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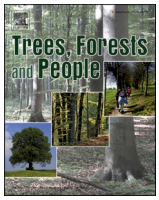

The role of tourists' and residents emotions on resilient landscape restoration after extreme events

Tiziano Tempesta, Carolina B. Pellizzari, Daniel Vecchiato *

Universitá degli Studi di Padova - Department of Land, Environment, Agriculture and Forestry (TESAF), via dell'Universitá, 16, Legnaro (PD), 35020, Italy

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ABSTRACT

Forest areas and mountainous territories provide crucial ecosystem services, among which cultural-recreational services are of particular relevance in the Alps. In 2018, the mountain area of Northeast Italy was struck by the VAIA windstorm, resulting in extensive damage to trail networks and substantial landscape transformations in valleys. Restoring the storm-affected area while considering forest resilience and public preferences became a critical need. This research is aimed at assessing the landscape scenic preferences of visitors and residents of the area impacted by the storm with reference to alternative intervention strategies for restoring the VAIA-affected forests. The psychophysical approach was applied to understand residents preferences and a survey was conducted in May 2022, involving 713 residents in the Veneto region. Respondents were requested to evaluate the scenic quality of 8 landscape typologies characterized by panoramic and non-panoramic views, forests with and without fallen trees, and meadows cultivated or abandoned. They were also required to associate eight proposed categories of emotions with the landscapes, providing scores accordingly. To analyze the factors affecting landscape scenic quality we estimated two regression models. The first model highlighted that the scenic quality of the landscape is positively correlated with panoramic views, cultivated meadows, and forests, while abandoned areas or trees felled by VAIA have negative correlations. The second model demonstrated the existence of a strong relationship between landscape quality and the emotions evoked, with certain emotions significantly impacting scenic quality perception. The second model explains a higher proportion of the scenic quality scores than the first one ($R^2 = 0.788$ vs $R^2 = 0.527$) meaning that emotions are a better predictor of scenic quality than the physical characteristics of the territory. Our results suggest that, in order to improve the recreational services of the mountain territories, for restoring the VAIA-affected forests it will be necessary to remove the felled trees and at the same time increase the presence of panoramic views by substituting in some areas the forests with cultivated meadows.

1. Introduction

The management and planning of landscapes exert a significant influence on environmental quality, and consequently on people's lives. Given the importance of well-managed landscapes and the challenges faced by decision-makers in safeguarding their heritage and promoting sustainable development, the European Landscape Convention (ELC) was established by European Union member states in the year 2000 (Council of Europe, 2000). According to the ELC, "Landscape means an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors" (art. 1, a). As per the landscape definition provided by ELC, it's crucial to note that a landscape is shaped not solely by its physical territory but primarily by how it is perceived. The interaction of nature and human factors can be easily observed in the alpine area, which has suffered continuous changes in its landscape through the years caused by both natural and anthropogenic factors (Garbarino et al., 2014; Plieninger et al., 2013; Whitaker, 2023). The combination of different land uses and objectives such as nature conservation, wood production, agriculture, hiking trails, roads, and dwellings, results in a multifunctional character of the landscape (O'Farrell and Anderson, 2010). Multifunctional landscapes provide a series of ecosystem services, such as climate regulation, biodiversity, provision of raw materials, as well as scenic beauty (Fagerholm et al., 2020). Among these benefits, cultural ecosystem services, including tourism activities, can be considered an important contributor to the economy of local business and well-being of residents and tourists, both

* Corresponding author.
E-mail address: daniel.vecchiato@unipd.it (D. Vecchiato).

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physically and mentally (Huber et al., 2020). The benefits of such landscapes on well-being include the promotion of physical activities, social integration, engagement and participation, stress reduction, and evocation of positive emotions (Abraham et al., 2010; Ulrich et al., 1991).

To be perceived as an option for recreational activities and contribute to improved well-being, rural green landscapes must exude visual appeal that resonates with their users (Pretty et al., 2005). Mountainous regions are particularly crucial in meeting the growing demand for picturesque landscapes, thus underscoring their significance in providing these essential services (Schirpke et al., 2016). Therefore, among the many aspects that influence the environmental quality of ecosystems and landscapes, decision-makers should also take into consideration residents and tourists' preferences while planning the management of a landscape, using a bottom-up assessment to improve well-being. In fact, the ELC states that territorial policies will have to set themselves landscape quality objectives which designate 'the formulation by the competent public authorities of the aspirations of the public with regard to the landscape features of their surroundings' (art. 1, c). To this end, they will have to 'evaluate the identified landscapes, taking into account the specific values that are attributed to them by the subjects and populations concerned' (art. 6, C-b).

The perception of a landscape is subjective and can vary among socio-demographic and cultural groups in addition to the landscape-related level of expertise (Dupont et al., 2015; Schirpke et al., 2021; Zoderer et al., 2016). Moreover, different types of landscape attributes affect visitors' emotions, these being positive or negative (Han, 2010). Improving the positive emotions of populations is beneficial for both the human and natural components since they increase well-being and health. Many studies have shown the link between nature and human well-being and how people prefer natural environments over built landscapes (Bowler et al., 2010; Han, 2010; Tempesta and Vecchiato, 2015; Ulrich, 1981); however, it remains uncertain whether the specific type of natural environment plays a significant role in this regard. More recently, studies have explored which landscape composition and configuration evoke positive emotions in people, thus helping understand preferences for landscape composition (de Vries et al., 2021).

Multifunctional landscapes, especially a mix of forest and open space, were shown to be preferred by visitors in terms of their visual quality (García-Llorente et al., 2012; Tattoni et al., 2021). In a photo-based survey carried out in the central Alps, respondents attributed higher aesthetic values to the Alpine landscape (meadows, pastures, and single trees) with respect to areas with settlements or intensive agricultural use (Schirpke et al., 2016). Specifically in higher altitudes, studies found that water bodies, glaciers, and perpetual snow were the most preferred landscapes, followed by agro-forestry areas (larch meadows), pastures (summer pastures) and natural grasslands. Among the least preferred landscape the authors found urban areas, fruit trees and berry plantations as well as vineyards (Schirpke et al., 2021). As previously stated, emotions play a significant role in shaping one's preferences for a particular landscape. In the Alps, empirical research confirmed the preference for variegated and multi-faceted landscapes, with a mix of tree species and open areas with grazing animals and pointed to the significative effect of emotions not only on preferences but also on the willingness to pay, expressed as an extra tax for an overnight stay (Notaro et al., 2019).

The Italian Alpine area is the destination of many tourists in both summer and winter seasons due to its landscape, facilities, and tourist activities (Tempesta and Vecchiato, 2018). The Italian Alps host a unique landscape, the Dolomites, which are listed among the UNESCO World Heritage Sites (UNESCO World Heritage Centre, 2024). In October 2018, however, this region was impacted by the VAIA storm, a violent windstorm with winds up to 200 km/h that damaged several forest areas of Italy, covering the regions of Trentino-Alto Adige, Veneto, Friuli Venezia Giulia, Lombardia, Piemonte, and Valle d'Aosta (Giannetti et al., 2021). Focusing only on the aftermath of the Veneto region, VAIA affected mainly the provinces of Belluno and Vicenza and caused severe damages to approximately 18,000 hectares of forest, which represents 5% of the forest assets of the region (Udali et al., 2021).

The damages of the VAIA storm were not only related to the timber industry, but it also affected other crucial ecosystem services such as water regulation and cultural services. The first is related to hydrological and geomorphological aspects that were affected by the windthrow due to the changes in land cover, large amount of precipitation, and steep slopes found in the mountains, which resulted in the change of water runoff direction and landslides (Faes et al., 2023; Mauri and Tarolli, 2023). As to the cultural services, the recreational use of the area was impacted both by damages to the infrastructure and trails network and by drastic changes to the landscape (more details are available in Vecchiato et al., 2023). After a period, the trails were fixed, however the impacts on the landscape are far more complex since the fallen trees and consequent change in composition of the landscape represent an impact but not necessarily represent a deterioration of the landscape. When planning the restoration of areas impacted by the VAIA storm, these landscape considerations must be factored in. Indeed numerous options are currently being evaluated for the restoration of the affected areas. These options include implementing reforestation with a nature-based approach, using planted trees, and preserving specific areas as meadows while removing fallen trees. The interventions required in the forested areas impacted by VAIA must consider several factors, most notably the landscape's quality and the preferences of the local community and visitors. These preferences extend not only to residents but also to all individuals who visit these areas for tourism and recreational activities in the mountainous regions of the Veneto region.

The aim of this research is to understand and analyze, on the one hand, the landscape aesthetic perception of residents in the Veneto region and, on the other, how aesthetic perception is related to their emotions. In this regard, a survey was carried out in May 2022 involving a sample of 713 residents in the Veneto region. We applied the psychophysical approach (Daniel and Vining, 1983) to a photo-based survey which allowed the identification of landscape preferences of the resident population, thus supporting management authorities in delivering cultural ecosystem services.

2. Materials and methods

There are several approaches to evaluating landscape visual quality. In general terms, they can be divided into the objectivist approach, where visual quality is inherent to the landscape or the object, and the subjectivist approach, where landscape quality is a construct of the observer. With the introduction of the landscape definition by the ELC, the subjectivist approach became popular for informing policies (Tveit et al., 2018). The chosen method for this research, the psychophysical model, is in between the objectivist and subjectivist approaches (Daniel and Vining, 1983; Tveit et al., 2018). It aims to establish relationships between measured physical characteristics of a scene (taken from photographs or geographical databases) and landscape preferences, emphasizing the role of the observer in interaction with the landscape. In other words, when it comes to landscape assessment, the psychophysical methods "seek to determine mathematical relationships between the physical characteristics of the landscape and the perceptual judgments of human observers" (Daniel and Vining, 1983). In this respect, the psychophysical method relies on data collected by means of a questionnaire, where respondents are asked to provide their perception of different landscape types through a rating scale (Likert), in order to "measure" their opinion in terms of appreciation and/or emotions.

This study applied the psychophysical approach (Daniel and Vining, 1983) focusing both on the visual aesthetic of the landscape and their effect on visitors' emotions through a photo-based survey. The target area of this research is in Northeastern Italy, more specifically the mountain area of the Veneto region that was affected by the VAIA storm (Fig. 1).

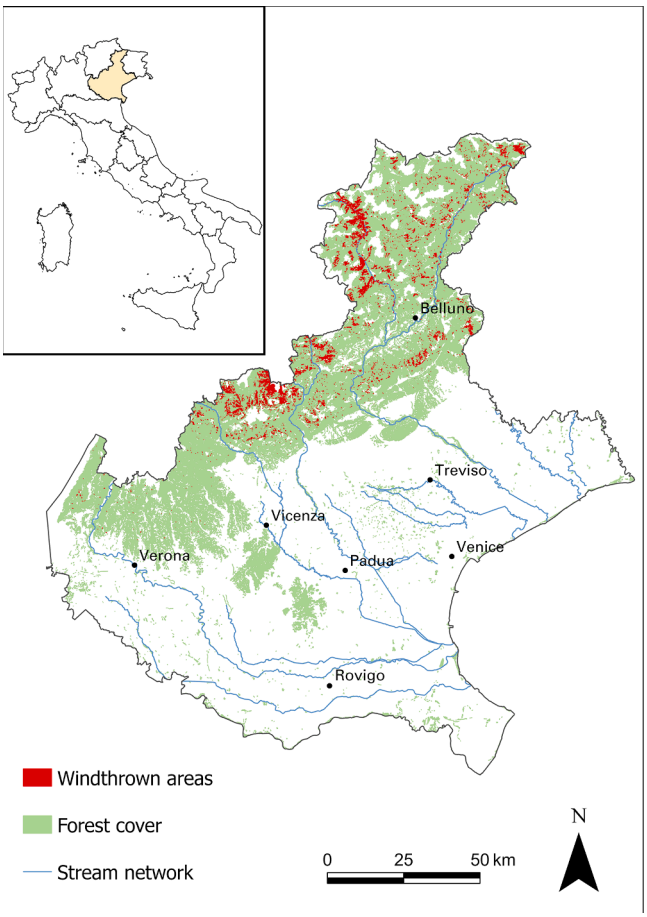


Fig. 1. Map of the Veneto areas hit by the VAIA storm (courtesy by Professor Emanuele Lingua, Department of Land, Environment, Agriculture and Forestry (TESAF), Universitá degli Studi di Padova).

2.1. Experimental design

Since the quality of the landscape plays a significant role in directing tourist destinations, the research aimed to analyze the potential impact on the visual perception of the mountain landscape quality caused by the VAIA storm, as well as the potential actions that could be taken in the future to restore the forests and the territory.

Numerous studies were conducted in the past with the goal of identifying factors that can enhance or diminish the visual perception of the landscape quality. In 2008, Ode, Tveit and Fry conducted a synthesis of these research efforts and identified nine key factors (or key concepts) that can influence landscape quality (Ode et al., 2008):

1. stewardship
2. coherence
3. disturbance
4. historicity
5. visual scale
6. imageability
7. complexity
8. naturalness
9. ephemera

If those factors are applied to the changes in landscape quality caused by the VAIA storm, it is possible to hypothesize some potentially contrasting effects. In some cases it might have enhanced the panoramic view or visual scale (positive effect), while the presence of fallen trees reduced the perceived landscape stewardship (negative effect), decreased the level of coherence (negative effect), and excessively increased complexity (negative effect). The actions to be taken to restore the landscape have certain priorities that must be necessarily respected, including: (i) the security of the territory must be guaranteed, and (ii) the highest possible quantity of felled timber must be removed to prevent the spread of the bark beetle (*Ips typographus*), which could cause significant damage to the entire forest heritage. These objectives, however, may be implemented through different management actions:

1. Actions for restoring the damaged forest structure:
   (a) Natural reforestation with the removal of felled trees.
   (b) Natural reforestation without the removal of felled trees.
   (c) Artificial reforestation implemented by planting new trees.
2. Establishment of meadows and pastures.
3. Removal of fallen trees in forests that have suffered minor damage.

To assess the landscape outcomes of these different strategies, photographs representing different landscape types have been selected following the scheme outlined in Fig. 2.

First, a distinction was made between landscapes with a high degree of panoramic views and the ones presenting less panoramic views because, as observed, the main positive landscape effect of the VAIA storm is the increase in the panoramic nature of the mountain landscape. Second, two possible land use configurations were distinguished: one characterized by the presence of forests and the other by the presence of forests, meadows and pastures. Finally, to further consider the impact of the VAIA storm, the possibility that felled trees are still largely present in the forests or that the meadows are uncultivated and undergoing spontaneous reforestation was considered. Hence, 8 possible landscape configurations were identified:

1. Type 1: Forest landscapes with high panoramic views where trees felled by the VAIA storm are visible.
2. Type 2: Forest landscapes with high panoramic views where no trees felled by the VAIA storm are visible.
3. Type 3: Landscapes with both forests and non-abandoned meadows and pastures with high panoramic views.
4. Type 4: Landscapes with both forests and abandoned meadows and pastures with high panoramic views.
5. Type 5: Forest landscapes with reduced panoramic views where trees felled by the VAIA storm are visible.
6. Type 6: Forest landscapes with reduced panoramic views where no trees felled by the VAIA storm are visible.
7. Type 7: Landscapes with both forests and non-abandoned meadows and pastures with reduced panoramic views.
8. Type 8: Landscapes with both forests and abandoned meadows and pastures with reduced panoramic views.

The photos used to illustrate each landscape configuration were collected by using both the personal archives of the authors and by conducting 14 field visits in areas affected or unaffected by the VAIA storm. To account for the territorial and environmental variability of the Venetian mountains, four photographs were selected for each landscape type (Fig. 3), resulting in a total of 32 images for evaluation. We selected four photos for each landscape type in order to limit the chance of having responses influenced by the specific photo, rather than the landscape type it represented. To avoid excessive cognitive load in the landscape evaluation, each interviewee was presented with 8 photos, one for each landscape type. Therefore, the sample was divided into four blocks, each consisting of 178 or 179 interviewees. Depending on the block, the images related to the eight landscape types were presented in a different order.

2.2. Data collection and survey structure

To analyze the landscape preferences of Veneto residents regarding

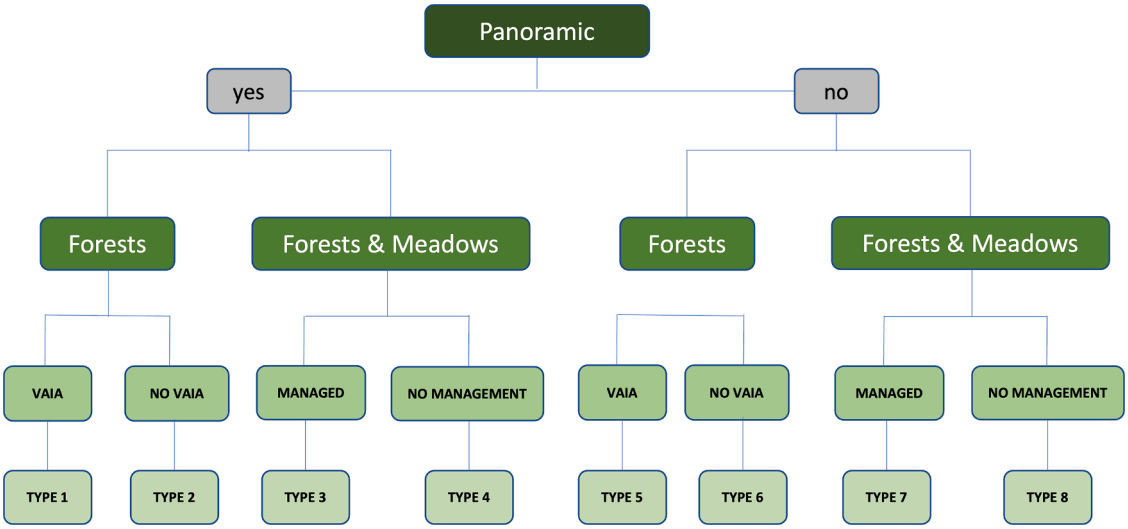


Fig. 2. Framework for identifying the types of landscapes subject to the respondents evaluation.

potential restoration efforts in the forested areas affected by the VAIA storm in May 2022, an online survey was conducted through a specialised and certified research company. The questionnaire was submitted to a panel of respondents, and the data collection resulted in a stratified sample (by gender, age, and province of residence) of 713 residents in the Veneto region. The number of interviewees was distributed among the provinces of Veneto in proportion to the population aged 18 to 75. The survey was conducted through a questionnaire divided into three sections: (i) socio-economic characteristics, (ii) engagement in hiking activities and the VAIA storm, and (iii) analysis of landscape preferences. In the first section, the collected information was used to characterize the interviewees from a social and economic perspective. This included data such as age, educational level, place of residence, family size, income, and occupational sector. Regarding the occupational sector, respondents were also asked if they were involved in activities related to mountain tourism or the timber industry. To better understand the relationship between the interviewees and the Venetian mountains, they were asked whether their family owned a house in the Venetian mountains or in other regions. In the second section, interviewees were asked to provide the total number of trips they took in the past year, as well as the number of vacation days. They were also asked to specify the motivations behind their hiking or mountain vacation experiences. Additionally, some questions aimed to determine whether interviewees had personally witnessed the damages caused by the VAIA storm, if these damages had in any way influenced their tourism and recreational activities, or if they had suffered personal losses due to the storm. Finally, respondents were asked to assess the significance of the damage caused by VAIA to the main ecosystem services provided by forests using a Likert scale ranging from 1 (very little) to 5 (a great deal). The following ecosystem services were considered: tourism and recreational activities, landscape beauty, timber production, water purification, preservation of hydrogeological balance, carbon dioxide absorption by forests, and biodiversity conservation.

2.3. Data analysis

As previously mentioned, the landscape evaluation was carried out using the psychophysical method, which establishes a connection between the assessment of the aesthetic quality of the landscape (typically done through the use of scores) and the physical characteristics of the landscape.[1]

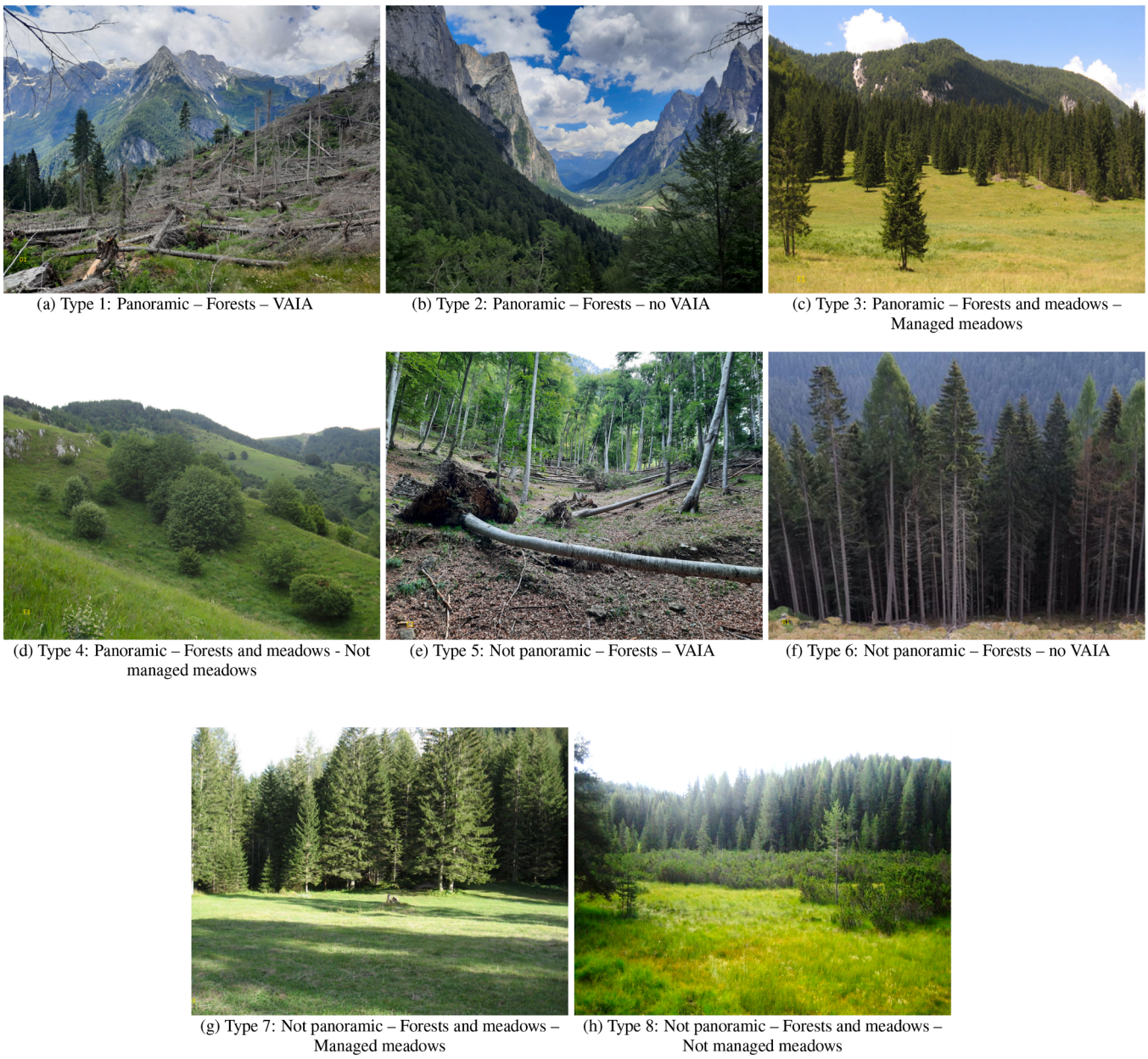
In our application, we focused on two main domains: aesthetic appreciation and emotional responses. For the first domain, for each of the eight images, each interviewee was asked to indicate their level of aesthetic-visual appreciation using a Likert scale from 1 to 7 (with 1 = dislike and 7 = like very much). To understand the emotional basis underlying the evaluation of visual-perceptual quality, respondents were also asked to indicate which emotion they associated with each image using the following schema. Based on the list proposed by Schindler et al. (2017), which reviewed studies on emotions associated with aesthetic experiences, eight emotions that are particularly relevant to the characteristics of the analyzed landscapes were selected: (i) it relaxes me, (ii) it bores me, (iii) it intrigues me, (iv) it concerns me, (v) it fascinates me, (vi) it makes me sad, (vii) it makes me happier, (viii) it gives me a sense of oppression. For each of the emotions, respondents were asked to express a rating using a Likert scale ranging from 1 (very little) to 5 (very much). To analyze the effect of the VAIA storm on landscape perception, the average scores assigned to each of the eight landscape configurations selected were first compared using ANOVA. Then, a linear regression function was used to estimate the relationship between the score assigned to aesthetic-visual quality, landscape types, and landscape characteristics. Two regression functions were estimated in this regard. In the first function, the five factors used to identify the eight landscape types in Fig. 2 were considered as independent variables in dummy format (present/absent) (Table 1).

In the second regression function, the independent variables were derived from the percentage of the image occupied by the following elements:

- Forests in the foreground or background
- Mountains in the background
- Rocks on the mountains in the background
- Cultivated meadows and pastures
- Abandoned meadows and pastures
- Trees felled by the VAIA storm
- Undergrowth

The percentages were calculated after excluding the portion of the image occupied by the sky. A similar procedure was followed to analyze the relationship between emotions and aesthetic-visual quality. In this

[1] For a more in-depth understanding of landscape assessment methods, you can refer to Lothian (2017).



(a) Type 1: Panoramic – Forests – VAIA
(b) Type 2: Panoramic – Forests – no VAIA
(c) Type 3: Panoramic – Forests and meadows – Managed meadows
(d) Type 4: Panoramic – Forests and meadows - Not managed meadows
(e) Type 5: Not panoramic – Forests – VAIA
(f) Type 6: Not panoramic – Forests – no VAIA
(g) Type 7: Not panoramic – Forests and meadows – Managed meadows
(h) Type 8: Not panoramic – Forests and meadows – Not managed meadows

Fig. 3. Example of the pictures belonging to each of the eight landscape types considered in the survey. The reported pictures were scaled down with respect to the effective size they were presented to respondents.

Table 1
Independent variables used in the first regression function.

Variables*	dummy coding
panoramic	1 = Panoramic views
	0 = Not panoramic views
VAIA	1 = Presence of trees felled by the VAIA storm
	0 = Absence of trees felled by the VAIA storm
abandonment	1 = Abandoned meadows and pastures
	0 = Managed meadows and pastures
meadows and forests	1 = Presence of meadows and forests
	0 = Presence of forests

* Variables refer to the characteristics presented in Fig. 2.

case, however, factor analysis was applied to reduce the number of independent variables (the emotions in our case) to be included in the estimated models. The varimax rotation procedure was used to identify the factors; in the extraction procedure, we considered the factors with an eigenvalue greater than or equal to 1. Two factors were then identified that explain 78.8% of the total variance. A regression function was then estimated to establish a relationship between the two selected factors (positive and negative emotions, Table 10) and the scores assigned to aesthetic-visual quality. In this way it was possible to test the relationships between the aesthetic scores and the emotions connected to the landscapes.

3. Results

3.1. Sample socio-economic characteristics and recreational activities in the mountains

The sampled individuals were stratified based on their province of residence and gender, and as seen in Table 2, the sample mirrors the provincial distribution of the Veneto population. Regarding gender, there's a slight male majority (51.7%), but the sample can still be

Table 2
Socio-economic characteristics of the respondents.

Variable	Levels	Respondents		Veneto (2020)*	
		n.	%	n.	%
Province of residence	Verona	133	18.7	927,810	19.1
	Vicenza	125	17.5	854,962	17.6
	Belluno	26	3.6	199,704	4.1
	Treviso	130	18.2	880,417	18.1
	Venezia	116	16.3	843,545	17.3
	Padova	152	21.3	932,629	19.2
	Rovigo	31	4.3	230,763	4.7
	Total	713	100.0	4,869,830	100.0
Age	18–29	126	17.7	575,068	14.0
	30–44	174	24.4	873,748	21.3
	45–54	160	22.4	817,194	19.9
	55–64	148	20.8	703,937	17.1
	65–75	105	14.7	596,987	14.5
	Above 75	0	0.0	538,680	13.1
	Total	713	100.0	4,105,614	100.0
Education	Elementary or lower secondary school diploma	91	12.8	1986	47.0
	High school diploma	374	52.5	1614	38.2
	Bachelor's degree	248	34.8	624	14.8
	Total	713	100.0	4224	100.0
Occupation	Agriculture	11	1.5	73,136	1.8
	Industry or crafts	148	20.8	734,800	17.9
	Services (commerce, public employment, etc.)	327	45.9	1,307,379	31.8
	Not active (retired, student, housewife)	227	31.8	1,990,299	48.5
	Total	713	100.0	4,105,614	100.0
Number of members in the household	1	91	12.8		
	2	206	28.9		
	3	208	29.2		
	4	160	22.4		
	5 or more	48	6.7		
	Total	713	100.0		
Geographical area of residence	Plains	609	85.4		
	Hill	77	10.8		
	Mountain	27	3.8		
	Total	713	100.0		
Urbanistic characteristics of the municipality of residence	Urban center	213	29.9		
	Suburb	269	37.7		
	Rural center	185	25.9		
	Agricultural zone	46	6.5		
	Total	713	100.0		

* Data based on 2020 CENSUS by the Italian National Institute of Statistics (ISTAT: https://www.istat.it).

considered representative of the overall population. The number of residents in the province of Belluno, the province most affected by the VAIA storm, is limited in absolute terms, but still in line with the percentage of the reference population of the Veneto Region living in such province. As previously mentioned, due to the data collection methods, the sample cannot be considered representative of other characteristics such as age and education. There are no individuals over 75 years old in the sample although in Veneto they make up 13% of the population (Table 2). If this age group is excluded, the age distribution of the sample is quite similar to the regional distribution. However, the sample significantly deviates from the regional situation in terms of education (Table 2). In Veneto, 14.8% of the population aged 15 and older holds a university degree, while in the sample, this percentage is 34.7% for those aged 18 and above. A similar situation can be observed for respondents with a high school diploma. This might be due to the exclusion of over 75 people, due to the internet data collection approach. Regarding the occupational sector, respondents from the service sector and industry and crafts are overrepresented (Table 2). It can also be observed that, in general, farmers are slightly underrepresented. The majority of the sample comes from households with 2–4 members. The geographical area of residence largely reflects the provincial distribution of the sample, with 3.8% residing in mountainous areas, 10.8% in hilly areas, and the remaining fraction in the plains (Table 2). Most respondents reside in an urban context (city center and suburbs), while 32.4% live in rural areas (Table 2). This data is important because the place of residence can have significant implications for the demand for green areas and, therefore, mountain visits.

The respondents have a very close relationship with the mountain. Only 22.4% have not undertaken excursions or vacations in the mountains in the past year. From the total number of respondents, 42.5% have engaged in both excursions and vacations[2], 29.7% have only undertaken excursions, and 5.3% have only taken vacations. Based on the data collected, it can be estimated that the number of recreational events held in the Venetian mountains annually is approximately 12.6 million.

3.2. The VAIA storm and ecosystem services

To gain an understanding of the effect of the VAIA storm on ecosystem services, respondents were first asked if it had interfered with their recreational and tourism choices in the last year (Table 3) (data collected in May 2022, VAIA storm occurred in October 2018). According to the respondents, the presence of felled trees was still very

Table 3
Effect of the VAIA storm on tourism (data collected in May 2022, VAIA storm occurred in October 2018).

Question	n.	%
In the areas you visited in the mountains in the last year, the presence of felled trees was		
Very high and widespread across the area	109	21.5
Very high but only in a few areas	191	37.7
Rather limited but very widespread across the area	101	19.9
Rather limited and only in a few areas	105	20.7
Total	506	100.0
In the past year, the trails you frequented were		
Completely accessible	121	24.9
Largely accessible	296	61.0
Partially accessible due to the widespread presence of fallen trees and hydrogeological disturbances	68	14.0
Total	485	100.0
Did you have to give up some hikes due to trail damage?		
Yes	99	20.6
No	381	79.4
Total	480	100.0
Did you take into account the damages caused by the VAIA storm when choosing a mountain excursion destination in the last year?		
No	322	64.4
Sometimes	149	29.8
Very often	29	5.8
Total	500	100.0
Did you take into account the damages caused by the VAIA storm when choosing a mountain vacation destination in the last year?		
No	222	65.7
Very little	82	24.3
A lot	34	10.1
Total	338	100.0

Data refer to respondents that made at least a visit or vacation and eventually an excursion in the Veneto mountains in the last years.

[2] Excursion refers to short trips, usually taken for a specific purpose, implying a one-day journey, whereas vacation refers to longer trips, usually farther from one's home for the purpose of relaxing and recreation, and require at least one overnight stay.

high and widespread in the area (21.5%) or very high but only in a few areas (37.7%). Only a few declared that the phenomenon was not widespread and only affected a few areas. Nevertheless, the trail network was largely or completely usable (86%). However, one-fifth of the respondents had to interrupt an excursion due to the effects of VAIA. Despite the significant efforts made by the Italian Alpine Club (CAI) for trail maintenance and restoration, it is evident that in some areas, it may be challenging to fully restore the situation to what it was before October 2018. This is evidenced by the fact that 5.8% stated that they often took into account the damage caused by VAIA when deciding where to go for an excursion, and an additional 29.8% considered it sometimes. Regarding tourism, 10.1% stated that they chose their vacation destination with a high consideration of the damage caused by VAIA.

In Table 4, the average scores for each of the ecosystem services affected by the VAIA windstorm, according to people perception, are reported. According to the respondents, the most significant damage is caused to the beauty of the landscape, followed in order of importance by the conservation of the hydrogeological system and the conservation of biodiversity. Services that have a greater commercial relevance, such as timber production and tourism and recreational activities, appear to be less important. The difference between the averages is statistically significant with a 99% probability, with the exception of the pair "Timber production - Reduction of carbon dioxide concentration".

3.3. The effect of the VAIA storm on the visual perception of landscape quality

Respondents evaluated all the proposed photographs associated with the eight landscape types. In Table 5, the scores for each of the eight landscape types to which the pictures belong are reported, while an example of representative pictures of each category is presented in Fig. 3.

According to the respondents scores, the most preferred landscapes are the panoramic ones where there is no land abandonment or fallen trees due to VAIA, followed by the non-panoramic landscapes without degradation factors. Conversely, the least appealing landscapes are those where trees felled by the VAIA storm are present. It can be noted that the presence of fallen trees results in a drastic reduction in the perceptual quality of mountain landscapes. The difference in average scores (tested with ANOVA) is statistically significant with a 95% probability for all 28 pairs of images, with the exception of types 2 and 3 (Panoramic - Forests - no VAIA ⇔ Panoramic - Forests and meadows - managed), 5 and 1 (Non panoramic - Forests - with VAIA ⇔ Panoramic - Forests - with VAIA), and 6 and 4 (Non panoramic - Forests - no VAIA ⇔ Panoramic - Forests and meadows - with abandonment). The results confirm the hypotheses formulated by Ode et al. (2008) regarding the nine key concepts underlying landscape preferences: panoramic views and care for the environment are two factors that significantly enhance the perceptual preference for mountain landscapes. In some cases, the alternation of meadows and forests also appears to improve the perceptual quality of the landscape.

Table 4
Relevance of the damages caused by the VAIA storm to the forest's ability to provide ecosystem services, according to people's perception.

Ecosystem Services	Mean*	St. Dev.	95% confidence interval	
			inf.	sup.
Beauty of the landscape	4.143	0.040	4.064	4.222
Conservation of the hydrogeological system	3.875	0.047	3.783	3.967
Conservation of biodiversity	3.719	0.046	3.629	3.810
Reduction of carbon dioxide concentration	3.442	0.043	3.357	3.527
Timber production	3.321	0.052	3.219	3.423
Tourism and recreation	3.290	0.054	3.185	3.396
Water purification	2.888	0.056	2.777	2.998

* Score based on a Likert scale ranging from 1 (very little) to 5 (a great deal).

Table 5
Perception of visual quality of the analyzed categories of mountain landscapes.

Landscape type	Mean*	St. Dev.	95% confidence interval	
			inf.	sup.
1 - Panoramic - Forests - VAIA	2.461	1.628	2.342	2.581
2 - Panoramic - Forests - no VAIA	6.236	1.039	6.159	6.312
3 - Panoramic - Forests and meadows - managed	6.259	0.984	6.187	6.332
4 - Panoramic - Forests and meadows - abandoned	5.373	1.412	5.269	5.477
5 - Non panoramic - Forests - VAIA	2.513	1.511	2.402	2.624
6 - Non panoramic - Forests - no VAIA	5.522	1.422	5.417	5.626
7 - Non panoramic - Forests and meadows - managed	5.816	1.159	5.731	5.902
8 - Non panoramic - Forests and meadows - abandoned	4.893	1.543	4.780	5.007

* Scores derived from a Likert scale ranging from 1 (dislike) to 7 (like very much). Observations = 5704 (every respondent - N = 713 - rated 8 pictures).

To better understand the effect of the characteristics considered in identifying the eight landscape types on actual landscape quality, two regression models were estimated, as previously mentioned. In the first model, the perception of aesthetic quality (respondents aesthetic rating) was related to the four characteristics that allowed for the identification of the eight landscape types as shown in Fig. 2 (Table 6). The coefficient of determination (adjusted R^2) for the model is 0.527, which can be considered satisfactory given the large sample size (5704 individual evaluations). All independent variables are significant with a 99% probability, and the model does not exhibit multicollinearity issues (variance inflation factor, VIF <= 2) or heteroscedasticity.

As can be observed, the factor with the most significant negative impact is the presence of trees felled by the VAIA storm. The alternation of meadows and forests improves the landscape quality compared to a situation with only forests. In addition to the effect of panoramic views, the model highlights that the presence of forests is less favoured compared to the alternation of meadows and forests. The abandonment of mountain pasture cultivation also leads to a deterioration in landscape appreciation.

In the second model (Table 7), the independent variables consist of the percentage of the image occupied by each of the elements considered. This model has a lower interpretative capacity than the previous one (R^2 = 0.425; standard error of the estimate = 1.503). However, it provides a better interpretation of the impact of the various landscape characteristics on aesthetic-visual quality. The model confirms what emerged from the model in Table 6 but, regarding forests, it allows us to establish that while forests located in the foreground or background that

Table 6
Influential factors on the perception of visual quality of the landscape. Dependent variable: landscape appreciation score.

Variables*	Coefficients	Robust St. Err.
(Constant)	5.681***	0.040
panoramic	0.396***	0.036
VAIA	− 3.391***	0.054
abandonment	− 0.905***	0.048
meadows and forests	0.159***	0.044

*** $p < 0.01$; Adjusted R^2 = 0.527 * Variable names refer to the characteristics presented in Fig. 2 and are described in Table 1. Std. error = 1.363; Breusch-Pagan test = 139.18 ($p < 0.0001$); N = 5704.

Table 7
Results of regression model 2. Dependent variable: landscape appreciation score. Independent variables relate to the percentage of the view occupied by landscape elements considered and aesthetic-visual landscape quality.

Variables	Coefficients	St. Err.
Constant	5.950***	0.1413
% mountain slopes occupied by forests	0.001***	0.0024
% forests located in the foreground or background	− 0.006***	0.0016
% undergrowth	− 0.006***	0.0017
% abandoned meadows and pastures	− 0.011***	0.0015
% meadows and pastures (not abandoned)	0.005***	0.0017
% trees felled by VAIA	− 0.049***	0.0016

***$p < 0.001$; Omitted variable: % mountain covered with rocks.
Adjusted $R^2 = 0.425$; Std. error = 1.503; Breusch-Pagan test = 510.93; $p < 0.0001$; $N = 5704$.
The percentage occupied by the elements considered was calculated excluding the part of the image occupied by the sky.

reduce panoramic views tend to reduce the aesthetic-visual quality of the landscape, those in the distance on the mountain slopes have the opposite effect. The view of the undergrowth, especially if poorly maintained or containing remnants of felled trees, has a negative effect as well. Furthermore, the model can provide more operational and managerial insights. Along the trails used by tourists and hikers, it would be advisable that, where possible, instead of leaving the trees felled by the VAIA storm, the meadows and pastures should be left, allowing for better panoramic views, especially of the surrounding mountains covered with forests.

3.4. Landscape and emotions

Landscape perception has strong emotional foundations. Generally, more pleasant landscapes should be associated with positive emotions, and vice versa for less pleasant ones. The connection with emotional bases is particularly important because it means that the quality of the landscape can alter people's physiological states and, therefore, the restorative capabilities of the environment (Bowler et al., 2010; Cackowski and Nasar, 2003; Han, 2010; Ulrich et al., 1991). The data reported in Table 8 support this initial hypothesis. In the case of the analyzed mountain landscapes, visual perception of landscape quality is associated with positive emotions. In particular, landscapes where fallen trees are visible have generated a strong sense of concern and sadness. Conversely, panoramic landscapes in which there are no signs of neglect and abandonment (types 2 and 3) are the ones that evoke positive emotions such as a sense of relaxation and happiness.

Finally, the model that relates visual-perceptual quality to the emotions evoked by the landscapes among the respondents has been estimated. In the model (Table 9), all eight emotions were considered as independent variables. The model has a good interpolating capacity (adjusted $R^2 = 0.78$), which again testifies to the existence of a relationship between landscape quality and the emotions it can evoke. The independent variables are all statistically significant with a 99.9% probability. However, it cannot be completely ruled out that multicollinearity exists because the variance inflation factor (VIF) for some variables is close to 5. The emotions that contribute most to improving the visual-perceptual quality of the landscape are "fascinates me", "relaxes me", and "makes me happy". Conversely, "makes me sad" and "worries me" act in the opposite direction.

To overcome potential problems arising from multicollinearity, a factor analysis was conducted, and two factors were extracted, explaining a total of 78.8% of the total variance (Tables A.11 and A.12). The first factor is strongly correlated with positive emotions, while the second is correlated with negative emotions. A function relating the two factors to the scores attributed to the visual-perceptual quality of the landscape was then estimated (Table 10). The model has a good

Table 8
Emotions associated with different landscape types.

Landscape types		Positive emotions				Negative emotions			
		Relax	Curiosity	Fascinates	Happy	Boring	Worry	Sad	Oppression
1 - Forest landscapes with high panoramic views in which trees felled by storm VAIA are visible	Mean*	1.69	2.26	1.82	1.57	2.00	3.64	3.70	2.99
	St. Dev.	0.951	1.099	1.029	0.865	1.150	1.227	1.229	1.336
2 - Forest landscapes with high panoramic views in which no trees felled by storm VAIA are visible	Mean*	3.88	3.58	3.97	3.75	1.32	1.37	1.32	1.34
	St. Dev.	0.979	0.991	0.973	1.010	0.620	0.649	0.650	0.712
3 - Landscapes in which, in addition to woods, there are also meadows and pastures that are not abandoned and with high panoramic views	Mean*	4.05	3.59	3.99	3.84	1.31	1.32	1.28	1.26
	St. Dev.	0.889	1.071	0.952	0.951	0.628	0.692	0.660	0.648
4 - Landscapes in which, in addition to woods, there are also abandoned meadows and pastures with high panoramic views	Mean*	3.46	3.09	3.31	3.25	1.55	1.51	1.45	1.42
	St. Dev.	1.061	1.05	1.09	1.075	0.858	0.814	0.748	0.762
5 - Forest landscapes with reduced panoramic views in which trees felled by storm VAIA are visible	Mean*	1.62	2.25	1.82	1.57	2.05	3.50	3.46	2.91
	St. Dev.	0.770	1.050	0.919	0.774	1.095	1.147	1.200	1.214
6 - Forest landscapes with reduced panoramic views in which no trees felled by storm VAIA are visible	Mean*	3.51	3.29	3.48	3.32	1.57	1.53	1.46	1.58
	St. Dev.	1.121	1.073	1.109	1.135	0.824	0.766	0.739	0.861
7 - Landscapes in which, in addition to woods, there are also meadows and pastures that are not abandoned and with reduced panoramic views	Mean*	3.80	3.31	3.61	3.61	1.38	1.33	1.27	1.29
	St. Dev.	0.982	1.049	0.994	0.972	0.712	0.645	0.603	0.651
8 - Landscapes in which, in addition to woods, there are also abandoned meadows and pastures with reduced panoramic views	Mean*	3.19	2.77	2.95	2.97	1.83	1.56	1.63	1.60
	St. Dev.	1.109	1.063	1.117	1.105	0.983	0.815	0.847	0.860

* Rating score ranging from 1 (very little) to 5 (very much)

Table 9
Relationship between aesthetic perceptive value of the landscape and emotions. Dependent variable: visual aesthetic quality score.

	Coefficients	Robust St. Err.	VIF†
(Constant)	2.785***	2.785***	0.088
Makes me happy (Happy)	0.273***	0.024	5.072
It relaxes me (Relax)	0.278***	0.024	4.919
Fascinates me (Fascinates)	0.413***	0.025	4.953
It intrigues me (Curiosity)	0.069***	0.018	2.326
It bores me (Boring)	− 0.079***	0.019	1.505
It gives me a feeling of oppression (Oppression)	− 0.084***	0.020	2.968
It worries me (Worry)	− 0.146***	0.025	4.175
It makes me sad (Sad)	− 0.267***	0.024	4.502

***$p < 0.001$; $N = 5704$; Adjusted $R^2 = 0.78$; Breusch − Pagan test = 151.14 ($p < 0.0001$). † variance inflation factor (VIF)

interpretative capacity (adjusted $R^2 = 0.78$) and does not exhibit multicollinearity and heteroscedasticity issues. The coefficients are all significant with a 99.9% probability. Once again, this clearly demonstrates that positive emotions increase the value in terms of perceived visual-aesthetic quality of the landscape, while negative emotions decrease it.

4. Discussion and conclusions

This research unveils the perceptions and preferences of both residents and visitors living in the Veneto Region regarding landscape features within a mountainous region that was severely impacted by an extreme event, more specifically the VAIA storm that hit Northeastern Italy. The study area is part of the European Alps, covering some of the UNESCO site of the Dolomites, a popular destination for recreation and tourism, which according to our findings (Tables 3 and 4) was one of the many ecosystem services affected by the storm. From the analysis of the respondents' preferences, some important inputs for future actions regarding landscape management are drawn.

First, regarding the aesthetic quality, our results (Tables 5 and 6) point to a preference for a set of physical characteristics of the landscape, including panoramic views and a mix between forests and meadows, a landscape type that is traditionally connected to this area. The results confirm the hypotheses formulated by Ode et al. (2008) regarding the nine key concepts underlying landscape preferences: panoramic views and care for the environment are two factors that significantly enhance the perceptual preference for mountain landscapes. In some cases, the alternation of meadows and forests also appears to improve the perceptual quality of the landscape. This finding is consistent with previous research conducted in the Alps. For instance, Tattoni et al. (2021) observed a tourist preference for open areas with scattered trees, while Schirpke et al. (2021) noted a similar preference for agro-forestry and pastures at higher altitudes. In the Alpine part of Switzerland, Hunziker (1995) found a preference of locals and tourists for forest patches in agricultural areas, perceived as of high visual quality. Even though the focus of their research was different from ours (they investigated the impact of agriculture policy on land abandonment and spontaneous reforestation), the preference for a mixed landscape situation with the combination of forest and meadows in the alpine area is a match to our findings. A similar result was obtained by Vecchiato and Tempesta (2013), where, estimating the benefits of a huge peri-urban forest, they found that a mixed afforestation management option, with both forest and meadows, was the benefits maximizing solution for the project. On the other hand, our results indicate that the presence of unmanaged meadows and trees felled by the VAIA storm have a negative effect on people's perception of landscape quality. Such effect should be taken into account for tourism promotion. In fact, nearly 10% of our sample stated that the choice of a vacation destination in the Dolomites is highly linked to the consideration of the damage caused by VAIA. In some ways, it can be assumed that, at least in people's perception, the persistence of the damages caused by VAIA continues to influence the tourist and recreational behavior of mountain visitors. Based on these results, it is suggested that the fallen trees should be removed and replaced by managed meadows with forest patches, thus keeping the panoramic views and avoiding the further spreading of the bark beetle epidemic that surged after VAIA. This aligns with the discovery by Paletto et al. (2022), revealing that a significant portion of individuals consider snags and deadwood to have a detrimental aesthetic impact on the landscape. The findings also resonate with those presented by Arnberger et al. (2018) in the United States and Germany, where visitors similarly expressed their aversion to the presence of deadwood in forests affected by bark beetle infestations. From a management and policy perspective, this highlights the importance of promoting policies devoted to the maintenance of the alpine landscape.

Table 10
Relationship between visual aesthetic value and factors relating to emotions. Dependent variable: visual aesthetic quality score.

Variables	Coefficients	Robust St. Err.
Constant	4.884***	0.012
Positive emotions	1.346***	0.013
Negative emotions	− 1.118***	0.015

***$p < 0.001$; $N = 5704$; Adjusted $R^2 = 0.78$; Breusch-Pagan test = 369.69 ($p < 0.0001$).

Second, we investigated the connections between landscape types and the emotions they evoke, since, as suggested by various authors (Lippert et al., 2022; Mealey and Theis, 1995; Notaro et al., 2019), landscape perception has strong emotional foundations. In addition to specific physical landscape features, our findings (Table 10) suggest that emotions were shown to be influential on people's landscape perception, with positive emotions such as happiness, relaxation, curiosity and fascination positively affecting their perception of landscape quality whereas negative emotions such as sadness, worry and oppression negatively influencing this perception. This is aligned with the literature exploring the use of emotions as predictors of landscape quality. The preference for panoramic views is aligned with Breiby and Slåtten (2015) who found that scenery/views have a positive effect on tourists' emotions and intention to visit a natural area in Norway. Our results are also somewhat aligned with those of Notaro et al. (2019) who found that emotions were a predictor of preference heterogeneity for different land uses in the Alpine area, with people who presented negative emotions preferring to change the status quo, meaning that they showed a higher preference for a change in the landscape composition towards one composed of a mix of tree species and a mix of crop species. The negative effects of abandoned areas and those affected by the storm are to a certain degree aligned with those presented by Hussain et al. (2019) in the Austrian and Swiss Alps, where visitors' perceived mental benefits (stress reduction, attention restoration) were higher when visiting a managed meadow compared to abandoned ones. We also find a coherence of our results with the ones of Tindale et al. (2023) who even though focused on grasslands, also detected negative emotions related to the loss and degradation of the landscape. Therefore, our results highlight how the connection between landscape perception and emotional bases is particularly important because it means that the quality of the landscape can alter people's physiological states and, therefore, the restorative capabilities of the environment (Beckmann-Wübbelt et al., 2021; Da Schio et al., 2021; Doimo et al., 2020; Pichlerová et al., 2023).

This study adds to the current scientific literature on the role of emotions on people's perception by applying the psychophysical method to an area affected by an extreme event and by finding that emotions are a better predictor of peoples' perception of landscape quality, with a higher explanatory power (R^2=0.788) than the model using only the physical characteristics of the landscape as explanatory

variables (R^2=0.527). These results serve as input for decision-makers in order to plan restoration policies, suggesting that both people's perceptions and their preferences towards specific landscapes should be taken into consideration to evoke positive emotions, and to plan restoration policies after extreme events. Specifically for this study area, it is possible to conclude that from a management perspective, actions devoted to the maintenance of the alpine landscape, traditionally composed by a mix of forests and meadows should be performed with the removal of dead trees that were felled by the windthrow to avoid further bark beetle infestation and improve overall landscape quality perception, with panoramic views. In addition, the sense of abandonment through the presence of unmanaged meadows and large amount of deadwood resulting from the windthrow evokes negative emotions on residents and visitors affecting the recreational services which is detrimental to the study area given its popularity in terms of tourism.

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CRediT authorship contribution statement

Tiziano Tempesta: Writing – original draft, Writing – review & editing, Validation, Supervision, Software, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Carolina B. Pellizzari:** Visualization, Writing – original draft, Writing – review & editing. **Daniel Vecchiato:** Writing – original draft, Writing – review & editing, Visualization, Validation, Supervision, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix. Additional tables

Table A.11
Factor analysis: correlation matrix.

	Happy	Relax	Fascinates	Curiosity	Boring	Oppression	Worry	Sad
Happy	1.000	0.856	0.850	0.691	-0.398	-0.544	-0.618	-0.644
Relax	0.856	1.000	0.835	0.654	-0.416	-0.596	-0.658	-0.676
Fascinates	0.850	0.835	1.000	0.733	-0.435	-0.530	-0.587	-0.621
Curiosity	0.691	0.654	0.733	1.000	-0.373	-0.365	-0.389	-0.425
Boring	-0.398	-0.416	-0.435	-0.373	1.000	0.537	0.424	0.472
Oppression	-0.544	-0.593	-0.530	-0.365	0.537	1.000	0.755	0.765
Worry	-0.618	-0.658	-0.587	-0.389	0.424	0.755	1.000	0.851
Sad	-0.644	-0.676	-0.621	-0.425	0.472	0.765	0.851	1.000

N = 5,704; Bartlett's Test of Sphericity = 39764.5 ($p<0.0001$)

Table A.12
Factor analysis: Rotated component matrix.

	Factors	
	Factor 1 Positive emotions	Factor 2 Negative emotions
Happy	0.836	-0.409
Relax	0.786	-0.478
Fascinates	0.858	-0.380
Curiosity	0.875	-0.136
Boring	-0.236	0.613
Oppression	-0.232	0.880
Worry	-0.318	0.849
Sad	-0.356	0.848

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