support in closer interpersonal relationships, as conceptualized by relational restoration theory (RRT; Hartig 2021), our research confirms that positive emotions also emerged during and after spending time in forests as restorative environments. Williams and Harvey (2001) studied transcendent emotions experienced in ancient forests. They found that forest environment rather than the type of activity performed in forests engendered absorption, intense positive mood, or timelessness. While it is possible that some of this study respondents experienced similar emotions in particularly sublime localities, these represented only a smaller part of forest landscapes visited

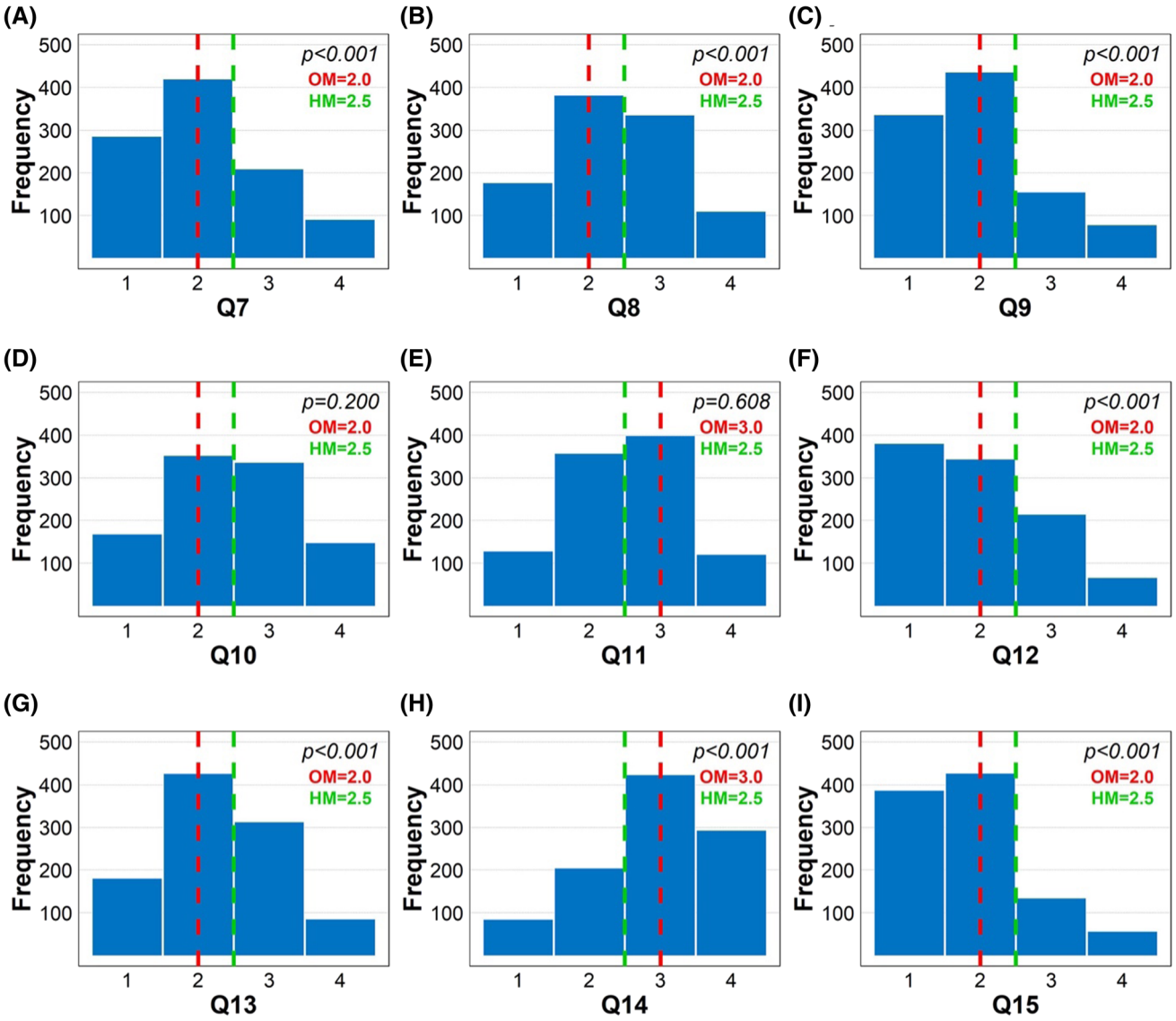

Fig. 3 One-sample Wilcoxon signed-rank test of the respondents' agreement (1, 2) or disagreement (3, 4) with the statements Q7–15 regarding appreciation of forests, nature, and environment (Table 2) against a hypothetical median (2.5). The dashed vertical lines indicate the hypothetical median (green) and observed median (red) of the collected responses on the Likert scales. The results are based on data from 1000 respondents

during the COVID-19 pandemic, mainly due to travel restrictions. Therefore, we deduce that the feeling of gratitude was mediated primarily by freedom perceived during forest visits in juxtaposition to restricted mobility. A plethora of adverse circumstances related to COVID-19 pandemics were also responsible for the higher recency of the stated feelings of anger (avg. Q6 = 2.78 in Fig. 2F).

Appreciation of forests, nature, and environment

In relation to previous results, we found a higher appreciation of nature (avg. Q7 = 2.10, Fig. 3A) and forests (avg. Q9 = 1.97, Fig. 3C) during the COVID-19 pandemic. Relatedly, Grima et al. (2020) reported an increase in the perceived importance of urban forest areas as places providing opportunities for various activities and stress relief during the chaotic pandemic situation. In contrast, there was only a slight or no average increase in the concern about the state of the environment (avg. Q8 = 2.38, Fig. 3B), in the level of engagement in recycling (avg. Q10 = 2.46, Fig. 3D), or the interest in the state of forests in Slovakia (avg. Q11 = 2.51, Fig. 3E) compared to prepandemic levels. On the one hand, interest in the state of Slovak forests probably increased well before the pandemic due to increased salvage cutting in Slovak and European forests, connected with windthrow and

windbreak events, followed by bark-beetle outbreaks as the most important disturbances in Central European forests (Sisak et al. 2016). These were critically framed by the long-term, state-wide campaigns against forest cutting, especially in protected areas. For example, a Google search for links mentioning the "We are the Forest" ("My sme les" in Slovak) campaign launched in 2018 scored approximately 24 000 results as of June 2022. The resulting sensitization of the Slovak population toward forest conservation could account for the absence of a further increase in the concern for the condition of the Slovak forests. Regarding the conspicuous shift toward opinions that forests were subject to overexploitation (avg. Q12 = 1.96, Fig. 3F), it is difficult to discriminate between the direct experience of forest environments, personal beliefs, and the effect of forest conservation campaigns. On the one hand, the shift could be explained by the general increase in depression and anxiety due to the COVID-19 pandemic (Santomauro et al. 2021), increased awareness of the impermanence of life (Ray 2020), and the fear of losing forests as some of the few quality environments that remained accessible even during the pandemic. On the other hand, a relatively high level of fear of forest loss in the Slovak populations was recorded well before the COVID-19 pandemic outbreak. For example, an expanded international consumer survey (Consumers and Biobased Materials 2018) showed that 51% of the Slovak respondents were concerned about possible forest overexploitation. That figure was similar to Brazil (53%) and Italy (52%), but considerably higher than in Sweden (31%) or USA (37%). The important role of emotions and subsequent cognitive evaluation of the status and exploitation of the forests is highlighted in Table 3. It shows that there was a positive and significant correlation between perceived forest overexploitation on the one hand and the respondents' feelings of freedom and gratitude associated with forest visits, as well as a strong appreciation of forest ecological functions on the other hand. Conspicuously, a significant dependence on NFV ($P_{NFV1} = 0.12$) or regions, identified by the respondents' places of residence, was not observed. It appears that in both surveys, the later cognitive evaluation could have been more important than the immediate perceptual response. A similar pattern was reported in other studies on forest sensory stimuli, e.g., Ohla et al. (2018) and Hedblom et al. (2019).

The respondents' opinions expressed in Q7–12 were also reflected in the stark contrast in the ranking of forest functions according to their perceived importance (Q13–15). In the course of the pandemic, respondents became more convinced that forests should primarily provide ecological functions (avg. Q15 = 1.86, Fig. 3I), followed by recreational (avg. Q13 = 2.30, Fig. 3G) and production functions (avg. Q14 = 2.92, Fig. 3H), whereby production functions scored the highest discontent among all items. Interestingly, the forest recreation function (Q13) lagged behind the ecological function, probably owing to its negative perceived impact on nature in the form of uncontrolled and widely publicized cases of tourism infrastructure development in some national park areas (Oremusová et al. 2021). Additionally, the ecological function of forests is being widely discussed as an important part of global climate change mitigation efforts (Grassi et al. 2017).

Forest-related predictors of emotional and behavioral patterns

The links between the change in the recognition and perception of forests, their status, importance, benefits for well-being and emotional state, and stated behavior were investigated by ordinal regression analysis.

Pandemic-induced change in the number of forest visits

The ordinal regression model with logit link function explained approximately 8% (Nagelkerke's pseudo-$R^2 = 0.083$) of ΔNFV variability as the dependent variable (Table 4). Although effect sizes in longitudinal studies are often much smaller than effect sizes in controlled cross-sectional studies (Adachi and Willoughby 2015), the established effect size paralleled the 8.91% NFV increase during the pandemic (Pichlerová et al. 2021). The two values highlight the important role of forests in coping with the pandemic and mirror the complexity of the pandemic situation and its impacts. For instance, while the pandemic made forests some of the few places available for spending time outdoors, its accompanying measures produced considerable obstacles to reaching them, particularly for elderly people. In addition to seeking well-being and stress relief, NFV increased owing to other important motivations. These likely included spending time with others in a less restrictive environment, as well as maintaining an existential sense of belonging that normally goes far beyond a sense of well-being and concerns identity and self-anchoring (Häggström 2019). Even against this situational backdrop, the Wald statistics suggested that demographic characteristics, i.e., age (AC) and the settlement size (SS) were significant predictors of ΔNFV. Specifically, younger respondents and respondents from smaller settlements had a higher probability of making more forest visits during the pandemic than before, indicated by the negative, statistically significant estimate values. The importance of demographic characteristics in the ordered logit model (Table 4) was in agreement with findings that NFV increased during the COVID-19 pandemic and was associated with shorter distances to the nearest forest

Table 3 Ordinal logit regression between the perceived forest overexploitation and the region, number of forest visits, emotions linked to visiting forests, and the importance of forest functions. Explanations and abbreviations: *Q12* since the outbreak of the COVID-19 pandemic, I've started to think more than before that forests in Slovakia are being overexploited, *NFV1* number of forest visits before the COVID-19 pandemic, *NFV2* number of forest visits during the pandemic, *REG* region. Since the outbreak of the COVID-19 pandemic: *Q4* I've started to associate my stay in the forest with my feelings of gratitude more than before, *Q5* I've started to associate my stay in the forest with my feelings of freedom more than before, *Q13* I've started to think more than before that forests should play mainly a recreational function, *Q15* I've started to think more than before that forests should fulfill an ecological function. In Q4–5, Q13, and Q15, the indices 1–4 correspond to the responses "Fully agree", "Rather agree", "Rather don't agree", and "Don't agree", respectively, on the Likert scale. The results are based on data from 1000 respondents

Parameter estimates							
Nagelkerke's pseudo-R^2: 0.413 Link function: Logit; $p < 0.001$	Estimate	Std. error	Wald	df	Sig.	95% Confidence interval	
						Lower bound	Upper bound
Threshold							
Q12 (1)	− 5.520	0.385	205.927	1	< 0.001	–6.274	–4.766
Q12 (2)	–3.537	0.371	90.721	1	< 0.001	–4.265	–2.809
Q12 (3)	–1.015	0.333	9.290	1	0.002	–1.668	–0.362
Location							
NFV1	–0.028	0.018	2.450	1	0.118	–0.064	0.007
NFV2	0.006	0.015	0.166	1	0.684	–0.024	0.036
REG 1	0.161	0.225	0.508	1	0.476	–0.281	0.602
REG 2	0.138	0.168	0.676	1	0.411	–0.191	0.467
REG 3	–0.062	0.173	0.128	1	0.721	–0.401	0.277
REG 4	0[a]			0			
Q4 1	–1.111	0.396	7.882	1	0.005	–1.887	–0.335
Q4 2	–0.859	0.363	5.605	1	0.018	–1.571	–0.148
Q4 3	–0.198	0.352	0.317	1	0.574	–0.888	0.492
Q4 4	0[a]			0			
Q5 1	–0.891	0.403	4.884	1	0.027	–1.681	–0.101
Q5 2	–0.067	0.371	0.033	1	0.856	–0.794	0.660
Q5 3	–0.064	0.360	0.032	1	0.859	–0.769	0.641
Q5 4	0[a]			0			
Q13 1	–0.460	0.337	1.858	1	0.173	–1.120	0.201
Q13 2	–0.305	0.304	1.005	1	0.316	–0.902	0.291
Q13 3	–0.149	0.306	0.239	1	0.625	–0.749	0.450
Q13 4	0[a]			0			
Q15 1	–4.266	0.421	102.691	1	< 0.001	–5.091	–3.441
Q15 2	–3.394	0.410	68.544	1	< 0.001	–4.197	–2.590
Q15 3	–2.330	0.423	30.288	1	< 0.001	–3.160	–1.501
Q15 4	0[a]			0			

[a]This parameter is set to zero because it is the reference level

(Pichlerová et al. 2021). In addition, people who stated that their appreciation of forests had grown strongly during the pandemic (Q9) were also likely to visit forests more often than before.

Among factors linked with the health effects of time spent in forests and the appreciation of forests as valuable restorative environments, there was a tendency toward NFV increase (ΔNFV1) with the stated stress reduction after a forest visit (Q2, $p = 0.106$). While fighting stress and improving well-being are often considered together as part of the forest health effect on people (Oh et al. 2017; Doimo et al. 2020), a significant effect of improved SWB from ΔNFV was not detected. We deduce that stress reduction functioned as a more direct motivation for forest visits than SWB. For instance, stress reduction is currently easily measurable and thus "objectified" by commercially available and widely used activity trackers. In comparison, evaluating one's SWB involves more complex mental

Table 4 Ordinal logit regression between the change in the number of forest visits (ΔNFV = NFV2 − NFV1) before (NFV1) and during (NFV2) the COVID-19 pandemic and selected demographic indices, subjective well-being, and the feelings and emotions linked with or aroused by forests. Abbreviations and explanatory notes: ΔNFV1, 2, 3, is greater than, equal to, or smaller than 0, respectively (ΔNFV3 is not shown as redundant); *AC* age category (in ascending order), *SS* settlement size (in ascending order), *Q1* after visiting the forest I feel better than before visiting the forest, *Q2* after visiting the forest, I am less stressed, calmer; since the outbreak of the COVID-19 pandemic: *Q9* I've become even more aware of the importance of forests, *Q12* I've started to think more than before that forests in Slovakia are being overexploited, *Q14* I've started to think more than before that forests should fulfill mainly a production function. In Q1, Q2, Q9, Q12, and Q14, the indices 1–4 correspond to "Fully agree", "Rather agree", "Rather don't agree", and "Don't agree", respectively. The results are based on data from 1000 respondents

Parameter estimates							
Nagelkerke's pseudo-R^2: 0.083 Link function: Logit; $p < 0.001$	Estimate	Std. error	Wald	df	Sig.	95% Confidence interval	
						Lower bound	Upper bound
Threshold							
ΔNFV1	–2.243	0.750	8.940	1	0.003	–3.713	–0.773
ΔNFV2	–0.510	0.747	0.466	1	0.495	–1.973	0.953
Location							
AC 1	–0.815	0.214	14.546	1	< 0.001	–1.234	–0.396
AC 2	–0.944	0.156	36.681	1	< 0.001	–1.249	–0.638
AC 3	–0.527	0.155	11.543	1	< 0.001	–0.831	–0.223
AC 4	0[a]			0			
SS 1	–0.646	0.210	9.460	1	0.002	–1.058	–0.234
SS 2	–0.560	0.199	7.932	1	0.005	–0.949	–0.170
SS 3	–0.382	0.218	3.085	1	0.079	–0.809	0.044
SS 4	–0.417	0.206	4.081	1	0.043	–0.821	–0.012
SS 5	–0.115	0.223	0.264	1	0.607	–0.552	0.323
SS 6	0[a]			0			
Q1 1	0.391	0.602	0.422	1	0.516	–0.789	1.572
Q1 2	0.410	0.604	0.462	1	0.497	–0.773	1.594
Q1 3	–0.120	0.659	0.033	1	0.855	–1.412	1.171
Q1 4	0[a]			0			
Q2 1	–0.902	0.558	2.616	1	0.106	–1.996	0.191
Q2 2	–0.714	0.563	1.610	1	0.204	–1.817	0.389
Q2 3	–0.444	0.618	0.515	1	0.473	–1.656	0.768
Q2 4	0[a]			0			
Q9 1	–0.650	0.318	4.179	1	0.041	–1.273	–0.027
Q9 2	–0.634	0.308	4.251	1	0.039	–1.237	–0.031
Q9 3	–0.396	0.316	1.567	1	0.211	–1.015	0.224
Q9 4	0[a]			0			
Q12 1	0.579	0.329	3.091	1	0.079	–0.067	1.225
Q12 2	0.613	0.329	3.467	1	0.063	–0.032	1.258
Q12 3	0.438	0.329	1.776	1	0.183	–0.206	1.083
Q12 4	0[a]			0			
Q14 1	0.025	0.242	0.010	1	0.919	–0.450	0.499
Q14 2	–0.049	0.182	0.073	1	0.787	–0.407	0.308
Q14 3	0.032	0.152	0.045	1	0.832	–0.265	0.329
Q14 4	0[a]			0			

[a]This parameter is set to zero because it is the reference level

processes. It is possible that a positive SWB response to NFV increase (ΔNFV1) was a slower and incremental process, only gradually integrating the experience of stress-reduction. For example, Lee et al. (2022) suggested that if the stress of forest users is reduced, direct or indirect mental well-being is also increased. Interestingly, people

Table 5 Ordinal logit regression between the recency of feelings of anger and selected demographic factors, number of forest visits, and emotions linked to spending time in forests. Explanations and abbreviations: *Q6* recency of the last feeling of anger, *NFV1* number of forest visits before the COVID-19 pandemic, *NFV2* number of forest visits during the pandemic, *SX* sex, *AC* age category, *Q2* after visiting the forest, I am less stressed, calmer; *Q4* since the outbreak of the COVID-19 pandemic, I've started to associate my stay in the forest with my feelings of gratitude more than before; in Q2 and Q4, the indices 1–4 correspond to the responses "Fully agree", "Rather agree", "Rather don't agree", and "Don't agree", respectively, on the Likert scale. The results are based on data from 1000 respondents

Parameter estimates							
Nagelkerke's pseudo R^2: 0.123 Link function: Logit; $p < 0.001$	Estimate	Std. error	Wald	df	Sig.	95% Confidence interval	
						Lower bound	Upper bound
Threshold							
Q6 (1)	–2.193	0.539	16.566	1	< 0.001	–3.250	–1.137
Q6 (2)	–1.124	0.536	4.398	1	0.036	–2.174	–0.074
Q6 (3)	0.079	0.534	0.022	1	0.883	–0.969	1.126
Q6 (4)	1.145	0.537	4.548	1	0.033	0.093	2.197
Q6 (5)	4.335	0.650	44.553	1	< 0.001	3.062	5.608
Location							
NFV1	0.031	0.016	3.867	1	0.049	0.000	0.062
NFV2	–0.016	0.014	1.315	1	0.252	–0.043	0.011
SX 1	0.240	0.115	4.371	1	0.037	0.015	0.465
SX 2	0[a]			0			
AC 1	–1.312	0.205	40.887	1	< 0.001	–1.714	–0.910
AC 2	–1.362	0.152	79.871	1	< 0.001	–1.660	–1.063
AC 3	–1.015	0.149	46.589	1	< 0.001	–1.306	–0.724
AC 4	0[a]			0			
Q2 1	0.115	0.505	0.052	1	0.820	–0.875	1.104
Q2 2	–0.143	0.508	0.079	1	0.778	–1.139	0.853
Q2 3	–0.249	0.560	0.197	1	0.657	–1.346	0.849
Q2 4	0[a]			0			
Q4 1	–0.481	0.230	4.354	1	0.037	–0.932	–0.029
Q4 2	–0.085	0.218	0.153	1	0.696	–0.512	0.342
Q4 3	–0.139	0.234	0.354	1	0.552	–0.598	0.320
Q4 4	0[a]			0			

[a]This parameter is set to zero because it is the reference level

who began to think during the pandemic that forests were overexploited (Q12) had a marginally significant probability of making fewer forest visits than before. We hypothesize that the concern for forest overexploitation was at least tangentially linked with a feeling of anxiety triggered by the COVID-19 pandemic situation, especially in socially and psychologically more vulnerable individuals.

Overall, the results suggest that NFV change occurred not only due to causal relationships between the time spent in nature and stress relief or well-being connected to it but also simply because forests became a place to retreat to—whether alone or with family and friends. For many visitors, forests provided the same functions during this extraordinary period as public spaces (Weinbrenner et al. 2021) and numerous other restorative environments. These aspects, which stress the exchange of instrumental and emotional support in closer relationships, are highlighted by RRT. We hypothesize that although RRT may belong to the deciding factors affecting ΔNFV, its effects were often generated in forests, so there were overlaps or even positive synergies between various aspects emphasized by SRT, ART, and RRT.

Recency of feelings of anger

Ordinal regression revealed that the prepandemic NFVs (NFV1, $p = 0.049$), sex (SX, $p = 0.037$), age category (AC, $p < 0.001$), and the feeling of gratitude associated with spending time in forests (Q4, $p = 0.037$) explained

approximately 12% of variability (Nagelkerke's $R^2 = 0.123$) in the recency of anger episodes (Q6) during the COVID-19 pandemic (Table 5). Specifically, there was a higher probability of more recent anger episodes in women and younger individuals. According to Vahia et al. (2020), older people may have traits of resilience related to life experience, wisdom, and quality of relationships that have enabled them to withstand the stresses of the recent pandemic better than younger people. In terms of forest recreation, only prepandemic forest visits (NFV1) were predictive of anger recency during the pandemic in that the likelihood of a recent feeling of anger was reduced by 0.031 through each additional visit. Interestingly, a comparable influence of forest visits taken during the pandemic (NFV2) was not observed. Since only 5.8% of the respondents stated that they did not take at least one monthly forest visit during normal conditions, compared to 17.6% during the pandemic, we hypothesize that the effect of NFV1 resulted from a long-term, gradual build-up of resilience against anger-provoking stimuli. The analysis in "Pandemic-induced change in the number of forest visits" section also showed that older people were more likely to reduce NFV in response to COVID-19. Also, Beall et al. (2022) found that those who engaged in more outdoor and nature-based activities prior to the pandemic experienced a smaller decrease in SWB. In contrast, the NFV2 effect on the feelings of anger was probably mitigatory rather than preventive, especially in younger people who tended to visit forests more frequently after the pandemic outbreak. It is likely that the possible mitigatory effects did not last as long under extreme COVID-19 pandemic pressures. For example, a short exposure (5 min) to a forest video during total lockdown induced a momentary self-perceived relaxing effect (Zabini et al. 2020). A subsequent recognition and appreciation of the possible mitigatory effect by forest visitors could have the potential to establish an unexpected positive link between anger and gratitude (Q4) when understood as feelings. Interestingly, anger and gratitude showed a negative correlation when assessed and analyzed as overall tendencies or personality traits (Breen et al. 2010). Although we did not study the underlying processes in more detail, our results highlight both preventive and mitigatory benefits of time spent in forests. This further supports the role of forests as a valuable restorative environment that, according to Hartig (2021), allows a person to gain distance from the demands that caused the given need for restoration and promotes restoration by distracting them, further attracting and holding their attention, and resulting in increased self-reported happiness and reduced anger or anxiety.

Pro-environmental behavior

The model comprising the effects of feelings evoked by visiting forests, the perception of forests, and the assessment of their exploitation explained more than half of the variability in the respondents' pro-environmental behavior represented by the increase in recycling during the pandemic (Table 6). The increase in recycling was selected as the dependent variable since the share of Slovak respondents that favored recycling as an important pro-environmental behavior was the highest among countries partaking in the Consumers and Biobased Materials survey (2018). In contrast to the previously analyzed independent variables, demographic factors did not emerge as prominent predictors of the increase in recycling (Q10). Although modest gender differences in environmental concern within the general public exist in North American and European countries (McCright and Sundström 2013), this pattern has not been examined during the COVID-19 pandemic. With regard to age, various studies have not provided conclusive findings. Johnson and Schwadel (2018) found large age effects, with young people being more likely to be pro-environmental in their views. In contrast, Wang et al. (2021) found a positive relationship between aging and pro-environmental behavior. Our results from the pandemic period showed an increased, marginally significant tendency ($p = 0.054$) toward more recycling only with respect to settlement size, specifically among individuals living in small settlements (SS 2: 1000–4999 inhabitants). In contrast to findings that nature and forest recreation and the appreciation of the natural world usually boost pro-environmental behavior (Alcock et al. 2020), we did not detect this pattern with regard to ΔNFV. We deduce that since nature and forests were among few places to visit during the pandemic, NFV change occurred for very diverse reasons, not necessarily triggering the link between the state of the environment and human behavior. Taken alone, even feeling better after forest visit (Q1) was a marginally significant predictor of no increase in recycling. Only individuals who also developed feelings of gratitude connected with spending time in forests (Q4), declared an increased appreciation of the environment (Q8) and began to think more that forests were subject to overharvesting (Q12) also began to recycle more during the pandemic. Here, the variability in people's natural or culturally shaped disposition toward gratitude or reciprocity may be very relevant. According to Singh (2015), the feeling of gratitude toward nature and forests is produced by the perception of various natural ecosystems as gifts to humans and nonhumans, embedded in reciprocity and communication with their biophysical environments. In terms of

Table 6 Ordinal logit regression between claims of recycling and selected demographic indices, the change in the number of forest visits (ΔNFV = NFV2 − NFV1) before (NFV1) and during (NFV2) the COVID-19 pandemic, and the feelings and emotions aroused by forests. Explanations and abbreviations: *SS* settlement size (in ascending order); ΔNFV1, 2, 3 is greater than, equal to, and smaller than 0, respectively; *Q1* after visiting the forest I feel better than before visiting the forest; since the outbreak of the COVID-19 pandemic: *Q4* (*Q5*) I've started to associate my stay in the forest with my feelings of gratitude (freedom) more than before, *Q8* I've become more interested in the environment than before, *Q10* I've started recycling more than before, *Q12* I've started to think more than before that forests in Slovakia are being overexploited, *Q15* I've started to think more than before that forests should fulfill an ecological function. In Q1, Q4, Q5, Q8, Q10, Q12, and Q15, indices 1–4 correspond to the responses "Fully agree", "Rather agree", "Rather don't agree", and "Don't agree", respectively, on the Likert scale. The results are based on data from 1000 respondents

Parameter estimates							
Nagelkerke's pseudo R^2: 0.564 Link function: Logit; $p < 0.001$	Estimate	Std. error	Wald	df	Sig.	95% Confidence interval	
						Lower bound	Upper bound
Threshold							
Q10 1	–8.317	0.905	84.384	1	< 0.001	–10.092	–6.543
Q10 2	–5.787	0.897	41.664	1	< 0.001	–7.545	–4.030
Q10 3	–2.842	0.878	10.471	1	0.001	–4.563	–1.120
Location							
SS 1	–0.266	0.229	1.347	1	0.246	–0.716	0.183
SS 2	–0.417	0.217	3.708	1	0.054	–0.842	0.007
SS 3	–0.329	0.236	1.948	1	0.163	–0.792	0.133
SS 4	–0.038	0.224	0.029	1	0.865	–0.477	0.401
SS 5	0.040	0.243	0.027	1	0.870	–0.436	0.516
SS 6	0[a]			0			
ΔNFV1	0.246	0.165	2.212	1	0.137	–0.078	0.570
ΔNFV2	0.062	0.158	0.156	1	0.693	–0.247	0.372
ΔNFV3	0[a]			0			
Q1 1	1.156	0.647	3.190	1	0.074	–0.113	2.424
Q1 2	1.199	0.648	3.417	1	0.065	–0.072	2.470
Q1 3	0.774	0.709	1.192	1	0.275	–0.616	2.164
Q1 4	0[a]			0			
Q4 1	–2.194	0.486	20.427	1	< 0.001	–3.146	–1.243
Q4 2	–1.882	0.458	16.902	1	< 0.001	–2.780	–0.985
Q4 3	–1.746	0.445	15.381	1	< 0.001	–2.619	–0.874
Q4 4	0[a]			0			
Q5 1	–0.964	0.479	4.042	1	0.044	–1.903	–0.024
Q5 2	–0.679	0.453	2.244	1	0.134	–1.567	0.209
Q5 3	–0.450	0.445	1.022	1	0.312	–1.323	0.423
Q5 4	0[a]			0			
Q8 1	–4.581	0.380	145.401	1	< 0.001	–5.326	–3.837
Q8 2	–3.200	0.342	87.482	1	< 0.001	–3.871	–2.530
Q8 3	–1.835	0.325	31.889	1	< 0.001	–2.471	–1.198
Q8 4	0[a]			0			
Q12 1	–1.818	0.471	14.916	1	< 0.001	–2.740	–0.895
Q12 2	–1.725	0.473	13.306	1	< 0.001	–2.651	–0.798
Q12 3	–1.133	0.479	5.597	1	0.018	–2.073	–0.194
Q12 4	0[a]			0			
Q15 1	–0.213	0.527	0.164	1	0.686	–1.246	0.819
Q15 2	–0.133	0.528	0.064	1	0.801	–1.167	0.901
Q15 3	–0.083	0.553	0.023	1	0.880	–1.168	1.001
Q15 4	0[a]			0			

[a]This parameter is set to zero because it is the reference level

reciprocity, beliefs that the pandemic represents a warning signal from nature were often articulated during the pandemic peak time (Haasova et al. 2020). Therefore, they may also have facilitated increased pro-environmental behavior, irrespective of demographic characteristics, NFVs, and other factors. However, for most factor levels, people with a higher appreciation of forests who claimed to have positive feelings linked to forests were more likely to pursue increased pro-environmental behavior in the form of recycling.

Recommendations for further research, policies, and management

In line with the most recent analysis of the trends in FES research (Chen et al. 2022), our results suggest that further in-depth studies of the internal correlation between FES and human well-being would likely produce further relevant findings. Their established effect size and statistical significance show that FES oriented at restoration, stress relief, and SWB have been recognized and appreciated by the large majority of citizens, even more so when faced with global threats. It is important that public health, land, and forest administrators and managers acknowledge these and other perceived forest benefits and transpose them into currently prevalent resource-oriented concepts, policies, and management plans. Rapid implementation is urgently needed since the forest-based bioeconomy concept still largely fails to address synergies and conflicts with broader ecological processes and ecosystem services (D'Amato et al. 2017). At the same time, the designation and provision of sufficient forest areas able to support the restoration of the human psychological agency should be accompanied by public awareness of science-based forestry interventions that strengthen the climate resilience of multifunctional managed forests. The sensitization of the public to management and conservation requirements for forests, particularly in periurban areas, is essential since forest visitors tend to perceive forests as a public space (Weinbrenner et al. 2021).

Ultimately, it remains the responsibility of governments to recognize and acknowledge the demands for and benefits of forest recreation for the whole society and provide sufficient incentives for forest owners and managers to safeguard and produce an expanded, inclusive FES portfolio based on forests that are less vulnerable to disturbances. In Europe, this vision appears to overlap with the desired turn of the forestry sector toward closer-to-nature forestry management as a concept proposed in the EU Forest Strategy for 2030 (Larsen et al. 2022).

CONCLUSIONS

Research on SWB and on forest perception, emotions, and pro-environmental behavior in relation to forests and forest visits before and during the COVID-19 pandemic showed several significant effects, mainly in terms of perceived stress reduction, recency of feelings of anger, and preparedness to engage in the circular economy through recycling. The results supported our working hypotheses that the pandemic strengthened the perception of forests as a high-quality restorative environment and that emotions associated with spending time in forests played an important role in the perceived importance of forests and their utilization. However, it is possible that in addition to the immediate perceptual response, the subsequent cognitive evaluation of forest sensory stimuli was also involved in the respondents' assessments, and forest visitors should be sensitized to management and conservation requirements for forests. The established association between forest visits and the feeling of gratitude as one of the identified emotions could be a valuable asset in the creation of a desired, inclusive, and resilient FES portfolio on a wider scale. The alignment of patterns established on the national scale with the global assessment of nature's contribution in coping with the COVID-19 pandemic suggests that the study's novel findings can be generalized in the context of other similar situations and trends exacerbating the demands and pressures on individuals and human society as a whole.

Author contributions Conceptualization, MP, JV, VP, and DÖ; methodology, VP, JV; formal analysis, JV, VP; writing—original draft preparation, MP, VP, KL, DT, and LN; writing—review and editing, DÖ, MP; visualization, JV, VP; project administration, MP; funding acquisition, MP. All authors have read and agreed to the published version of the manuscript.

Funding This research was funded by the Project RISE-WELL—Critical solutions for elderly well-being (Grant Agreement No. 860173) awarded by the European Commission through the MSCA-ITN-EID: European Industrial Doctorates Funding Scheme (H2020-MSCA-ITN-2019), the Project CHARMED—Characterization of a green microenvironment and to study its impact upon health and well-being in the elderly as a way forward for health tourism (Grant Agreement No. 734684) awarded by the European Commission through the Horizon 2020-MSCA-RISE-2016 Scheme, and the Grant Number 1/0836/18 awarded by the Scientific Grant Agency of Ministry of Education, Science, Research, and Sport of the Slovak Republic.

Data availability The data presented in this study are available on request from the corresponding author.

Declarations

Conflict of interest The authors declare no conflicts of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

Ethical approval Ethical review and approval were waived for this study under the principal investigator's institution (Technical University in Zvolen, Slovakia) policy stipulating that ethical review needs to be conducted only when more than minimum risk is identified. No potential or real, past, actual, or future risk whatsoever to the respondents participating in the presented research, its evaluation or presentation was identified.

Informed consent Informed consent was obtained from all subjects involved in the study.

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