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Effect of Thinning on Forest Scenic Beauty in a Black Pine Forest in Central Italy

Isabella De Meo [1,*], Paolo Cantiani [2] and Alessandro Paletto [2]

[1] CREA-Research Centre for Agriculture and Environment, 50121 Florence, Italy
[2] CREA-Research Centre for Forestry and Wood, 52100 Arezzo, Italy; paolo.cantiani@crea.gov.it (P.C.); alessandro.paletto@crea.gov.it (A.P.)
* Correspondence: isabella.demeo@crea.gov.it; Tel.: +39-338-564-3741

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Abstract: Forest management practices determine changes in stand characteristics and consequently influence public perception of forest scenic beauty visually appreciated by visitors. To understand the relationship between forest management practices and public perception, the present study evaluated the effects of thinning on the forest scenic beauty analyzing visitors' preferences towards images of forest managed in different ways. The investigation was implemented in a black pine (*Pinus nigra* spp.) forest located in Central Italy, where a designed thinning experiment was conducted during the winter of 2016. Silvicultural interventions were based on three options: traditional thinning (medium-intensity thinning from below), selective thinning, and absence of intervention (control). Then, through the face-to-face administration of a questionnaire to a sample of 200 visitors, visitors' aesthetic preferences for stands' characteristics affected by management interventions were assessed. The survey also investigated the perception of the effect of silvicultural treatments on the scenic beauty using pairwise comparison method. Results evidence a strong relation between scenic beauty and forest attributes. In particular, the results show that visitors prefer mixed forest with varying tree heights and layers, and consequently a high and variable quantity of light reaching the soil. Results also show that visitors prefer managed forests, and both kinds of thinning have a positive effect on the scenic beauty.

Keywords: selective thinning; thinning from below; visual aesthetic component; public perception; questionnaire survey

1. Introduction

The social perception of forests has changed according to the evolution of forest management paradigms, due to the interests and needs of society in different historical periods. The three main historical periods covering from the Middle-ages up until today are: the pre-industrial, the industrial, and the post-industrial period. Each of them was characterized by specific forest management priorities, objectives, and practices [1–6].

After the industrial revolution, the shift from a rural society to an urban one generated a deep change of the relationship between society and forest resource. A new interest in the social acceptability of forest management came up together with an increasing appreciation of non-utilitarian forest values [7–10]. In this socio-cultural framework, two main principles in forest management emerged: multifunctionality and sustainability. Since the early 1990s, forest management was influenced by many issues: the simultaneous realization of social, economic, and ecological functions; the emphasis on considering forest resources beyond timber; and the recognition of the spiritual values and natural beauty of the forests [11–15].

In urbanized societies, the increasing attention to recreational, spiritual, and aesthetical values of forests explains people's interest in spending time in forest. People who visit forests can be motivated by a variety of needs and expectations, and receive several psychological, physical, and spiritual benefits [16–21].

Visitors who reach the forest can be involved in recreational activities or can appreciate firstly the aesthetic experience inside the forest environment. The two aspects may vary among individuals, but also for the same individual, according to the place, the time, the physical and psychological status during the visit. The main aspect of visitors' aesthetic experience in a forest is visual and the natural scenic beauty of the forest environment is the dominant component in visitors' experience. In reason of this, studies concerning forest aesthetics mainly focus on visitors' perception, preferences and judgements of the beauty of the forest environment [22–26]. According to Daniel and Boster (1976) [27] and Daniel and Vining (1983) [28], the aesthetic characteristics of forest which can be visually appreciated by visitors are defined as "scenic beauty".

Understanding aesthetic preferences of visitors can be a fundamental support for forest managers to adequately account for forest scenic quality and aesthetic sensibilities of visitors. Furthermore, the scenic beauty of the forest landscape affects the recreational value, being the forest itself the location for recreation activities [29]. The increasing attention to forest scenic beauty and public perceptions of managed forests has required foresters to consider the aesthetic merit of their decisions [30]. Otherwise, while including scenic beauty among ecosystem services provided by forests, managers must try to find an equilibrium with ecological processes, based on the principles of ecosystem management [10,31,32].

Research on forest scenic beauty began in the late 1960s focusing on public demand for enjoyable recreation environments and forest management actions to increase the forest beauty. Since the 1970s, research has investigated more in detail aesthetic preferences for forests [30,33–35]. Research on the effect of silvicultural treatments on the forest scenic beauty is crucial to support managers, evidencing how different silvicultural treatments affect visitors' perceptions about the forest scenic beauty. The main objective of these studies is to increase forest managers' knowledge about the features of forests that can enhance aesthetic values, and the impacts of different management options on those values [29,36–42].

A simple way to obtain this information is to investigate visitors' opinions on the effect of management interventions (i.e., silvicultural treatments) on the forest aesthetic through verbal questions. However, verbal method may give partial results because sometimes people do not know how a management intervention is implemented. Therefore, methods based on visual stimuli are more valid compared to verbal methods to investigate people's perceptions [29,36,42–45]. Visual stimuli methods are adapted from psychophysics, a branch of psychology established in the early 1800s [46]. These methods—based on the psychophysical approach—seems to offer the greatest prospect for incorporating public preferences into planning and management guidelines [47,48], relating individual physical attributes of the forest with overall measures of scenic quality [47,49].

Each of these methods requires information from a survey or an experimental situation and a common way to design the survey is using photographic or computer images [42,50,51]. The structure for psychophysical landscape studies includes three steps: (i) photographs of the landscape are shown to groups of observers who express their preferences and the landscapes are scaled from low to high scenic quality; (ii) landscape characteristics are measured; (iii) the measurements of the physical characteristics of landscape are related to the perceptual judgment-based indexes of scenic quality [22].

One of the most established method to assessing aesthetic values based on visual representations of a forest is the Scenic Beauty Estimation (SBE), developed by Daniel and Boster (1976) [27] using psychophysical techniques. In this method, systematic photography of randomly located views within forested areas are presented to a sample of observers who individually rate the scenic beauty of the image on a ten points scale. Then, researchers try to relate the ratings to the physical features of the forest [22,37,46,52].

Starting from these considerations, the main objective of the present study is to investigate visitors' perception of the effect of thinning on the forest scenic beauty. The research question is thus to understand the effects of different silvicultural treatments on visitors' aesthetic preferences. The research was conducted in a case study in Central Italy: the Pratomagno forest. The area is involved in the Project LIFE13 BIO/IT/000282 SelPiBio (Innovative silvicultural treatments to enhance soil biodiversity in artificial black pine stands) for demonstration of innovative silvicultural treatments in artificial black pine stands.

2. Materials and Methods

2.1. Study Area

The study was carried out in the north-west of Arezzo province, in Tuscany region (43°39′ N 11°39′ E), in the area of the Pratomagno massif, whose main axis of development is parallel to the Apennine ridge between Tuscany and Romagna [53] (Figure 1). The Pratomagno forest area covers around 3000 ha and the main species are European beech (*Fagus sylvatica* L.) and Turkey oak (*Quercus cerris* L.), while black pine (*Pinus nigra* spp.) stands cover a surface of about 800 ha. The latter is the result of a reforestation programme, which began in 1954 and ended in the late 1980s [54]. Currently, the Pratomagno forest is the result of a reforestation in transition toward mixed forests, typical of the area, where natural forests are dominated by European beech, chestnut, and oak species. Regarding the ownership, approximately 95% of the Pratomagno is covered by public forests belonging to Tuscany Region and managed by the Unione dei Comuni del Pratomagno, a local authority formed by the union of some municipalities. The remaining 5% of the area is small private forests.

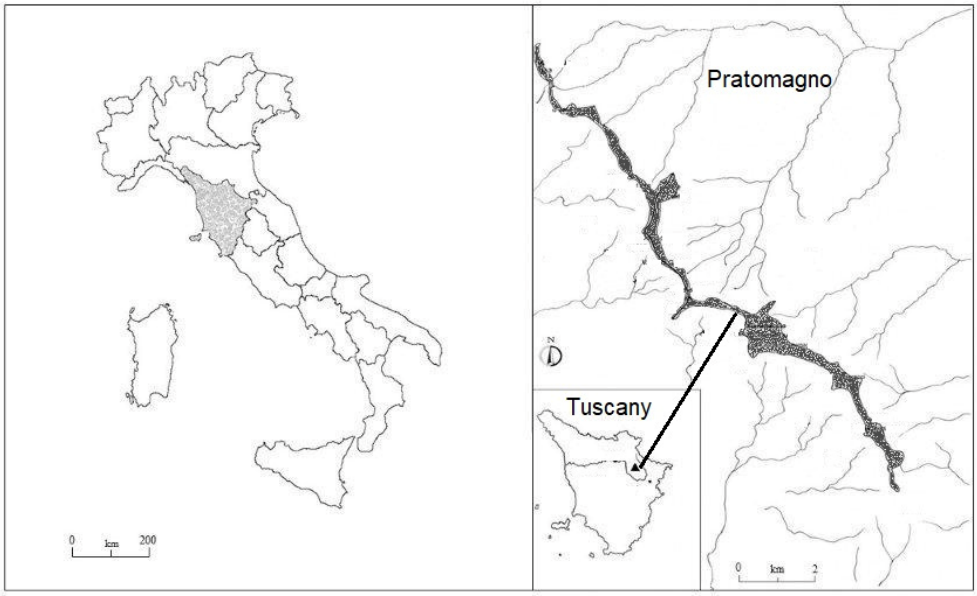


Figure 1. Location of the study area (Pratomagno forest) in Tuscany Region (Italy).

The Pratomagno massif has an average elevation of 1150 m a.s.l., with a south-west exposure and average slope of 40%. From the geological point of view, it is composed of layers of sandstone and of siltstone and silt argillites belonging to the 'Macigno del Chianti' geological formation. The argillites and siltstones provide a very thin layer of up to 15 cm, while the thickness of the sandstone layers exceeds half a meter; this implies the emersion of large banks of well visible thick sandstone [54].

The climate is submontane, with yearly average precipitations higher than 1600 mm and a minimum in mid-summer, often source of a severe summer drought, worsened by constant strong winds [53]. The average annual temperature is 10.5 °C (maximum of 19 °C in July and minimum

of 1.5 °C in January), while the average rainfall is 997 mm with a maximum peak in autumn and minimum precipitation in June.

The characteristic for which Pratomagno massif is well-known lies in its name: a large meadow that runs along its ridge for about twenty kilometers. This long meadow placed so high and from which visitors can enjoy incredible views makes Pratomagno an ideal place to live an aesthetic experience inside the natural environment. Furthermore, the forests dominated by European beech and silver fir high forests, abandoned sweet chestnut orchards and oak coppices cover its slopes, making this area an ideal place for diverse recreational activities in forest, from walking to trekking, from biking to mushroom picking.

The present research was developed in two specific sites of the Pratomagno massif:

- Pian dei Lavacchi, a rest area that leads in a few minutes' walk to the nearby Monte Lori, the southernmost peak of the area, from which originates the most frequented path of the entire mountain. This path leads up to the Croce del Pratomagno, the symbol of this area. Pian dei Lavacchi is the area where were conducted the interviews with forest visitors.
- Abetina, an area located further south than Pian dei Lavacchi, where some demonstration areas of the project LIFE SelPiBio are situated. Abetina was chosen as the place for taking the photographs of the forest shown during the administration of the questionnaire.

2.2. Thinning in Black Pine Plantations

The reforestation of the Pratomagno was carried out in the framework of the wide land restoration planned in degraded lands, but also in mountain zones, in most of the European countries after the First and Second World War [54,55]. According to the second Italian National Forest Inventory (2005), black pine (*Pinus nigra* J.F. Arnold spp.) stands in Italy cover an area of 236,467 ha, corresponding to 2.5% of the total forest area. In Tuscany, the area covered by black pine forests is 20,500 ha with an average stand age of approximately 60 years [56,57].

Like other artificial pine stands worldwide, the main function was not timber production under intensive forest management, that leads to a loss in the diversity and resilience of forest systems [58]. Conversely, these stands were established with fast-growing pioneer conifers (e.g., *Pinus nigra* spp. in mountain areas, *Pinus pinaster* Aiton, *Pinus halepensis* Mill. in coastal areas) with purposes ranging from soil protection to recreation and from dune protection to scenic beauty [59,60]. The strategy was to plant pioneer species and to facilitate the introduction of late-successional broadleaves and the transition toward mixed forests, more resilient and resistant ecosystems, characterized by a higher level of structural complexity and biodiversity [59,61].

Black pine was usually planted in pure stands at high densities to ensure the forest coverage in a short period of time. To support the transition toward mixed forests, multiple thinning should be applied during the rotation period, with pre-commercial thinning at about age 30, followed by additional thinning every 15 years [62]. However, multiple thinning is expensive and interventions have generally been delayed or even totally neglected, due to the low economic value of the timber. Currently, most of these stands represent the most simplified forest systems in Italy, characterized by a low biodiversity level and mechanical stability's problems [59,63]. Notwithstanding, the low value of timber production and the ecological fragility of these artificial ecosystems, a new interest is rising in the whole Europe toward these stands. This interest is mainly due to their potential to provide multiple ecosystem services and to their role in the development of innovative forest management techniques, aimed at guiding natural evolution to more complex and stable forest systems [64–66].

In these stands, thinning interventions are necessary, which follow the natural process of density reduction due to competition and stimulate the radial growth in remaining trees [67]. Different criteria of thinning can be adopted and in black pine plantations the most common and applied treatment is the thinning from below, which removes only dominated, small, or standing dead trees below the main canopy layer, with the aim to concentrate growth on the better trees remaining. During this thinning, lying deadwood is not removed from the forest [54]. Black pine stands can benefit from late

thinning from below of medium-heavy intensity; when the treatments are carried out on the dominant layer the species react positively, and both timber harvesting and ecosystem services provision are improved [68,69]. The positive results obtained with thinning from below of heavy intensity (able to influence the structure of the forest even in the dominant layer) were the basis of the application of the selective thinning in these stands. Selective thinning, widely used in many forest systems, has been rarely applied in Italian planted pine forests [54].

In selective thinning, the choice of the trees to be cut is based on a positive selection of candidate trees: the best trees are first selected according to their vigor and stability and then their growth and development are actively encouraged by removing the direct crown competitors in the dominant layer. With selective thinning all standing dead trees and lying deadwood slightly decomposed (1st and 2nd decay classes) are also removed, while native broadleaves trees are favored [63,70,71].

Regarding the plantations of the present study, in the Pratomagno district three management plans have been implemented since 1980. It is interesting to underline that the management strategies have changed in the years, with the first two plans focused on silvicultural guidelines, while the last one offering indications for the overall sustainable forest management of the stands. Among the different forest strategies, attention must be given to the one oriented to facilitate the transition towards a stratified mixed forest through targeted silvicultural interventions.

In the Pratomagno forest, thinning interventions took place in September 2016 in the framework of Project LIFE SelPiBio and were based on three silvicultural options: traditional thinning (medium-intensity thinning from below), selective thinning, and absence of intervention (control). With the selective thinning, 100 trees per hectare regularly distributed were selected among the better formed and mechanically-stable trees. The percentage of trees removed by number, basal area, and volume has been respectively 36%, 23%, and 19% after the traditional thinning and 31%, 29%, and 30% after the selective thinning [54].

The two kinds of thinning lead the forest stand to different changes in the forest structure. After the thinning from below the ratio between the number of dominant, codominant, and dominated trees (according to the simplified classification of Kraft in Pretzsch, [72]) change from 3.9;3.9;2.2 to 5.2;4.2;0.6. After the selective thinning, the ratio changes from 3.3;4.4;2.3 to 3.6;4.0;4.4. These values evidence that, after the thinning from below, the dominated layer almost disappears and the vertical structure of the forest is simplified. Conversely, after the selective thinning a part of the dominated layer remains in the spaces of the forest between the candidate trees creating a more complex forest structure [70].

Even the horizontal structure is influenced by the two kinds of thinning. After the thinning from below the canopy cover is reduced by 16.8%, after the selective thinning by 26.0%. Similarly, the PAR (Photosyntetically Active Radiation), used as a proxy for brightness on the ground, increases by 87% after the thinning from below and by 232% after the selective thinning [73]. From the visual perception point of view, it is important to evaluate how in the selective thinning these variations are the consequence of openings of the canopy cover which are differently distributed horizontally. Conversely, the reduction of canopy cover after the thinning from below is uniform, not concentrated around the candidate trees. Moreover, with selective thinning, competitors of the candidate trees are removed and this fact determines the formation of micro-gaps that make the brightness at ground level more irregular.

2.3. Questionnaire Survey

A questionnaire was designed to explore a range of issues relating to identifying and investigating relationship between visitors and forests. The main issues are the importance and characteristics of recreation in forest, the aesthetic preferences given to forest features and the visitors' perception of the effect of silvicultural treatment on the forest scenic beauty.

The questionnaire was developed by the researchers involved in the Project LIFE SelPiBio together with the forest managers of the demonstration areas where the forest interventions have been realized. The choice to work in group (managers and researchers) was advantageous for both. Forest managers'

technical competence was crucial to support the organization of the questionnaire survey, on the other side results of the questionnaire provide useful information to direct forest management choices.

The questionnaire (Annex 1) consists of 20 open-ended and closed-ended questions—such as yes/no questions, multiple or single choice questions, or ranking questions—arranged into four thematic sections: "Personal information", "Recreational use of forest", "Opinions on forest characteristics and functions", and "Perceptions of silvicultural interventions in Pratomagno forest". The division into sections is realized not only to prevent respondents from getting tired, but also to facilitate data collection [71,74]. The questionnaire was pre-tested with five respondents, namely customary forest visitors of Pratomagno forest. Many revisions were then made by researchers in accordance with respondents' comments. In the final version, the language is simple and questions stimulate the expression of opinions, perceptions, and feelings.

The present paper focuses on two questions of the section "Opinions on forest characteristics and functions" and on the section "Perception of silvicultural interventions in Pratomagno forest". The influence of socio-demographic characteristics of respondents (gender, age, level of education) on the answers is also considered using data related to personal information.

The first thematic section ("Personal information") focuses on the personal data of the respondent such as: gender, age, level of education, actual job, place of residence and of birth.

The two questions relating to "Recreational use of forests" focus on visitors' aesthetic preferences for characteristics of forest stands affected by management interventions. The questions are in closed-form with a single choice. In particular, the first one investigates preferences for different tree species composition identifying three main categories: (1) broadleaved forests, where the coniferous percentage is less than 20%; (2) coniferous forests, where the broadleaved percentage is less than 20%; and (3) mixed forests with two or more species. The second question focuses on visitors' preferences for forest structure considering: (1) regular structure, with homogeneous distribution in the space of trees with similar height and size; (2) irregular structure, with random distribution in the space of trees of different age, with diverse height and size.

The section "Perception of silvicultural interventions in Pratomagno forest" is composed by four questions investigating how different silvicultural treatments affect visitors' perceptions about the forest scenic beauty. In this section, visitors' perceptions and preferences are investigated using photographs, considered as acceptable replacements of real environments for the study of scenic beauty [75,76]. For this purpose, three photographs of Pratomagno forest after different forest management strategies have been shown to visitors.

During the realization of the photographs as much attention as possible has been focused on minimizing scenic variability not associated with the silvicultural interventions and avoiding untypical details in the view (e.g., paths, roads, streams, rocks, small buildings). Photographs were taken with care to avoid elements that can affect scenic beauty perceptions and some principles were accepted as follows [29,76,77]: (i) all photographs were realized using a Canon digital camera during a day of late April, when full sun was shining directly into the forest, and flash was not used; (ii) all the black pine stands in the photographs were located on side slopes of 10–25%; and (iii) photographing at the same angle as the slope of plots, and if there was high heterogeneity, more pictures were taken from different orientations. All photographs were taken from the same altitude, and from a path, thought to be the most usual place for forest visitors to observe the forest landscape. The forest area under silvicultural interventions were positioned at roughly similar distances below the horizon.

The final images were selected from a much larger material composed of photographs representing the three forest management scenarios of the Pratomagno forest: (1) Control, without intervention; (2) Selective thinning; (3) Traditional thinning.

The first three questions of the section "Perception of silvicultural interventions in Pratomagno forest" dealt with visitors' perception of the effect of silvicultural interventions on different experiences that visitors can live and appreciate in forest. Three main experiences that can motivate people to visit forest were considered: touristic-recreational, contemplative/aesthetic, and sports/physical

experience. These experiences were defined in collaboration with the local forest managers considering the main activities carried out by visitors in the Pratomagno forest. In addition, have been selected three experiences characterized by an increasing degree of interaction with the resource: from a low interaction of the sports/physical experience where forest resource is only the scenario in which the outdoor activity takes place to a high interaction of the contemplative/aesthetic experience where the forest resource is the focal point of the experience. The images representing the Pratomagno forest after the different silvicultural treatments were shown to respondents. After, they were asked to indicate how much each forest is suitable to fulfill the above-mentioned experiences. Suitability was rated on a 5-point Likert scale (1 = not at all suitable; 2 = not very suitable; 3 = quite suitable; 4 = suitable; 5 = very suitable). A 5-point Likert scale format was adopted in order to consider "neutral" or "undecided" option as midpoint of the scale. In addition, a 5-point scale was preferred to the 7-point or 9-point scale to facilitate the choice of respondents and reduce the time required to complete the questionnaire.

The last question investigates visitors' perception of the effect of the different silvicultural treatments on the scenic beauty of the Pratomagno forest. The respondents assessed the above mentioned photographs showing the three forest management scenarios using a pairwise comparison method. The respondents were instructed to evaluate the scenic beauty of the stands and not the quality of the photographs. They were not informed how the stands had been treated and that the purpose was to investigate the visual effects of different kinds of thinning.

The final version of the questionnaire was administered to a sample of visitors in the period from June to September 2017. The questionnaire was administered face-to-face by a lead interviewer and an assistant, responsible for showing the photographs, making observations, and taking notes. The interviews were conducted in the Pian dei Lavacchi, where there is a large lawn, a restaurant, and from which originates the most frequented paths of the entire Pratomagno massif. Visitors were sampled with a systematic sampling method (one visitor out of two was sampled) at Pian dei Lavacchi forest recreation area while they were arriving. The interviews were conducted both in the working days and in the weekend to include in the sample different types of visitors. At the end of the data collection period, 23 days of interviews were conducted, 5 in working days, and 18 during Saturdays and Sundays, and 890 forest visitors were contacted.

2.4. Statistical Analysis

All statistical analyses were carried out using XLStat 2017. The data collected using the Likert scale response format were statistically compared using Kruskal-Wallis non-parametric test to highlight differences among the three experiences in the three forest management scenarios. For the two questions relating to visitors' preferences for forest stands characteristics, the χ^2 test was used to analyze the influence of socio-demographic characteristics (i.e., gender, age) of respondents on the answers.

The data collected with the question investigating visitors' perception of the effect of the different silvicultural treatments on the scenic beauty of the Pratomagno forest were elaborated using the Analytic Hierarchy Process (AHP) approach. The AHP is a multiple-criteria decision making method used to rank the alternatives by considering the importance of the different criteria to facilitate decision-making for complex choices [78,79]. In this study, the respondents compared the three photographs of Pratomagno forest in pairs with respect to the scenic beauty.

The results of pairwise comparison were used to calculate the factor priority score (w). In particular, the factor priority score—normalized Eigen vector of the comparison reciprocal matrix (A)—is used to define a ranking of the preferred photographs. The reciprocal matrix A is tested for consistency in the following way [79]:

$$CI = \frac{(\lambda_{max} - n)}{(n-1)} \quad (1)$$

$$CR = \frac{CI}{RI} \quad (2)$$

where: λ_{max} is the largest Eigenvalue of matrix A; n is number of rows or columns in the matrix; CI is the consistency index; CR is the consistency ratio; and RI is the expected consistency index obtained from random generated comparisons of the same order n.

The value of CR should be lower or equal to 0.1 (10%) to have consistency of the matrix A.

3. Results

3.1. Socio-Demographic Characteristics of the Respondents

The response rate was 22.2%, with 200 questionnaires collected and processed. The non-response rate ranges between a maximum of 85% on holidays and Sunday and a minimum of 70% on Saturday and working days. The response rate of this survey is very low compared with other in-situ studies carried out in Italy that show a response rate between 70% and 90% [41,80,81].

A possible reason for the low response rate could be the gender and age of the interviewer and the assistant, both males and 25-years-old. Previous studies have shown that adult people and females have higher disposition to involve respondents compared to males and young people [82,83]. However, many other reasons may have influenced the low response rate of this survey such as target of visitors and place of interviews.

Of the respondents, 62% were men and 38% were women. Considering their provenience, 88.5% came from Arezzo province, where the Pratomagno forest is located, while 10.5% came from the Firenze province and 1.0% from other Italian regions. No visitor came from foreign countries.

Six age classes were considered (less than 25 years old, 25–34, 35–44, 45–54, 55–64, and more than 65 years old). The results show a quite regular distribution of the respondents over the six classes, with the following distribution by age groups: 20.9% are less than 25 years old, 16.6% 25–34 years old, 16.6% 35–44 years old, 23.1% 45–54 years old, 10.1% 55–64 years old, while the remaining 13.1% are 65 or more years old.

The frequency distribution based on education level is as follows: 5.5% of respondents has elementary school degree; 13.6% medium school degree; 44.7% high school degree, 36.2% University degree (Bachelor's or Master's degree), while none of the respondents has a post-University degree.

Considering the current employment status, the sample is mainly composed of private sector employees (41.5% of total respondents), followed by students (19.0%), pensioners (14%), public sector employees (10.5%), and housewives (4.5%), while the remaining 10.5% are unemployed people.

Observing our data and those of official statistics, the sample of respondents of this survey can be considered representative of the inhabitants of the Arezzo province. The official statistics (2019) show a population of 341,766 inhabitants and 148,230 families in the Arezzo province thus distributed by age class: 21.2% with less than 25 years old; 10.3% between 25 and 34 years old; 12.8% between 35 and 44 years old; 16.1% between 45 and 54 years old; 14.1% between 55 and 64 years old; and the remaining 25.5% with more than 64 years old. The average age is 46.6 years old. Concerning the gender, 51.2% of inhabitants are female and the remaining 48.8% are male.

3.2. Preferences for Forest Characteristics

The results of the two questions relating to "Recreational use of forests" show the preferences for different forest types (tree species composition) and stands structure.

Concerning tree species composition, most respondents expressed an aesthetic preference for mixed forests (Table 1). On the contrary, pure broadleaved forests or pure coniferous forests are less appreciated by visitors, with about 15% of respondents preferring these tree species compositions.

Table 1. Visitors' preference for forest characteristics (frequency distribution).

Socio Demographic Characteristics	Species Composition			Stand Structure	
	Coniferous Forests	Broadleaved Forests	Mixed Forests	Regular Structure	Irregular Structure
Gender					
Males	17.9	16.3	65.9	25.00	75.00
Females	12.0	17.3	70.7	19.74	80.26
χ^2 test		$p = 0.546$		$p = 0.488$	
Age					
Less than 25	26.2	19.0	54.8	23.81	76.19
25–34	15.2	12.1	72.7	21.21	78.79
35–44	12.1	9.1	78.8	17.65	82.35
45–54	15.2	23.9	60.9	26.67	73.33
55–64	5.0	10.0	85.0	20.00	80.00
More than 65	11.5	19.2	69.2	23.08	76.92
χ^2 test		$p = 0.307$		$p = 0.961$	
Education level					
Elementary school	18.18	18.18	63.64	36.36	63.64
Medium school	11.11	25.93	62.96	22.22	77.78
High school	16.85	12.36	70.79	23.60	76.40
Bachelor's degree	19.05	19.05	61.90	19.05	80.95
Master's degree	13.46	17.31	69.23	21.15	78.85
χ^2 test		$p = 0.886$		$p = 0.857$	
Employment					
Public sector employees	14.3	14.3	71.4	19.05	80.95
Private sector employees	10.8	20.5	68.7	24.10	75.90
Housewives	11.1	0.0	88.9	33.33	66.67
Students	28.9	10.5	60.5	26.32	73.68
Pensioners	10.7	17.9	71.4	25.00	75.00
Unemployed	19.0	19.0	61.9	9.52	90.48
χ^2 test		$p = 0.383$		$p = 0.691$	
Total	15.6	16.6	67.8	22.7	77.3

The results show no significant relationship in preferences by demographics for tree species composition despite some differences shown in Table 1. Young people (less than 25 years old) showed a greater preference for coniferous forests (26.2%) than did other age groups, while respondents with age between 45 and 54 years show a higher preference (23.9%) for broadleaved forests compared to other age groups. However, the Chi-square (χ^2) test showed no significant difference among the age groups.

Considering the level of educational of the respondents, the only peculiarity is the higher preference for broadleaved forests showed by respondents with a medium level of school education (25.9%).

Regarding the current employment status, a higher preference for pure coniferous forest was expressed by students (28.9%), while about 90% of the housewives prefer mixed forests.

The results concerning stand structure show that most respondents expressed a preference for an irregular stand structure, characterized by a random distribution of the trees in the space and a high diameter differentiation of trees. The results showing the relationship between the socio-demographic characteristics of the respondents and their preference for forest structure also reveal a widespread preference for an irregular stand structure, comprised between around 65% and 90%. The Chi-square test ($\alpha = 0.05$) did not reveal any significant information regarding the distribution of the respondents according to the gender, the age, the education, and the current employment status.

Considering the level of education, a peculiarity is that people with an elementary degree showed a greater preference for a regular stand structure (36.4%) than did other groups. Regarding the current employment status, the higher preference for an irregular stand structure was expressed by unemployed people (90.5%).

3.3. Perception of the Effect of Silvicultural Treatments on the Scenic Beauty

The results of pairwise comparison (Table 2) show that the effects of thinning affect the respondents' perception of the Pratomagno forest's visual beauty. Thinning had a positive effect on the scenic beauty score compared to the situation of the forest with no intervention (priority score of 0.26). In particular, selective thinning increases the scenic beauty score more than traditional thinning (priority score of 0.40 and 0.33, respectively).

Table 2. Scenic beauty scores of the photographs of Pratomagno forest after three different silvicultural treatments by groups of respondents.

Socio Demographic Characteristics	Unthinned Forest	Selective Thinning	Thinning from Below
Gender			
Males	0.2664	0.3996	0.3340
Females	0.2569	0.4044	0.3387
Age			
Less than 25	0.2759	0.4067	0.3173
25–34	0.2640	0.3961	0.3399
35–44	0.3242	0.3553	0.3204
45–54	0.2265	0.3968	0.3767
55–64	0.2165	0.4456	0.3379
More than 65	0.2708	0.4261	0.3031
Education level			
Elementary school	0.3338	0.4005	0.2657
Medium school	0.2078	0.4305	0.3616
High school	0.2674	0.4195	0.3131
Bachelor's degree	0.2085	0.4515	0.3400
Master's degree	0.2935	0.3345	0.3720
Employment			
Public sector employees	0.2010	0.3738	0.4252
Private sector employees	0.2999	0.3874	0.3127
Housewives	0.2441	0.4911	0.2648
Students	0.2340	0.4111	0.3549
Pensioners	0.2555	0.4401	0.3044
Unemployed	0.2551	0.3649	0.3800
Total respondents	0.2628	0.4014	0.3358

These results show that thinning is considered to have a positive visual impact, demonstrating that the sample of visitors prefer managed forests, while unmanaged forests (current situation of Pratomagno forest) are evaluated negatively from the aesthetic point of view. The selective thinning, aimed at removing all standing dead trees and lying deadwood slightly decomposed and at creating a more complex forest structure, is considered the silvicultural treatment with the greater positive effect on respondents' perception of forest scenic beauty.

The positive effect of the thinning on the scenic beauty of Pratomagno forest was considered smaller in the case of thinning from below which removes more small trees and after which the dominated layer almost disappears and the vertical structure of the forest is simplified. Conversely, the unmanaged forest—characterized by the higher number of trees per hectare and the higher canopy cover—is evaluated as being worse than a thinned forest.

The results showing the relationship between the socio-demographic characteristics of the respondents and their evaluations of photographs were quite similar, with the selective thinning having the higher scenic beauty score, and the forest without silvicultural interventions having the lower. However, some deviations can be observed in Table 2. When considering the age of respondents, the group with the age between 35 and 44 years assign the same scenic beauty score to the photograph of the forest after thinning from below and to the one of the unmanaged forest. The effects of thinning were seen less positively among respondents with elementary school degree who prefer unmanaged forest to forest under thinning from below. On the contrary, highly educated respondents had more critical attitudes than less educated persons towards selective thinning. When considering the profession of the respondents, unemployed people and employees of the public sector regarded the thinning from below as an improvement to the scenic beauty of a forest more often than the other respondents did.

3.4. Impact of Thinning on Visitors' Experiences in Forest

The results concerning respondents' perception of the effect of thinning on different experiences that visitors can appreciate in forest evidence some interesting differences (Table 3). Both types of thinning affected the respondents' perception of the forest's suitability for the three experiences. The Pratomagno forest after selective thinning photo received the highest score for suitability to touristic-recreational and sport-physical experience in forest, while the Pratomagno forest after thinning from below photo was the highest scored by respondents for contemplative/aesthetic experience.

Table 3. Values of forest's suitability for different experiences after silvicultural interventions.

Experiences	Unthinned Forest	Selective Thinning	Thinning from Below	Kruskal-Wallis Test ($\alpha = 0.01$)
Touristic-recreational experience	2.06	3.68	2.60	$p < 0.0001$
Contemplative/aesthetic experience	3.71	3.51	3.92	$p = 0.001$
Sports/physical experience	2.73	4.20	3.15	$p < 0.0001$
Kruskal-Wallis test ($\alpha = 0.01$)	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	

The non-parametric Kruskal-Wallis test ($\alpha = 0.01$) was applied to determine the statistical significance of differences between experiences under the same silvicultural treatment. The test showed statistically significant differences between the three experiences in all the images representing the forest after selective thinning, after thinning from below and in the unmanaged forest.

The significance of differences of the values given to the same experience under different silvicultural treatments was assessed by the non-parametric Kruskal-Wallis test ($\alpha = 0.01$). The test showed significant statistically differences for all three experiences: touristic-recreational experience ($p < 0.0001$), sport-physical experiences ($p < 0.0001$), and contemplative/aesthetic experience ($p = 0.001$).

4. Discussion

The results of interviews conducted in this research are in accordance with findings of other studies, evidencing the strong relation between scenic beauty and forest attributes [30,44,84–86]. When considering how tree species composition can influence scenic beauty, the results evidence that most respondents prefer mixed forests to pure broadleaved forests or pure coniferous forests. These findings are in general agreement with other comparable studies concerning aesthetic preferences for tree species composition evidencing that the mix of tree species has a strong, positive effect on perceived scenic beauty [33,40,44,85,87–89]. Researches also evidence that, in general, the variety of species creates visual diversity of the forests which is appreciated by forest visitors [30,33,76,85,90]. In this sense, Tyrväinen et al. [91] evaluated that mixed pine and spruce stands are appreciated by visitors, while mixed stands of deciduous trees are disliked.

Furthermore, the present research contributes to confirm that, as suggested by other authors [30,36,85], tree species composition is a forest attribute not very influential on visitors' choices and influenced by

subjective motivations and people's origin. Subjective expectations, cultural, social, and contextual reasons affect preferences for species; moreover, certain species are preferred as more fitting in a certain setting, and thus preferences can differ from a situation to another. As a confirmation of this, in the present study most respondents rated mixed forests first, despite the interviews have been realized in a rest area of Pratomagno surrounded by a pure artificial pine stand.

Results of direct questions concerning preferences for forest attributes also evidence that most respondents prefer an irregular structure, with a random distribution of the trees in the space and a high diameter differentiation. The preferred forest stand is thus a mixed forest with different tree heights, varying tree layers, presence of large and thin trees, and consequently a high and variable quantity of light reaching the forest floor. The preferences and the high scenic beauty of this naturally appearing forest setting characterized by a great structural diversity are in accordance with main findings of other similar studies [30,85,92,93].

The results concerning how thinning affect forest scenic beauty are based on photographs of Pratomagno forest realized about one year after the interventions. As observed by other studies photographs can be considered satisfactory surrogates of real vistas for the investigation of visual quality [27,43,94,95]. However, the use of photographs can present some problems: (i) a broad search of forest settings may be necessary to find a set of photographs representing in a satisfactory way the real situation of the forest; (ii) when forest interventions have not yet been realized, non-existing stand types cannot be included in the study; (iii) photographs represent the forest situation only in a specific place and at a certain time.

Results show that both kinds of thinning have a positive effect on the scenic beauty score compared to the situation of the forest with no intervention, evidencing that visitors prefer managed forests. Selective thinning increases the scenic beauty more than traditional thinning. Reasons for this can be found in the fact that selective thinning from one side creates a more complex and naturally appearing forest structure characterized by increased visibility, but from another side removes standing dead trees and part of lying deadwood that have scenically negative impacts. It can be said that this kind of intervention presents the positive effects of thinning but not those usually considered as negative. In particular, several studies evidence that the appearance of deadwood has a clear negative impact on scenic beauty because deadwood is considered an indicator for a "dying" forest [52,85,92,96]. In a study conducted in three parks in United States and Germany, Arnberger et al. [97] highlighted that visitors prefer healthy mature forest stands and dislike forests with substantial deadwood. Conversely, Pastorella et al. [98] show that a high percentage of visitors in a case study (peri-urban forest of Sarajevo city in Bosnia-Herzegovina) perceive positively standing dead trees and lying deadwood in forest. Tyrväinen et al. [91] highlighted that for the visitors the three most important forest management interventions to increase the landscape value of the Helsinki urban forest are: management of understory and bush layer, thinning, and dead snags.

Concerning positive effect of thinning, results of this research are in accordance with other studies evidencing the positive effect on scenic beauty due to the fact that thinning treatments increase visibility in the forest, which is usually considered positive [39,42,99,100]. The results evidenced that thinning affected visitors' perception of forest's suitability for different kinds of forest experiences, named touristic-recreational, sport-physical, and contemplative/aesthetic. In particular, the forest after selective thinning was evaluated as the most suitable for touristic-recreational and sport-physical experience, while the thinning from below was the highest scored for contemplative/aesthetic experience.

In accordance with other studies, it seems that the influence of thinning on recreational, sportive and psychological restorative effect of forest is influenced not from the thinning in se, but by a selection of indices (accessibility, stand density, presence of deadwood) depending on the presence or absence of thinning [101]. Increased visitor accessibility was interpreted as being more important than stand density in increasing recreational appeal of a forest [102]. This result is confirmed by the highest score of selective thinning in increasing forest suitability for recreational experience. The present research confirms the idea that forest visitors favors a medium to dense forest environment and indicated

forest accessibility as a crucial feature for increasing the recreational appeal of a stand [103]. Therefore, forest managers should consider with attention the intensity of thinning and the influence on users' appreciation for recreational and restorative effect.

5. Conclusions

This study provided information on visitors' perception of the effect of different silvicultural treatments on the forest scenic beauty. In particular, the research aims to understand the effects of different kinds of thinning on visitors' aesthetic preferences. We chose to analyze the visitors' preferences and perceptions by a questionnaire survey approach. The effect of thinning on visitors' perceptions of the scenic beauty of the Pratomagno forest was investigated using photographs as alternative to direct questions. This choice was made since visitors are not experts of the forest sector and have poor knowledge of technical issue, so they are probably unable to give responses concerning the effect of specific silvicultural operations. On the contrary, they can express their preference for different images.

Results of this study found that different thinning operations influenced visitors' preferences and so can affect the settings for their different experiences in forest. These findings confirm that forest managers and planners must be aware of how thinning operations can affect visitors' choices, and consequently forest attractiveness. Based on this knowledge, they can make conscious choices targeted at avoiding reductions in people's interest in spending time in the forest and at increasing the cultural ecosystem services related to forest environment.

The results of the present research can be integrated with the results of other studies aimed to identify the preferences and values that visitors attribute to the forest attributes and the effects of forest interventions on forest scenic beauty. In the future, other researches can be conducted, including different tree species, and developed in other parts of Europe. Understanding the diverse attributes of forests that make them attractive to be visited is a crucial issue for the forest managers to better address forest management interventions. Information from these studies are important for implementing cultural ecosystem services in forestry policy, forest planning, and management.

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