How Dead Wood in the Forest Decreases Relaxation? The Effects of Viewing of Dead Wood in the Forest Environment on Psychological Responses of Young Adults

Emilia Janeczko 1,*, Ernest Bielinis 2, Ulfah Tiarasari 3, Małgorzata Woźniacka 1, Wojciech Kędziora 4,*, Sławomir Przygodzki 5 and Krzysztof Janeczko 4

Abstract: The intensity of the neutral environment impact on humans may be determined by specific features of space, including dead wood occurrence. Dead wood is claimed to be disliked by the public because it reduces the scenic beauty and recreational values of the forest. The attractiveness of a forest with dead wood may be determined by its variants. Much is known about the preference for landscape with dead wood, but there is little information available about how such a landscape affects a person’s mental relaxation, improves mood, increases positive feelings, levels of vitality, etc. Hence, the aim of our research was to investigate the psycho-logical relaxing effects of short 15-min exposures to natural and managed forests with dead wood. In the study, three areas within the Białowieża Primeval Forest were used to measure the impact of different types of forest with dead wood (A: forest reserve with dead wood subject to natural decomposition processes; B: managed forest with visible cut wood and stumps; C: man-aged forest with dead trees from bark beetle outbreak standing) on human psychological relaxation in a randomized experiment. The participants of the experiment were forty-one young adults aged 19–20. Each respondent experienced each type of forest at intervals visiting it. Four psychological questionnaires were used in the project (Profile of Mood States (POMS), Positive and Negative Affect Schedule (PANAS), Subjective Vitality Scale (SVS), and Restorative Outcome Scale (ROS)) before and after the short exposure to the forest were evaluated. The results show that a forest landscape with dead wood affects the human psyche, and the relaxing properties of such a landscape are better in a protected forest with natural, slow processes of tree dieback than those obtained in managed forests.

Keywords: forest landscape; outdoor recreation; mental health; dead wood; Białowieża forest

1. Introduction

In recent years, a certain re-evaluation of previous functions performed by forests has been observed in many countries [1–3]. Forests traditionally used as a source of timber are increasingly serving as recreational areas. They are places for various forms of leisure activities, for example: walking, running, riding, biking, picking berries and mushrooms, hunting, and fishing. Recreational use of forests dramatically increased as a result of increased leisure time and urban infrastructure developments [4]. The non-productive,
social functions of the forest enrich the labor market, provide a significant economic contribution to the local economy, are important for cultural development and environmental education of the public, and create profitable health and recreational conditions for the public. Contact with nature is extremely important for humans. Recreational outdoor activity in nature contributes to the renewal and preservation of mental health [5–7] as well as stress reduction [8–10]. Research showed that people’s moods and positive feelings are increasing in natural areas [7,8,11–13]. Son and Ha [14] found that increasing contact with nature serves to improve social and emotional interactions in modern society. As our knowledge about the positive impact of the natural environment on humans grows, there are also reports that the intensity of this impact may be determined by specific features of the space. Some scientists believe that the concept of “natural environment is therapeutic” cannot be accepted without some criticism [15]. Wyles et al. [16] points out that elements such as garbage appear in the natural environment, the presence of which may weaken the benefits of contact with nature. It seems that there may be more such elements. The results of the study of preferences regarding the aesthetics of forest landscape may be helpful in negative elements in nature. The research on forest landscape preferences is extensive (e.g., [17–24]). One of the elements of the forest landscape analyzed in this type of research was dead wood [21,22,25,26]. Pastorella et al. note [27], however, that people’s opinions about the presence of dead wood in forests are little studied.

The term dead wood refers to all non-living woody biomass not contained in the litter, either standing, lying on the ground, or in the soil. Dead wood includes wood lying on the surface, dead roots, and stumps larger than or equal to 10 cm in diameter [28]. A broad definition of dead wood and its components is presented by Merganičová et al. [29]. Overall, the dead wood can be subdivided into two main components: standing dead trees (snags) and lying dead wood (logs) [30]. Standing dead wood consists of standing dead trees, snags, and stumps, and lying dead wood includes downed dead trees, and lying dead wood pieces, which are often called logs [29].

Forest dead wood is an important indicator of the biodiversity level because it provides a habitat for many species. A wide range of plants and animals is strongly associated with standing and lying dead wood. Dying and dead trees, either standing or fallen and at different stages of decay, are valuable habitats (providing food, shelter and breeding conditions, etc.) for a large number of rare and threatened species: saproxylic insects, invertebrates, lichens, bryophytes, birds and mammals [31]. Dead wood is also a fundamental component of nutrient cycles, regulates water flows, prevents soil erosion, and contributes to carbon storage in the forest [30]. However, on the other side, dead wood is considered to be the cause of biotic and abiotic disturbances, an obstacle to forest management activities (i.e., reforestation, logging), and a threat to public safety (visitors and forest workers) [29]. For this reason in Europe, dead wood in forest ecosystems is traditionally perceived negatively by forest managers, because it may indicate “mismanagement, negligence, and wastefulness” of the applied forest management [29,31].

Dead wood is claimed to be disliked also by the public because it reduces the scenic beauty and recreational values of forests (e.g., [25,32–41]). On the other hand, dead wood is the second most photographed element of the forest, which highlights its important role in forest perception [26]. Public perception of natural dead wood may vary considerably according to the size and amount of the debris, the level of decay, the stand’s age, and whether additional information explained the debris’ value to biodiversity [40]. For example, research by Karjalainen [42] shows that if dead wood elements are sparsely distributed, they can serve as landmarks and increase a person’s ability to understand or read the landscape around them, and thus contribute to positive aesthetic perceptions. Dead wood enhancing the wilderness character of a forest stand and is also associated with sceneries of untouched natural forests or wilderness areas [43], where visitors can indulge in a sensation of being far away from a stressful daily life [39]. Schroeder and Daniel [44] found that people seem to like downed wood caused by natural events better than logging debris. Sheppard and Picard [45] proved that pests have a significant negative impact on the visual appeal of a landscape and
thus potentially on the visitor experience. However, reductions in visual quality due to pest (especially beetles or gypsy moth) attacks may be outweighed by the high visual quality of the overall scene. Low levels of beetle damage may even enhance the visual quality of a landscape temporarily. In turn, Hauru et al. [46] proved that sites with fresh logs were considered more aesthetically appealing than sites with old or no logs.

Preference for a particular environment does not mean, however, that it is highly relaxing [47,48]. Martens et al. [47] believe that perceived attractiveness of the natural area did not affect the change in well-being, thus questioning the close relationship between perceived attractiveness and the effect on well-being suggested in prior research. More and less fatigued person’s well-being did not change. Little is still known about whether the dead wood lowers the remedial value of the forest, which can be measured using appropriate psychometric techniques, such as adjective mood scale (POMS), positive and negative feeling scale (PANAS), vitality scale subjective (SVS) or the restorative scale (ROS). For example, Martens et al. [47] analyzed whether the positive effect of “wild” urban forest (not used economically for 6 years, thus showing a high amount of dead wood and no signs of economic use) and “tended” urban forest (in commercial use and maintenance with visible signs such as piles of felled logs near the path) on human restoration and well-being differs. Results indicate a stronger change in “positive effect” and “negative effect” in the tended forest condition. Well-being factors such as “activation” and “agitation” also changed after walking alone in the forest. The stronger decrease of “negative effect”, including depression and anger items, in the “tended” forest might be caused by the lower amount of dead wood, which could arouse sadness if people are not informed about the vital functions of dead wood [47]. Participants of both treatment conditions were not informed about the function of dead wood, and individual knowledge about dead wood was not known. In turn, Simkin et al. [48] compared the repair properties of old-growth forests and the mature commercial forest, which were both in rural areas. Both forests differed significantly in the amount of dead and decaying wood. Although the old-growth forest had much dead wood and woody debris, thus walking was more difficult in some places, it was not found to decrease its suitability for restoration. Research on social preferences in forest structures may be useful for forest management, e.g., to reduce the level of conflicts [17,49,50].

As the analysis of the literature shows, much is known about preferences regarding landscapes with dead wood, but there is little information about how such a landscape influences a person’s mental relaxation, improves mood, increases positive feelings, the level of vitality, etc. Research into landscape preferences indicates that that the attractiveness of a forest with dead wood may be determined by the variants of dead wood. Hence, the aim of this work is to investigate the restorative effects of short 15 min exposures to a natural forest and managed forest with dead wood. The aim is also to check if there is a difference in the remedial effects related to the variant of dead wood (option A: forest reserve with dead wood subject to natural decomposition processes; option B: managed forest with visible cut wood and stumps; option C: managed forest with standing dead trees infested by the bark beetle). The following hypotheses were adopted in the study:

**Hypothesis 1.** All analyzed forest areas with different variants of dead wood have a restorative effect on people (increase in perceived restorative results, subjective vitality and positive emotions, and a decrease in negative emotions).

**Hypothesis 2.** There are differences between the restorative effects of the forest reserve, the managed forest with traces of maintenance and harvest cuts, and the forest with standing dead trees infested by the bark beetle.

### 2. Materials and Methods

#### 2.1. Participants

Forty-one young people participated in the study. Volunteers who agreed to participate in the research were informed about the study goals as well as the procedure of its
conduct before the beginning of the experiment. Participants in the research were young adults aged 19–20. The volunteers we recruited were both women and men, residents of rural areas, mainly in Białowieża community (inhabited by slightly more than two thousand people) and its surroundings. The vast majority of participants (except two people) have lived in the area since birth. We sent email invitation letters to several tourist guides and distributed the invitation through various social media channels. The invitation contained information about the date and place of the meeting, its purpose, and the expected duration of the experiment. Tourist restrictions due to the pandemic caused by the SARS-CoV-2 virus meant that there were no tourists or occasional visitors to Białowieża in our study. Only healthy people without mental or physical diseases or metabolic syndromes participated in the study. The participants did receive some incentives for participating in the study. These were small gifts in the form of notebooks and albums promoting tourism in Poland. All operations undertaken in the research were in accordance with the ethical standards of the Polish Committee for Ethics in Science and the Declaration of Helsinki from 1964 with further amendments.

2.2. Study Sites

The research was conducted in the northeastern part of Poland, in the forests of the Białowieża Primeval Forest (Figure 1). The forest is a unique area, with fragments of primeval forests preserved, there are also tree stands transformed by humans to a different extent. This element was very important for the achievement of the goal of our work, as it made it possible to find, in close range, both a fragment of a forest “untouched” by human hands, a reserve forest in which natural processes leading to tree dieback occur and their effect is a large amount of dead wood at various stages decay (location A) and the forest in which typical management is carried out, related to, among others, selective tree cutting (location B). In the managed forest, due to biodiversity, some of the cut-down wood remains in place, so there are visible traces of cuts in the form of lying logs or cut stumps. We also chose the Białowieża Primeval Forest because it has recently been the subject of social discourse, both national and international, in connection with its control by the bark beetle, which caused significant havoc in forest stands, including stands managed for timber production ones, outside the reserves or the Białowieża National Park. Therefore, to compare the restorative effect of a forest with dead wood, we also took into account the stand with dead trees infested by pests (location C).

![Figure 1. Study sites (A: forest reserve, B: managed forest, C: managed forest infested by bark beetle) location within Białowieża Forest District.](image_url)
The area on which we conducted the research is administered by the Regional Directorate of State Forests in Białystok, and it is within the reach of the Białowieża Forest District, Zwierzyniec precinct. All three locations are quite close to each other, approximately 12 min by car from the starting point where the pre-test was carried out. These three places differ in the way they are managed and the type of dead wood:

Location A—tree stand located in the Władysław Szafer Landscape Reserve. The reserve was established in 1969 in order to preserve, for landscape reasons, the natural forest complexes of the Białowieża Primeval Forest along the Hajnówka-Białowieża road. It is a nature reserve with active protection. There is no felling and no harvesting in the reserve. Recreational use is minor. The stands have a varied age and size structure of trees, with numerous monumental trees, 50% of the stand is 170-year-old hornbeam, apart from it, there is spruce and oak (see Figure 2a,b, Table 1).

Location B—a commercial forest where typical forest management is carried out, including timber harvesting. It is a forest dominated by spruce at the age of about 160 and also with an admixture of oak and pine at the age of over 200 (see Figure 3a,b, Table 1). It is a multi-layered stand with 15% of the area damaged by fungi. Some dead wood has been left here to increase the biodiversity of the forest. Recreational use is minor.

### Table 1. Forests characteristics.

| Forest Site                      | Forest Reserve (A) | Managed Forest (B) | Managed Forest Infested by Bark Beetle (C) |
|---------------------------------|--------------------|--------------------|--------------------------------------------|
| Stand type                      | Fresh broadleaved forest | Fresh mixed broadleaved forest | Fresh mixed broadleaved forest |
| Stand age                       | 171                | 161                | 171                                        |
| Dominant tree species           | Hornbeam (*Carpinus betulus*) | Spruce (*Picea abies*) | Spruce (*Picea abies*) |
| Other tree species              | Few: spruce, oak  | Few: oak, pine      | Few: pine, alder                          |
| Stand volume (m³/ha)            | 265                | 614                | 232                                        |
| Tree height (m)                 | 28                 | 38                 | 38                                         |
| Canopy density                  | Broken canopy      | Broken canopy      | Broken canopy                             |
| Stocking degree                 | 1.0                | 1.1                | 1.0                                        |
| Diameter at breast height (cm)  | 52                 | 60                 | 55                                         |
Location C—stand with many dead, mainly standing trees (see Figure 4a,b, Table 1). It is the result of the damage caused in the forest in recent years by the spruce bark beetle (*Ips typographus* L.). Infested trees were not removed; they were left behind because of protests by environmentalists. The stand has a multi-layered structure, typical of old forests. Recreational use is minor.

Weather data on the days of research (15 and 17.09.2020) was collected from the meteorological station at Białowieża (location: 52.70° N, 23.87° E). The outdoor temperature on 15.09.2020 was 23 °C at 11 a.m. It was a sunny day with a 10% cloudiness. The SSE wind speed 6 km/h, and air humidity was 63%. Whereas the outdoor temperature on 17.09.2020 was 15 °C at 11 a.m. It was a sunny day with 30% cloudiness. The NNW wind speed 22 km/h, and air humidity was 64%. The temperature in the examination rooms was on average 21.8 °C. The levels of sound and light intensity were measured using smartphone iPhone Xs Max by “Sound Meter” and “Light Meter” applications. Measurements inside the buildings and outside, in the forests, were carried out once, while outside several measurements of sound and light were taken in the crossings with other forest routes. The mean sound level (±SD) measured with the sound level meter indoors amounted to 58.12 ± 11.26 dB, while the mean sound levels in the first location were 55.33 ± 13.11 dB.
(location A) and 51.32 ± 5.14 dB (location B) and 53.27 ± 13.19 dB (location C). The mean light intensity indoors measured with the “light meter” amounted to 174.34 ± 36.80 lx (light was switched off in the examination room), whereas the mean light intensities in the first location amounted to 341 ± 51.09 lx (location A) and 460 lx ± 57.15 lx in the second location (location B) and 1115.33 ± 719.36 lx in the forest infested by bark beetle with standing dead trees (location C).

3. Procedure

The psychological condition of the participants was measured in rooms, before the experiment (pre-test) and just after its end (post-test). The experiment was carried out in two days. The respondents were randomly divided into groups. Each group visited all three sites in one day. Partial counterbalancing was used in the experiment. For example, for the first group it was a reserve forest, then a managed forest with lying dead wood, and then the forest stand infested by bark beetles with standing dead trees. The order of the exhibitions was dictated by logistical considerations, and efforts were made to maintain a similar travel time between consecutive exhibitions. Each participant viewed the forest landscape for approximately 15 min, sitting or standing a few meters distance from the others to have the chance to relax and act according to the researcher’s instructions. The stand was viewed from the nearby road. The participants were not allowed to use mobile phones during the study, neither could they talk to each other, drink energy drinks, or smoke cigarettes.

3.1. Measurements

Four psychological questionnaires were used to measure the effects of viewing of dead wood in the forest environment on psychological responses on the participants:

(I) The Polish version of D. Watson’s and L.A. Clark’s Positive and Negative Affect Schedule (PANAS) elaborated by Brzozowski [51] was used to evaluate the feelings of participants. It is composed of 20 questions of which the same number refers to positive and to negative feelings. Each question was evaluated with a five-point Likert type scale (1—strongly disagree, 5—strongly agree). The credibility and validity of the PANAS questionnaire are high [47]; this questionnaire has already been applied in many studies [48,52–58].

(II) Restorative Outcome Scale (ROS)—test contains six items, each of which is evaluated by the participants by a seven-point Likert type scale (1—very unlikely, 7—very likely). In the research, we used the scale modified for forest-related experience [53,54]. The modified scale was adapted to the Polish language [55]. According to Korpela et al. [11,59], it is a credible tool to evaluate the level of restorative outcome. This tool has been used previously concerning relaxing features of the forest environment [48,53–55,58].

(III) The Subjective Vitality Scale (SVS), a test for the evaluation of vitality, which reflects feelings of energy, vitality, and well-being, was used; namely, the version with four items (e.g., “I feel alive and vital” or “I look forward to each new day”), adjusted for research in forest areas [53,54]. Four items were evaluated by the participants with the use of a seven-point Likert type scale (1—very unlikely, 7—very likely).

(IV) The 65-position version of the Profile of Mood States questionnaire (POMS). The Polish adaptation of the questionnaire (originally compiled by D.M. McNair, M. Lorr, L.F. Droppelman) was performed by Dudek and Koniarek [60]. POMS is a credible and contemporary measure of mood state, used previously for the evaluation of the forest environment’s effect on individuals’ moods [53–55,58,61,62]. It is a tool that measures six subscales of mood state: confusion or bewilderment, fatigue, anger or hostility, tension or anxiety, depression or dejection, and vigor. For each question, a five-point Likert type scale was used to estimate the mood state of the participants from 0 (strongly disagree) to 4 (strongly agree).
The PANAS, ROS, SVS, and POMS questionnaires allow various time frames to be used, but, in this study, as in earlier studies [10,55,58], the used time frame was “at this particular moment”.

3.2. Data Analysis

Raw data retrieved from psychological questionnaires were used for statistical analysis purposes. To compare the measurements of the pre-test and post-test, a paired t-test was used. The distribution of data was similar to the normal distribution. A parametric, one-factor repeated measure ANOVA was conducted to analyze the effects of different expositions on the POMS, PANAS, ROS, and SVS scores. The psychological restorative effect of viewing of dead wood in the forest environment (locations A, B, and C) and effect in the room environment were compared. After ANOVA, post hoc comparisons using Tukey’s HSD test were conducted. Statistical analyses were accomplished with the use of SPSS Statistics (Version 25, Armonk, NY, USA). The analyses considered the results for which “p > 0.05” was statistically significant in both the ANOVA and post hoc tests.

4. Results

4.1. Profile of Mood States

The results of post hoc analysis conducted after ANOVA show that there were statistically significant differences in forest restorative effects involving dead wood in the two POMS subscales: tension and fatigue (Table 2). A statistically significant difference was also found in relation to the Total Mood Disturbance (TMD) score on the Profile of Mood States (POMS). It was noticed that the highest mean values of tension were recorded in the participants of the study, still at the pre-test stage, before going out into the field and exposure to the forest landscape (Table 2). Each time, exposure to the forest decreased the values of the tension parameter. Exposure to a stand infested by the bark beetle (C) caused greater tension in the participants of the study than exposure to a managed forest (B). The lowest mean value of the subscale was obtained in the case of exposure to the forest reserve (A) with visible traces of natural, slow decomposition processes of wood. The level of mean fatigue value before visiting the forest was also higher than that determined after the experiment, regardless of the variant depicting dead wood. This difference was also statistically significant. Here, however, in contrast to the tension factor, the greater value of fatigue was recorded in the case of the reserve forest (A), and the lowest with the managed forest with traces of intentional cuts (B). Considering all the scales, it was found that the TMD value before going to the forest was almost 40% higher than the one determined because of forest exposure, regardless of the observed variant of the landscape with dead wood. The lowest average value of this result was recorded for the forest reserve (A). The mean value of TMD in the managed forest (B) was very similar (only slightly higher) than that resulting from exposure to the forest landscape with standing dead trees infested with bark beetles (C).

| Measure       | Pre-Test | Forest Reserve (A) | Managed Forest (B) | Managed Forest Infested by Bark Beetle (C) | F Ratio | Prob > F |
|---------------|----------|--------------------|--------------------|-------------------------------------------|---------|----------|
|               | Mean     | SD                 | Mean               | SD                                         |         |          |
| Tension       | 8.66a    | 7.14a              | 5.93b              | 6.03                                      | 7.2ab   | 6.96     | 7.63ab   | 8.38   | 3.2424 | 0.0245 * |
| Depression    | 12.63    | 10.73              | 9.56               | 9.69                                      | 9.98    | 10.17    | 9.59     | 12.09  | 2.2567 | 0.0853  |
| Anger         | 11.68    | 9.51               | 9.78               | 9.51                                      | 9.76    | 8.48     | 10.61    | 10.4   | 1.5106 | 0.2153  |
| Fatigue       | 10.2a    | 6.88               | 7.05b              | 5.71                                      | 6.83b   | 5.81     | 6.9b     | 6.62   | 5.5306 | 0.0014 **|
| Confusion     | 8.0      | 4.6                | 6.41               | 3.99                                      | 7.12    | 4.31     | 6.8      | 4.57   | 1.9745 | 0.1215  |
| Vigor         | 15.71    | 7.37               | 18.49              | 6.83                                      | 17.07   | 7.22     | 18.29    | 7.21   | 2.5418 | 0.0596  |
| TMD           | 35.46a   | 38.6               | 20.24b             | 35.27                                     | 23.8b   | 36.1     | 23.25b   | 41.17  | 4.2265 | 0.0070 **|

“*” and “**” respectively marks the statistically significant differences (p < 0.05) and (p < 0.01).
4.2. Positive and Negative Effect Schedule

Significant interactions were observed for PANAS Positive score that increased significantly with forest exposure (Table 3). This indicator had the lowest mean value at the pre-test stage. Then, as a result of exposure to the forest, its value increased, assuming the highest average value in relation to exposure to the forest reserve (A). The lowest average value was recorded with exposure to a forest infested by bark beetles (C).

Table 3. Means and SD of psychological measures of PANAS during the experiment (the same letters after means or no letters at all, indicate where there is no difference between means).

| Measure          | Pre-Test   | Forest Reserve (A) | Managed Forest (B) | Managed Forest Infested by Bark Beetle (C) | F Ratio | Prob > F |
|------------------|------------|--------------------|--------------------|-------------------------------------------|---------|----------|
|                  | Mean | SD     | Mean | SD     | Mean | SD | Mean | SD |
| PANAS Positive   | 2.82b | 0.75 | 3.19a | 0.77 | 3.07a | 0.73 | 3.05ab | 0.8 | 3.001 | 0.0333 * |
| PANAS Negative   | 1.52 | 0.61 | 1.49 | 0.55 | 1.64 | 0.8 | 1.62 | 0.78 | 0.8742 | 0.4566 |

"*" respectively marks the statistically significant differences ($p < 0.05$).

4.3. Restorative Outcome Scale and Subjective Vitality Scale

ROS and SVS significantly increased after viewing the forest with different variants of dead wood (pre-test vs. post-test, Table 4). The same letters after means, or no letters at all, indicate where there is no difference between means. A higher average value of ROS was achieved in the case of exposure to the forest reserve (A) with visible traces of natural, slow decomposition processes of wood. Among the three analyzed forest environments, this coefficient had the lowest value with a managed forest (B). The same was the case with SVS. The highest average value was that index in the case of exposure to the forest reserve (A), only slightly lower in the forest infested with the bark beetle (C) and the lowest in the managed forest (B).

Table 4. Means and SD of psychological measures of ROS and SVS during the experiment (marking means with small letters show that they are different to means with different letters).

| Measure | Pre-Test   | Forest Reserve (A) | Managed Forest (B) | Managed Forest Infested by Bark Beetle (C) | F Ratio | Prob > F |
|---------|------------|--------------------|--------------------|-------------------------------------------|---------|----------|
|         | Mean | SD     | Mean | SD     | Mean | SD | Mean | SD |
| ROS     | 3.93b | 1.35 | 4.76a | 1.22 | 4.43a | 1.34 | 4.51a | 1.79 | 5.2371 | 0.0020 ** |
| SVS     | 3.96b | 1.49 | 4.54a | 1.6 | 4.34ab | 1.48 | 4.49a | 1.49 | 3.1245 | 0.0285 * |

"**" and "*" respectively marks the statistically significant differences ($p < 0.05$) and ($p < 0.01$).

5. Discussion

Our research provides further evidence that the forest significantly contributes to the regeneration of human mental strength. It turns out that with the current decline in biodiversity in the world, people derive their energy from landscapes that embody not only recreational functions, but also beneficial ecological functions (forest reserve). According to the results of our research, the total change of mood was highest in the forest reserve (A), where the natural, slow decay processes were visible. Our research shows that greater environmental diversity is conducive to mood improvement and has greater restorative properties. This is confirmed by the results not only on the POMS scale, but also on the other three scales (PANAS positive, ROS, and SVS). Additionally, Watson et al. [57] found that environmental diversity is positively related to human well-being. There is no conflict between biodiversity and the restorative properties of the forest. Our research results are not reflected in the studies by Martens et al. [47], Simkin et al. [48] or Herzog et al. [63], which showed that a managed forest, in contrast to the natural one, has greater restorative
values. Perhaps this is because we compared forest environments (also managed and natural) with different variants of dead wood in every one of them.

We noted statistically significant differences with two of the six POMS scales, namely tension and fatigue. As for tension, its highest average value was associated with the exposure of the economic forest with dead standing trees infested by the bark beetle (C). It seems that in this case the forest could have been perceived as less safe, threatening human health and life. Although the participants of the experiment were at a safe distance from the infested trees, they could subconsciously feel the threat of the presence of dead trees, which will fall eventually. The forest reserve, with dead pieces of wood lying naturally with ongoing decay processes, may have seemed safer, so its exposure caused the most significant decrease in tension compared to the pre-test. On the other hand, the forest reserve (A) decreased the level of fatigue to a lesser extent than the managed forest (B). Perhaps it is related to the fact that the forest reserve has a greater number of stimuli, a greater number of landscape components, greater species diversity, which may affect the speed of reduction of fatigue. Interestingly, we expected that exposure to forest landscape involving dead wood could have a particular impact on the Depression scale as dead wood could be an indicator for a ‘dying’ forest [36,39,47] and as Sreetheran and van den Bosch [64] point out, it can be associated with sad or scary thoughts. Previous studies showed that a stronger decrease in the “negative impact”, including depression and anger, in a cultivated forest may be because of a lower amount of dead wood, which may be sad [65,66]. However, the results obtained by us did not show any statistical correlation in this case.

Our research confirms that the forest environment has a restorative effect also by changing emotions, in particular increasing positive emotions. In previous studies [58], we observed that a visit to the forest also favors the reduction of negative emotions, this time we found statistically significant differences only in relation to the increase in positive feelings. Other studies also showed that recreation in the forest reduces negative emotions [7,13,48,55]. However, in general, these studies compared extremely different environments (forest vs. city). Our research focused on differences within the same forest environment with a specific variant of dead wood. Going to the forest evoked positive feelings among the participants, it was connected with something pleasant. However, exposure to a landscape with dead wood did not reduce negative feelings. This proves that not every forest environment is equally reconstructing. The greatest increase in positive feelings was recorded in the case of the forest reserve (A). Among the two variants of the managed forest, the growth of positive feelings was caused by a forest with traces of human harvesting activity (B) than a forest with dead standing trees, infested by the bark beetle (C). It seems that in this case, human activity in the forest evokes greater understanding, is more acceptable, and evokes more positive emotions than the damage caused by natural processes, caused by the beetle outbreak.

Considering the results of the ROS and SVS scales, we found that each of the forest variants included in the experiment had a restorative effect on the psyche of the participants and contributed to an increase in the subjective feeling of vitality. The results of many studies show that the ROS and SVS scale values increased because of recreation in the forest environment [10,48,53–55,67,68]. We observed that this increase was the strongest as a result of exposure to the reserve forest, then the commercial forest with standing dead trees infested by bark beetles, and the weakest in the managed forest with traces of harvesting work. Additionally, this last observation leads us to conclude that preferences for a particular environment do not necessarily mean that it is restorative, as previously noted by Martens et al. [47] and Simkin et al. [48]. Preference studies conducted in coniferous forests infested by the bark beetle showed high social sensitivity to beetle activity [45,69,70]. The greener and more buoyant the forest was, the more it was appreciated for vitality. Conversely, dead and dying material (e.g., dead trees, felling residues) negatively affected preferences regardless of their genesis [69–72]. These aesthetic effects are especially felt when beetle damage is observed nearby compared to intermediate or
background zones [73]. Our research has shown that a forest with dead wood and standing trees has better restorative properties in virtually all the scales considered (except the tension scale) than the economic stand with traces of harvesting work. The results of our research indicate which forest model provides people with greater health benefits. Research findings support forest managers and policymakers at both national and regional levels interested in more effective environmental and health education. Understanding the impact of the forest management model on people’s well-being is valuable in developing effective forest management strategies, but also important for the benefit of society (e.g., reduced spending on health systems, increased labor productivity, reduced absenteeism).

Our research shows that recommendations for forest management to leave a certain amount of dead wood in the forests due to the need to increase biodiversity are also important from a social point of view. Dead wood in forests, especially that which is associated with natural processes, should be a permanent component of the forest landscape. National parks and forest reserves, where dead wood is more abundant, might be suitable places for restorative purposes. However, managed forests, in which the amount of dead wood is increasing in recent years, are also worth consideration for that matter.

6. Limitations

The experiment was conducted in a group of young adult Poles. This may mean that our results may apply to this group only. Many studies are showing that the socio-cultural thread is important in human research. For example, the studies by Tyrväinen et al. [25], Pastorella et al. [27], Jorgensen et al. [74], and Tveit et al. [75] showed that the level of education and age influence the preferences of dead wood and its recreational value. Research by Fjørtoft [76] shows that young people find more beauty in what is wild, disordered and that a more complex dead wood forest offers greater variety and opportunities for manipulation, exploration, and experimentation. Respondents with higher household income may also have a higher level of education and thus be more aware of the ecological importance of dead wood due to their greater knowledge. Therefore, we suggest that in the future the influence of demographic attributes on the forest landscape experience and the resulting level of forest restorativeness be investigated.

It seems to us that an important element that should be taken into account in future research on the perception of dead wood in forests may also be the level of ecological awareness. Indeed, it appears that ecological knowledge has an impact on the perception of the environment and landscape preferences, regardless of whether it is prior professional knowledge or basic information about the environment (e.g., [39,40,77]). Knowledge of the ecological role increases people’s appreciation of dead wood. We did not investigate whether and what knowledge about dead wood the participants in the experiment had. We can only assume that they had this type of knowledge. Especially since the Białowieża Forest has been “active” in the media all the time in recent years due to a strong transnational conflict over multifunctional, sustainable forest management. Information about Białowieża Forest, bark beetle outbreak, and forest dieback reached a very large group of Polish society, which could be important for our research. Future research could focus on whether the remedial properties of dead wood forests change after respondents are made aware of the role of dead wood in the forest landscape.

We only studied the effect of short exposures on a forest environment with dead wood, and we do not know how the physical activity or a longer stay in the forest contributes to the increased psychological benefits of exposure to this type of landscape. In future research, it is worthwhile to establish whether prolonged exposure to a forest landscape with dead wood provides the same benefits as exposure to a forest with a trace amount of dead wood. In future research on the relaxation value of forests, including the perception of the role of dead wood in forests, it is worth noting the major changes in recreational activity patterns and ways of experiencing nature due to the ongoing COVID-19 pandemic.
7. Conclusions

Contact with the forest, despite dead wood, is more restorative than no contact: the values of all scales were higher in the pre-test stage than after. The restorative value of a managed forest is lower than that of a forest reserve. Exposure to a stand infested by the bark beetle caused greater tension in the participants of the study than exposure to a managed forest with fallen logs. The greater value of fatigue was recorded in the case of the forest reserve, and the lowest in the case of the managed forest with traces of intentional cuts. Before the experiment, the level of positive feelings was lower. There was an increase in positive feelings as a result of exposure. The forest reserve has the best effect, the forest infested with bark beetles is the least effective among tested ones.

Author Contributions: Conceptualization, E.J., E.B., U.T., M.W., W.K., S.P., and K.J.; methodology, E.J. and E.B.; software, E.B.; validation, E.J. and M.W.; formal analysis, E.B.; investigation, U.T., S.P., and M.W.; resources, E.J.; data curation, E.J.; writing—original draft preparation, E.J.; writing—review and editing, E.B. and W.K.; visualization, W.K. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest.

References
1. Konijnendijk, C.C. A decade of urban forestry in Europe. *For. Policy Econ.* 2003, 5, 173–186. [CrossRef]
2. Eriksson, L. Exploring underpinnings of forest conflicts: A study of forest values and beliefs in the general public and among private forest owners in Sweden. *Soc. Nat. Resour.* 2012, 25, 1102–1117. [CrossRef]
3. Bang, K.-S.; Kim, S.; Song, M.K.; Kang, K.I.; Jeong, Y. The Effects of a Health Promotion Program Using Urban Forests and Nursing Student Mentors on the Perceived and Psychological Health of Elementary School Children in Vulnerable Populations. *Int. J. Environ. Res. Public Health* 2018, 15, 1977. [CrossRef]
4. Olsson, O. Out of the Wild: Studies on the Forest as a Recreational Resource for Urban Residents. Ph.D. Thesis, Umeå Universitet, Umeå, Sweden, 2014.
5. Beil, K.; Hanes, D. The influence of urban natural and built environments on physiological and psychological measures of stress—A pilot study. *Int. J. Environ. Res. Public Health* 2013, 10, 1250–1267. [CrossRef]
6. White, M.P.; Pahl, S.; Ashbullby, K.; Herbert, S.; Depledge, M.H. Feelings of restoration from recent nature visits. *J. Environ. Psychol.* 2013, 35, 40–51. [CrossRef]
7. Tyrväinen, L.; Ojala, A.; Korpela, K.; Lanki, T.; Tsunetsugu, Y.; Kagawa, T. The influence of urban green environments on stress relief measures: A field experiment. *J. Environ. Psychol.* 2014, 38, 1–9. [CrossRef]
8. Hartig, T.; Evans, G.W.; Jamner, L.D.; Davis, D.S.; Gärling, T. Tracking restoration in natural and urban field settings. *J. Environ. Psychol.* 2003, 23, 109–123. [CrossRef]
9. Hartig, T.; Staats, H. The need for naturalistic reforestation as a determinant of environmental preferences. *J. Environ. Psychol.* 2006, 26, 215–226. [CrossRef]
10. Bielinis, E.; Lukowski, A.; Omelan, A.; Boiko, S.; Takayama, N.; Grebner, D.L. The effect of recreation in a snow-covered forest environment on the psychological wellbeing of young adults: Randomized controlled study. *Forests* 2019, 10, 827. [CrossRef]
11. Korpela, K.; Ylén, M.; Tyrväinen, L.; Silvennoinen, H. Determinants of restorative experiences in everyday favourite places. *Health Place* 2008, 14, 636–652. [CrossRef]
12. Pasanen, T.P.; Ojala, A.; Tyrväinen, L.; Korpela, K.M. Restoration, well-being, and everyday physical activity in indoor, built outdoor and natural outdoor settings. *J. Environ. Psychol.* 2018, 59, 85–93. [CrossRef]
13. Jung, W.H.; Woo, J.M.; Ryu, J.S. Effect of a forest therapy program and the forest environment on female workers’ stress. *Urban For. Urban Green.* 2015, 24, 274–281. [CrossRef]
14. Son, J.W.; Ha, S.Y. Examining the influence of school forests on attitudes towards forest and aggression for elementary school students. *J. Korean Inst. For. Recreat* 2013, 17, 49–57. [CrossRef]
15. Milligan, C.; Bingley, A. Restorative places or scary spaces? The impact of woodland on the mental well-being of young adults. *Health Place* 2007, 13, 799–811. [CrossRef]
16. Wyles, K.J.; Pahl, S.; Thomas, K.; Thompson, R.C. Factors That Can Undermine the Psychological Benefits of Coastal Environments: Exploring the Effect of Tidal State, Presence, and Type of Litter. *Environ. Behavior* 2016, 48, 1095–1126. [CrossRef]
17. Jensen, F.S. Landscape managers’ and politicians’ perception of the forest and landscape preferences of the population. *For. Landsc. Res.* 1993, 1, 79–93.
18. Vander Stoep, G.A.; Duniavy, L. Public involvement in developing park and open space recreation management strategies. In *Proceedings of the 1992 Northeastern Recreation Research Symposium, Saratoga Springs, NY, USA, 5–7 April 1992; General Technical Report NE—176; U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: Newtown Square, PA, USA, 1992; pp. 63–68.

19. O’Leary, T.N.; McCormack, A.C.; Clinch, P. Tourists’ perceptions of forestry in the Irish landscape—An initial study. *For. Landsc. Res.* **1998**, *1*, 473–490.

20. Eriksson, L.; Nordlund, A.M.; Olsson, O.; Westin, K. Recreation in different forest settings: A scene preference study. *Forests* **2012**, *3*, 923–943. [CrossRef]

21. Silvennoinen, H.; Pukkala, T.; Tahvanainen, L. Effect of Cuttings on the Scenic Beauty of a Tree Stand, Scandinavian. *J. For. Res.* **2002**, *17*, 263–273.

22. Gundersen, V.S.; Frivold, L.H. Public preferences for forest structures: A review of quantitative surveys from Finland, Norway and Sweden. *Urban For. Urban Green.* **2008**, *7*, 241–258. [CrossRef]

23. Giergiczny, M.; Czajkowski, M.; Żylicz, T.; Angelstam, P. Choice experiment assessment of public preferences for forest structural attributes. *Ecol. Econ.* **2015**, *119*, 8–23. [CrossRef]

24. Filyushkina, A.; Agimass, F.; Lundhede, T.; Strange, N.; Bredahl, J.J. Preferences for variation in forest characteristics: Does diversity between stands matter? *Ecol. Econ.* **2017**, *140*, 22–29. [CrossRef]

25. Tyrväinen, L.; Silvennoinen, H.; Kolehmainen, O. Ecological and aesthetic values in urban forest management. *Urban For. Urban Green.* **2003**, *1*, 135–149. [CrossRef]

26. Rathmann, J.; Sacher, P.; Volkmann, N.; Mayer, M. Using the visitor-employed photography method to analyse deadwood perceptions of forest visitors: A case study from Bavarian Forest National Park, Germany. *Eur. J. For. Res.* **2020**, *139*, 431–442. [CrossRef]

27. Pastorella, F.; Avdagić, A.; Ćabaravdić, A.; Mraković, A.; Osmanović, M.; Paletto, A. Tourists’ perception of deadwood in mountain forests. *Ann. For. Res.* **2016**, *59*, 311–326. [CrossRef]

28. FAO. *Global Forest Resources Assessment Update 2005: Terms and definitions. Working Papers 83/E. Forest Resources Assessment Programme*; FAO: Rome, Italy, 2004.

29. Merganičová, K.; Merganič, J.; Svoboda, M.; Bače, R.; Šebel, V. Deadwood in forest ecosystems. In *Forest Ecosystems—More Than Just Trees*; Blanco, J.A., Lo, Y.H., Eds.; InTech Book: London, UK, 2012; pp. 81–108.

30. Paletto, A.; Tosi, V. Deadwood density variation with decay class in seven tree species of the Italian Alps. *Scand. J. For. Res.* **2010**, *25*, 164–173. [CrossRef]

31. Radu, S. The ecological role of deadwood in natural forests. *Environ. Sci. Eng.* **2006**, *3*, 137–141.

32. Brown, T.C.; Daniel, T.C. Predicting scenic beauty of timber stands. *For. Sci.* **1986**, *32*, 471–487.

33. Edwards, D.; Jay, M.; Jensen, F.S.; Lucas, B.; Marzano, M.; Montagné, C.; Peace, A.; Weiss, G. Public preferences for structural attributes of forests: Towards a pan-European perspective. *For. Policy Econ.* **2012**, *19*, 12–19. [CrossRef]

34. Liao, W.; Nogami, K. Prediction of near-view scenic beauty in artificial stands of Hinoki (Chamaecyparis obtusa S. et Z.). *J. For. Res.* **1999**, *4*, 93–98. [CrossRef]

35. Ribe, R.G. The aesthetics of forestry: What has empirical forest research taught us? *Environ. Manage.* **1989**, *13*, 55–74. [CrossRef]

36. Ribe, R.G. A general model for understanding the perception of scenic beauty in northern hardwood forests. *Landscape J.* **1990**, *9*, 86–101. [CrossRef]

37. Jensen, F.S. The effects of information on Danish forest visitors’ acceptance of various management actions. *Forestry* **2000**, *73*, 165–172. [CrossRef]

38. Nielsen, A.B.; Heyman, E.; Richnau, G. Liked, disliked and unseen forest attributes: Relation to modes of viewing and cognitive con-structs. *J. Environ. Manag.* **2012**, *113*, 456–466. [CrossRef] [PubMed]

39. Gundersen, V.; Frivold, L.H. Naturally dead and downed wood in Norwegian boreal forests: Public preferences and the effect of information. *Scand. J. For. Res.* **2011**, *26*, 110–119. [CrossRef]

40. Gundersen, V.; Stange, E.E.; Kaltenborn, B.P.; Vistad, O.I. Public visual preferences for dead wood in natural boreal forests: The effects of added information. *Lands. Urban Plan.* **2017**, *158*, 12–24. [CrossRef]

41. Arnberger, A.; Ebenberger, M.; Schneider, I.E.; Cottrell, S.; Schluter, A.C.; von Rushckowski, E.; Venette, R.C.; Snyder, S.A.; Gobster, P.H. Visitor preferences for visual changes in bark beetle-impacted forest recreation settings in the United States and Germany. *Environ. Manag.* **2018**, *61*, 209–223. [CrossRef] [PubMed]

42. Karjalainen, E. The Visual Preferences for Forest Regeneration and Field Afforestation—Four Case Studies in Finland. Ph.D. Thesis, Finnish Forest Research Institute, Helsinki, Finland, 2006.

43. Hallikainen, V. The Finnish Wilderness Experience. *Res. Pap.* **1998**, *711*. Available online: https://jukuri.luke.fi/handle/10024/521343 (accessed on 30 June 2021).

44. Schroeder, H.; Daniel, T.C. Progress in predicting the perceived scenic beauty of forest landscapes. *For. Sci.* **1981**, *27*, 71–80.

45. Sheppard, S.; Picard, P. Visual-quality impacts of forest pest activity at the landscape level: A synthesis of published knowledge and research needs. *Lands. Urban Plan.* **2006**, *77*, 321–342. [CrossRef]

46. Hauru, K.; Koskinen, S.; Kotze, D.J.; Lehvävirta, S. The effects of decaying logs on the aesthetic experience and acceptability of urban forests—implications for forest management. *Lands. Urban Plan.* **2014**, *123*, 114–123. [CrossRef]
Forests 2021, 68.
Takayama, N.; Morikawa, T.; Bielinis, E. Relation between psychological restorativeness and lifestyle, quality of life, resilience,

61. Lee, J.; Park, B.J.; Tsunetsugu, Y.; Ohira, T.; Kagawa, T.; Miyazaki, Y. Effect of forest bathing on physiological and psychological

76. Fjørtoft, I. Landscape as playscape: The effects of natural environments on children's play and motor development children.

75. Tveit, M.; Ode, A.; Fry, G. Key concepts in a framework for analysing visual landscape character.

74. Jorgensen, A.; Hitchmough, J.; Dunnett, N. Woodland as a setting for housing—appreciation and fear and the contribution to

73. Buhyoff, G.J.; Wellman, J.D.; Daniel, T.C. Predicting scenic quality for mountain pine beetle and western spruce budworm forest

72. Young, C.; Wesner, M. Aesthetic values of forests: Measuring the visual impact of forestry operations.

Acta Hort.

71. Kaufman, A.J.; Lohr, V.I. Does it matter what color tree you plant?

For. Sci.

70. Buhyoff, G.J.; Leuschner, W.A. Estimating psychological disutility from damaged forest stands. For. Sci.

1978, 24, 424–432.

97. Buhoyf, G.J.; Wellman, J.D.; Daniel, T.C. Predicting scenic quality for mountain pine beetle and western spruce budworm forest

79. Jorgensen, A.; Hitchmough, J.; Dunnett, N. Woodland as a setting for housing—appreciation and fear and the contribution to

78. Kaufman, A.J.; Lohr, V.I. Does it matter what color tree you plant?

871–907. [CrossRef]

77. Kaltenborn, B.P.; Bjerke, T. Association between environmental value orientations and landscape preference. Lands. Urban Plan.

2002, 59, 1–11. [CrossRef]

76. Fjørtoft, I. Landscape as playscape: The effects of natural environments on children's play and motor development children.

Youth Environ. 2004, 14, 21–44.

75. Tveit, M.; Ode, A.; Fry, G. Key concepts in a framework for analysing visual landscape character. Lands. Res. 2006, 31, 229–255. [CrossRef]

74. Jorgensen, A.; Hitchmough, J.; Dunnett, N. Woodland as a setting for housing—appreciation and fear and the contribution to

73. Buhyoff, G.J.; Wellman, J.D.; Daniel, T.C. Predicting scenic quality for mountain pine beetle and western spruce budworm forest

34, 1988, 346–353. [CrossRef]

72. Young, C.; Wesner, M. Aesthetic values of forests: Measuring the visual impact of forestry operations.

1987, 97, 346–353. [CrossRef]

71. Kaufman, A.J.; Lohr, V.I. Does it matter what color tree you plant?

For. Sci.

70. Buhyoff, G.J.; Leuschner, W.A. Estimating psychological disutility from damaged forest stands. For. Sci.

1978, 24, 424–432.

97. Buhoyf, G.J.; Wellman, J.D.; Daniel, T.C. Predicting scenic quality for mountain pine beetle and western spruce budworm forest

79. Jorgensen, A.; Hitchmough, J.; Dunnett, N. Woodland as a setting for housing—appreciation and fear and the contribution to

78. Kaufman, A.J.; Lohr, V.I. Does it matter what color tree you plant?

871–907. [CrossRef]

77. Kaltenborn, B.P.; Bjerke, T. Association between environmental value orientations and landscape preference. Lands. Urban Plan.

2002, 59, 1–11. [CrossRef]