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Disturbance Severity and Human–Nature Relationships: A New Approach to Analyze People's Well-Being along a Bark Beetle Infestation Gradient

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Citation: Kortmann, M.; Angelstam, P.; Mayer, M.; Leibl, F.; Reichert, J.; Thorn, C.; Thorn, S. Disturbance Severity and Human–Nature Relationships: A New Approach to Analyze People's Well-Being along a Bark Beetle Infestation Gradient. *Forests* **2022**, *13*, 1954. https://doi.org/10.3390/f13111954

Academic Editor: Radu-Daniel Pintilii

Received: 28 September 2022
Accepted: 16 November 2022
Published: 18 November 2022

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Abstract: Contact to nature and greenspace is important for emotional well-being and can promote human health. Forest landscapes provide such access to greenspace, especially in protected areas. However, forested protected areas are impacted by natural disturbances such as bark beetle infestations. On the one hand, such disturbances have positive impacts on ecological processes and biodiversity. On the other hand, they have allegedly negative impacts on the recreational value of a landscape. Limited knowledge about the public's perception of forests subject to natural disturbances still hampers forest management to balance ecological functions and visitors' recreational experience. Thus, our aim was to determine how attitudes towards nature influence the personal well-being in a naturally disturbed landscape. We investigated self-reported well-being and attitudes towards nature in a standardized questionnaire-based survey of 1008 German inhabitants in an experimentally adapted landscape visualization. Self-reported well-being was generally highest in landscapes with relatively few bark-beetle-killed trees. This was especially the case for people who felt included with nature and preferred an appreciative use or preservation of nature. Conversely, people who had previously visited a national park with visible bark beetle infestations rated their personal well-being highest in landscapes with larger proportions of beetle-killed trees. Our results indicate that it is necessary to analyze people's knowledge about and relations to forest landscapes as well as concepts of nature conservation, natural landscapes, and biodiversity to gain a better understanding of people's perceptions of natural disturbances.

Keywords: bark beetle disturbance; major environmental values; well-being; inclusion of nature in one's self; national park

1. Introduction

Ongoing urbanization leads to an increasing loss of human contact with nature [1,2]. However, interactions between humans and nature in both rural and urban settings are important for human well-being and can promote health [3–5]. Hence, access to forests

and other greenspaces for recreational purposes is of growing importance, especially during and in the aftermath of the COVID-19 pandemic [6–8]. Forests are a huge part of European greenspace, covering over 40% of the land area [9]. Human benefits of spending time in forests span from impacts on the physical health [10–12] to positive impacts on psychological health and mental well-being [10,13]. Human well-being is a multidimensional concept ranging from material well-being, bodily well-being, and security and freedom of choice to psychological well-being [14]. While it is mostly used in the context of human development on the level of countries [15], In our study, we focus on the impacts on well-being as used in Martens et al. (2011) [13], where well-being is the current mood or mental state of an individual [16]. In this context, well-being can be described by factors like positive affect, activation, negative affect, and arousal [13]. In contrast, other studies analyzed the economic well-being ("welfare") of people in areas characterized by large-scale forest disturbances using environmental economic valuation approaches [17].

Human–nature relationships are manyfold. Hence, the influences on our perception of nature and our well-being in nature are complex, covering traditions and ethics, values, attitudes, worldviews, and lifestyle [18]. Several studies tried to find common demands and preferences for forests, exploring that dependance on tree species, the level of naturalness, and other factors whereby forest visitors perceive forests differently. For example, Martens et al. (2011) [13] showed that managed forests have more positive effects on human well-being than unmanaged forests. Furthermore, people expect forests to be natural-looking, colorful, beautiful, inviting, diverse, and blend into the landscape [19]. However, most studies that analyzed the relation between green space and people's well-being have focused on urban forests. Still, rural forests and protected forest areas are also important types of greenspace. For example, national parks are specifically set aside to not only protect ecological processes, species, and ecosystem characteristics, but also to provide scientific opportunities and recreational space for the general public [20] (for Germany, see [21]). Furthermore, the studies we described above focus on well-being in forest landscapes, but there is still a lack of knowledge on well-being in forests affected by natural disturbances.

National parks in the boreal and temperate zone include large areas of coniferous forests that are naturally prone to large-scale, stand-replacing disturbances, such as wildfires, storms, and insect outbreaks [22,23]. In most national parks, at least in their core zones, natural disturbances are allowed to proceed without human intervention [24]. Examples include wildfires in the Yellowstone National Park, USA [22], and outbreaks of the spruce bark beetle (*Ips typographus* (L.)) in the Bavarian Forest, Germany, and Białowieża National Park, Poland [25,26]. The benign neglect of disturbances in protected area management, and thus maintenance or development of spatially diverse landscapes [27], frequently lead to an increase in the diversity of different taxonomic groups [26,28,29]. For instance, higher amounts of deadwood due to unmanaged bark beetle infestations lead to a diversity of invertebrates which includes the survival of many rare and endangered species or even the rediscovering of species specialized on deadwood thought to be already extinct [30,31]. Insects are crucial parts of ecosystems as important elements of the food chain and generate decisive ecosystem services, for instance, due to their pollination effects [32]. Furthermore, invertebrates are key species for monitoring overall biodiversity decline, as exemplified by the study of Hallmann et al. (2017) [33], who reported that within 27 years, the biomass of insects in Germany has decreased by about three quarters.

However, to the best of the authors' knowledge, there are not any studies yet available which analyzed to which degree these alarming results regarding the decline of the amount and diversity of insects in Germany are recognized by the general public. Nevertheless, people obviously care about more emblematic and familiar insect species like bees, as underlined by the high level of consent to the public initiative "Biodiversity & Natural Beauty in Bavaria" („Artenvielfalt & Naturschönheit in Bayern" in German) in Bavaria in 2019, which is more well-known as "Save the bees" ("Rettet die Bienen" in German) [34]. It

remains unclear, however, whether lay people link forest disturbances to such valued insect species such as bees [35]. The public outreach during the public initiative was dominated by necessary adaptations of agricultural practices or the preservation of meadow orchards while forest management practices or the (non)management of forest disturbances did not play an important role.

In contrast to these positive effects of natural forest disturbances on forest biodiversity, Flint et al. (2009) [36] reported that naturally disturbed forests are perceived as catastrophic by local residents and national park visitors, threatening safety, property, and well-being. They have also led to a deterioration of park–people relationships in the past [37–39]. Yet, it remains unclear if bark beetle infestations can diminish the positive impacts of forests on human well-being.

A balanced management strategy of protected areas should consider both the promotion of ecological processes and the preservation of the positive impacts on human well-being. Therefore, it is necessary to obtain detailed information on the extent to which trees affected by bark beetles are tolerated by the general public without diminishing their well-being derived from park visits. Recent studies on people's perceptions of natural disturbances were limited to surveys of either national park visitors or local populations adjacent to protected areas [40–44]. Still, people can also have contact to bark beetle infestations outside of protected areas, for example, in commercial forests in their neighborhood. In addition, the general public, including also nonvisitors of forests and protected areas, can have an impact on nature conservation and forest policies based on their electoral behavior (see for example [45] for Bavaria). Thus, a comprehensive assessment, covering both visitors and nonvisitors of national parks and other areas subject to large-scale bark beetle disturbances is crucial to achieve a holistic understanding of the factors contributing to self-reported well-being in landscapes affected by bark beetles.

Based on previous studies [39,45–47], it can be assumed that people generally derive their highest well-being from more green and vital forests with small amounts of dead trees. Nevertheless, personal characteristics including knowledge and previous experiences can further affect the preference for certain landscapes. For example, a strong connection with nature can promote proenvironmental behavior and environmental concern [48] (and references within). Furthermore, it also affects the perception of natural environments. Clayton (2021) [49], for example, showed that different relationships with nature can also affect the emotional well-being in certain landscapes. Being in nature can increase your commitment to the landscape and can lead to a less superficial evaluation of the respective landscape [50]. These experiences might also positively affect people's judgement of a landscape in the future. Furthermore, people who have been to a national park before might be more aware of the positive effects of natural disturbances on biodiversity, for instance, due to educational programs in the national parks on natural disturbances. Therefore, it is crucial to understand additional factors that might affect personal well-being in landscapes with different bark beetle infestation severities.

The aim of this study is to analyze the association between different infestation severities and subjectively perceived well-being based on a photographically simulated spruce forest covering an entire disturbance severity gradient. To assess the impact of bark beetle disturbance severity (i.e., the share of bark-beetle-killed trees in a landscape) on people's subjectively perceived well-being, we conducted a standardized questionnaire-based survey of 1008 German inhabitants representing an adequate sample of the German population. To control for different attitudes towards and relations with nature, we tested also inclusion of nature in one´s self (INS), major environmental values (2-MEV), and the information on prior visits to national parks characterized by significant bark beetle infestations.

We hypothesize that, when confronted with natural disturbance, the connection of people with nature will also affect their sense of well-being within this landscape. More specifically, with increasing inclusion of nature in self and more protective attitudes towards nature, people will choose more vital forests (i.e., forests with less dead trees) to comply with their personal well-being. Furthermore, we hypothesize that people who have visited

a national park before and were directly confronted with disturbed forest landscapes will choose landscapes with higher amounts of dead trees for their personal well-being.

2. Materials and Methods

We conducted an online survey hosted by Norstat Deutschland GmbH, which fulfills the ICC/ ESOMAR International Code on Market, Opinion, and Social Research and Data Analytics, to achieve a representative sample of the German population. Our questionnaire assessed three groups of variables (sociodemographic parameters, proxies for people's attitudes towards nature, and preferences for different bark-beetle-affected landscapes). Sociodemographic parameters included data on age, gender, and educational level (1: no educational degree, 2: elementary school, 3: lower secondary school, 4: higher secondary school, 5: university degree). Proxies for people's attitudes towards nature included first the respondents' sense of inclusion of nature in one´s self (INS) [51], which was determined as an indicator of a self-estimated connection with nature. The INS scale is easily comprehensible and hence a suitable tool for a broad field of respondents.

In addition, we used the bidimensional scale 2-MEV (major environmental values) of Kibbe et al. (2014) [52] to assess whether or not respondents prefer an exploitative or an appreciative use of nature. In context of an exploitative use of nature, utilization represents an anthropocentric dimension including the domination and exploitation of the environment and its natural resources. An appreciative use of nature is assessed in terms of preservation, a biocentric dimension defined by a preference for environmental protection. The 2-MEV scale is a widely used and validated tool to measure environmental worldviews [53]. Whereas the New Ecological Paradigm (NEP) scale is one-dimensional and assumes that people can either be biocentric or anthropocentric, but not both, the 2-MEV scale is two-dimensional and allows respondents to have high scores for preservation and utilization at the same time [53]. For example, a person with a huge interest to protect nature can also believe that one of the main purposes of nature is to benefit humans and would hence have high scores for preservation and utilization at the same time.

Finally, we included a question on previous national park visits. We asked the respondents whether they had visited any of Germany's 16 national parks at any time in their life before, and if so, which ones. Bark-beetle-affected national parks were defined as forested national parks (excluding marine and shore parks) with significant portions of Norway spruce (*Picea abies* (L.) H. Karst) that had experienced clearly visible bark beetle infestations in the past 30 years. This is approximately the time span in which bark beetle infestations are clearly visible in a landscape. Due to natural succession, visible signs of the infestations disappear in time. Additionally, we screened the most comprehensive German online press database (www.genios.de, accessed on 25 January 2018) using the simplified search string 'National Park name + bark beetle' to quantify media coverage of bark beetle outbreaks in the respective national parks in the last 30 years. We then used this information to validate our national park selection by only choosing parks with any media coverage on bark beetle infestations (Table A1). This resulted in seven national parks where visitors could have had previous encounters with natural disturbances.

A photomontage of a forest landscape affected by the European spruce bark beetle (*I. typographus*) was used to assess the respondents' self-reported well-being. For this purpose, we used image-editing software to create an image of an artificial landscape based on a photograph of the Bavarian Forest National Park. The landscape depicted in the image ranged from entirely beetle-killed to an entirely intact and unfragmented forest canopy. On the bottom of the picture, we added a movable slider (Figure 1). We then asked the respondents the following: "Imagine you are hiking through a forested national park. The hiking trail crosses areas with different proportions of living and dead trees (0–100%). Please move the slider to the position at which your personal well-being would be the highest." This approach allowed an uncomplicated landscape-scale assessment of the proportion of beetle-killed trees associated with a personal maximum of self-reported well-being. The personal, subjectively perceived well-being is not further

measured but used as an indication based on which people were asked to choose a certain proportion of dead and living trees. The possible disturbance severities ranged from zero to 100 including all integers. A German and English version of the questionnaire can be found in Supplementary File S1.

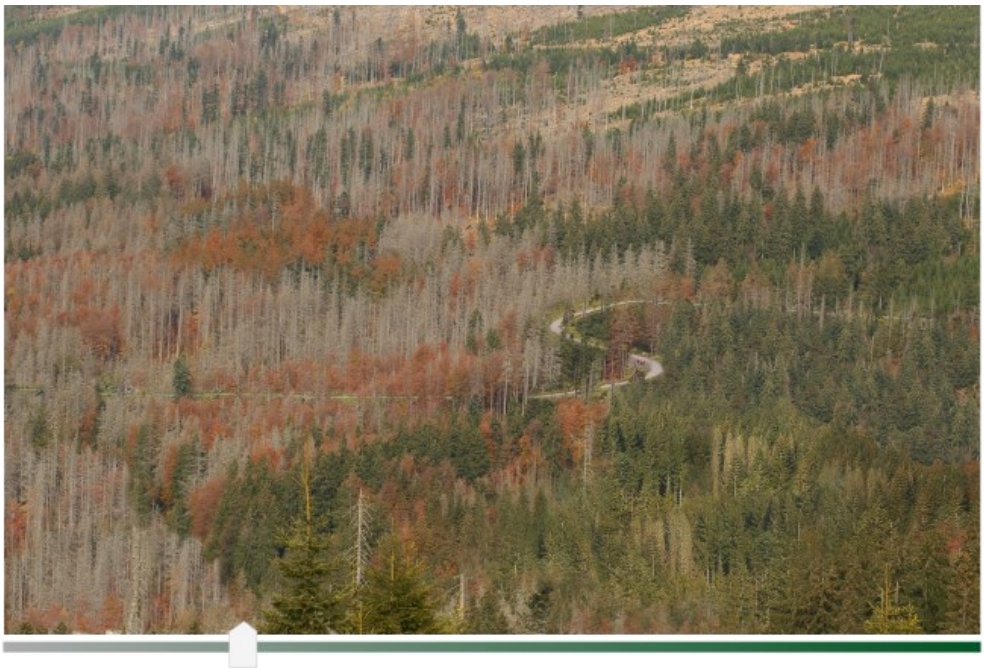

Figure 1. An artificial landscape depicting an outbreak of the European spruce bark beetle (*Ips typographus*). The landscape ranged from entirely killed (left side) to entirely intact (right side) forests. A hiking trail was inserted for visual purpose.

All data analyses were performed in R version 3.3.3 (www.r-project.org, accessed on 1 September 2022). First, multicollinearity among the predictor variables was tested through a variance inflation factor (VIF), in which values > 10 indicated highly related variables [54]. The maximum VIF detected in our variables was Preservation = 2.25. Consequently, no predictor variable was removed from the subsequent statistical analysis.

The reliability of items representing an exploitative versus an appreciative use of nature [52] was validated by means of Cronbach's α, provided by the function 'alpha' from the r-package 'psych' [55]. Cronbach's α is used to analyze the degree to which a set of items measures a single unidimensional latent construct (e.g., versus appreciative use of nature); α values < 0.65 indicate an unreliable measurement [56]. The α value of the utilization of nature was 0.77, and that of nature preservation was 0.73. The average item scores served as proxies for preservation and utilization, respectively.

Single generalized linear models were combined into one joint model using piecewise structural equation modeling (SEM). We tested the effects of age, gender and educational level, inclusion with nature, the utilization vs. preservation of nature, and previous visits to national parks (affected by bark beetle infestations) on the choice behavior of the participants (Figure 2). Different individual models were included for every response variable. Influences on the proportion of bark-beetle-killed trees associated with the highest perceived well-being were tested with a linear model in which age, gender, educational level, prior visits to national parks with bark beetle infestations, inclusion with nature, preservation, and utilization as predictors. Binomial linear models were employed to test the influence of socio-demographic parameters and attitudes on prior visits to national parks.

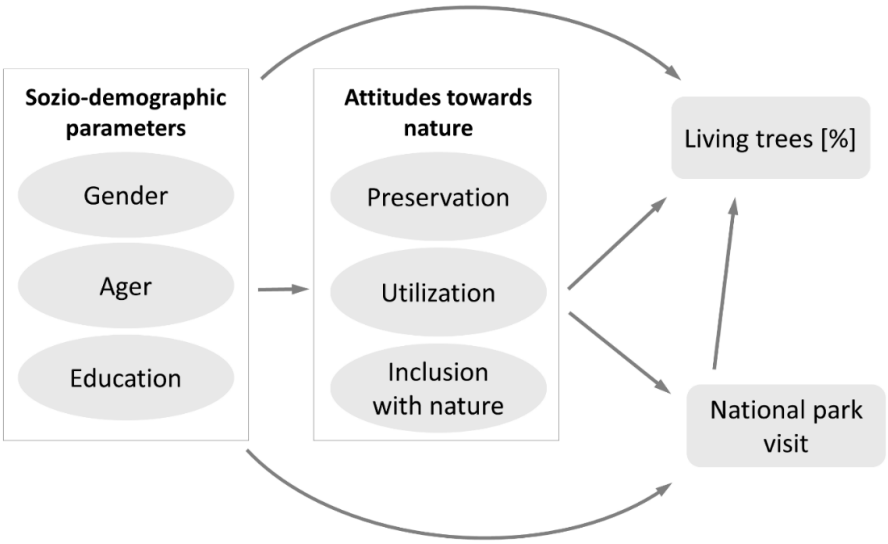

Figure 2. Variables used in the Structural Equation Modeling and the tested relations between the different variables.

Finally, different linear models were used to test the influence of age, gender, and educational level on inclusion with nature, preservation, and utilization. To account for the β-distribution of our data in the standard unit interval (0.1), the proportion of beetle-killed trees was additionally modeled via a maximum likelihood approach by means of a β-regression for proportions [57]. β-regression was used in this study to validate the results of the SEM. Therefore, the function 'betareg' was applied, with self-reported well-being as the response variable and age, gender, educational level, prior visits to national parks, inclusion with nature, preservation, and utilization as predictors. The results obtained via β-regression were very similar to those obtained with the SEM and are reported in the Appendix A (Table A2).

3. Results

The 1008 respondents who completed our questionnaire included 527 women and 481 men from all 16 German federal states. Their mean age was 44.7 (± 14.3 standard deviation) years, ranging from 18 to 70 years. According to The Federal Institute for Population Research (2019), the mean age of the German population was 44.5 in 2019. Within our respondents, 40% had a university degree (n = 287). This is above the German average of 31.3% for 25–64-year-old people [58]. An overview of the age distribution and educational levels is given in Figure 3.

A total of 41.6% (n = 416) of the respondents stated that they had visited at least one German national park with visible bark beetle infestations before. These national parks included the Bavarian Forest, Harz, Black Forest, Hunsrück-Hochwald, Saxon Switzerland, Eifel, and Berchtesgaden. On average, male respondents had visited more national parks (1.2 national parks) than female respondents (0.8 national parks) before.

The median and mean percentages of beetle-killed trees in the chosen landscape was 26% vs. 30 %, respectively. A preference for < 20 % dead trees was expressed by 41 % of the respondents (n = 409) and for < 50 % dead trees by 77 % of the respondents (n = 776) (Figure 4).

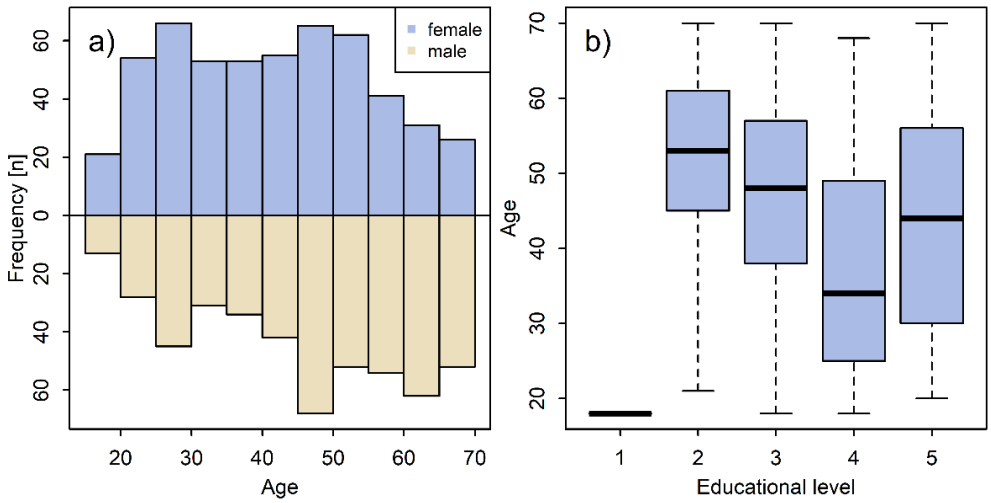

Figure 3. (**a**) Frequency of respondents age for female and male respondents. (**b**) Boxplot of respondents age per educational level (1: no educational degree, 2: elementary school, 3: lower secondary school, 4: higher secondary school, 5: university degree).

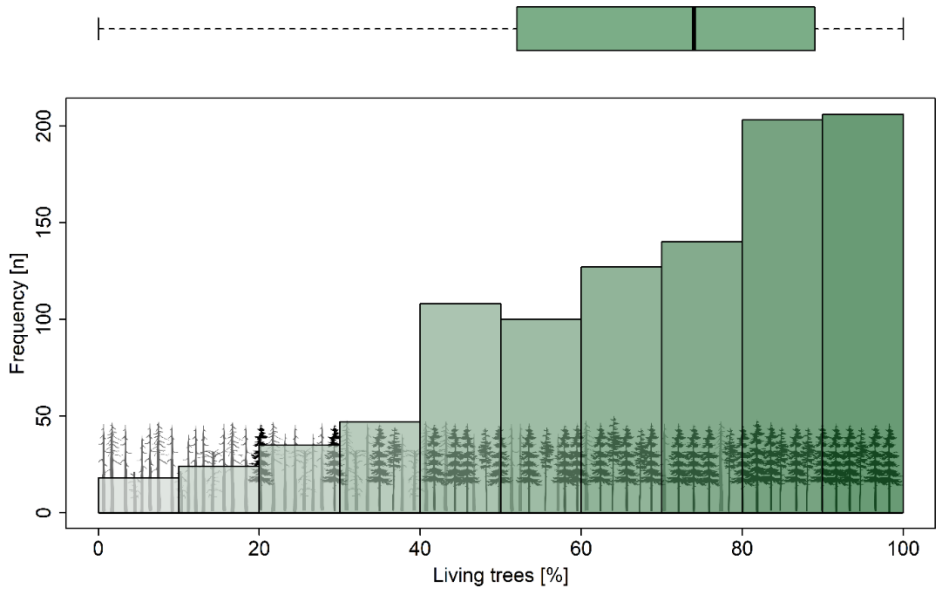

Figure 4. Frequency of respondents (n = 1008) and the percentage of living trees, where respondents rated their personal well-being highest. The boxplot shows the median self-reported highest well-being (median = 0.74).

The SEM showed a significant influence of age and gender on the psychological parameters (inclusion with nature, utilization, preservation) (Figure 5). Male respondents felt less included with nature and preferred its more exploitative use compared to women. Older respondents felt more included with nature (z = 7.41) and preferred its appreciative use (z = 9.01). Overall, respondents who felt more included with nature (z = 3.15) and placed higher value on preservation (z = 2.47) preferred landscapes with a larger proportion of living trees. Respondents with higher values for inclusion with nature and preservation were also more likely to have previously visited a national park with bark beetle infestations (z = 3.11, z = 4.65, respectively). Both male (z = 5.00) and older respondents (z = 2.74) as well as people with a higher educational level (z = 4.90) more often report previous national park visits. People with prior visits of national parks with bark beetle infestations preferred landscapes with slightly higher proportions of bark-beetle-killed trees (z = −2.30). Still, this effect was rather weak.

Table 1. Results of the structural equation model testing the influence of age, gender, education level, preservation, utilization, and inclusion with nature on prior visits and subjectively perceived well-being (n = 1008) using generalized linear models. The influence of gender, age, and education level on utilization, preservation, and inclusion with nature was tested using linear models. Boldface indicates statistical significance (significance level at 5%).

Response	Predictor	Estimate	Std. Error	z-Value
Prior visit	Gender	7.05×10^{-1}	1.41×10^{-1}	5.00
	Education	3.25×10^{-1}	6.64×10^{-2}	4.90
	Preservation	8.99×10^{-1}	1.93×10^{-1}	4.65
	Inclusion with nature	4.99×10^{-1}	1.60×10^{-1}	3.11
	Age	1.48×10^{-1}	5.39×10^{-2}	2.74
	Utilization	-1.41×10^{-2}	5.18×10^{-3}	−2.72
Perceived well-being	Inclusion with nature	7.55×10^{-2}	2.39×10^{-2}	3.15
	Preservation	2.17×10^{-1}	8.76×10^{-2}	2.47
	Prior visit	-1.51×10^{-1}	6.57×10^{-2}	−2.30
	Utilization	-5.91×10^{-2}	7.35×10^{-2}	-8.04×10^{-1}
	Gender	2.11×10^{-2}	3.07×10^{-2}	6.89×10^{-1}
	Education	4.36×10^{-2}	6.49×10^{-2}	6.72×10^{-1}
	Age	-9.37×10^{-4}	2.36×10^{-3}	-3.97×10^{-1}
Utilization	Age	-8.52×10^{-3}	1.35×10^{-3}	−6.32
	Gender	1.96×10^{-1}	3.78×10^{-2}	5.17
	Education	1.92×10^{-3}	1.81×10^{-2}	1.06×10^{-1}
Preservation	Age	1.06×10^{-2}	1.17×10^{-3}	9.01
	Gender	-1.73×10^{-1}	3.30×10^{-2}	−5.25
	Education	3.00×10^{-2}	1.58×10^{-2}	1.90
Inclusion with nature	Age	2.41×10^{-2}	3.25×10^{-3}	7.41
	Gender	-3.12×10^{-1}	9.13×10^{-2}	−3.41
	Education	6.58×10^{-2}	4.38×10^{-2}	1.50

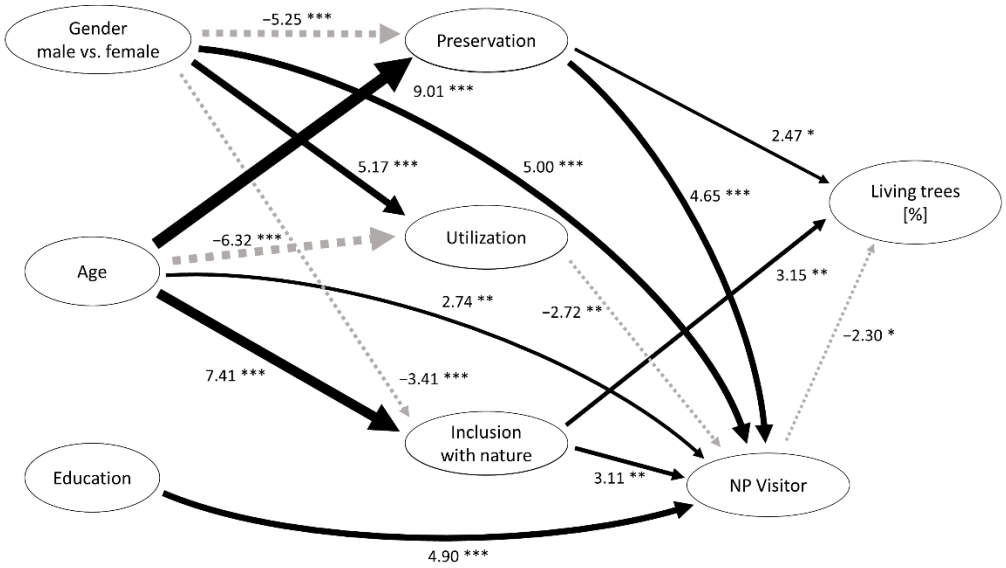

Figure 5. Structural equation model, with sociodemographic parameters on the left, preservation, utilization, and inclusion with nature in the center and previous visits of bark-beetle-affected national parks (yes/no) and the proportion of living trees on the right. Arrows are labeled with the corresponding z-values and significance levels (*** $p < 0.001$, ** $0.001 < p < 0.01$, * $0.01 < p < 0.05$). Arrow width corresponds to the z-values of the model (see Table 1 for coefficients). Black solid lines are for positive and grey dotted lines for negative effects. The figure shows only significant results.

4. Discussion

Overall, people chose landscapes with high percentages of living trees (70%) for their highest personal well-being. Our results revealed that respondents who felt most connected with nature and respondents who prioritized the preservation of nature chose landscapes with even higher portions of living trees. By contrast, respondents who had previously visited a national park with bark beetle infestations chose landscapes with larger proportions of bark-beetle-killed trees.

4.1. Environmental Perception

Female respondents in our study had higher values for preservation and inclusion with nature than male respondents, which confirms earlier findings [59,60]. While not a universal phenomenon, stronger positive environmental attitudes are generally reported more often by women than by men [61,62].

We also found a significant increase in preservation values with increasing age. Yet, there is little consensus on the effect of age on preservation values. Reported effects range from negative [63,64], to neutral [65], to positive [61]. Gifford and Nilsson (2014) [61] concluded that it is difficult to distinguish between cohort effects, i.e., impacts that more often occur in one age group than in another, era effects, which are driven by social–political changes in time, and true age effects. This might explain the ambiguous results of different studies.

4.2. Personal Well-Being Is Higher in Landscapes with Larger Proportions of Living Trees

The large majority of respondents in our study rated their personal well-being highest in landscapes with large proportions of living trees (Figure 4). This result is in line with other studies that found a preference for healthy, orderly forests [46,66] and a negative attitude towards dead wood or dying vegetation in the landscape [47,67]. As reported in previous studies, postdisturbance landscapes can be perceived as dead and desert-like and a risk for the forest ecosystem [39,43].

4.3. Impacts of Attitudes towards Nature

Our study shows that people higher values of preservation and inclusion with nature chose forests with significantly larger proportions of living trees for their personal well-being. This finding is in contrast with McFarlane et al. (2006) [40] and Müller and Job (2009) [42], where people with more proecological worldviews were less opposed to forests with bark beetle infestations and showed more positive attitudes towards bark beetles. These differences might derive from different concepts of nature conservation. Most European countries have a long history of cultural landscape management [68]. In this cultural context, persistence can be an important factor of the landscape [69]. Hence, nature conservation can be strongly linked to the preservation of the status quo. Contrary, in naturally dynamic landscapes, which are perceived more as wilderness without human interventions and management, dynamic processes might not contradict the idea of nature conservation. The difference between conservation and preservation is often discussed in the context of the measurements of human–nature relationships, which are adapted by different scientists to include new attitudes in the field of nature conservation and combine ecocentric and anthropocentric views that can change over time [70,71].

In natural forest landscapes without silvicultural use, such as national parks, bark beetle infestations and other natural disturbances might be more tolerated by the public, especially if learning about the roles of disturbances for conservation. In our data, which focuses on German citizenry with a long history of forest management, the cultural aspect as well as the preservation of the status quo might be the dominating view. Hence, people with high preservation values can perceive bark beetle infestations and dead trees as negative and incompatible with nature conservation.

4.4. National Park Visits Promote Well-Being in Disturbed Landscapes

Respondents who had previously visited a national park with bark beetle infestations located their highest personal well-being in landscape sections with larger proportion of beetle-killed trees. Hence, people presumably are able to change their perceptions of naturally disturbed forests following a national park visit. Asking national park visitors in different European national parks, Kortmann et al. (2021) [72] showed that the perceived restorativeness in disturbed landscapes was surprisingly high. In addition, after severe natural disturbances in the Bavarian Forest National Park, visitor numbers remained high in the following years [73]. Hence, visitors might learn that dead wood in a forest landscape does not reduce their recreational experience. Later on, they might even link their well-being to dead wood in the landscapes after positive experiences during a national park visit.

4.5. Methods

We used a new method to explore a well-being gradient along an ecological gradient created by natural disturbances. The method was easily applicable and allowed us to detect different choice behavior along the disturbance gradient. Due to the simpler character of our method, we were not able to determine where precisely these differences come from. Furthermore, we did not use a scale to measure peoples well-being but used it as a guiding principle for our respondents to choose a certain landscape section and disturbance severity. Hence, we cannot verify the validity of our approach. To transfer our new insights into environmental education and forest management, it would be necessary to gain additional information via further interviews and additional questions with this survey. Important additional questions would be for example what people associate with nature conservation and disturbed landscapes and how people imagine natural forest landscapes. Hence, further studies should include in-depth interviews of people with different relations to forest landscapes to explain, where the choices for certain disturbance severities stem from. These interviews might also focus on impacts of national park visits on visitors. Why do national park visitors perceive natural disturbances different after a visit than before and why does the well-being in disturbed landscapes change? Based on our results we suspect that all these additional factors and drivers are connected and need further observations.

5. Conclusions

We demonstrated that previous national park visits, attitudes towards nature, and inclusion of nature in one's self affected the subjectively perceived well-being of respondents in a naturally disturbed landscape. National park visitors seem to have generally more positive perceptions of disturbed forest landscapes. Despite the positive effects of bark beetle infestations on ecological processes and biodiversity, people do not necessarily perceive natural disturbances and nature conservation as compatible. To be able to understand the different perceptions of natural disturbances, it is necessary to analyze people's relations to forest landscapes as well as concepts of nature conservation, natural landscapes, and biodiversity. Since natural disturbances will likely increase in the future and affect more and more forest landscapes, it is necessary to understand the complex human–nature relationships in the context of forest landscapes and their management. Our research shows important aspects that need to be further analyzed and gives indications for future research projects.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/f13111954/s1.

Author Contributions: M.K., S.T., and C.T. contributed to the study conception and design. Material preparation, data collection, and analysis were performed by M.K. and S.T. Writing—review & editing: P.A., M.M., F.L., J.R. The first draft of the manuscript was written by M.K. and all authors commented on previous versions of the manuscript. All authors have read and agreed to the published version of the manuscript.

Funding: This work was supported by the scholarship program of the German Federal Environmental Foundation (20017/474).

Data Availability Statement: All data files are available from the figshare database (accession number 11662854, URL https://figshare.com/articles/questionnaires_18_xlsx/11662854, accessed on 18 November 2022).

Conflicts of Interest: The authors declare no conflict 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.

Appendix A

Table A1. German forest-dominated national parks with bark beetle disturbances, the number of respondents who reported visiting those parks (n = 927), and the number of press releases mentioning bark beetle infestations (n = 2878).

National Park	News Releases (n)	Visitors (n)
Bavarian Forest	1649	225
Harz	398	163
Black Forest	400	157
Hunsrück-Hochwald	260	51
Saxon Switzerland	167	105
Eifel	180	127
Berchtesgaden	180	99

Table A2. Beta-regression of bark-beetle-affected forest portion, with gender, age, and education level of respondents, inclusion with nature, utilization, preservation, and prior visits as predictor variables (n = 1008). Because a beta-regression is applicable only when the dependent values are between 0 and 1, the standardization $\frac{y*(n_{obs}-1)+0.5}{n_{obs}}$ suggested by Smithson and Verkuilen [74] was applied. Boldface indicates significance.

Variable	Estimate	Std. Error	z-Value	p-Value
Intercept	-4.71×10^{-1}	5.14×10^{-1}	-9.15×10^{-1}	0.360
Gender	5.55×10^{-2}	7.17×10^{-2}	7.73×10^{-1}	0.440
Age	-5.15×10^{-3}	2.61×10^{-3}	-1.98	0.048
Education	-1.65×10^{-2}	3.40×10^{-2}	-4.85×10^{-1}	0.630
Inclusion with nature	1.03×10^{-1}	2.66×10^{-2}	3.85	<0.001
Utilization	1.61×10^{-3}	8.11×10^{-1}	2.00×10^{-2}	0.984
Preservation	2.90×10^{-1}	9.67×10^{-2}	3.00	0.003
Visits	-2.12×10^{-2}	2.51×10^{-2}	-8.44×10^{-1}	0.400

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